

7. SITE SURVEYS¹

Larry A. Mayer,² N. G. Piasias,³ A. C. Mix,⁴ M. W. Lyle,⁵ P. Arason,⁵ and D. Mosher⁶

INTRODUCTION

To facilitate the selection of drill sites for Leg 138, a site survey program was conducted on board the Scripps Institution of Oceanography's research vessel *Thomas Washington* (Cruise Venture 1). During this cruise, which departed San Diego on 30 August 1989 and arrived in Manzanillo, Mexico, on 4 October 1989, more than 11,800 km of SeaBeam bathymetry, 8800 km of single-channel digital seismic data, and more than 200 m of sediment cores were collected. In addition to aiding in the selection of Leg 138 drill sites, the data collected during Venture Leg 1, in its own right, will provide important information about the response of the equatorial Pacific to global changes in climate. The site survey cruise, like the drilling program, concentrated its efforts on two north-south transects across the major eastern equatorial oceanic boundaries. In addition, during the cruise, scientists collected SeaBeam and seismic data between the two transects and conducted several ancillary programs. In this chapter, we briefly describe the data collected during this site survey cruise; SeaBeam bathymetry and seismic profiles for each drill site are presented in the individual site chapters.

110° W TRANSECT

The longitudinal position of this transect was selected for the following reasons: (1) the transect is sufficiently far west to be in an area where equatorial currents are well established and less influenced by boundary currents along Central and South America; (2) a transect of long-term ocean buoys deployed at this longitude provides important physical oceanographic data for this region; (3) the water depth is shallower than regions farther to the west, so that carbonate preservation should be better; (4) basement age is such that late Neogene sections might be recovered by drilling along the entire transect; and (5) studies of late Pleistocene and Pliocene sedimentary sections suggest that significant climate variability occurred here and that strong regional differences in oceanic response to global changes in climate have characterized this area of the Pacific.

Survey Sites

Seven sites were surveyed along a north-south equatorial transect (Fig. 1) across the major currents of the equatorial Pacific—the westward-flowing North Equatorial Current (NEC) (usually found north of 10°N), the eastward-flowing North Equatorial Countercurrent (NECC) (positioned between 5° and 10°N during Northern

Hemisphere summer and fall), and the westward-flowing South Equatorial Current (SEC) (found south of 5°N). These survey sites were positioned so that standard piston cores would provide records of changes in the intensities of these currents and the position of their boundaries during the late Pleistocene.

All sites are characterized by north-south-trending topography consistent with seafloor that originates from the East Pacific Rise (EPR). Sediment thickness generally increases toward the equator in a manner typical of the equatorial region (Fig. 2). Basement ages (t) along the 110°W transect were estimated (1) by dividing the distance from the rise crest by the EPR west-flank spreading rate (70 km/m.y.) and (2) using the age-depth calculation ($Z_{\text{obs}} = Z_{\text{axis}} + kv\sqrt{t}$) with the unloaded basement depth (Z_{obs}), 2.8 km for the axis depth (Z_{axis}), and a subsidence parameter for the EPR west flank of 0.325 (k). Ages calculated by the two methods were always within 10% of one another. Ages given are averages of the two calculations.

Station 4 (11° 15'N, 109° 37'W, 3531 mbsl—WEQ-2—Site 854): The northernmost site is located within the westward-flowing NEC. This site is north of the Clipperton Fracture Zone, in a region of north-to south-trending topography. The total relief in the surveyed region is about 240 m, with an average sediment cover of 40 m. The region lies south of an extensive area of rough basement topography having little sediment cover. Sediment recovered at this site (piston Core VNTR01-1PC) is a calcareous pelagic ooze. Preservation of radiolarians and foraminifers is moderate to good.

Station 5 (7° 12'N, 109° 44'W, 3741 mbsl—WEQ-7—Site 853): The second site along the 110° transect is located near the boundary of the westward-flowing NEC and the eastward-flowing NECC. Sediments recovered here will provide a record of the latitudinal movement of this oceanographic boundary. The north-south-trending topography of this site has a total relief of almost 400 m, while the average sediment cover is 60 m. Sediments cored at this site (Cores VNTR01-2PC and VNTR01-3PC) are calcareous pelagic oozes. Preservation of radiolarians and foraminifers is fair to good.

Station 5A (5° 21'N, 110° 5'W, 3855 mbsl—WEQ-3—Site 852): The third site in the transect is positioned near the northern seasonal boundary between the SEC and the NECC. The topographic relief at this site is 300 m and is subdued, compared with that at Station 5, by the increased sediment thickness, which averages about 110 m. The calcareous pelagic ooze recovered at this site (Core VNTR01-4PC) contains radiolarian and foraminiferal microfossils of moderate to excellent preservation, better than seen in cores farther north along the transect.

Station 6 (2° 45'N, 110° 5'W, 3764 mbsl—WEQ-4—Site 851): This station is located within the SEC and near the southern seasonal migration of the boundary between the NECC and the SEC. Sediment at this site will provide a record of the history of the SEC, as well as any significant southerly movement of the boundary between the SEC and the NECC. Sediment thickness at this location averages about 300 m. The calcareous pelagic ooze recovered at this site (Cores VNTR01-5 and VNTR01-6) contains well-preserved radiolarian and foraminiferal fossils. Both microfossil groups are dominated by elements typical of the higher productivity associated with the equatorial divergence zone.

Stations 6A and 6B (1° 1'N, 110° 34'W, 3772 mbsl and 0° 2'N, 110° 28'W, 3800 mbsl—WEQ-6—Site 849): Because of the observed narrow latitudinal extent of the equatorial divergence zone, two

¹ Mayer, L., Piasias, N., Janecek, T., et al., 1992. *Proc. ODP, Init. Repts.*, 138: College Station, TX (Ocean Drilling Program).

² Department of Surveying Engineering, Ocean Mapping Group, University of New Brunswick, P.O. Box 4400, Fredericton, New Brunswick E3B 5A3, Canada.

³ College of Oceanography, Oregon State University, Corvallis, OR 97331-5503, U.S.A.

⁴ College of Oceanography, Ocean Administration Bldg. 104, Oregon State University, Corvallis, OR 97331-5503, U.S.A.

⁵ Borehole Research Group, Lamont-Doherty Geological Observatory, Palisades, NY 10964, U.S.A.

⁶ Hlidarvegi 13, IS-200 Kopavogi, Iceland.

⁷ Department of Oceanography, Dalhousie University, Halifax, Nova Scotia B3H 4J1, Canada.

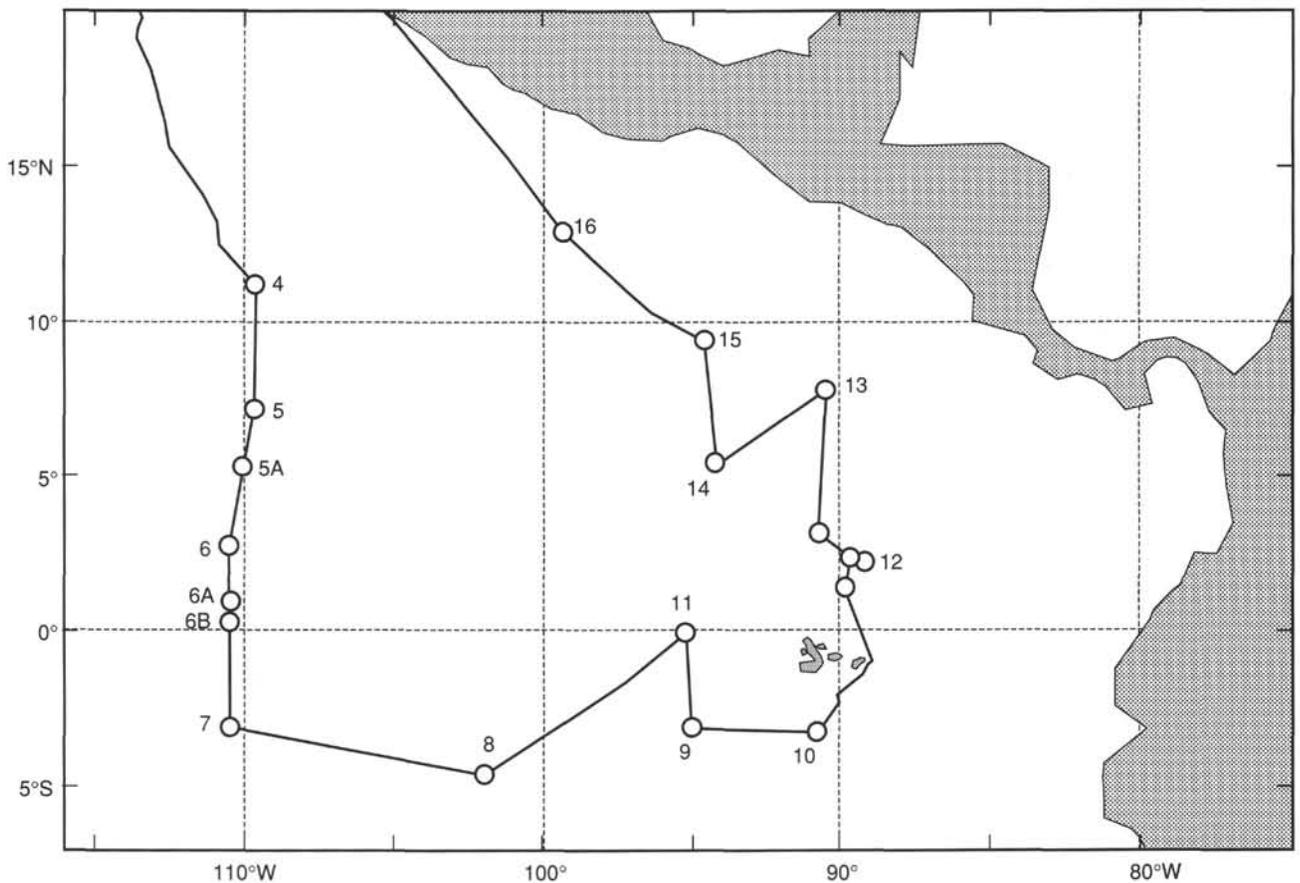


Figure 1. Track of Venture 1 cruise. Station numbers (open circles) are shown for reference.

closely spaced core stations were occupied near the equator. Cores VNTR01-7PC and VNTR01-8PC were collected at $1^{\circ} 1'N$ (3706 m) and $0^{\circ} 2'N$ (3791 m), respectively. These calcareous pelagic oozes displayed evidence of reducing conditions. The high degree of organic decomposition, evidenced by the presence of H_2S , is associated with magnetic susceptibility values near zero, below the upper 3 m of sediment. Radiolarian preservation is excellent in both cores, and foraminiferal preservation is moderate to very good in Core 7 and excellent in Core 8. The microfossil assemblages contain abundant elements typical of the divergence region.

The topographic relief at these sites is about 100 m, with average thicknesses of sediment of about 250 to 300 m. The equatorial site (Station 6B) was surveyed in more detail to provide seismic and SeaBeam data in case this site was considered by ODP.

Station 7 ($3^{\circ} 0'S$, $110^{\circ} 29'W$, 3860 mbsl—WEQ-5—Site 848): The southernmost site surveyed for the 110° transect is at $3^{\circ} S$. Topographic relief at this site is about 125 m. Core VNTR01-9PC, recovered here, contains calcareous ooze. Foraminiferal preservation varies from poor to good, and radiolarian preservation is good.

95° W TRANSECT

Unlike the $110^{\circ}W$ transect, which is located in a region where oceanic boundary effects are minimal, the transect at $95^{\circ}W$ was designed to sample sediment records within the region where the equatorial current system and the eastern boundary of the Pacific more strongly interact than at $110^{\circ}W$. Survey sites were selected within three general oceanographic settings: (1) sites at about $2^{\circ}S$ within the SEC and influenced by the advection of cold waters from the Peru Current; (2) a site at the equator west of the Galapagos Islands, where

the Equatorial Undercurrent (EUC) reaches its shallowest position and commonly surfaces; and (3) sites within the NECC and the Costa Rica Dome, where the eastern boundary of the Pacific causes waters of the NECC to turn and coalesce with those of the NEC. Divergence in the region of this cyclonic flow results in some of the highest open-ocean primary productivity rates ever observed.

Survey Sites

Six sites were surveyed along an approximately longitudinal transect from $2^{\circ}S$ to $15^{\circ}N$. Unlike the 110° transect, where the basement of all the sites originated as part of the Pacific Oceanic Plate, basement of the sites selected as part of the $95^{\circ}W$ transect was formed at different spreading centers, and thus the nature of basement in terms of age and structure is much more complex.

Stations 9 and 10 ($3^{\circ} 1'S$, $95^{\circ} 20'W$, 3535 mbsl—EEQ-4A; $3^{\circ} 5'S$, $90^{\circ} 50'W$, 3304 mbsl—EEQ-4—Site 846): Both the two southernmost sites in the $95^{\circ}W$ transect are in the SEC and within the region where the Peru Current joins the equatorial circulation system. Both sites occur in regions of very low topographic relief (maximum relief in both survey areas is on the order of 75 m). Sediment cores recovered in both areas (VNTR01-12PC and VNTR01-13PC) contain calcareous pelagic oozes that exhibit excellent to very good preservation of radiolarians and very good to moderate preservation of foraminifers. Of the two sites, core VNTR01-12PC has better preserved carbonates and higher late Pleistocene sedimentation rates. Both fossil groups contain abundant elements associated with both the tropical ocean as well as cooler eastern boundary currents.

Station 11 ($0^{\circ} 07.8'N$, $95^{\circ} 20'W$, 3345 mbsl—EEQ-3—Site 847): Station 11 is located within the South Equatorial Current; however,

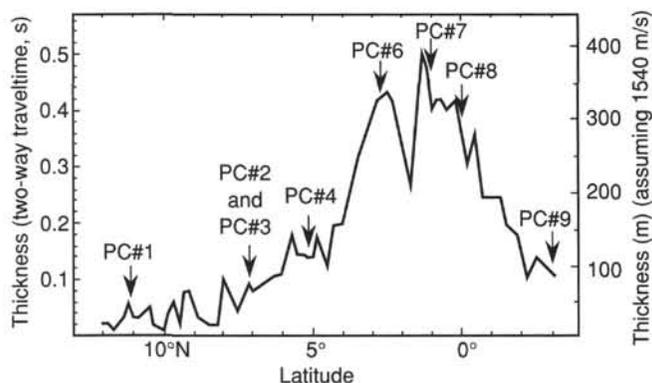


Figure 2. Sediment thickness along the 110°W transect. Location of piston cores shown for reference.

its equatorial position west of the Galapagos Islands also places it well within the influence of both the equatorial divergence zone and the surfacing of the eastward-flowing EUC. Station 11 differs from all previous sites surveyed in that its structural trend is northwest-southeast, rather than north-south. Topographic relief at this site is greater than that seen at the southerly sites of the transect: between 100 to 150 m. Sediment recovered at this site (VNTR01-11PC) is a calcareous pelagic ooze. Preservation of radiolarians is good, but not as good as that seen in the southern sites of the 95°W transect. Foraminifer preservation is good. Both fossil groups have many elements typical of very high production along the equator.

Station 13 (7°55'N, 90°27'W, 3448 mbsl—EEQ-2—Site 844): Station 13 is located within the oceanographic region known as the Costa Rica Dome. Here, the eastward-flowing NECC is deflected by the Central American landmass to the north and west to create a cyclonic flow that, combined with local wind stress curl, results in a shoaling of the thermocline into the photic zone. This upwelling of subthermocline waters results in some of the highest open-ocean biologic productivity of Earth's oceans. Topographic relief of the surveyed region is less than 100 m. Sediment recovered at this site (Core VNTR01-19PC) is a foraminifer-bearing siliceous clay. Preservation of radiolarians is moderate to good, while preservation of foraminifers ranges from poor to very good. Preservation of foraminifers was surprisingly good, given the consistently low calcium carbonate content of the sediment.

Station 14 (5°38'N, 94°12'W, 3585 mbsl—EEQ-5): Station 14 is located within the eastward-flowing NECC. Topographic relief of this site is about 75 m. Sediment recovered at this site (Core VNTR01-20PC) is a fossiliferous clay. Preservation of radiolarians is moderate, while preservation of foraminifers ranges from poor to moderate.

Station 15 (9°35'N, 94°32'W, 3720 mbsl—EEQ-1—Site 845): Station 15 is located within the westward-flowing NEC. Topographic relief of the survey area is about 100 m. Sediment recovered at this site (Core VNTR01-21PC) is a foraminifer-bearing siliceous clay. Preservation of radiolarians is moderate, while preservation of foraminifers ranges from poor to fair.

Station 16 (12°N, 100°W, 3585 mbsl): Station 16 is located 210 mi from the south coast of Mexico, within the eastward-flowing NECC. No detailed survey was conducted at this site because of time restrictions. Sediment recovered is a hemipelagic clay having abundant radiolarians. Most samples were barren of foraminifers. Ash layers were noted in the magnetic susceptibility record, but were not correlated to known ash events.

At each of the proposed drill-site locations, a site survey was conducted. The purpose of these surveys was to establish the local geologic setting of the proposed sites and to provide the data necessary for choosing the best possible drill-site location. Data collected included SeaBeam swath bathymetry; single-channel, digitally ac-

quired, seismic-reflection profiles; 3.5-kHz, high-resolution, sub-bottom profiles; gravity; and magnetics. Seismic data were shot using an 80-in.³ SSI water gun and were digitized at 1 ms by the SIO on-line acquisition system. Navigation was provided by transit satellite and, when available, GPS. An NGC77 data tape, microfilm of analog seismic data, and cruise report are on file with the ODP Site Survey Data Bank (at Lamont-Doherty Geological Observatory). Profiles and bathymetry for each of the drilled sites are presented in the individual site chapters.

The general locations of the proposed drill sites were constrained by the modern and past oceanographic and tectonic settings (see above). Upon approaching each target area, we slowed (to optimize the seismic record) and began a search for regions where sediments appeared most appropriate for drilling. Criteria used to select potential drilling targets were (1) maximum sediment thickness, but free from evidence of turbidites or other redepositional processes; (2) avoidance of sites showing evidence of present or recent erosion (i.e., hyperbole or channel structures); and (3) avoidance of disruptions in the sediment column, faulting, or seismic anomalies. When an acceptable site was found, we attempted to retrieve at least one seismic reflection profile line that crossed the site (although inadequate navigation sometimes prevented this) and nearly complete SeaBeam coverage of an area of several kilometers surrounding the site.

Coring Depth Transect

One of the major gaps in our knowledge of the late Pleistocene history of the Pacific Ocean is the lack of data about the chemical properties of seawater at water depths from 500 to 2000 m. The principal strategy for examining changes in intermediate levels of the ocean is via depth transects of cores from a small geographic area. To help fill this gap in our data base, during Leg 1 of the Venture Expedition, we surveyed and sampled a small region of the Cocos Ridge, which forms the northwest boundary of the Panama Basin. Because operations were restricted to Ecuadorian waters, we were not able to survey the central and northeastern parts of the Cocos Ridge, which lie in waters claimed by Costa Rica.

Station 12

The Cocos Ridge depth transect was designated as "Station 12." Four different coring sites were occupied, where three piston cores and two gravity cores were recovered (VNTR01-14PC and GC, 1944 mbsl; VNTR01-15GC, 1944 mbsl; VNTR01-16PC, 1546 mbsl; VNTR01-17PC, 1758 mbsl). Sediments at these shallow sites were foraminifer sands having very high water content. Because of the coarse-grained character of these sediments, recovery in the gravity cores was poor. Both trigger weight samples for piston Cores VNTR01-16PC and VNTR01-17PC washed out during ascent, and no sediment was recovered, other than small samples from above the gravity core valve or in the core catcher. We also attempted a gravity core on a shallow, sediment-covered seamount (~350-m relief), but recovered only a small amount of foraminifer sand and some rock fragments.

SEDIMENT MAGNETIC SUSCEPTIBILITY

We measured whole-core magnetic susceptibilities in all the piston cores during the Venture 1 cruise. Measurements were performed with a Bartington Instruments low-field magnetic susceptibility meter MS2, which was connected to a core-scanning sensor MS2C having a 100-mm internal diameter loop. The susceptibility meter interfaced with a Macintosh computer, which controlled the measurements, recording, and primary analysis of the signal.

Susceptibility was measured during the cruise within hours of retrieving the piston cores on deck. Individual unopened sections (usually 150 cm long) were put through the sensor loop, and magnetic

susceptibility was measured every 2 cm. Linear drift was corrected when the signal was near the detection limit by zeroing the meter before measuring each section and by taking a zero reading after measuring these sections. The piston cores have an inner diameter of 81 mm. The impulse response of the susceptibility sensor was measured for a very thin disk (<1 mm) having the same diameter (81 mm). The half-height of the symmetric impulse response is shown in Table 1. When measuring the ends of sections, the sensor often sees sediment on one side, but nothing on the other side, resulting in one-half the true value. From the area of the impulse response curve outside the core, we estimated the end correction factors presented in Table 2. These corrections seem reasonable (smooth continuations between sections), but sometimes produce spikes at the very end. For this reason, we deleted the end measurements (at 0 and 150 cm). We had to scale the susceptibility values obtained by the meter to get true susceptibilities. We estimated from the meter manual that this scaling factor was 6.667×10^{-6} SI for these cores.

Magnetic susceptibility, which is usually related to the abundance of terrigenous material and is roughly inversely proportional to the CaCO_3 content in pelagic sediments, was measured on all piston cores as a correlative tool. In Figure 3, we show the susceptibility of piston Cores 1, 3, 4, 6, 7, 8, and 9 vs. depth.

In Figure 3, we have normalized the amplitudes of the susceptibility measurements. The true values change markedly along the transect at 110° W (Fig. 4). The sharp decrease in average volume susceptibility toward the equator may be explained by a combination of the dilution effect from higher biogenic sedimentation rates at the equator and a southerly decrease in the supply of terrigenous (presumably eolian) material.

The magnetic susceptibility of Cores 10 through 14, 16, 17, and 19 through 22 are plotted in Figure 5. These susceptibilities have been scaled such that the downcore amplitude variations are similar between cores. A detailed report about magnetic susceptibility of the Venture 1 cores can be found in Arason (1990).

ADDITIONAL DATA COLLECTION PROGRAMS

Underway Fluorometry

Objectives

One of the ultimate objectives of our equatorial Pacific studies is to understand how plankton fix carbon sufficiently well that we can hindcast paleoproductivity from preserved sedimentary signals. For this reason, we wanted to collect background information about

Table 1. Impulse response of the 100-mm susceptibility sensor for an 81-mm diameter, <1-mm-thick disk.

Distance from sensor (cm)	Measured response	Normalized response
0	915	0.1886
1	766	0.1579
2	503	0.1037
3	292	0.0602
4	166	0.0342
5	95	0.0196
6	56	0.0115
7	34	0.0070
8	20	0.0041
9	13	0.0027
10	8	0.0016
11	5	0.0010
12	4	0.0008
13	3	0.0006
14	2	0.0004
15	1	0.0002
16	0	0.0000

Table 2. Section-end correction factors for magnetic susceptibility measurements.

Distance from end (cm)	Correction factor
0	2.000
1	1.485
2	1.244
3	1.129
4	1.072
5	1.042

productivity, phytoplankton, and the standing stock of fossil-producing zooplankton along the transects we cored and surveyed. Plankton tows are described in another section; below is a synopsis of our observations of seawater fluorescence.

We chose to measure fluorescence during this cruise because this property is related to the concentration of chlorophyll in seawater and can be easily calibrated. In addition, the flow through the fluorometer requires little maintenance and could be run without taking any station time and with little time commitment from any of the scientific party. Finally, because fluorescence measurements provide a way of measuring chlorophyll, this provides a way to tie sea-surface conditions measured during our cruise to long-term mean chlorophyll concentrations, which were measured by reflection spectroscopy using satellites.

Measurement Conditions

We measured fluorescence using a Turner Designs flow-through fluorometer with a 10-045 blue lamp light source, a 10-050 color specification 5-60 excitation filter, and a 10-052 color specification 3-66 reference filter, the recommended procedure for measuring chlorophyll. The fluorometer was attached to the clean seawater line of the *Thomas Washington*, which has an intake nominally at 9 ft. Thus, we were sampling fluorescence approximately at a water depth of 3 m. The fluorometer was wired to an a/d board on the VAX computer, and data were recorded at intervals of 5 min, beginning on the UTC morning of 3 September 1989. Every one to two days, a blank was run on seawater filtered through a Whatman glass-fiber filter. These filters were saved to calibrate the fluorescence measured to chlorophyll later. When the blank grew too high because of bacterial growth on the cuvette walls, the cuvette was removed and washed in a solution of 20% HCl and 30% H_2O_2 . On the second washing (1800 UTC, 16 September), we broke the only cuvette on board ship and had to shut down the fluorescence experiment. We collected filtered samples every 4 hr after that to continue the time series.

Results

We had expected to observe a chlorophyll signal that would mimic the equatorial current structure, with high chlorophyll at the equatorial divergence and within the SEC and with lower chlorophyll in the NECC. In a general way, we did observe this trend; however, most of the fluorescence signal was dominated by a strong diurnal cycle (Fig. 6). North of 6° N, waters were extremely low in chlorophyll and did not have a diurnal cycle. South of 6° N, the normal September location of the NECC/SEC boundary, mean chlorophyll increased, but the diurnal variation was approximately one-half of the total signal (Figs. 6 and 7). The amplitude of the signal did not vary between ship's stations and steaming (Fig. 7).

The highest fluorescence (chlorophyll) readings were invariably near local midnight, and the lowest were at approximately local noon. We observed this pattern for all 10 days that the fluorometer was working and while we were in the SEC. During this time period, we moved from 6° N to 5° S and from 110° to 95° W. This diurnal cycle

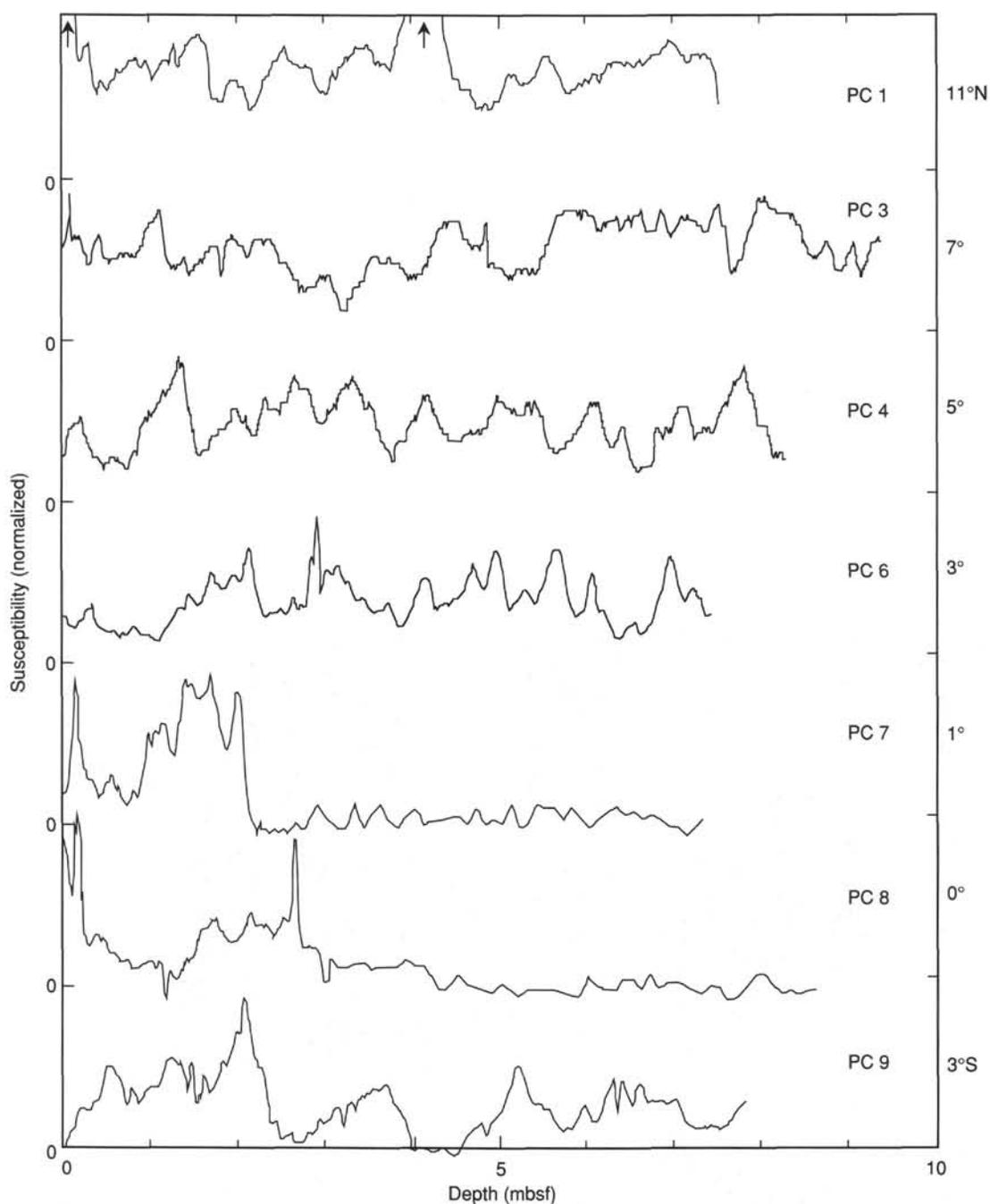


Figure 3. Magnetic susceptibility of piston Cores (right) 1, 3, 4, 6, 7, 8, and 9 (110°W transect). Approximate latitudes are shown to the bottom. Amplitudes have been normalized for comparison, but zero level is shown for each record. Spikes (denoted by arrows) at the top and at the 4-m depth in PC 1 (11°N) and a spike at the top of PC 8 (0°) have been omitted to facilitate plotting. We correlate the sharp anomaly at a depth of 1- to 3-m to represent climatic Stage 5.

(with a maximum during the dark hours of the day; Fig. 8) reflects the interaction of grazing, continued chlorophyll abundance during the dark hours and strong light inhibition of plankton.

When the diurnal signal is filtered out, one can see a regional pattern of chlorophyll in the equatorial Pacific. High chlorophyll abundances are associated with the equatorial divergence and a hemispheric asymmetry. The SEC north of the equator has lower average fluorescence than it does south of the equator. In addition, fluorescence (and the amplitude of the diurnal cycle) increases in the

eastern part of the transect near the Galapagos. We will continue to study this pattern using the filtered samples taken after the fluorometer was broken.

Plankton Tows

Vertical net hauls were taken at core stations to obtain data about the plankton standing stock (Table 3). The net diameter was 0.50 m with a mesh size of 64 μ m. At each station, hauls started at 150 m

Table 3. Plankton-tow information from the *Thomas Washington* Venture 1 cruise.

Station no.	Tow no.	Date (mon/day/yr)	Time (UTC)	Latitude	Longitude	Rate (m/min)	Closest XBT		
							Latitude	Longitude	Time
110°W transect									
3	1	9/03/89	06:56	11°14.60'N	109°37.00'W	25	10°17.9'N	109°39.0'W	22:04
5	2	9/05/89	11:40	7°09.00'N	109°44.10'W	30	6°15.4'N	109°54.3'W	20:08
5A	3	9/06/89	11:20	5°19.08'N	110°04.62'W	30	5°19.4'N	110°04.3'W	19:00
6	4	9/08/89	00:55	2°44.44'N	110°35.25'W	30	2°44.8'N	110°34.7'W	23:07; 9/07
6A	5	9/09/89	01:30	1°01.13'N	110°34.22'W	30	1°00.9'N	110°34.3'W	21:55; 9/08
6B	6	9/09/89	17:55	0°02.12'N	110°26.70'W	30	0°01.8'N	110°26.3'W	17:45
7	7	9/10/89	22:55	3°01.00'S	110°29.58'W	30	3°00.7'S	110°29.7'W	22:46
95°W transect									
11	9	9/16/89	16:35	0°10.72'N	95°14.77'W	30	0°10.0'N	95°21.4'W	18:41
9	10	9/18/89	15:20	3°03.60'S	95°05.29'W	30	2°59.4'S	94°48.7'W	18:04
10	11	9/20/89	08:40	3°07.45'S	90°49.78'W	30	3°07.3'S	90°50.1'W	08:37
Other stations									
8	8	9/13/89	16:50	4°31.99'S	102°01.04'W	30	4°18.0'S	101°30.5'W	21:34
12	12	9/22/89	03:00	1°29.02'N	89°51.47'W	30	0°58.7'N	89°40.1'W	17:53; 9/21
12A	13	9/22/89	18:37	2°35.85'N	89°42.28'W	30			
12B	14	9/23/89	08:00	2°25.10'N	89°20.60'W	20			
12C	15	9/23/89	19:55	3°21.08'N	90°47.05'W	30	3°20.2'N	90°46.2'W	18:55
13	16	9/25/89	15:49	7°55.33'N	90°23.83'W	30	7°53.6'N	90°27.7'W	17:57

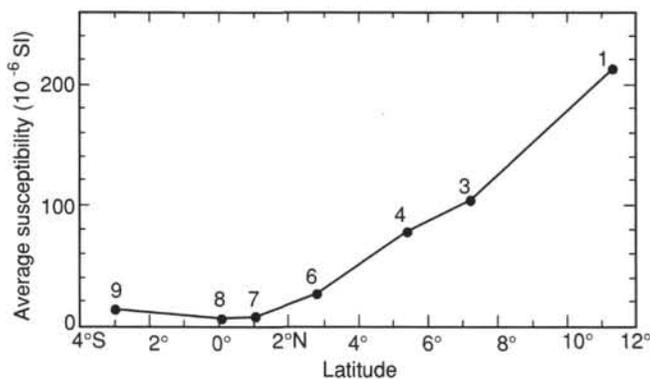


Figure 4. Average volume susceptibility of the piston cores (solid circles) of the 110°W transect.

(below the thermocline) and were pulled vertically at a rate of 25 to 30 m/min. The total volume of water sampled was 29.4 m³. Samples were washed from the cod-ends with seawater and placed in 500-mL Nalgene™ bottles. Approximately 2 mL of mercuric chloride (HgCl₂) was added as a poison. Samples were then stored in a refrigerated van to await post-cruise analysis. When possible, XBTs were taken at the same time to provide a record of the vertical thermal structure of the water column.

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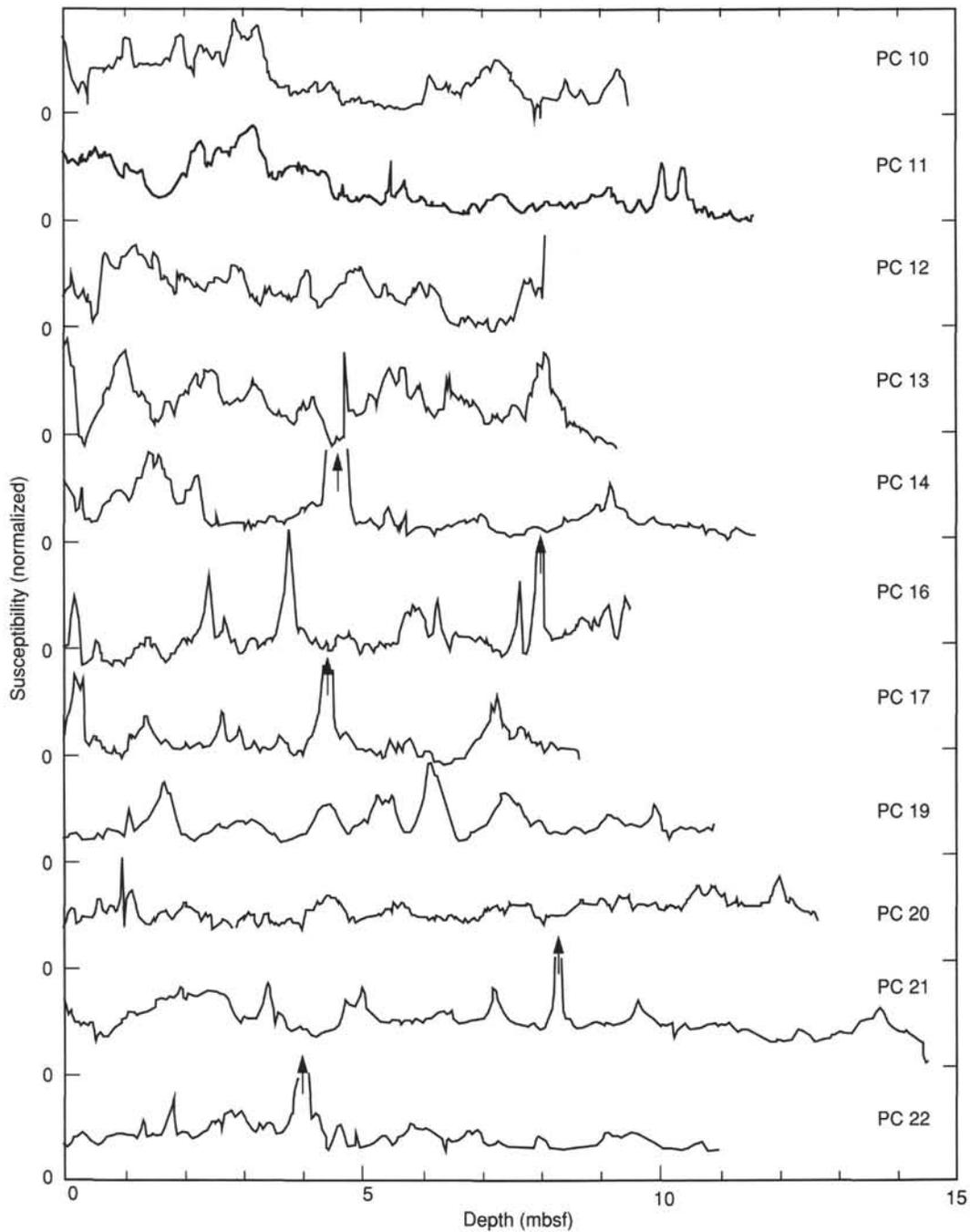


Figure 5. Magnetic susceptibility for piston cores taken as part of the 95°W transect. Amplitudes have been normalized for comparison, but zero level is shown for each record. Spikes (denoted by arrows) in PC 14 (4 m), PC 16 (8 m), PC 17 (4 m), PC 21 (8 m), and PC 22 (4 m) have been omitted to facilitate plotting.

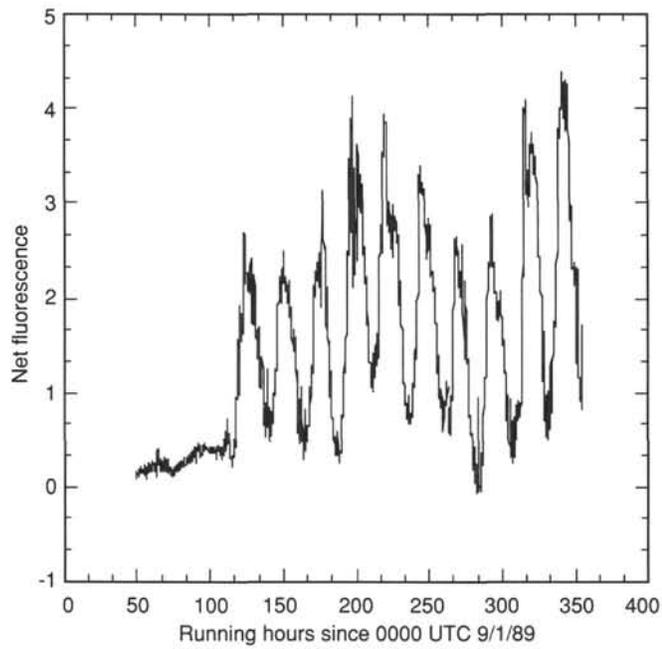


Figure 6. Net fluorescence vs. running time.

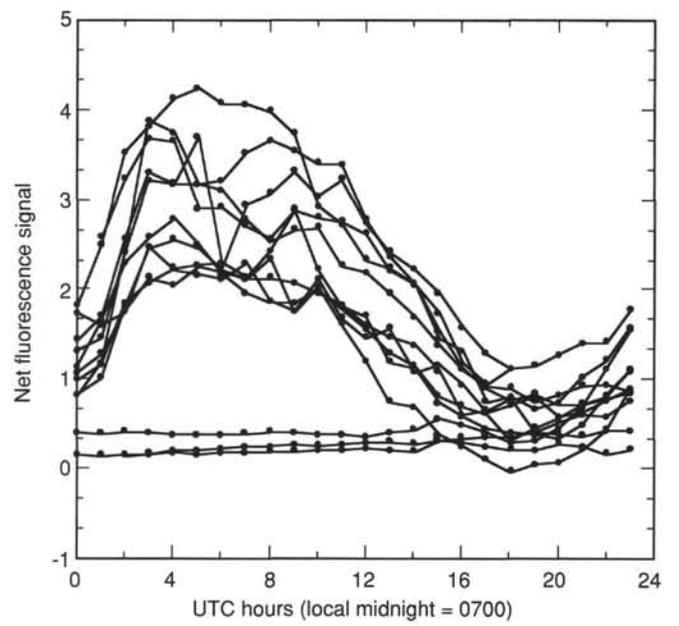


Figure 8. Net fluorescence vs. time (UTC). Note the absence of a diurnal signal from samples collected north of 6°N (the three records having net fluorescence of <0.5 throughout 24-hr period).

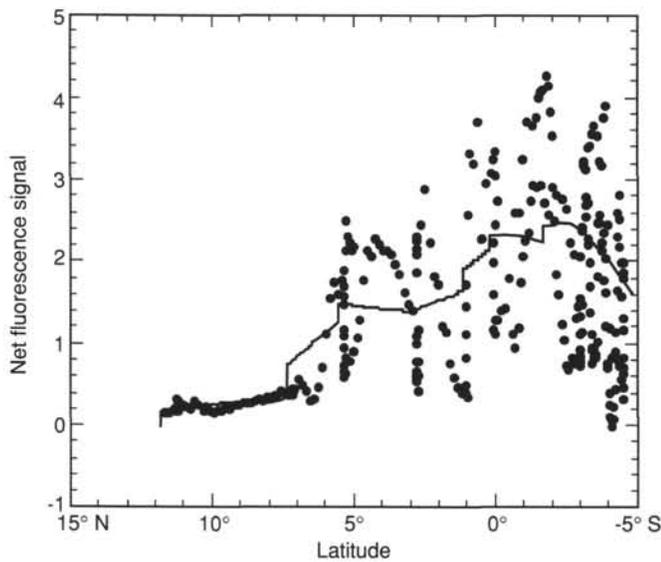


Figure 7. Net fluorescence vs. latitude. Dots indicate data. Line represents hourly data after filtering to remove diurnal signal.