# Seas Get Degrees

**Target Grade:** Elementary/Middle School
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**Semester**: Fall 2019

## Brief Overview

Water covers 75% of the Earth's surface, and it is estimated that humans have only explored around 5% of the ocean. We actually know less about our oceans than we know about our solar system! The ocean is home to millions of different species that are constantly interacting with one another. However, the ocean ecosystem is under constant stress from human activity that includes ocean acidification, temperature rise, overfishing, coral destruction, and pollution. In this lesson, mentees will explore the effects of human activity on the food web as well as model some of the simplest organisms in the sea, plankton. If you would like to learn even more about the ocean and all of its inhabitants, be sure to check out some of the references at the end of the lesson!

## Teaching Goals

- The **food chain** is a map of how organisms depend on one another for food. Species of organisms are interconnected, and overpopulation or loss of a species can majorly disrupt the entire food chain
    - **Food webs** are groups of food chains interconnected to model a larger ecosystem
    - Food webs are *delicate*: detrimental or beneficial effects on one level cause changes that cascade up and down the other levels
- **Microplastics** and other contaminants in the ocean are passed up through the food web
    - The increase in concentration of toxins in higher levels of the food web is called **biomagnification**
- Drifters such as plankton do not want to sink to the ocean floor where they would be rendered immobile, and need to maintain **neutral buoyancy**
- **The Engineering Design Process**, the process of planning, designing, and improving that engineers utilize in creating their products

## Careers and Applications

Marine biology is a very broad field that can range from studying photosynthesis in phytoplankton to tracking migration patterns in pods of whales. At the moment, we know less about our oceans than we do about our own solar system. There appears to be no limit to the diversity of life within the marine biome, but human activity such as overfishing and pollution have left lasting, detrimental effects on many species that could become irreversible if actions are not taken.

# Agenda

- Introduction
- Module 1: The World Wide Food Web (15-20 min)
- Module 2: Something's Fishy (10 min)
- Module 3: You Are What You Eat (10 min)
- Module 4: The Great Plankton Race (15-20 min)
- Conclusion

# Introduction

Ask mentees what their favorite sea creature is, and tell them that this lesson focuses on the ocean and the creatures within it. We will also talk about some of the detrimental effects that humans have left on the marine biome. Jump right into the first module.

# Module 1: The World Wide Food Web

## Introduction

Mentees will learn about food chains and food webs, which help to track the movement of energy through an ecosystem, and work together to design a food web.

## Teaching Goals

1. **Food Chain:** A map of organisms connected based on their dependence on each other for food
    a. **Food web:** A group of interconnected food chains that model a larger ecosystem
2. **Consumers** are organisms that eat other organisms to survive
3. **Producers** are organisms that can produce their own food through photosynthesis

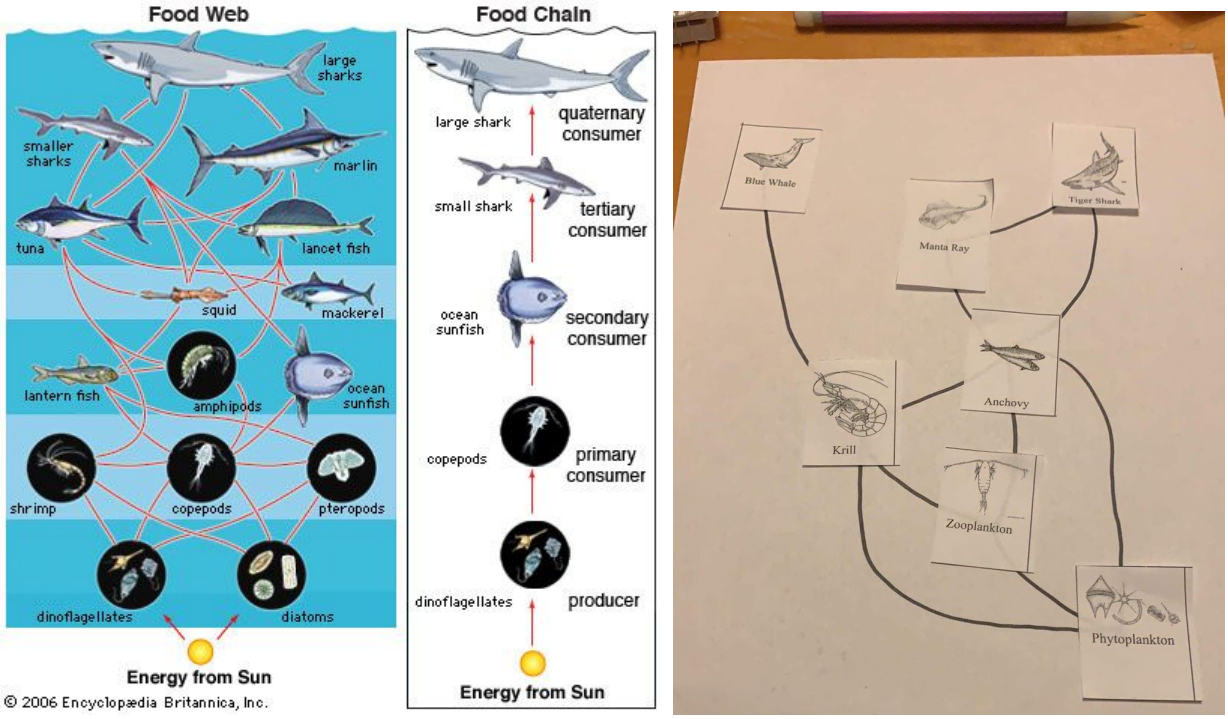
## Background for Mentors

A **food chain** is a way to map which organisms eat one another in a hierarchy. A **food web** is a combination of multiple food chains connected together. In a food web, organisms can be a food source for any number of other organisms, or consume any number of other organisms.

Organisms at the bottom of the food web called **producers** (generally much all plants and phytoplankton) synthesize their own food and tend to be a food source for many species. Their energy (and thus all energy for the food web) originates from the sun. **Consumers** are

organisms that eat other organisms to sustain themselves. As you traverse higher up through the food web, you'll find carnivores and hunters such as bears, eagles, lions, and humans.

The world's largest food web spans the marine ecosystem. The ocean makes up 75% of the Earth's surface and is home to an estimated 1.5 million species, which scientists speculate could even be upwards of 25 million! The diversity of our oceans leads to many unique food webs, each one differing by region and depth.




**Figures 1 and 2:** Example of a marine food web and food chain, and an example of what our completed food web should look like

## Materials

- 1 piece of Blank Printer Paper per group of 3-4 students
- 1 set of Paper Cutouts per group
- 2 rolls of Tape per site
- 2 rolls of String per site

## Procedure

1. Ask mentees if they know what a **food chain** is, and if they do, go a step further and ask about a **food web**, describing what they look like along the way.
2. See if you can get mentees to give an example of a simple 3-4 organism food chain beginning with grass. For example, grass gets eaten by grasshoppers, which get eaten by mice, which can get eaten by owls.
    a. Explain that grass is the **producer** and the other organisms are **consumers**, and that all energy originates from the sun.

3. Have mentees get into groups of 4 and pass out sets of organism print outs. Mentees should use string and tape to put the print outs onto a piece of paper to form a proper food web, with string acting as the connection between a consumer and its food.
    a. Producers should be at the bottom of the paper, and higher level consumers should be at the top.

**Additional Notes for Mentors**

If mentees do not understand what plankton are, explain to them that plankton are tiny, microscopic organisms that make up the producers (phytoplankton) and primary consumers (zooplankton) of the food web (we will go into more depth about plankton in module 4). If they have trouble finding connections between animals, try highlighting an existing connection that they made and point out some similarities between certain consumers.

# Module 2: Something's Fishy

## Introduction

Around 50% of fish that we consume come from the ocean, and historically, overfishing has been one of the biggest threats to the marine biome. In this module, mentees will play a game that models the impact that overfishing has on multiple levels of the food web.

## Teaching Goals

1. **Overfishing** is the term for the excessive removal of fish from the ocean, which decreases the available food supply for many consumer species
2. The food web is *delicate* - Detrimental or beneficial effects on one level cause changes that cascade up and down the other levels

## Background for Mentors

About half of the fish that we consume come from ocean fishing (the other half are farmed). **Overfishing** is the term for the excessive removal of fish from the ocean, an issue that can lead to detrimental long-term effects on the food web and the ecosystem as a whole (e.g., if we take too many small fish from the ocean, there will not be enough to feed the larger fish, and then seals, sharks, and other marine life will decrease in a cascading effect).

Essentially, the food web is *delicate*: any event affecting one species of the web (both detrimental or beneficial) will lead to a domino effect on multiple species, whether by direct or indirect means. Overfishing is similar to many events within the terrestrial food web such as dwindling bee populations, poaching of elephants, and removal of areas of the rainforest.

**Figure 3:** Industrial fishing like this leads not only to overfishing, but can also lead to other marine destruction such as ocean pollution and coral destruction

## Materials

- 1 Clothespin per student
- 1 Paper Cup per student
- 60 Beads per group of 4 students
- 1 Aluminum Tray per group

## Procedure

1. Relate back to the previous module and explain to mentees that about half of the fish we eat are fished from the ocean.
2. Ask mentees what they think would happen if we took too many fish from the ocean, and explain the effects of **overfishing**, and the effect that it leaves on the food web.
    a. The food web is *delicate*!
3. Split mentees into groups of 4 and give each group the materials. Explain that they will be sharks “hunting” for fish, modeled by the beads.
4. Have mentees fish out as many beads as they can with the clothespins, putting the beads into their cups. At the end of a 30 second round, any sharks that have at least 10 beads have survived. Take a poll of the class and count how many sharks survived. Have them return the beads to the tray.
5. Run 3 more rounds, removing 10 beads each time as a comparison to the effects of overfishing.
6. At the end of the 4 rounds, note the number of surviving sharks as an effect of fewer fish being available.

**Additional Notes for Mentors**

Be sure to emphasize that the main focus is on the total number of sharks that survive and not necessarily the group competition aspect. It is important to relate these numbers back to the real world, explaining that similar effects happen whenever an ecosystem is damaged by human activity. There are many, many more examples than overfishing.

# Module 3: You Are What You Eat

## Introduction

In this module, mentees will learn about what happens to trash, especially plastic, that ends up in the ocean. This classroom game will model the effects of microplastics in the food web and how it can all circle back to humans.

## Teaching Goals

1. **Microplastics** are tiny pieces of broken down plastic that result from litter and can end up inside of fish and other organisms
2. **Biomagnification** is the concentration of toxins, such as plastics, within an organism as it consumes more low-levelled organisms

## Background for Mentors

The ocean is facing a major case of invasion, and not by animal or plant - plastic pollution is a serious threat to marine sustainability and biodiversity. Plastic has been able to spread everywhere throughout the ocean, a fact that only became more alarming in 2018 when a deep sea exploration found a plastic bag in the Mariana Trench, the deepest point of the known ocean at a depth of 11,000 meters. Currently, the most significant area is The Pacific Garbage Patch, an area estimated to be at least the size of Texas that has high concentrations of plastics and other trash due to patterns in ocean currents. While only making up around 8% of its mass, small particles called **microplastics** make up around 94% of the pieces within the patch.

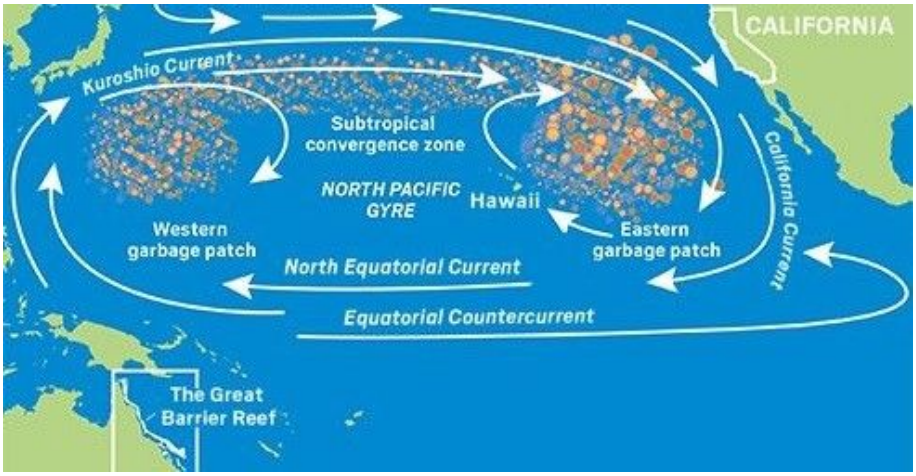



**Figure 4:** The currents that collect trash and lead to the formation of the Pacific Garbage Patch

Microplastics are classified as any plastic pieces smaller than 5 millimeters, and are generally the result of common items such as water bottles being broken down over time by ocean waves. Microplastics also used to be found as tiny beads in products such as hand sanitizers, lotions, and other personal care products in a form often referred to as “microbeads,” but multiple laws since 2015 have banned them. Microbeads were especially dangerous as they were produced as extremely small pieces and could easily be washed off into drains and other runoffs, where they could directly reach oceans or other bodies of water.

Plastic pollution and microplastics have been tracked heavily and can be found throughout the food web. A study found that krill were eating microplastics, mistaking them for plankton. Krill are a major source of food for many organisms like small fish and jellyfish, and eventually plastics make their way up into the upper levels of the food web. However, since plastics cannot be burned off as energy (as food can be), they never truly leave the body. This leads to **biomagnification**, where the concentration of microplastics becomes greater as you move up each level of the food web, an effect that circles back up to humans, the top of the food web.

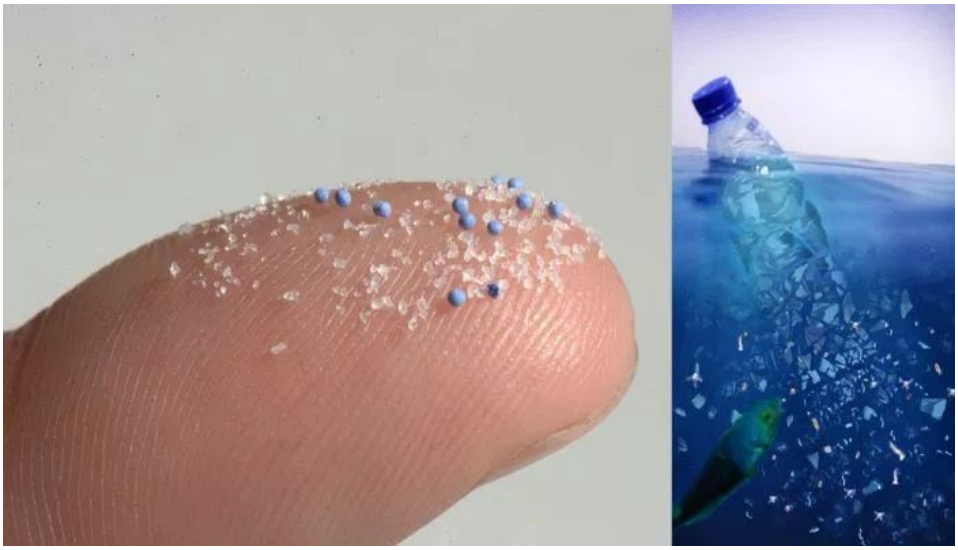


**Figure 5:** Different forms that microplastics can take within the ocean waters

## Materials

- 1 Small Paper Cup per student
- 1 Red Bead per student
- 5 Blue Beads per student

## Procedure

1. Ask mentees if they know what happens to plastic and other litter that ends up in the ocean (it gets broken down into smaller, microscopic pieces over time), and explain what **microplastics** are and the difficulty involved in cleaning them up.
2. Explain that the more food an animal eats, the more microplastics will end up inside of it

(*Will a small fish or a seal have more microplastic inside of it? The seal.*). Explain the term **biomagnification** and how microplastics come full circle to hurt humans.

3. Hand out small paper cups with 1 red bead and 5 blue beads in them. Explain that they are animals in the food web, and the cups are what they have eaten. Blue beads are food that can help them grow and survive, but red beads are microplastics they have accidentally consumed, and can never be removed from an animal.
4. Have the mentees play a single game of rock-paper-scissors against one other mentee. The winner has "eaten" the loser. Have the winner pour all the beads into their cup. The mentee who lost should now follow the winner around and cheer them on!
5. *There's a catch!* Each time mentees tie, they both have to remove one BLUE bead from their cups and give it to a mentor. This models an animal using energy (for example, when you run, you lose weight because fat is converted into energy that your body uses). If a mentee runs out of blue beads, they don't have to remove any more during ties.
6. Once a round has commenced, tell mentees that the winners are "higher up in the food web," and repeat steps 5 and 6 until there is a winner.
7. When there is one mentee left, this mentee is "the top of the food web." However, make sure mentees notice that as the rounds go on, the concentration of microplastics (the amount of red beads) increases up the food web, modelling **biomagnification**.

**Additional Notes for Mentors**

For sites with fewer mentees, the number of beads in each cup should be increased. You can also make the game longer by playing "best of three" or by having mentors play in the first round as well (in the case that a mentor wins, just have the mentee move up the food web instead). This module could become relatively rowdy and loud, so be sure to encourage mentees to support the winners without being too wild and disruptive of activities going on in nearby areas.

## Module 4: The Great Plankton Race

### Introduction

Mentees will learn about neutral buoyancy, a term that describes how plankton and other tiny organisms are able to drift around the ocean. They will than get to create their own plankton and compete to see which plankton has the best drifting ability.

### Teaching Goals

1. **Plankton** are tiny marine organisms that make up the bottom of the marine food web
2. **Neutral buoyancy** is the ability of plankton and many tiny organisms to drift through the ocean, neither sinking nor floating
3. **The Engineering Design Process**, the process of planning, designing, and improving that engineers utilize in creating their products

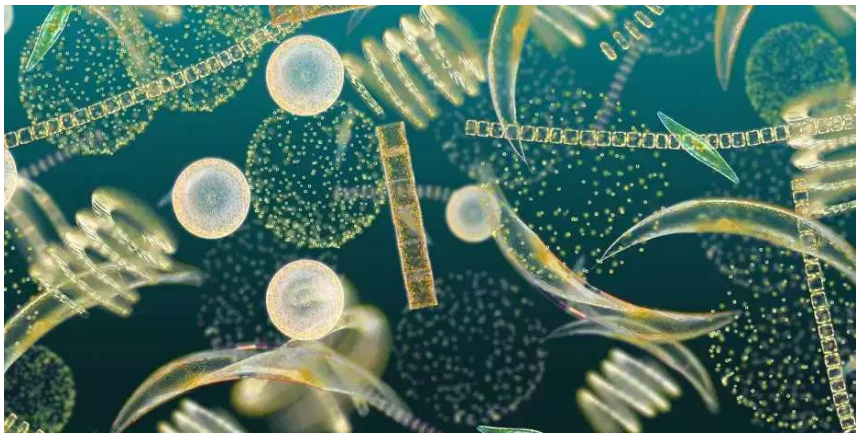
### Background for Mentors

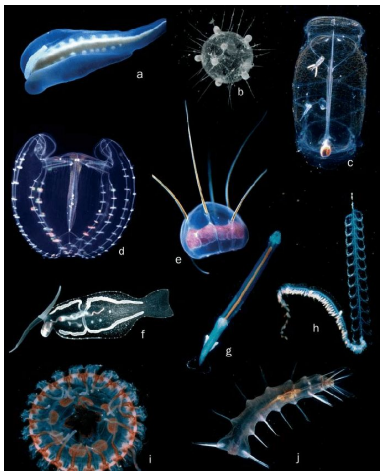
**Plankton** is a general term for the collection of thousands of species of microscopic organisms

that make up the bottom of the marine food web. They are generally weak swimmers and mostly rely on ocean currents to move around within the ocean. In fact, the name “plankton” comes from the Greek “planktos,” roughly translates to “drifter” or “wanderer.” The term **neutral buoyancy** refers to their characteristic of neither sinking nor floating in ocean water. In general, ocean currents and turbulence cause plankton to sink, but plankton require sunlight to function, and must remain near the ocean’s surface. Phytoplankton are able to decrease their density by producing oxygen during photosynthesis, but sink a bit during the night when they cannot photosynthesize. Zooplankton have various ways to avoid sinking. A common example is the ability to alter their shape to increase or decrease their surface area, also altering their density.

There are two main types of plankton. The first type is the phytoplankton, which produce food for themselves through photosynthesis, making up the producers of the marine food web. Phytoplankton are not only important as sources of food, but are also responsible for producing an estimated 50-80% of the world’s oxygen! Zooplankton, the other major type of plankton, are considered the “animal” type of plankton, consuming smaller phytoplankton or zooplankton for food. Plankton are also considered primary food sources for many other organisms near the bottom of the food web such as krill and small fish. When they die, plankton sink and can become food for deep-sea dwellers, but only around 1% reach depths of 1000 meters, explaining why the population density of organisms is much greater near the surface.

The marine food web, the largest food web in the world, would not be able to exist without plankton forming a solid foundation. However, they too are facing threats from both ocean acidification and rising ocean temperatures.






**Figures 6 and 7:** Examples of phytoplankton and zooplankton, which as essential for all life on Earth, whether directly or indirectly

## Materials

- 1 Bucket per site
- 3 Pairs of Scissors per site
- 8 Beads per group of 4 students

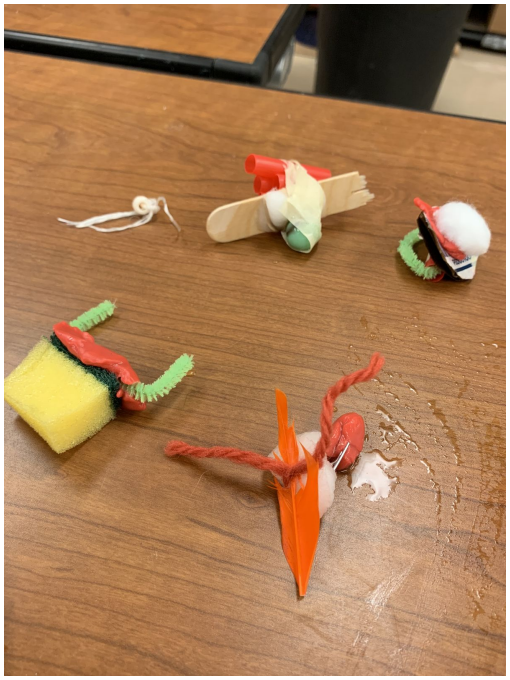
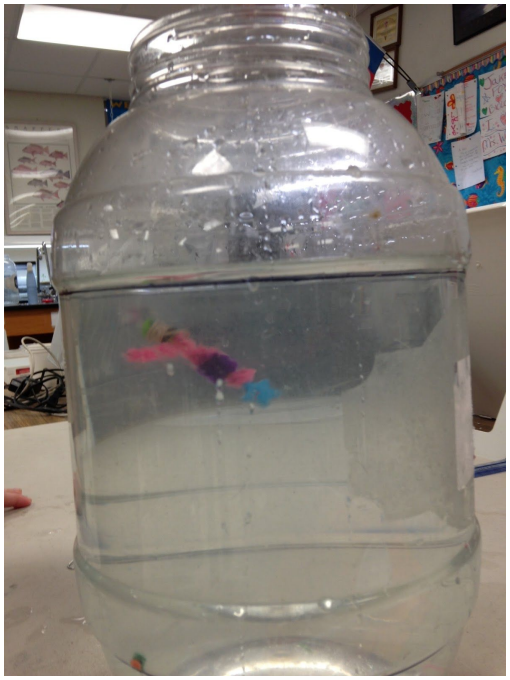
- 8 Cotton Balls per group
- 3 Craft Sticks per group
- 4 Googly Eyes per group
- 2 Marbles per group
- 2 Rolls of Masking tape per site
- 3 Pipe Cleaners per group
- ¼ Tub of Play Doh per group
- 2 Rubber Bands per group
- 1 Small Paper Cup per group
- 4 Paper Clips per group
- 2 Straws per group
- 1 Roll of Wire per site
- 2 Rolls of String per site

## Procedure

1. Ask mentees if they know what plankton are, and be sure to emphasize **(a)** the importance of plankton as the **base of the food web** and **(b)** that some plankton cannot control their own movement and rely on ocean currents to move.
    a. Be sure to explain the concept of **neutral buoyancy**, and how it relates to **density**.
2. Hand out materials to groups and explain that a plankton "race" will involve trying to create a plankton that will sink as slowly as possible. Each group may make multiple plankton with their given materials.
    a. Be sure to emphasize the fact that plankton come in thousands of shapes and sizes, so there is no single right way to build a plankton.
3. Have mentors drop plankton into the bucket of water to minimize water messes. The plankton that takes the longest amount of time (measured in seconds) to sink to the bottom of a bucket of water wins. Timing starts as soon as the plankton starts to sink, and a plankton will be disqualified if it does not appear to begin sinking within 10 seconds of touching the water.

### Additional Notes for Mentors

In general, simpler plankton are better. Materials that can soak up water such as cotton balls are great as they can achieve a density close to that of water when filled. Below are examples of plankton that worked well.

**Figures 8 and 9:** Examples of designs that worked well, and one being submerged

## Conclusion

Ask mentees about what materials worked well for their plankton and what materials didn't, and about their theories as to why. Remind them about the topics of overfishing and ocean pollution and ask them about a few things they themselves can do to help reduce these effects on the ocean.

## References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- What is Biomagnification and How is it Detrimental to Our Health?, WorldAtlas, https://www.worldatlas.com/articles/what-is-biomagnification-and-how-is-it-detrimental-to-our-health.html
- What's Hiding at the Most Solitary Place on Earth? The Deep Sea, Youtube, https://www.youtube.com/watch?v=PaErPyEnDvk

## Summary Materials Table

| **Material** | **Amount per Group** | **Expected $$** | **Vendor (or online link)** |
|---|---|---|---|
| Blank Printer Paper | 1 per group of 4 students | N/A | Inventory |
| Marine Organism Print Outs | 1 per group of 4 students | N/A | Designated Printers |
| Masking Tape | 2 rolls per site | N/A | Inventory |
| String | | N/A | Inventory |
| Clothespins | 4 per group of 4 students | $15.99 + tax | Amazon |
| Paper Cups | 4 per group of 4 students | N/A | Inventory |
| Large Aluminum Trays | 1 per group of 4 students | N/A | Inventory |
| Beads (Blue, Red) | 64 per group of 4 students (60 blue, 4 red) | $9.87 + tax<br>$4.16 + tax | Amazon<br>Blue<br>Red |
| Large Clear Plastic Bucket | 1 per site | $29.94 + tax | Home Depot |
| Cotton Balls | 8 per group of 4 students | N/A | Inventory |
| Craft Sticks | 3 per group of 4 students | N/A | Inventory |
| Googly Eyes | 4 per group of 4 students | N/A | Inventory |

| | | | |
|---|---|---|---|
| Marbles | 2 per group of 4 students | N/A | Inventory |
| Pipe Cleaners | 3 per group of 4 students | N/A | Inventory |
| Play Doh | ¼ tub per group of 4 students | $41.98 + tax | Amazon |
| Rubber Bands | 2 per group of 4 students | N/A | Inventory |
| Paper Clips | 4 per group of 4 students | N/A | Inventory |
| Straws | 2 per group of 4 students | N/A | Inventory |
| Wire | 1 roll per site | N/A | Inventory |
| Scissors | 3 per site | N/A | Inventory |