

**Expedition Objective:**

- To examine the conditions leading to the abundance and distribution of life in the sea.
- **Homework** - post in your expedition learning group according to the instructions in the Module Area of Canvas for this expedition

**Part I. Seawater Density & Ocean Layering**

View Presentation at <http://youtu.be/hz6FKaKxZdU> (14 minutes-long)

**1. Slide #31 - Density = Temperature + Salinity + Pressure**

What factors influence the density of seawater and how?

**2. Slide #32 - Density = Pycnocline**

What is the pycnocline?

What water depth range does the pycnocline occupy?

How would variations of sea surface temperature, either very cold water in the polar regions or very warm waters in the equatorial region, influence the development of the thermocline and therefore the pycnocline?

### 3. Slide #33 - Measuring Density

How do oceanographers convert measurements from a CTD into a value for seawater density (for example, discuss the graph on this slide)?

How do oceanographers assign a number value to seawater density (describe  $\sigma_t$ , and give its definition)

How does the density of seawater vary changing temperature?

How does the density of seawater vary with changing salinity?

### 4. Slide #34 Ocean Layering

Make a diagram showing the sea surface and sea floor, the location of the mixed layer, thermocline, and the deep water (include a water depth scale on the left edge of your drawing).

Where is the **mixed layer** in the ocean and what are its properties?

Where is the **thermocline in the ocean** and what are its properties?

Where is the **pycnocline in the ocean** and what are its properties?

Where is the **Deep Water** in the ocean and what are its properties?

## Part II. Supporting the Marine Ecosystem

View the webpages beginning at: [http://oceansjsu.com/105d/exped\\_ecosystems/1.html](http://oceansjsu.com/105d/exped_ecosystems/1.html)

### 1. Introduction - Photosynthesis to Chemosynthesis (8 minutes-long)

What is the primary chemical reaction that leads to life, as we know it, on this planet whether on land or in the sea?

How is this reaction different in photosynthesis versus chemosynthesis (we will study the latter in an upcoming expedition)?

What is the biochemical process that allows organisms to use the energy that is bound in carbohydrates produced by the chemical reaction mentioned above?

What is the main group of organisms that carry out photosynthesis in the ocean and in doing so, generating nearly 70% of the oxygen for our atmosphere?

List several of the critical roles of phytoplankton in enhancing life on our planet

### 2. Providing Nutrients to the Deep Water (2 minutes)

In this expedition, we will focus our attention on photosynthetic communities that derive their energy, either directly or indirectly, from solar radiation.

What is the range of water depths where you might expect to find phytoplankton in the global ocean? \_\_\_\_\_

How is the energy, gathered by these organisms, made available to organisms in the deep sea?

### 3. How is Carbon Stored in the Sea

Carbon stored in live organisms and their remains, called organic carbon, is the chemical basis for life on this planet -- all organisms contain carbon.

This carbon is derived from inorganic carbon, carbon contained in  $CO_2$  (carbon dioxide, a gas in the atmosphere and dissolved in seawater)

Organic carbon is contained in many forms in the ocean, only a small percentage of which is contained in organisms in the surface waters.

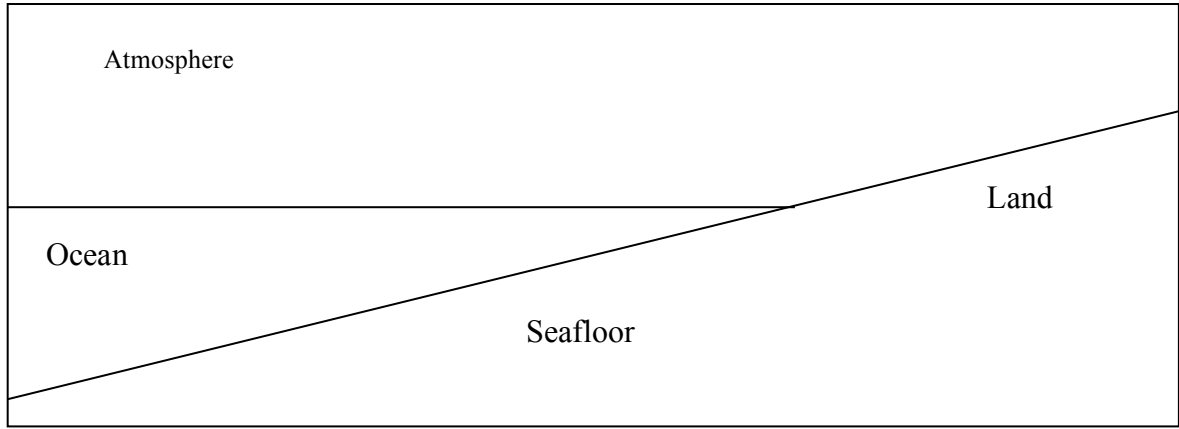
List of the forms and relative amounts of organic carbon in each form in the ocean.

Form of Organic Matter	Relative Abundance (%) in the Ocean
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Most people mistakenly believe that most organic carbon in the sea is tied up in organisms that they can see, however, this represent the tiniest fraction of the total carbon.....the vast majority is found in the forms that cannot be seen by the naked eye.

#### 4. The Carbon Cycle and Carbon Pump

Make a simple diagram (simpler than the one on the WWW page) showing the flow of carbon between the land, atmosphere, sea and seafloor.



What role do phytoplankton play in the flow of  $CO_2$  on our planet?

#### 5. Conditions for Life in the Sea

What conditions are needed for life in the sea?

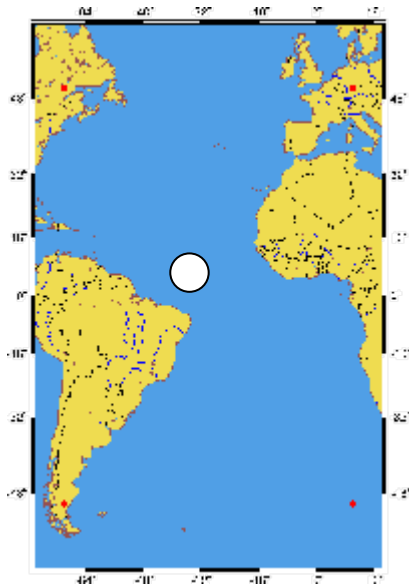
Of these conditions, which one places a limit on the amount of life in the sea and its distribution?

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#### 6. Limiting Nutrients (biolimiting nutrients)

How are nutrients recycled in the sea?

The table below shows the results of a collection of water bottle samples from different water depths in south Atlantic Ocean just off Brazil (Latitude  $0.5^{\circ}$  N, Longitude  $37.5^{\circ}$  W), as shown by the white dot on the map below. The samples were taken to the shipboard laboratory and analyzed for the variation in nitrogen (in the form of nitrate -  $\text{NO}_3$ ), phosphorous (in the form of phosphate -  $\text{PO}_4$ ) and temperature.



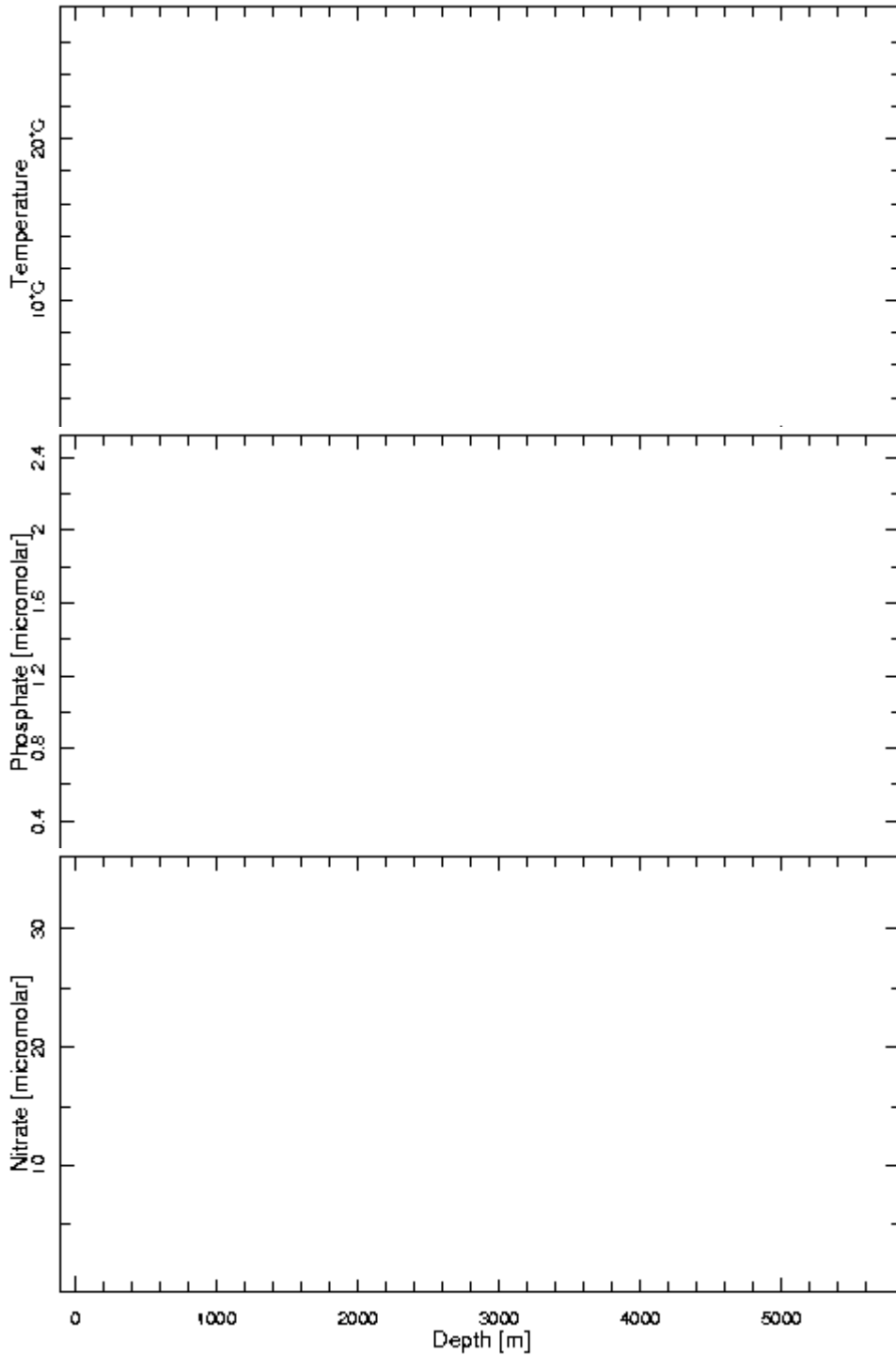
Z Water Depth	Nitrate $\text{NO}_3$	Phosphate $\text{PO}_4$	Temperature
meters	micromolar	micromolar	Celsius_scale
0	0.5347	0.2114	27.2889
50	0.6835	0.2717	26.8648
100	3.7872	0.6638	21.7973
150	10.9978	1.05	15.2152
200	15.7383	1.2276	12.8115
300	20.7088	1.7133	10.681
400	24.7634	2.0062	8.6871
600	33.0768	2.266	5.9297
800	33.3437	2.4429	4.7832
1000	31.4146	2.3459	4.4832
1200	26.9704	2.0174	4.4811
1400	23.7875	1.6837	4.3354
2000	18.3479	1.4823	3.5165
2500	18.0755	1.3423	3.0205
3000	16.0197	1.3006	2.7
3500	16.2994	1.2757	2.4705
4000	20.8376	1.5326	2.1561

Use a spreadsheet or plot by hand the variation in each of these properties on the graphs on the next page.

**DO THESE PLOTS ACCURATELY!!!!**

Make sure that your temperature plot is correct.

Turn page clockwise by 90° in order to plot data -- note water depth scale



37.5W 0.5N

On each plot above (Nitrate, Phosphate and Temperature), label the following water masses: **surface water**, **thermocline/pycnocline** and **deep water** (Nitrate, Phosphate and Temperature).



Do you see a relationship between the water masses as reflected in the temperature and the concentration of nutrients?

Why are these nutrients low in the surface waters?

Why are these nutrients considered biolimiting nutrients?

Why are these nutrients high in the deep waters?

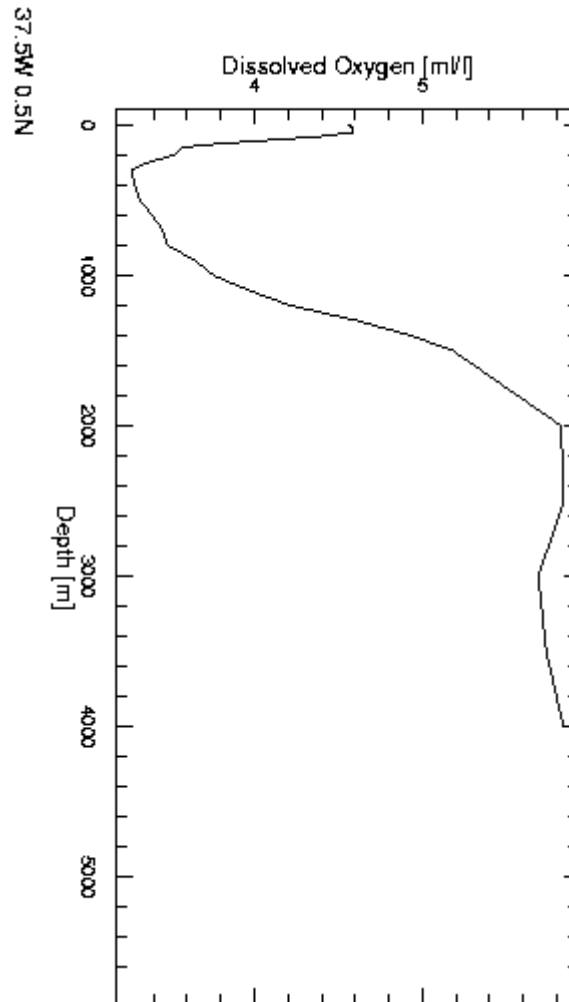
Explain the concept of limiting (or bio-limiting) nutrients and their importance to supporting life in the ocean.

## **7. Nutrient Distribution**

Next discuss the distribution of nutrients with water depth, as shown in your previous graphs, to concentration of oxygen in seawater with water depth as shown in the graph below:

Below you see a graph of the variation in the concentration of oxygen dissolved in seawater with water depth.

Label the regions of surface water layer, thermocline, and deep water on the graph.



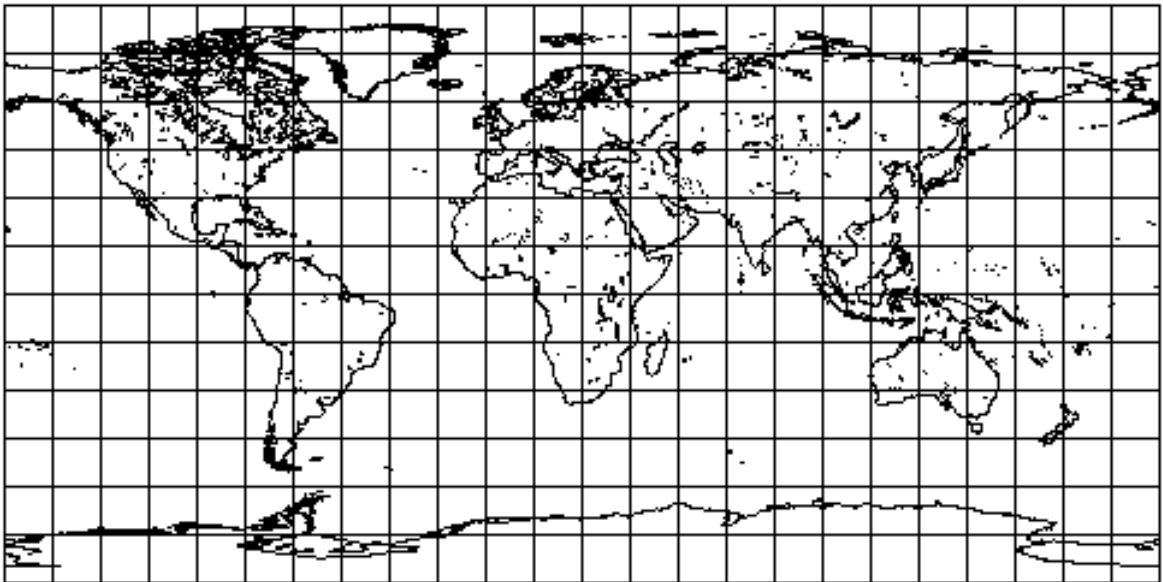
## 8. Distribution of Life in the Sea

What is primary productivity?

How is the distribution of amounts of primary productivity measured in the sea surface across all of the world's oceans?

How would you double-check the ocean color measurements of primary productivity using an oceanographic ship?

Use **HHH's** for regions of high productivity and **LLL's** to outline regions of very low productivity in the global oceans on the map below.

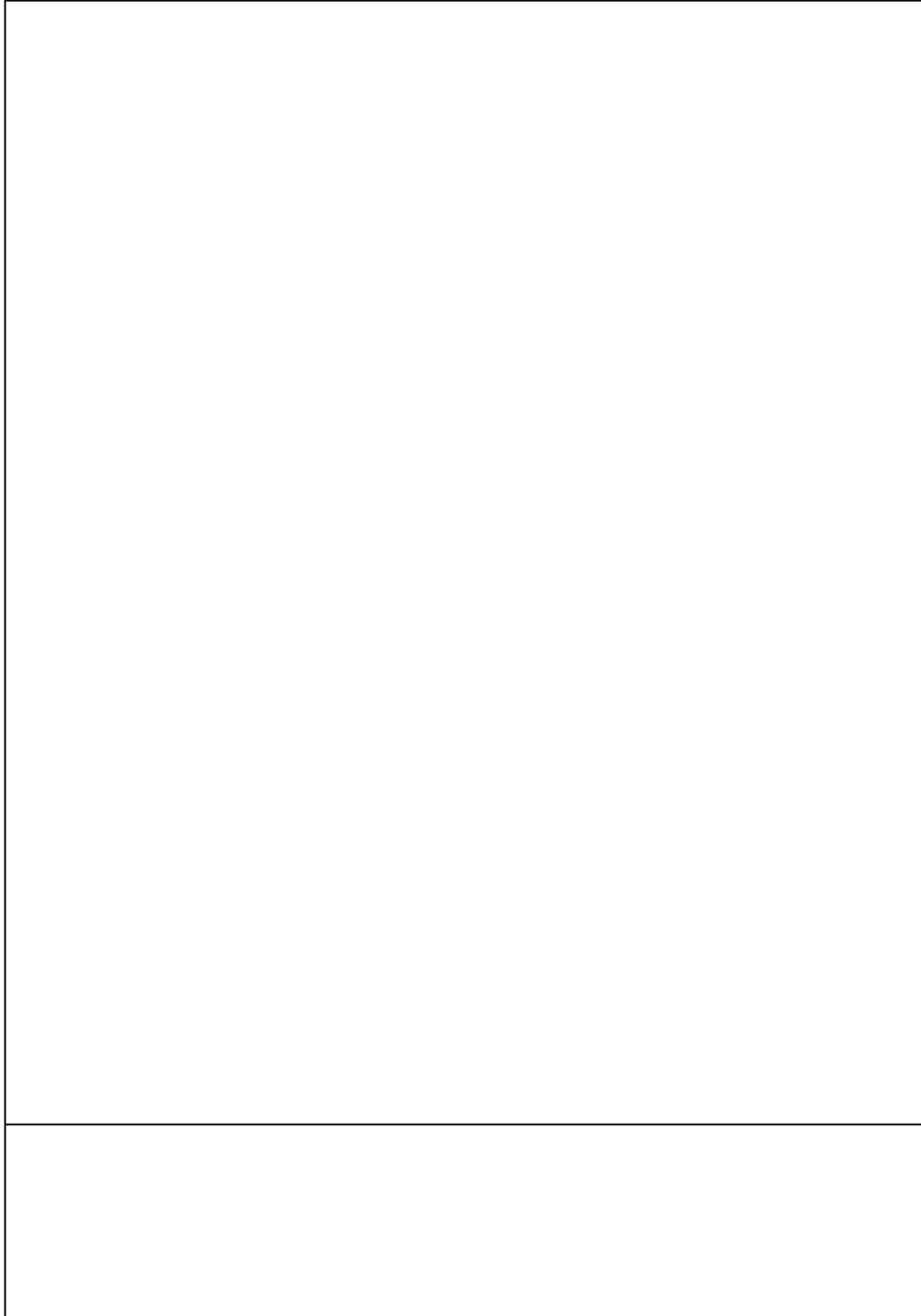


What are the primary controls on the distribution of marine life in the oceans?

How does the circulation of ocean water impact this distribution of marine life?

9. The Marine Food Web - From Primary Producers to Top Level Predators

Draw a marine food web (you may want to turn paper on side to draw the food web)

A large, empty rectangular box with a thin black border, intended for drawing a marine food web. The box is oriented vertically and occupies most of the lower half of the page.

What is meant by an “ecosystem” and for this class, a marine ecosystem?

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