Oceans 11
A Teaching Resource
Volume 2

Foreword

Oceans 11 curriculum was developed by the Nova Scotia Department of Education as part of a joint project with the federal Department of Fisheries and Oceans. This curriculum reflects the framework described in *Foundation for the Atlantic Canada Science Curriculum*.

Oceans 11 satisfies the second science credit requirement for high school graduation.

Oceans 11 includes the following modules: Structure and Motion, Marine Biome, Coastal Zone, Aquaculture, and Fisheries.

Oceans 11: A Teaching Resource, Volume 1 is intended to complement the curriculum guide, *Oceans 11*. The sample activities in this resource address the outcomes described in *Oceans 11* for the three compulsory modules: Structure and Motion, Marine Biome, and Coastal Zone.

Oceans 11: A Teaching Resource, Volume 2 is intended to complement *Oceans 11*. The sample activities in it address the outcomes for the modules Aquaculture and Fisheries. Teachers may choose to do one of these units or to divide their class into groups that focus on a unit.

Contents

Fisheries

Aquaculture

Introduction

As of 2004, aquaculture accounted for almost one-third of the volume of seafood consumed globally, yet Canada's contribution to the aquaculture totals was less than one percent. As the global population grows while traditional fisheries decline, aquaculture will become increasingly more crucial in meeting world needs and Canada will have to play a bigger role. This unit will explore the location of aquaculture sites currently in Nova Scotia and the Maritime provinces and determine what physical and biological features determine a suitable site. Species currently farmed and potential species will be identified, and the anatomy and physiology of representative species will be explored. We will look at aquaculture becoming an integral part of the Nova Scotian economy. The interrelationships among employment, business, related industries, special interest groups, environmental concerns, and health issues will be addressed.

The activities in this module enable students to practise and develop their laboratory skills while learning about the environmental factors influencing aquaculture operations. Students must also conduct research, present findings, and adopt an entrepreneurial spirit. Finally, this module has numerous connections to coastal zones and conflict resolution.

Materials

- binocular microscope
- clipboards
- dissection gloves
- dissecting kits
- dissecting trays
- lab aprons
- live oysters and paired oyster valves
- magnifying glasses
- mussels
- rubber gloves
- safety glasses

Grocery Survey

Question

What is the diversity of seafood represented in grocery stores?

Materials

- clipboard
- permission sheets
- introduction letter

Procedure

Collect data from two different grocery stores using the table that your teacher will hand out. You need information on 10 different seafood products. Decide within your group who will be collecting the data and at what stores. For instance, if you are in a group of four, two students could go to Store A and the other two could go to Store B. It is important to identify yourself to store employees and explain why you are there.

Once the data is collected, tabulate and present your findings to the class. This should take 3–4 minutes per presentation. Fill in information for only 10 products.

Here are some aspects to consider:

- What geographical location are the products taken from (harvesting location)?
- How do the different products vary in price?
- Was the organism obtained by aquaculture or traditional capture fisheries?
- Were more aquatic organisms farmed or fished? Are any both farmed and fished?
- If you do not eat a particular organism, who does?
- What are the preservation methods used for the samples?
- What kind of information does the packaging include?
- Is there other information you are looking for that is not included?

GROCERY SURVEY WORKSHEET

Name and Location of Store:

		Habitat		Preservation Method							Product of		
Product	Price/kg	Freshwater	Saltwater	Fresh	Frozen	Dried	Canned	Smoked	Salted	Pickled	Aquaculture	Fisheries	Harvesting Location

Grocery Survey
Teacher Notes

Outcomes

Students will be expected to

- identify, and compare aquaculture—locations and species—grown in Nova Scotia, in the rest of Canada, and globally (AQUA-1)
- describe and identify groups of organisms raised through aquaculture and their geographic locations, referring to anatomy and physiology of a major species and ecology of cultured species (AQUA-2)

Background Information

The assignment should be given out two weeks before the start of the unit to allow enough time to complete the survey for the start of the unit. Students could work in groups of three or four and collect information on ten organisms.

Students should approach the customer service desk in the grocery store and explain what they are doing and conduct themselves in a way that is a positive reflection on their school.

Group data could be presented. Each member of the group should have a role in the presentation. Allow approximately 3–4 minutes per presentation.

Each group could address the questions outlined in the procedure during their presentation.

Sample Evaluation

Survey assignments may be evaluated using one or more of the following criteria:

a. Satisfactory or incomplete

b. How comprehensive the data is and how well the questions are addressed

c. Peer evaluation of the presentation or the activity

d. A combination of b and c

A good discussion can arise from this activity about aquaculture versus fishing and the way of the future. Supply and demand, competition, and cultural differences can be explored during the discussion. (15 minutes)

Fishing or Farming: An Introduction to Aquaculture

Questions

- What do you know about farming, fishing, and aquaculture?
- What does aquaculture mean?

Procedure

Think about the characteristics listed below. For each of the columns farming, fishing, and aquaculture, answer with a yes and/or no. You should have a reason(s) for your choice for each characteristic for the class discussion that follows.

Characteristic	**Farming**		**Fishing**		**Aquaculture**	
Growth medium required (location found)	Yes	No	Yes	No	Yes	No
	Reasons:					
Good husbandry necessary (nurturing of product)	Yes	No	Yes	No	Yes	No
	Reasons:					
Demands specific harvest times (specific season)	Yes	No	Yes	No	Yes	No
	Reasons:					
Has enforced quotas (amount to be harvested)	Yes	No	Yes	No	Yes	No
	Reasons:					
Disease concerns (constantly checking)	Yes	No	Yes	No	Yes	No
	Reasons:					
Requires a nourishment supply (Where does the food come from?)	Yes	No	Yes	No	Yes	No
	Reasons:					
Population density affects population growth or spread of disease, etc.	Yes	No	Yes	No	Yes	No
	Reasons:					
Requires control of products' life cycle (managed or not	Yes	No	Yes	No	Yes	No
	Reasons:					

Characteristic	Farming		Fishing		Aquaculture	
managed)						
Weather conditions are a concern	Yes	No	Yes	No	Yes	No
	Reasons:					
Health of the stock is a concern	Yes	No	Yes	No	Yes	No
	Reasons:					
Has a specific geographical location (know coordinates)	Yes	No	Yes	No	Yes	No
	Reasons:					
Domestication of previously wild product	Yes	No	Yes	No	Yes	No
	Reasons:					
Government regulation(s) concerning product	Yes	No	Yes	No	Yes	No
	Reasons:					
Ownership of product (responsibility)	Yes	No	Yes	No	Yes	No
	Reasons:					
Harvest of product (Is it hunting?)	Yes	No	Yes	No	Yes	No
	Reasons:					

Fishing or Farming: An Introduction to Aquaculture
Teacher Notes

Outcome

Students will be expected to

- identify, and compare aquaculture—locations and species—grown in Nova Scotia, in the rest of Canada, and globally (AQUA-1)

Background Information

The activity could start with a quick survey of the class to determine how many believe aquaculture to be fishing and how many believe it to be farming.

Working in groups of three or four, students could discuss the characteristics and complete the chart. Group results could be tallied. The results could indicate that aquaculture is much closer to farming. Some characteristics may require further clarification.

As a wrap-up, the class could compose a working definition of aquaculture by brainstorming the results of the table.

Sample Results

An answer key for the teacher is provided to help with typical choices. Feel free to add more characteristics if you wish.

Characteristic	**Farming**	**Fishing**	**Aquaculture**
Growth medium required (location found)	Soil/water (hydroponics)	Water	Water
Good husbandry necessary (nurturing of product)	Yes	No	Yes
Demands specific harvest times (specific season)	Yes/No (greenhouse)	Yes/No (seasonal)	Yes
Has enforced quota (amount to be harvested)	Yes	Yes/No (depends on product)	Yes

Characteristic	Farming	Fishing	Aquaculture
Disease concerns (constantly checking)	Yes	No	Yes
Requires a nourishment supply (Where does the food come from?)	Yes–grower	No–wild	Yes–grower
Population density affects population growth or spread of disease, etc.	Yes	Yes (when too low) No (when at optimum)	Yes
Requires control of products' life cycle (managed or not managed)	Yes	No	Yes
Weather conditions are a concern	Yes	No	Yes
Health of the stock is a concern	Yes	No (when not enough)	Yes
Has a specific geographical location (know coordinates)	Yes	Yes/No	Yes
Domestication of previously wild product	Yes	No	Yes
Government regulation(s) concerning product	Yes/No	Yes	Yes/No
Ownership of product (responsibility)	Yes	No	Yes
Harvest of product (Is it hunting?)	No	Yes	No

Follow-up

At this point, you should show a video, or lead a trip if feasible, to allow the students to experience what an aquaculture site looks like and the way of life for that site.

The video catalogue is available online at http://lrt.EDnet.ns.ca. *Land and Sea: Aquaculture* is one possibility. Many of the videos that are appropriate to *Oceans 11* are listed in the appendix to the guide. See Appendix B for details on ordering.

Design a Brochure

Questions

- What environment is needed for a particular species?
- What are the living conditions of a marketable organism?
- What business opportunities exist for this organism?

Procedure

Scenario: You are a marine biologist for the Bedford Institute of Oceanography(BIO) and you have been asked by the Department of Fisheries and Oceans (DFO) and Nova Scotia Fisheries and Aquaculture (NSFA) to design a brochure for a particular local marine organism to improve it's marketability to the public. You may choose any aquatic organism, freshwater or saltwater, that is being farmed or could be farmed in or off the waters of Nova Scotia. The requirements for your brochure include the following:

- It must have a marine theme.
- The front cover must draw attention to the brochure so people would be intrigued enough to open it up and see what is inside.
- All important information about the organism must be inside (reproduction, feeding habits, type of habitat needed for optimum growth, cost of growing organism, market value).
- Aquaculture must be emphasized.
- Sketches of the organism must be used.
- The back page must also catch attention so the reader wants to open up the brochure.
- Include how the organism can be prepared to eat (recipes?).
- Don't clutter with too much material.
- Use a sheet of 21.5 cm × 28.0 cm piece of paper (it can be any colour).
- Art work and lettering can be any colour.
- It must be folded in half or thirds so it reads like a brochure.

Design a Brochure
Teacher Notes

Outcome

Students will be expected to

- describe and identify groups of organisms raised through aquaculture and their geographic locations, referring to anatomy and physiology of a major species and ecology of cultured species (AQUA-2)

Background Information

Designing a brochure is a way to allow students to express their creativity while learning about aquaculture in Nova Scotia. They will need to research a particular species thoroughly to determine its feeding habits, physiology and anatomy, and its suitability for aquaculture.

The brochures can be done entirely by hand using pictures cut from magazines or drawn by the student. Alternatively, there are several software programs (e.g., Microsoft Publisher) that offer many styles of brochures while allowing the students to incorporate digital, scanned, and downloaded images. If the technology route is chosen, review copyright issues with the students. Images on websites and clipart are usually copyrighted and require permission from the owner for their use.

Farmed Marine Organisms

Question

How are finfish, shellfish, and aquatic plants classified and what are their characteristics?

Procedure

Research your organism and fill in the chart with the information.

FINFISH: ATLANTIC SALMON	
Salmon’s Life Cycle	Basic Features
Adaptations	How It Moves
How It Gets Food	Other Information

SHELLFISH: EXAMPLE	
Life Cycle	Basic Features
Adaptations	How It Moves
How It Gets Food	Other Information

Farmed Marine Organisms
Teacher Notes

Outcome

Students will be expected to

- describe and identify groups of organisms raised through aquaculture and their geographic locations, referring to anatomy and physiology of a major species and ecology of cultured species (AQUA-2)

Background Information

The organisms that are grown and nurtured by aquaculture in our region can be divided into three divisions:

- Finfish
- Shellfish
- Aquatic Plants

Teachers may wish to have students, in groups, look at one of these.

FINFISH

These organisms are vertebrate animals with a bony internal skeleton that gives them support and protection. They have several pairs of fins that are used for movement and stabilization. The lateral line is part of their nervous system that helps maintain balance and position.

The four pairs of gills of finfish remove oxygen from the water. Blood is pumped into the gills, where it absorbs oxygen and diffuses carbon dioxide into the surrounding water by osmosis.

The muscle of finfish is the part most commonly eaten. This tissue can be sold fresh, frozen, smoked, canned, salted, etc. Some finfish are grown for animal feed, bait, or aquaria.

Finfish are grown in cages or ponds. Problems with finfish growth include

- Predators: Nets are used to keep predators such as seals and birds away.
- Diseases: Cages are cleaned regularly. The finfish can be vaccinated against certain diseases.

Examples of finfish are Atlantic salmon, rainbow trout (also known as steelhead), and Arctic char.

SHELLFISH

Most shellfish grown are mollusks (invertebrate animals with one or two shells or valves composed of calcium carbonate). Mollusks with two valves or shells are called bivalves. A strong adductor muscle holds the valves together.

Bivalves have siphons through which water enters and leaves the animal. Most shellfish are filter feeders, meaning they remove food from the water as it passes through their bodies. They have gills to remove the oxygen from the water. These siphons also are a means of removing the waste product of carbon dioxide from their bodies.

The entire animal may be eaten, (mussels and clams) or just the adductor muscle, (scallops). Shellfish are grown in cages, on longlines, or by bottom culture.

Problems with shellfish growth include:

- predators such as sea stars, worms, and birds, depending on where the shellfish are grown
- toxins in the water that can destroy the shellfish or make it unfit for consumption by humans
- diseases that can kill the organisms

Examples of shellfish are blue mussel, bay scallop, and American oyster.

The External Anatomy of an Oyster

Questions

- What features does an oyster have?
- What can we learn by looking at the exterior of this creature?

Materials

- live oysters and paired oyster valves
- dissecting tray or metal pie plate
- sturdy gloves
- dissecting scope
- magnifying glass, large
- paper towel
- Internet access

Safety

You and your partner will be working with a live oyster. Please do not harm the animal in any way. It should be returned to the aquarium in the same condition in which you found it.

Some edges of the shell can be very sharp.

Procedure 1

<table>
<tr><td colspan="2">THE EXTERNAL ANATOMY OF AN OYSTER

Name:</td></tr>
<tr><td>After putting on your gloves, obtain an oyster from the aquarium and a paired set of oyster valves (shells) and place on the dissecting tray. Observe the shells (also known as valves).

1. How many valves are there? ___

2. What general name is given to a mollusk with this many valves?</td><td>The oyster is more pointed at one end than the other. This pointed end, the anterior (the front), is called the umbo. It is also the oldest part. The posterior (the back) end is the larger, curved end.

On the inside of the valves there is an area of very dark pigmentation where the adductor muscle was located.

3. Which of the following would you expect to be the function of this muscle?

❏ opening and closing
❏ moving from place to place
❏ pump for filtering food</td></tr>
<tr><td>Hold the oyster valves together so that the flatter one is on top and the umbo points toward you.

4. Are the valves different in size?

❏ yes
❏ no

5. If so, which seems larger?

❏ top valve
❏ bottom valve</td><td>The flatter of the two valves is the right valve. The cup-shaped valve is the left valve. Locate the right and left valves. Located at the base of the umbo is the hinge. The right valve has a projection that fits into a groove in the left. A ligament joins the two valves at the hinge and assists in opening and closing the valves.

6. What type of human joint is similar to the oyster hinge? (This is an example of an analogous feature—similar in function but not in origin.)

❏ knee
❏ elbow
❏ shoulder
❏ hip
❏ knee and elbow
❏ elbow and shoulder
❏ shoulder and hip</td></tr>
<tr><td colspan="2">The height of the oyster is the distance from the umbo to the edge of the opposite end or bill.

7. What is the height of your oyster?</td></tr>
</table>

Procedure 2

By examining the valves of your oyster and/or your set of valves with a large magnifying glass or dissecting scope, look for evidence of the following organisms. Place a check in the box beside all organisms that you find evidence of.

- ❑ *Barnacle*: Empty barnacle shell on an oyster.
- ❑ *Barnacle scar*: An impression left on the valve from a previous barnacle attachment on the shell.
- ❑ *Boring Sponge*: Numerous tiny holes bored through the oyster's shell.
- ❑ *Hooked Mussel*: Silky threads remaining after a hooked mussel has been detached from the oyster.
- ❑ *Japanese Crab*: Scratches on the valves that would indicate attempts at prying the shells open.
- ❑ *Lacy Crust Bryozoan*: A crust on the surface of the oyster shell that resembles lace.
- ❑ *Limy Tube Worm*: A tube made from calcium carbonate, calcium, or lime that is attached to the shell.
- ❑ *Moon Snail*: Perfectly round hole bored through shell.
- ❑ *Oyster Mudworm*: A dark burrow that resembles a blister.
- ❑ *Oyster Spat Scar*: A smooth scar on the shell's surface.
- ❑ *Starfish*: Scratches on the valves that would indicate attempts at prying the shells open.
- ❑ *Whelk*: Scratches on the valves that would indicate attempts at prying the shells open.

Extension

Thank about the characteristics of these organisms. Classify each of the following as commensal (C), parasitic (P), or predatory (PD).

____ Barnacle

____ Boring sponge

____ Hooked mussel

____ Japanese crab

____ Lacy crust bryozoan

____ Limy tube worm

____ Moon snail

____ Oyster mudworm

____ Oyster spat

____ Starfish

____ Whelk

Analysis

Each of these organisms forms a commensal, parasitic, or predator/prey relationship with the oyster.

1. Define and give an example of a commensal relationship.

2. Define and give an example of a parasitic relationship.

3. Define and give an example of a predator/prey relationship.

The External Anatomy of an Oyster
Teacher Notes

Outcome

Students will be expected to

- describe and identify groups of organisms raised through aquaculture and their geographic locations, referring to anatomy and physiology of a major species and ecology of cultured species (AQUA-2)

Background Information

Oysters are very common in Atlantic Canada and are one of the most popular products of aquaculture. They are usually found naturally in estuaries, sounds, and bays, from brackish (mildly salty) water to very salty lagoons. They are very tolerant organisms, being able to withstand wide variations in temperature, salinity, suspended sediments, and dissolved oxygen.

Oysters are filter-feeders, drawing water in over their gills through the beating of cilia. Suspended food (plankton) and particles are trapped in the mucus of the gills and transported to the mouth, where they will be eaten, digested, and expelled as feces. Feeding activity is greatest in oysters when water temperatures are above 10 °C.

Oysters spawn when water temperatures become greater than 20 °C. They are broadcast spawners, releasing eggs and sperm into the water column. Fertilized eggs develop into a planktonic or swimming larval form. After about two weeks these larvae will cement themselves to a hard substrate (such as the valve of another oyster) and metamorphose. The newly attached oyster is known as a "spat."

Some oyster farmers are experiencing difficulties with ocean-based farms. Their "crop" is dying and the probable culprit is pollution.

Note: Empty shells (as long as they are still paired) could be used in place of live oysters. If you choose to use live oysters, they could be used in place of blue mussels for the dissection labs. They need to be boiled first, as experimenting on live animals is prohibited.

Sample Results

<table>
<tr><td colspan="2">THE EXTERNAL ANATOMY OF AN OYSTER

Name:</td></tr>
<tr><td>After putting on your gloves, obtain an oyster from the aquarium and a paired set of oyster valves (shells) and place on the dissecting tray. Observe the shells (also known as valves).

1. How many valves are there? 2

2. What general name is given to a mollusk with this many valves?

Bivalves</td><td>The oyster is more pointed at one end than the other. This pointed end, the anterior (the front), is called the umbo. It is also the oldest part. The posterior (the back) end is the larger, curved end.

On the inside of the valves there is an area of very dark pigmentation where the adductor muscle was located.

3. Which of the following would you expect to be the function of this muscle?

X opening and closing

❑ moving from place to place

❑ pump for filtering food</td></tr>
<tr><td>Hold the oyster valves together so that the flatter one is on top and the umbo points toward you.

4. Are the valves different in size?

X yes

❑ no

5. If so, which seems larger?

❑ top valve

X bottom valve</td><td>The flatter of the two valves is the right valve. The cup-shaped valve is the left valve. Locate the right and left valves. Located at the base of the umbo is the hinge. The right valve has a projection that fits into a groove in the left. A ligament joins the two valves at the hinge and assists in opening and closing the valves.

6. What type of human joint is similar to the oyster hinge? (This is an example of an analogous feature—similar in function but not in origin.)

❑ knee

❑ elbow

❑ shoulder

❑ hip

X knee and elbow

❑ elbow and shoulder

❑ shoulder and hip</td></tr>
<tr><td colspan="2">The height of the oyster is the distance from the umbo to the edge of the opposite end or bill.

7. What is the height of your oyster? Answers will vary.</td></tr>
<tr><td colspan="2">ANALYSIS

Each of these organisms forms a commensal, parasitic, or predator/prey relationship with the oyster.</td></tr>
</table>

8. Define and give an example of a commensal relationship.

Commensalism is a relationship in which one organism benefits and the other organism is neither harmed nor helped.

9. Define and give an example of a parasitic relationship.

Parasitism is a relationship in which one organism benefits at the expense (often the life) of the other organism.

10. Define and give an example of a predator/prey relationship.

Predators live by capturing and feeding upon other animals (prey).

Commensal: barnacles, hooked mussel, limy tube worm, oyster spat

Parasitic: boring sponge, lacy crust bryozoan, oyster mudworm

Predatory: Japanese crab, moon snail, starfish, whelk

Follow-up Activity

Have your students write an "oyster's-eye view" story involving the various organisms it has relationships (commensal, parasitic, and predator/prey) with. The story should include the reason for the relationship and the likely end result of that involvement.

Moss Muffins and Seaweed Soup

Questions

- Would you eat seaweeed? Why or why not?
- Which of the products do you think contain seaweed derivatives?

Introduction

Many kinds of seaweeds are edible and rich in vitamins and minerals and can be eaten directly. However, the most common uses for seaweed in North America are as stabilizers, thickeners, and colourants. Carrageenan is used to thicken and stabilize foods. Alginates (such as agar) make water-based products thicker, creamier, and more stable over time and temperature differences. Beta-carotene is used as a yellow-orange food colouring and multivitamin ingredient.

Procedure

Try to find the foods from the sample Food Products List and indicate which of the seaweed products are present. The sample Seaweed Information Sheet may be helpful.

SEAWEED INFORMATION SHEET

<table>
<tr><th colspan="2">Types</th><th colspan="2">Culture Use</th></tr>
<tr><th>Carrageenan</th><th>Alginates</th><th>Asian</th><th>Western</th></tr>
<tr>
<td>▪ Polysaccharide
▪ Extracted primarily from red algae species such as Irish Moss (Chrondrus crispus)
▪ Used as thickening and stabilizing agents in foods, pharmaceuticals, and cosmetics</td>
<td>▪ Polymers
▪ Extracted from brown algae species such as kelp (Laminaria sp.), rockweed (Fucus sp.) and knotweed (Ascophyllum sp.)
▪ Used in antacid preparations, in preparing dentistry molds, as a thickening agent in ice cream products and cosmetics</td>
<td>▪ Seaweeds correspond to many of the vegetables eaten in western cultures—nori and other seaweeds are often used as wraps for rice, vegetables, and fish</td>
<td>▪ Tend to use seaweeds only for the substances such as carrageenan and algin that can be extracted from them</td>
</tr>
<tr><th colspan="2">Growing Seaweeds</th><th colspan="2">Structure of Aquatic Plants</th></tr>
<tr>
<td colspan="2">▪ Relatively new concept in Canada
▪ Can be grown in open water, inland ponds, and even large indoor tanks</td>
<td colspan="2">▪ Different from that of terrestrial plants
▪ The flattened structures that resemble leaves are called blades</td>
</tr>
</table>

▪ Light is the most crucial component in the photosynthetic process. Different seaweed species grow more effectively at different depths due to the abundance or lack of light. ▪ Larger commercial seaweeds are usually classified in one of three phyla: the green chlorophytes such as sea lettuce, the red rhodophytes such as Irish moss, or the brown phaeophytes such as kelp and fucus ▪ There are concerns with natural herbivores such as periwinkles and sea urchins that feed on the seaweeds ▪ Irish Moss has been harvested in the Maritimes for many years, but more recently rockweeds and other species have gained interest	▪ The stem-like structures are called stipes ▪ The root-like structure at the base of the plant is termed a holdfast ▪ The blades, stipe, and holdfast comprise the body of the plant, called the thallus ▪ Some aquatic plants have little flotation bubbles called gas bladders that enable the plant to float in the sea water

Sample Food Products List

Product	**Carrageenan**	**Alginates**	**Beta-Carotene**	**Product**	**Carrageenan**	**Alginates**	**Beta-Carotene**
brownie mix				mayonnaise			
cheese				multivitamins			
chocolate milk				pen ink			
coffee cream				pet food			
cottage cheese				pudding			
egg substitute				relish			
evaporated milk				salad dressing			
fire extinguisher				shaving cream			
frozen foods				shoe polish			
frozen yogurt				sour cream			
gravy (canned)				toothpaste			
ice cream				whipped topping			
infant formula				whipping cream			
margarine				yogurt			

Moss Muffins and Seaweed Soup
Teacher Notes

Outcome

Students will be expected to

- identify, analyze, and evaluate various aquaculture business opportunities (AQUA-5)

Sample Results

SAMPLE FOOD PRODUCTS LIST

Product	**Carrageenan**	**Alginates**	**Beta-Carotene**	**Product**	**Carrageenan**	**Alginates**	**Beta-Carotene**
brownie mix		**X**		mayonnaise			**X**
cheese			**X**	multivitamins			**X**
chocolate milk	**X**			pen ink			
coffee cream	**X**			pet food			
cottage cheese	**X**			pudding	**X**		
egg substitute			**X**	relish	**X**	**X**	
evaporated milk	**X**			salad dressing		**X**	**X**
fire extinguisher				shaving cream			
frozen foods		**X**	**X**	shoe polish			
frozen yogurt	**X**			sour cream	**X**		
gravy (canned)	**X**	**X**		toothpaste	**X**		
ice cream	**X**		**X**	whipped topping	**X**		**X**
infant formula	**X**			whipping cream	**X**		
margarine			**X**	yogurt	**X**		

Follow-up Activity

Students might be asked to collect Irish moss, and the class could make Irish moss blancmange pudding.

IRISH MOSS BLANCMANGE

200 mL cup Irish moss

1 L water

500 mL tin evaporated milk

pinch salt

5 mL flavouring

Wash Irish moss thoroughly to remove sand, and soak for thirty minutes. Rinse the moss very well. Place the Irish moss and the litre of water in the top of a double boiler. Boil until thick. Strain out the moss, saving the liquid. Add milk, salt, and flavouring to the liquid. Pour into moulds to set.

Once set, serve with sugar and cream. Fruit may be added if desired.

Irish moss can be obtained at low tide off the Nova Scotia coast. It grows on rocks and ledges.

Where Do They Grow?

Questions

- Where are aquaculture businesses located in Nova Scotia?
- What types of aquaculture businesses are located here?

Introduction

There are many different aquacultural animals and plants farmed on and around Nova Scotian fresh, brackish, and marine waters. You will look for the specific locations where certain animals are farmed in Nova Scotia and try to draw some conclusions regarding why certain species are farmed in certain areas.

Materials

- Nova Scotia map
- coloured pencils

Procedure

From the data below of aquacultured species per county, you are to colour-code each species by constructing a key and then placing the species in the appropriate county.

Use a rectangle and the colour indicated to designate each of these species:

FINFISH

Colour	**Species**
light green	Atlantic salmon
yellow	Arctic char
orange	rainbow trout
dark green	speckled trout
red	American oyster

Use a triangle and the colour indicated to designate these species:

SHELLFISH

Colour	**Species**
black	American oysters
red	bay quahogs
blue	blue mussels
yellow	clams
purple	European oysters
light brown	sea scallops

Use a circle and the colour indicated to designate these species:

PLANTS

Colour	**Species**
purple	eel
orange	halibut
blue	Irish moss
light blue	sea cucumbers
green	sea parsley

Below you will find the organisms that are farmed in each county in the province. Please note that this information from Nova Scotia Department of Fisheries and Aquaculture and could and will possibly change as aquaculture becomes more productive. Also note that some of these farms are hobby farms and do not have major production occurring at their sites.

Organisms and Counties

County	**Organisms (as of February 16, 2007, Nova Scotia Department of Agriculture and Fisheries)**
Inverness	Atlantic salmon, American oysters, blue mussels, rainbow trout, sea scallops, speckled trout, Arctic char, brown trout
Victoria	Atlantic salmon, American oysters, blue mussels, rainbow trout, speckled trout, cocktail oyster
Cape Breton	American oysters, blue mussels

Richmond	American oysters, Arctic char, Atlantic salmon, blue mussels, rainbow trout, sea scallops, speckled trout
Guysborough	American oysters, Atlantic salmon, blue mussels, European oysters, sea scallops, bay quahog, surf clams, rainbow trout, brown trout, speckled trout
Halifax	Atlantic salmon, blue mussels, European oysters, rainbow trout, sea scallops
Lunenburg	American oysters, Atlantic salmon, blue mussels, European oysters, clams, rainbow trout, sea scallops, speckled trout, Atlantic cod, halibut
Queens	American oysters, European oyster, Atlantic salmon, rainbow trout
Shelburne	Atlantic salmon, blue mussels, European oysters, Irish moss, rainbow trout, sea cucumbers, sea parsley, cod, sea scallops, American oysters, Atlantic halibut, clams, bay quahogs
Yarmouth	American oysters, blue mussels, European oysters, sea scallops, halibut, rainbow trout, Atlantic salmon
Digby	Atlantic salmon, blue mussels, European oysters, halibut, rainbow trout, Arctic char, sea scallops, Atlantic cod, haddock, soft shell clams
Annapolis	American oysters, Atlantic salmon, European oysters, sea scallops, bay scallops
Kings	rainbow trout, speckled trout, Atlantic salmon, Arctic char
Hants	rainbow trout, halibut, sablefish
Colchester	American oysters, Arctic char, Atlantic salmon, bay quahogs, blue mussels, European oysters, rainbow trout, speckled trout
Cumberland	American oysters, Atlantic salmon, eel, rainbow trout, speckled trout, blue mussels, halibut, Atlantic char, Arctic char
Pictou	American oysters, Atlantic salmon, bay quahog, blue mussels, rainbow trout, speckled trout, surf clam, bay scallops, bar clam
Antigonish	American oysters

Construct a key that displays all the above animals each with a specific colour and shape. Then place each appropriate colour and shape beside each county in Nova Scotia. Also label each county on your map.

KEY:

[insert graphic: full page map of Nova Scotia with counties]

Analysis

Based on your completed map, propose an explanation regarding why aquaculture sites are or are not developed in particular areas.

Where Do They Grow?
Teacher Notes

Outcomes

Students will be expected to

- identify, and compare aquaculture—locations and species—grown in Nova Scotia, in the rest of Canada, and globally (AQUA-1)
- describe and identify groups of organisms raised through aquaculture and their geographic locations, referring to anatomy and physiology of a major species and ecology of cultured species (AQUA-2)

Background Information

Within the province of Nova Scotia, there are a significant number of aquaculture operations, most of which go unnoticed by the general public.

Information on all registered sites in the province is regularly updated by the Nova Scotia Department of Agriculture and Fisheries and is available on their website under “Aquaculture Site Mapping.”

As an alternative, pairs of students could be assigned a county and could map the various species farmed in that county, or each pair could map only one species for the whole province. The pairs could then report their findings to the class.

This exercise could be done as a class activity, grouping the students into three groups to put information on the map. A large map of Nova Scotia may be used.

The Business of Aquaculture

Questions

- Are there employment opportunities in aquaculture locally, nationally, and globally?
- What science- and technology-based careers are available in aquaculture?

Materials

- graph paper
- ruler
- pencil
- Internet access
- access to library database/CD-ROM

Procedure

Using the data contained in the table on the next page, construct a graph to indicate the change in the number of jobs in aquaculture from 1998 to 2008 for the following four divisions:

- finfish
- shellfish
- all others (Irish moss, dulse, etc.)
- total jobs

Plot all four lines on the same graph.

Analysis

1. What trends are there in the graph? Be specific.

2. What factors might account for declines or increases in employment from one year to the next?

3. Based on the graph, give evidence to support the growth of aquaculture as an industry. Is there one sector (finfish, shellfish, other) that appears more promising than the others? Explain your answer.

4. What careers are available in aquaculture?

5. What opportunities are there locally, nationally, and globally?

Follow-up Activity

Using the data from "Where Do They Grow?" and the Internet, determine the employment opportunities in aquaculture locally, nationally, and globally. Also find and describe two examples of science-based careers and two examples of technology-based careers related to aquaculture.

NS Aquaculture Employment Statistics (1998–2008)

Year	Employment Tenure	Finfish	Shellfish	Other	Total
1998	Full Time	141	199	43	383
	Part Time (less than six months)	131	289	70	490
	Part Time (more than six months)	200	95	7	302
	Sector Total	**472**	**583**	**120**	**1175**
1999	Full Time	223	190	31	444
	Part Time (less than six months)	145	286	73	504
	Part Time (more than six months)	54	83	19	156
	Sector Total	**422**	**559**	**123**	**1104**
2000	Full Time	178	155	28	361
	Part Time (less than six months)	140	311	62	503
	Part Time (more than six months)	29	153	12	194
	Sector Total	**347**	**619**	**102**	**1058**
2001	Full Time	152	150	15	317
	Part Time (less than six months)	213	353	4	570
	Part Time (more than six months)	42	158	8	208
	Sector Total	**407**	**661**	**27**	**1095**
2002	Full Time	109	93	21	223
	Part Time (less than six months)	94	383	29	506
	Part Time (more than six months)	46	176	38	260
	Sector Total	**249**	**652**	**88**	**989**

Year	Employment Tenure	Finfish	Shellfish	Other	Total
2003	Full Time	141	253	20	414
	Part Time (less than six months)	110	354	36	500
	Part Time (more than six months)	34	145	34	213
	Sector Total	**285**	**752**	**90**	**1127**
2004	Full Time	98	178	18	294
	Part Time (less than six months)	106	290	33	429
	Part Time (more than six months)	37	111	18	166
	Sector Total	**241**	**579**	**69**	**889**
2005	Full Time	93	158	20	271
	Part Time (less than six months)	89	313	0	402
	Part Time (more than six months)	22	138	56	216
	Sector Total	**204**	**609**	**76**	**889**
2006	Full Time	92	72	28	192
	Part Time (less than six months)	102	309	137	548
	Part Time (more than six months)	22	47	0	69
	Sector Total	**216**	**428**	**165**	**809**
2007	Full Time	109	161	22	292
	Part Time (less than six months)	69	250	2	321
	Part Time (more than six months)	29	50	49	128
	Sector Total	**207**	**461**	**73**	**741**
2008	Full Time	125	114	20	259
	Part Time (less than six months)	61	230	0	291
	Part Time (more than	23	67	60	80

Year	Employment Tenure	Finfish	Shellfish	Other	Total
	six months)				
	Sector Total	**209**	**411**	**80**	**700**
2009	Full Time	125	100	20	245
	Part Time (less than six months)	46	247	0	293
	Part Time (more than six months)	46	103	60	209
	Sector Total	**217**	**450**	**80**	**747**

The Business of Aquaculture
Teacher Notes

Outcome

Students will be expected to

- identify, analyze, and evaluate various aquaculture business opportunities (AQUA-5)

Background Information

Aquaculture is a growth industry for Nova Scotian entrepreneurs. This activity requires students to graph data and infer trends from that data. It also requires that they do research into national and global employment trends.

If computers are available, students could construct the graph using a spreadsheet program.

This activity could be expanded to include the contribution that aquaculture makes to the Nova Scotian economy (Aquaculture Production and Sales) and how this has changed from 1994 to 2000. This information is available at www.gov.ns.ca/fish/aquaculture/stats/. For instance, the total sales from aquaculture production in 2000 exceeded $50 million.

Aquaculture—A Global Perspective

Questions

- What countries in the world are involved in aquaculture?
- Which countries are the biggest players?
- How does Canada's involvement compare?
- What factors seem to be driving some countries to be more involved than others?

Procedure

1. You will have to use the Internet or other sources to find data from the Food and Agriculture Organization of the UN. If you have access to the Internet, try www.fao.org, then follow the links to Fisheries and Aquaculture > Aquaculture > Global Aquaculture Production (online query). The Fisheries Global Information System (FIGIS) contains data on global aquaculture production.

2. Record production data in tonnage for the top 10 countries for the most recent year covered. Be sure to include Canada even if it is not in the top 10.

3. Construct a bar graph or pie chart to display your findings, using graph paper. Again access United Nations or other data and construct a bar graph or pie chart showing the top 10 most populated countries in the world.

4. Answer the Aquaculture—A Global Perspective sheet on the following page.

Production Data

	Country	**Production**		**Country**	**Production**
1			6		
2			7		
3			8		
4			9		
5			10		

Aquaculture—A Global Perspective

Name:

QUESTIONS

- What countries in the world are involved in aquaculture?
- Which countries are the biggest players?
- How does Canada's involvement compare?
- What factors seem to be driving some countries to be more involved than others?

ANALYSIS OF DATA AND GRAPHS

1. Does there seem to be a relationship between the population of a country and it's involvement in aquaculture?	2. What do you think are the factors that determine a country's involvement in aquaculture?
3. What is Canada's contribution to the world aquaculture production totals?	4. Access to the ocean plays a major role in determining a country's ability to use aquaculture. How does Canada's coastline compare with that of the top two producers in the world?
5. Canada is a different country, in many ways, from the number one producing country. Given our extensive coastline, how might our comparative involvement be explained?	6. The population of the world continues to grow, which continues to put a strain on available food supplies. The traditional fisheries are in decline due to overfishing, as can be seen with our own cod fishery in the North Atlantic. In light of these trends, Canada may have to play a more significant role in aquaculture production. What are some of the problems the Canadian aquaculture industry must solve before it can increase its production?

FOR FURTHER INVESTIGATION

7. Compare data for the most recent year given to that from 10 years previous to that date. Use percentage to state the increase. Can you propose an explanation for this trend?	8. National aquaculture production data is given in tonnes as well as in market value in U.S. dollars. Do the numbers for tonnes correspond to the numbers in dollars? Which countries seem to have the greatest differences in the numbers? Can you think of any possible explanations?

Aquaculture—A Global Perspective
Teacher Notes

Outcome

Students will be expected to

- identify, and compare aquaculture—locations and species—grown in Nova Scotia, in the rest of Canada, and globally (AQUA-1)

Background Information

The Food and Agriculture Organization of the UN has reliable data that is continually updated, but it usually takes more than a year for the most recent year's data to be posted. Typing in the keyword FIGIS on a search engine will most likely get the student to the site most quickly.

China seems to be the world's largest producer at over three-quarters of the global share, with India second. The students should be able to recognize the demand due to population size. For example, Canada produced a fraction of 1 percent as of 2004, and most of the product was of higher-value species, whereas China and India produce species that are affordable to the masses. Students might speculate on why Canada does not exploit aquaculture as other countries may.

The Land and Sea video *Aquaculture* (V1806), available from Education Learning Resources and Technology Services portrays problems aquaculturists encounter here in the Maritimes when trying to set up operations. Many of the concerns vented by stakeholders in the video have since been researched and addressed, but it still gives an accurate feel for the fears some hold.

We have the luxury of "not obstructing the view" with aquaculture farms. Most government websites promote the economic benefits of aquaculture. Students might discuss the question, What might be said about the crucial role it will play in coming years in feeding the world? Students might like to debate the topic, Given Canada's extensive coastline, it will undoubtedly play a much larger role in the future.

Food Conversion Ratios (FCRs)

Questions

- What animals are the most efficient eaters? Are we using the most efficient animals as a source of protein?
- What do the "food" issue and aquaculture have in common?
- Is this agriculture?

Procedure

Food conversion ratios (FCR) give an indication of an animal's ability to convert mass of dry food into body mass. For instance, if an animal requires 2 kg of dry food to gain 1 kg of body mass it has a FCR of 2:1. Some animals are more efficient than others. Below is a table showing probable food and body masses of various food species. Calculate the FCR for each animal by dividing the mass of feed by the increase in body mass.

Food Conversion Ratios

Animal	**Kg of Feed Consumed**	**Kg Increase of Body Mass**	**Food Conversion Ratio (FCR)**
beef cattle	2500	496	
chicken	78	36	
pork	485	194	
salmon	346	339	

Analysis

<table>
<tr><td colspan="2">FOOD CONVERSION RATIO (FCR) CHART

Name:</td></tr>
<tr><td>1. Is an animal with a higher or lower ratio a more efficient feeder?</td><td>2. Which animal has the lowest FCR? Which has the highest FCR?</td></tr>
<tr><td>3. Which animals represent the highest prices in the grocery store?</td><td>4. Is there a correlation between the animal's FCR and its price as a food?</td></tr>
</table>

5. If a country was interested in feeding large numbers of people with limited resources, which organisms would be the better choices? Explain.	6. How do you think an FCR could be calculated for mussels? How would it rank on an FCR chart?

Extension

Research is being done on using soy protein in salmon feed instead of fish protein and oils. Investigate various sources to find out how this is affecting the FCR for salmon and how its trophic level would change.

Food Conversion Ratios (FCRs)

Teacher Notes

Outcome

Students will be expected to

- explain aquaculture-related issues (AQUA-6)

Background Information

Although data vary to some extent depending on the source, the FCRs that are calculated should be fairly realistic. Beef FCR values are usually 5:1 or higher. Pork is around 2.5:1, chicken is roughly 2:1, and salmon is 1 to 1. There is some question as to the accuracy of the ratios as feed is in dry kilograms and body mass is "wet," but the numbers are reliable enough to make comparisons.

Information to discuss could include

1. As the population grows, the stress on the soil, water, and other environmental factors will influence the trophic levels at which humans feed.

2. Protein source animals that require large amounts of feed to grow are, and will increasingly be, considered a luxury or an extravagance in many circumstances.

3. An awareness of our need to be ecologically responsible eaters should be paramount.

There is an Education for Sustainable Development (ESD) context that the students might explore in a variety of ways. Food, hunger, and sustainability of aquaculture (and agriculture) are important issues for discussion.

Water Quality in a Mini-System

Questions

- What conditions are necessary to maintain a healthy aquatic community?
- What types of measurements can be made to determine water quality?
- What are the variables used here?

Materials

- goldfish (feeders) and fish food
- clean gravel
- live aquatic plants
- goldfish bowl or small aquarium or large pickle jar
- aquarium test kits for ammonium, pH, nitrates, hardness or similar lab kits or probes
- thermometers
- aquarium vibration air pumps, tubing, and air stones

Background

A number of variables affect water quality and in turn affect the health of aquatic organisms. Aerobic organisms (oxygen breathers) require sufficient levels of oxygen. Currents, population densities, and temperature are a few of the factors that affect dissolved oxygen levels in the water. As organisms excrete wastes, a cycle of bacterial growth is set in motion that produces ammonia and then nitrates that, in higher levels, are harmful to some organisms. Most organisms have a healthy pH range in which they function, and the same can be said for temperature. Pollution, overfeeding, and other factors can move the pH into a danger zone. Severe weather conditions, either hot or cold, can spell disaster.

Procedure

This may be done in groups.

1. Conduct a series of tests over several weeks that will monitor an aspect of water quality. Given the list of materials above as well as any others you may want to add, devise and experiment to test one or more aspects of water quality. Make sure that is a controlled experiment.

2. The more trials done the more accurate your data will be. You may partner with another group.

3. Check your plan with the teacher before proceeding.

4. Testing should take place over a number of weeks or even months.

5. Construct a table to record your data and make observations on any changes in water quality and fish health.

Analysis

1. Over the course of the study, what conditions changed and how did they change?

2. Most negative changes to water quality can be traced back to problems with feeding, waste buildup, overcrowding, temperature, circulation, and bacterial cycles. Explain possible causes for the changes in your mini-system.

3. If you were to set up another mini-system, what could you do differently to improve the water quality?

<table>
<tr><td colspan="2">WATER QUALITY IN A MINI-SYSTEM

Name:</td></tr>
<tr><td>Variables:</td><td>Procedures: Checked by teacher</td></tr>
<tr><td colspan="2">Data Table:</td></tr>
<tr><td colspan="2">Analysis

1. Over the course of the study, what conditions changed and how did they change?

2. Most negative changes to water quality can be traced back to problems with feeding, waste buildup, overcrowding, temperature, circulation, and bacterial cycles. Explain possible causes for the changes in your mini-system.

3. If you were to set up another mini-system, what could you do differently to improve the water quality?</td></tr>
</table>

Water Quality in a Mini-System

Teacher Notes

Outcome

Students will be expected to

- describe, measure, and analyze conditions for aquaculture operations (AQUA-3)

Background Information

By trying to maintain a simple aquarium, the students should be able to gain an appreciation for the water quality complexities involved in aquaculture. The experiment could be an extension of an experiment done for the Marine Biome unit and might be as simple as a pickle jar aquarium to a full-blown reef tank.

Pickle jars can be obtained from restaurants and cafeterias, although plastic is becoming more prevalent. Large plastic juice bottles are also useful.

Feeder goldfish are very inexpensive. They are sold by some pet stores as a live food for larger carnivorous pet fish.

Small test kits can also be obtained from pet stores to test pH, hardness, ammonia, and nitrates. Most scientific supply companies also carry a wide array of test kits including dissolved oxygen.

Some of the variables the students may manipulate are placement of their system in relation to natural light and heat, use of an air stone, frequency of water changes, whether or not to use live plants, amount and type of food, and population density of fish. They will likely come up with more variable ideas as they brainstorm and create strategies. The breathing rate of the fish could be recorded by watching the operculum (gill covering). General activity could be recorded, but this tends to be a bit more subjective.

Design a rubric with the students so that they know how they will be assessed.

Aquaculture Entrepreneur Game

Questions

- What are the steps involved in starting up an aquaculture business? What types of decisions must be made along the way?
- What are some of the factors that could affect the business in both positive and negative ways?
- What careers are involved?

Materials

- sheet of bristol board, large piece of cardboard or similar game board material
- pair of dice
- game pieces of your design or choice
- play money of your design or choice
- business card stock for chance cards (optional)

Procedure

Choose 1 or 2.

1. Develop your own game and exchange games with each other.

2. For this game you will be given a basic outline with rules and some suggestions to get you started. Then you must develop the board, the playing pieces, and three chance cards for each stage of the game to go along with the chance cards already suggested. After playing the game, you may want to make changes to the rules to promote smoother play.

Sample Basic Rules

1. Each player or team must make progress around the various stages of board.

2. The first player to finish wins a $100,000 bonus, the second a $50,000 bonus and the third a $25,000 bonus.

3. The player with the most profit at the end wins.

4. Players roll the dice in turn to advance around the board to each stage. You do not have to roll an exact number to enter a stage.

5. Once you reach a stage, you must draw a chance card.

6. To move off a stage and continue, you must roll a double. After the third try, you move anyway.

7. Players may choose salmon, mussels, or seaweed to farm. Checking the numbers below may aid in coming to a decision on a species.

8. **Financing:** You may borrow different amounts of money, which will be paid back to the bank with interest after you have marketed your product. You may borrow $200,000 @ 7 % interest, $400,000 @ 8 % interest, $700,000 @ 9 % interest, or $1 million @ 10 % interest. One million dollars is the maximum you can borrow.

9. **Start up costs:** It will cost $200,000 to set up each salmon cage, $100,000 to set up each 1 ha mussel farm, and $50 for each 1 ha seaweed farm.

10. **Growing to market costs:** It will cost $150,000 per salmon cage due to the cost of feed and other expenses to grow your salmon to market size. Mussel farms will cost $25,000 to maintain, as no food is required. Seaweed farms will cost only $5,000 as very little maintenance is required. Species actually take different lengths of time to mature, but for simplicity of the game, the costs will represent costs to grow to market size regardless of time.

11. **Marketing your Product:** Gross profit is the amount you make before your expenses are paid. You will calculate your net (the money that is yours to keep) after you pay start-up, operating, and marketing costs. Salmon cages will gross $500,000 each. A mussel farm will gross $200,000 per hectare, and a seaweed farm will gross $100,000 per hectare.

12. Chance cards obtained along the way may change any of the above numbers.

STAGES

Each stage should be clearly labelled and be a larger block on your game board, as several pieces are likely to be there at a time. You may design any number of smaller spaces, as well as side paths, between the stages.

The stages are

- Market analysis and plan
- Site approval
- Getting financing
- Start-up
- Growing to market size
- Marketing your product

Chance Cards

A number of chance cards are provided on the following pages, which you may use to generate ideas for your own chance cards. You must develop three chance cards for each stage, as players must draw a chance card each time they land on a stage. Try to balance positive chances with negative chances. A chance card should not try to bankrupt a player in one play. You will need to do a bit of research to develop accurate chance cards. Some chance cards will only apply to certain species being farmed. If it doesn’t affect you, place it on the bottom of the pile and continue play.

Analysis

The game can be played several times to represent several growth cycles. Profits could be carried over so as to build the business. When the game is finished you should evaluate the decisions you made, note any decisions you think were unwise, and explain why. Make suggestions on how you might increase your profits in a future game.

Chance Cards

Market Analysis and Plan Markets are opening up in Asia for top quality seaweeds that can be grown in your area.	**Market Analysis and Plan** Many new salmon farms have opened up in South America and are dumping product on the market, selling at a slightly lower price than the Canadian prices.
Site Approval The Minister of Economic Development is trying to create more jobs in your area. Your application has been "fast tracked." Proceed directly to the next stage.	**Site Approval** The site you have chosen is environmentally sensitive. The Department of the Environment must do an assessment. Miss a turn.
Site Approval Your application to the government for a site licence is missing data for your financial plan. The application must be completed and sent back in. Miss a turn.	**Getting Financing** The government has offered you a grant of $50,000 to help get your business started. This is a grant and does not need to be paid back.
Start Up A supplier is having a sale on materials to build salmon cages. Your costs per cage will be reduced from $200,000 to $150,000 per cage.	**Getting Financing** The Department of Economic Development is promoting new businesses in your area and is offering loans at 2 % lower than the banks. You will save 2 % when paying your loan.

Start Up A supplier is having a sale on materials to set up mussel farms. Your costs per hectare will be reduced from $100,000 to $75,000.	**Growing to Market Size** Your salmon farm has developed a problem with lice. You must pay the vet to treat the problem. The cost is $10,000 per cage.
Growing to Market Size A very bad storm has torn some of your mussel socks from their buoys. You must hire divers to salvage the socks from the bottom and reattach them. Cost $10,000 per hectare.	**Growing to Market Size** An extremely cold winter has caused high mortality in your salmon stock. Your final profit will be reduced by 25 %.
Growing to Market Size Seals have chewed through the netting of your cages and eaten some of your salmon and some of your fish have escaped. Cost $10,000 per cage.	**Marketing Your Product** Because salmon is high in omega-3 fatty acids, the health food industry has become more interested. Your salmon farms are now grossing $600,000 per cage.
Marketing Your Product Someone has died of toxic shock from eating mussels contaminated by a red tide. The media have been covering the story, people are nervous. Your gross price has dropped to $150,000 per hectare.	**Marketing Your Product** Japan has found a new use for the seaweed ascophyllum and are paying a better than average price for it. Your gross will increase to $125,000 per hectare.

Aquaculture Entrepreneur Game
Teacher Notes

Outcome

Students will be expected to

- analyze site planning from various perspectives and report on both the risks and benefits to society and the environment (AQUA-4)

Background

Brainstorming and research will be necessary for students to develop good chance cards. As the game is played, changes can be made to fine tune the variables. The activity should enable students to discover some of the complexities involved in operating an aquaculture business.

Fisheries

Introduction

This module explores the marine fishing industry. Students will begin by developing a basic understanding of fisheries, fisheries management theory, and the current status of the world's fish stocks, with particular emphasis on those in Atlantic Canada. Students will examine management strategies for the future so they can discuss fish populations.

Materials List

- dissecting kit
- dissecting microscope
- dissecting tray
- fish with large scales (bass, perch, haddock)
- forceps
- glass slides
- kidney beans, dry, 2 L
- lab gloves
- lab aprons or coats
- lentils, dry, 1 L
- lima beans, dry, 2 L
- pinto beans, dry, 4 L
- plastic netting with 3/4", 1/2", 1/4", and 1/8" holes (clementine boxes are covered with 1/8"; other sizes could be adapted by cutting bigger holes in 1/4" onion bags)
- rectangular container roughly 30 cm × 15 cm × 12 cm (12" × 6" × 5")
- ruler
- safety glasses
- scalpel

Commercial Fishery Project

Questions

- What is needed for a fishery that is sustainable?
- How is the fishery a local and global resource?
- What are the relationships among food, sustainability, health, fisheries, oceans, and distribution?

Procedure

As a class, develop a rubric for this project.

In a small group, select a commercial fishery. Prepare a display describing this fishery. Your presentation should include illustrations, photographs, and/or video clips. You can also include a written description, and real equipment or resources from the fishery. Your project will be presented to your peers at the end of the module. Your presentation can be in the form of display and explanation, slide presentation, video presentation, or a combination of your own choosing.

Topics that can be covered in your presentation include

- the resource species— its distribution, general biology, behaviour and population dynamics
- the ecosystem that supports the resource, food types, predators, and habitat
- the fishery—its past history of catches, season, and fishing grounds
- technology of the fishery—boats, gear, electronics, fishing techniques, where the boats and gear are built
- community foundations—locations of the fishing ports, where the fishermen live, urban or rural settings, what role this fishery plays in their community
- markets—products made from the catch, where it is processed, where it is sold, how it is transported, who works in the processing plants, who gets most of the jobs and money
- possible issues to the resource—overfishing, pollution, global changes, etc.
- possible issues to the fishery—market problems, transportation problems, management problems, conflicts with other groups of fishers
- management—the major management controls on this fishery, who makes the management decisions, what involvement fishers or other people in the industry have
- current issues in this fishery and in its management

Your presentation can include

- display of fresh specimens of the fish (on ice)
- display of products made
- interviews with fishers involved in the fishery
- interviews with older fishers to examine the history of the fishery

There are many sources available, including the local media, Department of Fisheries and Ocean's *Stock Status Reports* and *Underwater World* fact sheets, the Internet, and local contacts with people involved in the fisheries. Be sure to include a reference list for your sources.

Commercial Fishery Project
Teacher Notes

Outcome

Students will be expected to

- explain the importance of a sustainable fishery as a resource to global and local food supply and employment with reference to terminology (FISH-1)

Background Information

Each group should cover a different topic.

Groups should provide a handout and an activity as part of their presentation to help teach their topic to the class.

Three to five classes would allow groups to thoroughly research, prepare, and present.

Students may need two classes to start their projects. Their topics should be verified by the teacher. Students will decide who will do what and decide their method of presentation. A time line should be developed.

Aging Fish

Questions

- How is the age of a fish determined?
- Why is this technique important to fishery management?

Materials

- a fish with large scales (bass, perch or haddock)
- scalpel to separate scales from fish
- dissecting microscope 20–40 X or compound microscope 10–100 X
- glass slide
- paper and pencil
- forceps (tweezers)
- ruler
- hand lens (optional)
- measuring tape

Background Information

Fishery scientists must obtain accurate age data to determine the age composition of a population. The density of different age groups will indicate that the population is increasing, decreasing, or stable. It will also indicate whether a reasonable number of individuals are reaching reproductive age. Age data also allow scientists to make growth comparisons for each year class as well as their growth rates. Data can indicate changes in the environment such as food availability, pollution, and temperature. Age data allow the scientist to construct a model of the population and enable proper decisions in managing the stock.

Growth rings on fish scales are indicative of growing seasons. Growth is generally more rapid during the summer months, leaving wider, lighter growth areas in the scales, with a darker tighter band being laid down during the winter months. A darker ring is called the annulus and indicates the end of one year of growth. This is very similar to rings in a tree trunk. Scale rings can be observed using a dissecting microscope or a hand lens.

There are two types of scales—ctenoid (scale with small sharp spines) and cycloid (scale without spines).

Ctenoid Scale Cycloid Scale

[insert graphics for ctenoid and cycloid scales]; [Photos to be added with final publication.]

Procedure

1. Choose a fish from the specimens available. Determine its length with the measuring tape. Record the length. _____

2. Remove one scale from your specimen by using a scalpel to lift a scale from the body and then remove the scale with the help of the forceps. The scales stick together, so make sure you only have one scale. Make a wet mount of the scale.

3. Sketch your scale and note the magnification of your sketch.

4. Determine the distance between annuli (plural for annulus) on your scale by using the ruler. Determine the age of this fish by counting the number of annuli present on the scale. _____

5. Record the length and age of your fish in the chart your teacher has drawn on the board. Be sure to copy the results of all the groups.

AGING FISH

Name:

QUESTIONS

- How is the age of a fish determined?
- Why is this technique important to fishery management?

DATA TABLE

GRAPH

Attach your graph analysis.

ANALYSIS

1. Using the data table you completed in the experiment, draw a graph to determine whether there is a correlation between age and length. Plot "Age of Fish" on the *x*-axis and "Length of Fish (cm)" on the *y*-axis. Be sure to label the axes and give the graph a descriptive title.

2. Based on your completed graph, state whether you believe there is a correlation between age and length of fish. Explain your answer by referring to the data illustrated on your graph.

3. Could data on the length frequency be used to interpret management of a fish population? Explain.

Aging Fish
Teacher Notes

Outcome

Students will be expected to

- describe, identify, and analyze the external and internal anatomy of a major finfish or shellfish species that is part of the commercial fishery (FISH-2)

Background Information

This activity is designed to introduce students to one of the essential tasks of the fisheries biologist. The age of fish caught from the wild is often the most important information available for the study of fish populations, and the necessary data are usually gathered by the methods introduced here.

Various species of fish can be obtained from larger grocery stores and fish markets. If possible, obtain a variety of sizes and species of fish with large scales.

Fisheries Terminology

Questions

- What terms are needed to understand the fisheries?
- What do some of them mean?

Procedure

Part 1: Divide the terms among the students. For the terms below, complete the chart. Put the term to be defined in the middle circle. Find a definition.

ortholith	recruitment	purse seine
fish	fishery	gillnet
otter trawling	fisheries management	longlining
shellfish	aquaculture	bycatch
fishery resources	mariculture	biomass
groundfish	fish ranching	stock
stock	dragging	maximum sustainable yield
pelagic	year class	target catch
fisheries dynamics	overfishing	

Part 2: Make a collage of various issues in the fisheries industry.

[insert graphic: Frayer-Fisheries Terminology 2.eps]

Fisheries Terminology

[insert x2: Frayer-Fisheries Terminology 2.eps]

Fisheries Terminology
Teacher Notes

Outcome

Students will be expected to

- explain the importance of a sustainable fishery as a resource to global and local food supply and employment with reference to terminology (FISH-1)

Background Information

This activity would be a good way to introduce the Fisheries unit, as it would familiarize students with some of the terminology associated with the fishery. This could be done in a variety of ways. Using various graphic organizers or groupings may be helpful so that students can become familiar with the terms. Students could complete this activity in groups and share results.

Procedure

Have students decide how the terms are connected. In groups, this can be discussed and simple charts might be used for presentations. All students should become familiar with the connections among the terms.

Sample Results

Glossary for Teachers

aquaculture: the farming and nurturing of an aquatic organism in fresh water or sea water to a mature size to be harvested for market.

biomass: the total living weight of a species in a specific area or region.

bycatch: any other species of fish that are caught in addition to the target catch.

dragging: a fishing technology in which a large net is towed to remove fish from the ocean floor.

fish: a very broad range of the marine species including both finfish and invertebrates that can be exploited by humans.

fish ranching: the capturing and nurturing of wild fish until they are ready for market or release into the wild.

fisheries dynamics: a quantitative study of the changing size and nature of fisheries systems as a whole.

fisheries management: intervention by a governing body to try to maintain the fish resources at levels that will best meet the needs of humanity over the long term.

fishery: a human system designed to extract particular fish from the water.

fishery resources: all the different species of marine fish found in the ocean.

gillnet: a fishing technology that captures fish by using a large net suspended just below the surface of the open ocean.

groundfish: species of fish that reside on the ocean floor for the majority of their lives.

longlining: a fishing technology used to catch fish by placing a long line of baited hooks on the ocean floor or in the water column, attached to a marker.

mariculture: the nurturing of any marine organism through part or all of its life cycle.

maximum sustainable yield: the maximum amount of fish of a specific species that can be caught without impairing the future population of that species.

ortholith: a structure found in the anterior part of a finfish that is used for hearing and balance.

otter trawling: a fishing technology in which a large net is towed to remove fish from the pelagic region of the ocean.

overfishing: fishing hard enough to exceed the maximum sustainable yield.

pelagic: refers to fish found in open waters well above the sea floor.

purse seine: a fishing technology close to the shoreline that captures fish in a circular device so they can be removed.

recruitment: the number of fish that join a particular population of a species during a season.

shellfish: any marine species that has a shell or valve covering part or all of it's body (e.g., lobster, mussel, clam, scallop, periwinkle).

stock: a separate population of the same species; a distinct population of a commercially harvested species of fish.

target catch: the specific species that fishers are trying to catch.

year class: fish in a stock spawned during the same year.

Fishing Technology

Questions

- What types of technology are used in the fishing industry?
- What risks and benefits do these technologies hold for society and the environment? Do all stakeholders feel the same way about the risks and benefits?
- What influence has society had on the development of fisheries technologies?

Procedure

1. Read the passage, "Fishing Technology."

2. In groups, choose one of the following technologies to investigate:

- trawl net
- scallop dredge
- seine net
- longline
- traps and pots
- gillnet

Use the Internet, newspaper, books, and magazines to answer these questions:

- How does this technology work?
- What is the target catch for this technology?
- How has society influenced the development of this technology?

a. What are the risks and benefits involved in the use of this technology?

b. What are the risks and benefits to society and the environment?

c. Do all parties (fishers, governmental agencies, conservation groups) agree on what the risks and benefits are?

d. How could the risks from this technology be minimized?

e. What impact has this technology had on the fishery up to now?

f. What impact would minimizing these risks have on the fishery in the future?

Include all source information, using an appropriate documentation style decided on in class. Interviews with local fishers must also be documented by giving the name of the person along with the date and place of the interview. It is important to indicate where your information came from. (Copyright violation and plagiarism are illegal.)

Once you have acquired the necessary information, prepare a presentation of this information for the class. Your presentation can be a traditional one involving handouts and overheads, a slide show presentation, a video, or a role-play simulation.

Fishing Technology

All the Nova Scotian fisheries, including the ones using small boats, are becoming more technically advanced. New developments such as satellite navigation and advanced echo sounders allow fishers to quickly and reliably find the best fishing spots. More powerful engines let them get to the grounds and back faster. We know that many of our fish resources are already under pressure. Some species have been under pressure for centuries and still are, others for decades, and some for years.

Most fishermen use one type of gear on their vessels. Some captains may switch their gear. New technologies being used are for specific gear, and owners do not need to modify their vessels but only change or add an accessory to their gear.

Through the years people have captured fish from the ocean in numerous ways. More efficient fishing vessels and gear are always evolving in the quest to catch more fish in less time. Scientists, engineers, fishers, and gear technologists are working together to create more-selective fishing gear in hopes of decreasing the number of bycatch species and increasing the target catch. Technology such as different mesh shapes and sizes, deflectors, larger hooks, Nordmore grates, and twin trawls are now being used as selective technologies to solve the bycatch problem. All of these technologies and those yet to be invented are going to reduce the overall impact of fishing in the North Atlantic.

There are two basic types of fishing gear: mobile and static. Mobile, or moving gear, includes trawl nets, scallop dredges, and seine nets. Static, or still gear, includes gillnets, longlines, and pots and traps.

Fishing technology has been rapidly evolving. Newer technologies have enabled fishers to work more efficiently and safely. This has reduced physical strain and the time required to accomplish the same work. It could be argued that the technology is *too* efficient in many cases: technology enabled factory trawlers to catch fish so efficiently that many stocks are now endangered and certain fisheries closed. Mesh size has been somewhat effective in reducing the number of immature fish taken but does not discriminate between species taken.

There are strict quotas on certain species and a ban on others. When fishers catch their quota of one species, they are fined if they land any additional fish of that species. Fishers may still be open to catch other species and so continue to fish, but current fishing technologies do not readily discriminate one species from another. While fishing for remaining legal quota fish, additional fish of the “over-the-limit” species are still caught and must be thrown back into the ocean, in most cases dead.

There are many perspectives and passionate opinions when fishing technologies are considered in the context of the environment, fishing efficiency, safety, sustainability of stocks and livelihoods.

Fishing Technology
Teacher Notes

Outcome

Students will be expected to

- compare the risks and benefits to society and the environment of applying scientific knowledge or introducing a technology to the fisheries (FISH-5)

Background Information

Students should be encouraged to present their information in a variety of formats, including interviews, role-plays, panel discussions, video productions, journalistic exposés, and court trials. A rubric should be developed with the class.

Mesh—What Size Should We Use?

Questions

- What effect does regulated mesh size have on fisheries resources?
- What effect does mesh size have on catch composition?

Introduction

Many of the fishing vessels of the North Atlantic are trawlers. You are going to operate a trawler and use trawling techniques to understand the impact this has on the species composition of fishing grounds. During the trial hauls, each group member will take a turn as captain.

Your fishing grounds (container of beans) are composed of various fish (different types of beans). There are skates, spiny dogfish, yellowtail flounder, and cod. Most fish are edible, but only certain species have a market that makes them valuable to keep. Fish other than the target catch are called bycatch and are discarded at sea. Your group has to develop a strategy for maximizing your profit.

Important information:

- Groundfish (cod and yellowtail flounder) are the most profitable for fishers. They are the target catch.
- At the moment, there are no buyers for dogfish or skates. These species are **bycatch**; they will be discarded (thrown back in) when caught.
- Undersized cod cannot be kept. When juvenile cod are caught, they die from stress and need to be removed (until your final trawl is completed). Take them out of the container.

Materials

- one rectangular container (30 cm × 15 cm × 12 cm) (container of various beans)
- fishing ground
- three data forms
- four fishing nets with various mesh sizes (15 cm × 10 cm)
- lima beans, dry, 2 L
- pinto beans, dry, 4 L
- kidney beans, dry, 2 L
- black beans, dry, 1 L
- lentils, dry, 1 L

Procedure

1. Form groups of five to six students.

2. Make a practice run. Use two hands to pull the net across the “fishing grounds” and lift the catch out of the “ocean.” Experiment with all four mesh sizes. Return all “fish” back to the “fishing grounds” after each haul. Decide, as a group, the mesh size that you will use for the rest of this fishing trip.

3. Designate a captain, a first mate (to fish) and an observer (to record catch composition) and crew members (to assist in the sorting of the catch). Choose a mesh size. Make your first haul. Count and record the data in a table. Remember to set aside the undersized cod.

4. Is there a way to calculate the total numbers of your catch without counting all the individuals? You do need to have an estimated number for each species but you do not need to sort all species. Could you take half of your catch, count it, and extrapolate the total catch? Try it and see how accurate you were.

5. Complete two more hauls and record the data. Try to extrapolate numbers of individual species. If there are only a few of one species, count all of that species to get an accurate count. Examine the fishing grounds. Is there any noticeable change to the composition of fish found there?

6. Calculate the total of each species for the entire trip (all three hauls). Present your total catch of each species to your peers.

Analysis

MESH—WHAT SIZE SHOULD WE USE? Name:
1. Which group caught the most marketable species and made the most profit?
2. What mesh size did they use?
3. Did you change your fishing technique during the activity? Why or why not?
4. How does the mesh size your vessel selected affect the catch composition and the fishing grounds itself?
5. What effects would your fishing have on this fishing ground over time?
6. What would your profit look like if you could only use the largest mesh size? the smallest mesh size?
7. The amount of fish that can be taken from a fishing region without reducing the stock's total biomass is called the maximum sustainable yield. If you were placed on a fisher's association, what size mesh would you recommend trawlers use?

8. Colour-code your catch data and, on a line graph, place the total number of individual species caught per catch, and the total number of individual species caught during the entire trip. Place the four species on the *x*-axis and the total number caught on the *y*-axis.
9. Does changing your mesh size represent a scientific or a technological solution to a problem? Explain your answer by including definitions of **science** and **technology**.
10. How might society influence the design of fishing technology?
11. What scientific understanding may have led to the development of fishery technologies?

Mesh—What Size Should We Use?
Teacher Notes

Outcome

Students will be expected to

- compare the risks and benefits to society and the environment of applying scientific knowledge or introducing a technology to the fisheries (FISH-5)

Background Information

All of the pieces of mesh should be 15 cm × 10 cm. Use various mesh sizes. You can reinforce the sides of the nets with pipe cleaners.

The plastic netting used as onion bags in grocery stores is sometimes useful and can be modified.

The fish will be dry beans of the following types:

- lima beans
- pinto beans
- kidney beans
- black beans
- lentils

Each group gets a “fishing grounds” containing the following mixture:

- 250 mL of lima beans (skate)
- 500 mL of pinto beans (cod)
- 250 mL of kidney beans (dogfish)
- 125 mL of black beans (yellowtail flounder)
- 125 mL of lentils (juvenile cod)

Have students consult their notes on Fishing Technology to help complete this activity.

What Is the Fishery All About?

Questions

- What is a fishery?
- What are the major divisions within the fishery?
- What type of fishing technology makes up each of these divisions?
- Which division removes the greatest amount of fish?
- What are the fishery resources? List as many of these resources as you can.
- What is fishery management? Who is managing the fisheries?
- Are the managers doing a good job?
- What types of quotas can a fishery have?
- Which type of quota is better? Why?
- Who is at fault for the present state of the fishery? Why?
- Who should be involved in managing the fishery for the future? Why?

Materials

various videos, other resources, and guest speakers

Procedure

If using a video such as the *Land and Sea: Fisheries Futures* and *1st Edition: Fishermen's Panel*, be prepared to discuss answers to the questions as well as opinions about the present state and future of the fisheries during the class discussion that will follow the video.

What Is the Fishery All About?
Teacher Notes

Outcome

Students will be expected to

- identify, describe, and analyze multiple perspectives of the main organizations in research and decision making in fisheries management in Canada (FISH-6)

Background Information

Fisheries Futures (V1728) is an episode of *Land and Sea*. Host Peter Verner presents opposing views on the ownership and management of the fishery. Who owns the fish on the Scotian shelf? What is the future of Nova Scotia's fishing industry? The competitive quota system denotes common ownership of the fishery. The area can be fished until the season's quota is reached. Will individual quotas lead to concentration of the fishery in the hands of a few powerful owner/processors?

Fishermen's Panel (V1554) is from an episode of *1st Edition*. Host Jim Nunn talks to fishermen concerning the state of the east coast fishery. Panelists are longline fishermen Derek Jones, Randy Baker, Cameron MacKenzie, and Nobel Smith and dragger fishermen Ken Taylor and Brian Giroux. There are too few fish and too many fishermen. Some Nova Scotians argue that it is time to change the way we fish and want to replace big trawlers and draggers with the more environmentally friendly fishing practice of hook and line. The panel of six fishermen debate the idea.

Both of these videos are available through Education Media Library (see Appendix B, *Oceans 11*).

Anatomy

Questions

- What are the anatomical features of the fish?
- What comparisons can be made between cod anatomy and that of other marine organisms you have dissected?

Materials

- small cod (about 50 cm long)
- dissecting tools
- dissecting tray
- plastic gloves
- plastic apron
- magnifying glass or dissecting microscope

Procedure

Use the diagrams on the next two pages to help you examine the external and internal anatomy of cod. Other fish may be substituted (perch, pollock)

Oberve the following:

- overall shape of the fish: hard, bony head leading to streamlined body
- mouth structure: when the mouth is opened, it produces a large space inside, which allows for sucking in food
- gills under their covers
- eyes, nostrils near tip of snout, barbel below, sensory “lateral line” running down the flank
- scales: remove one, examine it, particularly the growth rings (like those in a tree trunk)
- fins: three dorsal fins, two anal, caudal, pair of pectoral and pair of ventral fins. Note that the fins are supported by rays.

Find the vent, just ahead of the foremost anal fin. Insert the tip of a scalpel there and cut forward along the mid-line until reaching bone. Opening the body cavity should reveal:

- stomach and intestine
- liver
- gonads (ovaries or testes)
- swim bladder
- heart (close to the gills so that it can pump blood through them)

Take a larger knife and cut the fish in half down the mid line, from just behind the head back to the tail. The idea is to expose the backbone and ribs, removing all of the overlying flesh on one side.

You should observe

- the arrangement of vertebrae in the backbone
- the sequence of bones linking the vertebrae with the rays in the fins
- that all of the bones behind the head are in the mid-line of the fish, except for some ribs that curve around the body cavity
- that most of the fish behind its head is just muscle and bone, with the other organs tucked into the body cavity (It is mostly this muscle that people eat.)

Anatomy of a Fish

[insert drawings/diagrams of cod]

Anatomy
Teacher Notes

Outcome

Students will be expected to

- describe, identify, and analyze the external and internal anatomy of a major finfish or shellfish species that is part of the commercial fishery (FISH-2)

Background Information

If a fish dissection was done in the Marine Biome unit, this experiment could be omitted. Fresh or frozen specimens are required for this experiment; fresh specimens are preferred. Cod works well, but haddock or pollock could be used. Frozen specimens should be thawed under cold running water. Because cod are endangered in some areas, it may be prudent to substitute preserved perch ordered from a scientific supply company.

Gadus morhua is the scientific name for the Atlantic cod. Once plentiful on the east coast of Canada, the Atlantic cod is now generally listed as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) although it ranges from lower risk to critically endangered in specific areas. Atlantic cod are characterized by three dorsal fins, two anal fins, a very slightly forked tail, a large mouth, and a barbel or fleshy whisker on its chin. Average weight is 3–4 kg; they can weigh up to 30 kg. Cod are groundfish. They usually stick close to the bottom of the ocean and spend the winter at depths of 200–600 metres. They migrate to shallower banks and coastal waters in the summer. The cod fishery has a long history dating back to the 1500s when European fishers first visited the coastal waters of Atlantic Canada to fish. A moratorium was placed on the cod fishery in 1994 due to overfishing and a severe depletion of the stock. After more than ten years, the stock has still not made any significant comeback and the Atlantic cod fishery remains closed.

More information on the Atlantic cod can be found on the Department of Fisheries and Oceans website http://www.dfo-mpo.gc.ca/index-eng.htm. Follow the links **Aquatic Species** > **Underwater World** > **Atlantic Cod**.

Follow-up Activity

Students might try a dish containing cod. One possibility is to make fish cakes.

OLD FASHIONED FISH CAKES

0.45 kg (1 lb.) fresh or dried fish (species of choice)

4 medium white potatoes

1 medium onion

2 eggs

salt and pepper to taste

Boil fish until tender and flaky. Crumble in medium bowl, let cool. Boil potatoes and mash. Chop onion fine and add to fish. Add all other ingredients; mix thoroughly. Form into cakes and fry in hot oil until golden brown.

Makes 8 cakes.

Extension

Students might conduct research to identify the major finfish and shellfish species that are part of the commercial fishery. *The Sable Gully* CD contains statistics on species caught in the fisheries (see Appendix C, *Oceans 11*)

Length/Frequency/Age Relationships

Questions

- Are fish of a certain age always the same length, or does the length vary? Explain.
- What factors might affect the length of a fish for a certain age?

Materials

- five different colours of construction paper, straws, or plastic strings
- plastic container
- ruler

Procedure

1. Length/Frequency/Age Histograms

In this activity, fish of different ages are represented by different colours of construction paper. For example, one-year olds may be green, two-year olds blue, etc. Your teacher will list the colours that represent each age. You must catch a sample of fish (roughly 50 or more) from the ocean, then measure and record the data in a table. From the data collected, construct a series of length histograms for each age. (Grab a handful of fish from the ocean. Tabulate the data.)

2. Mean Length vs. Age Graph

Calculate the mean length for each age and draw a graph with age on the *x*-axis and mean length on the *y*-axis. Make sure to properly label the graph and include appropriate scales with units for each axis.

Analysis

Length/Frequency/Age Relationships Name:	
1.	Did certain lengths show up more frequently for certain ages?
2.	What factors might cause two five-year-old fish to be different lengths?
3.	In analyzing mean length versus age, did the population generally increase in size with age?
4.	If these data were recorded for a number of years, what types of changes in the graph might cause

a fisheries biologist to be concerned, and why?			
SAMPLE DATA TABLE			
1st Year Red	2nd Year Green	3rd Year Yellow	4th Year

Length/Frequency/Age Relationships
Teacher Notes

Outcome

Students will be expected to

- compile and organize fish population data and explain the dynamic interrelationships among the physical environment, the biological environment, and the health and distribution of a fish stock (FISH-4)

Background Information

Five different colours of paper are required for each year-class of fish from one to five years. Use one colour to represent each class of fish. The coloured strips should be cut to length as follows:

first year-class	20—1 cm strips 60—1.5 cm strips	red red
second year-class	10—1.5 cm strips 45—2 cm strips 15—2.5 cm strips	green
third year-class	7—2.5 cm strips 50—3 cm strips 23—3.5 cm strips	yellow
fourth year-class	22—3.5 cm strips 40—4 cm strips 18—4.5 cm strips	blue
fifth year-class	35—4.5 cm strips 40—5 cm strips 5—5.5 cm strips	white

Make multiples of these quantities if you need more fish. Masters are found on the following pages.

Size of Fish Stock

First-Year Class

[insert graphics for fish stocks]

[**Note to Teachers:** Please see the Microsoft Publisher file for Fish Stocks on the teacher password-protected site for the graphics for these pages. The files will be included in the final publication.]

60–1.5 cm strips: red

20–1 cm strips: red

Size of Fish Stock

SECOND-YEAR CLASS

[insert graphics for fish stocks]

10–1.5 cm strips: green

45–2 cm strips: green

15–2.5 cm strips: green

Size of Fish Stock

THIRD-YEAR CLASS

[insert graphics for fish stocks]

7–2.5 cm strips: yellow

23–3.5 cm strips: yellow

50–3 cm strips: yellow

Size of Fish Stock

Fourth-Year Class

[insert graphics for fish stocks]

22–3.5 cm strips: blue

18–4.5 cm strips: blue

40–4 cm strips: blue

Size of Fish Stock

FIFTH-YEAR CLASS

[insert graphics for fish stocks]

35–4.5 cm strips: white

35–5 cm strips: white

5–5.5 cm strips: white

10–5 cm strips: white

Size of a Fish Stock

Questions

- What methods can be used to determine the size of a fish stock?
- Are the methods reliable?
- What factors might lead to unreliable data?

Materials

- macaroni or beans or any other substitute to represent fish
- large sheet of paper or bristol board

Procedure

Fisheries biologists use a number of different methods to make as accurate an estimation as possible before setting TACs.

Mark a large sheet of paper or bristol board with ten rows and ten columns. Label the columns from A to J and number the rows 1–10. Each group in the class will be assigned a quadrant in which to do a population sample. For example, one group might have C9, another H3, and so on.

TRIAL 1

Spread the fish more or less evenly over the ocean (paper quadrants). Each group must catch all the fish in their assigned quadrant. Then, devise a method to estimate the total population of the fish stock. All groups should place their final population estimates for Trial 1 in a class table.

TRIAL 2

There is a large school of sharks that like to feed on fish around quadrants H6, H7, G6, and G7. Make sure the fish are not in those quadrants or any of the quadrants touching those four. Sample the population again, using the same quadrant as before, and record all the data.

TRIAL 3

The fish are now a schooling fish. The whole stock will not spread out to any more than a four-quadrant area. Place all the fish together in a four-quadrant area, then sample and record.

TRIAL 4

Create other scenarios.

Analysis

<table>
<tr><td colspan="2">ESTIMATING THE SIZE OF A FISH STOCK
Name:</td></tr>
<tr><td>1. Do you feel your population estimates were relatively accurate in each of the three trials? Explain why or why not.</td><td>2. Which trials, if any, gave inaccurate estimates? Give evidence to support your answer.</td></tr>
<tr><td rowspan="2">3. List several other factors that may make this type of population sampling inaccurate.</td><td>4. If you were responsible for setting the TAC (total allowable catch) for the fish stock and your population sample was done in a quadrant where a school was present, how might this affect the fishery?</td></tr>
<tr><td>5. If you were sampling in a quadrant nowhere near the school of fish, how might that affect the economy and the livelihood of the fishers?</td></tr>
</table>

Size of a Fish Stock
Teacher Notes

Outcome

Students will be expected to

- compile and organize fish population data and explain the dynamic interrelationships among the physical environment, the biological environment, and the health and distribution of a fish stock (FISH-4)

Background Information

Students should be assigned quadrants that sample a diverse area of the ocean. One group should be assigned one of the quadrants in or around the shark area in Trial 2, and a group should be in a school quadrant for Trial 3.

Sustainable Fishery

Questions

- What issues are the most critical in maintaining a sustainable fishery?
- Are the issues being addressed or ignored?
- Is the problem fixable and how much time do we have to fix it?

Procedure

You are a leading Canadian research group on fisheries issues. The Minister of Fisheries and Oceans has asked you to prepare a report on an issue critical to the future sustainability of the fishery and the environment. The report should include any progress that has been made as well as areas that need to improve or change. Include a time frame that highlights the urgency for change.

You will have 5–10 minutes to present your topic to the minister and other members of the government. Your presentation may include a poster, overheads, a short slide show presentation, video clips, brief interviews, charts, graphs, or any other visual aids you choose. You may use the library, textbooks, EBSCO, or other Internet sources to obtain data. Some possible issues you may want to address are

- drift nets
- bycatch or bykill
- fishing on the nose and tail of the Grand Banks
- ocean pollution
- bottom destruction by draggers
- overfishing and maximum sustainable yield
- biological amplification or magnification in the food chain
- oil spills
- commercial whaling

You may want to address other issues not listed here. Check with the teacher before proceeding.

Sustainable Fishery

Teacher Notes

Outcomes

Students will be expected to

- explain the importance of a sustainable fishery as a resource to global and local food supply and employment with reference to terminology (FISH-1)

Background Information

Student groups should not duplicate topics. The students might be requested to pass in a rough research draft of approximately 250 words before proceeding to the presentation.

Design a rubric with your students.

Sustainable Yield

Questions

- What factors affect the population of a stock?
- How many fish can be taken before the maximum sustainable yield (MSY) is exceeded?

Materials

- paper or Styrofoam cups
- M&M candies with the M on one side (no peanuts) or similar candies with dots marked on one side.

Procedure

- You will be using M&Ms to represent a fish stock. The different colours will represent different year-classes of fish. After the end of each year, the class will move on to the next year. (See the table.) You will study the population over 10-year periods.

M&M Fish Stock

FISH AGE						
Study Year	**1st year class**	**2nd year class**	**3rd year class**	**4th year class**	**5th year class**	**6th year class**
1	red	orange	yellow	green	blue	brown
2	brown	red	orange	yellow	green	blue
3	blue	brown	red	orange	yellow	green
4	green	blue	brown	red	orange	yellow
5	yellow	green	blue	brown	red	orange
6	orange	yellow	green	blue	brown	red
7	red	orange	yellow	green	blue	brown
8	brown	red	orange	yellow	green	blue
9	blue	brown	red	orange	yellow	green
10	green	blue	brown	red	orange	yellow

Start with a fish stock of 60 randomly coloured M&Ms in a cup. You should have a bank of extra M&Ms of all colours to add to the population as required. Shake the stock cup and carefully dump the M&M fish out onto the table. The size of the population should be counted and recorded at the end of each year of the study for ten years.

Each shake/dump of the cup equals one year.

Basic Rules

Natality	**Mortality**
For each of the 10 years, the fourth-, fifth-, and sixth-year classes will be your breeders. The fourth-year class is younger with lower fecundity; only the ones that have an M showing up will produce young. Before shaking the cup, add two M&Ms of next year's first-year class fish. For example, in your sixth year of the study, for each blue with an M up as well as all browns and reds, you will be able to add two reds to the cup for the seventh-year shake.	Assume that these fish don't live past six years. All the sixth-year class must be removed from the sample before the next year (shake of the cup). Note: the colour removed (sixth-year class) will be the colour used for the next year's first-year class).
Predation	**Fecundity**
After the M&Ms are shaken and dumped, any first-year class fish with an M facing up are eaten by predators and must be removed before the next shake.	Fish stocks must maintain a certain number of breeding individuals to be able to effectively find mates and breed. If, at any time, a certain year class is at two or lower, that year class will not be able to breed and you may not add two offspring from those individuals to the next year.

Part 1: Basic

Run the model once for 10 years using just the basic rules. Record the population numbers and display the results in a graph.

Part 2: Add Fishing

Run the model again for 10 years using just the basic rules and add fishing. You may theoretically choose to use a large mesh size for your net that only catches the oldest year-class fish, or a smaller mesh size that catches younger year classes as well. You may also choose to catch all of the fish in a certain year class, half the class with the M facing up.

Be sure to record and report the fishing parameters you choose. Record the population numbers and display the results in a graph of your choice.

Part 3: "The Full Meal Deal"

Run the model once more, this time adding two or three different variables to the basic rules plus fishing. You may can modify your previous fishing variable. The variables you choose should be clearly reported with the population graphs and results as well as your reasons for choosing these variables. Try to balance positive and negative variables.

- Possible variable choices could include abiotic changes in temperature, storm patterns, or currents; biotic factors such as more or fewer predators or prey, loss of habitat, disease.
- These variable could affect several or all of the 10 years and they may affect only certain year classes.
- You may place a moratorium (a ban) on fishing at any point within the 10-year period if you feel your stock is being seriously depleted, but you will have many concerned fishers to answer to.
- Be creative but realistic.

Analysis

1. For each of the three models, did your stock (population) increase or decrease? By how much?

2. Calculate the annual rate of increase or decrease in the stock in each of the three models.

3. Which factors seemed to affect your stock in a negative way? In a positive way?

4. The maximum sustainable yield, or MSY, is the maximum number of individuals that can be harvested from a population without causing a decline. Did you exceed the MSY in either of or both parts 2 and 3? Given your results from part 2, what percentage of the population do you think could have been safely harvested? Give reasons for your answer.

5. Did you have to place a moratorium on fishing at any time? Was it effective in rectifying the problem?

6. Compare your graphs with others in the class and discuss the differences and similarities.

Sustainable Yield

Teacher Notes

Outcome

Students will be expected to

- construct, interpret, and evaluate various ecological factors (FISH-3)

Background

It may be advantageous to demonstrate several years of the Part 1: Basic in order to give the students an idea of how the model works with year-class colour changes. A wrap-up discussion with each group informally reporting on their results would generate questions and ideas and further reinforce the concepts.