Investigation of an eastward flowing undercurrent east of the Galapagos Islands

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Project Summary

A meridional transect east of the Galapagos Islands along 089ºW and from 2ºS to the equator will be analyzed to determine the velocity structure and temperature, salinity, and oxygen composition of a subsurface eastward current. The study will be conducted aboard the R/V Thomas G. Thompson on 20-28 January 2005. Temperature, salinity, and oxygen measurements using a CTD and an YSI saline meter and velocity vectors using an ADCP will be observed in order to understand the process of the formation of the subsurface eastward flowing current. The data collected would allow others in future studies to understand the dynamics of this relatively mysterious eastward flowing subsurface current.

Introduction

It is well known that the El Niño Southern Oscillation (ENSO) events originate in the equatorial region of the Pacific Ocean. The weakening of the trade winds releases the potential energy stored from the higher dynamic sea height and higher temperature waters in the western Pacific towards the central and eastern tropical Pacific. The ENSO events occurs every 3 to 8 years and causes global changes in weather patterns, most notably in the eastern tropical Pacific. This region, between the Galapagos Archipelago and the coast of Peru, receives a lot more rain and has observed sea surface temperature anomalies of 10ºC (Chavez and Brusca 1991).

The Equatorial Undercurrent (EUC) is an eastward subsurface current that flows along the equator. The trade winds cause a zonal pressure gradient in the tropics. This imbalance in pressure causes a geostrophic convergence along the equator allows the EUC to exist (Blanke and Raynaud 1997). The EUC, also known as the Cromwell

Current, flows underneath a westward current called the South Equatorial Current and acts as a conduit to balance the movement of water back to the east (Christensen 1971). The signature of the EUC is a 13ºC thermostad, a high salinity core, and a high dissolved oxygen concentration tongue (Lukas 1986).

The equatorial undercurrent plays a major role in the upwelling of nutrients during a non El Niño year (Wilson and Adamec 2001). With the EUC acting as a conduit, knowing where it ends is important to understand. Christensen (1971) claims that the mechanisms involved in the attenuation of the EUC are unclear, and says that the terminus is located near the Galapagos Islands. Lukas (1986) says it flows into a pool southeast of the Galapagos Islands. Steger (1998) predicts that biological activity will be absent when there is no EUC in the region of the Galapagos Islands.

Proposed Research

The focus of my goal is to profile one area perpendicular to the subsurface eastward current along the equator and determine if it is the formation of a new current or a continuation of the EUC based on temperature, salinity, oxygen, and velocity data collected in the student cruise along with historical data. My work should also complement the same properties collected in the equatorial region from other studies such as the Tropical Atmosphere Ocean Project's (TAO) array because it extends the equatorial observations from 095ºW to 089ºW (Figure 2). The time of the year that I will gather my data is special because it is around the transition point of seasonality within the region.

My work will consist of two parts. The first part will be data collection. The shipboard measurements will occur on the second leg of a two-leg student cruise aboard the Research Vessel Thomas G. Thompson. The ship will get underway from Puerto Ayora on Santa Cruz Island at 1900 on 20 January 2006, but the beginning of my measurements is not scheduled to begin until the afternoon of 26 January 2006. For convenience, the logistics are available of my portion of the cruise (Table 1). The total estimated time for my data sampling is 19.2 hours. The sampling will begin with a CTD and YSI saline meter cast at station XO5 (Figure 1) to gather salinity, temperature, and oxygen measurements. The depth of the cast will be 500 m because previous measurements show that the core of the eastward subsurface current varies from 30 to 300 m (Lukas 1986). When the CTD and YSI saline meter instruments are retrieved, the ADCP will be brought online to begin the velocity measurements. The Thompson will then begin a 7 knot transit along the 089ºW longitude and while the ADCP continuously processes the velocity measurements. The meridional transect starts at the equator and ends at 2ºS, but the measurements may begin at 2ºS and head toward the equator. The EUC varies in latitude from 2ºS to 2ºN (Lukas 1986; Steger 1998). Due to time constraints, I can only measure the southern domain of the EUC. I would like to set the depth cell size, which is similar to the distance between two current meters above one another, to 10 m. In addition, I would like the number of depth cells, which are similar to the number of current meters, to range from 48 to 50, depending on the configuration on the Thompson (RD Instruments 1996).

For greater confidence in my work, I will find some time to calibrate the ADCP using the work of Joyce (1989). The calibration will be performed either before the

ADCP is brought online for Miriam Lucero, one of the Ecuadorian scientists that will be aboard. The caveat for reducing the amount of in situ calibrations of the ADCP is that I have to be meticulous in accounting for sound speed variations along my transect. Doing so will prevent large errors in my calculations (Joyce 1989).

The second half of my data analysis will consists of evaluating the data with software tools such as MATLAB, LABViEW, VmDas, and WinADCP. I am currently taking a MATLAB programming course and a LABViEW course so that I can understand how to implement those tools to analyze the velocity vectors and plot the oxygen, salinity, and temperature properties in a 2 or 3-dimensional profile. Either the VmDas or WinADCP software will be used to process the data collected by the ADCP.

I hope that the data I gather will help not only my understanding of the dynamics of the Galapagos Islands region, but other students in the cruise as well. Since the EUC plays an important role in the biological facet of oceanography by upwelling west of the Galapagos Islands to provide nutrients, then I believe the subsurface undercurrent to the east is important to the biology off the coast of South America.

Figures and Tables

Figure 1 shows my proposed sampling stations in red. This meridional transect is located on 089ºW and stretches from 0º to 2ºS (Steger et al. 1998).

Figure 2 shows the locations of all the Tropical Atmosphere Ocean (TAO) instruments available to collect data along the equator (Tropical Atmosphere Ocean Project 2005).

Table 1 shows the logistics of the stations I want to sample. Two ARGO floats are available and will be deployed from one of the stations along the transect, depending on the location of the subsurface current.

Figure 1.

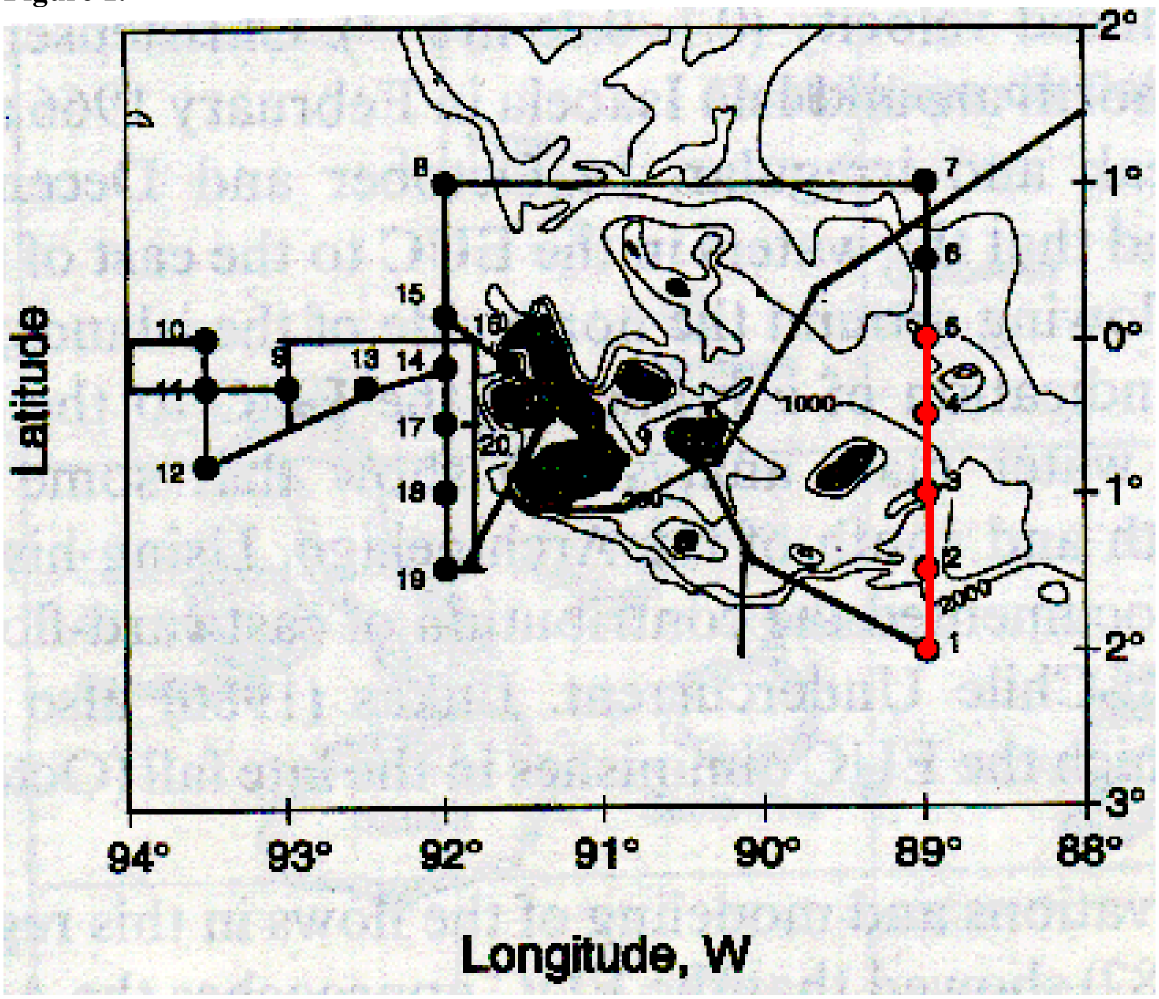
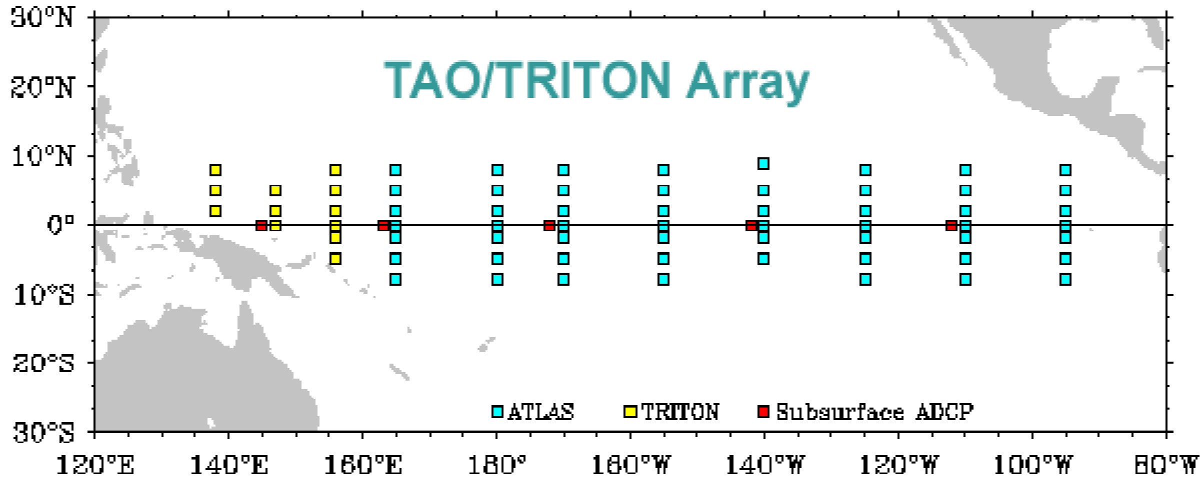


Figure 2.



TAO/TRITON Array
30°N
20°N
10°N
0°
10°S
20°S
30°S
120°E
140°E
160°E
180°
160°W
140°W
120°W
100°W
80°W
ATLAS
TRITON
Subsurface ADCP

Table 1.

Station	Equivalent Steger Station	Latitude	Longitude	TGT SOA* (kts)	Estimated time needed (hours)	Measurements Performed±
XO5	5	0º	089ºW		0.4	500m CTD drop w/ YSI Salinometer
Transit				7	4.3	ADCP online
XO4	4	0º30.00'S	089ºW		0.4	500m CTD drop w/ YSI Salinometer
Transit				7	4.3	ADCP online
XO3	3	1º00.00'S	089ºW		0.4	500m CTD drop w/ YSI Salinometer
Transit				7	4.3	ADCP online
XO2	2	1º30.00'S	089ºW		0.4	500m CTD drop w/ YSI Salinometer
Transit				7	4.3	ADCP online
XO1	1	2º00.00'S	089ºW		0.4	500m CTD drop w/ YSI Salinometer
				Total Time	19.2	

* Thomas G Thompson's Speed of Advance
±ARGO floats will be deployed at station with strong undercurrent signal

Proposed Budget

Expenditures	Units Needed	Unit Cost (per day, unless otherwise stated)	Project Real	Costs Not Real	Real Running Cost	Hypothetical Running Cost
Equipment Rental						
P13 YSI Salinity Meter	2	$15.00	$15.00	$30.00	$15.00	$30.00
J04 GPS, Northstar 951XD	2	$15.00	$15.00	$30.00	$30.00	$60.00
P08B CTD(Seabird Seacat) combo w/Toshiba	2	$60.00	$60.00	$120.00	$90.00	$180.00
Ship Time and Nautical Gear					$90.00	$180.00
R/V Thomas G Thompson	2	$18,000	$0.00	$36,000	$90.00	$36,180.00
H01 Hydraulic Winch	2	$45	$45.00	$90.00	$135.00	$36,270.00
Analytical Costs						
G08 Toshiba Portable combo w/ Seacat CTD	2	see P08B			$135.00	$36,270.00
LABViEW Software	1	N/A			$135.00	$36,270.00
MATLAB 6.5 Software	1	N/A			$135.00	$36,270.00
VmDAS Software	1	N/A			$135.00	$36,270.00
WinADCP	1	N/A			$135.00	$36,270.00
Non-pooled equipment					$135.00	$36,270.00
Acoustic Doppler Current Profiler	2	N/A			$135.00	$36,270.00
ARGO Drifter Floats	2	N/A			$135.00	$36,270.00
Total					$135.00	$36,270.00

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