

Lesson Plan

Activity Title: Fisheries and Aquaculture

Subject (Focus/Topic): Biology/Ecology

Grade Level: grades 9-11

Average Learning Time: Approximately 1.5 class periods.

Lesson Summary (Overview/Purpose): The purpose of this lesson is to introduce students to aquaculture and fisheries studies focusing on sustainable harvesting and/or responsible aquaculture practices. They will perform a simulation of fishing adapted from www.facingthefuture.org, followed by watching a short video of the current state of fisheries.

Overall Concept (Big Idea/Essential Question):

What does sustainably- harvested seafood mean? What are current problems with fishing and aquaculture and what are possible solutions?

Specific Concepts (Key Concepts):

As a result of this lesson, students will understand the differences between commercial fishing and aquaculture. Students will also understand what sustainability means for human economics and within ecosystems. Finally, students will identify pros and cons to fisheries and aquaculture and provide solutions to current challenges.

Focus Questions (Specific Questions):

What is a fishery?

What is aquaculture?

What does sustainable mean (in a social and environmental context)?

What are problems associated with fishing and aquaculture?

What are solutions to problems with fishing and aquaculture?

Objectives/Learning Goals:

- Following a brief discussion, students will be able to describe the difference between commercial fishing and aquaculture/fish farming orally with 80% accuracy.
- By simulating fishing, students will be able to describe 3 reasons why their fishery did not survive and suggest 2 ways to increase its sustainability.
- By watching a video about the current state of fisheries and aquaculture practices, students will be able to list 5-10 problems with fishing and aquaculture practices.
- By watching a video about the current state of fisheries and aquaculture practices, students will be able to list 5-10 solutions to challenges in fishing and aquaculture.

Background Information: Taken from *Do you know the fish you're eating?* (PBS *Marine Fisheries and Aquaculture Series*).

An Overview of the World's Fisheries

What is a commercial fishery?

A commercial fishery is the industry of catching a particular fish species or other marine species for profit. Commercial fisheries exist throughout the world.

What is the status of our fisheries?

Although humans have exploited marine species for millennia, advances in technology over the last few decades have greatly altered the way humans exploit fisheries.

Overfishing—fishing faster than the fish can replenish—is now the greatest threat to marine biodiversity. Today, thirteen of the planet's fifteen major oceanic fishing areas are now fished at or beyond capacity. The problem has grown to such proportions that the populations of some fished species, such as haddock and bluefin tuna, have been decimated.

Is fish farming a better alternative?

With a growing world population and marine fisheries in decline, fisheries experts have long hoped that aquaculture might one day take up the slack. In some ways it already is, but a growing number of marine scientists believe that parts of the industry may instead contribute to the further decline of marine resources. The intense controversy pertains to which species are being farmed and how they are being farmed. Salmon, shrimp and tuna are examples of carnivorous animals that must be fed other fish. Most farms raising these species ultimately consume more fish than they produce. The profit motive also inclines many farms to implement large-scale, industrial practices that can result in pollution, the destruction of marine habitat, and a tendency to generate diseases that pose a risk to both wild fish and consumers. In order to be truly sustainable, aquaculture operations need to operate in ways that do not harm marine ecosystems or coastal communities; that neither consume more resources than they produce. In China, millions of people depend on farms that raise carp, an herbivorous fish that requires no fishmeal. Carp are omnivorous species like catfish and tilapia that can be farmed with very little need of fishmeal or fish oil. Farms that raise shellfish like abalone, clams, oysters and mussels also produce a net gain in protein for a hungry world. These kinds of aquaculture are best suited for truly taking pressure off our over-exploited oceans.

What's the big deal?

For human populations, fishing has long been a way of life, a source of food and income. It is the livelihood for some 200 million people worldwide. Approximately 20 percent of the animal protein consumed by humans is derived from fish. Since living marine resources continue to be overexploited by an industry too large for the resources available, many fisheries are collapsing. This means species are declining, a major world food source is being put at risk, jobs are being lost, and ecosystems are inalterably changing.

Overfished Marine Species in the United States

Albacore—North Atlantic

American Plaice—North Atlantic

Atlantic Halibut—North Atlantic
Atlantic Salmon—North Atlantic
Barndoor Skate—North Atlantic
Bigeye Tuna--Atlantic
Black Grouper—South Atlantic
Black Sea Bass—South Atlantic
Bluefin Tuna—West Atlantic
Bluefish—Mid Atlantic except Gulf of Mexico
Blue King Crab—Pribilof Islands, Saint Matthew Island
Blue Marlin--Atlantic
Bocaccio--Pacific
Butterfish—Mid Atlantic
Canary Rockfish--Pacific
Cod—Gulf of Maine
Cod—Georges Bank
Cowcod--Pacific
Darkblotched Rockfish--Pacific
Golden Tilefish—Mid Atlantic
Goliath Grouper (Jewfish)—South Atlantic, Gulf of Mexico, Caribbean
Greater Amberjack—Gulf of Mexico
Haddock—Gulf of Maine
Haddock—Georges Bank
Nassau Grouper—South Atlantic, Gulf of Mexico, Caribbean
Ocean Pout—North Atlantic
Queen Conch--Caribbean
Red Drum—South Atlantic, Gulf of Mexico
Red Grouper—South Atlantic
Red Porgy—South Atlantic
Red Snapper—South Atlantic, Gulf of Mexico
Sailfish—West Atlantic
Shark Complex*
Snow Crab—Bering Sea
Snowy Grouper—South Atlantic
Speckled Hind—South Atlantic
Tanner Crab—Eastern Bering Sea
Thorny Skate—North Atlantic
Vermillion Snapper—Gulf of Mexico
Widow Rockfish—Pacific
Warsaw Grouper—South Atlantic
White Hake—North Atlantic
White Marling00Atlantic
Windowpane Flounder—Mid Atlantic
Winter Flounder—North, Mid Atlantic
Yelloweye Rockfish—Pacific
Yellowtail flounder—Mid Atlantic
Yellowtail flounder—Cape Cod/Gulf of Maine

*The Large Coastal Shark Complex is listed by its management complex rather than individual stocks. The complex includes Spinner Shark, Silky Shark, Bull Shark, Tiger Shark, Lemon Shark, Nurse Shark, Scalloped Hammerhead Shark, Great Hammerhead Shark, Smooth Hammerhead Shark, Dusky Shark, Bignose Shark, Galapagos Shark, Night Shark, Caribbean Reef Shark, Narrowtooth Shark, Sand Tiger Shark, Bigeye Sand Tiger Shark, Whale Shark, Basking Shark, and White Shark.

Overall Fishing Stock Status, 2004

Total stocks or stock complexes in the U.S.: 688

Number of stocks overfished: 56

Number of stocks not overfished: 144

Number of stocks approaching overfished status: 1

Number of stocks for which status is not known, not defined, or not applicable:
487

Source: NOAA's National Marine Fisheries Service, "Report to Congress: Status of the U.S. Fisheries for 2004,

http://www.nmfs.noaa.gov/sfa/domes_fish/StatusofFisheries/SOS8%20-05.htm

Materials:

Video- Can the ocean keep up with the hunt?

Plain M&Ms, one 14-ounce bag for up to 30 students

Peanut M&Ms, one 14-ounce bag for up to 30 students

Small cups, 1 per student

Serving bowls, medium size, 1 per group

Spoons, 1 per group

Straws, 1 per student

Timer

Handout ***Fishing Log***, 1 per student

Handout ***Fishery Facts***, 1 per student

Technical Requirements:

Teachers will need internet access to view video clips (via You Tube) or secure a copy of Can the Ocean Keep up with the Hunt?

Teacher Preparation:

1. Check for peanut allergies in your class.
2. You will have groups of 3-4 students each, each group will start with 20 plain and 10 peanut M&Ms. Count out the first round of M&Ms and place them in cups.
3. Copy the *Fishery Facts* and *Fishing Log* handouts (below).

FISHING FOR THE FUTURE—FISHERY FACTS (The Curriculum Guide ©2002 www.facingthefuture.org)

The world's fisheries are under more pressure than ever before. From 1950 to 1990, there was a fivefold increase in the world annual fish catch. The average yearly per person fish consumption in the industrialized world (59 pounds) is three times that of people in the developing world (20 pounds). Fish demand remains high: An additional 15.5 million tons of fish will be required by 2010 just to maintain current rates of fish consumption. Today, 70 percent of the planet's marine stocks are fully exploited or overexploited.

The number of people fishing and practicing aquaculture worldwide has doubled since 1970. More than 21 million people are full-time fishers, and 200 million depend on fishing for their livelihood. Asia contains the vast majority of the world's fishers. In the early 1950s, developed countries took 80 percent of the world's fish catch. Today, they take only 36 percent of the catch, while developing countries take 64 percent. The technology used to catch fish and the number of fish caught per fisher varies enormously. Modern fleets are the most environmentally destructive, as they use enhancements such as airplanes, radios, seafloor maps, and video sonar to track down fish schools. Once they have found the fish, these fleets use large nets to drag up not only the targeted fish but also coral, the seafloor, and around 27 million tons annually of "by-catch"—nonmarketable fish that are killed and thrown overboard.

To compensate for reduced wild fish stocks, more and more fish are being farmed. Nearly a third of all fish for food is harvested from aquaculture. For every 11 pounds of beef grown globally, there are now 4.5 pounds of farm-raised fish produced. Fish farming causes environmental destruction comparable to the replacement of rain forest with cattle ranches. About 11 pounds of wild ocean fish need to be caught to feed each pound of farmed species. Thailand, which has one of the biggest aquaculture industries, has lost half its mangrove forests due to shrimp farming. Densely stocked salmon farms in British Columbia, Canada, produce waste (including fertilizer, effluent, and fishmeal) equivalent to that generated by half a million people.

Despite these numbers, there is still hope for the world's fisheries. Fisheries can be restored through the adoption of sustainable fishing practices. With the proper incentives, fishers can be encouraged and rewarded in their effort to sustainably manage marine resources. For example, partnerships between local communities and scientists in the central islands of the Philippines resulted in the establishment of marine reserves to help manage overexploited fisheries. The establishment of no-fishing zones in the reserves has increased catches in adjacent fishing grounds. Another solution is to use the power of the market to encourage sustainable fishing practices. The Marine Stewardship Council together with the World Wildlife Federation and Unilever, one of the largest makers of fish products, has developed a certification process that includes a label telling consumers that fish products came from fisheries certified as sustainable.

References: *The New Internationalist* magazine issue 325, www.newint.org; The United Nations Food and Agriculture Organization, www.fao.org; Environmental News Service, February 2002, www.enn.com
Fishing for the Future The Curriculum Guide ©2002 www.facingthefuture.org

Fishing Log (see www.facingthefuture.org for actual handout)

Ocean Group:

Fishers:

Record your group's catch and fish left in ocean after each season:

Season	Catch		Fish Left in Ocean
	High Value Fish	Medium Value Fish	Total Catch
1			
2			

- Write a brief description of the status/health of your fishery:

Season	Catch		Fish Left in Ocean
	High Value Fish	Medium Value Fish	Total Catch
3			
4			

- Discuss changes in fishing practices or regulations. Are any fisheries in trouble? What did they do and how did that impact your fishery?

Season	Catch		All Fish Left in Ocean
	High Value Fish	Medium Value	Fish Total Catch
5			
6			

- Write a brief description of the status or health of your fishery now:

- How could you have made your fishing sustainable?

Keywords:

Aquaculture- farming practices used to grow shellfish (crustaceans, molluscs), fish, and plants

Fish farming- term used to describe farming of fish species in pens or aqua-cages

Population- A group of interbreeding organisms that represents the level of organization at which speciation begins. Population is measured as the total number of individuals of the species

Sustainable – biological systems that are healthy and productive in the long term

Quota- A fisheries management tool implemented to limit the quantity of a species of fish that fishermen are permitted to land in a given amount of time or geographical area.

Pre-assessment Strategy/Anticipatory Set (Optional):

- Take a class poll. Have students write brief answers to the following questions in their notebook to access background knowledge: *How often do you eat seafood (fish, shellfish, shrimp, seaweed products, crab/lobster, etc.)- once a month, once a week, 2-3 times per week, almost every day? Where do you (or your parents) purchase your seafood? Do you know where it was caught or raised if it is farmed? Do you know what types of food your seafood needed to eat before it was caught?*

Lesson Procedure: *Adapted from www.facingthefuture.org*

1. Introduce and discuss the concept of sustainability.
2. Explain the Rules:
 - a. Each student will be a “fisher” whose livelihood depends on catching fish.
 - b. Peanut M&Ms represent the largest and most valuable fish (tuna, swordfish, etc).
3. Plain M&Ms represent the next most-valuable fish (cod, salmon, etc).
 - a. Each fisher must catch at least two fish (large or small) in each round to survive (i.e., get enough fish to either eat or sell).
 - b. When the fishing begins, students must hold their hands behind their backs and use the “fishing rod” (straw) to suck “fish” (M&Ms) from the “ocean” (bowl) and deposit them into their “boat” (cup).
 - c. The fish remaining in the ocean after each fishing season represent the breeding population, and thus one new fish will be added for every fish left in the ocean (bowl).
4. Divide the class into groups of 3-4 students and have each group choose an ocean name such as North Atlantic, North Pacific, Arctic, Mediterranean, etc.
5. Give each group one serving bowl and each student one cup, one straw, and one copy of the handout *Fishing Log*.
6. Put 20 plain and 10 peanut M&Ms in each group’s bowl.
7. Say “start fishing” and give the students 20 seconds for the first “season” of fishing.
8. Have each fisher count his or her catch (M&Ms in their cup) and record the data in their *Fishing Log*.
9. Fishers who did not catch the two-fish minimum must sit out for the following round.
10. Add one new fish for every fish left in the ocean (bowl).

11. Allow fishers to use their hands on the straws during the second session to represent “new technology.”
12. After the second fishing season, give one fisher from each group a spoon representing more new fishing technology such as trawl nets, sonar equipment, etc. Continue the game for round 3.
13. Ask, “What happened when ocean group [name] ran out of fish? How are the fishers going to survive now?” (One option is to move to another ocean.) Allow students to “invade” other ocean groups when their ocean is depleted, but don’t tell them that they can do this beforehand. Fishers may either go as a group to another ocean or they may disperse to other oceans.
14. Repeat fishing, recording, and replenishing fish stocks until either sustainable fishing is achieved or until all (or most) groups fish out their ocean.
15. Follow up the simulation with these questions: How did you feel when you realized that you had depleted your fish stock? How did you feel when other fishers joined your ocean group? How does this activity relate to real ocean and fishery issues? What’s missing in this game? (Impacts to non-human animals that rely on fish for their survival, population growth, etc.). What happens to a resource when you have infinite population growth, growing technology, and a finite resource? Are there any commonly owned resources in our region or community?
16. Watch [Can the Oceans Keep up with the Hunt](#).

Assessment and Evaluation:

Students can be evaluated by a written reflection of their experience as a “fisher” and following the short video. The reflection should focus on the need of fisheries to support human life, the benefits of aquaculture, and the problems with current fishing and aquaculture practices. The reflection should also focus on the decisions that the student can make that will have a positive influence on fisheries or aquaculture.

A second method to evaluate student understanding from this lesson is by a class discussion. Prior to the discussion, have students write down answers to these questions (or additional): Do you think that fishing should be regulated? Do you think the benefits of aquaculture outweigh the negative consequences? What choices do you have that can make a difference in fish populations and ocean ecosystems? After students have had a chance to write answers, begin a discussion and encourage participation by using a “talking stick” and require at least one comment per student.

Standards:

National Science Education Standard(s) Addressed:

Life Science--Content Standard C: The Interdependence of Organisms

- The atoms and molecules on the earth cycle among the living and nonliving components of the biosphere.
- Energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores to carnivores and decomposers.

- Organisms both cooperate and compete in ecosystems. The interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years.
- Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions between organisms.
- Human beings live within the world's ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology, and consumption. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems will be irreversibly affected.

Science in Personal and Social Perspectives--Content Standard F: natural resources

- Human populations use resources in the environment in order to maintain and improve their existence. Natural resources have been and will continue to be used to maintain human populations.
- The earth does not have infinite resources; increasing human consumption places severe stress on the natural processes that renew some resources and it depletes those resources that cannot be renewed.
- Humans use many natural systems as resources. Natural systems have the capacity to reuse waste, but that capacity is limited. Natural systems can change to an extent that exceeds the limits of organisms to adapt naturally or humans to adapt technologically.

Ocean Literacy Principles Addressed:

- **5c** Some major groups are found exclusively in the ocean. The diversity of major groups of organisms is much greater in the ocean than on land.
- **5d** Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (symbiosis, predator-prey dynamics and energy transfer) that do not occur on land.
- **5e** The ocean is three-dimensional, offering vast living space and diverse habitats from the surface through the water column to the seafloor. Most of the living space on Earth is in the ocean.
- **5f** Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate and circulation, ocean life is not evenly distributed temporally or spatially, i.e., it is "patchy". Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert.
- **6e** Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes

to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.

- **7c** Over the last 40 years, use of ocean resources has increased significantly, therefore the future sustainability of ocean resources depends on our understanding of those resources and their potential and limitations.

State Science Standard(s) Addressed:

- 9-11 LS2F The concept of sustainable development supports adoption of policies that enable people to obtain the resources they need today without limiting the ability of future generations to meet their own needs. Sustainable processes include substituting renewable for nonrenewable resources, recycling, and using fewer resources.
- 9-11 LS2B Living *organisms* have the capacity to produce very large *populations*. *Population density* is the number of individuals of a particular *population* living in a given amount of space.
- 9-11 LS2C *Population growth* is limited by the availability of matter and energy found in resources, the size of the *environment*, and the presence of competing and/or predatory *organisms*.
- 9-11 LS2D Scientists represent *ecosystems* in the *natural world* using mathematical *models*.
- 9-11 LS2E Interrelationships of *organisms* may *generate ecosystems* that are stable for hundreds or thousands of years. *Biodiversity* refers to the different kinds of *organisms* in specific *ecosystems* or on the planet as a whole.

Additional Resources:

- Can Oceans Keep up with the Hunt? (video)
- <http://www.pbs.org/emptyoceans/educators/activities.html>
- <http://planetgreen.discovery.com/food-health/noaa-debuts-nations-first-safe-sustainable-aquaculture-policy.html>
- Strange Days on Planet Earth, Vol. 2, aquapods

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