INQUIRY & INVESTIGATION

Designing a Solution to the Global Problem of Overfishing Using the Engineering Design Process

COURTNEY GOODE

Abstract

Given that science and engineering practices are a large focus in the Next Generation Science Standards, biology teachers need to find ways to incorporate the engineering design process into their curriculum. To address this need, I present a lesson that allows for student collaboration in designing and developing a solution to a global problem resulting from overfishing and our use of unsustainable fishing practices. This lesson also demonstrates to students that larger, global issues that seem insurmountable to solve can be broken down into smaller, more manageable pieces. My approach involves having students research a problem related to sustainable fishing practices and design a physical model of a solution to combat their specific issue. Peer review is then used in order to help students revise and edit their models during the lesson in response to the peer feedback received. The lesson will culminate in a presentation to the class about the biological, social, and economic ramifications of both their assigned problem and a potential solution.

Key Words: *Next Generation Science Standards; NGSS; engineering design process; overfishing; bycatch.*

○ Introduction

The *Next Generation Science Standards* (NGSS) put an emphasis on science and engineering practices while also focusing on student-centered activities and the involvement of inquiry in our lessons (NGSS Lead States, 2013). To many biology teachers, the involvement of engineering in our curriculum is a brand new concept and not something that many of us have training or background in. As the NGSS are rolled out in more and more schools and districts, and teachers begin looking for open education resources for guidance and ideas, it becomes obvious that few lessons geared for the biology classroom that involve engineering are currently available. Many of the lessons that are available incorporate design-based learning (DBL), used to inspire high school students to pursue careers in science or engineering (Apedoe et al., 2008). Studies have found that students involved in DBL classrooms obtained more content knowledge and were better equipped with problem solving and science inquiry skills than those in classrooms using traditional science teaching methods (Kolodner et al., 2003; Silk et al., 2007; Mehalik et al., 2008). Commonly, the engineering design process is taught as a series of steps in which the designers define a problem, conduct background research on it, and specify the requirements for solving it before brainstorming and deciding upon a solution that they will then build and test a prototype for. This prototype will go through testing where modifications can be made until the solution meets the requirements specified earlier in the process. This makes engineering design a much more circular, rather than linear, process (see https://www.teachengineering.org/k12engineering/designprocess). The lesson I present here specifically addresses NGSS performance expectations HS-ETS1-1, HS-ETS1-2, and HS-LS2-7 (Ecosystem Stability and Response to Climate Change; NGSS Lead States, 2013).

I used this lesson as the culmination of units on ecology and human impacts on the ecosystem. To be successful in designing a solution, students should have prior knowledge on the ecological principles of food webs, trophic cascades, predator–prey relationships, and eutrophication in ecosystems. This lesson also requires students to research many different aspects of this biological problem, so students should have strong research skills and access to technology that enables this research. Finally, students should be able to design tests on their solutions that may or may not meet a goal they themselves establish. For these reasons, this lesson is best used later in the year as a culminating assessment for a larger ecology or human impacts unit.

○ Background

The old adage that there are "plenty of fish in the sea" no longer applies to the world in which we live. Increased fishing pressure, coupled with destructive fishing practices, has led scientists to estimate that 70% of the world's marine fisheries are either fully

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exploited or overfished (FAO, 2014). Since the 1980s, advances in fishing technology have increased the potential to catch larger quantities of fish more efficiently. Additionally, the commercial demand for fish has increased, sending out more boats to target fish stocks that have been depleted as a result of the increased efficiency. This increased technology and demand have together resulted in a reduction of almost 700,000 tons of fish landings worldwide each year (Watson & Pauly, 2001). In addition to the depletion of marine fish stocks, the destructive fishing practices used have also contributed to habitat destruction as well as unemployment and socioeconomic implications for the many people who rely on the fishing industry for business (Watson & Pauly, 2001). Some 200 million people worldwide are estimated to rely on the seafood industry for their livelihood, and these are the people most at risk if the seafood industry continues this downward spiral (Tuan, 2003). We could very well be the last generation with seafood on the menu – some scientists estimate that menus could be devoid of seafood, due to a lack of available fish, as early as 2048 (Biello, 2006).

The various methods used in the fishing industry typically depend on the type of seafood targeted, as well as on where and how it lives. Four common fishing methods used (and focused on for the purpose of this lesson) include purse seines, gill nets, longlines, and bottom trawls (for descriptions of each, see Appendix 3). Each of these methods catch and kill species not targeted by the fishery (bycatch) and add to the global problem of ghost fishing (described in Appendix 3).

Overfishing can commonly be seen as an insurmountable global issue, but to date, many solutions to address smaller issues contained within the umbrella issue of overfishing have been addressed and deemed successful. One proposed solution has come in the form of newly designed fishing gear such as turtle exclusion devices, which consist of a grid of bars at either the top or bottom of a trawl net that, when struck by larger animals such as sea turtles, sharks, and marine mammals, collapses into an opening that releases the animal before drowning (NOAA Fisheries, 2015). Other solutions have addressed the issue from an education standpoint such as the Monterey Bay Aquarium Seafood Watch App. The Seafood Watch Program was created in 2000 (https://www.seafoodwatch.org) and originally began as pocket guides, but has since evolved into apps for smartphones that raise public awareness in regard to sustainable seafood. Exit surveys showed that 92% of visitors who took a pocket guide during their aquarium visit agreed that they were now more likely to make sustainable seafood choices and select seafood labeled "environmentally responsible" over other options when dining out or shopping for seafood at grocery stores (Kemmerly & Macfarlane, 2009). Even the idea of farming our own fish (known as aquaculture) has been proposed but, in many cases, has created more issues than it solves (for a description of these issues, see Appendix 3).

Overfishing of the world's oceans can seem like an unsolvable problem when viewed on such a large scale. However, this lesson is evidence that when larger issues are broken into smaller, more manageable problems, a variety of solutions can often become clearer.

○ Materials & Resources Needed

For every group of three or four students, provide a variety of materials that they can use for creating their model. Materials provided may include frozen dessert sticks, craft pom poms, toothpicks, craft "fun foam," cups, yarn, straws, pipe cleaners, hot glue, liquid glue, construction paper, tape, cardboard boxes, scissors, paper plates, etc. Students are also welcome to bring in additional materials as they advance in their design process. Students will also need access to computers for research purposes.

○ Procedure

This lesson guides students through the engineering design process (Figure 1) to create a new solution to an existing problem (from the list provided below) within the larger context of overfishing. Students will work in groups to research their specific overfishing problem and present their problem and model as a possible solution to the class, explaining how their model would work while considering economic, social, and biological ramifications of implementing their design. To start, create groups of about four students each. Allow each group to choose, from the following list, a smaller problem that is created by the larger issue of overfishing:

- Bycatch of marine turtles
- Bycatch of marine mammals

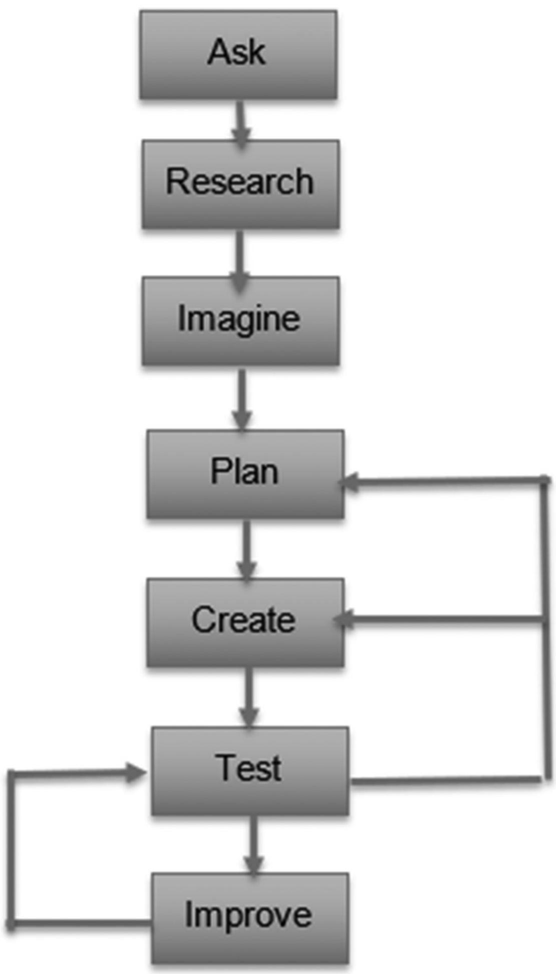

Figure 1. A flowchart for the engineering design process. It is important to note that the process is ongoing, and it is often necessary to revisit previous steps during the process. This is just one example of the repetition of steps that may need to take place.

- Increased algal growth on coral reefs
- Devastation of habitat by trawling
- Ghost fishing
- Illegal and unregulated catch amounts
- Lack of protection/regulation of Marine Protected Areas
- Eutrophication of aquaculture farms
- Antibiotics in fish in aquaculture farms
- Aquaculture taking up too much coastal space
- Bycatch from purse seines
- Bycatch from trawling
- Bycatch from longlines
- Bycatch from gill nets

Students will then work through the steps of the engineering design process to create their solution. A worksheet that leads them through the steps and allows them a place to record their thoughts is provided in Appendix 1.

(1) Ask/Empathize Part 1: Identify the Needs and Constraints

Students should understand the need for improvement within their given conservation issue and identify the constraints that currently exist.

(2) Research the Problem/Empathize Part 2

Students should conduct research on

- the social impact of their problem (how will this affect different cultures in different areas of the world?) and the social impact of their potential solution (to be completed after they choose a solution);
- the economic impact of their problem and the economic impact of their solution (e.g., what is the cost to fishermen if your solution involves replacing all of their fishing gear with new equipment?);
- the ecological impact of their chosen problem (e.g., what species might be lost if the problem is not addressed?); and
- a solution that is already in place to solve their problem (could be a legislative solution, not necessarily a physical device; however, the solution must be an actual physical design, not just legislative changes, and they must include this in their final presentation).

(3) Imagine: Develop a Possible Solution

Students should brainstorm many possible solutions. This brainstorm session could take the form of the group having sticky notes and writing their ideas down on as many sticky notes as possible in a given time frame. Encourage creativity during this phase and tell the students that there are no bad ideas at this stage in the process.

(4) Plan: Select a Promising Solution

Students should discuss the constraints and possibilities of all the solutions laid out on the sticky notes. They should do this by creating their own decision matrix for the group's top five solutions (Table 1). In this decision matrix, they should include four or five constraints in the top columns (e.g., cost, time to build, ease of build, interest level) and a ranking system of 1–5, where 1 is the worst case and 5 is the best case (for example). The students will then rank each of the five solutions in each of the five constraint categories they listed using their scale and total the points for each solution on the right. They should then decide on one solution (with the highest assigned points value) to move forward with. A copy of this decision matrix should be included in their presentation.

(5) Create: Build a Prototype

Students must draw out a blueprint for the model they will create. They must then build the model, using materials given in class or materials they brought from home. The model does not actually have to function but must be a representation of what a functional model would look like. When possible, students should test their prototype on plastic toys (fish, turtles, sharks, etc.) in a bucket to see if their design actually reduces bycatch or addresses the solution they are working on. If time permits, have students set up a measurable goal to test (e.g., "our design will reduce turtle bycatch by 15%") and see if their model can meet that goal. Students should then be allowed to redesign until the goal is met. Similar goals and trials can be set up for many of the non-bycatch-related issues as well.

(6) Test and Evaluate Prototype

Before the presentations, have a day for peer review during which students will round robin to other groups, hear a short presentation of the model, and offer support/guidance. In my classroom, I included this peer feedback given to other groups as a portion of their overall grade on the presentation. I was able to listen to each group give advice and ask clarifying questions to the group that presented.

Table 1. Example decision matrix.

Idea	Cost	Ease to Build	Time to Build	Interest Level in Solution	Total
Dissolvable nets	1	1	1	4	7
App to educate consumers	2	2	1	4	9
Sound on nets	1	2	2	1	6
Device to allow escape	2	3	3	3	11
Robot to survey area	1	1	1	5	8

This kept them on task during this process. Students could also do this on sticky notes and leave them on the table for the group to review afterwards. Consider providing the students with guiding questions or sentence starters to help with this process. Give the students a color code using yellow sticky notes for positive feedback, blue sticky notes for questions, and green sticky notes for things the group should consider (constructive feedback). Each student must leave at least one of each sticky note at the table during a presentation for peer review.

(7) Improve: Redesign as Needed

Give the students a day to edit/refine their models after the peer review process and before their presentation to the class. The feedback they received and how they addressed it in their model must be addressed in the presentation.

Students will conclude the lesson by presenting their research on their problem and solution, their model, and the edits they addressed after peer feedback. A rubric with suggestions for how to grade this presentation can be found in Appendix 2. A table representing some previous or possible examples from students is included in Appendix 3 along with some applicable testing strategies for teacher reference.

○ Conclusion

My students really enjoyed the ability to delve into a potentially manageable piece of the overfishing problem, as well as having the creative freedom to come up with a way to solve the problem. Some leniency must be allowed for the students' understanding of current and potential technology, and they must be allowed a certain amount of creativity during this process. This leniency might not be as necessary in a class that can spend longer on this DBL unit as a whole and where technology (and researching potential technology) might be a larger focus, but we have limited time (one week) for ours. Students not normally engaged in class during traditional periods seemed far more engaged and productive as group members during this unit. The inquiry and many facets of this lesson also allowed students to work toward their strengths, and they all seemed far more confident in their final product.

In terms of learning outcomes, this lesson was evaluated for its effectiveness in raising awareness about concerns related to seafood sustainability. A mixed-method questionnaire was given in person to 106 students on day 5 of the lesson progression. The lesson was effective in raising awareness in >50% of the students regarding the Monterey Bay Aquarium's Seafood Watch app as a potential solution to global overfishing. The Seafood Watch app was given as an example to students as a possible solution to overfishing in the introduction of the project. The lesson was equally effective in raising awareness about seafood sustainability in both students that identified as recreational fishermen and non-fishermen, in that >50% of the students in both categories increased their knowledge about seafood sustainability as determined by a two-sample z-test.

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COURTNEY GOODE is a teacher at Sage Creek High School, Carlsbad CA 92010, and a graduate of the Advanced Inquiry Program through the University of Miami and San Diego Zoo Global; e-mail: cgoode@carlsbadusd.net.

Appendix 1: Engineering a Solution to Overfishing Student Handout

Name: ____ Period: ____________

Background: For years, our unsustainable fishing practices have been depleting our oceans of fish and destroying fragile and valuable marine ecosystems along the way. In this activity, you and your group will undergo the engineering design process steps to come up with your own, creative and unique solution to address a small component of the global overfishing problem. You must consider economic, social and cultural impacts of both your problem and your accompanying solution. You will design a prototype of your solution and present it to the class. Your presentation will be modeled after a pitch your group would make to an agency such as the National Science Foundation (NSF) who might be interested in funding your design and creating the product.

Problems: The following is a list of overfishing-related problems. You and your group of no more than 4 individuals will choose one of the following to be the focus of your research and your solution:

- Bycatch of marine turtles
- Bycatch of marine mammals
- Increased algal growth on coral reefs
- Devastation of habitat by trawling
- Ghost fishing
- Illegal and unregulated catch amounts
- Lack of protection/regulation of Marine Protected Areas
- Eutrophication of aquaculture farms
- Antibiotics in fish in aquaculture farms
- Aquaculture taking up too much coastal space
- Bycatch from purse seines
- Bycatch from trawling
- Bycatch from longlines
- Bycatch from gill nets

The process: You will then work through the steps of the engineering design process to create your solution:

1. Ask/Empathize Part 1: Identify the Needs and Constraints – Identify the need for improvement within your given conservation issue and identify constraints that currently exist.

    Needs:

    Constraints:

2. Research the Problem/Empathize Part 2 – Conduct research on:

    (a) The social impact of your problem. For instance, how will this problem affect different cultures in different areas of the world if left untreated?

    Research notes:

    (b) The economic impact of your problem. For instance, what is the cost to fishermen if this problem continues? What is the cost to the country in terms of goods/services/travel losses if the problem worsens?

    Research notes:

    (c) The ecological impact of your problem. For instance, what species/habitat could we potentially lose if this problem continues?

    Research notes:

(d) A solution that is already in place to solve your problem (could be a legislative solution, not necessarily a physical device; however, your solution must be an actual physical design, not just legislative changes). All of this research must be included in your final presentation.

Research notes:

3. Imagine: Develop a Possible Solution – Brainstorm as many possible solutions as you can below. At this stage in the design process, there are no bad ideas. This is done individually. Write down your top 5 ideas after the brainstorm session.

4. Plan: Select a Promising Solution – Discuss the constraints and possibilities of all the solutions brainstormed above with your group using a decision matrix that you as a group design and work through. Choose the solution with the highest score.

   (a) Write your solution below.

   (b) Research – What are the economic and social impacts of your solution? For instance, what is the cost to fishermen if your solution involves replacing all of their fishing gear with new equipment?

5. Create: Build a Prototype – Draw out a blueprint for the model you will create below. Label the materials you will use on your diagram. You must show me this design before building the prototype. The model does not actually have to function, but it must be a representation of what a functional model would look like. An image of this blueprint must be included in your presentation.

6. Test and Evaluate Prototype – If possible, test your model using the materials. Set a goal for how well you want your design to perform and see if it meets that goal. If it doesn't meet that goal, redesign and edit until it does. If testing your design is not possible, then after peer review, what are some components that you might need to edit/address before your presentation?

7. Improve: Redesign as Needed – Make edits/adjustments/modifications to your prototype before the presentation.

Appendix 2: Rubric for Presentation & Model

Component	5 – Stellar	4 – Well Done	3 – Moderate	2 – Limited	1 – I Need Help!
Research on biological/ social and economic impacts of *issue* considered	Research includes a detailed discussion of the biological importance of their issue as well as social and economic impacts to the local communities if the issue should continue. Cost associated with problem is presented.	Research includes discussion of the biological importance of their issue as well as social and economic impacts to the local communities if the issue should continue but could include some more details for one or more of the impact areas. Cost associated with problem is presented.	Research includes discussion of the biological importance of their issue as well as social and economic impacts to the local communities if the issue should continue but lacks details on more than one of the impact areas. Cost associated with problem is presented.	Research is missing a discussion of one of the impact areas (either biological, social or economic). Cost associated with the problem is not presented.	Research is missing for two (or more) of the impact areas (either biological, social or economic). Cost associated with problem not considered.

(continued)

Continued

Component	5 – Stellar	4 – Well Done	3 – Moderate	2 – Limited	1 – I Need Help!
Research on biological/ social and economic impacts of *solution* considered	Research includes a detailed discussion of the biological importance of their solution as well as potential social and economic impacts to the local communities. Cost associated with solution is presented.	Research includes discussion of the biological importance of their solution as well as social and economic impacts to the local communities but could include some more details for one or more of the impact areas. Cost associated with problem is presented.	Research includes discussion of the biological importance of their solution as well as social and economic impacts to the local communities but lacks details on more than one of the impact areas. Cost associated with problem is presented.	Research is missing a discussion of one of the impact areas (either biological, social or economic). Cost associated with the solution is not presented.	Research is missing for two (or more) of the impact areas (either biological, social or economic). Cost associated with the solution is not considered.
Design/ blueprint of solution model	Blueprint/ drawing is detailed and created prior to model. Blueprint image included in presentation.	Blueprint/ drawing created prior to model but lacks detail. An image of the blueprint was included in presentation.	Blueprint drawing was created prior to the model but was not included in the presentation.	Blueprint/ drawing is done but lacks details. Blueprint image not included in presentation.	No blueprint/ drawing was created and was not included in the presentation.
Peer feedback	Thoughtful peer feedback was given and followed the directions.	Peer feedback was given and followed the directions but lacked details in terms of constructive criticism.	Peer feedback was given but only clarifying questions were asked. Limited on constructive criticism.	Only positive feedback with no constructive criticism or clarifying questions were given.	No peer feedback was given to the other group.
Solution model	Model is detailed, organized and all peer feedback was addressed.	Model is organized but lacks detail. Peer feedback was addressed.	Model meets the bare minimum requirements in terms of details and peer feedback was addressed.	Model is not finished and peer feedback is not addressed.	No model is presented.
Visual presentation quality (Google Slides, PowerPoint, Prezi)	Presentation given is clear, concise and short bullets are used to make statements.	Presentation given is clear, concise and short bullets are used to make statements.	Presentation given is clear, and moderately long (wordy) bullets are used to make	Presentation given is unclear, and moderately long bullets are used to make statements.	Presentation given is unclear, and long bullets are used to make

Continued

Component	5 – Stellar	4 – Well Done	3 – Moderate	2 – Limited	1 – I Need Help!
	Graphics/images are used in an appropriate manner. Presentation is professional.	Graphics/images are used in a good manner. Presentation is professional.	statements. Graphics/images are used in a good manner. Presentation lacks professional quality.	Graphics/images are used in a fair manner. Presentation lacks professional quality.	statements. Graphics/ images are not used. Not professional in appearance.
Team presentation (5–8 minutes)	Every student speaks clearly and loudly using appropriate grammar. Information is presented in a succinct manner. Presentation is 5–8 minutes long. No reading off of slides or notes.	Every student speaks clearly, good grammar is used and presentation is given in a clear manner. Presentation is 5–8 minutes long. Minimal reading off of slides or notes.	Every student speaks clearly, with good grammar used. Presentation is given in a somewhat clear manner. Presentation is over or under 5–8 minutes long. Some reading off of slides or notes.	Every student speaks with some grammar mistakes presented. Information is presented in a somewhat clear manner. Presentation is over or under 5–8 minutes by a large margin. Dependent on notes or slides.	One (or more) students do not speak during presentation. Grammar used is poor and information presented is often unclear. Presentation is over or under 5–8 minutes by a significant margin. Dependent on notes or slides.
Creativity	Solution presented is creative, unique, and unlike any solution already proposed for this issue while still maintaining feasibility.	Solution presented has some creative qualities but may have similarities with other solutions already in place, or is not feasible.	Solution presented lacks creativity or is so far-fetched it is not feasible. Solution has similarities to others already in place.	Solution presented involves a less-than-creative approach or is too similar to other solutions already in place.	Solution presented is a copy of a solution already in place.
Works cited	A minimum of 3 references are cited in proper APA format and referenced in the presentation with in-text citations.	3 references are cited, most in proper APA format, and referenced in the presentation with in-text citations.	Less than 3 references are cited in proper APA format and referenced in the presentation. No in-text citations presented.	Less than 3 references are cited and referenced in the presentation, but not in proper APA format. No in-text citations presented.	No references are cited or referenced in presentation.

Appendix 3: Table of Overfishing Issues & Possible Student-Generated Solutions to Those Issues

Issue to Be Addressed	Short Description of the Issue	Possible Solution	Possible Means to Test Solution
Bycatch of marine turtles	Undesired catch of sea turtles across all fishing methods.	Students created an app meant to educate others about turtles. They created multiple subpages to educate people about fish they eat that might be a threat to sea turtles due to fishing methods to decrease demand of those fish.	Students tested an app prototype on others in the class and deemed success via pre- and post-surveys.
Bycatch of marine mammals	Undesired catch of marine mammals across all fishing methods.	Use of sound to deter mammals. Use of observer on vessel. Devices that passively listen to mammals nearby.	Not entirely testable in a classroom setting. Students must research the hearing range of the mammals and consider how their addition of sound to the ocean might affect other animals. Students should include in their presentation a description of how they would test their devices and what parameters they want each to meet.
Increased algal growth on coral reefs	Removal of grazers due to overfishing allows more algal growth on coral, which harms the growth of the coral reef.	Synthetic reef that "attracts" algal growth away from reef.	Place synthetic reef and "live rock" or coral skeleton in similar conditions and monitor algal growth.
Devastation of trawling on the habitat	Dragging of the trawl on the bottom of the ocean knocks over rock structures and disturbs sediment.	Students devised an array of devices meant to ensnare trawls that would surround rocky structures or areas that should be protected.	Students built their device and a model trawl and tested that their device would ensnare the net and stop trawling.
Ghost fishing	Discarded fishing gear in the ocean continues to trap wildlife.	Robotic devices that clean fishing zones of debris.	Students created their device in a tank and a model of tangled monofilament and used a straw to create suction to model their robot collecting debris. More sophisticated tests may be possible in an engineering class.

Continued

Issue to Be Addressed	Short Description of the Issue	Possible Solution	Possible Means to Test Solution
Illegal and unregulated catch amounts	Some countries are under- or over-reporting their fish catch to alter legal limits.	Students created a scale to be placed in the holding tanks of boats that would communicate with satellites to report catch data.	Not always possible to test in typical classroom conditions but perhaps in an engineering class. Students should include a description of how they would test their prototype and the requirements they want it to meet to be deemed successful.
Lack of protection/ regulation of Marine Protected Areas	Areas created in the ocean with increased take restrictions, but laws cannot always be enforced across large spaces.	Students created a buoy array with cameras/ sensors that would detect when boats entered the area.	Not always testable in typical classroom situations but perhaps in an engineering class. Students should include a description of how they would test their prototype and the requirements they want it to meet to be deemed successful.
Eutrophication of aquaculture farms	Aquaculture farms are built on coastal space where the addition of nutrients (from fish feces) can runoff into local waters and cause algal and bacterial blooms.	Students created a seaweed farm nearby to filter the excess nutrients.	Students tested algae from a local pet shop in a tank to determine if it filtered nutrients commonly found in fish farms using nitrate and phosphate test kits.
Antibiotics in fish in aquaculture farms	Many aquaculture farms feed the fish antibiotics to combat the eutrophication issue.	Students create devices meant to sweep the tank and collect the excrement. What they collect is generally used as fertilizer for surrounding farms.	Students created a model of a fish tank with another holding tank where fish can be placed while cleaning is occurring. They demonstrated the sweeping of the original tank and collection of the materials.
Aquaculture taking up too much coastal space	Large expanses of valuable coastal space are taken up by aquaculture farms and their need to be close to the ocean waters.	Students created a vertical farm.	Depending on resources, this may not be feasible to test in a typical classroom. Students can build models, but testing can be difficult. Students should include a description of how they would test their prototype and the requirements they want it to meet to be deemed successful.

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Continued

Issue to Be Addressed	Short Description of the Issue	Possible Solution	Possible Means to Test Solution
Bycatch from purse seines	Purse seines catch large schools of fish but also other species that are swimming in the area by encircling the school with a net that cinches at the bottom. Many times, nets are set on other animals that can easily be seen from the surface as an indication that the desired fish species is in the area (NOAA Fisheries, 2019b).	Students focused on sharks specifically for this issue but researched a chemical that deters sharks and is safe in the ocean. They then created "bath bomb"-type devices that can be used while fishing.	Students are not able to get the actual chemical but did model a "bath bomb"-type device that dissolved in the water while fishing. Students should include a description of how they would test their prototype and the requirements they want it to meet to be deemed successful.
Bycatch from gill nets	A gill net is an upright net in the water column with a mesh size large enough to entrap targeted fish species by their gills. Any animal that is swimming with a head that will fit through the mesh of the net will be caught and drown/suffocate (NOAA Fisheries, 2019a).	Students created an app meant to educate consumers about what gill nets are and the bycatch they create.	Students created a model of the app and tested the app on students in the class. Success was determined via pre- and post-survey of those that used it.
Bycatch from longlines	Longlines are one main fishing line that can be miles in length with extender lines with baited hooks placed at regular intervals. Baited hooks on longlines attract and hook anything that eats that bait (NOAA Fisheries, 2017).	Students created hook covers that deploy when the larger mouth of a turtle or shark tries to take the bait.	Students created different-sized mouths and their hook covers and tested if their device would lower to cover the hook when different-sized mouths attacked the bait.
Bycatch from trawls	A bottom trawl is a weighted net on rollers on the bottom and flotation on the top of the net to hold it open. These nets are then dragged across the seafloor as the boat slowly motors forward. These trawls catch anything that fits in their net and is in their path, as well as destroying the habitat (NOAA Fisheries, 2018).	Since trawling is commonly used for shrimp, students designed a structure with lights – one that attracts shrimp and one that deters them – based on research they found.	If ethics and time permit, students could test the lights on shrimp in a small tank to determine if they are indeed attracted to one and deterred from the other.