How Does the Estuary Serve as a Nursery?

Among their many functions, wetlands serve as important protective breeding and nursery grounds for fish and other aquatic animals. Aquatic animals such as plankton establish themselves as essential links in the food chain by providing food sources for fish populations. Changes resulting from human activities near the estuary may have severe effects on the aquatic community. Plankton and fish may not be able to adapt to the change, causing a deficiency in food supplies for organisms in the upper food chain.

Objectives

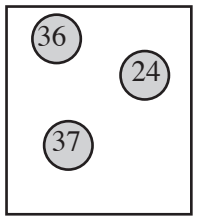
When you have completed this activity, you should be able to:

- Demonstrate the methods used by ecologists to sample populations of plant and animal life in the water.
- Classify the types of organisms that are found as plankton in an estuary.
- Predict the effects of some human and environmental forces on conditions in an estuary.

Procedure

A *sample* is one method that ecologists use to examine a population without observing and counting every organism. A sample can be taken by randomly choosing an area of a certain size and counting all the organisms present. To see how this works, do the following:

1. Take a canning jar ring and drop it anywhere on this page. Count the number of times the letter **E** appears in the circle.
2. Repeat this two more times. Add up your three counts and divide the total by 3. This gives you the average number of **E**s in an area of 43 cm^2 (the area inside the ring).
3. To estimate (make an educated guess about) the total number of **E**s on the page, multiply your average by 9.2, since the page is about 9.2 times as big as the area inside the circle. Round to the nearest whole number.



36
24
+37
97

97 / 3 = 32.3
32.3 x 9.2 = 297

Source

OEAGLS EP-16 "The Estuary: A Special Place" by Rosanne W. Fortner and Ron Mischler.

Earth System Understandings

This activity focuses on ESU 3, science methods and technology, 4, interaction, and 5, change through time. See the introduction to the activity set.

Materials

- "Plankton samples" in Figures 2 and 3.
- Ring from a canning jar (wide mouth, having an inside diameter of 7.4 cm).
- Pencil.

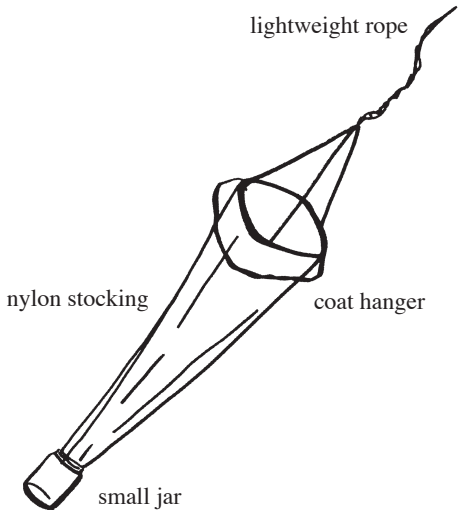
Teacher's Note

Have the students practice the technique and calculations for the **E** "population" on one or two printed pages before going on to the plankton pages.

If for some reason you wish to use the regular-mouth jar rings, having the i.d. of 5.7 cm, use 25.5 cm^2 for the area in Step 2, and use 15.4 for the multiplication factor in Step 3.

In sampling for Figures 2 and 3, students will often have organisms that are only partly visible in the ring. Follow the general rule that if one half of the organism or more is visible, the students should count that as one whole organism. For algae clumps, it is probably most accurate to count every strand of algae as a different organism, rather than counting clumps or clusters.

Figure 1. Student-made Plankton Net.



Hint

In the table on the worksheet, the first type of algae listed is Diatoms. When recording your sample, count both kinds shown, and list them together as Diatoms. Do the same for the green and blue–green algae. The number you write will be a total for both species in each category. In the case of the zooplankton, only one species of each of the different groups is shown.

Answers to Procedure

For most of the following, results would probably be more accurate if the entire class would pool its information.

A. 1. Spring
2. Summer
3. Spring
4. Summer
5. Spring
6. Spring
7. Summer

Now let's pretend that a jar of water has been collected from the Old Woman Creek estuary. It was collected in a special way. A plankton net (Figure 1: student–made plankton net) was towed behind a boat for about five minutes. The net had a jar at the end that caught all the tiny organisms in the water, while the water escaped through holes in the net.

The jar of water has thousands of organisms in it. You can tell they are there because they keep the water churned up in the jar, but you can't see them well enough to tell what they are. You need a microscope.

Figures 2 and 3 show some of the animals you might see through the microscope. Figure 2 is from a plankton sample collected in May, and Figure 3 is from an August sample. Look at the organisms shown and compare them to the pictures in the chart on your worksheet. Be sure you tell which are algae, zooplankton, and fish larvae.

4. Repeat the sampling method you used for the letter e but this time sample the organisms in Figures 2 and 3. It is best if you actually trace your sampling circles on Figures 2 and 3. This will make it easier for you to record on the chart and still not disturb your sample (move the ring). Also, you can come back to your samples and recheck them as the need arises. Record your results on the worksheet.

Figures 2 and 3 are based on actual plankton samples collected along the Lake Erie shore. Both the numbers and types of organisms are therefore fairly accurate examples of what may be found in the Old Woman Creek area.

Hopefully, those of you who said, "But why not just count all the **E**s?" on the **E** sampling page can see better why scientists frequently resort to sampling techniques. (Imagine a scientist trying to count all the individual organisms in the estuary!)

5. Answer the following questions based on the samples you "collected."

A. Which season had these characteristics?
1. The greatest number of diatoms
2. The greatest number of blue-green algae
3. The greatest number of zooplankton
4. The warmest water
5. The most gizzard shad larvae
6. The most yellow perch larvae
7. The most sheepshead larvae

B. Young perch eat a lot of algae. Which season would have the most food for baby perch? In which season are the perch spawned (eggs deposited)?

C. Do all the types of fish in the sample spawn at the same time? How can you tell?

D. You have noted that the water is warmer in which sample? Water temperature is an important factor in determining when fish spawn. Which species appear to require warmer water for spawning?

E. What would be the advantage of having different fish spawn at different times?

F. Fish may enter an estuary to spawn. Based on what you learned in the previous estuary activity, why else might fish come into the estuary?

G. You now have information about the microscopic organisms in an estuary. In "What is the role of plants in an estuary?" you investigated the activities of some of the macroscopic (visible to the unaided eye) organisms in an estuary. Using what you have learned, predict the effect of the following events on the plants and animals of the estuary.

1. Heavy spring rains raise the level of the creek 1 foot higher than it is now. The water also flows very fast.

2. Hot water is dumped into the estuary by a utility company.

Answers to Procedure

B. Perch spawn in spring (March-May). There is more food for them in summer, however. Note that they have yolk sacs in the May plankton sample. The larvae use the yolk as food, then begin to feed on algae.

C. No. There are no bass or sheepshead in the May sample. They appear as yolk-sac larvae in the August sample.

D. Summer water is warmer. Sheepshead and white bass appear to require warmer water for spawning.

E. Spawning times could be related to the availability of food for the larvae. There may also be temperature tolerances of the fish to be considered, and some fish are sensitive to overcrowding. Another reason could be to keep species from interbreeding. Discuss all possibilities that students suggest.

F. Fish might also enter the estuary to eat or to find shelter among the water plants.

G1. Rooted plants may be washed out or completely submerged which would kill plants that are ordinarily emergent. The mud of the bottom could be washed out, preventing plants from becoming reestablished. Plankton would be swept out into the open water of the lake. Adult fish might find more spawning sites in the submerged plants, but there is a greater chance of eggs and larvae washing away into the lake where they could be killed by temperature changes or eaten by other fish. Muddy water would reduce the ability of sight-feeding fish to find food. If larvae remained, their food supply would probably be reduced because of plankton loss. Shore birds would probably have more trouble catching small fish, and the nest sites for the birds could be destroyed.

G2. Plants could be killed. Plant plankton would probably increase in number up to a certain water temperature. Zooplankton would probably be killed. Fish that depend on warmer water temperatures to determine their spawning time

(*Cont'd*)

might spawn earlier than usual. If the temperature got too high, some fish would not enter the estuary at all. Fish larvae might have more algae to eat, but excess heat could kill both eggs and larvae. The food supply would be affected.

G3. Removal of bottom sediments would cause destruction of the water plants rooted there. Fish, shore birds and other animals that depended on the plants for breeding areas, food or shelter would no longer enter the estuary. Plankton would be washed out into the lake. (No water plants would be available to hold them back.)

G4. Nobody wants a marsh as a backyard. We can assume that the water edges are bordered by seawalls or sand beaches in front of the homes. The character of the estuary would be completely changed. Few rooted plants could survive and there would be few plankton. Adult fish would move further inland to spawn, or spawning may be prevented, thus no eggs would be produced to continue the species in that area. Food supply would decrease, so animals would need to find other feeding grounds. Few plants would remain so that there would be no nest sites. Students will probably have interesting ideas on what changes would be involved. All possibilities should be discussed.

3. The estuary is dredged out so that boats can go up the creek. The mouth of the estuary is deepened and probably protected by a sea wall. A portion to be used as a marina is deepened as well to a depth of 2 to 3 meters.

4. The estuary is filled in on the sides so that new homes can be built near the water.

Review Questions

1. Explain what is meant by population sampling.

2. Describe a sampling method for a microscopic community.

3. What types of organisms might be found in an estuary plankton sample? Do you think having a diversity of organisms in an estuary is important? Why or why not?

4. Explain how a temperature increase could affect the number of plankton in a lake. Select another human induced change discussed in the activity and explain its potential effect on the microscopic community. How will these changes affect fish and other animal species in the food chain?

5. Why are estuaries considered to be "endangered environments?"

Extension

Have the students create their own "plankton sample." Place a handful of straw in a container of water in the sun. Using a microscope, examine changes in the number and types of organisms in the water over several days.

References

Eisenhower National Clearinghouse has online information about wetland resources (www.goenc.com).

The E.P.A. has educational resources available for the classroom. Contact the Wetlands Helpline 1-800-832-7828 for printed material, posters, and other resources.

Some state agencies may provide field trips for students. They also could have manuals available regarding wetlands in your area. Contact your state's natural resource agencies for more information.

Figure 2. Estuary Plankton Sample, May (water temperature 13°C).

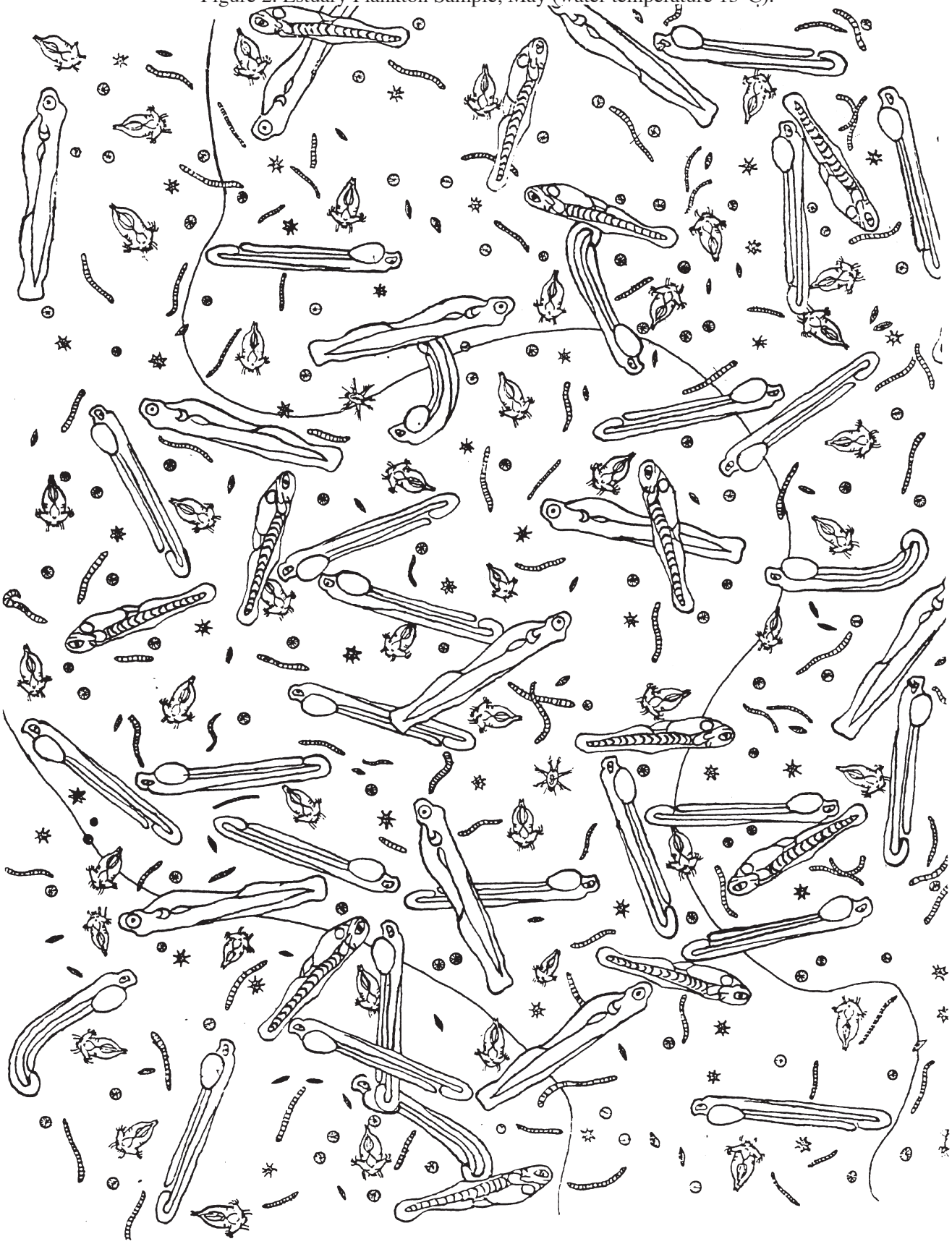


Figure 3. Estuary Plankton Sample, August (water temperature 21°C).

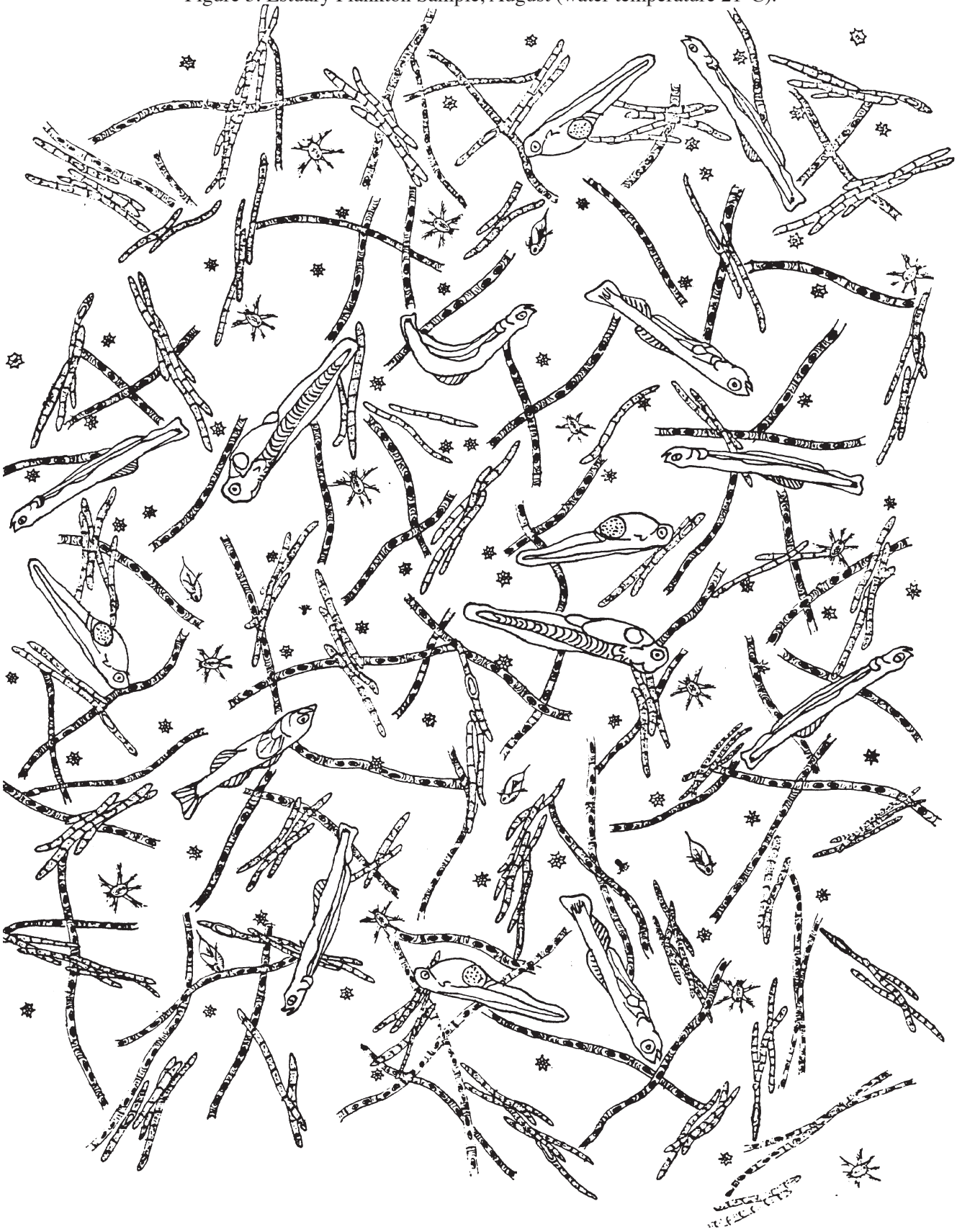


Figure 4. Worksheet for Estuary Plankton Sample.

PLANKTON SAMPLE

Organism	May Sample (Fig. 6) 1	2	3	Ave.	Total Pop	Aug. Sample (Fig. 7) 1	2	3	Ave.	Total Pop.
Algae:										
Diatoms 										
Green										
Blue-green										
Zooplankton:										
Cladocerans 										
Copepods 										
Protozoans 										
Rotifers 										
Fish Larvae:										
Yellow Perch  Yolk-sac larva										
 Regular larva										
Gizzard Shad  Yolk-sac larva										
 Regular larva										
White Bass  Yolk-sac larva										
 Regular larva										
Sheepshead (freshwater drum)  Yolk-sac larva										
 Regular larva										
Emerald Shiner  Yolk-sac larva										
 Regular larva										

***Yolk--sac larvae have just emerged from eggs. A yolk-sac larva is younger than a regular larva.**

Extending Your Knowledge

Wetlands can also be thought of as nurseries for birds because many species of birds build nests in the watery environments to raise their offspring. Migratory birds may depend on specific wetland sites as resting stops during their journeys.

Table 1 illustrates the percentage population changes for some wetland species during 1989-1990 and 1990-1991 and the overall trend from 1966-1991. In the contiguous 48 states, wetlands represent approximately 5 percent of the land area. Combined with deep water habitats (e.g. lakes), this figure increases to 9.3% for the conterminous U.S. Any decrease in this small number could have dramatic impacts. During the mid-1970s to the mid-1980s wetlands decreased in area by 2.5%, representing a loss of over 2.5 million acres. Including deep water habitats these figures are altered to a percentage loss of 1.2% and an area loss of 2.3 million acres.

Some scientists use *proxy data* as indicators of changes in habitat for specific species, such as wetland species. One example is the use of bird data. Table 1 lists data from the Breeding Bird Survey (BBS). What do the data suggest about wetland changes, that is, could species changes be attributed to wetland loss? From what you have learned in this activity set, what human induced changes could result in the loss of wetland environments? What do you think is the value of using this kind of data for detecting changes in wetlands?

1. Is it possible to compare the 1966-1991 bird survey figures with the wetland loss figures over the period of the mid-1970s to the mid-1980s?

2. Using the list of the birds included, examine the long-term population trends of selected waterfowl species. For example, examine the figures for Wood Ducks and Mallards over the 25-year period. Many people would think that mallard population trends would have exhibited an increase because of their adaptability to urban environments. Does the data set reveal this type of trend?

   Examine the trend for Canada Geese. Where are most of these geese located now – rural or urban environments?

Source

Adapted from "How do we learn about wildlife population changes?" Produced by Tony P. Murphy for the Ohio Sea Grant Education Program, the Great Lakes Protection Fund, and the George Gund Foundation.

Answers

1. Even though the time periods do not correlate exactly, it is possible to get an idea of the possible impact of wetland loss on waterfowl populations.

2. To answer these questions, it is necessary that the students select a variety of waterfowl in addition to those mentioned. They may wish to do additional research on a specific species that they observe locally or suspect to have changed.

   Mallards appear to have declined in numbers over the twenty five year period.

   Canada Geese seem to be adaptable to both rural and urban environments. In urban areas geese are protected from predators, which tends to promote their visiting those sites. Flocks may become an issue for housing developments or parks built next to lakes and ponds.

(*Cont'd*)

Table 1. Two year changes (1989-1990 and 1990-1991) and long term (1966-1991) population trends for selected wetland species, which were seen on 50 or more BBS routes in either two-year period. For the 3 intervals, percentage change per year (%/Year) is presented. Sample size (in N [number of routes]) is shown for each of the 2-year changes. For the third interval, the relative abundance is presented (R.A.). This is defined as the mean count on BBS routes over the 1966-1991 interval.

	1989 - 1990		1990 - 1991		1966 - 1991	
Species	%/Year	N	%/Year	N	%/Year	R.A.
Common Loon	3.9	103	23.5	121	2.2	0.74
Pied-billed Grebe	8.5	106	9.5	95	-1.6	0.21
Double-crested Cormorant	-24.5	137	12.7	138	6.5	0.61
American Bittern	27.9	132	-10.3	131	-1.6	0.41
Great Blue Heron	-0.35	741	3.3	748	1.5	0.77
Great Egret	-36.7	185	-32.4	170	1.1	1.41
Snowy Egret	-43.6	75	-28.1	61	6.9	0.81
Little Blue Heron	-13.8	131	17.1	124	-1.3	1.69
Cattle Egret	-27.6	182	20.1	188	2.4	12.56
Green-backed Heron	4.7	524	11	545	0	0.74
Black-crowned Night-Heron	-15.3	78	-32.8	84	-0.5	0.18
White Ibis	-36.7	59	183.4	51	2.2	4.36
Canada Goose	-2.1	352	15.2	379	7	2.51
Wood Duck	33.8	342	2	368	2.9	0.26
American Green-winged Teal	250.8	72	-43.5	80	-0.2	0.32
American Black Duck	158.9	65	-49	58	-0.7	0.27
Mallard	7.2	728	13.8	749	-4.1	5.06
Northern Pintail	52.3	114	-33.5	108	-15	1.85
Blue-winged Teal	15.4	192	-6.7	189	-1	1.53
Cinnamon Teal	-21.2	68	25.4	73	7.2	0.47
Northern Shoveler	23.2	82	10.8	88	0.5	1.04
American Wigeon	-21.4	86	2.8	87	0.3	0.95
Lesser Scaup	20.6	73	9.4	73	2.7	1.41
Common Merganser	-10.7	99	13.6	103	1.6	0.27
Ruddy Duck	19	57	49	62	2.4	0.68
Osprey	19.7	117	-2.6	119	2.6	0.12
American Kestrel	-0.2	738	4.5	724	0.6	0.92
Sora	71.3	132	5.2	140	-3.3	0.62
American Coot	-0.3	144	27.7	135	0.3	1.81
Killdeer	-8.9	1177	-5.7	1210	-0.1	5.57
American Avocet	4.5	68	-10	77	0.1	0.8
Spotted Sandpiper	-1.3	236	9.5	255	0	0.42
Upland Sandpiper	-1.9	188	16.3	195	3.6	1.9
Long-billed Curlew	-4.6	70	-2.9	71	-0.5	1.48
Marbled Godwit	22.1	69	-31.7	68	1	2.08
Common Snipe	-3.6	308	-9.1	303	0.4	2.08
Belted Kingfisher	-18.4	504	5.5	476	-1	0.38
Nashville Warbler	-7.5	226	0	217	1.7	4.94
Cerulean Warbler	24.2	70	-19.2	76	-2.7	0.21
Prothonotary Warbler	3.4	350	-11	373	1.1	1.31
Northern Waterthrush	-11.5	166	7.8	152	0.8	1.56
Wilson's Warbler	-8.1	130	4.1	135	0.9	1.34
Swamp Sparrow	-1	245	-17.2	245	0.4	1.07
Red-winged Blackbird	-0.4	1307	1.1	1325	-1	55.24
Yellow-headed Blackbird	0.6	218	-16	230	3	7.8

Note the two year changes for the Double-crested Cormorant. What reasons would you suggest for the different rates among years?

Investigate the species data for the Great Blue Heron, Little Blue Heron, and Green-backed Heron. In which two year period did the rates of change seem more positive?

Make a prediction about changes likely with prey species as the number of herons changed over time. In which two year period do you think the prey species would likely have been more abundant?

3. Would the loss of wetlands and deep water habitats have an equivalent impact on all waterfowl species? Why do some waterfowl population trends exhibit an increase and others a decline?

4. As a wildlife manager in one of the states or provinces surrounding the Great Lakes, you have to put forward a management plan for waterfowl. Base your waterfowl plan on the data from the population trends. How would you manage the various species? On which species would you increase/decrease the hunting "bag" limit? Why? Are there any additional aspects of your plan that could influence population trends? What are they and why have you used them?

Researchers gather the bird data using a type of census technique. Spot or territory mapping is used to describe the habitat examined. Various criteria were developed to establish the plots in the census: a "minimum plot size of 40-100 hectares (100-250 acres) in an open habitat, or 10-30 hectares (25-75 acres) in a closed habitat" (*Audubon Field Notes*, 1970, 724).

Instructions to BBS personnel include the following. Single uniform habitats should be selected as the study areas, if possible. For example, birch marsh, sand dunes, upland deciduous forest, upland coniferous forest, grassy field, etc. Plots should be square if possible. A detailed description of the plot should include: latitude and longitude from an official topographic map, general characteristics of the plot and surrounding landscape e.g., bog with scattered pines, farmland, etc., size in hectares and acres, altitude in meters and feet, soil type and/or bedrock, general topography e.g., mountains, valleys, peaks, hills, roads,

2. (*Cont'd*) Rates of change for cormorants could differ based on the weather, disease, and competition for nesting sites and food supply that varied during each year. Allow students to discuss their ideas about what could have caused the different rates of change.

   Students may respond in several ways. Data suggest that rates of change were more positive in the latter two years. Some may argue that lower number of prey species could have been present in the prior years which could have contributed to a decrease in herons sighted, thus the latter two years would have shown more prey. Others may suggest that prey species could have been more abundant in the earlier years because they were less threatened with predation, and in the latter two years their numbers would have shown a decline. Discuss possibilities that students suggest.

3. Various factors are responsible. Not all waterfowl depend on the same type of habitat – some live in wetlands, while others prefer deep water habitats. In fact, deep water habitats have increased slightly over the ten year period discussed. Also, some species adapt more readily to

Teacher's Note

You may want to have students create a picture of their perception of what a plot would look like.

etc., a large scale map showing the main vegetation types, their distribution and the location of the plot with its boundaries marked on the map, and any other relevant information. A grid system may be used to show the locations of birds and census takers, if reference to physical locations is not possible.

A minimum of 10 visits should be made to a closed habitat and eight to an open habitat during the breeding seasons of the majority of the birds in the plot. These visits should be spaced as evenly as possible during breeding. In addition, visits should be concentrated in the morning when most of the bird song activity occurs. If this same plot is surveyed in later years, the same pattern should be utilized if possible. All the details concerning each trip to the plot should be recorded – weather conditions, hours spent there, birds seen and heard, etc.

The following method was used in the bird census. "The bird population of any given habitat should be based on the number of territorial males rather than the number of pairs. The reason for this is that ordinarily the number of breeding females cannot be accurately determined without a great deal of extensive study involving much more time than is generally spent in conducting the census" (Hall, 1964, 414). Currently, the organizers (Cornell Laboratory of Ornithology) instruct people to mark the approximate position (and sex when possible) of birds as they are encountered (visually and/or aurally). Record all birds using the plot. Birds simply flying over the plot should not be included.

Review Questions

1. What methodology is followed in the BBS to survey areas for birds? Discuss any limitations to the method that could threaten its accuracy.

2. What possible link is there between waterfowl population trends and the loss of wetland/deep water habitats?

Evaluation

1. Using waterfowl population trends as a central point, have the students create a poster (concept map) which illustrates all possible factors that impact this trend.

2. Have students write a report on the use of BBS data as proxy data. Does it really inform us of the overall health of the environment? Answers should be supported with evidence.

Online Resources

Have the class find information about the Breeding Bird Survey on the Internet using www.fws.gov/midwest/hapet/BreedingSurvey/Model.htm which is part of the U.S. Fish & Wildlife Service's network of web pages. Students can learn more about these projects at the Patuxent Wildlife Research Center, from the Migratory Bird Research and Monitoring Page http://www.mbr_pwrc.usgs.gov/.

Additional information is found on the NBS page – Bird Monitoring in North America, http://www.pwrc.usgs.gov/birds.html.

Have the class do an Internet search for information about birds that spend part or all of their time in the wetlands of the Great Lakes region. Each person can find something interesting about a species to share with other class members, or people can look for a specific fact about migratory birds and explore various options for finding

Extensions

1. In your examination you have observed three methods used by scientists to sample wetland plant and animal species: (1) transect, (2) random sampling technique, and (3) census or survey method. Critique the three methods presented. What are their strengths? What are their weaknesses? If you were conducting research on a wetland near your home or school, would you adopt similar sampling techniques or would you add other methods to your study. What do you think would be the best way to achieve species counts and measure biodiversity in a wetland area? You may want to do library research to support your answer.

2. Create your own project to demonstrate how a change in one plant or animal species, such as a bird or plankton type, could affect other species in an estuary. Use a poem, drawing, or an idea of your own to show the interrelationships between organisms in a wetland. Where might the role of humans be incorporated? Note that you could explore the effects of both the increase and decrease in abundance of the individual species you choose. (Hint: See the food web song included with the walleye activities.)

Hint for Extension

1. Point out to students that while a random sampling technique, as in the plankton sample, counts a number of organisms as representative of an entire area, a census method tries to achieve an exact count for a specified geographic area. Each type of count has value in different situations.

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Source of Breeding Bird Survey data

U.S. Fish and Wildlife Service, Office of Migratory Bird Management, Laurel, MD 20708.