Fish Surveys

How long would it take to count all the fish in the lake?

One fish, two fish, three fish . . .
Say! Let's not count them all, just yet—
Why not sample them with a net?

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Please note: Academic Standards are updated regularly and our alignments will be updated on the DNR Academic Standards Website at: www.mndnr.gov/education/teachers/edstandards_intro.html

Fish Surveys

Minnesota Academic Standards

Lesson *introduces* this Benchmark.
Lesson *partially* addresses this Benchmark.
Lesson *fully* addresses this Benchmark.

Language Arts

Grades 3, 4, and 5
I. Reading and Literature
B. Vocabulary Expansion:
Benchmark 1—The student will acquire, understand, and use new vocabulary through explicit instruction and independent reading. (no independent reading)

Grade 3
I. Reading and Literature
C. Comprehension:
Benchmark 7—The student will follow three-step written directions.

Grade 4
I. Reading and Literature
C. Comprehension:
Benchmark 9—The student will follow multi-step written directions.

Grade 5
I. Reading and Literature
C. Comprehension:
Benchmark 13—The student will follow multi-step written directions.

Math

Alignment to the 2007 Minnesota Academic Math Standards coming soon.
Grades 3, 4, and 5
I. Mathematical Reasoning:
Benchmark 1—The student will communicate, reason, and represent situations mathematically.
Benchmark 2—The student will solve problems by distinguishing relevant from irrelevant information, sequencing and prioritizing information and breaking multi-step problems into simpler parts.
Benchmark 3—The student will evaluate the reasonableness of the solution by considering appropriate estimates and the context of the original problem.
Benchmark 4—The student will know when it is appropriate to estimate and when an exact answer with whole numbers, fractions, or decimals is needed.
Benchmark 5—The student will express a written problem in suitable mathematical language, solve the problem and interpret the result in the original context.
Benchmark 6—The student will support mathematical results using pictures, numbers, and words to explain why the steps in a solution are valid and why a particular solution method is appropriate.

Grade 3
II. Number Sense, Computation, and Operations
B. Computation and Operation:
Benchmark 6—The student will demonstrate an understanding of the multiplication facts through 10 using concrete models.
IV. Data Analysis, Statistics, and Probability
A. Data and Statistics:
Benchmark 2—The student will collect data using observations or surveys and represent the data with pictographs and line plots with appropriate title and key.

Grade 4
I. Mathematical Reasoning:
Benchmarks 1, 2, 3, 4, 5, 6 (see above)
IV. Data Analysis, Statistics, and Probability
A. Data and Statistics:
Benchmark 1—The student will collect data using observations or surveys and represent the data with tables and graphs with labeling.
Benchmark 2—The student will use mathematical language to describe a set of data.

Grade 5

I. Mathematical Reasoning:

Benchmarks 1, 2, 3, 4, 5, 6 (see above)

Benchmark 7—The student will organize, record, and communicate math ideas coherently and clearly. ***A. Number Sense***

Benchmark 4—The student will use a variety of estimation strategies such as rounding, truncation, over- and underestimation and decide when an estimated solution is appropriate.

II. Number Sense, Computation, and Operations

B. Computation and Operation:

Benchmark 1—The student will use addition, subtraction, multiplication and division of multi-digit whole numbers to solve multi-step, real-world, and mathematical problems.

Benchmark 4—The student will multiply, without a calculator, a two-digit whole number or decimal by a two-digit whole number or decimal, such as 3.2 x 3.4.

Benchmark 5—The student will multiply, without a calculator, a three-digit whole number or decimal by a one-digit whole number or decimal, such as 3.51 divided by 3.

Patterns, Functions, and Algebra B. Algebra:

Benchmark 1—The student will evaluate numeric expressions in real-world and mathematical problems.

IV. Data Analysis, Statistics, and Probability

A. Data and Statistics:

Benchmark 2—The student will use fractions and percentages to compare data sets.

Benchmark 3—The student will collect data using measurements, surveys, or experiments and represent the data with tables and graphs with labeling.

Benchmark 4—The student will find mean, mode, median, and range of a data set.

History and Social Studies

Grade K–3

IV. Historical Skills

A. Concepts of Time:

Benchmark 1—Students will define and use terms for concepts of historical time. (recent past, present, future)

VII. Government and Citizenship

D. Governmental Institutions and Processes of the United States:

Benchmark 1—Students will describe examples of specific services provided by government.

Grade 4–8

V. Geography

D. Interconnections:

Benchmark 2—Students will analyze how the physical environment influences human development.

VI. Economics

C. The Market Economy (Micro Economics):

Standard: The student will understand business organizations, market structures, and financial institutions that operate within our economy.

Benchmark 1—Students will identify and compare and contrast various industries and the occupations related to them.

Science

Grade 3

I. History and Nature of Science

A. Scientific World View:

Benchmark 1—The student will explore the use of science as a tool that can help investigate and answer questions about the environment.

B. Scientific Inquiry:

Benchmark 2—The student will participate in a scientific investigation using appropriate tools.

Benchmark 3—The student will know that scientists use different kinds of investigations depending on the questions they are trying to answer.

IV. Life Science

C. Interdependence of Life:

Benchmark 2—The student will know that changes in a habitat can be beneficial or harmful.

Grade 4

I. History and Nature of Science

A. Scientific World View:

Benchmark 1—The student will explore the uses and effects of science in our interaction with the natural world.

B. Scientific Inquiry:

Benchmark 1—The student will recognize when comparisons might not be fair because some conditions are not kept the same.

Benchmark 2—The student will discuss the responsible use of science.

Benchmark 3—The student will recognize that evidence and logic are necessary to support scientific understandings.

III. Earth and Space Science

A. Earth Structure and Processes:

Benchmark 1—The student will identify and investigate environmental issues and potential solutions.

Grade 5

I. History and Nature of Science

B. Scientific Inquiry:

Benchmark 1—The student will perform a controlled experiment using a specific step-by-step procedure and present conclusions supported by the evidence.

Benchmark 2—The student will observe that when a science investigation or experiment is repeated, a similar result is expected.

C. Scientific Enterprise:

Benchmark 1—The student will describe different kinds of work done in science and technology.

Environmental Literacy Scope and Sequence

Benchmarks

- Social and natural systems are made of parts. (PreK-2)
- Social and natural systems may not continue to function if some of their parts are missing. (PreK-2)
- When the parts of social and natural systems are put together, they can do things they couldn't do by themselves. (PreK-2)
- In social and natural systems that consist of many parts, the parts usually influence one another. (3-5)
- Social and natural systems may not function as well if parts are missing, damaged, mismatched or misconnected. (3-5)

For the full Environmental Literacy Scope and Sequence, see:
www.seek.state.mn.us/eemn_c.cfm

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Chapter 4 • Lesson 2

Fish Surveys

Grade Level: 3-5
Activity Duration: 60-90 minutes
Group Size: any
Subject Areas: Mathematics, Language Arts, Science, Social Studies
Academic Skills: calculation, comparison, computation, estimation, graphing, inference, listening, modeling, recording data, role-playing, simulation, small group skills
Setting: indoor or outdoor gathering area with tables
Vocabulary: creel survey, electrofishing, estimate, mark-recapture, migration, population, proportion, ratio, recapture, researcher bias, sample, survey, tag
Internet Search Words: electrofishing, fish sampling, fish surveys, lake surveys, mark-recapture, population surveys, surveys

Summary

This lesson will help students learn why and how fisheries managers conduct fish surveys. Students will become familiar with some of the equipment and survey methods that Minnesota DNR fisheries biologists use. Special authorization, equipment, and expertise are needed to conduct a fish population survey in an actual lake, but you can conduct a survey *simulation* with student participation. Using tagging survey techniques and a formula involving multiplication and division, students estimate the number of walleye in an aquarium representing a lake. They conduct a problem solving investigation that helps them determine why local anglers are catching fewer fish in Lake MinnAqua.

Student Objectives

The students will:

1. Estimate the population of walleye in a lake using a formula involving multiplication and division.
2. Conduct a fish survey simulation to estimate the population size in the lake.
3. Recognize three types of fish sampling equipment used by fisheries biologists.
4. Give two examples of how fish surveys and research are used in fisheries management. (Scientific data is used to create and measure the success of fishing regulations, to help answer questions about fish populations, and to estimate the size of fish populations in lakes.)

Instructor's Background Information

What is Fisheries Resource Management?

The Department of Natural Resources (DNR) is the lead agency responsible for fisheries management in Minnesota. Fisheries resource management covers a range of activities that include—in addition to providing angling opportunities—study, maintenance, enhancement, protection, and fish and water resource education. A crucial part of fisheries management involves knowing which fish inhabit the lakes, understanding changes and trends in fish populations over time, and assessing the health of fish populations. **Populations** are defined as the collection of organisms of the species inhabiting a given geographic area. This information helps fisheries managers address the needs of fish, aquatic ecosystems, anglers, commercial fishers, bait dealers, and everyone who enjoys the opportunities and resources that our waters provide.

Information from lake and creel surveys forms the foundation of every Minnesota DNR fisheries management activity undertaken to improve fishing—stocking fish, determining the effectiveness of fishing regulations, and restoring habitat. **Surveys** provide long-term information on trends in fish population size and structure (such as the proportion of fish in age or length groups), fish growth, reproductive success, species abundance, fishing pressure and harvest rates, seasonal fish movement or **migration** (the annual or seasonal movement of an organism from one habitat to another, which typically involves a return trip to original habitat), and habitat conditions in lakes. The Minnesota DNR also employs other angler survey techniques to gather economic and socio-demographic data that helps ensure effective management of the state's fisheries resources for all Minnesota citizens.

Materials

- Baseball cap or work shirt labeled Fish Biologist (make your own label)
- **Fish Survey Gear Cards** or examples of fish sampling gear (you could enlarge these cards to post around the room, or make them into overhead transparencies)
- Minnesota fishing regulations booklet (contact the Minnesota DNR Information Center at 651-296-6157 or 888-646-6367 to obtain a copy)
- Clear fishbowl or large glass bowl
- Large box of fish-shaped crackers
- Fish mount or color picture of a walleye
- An empty one- to five-gallon fish aquarium with its sides covered with blue paper, or painted blue (with tempera paint, which washes off later) or a plastic storage container
- **Lake MinnAqua Scenario and Tagging Survey Scenario**, to read to class
- **Fisheries Biologist Survey Training Sheet**, one per student
- **Lake Survey Data Sheet**, one per student
- Small aquarium net
- Several small, short, wide plastic containers (holding at least 16 oz.), one for each team of two students
- One or two bags of dried white beans (about 300 beans for each team of two students)

continued

Lake surveys and creel surveys provide fisheries managers with tools for monitoring trends in population abundance: whether populations are steady, increasing, or decreasing. This form of trend analysis has been conducted in Minnesota for more than 50 years, and is the backbone of fish population monitoring. It also helps fisheries managers form conclusions and predictions about fish populations.

Minnesota's Lake Survey Program

The primary tool guiding fish management is the lake survey. Lake surveys consist of periodic monitoring of fish populations, angler creel surveys (see definition under creel survey heading), water chemistry, and fish habitat. Lake survey data is used to track fish population trends, assess harvest rates, evaluate the effectiveness of management actions (such as stocking), set realistic management goals for a given lake, and address issues concerning fish populations. Fisheries staff conduct an average of 600 lake surveys each year. Lakes with high angling pressure are surveyed once every three to nine years. Smaller, more remote, or lightly-used lakes may be surveyed just once every ten to twenty years. Most lake survey fieldwork takes place between early June and late August, but specialized sampling sometimes begins in early spring—just after ice-out—and continues until lakes freeze in late fall.

Lake Survey Database

When the spring, summer, and fall fieldwork has been completed, there is much to do with the collected data. Information is entered into the lake survey database, checked for errors, analyzed, and reported. It usually takes approximately one year from the time the nets are lifted during a lake survey until the results of that survey are published on the Minnesota DNR website or are available as printed DNR reports. If you can't find a record for a lake that interests you, it's possible that the lake hasn't yet been surveyed or doesn't have public access. Or, the most recent data may have been collected prior to the development of the database and not yet entered. The lake survey database contains information on 4,500 Minnesota lakes and streams—more than any other state—and fisheries biologists add new information each year. Information from lake surveys is available to the public in the Lake Finder area on the Minnesota DNR website.

Fish Surveys

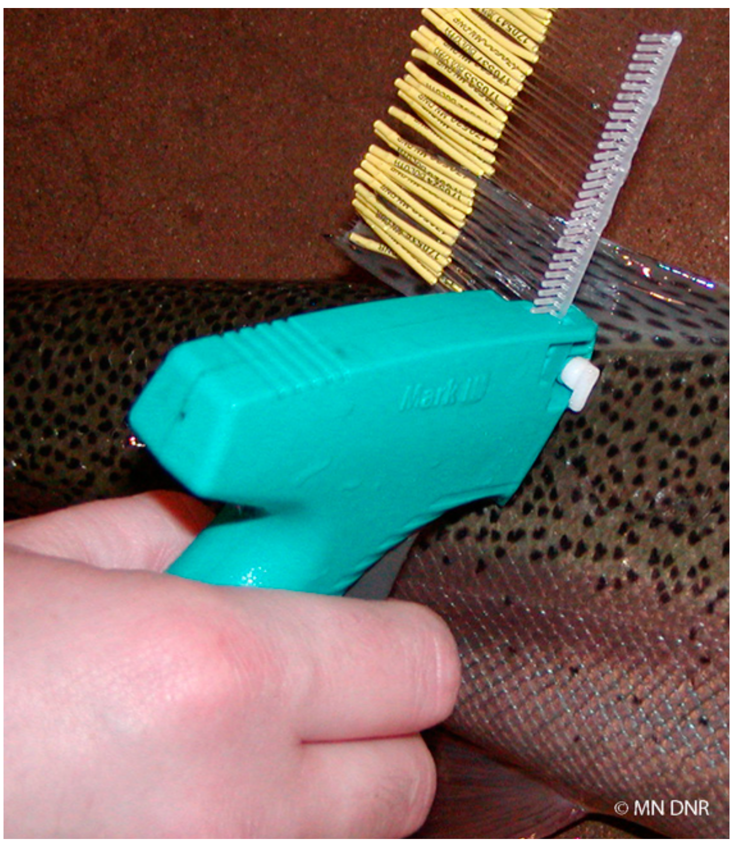
How do you determine the number of fish in a lake? Imagine trying to count each fish in Lake Winnebigoshish, Lake Mille Lacs, or Lake Superior! It wouldn't be feasible or practical to count and measure every fish in a lake. Instead, fisheries biologists collect a **sample**—a representative smaller number of fish—from lakes in order to make inferences about the entire population. This sample and data must be collected using methodical, consistent surveys of fish populations, fish habitat, and fishing activity. Fish surveys involve **estimating**, a determination of the approximate number of fish in the water, using special equipment, procedures, and training. Fisheries biologists use mathematical methods to accurately estimate fish populations.

Survey Techniques

Fisheries managers and their crews use various survey techniques for each fish species, depending on the species' behaviors or sizes. These techniques include tagging surveys, netting surveys, electrofishing, creel or angler surveys, and biological surveys.

Tagging Surveys

In tagging surveys, fisheries biologists place marks, or **tags** on fish. They begin by catching a sample of fish and tagging them. The tags identify each fish with a unique number or code, so that the fish can be tracked over time. If the tagged fish is caught again, or **recaptured**, by an angler, commercial fisherman, or biologist, its tag shouldn't be removed. The number on the tag should be reported to the DNR, with the time and location of the catch, the fish's length and weight, and the name of the person who caught the fish. The new information is then compared with the earlier information: when and where the fish was tagged and released and its size. By comparing this data, biologists gain information that can help them determine mortality rates, growth rates, travel distances, age, and preferred habitat. Tagging surveys also can be used to devise a population estimate.



If you catch a fish with a tag, call the DNR to make a report.

Materials (continued)

- One or two bags of dried brown beans (about 300 beans for each team of two students)
- Plastic sandwich bags, one for each team of two students
- One calculator for each team of two students
- Post-it notes (at least four inches wide) or small pieces of paper with tape, one for every pair of students
- Optional storybook, *One Fish, Two Fish, Red Fish, Blue Fish*, by Dr. Seuss

Some Species Codes Used in Survey Reports

WAE	walleye
NOP	northern pike
YEP	yellow perch
LMB	largemouth bass
MUE	muskellunge
TLC	tullibee
BLG	bluegill
PMK	pumpkinseed sunfish
BRB	brown bullhead
WTS	white sucker

Biologists have other methods of marking fish. These methods don't identify individual fish, but they do provide general population information. One such method involves the clipping of a portion of a fin. This doesn't harm the fish. To ensure survey accuracy, a fish tagging method shouldn't affect the survival or movement of the fish. Fin clipping and tagging are performed on fish that are to be stocked in lakes—this distinguishes them from naturally-reproduced fish. (This marking method is used in Lake Superior.)

One method that biologists use to mark fish involves clipping a fin.

When released into the stream or lake, tagged or clipped fish can be recaptured with nets, by **electrofishing** (see definition of electrofishing under the Fish Sampling Techniques heading) or by angling. Recaptured fish are counted and measured. This provides fisheries biologists with information on migrations and population changes. This method is known as a **mark-recapture** population survey.

Population Estimation Methods
To estimate the size of fish populations, biologists sometimes use mark-recapture sampling methods. For example, a biologist might set live traps for a certain kind of fish. Once collected, each is marked, tagged, or clipped and released After a time, perhaps a week, the traps are reset to catch another sample of fish. Some of the fish in the second group will be newly-caught, but others will be recaptured marked fish. The mathematical concepts of ratio and proportion are then used to estimate the total number of that fish type in the lake. **Ratio** is a comparison expressed as a fraction. For example, there is a ratio of three walleyes to two sunfish in a population (3/2, 3:2). A proportion is an equation that states equality between two ratios.

Survey Assumptions
Mark-recapture methods are based on a number of assumptions. Making assumptions is an important part of scientific research. The most basic assumptions made by scientists are that observations of individual organisms (or groups of organisms) will apply to the rest of the population that is not captured or seen, and that every individual in a population can always be identified as a member of the same species

and counted accurately. The assumptions are carefully determined to ensure the methods will reflect reality. Here are some other assumptions related to mark-recapture sampling.

1. During the survey period, there are no fish leaving or entering the survey area (no immigration or emigration). The survey methods also assume that significant death or mortality, and significant recruitment or birth, aren't occurring.
2. The tags or marks placed on the fish aren't lost and are clearly recognizable.
3. Differential mortality doesn't occur during the time of the survey. In other words, it's assumed that there's no change in ratio between marked and unmarked fish during the interval between samplings. This means, for example, that the marking technique doesn't make a fish more susceptible to predators.
4. Marked and unmarked fish are equally vulnerable to sampling gear. Every individual in the population has an equal chance of being captured, ensuring that all samples are random samples.
5. There is random mixing—the marked group is always proportionally represented in relation to the total population in the collected samples. The time between samplings must be long enough to allow for thorough mixing of marked animals, but not so long to allow significant increase by immigration or reproduction.

Researcher Bias

To eliminate **researcher bias**, biologists use a specific, consistent technique to conduct a population survey. Researcher bias occurs when a researcher, knowingly or unknowingly, influences the results of an experiment due to personal viewpoint or an individual variation in technique. Each survey sample must use exactly the same technique and equipment; samples must be repeated at approximately the same time of year to ensure similar environmental conditions for all surveys. Specific results are comparable from survey to survey. To obtain a broad overview of the entire fish population in a lake, multiple survey samples may be taken from different locations of the lake.

Mark-recapture population estimate methods include the Peterson method and the Schnabel population estimate method. Both involve mathematical formulas using sample numbers from surveys to estimate the size of a total species' population. The Petersen method can be used for a single marking and recapture sample. The Schnabel method uses results from several samples. Each method results in an estimate, or approximate value for the total number of fish in a lake's population.

In this lesson's activity, students will use the Petersen method and average their results. But the two methods are similar.

Biologists and researchers use mark-recapture methods to estimate the size of wildlife populations other than fish.

Petersen method:
N = MC/R

Schnabel population estimate method:
N = (MC Sample A + **MC** Sample B + **MC** Sample C)/(**R** Sample A + **R** Sample B + **R** Sample C)

Or

$$\frac{\text{the sum of } \mathbf{MC} \text{ values for each sample}}{\text{the sum of } \mathbf{R} \text{ values for each sample taken}}$$

M = the number of fish originally **M**arked or tagged

C = the number of fish **C**aught at the time of recapture

R = the number of marked or tagged fish in the sample catch **R**ecaptured in the trap net

N = the estimate of population size or the estimate of the **N**umber of fish present at the time of the release of the originally marked individuals

These population estimate formulas are based on the concept of ratios: N/C = M/R or, N is to C what M is to R

Fish Sampling

Fisheries biologists use various techniques and equipment to trap fish for tagging and collecting data. Examples of data collected from fish-in-hand include length and weight and scale samples, which are later analyzed to determine age. After data is collected, most fish are returned to the water unharmed. (Some mortality does occur in surveys using gill nets.) In all survey techniques, a few fish are sacrificed for laboratory analysis, which determines sex, stomach contents, disease, and internal parasites.

Catches are reported separately, by gear type. In some more "active" fish sampling techniques, the capture gear is moved through the water by machinery or human power, such as electrofishing, pole seines, or angling. "Passive" capture gear is usually set and remains stationary. Passive capture gear includes entanglement devices (gill nets and trawls) and entrapment devices (trap nets, minnow traps, and weirs).

Behavior patterns determine whether a fish species will be collected with passive or active sampling technique.

The primary technique for fish population monitoring in Minnesota involves standard net surveys. Catches from surveys are standardized by calculating the number of fish of one species caught per unit of sampling effort. For example: if 10 nets were set during a survey and 40 walleye were caught, the net catch would be reported as 4.0 walleye per gill net set.

Minnesota's surveyed lakes have been categorized into 43 classes, or groups, based on similarities in their chemical and physical characteristics and fish communities. The term **normal range** describes the range of values for net catches, or average fish size, for each lake class. From many years of research and data collection, the DNR fisheries staff has determined normal range values for the fish species in each lake class—if the walleye gill net catch for a 1996 survey on Lake MinnAqua was 6.0 walleye per net, and the normal range for other lakes in the same lake class was reported as 2.0 to 4.5 walleye per net, the current population of walleye in Lake MinnAqua could be interpreted as higher than expected for that type of water body.

An electrofishing boat.

Using a backpack electrofishing unit.

Fish Sampling Techniques

- **Electrofishing** is an active fish sampling technique that uses equipment that produces an electrical charge that temporarily stuns fish and causes them to float to the surface. The voltage used varies by species and by the conductivity of the water at the survey site. The stunned fish are easily retrieved, measured, and weighed. Fish caught in this manner recover rapidly, and swim away when researchers put them back into the water. To estimate fish abundance with this technique, the number of fish surveyed per hour is compared to the normal ranges in the lake class.

Electrofishing is most often used for sampling largemouth bass, smallmouth bass, trout, and walleye. These fish tend to avoid nets or live in small streams where netting would be difficult.

- **Gill nets** are a passive type of fish sampling gear. Gill nets used in Minnesota waters are usually six feet tall and 250 feet long, with five 50-foot sections of mesh openings ranging from two inches to four inches wide. Varying mesh openings allow sampling of a broad range of fish sizes. The tops of gill nets have floats that are weighted along the bottom. Nets are suspended or positioned along the bottom like a fence. The gills catch fish small enough to put their heads through the mesh as they swim into the net. When they try to back out, they become wedged or entangled in the net. Gill nets are usually set in water more than nine feet deep, and left for 24 hours. Most fish taken in gill nets don't survive—those that do are released. Only a small portion of the lake's fish population is sampled during an individual survey. These nets are very effective for sampling northern pike, walleye, cisco, trout, salmon, whitefish, and yellow perch—all of these fish swim in water deeper than nine feet.
- **Trap nets** are another type of passive sampling gear and are commonly used to capture bluegills, crappies, bullheads, and other species near shore. The standard trap net is three feet tall by six feet wide with a 40-foot "lead" or "leader." The long lead net diverts fish into an enclosure and through a tunnel into a "pot," or trap. These trap nets are usually set perpendicular to shore in water less than four feet deep, and left in place for 24 hours. Most of the fish collected in trap nets are returned to the water unharmed as soon as biological data is recorded. The number of trap nets set during a survey depends on the lake's acreage.
- A **trawl** is a net attached to a boat with ropes. It's dragged along the bottom. Fish are funneled to a part of the net, and stay there until the net is pulled to the surface and into the boat. After fisheries personnel record the biological data, the fish are released into the lake unharmed. A trawl is active sampling gear, and captures small and young fish.
- A **seine** is a long, rectangular, small-meshed net whose ends are tied to two large poles called brails. If the seine is large, the bottom of the net is weighted to hold it close to the bottom. Seines come in many sizes. Two people must work together to corral the fish into an area where they can be trapped in the net and pulled from the water for the various survey measurements. Afterward, the fish are returned to the water unharmed. Like a trawl, a seine is active sampling gear used to capture small and young fish.

Vegetation Surveys

Analyses of aquatic vegetation are part of many lake surveys. Fisheries biologists' observations help them devise a general, lake-wide description of the abundance of shoreline and aquatic plants.

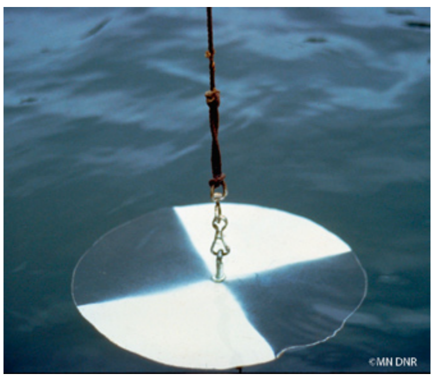
A gill net.

A trap net.

A trawl.

A seine net.

The standard **Secchi disk** is an eight-inch circular metal plate painted with a white and black pattern. To measure water clarity, the disk is lowered into the water until it disappears from view. The depth at which the disk can no longer be seen (the Secchi depth) is recorded. Secchi disk readings vary by season. The water is usually clearest in the spring, shortly after ice-out. Measurements are usually taken when fish samples are taken during summer lake surveys.



A creel. Creel is an old term describing a basket, usually wicker, that anglers used to hold their catches.

Water Analysis

Water analysis encompasses a variety of testing methods, including chemical tests to determine water temperature, dissolved oxygen levels, water pH, water fertility (a measure of nutrients present), phosphorous, nitrogen levels, and Secchi disc readings to measure water clarity. Besides measuring lake productivity, water analysis provides information on fish distribution in lakes.

Creel Surveys

Although a lake survey collects data on fish, vegetation, and water quality, a **creel survey** collects data on what anglers are catching by means of an on-the-spot interview. A creel survey might occur at a lake access point or as a roving survey out on the lake. Creel surveys help fisheries resource managers estimate fishing pressure, discern whether anglers are successfully catching fish, and assess a lake's fish harvest. Throughout the summer, on lakes across the state, DNR creel clerks ask anglers for the times they began and ended their fishing, the number of people in their parties; their home zip codes, the fish species they sought; the fishing equipment used; the weight, length, and number of fish they either kept or released; and where they fished in the lake. Creel survey data helps fisheries managers evaluate fishing regulations and angler satisfaction.

Lake and Stream Plans for Managing Fish Populations

Fisheries managers consider many factors to determine the information to collect from a lake or stream, and which sampling methods to use. Survey data is used to create the Lake and Stream Plans that guide fisheries work.

Sampling methods that yield a large number of samples may produce a more accurate population estimate, but taking more samples can cost more money. As managers make decisions regarding Lake and Stream Plans, budget concerns play a role, as well as considerations involving past and present lake conditions, species, management goals, and the needs of anglers and other users.

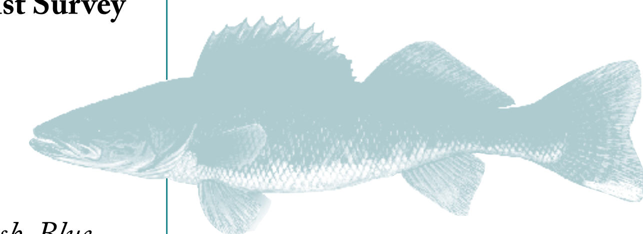
Lake surveys help fisheries managers determine how to best refine their Lake and Stream Plans and manage fish populations. Problems or questions about lake ecosystem and their fish populations are addressed. If anglers' catches are decreasing, a lake survey may reveal that the lake's fish population is declining. Or perhaps the anglers are using the wrong kind of bait. If a lake survey shows a declining fish population, the manager could decide that special regulations for harvest or size limits are necessary, that the fish population could benefit from stocking programs, or that habitat protection or restoration is necessary to ensure a healthy fish population for the future.

Procedure

Preparation

1 Gather materials.
2 Copy and cut out **Fish Survey Gear Cards**. Use one set for a demo. If desired, enlarge these images and post them in the room, or make overhead transparencies to show the class. Examples of real fish survey gear can also be used.
3 Fill the clear fishbowl with small fish crackers.
4 Put 300 white beans into the “lake” (empty aquarium or container). Set 300 brown beans aside in a plastic sandwich bag.
5 Put 250 white beans into each smaller plastic container (one for each team of two students). Place 250 brown beans in each plastic sandwich bag (one for each team of two students).
6 Create a Fisheries Biologist label and attach it to the front of a baseball cap or large work shirt.
7 Copy one **Lake MinnAqua Scenario** with the **Tagging Survey Scenario** on the bottom to read to the class.
8 Copy one **Fisheries Biologist Survey Training Sheet** and one **Lake Survey Data Sheet** for each student.
9 Make an overhead transparency of the **Fisheries Biologist Survey Training Sheet** and the **Lake Survey Data Sheet**.

Activity



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Warm-up

Option: Read the Dr. Seuss book *One Fish, Two Fish, Red Fish, Blue Fish* to your class. This children’s story is known to most students, and they’ll be able to identify with it. It provides common ground—a base on which to construct knowledge. The book is about fish, counting, colors, and more. It can prompt your students to start thinking about fish, counting fish, and diversity. The lesson builds on the story by addressing real-world fish counting using an estimation method for determining the size of fish populations and various fisheries management tools.

Counting and Estimating

1 Ask students how they might determine the number of students in the class. They will probably say you can count them. Ask someone to count the students in the class.
2 Ask the students if they have heard of a population census. A census is a government count of the number of people in a community, state, or nation. A census can provide certain information such as population growth over time or the proportion of children to adults in a population. This information can be used to determine a need for new schools, or the number of new teachers needed. What if we want to find out how many fish are in a lake? How do fisheries biologists conduct a fish census?

3 Hold up a fishbowl full of fish crackers. Ask someone to count the number of fish in the fishbowl. You can decide that counting might take too long—but how can we more quickly figure out how many fish are in the bowl? Ask the students to try to guess, as accurately as possible, the number of fish crackers are in the fishbowl, and to write their guess (and their name) on a small piece of paper. Collect the students' guesses. Now have a student count the fish crackers in the bowl (they can count by tens, or count with partners and add up the totals.) Determine whose guess was most accurate. Ask students what methods they used to make their guesses.

4 On the whiteboard or overhead projection device, define **estimate** for the class: to determine the approximate value or number of something. There are ways scientists can estimate the size of a population when counting every individual isn't practical, and the methods for making scientific estimates are more accurate than guessing. We estimate numbers of fish in a lake not because there are too many to count, but mostly because it would be too difficult or too costly to count each individual fish.

5 Why count fish? Hold up a Minnesota fishing regulations booklet. Ask the students if they've ever been fishing, and ask them why we have fishing rules. Briefly explain that fisheries biologists collect biological information from lakes to design regulations. This biological information helps fisheries managers solve a variety of problems that fish may have in lakes, rivers, streams, wetlands, and watersheds. One thing a fisheries biologist might want to know is how many fish of a given species live in a particular lake, so fisheries managers can figure out if current regulations successfully protect that fish population. (Although knowing how many are *in* the lake is important, we must also know how many fish are *leaving* the lake, or being harvested, to make final population size determinations.)

A walleye.

Lesson

Part 1: A Problem in Lake MinnAqua

1 Read the **Lake MinnAqua Scenario** to the class.

2 Display the covered aquarium with the pre-counted white beans in it. Tell the class: "This is Lake MinnAqua." Ask your students how many walleye are in Lake MinnAqua. After a few guesses, explain to the students that just like in a real lake, counting fish in a covered aquarium is more difficult than counting fish crackers in a clear fishbowl. You cannot see the whole fish population in the covered aquarium, just as you would not be able to count every walleye in Lake MinnAqua.

3 Tell students that they might be able to estimate the fish population in the lake using samples. But to solve the walleye problem of Lake MinnAqua, they will have to find a way to make an accurate estimate. Define "sample" on the whiteboard: a representative number of organisms collected to infer information about the entire population.

Part 2: Sampling Gear and Tagging Surveys

1 Display photos or examples of fish sampling equipment. Ask for five volunteer groups of three or four students and hand each group a **Fish Survey Gear Card**. Ask each group to read their card and demonstrate how each sampling method is set up and used to collect or sample fish.

2 Announce that the students are fisheries biologists who will conduct a tagging survey to estimate the size of the walleye population Lake MinnAqua. Hold up the mount or photo of a walleye and show the students how a fish can be tagged or marked. Show examples of various types of tags used to mark fish. On the whiteboard, define tag (to identify or mark). Define survey (a method used to determine the numbers of a population, the extent or condition of a situation, or the value of something).

3 Hand a **Fisheries Biologist Survey Training Sheet** to each student. Tell the students that, as fisheries biologists, they're required to document their tagging survey procedure and results. The data they gather can be used to identify fisheries issues and to solve the problem of estimating how many walleye are in the lake. The data and conclusions can be shared with the public.

4 Read and explain the **Tagging Survey Scenario** (at the bottom of the **Lake MinnAqua Scenario Sheet**) to the class. After you are finished discussing the **Tagging Survey Scenario,** tell the students, "Now, it's time for your fish survey training!"

Part 3: Fish Survey Training—The Mark Run

1 Ask a student volunteer to come to the front of the class to begin training for the Lake MinnAqua Walleye Survey. Put the baseball cap or work shirt with the Fisheries Biologist label on the student volunteer. All DNR Fisheries personnel must be in uniform when they are doing fieldwork!

2 Explain the proper sampling techniques: don't look into the "lake" while taking the sample, and take one quick scoop in the lake with the net. The student will tag or mark the fish that are captured. Give the small aquarium net to the volunteer and ask the student to use the net to take one scoop of walleye from the lake. Count the number of fish captured. (There should be approximately 80-100 white beans.)

3 Mark the captured walleye by exchanging them with an equal number of brown beans. Have the class record the number of marked walleye for the "M" value on the **Fisheries Biologist Survey Training Sheet** under Mark Run Data. Have the volunteer put the brown beans, or "marked walleye," into the aquarium with the white beans (the rest of the walleye population) that are still in the lake.

Do not place the replaced white beans back into the "lake."

This first capture of fish is the "mark run." Tell the class the fisheries biologist has marked or tagged a sample of walleye from Lake MinnAqua and is now returning them to the lake. Stir the beans for fifteen seconds to simulate the fish swimming around in the lake.

Part 4: Fish Survey Training—The Recapture Run

1. The next step in our Fish Survey Training is to take a "recapture run" sample.
2. Choose another volunteer to come to the front of the class and use the net to pull the next sample of "walleye" from Lake MinnAqua for the recapture run. Put the baseball cap or work shirt on the new volunteer fisheries biologist trainee before they take their sample.

If students look into the lake while taking a scoop, they will invariably "aim" for the marked brown beans, skewing their data!)

3. Again, explain the proper sampling techniques to use: don't look into the lake while taking a sample, and take one quick scoop in the lake with the net. It is important to use a consistent sampling technique. We use a consistent technique to eliminate researcher bias in our survey. Define researcher bias and write the definition on the whiteboard: researcher bias occurs when a researcher, knowingly or unknowingly, influences the results of an experiment due to personal viewpoint or technique.
4. Count the total number of beans in the net, both brown and white, and write the number on the **Fisheries Biologist Survey Training Sheet** for C. This is the total number of fish caught. Now count only the brown beans and write that number down for R. The brown beans in the student's net sample are the recaptured marked fish. Return the fish (the entire recapture run) to the lake and stir for fifteen seconds to simulate fish swimming and moving in the lake. We are sampling with replacement, or putting each sample back into the general population in the lake.

Part 5: Fish Survey Training—Do the Math!

1. Review with students:
   - **M** = the number of walleye originally **M**arked or tagged (the number of brown beans from the mark run)
   - **C** = the **C**atch sample size taken at the time of recapture (the total number of brown and white beans in the student volunteer's sample net in the recapture run)
   - **R** = the number of marked walleye in the sample that are **R**ecaptured (the number of brown beans that are recaptured in the sample net in the recapture run)
   - **N** = the total **N**umber of walleye estimated to be in Lake MinnAqua at the time of the release of the originally marked fish (the estimate of the total Number of all beans in the lake)
2. Students will now learn how to complete the calculations needed to estimate the total walleye population in Lake MinnAqua (**N**) using the Petersen method. Complete the calculation on the Training Survey section on the Lake Survey Data Sheet as a class. What is the value for "**N**"? How many walleye are estimated to be in lake MinnAqua?

3 Now have students compare their estimates to the real population of walleye in Lake MinnAqua. Explain that, in reality, you wouldn't know how many walleye are in the lake because it would be very difficult, if not impossible, to catch each walleye. In this case, we know the total number of beans so we can see the accuracy of our estimates. Tell the students that there were actually 300 walleye (beans) in Lake MinnAqua. Discuss with the class how close the estimate (**N**) was to the total number. At this point, you may wish to have students do Step 1 of the Extension.

4 Ask students if they think that the mark-recapture method is a good way to estimate the walleye population in the lake. Why or why not? Can students think of other situations where the mark-recapture method could be used to estimate the population of a different animal species?

Graduating Fisheries Biologists

Hum "Pomp and Circumstance" and tell the class they have all graduated and are now Fisheries Biologists. They are ready to conduct their own fish surveys in Lake MinnAqua!

To shorten the length of this lesson, or for third-grade students, stop here.

Part 6: Try It On Your Own—Fisheries Biologist Surveys of Lake MinnAqua

1 Put students into groups of two and explain that, for safety reasons, fisheries biologists work in teams when they go travel on the lake by boat.

2 Each student group will conduct mark-recapture lake surveys in their own Lake MinnAqua (smaller plastic cups) and use their hands as nets. It's important that their lake surveys are accurate, so they will be doing three recapture samples and taking the average.

3 Distribute the smaller plastic cups, each containing 250 white beans, to each team. Distribute plastic sandwich bags with 250 brown beans to each team.

4 Tell the class that each team, using the Peterson method, will work together to complete a lake survey to estimate the size of the walleye population. Follow the directions for completing the **Lake Survey Data Sheet** and for doing the calculations. If students need help with their calculations, have them ask the fisheries supervisor (instructor) for assistance. If necessary, the instructor can put a transparency of the data sheet on the overhead projector, or put the data up on an interactive whiteboard and guide the teams through the calculations. Each team will come up with an estimate for the number of walleye in the lake.

5 After they complete the survey and calculations on the **Lake Survey Data Sheet**, ask the teams to compare each value with the actual number of fish in the lake. Were some group estimates more accurate than others? How much did the various group estimates vary? Why might one group's estimate be more accurate than another's? Ask teams if they carefully avoided researcher bias during their surveys.

What Did We Learn About the Problem in Lake MinnAqua?

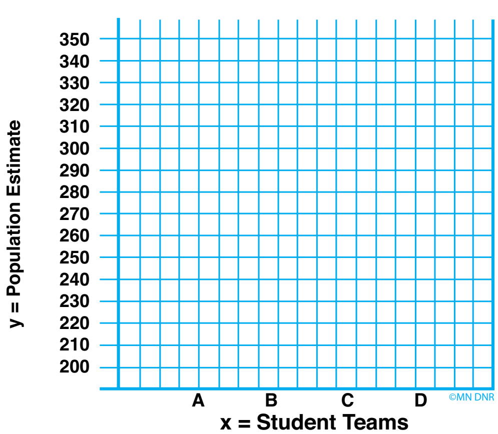
1 Ask students what has happened to the walleye population in Lake MinnAqua. Remind students of the lake survey that was done in the past (three years ago), compare their data from their present surveys, and discuss what can be determined regarding the lake's walleye population since the last survey. (The walleye population has declined in the three years since the previous lake survey was performed.)

2 What's next? The fisheries supervisor will want to do more research to find out what has caused the population decline, and to determine how to restore the walleye population in the future. It might be determined that:
- Special fishing regulations need to be applied to Lake MinnAqua.
- Shoreline habitat may have to be restored so that walleye can spawn and find food.
- A stocking program may be needed to restore the population.
- To help improve water quality, lakeshore residents may have to reduce the phosphorous content of their lawn fertilizers.
- An exotic species may have entered the lake, negatively affecting the walleye population, and it will need to be controlled.

Part 7: Averaging Class Survey Results

1 Ask each team to write their walleye population estimate on a Post-it note.

Walleye Population Estimates



2 Draw a graph on the whiteboard. Label the x-axis N=Population Estimate (use 200 to 350) and the y-axis Student Teams. (Have teams make up names or name them A, B, C, etc.) Title the graph Walleye Population Estimates. Have each team write their estimate as a number and as a point on the graph. Have students copy the graph of the class results on their **Lake Survey Data Sheets.** What is the range of values on the graph for our class survey data? Add the numbers on the graph together. (The instructor may decide to permit the use of a calculator.) Have students record this number on their Lake Survey Data Sheets.

3 Calculate the average population estimate by dividing the total by the number of estimates (teams) on the graph. For example, if there are fifteen team estimates on the graph, add the fifteen estimates together, and then divide the sum of the estimates by the number fifteen. This is the class average estimate for the number of fish in Lake MinnAqua. Discuss with students whether this value is

the mean, mode, or median for our class survey data set. (It's the mean). Have students record this value on the **Lake Survey Data Sheet.** What is the actual number of walleye that were in Lake MinnAqua? (250) How does the mean, or average, compare to the actual number?

4 Determine the median, mean, and mode values. How does each compare to the actual number of walleye in the lake? When does a fisheries biologist use mean? Mode? Median? It's up to the researcher to decide, depending on the goals of the study. The important thing is to know which type of data is being used. Median, mean, and mode are all "types" of averages. These types of averages are referred to as "measures of central tendency" in statistics. The mean is the arithmetic average, median is the middle value in a set of data, and mode is the most frequently occurring value in a set of data. When reporting research information, it's important to be specific about the type of average to use.

5 Determine the range of values on the graph. Ask the students to explain why the class obtained a range of values in their lake survey data.

Wrap-up

1 Discuss the importance of using consistent sampling techniques (such as scooping or netting in the same location, and in the same way, for each sample).

2 Compare the data of the various teams. Why do the numbers vary? (One reason might be that variations will occur if the fish sample sizes are different. Or, each team may have used a different technique for scooping fish.)

3 The Petersen method uses one sample to estimate population size. How can this be a problem? (The single sample may not have been representative of the entire fish population. Other sampling methods called the Schnabel and Schumacher methods use multiple samples.) How can this be helpful? (Using multiple samples increases the accuracy of the estimate because the chances of obtaining representative samples are increased.)

4 Discuss how the number of recaptured fish in the sample determines the estimated size of the total population.

5 What are some of the difficulties that fisheries biologists might encounter when doing lake surveys? (Bad weather conditions, poor sampling technique, researcher bias, lifting heavy nets filled with fish, all the tagged fish clustering in one part of the lake, not catching any fish in the sampling nets, many different fish species in a lake.)

6 What are the benefits of fish tagging? (Tags can identify individual fish by giving each fish its own number or code, allowing that fish to be tracked over time.) How might fisheries biologists increase the accuracy of tagging surveys? (They might take multiple samples.)

Mode The most frequently occurring value, or the value that repeats most often, in a group of data. It will be the number with the most points around it on the graph of the class data. A group of observations can have more than one modal value. Modes are often used for qualitative data, or data that describe qualities rather than quantities.

Median The middle value—half of the values are above and half the values are below the median value. Median is also defined as the middle piece of data, after data have been sorted from the smallest to the largest.

Mean The balance point, or average, of the values. The arithmetic mean of a set of values is a sum of all values, divided by their number.

Range The difference between the highest and lowest values on the graph.

7 How do lake surveys help fisheries managers? (Lake survey data is used to estimate fish population sizes and track population trends, evaluate the effectiveness of management actions such as stocking, and establish realistic management goals for a given lake.)

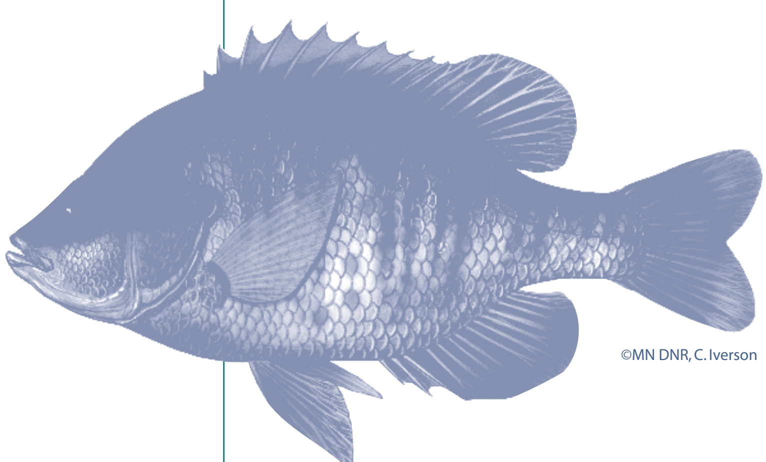
Assessment Options

1 Have students create a brochure to explain the benefits of lake surveys to another class.
2 Ask students to write a simple outline of a mark-recapture survey and explain why fish surveys are used to estimate the size of a fish population.
3 Have students explore the mark-recapture method further by completing the following exercises:

A. You have been asked to determine the walleye population in two lakes in your area. One lake is quite small; the other is a large lake. In your mark run you catch, tag, and release 50 walleye from each lake. The next day, you return to complete your recapture run. You use the same technique and catch 50 walleye from each lake. In the net, you have recaptured two tagged fish from the large lake, and twelve tagged walleye from the small lake.

The Petersen Index: **N = MC/R**

1. Use the Petersen method to estimate the size of the walleye population in the large lake.
2. Use the Petersen method to estimate the size of the walleye population in the small lake.
3. Explain why the large lake would have fewer recaptured walleye than the small lake.



B. Which of the following lake survey results are from the lake with the largest walleye population?
   a. small mark run sample (**M**), small recapture run sample (**C**), large number of recaptured tagged walleye (**R**)
   b. small mark run sample (**M**), large recapture run sample (**C**), large number of recaptured tagged walleye (**R**)
   c. large mark run sample (**M**), large recapture run sample (**C**), large number of recaptured tagged walleye (**R**)
   d. large mark run sample (**M**), large recapture run sample(**C**), small number of recaptured tagged walleye (**R**)

   Survey d. was done in the lake with the largest walleye population. We know this because the mark run and the recapture run were both large samples, and only a small number of tagged walleye were recaptured in the recapture run. A low proportion of tagged fish in the recapture run indicates a larger population. Survey a. was done in the lake with the smallest walleye population because a small number of walleye were captured in the recapture run, and a large proportion of those were recaptured tagged walleye. A small recapture run with a high proportion of recaptured fish indicates a small population.

4 Assessment options include the Checklist and Rubric on the following pages.

In Exercise B, students can use example numbers to help them deduce the answer.
a. 40, 40, 30
b. 40, 75, 30
c. 100, 100, 35
d. 100, 100, 10

Checklists are tools for students and instructors. Checklists involve students in managing their own learning. They help students understand and set learning goals before the lesson begins, and help them monitor their progress during the lesson, ensuring that they meet learning goals and objectives by the end of the lesson. Students can also use checklists to discover areas that may need improvement. Checklists help instructors monitor each student's progress throughout the lesson, facilitating appropriate adjustment of instruction to ensure learning by the end of the lesson. The instructor may wish to have students add several of their own learning goals to the checklist to personalize it, and to accommodate varied learning needs and styles.

Grade

22-25 points = A
Excellent. Work is above expectations.

19-22 points = B
Good. Work meets expectations.

15-18 points = C
Work is generally good. Some areas are better developed than others.

11-14 points = D
Work does not meet expectations; it's not clear that student understands objectives.

0-10 points = F
Work is unacceptable.

Fish Surveys Checklist

Possible Points	Points Earned Student	Points Earned Instructor	
3	______	______	Student can identify three types of fish sampling equipment and describe how each is used.
4	______	______	Student can describe two examples of how fish surveys are used in fisheries management.
3	______	______	Student can explain why scientific research is used in fisheries management.
3	______	______	Student can explain why a formula is used to estimate a lake's fish population.
2	______	______	Student can define and give an example of researcher bias.
4	______	______	Student accurately uses the Peterson Mark/Recapture Method to estimate the size of a walleye population in a simulated lake.
2	______	______	Student can graph class results and determine the class average estimate.
4	______	______	Student can identify the significance of the letters N, M, C and R in the Peterson Mark/Recapture Method.
Total Points			
25	______	______	**Score** ______

Fish Surveys Scoring Rubric

The Peterson Method Criteria	4 Excellent	3 Good	1 Poor	0 Unacceptable
Peterson Mark-recapture method equation	Can use the Peterson Method equation, and identify what the letters N, M, C and R stand for. Can describe the mark-recapture method.	Can use the equation, and identify what the letters stand for. Can describe the mark-recapture method with assistance.	Needs help using the equation. Doesn't know what the letters stand for, or can't describe the mark-recapture method without assistance and prompting.	Can't use the formula or understand what the letters stand for. Can't describe the mark-recapture method.
Mark /recapture lake survey exercise	Can explain why a formula is used to estimate a lake's fish population.	Understands why a formula is used to estimate a lake's fish population when explained.	Has difficulty clearly understanding why a formula is used to estimate a lake's fish population when explained.	Doesn't understand why a formula is used to estimate a lake's fish populations when it is explained.
Calculating population estimates	Accurately uses the Peterson method to estimate the size of a walleye population in a simulated lake and determine the class average estimate.	Accurately uses the Peterson Method to estimate the size of a walleye population in a simulated lake.	Uses the Peterson Method to estimate the size of a walleye population in a simulated lake with moderate assistance.	With step-by-step guidance, uses the Peterson Method to estimate population size.
Fish sampling equipment	Can recognize three types of fish sampling equipment and describe how each is used.	Can recognize two types of fish sampling equipment and describe how each is used.	Can recognize one type of fish sampling equipment and describe how each is used.	Can't recognize fish sampling equipment.
Use of fish survey data	Can describe two examples of how fish surveys and research are used in fisheries management.	Can describe two examples of how fish surveys and research are used in fisheries management.	Can be prompted to describe one example of how fish surveys and research are used in fisheries management.	Can't describe how fish surveys are used in fisheries management.

Score ______ (Calculate score by dividing total points by number of criteria.)

Diving Deeper

Extensions

1 Have student groups determine the percent error, the closeness of their population estimate from the survey results to the actual population size. It's helpful to know how accurately we expect an estimate to fall relative to the actual number of fish in the lake. Students can do this by determining the percent error. The percent error the proximity of an estimate to the actual population size. This formula is used to estimate percent error for your survey method.

Percent error is easily calculated if you know the total number of fish in a lake. But in a real lake, this isn't possible. Instead, fisheries biologists perform a more complex calculation to determine the confidence intervals for their lake surveys. Remember that *N = the estimate of population size or the estimate of the Number of fish present at the time of the release of the originally marked individuals*

$$\% \text{ error} = \frac{\mathbf{N}}{\text{The actual number of fish in the lake}} \times 100$$

2 Have each student use the Internet to go to the DNR website to look up Lake Survey information for a local lake. (See **Lesson 6:3—Planning a Fishing Trip**.) Students can use this Lake Data Report to answer the following questions about the lake:
- What kinds of fish are in this lake?
- When was the last lake survey done?
- What species of fish is the most numerous in this lake?

3 Write an outline for a lake survey simulation to determine the relative sizes of two different fish populations in a lake. The total number of fish in each of the two species can be determined by using proportions.

4 Invite a fisheries biologist to your classroom to demonstrate and discuss fish survey equipment.

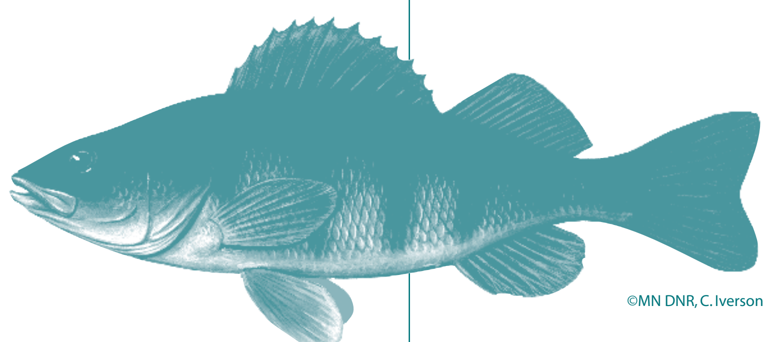
5 In the Warm-up, instead of counting the students in the class, ask students to count the number of boys in the class and the number of girls in the class. Is there an equal number? If there are approximately the same number of boys and girls, there's a similar proportion of boys to girls. Now use the following Lake MinnAqua problem scenario: Walleye eat bluegill. For the walleye to have enough to eat, there must be more bluegill in Lake MinnAqua than walleye. What is the proportion of bluegill to walleye in Lake MinnAqua? Put an unequal number of the two fish species in the "lake/aquarium" (two different colors of fish crackers, or two different colors of beans). For example, use a proportion of 3 to 1, or 4 to 1. Tell students the fisheries biologists must determine the best estimate for the proportion of the two species (walleye and bluegill) in the lake--the number of bluegills for every walleye in the lake.

Choose at least three student volunteers and have them come up to Lake MinnAqua one at a time. Have each take a sample (define sample) using the net. Remind each to not look in the lake and to take one sweep with the net. Return the fish to the lake after each sample and stir the fish to simulate them swimming in the lake. For each sample, write down the number of beans of each color. What is the proportion of bluegill to walleye in each sample? Conclude by discussing the results and determining the estimate of the proportion of walleyes to bluegills in Lake MinnAqua. Discuss why counting every fish in a lake to get an exact number isn't possible, and why collecting samples to gain information is useful. If you have time, take more samples, allowing each student a turn.

For the Small Fry

K-2 Option

Do the Warm-up. Invite a fisheries biologist to bring nets and fish survey equipment to class, and explain how they're used to capture fish. Use the aquarium with beans or fish crackers to show students that it isn't easy to estimate the number of fish in a lake when you can't see all of them.



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INSTRUCTOR COPY

Lake MinnAqua Scenario

You're a fisheries biologist working for the state. Area residents have been calling your office to report that they're not catching as many walleye in Lake MinnAqua as they have in past years. The resort owners on the lake are concerned that people will stop coming to Lake MinnAqua to fish.

The fisheries supervisor knows that the walleye fishing on Lake MinnAqua has been very good for as long as she can remember. She also knows that fishing on the lake is very important for the local economy, and that people travel here from long distances for the fishing.

Any negative change in the quality of fishing on the lake can have a serious impact on local residents who depend on tourism for their livelihoods. The herons, loons, and eagles around the lake also depend on the fish in Lake MinnAqua for food. If there *are* fewer fish in the lake, it can be a sign that something unknown—loss of fish-spawning habitat, too much fishing pressure, or poor water quality—is causing the walleye to migrate or die. Any problems should be identified so the fisheries manager can decide which management tools to use to address the population decline.

But it's difficult to know from a few fishing trips how many fish are in the lake. Maybe the fish just aren't interested in the bait that the anglers are using this year. The fisheries manager needs to find out how many walleye are really in Lake MinnAqua.

A lake survey was done three years ago on Lake MinnAqua. The estimated walleye population at that time was 1,000 fish. The fisheries supervisor sends the fisheries biologists to Lake MinnAqua to do research, and to conduct a new lake survey to find out how many walleye are in the lake this year.

Tagging Survey Scenario

A tagging survey is a scientific method that can be used to estimate the number of fish of a given species in a lake. You'll use a net to take a sample of walleye (beans) from Lake MinnAqua, count them, mark them with tags, and release them back into the lake. Because fish move around, or migrate, in the lake, and Lake MinnAqua is fairly large, the fisheries biologists must take several samples at various locations throughout the lake while conducting population surveys. For each sample, the fisheries biologists will record the total number of walleye captured as well as the number of tagged walleye that are recaptured.

Fisheries biologists know that the total number of walleye in the lake can be estimated by determining the ratio of the number of tagged walleye recaptured in the nets to the number of known marked or tagged walleye that were first released in the lake. (Define *ratio* on the whiteboard board or overhead projection device. Ratio is the relationship or proportion between two or more values.)

Electrofishing
Electrofishing is done on small streams with a backpack unit. On lakes or large rivers a unit is mounted on a specially-designed boat.

Electrofishing sends an electrical charge through the water to temporarily stun fish and make them to float to the surface. The stunned fish can be retrieved, measured, and weighed. Fish caught by electrofishing recover rapidly and swim away when returned to the water. Electrofishing is most often used for sampling largemouth bass, smallmouth bass, trout, and walleye, which tend to avoid nets or live in small streams.

Gill Netting
A gill net in Minnesota is usually six feet tall and 250 feet long. There are five sections. Each section has a different size opening in the mesh. With mesh openings ranging from two inches wide on the same net, a broad range of fish sizes is sampled. The tops of gill nets have floats that are weighted along the bottom. Nets are suspended or positioned along the bottom like a fence. Fish small enough to put their heads through the mesh as they swim into the net are caught by the gills when they try to back out. Gill nets are nets are very effective for sampling northern pike, walleye, cisco, trout, salmon, whitefish, and yellow perch—all of these fish swim in water more than nine feet deep.

Trap Netting

The standard trap net is three feet tall by six feet wide with a 40-foot "lead" or "leader." Fish swim up to the long lead net and follow it through a tunnel into a "pot," or trap they can't escape. Trap nets are commonly used to capture bluegills, crappies, bullheads, and other species near shore.

Using a Trawl

A trawl is a net attached to a boat with ropes. It's dragged along the lake bottom. Fish are funneled to a part of the net, and stay there until the net is pulled to the surface and into the boat. Trawls are used to capture small and young fish in large lakes.

Seining
A seine is a long, rectangular, small-meshed net whose ends are tied to two large poles, one on each end. The bottom of the net is weighted to hold it close to the bottom. Seines come in many sizes. Two people must work together to corral the fish into an area where they can be trapped in the net and pulled from the water. Shoreline seines are used to capture small and young fish near shore.

STUDENT COPY

Name ______________________________ Date ______________

Fisheries Biologist Survey Training

Peterson Method Mark-Recapture Population Survey

Mark Run Data

M (or the number of marked walleye) = ________

Recapture Run Data

C = ________

R = ________

Calculating N

$$N = \frac{M \times C}{R} = \frac{\_\_\_\_ \times \_\_\_\_}{\_\_\_\_} = \_\_\_\_\_\_\_\_$$

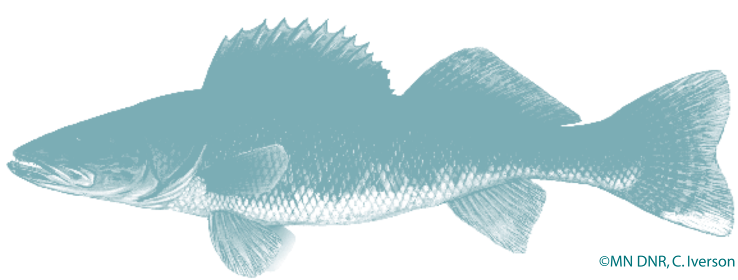
What Do These Letters Mean?

M = **the number of walleye originally Marked or tagged and released into the lake (the number of brown beans from the mark run)**

C = **the Catch sample size taken in the recapture run (the total number of beans in the student volunteer's sample net in the recapture run)**

R = **the number of marked walleye in the sample that are Recaptured (the number of brown beans that are recaptured in the sample net)**

N = **the estimate of the total Number of walleye in the lake (the estimate of the total number of all beans in the lake)**



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Name ______________________________ Date ______________

Lake Survey Data Sheet

You and your team have been assigned to conduct a Lake Survey. Use the Peterson mark-recapture method to estimate the size of the walleye population in Lake MinnAqua.

Mark Run Data

Directions: Use your hand as a net to capture walleye (white beans) from the lake (container). Count this number of beans and set them aside. Count the same number of brown beans and put them back into the lake. Write this number in the blank below. The brown beans represent the marked walleye.

M (or the number of marked walleye) = ________

Recapture Run Data

Directions: Stir the beans for fifteen seconds. Without looking into the lake, use your hand to capture another sample of walleye. Count the total number of walleye you caught. Write this number by C. Now separate and count the number of brown beans, or marked fish. Write this number by R.

C = ________

R = ________

Calculating N

Directions: Write the values for M, C, and R in the blanks below. Now do the Math! What did you get for N, the walleye population estimate for Lake MinnAqua?

$$N = \frac{M \times C}{R} = \frac{\_\_\_\_ \times \_\_\_\_}{\_\_\_\_} = \_\_\_\_\_\_\_\_$$

What Do These Letters Mean?

M = the number of walleye originally **M**arked or tagged and released into the lake (the number of brown beans from the mark run)

C = the **C**atch sample size taken in the recapture run (the total number of beans in the student volunteer's sample net in the recapture run)

R = the number of marked walleye in the sample that are **R**ecaptured (the number of brown beans that are recaptured in the sample net)

N = the estimate of the total **N**umber of walleye in the lake (the estimate of the total number of all beans in the lake)

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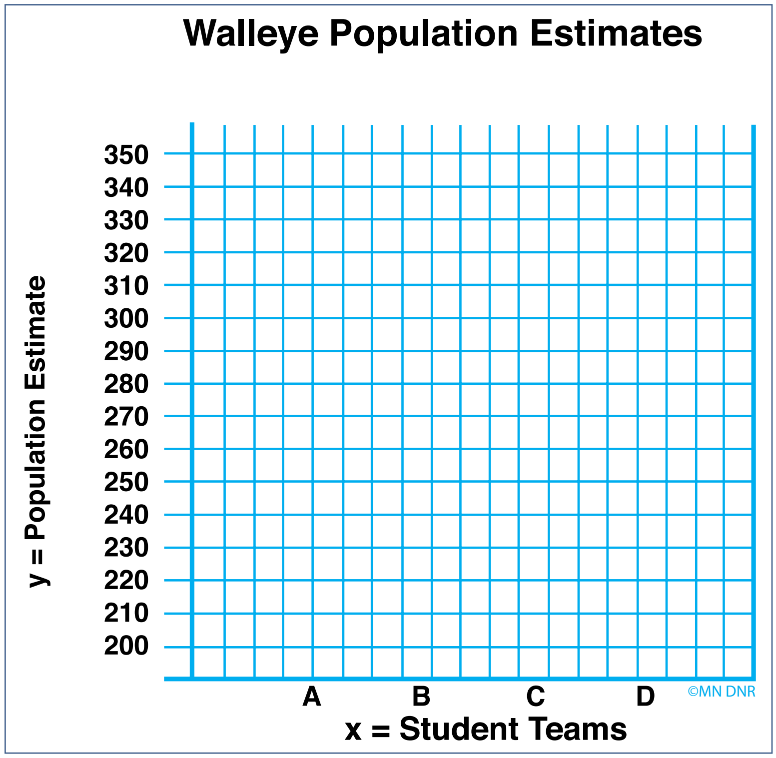
Lake Survey Data Sheet Questions

1. What is your survey team's estimate for the walleye population in Lake MinnAqua?

2. Place the values for each survey team's walleye population estimate in the proper place on the graph.



3. What is the **range** of values on the graph for our class survey data?

4. Using the graph, add the populations estimate numbers of all the survey teams. What is the **sum** of these numbers?

5. Divide this number by the number of estimates on the graph to find the **class average estimate** for the number of fish in Lake MinnAqua. For example, if there were fifteen team estimates on the graph, divide the sum you found in Question 3 by 15. This is the class average estimate. What is your class average estimate?

6. Is the class average estimate the median, mean, or mode for the class survey data?

7. What was the actual number of walleye (total number of beans) found in Lake MinnAqua?

8. Is the class average estimate value greater than, less than, or equal to the actual number of walleye in Lake MinnAqua?
   How close is the class average estimate value to the actual number of walleye in Lake MinnAqua?
   How close was your survey team's population estimate to the actual number of walleye in the lake?

9. The class average estimate value probably is not the same number as the actual number of walleye in the Lake. Why?

10. Compare your team's estimate to the class average estimate. Which estimate is closer to the actual number of walleye in the lake?

11. Why might a fisheries biologist take more than one sample for a lake survey?

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Lake Survey Data Sheet Questions Answer Sheet

The answers for Questions 1-5 and 8 will vary.

6. **Is the class average estimate the median, mean, or mode for the class survey data?**
   Mean

7. **What was the actual number of walleye (total number of beans) in Lake MinnAqua?**
   250

9. **The class average estimate value probably is not the same number as the actual number of walleye in the Lake. Why?**
   It's an estimate. The Petersen method and the Schnabel formula allow fisheries biologists to estimate population sizes. It isn't feasible to count every fish in a lake to get an exact number.

10. **Compare your team's estimate to the class average estimate. Which estimate is closer to the actual number of walleye in the lake?**
    Most likely, students will say the class mean is closer. Why? Using more than one sample and averaging all the survey teams' results provides a more accurate number than an individual team estimate that used many fewer samples.

11. **Why would a fisheries biologist collect more than one sample for a lake survey?**
    Using more than one sample in a survey can show a more accurate population estimate.

    When conducting lake population surveys, fisheries managers consider many factors to determine sampling methods. Sampling methods that yield a large number of samples may produce a more accurate population estimate, but taking more samples can cost more money. As managers make decisions regarding Lake and Stream Plans, budget concerns play a role, as well as considerations involving past and present lake conditions, species, management goals, and the needs of anglers and other users.