MEASURING PRIMARY PRODUCTIVITY – MARINE ADAPTATION
STUDENT LAB TEMPLATE

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Abstract

Marine primary producers are usually not plants as we typically think about them, but rather seaweed or single-cell algae. The classic example of a marine primary producer is a marine diatom. In this experiment, you will use marine diatoms to measure primary productivity. Real-time data from several sources may be used to increase your understanding of this topic.

Objectives

At the end of this lab, you will have a better understanding of the concept of primary productivity and have used one or more methods to calculate primary productivity. You will have also been introduced to the concepts of marine primary productivity, net productivity versus gross productivity, and the importance of comparing dry weight versus wet weight.

Introduction

Although often ignored in the classroom, the marine environment produces 32 percent of the world's primary productivity on 71 percent of the Earth's surface area. Although this is far less than the 68 percent from the continental surfaces (29 percent of the Earth's surface area), this productivity is still very important, and the figure might be somewhat misleading because the majority of this productivity takes place along the shallow coastal areas of the ocean. The majority of the ocean has comparatively a low primary productivity rate. The tropical rainforest has a net primary productivity of 9,000 kcal/meter^{-2}/year, which is the same as estuaries and swamps and marshes. However, the open ocean is more comparable with the desert biomes (less than 200 kcal/m^{-2}/yr).

What type of photosynthesizers are found in this marine environment? The majority are forms of algae, with an estimate of 60 percent of the photosynthesizing being performed by marine diatoms. In the classroom, we can grow bottle samples simulating the ocean environment, and by varying limiting factors such as light or nitrogen, we can mimic various ocean areas. The primary productivity in these samples can be estimated using various techniques, from the very simple draining of the culture and measuring dry weight of the plants to the use of a spectrophotometer to compare light transmission or even the use of a calorimeter cup and burning the plant material to determine the calorie content of the material. Algal material is particularly good for this type of energy determination, as there are no stems, roots, or dirt to deal with when performing the burn (1 gram of plant material yields about 4.25 kcal).

Additional laboratory experiences can be performed using the Institute of Marine and Coastal Sciences Web site at Rutgers University (marine.rutgers.edu/opp/). This Web site provides many types of information, including datasets of primary productivity measurements based on carbon 14 uptake and simulated fluorescence techniques just for the purpose of primary productivity modeling.

Background Research Information Link

Web Sites

PhysicalGeography.net: Primary Productivity of Plants

http://www.physicalgeography.net/fundamentals/9l.html

Ocean Color From Space: Primary Productivity

http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/OCDST/ocdst_primary_productivity.html

Ocean Primary Productivity Study: Rutgers

http://marine.rutgers.edu/opp/

Materials

- Light source (grow light)
- Dowel rods (for holding the neck of the bottle)
- Salt for making ocean water plus essential nutrient and vitamin package (from pet store)

- Distilled water
- Two bottles with caps per set-up or per student group (size 500 ml to 1000 ml suggested)
- Aluminum foil
- Marine diatom cultures (Carolina Biological), _ culture per bottle
- Pipettes (size to measure 2.5 ml)
- Weighing paper, filter paper, or blotting paper
- Drying oven or cabinet

Alternative: Comparison of methods of measuring primary productivity

- Spectrophotometer
- Calorimeter cups and burner
- Colorimeter
- Other methods to measure total organic carbon (TOC), dissolved oxygen, and carbon dioxide

Alternative: Comparison of growth conditions on primary productivity

- Nutrients such as nitrogen, magnesium, phosphate, sodium chloride, etc.
- Light filters or shading for bottles

Procedure

Your assigned task is to grow marine diatoms and calculate the primary productivity from your cultures using one of the available methods. If your class is using a classwide method of determining primary productivity, you will determine the growing conditions for your culture. Examples might be to mimic the decreasing light intensity in the marine environment or available nutrients in the culture. If your class is measuring primary productivity using different methods of measurement, you may want to use a standard culture setup.

Culture Production

1. Make up ocean water according to directions on package and add nutrient and vitamin package.

2. Cover one bottle with aluminum foil.
3. Add 400 ml of ocean water to each 500 ml bottle.
4. Roll diatom culture between hands to stir. Measure 2.5 ml of culture and add to the covered bottle. Do the same with the second bottle, which is uncovered. Loosely replace caps and place under grow lights, with the neck of the bottle tipped up with a dowel rod.

Growth and Measurement

5. Allow culture to grow for two weeks or until the clear bottle culture becomes opaque.
6. Determine respiration rate and net productivity using one of the available techniques, such as dry weight, spectrophotometer*, or calorimeter*. Calculate gross productivity. An extrapolation of the data can allow you to determine if your cultures mimic the 60 percent of total marine primary productivity rate of marine diatoms in the ocean environment.

*Use spectrophotometer, calorimeter, and colorimeter per manufacture's directions.

or

7. Determine primary productivity by a predescribed method and compare the effects on primary productivity caused by changes in culture conditions.

Lab Tips

- Decide before you begin the experiment what method of measurement you will use or what growth conditions you will use.
- Determine which culture treatment will provide you with the raw data on net productivity and respiration.
- Determine the initial light transmission of the culture before the growth period.
- Determine the initial color of the culture before the growth period.

Data and Observations

Record the conditions under which you grew your plants and write a description of your plants at the beginning and ending of the experiment. Your data should include beginning wet and dry weights and concluding wet and dry weights. These will be needed to complete the required calculations.

Net productivity + respiration = gross productivity

Analysis

The question set from Measuring Primary Productivity -- Grass Plants may be used to aid in this analysis.

If your class used different methods to **measure** primary productivity, use the data from the entire class to produce graphs illustrating the net productivity, respiration, and gross productivity as determined by the various methods of measurement. Determine which of these methods is the most accurate and provide evidence in support of your answer. Where might errors of measurement have occurred?

If your class used different **culture** methods, use data from the entire class to compare respiration and net and gross productivity rates. Graph your comparisons. Provide an explanation of your graphs and determine which culture condition provided the most primary productivity. Explain in paragraph form why the best culture condition was the best and why the worst was the worst. Why or why not were these the expected results?

Additional Reading Sources:

Ocean Color From Space: Primary Productivity

http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/OCDST/ocdst_primary_productivity.html

Ocean Primary Productivity Study: Rutgers

http://marine.rutgers.edu/opp/