Introduction

Seafood serves as a primary source of food and protein for many people across the world, and the economies of many nations are heavily influenced by fish stocks and fisheries management. While efforts are in place to manage fisheries in many places around the world, there are still risks associated with fishing on a commercial scale. Many fishing vessels are equipped to target specific species of fish, for example cod, but the large nets and trawls used for efficiency have a downside. This downside is called “bycatch”. Bycatch is defined as any non-targeted species that are brought in accidentally within the catch. Bycatch organisms can include everything from different fish species, to marine mammals, reptiles, and even birds. According to the World Wildlife Fund, 40% of fish catch worldwide is bycatch and is thrown back into the ocean either dead or dying. Bycatch also kills 300,000 small whales and dolphins, 250,000 endangered sea turtles, and 300,000 sea birds every year.¹ In this lesson, students will use the engineering design process to create an alternative to modern fishing nets to try and reduce the amount of bycatch. They will also practice data collection and review.

Learning Objectives

- Understand the connectedness between humans and the environment
- Understand what bycatch is
- Describe the impact bycatch has on the ocean ecosystem
- Develop improved fishing net models to reduce bycatch
- Use critical creative thinking to review their designs and improve them
- Apply the EarthEcho engineering design process
Engineering Connection

Students will use the engineering design process to create models of nets that can be used to reduce bycatch. Engineers have been using this process to create different products. One example that is already in place in many countries is the TED or turtle excluder device. This device was engineered by scientists to help sea turtles escape large nets and not drown or become bycatch. This lesson will inspire students to use STEM and creative thinking to produce their own sustainable fishing nets.

Resources for Teachers

What's the Catch? Expedition videos:
- What is bycatch?: https://www.bycatch.org/about-bycatch
- Wild seafood and bycatch: https://www.seafoodwatch.org/ocean-issues/wild-seafood/bycatch
- Reducing bycatch video: https://oceantoday.noaa.gov/reducingbycatch/

Procedure

Materials Needed:
- Buckets
- Smaller containers (example: small aquariums)
- Fishing net materials (examples: small aquarium nets, reusable cups, mesh bags)
- Water
- Paper and pencils for data collection
- Small (5/8th inch), medium (7/8th inch) and large (1 5/8th inch) marbles

Starter:
Have students list all of the types of seafood they have eaten, A) in the country where they live B) in any other countries they have visited. Students then share their lists with the rest of the class or a buddy share.

Lead a class discussion with the following questions/topics:
- Does it matter what is caught in the sea and why?
- Discuss overfishing, bycatch, juvenile fish, the need for biodiversity.
After the discussion show the class the following videos:

What's the Catch?
This is a Sustainable Fish (2.42 minutes) [https://www.youtube.com/watch?v=6ps0truARKs](https://www.youtube.com/watch?v=6ps0truARKs)

Discuss the problems shown on the video and ask students to think of solutions to the problems.

Before the activity, fill your assorted buckets or containers with water and add different sizes of marbles and/or balls to each container. Pick one type of marble (color or size) as the target fish for each group. The other sizes are now bycatch (or potential bycatch).

**Engage**

Divide your students into groups. Each group will need a container with water and marbles, a smaller empty container, paper, pencils, blindfold, and a fishing net of their choosing. Students will each take a turn with a blindfold on fishing for their assigned targeted “species of fish” (specific marble color/size). Each student in the group will take two turns with their net and put what they catch in the second container without water. Students should use their paper to complete the chart below for each student in the group after they have taken their two turns.

<table>
<thead>
<tr>
<th>Initial number of marbles in your ocean</th>
<th>Number of marbles removed while fishing - targeted species large size</th>
<th>Number of marbles removed while fishing - medium-sized bycatch</th>
<th>Number of marbles removed while fishing – small-sized bycatch</th>
</tr>
</thead>
</table>

EARTHECHO Expeditions

What's the Catch?
Have students record the percentages:

Practice Skill: Percent Proportion

# is a percent of another #

\[
\frac{\text{is}}{\text{of}} = \% \quad \text{of} \quad 100
\]

For example, your group collects 50 “fish” (marbles) during your trial. Of those 50 fish, only 25 are your target fish species.

25 target fish is what percent of the fifty total fish catch?

\[
\frac{25}{50} \quad \text{Step 1: divide fraction}
\]

\[
\frac{.5}{100} \quad \text{Step 2: multiply by 100 to get percentage}
\]

\[
50\% = x \quad \text{Step 3: label percent}
\]

Explore

Once the students have completed their turns fishing and collecting data, have them sit and create a large data table on the board, students will need to tally their groups’ data.

<table>
<thead>
<tr>
<th>Group</th>
<th>Targeted Fish (# caught)</th>
<th>Bycatch (# caught)</th>
<th>Type of fishing net used</th>
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</thead>
<tbody>
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</tbody>
</table>
Explain

Lead a class discussion on the results and how the different types of nets did or did not work. Review why bycatch is a problem for marine and freshwater life.

Elaborate

STEM Design Challenge - this is where students will be able to use the engineering design process to create prototypes of nets that reduce bycatch. Students can start by drawing their net ideas and use materials, like the nets you’ve provided or other fabric, to create a net. Have students repeat the procedure in the engage session to test their nets. Use the engineering design process graphic below as a guideline for students to use. Lastly, use the rubric in the assessment section to score their designs.

Additional Elaborate Activity

Have students use the internet to design a leaflet explaining the problems associated with overfishing and how an individual person can help to sustain fish stocks by choosing carefully the species of fish that they eat. In addition, have students compare and contrast fish farming with overfishing.

WEBSITES FOR STUDENTS’ REFERENCE

https://www.sustainweb.org/sustainablefishcity/top_ten_swaps/

Students in the UK can use the Good Fish Guide to find out which fish are the most sustainable in their area: https://www.mcsuk.org/

Students in the US can use the Seafood Watch Guide to find out which fish are the most sustainable in their area: https://www.seafoodwatch.org

Students in Australia can use the Sustainable Seafood Guide (AU) to find out which fish are the most sustainable in their area: https://goodfish.org.au/
Engineering Design Process

STEP 1
INVESTIGATE: Identify the Problem

STEP 2
INVESTIGATE: Identify Criteria and Constraints

STEP 3
PREPARE: Possible Solutions and Generate Ideas

STEP 4
PREPARE: Research the Possibilities

STEP 5
PREPARE: Select an Approach/Prototype/Solution

STEP 6
ACT: Build a Model or Prototype

STEP 7
REFLECT: Refine the Design

STEP 8
DEMONSTRATE: Share with Others and Community

WWW.EARTHECHO.ORG/EXPEDITIONS
Evaluate
Use assessment rubric to provide feedback to students on their net designs.

Assessment

<table>
<thead>
<tr>
<th>Group</th>
<th>Innovation Expert</th>
<th>Sustainability Superstar</th>
<th>Environmental Apprentice</th>
<th>Eco Guardian</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Effectiveness:</strong> How much bycatch did your net catch?</td>
<td>30%</td>
<td>50%</td>
<td>60%</td>
<td>80%</td>
</tr>
<tr>
<td><strong>Scale:</strong> Could your prototype be made into a larger size?</td>
<td>Yes</td>
<td>Maybe</td>
<td>Possible</td>
<td>One of a kind</td>
</tr>
<tr>
<td><strong>Durability:</strong> Did your net require fixing or adjusting during your tests?</td>
<td>Minor adjustments</td>
<td>Some repairs required</td>
<td>Major repairs needed but net stayed intact</td>
<td>Major repairs and net did not hold</td>
</tr>
<tr>
<td><strong>Disruption:</strong> Did your device work with minimal disruption to its surroundings?</td>
<td>Completely undisturbed</td>
<td>A few disturbances</td>
<td>Some disturbances</td>
<td>Major disturbances</td>
</tr>
</tbody>
</table>
**Next Generation Science Standards: 5-ESS3-1.**
Obtain and combine information about ways individual communities use science ideas to protect the Earth’s resources and environment.

**MS-ESS3-3.**
Apply scientific principles to design a method for monitoring and minimizing human impact on the environment.

**ESS3.C: Human Impacts on Earth Systems**
Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.

**3-5:** Use evidence to construct or support an explanation or design a solution to a problem.

**3-5:** Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.

**Australian Standards**

**Year 6**

**Biological Science**
The growth and survival of living things are affected by physical conditions of their environment (ACSSU094)

**Science as A Human Endeavour**
Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions (ACSHE098)

**Use and Influence of Science**
Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)

**Science Inquiry Skills**
With guidance, pose clarifying questions and make predictions about scientific investigations (ACSIS232)

**Planning and Conducting**
Identify, plan and apply the elements of scientific investigations to answer questions and solve problems using equipment and materials safely and identifying potential risks (ACSIS103)

**Processing and Analysing Data Information**
Compare data with predictions and use as evidence in developing explanations (ACSIS221)
Evaluating
Reflect on and suggest improvements to scientific investigations (ACSIS108)

Communicating
Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS110)

Year 10
Earth and Space Science
Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere (ACSSU189) (see elaborations)

ELABORATIONS
- investigating how human activity affects global systems
- modelling a cycle, such as the water, carbon, nitrogen or phosphorus cycle within the biosphere
- explaining the causes and effects of the greenhouse effect
- investigating the effect of climate change on sea levels and biodiversity
- considering the long-term effects of loss of biodiversity
- investigating currently occurring changes to permafrost and sea ice and the impacts of these changes
- examining the factors that drive the deep ocean currents, their role in regulating global climate, and their effects on marine life

Science as A Human Endeavour
Advances in scientific understanding often rely on technological advances and are often linked to scientific discoveries (ACSHE192)

Use and Influence of Science
People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people's lives, including generating new career opportunities (ACSHE194)

Science Inquiry Skills
Formulate questions or hypotheses that can be investigated scientifically (ACSIS198)

Planning and Conducting
Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods (ACSIS199)
Processing and Analysing Data Information

Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies (ACSIS203)

Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS204)

Evaluating

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data (ACSIS205)

Communicating

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS208)

Creating Designed Solutions:

- Investigating: Critique needs or opportunities for designing and investigate, analyze, and select from a range of materials, components, tools, equipment, and processes to develop design ideas. (VCDSCD049)
- Generating: Generate, develop, and test design ideas, plans, and processes using appropriate technical terms and technologies including graphical representation techniques. (VCDSCD050)
- Producing: Effectively and safely use a broad range of materials, components, tools, equipment, and techniques to produce designed solutions. (VCDSCD051)
- Planning and Managing: Use project management processes to coordinate production of designed solutions. (VCDSCD053)

UK Science Standards:

Planning different types of scientific enquiries to answer questions, including recognizing and controlling variables where necessary:
- taking measurements, using a range of scientific equipment with increasing accuracy and precision, taking repeat readings when appropriate
- recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, scatter graphs, bar and line graphs
- using test results to make predictions to set up further comparative and fair tests
- reporting and presenting findings from inquiries, including conclusions, causal relationships and explanations of, and a degree of trust in results, in oral and written forms such as displays and other presentations.
- identifying scientific evidence that has been used to support or refute ideas or arguments
- ask questions and develop a line of inquiry based on observations of the real world, alongside prior knowledge and experience
- the use of conceptual models and theories to make sense of the observed diversity of natural phenomena
- the assumption that every effect has one or more cause

References

- “Publication & Resources.” WWF, wwf.panda.org/about_our_earth/all_publications/?166941/Bycatch-Factsheet