YOU'RE EXCLUDED!

An activity exploring technology changes in the trawl industry

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Objectives

Students will: 1) describe a trawl technique to catching fish 2) identify ways that changes in technology can impact fish populations (positively and negatively) 3) define bycatch and excluder device, 4) use grad-appropriate engineering design standards inquiry skills for problem-solving, and 5) understand the iterative nature of gear modification.

Method

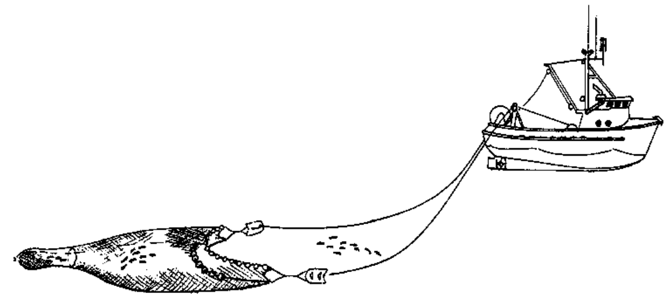
Students will conduct a simulation to understand changes in fishing gear and will then design and test their own excluder devices.

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, tape, silly putty, scissors, hair nets, items that float, etc)!

Background on Trawl Fishing

There are many different kinds of fishing gear used in Oregon to catch fish. One of the ways used to catch fish in Oregon is the 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 cod end that collects the catch. The average bottom trawl opening is 40 to 60 feet wide and 8-10 feet tall. The nets are towed either mid-water, or near the bottom. Trawlers have a large trawl door that is 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.



drawing by Herb Goblirsch

Trawl nets are very effective at catching fish; many of the fish caught in Oregon were caught with a trawl. In the 1990's concerns about Oregon's trawl fisheries began to emerge.

Concerns with Trawling

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

<u>Bycatch:</u> Bycatch is catching species other than those which are being targeted. One of the environmental concerns with trawl fishing is that nets need to have a mesh size that is 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 economically and environmentally. Fishermen cannot sell most bycatch, either because there is not a market for it, or because they do not have the correct permits. Environmentally, catching species that are protected is not allowed, so can shut down the entire fishery.

<u>Over capacity:</u> Over capacity is when there are too many people catching too much fish. As the trawl fishing industries grew in Oregon from the 1970s-

1990s, more people were fishing. As they did well, they got bigger and bigger boats. This leads to a situation where there were too many boats for the number of fish available to catch.

Over Fishing & 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 overfishing what the population could sustain. Around this same time, scientists realized that some species of rockfish can live for much longer than expected and reached reproductive age later than had been realized. Many species of rockfish were being captured before they were able to reproduce, which when combined with overfishing, meant that there were problems with rockfish populations.

Changes in the Trawl Industry

In the 1990s, the issues with the west coast trawlers were all cumulating, and a "Groundfish Disaster" was declared. "Groundfish" is a complex of ~90 species that are all managed together. Most of them live on or near the bottom of the ocean, and many are caught by trawlers. There were many changes that happened then that impact the trawl industry.

Decreasing number of boats fishing: With numbers of fish populations dwindling, many fishermen were not able 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 were no longer allowed to trawl. Some became charter boats, some became research vessels, and some were simply no longer fished. This had the result that those fishermen who were still fishing were able to make an income.

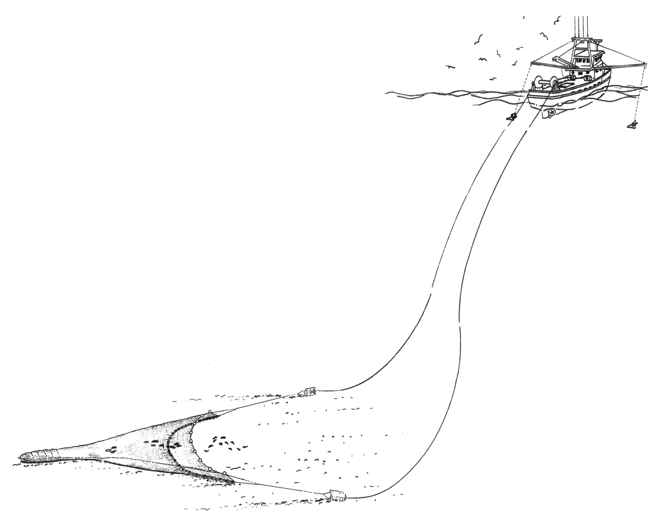
Limited Entry: This meant that only those vessels with the appropriate permits would be allowed to trawl.

Quotas: Quotas mean that only a set amount of fish are allowed to be caught, and once that number is reached, there is not more fishing.

Closures: A coast wide (from Baja to BC) Rockfish Conservation Area was established, and no 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, if you catch more of something you do not want to catch, you can sell it to someone else who has the permit for that species.

Gear changes: There are now standards for minimum mesh sizes.

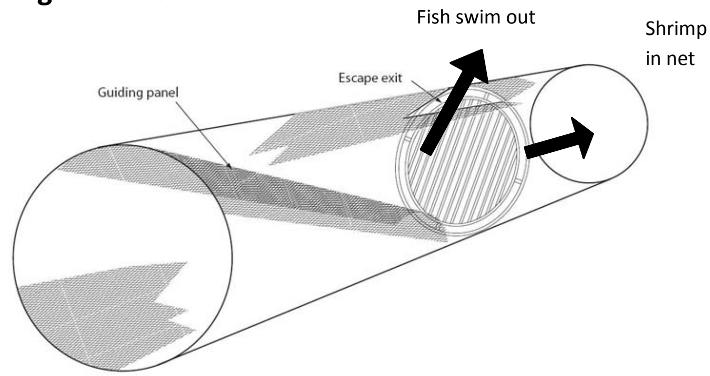


drawing by Herb Goblirsch

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 have been essential in balancing efficiency with selectivity used in the fishing industry have been engineered by fishermen. Selectivity is when fishermen are targeting only specific species; they only want to catch 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 advantage to having sustainable fisheries is that fishermen get to continue to harvest fish in the long run and consumers can purchase fish knowing the impact is not harmful to the overall fish population or environment. Bycatch reduction devices have helped to certify some of Oregon's trawl fisheries as sustainable.

> According 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)."

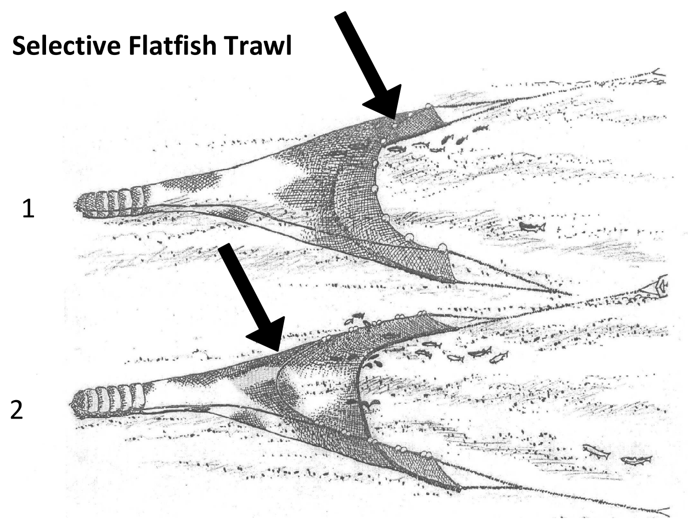
Oregon Grate



drawing from Oregon Department of Fish and Wildlife

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.

Selective Flatfish Trawl



drawing from West Coast Groundfish Observer Manual

Selective Flatfish Trawl/Pineapple trawl (net #2) has a larger opening, allowing rockfish to hop out of the net, while flatfish remain in the net. Arrow shows the difference in top of net opening.

Procedure:

1. Prepare the "ocean" by mixing all the beans and grains listed into a bin or tray, if doing a dry version, and/or dog food/marshmallows in the tank if doing a wet version.
2. Have students go to the fishing grounds (wet and/or dry) and have them take their hand and "fish" by scooping up the beans. 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 how some of the beans they do not want to catch. Discuss why they do not want bycatch (some are protected species, fishermen have a market for selling all of the same species—it's harder to sell a mixed group of fish).
4. Pull out the various supplies, and have the students work (individually or small groups) on an excluder device. Give them a specific scenario (catch certain beans and exclude certain beans).
5. Show video footage of actual excluder devices working (this can be before or after the activity).

Activity options:

1. For younger students, instructor can make excluder devices in advance and have them use different ones and discuss how they worked.
2. For older students, give them a challenge to create a bycatch reduction device.
3. Have all students working on the same challenge (i.e., exclude same bean) and compare:

- Which devices are the fastest?
- Which devices have the least bycatch?
- Once made, compare devices between the groups--which catch the MOST fish (i.e., those fishermen will make the most $)
- Different fish may be worth different values—(i.e., lima beans may be halibut, and 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:

- Why would fishermen only want to catch certain fish?
  - Economics/markets
  - Restricted species
- What would you need to know/think about to make a net and excluder device that works?
  - Hydro dynamics and drag (could have students do an exercise dragging a hair net through the water and dragging 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 in the sand?
- What would fishermen consider when designing a net/excluder device?
  - Less drag=less gas needed
  - Faster fishing=less gas needed
  - Complying with environmental regulations
- How do you think scientists and fishermen work together to create new excluder devices?
  - Trial and error—did all of your first ideas work?
- What does "iterative" mean? How might "iterative" describe developing fishing gear? How many times did you try your device? Did you modify it to improve it?
- How do fishermen 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 of each side of the boat, one with the excluder, one without, to test under similar conditions
  - Repeat the experiments
- Which of the devices worked the best? What were you surprised about? What was challenging?
- What does it mean to balance "efficiency" with "selectivity"?
- 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?

References

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http://www.nwfsc.noaa.gov/research/divisions/fram/observer/observermanual/observermanual.cfm

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

Pacific Fishery Management Council Web site: http://www.pcouncil.org/

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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 of the materials set out; students will have to learn to make the best product with the lowest cost.
  - Cost: assign different species (beans or whatever being caught) different values, so that they can calculate earnings
  - Cost & Environmental Impacts: assign a value to those species (beans or whatever being caught) are protected, endangered, etc, and impose a fine on the students who catch those species.
  - Environmental impacts: For a wet tank, using either playdough or sand, determine if the gear damages the "seafloor". This can be determined by marks in the sand or playdough or residual sand or playdough stuck in/on the "gear"
- Evaluating the designs: introduce the concept of "iterative" design. Meaning something is designed, tested/used, refined, tested/used, refined, etc.

Engineering Design Standards
Grades K-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 that may be met by "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)