

NOAA Technical Memorandum NMFS



**THE PHYSICAL OCEANOGRAPHY OFF THE CENTRAL CALIFORNIA
COAST DURING MAY-JUNE, 2000: A SUMMARY OF CTD DATA
FROM PELAGIC JUVENILE ROCKFISH SURVEYS**

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

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ABSTRACT

Hydrographic conditions during three periods of approximately ten days each from mid-May through mid-June 2000 in the coastal ocean bounded by Cypress Pt. (36°35'N) and Pt. Reyes, California (38°10'N), and from the coast to about 75 km offshore, are summarized in a series of horizontal maps and vertical sections. A total of 217 standard conductivity-temperature-depth (CTD) casts were obtained during the NOAA R/V *David Starr Jordan* cruise DSJ0002 over the course of three consecutive sweeps of the region. Data products contained in this report include (1) a master list of CTD stations during the cruise; (2) surface meteorological time series from the region's four National Data Buoy Center (NDBC) meteorological buoys; (3) horizontal maps of sea surface temperatures (SST) from AVHRR satellite images; (4) acoustic Doppler current profiler (ADCP) data; (5) horizontal maps of temperature, salinity, and density (sigma-theta [σ_θ]) at depths of 2 m, 10 m, 30 m, 100 m, 200 m, 300 m, and 500 m; (6) temperature, salinity and σ_θ along four cross-shelf vertical transects; and (7) dynamic height topography (0/500 m and 200/500 m) in the survey region.

INTRODUCTION

The current regime off central California is hydrodynamically complex, composed of both geostrophic and wind-driven forces. The California Current provides the backdrop for large-scale, seasonal circulation patterns (Hickey 1979), while coastal upwelling occurs regionally for most of the year, especially from April to September (Huyer 1983). On the mesoscale (10-100 km), irregularities in the coastline interact with the wind stress field (Kelly 1985), resulting in turbulent jets, eddies and upwelling filaments, all of which are common features along the central California coast (Mooers and Robinson 1984; Flament et al. 1985; Njoku et al. 1985; Rosenfeld et al. 1994). Moreover, wind-driven fluctuations in coastal flow (Chelton et al. 1988) and freshwater discharge from San Francisco Bay add further complexity to the circulation regime.

Since 1983, the National Marine Fisheries (NMFS) Southwest Fisheries Science Center's (SWFSC) Santa Cruz Laboratory has worked on developing a recruitment index for rockfish within the hydrographic region off central California. Annual juvenile rockfish surveys aboard the National Oceanic and Atmospheric Administration (NOAA) research vessel (R/V) *David Starr Jordan* (DSJ) have provided information regarding distributional and abundance patterns of young-of-the-year pelagic juveniles in the area between Monterey Bay and Pt. Reyes (latitude 36°30'-38°10'N) (Wyllie Echeverria et al. 1990). Results of this research show a complex pattern in the spatial distribution of pre-recruits of a variety of commercially significant species (e.g., widow rockfish, *S. entomelas*; chilipepper, *S. goodei*; yellowtail rockfish, *S. flavidus*; and bocaccio, *S. paucispinis*). Moreover, extreme interannual fluctuations in abundance have occurred, with combined back-transformed mean log_e catches ranging from 0.1-78.6 juvenile rockfish/tow (Adams 1995¹).

Realizing that a basic description of the physical environment is necessary to better understand the distribution and abundance of young-of-the-year rockfish, collection of conductivity-temperature-depth (CTD) data was initiated in 1987 as part of the NMFS SWFSC Santa Cruz Laboratory's annual juvenile rockfish surveys. The staff of the NMFS SWFSC Pacific Fisheries Environmental Laboratory (PFEL) subsequently began analyzing the CTD data to assist in this recruitment fisheries oceanography study. Ultimately, it is our goal to determine and forecast the manner in which rockfish year-class strength is affected by variations in the physical environment.

This report summarizes results obtained from the CTD data collected in 2000. Due to the large quantity of data analyzed and the extensive array of results presented herein, we make little attempt to provide detailed interpretations of our findings. Reports covering the juvenile rockfish surveys of 1988 (DSJ8804 and DSJ8806), 1989 (DSJ8904), 1990 (DSJ9003 and DSJ9005), 1991 (DSJ9102 and DSJ9105), 1992 (DSJ9203 and DSJ9206), 1993 (DSJ9304 and DSJ9307), 1994 (DSJ9403 and DSJ9406), 1995 (DSJ9506), 1996 (DSJ9606), 1997 (DSJ9707), and 1998 (DSJ9807) have been published (Schwing et al. 1990; Johnson et al. 1992; Sakuma et al. 1994a; Sakuma et al. 1994b; Sakuma et al. 1995a; Sakuma et al. 1995b, Sakuma et al. 1996, Sakuma et al. 1997, Sakuma et al. 1999, Sakuma et al. 2000). A companion volume (Schwing and Ralston 1990²) contains individual traces of temperature, salinity, and sigma-t (σ_t , a representation of water density) plotted against depth for each CTD cast conducted in 1989. Further scientific analysis of these data, and their linkages to fisheries recruitment, will be compiled in future peer-reviewed scientific publications (e.g., Schwing et al. 1991).

MATERIALS AND METHODS

¹Adams, P. B. (editor). 1995. Progress in rockfish recruitment studies. SWFSC Admin. Rep. T-95-01, 51 p., unpublished report.

²Schwing, F. B., and S. Ralston. 1990. Individual cast data for CTD stations conducted during cruise DSJ8904 (May 14-June 13, 1989). SWFSC Admin. Rep. PFEG-91-01, 7 p. + figs., unpublished report.

MATERIALS AND METHODS

Meteorological Data

Surface data were obtained from four NOAA National Data Buoy Center (NDBC) moored buoys located within the rockfish survey region. These four buoys are 46013 (Bodega Bay; 38°12'N, 123°18'W), 46026 (Farallones; 37°48'N, 122°42'W), 46012 (Half Moon Bay; 37°24'N, 122°42'W) and 46042 (Monterey Bay; 36°48'N, 122°24'W) (Appendix 2). Daily averages of sea surface temperature (SST) and the east and north wind components were calculated from hourly mean buoy measurements. The angle of the alongshore wind component, relative to north, was determined by a principal component analysis (PCA) of the daily-averaged wind data from each buoy. This angle can be thought of as the predominant direction toward which the wind blows.

Annual climatologies and variance were determined for SST and the alongshore wind component at each buoy with a biharmonic analysis of all daily mean data over the buoy's entire operating period. These operating periods were 1981 to 2000 for buoy 46013, 1982 to 2000 for buoy 46026, 1981 to 2000 for buoy 46012, and 1987 to 2000 for buoy 46042. The annual cycles were estimated by a least squares regression of the data to an annual and semiannual harmonic signal of the form

$$SST(t) = A_0 + A_1 \cos(2\pi t) + B_1 \sin(2\pi t) + A_2 \cos(4\pi t) + B_2 \sin(4\pi t)$$

where t is the Julian Day/365 and the A_i and B_i are coefficients determined by regression at each buoy. The fits were not improved significantly by including higher harmonics. Standard errors were calculated for each Julian day, then fit with the same biharmonic model.

SST Data from AVHRR Satellite Imagery

Beginning in February 1998, products generated by the NOAA CoastWatch Group in La Jolla, California were changed from previous years. SSTs were derived from advanced very high resolution radiometer (AVHRR) data from channel 4 and 5 of the NOAA-11 polar orbiting satellite and were designated as non-linear multichannel SST. A cloud masking routine was run on each image file, and then the images were partitioned into different geographic regions along the West Coast. This yielded a high resolution image file which could then be read and analyzed. In 2000, the NOAA CoastWatch Group began producing 5 night composite images, which could be scaled and downloaded directly from their website (<http://cwatchwc.ucsd.edu>) in JPEG format. These images were created using the images from the last 5 nights to obtain a median composite. The 5 night composite images were selected over the daily images, which were used in the past, as these were more comparable in temporal scale to the juvenile rockfish survey design. Image files were downloaded to the ship's PC by using a cellular telephone, a cellular telephone modem interface, and a commercial modem communications software. All images which were clear or relatively clear of clouds/fog were saved on a PC and stored at the NMFS SWFSC Santa Cruz Laboratory and at the NMFS SWFSC PFEL as part of the Oceanographic database system.

Juvenile Rockfish Survey Design

Annual cruises aboard the NOAA R/V DSJ began in 1983 and have been conducted during late spring (April-June), a time when most pelagic-stage juvenile rockfishes are identifiable to species, but prior to their settling to nearshore and benthic habitats. Throughout this time, a standard haul consisted of a 15-minute nighttime tow of a large midwater trawl set to a depth of 30 m. Additional tows were made at other depths (i.e., 10 and 100 m) as allowed by constraints imposed by time and bottom bathymetry.

In 1986, the sampling design was altered to permit three consecutive "sweeps" through a study area bounded by Cypress Pt. (36°35'N) and Pt. Reyes (38°10'N), California, and from the coast to about 75 km offshore. Five or six stations along a transect were sampled each night and seven transects were completed for each sweep. Starting in 1987, a CTD cast was conducted at each trawl station occupied. In addition, daytime activities were restructured to permit sampling of a new grid of standard CTD stations (Appendix 2). Standard CTD stations were specific locations where CTD

casts were scheduled and repeated for each sweep of each cruise. CTD cast locations that were only specific to a particular sweep during a cruise were considered as additional CTD stations. Although each sweep typically lasts approximately ten days (seven nights of scheduled work plus three nights of additional discretionary sampling), adverse weather conditions can extend the duration of a sweep. Logistical constraints can also restrict the number of casts completed. Discretionary sampling typically was focused on specific bathymetric features, such as Cordell Bank or Pioneer Canyon, or devoted to the intense study of oceanic features or processes that may be key to successful recruitment. CTD casts conducted during discretionary sampling were considered additional stations and not included in the grid of standard CTD stations used in this report.

Collection of ADCP Data at Sea

An Acoustic Doppler Current Profiler (ADCP) manufactured by RD Instruments of San Diego, CA. was operated continuously on each cruise. The ADCP is constructed of naval bronze and is permanently mounted in a sea chest within the hull of the vessel. The unit contains four downward looking 150 kHz transducers pointing at a fixed beam angle in four different directions. RD Instrument's Data Acquisition Software (DAS) was used to log acoustic data to a shipboard PC. The ADCP emits acoustic pulses (pings) which are used to measure velocity, magnitude, and direction of the column of water beneath the ship. Ship heading was obtained from a gyrocompass and positions were obtained by a Global Positioning System (GPS) receiver.

Collection of CTD Data at Sea

CTD data from the 2000 juvenile rockfish survey presented in this report was collected with a Sea-Bird Electronics, Inc., SEACAT-SBE-19 profiler mounted on an SBE-32 water sampler carousel, which interfaced via conducting cable to a SBE-33 deck unit³. This allowed for real-time data acquisition. This particular unit was rated to a depth of 600 m and contained 256K of memory. The CTD was also equipped with a WETStar model WS3-030 miniature fluorometer. Four data channels were used to record pressure (0.05% of full scale range [50-5,000 psia]), temperature (0.01 °C from -5 to +35 °C), conductivity (0.001 S/m from 0 to 7 S/m), and fluorometer voltage at a baud rate of 9,600. The temperature and conductivity sensors of the profiler have been recalibrated annually by Sea-Bird Electronics, Inc., prior to its use aboard ship.

During deployment, the vessel was brought to a dead stop and the profiler was attached to a hydrographic winch cable. The profiler was then switched on and suspended underwater at the surface for a period of two minutes to allow the conductivity, temperature, and fluorometer sensors to equilibrate. The rate of descent was 45 m/minute to a depth 10 m off the bottom down to a maximum depth of 500 m. Only data collected on the downcast were ultimately preserved for analysis. During the cast, certain collection information was recorded on data sheets, including (1) the date, (2) time, (3) a profiler-assigned cast number, (4) a cruise-specific consecutive index number, (5) the trawl station number (when appropriate), (6) latitude, (7) longitude, (8) bucket temperature (temperature [°C] of a bucket sample of surface water using a mercury thermometer), (9) bucket salinity (salinity of a bucket sample of surface water using a hand-held portable salinometer), and (10) bottom depth in meters. In addition, a water sample from the chlorophyll maximum layer was collected twice a day (using one of the bottles attached to the SBE-32) for later use in calibrating the WETStar fluorometer data. Position fixes were obtained using the GPS. Collection information recorded on the data sheets were eventually entered into data files on a PC.

Data collected from a short series of casts (usually no more than 5-7) were periodically uploaded to a laptop computer. During this step, each cast was stored as a separate file. After uploading, the profiler was reinitialized and the files on the laptop computer were backed up onto a desktop computer on board the vessel.

³Sea-Bird Electronics, Inc., 1808 - 136th Place NE, Bellevue, Washington 98005, USA. Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

An additional source of hydrographic data was the vessel's Sea-Bird Electronics, Inc., thermosalinometer (TS) unit, which provided a continuous data stream of surface temperature and salinity. These data were logged by the vessel's scientific computer system and transferred to a PC for further processing, analysis, and comparison with, and verification of, CTD observations. Position fixes for the TS unit were based on GPS.

ADCP Data Processing

ADCP data were processed using the CODAS 3 software from University of Hawaii⁴. Data from each cruise were scanned and loaded into a cruise-specific CODAS database. The navigation fix data were extracted. Manual screening was done for profiles which included bottom reflection. Calibration and alignment corrections were computed and applied to the database. The absolute reference layer currents were then computed, smoothed, and used to produce absolute current profiles. Currents were plotted as vectors at eight different depth bins using the 'vector' plotting routine in CODAS.

CTD Data Processing

The first step in data processing was to convert the uploaded CTD files to ASCII files. This was accomplished using programs supplied by Sea-Bird Electronics, Inc., in SEASOFT menu-driven release Version 4.238⁵. All files were batch-processed through the SEASOFT modules DATCNV, FILTER, ALIGNCTD, LOOPEDIT, BINAvg, and DERIVE (refer to footnote 4 and past Technical Memorandums, e.g., Sakuma et al. 1995b, for more information) and output as ASCII files macros. All data were averaged into two-meter depth bins. Each CTD ASCII file was subsequently manually edited to remove large outliers (i.e., data spikes) in salinity and/or density, which sometimes occurred near the surface and at the thermocline. Comparisons were made between CTD temperature and salinity from the two-meter depth bin, TS temperature and salinity, bucket temperature, and bucket salinity at each CTD station using a simple regression to check for data outliers and any blatant calibration problems (Appendix 6).

Processed hydrographic data were summarized, by sweep, in a series of horizontal maps and vertical sections. Although additional CTD casts were completed during DSJ0002, only casts from the grid of standard CTD stations and those casts which provided a relatively continuous sampling track within a specific sweep were included in the data summary for the horizontal maps (Appendix 7). This was done in an attempt to generate a relatively synoptic representation of each individual sweep and to spatially standardize hydrographic comparisons among sweeps. Vertical sections from the three sweeps of DSJ0002 were also spatially standardized (Appendix 8). However, the Farallones transect line was less synoptic than the Pt. Reyes, Pescadero, and Davenport transect lines, because casts were combined over a 2- to 3-day time period instead of the more usual 24-hour period. In addition, the Farallones transect line does not follow a straight course, which may lead to some distortion of the vertical section contours nearshore. All contouring of CTD data for horizontal maps and vertical sections was done using SURFER FOR WINDOWS graphics software⁶, which estimates values throughout a specified region based on the available data. Kriging was selected as the optimal interpolation method used for the algorithm grid (Cressie 1991).

The TS raw data were edited to provide a nearly continuous sampling track for each sweep of DSJ0002. However, there appeared to be a consistent offset between salinity recorded by the TS and salinity recorded by the CTD at 2-m depth for the entire cruise (Appendix 6). Because the CTD

⁴Firing, E., J. Ranada, and P. Caldwell, 1995. Processing ADCP Data with CODAS Software System. Available electronically from: <http://noio.soest.hawaii.edu/pub/codas3/manual.ps>.

⁵CTD Data Acquisition software, SEASOFT Version 4.238, October 1999, Sea-Bird Electronics, Inc., 1808 - 136th Place NE, Bellevue, Washington 98005, USA. Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

⁶SURFER FOR WINDOWS, Golden Software, Inc., 809 14th Street, Golden, Colorado 80402, USA. Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

was calibrated annually by the manufacturer, and because problems occurred with the TS unit in the past during DSJ9203, DSJ9304, and DSJ9406, TS salinity values were considered less reliable and, when necessary, were adjusted using a regression comparison with the CTD. That is,

$$TS' = \alpha + \beta(TS)$$

where TS' is the adjusted thermosalinometer value (either temperature or salinity), TS is the unadjusted value, and α and β are the intercept and slope parameters of the regression of 2-m CTD data (temperature or salinity) on the corresponding TS value. TS data were subsequently contoured using SURFER FOR WINDOWS⁶.

Satisfactory calibrations for the WETStar fluorometer using the SBE-32 bottle samples from DSJ0002 have yet to be resolved. Due to the lack of an accurate calibration, the fluorometer data for DSJ0002 will not be presented.

Dynamic height was calculated for stations occupied during DSJ0002 using a 500-db base. CTD casts conducted in areas with bottom depths less than 500 m were not included in this analysis. The dynamic height topography of the 0-db surface relative to the 500-db surface and the 200-db surface relative to the 500-db surface for the three sweeps of DSJ0002 were output from the DERIVE module of SEASOFT Version 4.238⁵ and these data were gridded in SURFER FOR WINDOWS⁶. A 0.01 contour interval was chosen for the 0 db surface relative to the 500-db surface maps and a 0.005 contour interval for the 200-db surface relative to the 500-db surface (Appendix 9).

To date, no attempt has been made to calculate vertical sections of geostrophic velocity because the large number of shallow stations during the juvenile rockfish surveys necessitates the extrapolation of isopycnals into the shore, a procedure that is subject to great uncertainty. In addition, recent studies (Berryman 1989; Tisch 1990) suggest that geostrophic velocities calculated for stations spaced closer than the internal Rossby radius frequently feature alternating current bands of reversed flow, which are thought to be associated with inertial currents. The Rossby radius in the survey region is generally about 10-20 km, which is similar to the typical station spacing of the rockfish surveys. We are presently investigating the method that best determines geostrophic velocities from dynamic heights, based on closely spaced shallow water stations, before attempting to calculate the geostrophic velocity field during these surveys.

RESULTS

Data Products

Below are a few brief comments on each of the data products contained in this report in the order that they appear.

Appendix 1: List of CTD Stations Summarized from Cruise DSJ0002

The station list includes, from left to right, CTD cast number (only acceptable casts included), date, local military time, latitude and longitude (degrees, minutes), and station bottom depth. Cruise DSJ0002, Sweep 1 (May 11-18) includes 76 standard stations (casts 1-76), Sweep 2 (May 18-26) includes 69 standard stations (casts 79-147), and Sweep 3 (May 29-June 6) includes 72 standard stations (casts 152-224).

Appendix 2: CTD Stations and Bathymetric Maps of Survey Region with Locations of the NDBC Buoys

The locations of the standard CTD stations for DSJ0002 along with the locations of the NDBC buoys, the place names, and the bottom bathymetry of the survey areas are shown.

Appendix 3: Meteorological Time Series

Time series of daily-averaged SST and alongshore wind are presented for January-June 2000 based on data available from the four NOAA NDBC buoys located within the survey region. In each plot, the bold solid line represents the daily-mean values of the parameter. The bold dotted line represents the biharmonic fit to the climatology derived from daily data over the operating period of the buoy to date. The gray shaded envelope about the biharmonic fit line is ± 1 standard error of the daily values on each Julian day. Negative values denote southward (upwelling-favorable) winds. The "PCA direction" on the alongshore wind plots represent the direction of the alongshore wind relative to north, which was derived from a principal component analysis.

Appendix 4: AVHRR Satellite Images of Multichannel SST

SSTs along the central and northern California coast from radiances sensed by channel 4 and 5 of the NOAA-11 polar orbiting satellite are presented for each of the three sweeps during DSJ0002. Each image represents a median 5 night composite obtained directly from the NOAA CoastWatch Group's web site at <http://cwatchwc.ucsd.edu>. The temperature color spectrum ranges from 8-18°C. Areas experiencing upwelling appear as blue and dark blue, whereas areas with warmer water appear as orange and red. Cloud cover and/or fog appear as blacked out areas.

Appendix 5: ADCP Data

Current velocity fields are presented as a series of horizontal vector plots. A separate set of figures was prepared for each of the three sweeps. Within each set, currents are shown at eight discrete depth layers (21-25 m, 25-75 m, 75-125 m, 125-175 m, 175-225 m, 225-275 m, 275-325 m and 325-375 m). Each current vector represents data collected over a 90 minute time period. The vectors point in the direction of flow and the length of the arrows is proportional to the current speed in cm/second. A velocity scale is provided on each figure.

Appendix 6: Regression Comparisons of CTD, TS, and Bucket

The plots presented show comparisons between CTD, TS, and bucket temperatures and CTD and TS salinities. The solid lines represent the lines of equality in order to show how the different data varied from each other. The regression statistics for each comparison were as follows:

$$\begin{aligned} &\text{CTD temperature versus TS temperature,} \\ &\quad \text{CTDtemp.} = \text{TStemp.} \times 0.995 - 0.357 \\ &\quad R^2 = 0.99 \\ &\text{CTD temperature versus bucket temperature,} \\ &\quad \text{CTDtemp.} = \text{buckettemp.} \times 0.991 - 0.112 \\ &\quad R^2 = 0.98 \\ &\text{TS temperature versus bucket temperature,} \\ &\quad \text{TStemp.} = \text{buckettemp.} \times 0.975 + 0.491 \\ &\quad R^2 = 0.98 \\ &\text{CTD salinity versus TS salinity,} \\ &\quad \text{CTDsal.} = \text{TSsal.} \times 0.909 + 3.385 \\ &\quad R^2 = 0.95 \\ &\text{CTD salinity versus bucket salinity,} \\ &\quad \text{CTDsal.} = \text{bucketsal.} \times 0.806 + 6.551 \\ &\quad R^2 = 0.85 \\ &\text{TS salinity versus bucket salinity,} \\ &\quad \text{TSsal.} = \text{bucketsal.} \times 0.858 + 4.443 \\ &\quad R^2 = 0.84 \end{aligned}$$

Appendix 7: Horizontal Maps of CTD and TS

a) Maps of TS temperature and salinity

Maps of surface temperature (°C) and salinity obtained from the vessel's TS continuous profiling unit are presented for each sweep of DSJ0002. The TS maps are located in front of the

corresponding horizontal map for the CTD at 2 m. The contour intervals are 0.5 °C for temperature and 0.1 for salinity. They are included to provide some verification of hydrographic spatial patterns inferred from the CTD data. The 2-m CTD and surface TS maps display good agreement, despite the fact that the data used to generate each were collected by different instrument packages.

b) Maps of CTD temperature, salinity and density, by depth

Horizontal maps of temperature (°C), salinity, and density (sigma-theta [σ_θ]) (kg/m³) are presented at depths of 2 m, 10 m, 30 m, 100 m, 200 m, 300 m, and 500 m. The locations of the CTD casts used in generating the horizontal contours are shown by a + symbol. The 2-m depth was selected to represent surface conditions because (1) the quality of data in the first few meters below the surface was not acceptable at some stations, and (2) localized, ephemeral conditions, related to factors such as strong surface heating and low vertical mixing that did not reflect the realistic, longer-term conditions of the region, were generally confined to the upper 5 m (refer to footnote 3). The 30-m depth was contoured to coincide with the standard midwater trawl depth during the surveys. The contour intervals are 0.5°C, 0.1, and 0.1 kg/m³, respectively for depths 2-100 m. For the 200- to 500-m depths, the contour intervals were lowered to 0.1°C, 0.02, and 0.02 kg/m³.

Appendix 8: Vertical sections

Vertical sections of temperature, salinity and density are presented for four cross-shelf transects off Pt. Reyes, the Farallones, Pescadero, and Davenport for DSJ0002. Station maps denote the location of each transect and the offshore extent of stations (marked by a +) used to generate plots for each sweep. The locations of CTD casts used in generating the vertical sections are shown on each section by a ♦. The contour intervals are 0.5°C for temperature, 0.1 for salinity, and 0.2 kg/m³ for density.

Appendix 9: Dynamic Height Topography

Horizontal maps of dynamic height (0/500 m and 200/500 m) are presented for the three sweeps of DSJ0002. Contour intervals are 0.01 for the 0/500 m maps and 0.005 for the 200/500-m maps. The locations of the CTD casts used in generating the horizontal contours are shown by a + symbol. Geostrophic currents have higher dynamic heights on their right, and are proportional to the distance between lines of constant height.

Synopsis of Meteorological and Hydrographic Conditions

For the second consecutive year, central California experienced periods of robust coastal upwelling in spring and early summer. Although not as strong as the record upwelling levels of 1999 (Schwing and Moore, 2000; Schwing et al., 2000; Sakuma et al., 2001), conditions in 2000 were much more favorable for biological production than in the recent El Niño event in 1997-98. Based on the NDBC time series, warmer than normal buoy SSTs were established during a northward (downwelling-favorable) wind event prior to the 2000 survey, and were reinforced by another downwelling wind episode during sweep 1. This was followed by unseasonably strong upwelling in the latter part of May, which contributed to the development of anomalously cool SSTs during sweep 2 and, especially, sweep 3. However the winds during sweep 2 displayed considerable alongshore shear. A downwelling event affected the southern portion of the survey region, maintaining warm SST anomalies there. The Bodega buoy featured cooler than normal SSTs associated with relatively strong upwelling winds. This heterogeneity is reflected in the maps of upper ocean temperature and salinity. On the planetary scale, La Niña conditions intensified in the Pacific Ocean for a second year. Although not as intense as the 1998-99 La Niña event, it nevertheless was an important factor in the state of the north Pacific and the waters off central California (Bograd et al., 2000; Durazo et al., 2001). Strong clockwise wind anomalies over the northeast Pacific in association with an unusually strong North Pacific High resulted in the anomalous upwelling winds along the west coast during much of 1999 and 2000. Since late 1998, a horseshoe-shaped region of cooler than normal upper ocean temperatures stretched across the basin from the western tropical Pacific to Baja California, through the California Current region and into the Gulf of Alaska. These negative temperature

anomalies were particularly strong off the North American west coast and in the California Current. The SST anomalies were a general reflection of upper water column temperature and sea surface height anomalies throughout the northeast Pacific. It is thought that these cool ocean conditions were created and maintained by regional wind anomalies, primarily through Ekman processes, geostrophic transport, sensible and latent heat fluxes, and vertical mixing (Schwing et al., 2001).

Because of downwelling-favorable winds during sweep 1, the alongshelf front separating coastally upwelled and California Current waters was relatively near the coast. There is no clear signal in the hydrography or ADCP velocities of an upwelling filament extending westward from Pt. Reyes, a common feature during spring and summer. Upper ocean temperatures (10.5-11°C) and salinities (33.4-33.6) adjacent to the coast reflect the lack of upwelling prior to and during this sweep. The re-intensification of upwelling during sweep 2, particularly in the northern portion of the survey region, is evident in the maps for that sweep. ADCP data indicate more offshore flow in the upper water column off Pt. Reyes, compared to sweep 1. Near-surface temperatures of 9-10°C and salinities greater than 33.8 were found near the coast, evidence of recent upwelling.

In sweeps 2 and 3, the interaction of the upwelling filament near Pt. Reyes with the adjacent offshore water is reflected in a stronger alongshelf density front in the upper 50 m. This front also was located further offshore than in sweep 1. A second strong frontal region is seen west of Monterey Bay, where the cool-centered Monterey Bay Eddy (Baltz, 1997) intersected with nearshore water from the Año Nuevo upwelling center (e.g., sweep 2, 30 m). Another mesoscale circulation feature, the Pioneer Seamount Eddy (Baltz, 1997), was observed in the upper water column, centered at about 37.4°N 123.6°W. However the hydrographic structure and velocity field at 100 m and deeper display little evidence of these features.

ADCP velocities indicate a continuous poleward California Undercurrent at depths greater than 175 m, with relatively little influence from eddies or other mesoscale features. The dynamic topography at the surface (relative to 200 m) and at 200 m (relative to 500 m) was low during all three sweeps, relative to typical values for this series of surveys. This represents the presence of a more dense (cooler, more saline) water column, possibly a relict of the previous year's strong and persistent upwelling.

Although the total rate of upwelling during the 2000 juvenile survey was not as great as the record-setting levels in 1999, there is evidence that the central California coastal region was biologically more productive in 2000. Conditions in the previous year led to much of the nutrient-rich upwelled water advecting over 200 km offshore (Sakuma et al., 2001), contributing to lower primary and secondary production in the coastal zone as well as considerable offshore advection of coastal organisms. Episodes of strong coastal upwelling during the 2000 season set the stage for high levels of primary production along the central California coast. The occasional wind reversals toward downwelling, and the associated onshore advection of near-surface waters, during 2000 may have helped retain juveniles and their prey within the coastal zone.

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**APPENDIX 1: LIST OF CTD STATIONS SUMMARIZED FROM CRUISE
DSJ0002**

DSJ0002 Sweep 1

cast	DATE:TIME	LATITUDE	LONGITUDE	DEPTH(M)
1	11MAY00:19:57	36 52.9	121 56.3	41
2	11MAY00:20:42	36 50.6	121 59	89
3	11MAY00:22:54	36 46	121 52.1	66
4	11MAY00:23:50	36 44.4	121 58.7	330
5	12MAY00:01:58	36 42.4	121 53.7	81
6	12MAY00:02:40	36 38.6	121 51.7	43
7	12MAY00:04:35	36 40.8	121 56.7	93
8	12MAY00:06:13	36 40.1	122 9.9	1116
9	12MAY00:07:44	36 46.3	122 16	835
10	12MAY00:09:08	36 40	122 22.3	1900
11	12MAY00:10:36	36 46.3	122 28.3	2150
12	12MAY00:12:12	36 39.8	122 35.2	2200
13	12MAY00:13:42	36 46.3	122 40.6	2600
14	12MAY00:15:12	36 40.1	122 47	2745
15	12MAY00:16:40	36 33.7	122 40.8	2745
16	12MAY00:18:14	36 33.7	122 28.4	2745
17	12MAY00:19:40	36 33.8	122 16.2	2500
18	12MAY00:20:40	36 35	122 10.5	2320
19	13MAY00:00:58	36 34.7	122 2	763
20	13MAY00:01:56	36 38.8	122 3	836
21	13MAY00:05:14	36 47.6	122 10.3	690
22	13MAY00:06:25	36 52.4	122 10	105
23	13MAY00:07:44	36 52.8	122 22.2	882
24	13MAY00:09:22	36 52.7	122 34.6	1600
25	13MAY00:11:00	36 52.7	122 47	2333
26	13MAY00:12:37	36 52.5	122 58.9	2700
27	13MAY00:14:02	36 58.6	122 53.1	1373
28	13MAY00:15:23	37 4.9	122 47.1	686
29	13MAY00:16:55	37 4.9	122 34.7	116
30	13MAY00:18:18	37 4.8	122 22.2	59
31	13MAY00:20:44	36 58.9	122 17.5	88
32	13MAY00:23:17	36 58.9	122 24	133
33	13MAY00:23:50	36 59	122 25.7	580
34	14MAY00:04:30	37 0.8	122 36.1	281
35	14MAY00:06:11	37 10.2	122 28.5	74
36	14MAY00:07:37	37 10.7	122 40.5	114
37	14MAY00:08:55	37 10.4	122 53.2	442
38	14MAY00:10:35	37 10.8	123 5.4	908
39	14MAY00:12:01	37 16.3	123 11.4	1190
40	14MAY00:13:20	37 22.2	123 5.1	830
41	14MAY00:14:47	37 22.2	122 52.8	192
42	14MAY00:16:08	37 22.3	122 40.6	85
43	14MAY00:17:20	37 22.3	122 28.6	32
44	14MAY00:20:37	37 16.4	122 34.1	88

cast	DATE:TIME	LATITUDE	LONGITUDE	DEPTH(M)
45	14MAY00:23:08	37 17.8	122 39.3	96
46	15MAY00:00:20	37 16.3	122 49	184
47	15MAY00:04:20	37 17.5	122 58.7	520
48	15MAY00:07:02	37 30.9	122 59.3	214
49	15MAY00:08:30	37 30.8	123 11.7	1280
50	15MAY00:10:12	37 30.8	123 24.1	2380
51	15MAY00:11:52	37 30.8	123 35.3	2964
52	15MAY00:13:14	37 38.3	123 36.3	3340
53	15MAY00:14:31	37 46.1	123 36.3	2700
54	15MAY00:16:08	37 46.1	123 24	1510
55	15MAY00:17:41	37 46.2	123 11.6	128
56	15MAY00:20:35	37 39.6	123 2.7	106
57	15MAY00:23:00	37 40.3	123 11.4	1244
58	16MAY00:00:09	37 44.4	123 8.4	105
59	16MAY00:03:09	37 52.4	123 20.7	114
60	16MAY00:04:50	37 51.7	123 29.2	1464
61	16MAY00:06:23	38 1.7	123 30.2	149
62	16MAY00:07:45	38 1.8	123 42.5	2562
63	16MAY00:09:21	38 1.7	123 54.7	3477
64	16MAY00:11:17	38 10	124 6.9	3660
65	16MAY00:13:11	38 18.6	123 54.8	2836
66	16MAY00:14:52	38 18.5	123 42.2	1464
67	16MAY00:16:43	38 18.5	123 30.2	264
68	16MAY00:18:05	38 18.5	123 17.9	110
69	16MAY00:20:34	38 11.1	123 23.5	235
70	17MAY00:00:28	38 9.3	123 15.9	116
71	17MAY00:01:13	38 10.8	123 10.7	95
72	17MAY00:02:52	38 9.7	123 5	74
73	17MAY00:06:35	38 1.6	123 17.6	119
74	17MAY00:08:08	38 1.6	123 5.6	64
75	17MAY00:20:38	37 47.7	122 52.2	56
76	18MAY00:00:09	37 40.9	122 53.8	57

DSJ0002 Sweep 2

cast	DATE:TIME	LATITUDE	LONGITUDE	DEPTH(M)
79	18MAY00:20:29	36 50.7	121 59.2	88
80	18MAY00:23:14	36 45.6	121 53.7	141
81	18MAY00:23:56	36 44.6	121 58.8	385
82	19MAY00:01:48	36 41.1	121 53.2	78
83	19MAY00:02:16	36 38.5	121 51.7	41
84	19MAY00:04:25	36 39.2	121 59.2	100
85	19MAY00:05:40	36 40.2	122 9.9	1098
86	19MAY00:07:14	36 46.3	122 16	806
87	19MAY00:08:52	36 40.1	122 22.2	867

cast	DATE:TIME	LATITUDE	LONGITUDE	DEPTH(M)
88	19MAY00:10:27	36 46.3	122 28.5	2104
89	19MAY00:11:51	36 40.1	122 34.8	2379
90	19MAY00:13:30	36 46.2	122 40.5	2150
91	19MAY00:15:26	36 33.7	122 41.1	2745
92	19MAY00:17:12	36 33.8	122 28.5	2745
93	19MAY00:18:57	36 33.6	122 16.2	2562
94	19MAY00:20:31	36 35.1	122 10.5	2790
95	19MAY00:23:58	36 35.6	122 2.8	530
96	20MAY00:00:45	36 38.8	122 3	900
97	20MAY00:03:10	36 41.5	122 6.6	1922
98	20MAY00:05:08	36 44.6	122 7.8	915
99	20MAY00:06:40	36 52.6	122 10.1	100
100	20MAY00:08:05	36 52.6	122 22.2	870
101	20MAY00:09:46	36 52.6	122 34.6	1600
102	20MAY00:11:26	36 52.6	122 47	2288
103	20MAY00:13:05	36 52.7	122 59.4	2700
104	20MAY00:14:35	36 59	122 53	1370
105	20MAY00:15:56	37 5	122 47.1	686
106	20MAY00:17:29	37 5.1	122 34.6	115
107	20MAY00:18:43	37 5	122 22.4	60
108	20MAY00:20:11	36 59.4	122 18	85
109	20MAY00:23:04	36 58.1	122 21.5	210
110	20MAY00:23:46	36 59.2	122 25.6	580
111	21MAY00:03:48	36 57.9	122 34.7	543
112	21MAY00:05:56	37 10.8	122 28.4	70
113	21MAY00:07:16	37 10.8	122 40.7	114
114	21MAY00:08:35	37 10.8	122 53.1	434
115	21MAY00:10:12	37 10.7	123 5.4	878
116	21MAY00:11:33	37 16.6	123 11.3	1190
117	21MAY00:12:48	37 22.3	123 5.4	824
118	21MAY00:14:22	37 22.4	122 53	201
119	21MAY00:15:33	37 22.1	122 42.1	90
120	21MAY00:17:08	37 22.3	122 28.4	30
121	21MAY00:20:32	37 16.5	122 34	86
122	21MAY00:23:08	37 15.2	122 38.5	96
123	22MAY00:00:18	37 16.7	122 49	180
124	22MAY00:04:25	37 14.7	122 58.2	490
125	22MAY00:06:50	37 30.8	122 59.3	214
126	22MAY00:08:16	37 30.7	123 11.5	1281
127	22MAY00:10:08	37 30.6	123 23.9	2379
128	22MAY00:11:58	37 30.7	123 36.2	2900
129	22MAY00:14:36	37 38.4	123 36.3	3339
130	22MAY00:16:51	37 46.2	123 24.3	1509
131	22MAY00:18:30	37 46.1	123 11.7	116
132	22MAY00:20:18	37 39.5	123 2.7	109
133	22MAY00:23:53	37 40.6	123 13	1244
134	23MAY00:00:56	37 44.2	123 9.1	112

cast	DATE:TIME	LATITUDE	LONGITUDE	DEPTH(M)
135	23MAY00:05:39	37 52.2	123 28.7	1464
136	23MAY00:09:37	38 1.6	123 54.8	3477
137	23MAY00:20:33	37 17.2	122 34.5	86
138	24MAY00:05:25	37 14.4	123 1	604
139	24MAY00:16:48	38 18.4	123 30	260
140	25MAY00:03:44	37 46.1	122 51	60
141	25MAY00:19:35	38 1.6	123 5.5	63
142	25MAY00:20:50	38 10	123 0	52
143	25MAY00:23:09	38 8.5	123 4	72
144	26MAY00:00:01	38 10.1	123 10.1	92
145	26MAY00:02:34	38 8.8	123 15.2	114
146	26MAY00:03:25	38 10.1	123 22	184
147	26MAY00:05:33	38 10	123 34.7	823

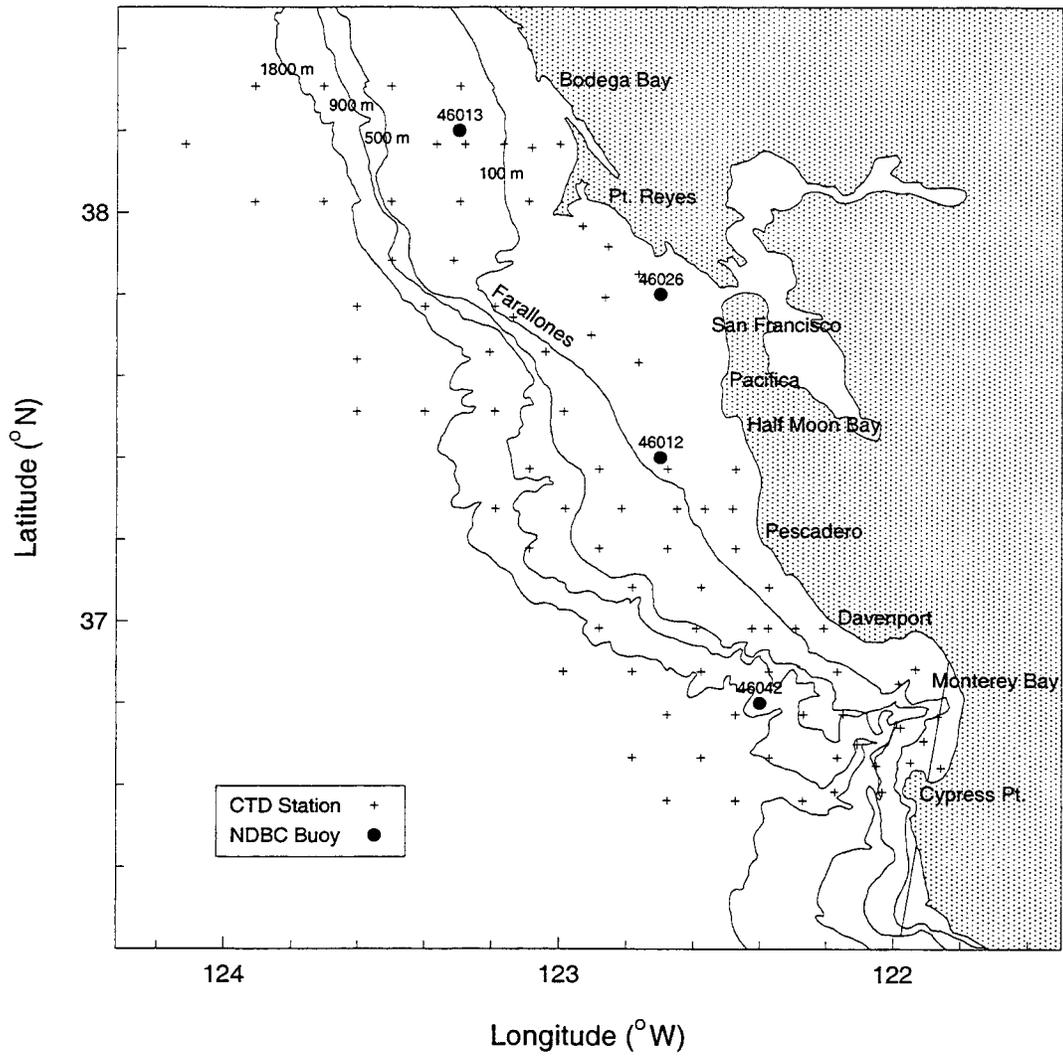
DSJ0002 Sweep 3

cast	DATE:TIME	LATITUDE	LONGITUDE	DEPTH(M)
152	29MAY00:20:53	36 51.3	121 59.3	80
153	30MAY00:20:34	36 51.1	121 59.7	82
154	30MAY00:22:47	36 45.6	121 51.7	66
155	30MAY00:23:36	36 44.6	121 58.7	364
156	31MAY00:02:38	36 41.9	121 53.3	80
157	31MAY00:03:17	36 38.5	121 51.6	38
158	31MAY00:05:02	36 40.3	121 58.2	99
159	31MAY00:06:20	36 40	122 9.2	1135
160	31MAY00:07:54	36 46.5	122 16.2	825
161	31MAY00:09:20	36 40	122 22.2	1740
162	31MAY00:11:00	36 46.3	122 28.4	2100
163	31MAY00:13:07	36 40	122 34.4	2400
164	31MAY00:15:05	36 40.2	122 46.9	2745
165	31MAY00:16:27	36 33.8	122 40.8	2745
166	31MAY00:18:01	36 33.4	122 28.5	2745
167	31MAY00:19:44	36 33.6	122 16.5	2562
168	31MAY00:20:57	36 35	122 10.6	2540
169	01JUN00:01:30	36 34.4	122 2.4	818
170	01JUN00:05:30	36 46.9	122 10.2	874
171	01JUN00:06:35	36 52.6	122 10.1	100
172	01JUN00:07:57	36 52.7	122 22.2	824
173	01JUN00:09:44	36 52.6	122 34.4	1600
174	01JUN00:11:26	36 52.6	122 47.1	2280
175	01JUN00:13:01	36 52.6	122 58.9	2700
176	01JUN00:14:30	36 59.2	122 53	1370
177	01JUN00:16:00	37 5	122 47.1	686
178	01JUN00:17:35	37 4.7	122 34.8	117
179	01JUN00:18:54	37 5	122 22.4	59

cast	DATE:TIME	LATITUDE	LONGITUDE	DEPTH(M)
180	01JUN00:21:00	36 59.1	122 17.5	87
181	01JUN00:23:04	36 59.2	122 23	125
182	01JUN00:23:33	36 59	122 25.3	345
183	02JUN00:04:57	36 58.9	122 35.5	451
184	02JUN00:06:53	37 10.8	122 28.5	70
185	02JUN00:08:12	37 10.8	122 40.6	113
186	02JUN00:09:36	37 10.7	122 53.1	437
187	02JUN00:11:14	37 10.8	123 5.4	900
188	02JUN00:12:31	37 16.6	123 11.4	1190
189	02JUN00:13:53	37 22.4	123 5.3	824
190	02JUN00:15:27	37 21.5	122 53.1	219
191	02JUN00:16:50	37 22.4	122 40.7	87
193	02JUN00:20:35	37 16.6	122 34	87
194	02JUN00:23:45	37 17.2	122 39.7	97
195	03JUN00:00:46	37 16.7	122 48.9	180
196	03JUN00:05:00	37 17.4	122 59.9	581
197	03JUN00:07:01	37 30.7	122 59.5	235
198	03JUN00:08:25	37 30.9	123 11.8	1280
199	03JUN00:10:05	37 30.8	123 24.1	2380
200	03JUN00:11:40	37 30.9	123 36.4	2964
201	03JUN00:13:03	37 38.4	123 36.3	3340
202	03JUN00:14:27	37 46.2	123 36.4	2700
203	03JUN00:15:58	37 46.3	123 24.1	1510
204	03JUN00:17:32	37 46.3	123 11.5	112
205	03JUN00:20:40	37 39.3	123 2.3	110
206	03JUN00:23:12	37 39.7	123 12.8	1300
207	04JUN00:00:28	37 44.8	123 8.4	74
208	04JUN00:02:50	37 53.2	123 19.8	103
209	04JUN00:04:35	37 51.8	123 29.2	1500
210	04JUN00:06:10	38 1.5	123 30.4	174
211	04JUN00:07:23	38 1.6	123 42.6	2562
212	04JUN00:08:53	38 1.8	123 54.9	3477
213	04JUN00:10:47	38 10.2	124 7	3660
214	04JUN00:12:34	38 18.7	123 54.8	2836
215	04JUN00:14:02	38 18.7	123 42.4	1464
216	04JUN00:15:30	38 18.7	123 30.2	264
217	04JUN00:16:50	38 18.5	123 17.7	110
218	04JUN00:20:40	38 9.9	123 22.4	197
219	05JUN00:00:45	38 10.3	123 15.7	116
220	05JUN00:01:30	38 10.1	123 10	94
221	05JUN00:04:42	38 1.6	123 18.1	121
222	05JUN00:06:04	38 1.7	123 5.2	60
223	05JUN00:23:34	37 47.2	122 52.4	56
224	06JUN00:03:06	37 35.2	122 49.3	75

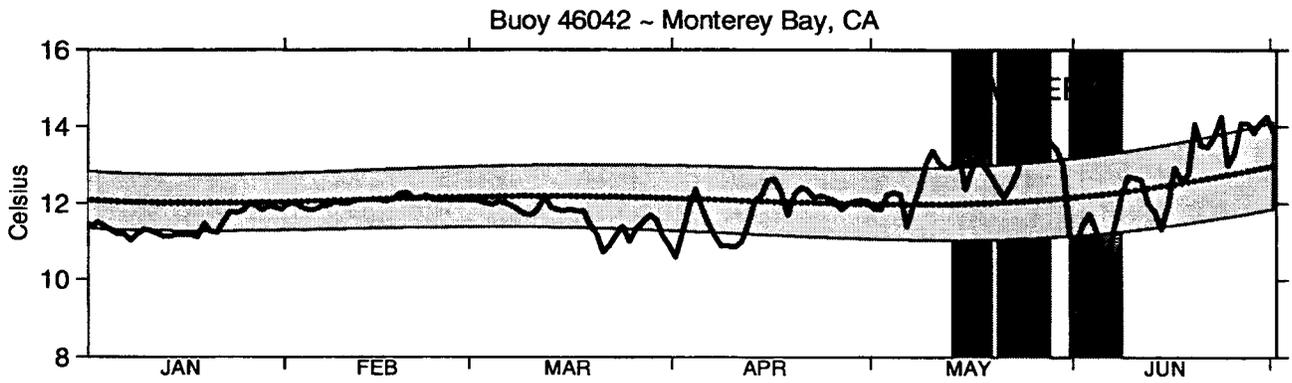
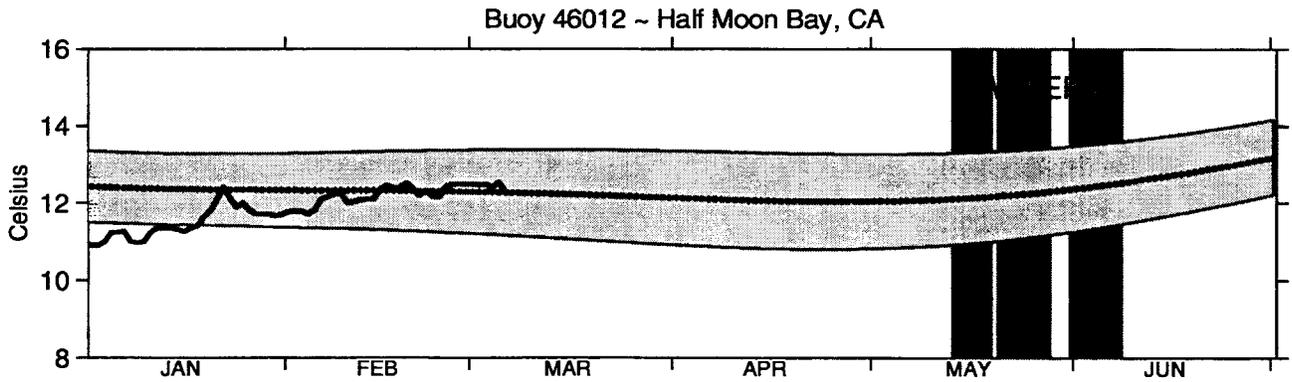
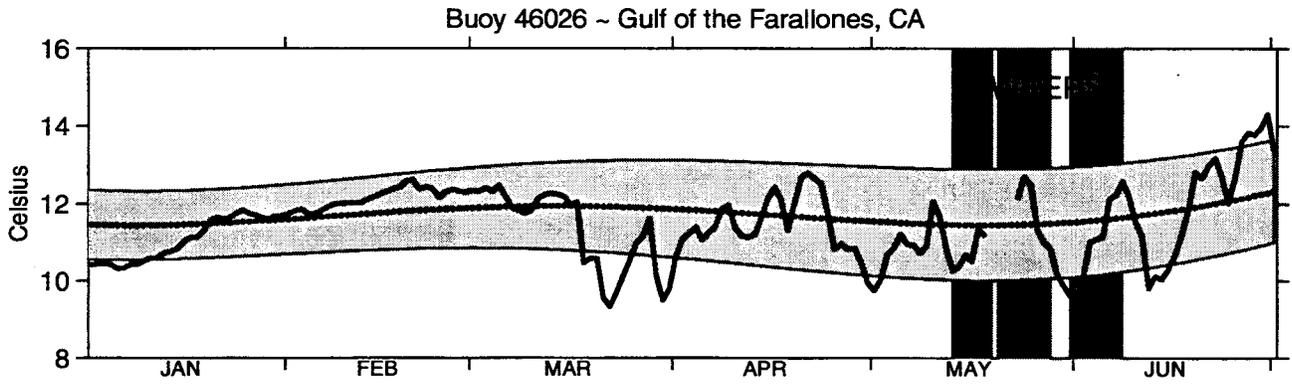
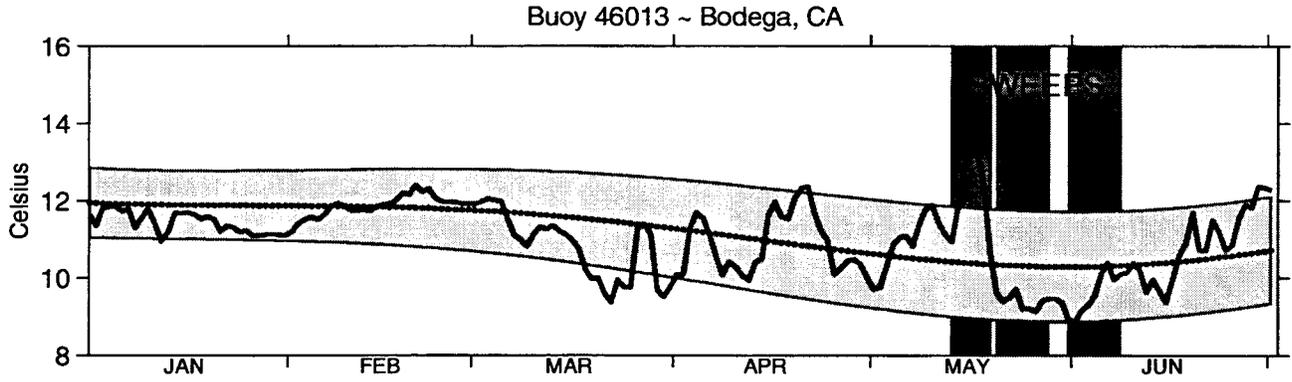
**APPENDIX 2: DSJ0002 CTD STATIONS AND BATHYMETRIC MAP OF
SURVEY REGION WITH LOCATIONS OF THE NDBC
BUOYS**

Standard CTD Station Locations

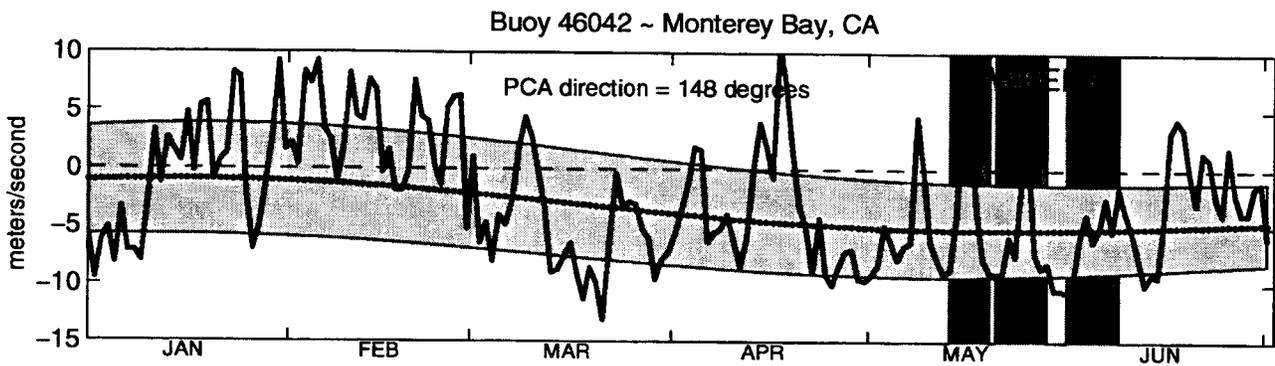
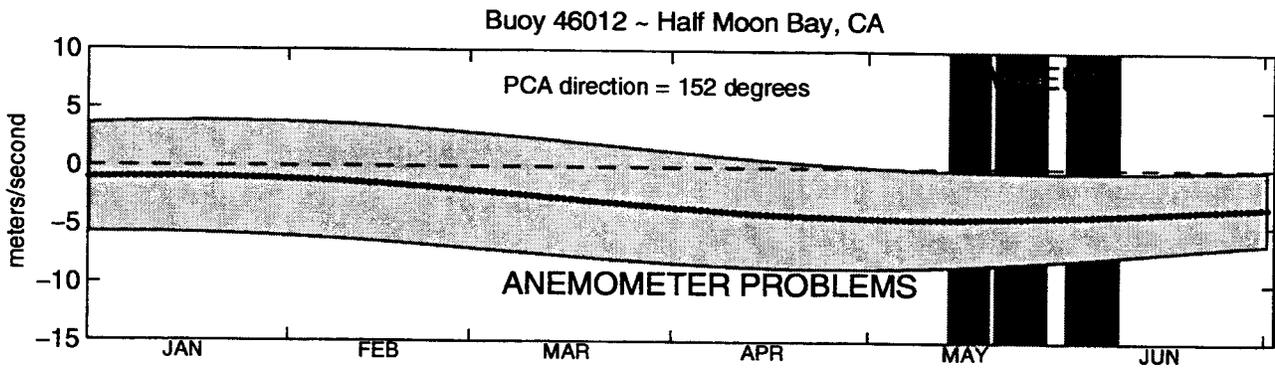
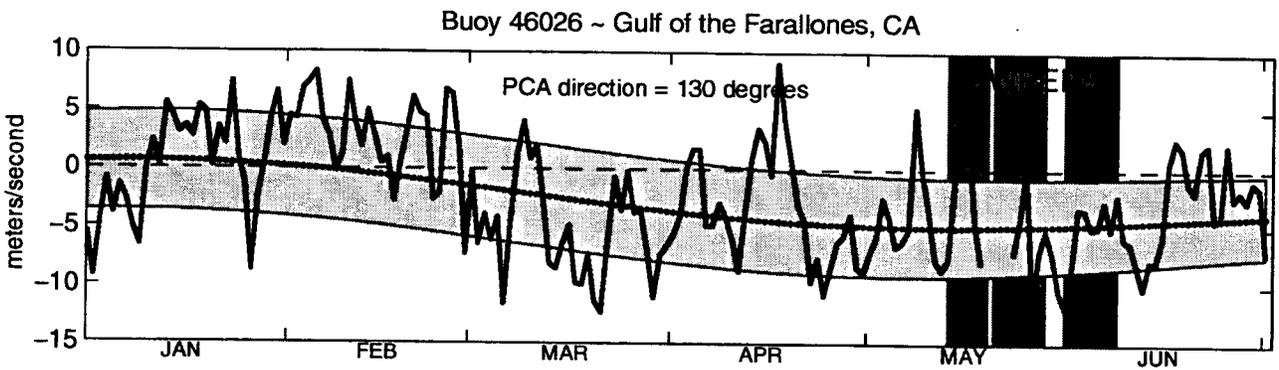
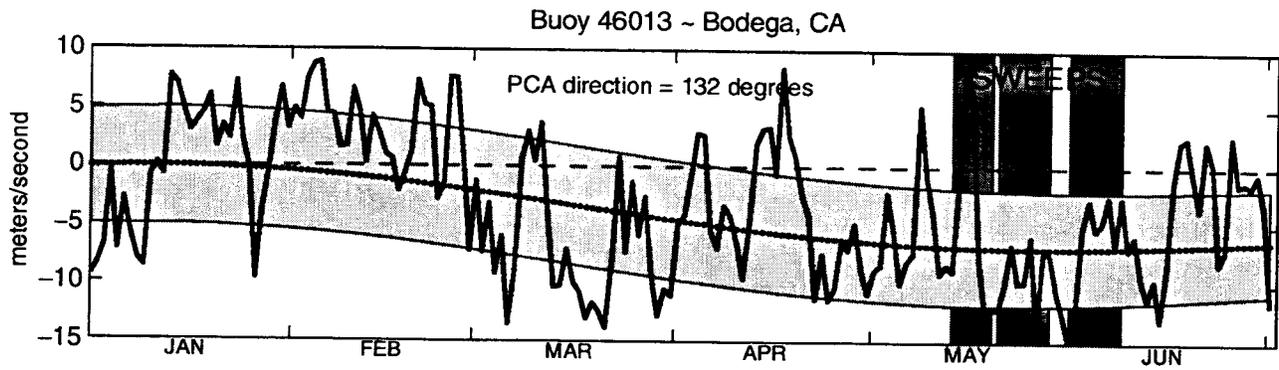


APPENDIX 3: METEOROLOGICAL TIME SERIES

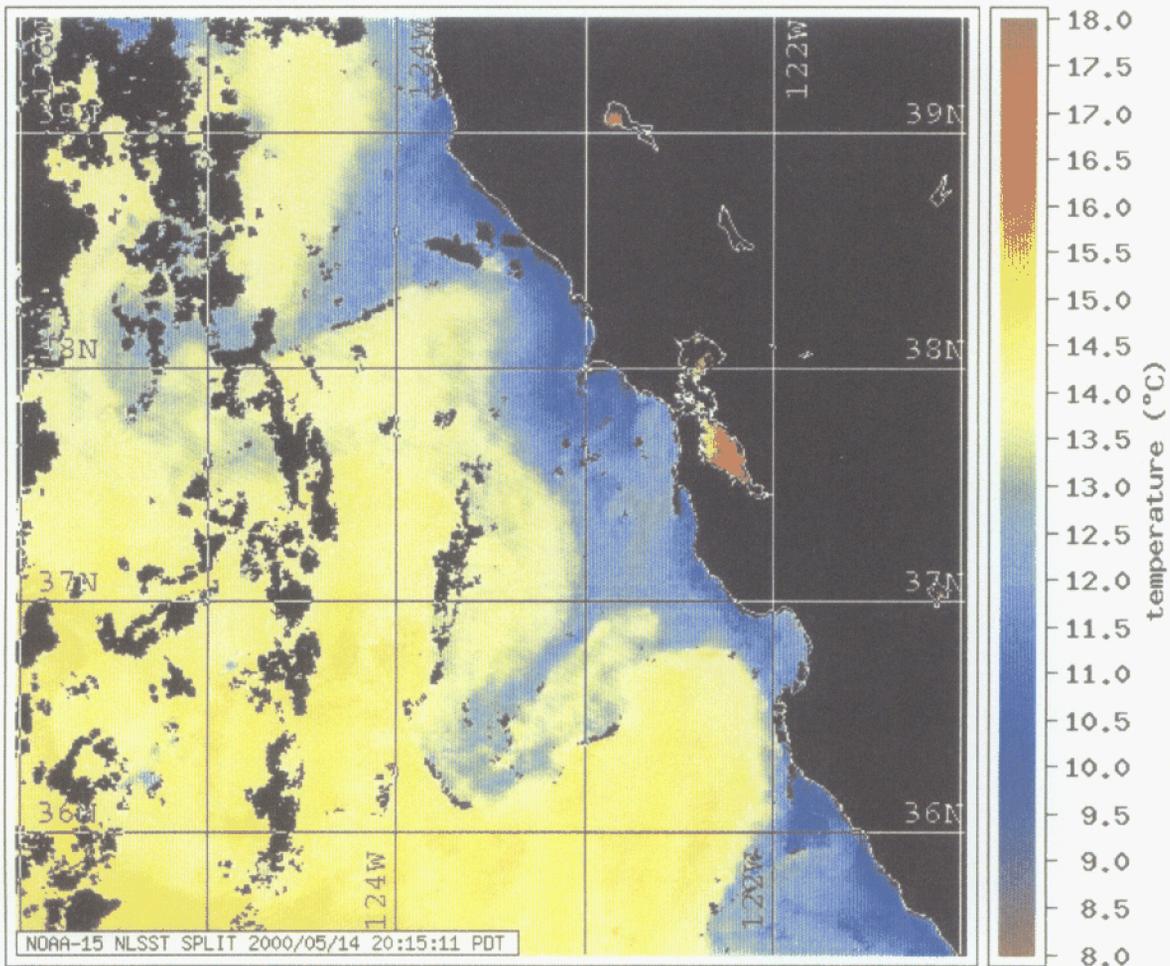
Sea Surface Temperatures from NOAA/NDBC Buoys ~2000

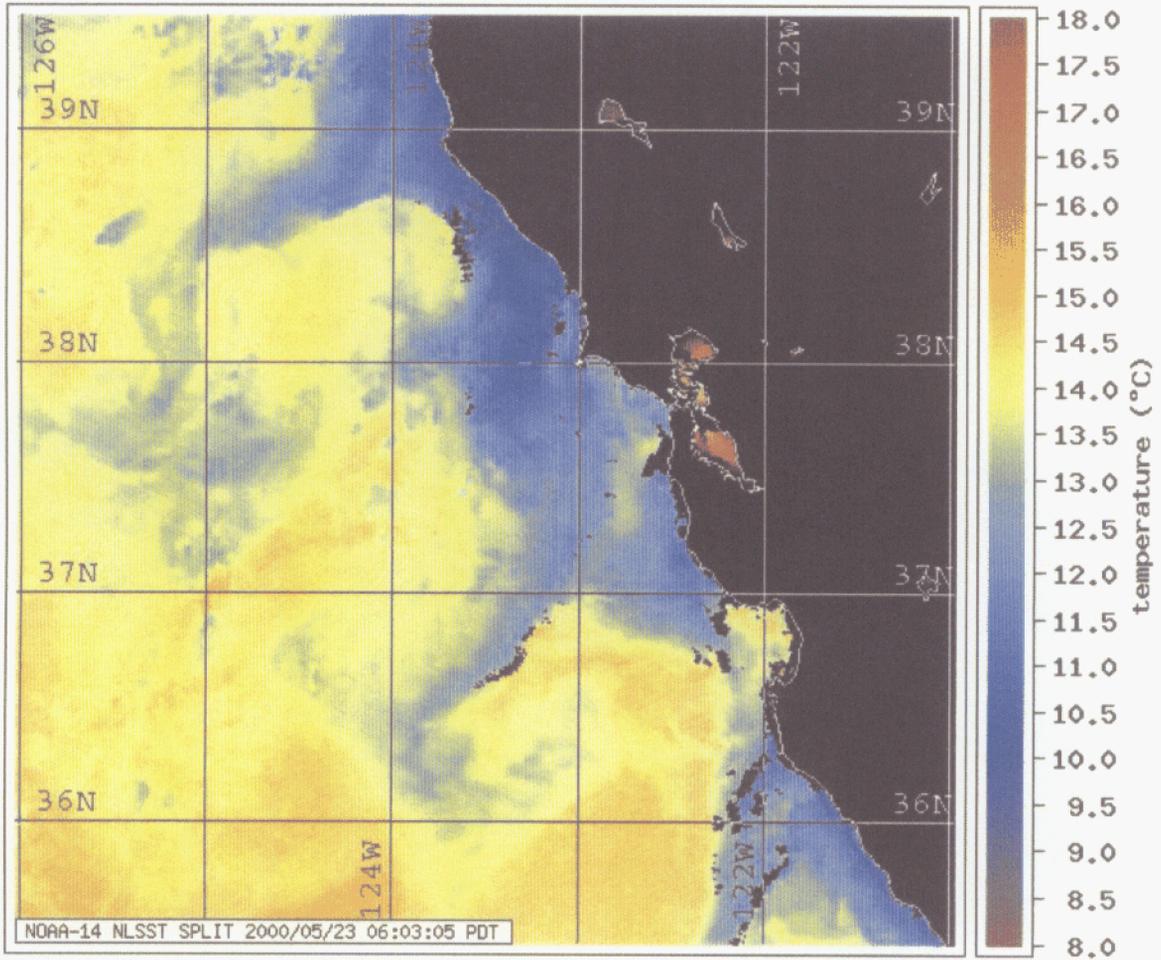


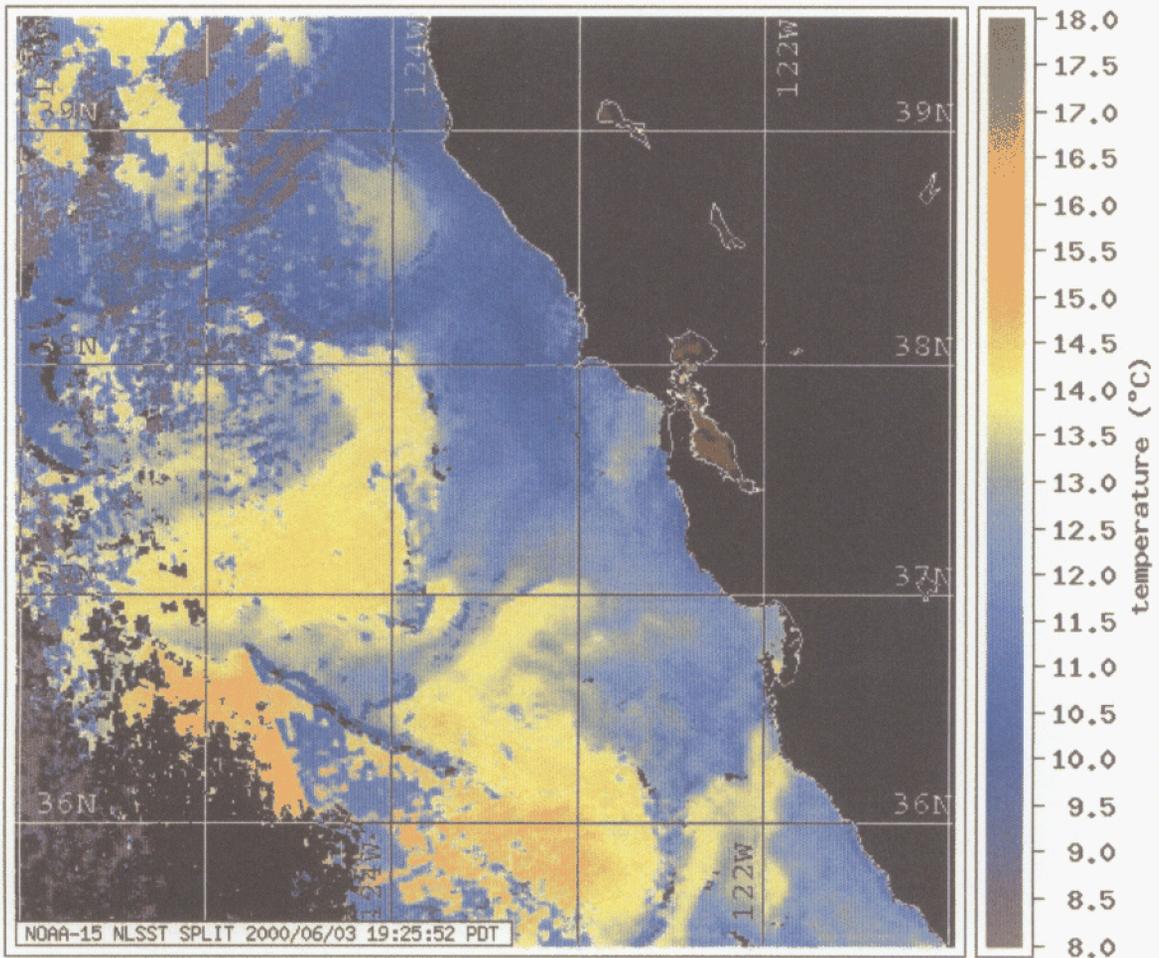
Alongshore Winds from NOAA/NDBC Buoys ~ 2000



APPENDIX 4: AVHRR SATELLITE IMAGES OF MULTICHANNEL SST



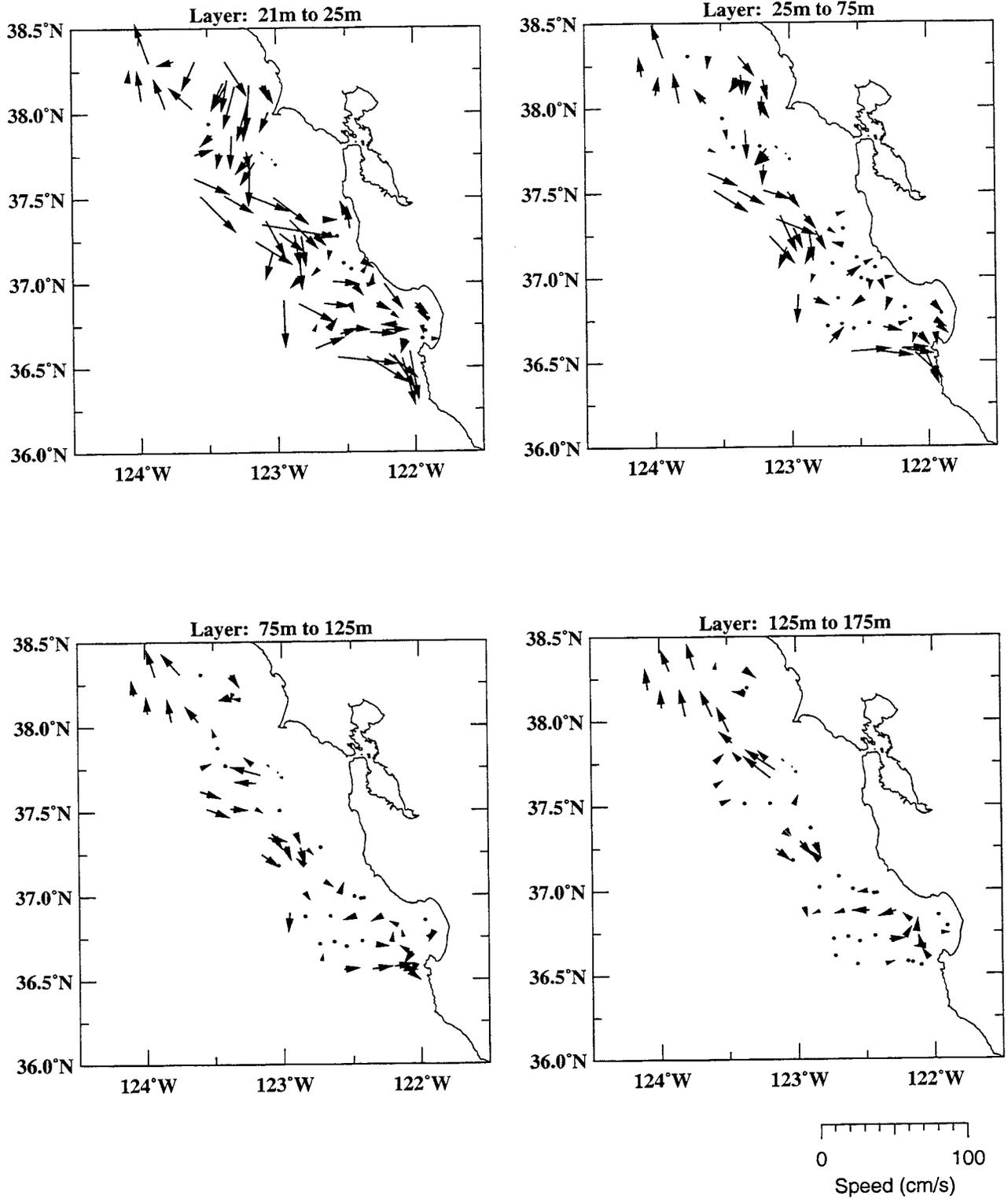




APPENDIX 5: ADCP DATA

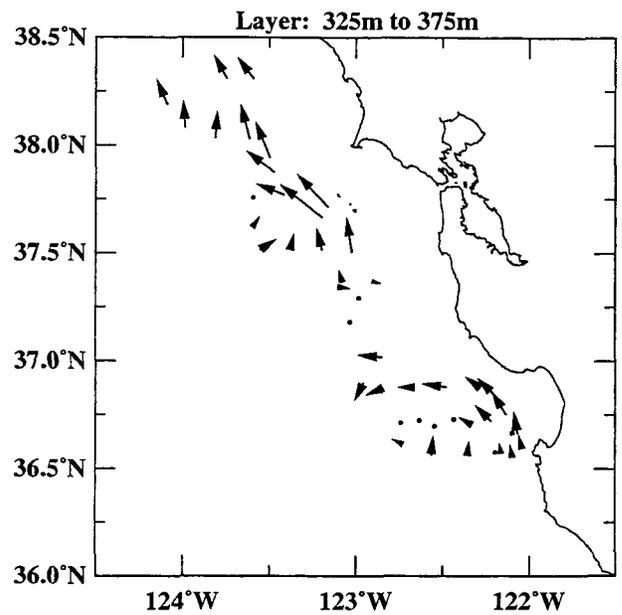
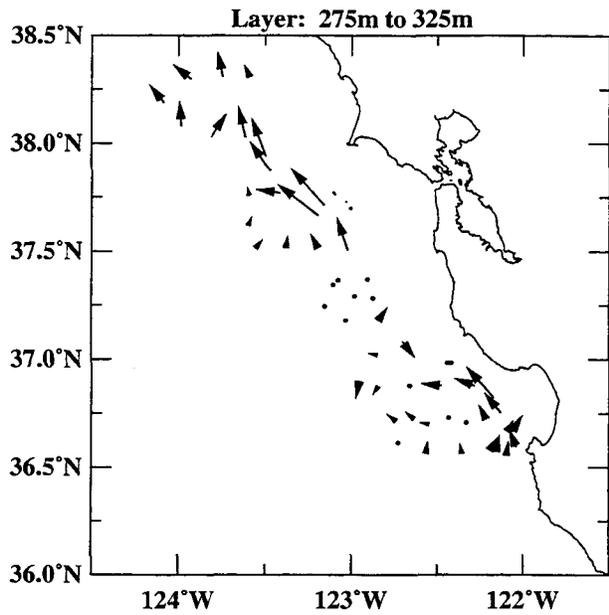
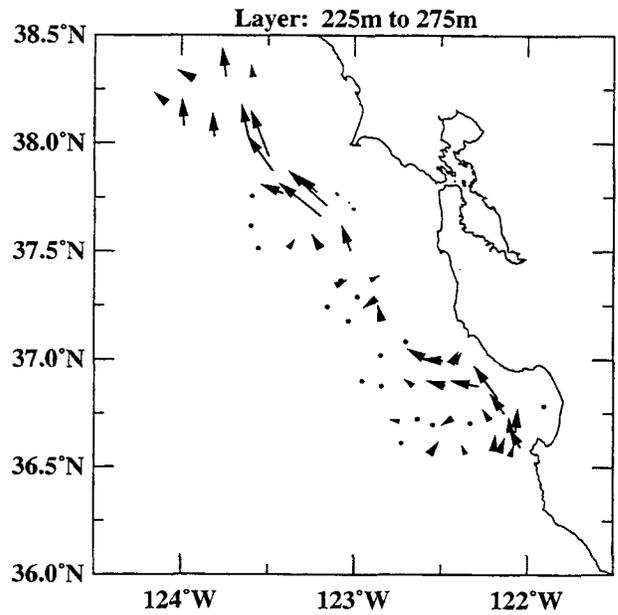
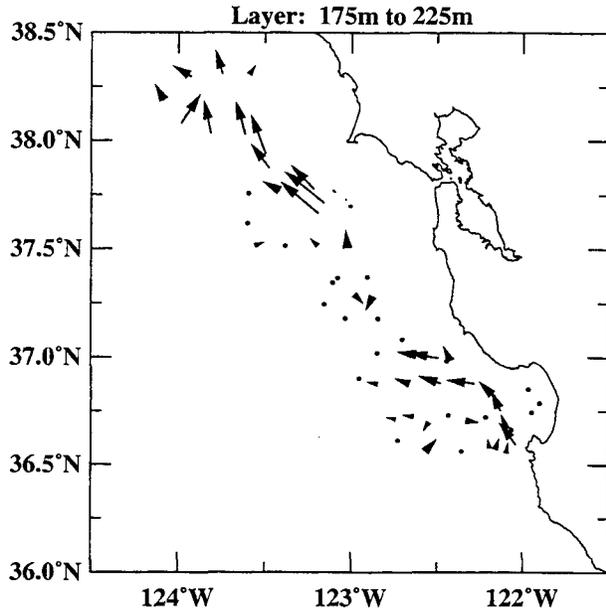
CRUISE DSJ0002 -- ADCP

Sweep 1



CRUISE DSJ0002 -- ADCP

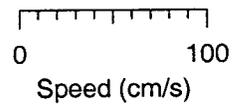
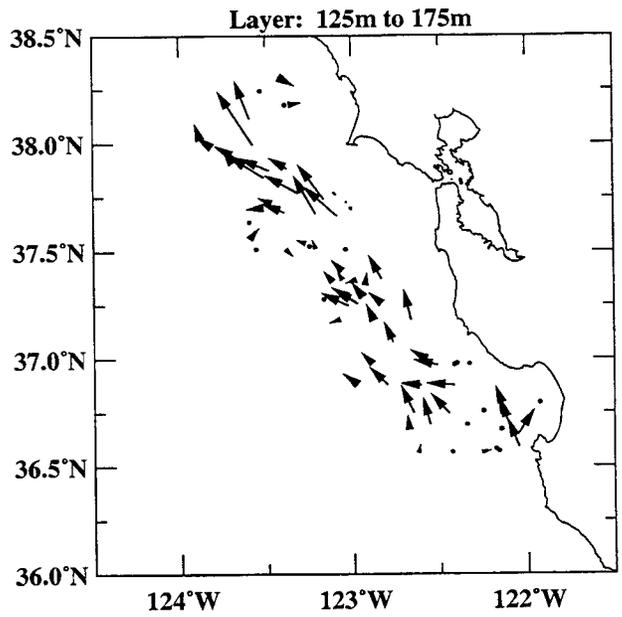
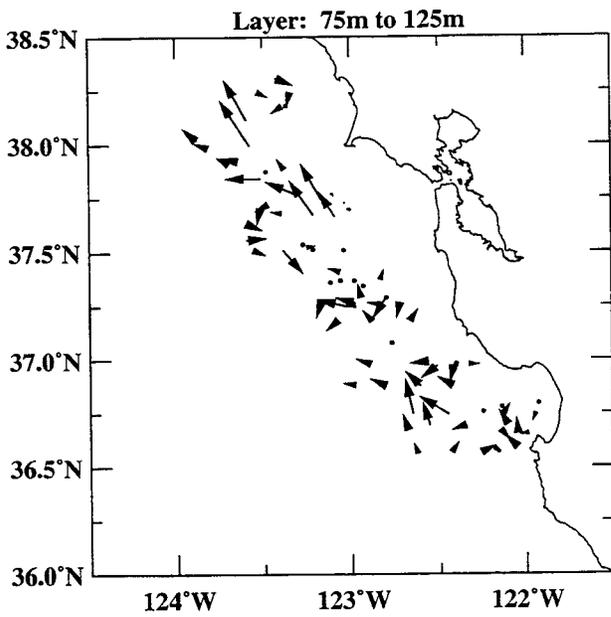
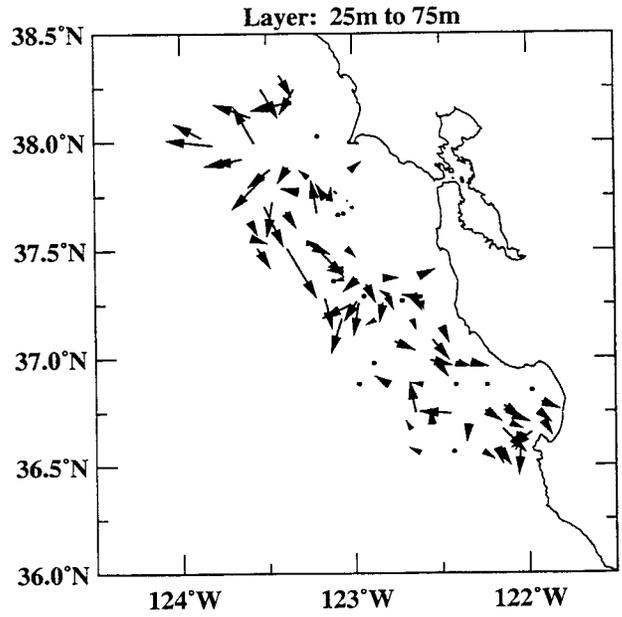
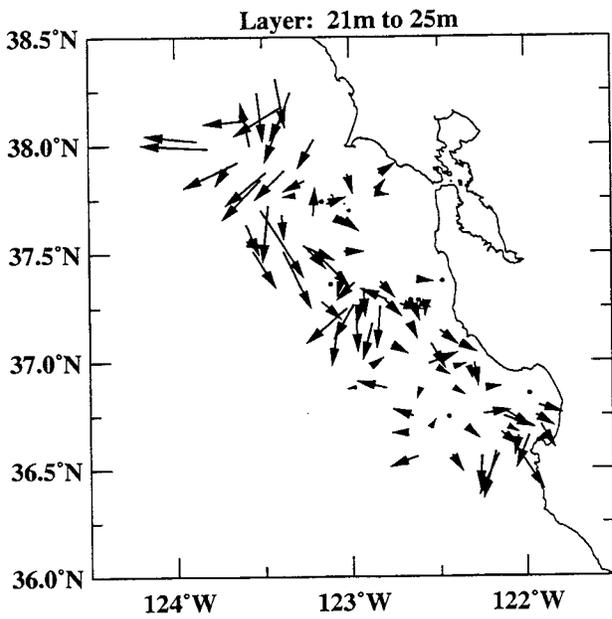
Sweep 1



0 100
Speed (cm/s)

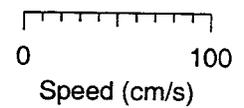
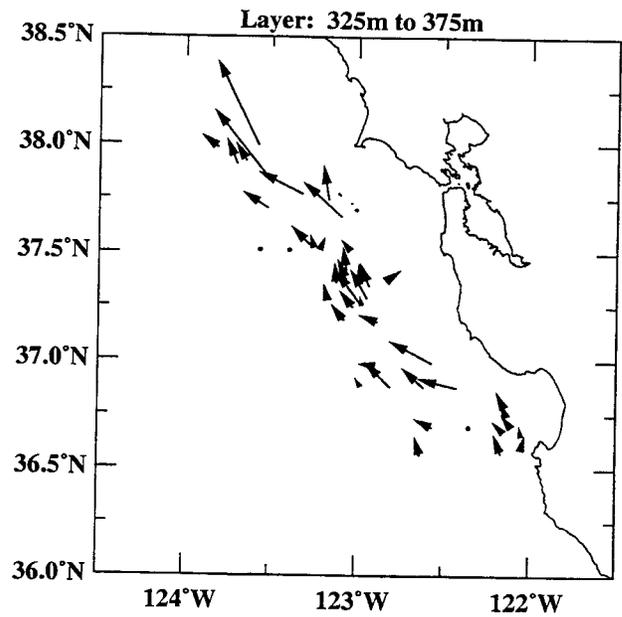
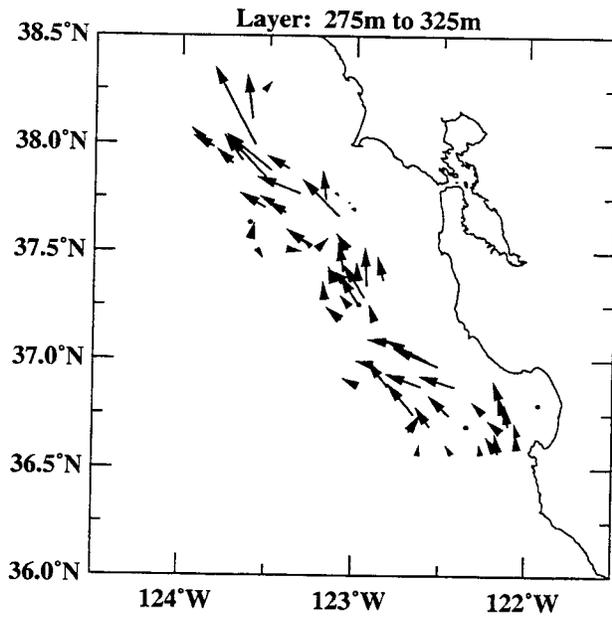
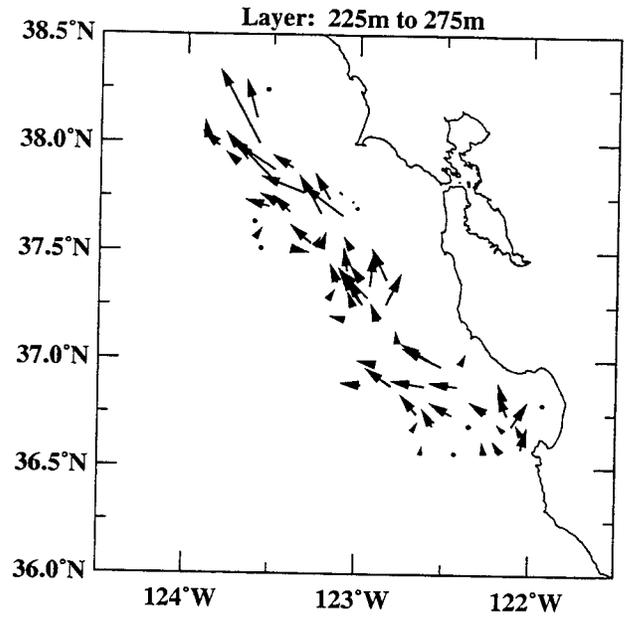
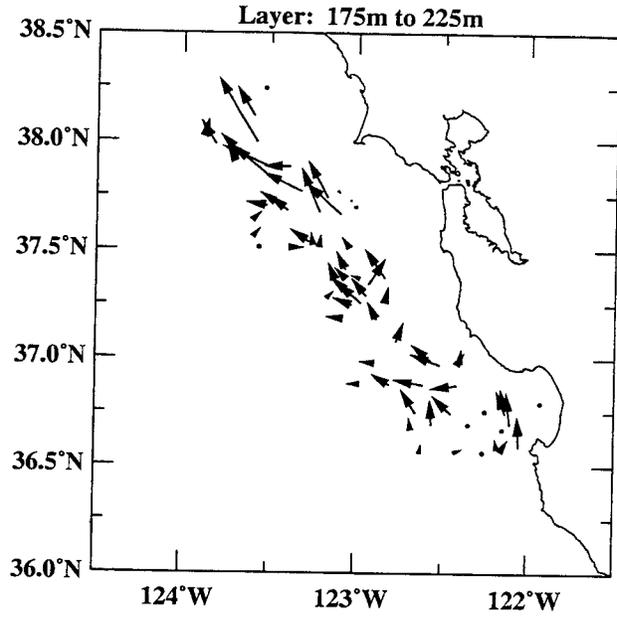
CRUISE DSJ0002 -- ADCP

Sweep 2



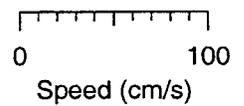
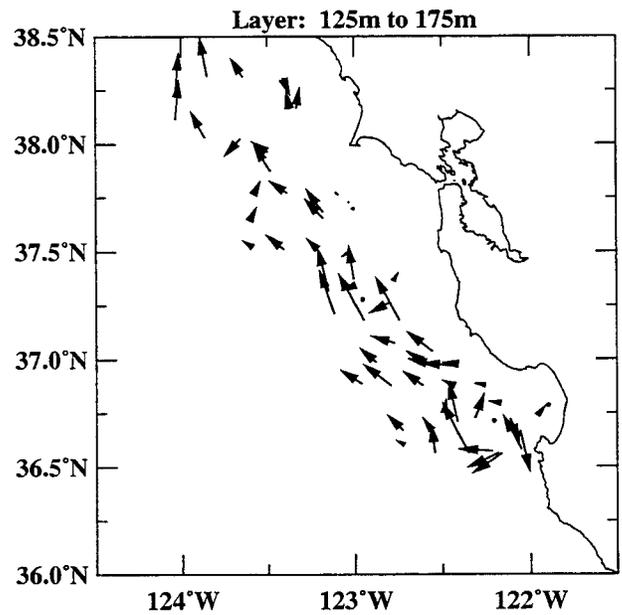
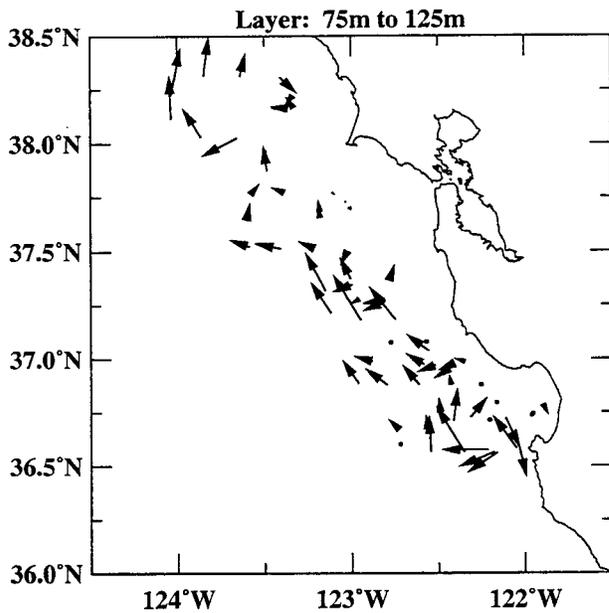
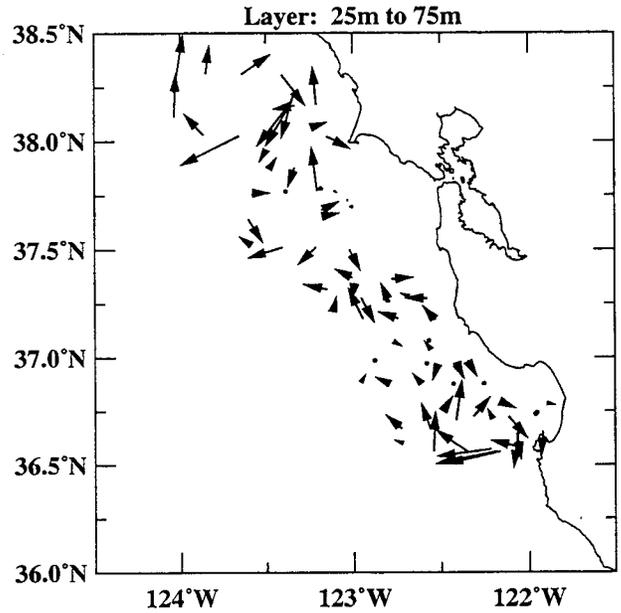
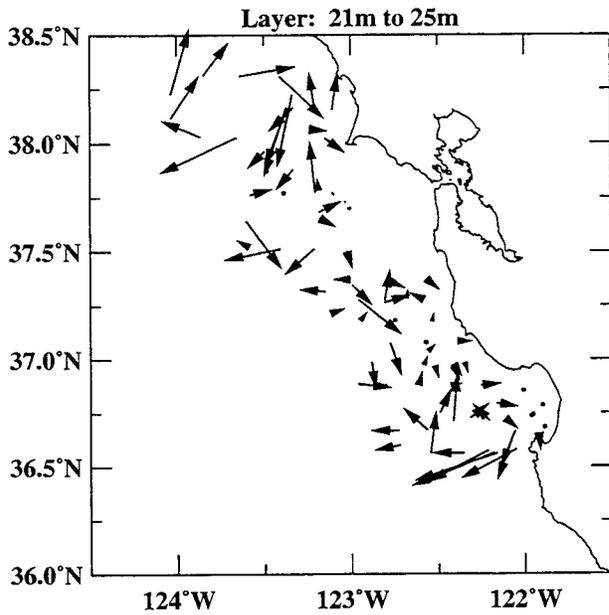
CRUISE DSJ0002 -- ADCP

Sweep 2



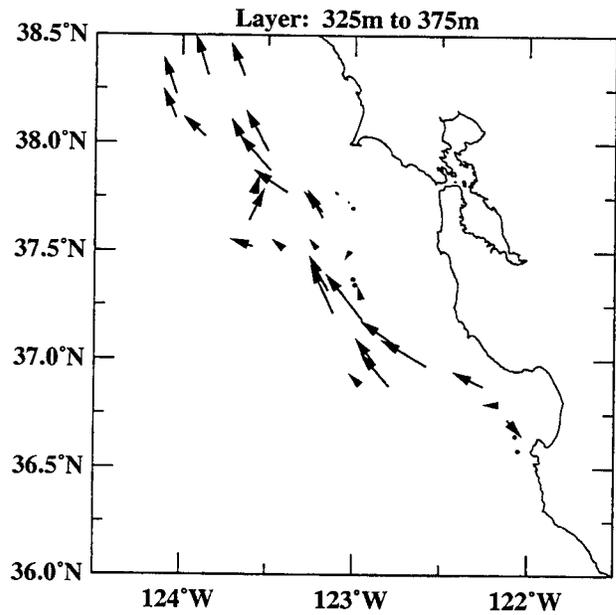
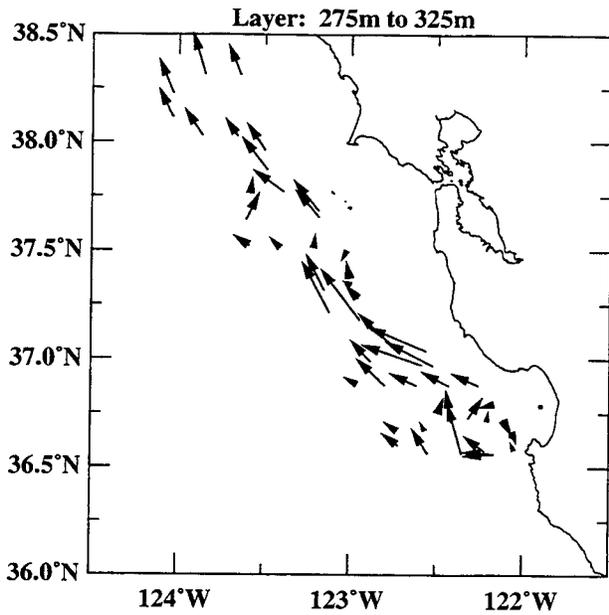
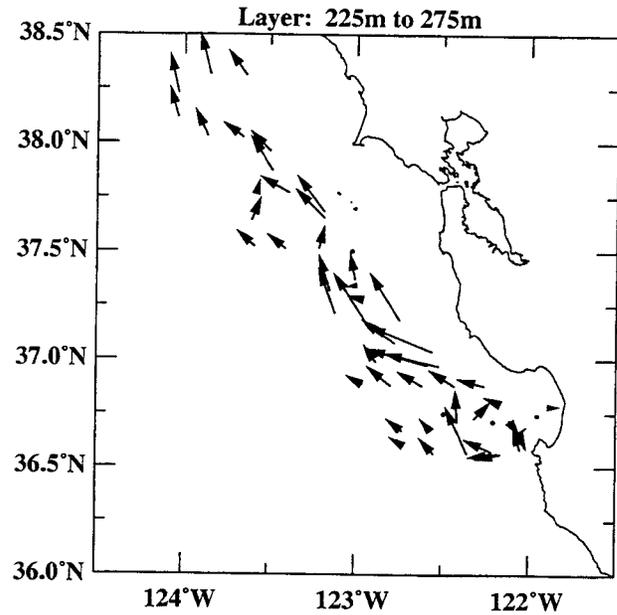
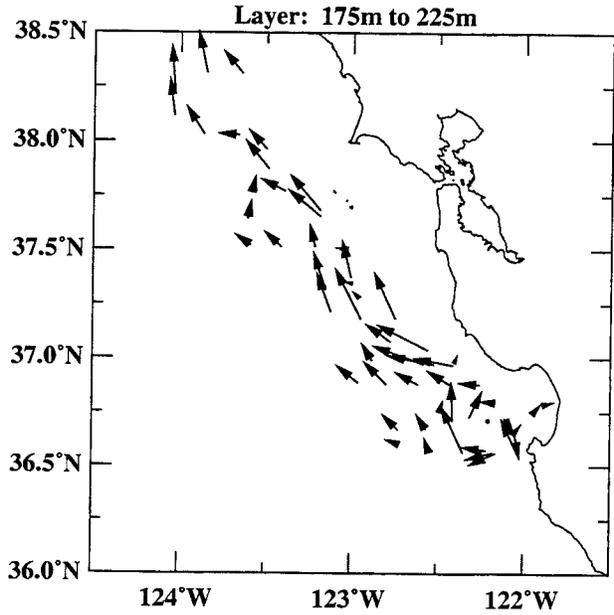
CRUISE DSJ0002 -- ADCP

Sweep 3



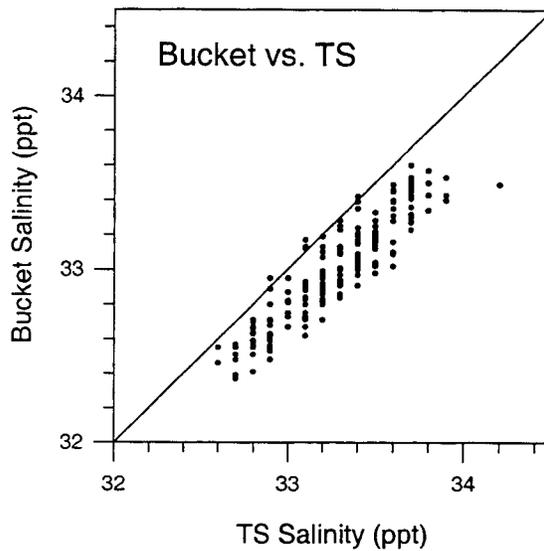
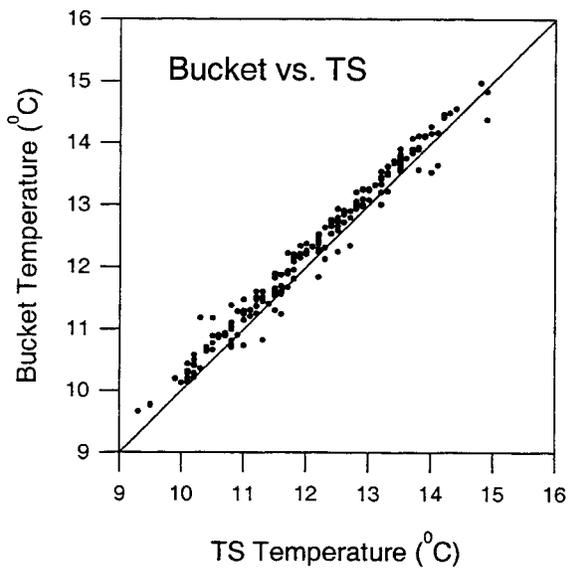
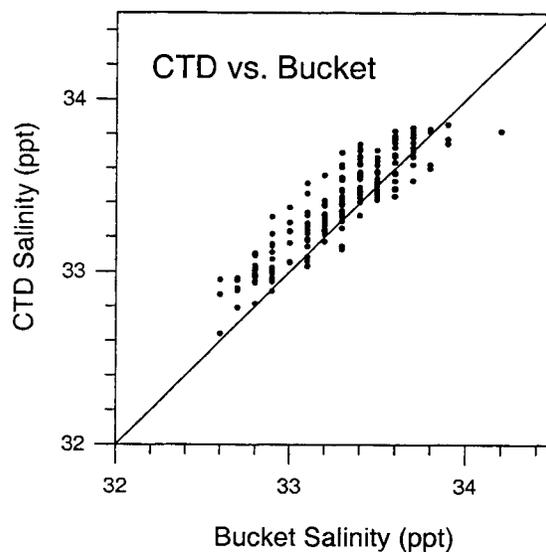
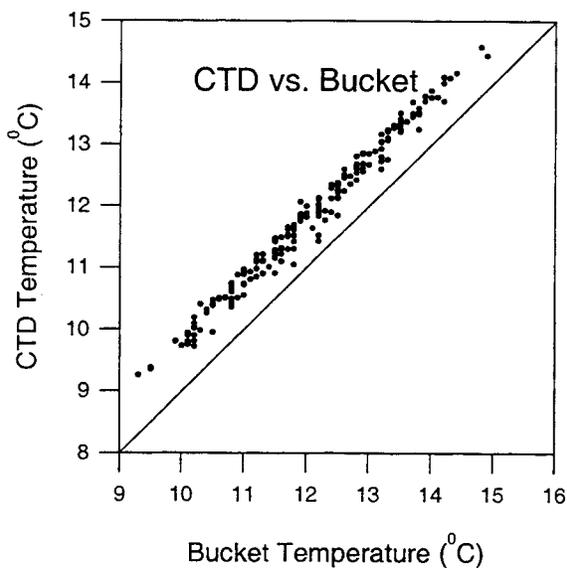
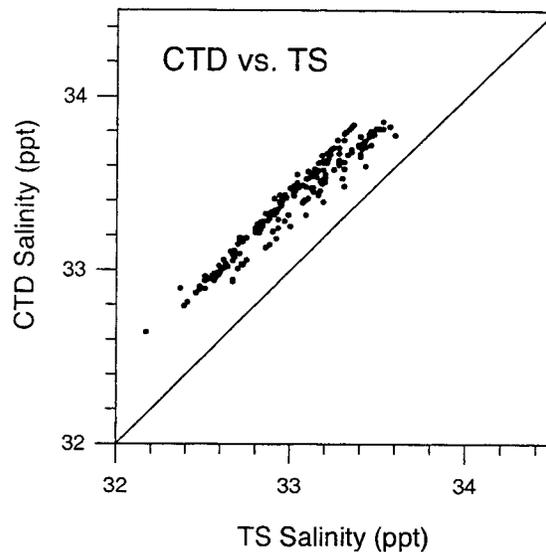
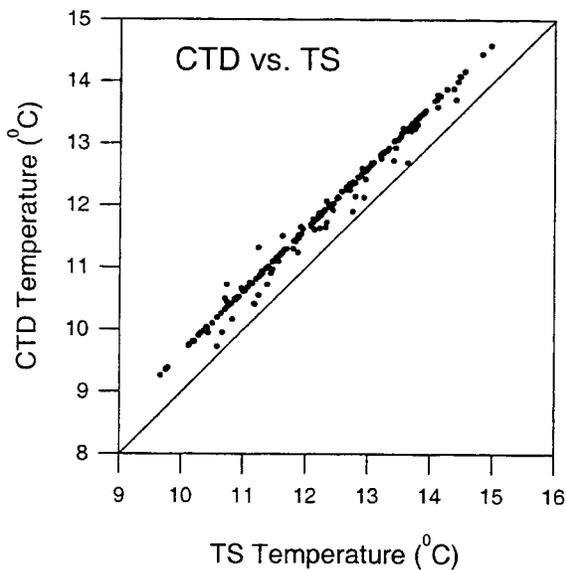
CRUISE DSJ0002 -- ADCP

Sweep 3



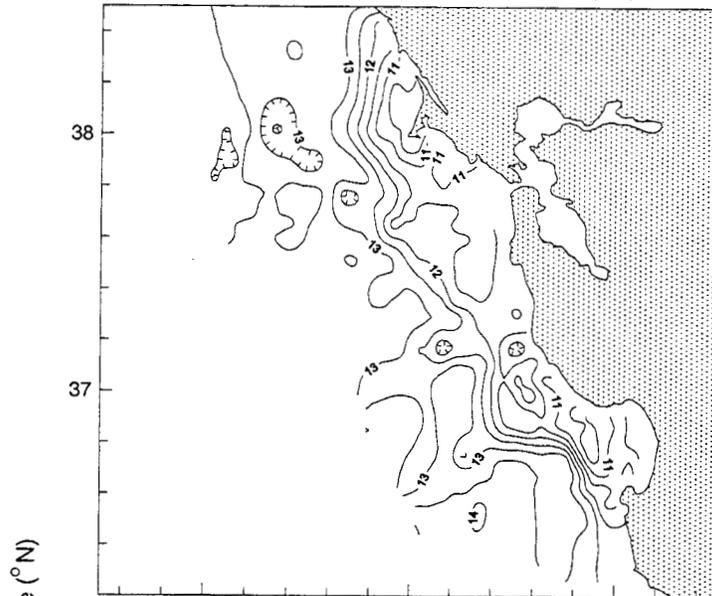
0 100
Speed (cm/s)

**APPENDIX 6: REGRESSION COMPARISONS OF CTD, TS, AND BUCKET
FOR DSJ0002**

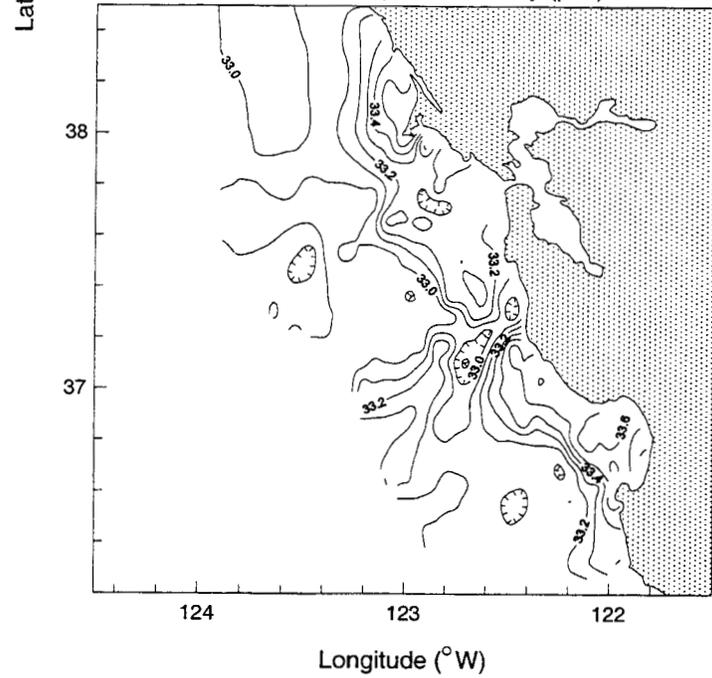


**APPENDIX 7.1: HORIZONTAL MAPS OF CTD AND TS FOR DSJ0002,
SWEEP 1**

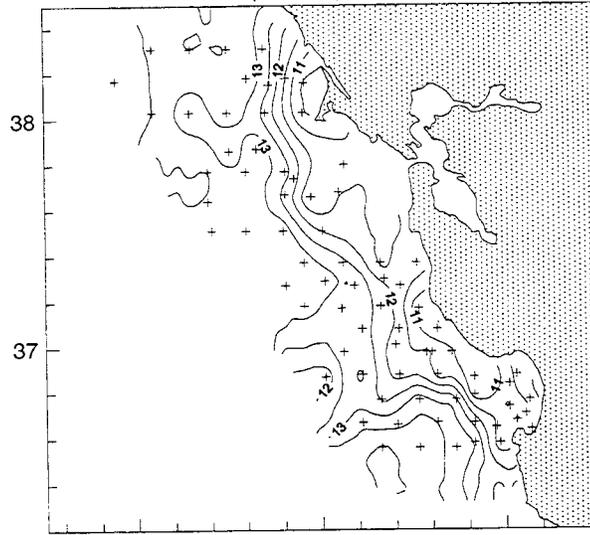
DSJ0002 Sweep 1 TS Temperature ($^{\circ}\text{C}$)



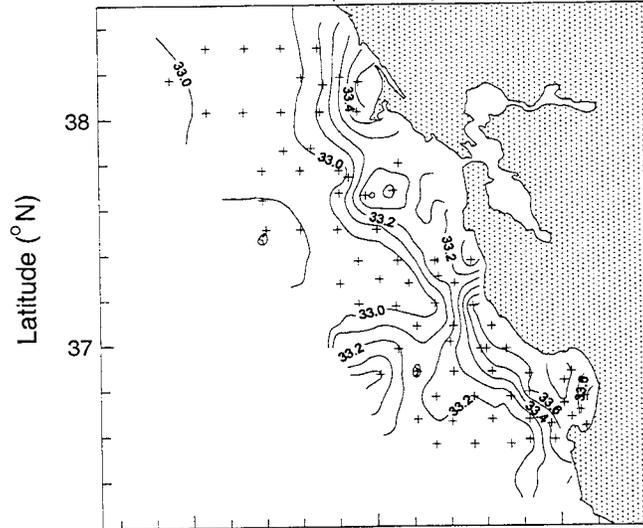
DSJ0002 Sweep 1 TS Salinity (psu)



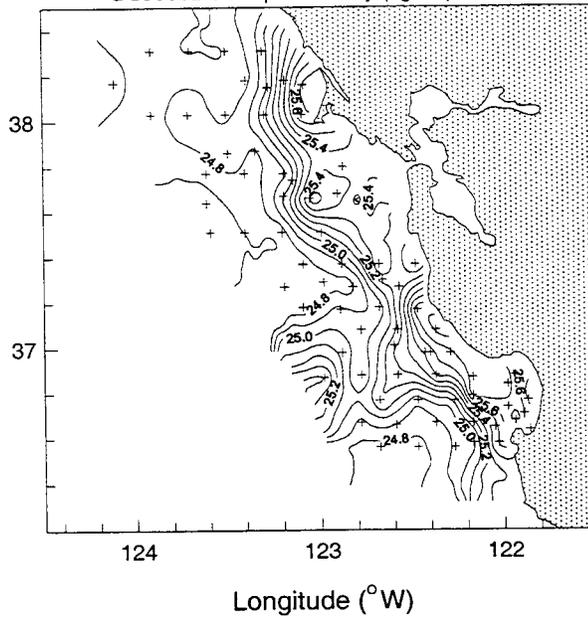
DSJ0002 Sweep 1 Temperature ($^{\circ}\text{C}$) at 2 m



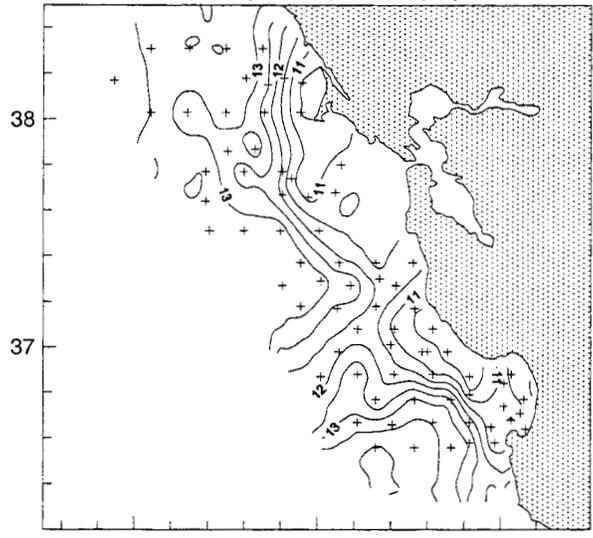
DSJ0002 Sweep 1 Salinity (psu) at 2 m



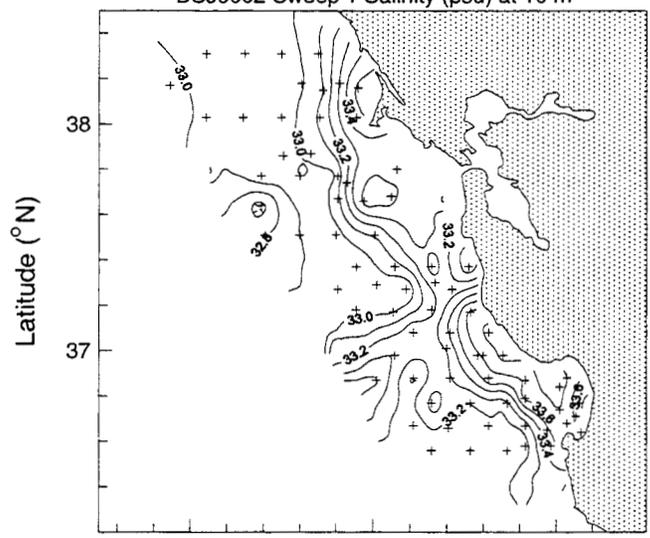
DSJ0002 Sweep 1 Density (kg/m^3) at 2 m



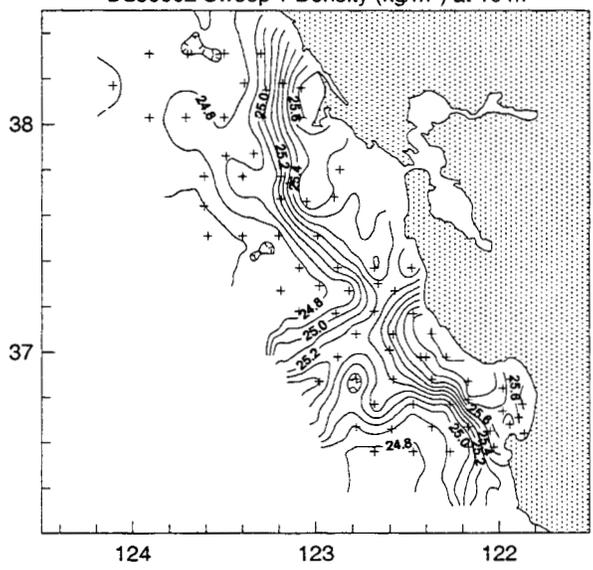
DSJ0002 Sweep 1 Temperature (°C) at 10 m



DSJ0002 Sweep 1 Salinity (psu) at 10 m

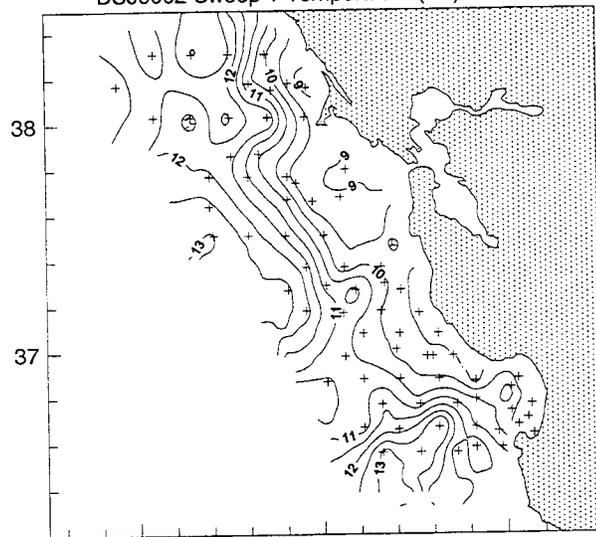


DSJ0002 Sweep 1 Density (kg/m³) at 10 m

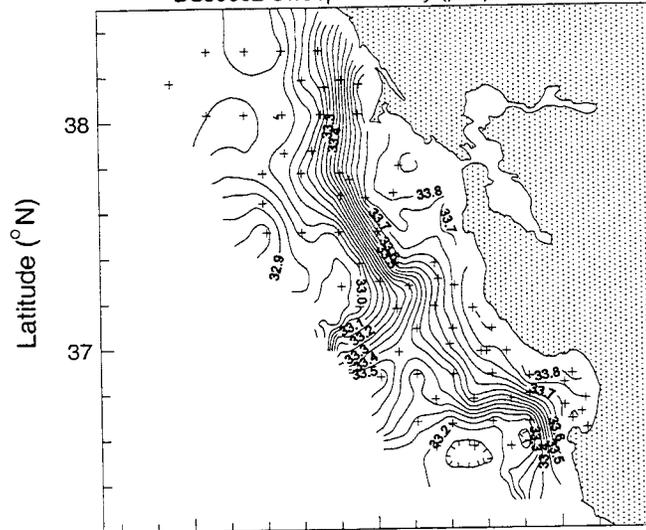


Longitude (°W)

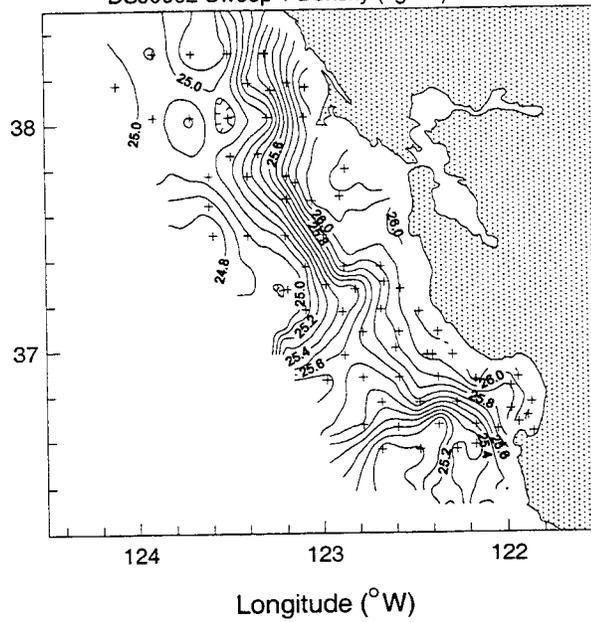
DSJ0002 Sweep 1 Temperature ($^{\circ}\text{C}$) at 30 m



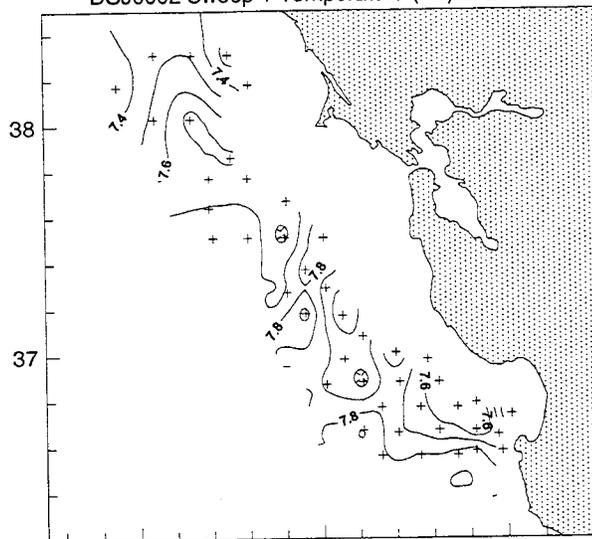
DSJ0002 Sweep 1 Salinity (psu) at 30 m



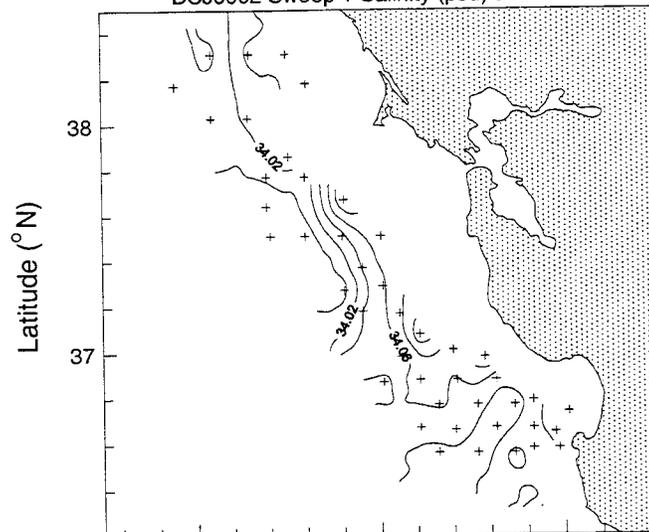
DSJ0002 Sweep 1 Density (kg/m^3) at 30 m



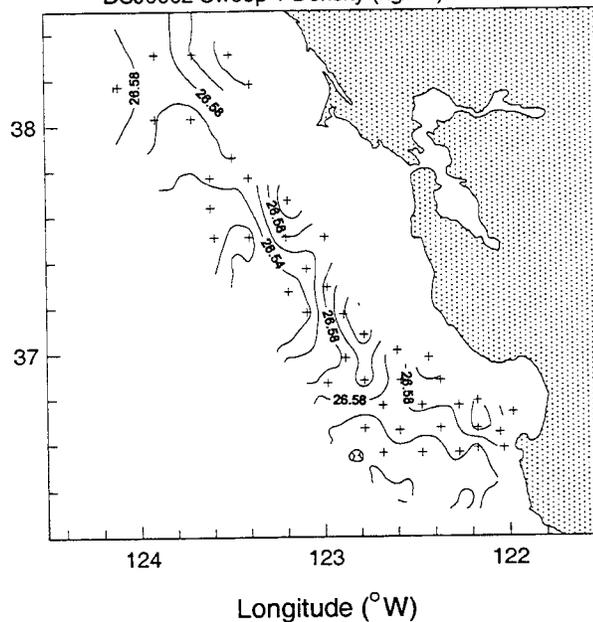
DSJ0002 Sweep 1 Temperature ($^{\circ}\text{C}$) at 200 m



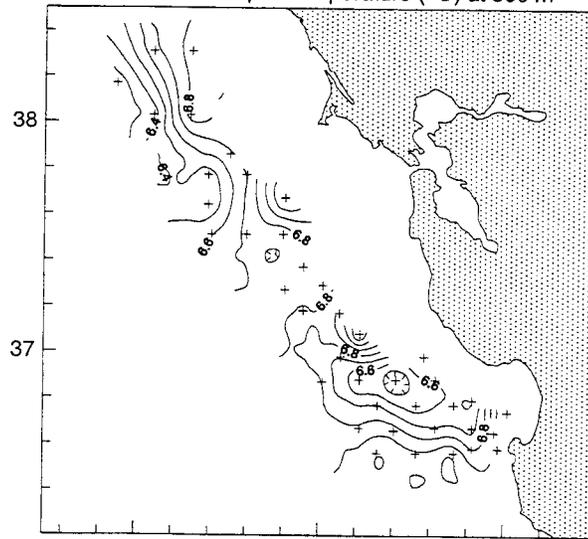
DSJ0002 Sweep 1 Salinity (psu) at 200 m



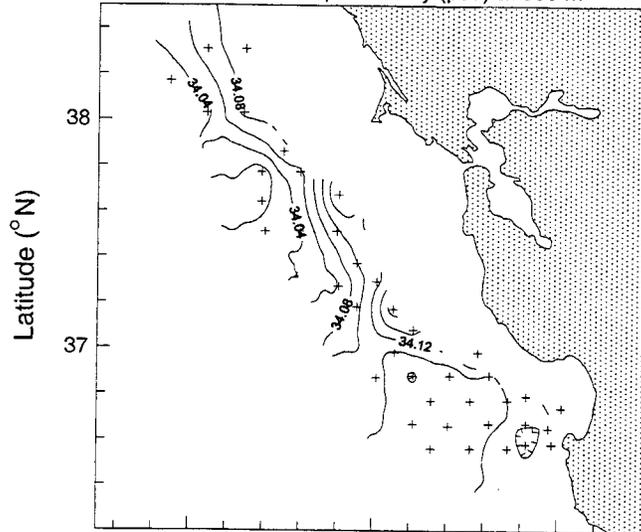
DSJ0002 Sweep 1 Density (kg/m^3) at 200 m



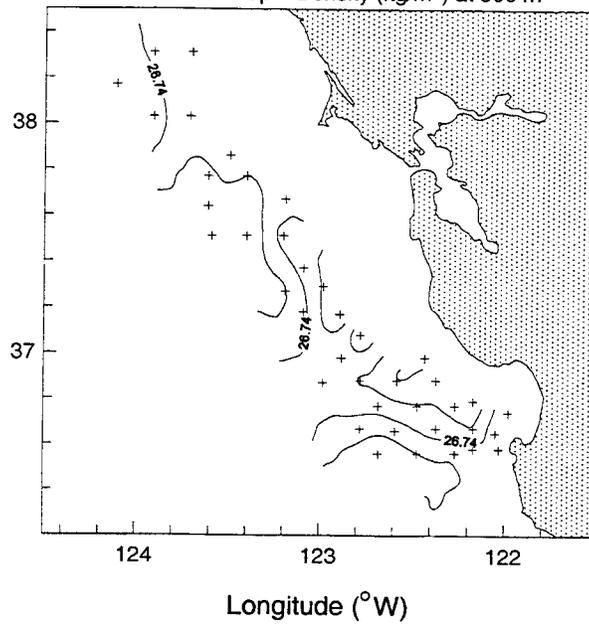
DSJ0002 Sweep 1 Temperature ($^{\circ}\text{C}$) at 300 m



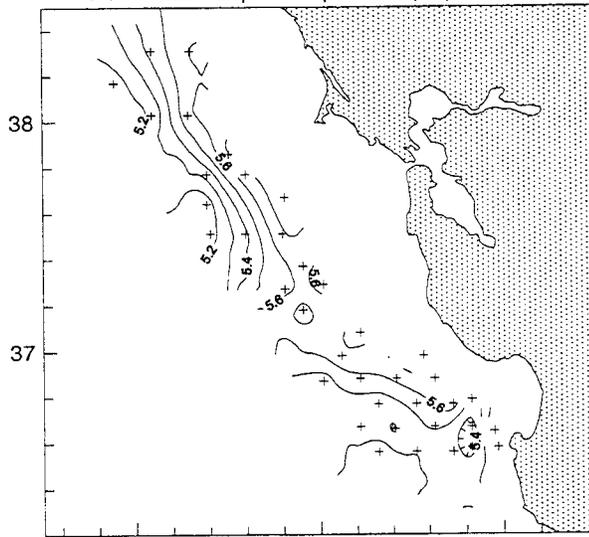
DSJ0002 Sweep 1 Salinity (psu) at 300 m



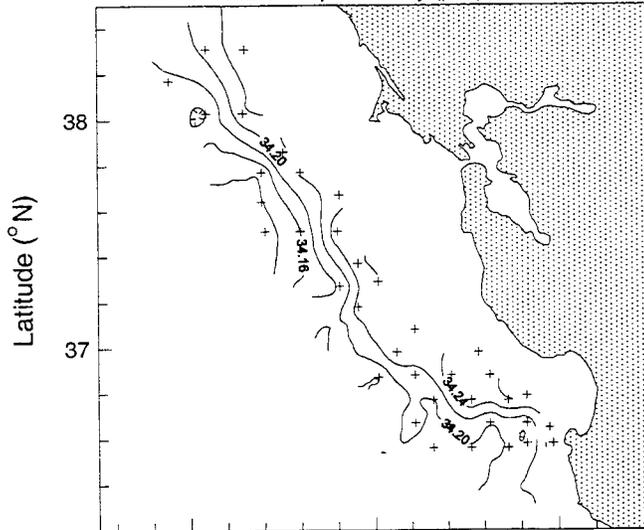
DSJ0002 Sweep 1 Density (kg/m^3) at 300 m



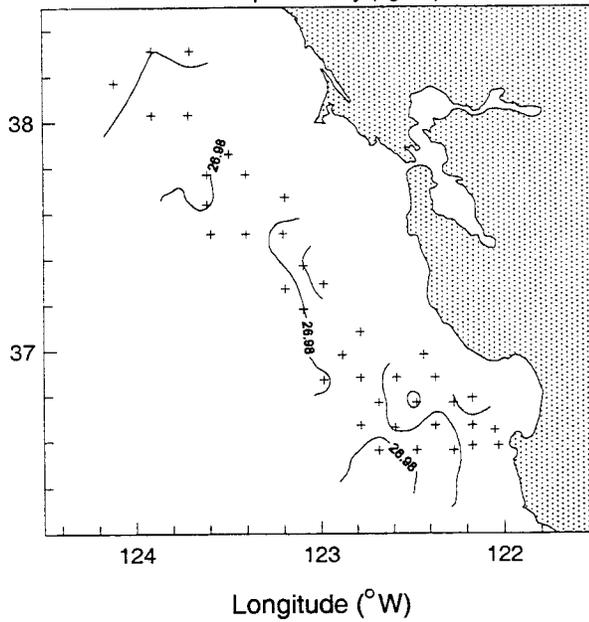
DSJ0002 Sweep 1 Temperature ($^{\circ}\text{C}$) at 500 m



DSJ0002 Sweep 1 Salinity (psu) at 500 m

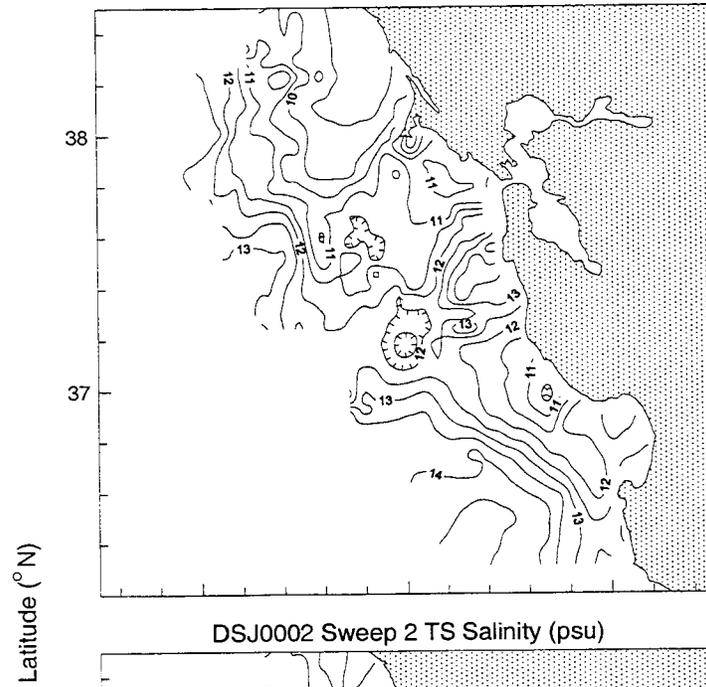


DSJ0002 Sweep 1 Density (kg/m^3) at 500 m

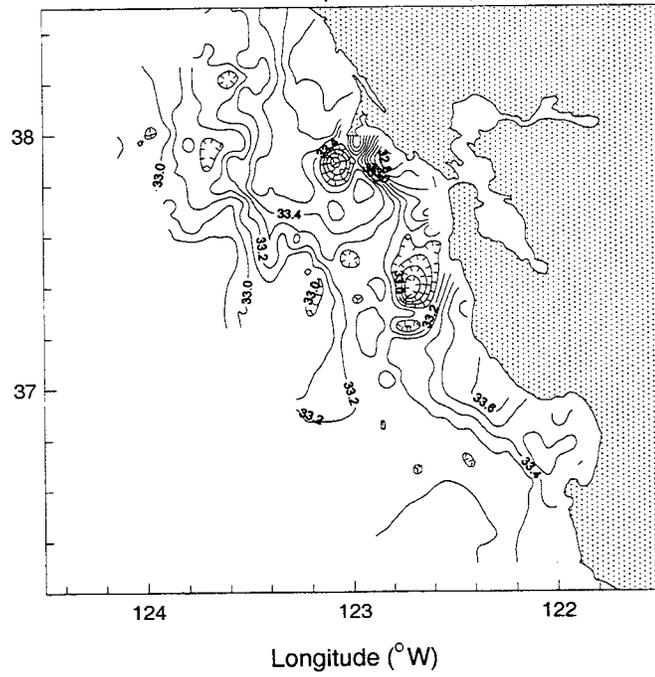


**APPENDIX 7.2: HORIZONTAL MAPS OF CTD AND TS FOR DSJ0002,
SWEEP 2**

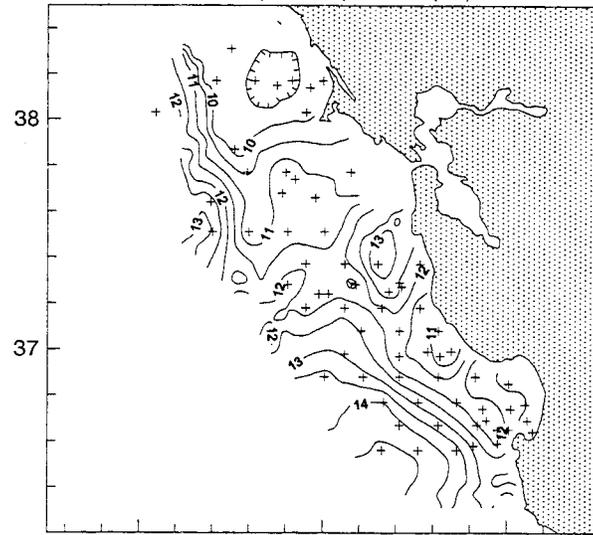
DSJ0002 Sweep 2 TS Temperature ($^{\circ}$ C)



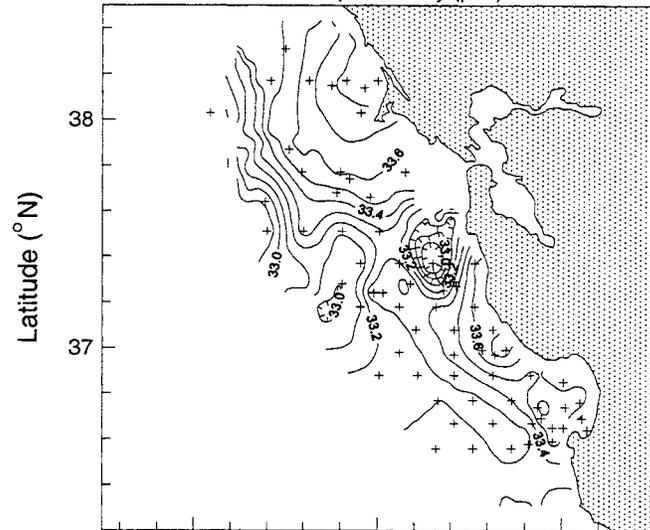
DSJ0002 Sweep 2 TS Salinity (psu)



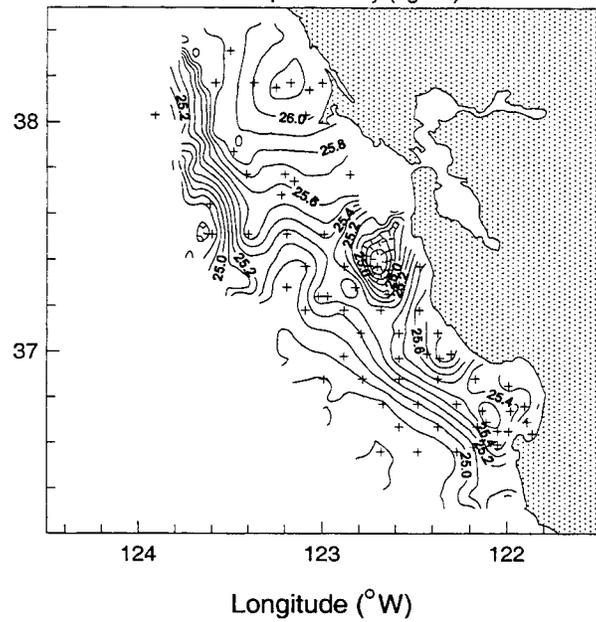
DSJ0002 Sweep 2 Temperature ($^{\circ}\text{C}$) at 2 m



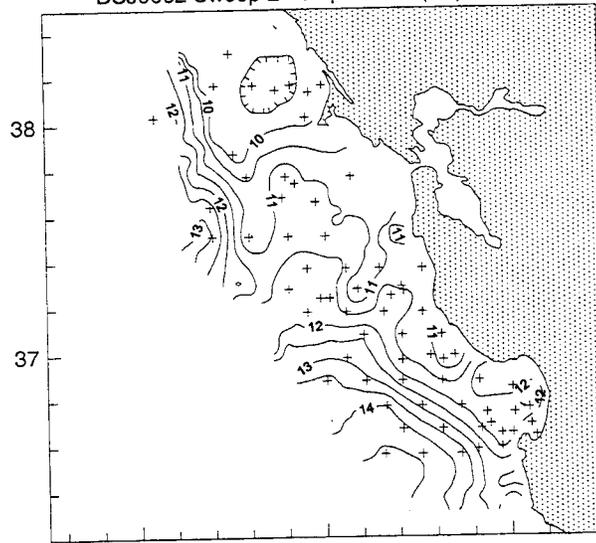
DSJ0002 Sweep 2 Salinity (psu) at 2 m



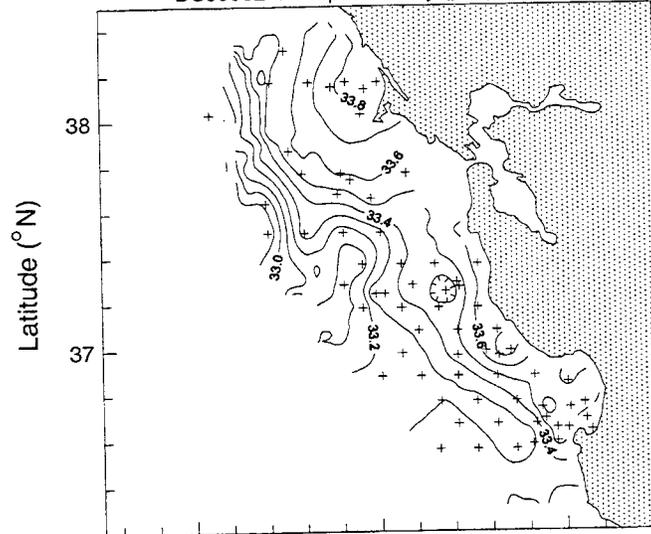
DSJ0002 Sweep 2 Density (kg/m^3) at 2 m



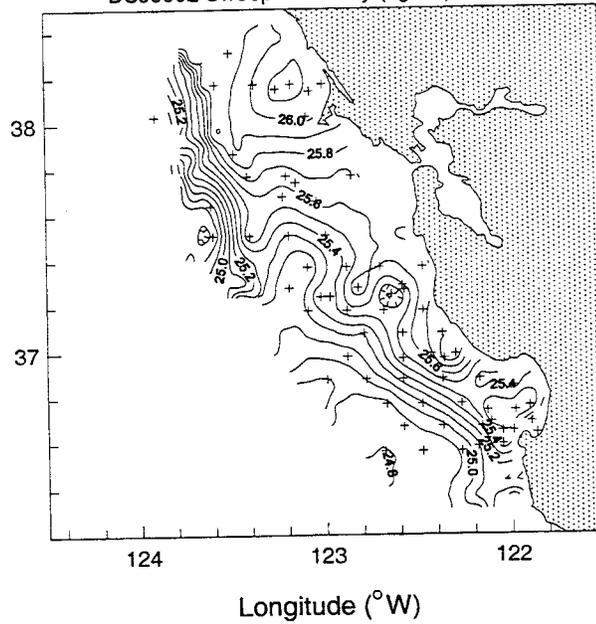
DSJ0002 Sweep 2 Temperature ($^{\circ}\text{C}$) at 10 m



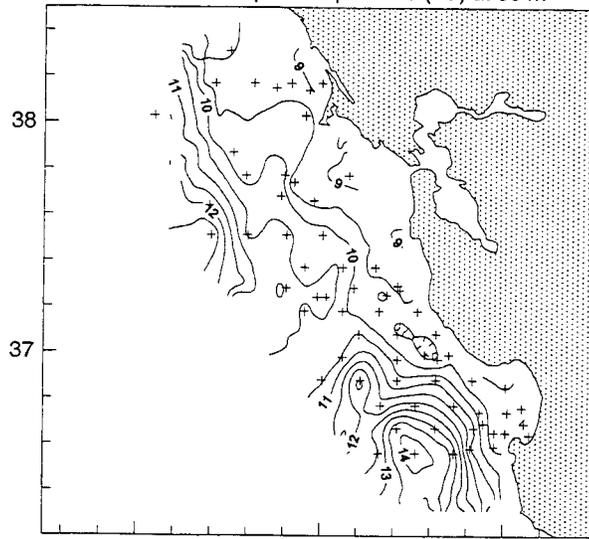
DSJ0002 Sweep 2 Salinity (psu) at 10 m



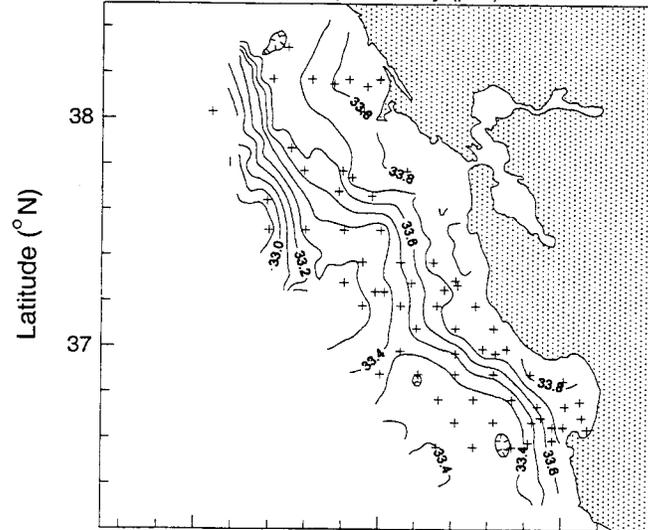
DSJ0002 Sweep 2 Density (kg/m^3) at 10 m



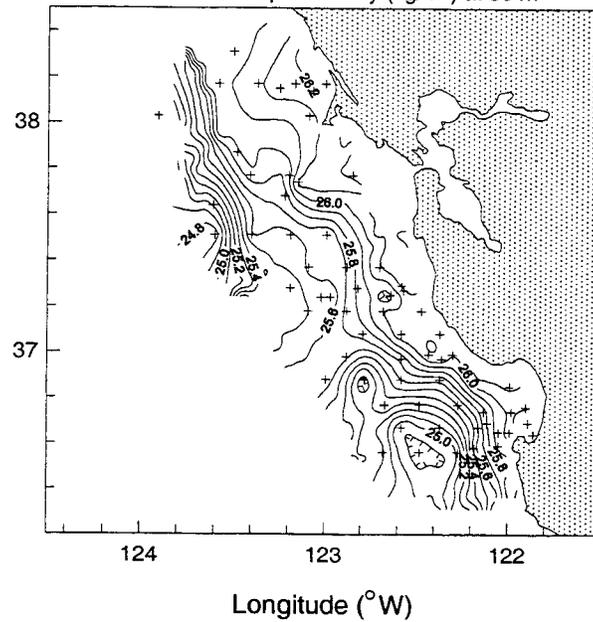
DSJ0002 Sweep 2 Temperature ($^{\circ}\text{C}$) at 30 m



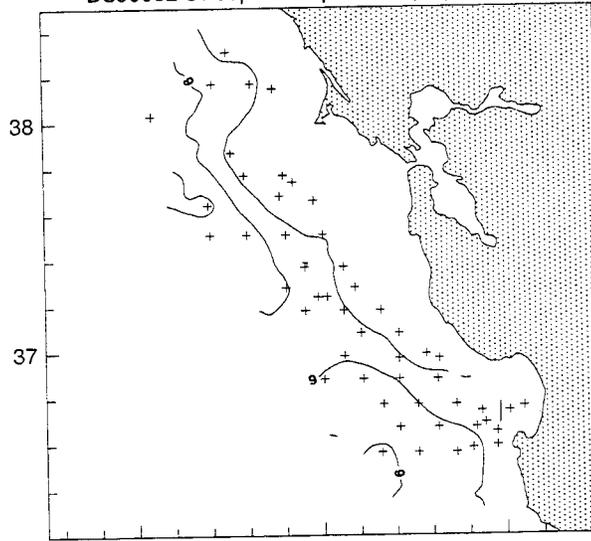
DSJ0002 Sweep 2 Salinity (psu) at 30 m



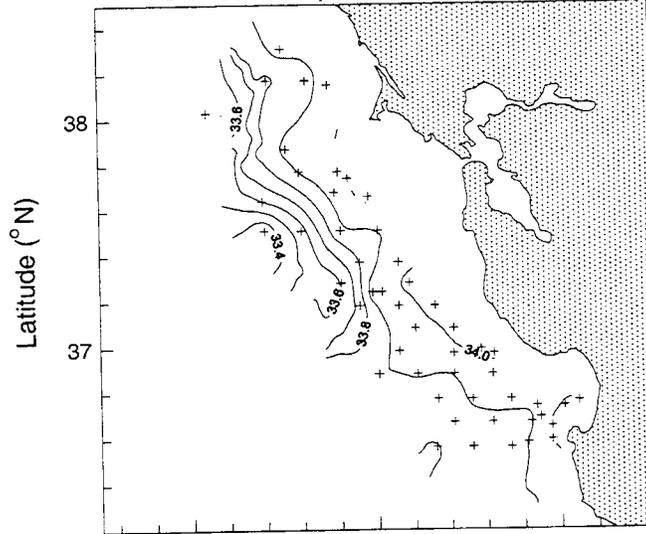
DSJ0002 Sweep 2 Density (kg/m^3) at 30 m



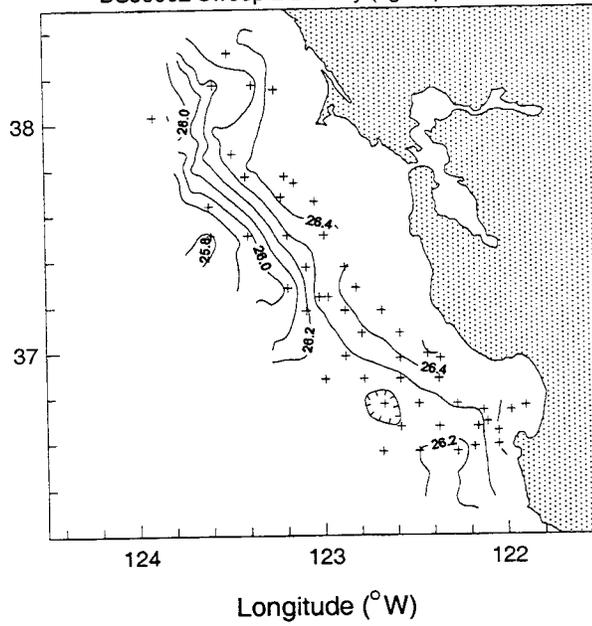
DSJ0002 Sweep 2 Temperature ($^{\circ}$ C) at 100 m



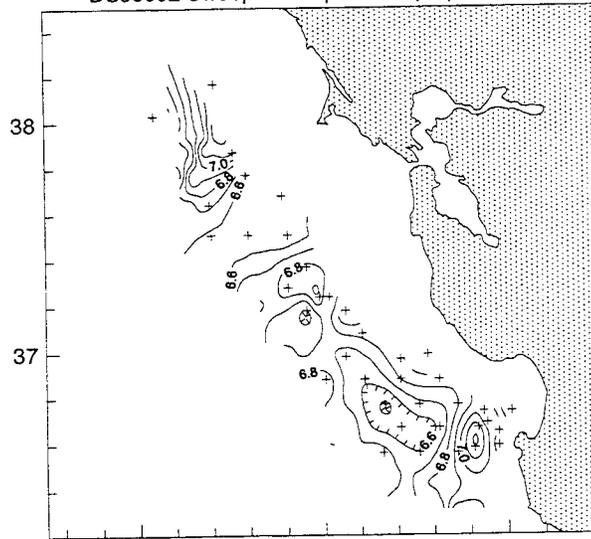
DSJ0002 Sweep 2 Salinity (psu) at 100 m



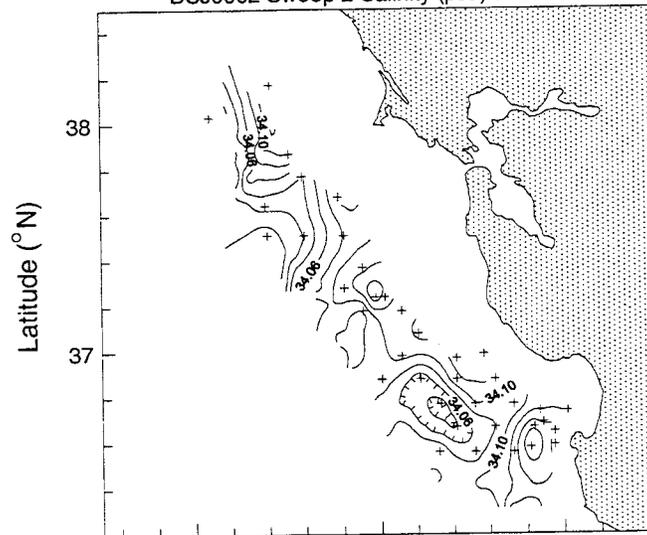
DSJ0002 Sweep 2 Density (kg/m^3) at 100 m



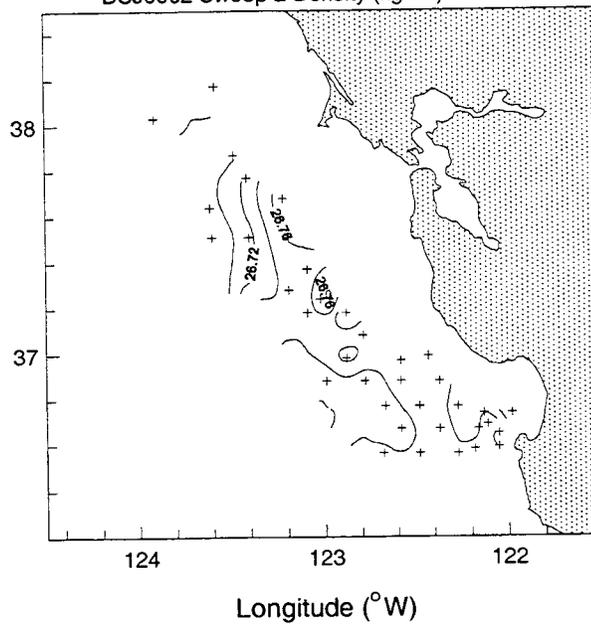
DSJ0002 Sweep 2 Temperature ($^{\circ}\text{C}$) at 300 m



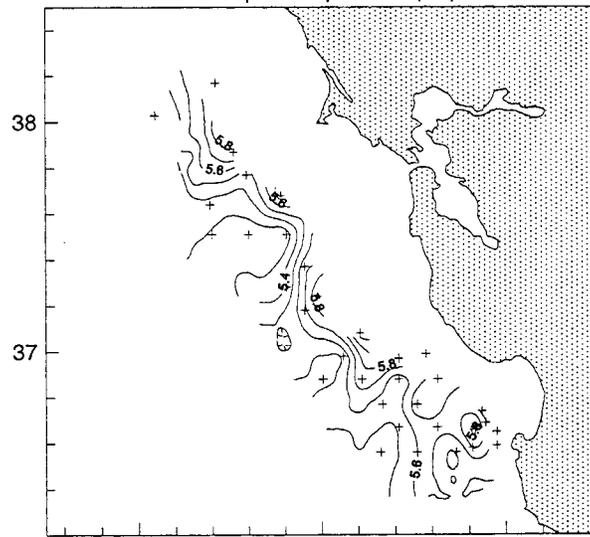
DSJ0002 Sweep 2 Salinity (psu) at 300 m



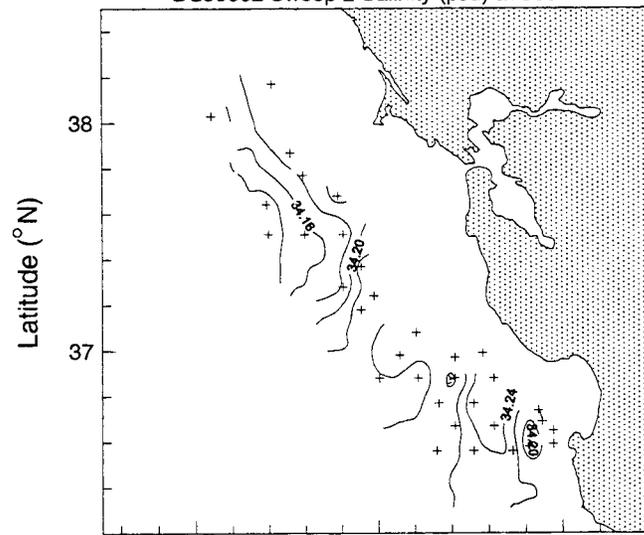
DSJ0002 Sweep 2 Density (kg/m^3) at 300 m



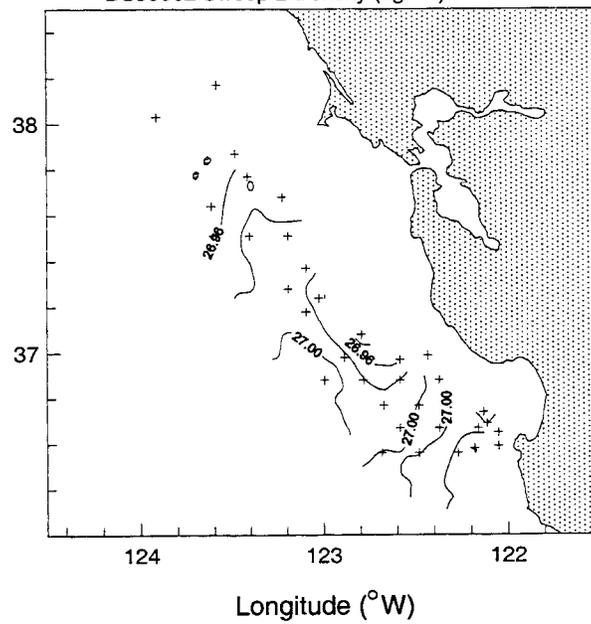
DSJ0002 Sweep 2 Temperature ($^{\circ}\text{C}$) at 500 m



DSJ0002 Sweep 2 Salinity (psu) at 500 m

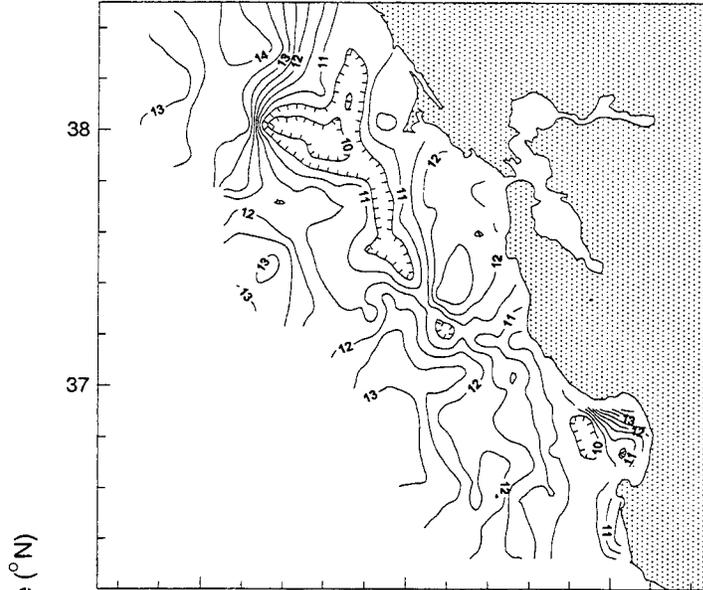


DSJ0002 Sweep 2 Density (kg/m^3) at 500 m

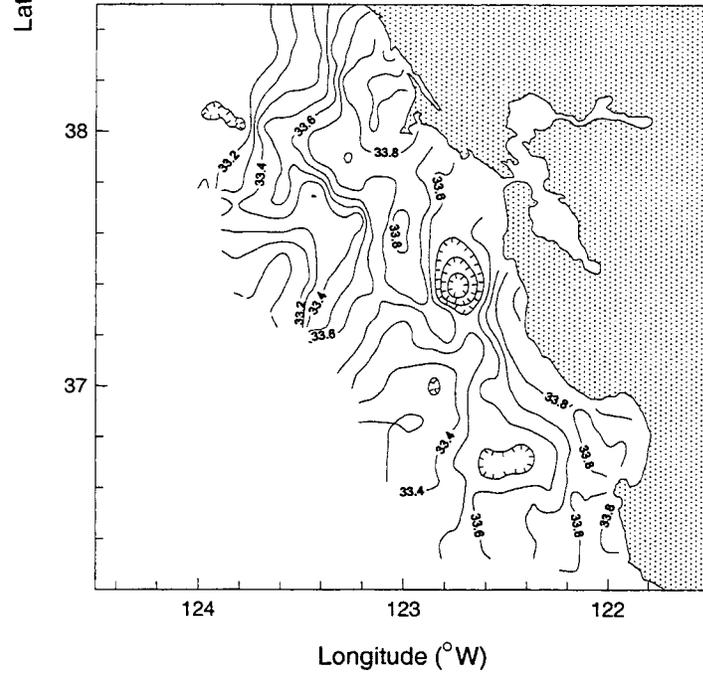


**APPENDIX 7.3: HORIZONTAL MAPS OF CTD AND TS FOR DSJ0002,
SWEEP 3**

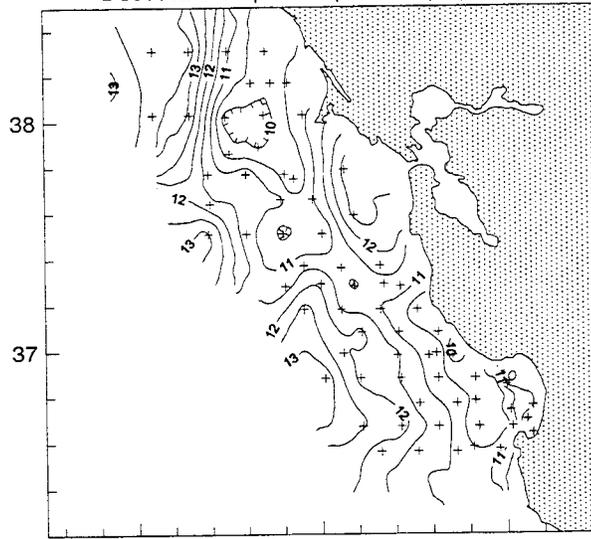
DSJ0002 Sweep 3 TS Temperature (°C)



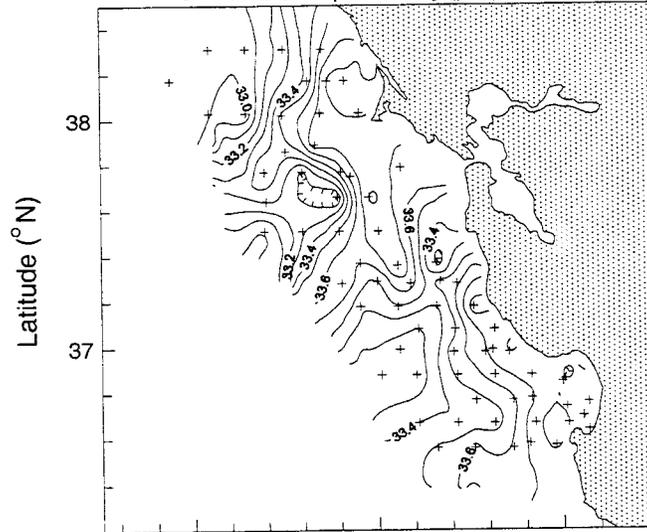
DSJ0002 Sweep 3 TS Salinity (psu)



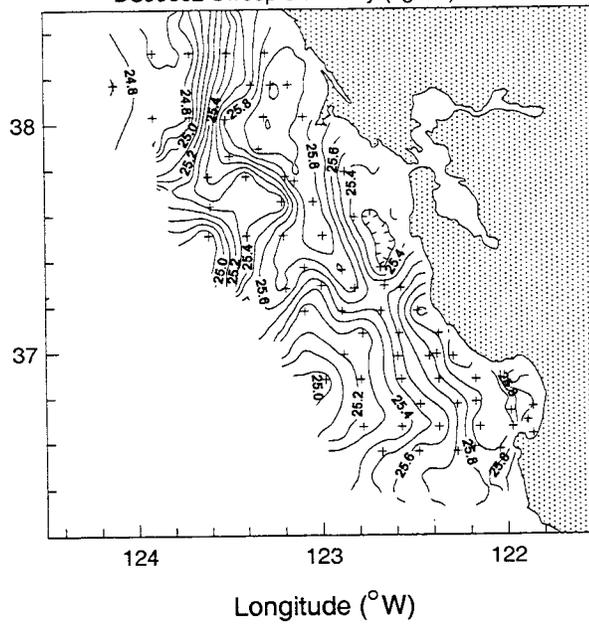
DSJ0002 Sweep 3 Temperature ($^{\circ}\text{C}$) at 2 m



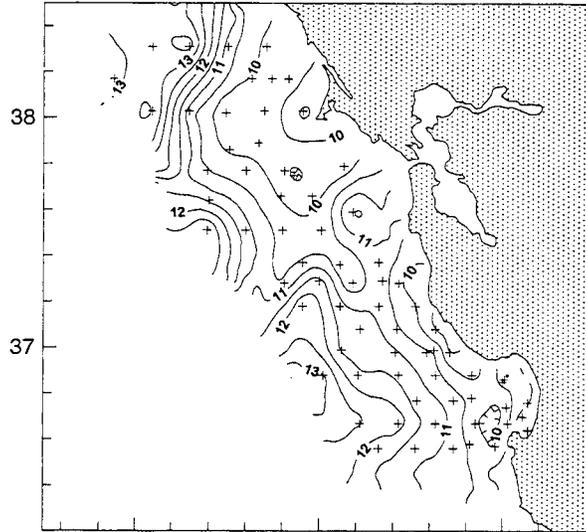
DSJ0002 Sweep 3 Salinity (psu) at 2 m



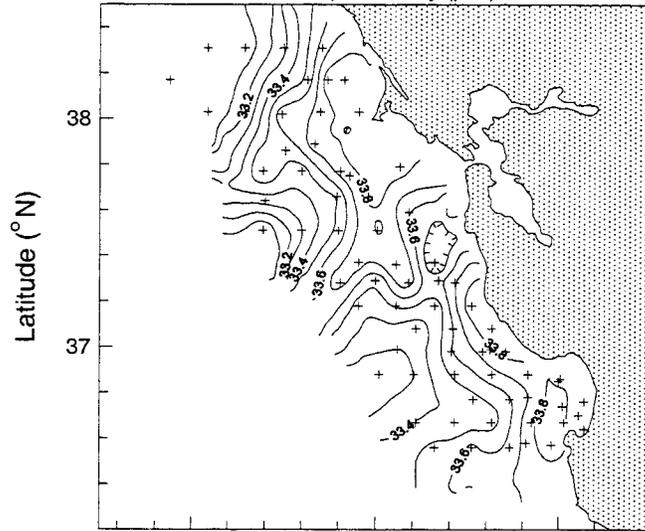
DSJ0002 Sweep 3 Density (kg/m^3) at 2 m



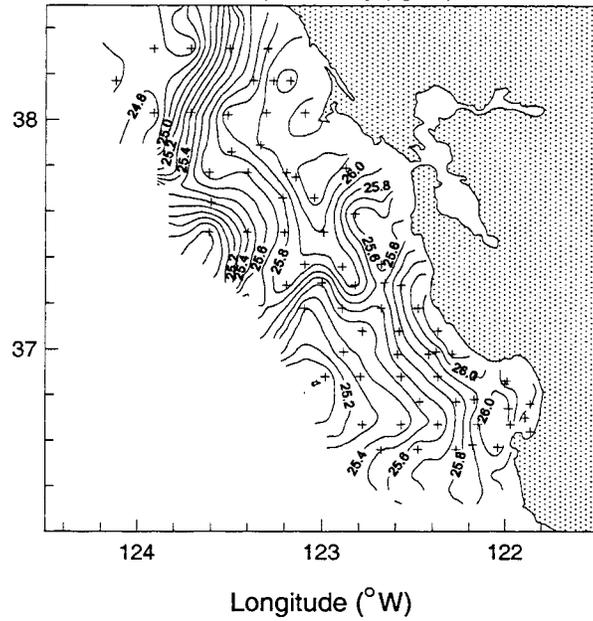
DSJ0002 Sweep 3 Temperature ($^{\circ}\text{C}$) at 10 m



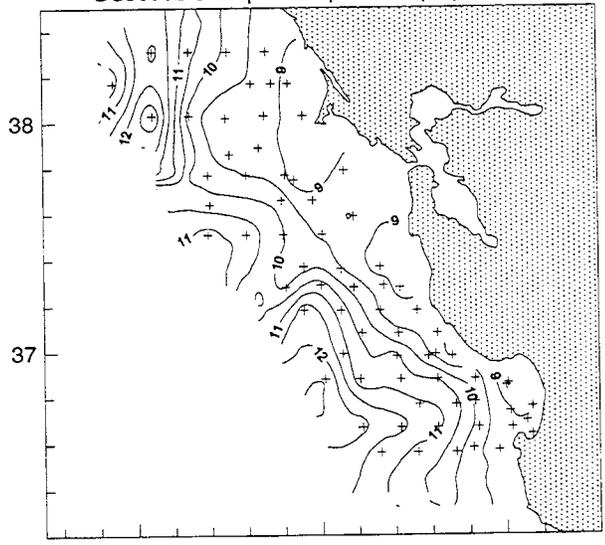
DSJ0002 Sweep 3 Salinity (psu) at 10 m



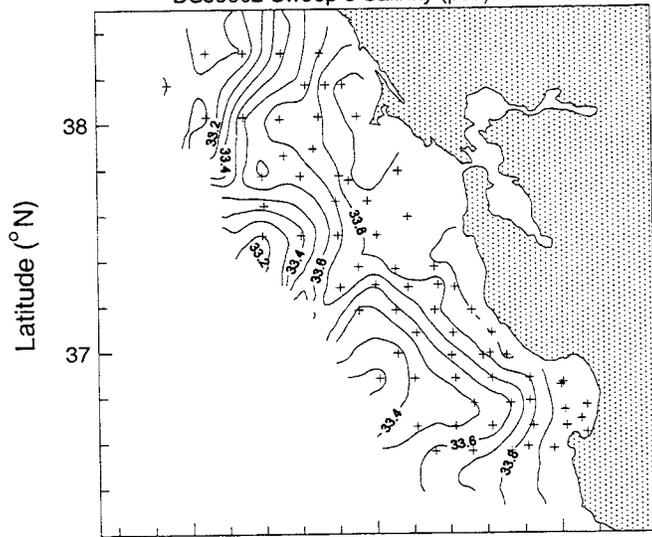
DSJ0002 Sweep 3 Density (kg/m^3) at 10 m



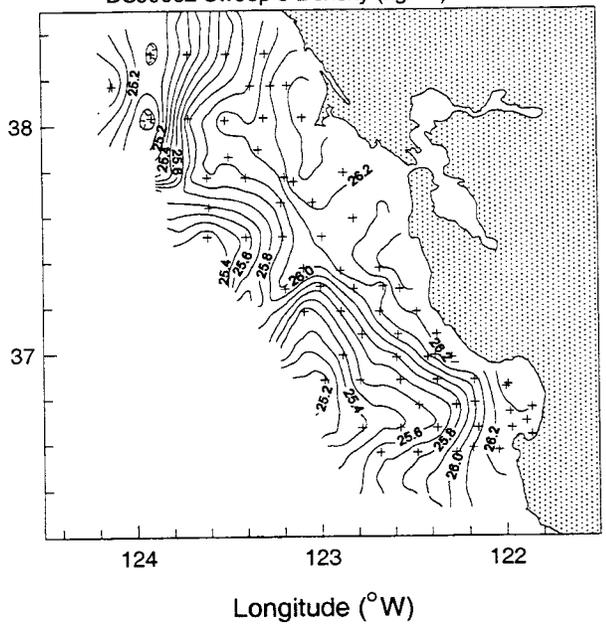
DSJ0002 Sweep 3 Temperature (°C) at 30 m



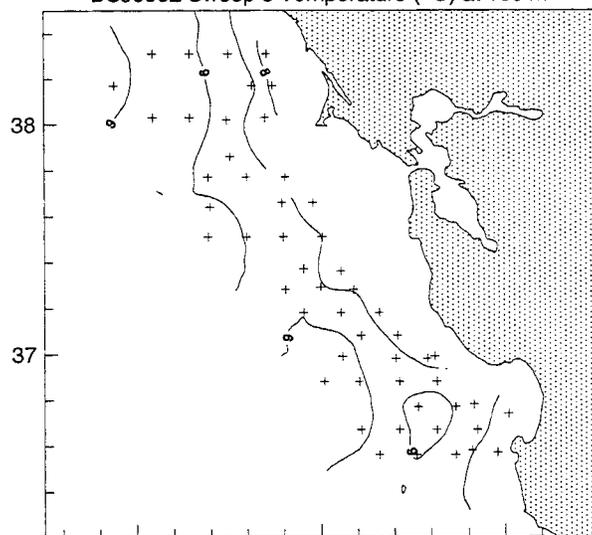
DSJ0002 Sweep 3 Salinity (psu) at 30 m



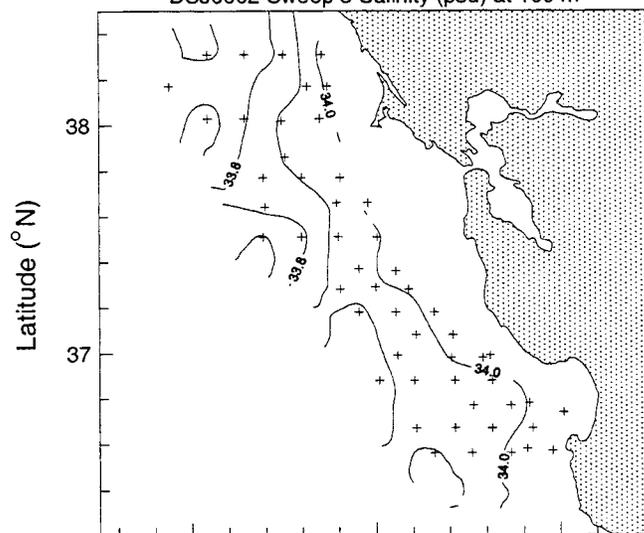
DSJ0002 Sweep 3 Density (kg/m³) at 30 m



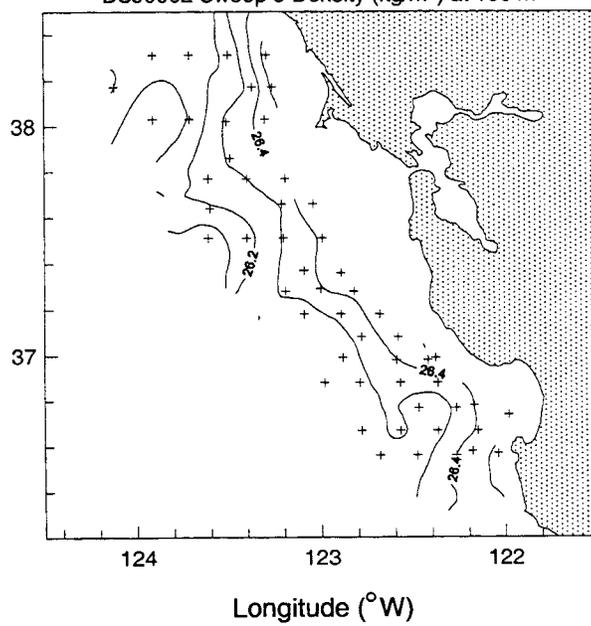
DSJ0002 Sweep 3 Temperature (°C) at 100 m



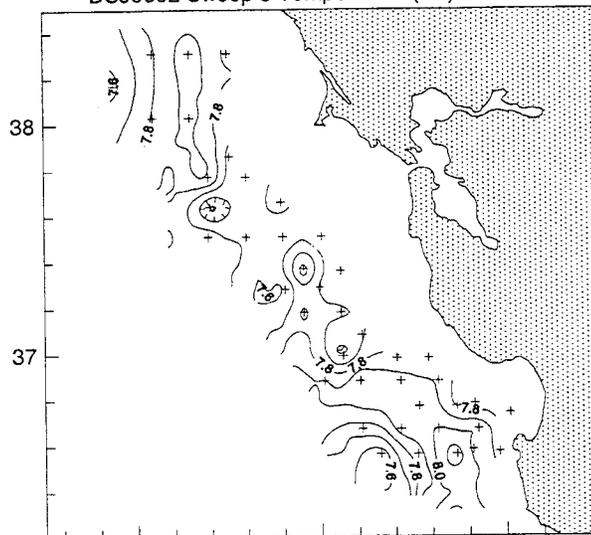
DSJ0002 Sweep 3 Salinity (psu) at 100 m



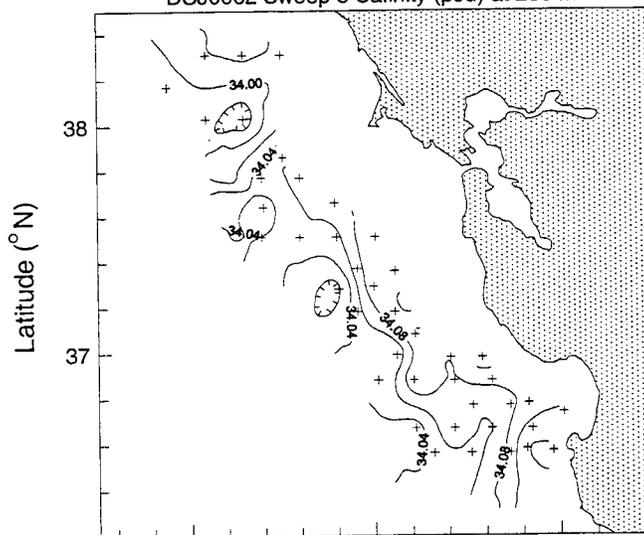
DSJ0002 Sweep 3 Density (kg/m³) at 100 m



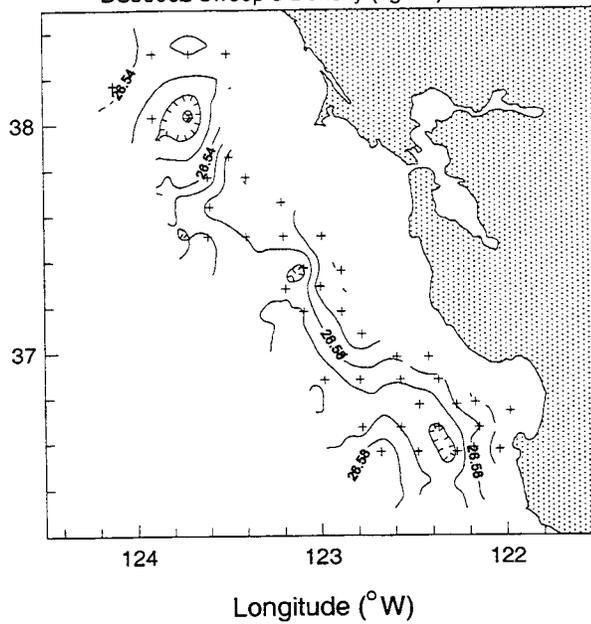
DSJ0002 Sweep 3 Temperature ($^{\circ}\text{C}$) at 200 m



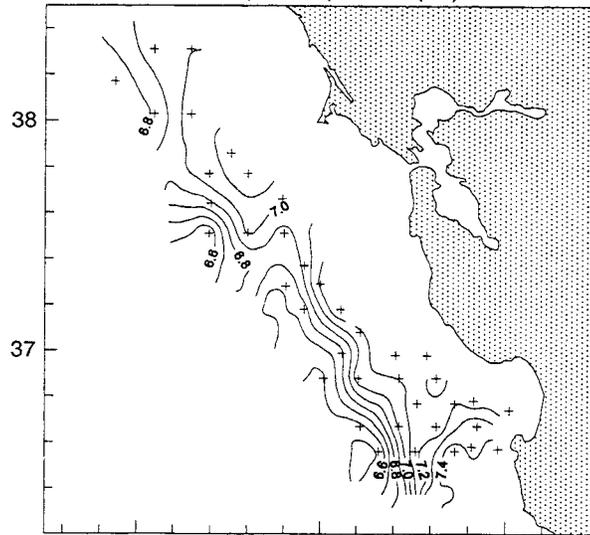
DSJ0002 Sweep 3 Salinity (psu) at 200 m



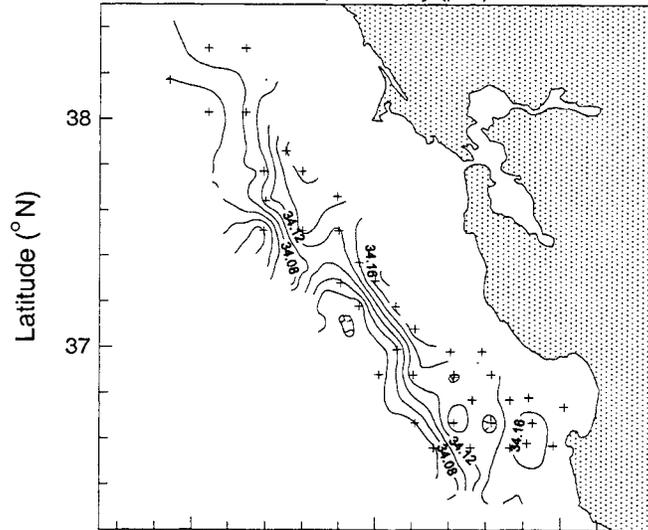
DSJ0002 Sweep 3 Density (kg/m^3) at 200 m



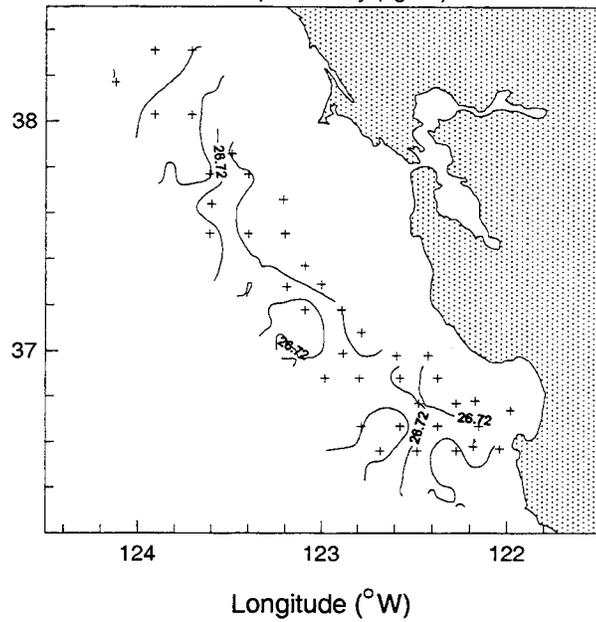
DSJ0002 Sweep 3 Temperature ($^{\circ}$ C) at 300 m



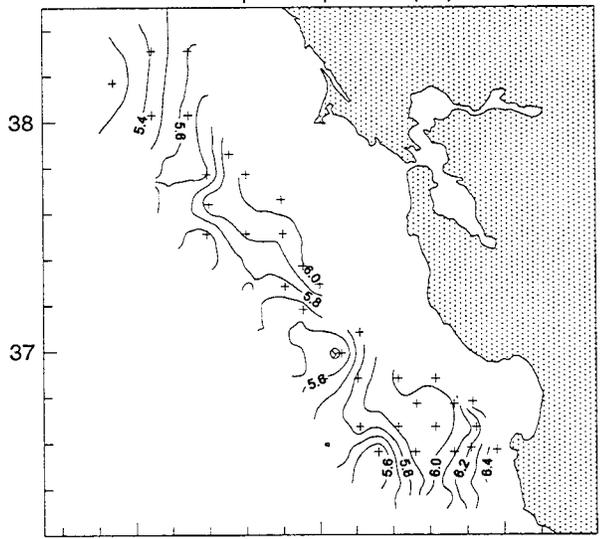
DSJ0002 Sweep 3 Salinity (psu) at 300 m



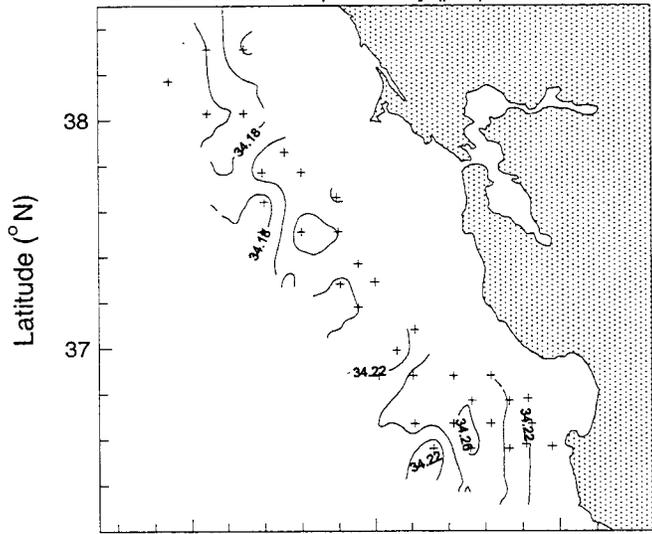
DSJ0002 Sweep 3 Density (kg/m^3) at 300 m



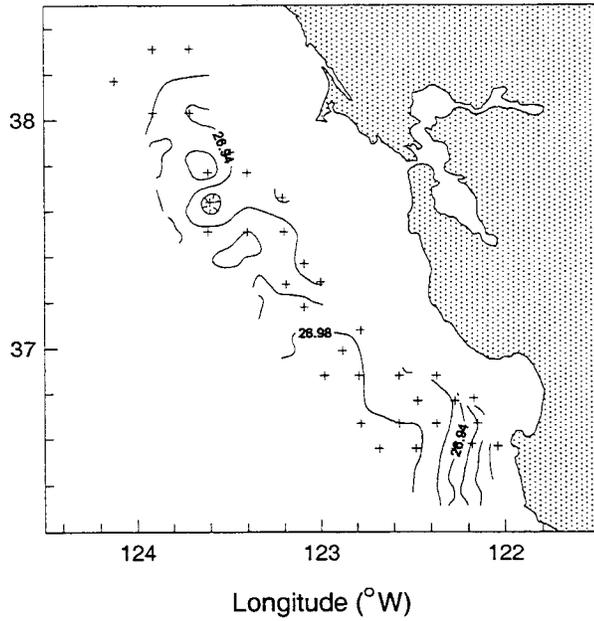
DSJ0002 Sweep 3 Temperature ($^{\circ}\text{C}$) at 500 m



DSJ0002 Sweep 3 Salinity (psu) at 500 m

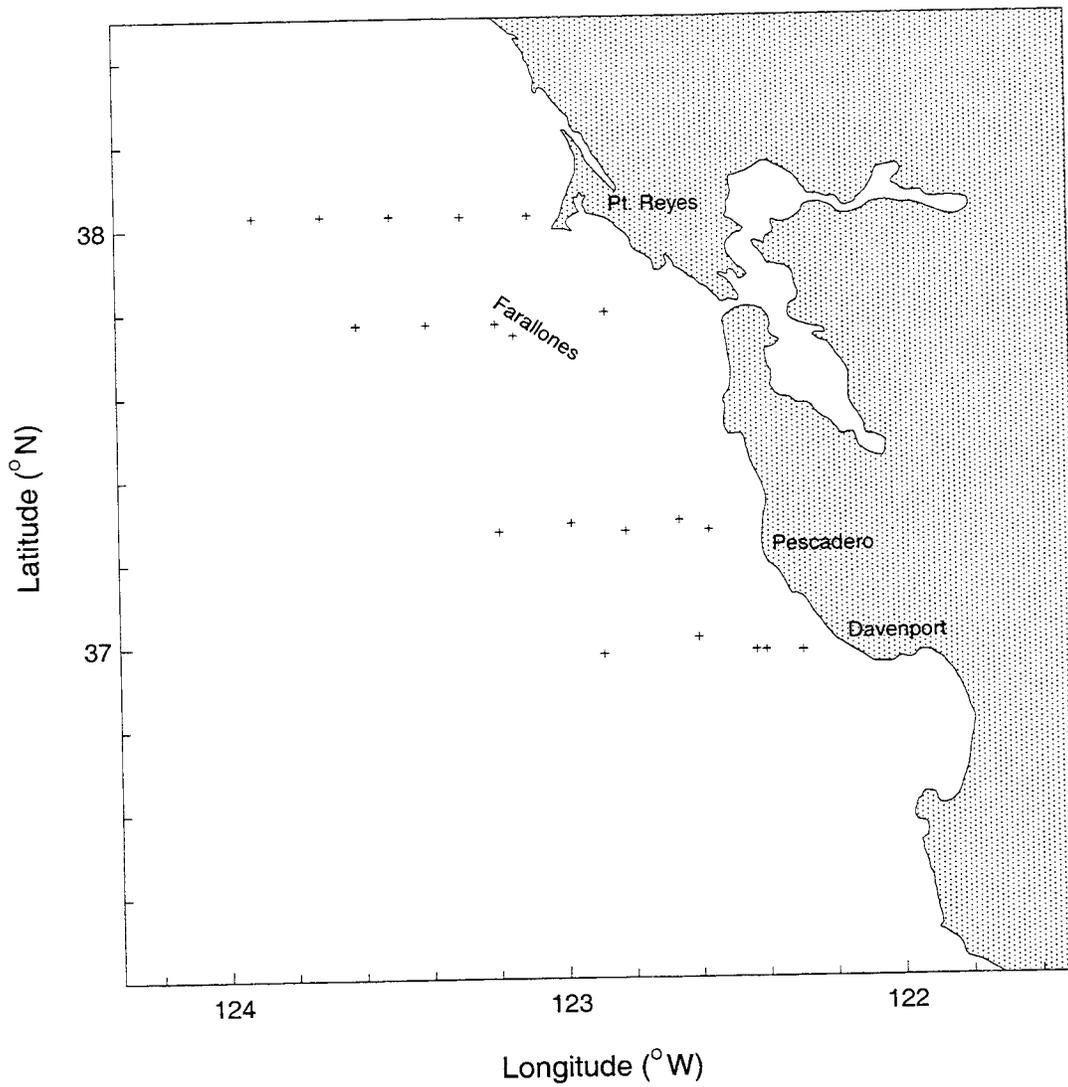


DSJ0002 Sweep 3 Density (kg/m^3) at 500 m

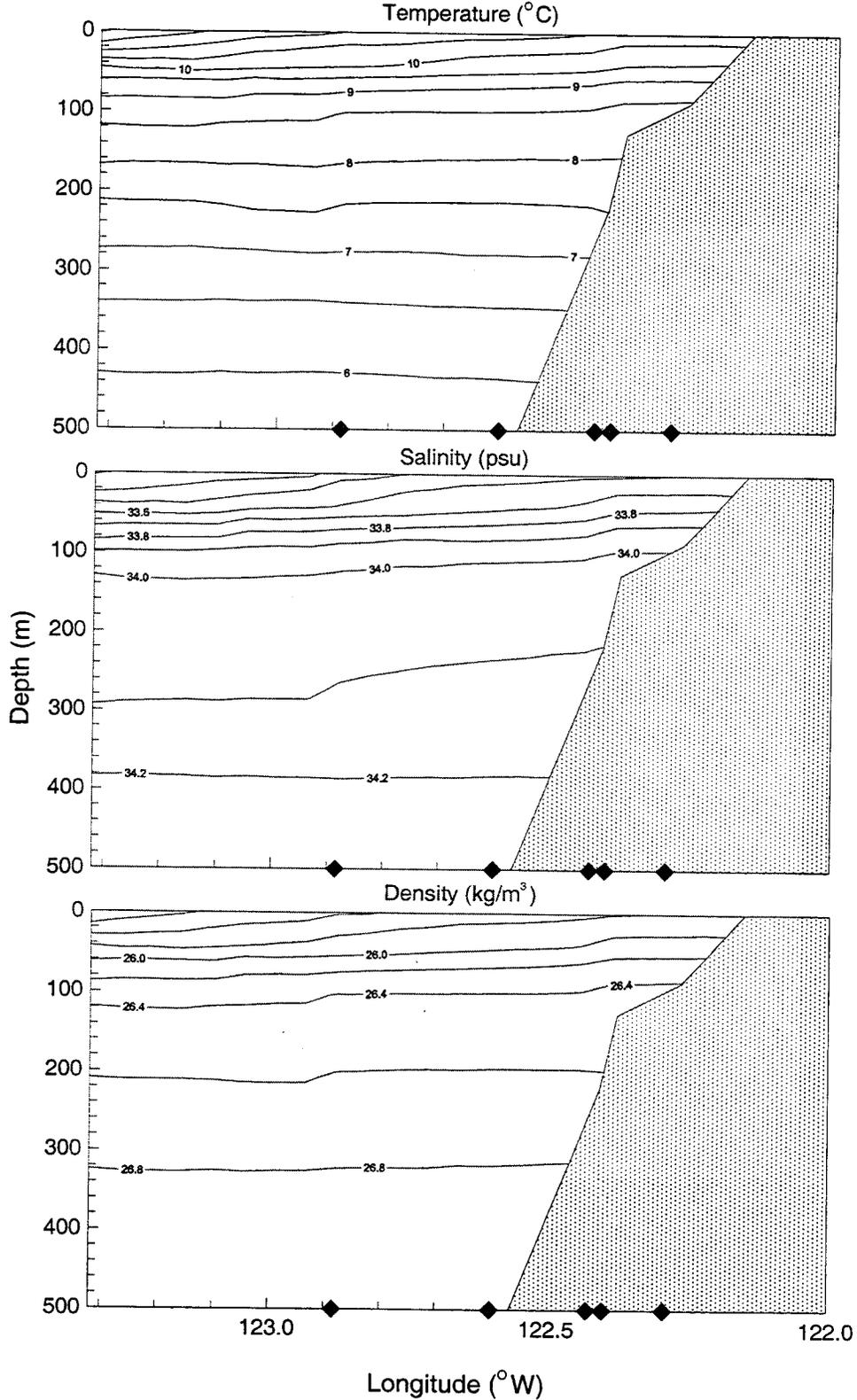


APPENDIX 8: VERTICAL SECTIONS FOR DSJ0002

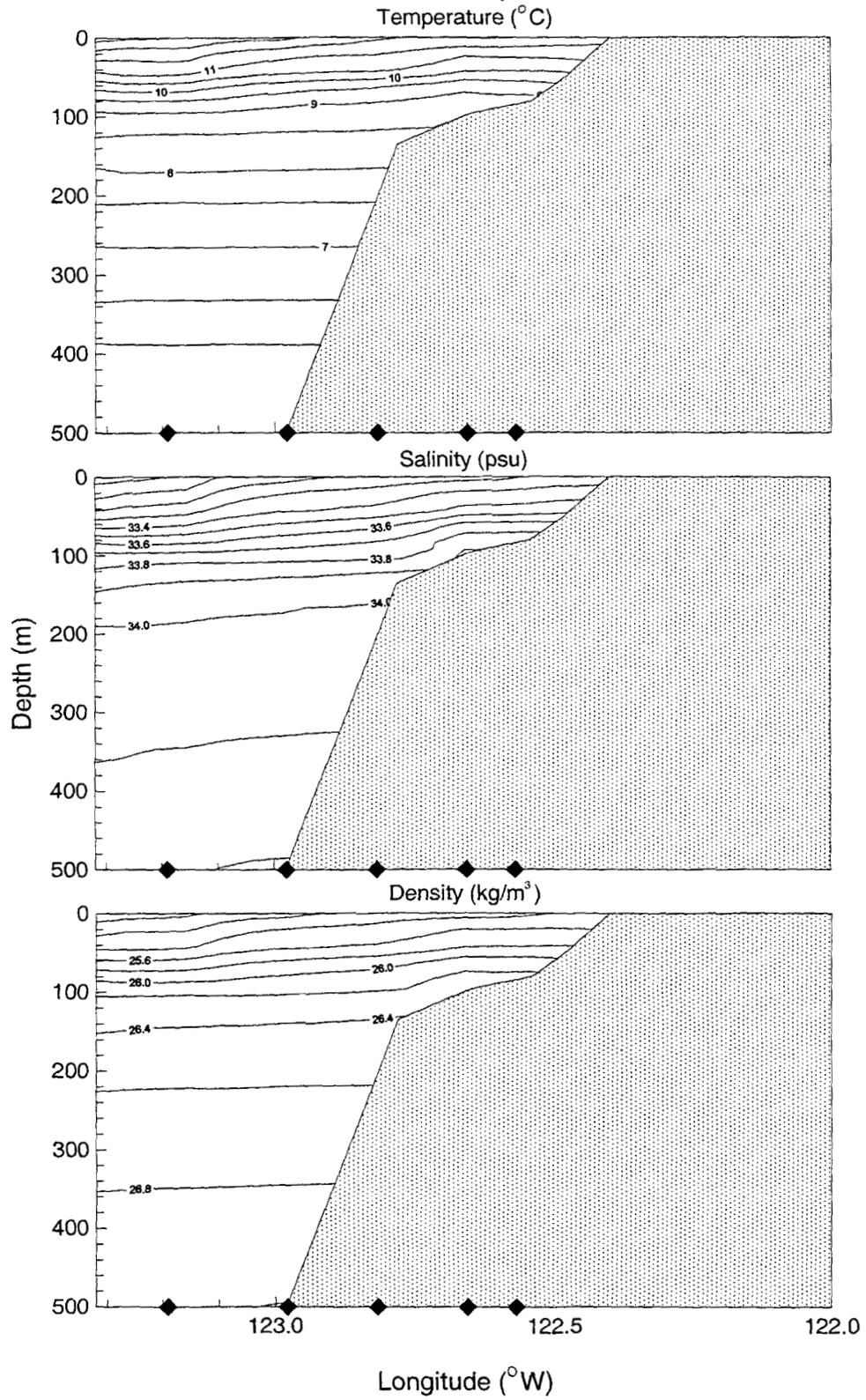
DSJ0002 Sweep 1 Vertical Transect Stations



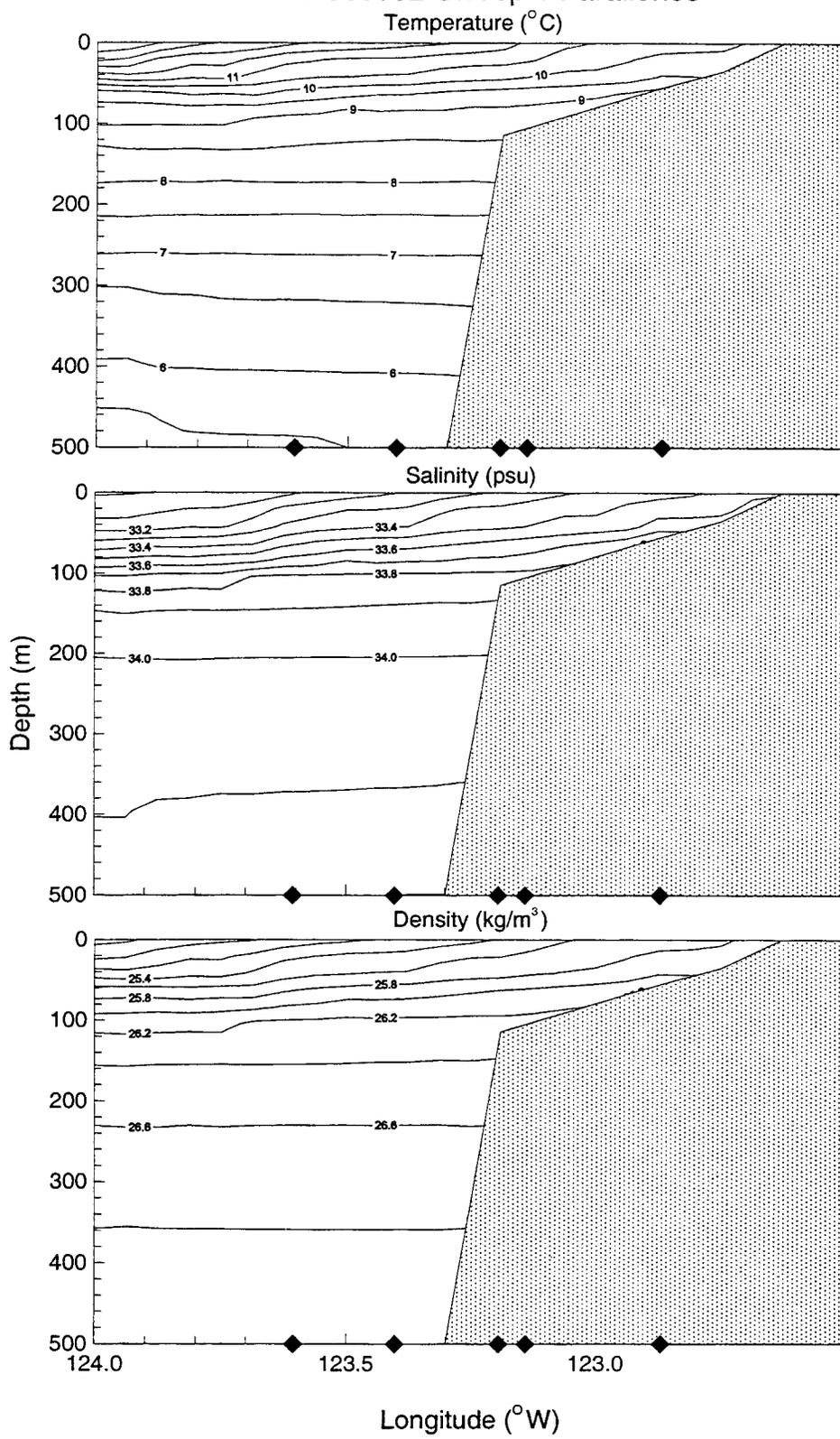
DSJ0002 Sweep 1 Davenport



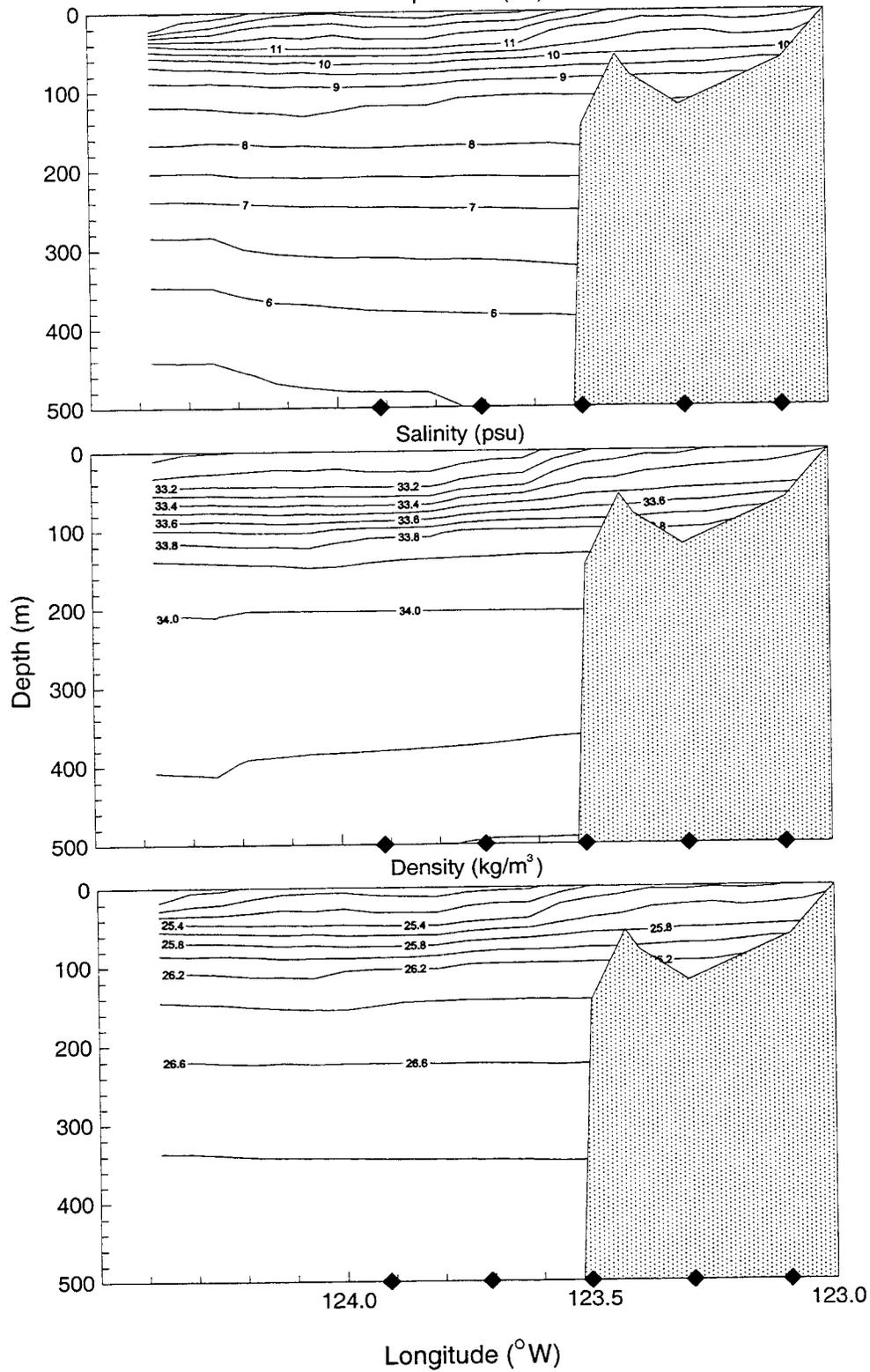
DSJ0002 Sweep 1 Pescadero



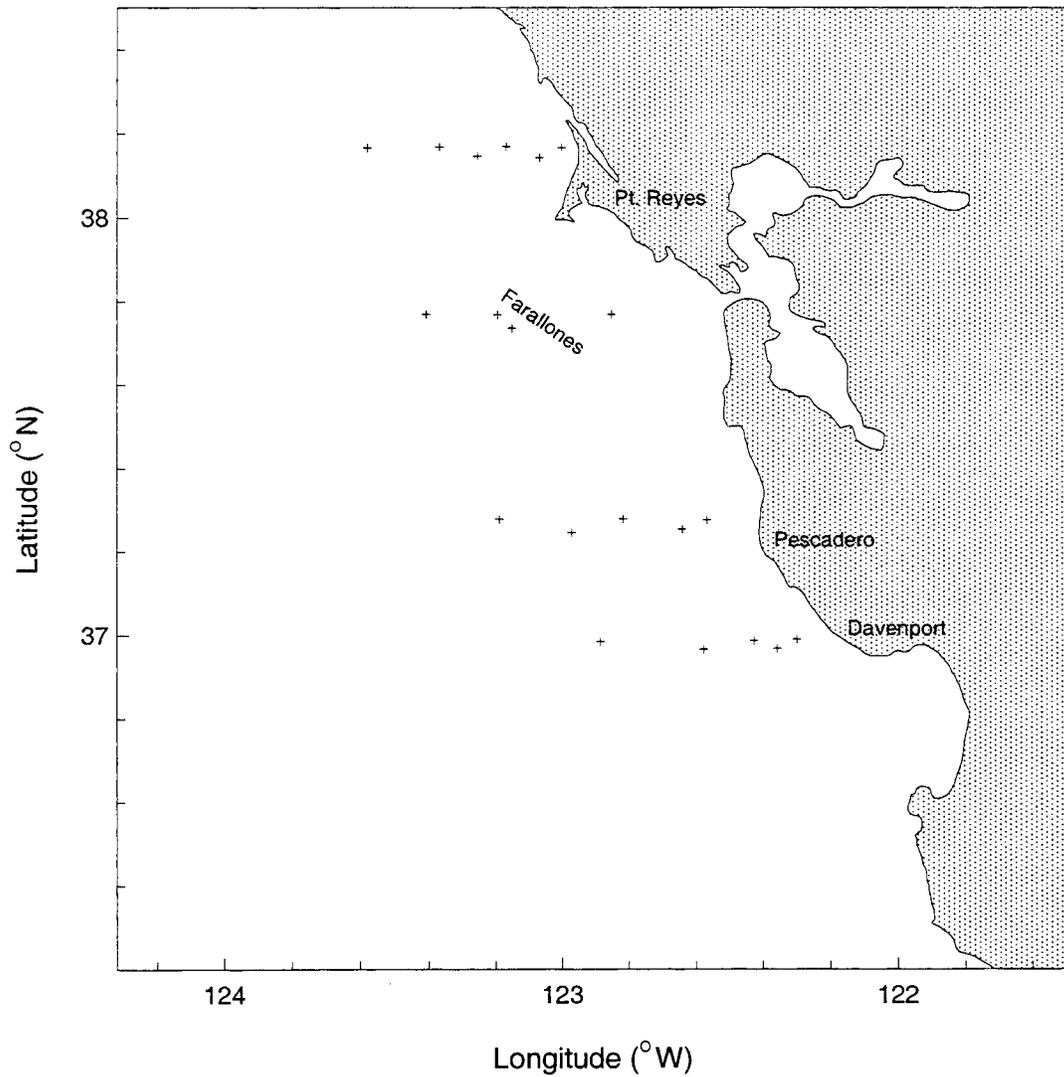
DSJ0002 Sweep 1 Farallones



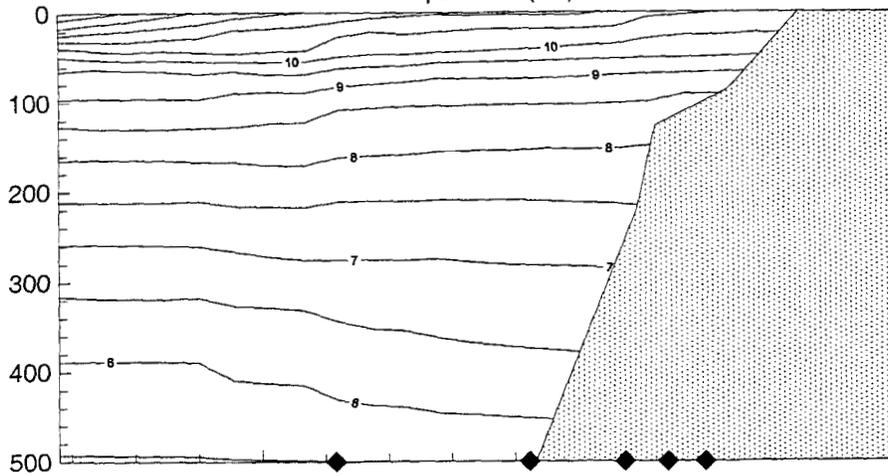
DSJ0002 Sweep 1 Point Reyes Temperature ($^{\circ}\text{C}$)



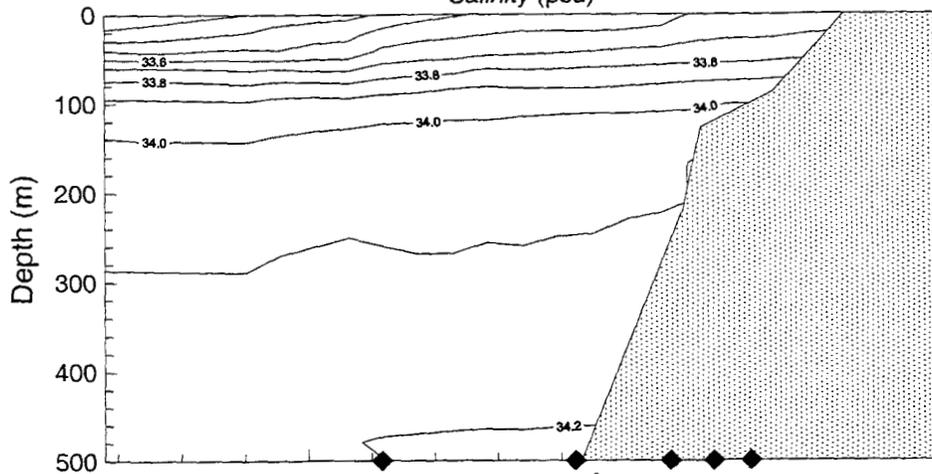
DSJ0002 Sweep 2 Vertical Transect Stations



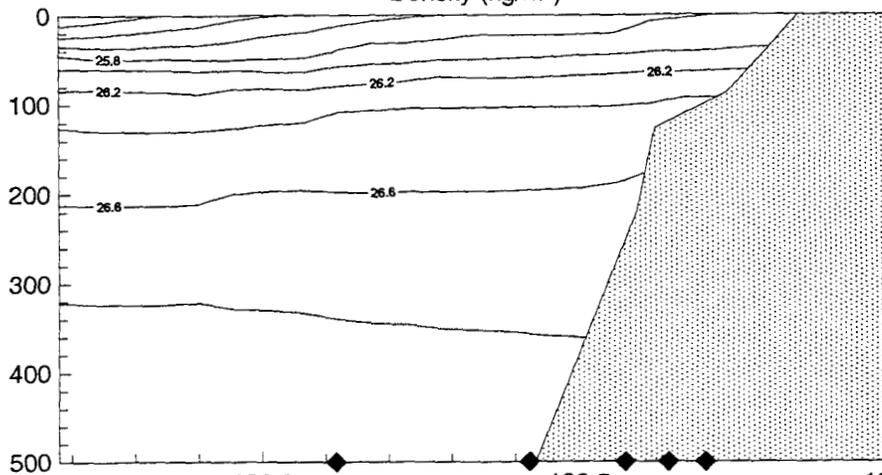
DSJ0002 Sweep 2 Davenport
Temperature (°C)



Salinity (psu)

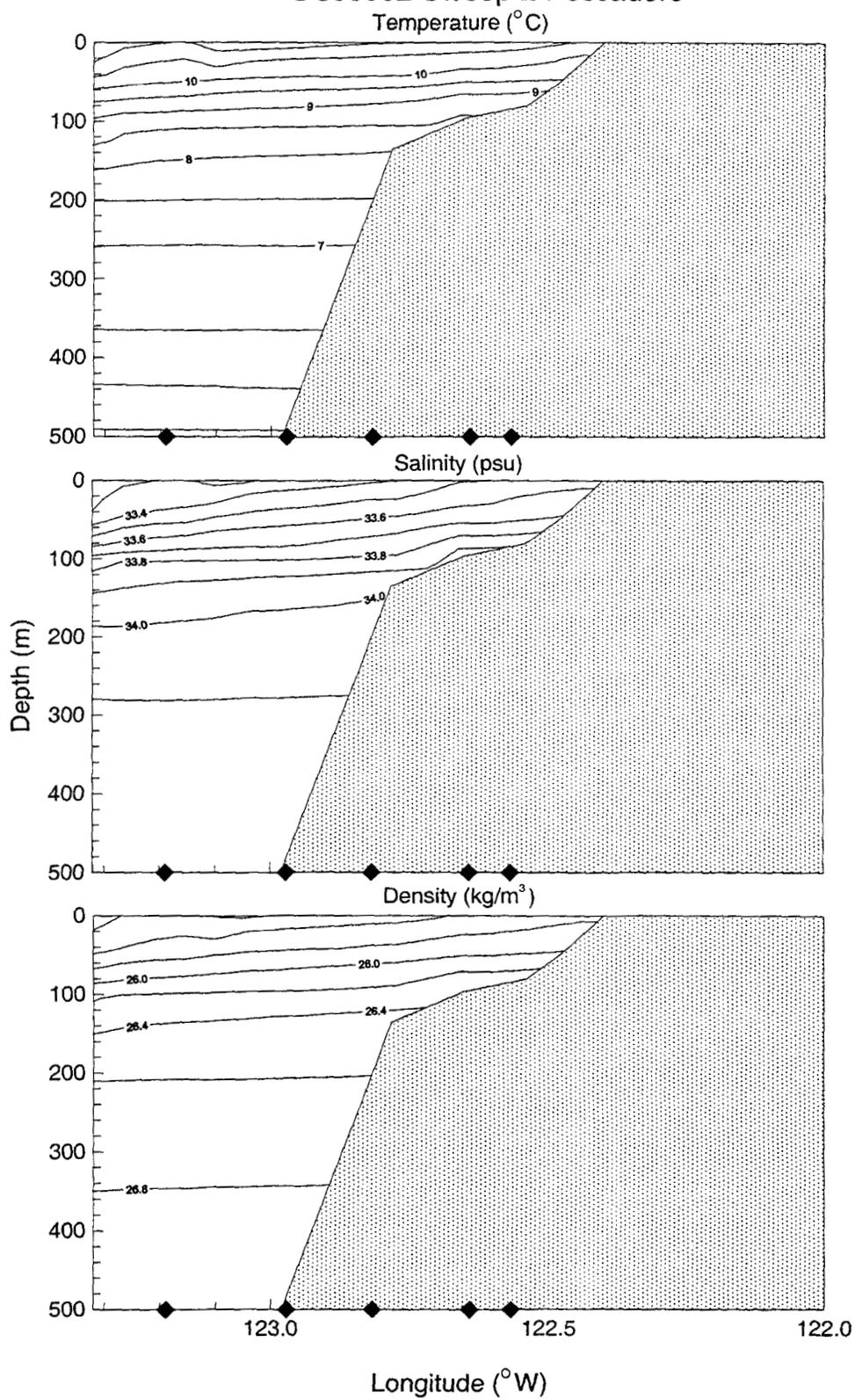


Density (kg/m³)

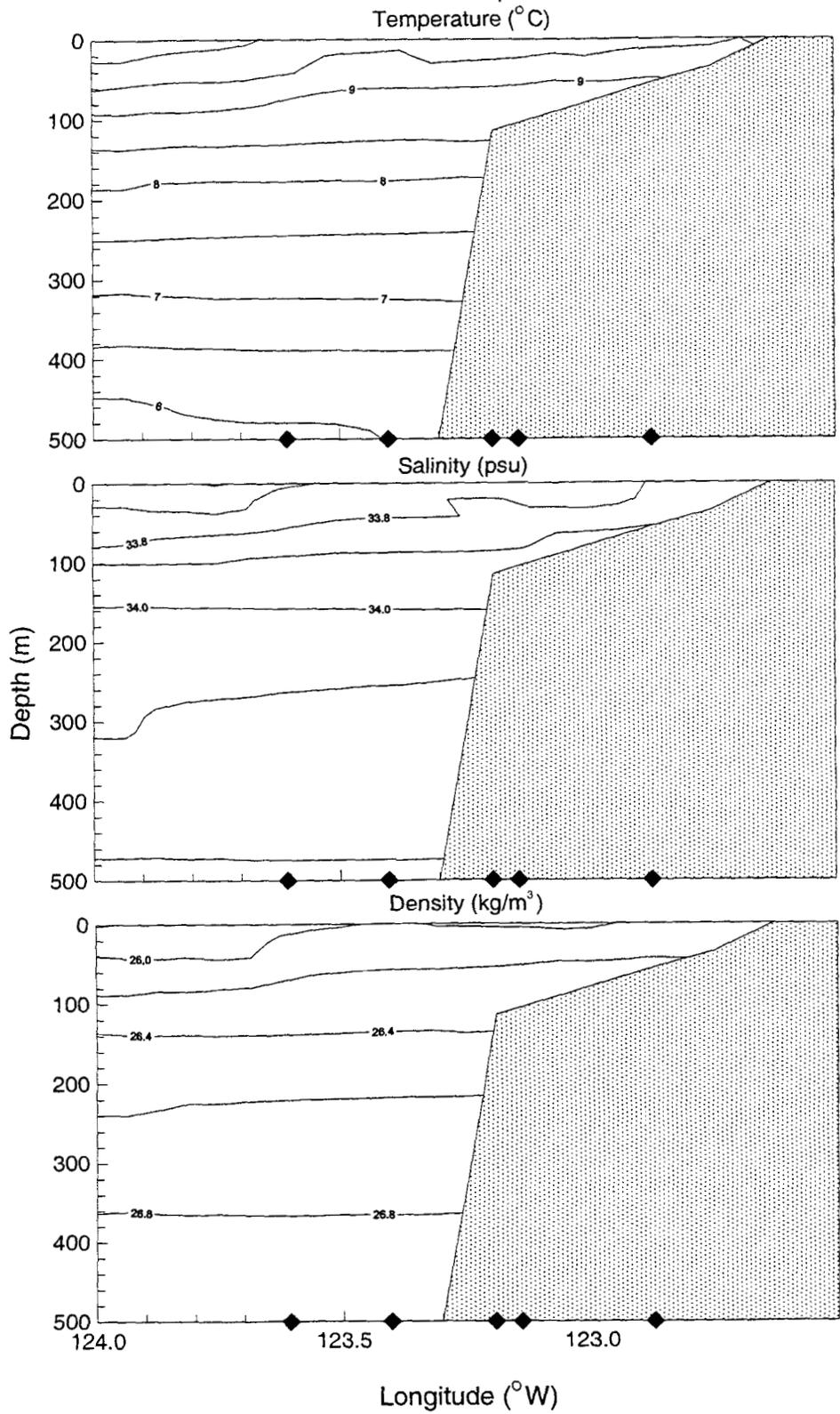


Longitude (°W)

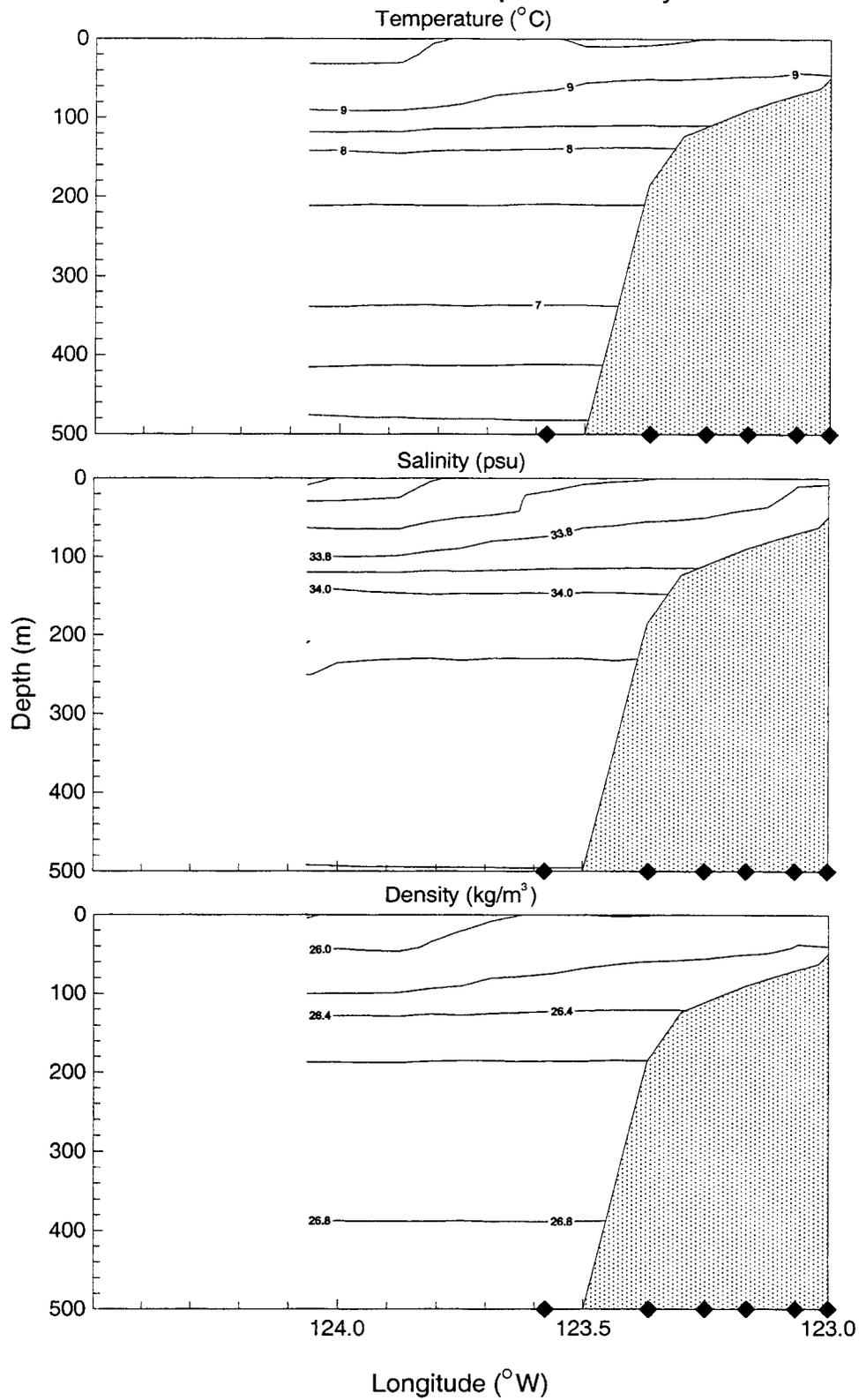
DSJ0002 Sweep 2 Pescadero



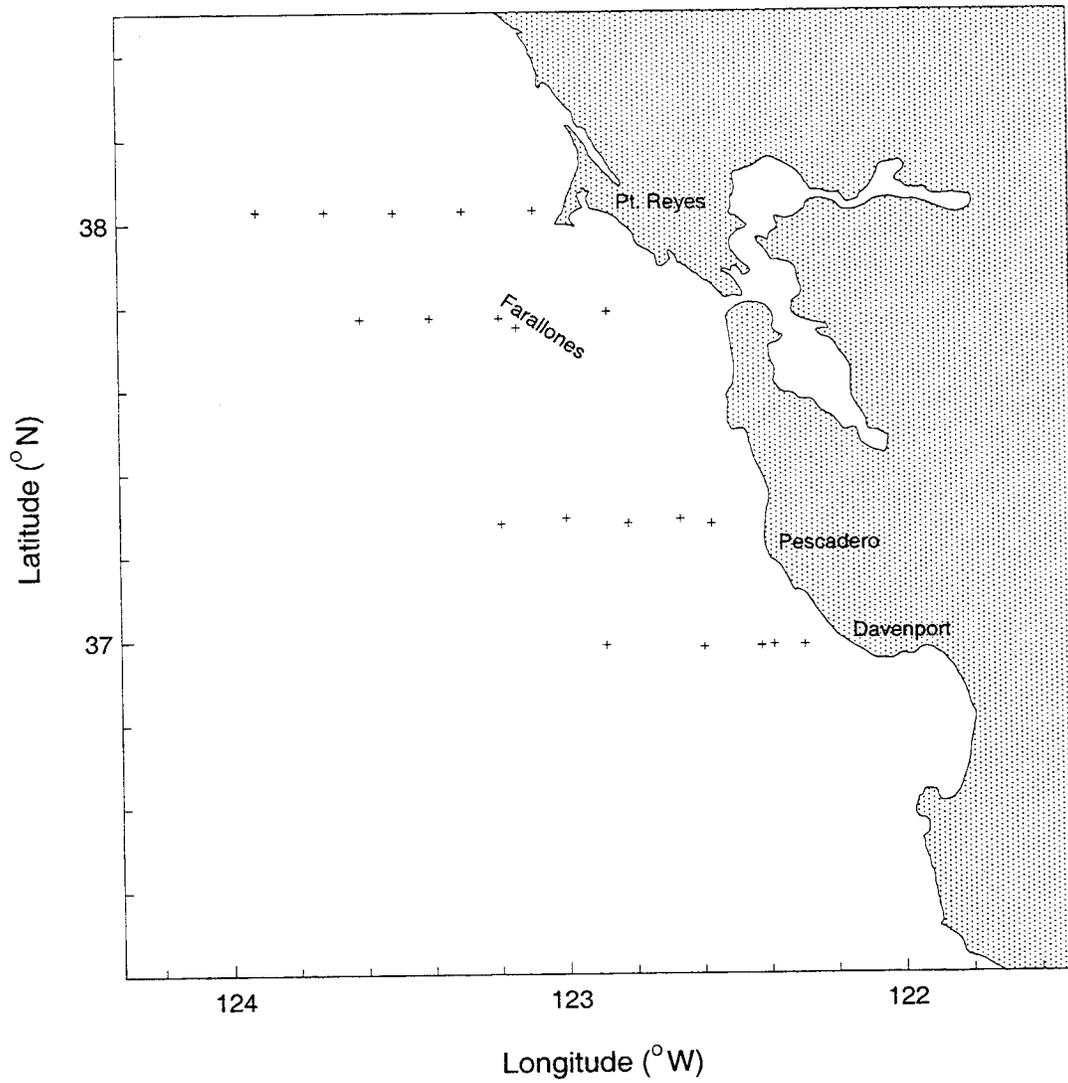
DSJ0002 Sweep 3 Farallones



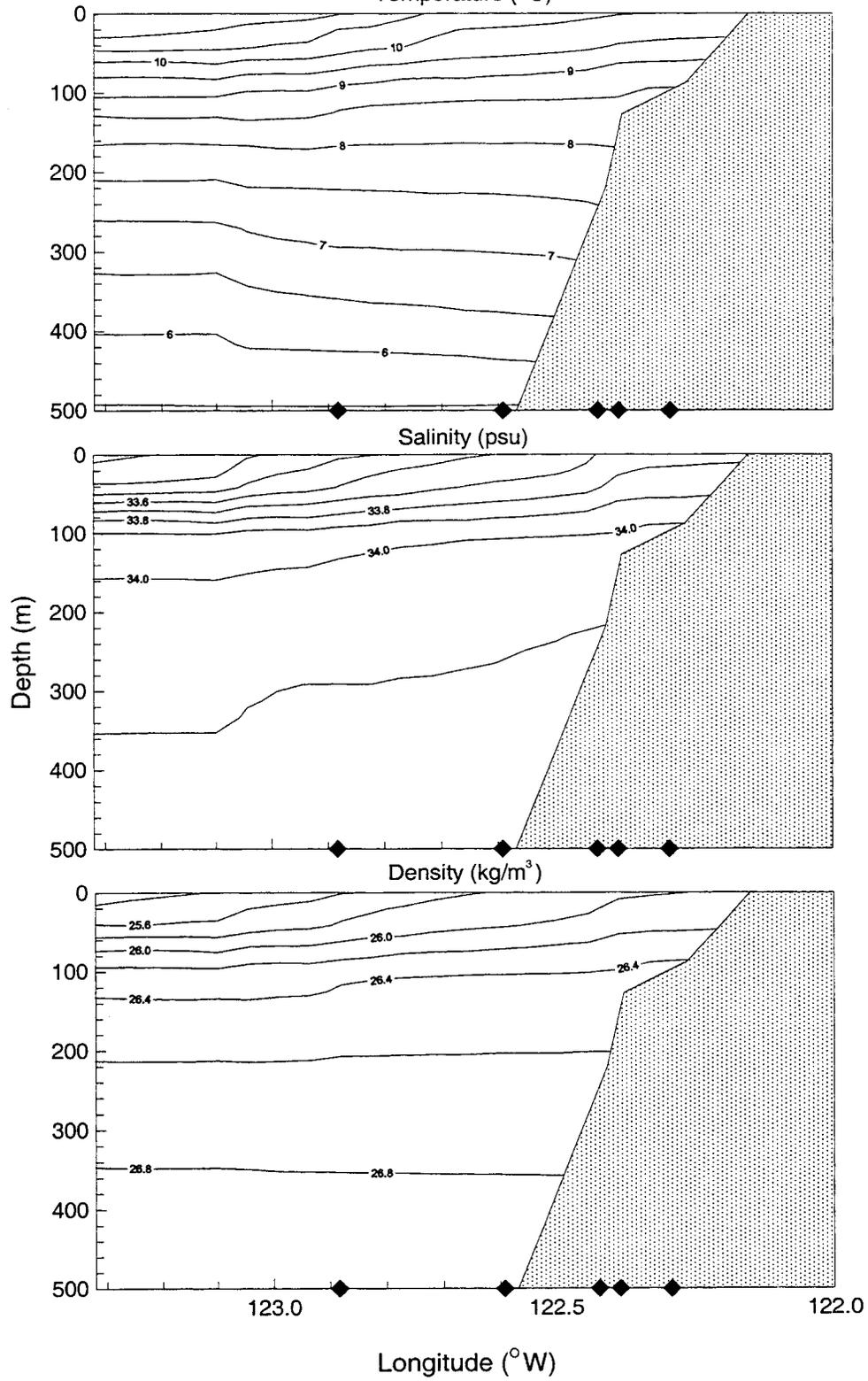
DSJ0002 Sweep 2 Point Reyes



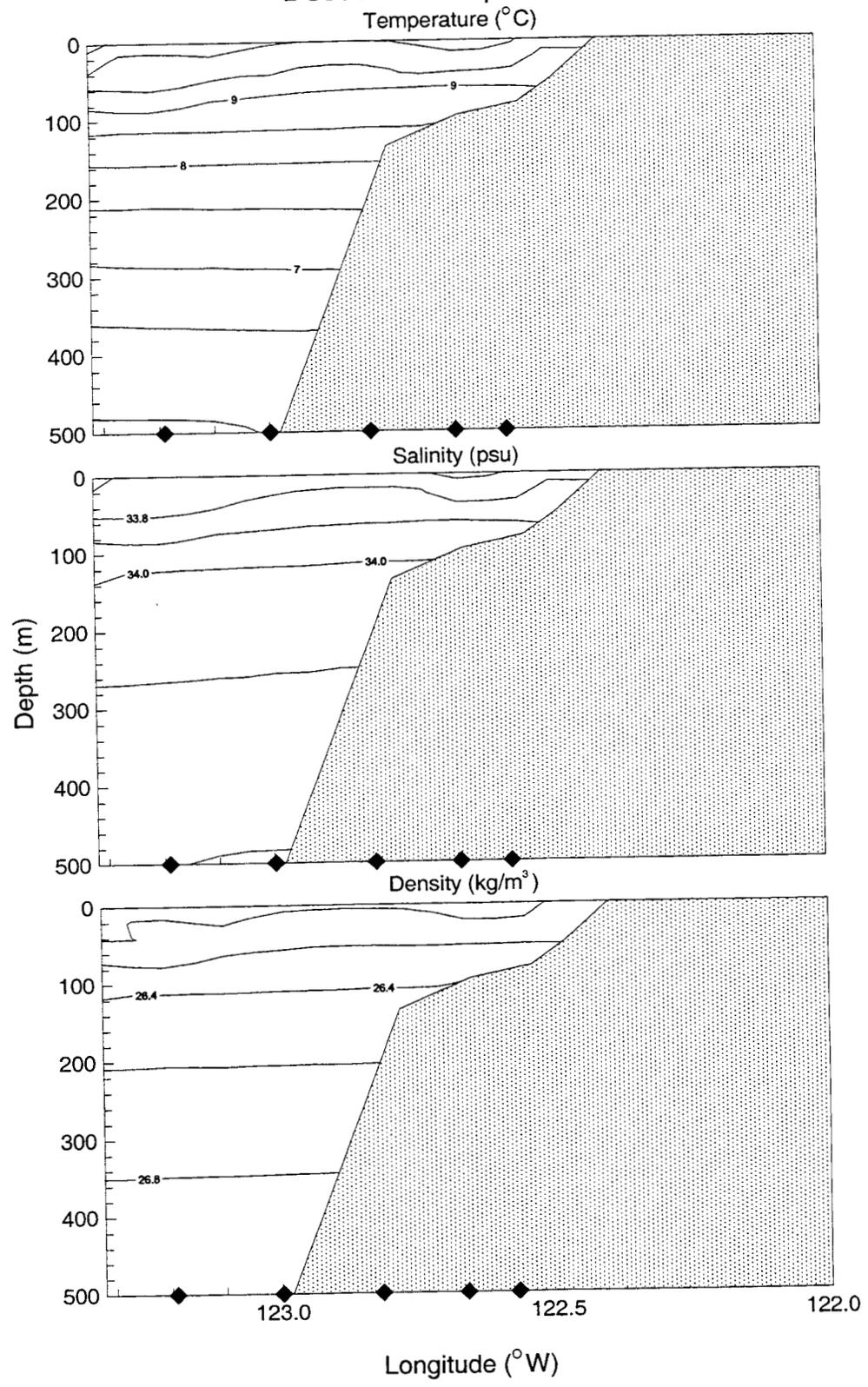
DSJ0002 Sweep 3 Vertical Transect Stations



DSJ0002 Sweep 3 Davenport
Temperature ($^{\circ}\text{C}$)

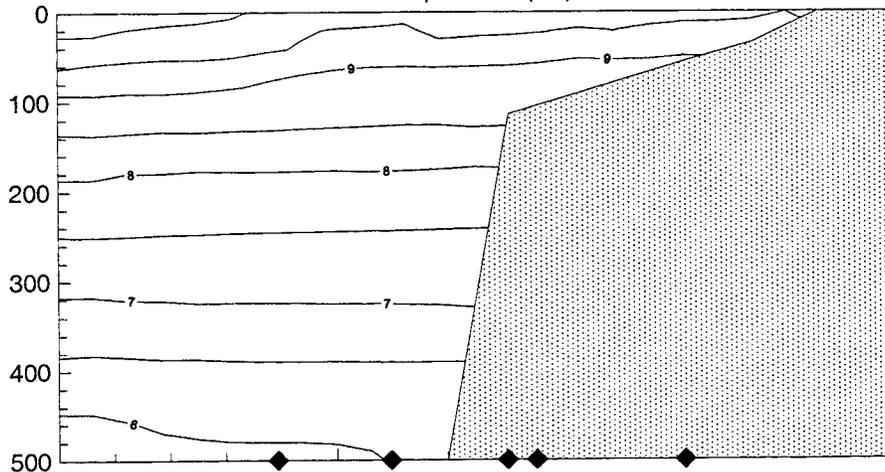


DSJ0002 Sweep 3 Pescadero

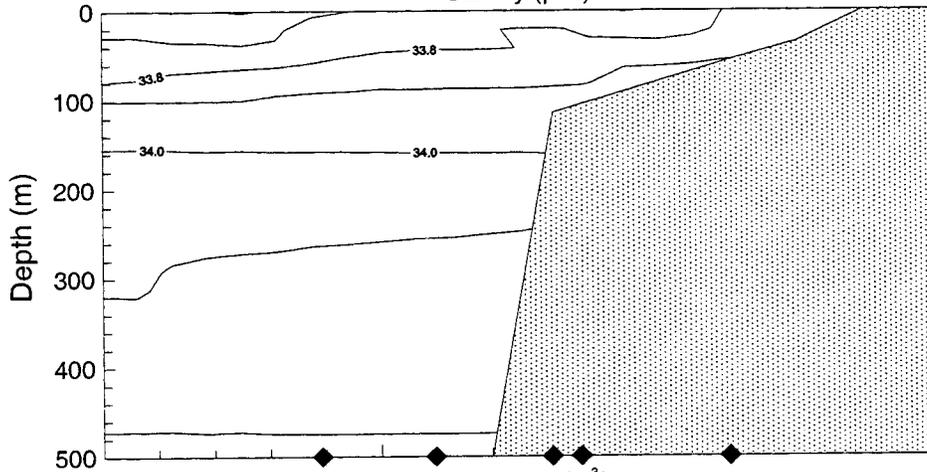


DSJ0002 Sweep 3 Farallones

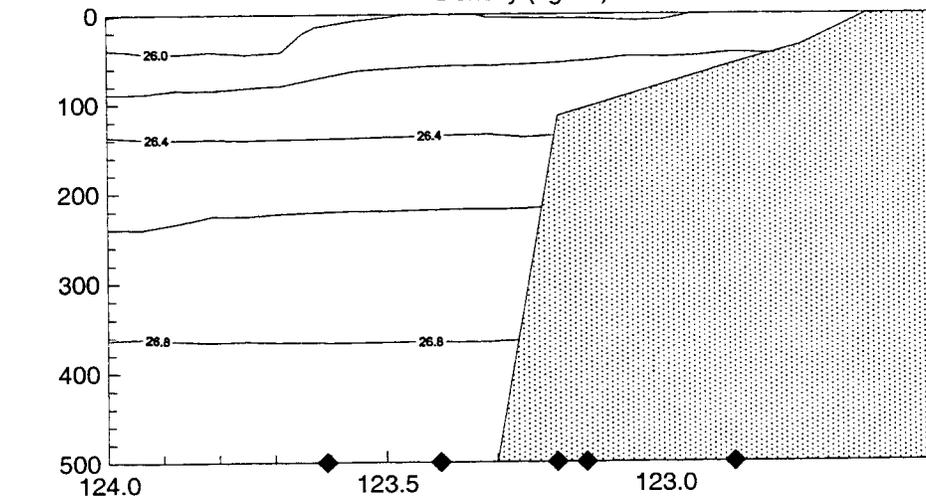
Temperature ($^{\circ}\text{C}$)



Salinity (psu)



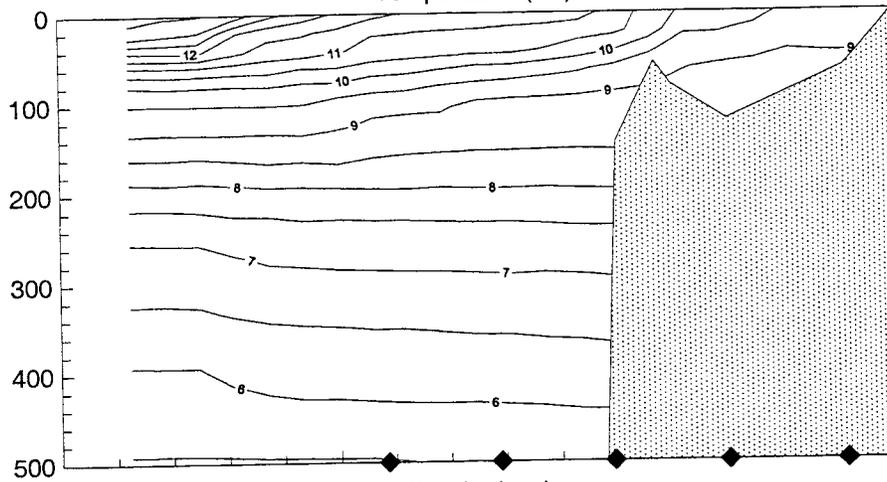
Density (kg/m^3)



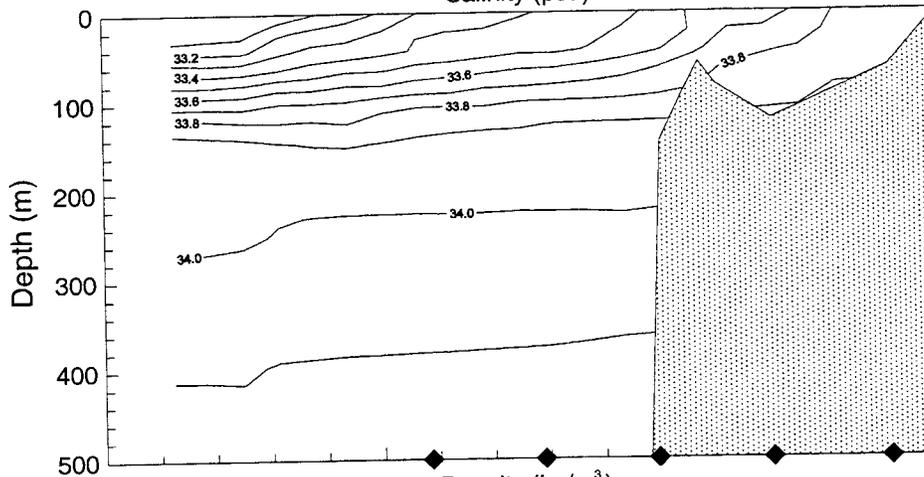
Longitude ($^{\circ}\text{W}$)

DSJ0002 Sweep 3 Point Reyes

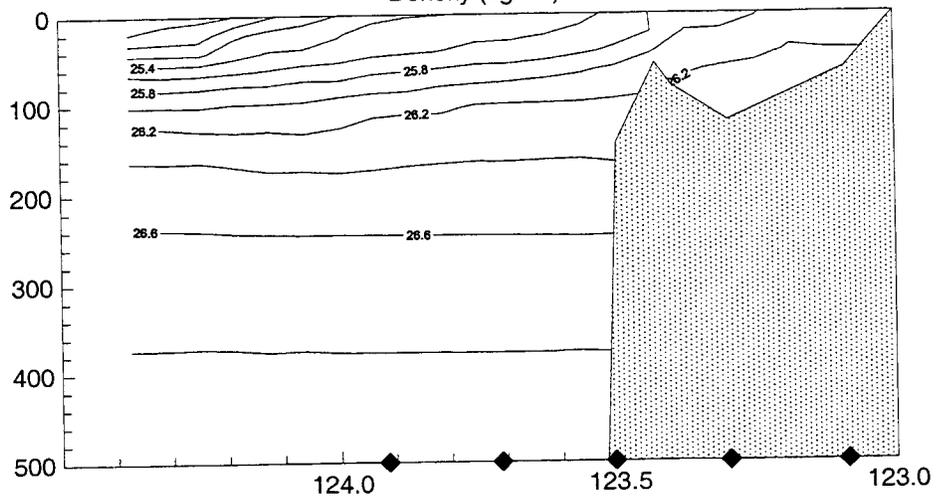
Temperature ($^{\circ}\text{C}$)



Salinity (psu)



Density (kg/m^3)

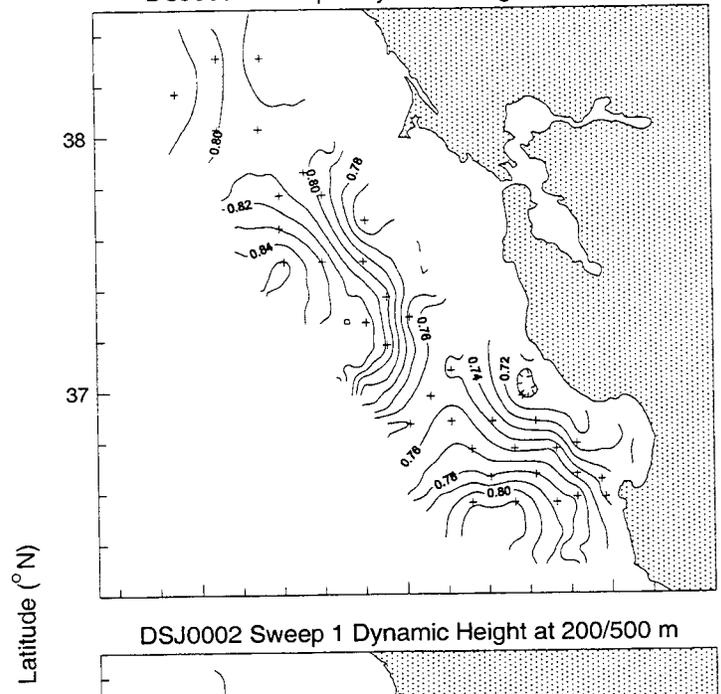


Longitude ($^{\circ}\text{W}$)

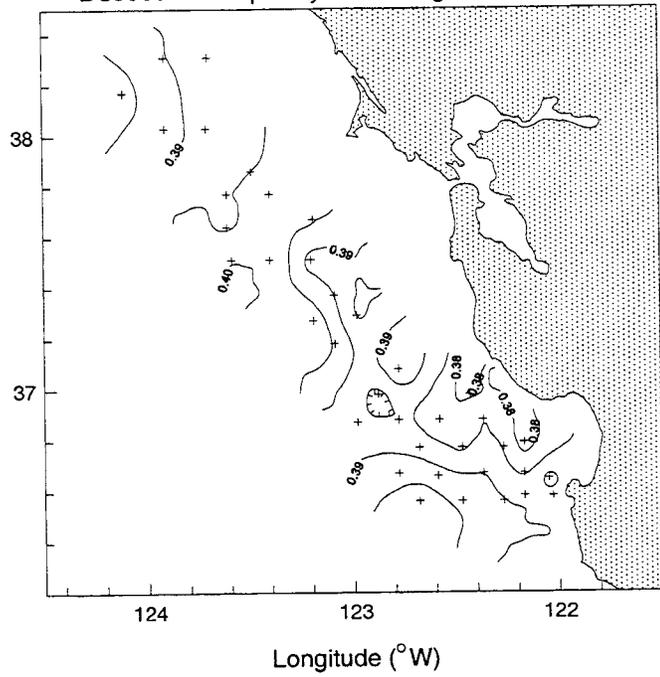
APPENDIX 9: DYNAMIC HEIGHT TOPOGRAPHY FOR DSJ0002

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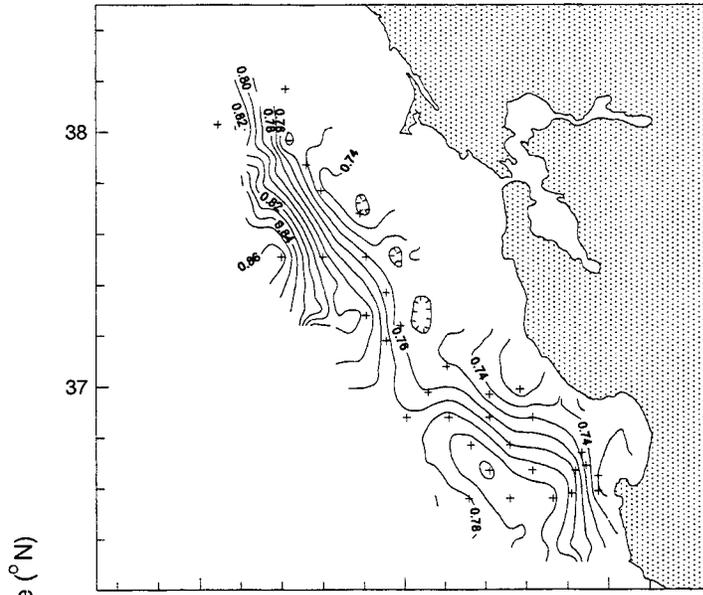
DSJ0002 Sweep 1 Dynamic Height at 0/500 m



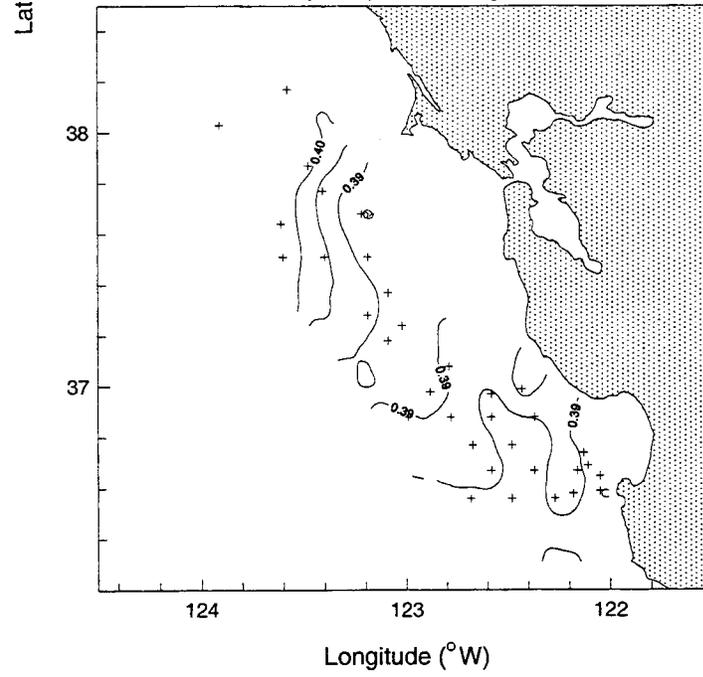
DSJ0002 Sweep 1 Dynamic Height at 200/500 m



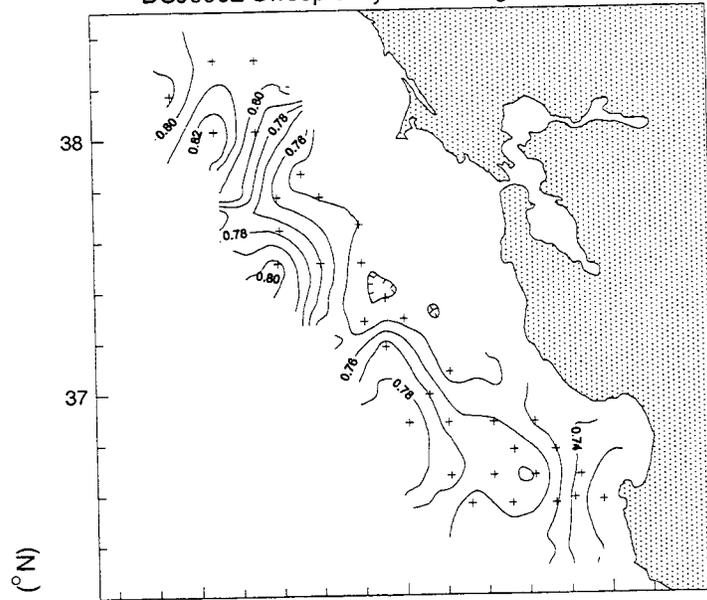
DSJ0002 Sweep 2 Dynamic Height at 0/500 m



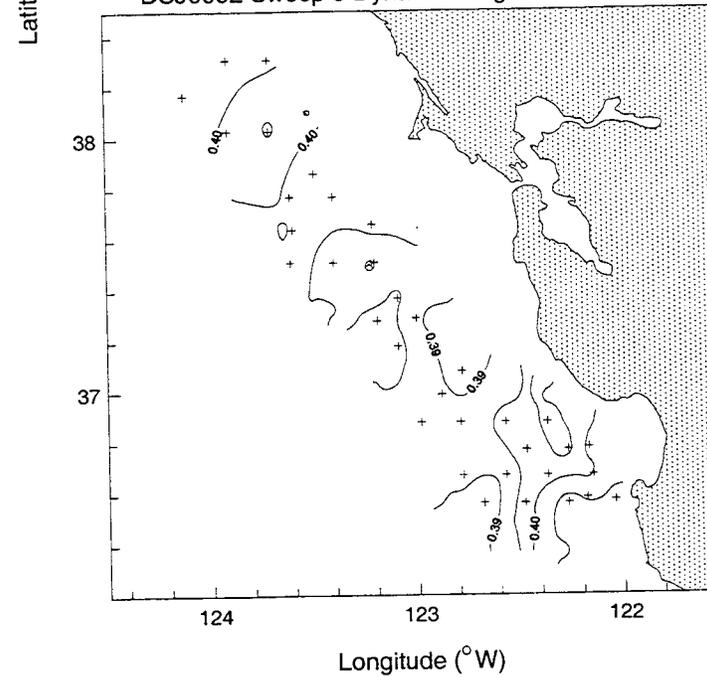
DSJ0002 Sweep 2 Dynamic Height at 200/500 m



DSJ0002 Sweep 3 Dynamic Height at 0/500 m



DSJ0002 Sweep 3 Dynamic Height at 200/500 m



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