Oxygen, Carbon Dioxide, and Plankton

Overview

Students will study videos, charts, ship scientist's logs, and data gathered over a week from the Research Vessel *Sea Explorer* (located at the Orange County Marine Institute in Dana Point, CA). They will be challenged to form a model that explains what was occurring in the waters off Dana Point over that time. They will also learn about the shipboard research equipment used to collect the data.

Concepts

- Plants *photosynthesize* and animals *respire*. Plants use carbon dioxide (CO_2) and produce oxygen (O_2). Animals use O_2 and produce CO_2. This ties plants and animals together in the global *ecosystem*. In the ocean, this relationship between animals and plants is directly tied to seawater chemistry.
- In photosynthesis, CO_2 and H_2O are converted to organic material, such as plant tissue, in the presence of light energy. O_2 is a by-product. In respiration, organic material and O_2 are "burned" so that organisms can get the energy they need. CO_2 is the by-product.
- By measuring chemical components in seawater, we can tell what the living part of the ocean is doing.
- By examining changes in the assortment of *plankton* and seawater chemistry over time, it is possible to observe a link between the oceans living and non-living components.
- Because of reduced light at depth, the assortment of plankton (less *phytoplankton*, more *zooplankton*) and the deep ocean water chemistry varies.

Materials

- Movies of oceanographic equipment
- Plankton ID charts (found at end of this activity).
- Chemistry data given in this activity.
- Graph paper

Preparation

Because the QuickTime videos are critical to this activity, students will need access in small groups to a computer with the CD-ROM. Teachers may want to do the "Engagement" as a class, then break students into small groups who can explore the video, while other groups work on non-video activities (for example, reading the scientist's log, graphing the measurements, etc.). Then, the whole class can get together to discuss their results.

Print out at least one copy of the plankton identification chart for each group.

Procedure

Engagement

The *pH* of seawater indicates the level of dissolved carbon dioxide (CO_2) in seawater. Oxygen (O_2) is easily measured in seawater using either wet chemistry or an oxygen probe device. The concentrations of these components are often tied directly to the activity of the *biomass*, in this case, the biomass of plankton. Medical doctors sometimes measure the same properties in a person's blood. By looking at the blood's chemistry, doctors can make assessments about the living part of the patient's body. Oceanographers do a similar thing: by studying a non-living component of ocean water--its chemical makeup--they better understand the living part.

Oxygen is made by plants and used by animals. In the ocean, plants are restricted to the near surface *photic zone* because of their need for sunlight. O_2 concentration is highest where plants are blooming [Fig. 1, left]. In seawater, O_2 ranges from 0 to 9-10 PPM (parts per million). The pH scale ranges between 0 to 14; 7 is neutral. If the pH is higher than 7 then the water is alkaline, lower than 7 means that it is acidic. The range in seawater pH is generally between 8.1 and 8.4 [Fig. 1, middle]. The pH reflects the CO_2 concentration in the water. High pH implies low CO_2 [Fig. 1, right].

pH and Carbon Dioxide

pH

❏ the pH scale has values from 0 to 14
- 7 is neutral
- pH > 7 (alkaline)
- pH < 7 (acidic)

❏ pH of the ocean normally ranges from 8.1 to 8.4 at the surface

❏ pH is directly influenced by carbon dioxide levels

Animal Activity: Increases acidity (lower pH values)
respiration decreases O_2 levels and increases CO_2 levels

Plant Activity: Decreases acidity (higher pH values)
increases O_2 and decreases CO_2 from the water through photosynthesis

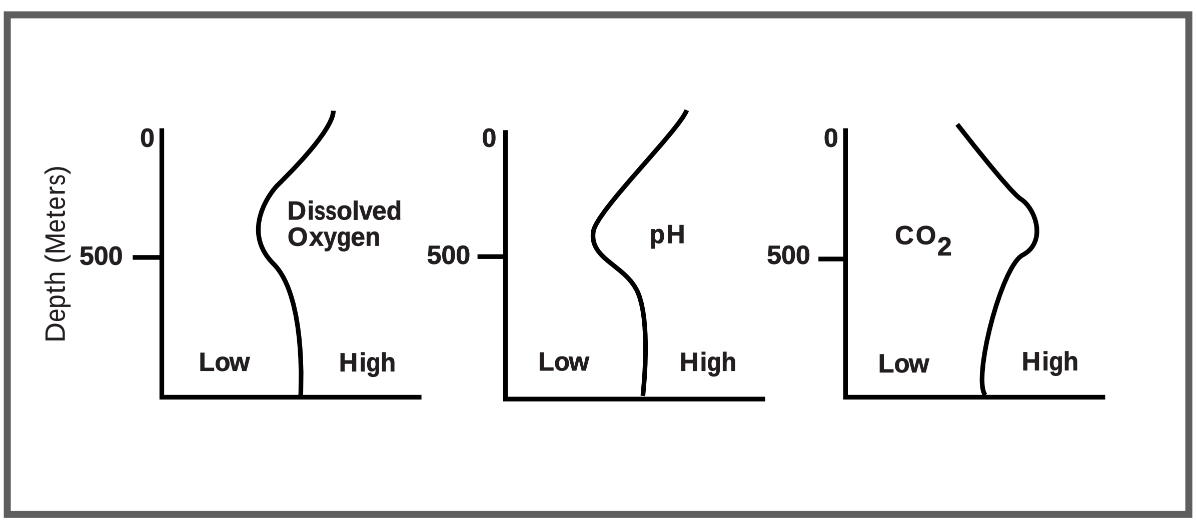


Figure 1. **Generalized depth distribution of dissolved oxygen, pH and carbon dioxide.** The general relationship between dissolved oxygen, pH, and dissolved carbon dioxide is shown.

Watch the movies of a plankton net, Van Dorn bottle, Secchi disk, pH analysis, and oxygen probe [Movies 1-5]. Three times during one week, the research vessel *Sea Explorer* [Fig. 2] was used to sample the plankton and measure the chemistry of the water at the surface and 50 meters down.

Figure 2. **Research Vessel *Sea Explorer***

Movie 1. **Plankton Net.**

Movie 2. **Collecting subsurface water with a Van Dorn bottle**.

Movie 4. **Determining pH**.

Movie 3. **Determining light penetration with a Secchi disk**.

Movie 5. **Measuring dissolved oxygen**.

Table 1 Scientists Log

Day	Plankton Sample #	Photic zone (m)	Surface O_2 (ppm)	Surface pH	50 m O_2 (ppm)	50m pH	Notes
1	1	30	7	8.0	6	8.1	Last week seawater **clear and blue**, winds blew toward the shore. Gathered surface sample using plankton net [Fig. 4a]. Recorded photic zone using Secchi disk and water chemistry using Van Dorn bottle.
3	2	2	9.8	8.5	7	8.1	Winds shifted to offshore direction. **Water was turbid and cloudy, with a red tinge** [See sample, Fig. 4b].
7	3	20	8.5	8.3	7.5	8.2	Winds calmed, blew onshore again. **Red color diminished. Water was clear** [See sample, Fig. 4c].

Activity

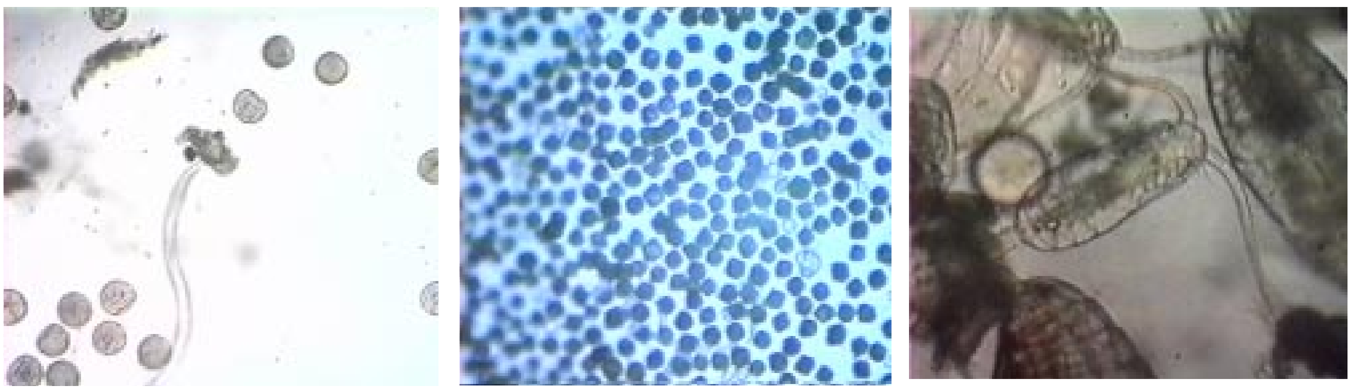
1. Read the scientist's log [Table 1] completely.
2. Make graphs that show: oxygen level at the surface versus time, oxygen levels at 50 meters depth versus time, pH levels at the surface versus time, pH levels at 50 meters depth versus time, and depth of the photic zone versus time.
3. Groups using the computer should:
   a. Watch the videos [Movies 1-5] about how the measurements were taken.
   b. Study each of the plankton sample figures [Fig. 4]. Identify what kinds of plankton you observe in each sample using the identification chart. Also, note the relative quantity of total plankton (for example, a lot or very few) in each sample. Record your results. In each sample, do you see relatively more phytoplankton (plants) or more zooplankton (animals)?
4. Based on your graphs and the results of your plankton study, how do you explain the changes in seawater chemistry observed?

Explanation

Plankton are at the bottom of the *food chain* and have specific requirements: sunlight, water and *nutrients*. If plants do not get these, they hibernate or die. Without plants to eat, the animals die. Plankton Sample #1 reflects this condition with a general absence of both phytoplankton (plants) and zooplankton (animals) [Fig. 4]. Such low productivity lowers the oxygen concentration at the surface, almost matching oxygen levels at depths where no productivity occurs.

When winds blow offshore, the warm surface water is pushed away and cold nutrient-rich water rises up. This process is known as *upwelling*. When this happens, near-surface plants bloom. One type of plant--dinoflagellates (in this case Gonyaulax sp.)--thrives under these conditions. This is one of the chief types of plankton that occurs in a "red tide." This is reflected in Plankton Sample #2, which was collected on Day 3 [Fig 4]. The increased plant activity boosts the oxygen levels near the surface and also lowers the carbon dioxide level.

Phytoplankton blooms lead to increases in the zooplankton population. So, days later, the zooplankton and phytoplankton are blooming, as is seen in Plankton Sample #3 collected on Day 7 [Fig. 4]. Over time, zooplankton use up the oxygen and add carbon dioxide to the near-surface water.



(a) **Day 1** (b) **Day 3** (c) **Day 7**

Figure 4. Plankton samples.

Extension

What is the impact of "red tides" and "brown tides" on fisheries, coastal activities, and local economics? What causes them to occur? Have students research these topics and report on what scientists are doing to help better understand these events.

If you live near the coast or can access coastal data, watch for "red tide" alerts. If they occur, research the wind conditions (for example, strength and direction) that preceded the "red tide."

Vocabulary

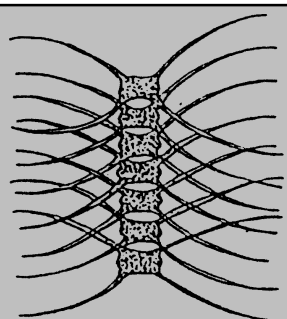
biomass	*ecosystem*	*food chain*
nutrients	*pH*	*photic zone*
photosynthesize	*phytoplankton*	*plankton*
respire	*upwelling*	*zooplankton*

Source

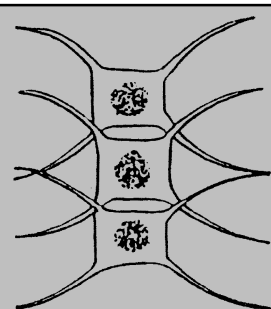
Adapted from Orange County Marine Institute/San Juan Institute Activity Series.

PHYTOPLANKTON

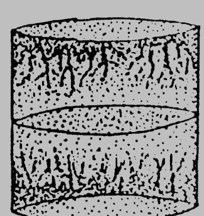
Diatoms



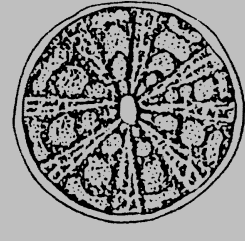
Choaetoceros



Choaetoceros

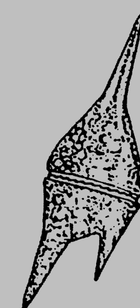


Coscinodiscus

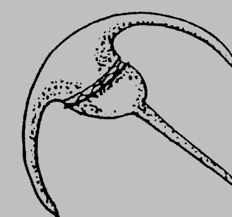


Coscinodiscus

Dinoflagellates

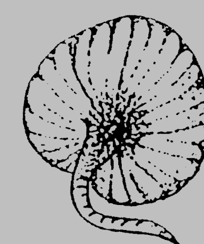


Ceratium



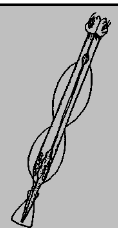
Ceratium

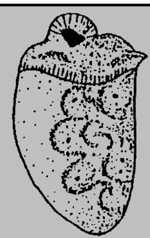
Coscinodiscus

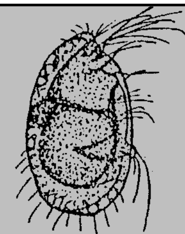


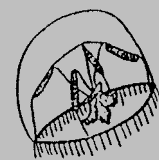
Coscinodiscus

Zooplankton Permanent

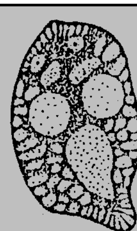

Arrow Worm Sagitta

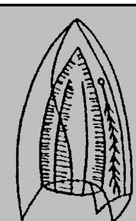

Cladocera


Ostracod

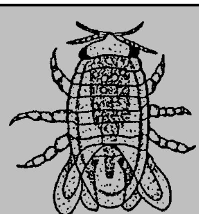

Leptomedusa

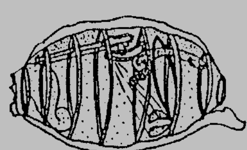

Euphausid

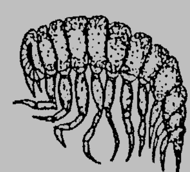

Flatworm


Siphonophora

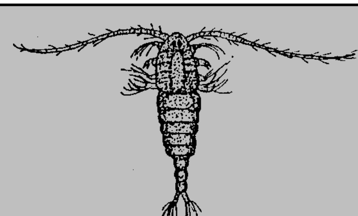

Oikopleura (Tunicata)

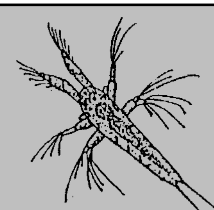

Isopod


Doliolum

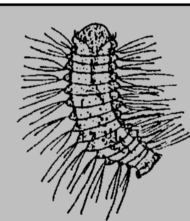

Amphipod

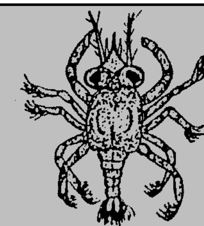

Copepod (Side View)

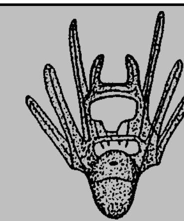

Copepod (Side View)

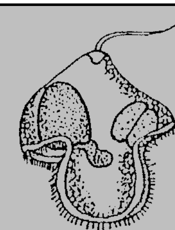

Copepod Larva

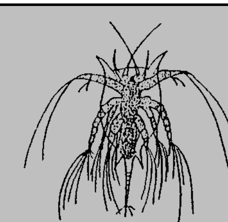
Zooplankton Temporary

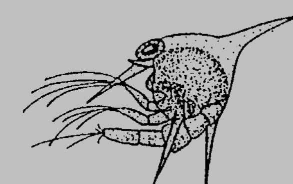

Polychaete Worm

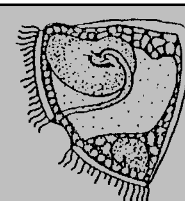

Megalops Larva of Crab

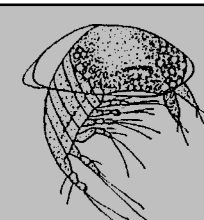

Sea Urchin Larva

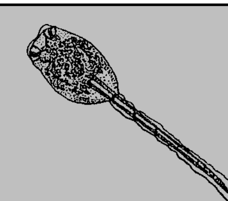

Trochophore Larva

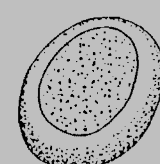

Nauplius Larva of Barnacle

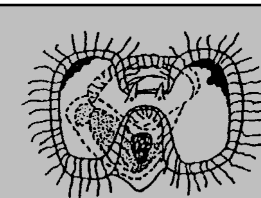

Zoea Larva of Crab


Bryozoa Larva


Cypris Larva of Barnacle


Tunicate Larva


Fish Egg


Veliger Larva of Gastropod