Well, Well, Well

SUMMARY

In this activity students investigate the relationship between winds, surface currents, sea surface temperature and upwelling and downwelling off the coast of OR and WA. Students analyze data to make predictions on today's upwelling or downwelling conditions.

OBJECTIVES

- Students will be able to explain the process of upwelling and downwelling.
- Students will be able to use real-time data from ocean observing systems to analyze the relationship between wind, surface currents and sea surface temperature to make predications on water conditions.

MATERIALS

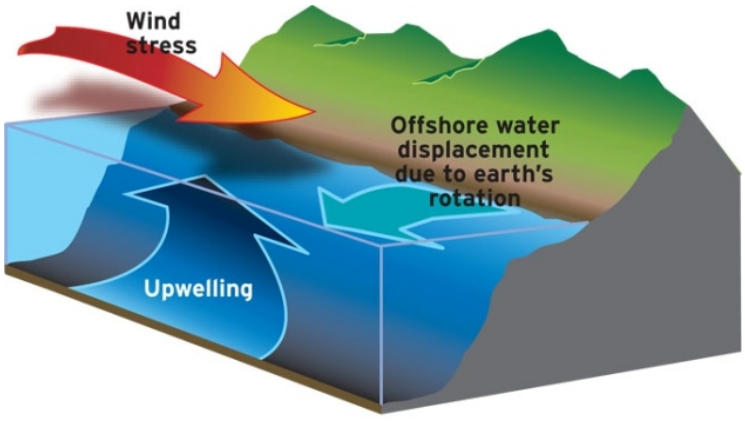
- Computer lab with Internet access or projection screen

BACKGROUND

Seasonal upwelling is a very important process in the coastal ocean of the Pacific Northwest.

Every summer, from about April to September, the Oregon and Washington coast are dominated by upwelling favorable winds - winds blowing ***from*** the North ***to*** the South (these are called called northerly winds, or Northerlies).

These northerly winds, combined with the along with the rotation of the Earth, result in surface waters moving off-shore and out to sea. As the surface waters move away from the coast, deeper ocean water rises up to the surface.



The deeper ocean water is colder, saltier, rich in nutrients like nitrogen and phosphorus and lower in both pH and dissolved oxygen. Upwelling brings the nutrient-rich deep water to the surface. The nutrient-rich surface waters along with sunlight triggers fast phytoplankton growth and reproduction.

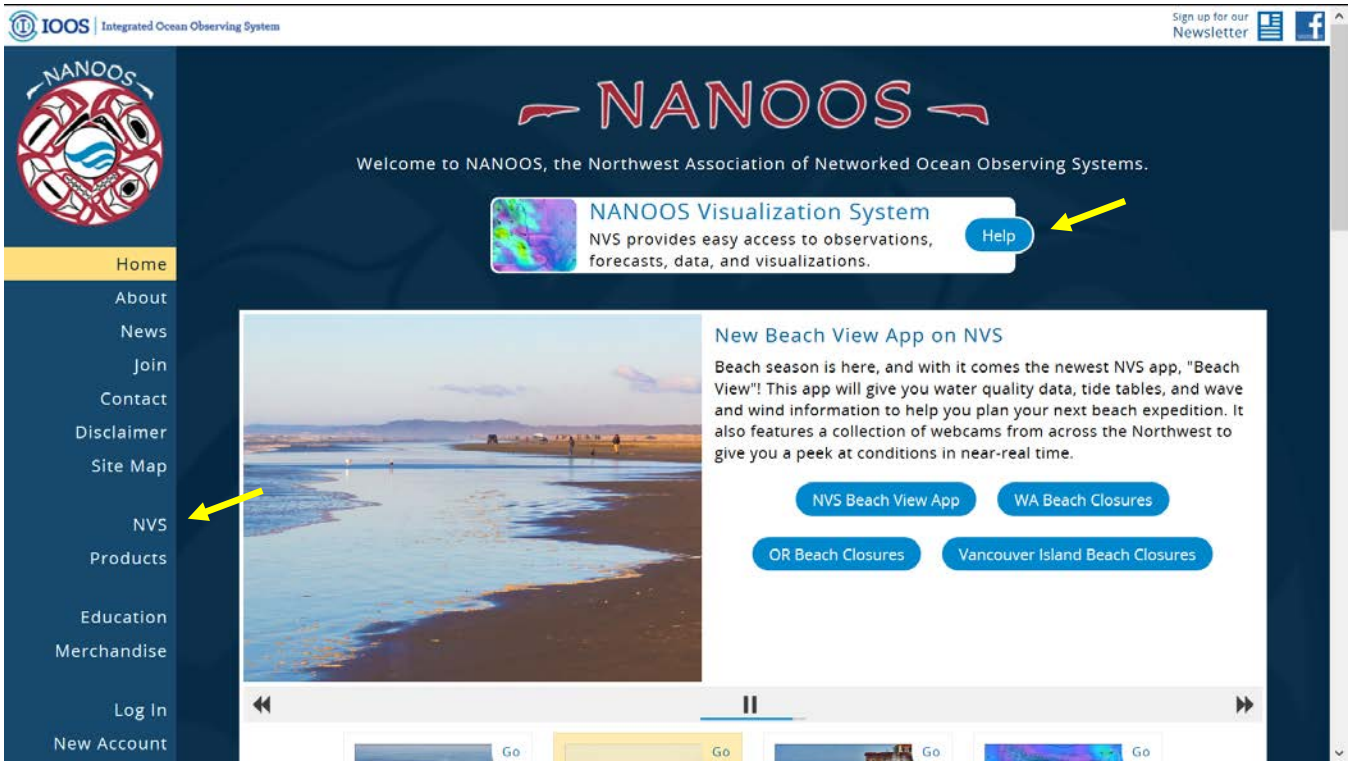
The phytoplankton, the base for marine food webs, provide food for zooplankton, which in turn, are the food for larger fish. This seasonal upwelling along Oregon and Washington's coast support the productive ocean ecosystem and its important fisheries.

Is upwelling currently happening? Follow this scavenger hunt to see if you can find the clues and signs of upwelling in the data!

GET STARTED

1) Go to www.nanoos.org

2) Navigate to the **NANOOS Visualization System (NVS)**



3) Once on the home page of NVS, select the "**Data Explorer**" button. **NVS Data Explorer** is the "kitchen sink" of NVS – it has a LOT of different data.

4) Orient yourself to the menus in the left-hand column of **NVS Data Explorer**:
   a. Layers: contains various map overlays that can be displayed on the map including nautical charts, forecasts from computer models, and remote sensing data from satellites and high frequency radar
   b. Platforms: contains list of fixed (stationary) and mobile platforms – including buoys, shore stations, shellfish rafts, gliders, and ships
   c. (Routes: used to plan trips, probably not needed for this exercise)
   d. Filters: provides a list of parameters that can be used to narrow the data sources that are displayed. For example, selecting "water temperature" will display only the buoys, shore stations, computer model forecasts and satellite data etc. that are measuring for water temperature.
   e. Legend – provides a list of the various icons used in NVS

Have fun looking around on all the different data types and different ways ocean scientists are collecting data.

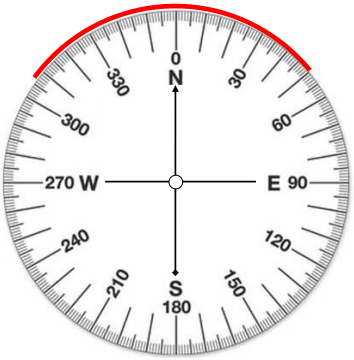
5) You might see missing data, or assets that do not seem to be working. Monitoring in the ocean is difficult and expensive; it's not an easy place for scientific equipment and sensors to be! Scientists are constantly looking to see IF their sensor is collecting data even before they look at the data. Sometimes, even if there is data, you might see data that seems wrong – if a sensor is working incorrectly, it may be giving "bad" data.

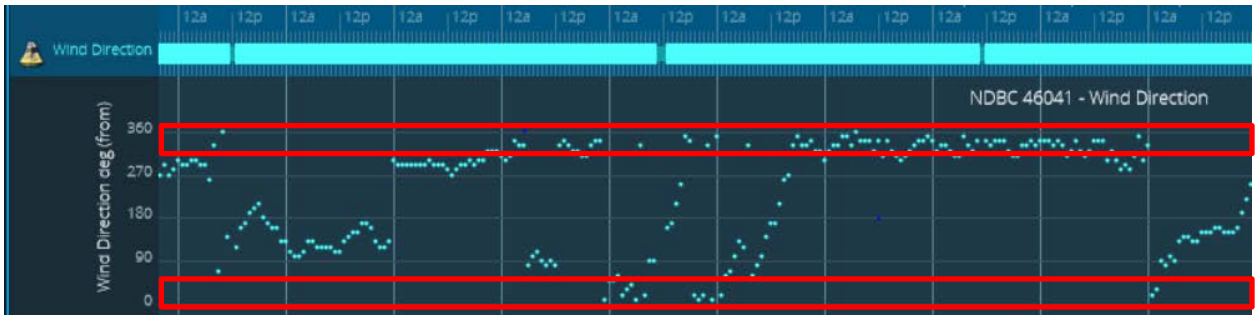
FIND THE SIGNS - Is it Upwelling off the Pacific Northwest Coast?

Indicator #1: Wind direction

Wind direction is the most important parameter which controls upwelling in the PNW. Winds blowing from the NORTH to the SOUTH start the upwelling process. Winds blowing FROM the NORTH to the SOUTH will be indicated as either close to **310 to 360 degrees** or from **0 to 50 degrees** on NVS.

On the compass rose below, the red curve shows the general direction wind blowing ***from*** that would be upwelling favorable winds.





Wind direction in red would be blowing from the NORTH towards the SOUTH

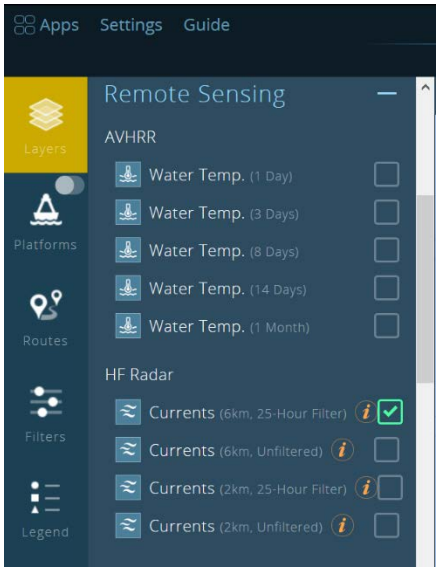
Find a buoy along the WA Coast that is currently measuring wind direction. Has the wind direction been blowing steadily (more than 48 hours) from the North in the past 7 days?

Find a buoy along the OR Coast and look for similar wind direction information

		Yes	No	?
Indicator #1	Coastal WA winds are blowing **from the North** (wind direction is between 310 to 360 or between 0 to 50 degrees) for more than 48 hours			
	Coastal OR winds are blowing **from the North** (wind direction is between 310 to 360 or between 0 to 50 degrees) for more than 48 hours			

Indicator #2: Surface Currents

Scientists at Oregon State University use HF (high frequency) radar to measure the speed and direction of ocean surface currents off the OR Coast. HF Radar stations are set up on land stations overlooking the OR Coast. Both HF radar and satellites collect data on the ocean even though the actual sensors are far away from the ocean (i.e. on land or orbiting the Earth). This is called remote sensing.



Surface currents which show water moving south and/or west could be a sign of upwelling. Select "Remote Sensing" and then under HF Radar, select "Currents (6km, 25-Hour Filter)".

Zoom into the North and Central Oregon Coast to find and examine the surface currents at 4 locations: Cannon Beach, Pacific City, Newport, and Florence.
(Tip: to make it easier to see the HF radar data, slide the button next to Platforms from green to gray to turn off all the icons for platforms)

Mark the surface current direction 1) next to the shore and 2) the farthest out to sea the current was measured

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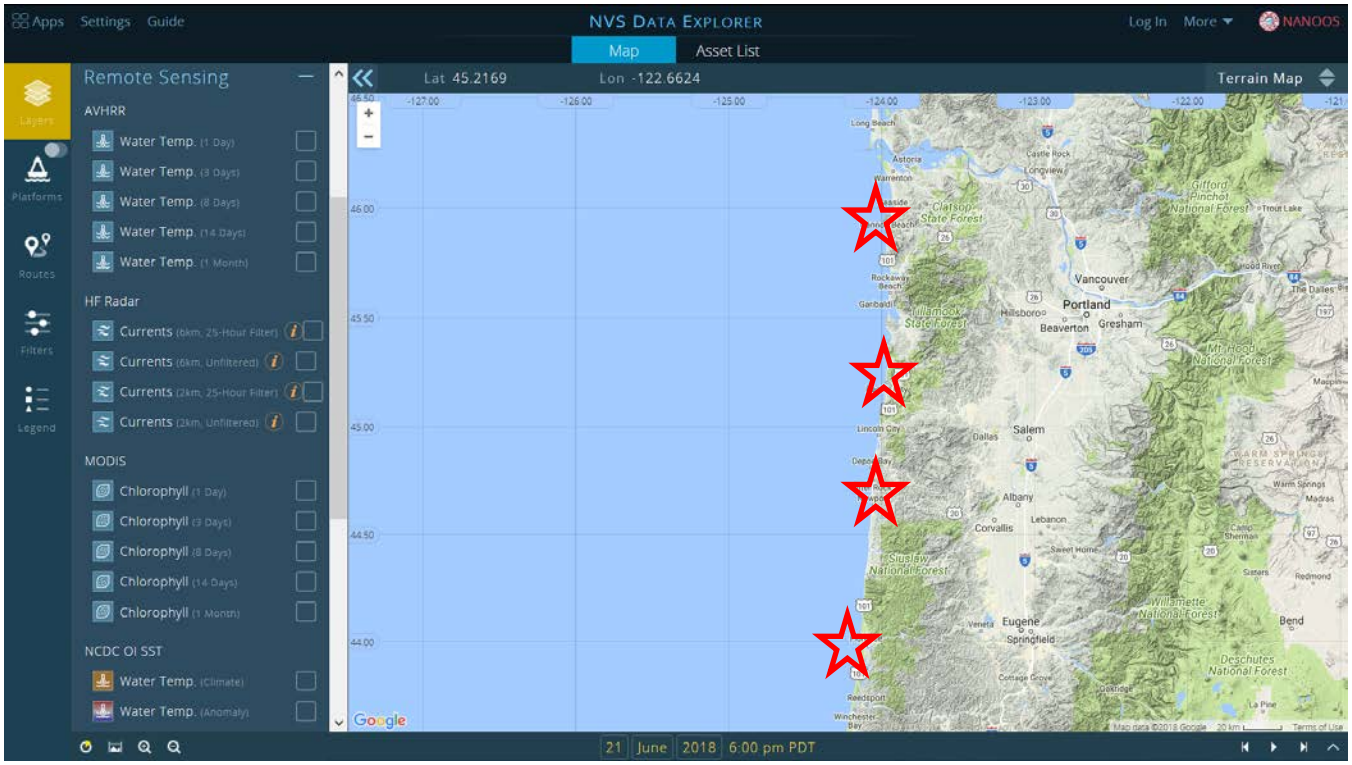


		Yes	No	?
Indicator #2	Surface currents are moving south and/or west?			

Indicator #3: Water temperature and salinity

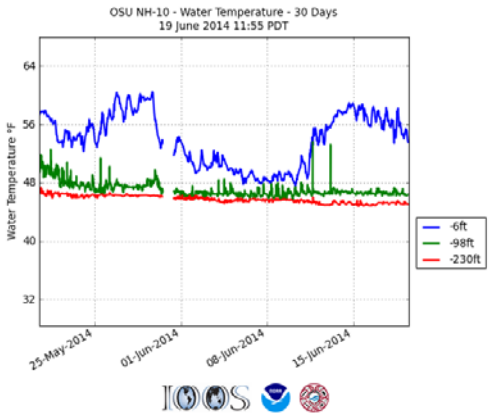
During upwelling, water temperature and salinity in the surface waters along the coast will show a change.

If it is upwelling, will Water Temperature at the surface INCREASE or DECREASE? _____

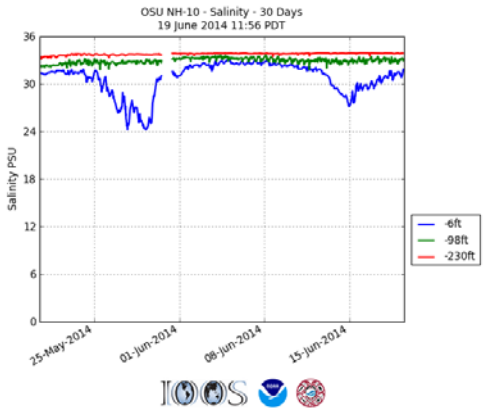
If it is upwelling, will Salinity at the surface INCREASE or DECREASE?_____

Below is data from a buoy off the central OR Coast from the summer of 2014. Look at these 2 graphs and focus on the blue lines (data from near the surface of the ocean), and the red lines (data from the bottom of the ocean) - when does it look like it was upwelling at this site?

WATER TEMPERATURE



SALINITY



On NVS, find a buoy along the WA Coast that measures water temperature and salinity. Do you see a change in temperature or salinity of the surface water (-6ft or -2m) in the past 7 or 30 days? How about in deeper water (-60m or -73m)? Record data below, did you see:

⇧⇩Change in **surface** water temperature?:

⇧⇩Change in **surface** water salinity?:

⇧⇩Change in **deep** water temperature?:

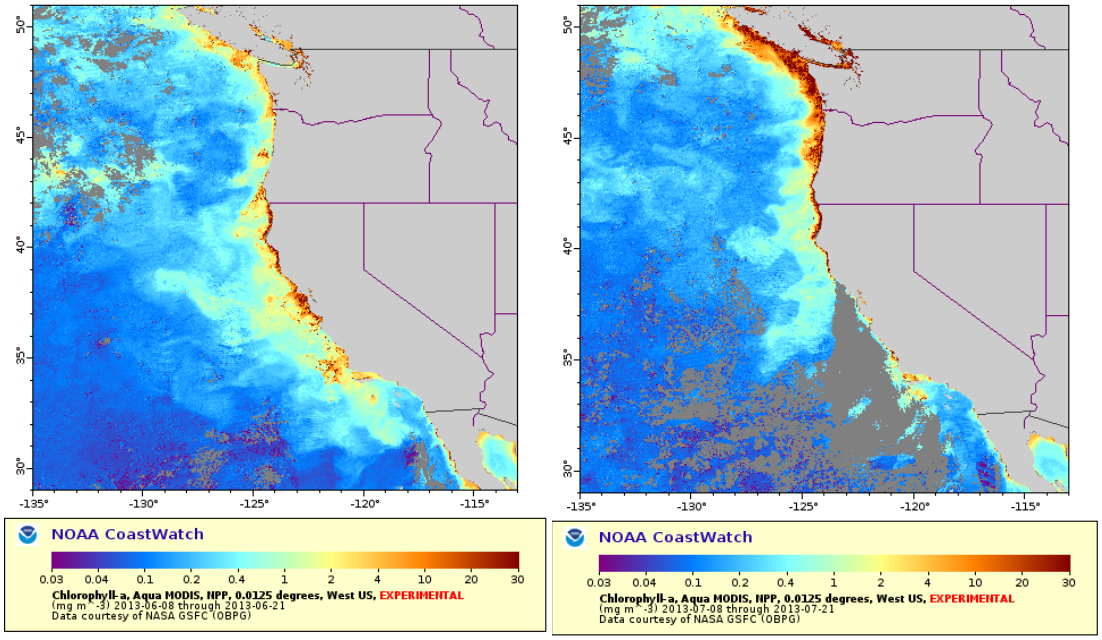
⇧⇩Change in **deep** water temperature?:

		Yes	No	?
Indicator #3	There was a decrease in surface water temperature in the past month			
	There was an increase in surface water salinity in the past month			

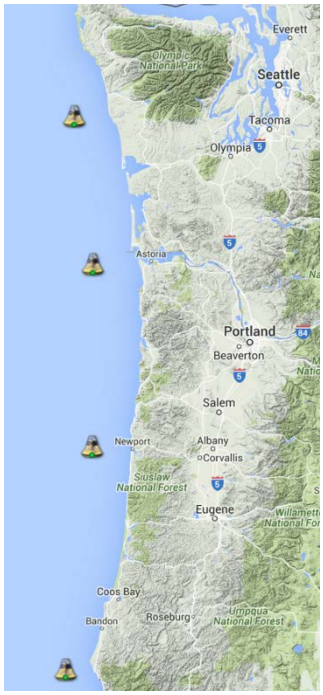
Indicator #4: **Phytoplankton**

The abundance of phytoplankton, the base of the coastal ocean's food web, is measured by **chlorophyll**, a photosynthesizing pigment in plant cells.

Here is an example of how the chlorophyll concentrations can change during upwelling – the first visualization is from Jun 8-21, 2013, when it was not upwelling, and the second visualization is from July 8-21, 2013, when it had been upwelling for over a week.



On NVS Explorer, under "Layers", choose "Remote Sensing", scroll down to Satellite data and select the MODIS Chlorophyll data. Select either "14 day" or "1 month" view, and be sure to look at the timeline on the bottom of the page to select a time range which has data (select a date/time within the cyan/blue color bar).



What is the highest concentration of chlorophyll (mg of chlorophyll per cubic meter of water - mg/m^3) next to these 4 buoys that are 15 to 20 nautical miles off the coast? (NDBC Cape Elizabeth, NDBC Columbia River Bar NDBC Stonewall Bank and NDBC Oregon) coast?

		Yes	No
Indicator #4	Chlorophyll concentrations are above 25 mg/m^3		

PUTTING IT ALL TOGETHER

Now that you have sleuthed through the data for clues, your final task is to determine if upwelling is in fact happening.

There can be a time lag between when the winds start the upwelling to when we see the resulting chlorophyll increase, so all of the indicators may not be in the yes category yet. If that is the case, check back in a few days to see if anything changed?

		Yes	No	?
Indicator #1	Coastal WA winds are blowing **from the North** (wind direction is between 310 to 360 or between 0 to 50 degrees) for more than 48 hours			
	Coastal OR winds are blowing **from the North** (wind direction is between 310 to 360 or between 0 to 50 degrees) for more than 48 hours			
Indicator #2	Surface currents are moving south and/or west			
Indicator #3	There was a decrease in surface temperature in the past month			
	There was an increase in surface salinity in the past month			
Indicator #4	Chlorophyll concentrations are above 25 mg/m^3			

CONCLUSION:

Introductory Activity, Upwelling

Objective

- Demonstrate the process of upwelling and downwelling

Materials

- Pitcher
- 2 pans
- Small container
- water
- Food coloring or dye
- Large eye dropper, syringe or similar
- Drinking straw
- Ice

Procedure

1. Divide students into small groups to perform the following exploration.
2. Using the pitcher, fill both pans with room-temperature water to about 1/2 inch from the top. One pan will be a control.

3. Let the pans sit undisturbed until the water is quiet, about 5 minutes.

4. Prepare colored ice water in the small container.

5. Slowly release a cold, colored water at the bottom (near one end) of each pan. This will represent nutrient-rich water. Record observations.

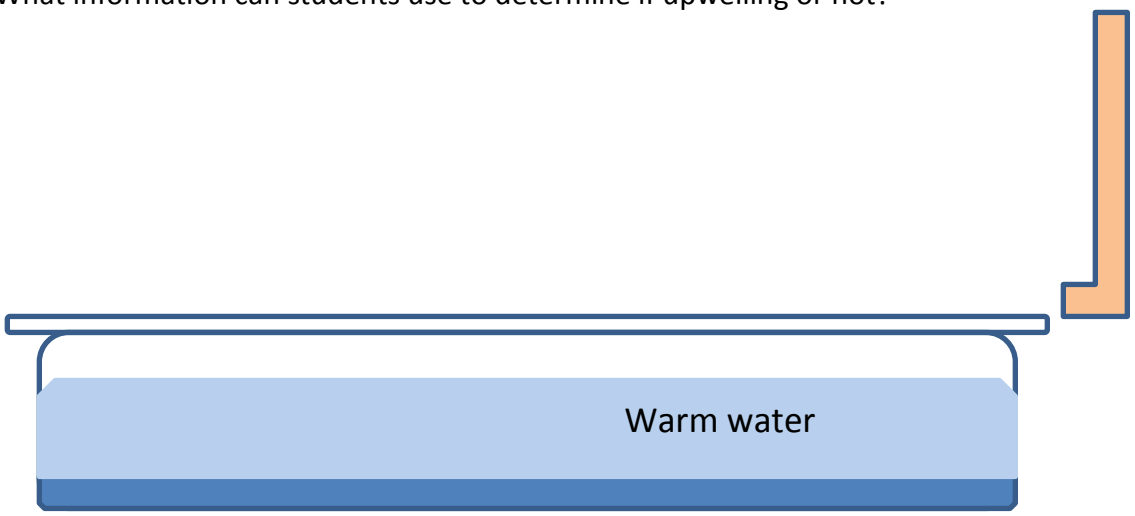
6. Rest the straw on the end (opposite the colored water) of one pan. Gently blow across (not into) the water, creating offshore waves.

7. Compare the results with the control pan. Record your observations.
8. Have one person in each group report the observations. Compare these results. What happens to the "nutrient-rich" water when the surface water is moved away by the wind? What happened to the warmer surface water at the opposite end of the pan?

9. Ask the students what happens to the cold, deep water when the surface waters are pushed away from the shore by the wind? What happens when the surface waters are pushed towards shore by the wind? Have students draw a side view of what they observed in the pan. Allow students to compare drawings until the majority of the class agrees on a drawing that accurately represents what happened. Introduce the terms “upwelling” and “downwelling at

this point.

10. Review the process of upwelling, explaining how the movement of surface waters away from shore causes deeper, colder waters to rise. Ask the students what would be carried to the surface with the colder, deeper waters? How would this movement of nutrients affect the phytoplankton? If phytoplankton are blooming, what other organisms would be affected? What information can students use to determine if upwelling or not?



Cold, colored water

EXTENSION ACTIVITY

What role does upwelling play in ocean acidification in the PNW?

In the News:
"As oceans acidify, shellfish farmers respond. Scientists collaborate to mitigate climate impacts in the northwest."
https://www.hcn.org/issues/49.16/climate-change-as-oceans-acidify-shellfish-farmers-respond

Have students work in groups to come up with a diagram of how upwelling and ocean acidification are linked.

Students can also investigate:

What role does upwelling play in coastal hypoxia?
What role does upwelling play for salmon in the PNW?