Variability in vertical distribution of mesozooplankton populations in a high productivity plume of the Galapagos Archipelago, Ecuador

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Running Head: Vertical distribution of mesozooplankton in the Galapagos Archipelago, Ecuador.

Jennifer Nomura

University of Washington

School of Oceanography

jmnomura@u.washington.edu

206 · 465 · 8112

Project Summary

Global patterns of high phytoplankton and zooplankton production are indicative of high levels of fish recruitment and thus are of significant import to marine mammal populations and coastal fishing communities. Whereas distribution of phytoplankton is associated with the euphotic zone, zooplankton exhibit diel vertical migration (DVM) in order to maximize energy gain and reduce the risk of predation, in turn affecting a significant percertage of carbon flux from the euphotic zone. Timing and extent of migrations are correlated with variation in size and physical parameters including light levels and depth of the mixed layer. I hypothesize that mesozooplankton assemblages (>300µm) will exhibit divergent daily and nightly vertical spatial distribution indicative of DVM within the high productivity plume west of Isabela Island in the Galapagos Archipelago, Ecuador. Further, there will be differences in vertical distribution of mesozooplankton between shallow (200 m) and deep-water (1200 m) habitats as the mesozooplankton will travel beyond 200 m when not constrained by depth limitations. Distribution will be established through repeated day and night 1 m diameter closing net tows (300µm mesh) from the R/V Thomas G. Thompson and consist of three discrete depth bins defined by the chlorophyll a maximum. Information on vertical spatial variability within mesozooplankton populations will contribute to our understanding of the poorly described marine environment surrounding the Galapagos Archipelago by defining regions of secondary productivity instrumental in supporting the unusual regional biota.

Introduction

Situated on a platform in the eastern equatorial Pacific at an intersection of three great oceanic currents, the Galapagos Archipelago lays at the eastern edge of a highly productive region in the otherwise unproductive open expanse of the Pacific Ocean. The archipelago's western flanks induce upwelling of the Equatorial Under Current (EUC) bringing nutrients, high primary productivity (Houvenahgel 1984, Feldman 1986, Chavez and Brusca 1991), secondary productivity and fish recruitment (Witman and Smith 2003). Pan-Pacific current import fuels diversity within the islands fueling a mix of warm- and cold-water fauna on the central shelf (Okey et al. 2004). Though the terrestrial biota of the archipelago are famously documented, our understanding of the surrounding marine environs remains minimal by comparison.

Figueroa and Hoefel (unpubl), in an ongoing effort to determine species abundance and composition of Galapagos zooplankton, collected samples from across the archipelago and have reported that divergent patterns of distribution for copepods have emerged separating the western, central and southern regions. Edgar et al. (2004) further divide the islands into five bioregions supporting distinct mixes of fish and macro-invertebrate communities including the high productivity area west of Isabela Island as a distinct bioregion.

While phytoplankton lack the means of motility displayed by the secondary producers, zooplankton often exhibit diel vertical migrations to and from the euphotic zone to maximize energy gain and reduce risks of daylight predation from planktivorous nekton (De Robertis et al. 2000, Rollwagen Bollens and Landry 2000, Strom 2002, Tarling et al. 2002) in turn affecting a significant portion of carbon flux from the euphotic zone (Roman et al. 1995). De Robertis et al. (their figure 1, 2000) show timing of vertical migration to coincide with zooplankton size where larger animals ascend 30 minutes later and descend 45 minutes earlier than smaller bodied organisms and suggest the larger organisms are more conspicuous to planktivorous predators. Longhurst (1976) suggests that larger zooplankton are faster swimmers exhibiting greater vertical migration than smaller class sizes correlating extent of migrations with size as well as with physical parameters including light levels and depth of the mixed layer.

New primary production in the eastern and central equatorial Pacific was estimated at 1 gigaton C per year by Chavez and Barber (1987) representing 18-56% of global new production. A basis of the marine food web, global regions of high primary and secondary production are associated with high levels of fish recruitment (Feldman 1986). While satellite imagery depicting sea surface color permits observation of the global distribution of primary producers we have no such applications describing distribution of secondary producers -the zooplankton- resulting in the need to establish distribution via direct measurement.

Proposed Research

Study area is in the high productivity plume to the west of Isabela Island (Figure 2, Table 1). A 200 m site (Station 1) and a 1200 m site (Station 2) will be sampled from the R/V Thomas G. Thompson (Figure 3). Target times for stations are 1200 and 0000 and were chosen to best capture zooplankton within depth extremes during non-migrational periods. A three-hour leeway is allowable in either direction from target times giving windows of 0900-1500 and 2100-0300. Conductivity, temperature and depth (CTD) data will first be collected to identify the location of the thermocline and chlorophyll a maximum (chl a max) via fluorescence. Three depth bins will be designated upon the initial cast per station and remained fixed throughout the following samples. Proposed depth bins for a subsurface chl a max would isolate the peak of the bloom by 10-20 m above and below the peak between a surface layer bin and a depth bin to 180 m. Based on Roman et al. non-El Nino conditions support a subsurface chl a max for which anticipated depth intervals are 0-30m, 30-100m and 100-180m (their figure 4, 1995). A surface chl a max would likely require a deeper surface bin with anticipated depth intervals of 0-40m, 40-110m and 110-180m.

Depth-discrete vertical net sampling in each bin will profile the vertical distribution of mesozooplankton >300μm. Distribution will be established through repeated day and night net tows employing a 1 m diameter closing net rigged with 300μm mesh. All hauls will be split with a plankton splitter and shared with fellow scientist Natalie Tsui who will be examining coloration related to gut fullness. Mass of samples will be derived through displacement volumes where the difference of a parcel of water is taken from the volume of the sample and the water in a graduated cylinder. General composition of samples will be inferred by frequency of organisms enumerated through 100 counts and will not be species specific. A portion of the samples will be weighed wet prior to desiccated and again after 24 hrs in a 60° C oven for the ratio of gelatinous to crustaceous organisms.

Project Budget

Budget summary is inclusive of all major expenses for the eight day trip.

Item	Project cost	Weekly total
Thomas G. Thompson	$18,000 daily x 8 days	$144,000*
1 m plankton net 300μm mesh	$6 daily x 8 days	$48
Hydraulic winch	$45 daily x 8 days	$360
CTD	$135 daily x 8 days	$1080
Trip total		$1488

*Operation cost not included in budget

References

Chavez, F. P. and R. T. Barber. 1987. An estimation of new production in the equatorial Pacific. Deep-Sea Res. I. **34**: 1229-1243.

Chavez, F. P. and R. C. Brusca. 1991. The Galapagos Islands and their relation to oceanic processes in the tropical Pacific, p. 9-33. In M. James [ed.], Galapagos marine invertebrates. Plenum Press.

De Robertis, A., J. S. Jaffe and M. D. Ohman. 2000. Size-dependent visual predation risk and the timing of vertical migration in zooplankton. Limnol. Oceanogr. **45**: 1838-1844.

Edgar, G. J., S. Banks, J. M. Farina, M. Calvopina and C. Martinez. 2004. Regional biogeography of shallow reef fish and macro-invertebrate communities in the Galapagos archipelago. Journal of Biogeography **31**: 1107-1124.

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.

Houvenahgel, G. T. 1978. Oceanographic conditions in the Galapagos Archipelago and their relationships with life on the islands, p. 181-200. *In* R. Boje and M. Tomczack [eds.], Upwelling ecosystems. Springer Verlag.

Longhurst, A. R. 1976. Vertical migration, p. 116-137. In D. H. Cushing and J. J. Walsh [ed.], The ecology of the seas. Blackwell Scientific Publications.

Okey, T. A., S. Banks, A. F. Born, R. H. Bustamante, M. Calvopina, G. J. Edgar, E. Espinoza, J. M. Farina, L. E. Garske, G. K. Reck, S. Salzar, S. Shepherd, V. Toral-Granda, and P. Wallem. 2004. A trophic model of a Galapagos subtidal rocky reef for evaluating fisheries and conservation strategies. Ecological Modeling **172**: 383-401.

Rollwagen Bollens, G. C. and M. R. Landry. 2000. Biological response to iron fertilization in the eastern equatorial Pacific (IronEx II). II. Mesozooplankton abundance, biomass, depth distribution and grazing. Mar. Ecol. Prog. Ser. **201**: 43-56.

Roman, M. R., H. G. Dam, A. L. Gauzens, J. Urban-Rich, D. G. Foley and T. D. Dickey. 1995. Zooplankton variability on the equator at 140°W during the JGOFS EqPac study. Deep-Sea Res. II. **42**: 673-693.

Strom, S. 2002. Novel interactions between phytoplankton and microzooplankton: their influence on the coupling between growth and grazing rates in the sea. Hydro. Bio. **480**: 41-54.

Tarling, G. A., T. Jarvis, S. M. Emsley and J. B. L. Matthews. 2002. Midnight sinking behavior in Calanus finmarchicus: a response to satiation or krill predation? Mar. Ecol. Prog. Ser. **240**: 183-194.

Witman, J. D. and F. Smith. 2003. Rapid community change at a tropical upwelling site in the Galapagos marine reserve. Biodiversity and Conservation **12** (1): 25-45.

Tables

Table 1: Station descriptions with latitude and longitude, estimated equipment and time required and allowable time windows for station sampling.

Station	Latitude	Longitude	Equipment To be used	Estimated Time Req'd	Time constraints (be specific)
1	0° 35' S	91° 21' W	CTD, vertical closing nets	1.5 hrs per, 6 hrs total per stn.	0900-1500 and 2100-0300
2	0° 10' S	91° 36' W	CTD, vertical closing nets	1.5 hrs per, 6 hrs total per stn.	0900-1500 and 2100-0300

Figure legends

Figure 1: De Robertis et al. 2000 show dawn and dusk migrations by size classes. (A) Euphausiid abundance during dusk ascent at 50 m depth. Lines separate class sizes. (B) Euphausiid abundance during dawn ascent at 50 m depth. Lines separate class sizes.

Figure 2: Map depicting the Galapagos Islands and Isabela Island.

Figure 3: Map depicting the study sites in the vicinity of Isabela Island.

Figure 4: Roman et al. 1995 show mean (±SD) vertical profiles of temperature (C) and in situ fluorescence (D) from October 1992. Values relate to an equatorial station at 0°, 140°W during a non-El Nino year.

Figures

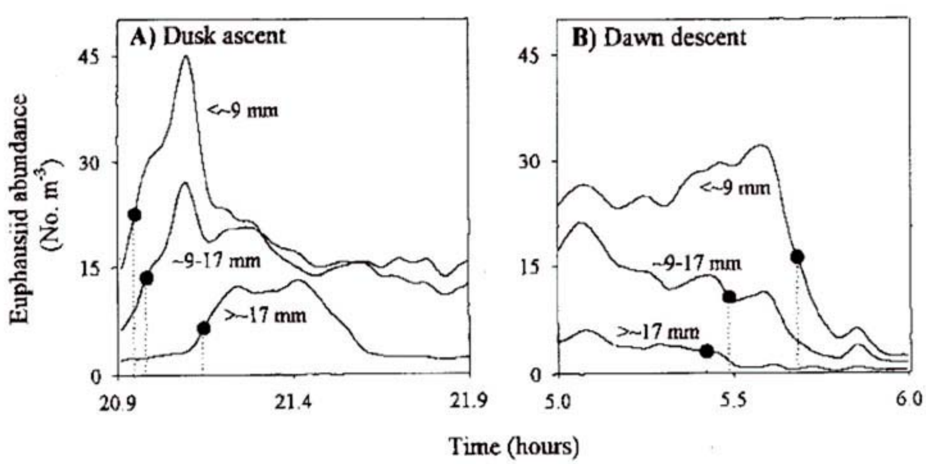


Figure1

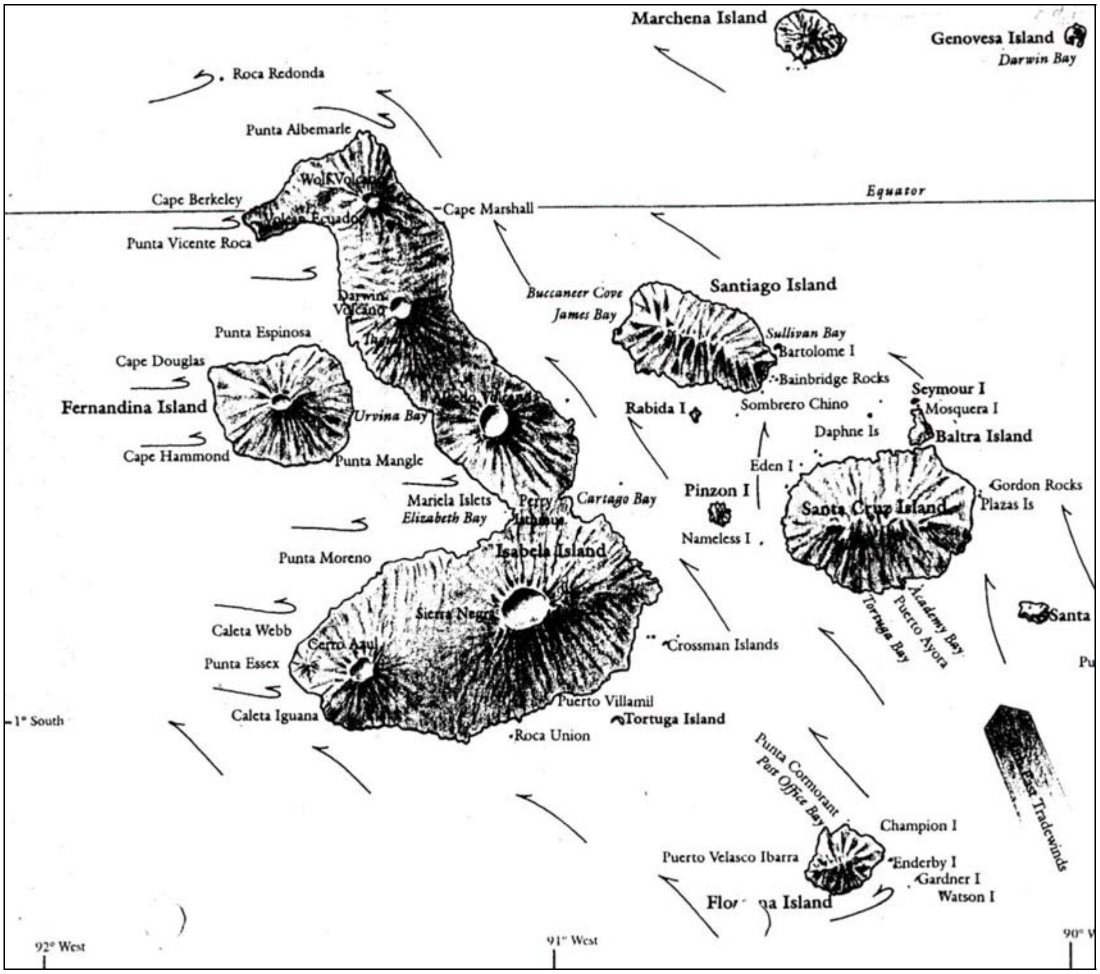
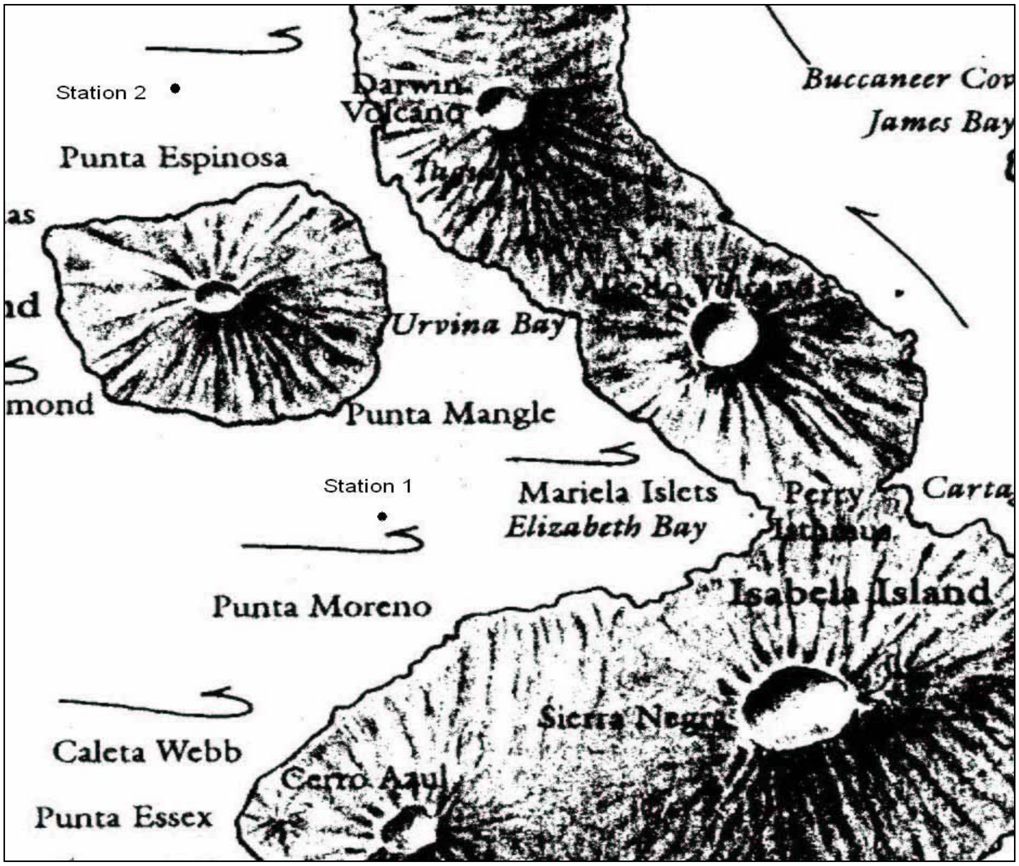

Marchena Island
Genovesa Island
Darwin Bay
Roca Redonda
Punta Albemarle
Wolf Volcano
Cape Berkeley
Cape Marshall
Equator
Punta Vicente Roca
Santiago Island
Buccaneer Cove
James Bay
Darwin Volcano
Punta Espinosa
Sullivan Bay
Bartolome I
Cape Douglas
Bainbridge Rocks
Seymour I
Fernandina Island
Rabida I
Sombrero Chino
Mosquera I
Urvina Bay
Daphne Is
Baltra Island
Cape Hammond
Punta Mangle
Eden I
Gordon Rocks
Mariela Islets
Elizabeth Bay
Cartago Bay
Pinzon I
Santa Cruz Island
Plazas Is
Perry Isthmus
Nameless I
Isabela Island
Punta Moreno
Sierra Negra
Academy Bay
Puerto Ayora
Tortuga Bay
Caleta Webb
Cerro Azul
Crossman Islands
Punta Essex
Puerto Villamil
Caleta Iguana
Tortuga Island
1° South
Roca Union
Punta Cormorant
Post Office Bay
East Tradewinds
Champion I
Puerto Velasco Ibarra
Enderby I
Gardner I
Watson I
92° West
91° West

Figure 2



Station 2
Darwin Volcano
Buccaneer Cove
James Bay
Punta Espinosa
Urvina Bay
Punta Mangle
Station 1
Mariela Islets
Elizabeth Bay
Perry Isthmus
Punta Moreno
Isabela Island
Sierra Negra
Caleta Webb
Cerro Azul
Punta Essex

Figure 3

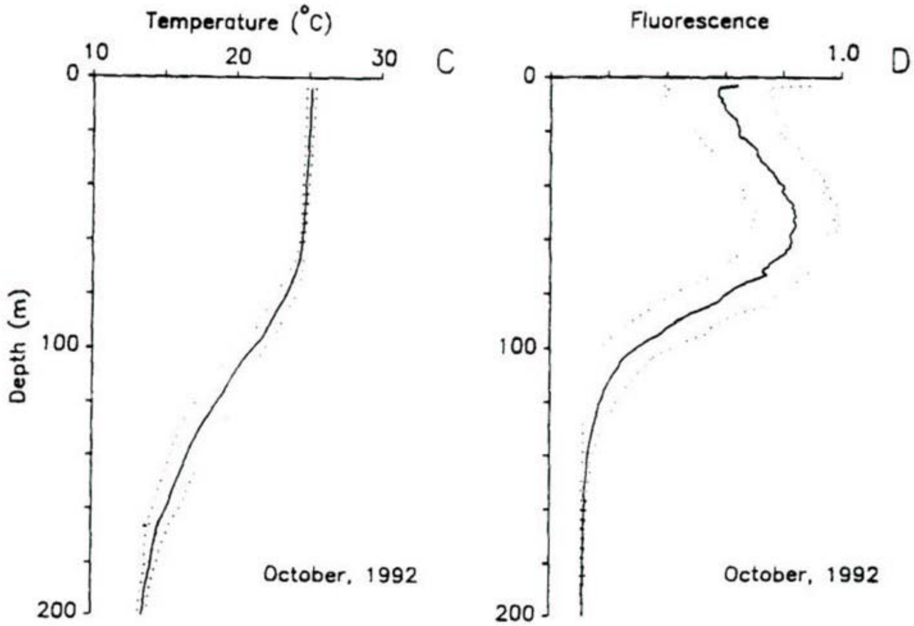

Temperature (°C)
10
20
30
C
0
100
200
Depth (m)
October, 1992
Fluorescence
1.0
D
0
100
200
October, 1992

Figure 4