Inter-island comparison of phytoplankton growth and grazing rates in unamended and iron-enriched incubations

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Summary

Chlorophyll *a* fractionated measurements in unamended versus iron enriched dilution bottle experiments will be conducted at 3 sampling sites around the Galapagos archipelago: one within the plume and 2 outside. With these experiments, intrinsic growth and grazing rates are measured, along with responses to iron enrichment of phytoplankton larger than 10 µm and less than 10 µm. The dilution experiments will be conducted in conjunction with AJ LaFevre who will be measuring the bacterial abundance through epifluorescence microscopy. Additionally, the sampling sites are shared with: Benjamin Gilmore, measuring primary production, Tasha Snow, documenting phytoplankton species composition, Katy Geri, documenting zooplankton species composition, and Tamra Dickinson, who is measuring various nutrients such that the combination will allow for further insight on the influence of iron enrichment in the waters around the Galapagos.

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Introduction

The Equatorial Pacific is a known High Nitrate Low Chlorophyll (HNLC) oceanic regime. High Nitrate Low Chlorophyll regimes are traditionally defined as relatively high concentrations of macronutrients such as nitrate and silica.(Frost 2005, pers. comm.). Annual mean concentrations of high macronutrients such as silica and nitrate consistently appear in this region (Levitus 1993), yet phytoplankton standing stock is low year round (Banse and D.C. English 1994). Iron enriched experiments in HNLC areas have shown increased phytoplankton standing stock increases due to iron enrichment (Tsuda et al. 2003, Cavendar-Bares et al.1999, Landry et al. 2000) especially in phytoplankton with diameters greater than 10 μm (Tsuda et al. 2003, Cavendar-Bares et al. 1999). In addition to observed increases in larger phytoplankton due to iron enrichments, higher grazing rates were observed within the iron enriched patch that were approximately twice those outside the patch (Landry et al. 2000), with a similar increase in grazing rates which suggests high grazing pressures within HNLC regions. Landry et al. (2000) also observed a temporal lag in the increase in grazing rates. Grazers exert control over the phytoplankton in the IRONEX iron-enriched patch even with the iron-induced blooms (Banse 1995). Thus, the "Ecunemical iron hypothesis" stated by Price et al. (1994) as, "grazer controlled phytoplankton populations in an iron limited system" can be used to characterize the HNLC oceanic region in the Equatorial Pacific.

However, although the Galapagos archipelago resides within the conventional HNLC ocean waters, a patch of high chlorophyll from the western side of Isabela and extending a hundred kilometers westward (Feldman 1986). This high chlorophyll patch, however is not evident on the eastern isles of the Galapagos, nor on the eastern side of

Isabela (Feldman 1986). Therefore, I would like to explore whether this difference is due to additional iron concentrations inside the plume by comparing dilution incubations with iron enriched treatments and unamended bottles using size-fractionated Chl *a* measurements from a sampling site within the plume and two east of Isabela.

My first expectation is that there is a spatial variation between the waters around the archipelago to iron additions such that within the plume, the difference between growth and grazing rates in the enriched and unamended treatments will be substantially smaller than the samples collected outside of the plume. If one of the causes of the plume is iron-richer waters, then an addition of iron to the samples from within the plume should not affect the growth rates of the phytoplankton as much as the samples outside of the plume. However, if the inter island waters are not iron-limited, such as the Equatorial Pacific (Price et al. 1994, Cavendar-Bares et al. 1999, Landry et al. 2000), then the amended and unamended bottles in all of the bottles should not substantially differentiate from each other.

More specifically, to determine growth and grazing rates within the experiments, size fractionated chl *a* measurements will be quantified within two size classifications: less than 10 µm , and phytoplankton greater than 10 µm. I expect that if the inter-island waters are iron limited regimes, then the increase in Chl *a* concentrations should be primarily due to phytoplankton larger than 10 µm as seen in Landry et al. (2000), Tsuda et al. (2003), and Cavender-Bares et al. (1999) while the Chl *a* for phytoplankton less than 10 µm should stay relatively constant within all of the bottles. Additionally, the samples originating from within the plume should exhibit a smaller change in Chl *a*

concentrations within the iron-enriched bottles with phytoplankton greater than 10 μm and the converse for the 2 samples east of Isabela.

If a cause for the plume is larger concentrations of iron, then grazing rates should exhibit a similar response to the iron enrichment experiments in the equatorial Pacific. For instance, I predict that the grazing will exhibit a temporal lag in the enriched bottles. Since our experiments are only 24 hours long, grazing rates should remain relatively constant throughout our incubations such that the iron enriched bottles from the east samples will exhibit the greatest increases in Chl *a* concentrations after the incubations. The larger grazers exhibit a longer temporal lag to the addition of iron nutrients (Landry 2000, Banse 1995), and I will be expecting the increase in Chl *a* concentrations to be due to larger phytoplankton (> 10 μm). Additionally, in accordance to the "Ecunemical iron hypothesis" by Price et al. (1994), in an iron limited environment, I should expect that the smaller grazers will maintain top down control on the smaller phytoplankton, which will be evident if the changes in Chl *a* concentration for phytoplankton <10 μm are much less than the growth of the larger phytoplankton.

The proposed study will attempt to answer whether the inter island waters are an iron limited system and whether the Galapagos plume or lack thereof in the east is due to iron concentrations. In order to do so, the proposed study will test the hypothesis that the waters east of Isabela are iron limited compared to the western side of the Galapagos archipelago. From the results, an understanding of the intrinsic growth and grazing rates will be obtained in addition to the effects of iron on those rates.

Proposed Research

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To determine the phytoplankton and microbial response with respect to grazing and growth rates, dilution bottle incubation experiments will be conducted from 20-28 January 2005 aboard the R/V Thomas G. Thompson. At each of our proposed sampling sites (Table 1, Fig. 1), seawater will be collected using a trace-metal clean CTD rosette at a depth determined by the PAR reading by the CTD and the transmitted light through the shading of the deck incubators.

The dilution experiments were modeled after Landry et al. (2000) such that AJ LeFevre and I will prepare 2 sets of 10 2.0L bottles and that each set of bottles will be used as unamended dilution treatments consisting of replicated bottles with 0.22, 0.45, 0.65, 0.86 and 1.0 unfiltered seawater. Two sets of bottles will be seawater controls and the other two will be enriched to 2.0 nM concentrations of iron ($FeSO_4$). Filtered seawater for the dilutions will be obtained using the same collected water and using a .2 µm pore size filter.

The sampling and preparation will be done on board before sunrise to ensure uniform light exposure for each bottle. Each bottle will be placed on deck incubators with shading sheets and running seawater to simulate the ambient temperature and light conditions at the sample depth. After a 24 hour incubation period, fluorometric chl *a* samples will be filtered into greater than 10 µm and less than 10 µm size classes with and extracted by the sonification and centrifugation techniques described in Arar and Collins (1997) and quantified using a flurometer. AJ LeFevre will be sampling out of the same bottles for her microbial slide for abundance counts.

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Proposed Budget

Item	Unit Cost (dollars)	# Units	Total Cost (dollars)	Effective Cost (dollars)
R/V Thompson	18000.00	8.00	144000.00	0.00
CTD (split LaFevre, Gilmore)	45.00	3.00	135.00	0.00
Filter rack/ pump	6.00	8.00	18.00	0.00
Centrifuge	6.00	8.00	18.00	0.00
Chlorophyll measurements	3.00	120.00	360.00	1080.00
Sonicator	0.00	8.00	0.00	0.00
Incubation bottles (split LaFevre)	3.00	60.00	180.00	0.00
	Total		144711.00	1080.00

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Figure Captions

Table 1. The three proposed sampling sites. Station 3 is inside the Galapagos plume, and Station 1 and 2 are east of Isabela

Figure 1. Map of the Galapagos Islands and the proposed sample sites.

Tables and Figures

Table 1.

	LATITUDE			LONGITUDE		
Station	Deg.	Min.	N/S	Deg.	Min.	W/E
1	0	55	S	90	0	W
2	0	55	S	90	40	W
3	0	32	S	91	19.5	W

Fig. 1