You're Excluded!

An Activity Exploring Changes in Trawl Industry Technology

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Objectives

Students will:
1.) Describe a trawl technique for catching fish

2.) Identify ways that changes in technology can positively or negatively affect fish populations

3.) Define 'bycatch' and 'excluder device'

4.) Use grade-appropriate engineering design standards and inquiry skills for problem solving

5.) Understand the iterative nature of gear modification

Method

Students will conduct a simulation to understand changes in fishing gear, and then will design and test their own excluder devices.

Materials

Nets of different sizes, dried beans of varying sizes (lima, pinto, black, green pea, rice), dog food, marshmallows, writing materials, large containers / trays to hold beans, tank for holding water, and as many random supplies as possible- this is about innovation so anything works.) Recommendations: paper or styrofoam cups, toothpicks, Q-tips, tape, straws, silly putty, scissors, hair nets, and items that float.

Background

Fishers in Oregon use many different kinds of fishing gear. One of the devices they used is called a trawl net. Trawl nets are large, funnel-shaped nets that vessels drag through the water. The net is wide at the mouth and tapers back to a narrow end that collects the catch. The average bottom trawl opening is 40 to 60 feet wide and 8 to 10 feet tall. The nets are towed either mid-water (between the ocean bottom and the surface) or near the bottom. There are three types of trawlers: bottom trawlers, mid-water trawlers, and shrimpers. Trawlers have a large trawl door attached to each side, or wing, on the front of the net. The water hits the doors, and the pressure of the water passing over the doors spreads the net open. Trawl nets are very effective at catching fish; many of the fish caught in Oregon are caught with a trawl. In the 1990s, concerns about Oregon's trawl fisheries began to emerge.

Concerns with Trawling

There were many different factors that led to concerns with trawling, all of which culminated in the 1990s. Following are some of the primary concerns.

Bycatch: Bycatch is catching species other than those that are targeted. One of the environmental concerns with trawl fishing is that nets need to have a mesh size small enough to catch fish—sometimes really small species, like shrimp. Because many fish live in similar habitats, the nets may catch fish other than what they were seeking, and often larger fish. Bycatch can be a problem both environmentally and economically. Environmentally, catching species that are not the target fish may lead to declines in the populations of those fish. Economically, catching species other than those being targeted will reduce a fisher's quota for those species, which is often very small; and once a fisher has reached his limit on those species, he may not fish anymore until he leases, or buys, additional quota (if possible) to cover any incidental catch of those non-targeted species.

Over Capacity: Over capacity is when there are too many people catching fish. As the trawl fishing industries grew in Oregon from the 1970s to the '90s, more people were fishing. As they did well, they acquired bigger and bigger boats. This eventually resulted in the existence of too many boats for the number of fish available to catch.

Over Fishing and Lack of Science: Over fishing is when too many fish are caught over enough years that the populations start to decline. With so many boats and improved gear, the west coast trawlers were over fishing what the population could sustain. Around this same time, scientists discovered that some species of rockfish can live much longer and reach reproductive age later than expected. Many species of rockfish were being captured before they were able to reproduce—which, when combined with over fishing, meant that there were problems with rockfish populations.

Changes in the Trawl Industry

In the 1990s, the issues with west coast trawlers had accumulated to the point where it became necessary to declare a "Groundfish Disaster". "Groundfish" is a term used to describe about 90 species that are managed together. Most of them live on or near the bottom of the ocean, and many are caught by bottom trawlers.

The Groundfish Disaster declaration led to many changes that affected the trawl industry.

Decreasing Number of Boats Fishing: With fish populations dwindling, many fishers were unable to catch enough fish and were having financial problems. There was a boat buy-back program, with the goal of decreasing the number of boats in the trawl industry. Boats that were bought in the buy-back were no longer allowed to fish. Some became research vessels, while others were simply no longer used. The reduced competition made it possible for fishers who were still fishing to continue making an income.

Limited Entry: This means that only those vessels with the appropriate permits are allowed to trawl.

Quotas: Quotas allow only a set number of fish to be caught, and once that number is reached, there is no more fishing.

Closures: A coast wide (from Baja to BC) Rockfish Conservation Area was established, and no bottom trawling is allowed in this area. This has been helping rockfish populations rebuild.

Catch Shares: The industry continues to change, and is in the process of becoming a catch-shares system. A catch share is similar to owning stock in a company, where you are allowed to catch that percentage of the stock. In this scenario, you can buy, sell, or trade quota for specific species to best benefit individual boats.

Gear Changes: There are now standards for minimum mesh sizes of trawl nets.

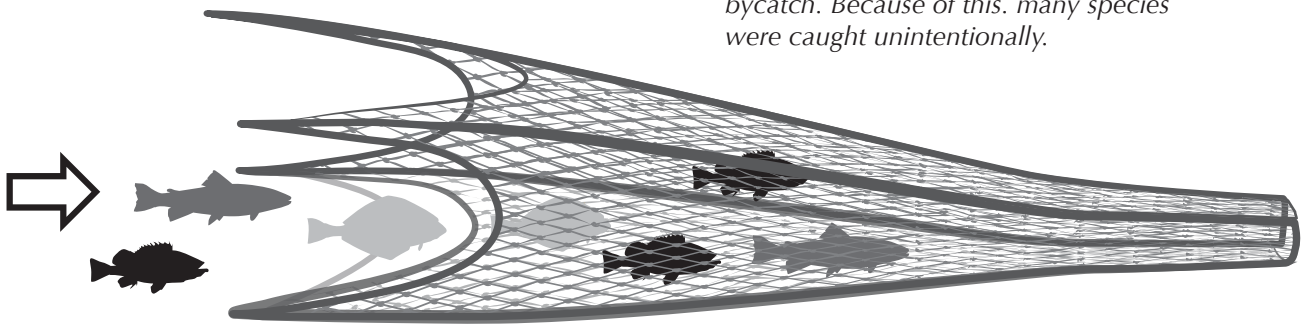
Bycatch Reduction Devices: One of the most exciting changes in trawl fisheries has been the development of devices that limit bycatch. Many of the "excluders"—devices that exclude certain species—have been engineered by fishers. Selectivity is when fishers are targeting specific species; they want to catch only those species that are economically valuable. By creating devices that promote selectivity, the fisheries can produce a sustainable product. Many fisheries can market their products as sustainable if they meet strict requirements in fishing practices. The advantages to having sustainable fisheries are that fishers may continue to harvest fish in the long run, and consumers may purchase fish knowing the impact is not harmful to the overall fish population or the environment. Bycatch reduction devices have helped to certify some of Oregon's trawl fisheries as sustainable.

According to the Pacific Fisheries Management Council, "Groundfish are managed through a number of measures including harvest guidelines, quotas, trip and landing limits, area restrictions, seasonal closures, and gear restrictions (such as minimum mesh size for nets and small trawl footrope requirements for fishing shoreward of the trawl Rockfish Conservation Area [RCAs are areas where fishing is prohibited to specific gears or sectors])."

You're Excluded!

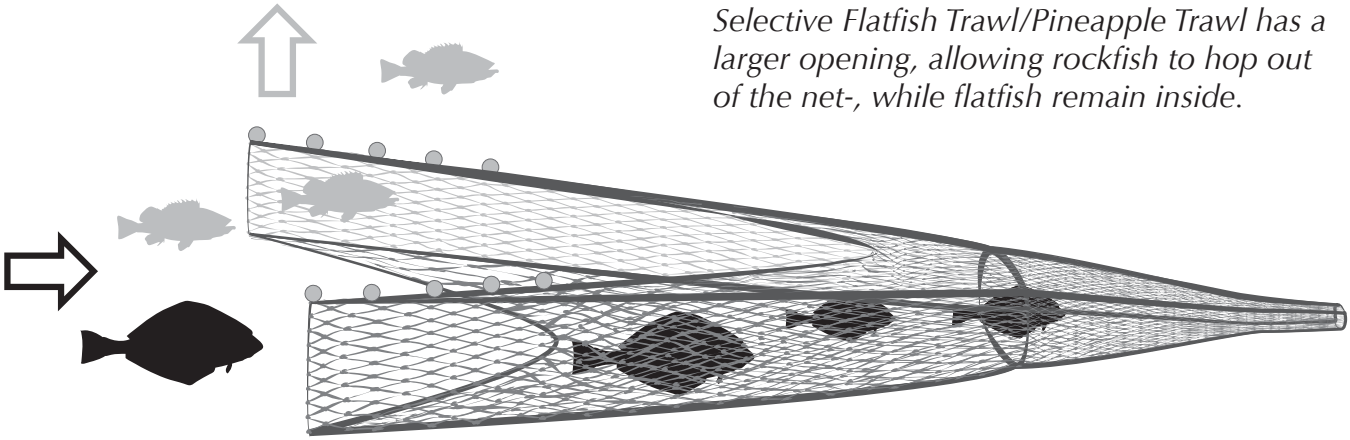
Old Net

Early trawl nets were not designed to exclude bycatch. Because of this. many species were caught unintentionally.

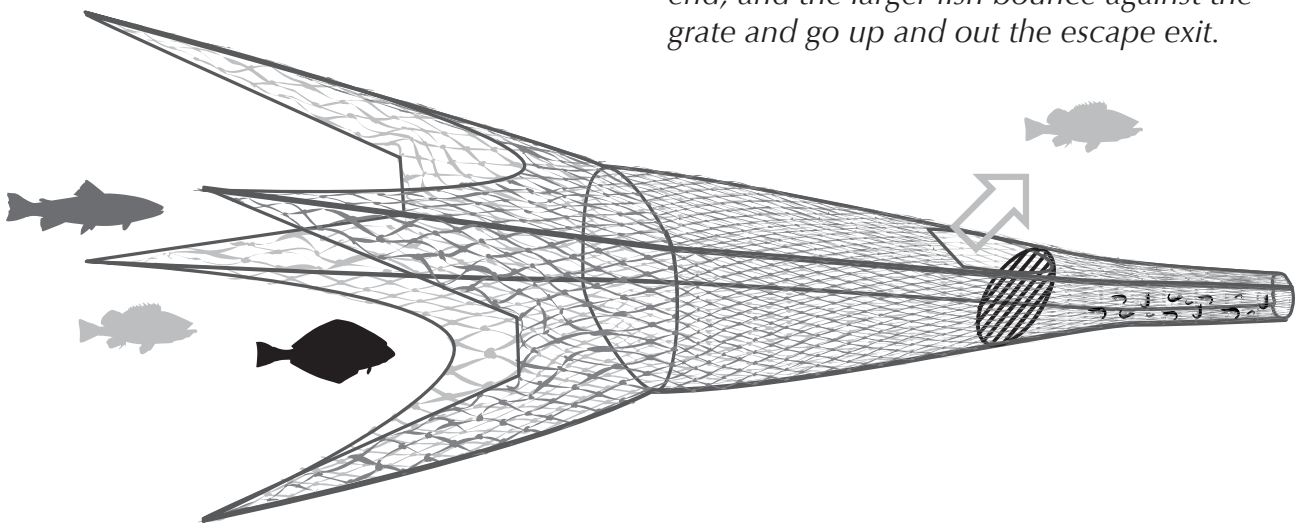


New Nets

Selective Flatfish Trawl/Pineapple Trawl has a larger opening, allowing rockfish to hop out of the net-, while flatfish remain inside.



Oregon Grate Excluder Device guides all fish through a tunnel, and then the smaller fish/shrimp go through the grate into the cod end, and the larger fish bounce against the grate and go up and out the escape exit.



You're Excluded!

Procedure

1. Prepare the "ocean" by mixing all the beans and grains listed into a bin or tray, if doing a dry version, or dog food and marshmallows in the tank if doing a wet version.

2. Have students go to the fishing grounds (wet or dry) and "fish" by scooping up the beans with their hands. What did they get? What do the different beans mean? Discuss how the various beans are different species of fish.

3. Talk about the concept of excluder devices and bycatch, and about how and why they wouldn't want to catch some of the beans (some are protected species; fishers have a market for selling all of the same species; it's harder to sell a mixed group of fish).

4. Set out the various supplies, and have students work (individually or in small groups) on an excluder device. Give them a specific scenario (catch certain beans and exclude others).

5. Show video footage of actual excluder devices working (this can be done before or after the activity).

Activity Options

1. For younger students, the instructor can make excluder devices in advance and have them use different ones and discuss how they worked.

2. Challenge older students to create a bycatch reduction device.

3. Have all students working on the same challenge (for example, exclude same bean) and compare:
   - Which devices are the fastest?
   - Which devices have the least bycatch?

Once made, compare between the groups to determine which devices catches the most fish,- and therefore earns those fishers the most money.

Different fish may be worth different values (for example, lima beans may be halibut, a high-value but low-volume fishery; while rice may be shrimp or whiting, which are a high-volume, but low-value fishery).

Discussion Questions

1. Why would fishers only want to catch certain fish?
   - Economics/markets
   - Restricted species

2. What would you need to know/think about to make a net and excluder device that works?

   - Hydrodynamics and Drag: Students could do an exercise dragging first a hair net and then a shower cap through the water.

   - Species Biology and Behavior: How do the different fish you might catch behave? Do they swim down? Up? Do they bury themselves in the sand?

3. What would fishers consider when designing a net/excluder device?

   - Less drag = Less gas needed
   - Faster fishing = Less gas needed
   - Complying with environmental regulations

4. How do you think scientists and fishers work together to create new excluder devices?

   - Trial and error; did all your first ideas work?

5. What does "iterative" mean? How might "iterative" describe the development of fishing gear? How many times did you try your device? Did you modify it to improve it?

6. How do fishers and scientists know the excluder devices are working?

   - Less bycatch
   - Use cameras to see how they work underwater
   - Tow two nets at the same time; off each side of the boat, one with the excluder, one without, to test under similar conditions
   - Repeat the experiments

7. Which of the devices worked best? What were you surprised about? What was challenging?

8. What does it mean to "balance efficiency with selectivity"?

9. These are current events; fishing gear is always being improved. What does this mean about how fisheries are managed? What does it mean about future fisheries management?

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Oregon Department of Fish and Wildlife website and excluder device video footage:
http://www.dfw.state.or.us/mrp/shellfish/commercial/shrimp/BRDs.asp [last accessed August 2011]

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Incorporating Engineering Design Standards:

This activity can be adapted to many levels, depending on the background material presented.
Tools can be everyday objects: tape, scissors, glue, etc.
Incorporating "cost" and "environmental impacts" into designs:

Cost: give a value to all the materials; students will have to learn to make the best product with the lowest cost.

Cost: assign different species (beans or whatever is being caught) different values, so they can calculate earnings.

Cost and environmental impacts: assign a value to those species (beans or whatever is being caught) that are protected, endangered, etc., and impose a fine on students who catch those species.

Environmental impacts: for a wet tank, using either playdough or sand, determine whether the gear damages the "seafloor." This can be determined by seeing marks in the sand or playdough, or by finding residual sand or playdough stuck in the "gear."

Evaluating the designs: introduce the concept of "iterative" design, meaning that something is designed; tested, used, and refined; tested, used, and refined again, etc.

Engineering Design Standards, Grades K through High School

This list provides the content standards organized to show the progression of the standards from kindergarten through high school in engineering design. Standards in bold may be met by the "You're Excluded" activity.

K.4D.1 Create structures using natural or designed materials and simple tools.
K.4D.2 Show how components of designed structures can be disassembled and reassembled.
1.4D.1 Identify basic tools used in engineering design.
1.4D.2 Demonstrate that designed structures have parts that work together to perform a function.
1.4D.3 Show how tools are used to complete tasks every day.
2.4D.1 Use tools to construct a simple designed structure out of common objects and materials.
2.4D.2 Work with a team to complete a designed structure that can be shared with others.
2.4D.3 Describe an engineering design that is used to solve a problem or address a need.
3.4D.1 Identify a problem that can be addressed through engineering design, propose a potential solution, and design a prototype.
3.4D.2 Describe how recent inventions have significantly changed the way people live.
3.4D.3 Give examples of inventions that enable scientists to observe things that are too small or too far away.
4.4D.1 Identify a problem that can be addressed through engineering design using science principles.
4.4D.2 Design, construct, and test a prototype of a possible solution to a problem using appropriate tools, materials, and resources.
4.4D.3 Explain how the solution to one problem may create other problems.
5.4D.1 Using science principles, describe a solution to a need or problem given criteria and constraints.
5.4D.2 Design and build a prototype of a proposed engineering solution and identify factors such as cost, safety, appearance, environmental impact, and what will happen if the solution fails.
5.4D.3 Explain that inventions may lead to other inventions and once an invention exists, people may think of novel ways of using it.
6.4D.1 Define a problem that addresses a need and identify science principles that may be related to possible solutions.
6.4D.2 Design, construct, and test a possible solution to a defined problem using appropriate tools and materials. Evaluate proposed engineering design solutions to the defined problem.
6.4D.3 Describe examples of how engineers have created inventions that address human needs and aspirations.
7.4D.1 Define a problem that addresses a need and identify constraints that may be related to possible solutions.
7.4D.2 Design, construct, and test a possible solution using appropriate tools and materials. Evaluate proposed solutions to identify how design constraints are addressed.
7.4D.3 Explain how new scientific knowledge can be used to develop new technologies and how new technologies can be used to generate new scientific knowledge.
8.4D.1 Define a problem that addresses a need, and using relevant science principles investigate possible solutions given specified criteria, constraints, priorities, and trade-offs.
8.4D.2 Design, construct, and test a proposed solution and collect relevant data. Evaluate a proposed solution in terms of design and performance criteria, constraints, priorities, and trade-offs. Identify possible design improvements.
8.4D.3 Explain how creating a new technology requires considering societal goals, costs, priorities, and trade-offs.
H.4D.1 Define a problem and specify criteria for a solution within specific constraints or limits based on science principles. Generate several possible solutions to a problem and use the concept of trade-offs to compare them in terms of criteria and constraints.
H.4D.2 Create and test or otherwise analyze at least one of the more promising solutions. Collect and process relevant data. Incorporate modifications based on data from testing or other analysis.
H.4D.3 Analyze data, identify uncertainties, and display data so that the implications for the solution being tested are clear.
H.4D.4 Recommend a proposed solution, identify its strengths and weaknesses, and describe how it is better than alternative designs. Identify further engineering that might be done to refine the recommendations.
H.4D.5 Describe how new technologies enable new lines of scientific inquiry and are largely responsible for changes in how people live and work.
H.4D.6 Evaluate ways that ethics, public opinion, and government policy influence the work of engineers and scientists, and how the results of their work impact human society and the environment.

P = Physical science; L = Life science; E = Earth and Space science; S = Scientific inquiry; D = Design (engineering)