Composition and distribution of phytoplankton around the Galapagos Archipelago

By

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Summary

Phytoplankton community composition and distribution will be determined at six sites around the Galapagos Archipelago. Samples will be collected with a CTD from the R/V Thomas G Thompson and analyzed via size fractionated chlorophyll and visual, microscopic analysis in order to relate the phytoplankton community composition to nutrient availability and zooplankton community composition. The measured phytoplankton distribution will be compared between high (three sites west of Isabela Island) and low (three sites east of Isabela Island) chlorophyll areas around the Galapagos. These analyses are predicted to show larger sizes and amounts of phytoplankton on the west side of Isabela and smaller sized and amounts of phytoplankton in the expected-to-be depleted iron environments east of Isabela. No matter what the conclusion, though, these findings will allow for better prediction and understanding of how the phytoplankton, as well as the organisms in the food web that are immediately linked to the phytoplankton, will react to different changes to the environment in the Galapagos.

Introduction

The Galapagos Islands are a volcanic archipelago that rises from the sea floor at the equator about 600 miles west of Ecuador, South America (Jimenez 1981). It is home to a thriving marine community that is both uniquely diverse and highly productive. This diversity comes as a result of the environment, which is just as diverse and variant as the organism community. With the contribution of three different major current systems (Equatorial Undercurrent from the west, Humbolt Current from the south, and California Current from the northeast) and the effects of both an open ocean and coastal regime, the Galapagos presents a unique scenario in the inner workings of its marine environment.

One of the most distinguishing and controlling factors of the Galapagos marine ecosystem is its large amount and distribution of primary productivity and chlorophyll. In comparison to the High Nitrate Low Chlorophyll (HNLC) areas surrounding the Galapagos, the archipelago supports blooms of phytoplankton and high chlorophyll concentrations throughout the year, which in turn allow for much more growth in the upper trophic levels within the food web. High chlorophyll concentrations throughout the islands are not spatially constant, however. Chlorophyll is observed to be in very high concentrations on the western side of Isabela Island and in much lower concentrations on the eastern side of the island in yearly averaged satellite images (Palacios 2002; Palacios 2004). This is a result of the varying physical and biological impacts between the different areas that is yet to be completely quantified for the archipelago.

A controlling factor of the bloom and spatial distribution of phytoplankton in the Galapagos is the upwelling of the Equatorial Undercurrent (EUC). The EUC's main upwelling site is the western side of Isabela where the highest concentrations of chlorophyll are spotted from satellite (Jimenez 1981). Nutrients and cool water is brought to the surface by the current as it runs into the Isabela on its eastward track, which fertilizes the surface waters (Jimenez 1981). On the eastern side of Isabela, warmer, tropical waters dominate the surface, bringing in less nutrients and warmer water (Jimenez 1981). These source differences in the two halves of the Galapagos and their contributions of nutrients are thought to be the main facilitator of the different chlorophyll/phytoplankton concentrations.

For the area around and within the Galapagos, one of the limitations that are seen to control the phytoplankton population growth that is also directly related to upwelling is the amount of iron present in the water. In the Galapagos, the island effect is hypothesized to be the main source of this iron input (Palacios 2002). This theory proposes that the iron comes

primarily from the island itself, both from dust and water runoff. As Richardson et al. (2004) found, upwelling brings iron to the surface and allows for phytoplankton growth in the equator. In the case of the Galapagos region, the primary source of iron comes from the upwelling while a smaller input is also coming from dust contributions to it at the surface (Landry et al. 1997; Palacios 2002). Due to the generally westward advection of the wind and upwelling on the west side of Isabela, there is little iron input into the eastern side of Isabela and large amounts of iron into the western side.

Differences in iron input directly and indirectly affect the phytoplankton growth rate, distribution, and composition. Iron limitations hinder the growth of both large and small-sized phytoplankton, but more severely limits the larger sizes. In initial conditions of iron limitations, the small celled phytoplankton make up the largest fraction of the phytoplankton community (Landry et al. I 2000). When iron is added, though, only large phytoplankton bloom while the smaller cells remain at the same constant rate, even though both have increased growth rates (Cavender-Bares et al. 1999; Landry et al. I 2000). This occurrence can be accounted for by the second controlling factor of the phytoplankton, grazers. The grazers of smaller phytoplankton comprise mostly of microzooplankton, which have growth rates that are equal to or greater than those of the phytoplankton (Landry et al. III 2000). For this reason, the microzooplankton can increase in numbers just as quickly as the phytoplankton and control their growth. Macrozooplankton, on the other hand, graze on larger celled phytoplankton and have a much slower growth rate than the phytoplankton (Bollens and Landry 2000; Landry et al. III 2000). Larger celled phytoplankton can then bloom until the macrozooplankton catch up and again control the population. After the contributions and considerations of both controls on the phytoplankton community, large cells dominate water that has been iron-enriched and small cells

dominate the community in iron-limited water (Cavender-Bares et al. 1999; Landry et al. I 2000).

In this experiment, the size distribution and community composition of phytoplankton in the Galapagos will be measured in order to relate the phytoplankton community to nutrient availability and zooplankton community composition. Samples will be collected with a CTD from the R/V Thomas G Thompson and analyzed via size fractionated chlorophyll and visual, microscopic analysis. The measured phytoplankton distributions will be compared between high (three sites west of Isabela Island) and low (three sites east of Isabela Island) chlorophyll areas around the Galapagos and then related to the other physical and biological data for each area. In the experiment, if the sizes and composition of the phytoplankton are found to be larger on the west side of Isabela Island than on the east side, then the environment may be under the same controls as those of the IronEx experiments, iron concentrations, zooplankton assemblages and grazing rates. If not, then there may be an alternate explanation that has not yet been observed for the eastern equatorial Pacific and is region specific.

Proposed Research

In order to determine phytoplankton community composition and distribution, I will be taking CTD casts at six different locations in the Galapagos Archipelago (Table 1) from the R/V Thomas G. Thompson. At each station, I will take five samples at different depths that will not exceed 200m in order to see a vertical profile of the phytoplankton assemblage. Depths will be determined relative to percentage incident light penetrations of 100%, 50%, 30%, 15%, and 1%, in order to relate findings to those of Jimenez (1981) and Chavez (1989). In the case that incident light penetration is not known for all five cites, depths that correspond to the surface,

half way to the chlorophyll max, chlorophyll max, half way from chlorophyll max to the bottom of the mixed layer, and bottom of the mixed layer (determined by density stratification) will be used instead.

Size fractionated chlorophyll will be used to determine what percent of the phytoplankton community comprises each size group. The size fractionation will be performed at each depth of each site in at least duplicates (triplicates if time allows). I will use a filter tower with 20um and 2um filters to extract the chlorophyll, leaving me with fractionation groups of >20um, 2-20um and <2um. This will allow for a separation of groups into broad size distinctions. Volumes of water used will vary depending on the concentration of phytoplankton at the station and the amount necessary to get good readings, but is estimated to be at about 100-200 ml for the higher concentrations of phytoplankton and 500ml for the lower concentrations of phytoplankton. After filtrations, each filter will be processed for chlorophyll in accordance with Newton and Van Voorhis (2002), which will extract the chlorophyll into acetone. The chlorophyll concentration will then be analyzed for fluorescence with a fluorometer. The chlorophyll will be tested in order to find the amount in each size grouping at the stations and allow for comparisons between distributions at different depths and sites.

Another technique that will be used to distinguish between phytoplankton assemblages in each site is microscopy and visual identification. Microscopy will be performed at each station, but will analyze only three depths (as time allows): surface, chlorophyll max, and below the chlorophyll max. Triplicates of 1ml from each depth sample will be put into a slide and analyzed visually. No chemical preservation will take place, as samples will be analyzed within 24hrs of being sampled. Each community of phytoplankton will be identified using the aid of identification guides (Tomas et al. 1993; Horner 2002) and the local Ecuadorian phytoplankton

experts on board. They will be analyzed to the smallest taxonomic rank possible, which will depend on the size and magnification of each cell and availability of identification information on the specific cell.

Data that will be used in the comparison of my data to other physical and biological effects around the Galapagos will come from the projects of other people on the ship. Nutrient data for some of the sites will come from Tamra Dickson's project. Zooplankton distributions and composition data will come from Katy Geri. Grazing rates as well as iron effects on the growth of the phytoplankton and zooplankton assemblages will be given by Wendy Guo. This data will be compiled and analyzed for the implications of its effects on the phytoplankton composition and distribution in the Galapagos.

Budget

Category	Item	Provider	Cost per Unit	# Units	Total Cost	My Cost
Platform	R/V Thomas G. Thompson	Pooled	$28,000.00	7	$196,000.00	$0.00
Biological Equipment	Filter Rack & Vacuum Tube	Pooled	$6.00	6	$36.00	$0.00
	Centrifuge	Pooled	$6.00	6	$36.00	$0.00
Physical Equipment	CTD (interocean)	Pooled	$15.00	6	$90.00	$0.00
	Lab Fluorometer	Pooled	$15.00	6	$90.00	$0.00
Water Sampling Equip.	UW Bottle (2.0L)	Pooled	$3.00	5 / 6	$90.00	$0.00
Miscellaneous	Chlorophyll Tests	Pooled	$3.00	15 / 6	$270.00	$0.00
	Guide Books	UW Library	$0.00	15	$0.00	$0.00

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Table 1. Site locations, maximum depths, and ancillary projects at my stations on the OCEAN 443 Galapagos cruise.

Site #	Latitude	Longitude	Max depth (m)	Ancillary Projects
TS 1	0° 32' S	91° 47' W	3100	Tamra, Katy
TS 2	0° 37' S	91° 19.5' W	160	Wendy, Ben, Katy, AJ, Diego
TS 3	0° 13.6' S	91° 36.4' W	2375	Jaqui, Katy
TS 4	0° 1' S	91° 8' W	1850	Katy, AJ, Wendy, Tamra
TS 5	0° 32' S	90° 47' W	500	Katy, Tamra
TS 6	0° 55' S	90° 00' W	175	Katy, Wendy, AJ, Ben