**Concepts**
What is the open ocean? What are some physical properties of the open ocean and how do currents affect these properties?

**Standards Addressed**
HCPS 5.1 & 5.3

**Duration**
Prep: 45 min
Activity: 2 periods (45 minutes each)

**Source Material**
MARE (currents lab)

**Vocabulary**
Open Ocean
Salinity
Current
Nutrients
Bathymetry
Abiotic
Biotic
Upwelling

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**THE OPEN OCEAN, WHAT IS IT AND HOW IS IT DIFFERENT?**

**Summary:** Students are introduced to what the open ocean is through brainstorming and pictures. The students then explore the physical (abiotic) features of the Pacific open ocean. The students also learn where Hawaii is situated in the Pacific and the characteristics of the ocean that surrounds us. Students then learn how the areas of the ocean change through a hands-on lab that models how currents move water.

**Objectives:**
1. Introduce Unit.
2. Describe the major physical properties of the ocean including salinity, temperature, depth, and nutrient levels.
3. Explore and describe how currents change the physical properties of the open ocean.

**Materials:**

1. **1st Period**
   - Chart Paper
   - Physical maps of the open ocean (see Unit)
   - Map walk worksheet

2. **2nd Period**
   - Currents Lab worksheet
   - 4 identical plastic bottles (12-16 oz. most water bottles work)
   - Tornado tube (this piece screws the two bottles together)
   - Room temp water, Hot tap water, Ice cold water
   - ½ Cup Kosher salt/sea salt (dissolves better than table salt)
   - Food coloring (not yellow. Red and Blue work great)
   - 2 trays
   - Clean up supplies (towel, paper towels)

**Making Connections:** This session is meant to introduce the students to the open ocean environment. The physical features of the open ocean are very dynamic and may be very different between areas. Physical features also define what types of organisms thrive in different areas.

**Background:** Our oceans are vast areas of water that span thousands of miles and may be several miles deep in some places. Previously, oceanographic trips took months to gather information that covered only small sections of the ocean over small time periods. Only
recently with the advent of satellite technology have we begun to grasp how ocean processes work on an ocean-wide scale. With new technology we can measure the physical (abiotic) characteristics of the ocean. We are now understanding that the open ocean is very dynamic and there are differences in temperature, nutrients, salinity, and currents on very small scales as well as ocean wide. Scientists are now tracking these differences in the ocean and studying how they affect the living (biotic) resources as well as our weather patterns and a myriad of other factors. Currents in the ocean may be huge, encompassing the entire ocean, or small enough to see from the beach. Currents move different bodies of water around mixing hot water with cold water or high nutrient water with low nutrient. This mixing is often very important to the organisms living in the ocean. Frequently, the most productive areas are those with a lot of mixing!

One such area of mixing occurs off the Kona coast of the Big Island. Cold, nutrient rich deepwater currents hit the deep ledges of the Kona coast and are diverted to the surface. This phenomenon, upwelling, brings nutrient rich water into the sunlight and stimulates the growth of phytoplankton, which is the basis of most foodwebs. This is the primary reason the Kona coast produces some of the largest blue marlin in the world.

**Preparation:**

1st Period:

1. Print and display environmental maps (there is a brief description of what each one displays under the procedure for the second period. **Note:** The maps look very good if they can be printed extra large and laminated.
2. Cover the title and key for each map with something removable (paper and scotch tape).
3. Print out one mapwalk worksheet for each student.
4. Read through procedure.

2nd Period:

1. Print out one copy of the currents lab for each student.
2. Gather all the necessary materials for the lab.
3. Determine how you will make and keep hot and cold water in your classroom.
4. Arrange the materials around the classroom in stations and make labels if you want to.
   - There will be a Temperature Current station and a Salinity Current station so there should be two groups of students. If there are too many students in each group you may duplicate one station or both or see the additional activity below.
5. Read through Lab activity.

Write out key concepts and summary questions on chart paper and display in the front of the class (see Assessment and Summary).

**Procedure:**

1st Period: We are going to be learning about the open ocean this year

1. Intro and Terms Brainstorm (10 min)
   - Brainstorm with the students on what they think the open ocean is and describe using chart paper. Use their definitions to define the open ocean. Here is a useful and kid friendly definition: The
Open Ocean is anywhere offshore (outside the reef) where you can’t see the bottom (greater than 150 feet).

On chart paper, discriminate between some biotic (living) and (nonliving) abiotic characteristics of the open ocean. Examples include biotic = fish, whales, plants while abiotic = ships, waves, salt in water. Try to limit the brainstorm to 10 min because it is easy to get sidetracked. Make sure everyone has an idea of what the open ocean is.

2. Group Map Walk (20 min)
Explain that the maps show satellite pictures/data of physical (abiotic) features of the open ocean. You should reveal (write on board) that there are 7 maps of physical (abiotic) characteristics of the open ocean, two are of bathymetry (depth) and one each of salinity, temperature, nutrients, currents, and wind. Draw attention to the key of each map as a clue to what that map displays.

   Explain the procedure of the worksheet. Students should hypothesize what each map shows and why. For example Map 1 shows depth because the water gets a different color the further away from shore you get. Remind students that there are two maps that show water depth. Break the class into groups and have each group start at a different map (3-4 members per group). Scaffold students if needed.

3. Revealing the Maps (20 min)
Have kids explain what they think each map is and why. Reveal each map and explain briefly how each characteristic is important and how the students may identify each map in the future. Explain the keys as needed. **NOTE!!** These maps with the exception of depth/bathymetry show the ocean at one period of time or an average! Currents move, temperatures change, and nutrients get used up! This means that the ocean is constantly changing. Also these maps show the surface of the ocean. This concept will be important for the next lesson.

**Map 1: Bathymetry of Hawaii**
This map shows the depth or bathymetry of the ocean bottom around Hawaii. The depth of the ocean is very important to what type of organisms live in those areas. The islands are shown in gray. Any area in red is probably shallow enough to support some coral. Notice how fast the ocean gets deep off of Kona. This is why we have so many large fish so close to shore here.

**Map 2: Bathymetry of the Pacific**
This map shows the depth or bathymetry of the ocean bottom throughout the Pacific Ocean. Make sure the students not where Hawaii is and how far away we are from other land. The key is broken into light blue areas that are less than 500 meters deep and dark blue/black areas than are deeper than 500 meters. Note the shallow areas close to land and the deep areas such as trenches.

**Map 3: Nutrients**
This map shows the nutrient levels of the Pacific ocean. Nutrients are measured by the amount of chlorophyll that plankton or other plants produce. The higher the chlorophyll the higher the amount of nutrients. Land masses are shown as green or yellow because they have a lot of plants. Oceans have lower nutrient levels and are shown as green to purple. Anywhere that has high nutrients in the ocean is usually a place with a lot of productivity and lots of living organisms.
Nutrients are measured in **milligrams per cubic meter** of water. A cubic meter is about the amount of water in a full bathtub.

**Map 4: Salinity Map**
This map shows the different areas of the ocean in terms of salinity or the amount of salt. There is less salt in the surface water at the poles of the world. This is because salty water is heavier than fresh and when is cools in the polar areas it sinks to the bottom. This will be demonstrated in the current labs. Salinity is measure in PSS which stands for **Parts of Salt per Sea water**. The lower the PSS the less salt. Hawaii is shown as empty white dots in the middle of the Pacific. Hawaii has fairly salty water around it.

**Map 5: Sea Surface Temperature (SST)**
This map shows the average temperature at the surface of the ocean throughout the world. Temperatures are in Celsius. Note that Hawaii is close the red, yellow, and green areas. This means that Hawaii may have different sea surface temperatures throughout the year. Areas where different temperature waters meet often stimulate high productivity.

**Map 6: Visible Hawaii/Hawaii’s Wind**
This map shows a photograph of Hawaii from space. The white lines are clouds (look to the Kohala mountains). Note how the clouds show how the winds push air through the islands from the north to south. Winds also push the ocean water to create currents. The area west of Kona shows how the sun reflects off the smooth water like a mirror just like if you use a flash camera in a mirror.

**Map 7: Currents**
This map shows some currents in the Western Pacific. Hawaii is on the far right side of the map. The currents are measured in how fast the water is moving. Note that these current patterns (swirls) will look like the colored currents in the lab.

**2nd Period: What currents bring and how the ocean is different?**
Currents are the oceans highways. They move different types of seawater from place to place. Currents may mix this water or remain separate. Currents also carry living organisms and the nutrients these organisms needs to survive. In this section students will predict and observe what happens when salt meets fresh water, cold hits warm water. How do these experiments relate to the students real world experiences.

Currents: Multiple Stations with Hot vs. Cold, Salt vs. Fresh. Here we are focusing on the kids experiences in Hawaii and tying that in with the lab

**Temperature Current Station**
1. Fill one bottle to the top with hot tap water
2. Screw the tornado tube onto the hot water bottle
3. Fill the other bottle almost to the top with icy cold tap water.
4. Add six drops of food coloring to the cold bottle.
5. Quickly screw the two bottles together over a towel.
6. Lay the bottles down gentle on their sides and do not disturb.
7. Have the students observe the bottles at eye-level and record any observations on their worksheets. Be sure to have them feel the bottles for differences in temperature or condensation.

**Salinity Current Station**

1. Fill two bottles with room temperature water. Leave a bit of space for food coloring in one.
2. Add six drops of food coloring and four tablespoons of salt to one bottle. This is the salty or high salinity bottle. (It helps if the food coloring in this bottle is different than the temperature bottle)
3. Screw the tornado tube onto the top of the bottle with fresh water.
4. Quickly screw the two bottles together over a towel.
5. Lay the bottles down gentle on their sides and do not disturb.
6. Have the students observe the bottles at eye-level and record any observations on their worksheets. Place a piece of white paper behind the bottles if the students have trouble observing the food coloring.

**Assessment and Summary:**

**HMK:** What is Hawaii’s salinity, depth, temp, chlorophyll.
Assessment: Fill out worksheets including questions.

**Key concepts** (What the students should know!)

1. What is a definition of the open ocean?
2. Name some living and non-living parts of the open ocean.
3. Name four important physical (abiotic) parts of the open ocean.
4. Describe what generally happens when two water bodies of different salinities meet
5. Describe what generally happens when two water bodies of different temperatures meet.

**Links:**

[http://fermi.jhuapl.edu/student/currents/index.html](http://fermi.jhuapl.edu/student/currents/index.html)
This link is a good general website for the major Atlantic currents and basic information.

[http://tidesandcurrents.noaa.gov/](http://tidesandcurrents.noaa.gov/)
This link is an excellent scientific link from NOAA with zoomable maps to the world’s tide and current data.
Map Walk

Directions: look at the different maps around the classroom. What do you think each map shows (temperature, water depth, salinity(salt), currents, wind, nutrients) and why?

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Map 1: Bathymetry of Hawaii
Bathymetry of the Pacific Ocean
Map 4: Salinity

Fig. A2-1. Annual mean salinity (PSS) at the surface.

Minimum Value = 21.56
Maximum Value = 36.72
Contour Interval: 0.20

World Ocean Atlas 2001
Ocean Climate Laboratory/NODC
Station 1: Salinity Currents

1. Use colored markers or crayons on the illustration below to mark your prediction about the movement of the colored, salty water in the bottles, and where it will end up. Label which bottle has the fresh water and which bottle has the salty water at the start of the exploration.

This is where the colored, salty water starts in the bottles.

This is where I predict the colored, salty water will end up.

2. Now color in what actually happened

This is where the colored, salty water started in the bottles.

This is where the colored, salty water ended up in the bottles.

3. Briefly describe your results. Include at least two things you observed.

4. How did your prediction compare with your results? Were you surprised by the results? Why or why not? Be Specific.

5. Based on your observations, describe what happens when waters of different salinities meet.
Station 2: Temperature Currents

1. Use colored markers or crayons on the illustration below to mark your prediction about the movement of the colored, cold water in the bottles, and where it will end up. Label which bottle has the cold water and which bottle has the hot water at the start of the exploration.

This is where the colored, cold water starts in the bottles.

This is where I predict the colored, cold water will end up.

2. Now color in what actually happened

This is where the colored, cold water started in the bottles.

This is where the colored, cold water ended up in the bottles.

3. Briefly describe your results. Include at least two things you observed.

4. How did your prediction compare with your results? Were you surprised by the results? Why or why not? Be Specific.

5. Based on your observations, describe what happens when waters of different salinities meet.