**Introduction to Biological and Physical Oceanography**

Katherine (Hudson) Gallagher, PhD

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**Course Description:**

In this course, we will explore the physical and biological components of the feature that makes up a majority of the surface area of the planet – the ocean. This course is designed to serve as an introduction to two key aspects of oceanography (the study of oceans). Through hands-on activities, we will explore two of the four core pillars of oceanography: physical oceanography, the study of how and why the ocean moves, and biological oceanography, the study of the organisms that call the ocean home and the ocean properties that help control their distributions. In addition, we will explore how the interaction of physical and biological oceanography structures ocean ecosystems and how oceanographic data is collected. Students will walk away from this course with a broad understanding of physical and biological oceanography, and an understanding of what a career in oceanography entails.

**Overall Layout:**

Each lesson (with the exception of lesson one) will include a short lecture to introduce the hands-on activity and/or review from the previous activity as needed. The hands-on activity will be followed by a group discussion on how the properties discussed in the activity are studied in the real world. As time allows, this will include videos/photos from my own research and explorations of publicly available datasets that students can use for their projects. These discussions can also be swapped for project time as necessary.

EDIT: Activities were swapped due to logistical challenges with data studies/interest level of the students. Now, all spring is the simulated scientific cruise.

**Lesson Plan:**

Lesson One: What Do We Know about the Ocean?

**Topics covered:** Class introductions, course overview, gauging current student knowledge about ocean environments, overview of my career path/current research

**Learning Objectives:**

Students will be able to:

1. review what topics from a generalize science class are relevant to ocean science
2. list what they know about the ocean
3. describe what I do as an oceanographer
4. explain the major hypothesis of my project

**Activities:**

1. Retention/accumulation game to illustrate current research project
   1. Materials:
      1. Small balls
   2. Setup: Balls, representing food items, will be distributed throughout the space. Some areas will have higher concentrations of balls, representing retentive oceanographic areas, and others will be continuously replenished, representing areas where accumulation of resources is high. Other areas will have few balls, representing low food availability.
   3. Execution: Teams of ~2-4 students will be grouped together as penguin “colonies”. Some colonies will be closer to areas of high retention/accumulation and others will be farther from one or both features. Taking turns, students will be tasked with collecting as many balls as possible. Students will only be able to collect one ball at a time before returning to their “colony”. Rounds will last ~1-3 minutes. After each round, teams may be redistributed according to the number of balls collected to represent the success of a “breeding season” due to the number of resources collected.
   4. Goal: Illustrate that penguin colonies closer to retentive/high accumulation areas have a greater probability of success due to the greater number of resources available to them.
   5. This activity is based on the following and adapted for this course:

<https://teachoceanscience.org/teaching_resources/education_modules/aquatic_food_webs/teach/#_Size_Selective_Predation>

* 1. As time allows, the tools I use to conduct this research can be discussed. I can also discuss my career path with the students and how I decided where I went to college since they are in 12th grade.

1. Brainstorming/illustrating/word cloud/flow chart formation of what students currently know about the ocean
   1. Can be done in small groups or as a class
   2. Materials:
      1. Large notepads and markers/writing utensils to write down ideas and relationships between them

Lesson Two: Physical Oceanography Part I

**Topics Covered:** water density, stratification of water columns, thermohaline circulation, how water columns are measured in the ocean

**Learning objectives:**

Students will be able to:

1. state how a water column is layered
2. define thermohaline circulation
3. interpret a temperature/salinity curve and/or a TS diagram

**Activities:**

1. Water density columns
   1. Materials:
      1. Plastic cylinders
      2. water (hot, cold, and room temperature)
      3. salt
      4. colored ice (prepared in advance)
      5. straws
   2. Setup: plastic cylinders will be filled about 1/2 full with salt water (fresh water + table salt) will be provided to each group. Warm, fresh water will be provided in a separate beaker/container. Salt water and fresh water can be dyed with food coloring to help visualization. Ice cubes dyed with food coloring will be prepared in advance. A hair dryer or straws will be used to produce wind.
   3. Execution: Students will be broken into groups depending on the number of beakers/bins available. They will be asked to hypothesize what will happen to the water when the colored ice cube is added. They will then carefully add an ice cube to the beaker and observe the results. Once the stratified water column has been formed, they will then carefully add warm fresh water and observe what happens to the water column. Drops of food coloring can be added to the top layer to observe the lack of mixing between the layers. Hair dryers/straws can be used to simulate wind to mix the water column.
   4. Goal: If done correctly, a 3 layer water column should be produced (salty water on bottom, and warm fresh water on top) and students should be able to observe the effects of stratification on mixing (low winds should only mix the top layer, but stronger winds may mix the entire water column).
   5. This activity is based on Activities 1.5 & 1.6 from the following:

Karp-Boss, Lee, et al. "Teaching physical concepts in oceanography: An inquiry-based approach." Oceanography 22.SUPPL. 3 (2009): 1.

1. Temperature and salinity observations in the real world
   1. Materials:
      1. Laptops
      2. whiteboard or large paper pads
   2. This will be a discussion about real-world observations of temperature, salinity, and density data. I will provide videos of Conductivity Temperature and Depth (CTD) sensors in action and explain what is happening throughout the video.
   3. After describing how CTDs work, I will draw an example TS curve on the board and walk students through the interpretation of the diagram. I will then provide example figures to small groups to ask them to identify key features of the curve.

Lesson Three: Physical Oceanography Part II

**Topics covered:** wind mixing, coastal upwelling/downwelling, ocean observing systems & data exploration

**Learning objectives:**

Students will be able to:

1. explain coastal upwelling
2. describe how an autonomous glider works
3. compare and contrast the benefits of an ocean observatory versus “one-off” sampling

**Activities:**

1. Coastal upwelling and wind mixing
   1. Materials:
      1. Rectangle plastic containers
      2. water (hot, cold, and room temperature)
      3. salt
      4. colored ice (prepared in advance)
      5. straws
   2. Setup: Rectangular plastic containers will be filled with water as in the previous lesson to create a two layer system. Dishes will be filled with a layer of cold salty water on the bottom and warm fresh water on top. Food dye will again be used to illustrate the layers.
   3. Execution: Students will use straws to move the surface water away from the “coast” (edge of the dish) and observe what happens to the water layers.
   4. Goal: Students should be able to observe upwelling (deep water moving up to the surface) when water is moved away from the edge of the dish, and potentially downwelling (surface waters being forced down) when water is pushed against the edge of the dish.
2. Coastal observing systems
   1. Materials:
      1. Laptops
   2. Discussion topics: I will discuss with students how autonomous gliders work through videos of gliders in the field. We will also discuss ocean observing systems such as MARACOOS, or the WHOI Pioneer Array and other similar systems and discuss the benefits and downsides of these systems. As time allows, this discussion can be followed by a group exploration of data products that illustrate coastal upwelling, such as the MARACOOS OceansMap (<https://oceansmap.maracoos.org/>)

Lesson Four: Biological Oceanography Part I

**Topics Covered:** phytoplankton, zooplankton, Reynold’s Number/viscosity of water, effects of currents on animal distributions

**Learning objectives:**

Students will be able to:

1. List different planktonic adaptations for neutral buoyancy
2. Differentiate between phytoplankton and zooplankton
3. Define Reynolds Number
4. Describe how animals can be impacted by ocean currents

**Activities:**

1. Phytoplankton race
   1. Materials:
      1. General art supplies
      2. glue
      3. construction paper
      4. tissue paper
   2. Setup: General art supplies (tissue paper, pipe cleaners, construction paper, pom poms, tape, etc) will be given to each team.
   3. Execution: Students will be placed in teams of 2-3 depending on class size. Teams will be asked to design a phytoplankton that will sink the slowest in air with at least 2 unique phytoplankton features described at the start of class (cilia, flagella, coccoliths, etc). Teams will be given ~30 minutes to design and build their phytoplankton. Once construction is complete, teams will be asked to describe their plankter. Then we will move into a stairway for the phytoplankton race! One member of each team will drop their phytoplankton from the top of the stairs and the last phytoplankton to the bottom wins!
2. Reynold’s Number
   1. Materials:
      1. Plastic columns
      2. Water
      3. Corn syrup
      4. ball bearings of various sizes
      5. phones/laptops (for stopwatches)
      6. paper (or laptops with excel can be used)
   2. Setup: The cylinders will be filled with 2 substances – water and corn syrup. Groups will be given a variety of ball bearings.
   3. Execution: In groups, students will record how long it takes balls of various sizes to sink in water and corn syrup. Students will make hypotheses about how fast the ball bearings will sink in the liquids. Students will also graph the data and we will discuss if the data support their hypotheses.
   4. Goal: Students will learn about how viscosity affects how things can move in water. Phytoplankton are so small that water is very viscous to them, so currents move phytoplankton around. Fish, however, are large enough to swim against currents.
   5. If time allows, videos of phytoplankton/zooplankton swimming can be shown to illustrate this concept further.

Lesson Five: Biological Oceanography Part II

**Topics covered:** marine food webs, predators and their adaptations, sampling methods including satellite and acoustic tagging methods and remote sensing

**Learning objectives:**

Students will be able to:

1. Classify different predator adaptations
2. List biotic and abiotic factors in the ocean
3. Explain why estuaries are important ecosystems

Activities:

1. Design a predator
   1. Materials:
      1. Construction paper/markers
      2. glue
   2. Execution: After a discussion on predators and potential adaptations of organisms in different marine environments, students will be asked to create a predator to thrive in a certain marine environment (deep sea, coastal, coral reef, etc). Adaptations could include things like countershading, fins for fast movement, but also behaviors such as schooling, that prevent the organism from becoming prey itself.
2. Predator/Prey interactions in Long Island Sound
   1. Materials:
      1. clear and opaque plastic bins
      2. pompoms
      3. tin foil
      4. spoons
   2. Setup: Bins will be filled with pompoms of various numbers. Opaque containers will be covered with tin foil/trash bag with a hole cut in it. Plastic spoons will be used.
   3. Execution: Students will be broken into teams based on the number of containers available. Each team will have one clear and one opaque container. For the first round, students will have approximately equal number of pompoms in each bin and will be asked to try to collect as many pompoms as possible with the spoon from each bin within 20-30 seconds. We will record the number of pompoms collected each round and each student will get to try at least once. In the second round, more pompoms will be placed in the dark bins, and the rounds will be repeated. We will once again graph the data and discuss.
   4. Goal: This activity is designed to illustrate the benefits of estuaries, which generally have high food availability for larval fish and low visibility, so they are not eaten. Students will see that it will be harder to “catch” food (pompoms) when it is dark, and easier when food are plentiful.
   5. This activity is based on the following: <https://teachoceanscience.org/teaching_resources/education_modules/fish_and_physics/access_classroom_resources/larvae_feeding>