167 Prospectus

California Margin

ABSTRACT

Leg 167 will investigate the evolution of oceanogaphic conditions in the north Pacific Ocean and will document changes in flow of the California Current system and associated changes in coastal upwelling. These data will be used to reconstruct north Pacific climate conditions through the Neogene, concentrating upon the time period since the advent of northern hemisphere glaciation, ~2.5 Ma to the present. Approximately one third of the proposed drill sites will also sample lower and middle Miocene sediments to reconstruct a Neogene history of the California Current. The results of Leg 167 drilling will also be used to better understand the links between climates of the north Pacific Ocean and western North America, particularly in terms of temperature change and changes in precipitation.

Thirteen proposed sites and five alternates are organized into three transects across the California Current (Baja Transect, ~30° N; Conception Transect, ~35° N; and Gorda Transect, ~40 ° N) and one coastal transect extending from northern Baja California to the California/Oregon border, 30°N to 42°N. Each of the three transects across the California Current will compare deep-water sites near the core of the California Current to coastal upwelling sites near shore. The coastal transect will examine variations in upwelling and productivity along the California margin, and will also examine intermediate water properties in many of the basins of the California Continental Borderland.

The proposed drill sites were chosen based upon two sites surveys—W9406 (*R/V Wecoma*) and EW9504 *(R/V Ewing*). Much of the survey data (bathymetric swath maps, seismic profiles, and preliminary physical properties data from the sediment cores), for those sites that require it, can be obtained from the following World Wide Web site: http://kihei.idbsu.edu/EW9504/camargin.html. SEG-Y versions of the seismic reflection data are also available from the National Geophysical Data Center (NGDC) where the digital data have been archived.

INTRODUCTION

The California Current system is probably the best investigated eastern boundary current system in the world, with numerous studies of its physical dynamics, chemical structure, biological standing stocks, and biogeochemical fluxes. Nevertheless, the response of the California Current system and associated coastal upwelling systems to climate change is poorly documented. Climate models and available paleoceanographic data indicate that the California Current system changed dramatically with the growth and decay of the North American ice sheets. The paleoceanographic records, however, remain too sketchy to test the models (Kutzbach, 1987; Lyle et al.,1992).

Ocean Drilling Program (ODP) Leg 167 (Fig. 1) represents the first time since 1978 that the Pacific margin of North America will be drilled to study ocean history. It will collect both high-resolution records appropriate for study of the late Pleistocene, as well as long-term sediment records to examine the entire Neogene interval. The proposed drilling program will drill sites to understand the links between the evolution of north Pacific climate and the development of the California Current system. The same material will also be used to understand the links between the north Pacific and North American climate. Other important scientific objectives that could be pursued along this margin (e.g., the development of the Alaska Gyre, involving drilling along Canada and Alaska, or the investigation of climatic connections between the eastern north Pacific and the tropical Pacific, involving drilling along the Mexican continental margin) cannot be addressed in this program.

The last major drilling effort along the California margin, Deep Sea Drilling Project (DSDP) Leg 63, occurred immediately before the first deployment of the advanced hydraulic piston core (APC), and to date there is only one APC core in this climatically

sensitive region, ODP Site 893, in the Santa Barbara Basin (Table 1, Kennett, J. P., Baldauf, J. G., et. al., 1994; Kennett, J. P., Baldauf, J. G., and Lyle, M. (Eds.), 1995). Recovered core from DSDP drilling is discontinuous and very disturbed, so it is impossible to use this material for modern high-resolution paleoceanographic studies. Reconnaissance studies have shown, however, that the Leg 167 survey area is highly sensitive to climate change (Fig. 2, Ingle, 1973). Strong climate signals are expected in the new ODP sites.

High-resolution studies of piston cores and the Site 893 drill site indicate that the region responds strongly to insolation changes. Strong signals that appear to be in the Milankovitch frequency bands are commonly observed. In addition, there appear to be suborbital frequency events that may be related to Dansgaard-Oeschger events in the Santa Barbara Basin (Behl and Kennett, 1995). What the sedimentary record reveals to us about Pleistocene paleoceanography of the region is now a subject of lively research (Gardner and Hemphill-Haley, 1986; Anderson et al.,1989; Lyle et al., 1992; Sancetta et al., 1992; Karlin et al., 1992; Prahl et al., 1995; Kennett and Ingram, 1995; Kennett et al., 1995). Much of the current research focuses upon the large temperature changes along the coast since the last glacial maximum and the possible formation in glacial intervals of a strong source of cold, oxygenated, intermediate waters.

BACKGROUND

Drilling along the California continental margin should provide important new information on north Pacific climate because of the sensitivity of the region to changes in the wind field. Understanding the dynamics of the currents and upwelling will enable us to understand how the average wind fields in the north Pacific have changed and where rainfall has been directed on North America.

The modern California Current system is probably the best-studied of the world's eastern boundary currents, and because of these modern measurements it is possible to reconstruct the past behavior of this eastern boundary current system with much greater confidence than for any other in the world. It is probably the best place in the world to understand how eastern boundary currents have responded to climate change. The California Cooperative Fisheries Program (CalCOFI) has taken seasonal measurements of hydrography and biology in transects across the current for more than 30 yr. Major physical oceanography experiments such as Coastal Upwelling Experiment and Analysis (CUEA), Coastal Dynamics Experiment (CODE), and the West Coast Satellite Time Series and Coastal Tranzition Zone program (Brink and Cowles, 1991, and references therein) are linking the dynamics of California Current flow and coastal upwelling to climate.

More long- and short-term studies of biogeochemical flux are available from this region than anywhere else in the world, including the VERTEX study (Knauer et al., 1979; Knauer and Martin, 1981), MULTITRACERS (Lyle et al., 1992; Dymond and Lyle, in press); Low Level Waste Disposal Project (Dymond and Lyle, in press, Fischer et al., 1983), long-term sediment trap deployments off Monterey (C. Pilskaln, pers. comm.), and short-term sediment trap deployments in the California Borderlands region (Dymond et al., 1981; Sautter and Thunell, 1991; Kennett, unpubl. data).

Dynamics of the California Current

The California Current combines diffuse flow extending hundreds of kilometers offshore with local high-velocity zones of southward flow. The southward jets separate nutrient-rich upwelled waters from the relatively barren offshore waters (e.g., Huyer et al., 1991). The core of the offshore California Current flow is located approximately 250–350 km from the coast at the border of Oregon and California and is about 300 km from the coast at Point Conception (~35°N; Hickey, 1979; Lynn and Simpson, 1987).

It is well known that the California Current is subject to both seasonal and interannual cycles. The pattern of winds along the coast controls seasonal variations (Fig. 3), whereas changes in the dynamic topography of the North Pacific Gyre produce interannual variability in the current (Fig. 4). California Current structure thus reflects both the local winds along the west coast of North America and basinwide events within the north and equatorial Pacific Ocean. The importance of both local and remote forcing in California Current flow has been emphasized by modeling efforts like that of Pares-Sierra and O'Brien (1989), who found that the local wind field in the northeastern Pacific is adequate to drive the annual cycle of the current and to create the general features of its structure. They could only model interannual variations of the California Current by coupling the local model with one driven by equatorial winds. Kelvin waves generated during el Niño events in the equatorial Pacific propagate up the western coast of North America and strongly affect the California Current.

The modeling suggests that in the much longer climatic cycles that are observable by paleoceanographic studies, the location and strength both of trade winds, and of westerlies should probably have a major impact on mean transport in the California Current. Shifts of the mean wind patterns (e.g., a shift in the position of the north Pacific high at 18 ka; Kutzbach, 1987; Kutzbach et al. 1993) should also strongly affect the structure of the California Current flow as well as the locations of maximum coastal upwelling. The available data support these interpretations.

Coastal California Upwelling

Upwelling along coastal California is driven by equator-ward winds that roughly parallel the coast (Figs. 3, 5, 6; Huyer, 1983). Ekman transport of surface waters by these winds causes transport of surface waters away from the coastline and upwelling of nutrient-rich waters from below. The upwelling waters are restocked by shallow flow inward toward the shelf beneath the

surface ocean layer. The winds are seasonally to the south in northern California but always blow toward the equator south of San Francisco. In addition, upwelling-favorable winds are strongest in the north during the seasonal upwelling period. This wind pattern today causes the strongest coastal upwelling in July to be located between Cape Blanco and San Francisco in the north, but in the winter months causes the strongest upwelling to be located south of San Diego (Fig. 6; Huyer, 1983).

The seasonal cycle of winds and upwelling described above is a direct result of the seasonal migration of the north Pacific high-pressure regime. The north Pacific high migrates between its southerly limit at 28°N in February and its most northerly limit, 38°N, in July (Fig. 3; Huyer,1983). Thus, by monitoring the strength and the seasonality of coastal upwelling along coastal California with paleoceanographic data, we will be able to track the latitudinal position and strength of the north Pacific high as climate changes.

Deep-water Circulation

The California margin should be strongly affected by changes in formation of bottom water in the Antarctic, because it is directly upon a flow path for this bottom water into the north Pacific (Fig. 5, Gordon and Gerard, 1970; Mantyla, 1975). Newly formed bottom waters enter into the Pacific near New Zealand and move up along the western boundary of the Pacific Ocean. They split and travel around the Hawaiian Islands before the addition of buoyancy consumes the water in the Alaska Gyre region. One of these paths flows directly into the California margin. The California margin should be a good location to monitor changes in Pacific deep-water properties. For this reason, in the Leg 167 drilling program, we emphasize depth transects, both in the north and in the south of the study region.

SCIENTIFIC OBJECTIVES

Summary of Primary Objectives

1. To understand how a major eastern boundary current system and associated upwelling centers respond to growth of northern-hemisphere glaciers (all sites).
2. To assess feedbacks between continental and oceanic climates in the north Pacific and North America (all sites).
3. To obtain depth transects suitable to study variations in north Pacific deep water properties and carbonate deposition (North Site CA1-1033 m; Site CA2-1951 m; Site CA3-2731 m; Site CA4-3075 m; Site CA6-3316 m; Site CA5-4242 m. South Site CA15-1182 m; Site CAM2-2047 m; Site CA8-2508 m; Site CA14-3495 m; Site CA11-3873 m).
4. To understand variations in the production, preservation, and burial of organic carbon in a well-studied, highly productive continental margin setting (all sites).
5. To sample gas hydrates (Site CA1).

Summarty of Secondary Objectives

6. To study tectonic development of the active continental margin of western North America (all sites).
7. To investigate the deformation of the Gorda Plate (Sites CA3 and CA4).
8. To test the response of continental margin sedimentation to Cordilleran uplift (all sites).
9. The acquisition of Franciscan and Gorda Plate basement where possible without compromising primary sedimentary objectives (Sites CA2, CA3, CA4, CA5, CA6, CA11, CA14, and CAM2).

The tectonic objectives, although of secondary importance, are also necessary for paleoceanographic reconstruction, because many of the sites have moved hundreds of kilometers with respect to North America during the Neogene. The continental basement underneath Site CA-2, for example, is now located just south of the Mendocino triple junction but may have been separated from the rest of North America as far south as northern Baja California (Bohannon and Parsons, 1995).

Highest priority on Leg 167 will be given to the sampling of upper Neogene sediments (Pliocene and younger), but five of the proposed drill sites will sample middle and lower Miocene sediments. The older sedimentary sections will be instrumental to understanding the Neogene paleoceanographic evolution of the north Pacific climate.

PROPOSED DRILL SITES AND DRILLING PLAN/STRATEGY

The sites proposed for drilling form three transects cutting across the California Current system at right angles to the coast and one long transect from north to south along the coast. The three east-west transects cut across the California Current at about 40°N (the Gorda Transect), at 35°N (the Conception Transect), and at about 30°N (the Baja Transect). These transects will reconstruct past offshore gradients of upwelling intensity in northern (summer upwelling), central (year-round upwelling, cool), and southern (year-round upwelling, warm) regimes. The depth range of the Gorda Transect, from ~1000 to ~4200 m, is ideal for the reconstruction of past deep-water properties. Similarly, a group of sites in central and southern California form another depth transect covering much the same depth range. The north-south "Coastal" Transect will connect the three offshore transects to assess latitudinal translation of upwelling cells. Very high sedimentation rates along the margin will allow study of oceanographic variations at century-millenial scales, as well as at the lower resolution orbital and tectonic scales. The coastal transect contains sites

through the California Borderlands and will address high resolution climate changes in the Southern California countercurrent, evolution of intermediate water properties on a productive continental margin, and sedimentation in anoxic to suboxic basins.

All sites will be triple-piston cored; two APCs will go to refusal, whereas the third will be taken to at least 50 m (further, if time is available). Extended core barrel (XCB) drilling will extend the drill holes to their total planned depth. Deep-water sites on each of the transects and two sites on the continental slope will be drilled to basement, which ranges between 200 and 450 m below seafloor (bsf). Basement will be sampled at all sites that reach it using the motor-driven core barrel (MDCB), if appropriate. This tool should collect a core about 4.5 m long in hard rock. Many sites in the coastal transect will be shallow, only to APC refusal or slightly deeper, to obtain the geographic coverage that is necessary to better understand the Pleistocene and late Pliocene climatic interval. We have also chosen four of the coastal sites to penetrate to at least 400 m, or to basement, to have shallow-water-depth drill sites for the important late and middle Miocene time intervals.

Gorda Transect

The Gorda Transect (Fig. 1) consists of the following Sites: CA-1, CA-2, CA-4, and CA-5; and the following alternates, in order of priority: Sites CA-6, CA-3, and CA-7. All sites will be important for the upper Neogene transect, because Site CA-1 should penetrate sediments with an age of ~1–2.5 Ma, Site CA-4 will sample sediments to ~5.1 Ma, Site CA-6 will penetrate to ~7.7 Ma, Site CA-3 to ~2.8 Ma, and Site CA-7 should sample sediments with a maximum age of 1–2.5 Ma. Site CA-2 (1951 m, Delgada slope) and Site CA-5 (4242 m, Delgada fan) will be important for understanding the complete Neogene, provided that enough time is available for the deeper drilling objectives at each site; both sites should have a mostly continuous record to about 30 Ma. To fit within the time constraints of Leg 167, drilling lower middle Miocene through Oligocene sediments at both

Sites CA-2 and CA-5 has been assigned a second priority status, and is not in the current drilling plan. Despite its shallow depth, Site CA-2 most probably resides upon the Pacific plate, so Sites CA-2 and CA-5 have also moved in tandem, northward along the California margin.

The sampling of gas hydrates is a primary objective at Site CA-1. The gas-hydrate interval should be located above a bottom-simulating reflector at about 160 mbsf. In addition to standard APC operations, the pressure-core sampler may be deployed if conditions are appropriate.

Conception Transect

The Conception Transect (Fig. 1) consists of the deep-water Site CA-11 (3873 m, 22.5 Ma crust) and two shallow Sites CA-9 (Santa Lucia slope; 974 m, ~3–4 Ma at total depth) and CA-15 (Tanner Basin; 1182 m, 4–8 Ma at total depth). The two shallow sites are in a deformed region of the North American continental margin, and Site CA-11 has moved northward with respect to them since the middle Miocene. We hope to recover a high-resolution record in the Santa Lucia slope region (Site CA-9), near the important upwelling center at Point Arguello. We believe that we will get an older sedimentary record from Tanner Basin (Site CA-15) to compare with Site CA-11.

Baja Transect

The deep-water Site CA-14 (3495 m) will be compared to a margin site in Animal Basin (Site CAM-2; 2047 m; Fig. 1). Both sites should contain middle Miocene sediments, however, Site CAM-2 probably contains a significant hiatus. Nevertheless, we should be able to compare a coastal and deep-water record for much of the interval from the beginning of the late Miocene to the Holocene. Both sites will be drilled to basement.

Coastal Transect

The shallow sites from other transects (Sites CA-1, CA-2, CA-9, CA-15, and CAM-2) make up a major part of the coastal transect. In addition, an important site on the central California margin (Site CA-8; 2508 m) and a series of shallow drill sites in the California Borderlands basins of southern California (Fig. 1) will be drilled to complete the regional coverage. Site CA-8 will sample a high-resolution sedimentary record that should span into the upper Miocene and that will tie the northern and southern drilling sites together. The proposed California Borderland sites (Sites BA-1, East Cortez Basin; BA-2, San Nicolas Basin; and BA-4, Santa Monica Basin) and alternate (Site CAM-3; San Clemente Basin) are all shallow, designed to sample only Pleistocene sediments. They will provide important information on the evolution of intermediate waters and the development of upwelling centers in this region. They will also be important for understanding organic carbon diagenesis and tectonic evolution of the California margin. Provided that important safety concerns can be met, a return to the location of ODP Site 893 in the Santa Barbara Basin is an objective of Leg 167. If we can redrill Site 893, we will gather important ancillary data on pore-water chemistry and sediment physical properties that were lost in the first drilling effort as well as provide new sediments for analysis.

LOGGING OBJECTIVES AND STRATEGY

A total of seven sites will be logged during Leg 167 (Sites CAM-2, BA-1, CA-1, CA-2, CA-8, CA-11, and CA-15); an additional four sites (Sites CA-4, CA-5, CA-9, and CA-14) will be logged if time permits. Variations in biogenic carbonate, opal, and terrigenous deposition associated with regional paleoclimate and paleoceanographic changes will be reflected in terms of corresponding changes in physical and geochemical properties. Coring may be discontinuous over deeper intervals because of gas expansion or coring disturbance, thus downhole log data present an excellent resource for developing continuous, quantitative paleoclimatic and paleoceanographic time series. Special software

for core-core and core-log data integration is being developed and will be used during Leg 167 for this purpose.

Logging at most sites will be comprised of standard Quad (natural gamma ray activity, resistivity, sonic velocity, density/porosity) and Formation Microscanner (FMS) runs, with inclusion of the Geological High-sensitivity Magnetic Tool (GHMT) if appropriate and available. Geochemical logging is only planned for Sites CA-8 and CA-15, with an additional plan for geochemical logging at proposed Site CA-2 if drilling exceeds 400 mbsf.

A primary logging objective of Leg 167 drilling is to obtain high-quality log data for all sites with sufficiently deep penetration depths or for those sites that are particularly central to the scientific objectives of the leg. A special emphasis during Leg 167 will be the collection of highest resolution log data by reducing the logging speed for the Quad runs to enhance the statistics of the nuclear measurements (particularly density and natural gamma). Post-collection processing of density and resistivity log data will significantly increase vertical resolution of these measurements (from ~80 cm to ~15 cm resolution) and increase log sample intervals from 15 cm to 2.5 cm. Many sites will be logged with several passes of the Quad tool to quantify tool vertical resolution and log repeatability. Because high sedimentation rates are expected at a number of sites, this enhanced log resolution opens up the possibility that log data may be useful for detecting and reconstructing continuous records of millennial-scale paleoclimate variability.

SAMPLING AND SHIPBOARD ANALYSIS STRATEGY

Leg 167 should recover more than 7 km of core. Because of the high recovery, shipboard scientists will have little time available for scientific efforts outside those needed to archive the cores and to develop continuous stratigraphic sections at each sites. In addition, on-

board sampling will be restricted to pilot studies and large-scale sampling will be deferred to a shore-based sampling party shortly after the cruise. Standard ODP sampling policies maybe exceeded in the composite spliced section.

Because the construction of continuous sediment profiles is key to the scientific objectives of Leg 167, priority will be given to the multisensor track logging for physical properties measurements. In addition, the color reflectance spectrometer will be used to record continuous color profiles on the split cores and the ODP digital camera system will be used to record high resolution digital images of all core material.

Most shipboard sampling on Leg 167 will be standard. We foresee the possibility, however, of interstitial-water sampling at a rate as high as 1/core in the upper 50 m of the sediment section, and whole rounds may be sampled at Site CA-1 if gas hydrates are encountered. U-channel samples maybe taken to facilitate high-resolution measurements of magnetic properties.

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FIGURE CAPTIONS

Figure 1. Site map of first and second priority California margin drill sites to be drilled on ODP Leg 167. The site locations are superimposed on 5-min topography of the west coast of North America.

Figure 2. Schematic representation of major oscillations of temperature-sensitive planktonic foraminiferal biofacies within the California Current system and related Alaskan Current Gyre during the later Miocene through Pleistocene interval, from Ingle (1973).

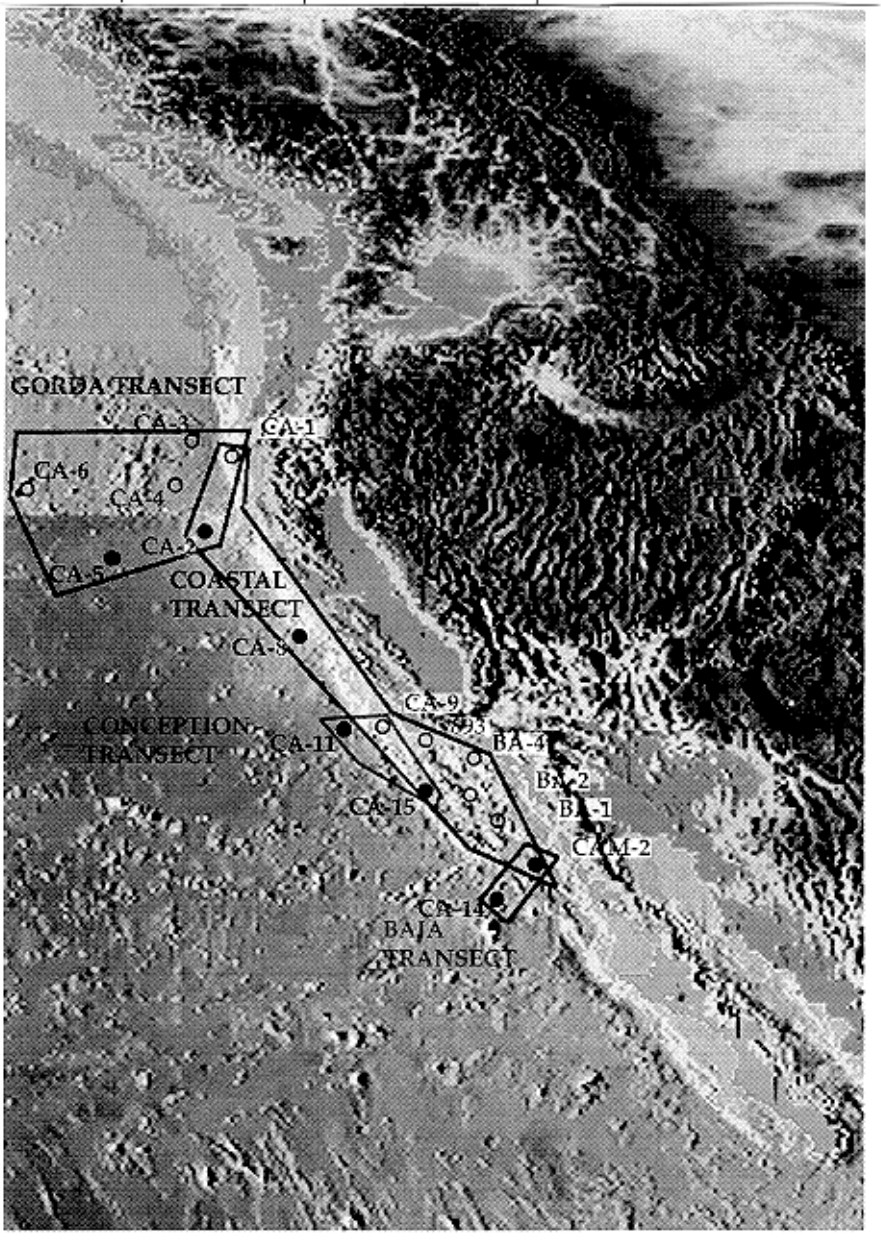
Figure 3. Surface atmospheric pressure, winter and summer, from Huyer (1983) compared to seasonal changes in northeast Pacific surface currents (Defense Mapping Agency, 1989). Surface winds will approximately parallel atmospheric pressure gradients. Note that seasonal variation in current patterns is driven by northeastern Pacific winds. Note also how the high and low pressure associated with the Asian monsoon helps to strengthen northeastern Pacific wind patterns in both summer and winter.

Figure 4. Illustration of strong interannual variation in California Current transport, from the CalCOFI data set (from Roessler and Chelton, 1987). Cold years (1949, 1950, 1954, and 1962) are typified by strong equator-ward transport of subarctic (low salinity) water. Warm years (1958, 1959) are typified by weak quatorward transport. Most of the interannual variation is coupled to ENSO events in the equatorial Pacific (Pares-Sierra and O'Brien, 1989).

Figure 5. Modern deep-water flow paths in the Pacific Ocean, based upon bottom potential temperature (Gordon and Gerard, 1970). Young bottom waters are directed toward the Leg 167 region.

Figure 6. Seasonal wind stress along the California margin from ship reports in the period 1854–1972, from Huyer, 1983. Darkest shading marks wind stress >1.5 dynes/cm^2, whereas intermediate and light shading represents 1.0–1.5, and 0.5–1.0, respectively. Upwelling wind stress (southward vectors parallel to the California margin) varies tremendously by season. Just north of the Leg 167 region at about 45°N, there is little seasonal upwelling; instead, there are short upwelling events. The northern end of the Leg 167 region exhibits the highest seasonality because of movements of the northeast Pacific high.

Figure 7. Offshore Ekman transport computed from long-term mean wind stress data for one-degree squares adjacent to the coast, for January, April, July, and September (from Huyer., 1983). Bars indicate the along shore extent of major upwelling studies.


127°47′
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GORDA TRANSECT
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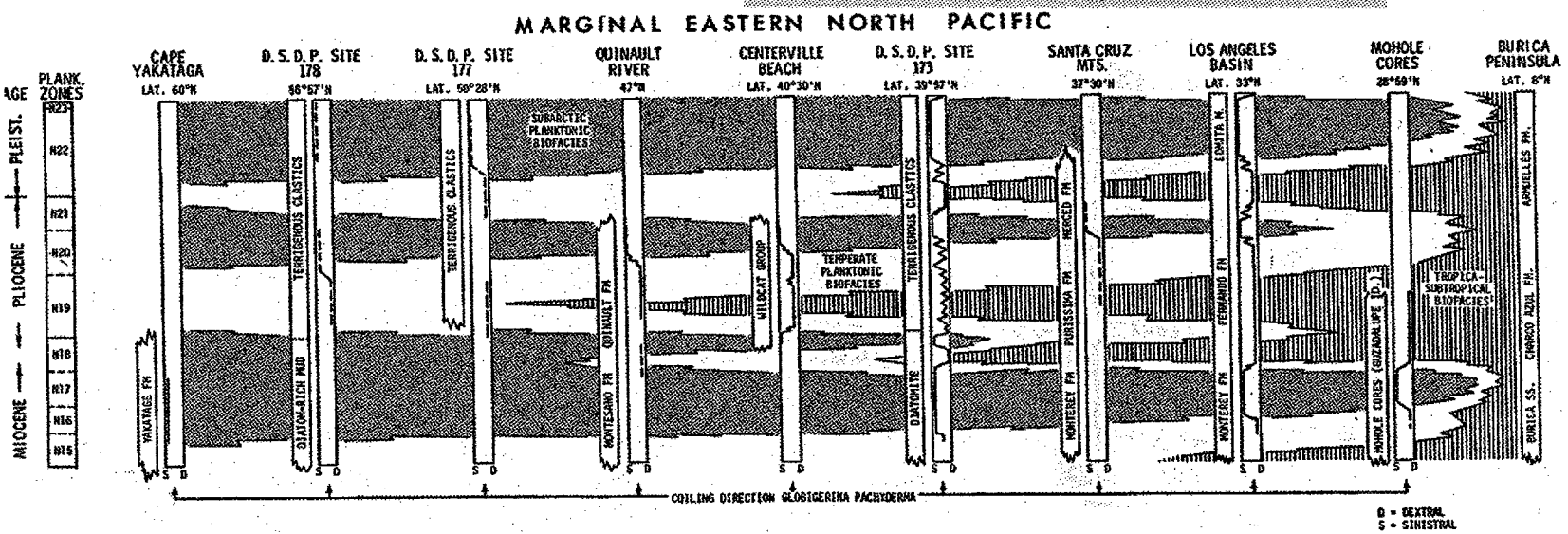
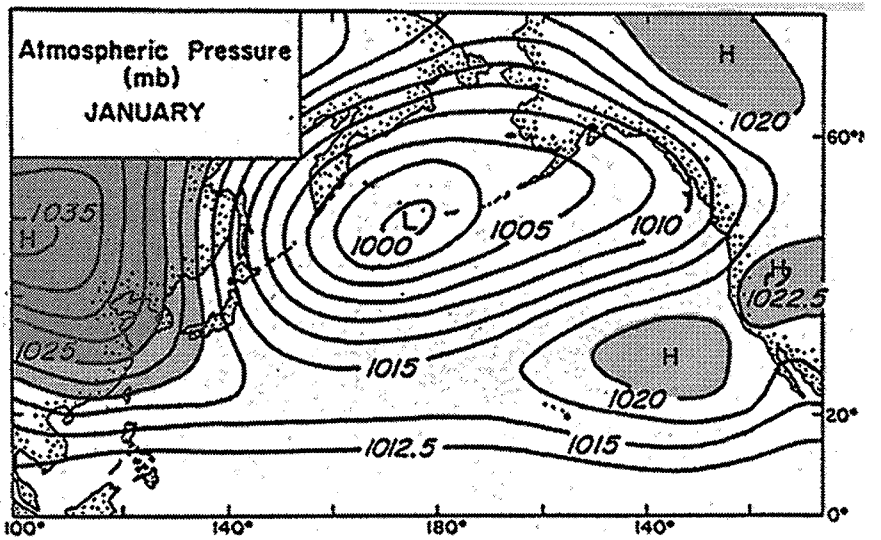
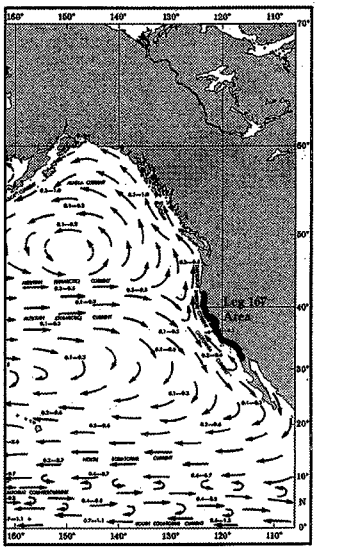
CA-2
CA-5
COASTAL TRANSECT
CA-8
CA-9
CONCEPTION TRANSECT
CA-11
BA-4
BA-2
BA-1
CA-15
CA-12
CA-14
BAJA TRANSECT
39°05′
36°59′
31°17′

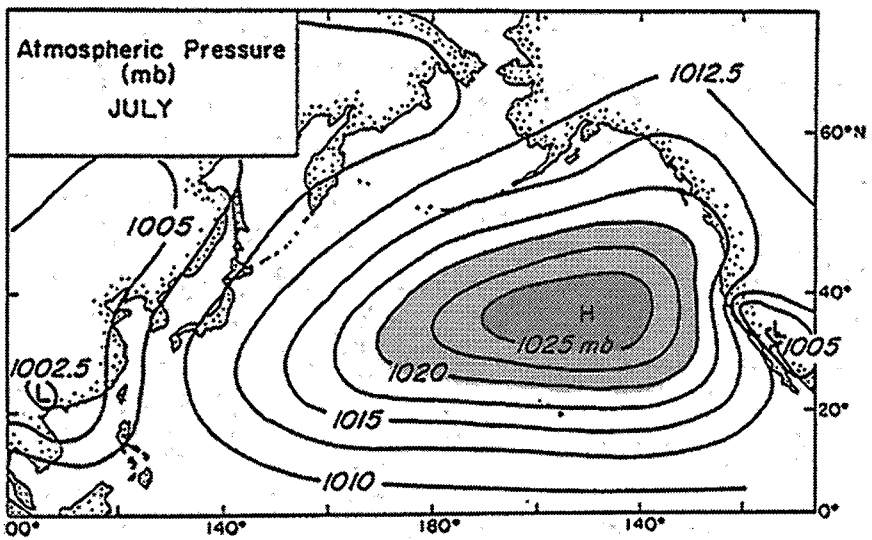
Late Miocene-Recent Shifts in the California Current, from Foram Assemblages



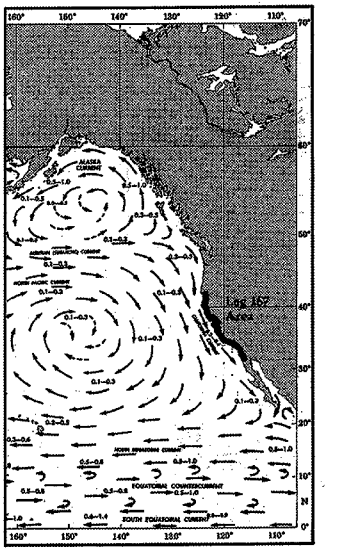


WINTER

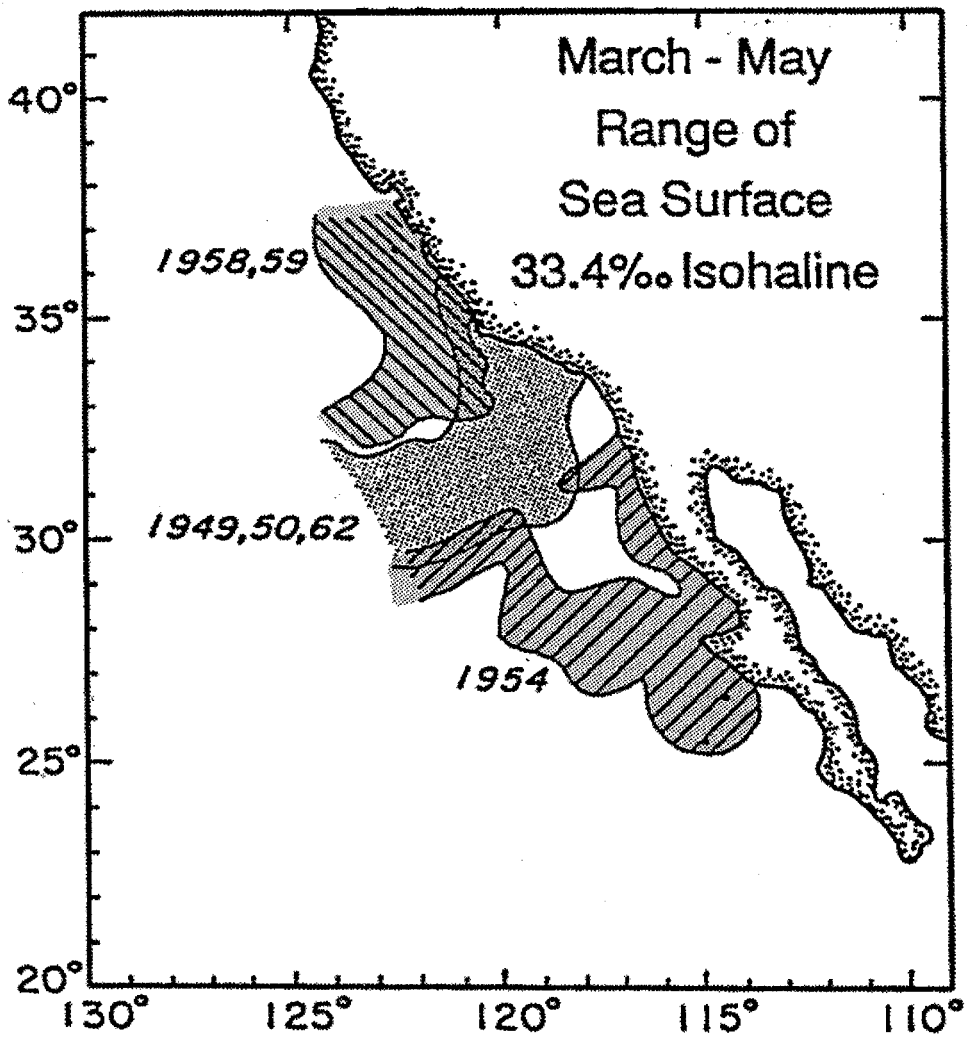




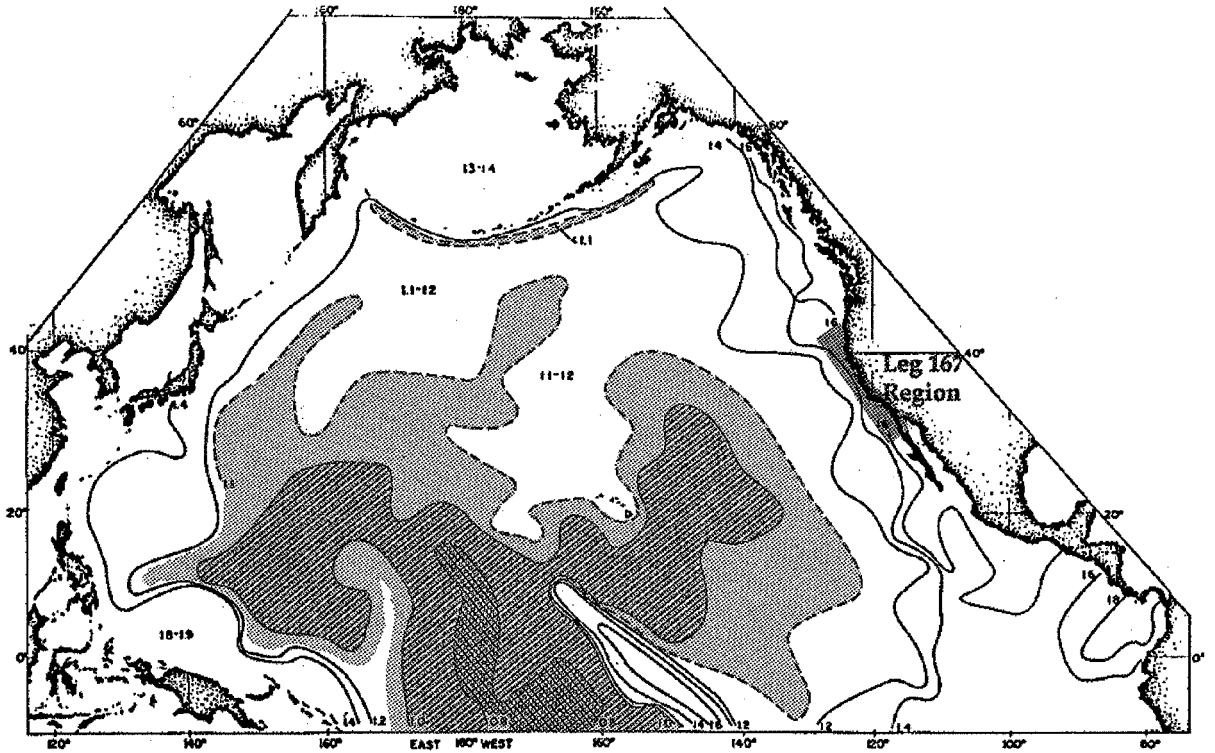
SUMMER



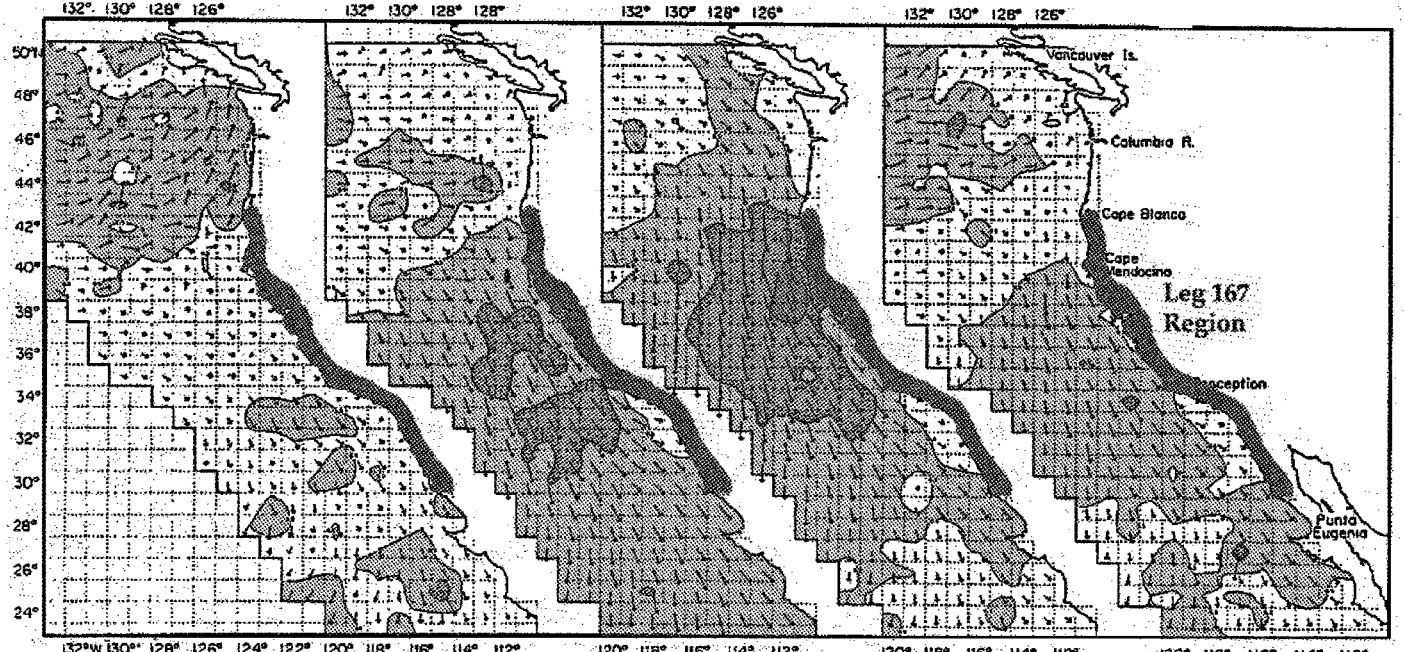
Interannual Variability, California Current

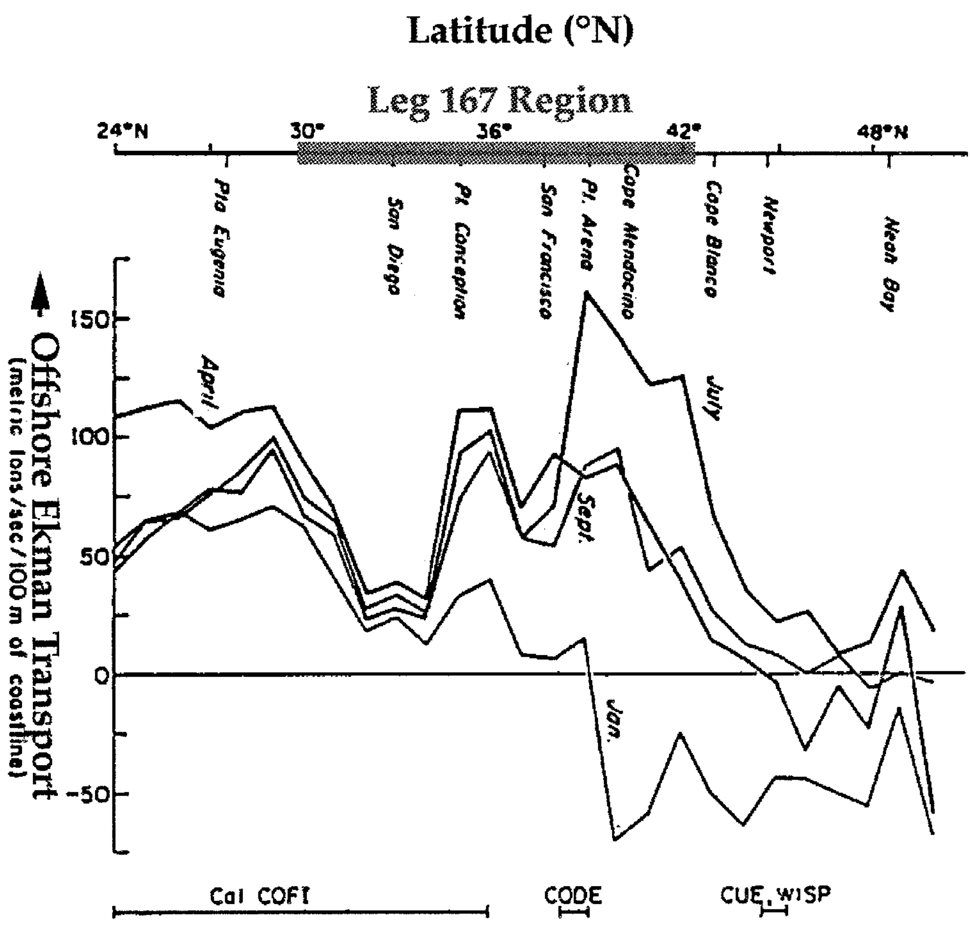


Deep Water Flow



Seasonal Wind Stress Along the Ca Margin




Latitude (°N)
Leg 167 Region
24°N
30°
36°
42°
48°N
Pta Eugenia
San Diego
Pt. Conception
San Francisco
Pt. Arena
Cape Mendocino
Cape Blanco
Newport
Neah Bay
April
July
Sept.
Jan.
150
100
50
0
-50
Offshore Ekman Transport
(metric tons/sec/100 m of coastline)
Cal COFI
CODE
CUE, WISP

RETURN To OCT-W. Iberia (Proposal 461-Rev)

Site Name	Latitude N Longitude W	Water Depth (m)	Penetr'n Sedmt/Bsmt (m)	Location	Operations	Transit 10.5 kt (days)	Coring Time (days)	Log (days)	Oper Total (days)	Total (days)	Comments Equipment	Cored Interval Sedmt-Bsmt APC/XCB/RCB	Estimated Recovery 98%/60%/60-20%
Leg ----- Port Call, ----?										0.0			
Transit: ----? to ----										0.0			
Iberia 7A	40*43.0'N	5150	920/100	Sample basement	RCB 300 m		4.9			4.9	1X C-4 Bit	0/0/300-0	180
priority 1	11*46.7'W				Base, 300 m Csg,RCB 620/100 m,Log,Abn		18.3	2.3		20.6	Base,__ m ___' Csg, MBR	0/0/620-100	392
					Prop Est=21.5 days					0.0			
Iberia 8A	40*40.9'N	4830	1050/100	Syn-rift magmatism	RCB 300 m		4.7			4.7	1X C-4 Bit	0/0/300-0	180
priority 1	11*15.3'W				Base, 300 m Csg,RCB 750/100 m,Log,Abn		19.7	2.3		22.0	Base,__ m ___' Csg, MBR	0/0/750-100	510
					Prop Est=21.9 days					0.0			
Iberia 9A	40*40.94'N	5150	750/400	Bsmt at detachment	Base, 300 m Csg,Wash 450 m, RCB 0/400 m,Log		15.5	2.3		17.8	Base,__ m ___' Csg, MBR	0/0/0-400	80
priority 1	11*35.6'W				(see Site 900)					0.0	400 m bsmt pen-slow+csg		
					Prop Est=13.6 days					0.0			
Iberia 10A	40*47.4'N	5500	830/100	Site 897-oldest bsmt	RCB 830/100 m,Log,Abn		16.2	2.3		18.5	1X C-4 Bit,MBR	0/0/830-100	518
priority 1	12*44.1'W									0.0			
					Prop Est=15.1 days					0.0			
Hole 901	40*40.5'N	4720	600/100	Hole 901A-contin't bsmt	RCB 600/100 m,Log,Abn		11.6	2.3		13.9	1X C-4 Bit,MBR	0/0/600-100	380
priority 1	11*3.6'W									0.0			
					Prop Est=11.0 days					0.0			
Galice 1A	42*40'N	4500	600/100	Pilot hole for deep S' reflt	RCB 600/100 m,Log,Abn		11.4	2.3		13.7	1X C-7 Bit, MBR	0/0/600-100	380
priority 2	12*48'W				Prop Est=11.3 days								
Transit from ---to----?										0.0			
					Estimated Time=	0.0	102.3	13.8	0.0	116.1	***Total =***	***4900***	***2620***
					Available Time =					56.0	***Est No Cores =***	***516***	***276***

Alternate Sites

Site Name	Latitude N Longitude W	Water Depth (m)	Penetr'n Sedmt (mbsf)	Location	Operations	Transit 10.5 kt (days)	Coring Time (days)	Log (days)	Oper Total (days)	Total (days)	Comments Equipment	Cored Interval APC/XCB/RCB	Estimated Recovery 98%/60%/85%
Iberia 9B	40*40.94'N	5150	950/600	Bsmt at detachment	Base, 300 m Csg,RCB 650/600 m,Log,Abn						22.6 days		
priority 1	11*35.6'W												
					Estimated Time=	0.0	0.0	0.0	0.0	0.0	***Est Recovery =***	***0***	***0***
					Available Time =					56.0	***Est No Cores =***	***0***	***0***

TABLE 2: PROPOSED LEG 167 DRILL SITES.

Site #	Priority	Latitude	Longitude	Water Depth (m)	Prop. Drill Depth (m)	Age (Ma)	PPSP/TAMU Approved Drill Depth (m)
GORDA TRANSECT							
CA-1D	**1**	**41°40.985'**	**124°56.002'**	**1033**	**250**	**2.5 ?** (guess)	**250***
CA-2B	1	40°04.855'	125°20.516'	1951	570	~29 (DSDP 173)	750
CA-3A	2	42°14.52'	125°51.727'	2731	265	2.8 (magnetics)	265
CA-4A	1	41°00.50'	126°26.05'	3075	275	5.1 (magnetics)	275
CA-5A	**1**	**39°05.248'**	**127°46.983'**	**4242**	**390**	**29.6** (magnetics)	**450**
CA-6A	1	41°00.946'	130°08.024'	3316	120	7.7 (magnetics)	150
COASTAL TRANSECT							
CA-7A	3	39°23.526'	124°15.017'	1235	250	2.5 ? (guess)	250
CA-8A	1	36°59.392'	123°16.581'	2508	400	8.0 ? (guess)	400
BA-4D	1	33°42.938'	118°49.147'	912	150	0.3 ? (guess)	200
BA-2B	1	32°48.061'	118°48.000'	1592	150	1.5-3 ? (guess)	150
BA-1B	1	32°16.984'	118°23.00'	1796	300	3.0 ? (guess)	400
CAM-3A	**3**	**32°29.907'**	**118°07.907'**	**1898**	**150**	**1.5-3 ?** (guess)	**150**
CONCEPTION TRANSECT							
CA-11E	1	34°32.366'	122°16.649'	3873	440	22.5 (magnetics)	500
CA-9D	1	34°32.095'	121°06.399'	974	(475)	3-4 (correlation to drilling)	200
CA-15A	1	32°50.01'	119°58.921'	1182	400	8.0 ? (guess)	400
BAJA TRANSECT							
CA-14A	1	29°57.95'	118°06.04'	3495	200	15.0 (magnetics)	250
CAM-2A	1	31°16.859'	117°38.051'	2047	285	12.0 ? (guess)	320

*Bold font indicates sites moved after consultation with PPSP.

TABLE 1: Previous Scientific Drilling on the California Margin.

SITE	YEAR DRILLED	LATITUDE	% RECOVERED
Rotary Drilled			
DSDP 36	1969	41°	**99%**
DSDP 35	1969	40.5°	**24%**
DSDP 173	1971	40°	**58%**
DSDP 34	1969	39.5°	**28%**
DSDP 33	1969	39.5°	**38%**
DSDP 32	1969	37°	**40%**
DSDP 467	1978	34°	**41%**
DSDP 468	1978	32.5°	**35%**
DSDP 469	1978	32.5°	**39%**
DSDP 470	1978	29°	**54%**
APC drilled			
ODP 893	1992	34°	**100%**

SITE SUMMARIES:

PROPOSED DRILL SITES

SITE: BA-1B

LOCATION: East Cortez Basin, California Borderlands

PRIORITY: 1

POSITION: 32° 16.984’ N 118° 23.00’ W (cross of EW9504 CAM-3 line 6 and line 8-10; EW9504 CAM-3 line 6 shotpoint 4442)

WATER DEPTH: 1796 m

SEDIMENT THICKNESS: 520 m (0.65 sec)

TOTAL PENETRATION: 300 m (PPSP approval to 400 m)

SEISMIC COVERAGE: EW9504 survey, miscellaneous regional.

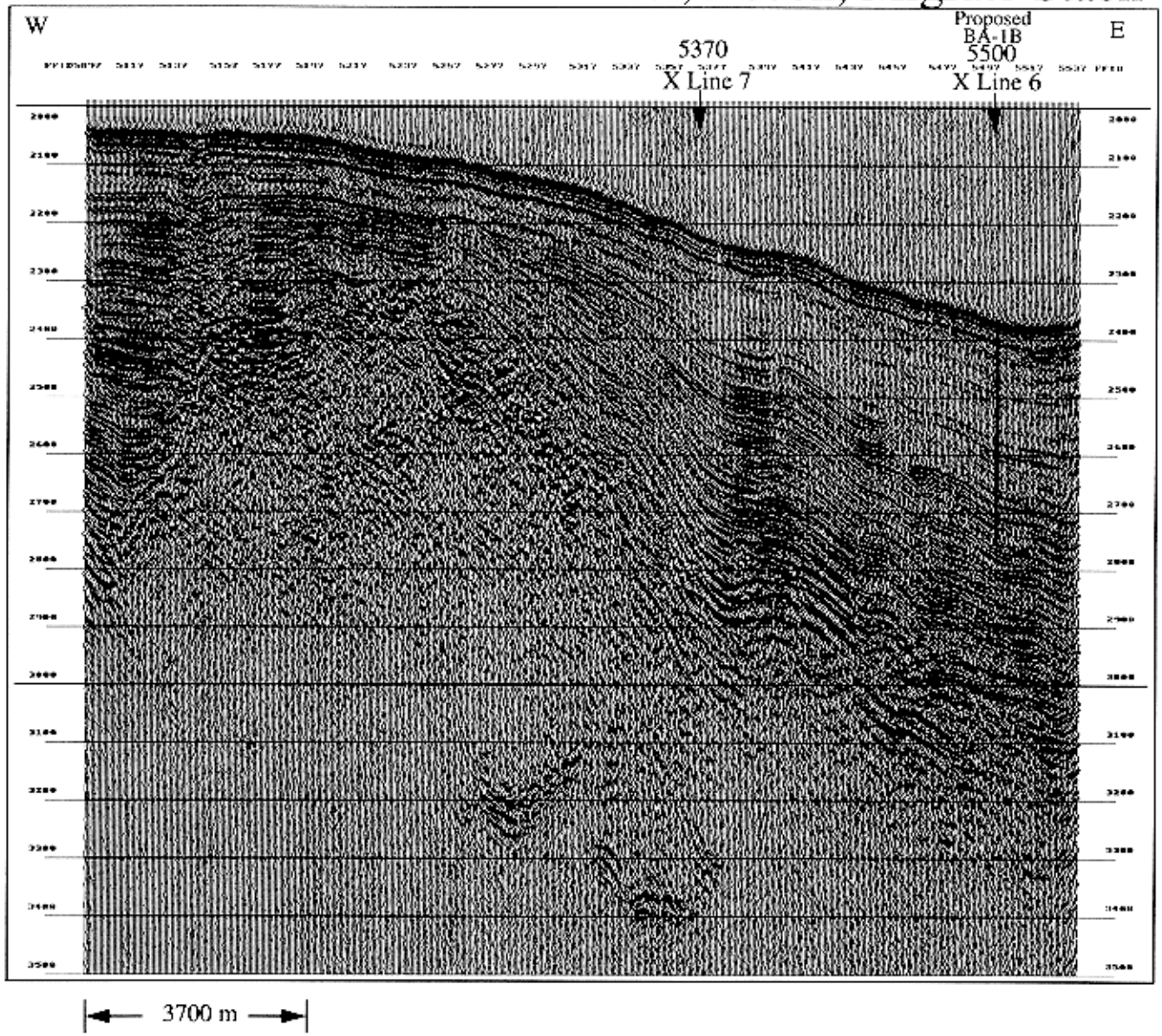
OBJECTIVES: 1. Sample complete Pleistocene section of hemipelagic sediment as part of Coastal Transect. 2. Sample upper Miocene–Holocene section if time is available

DRILLING PROGRAM: 2 APC’s to refusal, third APC to 50 m, XCB to total depth.

LOGGING AND DOWNHOLE OPERATIONS: Standard Quad Combo and FMS logging strings. GHMT magnetic log if core measurements indicate feasibility.

NATURE OF ROCK ANTICIPATED: Hemipelagic sediments, indurated at depth.

CAM-3/BA-1 Line 8-10 - Filter, Decon, Migrate Stack



SITE: BA-2B

LOCATION: San Nicolas Basin, California Borderlands

PRIORITY: 1

POSITION: 32° 48.061’ N 118° 48.00’ W (cross of BA2 lines 1 and 5; EW9504 BA2 shotpoint 446)

WATER DEPTH: 1592 m

SEDIMENT THICKNESS: 0.95 sec (760 m)

TOTAL PENETRATION: 150 m

SEISMIC COVERAGE: EW9504 BA-2 Survey, miscellaneous regional.

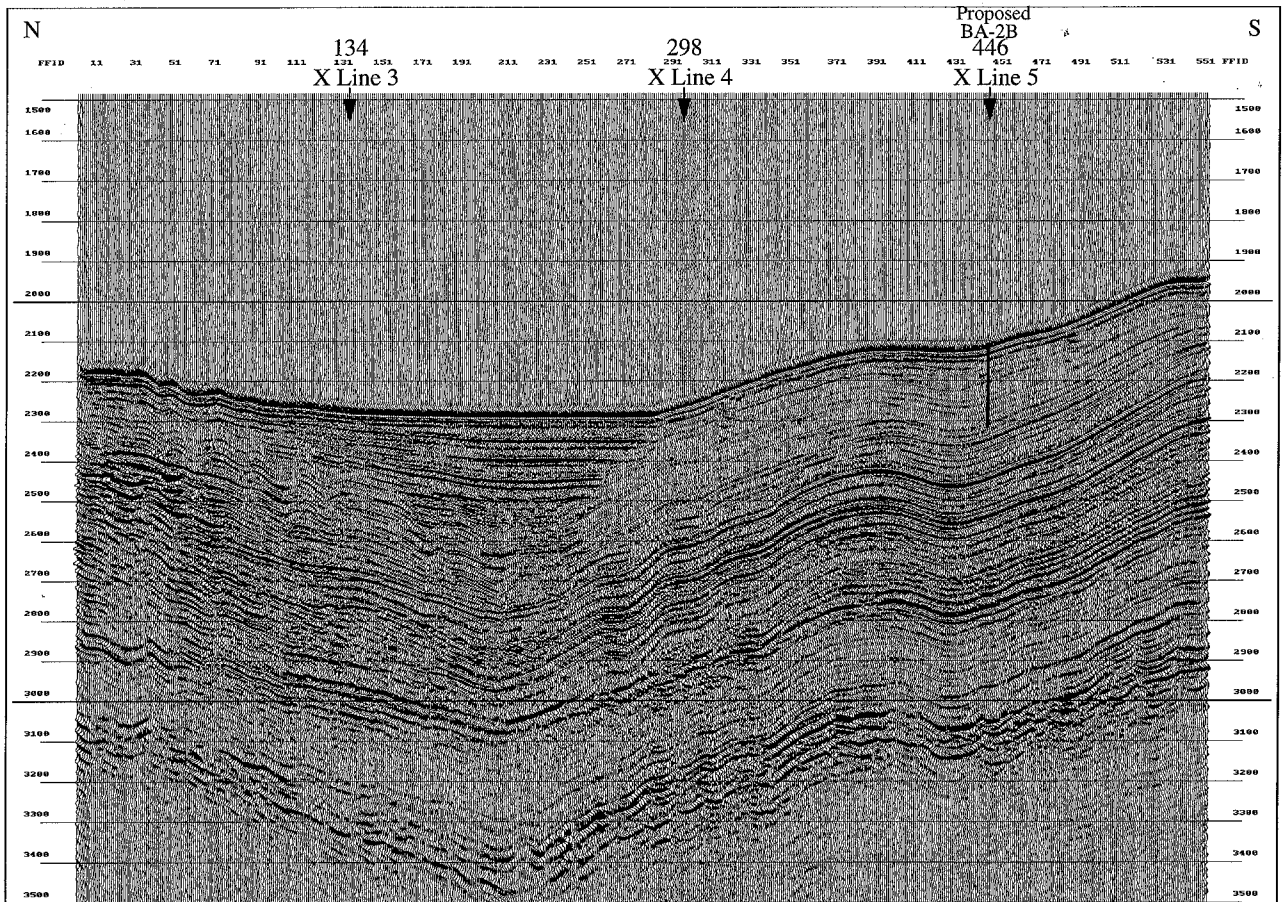
OBJECTIVES: Coastal Transect; to sample Pleistocene sediments and monitor modification of intermediate waters traveling over the Borderland province.

DRILLING PROGRAM: 2 APCs to refusal or 150 m, third APC to 50 m or longer if time available.

LOGGING AND DOWNHOLE OPERATIONS: None

NATURE OF ROCK ANTICIPATED: Hemipelagic sediments.

BA2 Line 1 - Filter, Decon, Migrate Stack



SITE: BA-4D

LOCATION: Santa Monica Basin, California Borderlands

PRIORITY: 1

POSITION: 33° 42.938’ N 118° 49.147’ W (cross of EW9504 line BA4 lines 1 and 4; EW9504 BA4 shotpoint 2996)

WATER DEPTH: 912 m

SEDIMENT THICKNESS: 0.81 sec (715 m)

TOTAL PENETRATION: 150 m

SEISMIC COVERAGE: EW9504 BA4 survey, miscellaneous regional.

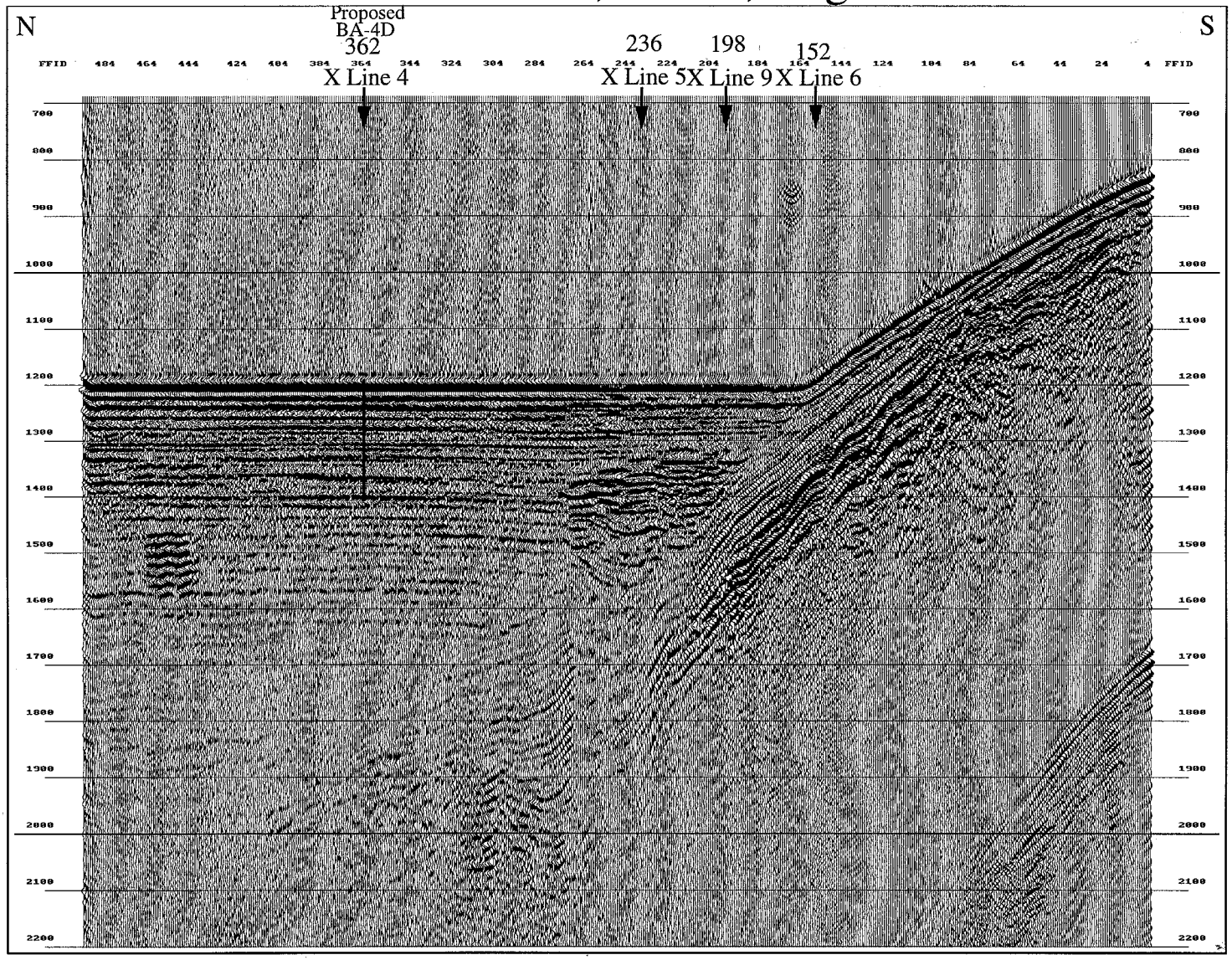
OBJECTIVES: Coastal Transect ; to sample a very high resolution upper Pleistocene. section for paleoceanographic analysis and sedimentation history of the Santa Monica Basin

DRILLING PROGRAM: 2 APCs to refusal or 150 m, third APC to 50 m or longer if time available.

LOGGING AND DOWNHOLE OPERATIONS: None.

NATURE OF ROCK ANTICIPATED: Hemipelagic sediments and distal turbidites.

BA4 Line 1- Filter, Decon, Migrate Stack



SITE: CAM-2A

LOCATION: Animal Basin, California Borderlands

PRIORITY: 1

POSITION: 31° 16.859’ N 117° 38.051’ W (Cross of EW9504 lines 1 and 2; EW9504 line 1 shotpoint 794)

WATER DEPTH: 2047 m

SEDIMENT THICKNESS: 0.34 sec (280 m)

TOTAL PENETRATION: 290

SEISMIC COVERAGE: EW9504 CAM2 survey

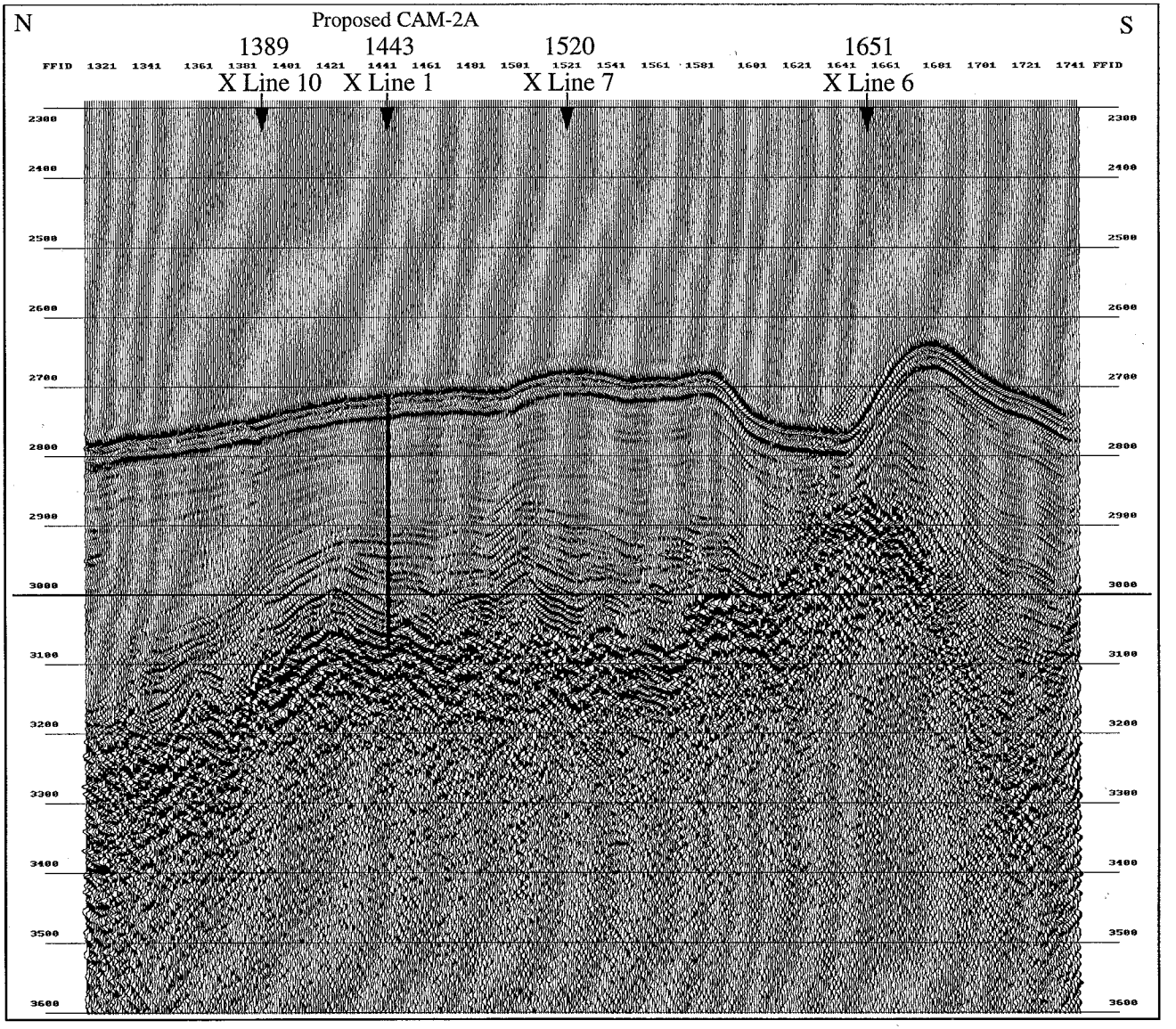
OBJECTIVES: Baja Transect and Coastal Transect. To sample middle Miocene to Holocene sediment section for paleoceanographic analysis. One of the intermediate sites in the southern California depth transect.

DRILLING PROGRAM: 2 APCs to refusal, third APC to 50 m or longer if time available. XCB to basement and to sample basement if possible.

LOGGING AND DOWNHOLE OPERATIONS: Quad Combo and FMS from standard suite. GHMT magnetic log if core measurements indicate feasibility.

NATURE OF ROCK ANTICIPATED: Hemipelagic sediments over metamorphic (possibly Franciscan) basement.

CAM-2 Line 2 - Filtered, Decon, Migrate Stack



SITE: CAM-3A

LOCATION: San Clemente Basin, California Borderlands

PRIORITY: 3

POSITION: 32°29.907'; 118° 07.907' (Cross of EW9504 CAM3 lines 2 and 11; shotpoint 5939)

WATER DEPTH: 1898

SEDIMENT THICKNESS: > 1.00 sec (> 800 m)

TOTAL PENETRATION: 150 m

SEISMIC COVERAGE: EW9504 CAM3 survey; miscellaneous regional

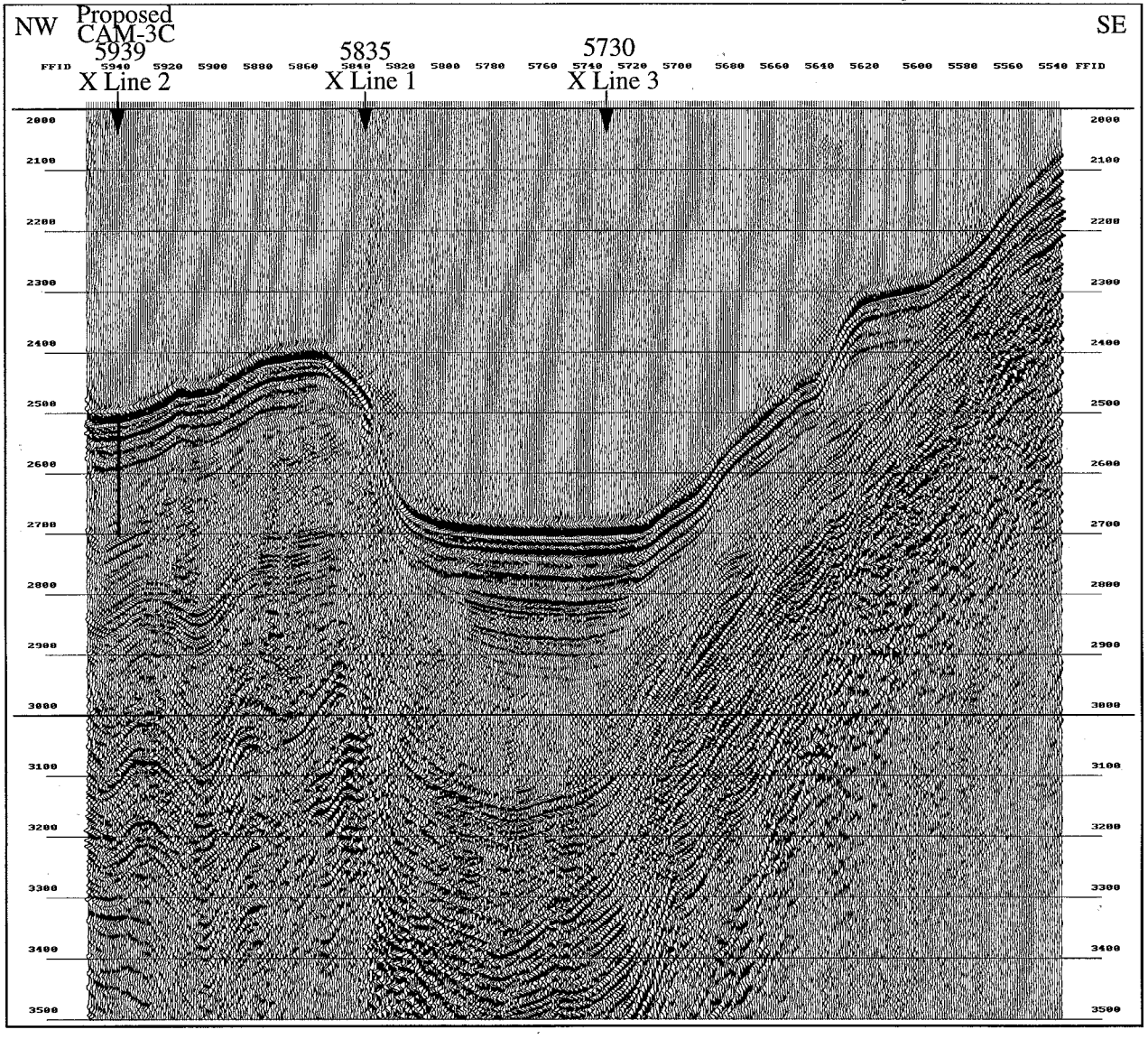
OBJECTIVES: Pleistocene section in Coastal Transect for paleoceanographic analysis and for studying modification of intermediate waters in the California Borderlands basins

DRILLING PROGRAM: 2 APCs to refusal or 150 m, third APC to 50 m or longer if time available.

LOGGING AND DOWNHOLE OPERATIONS: None.

NATURE OF ROCK ANTICIPATED: Hemipelagic sediment with occasional distal turbidites.

CAM-3/BA-1 Line 11 - Filter, Decon, Migrate Stack



SITE: CA-1D

LOCATION: Eel River Basin, Northern California slope

PRIORITY: 1

POSITION: 41° 40.985’ N, 124° 56.002’ W (Cross of W9406 lines 9 and 12)

WATER DEPTH: 1033

SEDIMENT THICKNESS: > 0.8 sec (>600 m)

TOTAL PENETRATION: 250 m

SEISMIC COVERAGE: W9406 CA1 surveys; EW9504 CA1 Survey, miscellaneous regional.

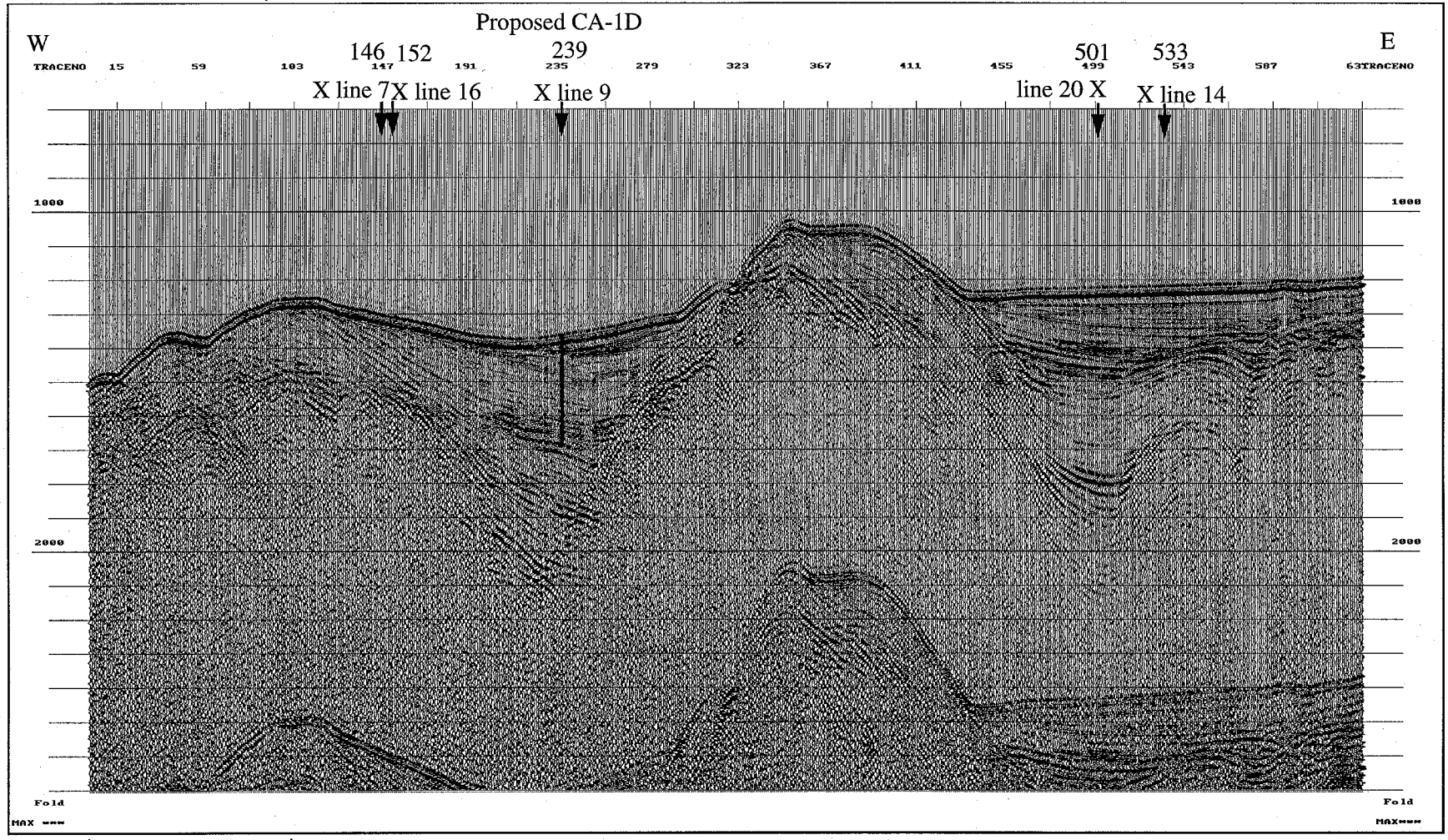
OBJECTIVES: 1. To investigate Pleistocene and late Pliocene paleoceanography on the Coastal Transect. 2. To sample gas hydrates at ~165 m depth, if found.

DRILLING PROGRAM: 2 APCs to refusal, third APC to 50 m or longer if time available. XCB to total penetration if not reached by APC.

LOGGING AND DOWNHOLE OPERATIONS: Quad Combo and FMS from standard suite.

NATURE OF ROCK ANTICIPATED: Hemipelagic sediments with some turbidites.

CA-1 Line 12 - Filtered Stack



SITE: CA-2B

LOCATION: Delgada Slope, northern California margin

PRIORITY: 1

POSITION: 40°04.855' N 125°20.516' W (Cross of W9406 CA2 line 12 and EW9504 CA2 line 23; EW9504 CA2 shotpoint 859)

WATER DEPTH: 1951 m

SEDIMENT THICKNESS: 0.695 sec (560 m)

TOTAL PENETRATION: 570 m

SEISMIC COVERAGE: W9406 CA2 survey, EW9504 CA2 survey; miscellaneous regional.

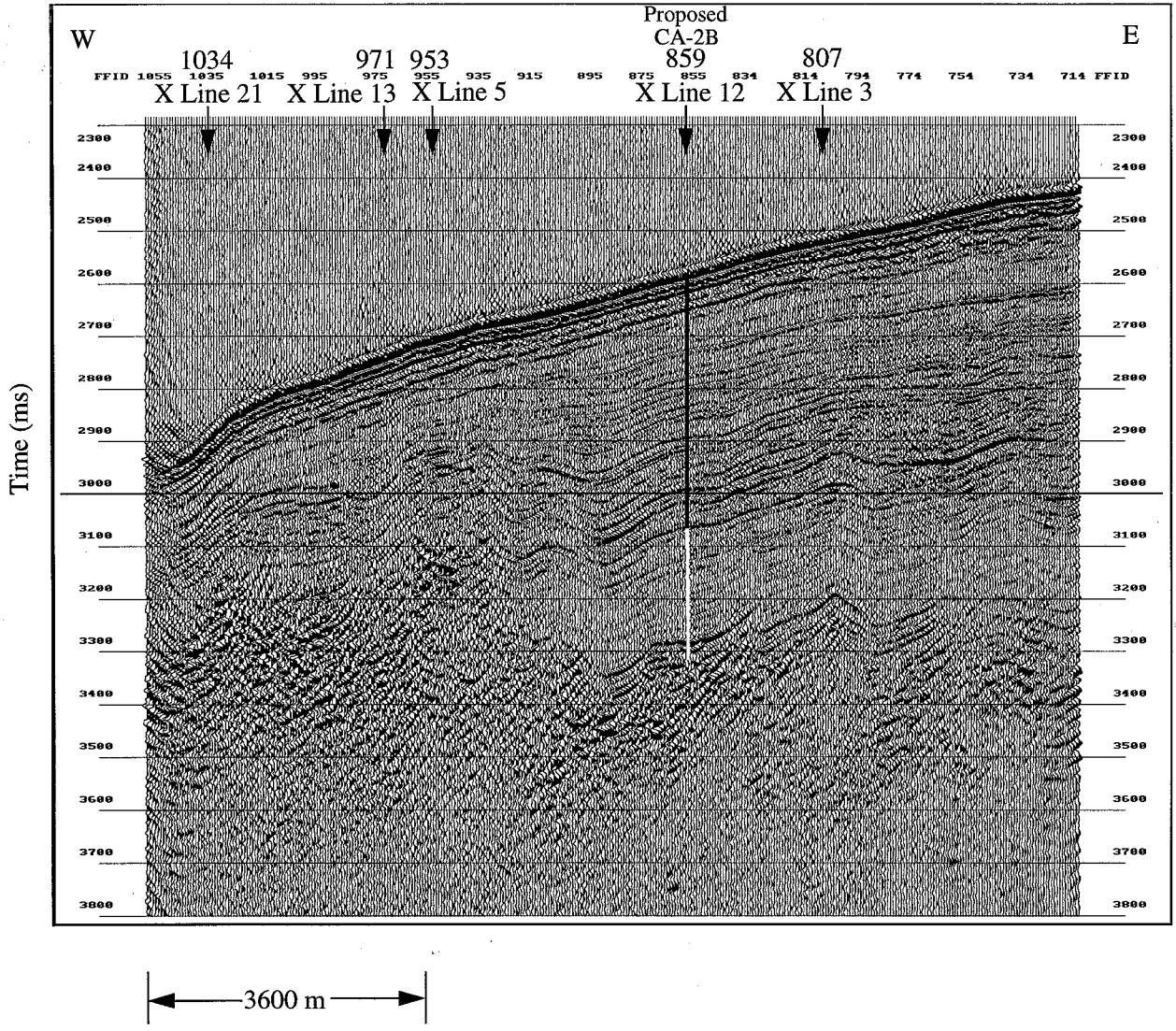
OBJECTIVES: Gorda Transect, Coastal Transect, northern depth transect. 1. To sample a complete Neogene section of hemipelagic sediments for paleoceanographic reconstruction. 2. Intermediate site for northern California depth transect.

DRILLING PROGRAM: 2 APCs to refusal, third APC to 50 m or longer if time available. XCB to total penetration, including minor basement sampling.

LOGGING AND DOWNHOLE OPERATIONS: Standard Quad Combo and FMS logging strings. GHMT magnetic log if core measurements indicate feasibility. Geochemical logging if drilled depth exceeds 400 m.

NATURE OF ROCK ANTICIPATED: Siliceous hemipelagic sediments with some minor turbidites overlying more carbonate-rich deeper section. Andesite basement (DSDP 173).

CA-2 Line 23 - Filter, Decon, Migrate Stack



SITE: CA-3A

LOCATION: Eastern flank, Gorda Ridge

PRIORITY: 2

POSITION: 42°14.52' N 125°51.727' W (EW9504 CA3 line 2 shotpoint 1132)

WATER DEPTH: 2731 m

SEDIMENT THICKNESS: 0.33 sec (260 m)

TOTAL PENETRATION: 265 m

SEISMIC COVERAGE: EW9504 CA3 survey, miscellaneous regional

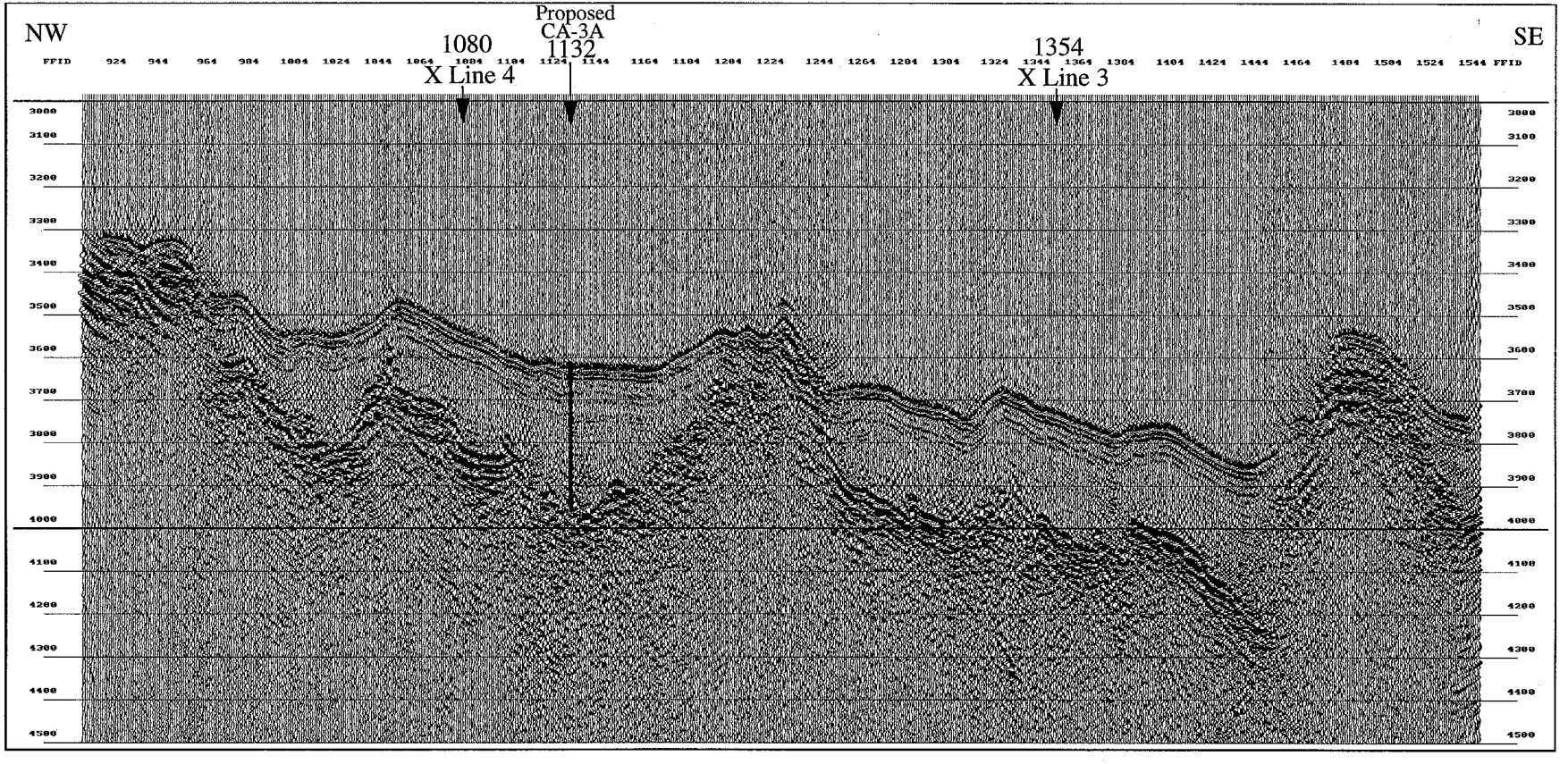
OBJECTIVES: Gorda Transect, northern depth transect. To sample high resolution 2.8 Ma to Holocene hemipelagic sediments at a moderate water depth.

DRILLING PROGRAM: 2 APCs to refusal, third APC to 50 m or longer if time available. XCB to total penetration, including minor basement sampling.

LOGGING AND DOWNHOLE OPERATIONS: none

NATURE OF ROCK ANTICIPATED: Hemipelagic sediments over MORB basalt.

CA-3 Line 2 - Filter, Decon, Migrate Stack



SITE: CA-4A

LOCATION: Eastern flank, Gorda Ridge

PRIORITY: 1

POSITION: 41°00.50' N 126°26.05' W (W9406 CA4 line 4 shotpoint 690)

WATER DEPTH: 3075m

SEDIMENT THICKNESS: 0.345 sec (270 m)

TOTAL PENETRATION: 275 m

SEISMIC COVERAGE: W9406 CA4 surveys; miscellaneous regional

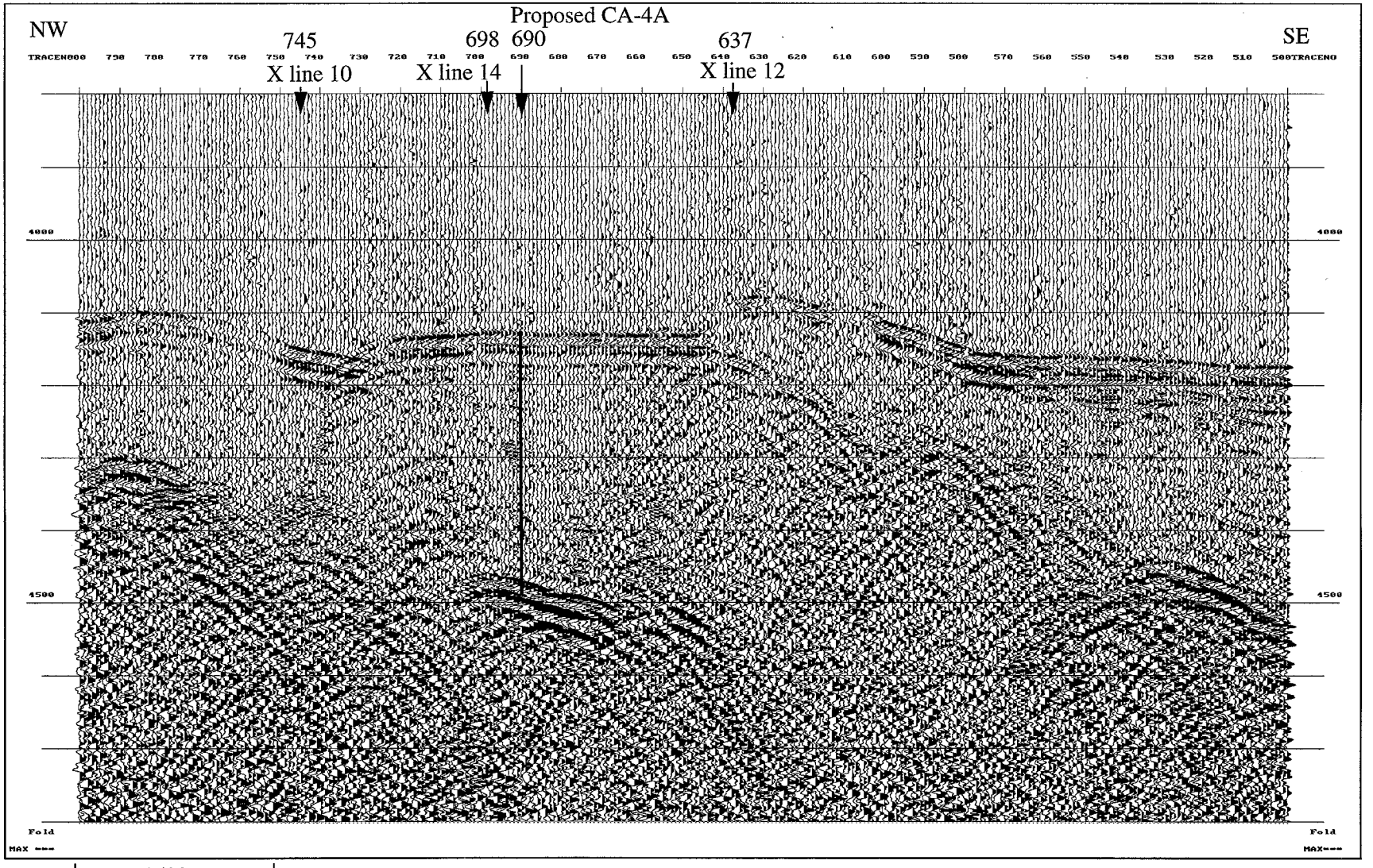
OBJECTIVES: Gorda Transect, northern depth transect. To sample high-resolution 5.1-Ma to Holocene hemipelagic sediments at a moderate water depth.

DRILLING PROGRAM: 2 APCs to refusal, third APC to 50 m or longer if time available. XCB to total penetration, including minor basement sampling.

LOGGING AND DOWNHOLE OPERATIONS: Second priority logging objective. Standard Quad Combo, FMS, and GHMT magnetic log if time permits.

NATURE OF ROCK ANTICIPATED: Hemipelagic sediments over MORB basalt.

CA4 Line 4 (Detail) - Filter Stack



SITE: CA-5A

LOCATION: Outer Delgada Fan

PRIORITY: 1

POSITION: 39°05.248' N 127°46.983' W (EW9504 CA5 line 4 shotpoint 1537)

WATER DEPTH: 4242

SEDIMENT THICKNESS: 0.48 sec (385 m)

TOTAL PENETRATION: 390

SEISMIC COVERAGE: EW9504 CA5 survey

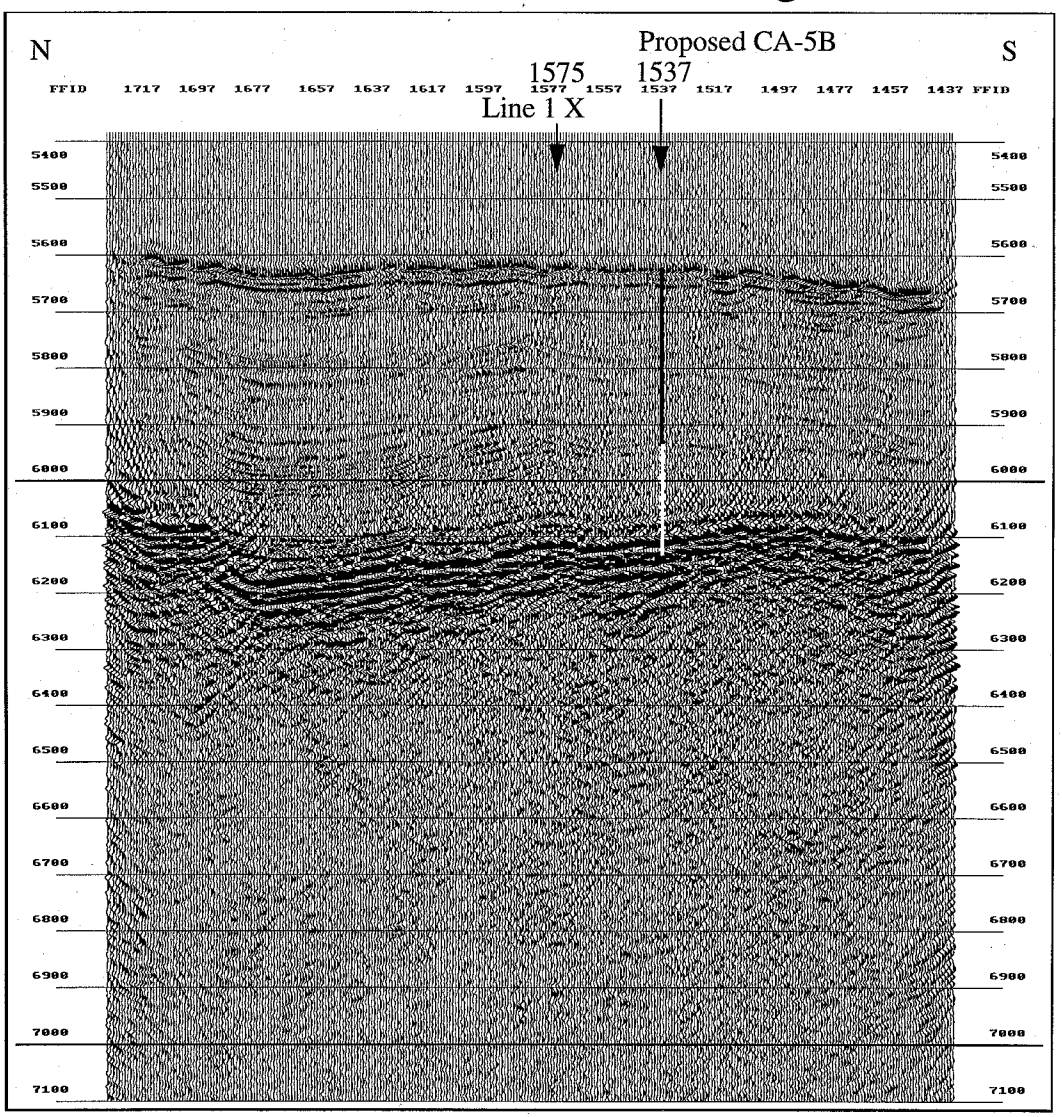
OBJECTIVES: Gorda Transect, northern depth transect. To provide a complete Neogene deep-water section for study of water-mass properties and evolution of the California Current.

DRILLING PROGRAM: 2 APCs to refusal, third APC to 50 m or longer if time available. XCB to total penetration, including minor basement sampling.

LOGGING AND DOWNHOLE OPERATIONS: Second priority logging objective; site will be logged only if drilled depth exceeds 400m. Standard Quad Combo and FMS logging strings and the GHMT magnetic log, if applicable, will be deployed.

NATURE OF ROCK ANTICIPATED: Hemipelagic sediments over MORB basalt. Possible cherts near basement.

CA-5 Line 4 - Filter, Decon, Migrate Stack



SITE: CA-6A

LOCATION: West flank, Gorda Ridge

PRIORITY: 2

POSITION: 41° 00.946'N 130° 08.024' W (EW9504 CA6 line 2 shotpoint 825)

WATER DEPTH: 3316 m

SEDIMENT THICKNESS: 0.14 sec (115 m)

TOTAL PENETRATION: 120 m

SEISMIC COVERAGE: Scan survey for DSDP leg 5; EW9504 CA6 survey

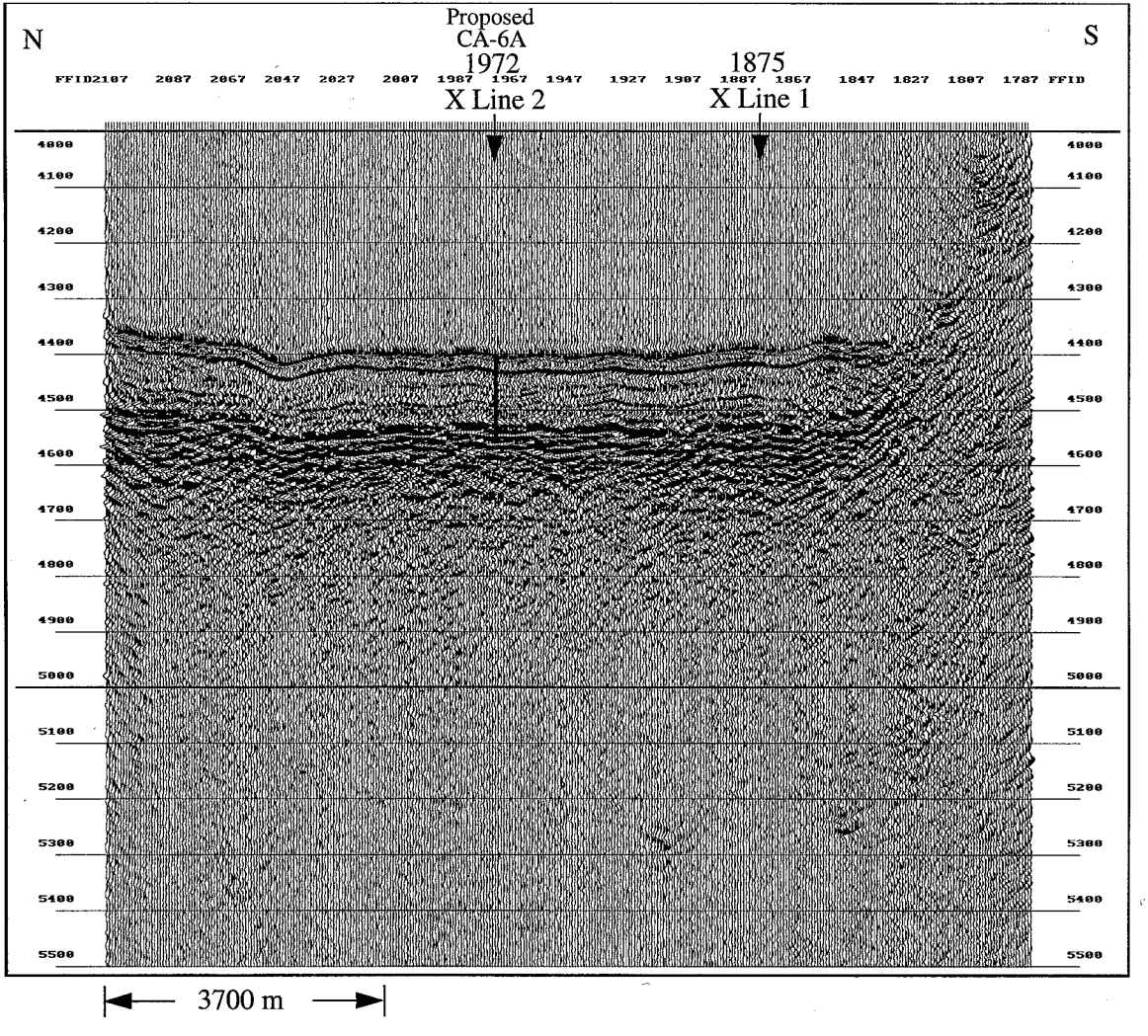
OBJECTIVES: Gorda Transect, northern depth transect. To obtain ~ 5 Ma to Holocene sediment section.

DRILLING PROGRAM: 2 APCs to basement, third APC to 50 m or basement if time available. Minor XCB sampling of basement.

LOGGING AND DOWNHOLE OPERATIONS: None.

NATURE OF ROCK ANTICIPATED: Pelagic clays and carbonates over MORB basalt.

CA-6 Line 4 - Filter, Decon, Migrate Stack



SITE: CA-7A

LOCATION: Point Arena Slope, northern California margin

PRIORITY: 3

POSITION: 39° 23.526' N 124° 15.017' W (cross W9406 line 5 and EW9504 line8; EW9504 CA7 line 8 shotpoint 455)

WATER DEPTH: 1235 m

SEDIMENT THICKNESS: > 1 sec (> 800 m)

TOTAL PENETRATION: 250 m

SEISMIC COVERAGE: W9406 and EW9504 CA7 surveys; miscellaneous regional

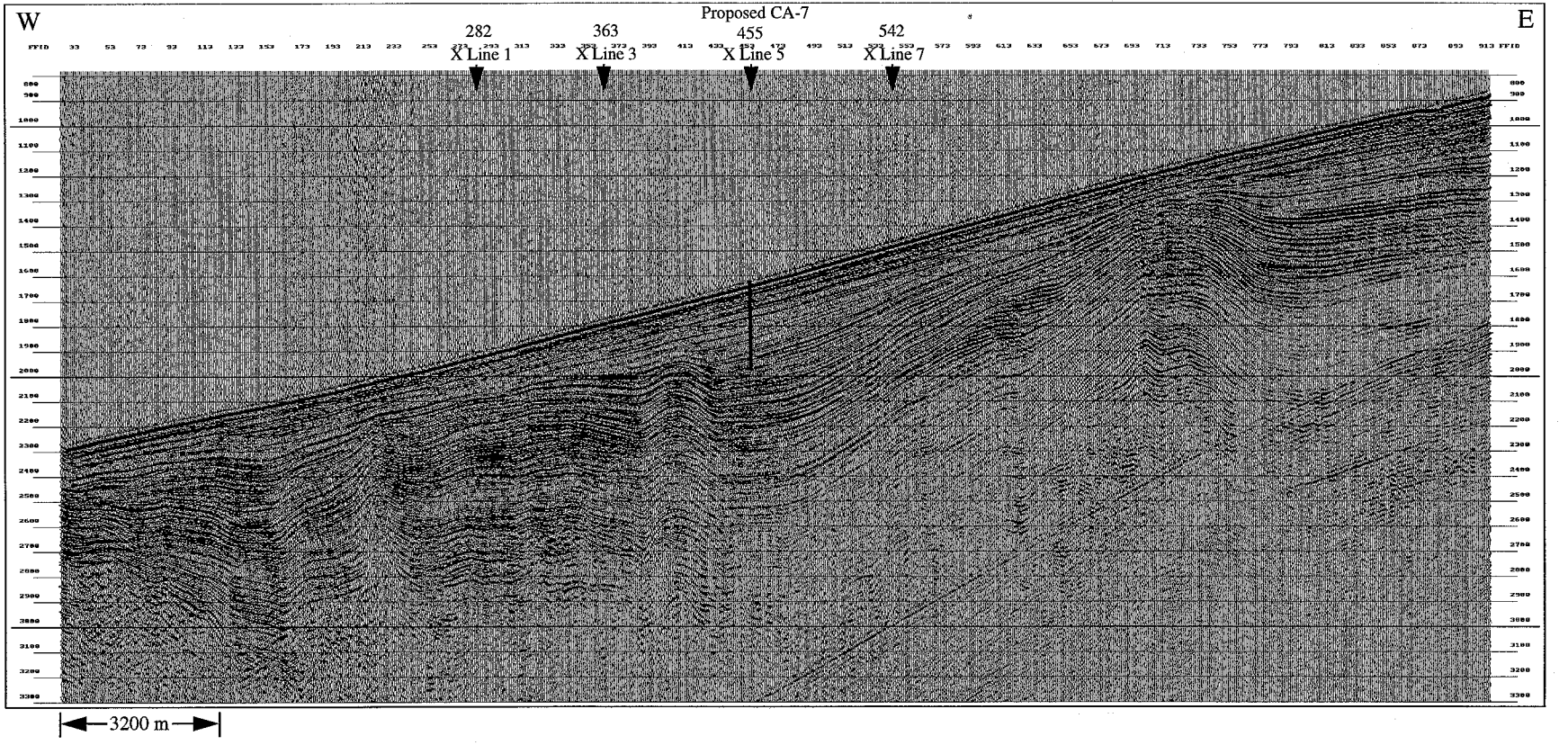
OBJECTIVES: Coastal transect. To sample a complete Pleistocene sediment section to study upwelling in the region of Point Arena.

DRILLING PROGRAM: 2 APCs to refusal, third APC to 50 m or longer if time available. XCB to total penetration, including minor basement sampling.

LOGGING AND DOWNHOLE OPERATIONS: None.

NATURE OF ROCK ANTICIPATED: Hemipelagic slope sediments with some turbidites.

CA-7 Line 8 - Filter, Decon, Migrate Stack



SITE: CA-8A

LOCATION: Sediment drift south of Guide Seamount, central California margin

PRIORITY: 1

POSITION: 36° 59.392’ N 123° 16.581’ W (EW9504 CA8 line 3 shotpoint 1542)

WATER DEPTH: 2508 m

SEDIMENT THICKNESS: > 1.2 sec (960 m)

TOTAL PENETRATION: 400 m

SEISMIC COVERAGE: EW9504 CA8 survey; miscellaneous regional.

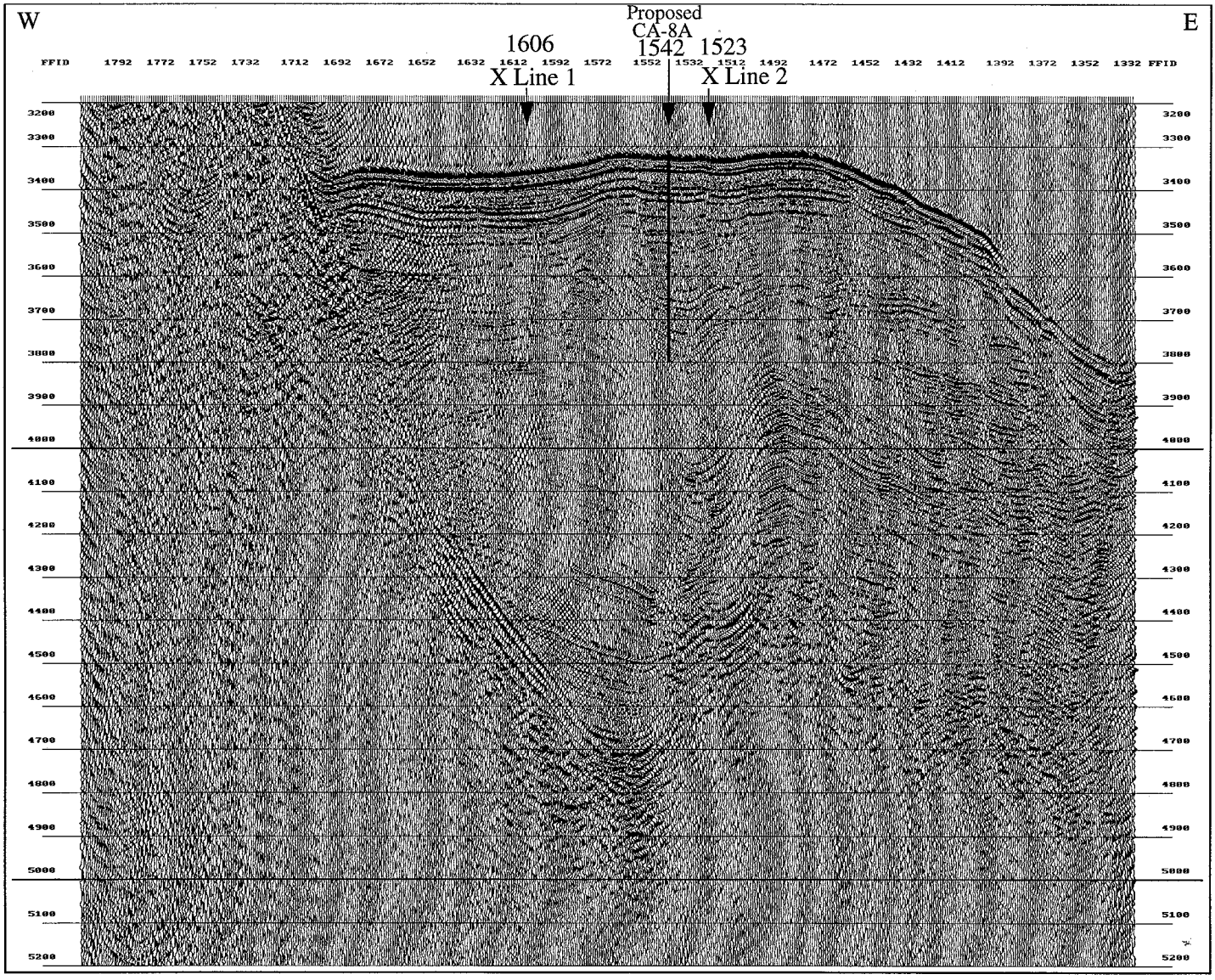
OBJECTIVES: Coastal transect, southern depth transect. To sample an upper Miocene to Holocene sediment section to reconstruct the history of upwelling near Monterey Bay, and as an intermediate depth site in southern depth transect.

DRILLING PROGRAM: 2 APCs to refusal, third APC to 50 m or longer if time available. XCB to total penetration.

LOGGING AND DOWNHOLE OPERATIONS: Standard Quad Combo, FMS, and geochemical logging strings. GHMT magnetic logging if core samples indicate feasibility.

NATURE OF ROCK ANTICIPATED: Hemipelagic sediments.

CA-8 Line 3 - Filter, Decon, Migrate Stack



SITE: CA-9D

LOCATION: Santa Lucia Slope, southern California margin

PRIORITY: 1

POSITION: 34° 32.095’ N 121° 06.399’ W (cross, CA9 line 6 and line 8 ; EW9504 CA9 shotpoint 3640)

WATER DEPTH: 974 m

SEDIMENT THICKNESS: 0.57sec (460 m)

TOTAL PENETRATION: 200 m

SEISMIC COVERAGE: EW9504 CA9 survey; miscellaneous regional.

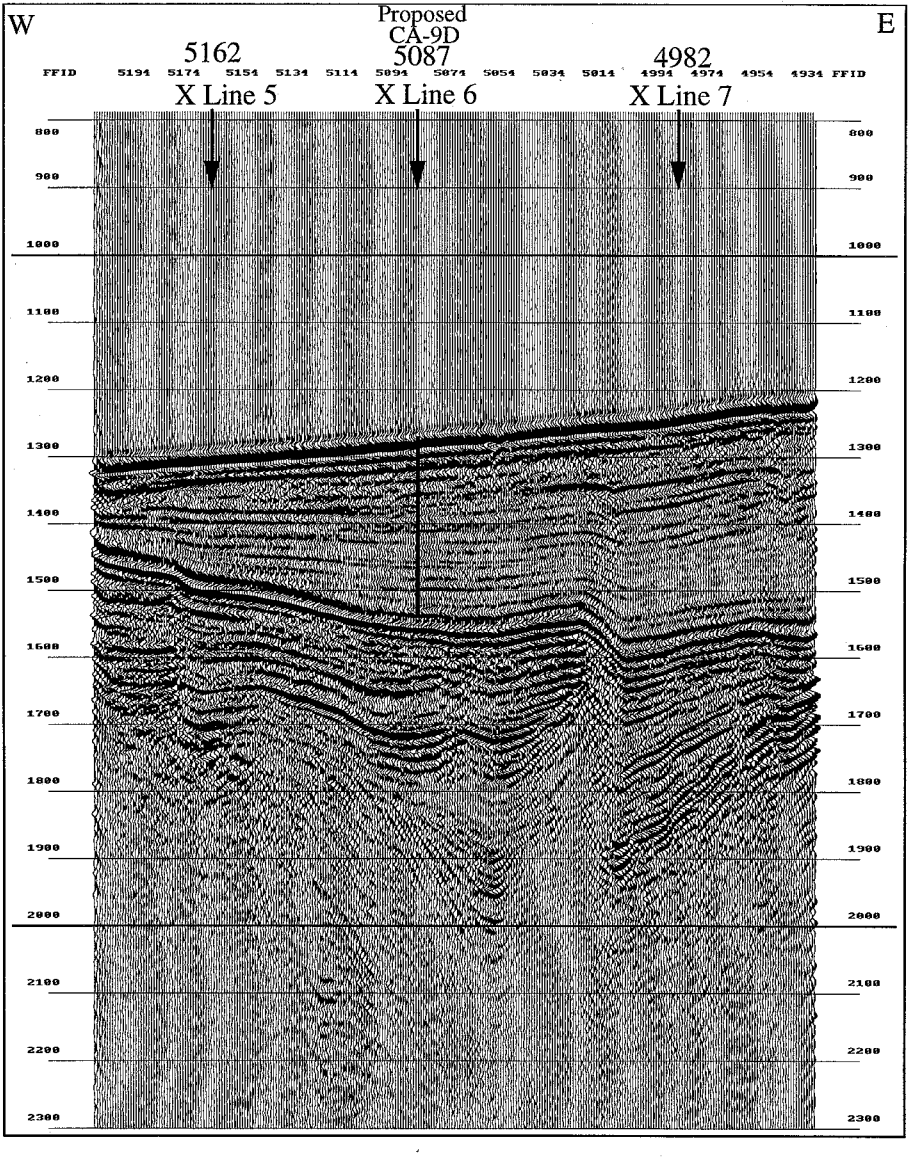
OBJECTIVES: Conception Transect, Coastal Transect. To develop a Pliocene–Holocene history of upwelling near Cape Conception, southern California margin.

DRILLING PROGRAM: 2 APCs to refusal, third APC to 50 m or longer if time available. XCB to total penetration.

LOGGING AND DOWNHOLE OPERATIONS: Second priority logging objective. Standard Quad Combo and FMS logging strings if time permits.

NATURE OF ROCK ANTICIPATED: Hemipelagic sediments with some turbidites.

CA-9 Line 8 - Filter, Decon, Migrate Stack



SITE: CA-11E

LOCATION: Pelagic site, off Point Conception

PRIORITY: 1

POSITION: 34° 32.366’ N 122° 16.649’ W (EW9504 CA11 line 7 shotpoint 3745)

WATER DEPTH: 3873 m

SEDIMENT THICKNESS: 0.52 sec (435 m)

TOTAL PENETRATION: 440 m

SEISMIC COVERAGE: EW9504 CA11 survey

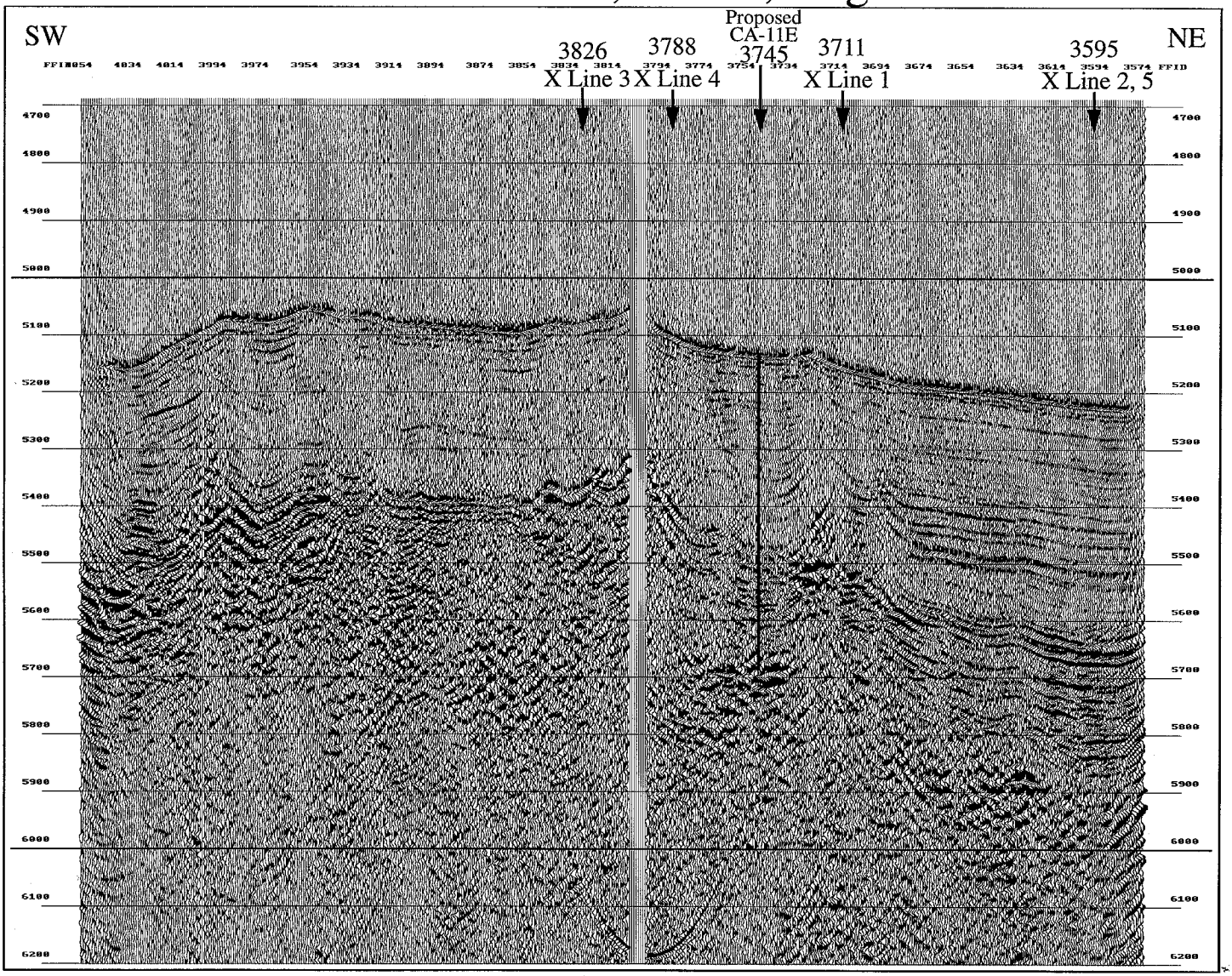
OBJECTIVES: Deep-water site, Conception transect, southern depth transect. To sample an lower Miocene (22.5 Ma) to Holocene sediment section to study evolution of the California Current and north Pacific deep-water properties.

DRILLING PROGRAM: 2 APCs to refusal, third APC to 50 m or longer if time available. XCB to total penetration, including minor basement sampling.

LOGGING AND DOWNHOLE OPERATIONS: Standard Quad Combo and FMS logging strings, and GHMT magnetic logging tool if core measurements indicate feasibility.

NATURE OF ROCK ANTICIPATED: Hemipelagic sediments over MORB basalt. Possible cherts near basement.

CA11 Line 7 - Filter, Decon, Migrate Stack



SITE: CA-14A

LOCATION: Ocean crust near Guadelupe Island, Mexico

PRIORITY: 1

POSITION: 29°57.95' N 118° 06.04' W (Cross of EW9504 seismic lines CA14-1 and CA14-3; EW9504 shotpoint 305, line CA14-1)

WATER DEPTH: 3495 m

SEDIMENT THICKNESS: 199 m (0.255 sec)

TOTAL PENETRATION: 205 m

SEISMIC COVERAGE: EW9504 CA14 survey

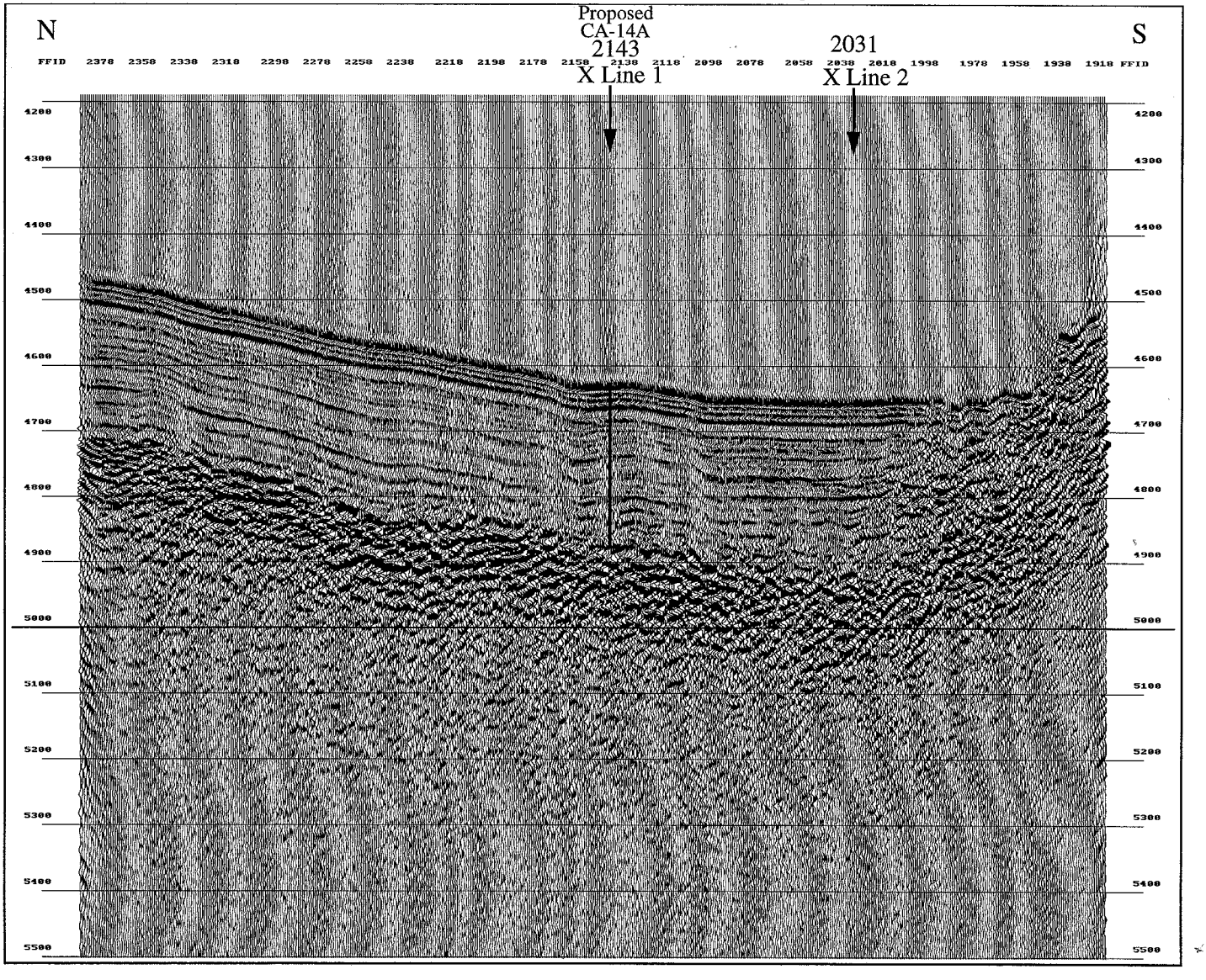
OBJECTIVES: Deep-water site, Baja transect, southern depth transect. To sample a middle Miocene (15 Ma) to Holocene sediment section to study evolution of the California Current and evolution of deep-water properties in the North Pacific.

DRILLING PROGRAM: 2 APCs to refusal, third APC to 50 m or longer if time available. XCB to total penetration, including minor basement sampling.

LOGGING AND DOWNHOLE OPERATIONS: Second priority logging objective. Standard Quad Combo and FMS logging strings if time permits.

NATURE OF ROCK ANTICIPATED: Hemipelagic sediments over MORB basalt.

CA14 Line 3 - Filter Decon, Migrate Stack



SITE: CA-15A

LOCATION: Tanner Basin, California Borderlands

PRIORITY: 1

POSITION: 32° 50.01' N 119° 58.921' W (cross of EW9504 CA-15 lines 4 and 6; EW9504 CA15 shotpoint 3130)

WATER DEPTH: 1182 m

SEDIMENT THICKNESS: >1.0 sec (800 m)

TOTAL PENETRATION: 400 m

SEISMIC COVERAGE: EW9504 CA15 survey; miscellaneous regional.

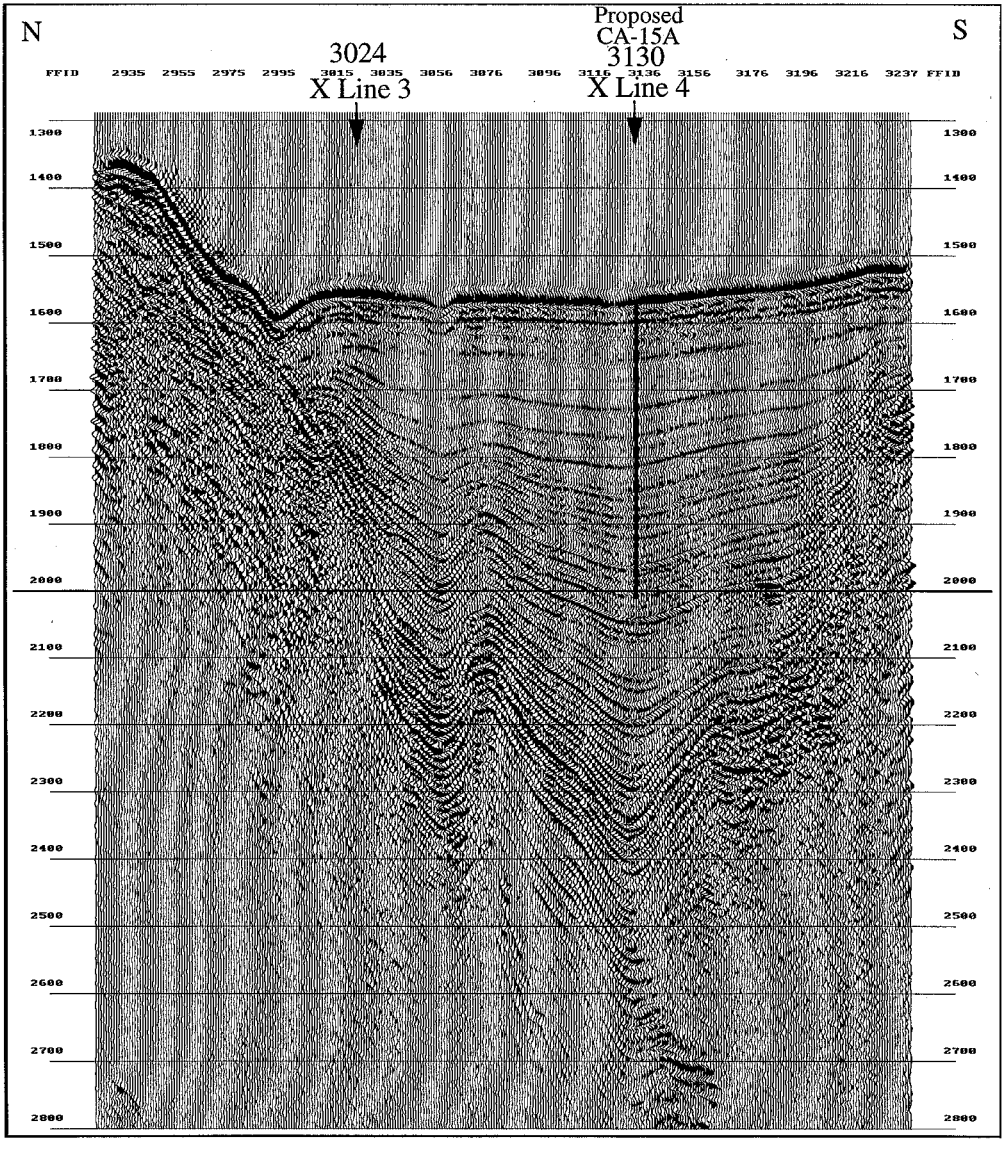
OBJECTIVES: Coastal Transect, Conception transect, southern depth transect. We believe that this site should be older than CA-9 and will provide a shallow site for the Conception transect. We plan to sample upper Miocene to Holocene sediments for paleoceanographic studies of the evolution of the California Current and north Pacific water masses.

DRILLING PROGRAM: 2 APCs to refusal, third APC to 50 m or longer if time available. XCB to total penetration, including minor basement sampling.

LOGGING AND DOWNHOLE OPERATIONS: Standard Quad Combo, FMS, and geochemical logging strings. GHMT magnetic logging if sediments appear feasible from core samples.

NATURE OF ROCK ANTICIPATED: Hemipelagic sediments over middle Miocene synrift sediments.

CA-15 Line 6 - Filter, Decon, Migrate Stack



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