Effects of cloud cover and differing light regimes on primary production in the Galapagos Islands region

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Summary

Primary production will be measured and cloud cover will be analyzed at three sites around the island of Isabela in the Galapagos Archipelago to gain an understanding of the affect of clouds on the biology of this region. Samples will be collected from the *R/V Thomas G. Thompson*, incubated for a 24-hour period shipboard, and analyzed using the classic Winkler Method for measuring dissolved oxygen. True color satellite images will also be downloaded for the sampling period and onboard observations will be made to measure the extent of cloud cover. Coupled together, these analyses and observations will provide an explanation of the role differing light intensity regimes have on productivity and will aid in understanding the variable biological ecosystem around the Galapagos Islands.

Introduction

Single-celled organisms, living in the water column of oceanic waters, produce oxygen and organic carbon through photosynthesis, in a process called primary production, which involves the usage of sunlight and nutrients (Ebbesmeyer, 1977). This production is the basis of the food web supporting the biology of the marine environment. The biology of the marine environment is very diverse resulting from differing water conditions, nutrient regimes, and light conditions. The purpose of this proposed study is to examine the relative contribution of clouds to the variation in photosynthetic irradiance and will focus on the effects of light intensity on primary production of the Galapagos Islands region.

The photosynthetic rate of phytoplankton varies over the entire range of light intensity from nearly full sunlight at the sea surface to complete darkness. The relationship between production, or photosynthesis, and light intensity is called the P vs. I curve, which is roughly linear (Miller, 2004). Higher light regimes produce enhanced photosynthesis rates compared to lower light regimes, however, at high light intensities a phenomenon called photoinhibition can take affect and have an adverse effect on photosynthesis (Harris and Lott, 1973). Differing light intensities in the water column can be the effect of many different variables, including clouds, attenuation by suspended solids, and tides (Anthony et al., 2004). Anthony et al. report that clouds can account for 14-17% of the total annual variation in irradiance and surface irradiances of 20-40% less on cloudy days in the summer than on cloudless days.

Contrary to common belief, Galapagos weather is not so warm because of the relatively cold waters surrounding the islands. This region has two main seasons: the warm and wet season from January to June and the cool and dry season from July to December. During the cool and dry season, warm tropical air passes over cool water causing large amounts of evaporation to accumulate over the region resulting in dense cloud cover. Calculations made from data provided by http://oceancolor.gsfc.nasa.gov reveal that the Galapagos region is annually covered by clouds 67% of the time, which presumably can be attributed to the cool and dry season, however observations of satellite images indicates that this can be the case anytime of the year. Sample collection for this study will take place 20-28 January, which is during the transition period from the cool and dry season to the warm and wet season, so it can be expected that clouds will be predominant.

This research will determine the effects of cloud cover on the primary productivity of the Galapagos region. Included will be an examination of the dissolved oxygen contents of

incubated bottles, which will be altered by screening to represent high and low light intensity regimes, and true color satellite images that will display cloud cover of the region. If there is a positive correlation between oxygen production and high light intensity and a negative correlation between oxygen production and low light intensity, than cloud cover may inhibit the primary production potential of the Galapagos Island region. I expect higher amounts of oxygen production in sample bottles exposed to higher light intensities, but I must take into consideration the effects of photoinhibition at extremely high light intensities.

The marine biology of the Galapagos Islands is very diverse so an understanding of how cloud cover affects the system could be very beneficial to the scientific community, as well as the studies of my fellow classmates. Understanding primary production of the Galapagos Island region will be one piece of the puzzle being put together by the Ocean 443 class. Fellow biologists can use this information to better understand community structure, grazing behaviors, and chlorophyll distributions. This area is also a hotspot for evolutionary theory so understanding all the factors that contribute to the vast diversity of the biological ecosystem is crucial. There are plenty of unknowns in the Galapagos region and no studies of this nature have been done there.

Sampling will be done at one station in Elizabeth Bay off the Island of Isabela, where a plume of chlorophyll rich water exists (Martin et al. 1994) and at two stations to the east of Isabela Island where the lowest concentrations of chlorophyll are found (Feldman 1986). All sample collection will be done from the University of Washington's research vessel, the *R/V Thomas G. Thompson* using a conductivity temperature depth (CTD) rosette. Incubations and analysis will also take place on the deck and in the lab of the *R/V Thomas G. Thompson* and satellite imagery should be downloaded shipboard presuming telecommunications are clear.

Proposed Research

In order to determine the effects of clouds on primary production in the Galapagos Islands region, samples will be collected, incubations will be conducted, and observations will be made aboard the *R/V Thomas G. Thompson* from 20-28 January 2006. Water samples will be collected from one station on the western side of Isabela Island and two stations on the eastern side of Isabela Island (Table 1) at or near the surface and at the 50% light extinction depth, as measured by the CTD rosette. Satellite images will be downloaded and the region confined by the points 92°W 1°N, 89°W 1°N, 92°W 2°S, and 89°W 2°S will be analyzed. Collection and analysis details are provided in the following sections.

Primary Production— Sample collection will commence during the nighttime, as to have incubations up and running during full daylight hours. Water will be collected in two niskin bottles by the CTD rosette and brought aboard the ship. Sample water will then be transferred carefully using plastic tubing connected to the niskin to prevent oxygen contamination into eighteen separate 120 ml glass bottles. Twelve of the filled bottles, six from one depth and 6 from the other, will be labeled, taped and placed into the shipboard incubator. The incubator to be used is an uncovered plastic tank filled with continuously flowing seawater. The remaining 6 bottles will immediately be injected with 1 ml of manganese chloride and 1 ml of sodium hydroxide-sodium iodide, to fix the oxygen in the bottle, shaken to promote thorough mixing, and placed in dark storage to be analyzed at a later time. At sunrise, cloud cover will be assessed and screening will be placed on incubating bottles. Ordinary screen door screening will be used

and the percentages of light blocked by the screening will be determined, with the use of a light meter in the lab before the cruise. When cloud cover is prevalent screening will be placed on control bottles and treatments will be left unscreened to replicate higher light levels. If and when skies are clear, screening will be placed on control bottles to protect from photoinhibition and treatments will be covered with multiple layers of screening to replicate lower light levels. Bottles will then be allowed to incubate for the remainder of the 24 hr period. After 24 h of incubation, each bottle will be opened and fixed using the same method as described above. Measurements of dissolved oxygen will be taken from each bottle using the classic Winkler (1888) method (Carpenter 1965). Once all measurements have been made values from the unincubated bottles ($O_{2\ initial}$) can be subtracted from the values obtained from the incubated bottles ($O_{2\ final}$), which will give total values of oxygen production.

Cloud Cover— Single day true color satellite images will be downloaded from http://oceancolor.gsfc.nasa.gov for the period of 20-28 January 2005 to correlate with shipboard experiments. Images will be captured by the SeaWiFS satellite and will be analyzed by fractioning cloudy pixels versus non-cloudy pixels. Shipboard observations will also be made were cloudiness will be rated on a 1-10 scale.

Proposed Budget

		Actual Cost	My Cost
Platform cost			
R/V Thomas G. Thompson	$18,000/day x 8	$144,000	$0
Shipboard Equipment and Analysis cost			
CTD system	$135 x 3	$405	$0
Deck incubator	$3/day x 3	$9	$0
Screening		$0	$0
Dosimat Titrator		$0	$0
Oxygen Analysis	$6 x 18 x 3	$324	$324
	Total amount:	**$144,738**	**$324**

References

Anthony, K.R.N., et al. 2004. Temporal variation of light availability in coastal benthic habitats: Effects of clouds, turbidity, and tides. Limnol. Oceanogr. **49**: 2201-2211.

Carpenter, J.H. 1965. The Chesapeake Bay Institute technique for the Winkler Dissolved Oxygen Method. Limnol Oceanogr. **10**: 141-143.

Ebbesmeyer, C.C. and J.M. Helseth. 1977. An analysis of primary production observed during 1966-1975 in central Puget Sound, Washington. Final report from Evans-Hamilton, Inc. Seattle, Washington. 68p.

Martin, J. H. et al. 1994. Testing the iron hypothesis in ecosystems of the equatorial Pacific Ocean. Nature. **371**: 123-129.

Harris, G. P. and J. N. A. Lott. 1973. Light intensity and photosynthetic rates in phytoplankton. J. Fish. Res. Board Can. **30**: 1771-1778.

Feldman, G. 1986. Patterns of phytoplankton production around the Galapagos Islands, p. 77-106. *In*: M. J. Bowman, C. M. Yentsch, and W. T. Peterson [eds.], Tidal mixing and plankton dynamics. Springer Verlag, Berlin.

Miller, C. 2004. Biological Oceanography. Blackwell Publishing.

Table 1. Locations of Sample collection

Station	Latitude (S)	Longitude (W)
EV1	0° 55.00'	90° 00.00'
WG11	0° 55.00'	90° 40.00'
WG15	0° 32.00'	91° 19.50'