

Net Results

OVERVIEW

Students will study and replicate a model of the factors affecting fisheries populations in the Chesapeake Bay (or any other bay). Through a game they will investigate how decisions by watermen, recreational fisherpeople, and lawmakers influence and are influenced by economics and the abundance or scarcity of fish and shellfish stocks.

OBJECTIVES

Students will:

Consider social, environmental, and economic impacts of overfishing from a variety of perspectives

GRADE LEVELS

8-12

SUBJECTS

VOCABULARY

Abundance, aquaculture, depletion, harvesting, harvesting gear, moratorium, natural mortality, regulation, replenishment, scarcity, waterman

TIME

2 hours

MATERIALS

For each student or pair of students:

Bottle Model diagram

For each group of six students:

Fishery Factor cards

Role cards and data charts

2 open top containers (250 ml or larger bowls, shoeboxes, Tupperware)

500 ml of dried pinto or small kidney beans

1 graduated cylinder (250 ml or larger)

4 measuring spoon sets (one per waterman and recreational fisherperson)

4 cups (50 ml or larger) (one per waterman and recreational fisherperson)

1 funnel with opening large enough to let beans through (or a piece of paper rolled into a cone)

Paper and pencils

NATIONAL SCIENCE EDUCATION STANDARDS

This activity supports the following National Academy of Sciences science education standards.

Grades 5-8:

Unifying Concepts and Processes—Systems, order, and organization

Unifying Concepts and Processes—Evidence, models, and explanation

Standard A: Science as Inquiry—Abilities necessary to do scientific inquiry

Standard C: Life Science—Populations and ecosystems

Standard F: Science in Personal and Social Perspectives—Populations, resources, and environments

Standard F: Science in Personal and Social Perspectives—Science and technology in society

Grades 9-12:

Standard C: Life Science—The Interdependence of Organisms

Standard E: Science and Technology—Understandings about science and technology

Standard F: Science in Personal and Social Perspectives—Population growth

Standard F: Science in Personal and Social Perspectives—Natural resources

Standard F: Science in Personal and Social Perspectives—Environmental quality

Standard F: Science in Personal and Social Perspectives—Science and technology in local, national and global challenges

NATIONAL SOCIAL STUDIES STANDARDS

This activity supports the following National Council for the Social Studies standards.

Middle Grades:

Standard III: People, Places, & Environments—h, k

Standard V: Individuals, Groups, & Institutions—e, g

Standard VI: Power, Authority, & Governance—c

Standard VII: Production, Distribution, & Consumption—f,

Standard VIII: Science, Technology, & Society—d, e

Standard IX: Global Connections—d

Standard X: Civic Ideals & Practices—e

High School:

Standard III: People, Places, & Environments—h, k

Standard V: Individuals, Groups, & Institutions—e, g

Standard VI: Power, Authority, & Governance—c

Standard VII: Production, Distribution, & Consumption—f

Standard VIII: Science, Technology, & Society—d, f

Standard IX: Global Connections—d

Standard X: Civic Ideals & Practices—e

BACKGROUND

Whether the topic is catch restrictions on the blue crab or a moratorium on rockfish, fisheries management is almost always a contentious topic for citizens, scientists, watermen, lawmakers, and recreational harvesters alike. Yet, these groups want the same thing—populations of fish and shellfish that support and promise a viable future for our commercial and recreational harvesting industry.

Unfortunately, the scarcity of many of these resources makes polite cooperation difficult to achieve. When the devastating impacts of a hurricane, a more efficient harvesting gear, or a loss of habitat reduces populations, the resource may dwindle, but the demand for it continues to increase. The tough choices arising from this scarcity are the heart of current fisheries management.

In this activity, students grapple with these decisions through a game that illustrates how harvesting pressure, regulations, and other factors affect and are affected by the fisheries populations. By witnessing the rise and fall of populations in response to their actions and attempting to reach a compromise that is acceptable to everyone, students will gain an understanding of the challenge of fisheries management.

BEFORE YOU BEGIN

1. Photocopy the Bottle Model Handout for each pair of students.
2. Collect and organize a set of materials for each group. This activity is written for groups of six to eight students. This group size will allow each student to have an active role in the game. However, if you wish to approximate more closely the real-life proportions of lawmakers, watermen, and recreational fisherpeople, you may want to play the game as a full class. To do this, you will need to modify the recommended starting population and harvesting levels described in the first step of the teacher procedures. Other options when you have an extra student or two in a group are to add an extra fisheries scientist or an additional lawmaker to serve as a DNR police person.
3. Photocopy one set of “Fishery Factor” cards for each group and cut each set into individual cards. Copy the card originals back-to-back so that the fronts of the cards read “Fishery Factor” and the backs have specific instructions.
4. In the game, students will assume the roles of several people whose actions influence fisheries. Photocopy one role card for each student and divide each playing group according to the following roles:
 - Lawmaker (one per group)
 - Fisheries scientist (one per group)
 - Watermen/commercial fisherpeople (at least three per group)
 - Recreational fisherpeople (at least one per group)

WHAT TO DO

Part 1

1. Divide students into pairs. Distribute copies of the “Bottle Model” handout and instruct pairs to work together to complete the questions on the worksheet. The handout introduces the factors that influence fisheries populations. The rest of the activity is based on this student handout.

Part 2

2. Walk your full class through the following sequence once. (These instructions are also provided to the students on the “Student Instructions” handout.)
 - The goal of the game is to maintain a fishery that is stable enough to keep everyone in business for at least ten rounds.
 - Divide students into group of six to eight students. Give each group a set of student instructions. Also give each student a role card that explains his/her role in the game. Give each group a few minutes to explain and clarify their roles within the group.
 - Each group places between 300 and 400 ml of beans in one of their containers, which they should label “Bay.” The beans in this container represent the stock of beanfish in the Bay. The rest of the beans go in the second container, labeled “Extra.” To make the

harvest more realistic, each group's Bay should be covered so that the harvesters cannot tell how much the stock has been depleted.

- The game is played in ten rounds, each representing a year. In each round, the watermen and recreational fisherpeople "harvest" from the container abiding by current harvesting laws. For the first round, watermen are allowed to scoop three tablespoons of beans into their cup; the recreational fisherpeople (who each represent 25 fisherpeople) are allowed to take two tablespoons. These harvesting levels will change in subsequent rounds.
- While the harvesters count their catch, the fisheries scientist calculates the reproduction of the species for the round and adds the appropriate quantity of beans to the Bay. For every one ml remaining in the container, the stock reproduces one ml.
- Students (except the lawmakers) must record their actions for this round on a data sheet on the back of their job card. Each bean harvested is worth \$100 for the first round. Once recorded, all harvests for the round can be emptied into the "Extra" container and used by the fisheries scientist when he/she replenishes the stock in future rounds.
- After the first round, you can apply the effects of supply and demand to the game. If fewer than 150 beanfish are caught commercially then the price per fish rises to \$110. If more than 210 beanfish are caught commercially, the price per fish falls to \$90.
- All harvesters and the fisheries scientists make verbal recommendations to the lawmaker as to the type and extent of regulations they feel should be in place in the upcoming year (round). The lawmaker records everyone's recommendation in his/her data sheet. When making recommendations or laws, students should consider the suggestions on their role cards. They should also remember that watermen need to make \$6,000 each round or they go out of business.
- Based on the recommendations, lawmakers make laws that must be followed by all harvesters in the next round.
- The round ends with the lawmaker drawing a "Fishery Factor" card that introduces additional and unexpected occurrences. If the instructions on a card conflict with the lawmaker's decision, the instructions on the card override the lawmaker's decision. Otherwise, both card instructions and laws apply.
- Repeat for ten rounds.

Part 3

1. After ten rounds of the game, have the students (individually or in groups) answer the follow-up questions on the student handout for Part 3.

Suggestions for a smooth game:

- Students may ask how to count broken or half beans. Any bean less than a full bean does not count toward the total; you may explain that these beans are under legal harvesting size.
- Any bean that falls off the spoon during harvesting goes back into the pool and does not count toward the student's harvest.
- To make sure that students are recording their harvests accurately, the fisheries scientist can count any person's harvest at any time. Anyone who has counted half beans or whose harvest is above the level recorded gets a \$1,000 fine.
- If the students in the role of recreational fisherpeople have trouble calculating the percentage of fisherpeople who caught more than one beanfish, suggest the following formula:
$$\% = (\# \text{ beanfish caught} - 25) \times 4$$

ASSESSMENT

The Bottle Model is only one representation of the way that replenishment and depletion influence a population. Ask students to draw and explain their own model of the way this process works.

EXTENSIONS

- Have students graph the data they collect (population and harvest) to investigate the following question: Does looking at harvest data really tell you how a species is doing? What are some of the problems associated with looking solely at harvest data when trying to determine the health of a species?
- Explore the role of technology in sustaining fish populations.
- Research and write about the influence of varying stakeholders on public policy.

<p>If watermen caught less than a combined total of 150 beanfish this round, not enough of the fish are making it to market to meet the demand for tasty beanfish. Consumers are willing to pay more for a bit of this scarce fish and will now pay \$110 per beanfish. If watermen caught more than a total of 210 beanfish this round, there is a surplus of beanfish at the markets. Seafood market owners are cutting their prices to get people to buy at their stores. Beanfish are selling for only \$90 per fish. This card applies to every round.</p>	<p>The Maryland General Assembly has called for a public vote (referendum) on whether or not to reduce the amount of beanfish recreational fisherpersons are allowed to catch by reducing their scoop size. Use a show of hands to determine whether or not those fishing for recreation should use one size smaller scoop. Everyone may vote.</p>
<p>Each waterman has the option of buying bigger, more efficient equipment for \$2000 that can be used until laws prohibit the use of such equipment. If you choose to make the purchase, subtract \$2000 from your earnings this round or use any surplus you might have. In coming rounds, use one spoon size bigger than you used in the last round.</p>	<p>Everyone move one seat to the left and take over the job and the data chart of the person whose seat you have just taken.</p>
<p>Maryland students have begun a project raising beanfish in the classroom. This week they released their fish into the Bay in an effort to help restore the population. As a result of their project, the beanfish population in the Bay grows by 20 ml.</p>	<p>A disease from the Pacific Ocean is introduced into the Bay through ballast water released from a large ship docked in Baltimore. The disease is devastating to the beanfish population. Reduce your current beanfish population by one third.</p>
<p>A hurricane and its tremendous rainfall washes tons of sediment into the Bay, smothering delicate beanfish eggs and killing submerged aquatic vegetation, the preferred food of beanfish. Reduce the beanfish population in the Bay by 25%.</p>	<p>Recreational fisherpersons have just been shown how to perform careful catch, a technique where fish are caught for recreation and released back into the water unharmed. Fisherpeople: start a new column for the number of fish, if any, you decide to release. Fish released may be put back into the Bay before the fisheries scientist calculates reproduction.</p>
<p>The removal of a dam opens up prime beanfish spawning grounds and they have a reproductive year. Add 40 ml of beanfish to the Bay. The dam also opens up new areas for those fishing for recreation who are now allowed an additional scoop each round unless regulations change.</p>	<p>Students create a forest and wetland between a large mall and a local waterway. This vegetation helps to reduce the amount of sediment, oil, and nutrient runoff washing from the mall into the waterway. As a result, fewer beanfish die population-related deaths, leaving more to reproduce. Increase your population by 10 ml.</p>
<p>Suddenly, New Zealand starts shipping beanfish to your area which are just as good as yours. They are also cheaper than yours! This drives the market value of your beanfish down \$20 per fish for one round.</p>	<p>No changes this round.</p>

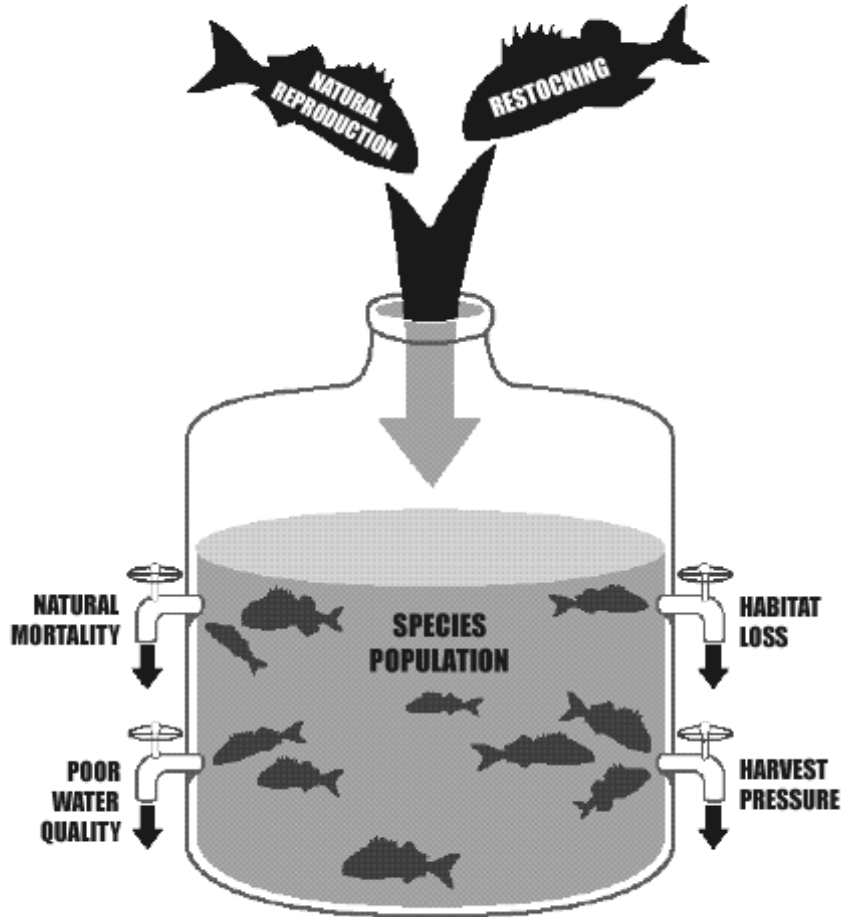
NET RESULTS – PART 1
The Bottle Model

1. Study the "Bottle Model" diagram below. This model represents the interaction between ways in which species are removed from the Chesapeake Bay and added back into the Bay (natural reproduction and stocking of waterways). Explain what you think the model illustrates about the factors that bring fish into the Bay and take them out of the Bay.

2. Under one faucet on the model, describe an event that could make the faucet flow faster. *For example, an event such as a heat wave could reduce the amount of oxygen in the Bay and increase natural mortality.*

3. If the event you described above did happen, what would happen to the population level in the bottle? Would the population be able to return to its original level after this event? How?

The Bottle Model



NET RESULTS—PART 2

Student Instructions

Your group is going to play a game that illustrates the way that people, fish and shellfish populations, and laws interact and influence each other. In the game, you will represent some of the people—lawmakers, scientists, watermen, and recreational fisherpeople—who influence and are affected by fisheries regulations.

1. Preparing for the game:

Your teacher will give each of you a Role card. Your Role card includes a chart for you to fill out during the game. Read your role description carefully and ask your teacher any questions you might have. Explain your role to the other members of your group and listen as they explain their roles to you.

2. Setting up the game:

Collect the rest of the game's materials from your teacher and distribute them among your group. Give the graduated cylinder to the fisheries scientist. Give each harvester (commercial and recreational) a set of measuring spoons. Label one of your containers "Bay" and put 400 ml of dried beans in this bowl. Cover your Bay with a cloth or a piece of paper so that the exact level of "beanfish" cannot be seen. Label the other container "Extra" and put the rest of your beans in this bowl.

3. Playing the game:

Round 1:

- Watermen may take up to three tablespoons of beanfish from the Bay. Recreational fisherpeople may take two tablespoons. Each person should put their individual harvest in a small cup so that they can count it later.
- After everyone has finished harvesting, fill in the data chart on the back of your role card. Check your role card to find out what this involves.
- Once the bean fish have been counted, watermen and fisherpeople pour their harvests into the "Extra" bowl.
- Using the graduated cylinder, the fisheries scientist measures the remaining population of beanfish in the Bay and calculates how much the fish reproduce. For every one ml of beanfish remaining, the scientist transfers one ml of beans from the "Extra" bowl to the Bay. The fisheries scientist fills out his/her data chart.
- Fisheries scientists, watermen, and recreational fisherpeople give recommendations to the lawmaker. Check your role card for ideas.
- The lawmaker decides which regulations (if any) harvesters must follow in the next round.
- The lawmaker draws a "Fishery Factor" card and reads it to the group.

Round 2 - Round 10

- Your group will repeat the procedure from **Round 1** following the new instructions from the Fishery Factor card and any new regulations (if there are any) from the lawmaker.
- The worth of beanfish may change as the game goes on. If your class is including the impact of supply and demand in your game, the cost of beanfish will vary depending on how many

are caught. If the total commercial catch is less than 150 fish, the cost per fish rises to \$110 due to scarcity. However, if the commercial catch is more than 210 fish, the cost per fish falls to \$90.

Every Round:

- The watermen must make \$6000 each round to make a living. If a waterman makes under this amount for a total of three rounds, he/she is out of business and becomes a recreational fisherperson. Surplus from good rounds can carry a waterman through times of shortage. This means that if a waterman makes \$6500 in one round, \$500 can be used to make up for a bad catch in another round.
- Recreational fisherpeople represent 25 anglers each. For every angler to catch a fish, the recreational fisherpeople need to catch at least 25 beans each round.
- The most important thing to remember about this game is that you get to make most of the rules! You will need to come up with imaginative solutions as you encounter the challenges of fisheries management.

NET RESULTS—Part 3

After you have played ten rounds of the game "Net Results," answer the following questions:

1. Summarize the results of the game. What trends did you see in the beanfish population over time?

2. Of the factors that increase and reduce the populations of species in the water, which can we control? Look back at the "Bottle Model" from Part I and circle the factors that people can control through various actions. Under each factor you circle, provide an example of an action that you, or other people, do or could do to decrease the flow from the faucet.

3. Describe three events, actions, or decisions in the game that most influenced the health of your fishery.

4. List and explain three things that you would do differently if you were to play "Net Results" again. How do you believe these changes would affect the outcome of the game?

5. Because this was a game, or a model of a real-life process, there were many things that were not quite realistic. Even so, this game should have given you a good sense of the challenges, cooperation, and compromise involved in fisheries management. What other factors might influence populations and catches if this experiment were done in real life?

6. This game deals with a very real issue: the role of laws in fisheries management. Think about how laws or regulations affected the watermen and recreational fisherpeople in your game. How did the regulations affect the fish population?

Write a persuasive paragraph to a classmate explaining whether or not you think we need laws, such as those you saw in the game, to manage fisheries. Use examples and evidence from the "Bottle Model," the game, and any prior knowledge you might have to support your perspective.

Lawmaker

Introduction to your role:

Your job is to make the laws that determine how many beanfish the commercial and recreational fisherpeople can take out of the Bay each year. Your goal is to listen to everyone's point of view about how the fishery is doing and then make regulations that are fair and sensible. It is a tough job, but someone has to do it! Ultimately, you are striving to keep the fishing industry healthy throughout the *entire* game.

At the end of each round, you will get a recommendation from each interest group (fisheries scientists, watermen, and recreational fisherpeople). Although the recommendations may say completely different things, you need to use them to help decide which regulations to make.

What does the lawmaker do?

As the lawmaker, you can regulate fishing in a number of ways. You can make everyone take fewer beanfish, or allow everyone to take more. You can change the size of the equipment that watermen and/or recreational fisherpeople are allowed to use (they all have a set of spoons sizes you can choose from). You can also set different limits for recreational fisherpeople and watermen. As a last resort, you can set a moratorium for a round or more. A moratorium is a ban on all harvesting of the species and will allow the species to reproduce without being harvested. The lawmaker is also responsible for enforcing the regulations he or she sets, when necessary.

Remember:

As a lawmaker, you take responsibility for many people's happiness, and sometimes for their financial survival. Watermen make a living by catching and selling beanfish. They are not making a decent living if they make less than \$6000 per round. They will go out of business permanently if they make less than this for a total of three rounds. This means that severe restrictions, or a moratorium might put them out of business. On the other hand, watermen depend on the existence of beanfish to catch, so overfishing might put them out of business in future rounds. Your goal is to find laws that will balance present and future needs.

Here are a few examples of regulations you can set:

- If the beanfish stock seems to be in wonderful shape, you can increase the amount everyone can catch or allow for an unlimited catch, where everyone can take as much as they want.
- If you are afraid that the beanfish stock is becoming too low, you can forbid the use of tablespoons to scoop up beanfish. This means that watermen and recreational fisherpeople will have to use their smaller spoons, which do not catch as many beanfish.

Round #	Scientist's suggestions	Watermen's suggestions	Recreational fisherpeople's suggestions	Final decision for the round
Round 1				
Round 2				
Round 3				
Round 4				
Round 5				
Round 6				
Round 7				
Round 8				
Round 9				
Round 10				

Fisheries Scientist

Introduction to your role:

You are the person who studies the Bay's fish populations. You are an expert who provides hard facts to the lawmaker about how the beanfish population is doing. In this game, you are also the person who measures the fish left after each round and calculates how many get put back in to the pool through natural reproduction. This means that you are the only person who really knows how the beanfish are doing. Your goal in this game is to make sure that there are always enough beanfish left in the pool to replenish the stock after each round. In other words, you want to make sure that there will be a future for beanfishing in the Bay.

What does the Fisheries Scientist do?

To provide sound data to the lawmaker, you need to keep track of the amount of beanfish in the Bay before and after harvesting and beanfish reproduction. You will start the game by placing 200 ml of beanfish in the Bay. After each round of harvesting, you will measure the amount of fish left and calculate how much the beanfish population will reproduce that year. To do this, you will add one ml of beans to the Bay for every ml of beans left. For example: if there are 95ml of beanfish left in the Bay when harvest is finished, you will add 95ml more. This will bring the total amount of beanfish up to 190ml.

Based on what you know about the beanfish population after each round, you will need to make a verbal recommendation to the lawmaker, telling him/her what you think should be done to maintain a healthy beanfish stock.

Remember:

Since you are the only members of your playing group who actually measure the beanfish stock, you will need to explain to the others how the stock is doing. Most importantly, you need to convince the lawmaker to make regulations that will keep the stock healthy, and not bring it down to low levels.

- If you can see that the current regulations are allowing the beanfish stock to become seriously low, you can recommend that the lawmaker limit watermen to one scoop each per round or that the recreational fisherpeople use a smaller harvesting tool.
- If you think that the beanfish are doing particularly well, you can recommend that the lawmaker allow them to harvest more beanfish.

Round #	Amount in Bay after harvest (in ml)	Amount added through reproduction (1ml for each remaining ml)	Final total after harvesting and reproduction (in ml)	Fraction gained or lost from previous round
Round 1				
Round 2				
Round 3				
Round 4				
Round 5				
Round 6				
Round 7				
Round 8				
Round 9				
Round 10				

Watermen/Commercial Fisherperson

Introduction to your role:

You make your living by catching beanfish from the Bay and selling them commercially. Your goal is to stay in business for the entire game while obeying the laws and regulations set by the lawmaker.

What does a Waterman do?

To stay in business, you need to catch enough beanfish to make \$6,000 (your expenses) each round. For the first round, each bean is worth \$100, meaning that you have to catch 60 beans in the first round. The worth of each bean may change throughout the game.

If you make more than \$6,000 in any round, you can save your surplus in your savings account for tighter times. If you make less than this amount in any round, you must make up the difference with surplus from another time or count the round as a strike against you. If you have a total of three strikes against you during the game, you go out of business and become a recreational fisherperson.

At the end of each round, you will need to give a verbal recommendation to the lawmaker, telling her/him how your business is doing and what you think should be done to keep you in business. Should you be allowed to use bigger and better gear or take more scoops? Should you or recreational fisherpeople be taking less? Are you making enough money to make a living? Do you want to save money in case times get tight? To help you make these recommendations, you need to keep track of your harvests using the chart on the back of this page.

Remember:

If there are no fish, you will have nothing to catch and no way to remain in business. On the other hand, if regulations are too strict, you may go out of business anyway. You may work with other watermen and/or the recreational fisherpeople, or you may wish to be secretive about your business. It's your choice.

Round #	Amount harvested (# of beanfish)	Price per bean this round	Total amount earned	Amount earned above (+) or below (-) \$6000	Savings account (total surplus)
Round 1					
Round 2					
Round 3					
Round 4					
Round 5					
Round 6					
Round 7					
Round 8					
Round 9					
Round 10					

Recreational Fisherperson

Introduction to your role:

You do not make your living fishing, but it is still very important to you. You fish for fun, because you like to eat beanfish, or because you like to make a little extra money by selling beanfish on the side. Even though each of you only catches a small number of beanfish, there are so many of you that your harvest can be significant. For this reason, you must follow whatever laws are set by the lawmaker just as the commercial watermen do.

What do the Recreational Fisherpeople do?

Because there are actually many more recreational fisherpeople than watermen, you will represent 25 fisherpeople. This means that if you take a scoop of beans that has 25 beans in it, each recreational fisherperson has caught one bean. Not bad. However, if you only catch 10 beans, then only 10 out of 25, $\frac{2}{5}$ ths, or 40% of the recreational fisherpeople have caught a bean. Not so good! When your harvests get below one beanfish per person, recreational fisherpeople begin to get worried.

At the end of each round, you will try to influence the lawmaker through a verbal recommendation telling her/him how well fishing is going and what you think should be done. Should fisherpeople be allowed to catch more each round or use bigger and better fishing gear? Or are you worried that too much is being taken? Keep track of the number of fish that you are catching with the chart on the other side of this page.

Remember:

Just because fishing is a recreation to you doesn't mean that you don't care what regulations are set by the lawmaker. You want the freedom to continue your way of life.

Round #	# of beanfish caught total	What percentage of the 25 fisherpeople you represent caught one feanfish (up to 100%)	Percentage of fisherpeople who caught more than one beanfish (up to 100%)	How content are your 25 fisherpeople with their catch?
Round 1				
Round 2				
Round 3				
Round 4				
Round 5				
Round 6				
Round 7				
Round 8				
Round 9				
Round 10				