SEPTEMBER 1995

THE PHYSICAL OCEANOGRAPHY OFF THE CENTRAL CALIFORNIA COAST DURING MARCH AND MAY-JUNE, 1994: A SUMMARY OF CTD DATA FROM LARVAL AND PELAGIC JUVENILE ROCKFISH SURVEYS

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NOAA-TM-NMFS-SWFSC-221

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

NOAA Technical Memorandum NMFS

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Errata. p. 35-39

NOAA Technical Memorandum NMFS

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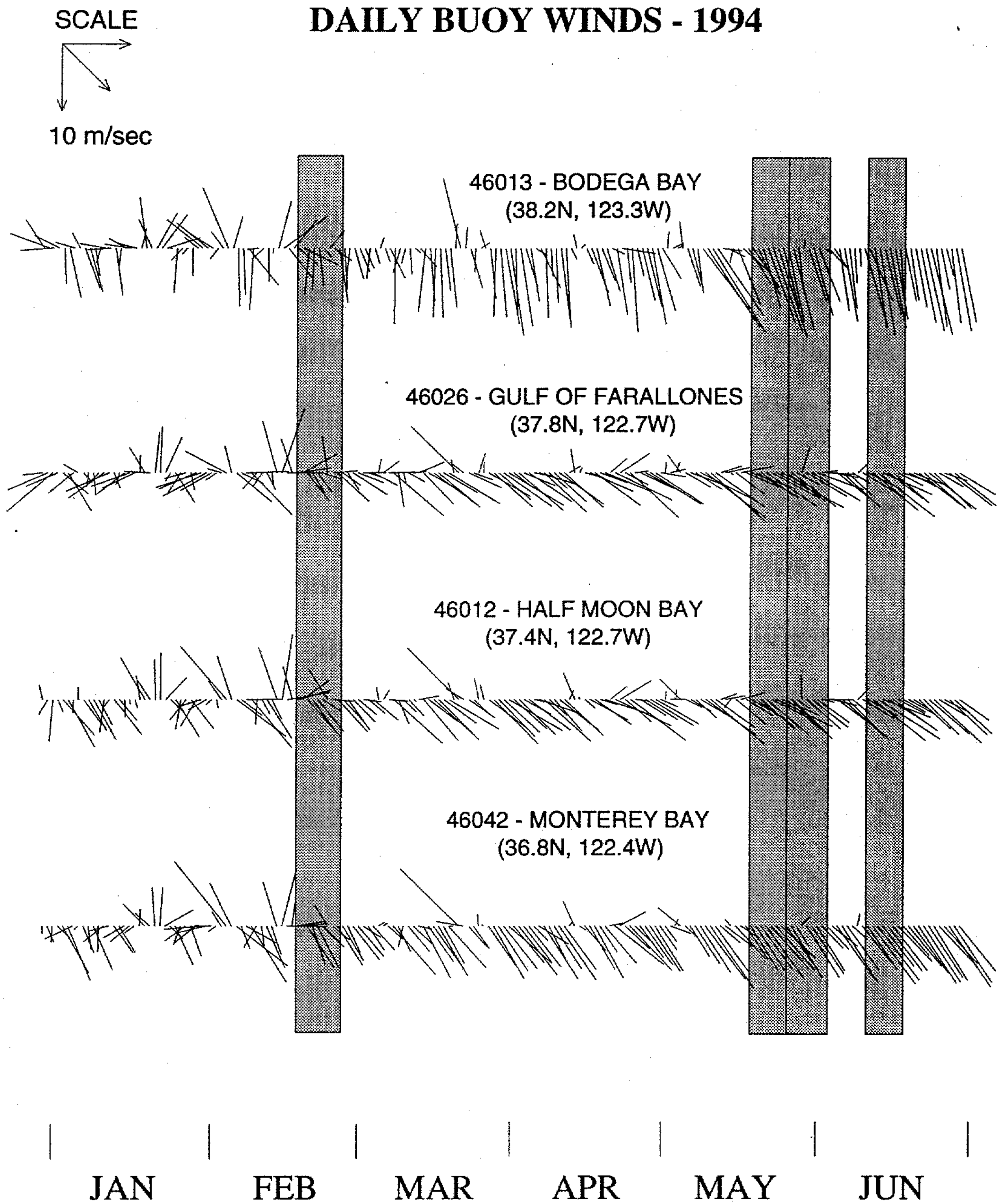
National Marine Fisheries Service
Rolland A. Schmitten, Assistant Administrator for Fisheries

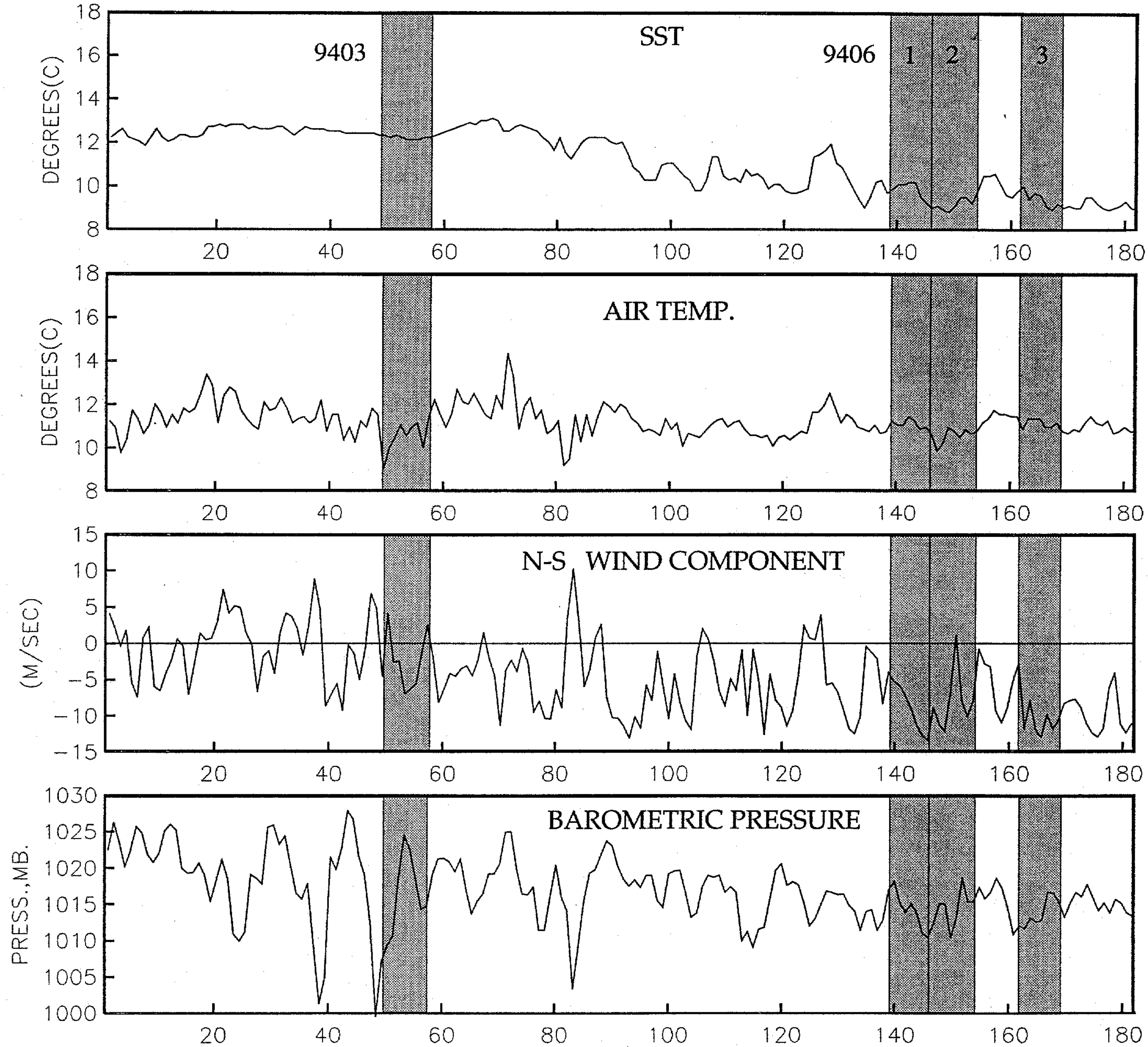
ERRATA

The following set of figures are corrected versions of the 1994 meteorological time series for the NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-221, "The physical oceanography off the central California coast during March and May-June, 1994: a summary of CTD data from larval and pelagic juvenile rockfish surveys" (Appendix 4, pages 35-39) by K.M. Sakuma, F.B. Schwing, H.A. Parker, K. Baltz, and S. Ralston. The wind series in the original figures are incorrect. Please incorporate these in your copy of the Technical Memorandum. We apologize for any inconvenience this may have caused.

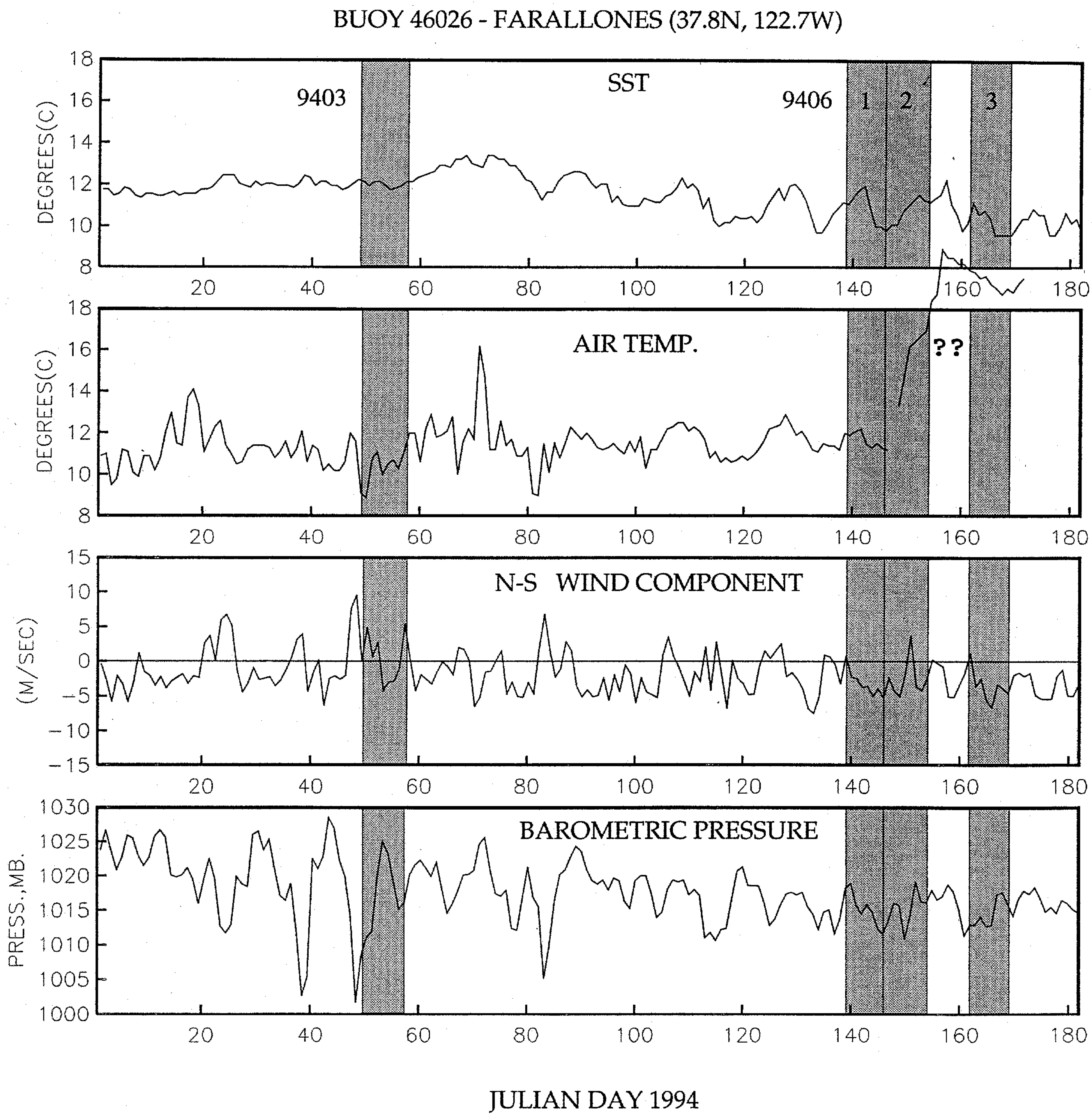
DAILY BUOY WINDS - 1994



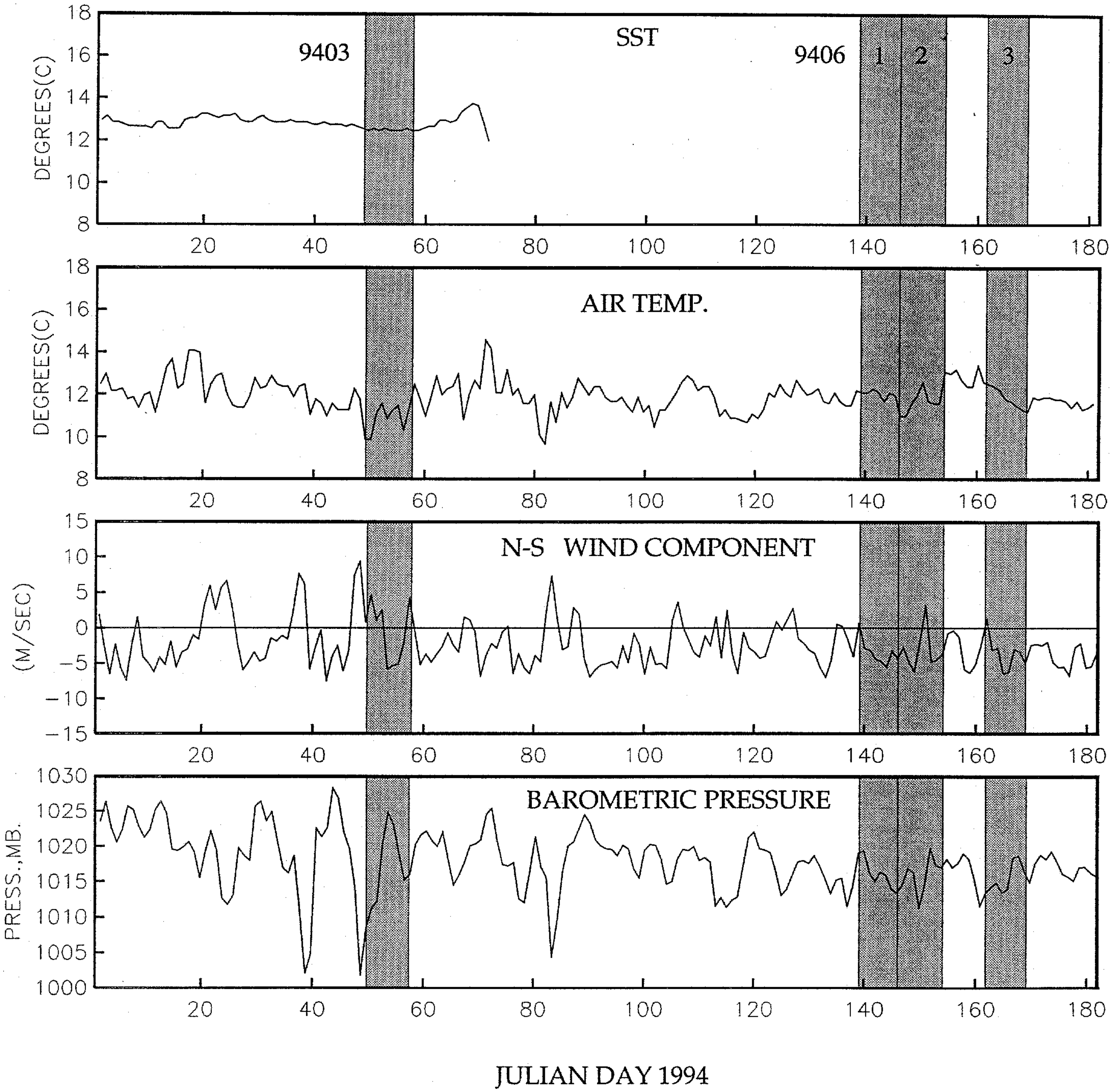
BUOY 46013 - BODEGA BAY (38.2N, 123.3W)



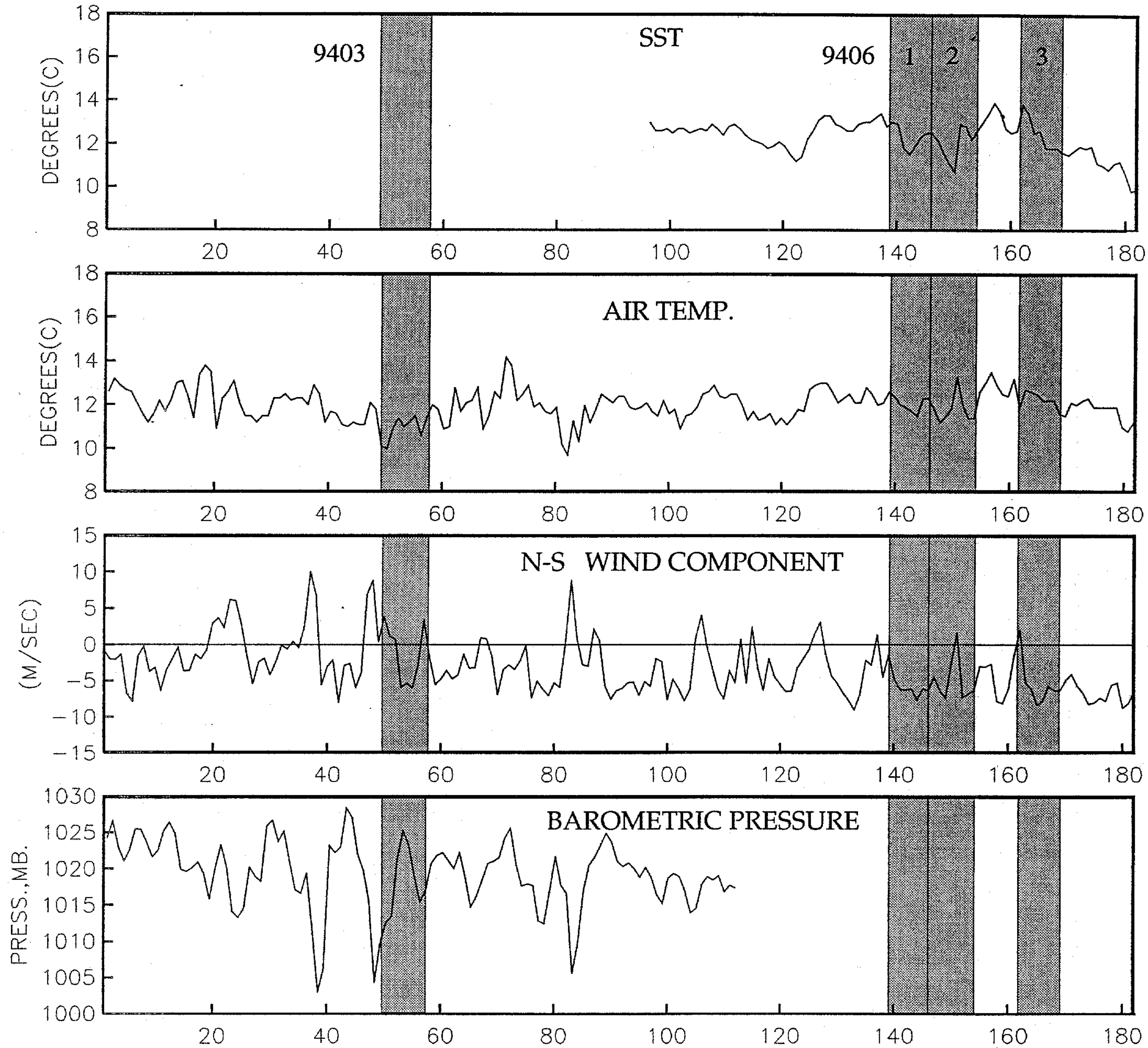
JULIAN DAY 1994


BUOY 46026 - FARALLONES (37.8N, 122.7W)
SST
9403
9406
1
2
3
DEGREES(C)
AIR TEMP.
??
N-S WIND COMPONENT
(M/SEC)
BAROMETRIC PRESSURE
PRESS.,MB.
JULIAN DAY 1994

BUOY 46012 - HALF MOON BAY (37.4N, 122.7W)



BUOY 46042 - MONTEREY BAY (36.8N, 122.4W)



JULIAN DAY 1994

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ABSTRACT

Hydrographic conditions during a 9-day period in early March 1994 in the area bounded by Cypress Pt. (36°35'N) and Bodega Bay (38°20'N), California, from the coast to approximately 240 km offshore are summarized in a series of horizontal maps and vertical transects. In addition, hydrographic conditions, during three periods of approximately ten days each from mid-May through mid-June 1994 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 also summarized. A total of 71 conductivity-temperature-depth (CTD) casts were obtained during the *David Starr Jordan* cruise DSJ9403, while 235 standard casts were taken during cruise DSJ9406 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 each 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 from advanced very high resolution radiometer (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

In recent years, attempts have been made to integrate the studies of fisheries biologists investigating the recruitment problem (Sissenwine 1984; Rothschild 1986) with those of physical oceanographers studying coastal circulation patterns. This development is due to the widely held perception that spatial and temporal variations in hydrodynamics, on a wide range of scales, have a direct influence on the retention of young-of-the-year in areas favorable for their growth and survival (e.g., Sinclair 1988). This realization has fostered the development of interdisciplinary studies in the area of recruitment fisheries oceanography (Wooster 1988; Office of Oceanic and Atmospheric Research 1989[1]).

Along the central California coast, rockfishes of the genus *Sebastes* are a major component of the west coast groundfish fishery (Gunderson and Sample 1980), with annual landings from 1985-93 averaging 32,740 MT yr^{-1} (Pacific Fishery Management Council 1994). Current management of the rockfish fishery is based largely on analyses of catch-at-age data. Such models are usually poorly constrained in the absence of other information (Deriso et al. 1985). Auxiliary data, such as an independent recruitment index, have the potential to assist in the management of this fishery.

Research conducted at the Southwest Fisheries Science Center's (SWFSC) Tiburon Laboratory since 1983 has attempted to develop a recruitment index for rockfish. Data obtained during annual juvenile rockfish surveys 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*; bocaccio, *S. paucispinis*; and shortbelly rockfish, *S. jordani*). Moreover, extreme interannual fluctuations in abundance have occurred, with combined stratified mean catches per haul ranging from 0.1-78.6 juvenile rockfish/tow (Eldridge 1994[2]).

Field studies have shown that the survey region is hydrodynamically complex. The California Current provides the backdrop for large-scale, seasonal circulation patterns (Hickey 1979). Coastal upwelling also 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 (Applied Environmental Science Division[3]) add further complexity to the circulation regime.

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[1]Office of Oceanic and Atmospheric Research. 1989. Program Development Plan for the NOAA Recruitment Fisheries Oceanography Program. National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Washington, D.C., 28 p.

[2]Eldridge, M. B. (editor). 1994. Progress in rockfish recruitment studies. SWFSC Admin. Rep. T-94-01, 55 p., unpublished report.

[3]Applied Environmental Science Division. Final Report, California Seabird Ecology Study. Volume II, Satellite Data Analysis. Science Applications International Corporation, Monterey, California.

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 Tiburon Laboratory's annual juvenile rockfish surveys. In the spirit of Wooster (1988), the staff of the SWFSC Pacific Fisheries Environmental Group subsequently developed an interest in analyzing the CTD data and were enlisted 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 1994. 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), 1992 (DSJ9203 and DSJ9206), and 1993 (DSJ9304 and DSJ9307) have been published (Schwing et al. 1990; Johnson et al. 1992; Sakuma et al. 1994a; Sakuma et al. 1994b). A companion volume (Schwing and Ralston 1990[4]) 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

Meteorological Data

Meteorological data were obtained for selected sites in the juvenile rockfish survey region. These sites include the region's four National Data Buoy Center (NDBC) moored buoys: 46013 (Bodega Bay; 38.2°N, 123.3°W), 46026 (Farallones; 37.8°N, 122.7°W), 46012 (Half Moon Bay; 37.4°N, 122.7°W) and 46042 (Monterey Bay; 36.8°N, 122.4°W) (Appendix 3). Daily averages of several surface meteorological parameters, including air and sea temperature, east and north wind components, and barometric pressure, were calculated for the time period that includes the 1994 late larval and juvenile rockfish surveys. Plots of several of these products are provided in this report to aid in the interpretation of results and to suggest possible atmospheric-oceanic interactions (Appendix 4).

Sea Surface Temperature Data from AVHRR Satellite Imagery

AVHRR (Advanced Very High Resolution Radiometer) satellite images were transmitted to the NOAA Research Vessel (R/V) *David Starr Jordan* (DSJ) 12-48 hours after a NOAA-11 polar orbiting satellite pass, from the NOAA CoastWatch Group in La Jolla, CA. The NOAA CoastWatch Group first received the images as geographically corrected HRPT image files from Ocean Imaging Co. of San Diego. The image files were checked for excessive cloud/fog cover and if clear enough were then calibrated into radiances from the satellite sensor's channels. These radiances were then converted into sea surface temperatures. 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 IMGMAP image file of approximately 270 kilobytes which can be read and analyzed by the PC based CCOAST or WIM software. CCOAST is a color satellite image display program developed by NOAA and NASA which operates in the MS-DOS environment. WIM (Windows Image Manager) is a Windows

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[4]Schwing, 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.

application that displays color and grayscale satellite images and was developed by Mati Kahru of Scripps Institution of Oceanography. The IMGMAP image files were compressed and downloaded to the Ship's PC by using a cellular telephone, a cellular telephone modem interface, and a commercial modem communications software. Modem to modem transmission rate averaged 6000-7000 bits per second. Once an image was received, the CCOAST and WIM software was used to decompress, display and manipulate the satellite image in order to discern temperature gradients and areas of upwelling activity. All images which were clear or relatively clear of clouds/fog were saved on a PC computer and stored at the Southwest Fisheries Science Center, Tiburon Laboratory as part of the Oceanographic database system. Five clear images were acquired during the March 2-10 late larval rockfish survey (DSJ9403) and thirty-one clear images were acquired during the May/June juvenile rockfish survey (DSJ9406).

ADCP Data Processing

Acoustic Doppler current profiler (ADCP) data were collected with an RD Instruments 150 kHz, hull-mounted transducer on the NOAA R/V DSJ. The data acquisition software (DAS) was provided by the manufacturer and data were logged using a 386-based PC. These data were processed at Pacific Fisheries Environmental Group with a series of post-processing programs described in Jessen (1992) and Jessen et al. (1992).

The data were collected in 64 depth bins, each 8 m deep, and averaged over 180 seconds into one ensemble. The onboard Magnavox Global Positioning System provided navigation information to the acquisition software. Information from the Sperry Gyrocompass allowed transformation of x-y coordinates to latitude and longitude coordinates. The first 4 m of the data were blanked as the depth of the transducer heads was 3 m, resulting in the 7-15 m bin providing the shallowest, usable data. The bottom tracking feature was employed only during the routine calibration-run segment of data collection. In general, bottom tracking is used in water shallower than 400 m, but for the purposes of this series of cruises, and for clearer post-processing, the bottom-tracking option was left off during the bulk of data collection.

A calibration run was conducted at the beginning of the cruise for the purpose of collecting data that would later quantify the rotation and sensitivity errors in the ADCP data. The rotation error (α) has two components: alignment error between the ship's centerline and the mounted instrument's orientation, as well as the gyrocompass error. The sensitivity errors (β), caused by errors in the beams' geometry, are generally small but important to quantify. The computation of these errors was guided by the methods prescribed in Joyce (1989). The calibration coefficients for this cruise were: $\alpha = 1.377$ and $\beta = 1.000$. The raw Doppler data were rotated by α and multiplied by $1+\beta$ prior to post-processing.

Initial processing required correction of navigation data followed by computation of ship's velocity from these data. Geographic positions as recorded by the DAS were checked for obvious "bad" points and, if necessary, were corrected by interpolation. From these, clean navigation data were generated for the $\boldsymbol{u}$ (eastward) and $\boldsymbol{v}$ (northward) components of ship velocity.

Subsequent processing involved determining the depth (bin number) to which data remained reliable for each three-minute ensemble. This depth of reliable data was a function of the bottom depth or the Percent Good Return (PGR). PGR is the percentage of data returns (pings) for a particular ensemble with good solutions, based on a signal-to-noise threshold or error velocity. PGR values below 50% were defined as poor data, and all data in the ensemble deeper than that were eliminated from further analysis.

The bottom depth provided another limit for the deepest bin of good data when the ship passed over the continental shelf. Bottom depth is evident when the bottom tracking feature is on or if there is a sharp subsurface increase in the AGC signal. The deepest bin as determined by PGR or bottom depth was defined as the bin to which data remained reliable for a particular ensemble.

Calculation of a reference layer velocity was the next step. A reference layer width of three bins (24 m) was chosen for these data. Choosing a reference layer depth was somewhat arbitrary, yet followed a general criteria of choosing one deep enough that the velocity within the referenced layer was nearly constant, yet shallow enough that all or nearly all the ensembles being processed had good data down to the depth of their reference layer. The bins used to define a reference layer varied between data sets.

An absolute reference layer velocity was calculated by subtracting the ship's velocity components, determined from the navigation data, from the components of the raw reference layer velocity. A low-pass filter with a cutoff period of 30 minutes was then applied to this absolute reference layer velocity to smooth the data. These smoothed absolute reference layer velocities were used for adjustment of the raw velocity profiles of each three-minute ensemble, resulting in the final absolute water velocity profiles. As a final check, bad data were determined from a visual examination of each profile and removed.

<u>Late Larval Rockfish Survey Design</u>

In early March of 1994, a 10 m^2 multiple opening closing net environmental sensing system (MOCNESS) was used to sample late larval stage rockfish in the area bounded by Cypress Pt. (36°35'N) and Bodega Bay (38°20'N) from the coast to approximately 240 km offshore (Appendix 3). At each station five nets were utilized to collect samples at various depths. Samples were collected during the day and at night aboard the R/V DSJ. A CTD cast was done at each MOCNESS station.

<u>Juvenile Rockfish Survey Design</u>

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 as 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. Trawls are now conducted at five or six stations along a transect each night; each sweep is composed of seven transects. 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 3). 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 3 nights of additional discretionary sampling), adverse weather conditions can extend the completion date 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.

Collection of CTD Data at Sea

All CTD data from the 1994 rockfish surveys presented in this report were collected with two Sea-Bird Electronics, Inc., SEACAT-SBE-19 profilers[5]. These particular units were both rated to a depth of 600 m and contained 256K of memory. 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), and conductivity (0.001 S/m from 0 to 7 S/m) at a baud rate of 9,600. Dual casts using both units yielded similar profile data for temperature and salinity. Both profilers have been recalibrated annually by Sea-Bird Electronics, Inc., prior to their 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 and temperature sensors to equilibrate. The rate of descent was 45 m/minute to a depth 10 m off the bottom if water depths were less than 500 m. Otherwise the profiler was lowered to a maximum depth of 500 m. During DSJ9406 the maximum depth was extended to 520 m to insure collection of data at 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, and (9) bottom depth in meters. Position fixes were obtained using the Global Positioning System (GPS). All collection information recorded on the data sheets was eventually entered into a data file (####.LST where #### is the four-digit cruise number) on a personal computer.

Data collected from a short series of casts (usually no more than 5-7) were periodically uploaded to a personal computer on board the vessel. During this step, each cast was stored as a separate file and named using the convention C####&&&.HEX, where #### is the four-digit cruise number and &&& is the three-digit consecutive index number. After uploading, the profiler was reinitialized and the *.HEX files on the personal computer were backed up on diskette.

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 stored on diskette and transferred to a personal computer on board the vessel for further processing, analysis, and comparison with and verification of CTD observations. Position fixes for the TS unit were based on GPS.

Data Processing

The first step in data processing was to convert the uploaded CTD *.HEX files to ASCII files. This was accomplished using programs supplied by Sea-Bird Electronics, Inc., in SEASOFT menu-driven release Version

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[5]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.

4.201[6]. All *.HEX files were batch-processed through the SEASOFT modules DATCNV, FILTER, ALIGNCTD, LOOPEDIT, BINAVG, and DERIVE (see Appendix 1 for data settings) and output as ASCII files using SAS macros (SAS 1988[7]). All data were averaged into two-meter depth bins and subsequently transferred to a SUN file server.

Each CTD ASCII file was 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, and bucket temperature at each CTD station using a simple regression to check for data outliers and any blatant calibration problems (Appendix 7). During DSJ9406 the TS unit began to malfunction and was subsequently replaced on June 8, 1994. In addition, the thermometer used to measure bucket temperatures was broken on June 12, 1994 and subsequently replaced. Therefore, because both the TS unit and the bucket temperature thermometer were replaced at approximately the same time, separate comparisons were done on data obtained from May 18-June 8 (CTD casts 1-215) and from June 11-June 18 (CTD casts 217-295).

Processed hydrographic data were summarized, by sweep, in a series of horizontal maps and vertical transects, and are presented in this report. Although additional CTD casts were completed during DSJ9406, only casts from the grid of standard CTD stations and only those casts which provided a relatively continuous sampling track within a specific sweep were included in the data summary for the horizontal maps (Appendix 8). 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 transects from the three sweeps of DSJ9406 were also spatially standardized (Appendix 9). However, the Farallones transect line was less synoptic than the Pt. Reyes, Pescadero, and Davenport 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 transect contours nearshore. All contouring of CTD data for horizontal maps and vertical transects was done using SURFER Version 4.0 graphics software[8], 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). Horizontal and vertical contours were post-processed using FREELANCE Version 4.0 graphics software[9] .

The TS raw data were edited to provide a nearly continuous sampling track for DSJ9403 and for each sweep of DSJ9406. 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 each cruise (Appendix 7). Because the CTD was calibrated annually by the manufacturer, and because problems occurred with the TS unit during DSJ9406 and in the past during DSJ9203,

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[6]CTD Data Acquisition software, SEASOFT Version 4.201, February 1994, 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.

[7]SAS Institutes Inc., SAS Circle Box 8000, Cary, North Carolina 27512. Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

[8]SURFER Version 4, Golden Software, Inc., 809 14th Street, Golden, Colorado 80402. Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

[9]Lotus FREELANCE Graphics for DOS, Lotus Development Corporation, 55 Cambridge Parkway, Cambridge, Massachusetts 02142. Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

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. Because the TS unit was changed during DSJ9406, separate adjustments were made on TS data recorded from May 18-June 8 and from June 11-June 18. Although there was an offset between TS salinity and CTD salinity at 2 m for DSJ9403 (Appendix 5), the TS values were not adjusted to the CTD values because a large proportion (~70%) of the CTD salinity values at 2 m were subsequently edited for large data spikes. TS data were subsequently contoured using SURFER and post-processed using FREELANCE.

Dynamic height was calculated for stations occupied during DSJ9403 and DSJ9406 using a 500 db base. CTD casts conducted in areas with bottom depths less than 500 m were not included in this analysis. In addition, some of the casts during DSJ9403 did not quite reach 500 m due to horizontal drift. Dynamic height data for these casts was extrapolated to 500 m using the data below 400 m. The extrapolation was based on fitting a polynomial ($y = ax^2 + bx + c$) where y was dynamic height and x was depth. 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 DSJ9403 and the three sweeps of DSJ9406 were output from the DERIVE module of SEASOFT Version 4.201 and these data were gridded in SURFER Version 4.0 and post-processed using FREELANCE. 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 10).

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: Data Settings for SEASOFT Modules

Listed are the settings of the SEASOFT modules DATCNV, FILTER, ALIGNCTD, LOOPEDIT, BINAVG, and DERIVE used to process the *.HEX files.

Appendix 2: Lists of CTD Stations Summarized from Cruises DSJ9403 and DSJ9406

The station lists include, 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 DSJ9403 (March 2-March 10) includes 71 stations (casts 10-80). Cruise DSJ9406, Sweep 1 (May 18-May 25) includes 66 standard stations (casts 1-76), Sweep 2 (May 26-June 2) includes 82 standard stations (casts 98-184), and Sweep 3 (June 11-18) includes 77 standard stations (casts 217-295).

Appendix 3: CTD Stations and Bathymetric Maps of Survey Region with Locations of the NDBC Buoys

The locations of the CTD stations for DSJ9403 and the standard CTD stations for DSJ9406 along with the locations of the NDBC buoys, the place names, and the bottom bathymetry of the survey areas are shown.

Appendix 4: Meteorological Time Series

Meteorological time series are presented for the four NDBC buoys as described above. The first figure in this section summarizes the daily average wind speed (m/s) and direction (relative to true north) at these stations, in stick vector form, for the period January through June 1994. Vectors point in the direction toward which the wind was blowing; an arrow pointing toward the top of the page represents a northward-directed wind.

The following figures show scalar time series of sea surface temperature, or SST (°C); air temperature (°C); the north-south component of wind speed (m/s), a crude indicator of upwelling-favorable wind; and barometric pressure (millibars) at each meteorological station for the first 180 calendar days of 1994. A positive wind value denotes a northward-directed wind component. The survey periods for DSJ9403 and DSJ9406 (divided by sweep) are shaded in all time series plots.

Appendix 5: AVHRR Satellite Images of Sea Surface Temperatures

Sea surface temperatures along the central and northern California coast from radiances sensed by channel 4 of the NOAA-11 polar orbiting satellite are presented for DSJ9403 and for each of the three sweeps during DSJ9406. Each image represents a single pass during the afternoon hours, local time. Sampling stations during the cruise/sweep are overlaid on the image as well. The temperature scale for the image from DSJ9403 (9-16 degrees Celsius) is slightly narrower than the temperature scale for the three sweeps from DSJ9406 (8-18 degrees Celsius). A narrower temperature scale was needed since the sea surface temperature gradients were not as strong during March as they were during May/June. 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 black.

Appendix 6: ADCP Data

The ADCP data are separated by the individual sweeps according to the dates defined previously. The combined series of absolute, three-minute water velocities for each sweep were averaged over 5-km intervals to produce the vector maps presented here. Current fields are presented for DSJ9403 at three depths (15-23 m, 95-103 m, and 191-199 m) and for each sweep of DSJ9406 at four depths (15-31 m, 47-63 m, 87-103 m, and 191-207 m). The vectors point in the direction of flow; their magnitudes are relative to the scaled, 50 cm/s vector displayed in the plot's legend.

Appendix 7: 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:

CTD temperature versus TS temperature,
CTDtemp. = TStemp. x 1.0204 - 0.2894
R^2 = 0.9919
CTD temperature versus bucket temperature,
CTDtemp. = buckettemp. x 0.9264 + 0.9580
R^2 = 0.9370
TS temperature versus bucket temperature,
TStemp. = buckettemp. x 0.9202 + 1.0659
R^2 = 0.9501
CTD salinity versus TS salinity,
CTDsal. = TSsal. x 0.7814 + 7.2823
R^2 = 0.8899

DSJ9406 CASTS 1-215

CTD temperature versus TS temperature,
CTDtemp. = TStemp. x 1.0055 - 0.0972
R^2 = 0.9984
CTD temperature versus bucket temperature,
CTDtemp. = buckettemp. x 0.9943 + 0.0608
R^2 = 0.9938
TS temperature versus bucket temperature,
TStemp. = buckettemp. x 0.9918 + 0.1208
R^2 = 0.9968
CTD salinity versus TS salinity,
CTDsal. = TSsal. x 1.0122 - 0.1079
R^2 = 0.9341

DSJ9406 CASTS 217-295

CTD temperature versus TS temperature,
CTDtemp. = TStemp. x 1.0000 - 0.0206
R^2 = 0.9988
CTD temperature versus bucket temperature,
CTDtemp. = buckettemp. x 1.0155 - 0.4528
R^2 = 0.9909
TS temperature versus bucket temperature,
TStemp. = buckettemp. x 1.0128 - 0.4114
R^2 = 0.9928
CTD salinity versus TS salinity,
CTDsal. = TSsal. x 1.0071 - 0.2031
R^2 = 0.9818

Appendix 8: Horizontal Maps of CTD and TS

a) Maps of TS temperature and salinity

Maps of surface temperature (°C) and salinity (ppt) obtained from the vessel's TS continuous profiling unit are presented for DSJ9403 and for each sweep of DSJ9406. The TS maps are located in front of the corresponding horizontal map for the CTD at 2 m. The contour intervals are 0.2°C for temperature and 0.05 ppt 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 quantitative 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 (ppt) and density (sigma-theta [σ_θ]) (kg/m^3) 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. The 10-m depth was selected to represent near-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 4). The 30-m depth was contoured to coincide with the standard midwater trawl depth during the surveys. The contour intervals are 0.2°C, 0.05 ppt and 0.05 kg/m^3, respectively for depths 2-100 m. For the 200- to 500-m depths, the contour intervals were lowered to 0.1°C, 0.02 ppt, and 0.02 kg/m^3.

Appendix 9: <u>Vertical Transects</u>

Vertical transects of temperature, salinity and density are presented for four cross-shelf transects off Pt. Reyes, Pacifica, Pescadero, and Davenport for DSJ9403 and off Pt. Reyes, the Farallones, Pescadero, and Davenport for DSJ9406. Station maps denote the location of each transect and the offshore extent of stations used to generate plots for each sweep. The locations of CTD casts used in generating the vertical transects are shown by an ↑. The contour intervals are 0.5°C for temperature, 0.1 ppt for salinity, and 0.2 kg/m^3 for density.

Appendix 10: <u>Dynamic Height Topography</u>

Horizontal maps of dynamic height (0/500 m and 200/500 m) are presented for DSJ9403 and the three sweeps of DSJ9406. 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.

<u>Synopsis of Hydrographic Conditions</u>

Following the unusually long 1991-93 El Niño-Southern Oscillation (ENSO) event, atmospheric and ocean conditions in the north Pacific returned toward more normal values in the first half of 1994 (Climate Diagnostics Bulletin 1994). Atmospheric circulation over the north Pacific was dominated by lower than normal surface and upper level pressures from February 1994 into the summer. However sea level pressure anomalies along the west coast were nearly normal during the 1994 groundfish surveys. Large-scale sea surface temperature (SST) anomalies were slightly positive over the subarctic Pacific and along the west coast out to about 135°W, but SST anomalies were negative immediately adjacent to the California coast. This pattern may be due to slightly greater than usual coastal upwelling. Upwelling anomalies in early 1994 were generally positive (greater upwelling) at these latitudes (Hayward et al. 1995) Sea level anomalies from San Francisco were slightly negative in 1994, relative to the large positive anomalies observed in 1992-1993 (Hayward et al. 1995).

The hydrographic and dynamic nature of central California coastal water during early 1994 suggests a return to more typical conditions following the ENSO period, consistent with the 1994 CalCOFI surveys off southern California (Hayward et al. 1995). The circulation off central California in early March 1994, inferred from near-surface dynamic heights relative to 500 db, was generally southward and meandering, in stark contrast to the strong and broad poleward flow in early 1992 (Lynn et al. 1995). ADCP and geostrophic currents were in general agreement and indicate a predominantly barotropic flow. Strong southward and offshore currents in the outer portion of the survey region probably correspond with a filament from the Pt. Arena upwelling center, and its interaction with the meandering eastern boundary of the California Current.

The dynamic thickness of the upper ocean in 1994 was 5-10 dyn. cm lower than in early 1992 (Lynn et al. 1995) and 1993 (Sakuma et al.

1994b), due to the post-ENSO return of more dense (cooler, more saline) water. The 1994 thickness values were more similar to early 1991, although the upper ocean was slightly warmer and fresher in 1994, suggesting a residual ENSO signal. Near-surface water in March 1994 was nearly isothermal (ca. 13°C) over most of the area, and featured a narrow salinity range (ca. 33.0 ppt), in contrast to later in the year. Buoy SSTs show little temporal variation at this time of year as well, despite large wind fluctuations. The northwest portion of the survey was slightly cooler, and the warmer (>13.6°C) and fresher (<32.5 ppt) Golden Gate plume was evident in the inner Gulf of the Farallones.

Temperature and salinity exhibited much more range on pressure surfaces of 100 m and greater than near the surface. Three types of water are apparent in the horizontal maps and vertical sections. The hydrography featured two very cool, low salinity cells- off Pt. Reyes (ca. 38°N, 124.5°W) and Pescadero (ca. 37.3°N, 123.5°W)- over about 200-400 m depth. The dynamic heights and ADCP data suggest a cyclonic circulation about these cells, which is apparent closer to the surface as well. This water likely was transported from the north by the California Current. Elsewhere cooler, more saline water over the inner slope contrasted with warmer, less saline water offshore. This resulted in a general upward tilt of isopycnals toward the coast, which produced a strong southward meandering geostrophic flow in the region normally occupied by a countercurrent.

The dynamic topography in May-June 1994 off central California showed a continuation of the meandering southward flow typical of this time of year. Again the upper ocean was as much as 10 dyn. cm thinner than during May-June 1992 (Lynn et al. 1995) and 1993 (Sakuma et al. 1994a). Dynamic heights were very similar in magnitude and structure to 1991, a cool, saline year (Ramp et al. 1995). Upper water column temperatures and salinities were near typical values for this area, and cooler and more saline in comparison to 1992 and 1993. Near-surface temperatures and salinities in the upwelling centers were similar in sweeps 1 and 2 (9.5-11°C and 33.6-33.8 ppt, respectively). Offshore values were 12-14°C and 33.0-33.3 ppt.

The northern and southern portions of sweep 3 appear to have been conducted under very different conditions. Winds were upwelling-favorable but relatively weak at the onset of the final sweep, but strengthened to >15 m/s late in the sweep. Horizontal maps suggest that upwelling was very intense near Pt. Reyes (<9°C, >34.0 ppt) during the latter half of sweep 3, and less intense a few days earlier off Año Nuevo (<11°C, >33.7 ppt). Strong southward near-surface currents were observed coincident with the center of the upwelling filament off Pt. Reyes. The different conditions were reflected in offshore waters as well; the northern offshore region was much cooler (>11°C) and more saline (<33.5 ppt) than the southern portion of sweep 3 (>14°C, <33.0 ppt), indicating a greater contribution of upwelled water in the north.

The distribution of hydrographic features was similar to most others years. The surface dynamic heights closely reflect the near-surface density field; greatest geostrophic velocities coincide with surface hydrographic fronts. Sweeps 1 and 3 were highlighted by a strong, relatively straight density front running approximately parallel to the coast. A warm anticyclonic meander was located due west of Monterey Bay centered at about 123°W in both sweeps. Both of these features are apparent deep into the water column. A feature unique to sweep 2 was a warm (11.5-11.8°C), fresh (33.0-33.2 ppt) plume off the Golden Gate, which clearly separated the two upwelled water masses. Slope water at 200 m depth was cool (<8.0°C) and fresh (<34.0 ppt) in all the 1994 surveys, relative to 1992 and 1993 (i.e., less spicy). A possible explanation for this is a reduced countercurrent, or increased transport in the California Current.

While the dynamic heights display a close correspondence to the near-surface distributions of temperature, salinity and density, many near-surface ADCP flow features that differ from the geostrophic circulation. A most notable difference is in the southern half of sweep 2; a strong northward current over the slope is implied from the ADCP data, while the geostrophic flow was very weak. In contrast to the generally coherent southerly geostrophic flow, ADCP currents were more spatially complex. This may be a more realistic reflection of how the instantaneous current field is shaped by the region's highly fluctuating wind forcing and complex topography, as well as by a rich mesoscale eddy field whose signal is not obvious in the dynamic heights. The total near-surface current field off central California has a substantial geostrophic component; dynamic heights do not appear to explain the entire synoptic circulation. In addition, the strongest geostrophic currents were associated with ocean fronts, while highest ADCP velocities often were found in the center of water masses (e.g., upwelling filaments).

Some features do appear in both forms of current fields, most notably anticyclonic features in the outer portion of the region off Monterey Bay (in sweeps 1 and, more strongly, 3) and Pt. Reyes (in all sweeps). However the dynamic heights reflect only rotation-type motions around density anomalies, while the ADCP data show a combination of rotation and translation of ocean features. An example is a warm, low saline feature centered about 37.6°N, 123.7°W during sweep 2, which appears in the AVHRR image of 29 May to be a warm filament extending northeast from the California Current. The dynamic topography implies an expected anticyclonic circulation around the filament, and the ADCP currents suggest the filament was simultaneously rotating and advecting to the northeast. The strong northward ADCP flow over the slope during sweep 2 suggests warm, fresh water may have been advected into the survey region from the south as well. A coherent southward flow west of Monterey Bay in sweep 3, which intensified and turned offshore, coincided with a cool filament originating at the Año Nuevo upwelling center. In all three sweeps, strong offshore ADCP currents were measured in the northwestern corner of the region, corresponding to the location of an offshore upwelling filament originating from south of Pt. Arena. The southward flowing filament of this upwelled water source also is seen in the near-surface ADCP, temperature and salinity fields, flowing past Pt. Reyes into the Gulf of the Farallones. Hence the advection of cool and warm filaments in response to intensifying and relaxing winds is better described by ADCP observations.

Unlike the southward flow noted throughout the upper 200 m during March, a northward countercurrent was seen in the 200 m ADCP and geostrophic currents during May-June. This countercurrent was weaker and less organized in sweep 1 than during the later sweeps. Ron Lynn, NMFS La Jolla (pers. comm.) reports that the 200 m geostrophic flow in this region was southward in April 1994. This series of snapshots of mid-depth flow off central California show the seasonal evolution of the countercurrent. As in March, the currents during DSJ9406 were predominantly barotropic, particularly from about 50 m and deeper, although an intensifying and broadening of the countercurrent with depth was apparent.

ADCP data over the shelf provide information on the currents in water too shallow for geostrophic calculations. Shelf currents are in general complex, but show evidence of an offshore Ekman surface flow near the coast. While the wind is generally southward in spring and summer, frequent wind relaxations and reversals may explain the spatially complex shelf flow (Schwing et al. 1991, Rosenfeld et al. 1994). The non-synoptic nature of these surveys makes it difficult to determine if the observed variability is spatial or temporal. For example, is the northward flow off Monterey Bay, especially in sweeps 1 and 3, due to wind relaxation events at the beginning of the sweeps, or is it part of a more persistent circulation pattern, as suggested by Breaker and Broenkow (1994)? A careful analysis is needed to separate the true spatial variability in the coastal ocean structure and currents from temporal fluctuations, such as those associated with the region's highly variable wind forcing.

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APPENDIX 1: DATA SETTINGS FOR SEASOFT MODULES

Module #1: DATCNV

```
Raw Data File =                              depends on cast
Configuration File [.CON] =                  depends on cast
Input File [.CON, .DAT, .HEX] Path =        C:\SEASOFT\HEXDATA\
Output Data File Path =                     C:\SEASOFT\CNVDATA\
Data Conversion Format =                    ASCII
Data Conversion Variables =                 <Press Enter to Modify>
      Conversion Units                      Metric
      Column # 0 =                          scan number
      Column # 1 =                          pressure, decibars
      Column # 2 =                          depth, salt water, meters
      Column # 3 =                          temperature, deg C
      Column # 4 =                          conductivity, S/m
      Column # 5 =                          none
        etc.
Number of Scans to Skip Over =              0
```

Module #2: FILTER

```
Input Data File =                            depends on cast
Input File [.CNV] Path =                    C:\SEASOFT\CNVDATA\
Output Data File Path =                     C:\SEASOFT\CNVDATA\
Low Pass Filter A, Time Constant (sec) =          0.500000
Low Pass Filter B, Time Constant (sec) =          0.000000
Variables to Filter =                       <Press Enter to Modify>
      Filter Type, scan number =                        None
      Filter Type, pressure, decibars =                 None
      Filter Type, depth, salt water, meters =          None
      Filter Type, temperature, deg C =                 None
      Filter Type, conductivity, S/m =            Low Pass Filter A
      Filter Type, salinity, PSS-78 [PSU]               None
      Filter Type, density, sigma-theta, kg^3 =         None
      Filter Type, =                                    None
```

Module #3: ALIGNCTD

```
Input Data File =                            depends on cast
Input File [.CNV] Path =                    C:\SEASOFT\CNVDATA\
Output Data File Path =                     C:\SEASOFT\CNVDATA\
Number of Seconds to Advance Cond Relative to Pres =    0.000000
Number of Seconds to Advance Temp Relative to Pres =    0.500000
Number of Seconds to Advance Oxygen Relative to Pres =  0.000000
```

Module #4: LOOPEDIT

Input Data File =	depends on cast
Input File [.CNV] Path =	C:\SEASOFT\CNVDATA\
Output Data File Path =	C:\SEASOFT\CNVDATA\
Minimum CTD Velocity (m/s) =	0.200000
Exclude Scans Marked Bad in LOOPEDIT =	Yes

Module #5: BINAVG

Input Data File =	depends on cast
Input File [.CNV] Path =	C:\SEASOFT\CNVDATA\
Output Data File Path =	C:\SEASOFT\CNVDATA\
Bin Type =	Depth Bins
Bin Size =	2.000000
Include Number of Scans Per Bin =	Yes
Exclude Scans Markded Bad in BINAVG =	Yes
Number of Scans to Skip Over =	0
Surface Bin Setup Parameters =	<Press Enter to Modify>
Include Surface Bin =	No
Surface Bin Minimum Value =	0.000000
Surface Bin Maximum Value =	0.000000

Module #6: DERIVE

Input Data File =	depends on cast
Input File [.CNV] Path =	C:\SEASOFT\CNVDATA\
Output Data File Path =	C:\SEASOFT\CNVDATA\
Input Variables =	<Press Enter to Display>
Name 0 =	scan number
Name 1 =	pressure, decibars
Name 2 =	depth, salt water, meters
Name 3 =	temperature, deg C
Name 4 =	conductivity, S/m
Name 5 =	salinity, PSS-78 [PSU]
Name 6 =	density, sigma-theta, kg/m^3
Variables to be Derived =	<Press Enter to Modify>
Column # 0 =	salinity, PSS-78 [PSU]
Column # 1 =	density, sigma-theta, kg/m^3
Column # 2 =	dynamic height
Column # 3 =	none
etc.	
Variable Coefficients =	<Press Enter to Modify>
Oxygen Coefficients =	<Press Enter to Modify>

since there is no oxygen meter enter all zeros

Time Window Size for doc/dt (seconds) =	2.00000
Time Window Size for Descent Rate and Accel (seconds) =	2.00000

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.            <DIR>         07-13-94    1:10p
..           <DIR>         07-13-94    1:10p
DSJ9406      <DIR>         07-13-94    1:10p
CNVDATA      <DIR>         09-22-94    7:59a
HEXDATA      <DIR>         09-29-94    9:35a
ASCIIDAT     <DIR>         10-01-94    9:53a
PROGRAMS     <DIR>         10-05-94   11:57a
LSTFILES     <DIR>         10-05-94    1:04p
CTD_CONV BAT           706 10-14-94    1:29p
ROSSUM   EXE         53984 07-09-94    3:06p
SINSTALL BAT           722 07-09-94    4:26p
OXFIT    EXE         21200 12-06-89   12:16p
ALIGNCTD EXE        279944 07-09-94    2:00p
ASCIIOUT EXE        273372 07-09-94    3:05p
BINAVG   EXE        283538 07-09-94    1:58p
CELLTM   EXE        274480 07-09-94    2:54p
CFGTOCON EXE         51440 07-08-94    5:01p
DATCNV   EXE        339876 07-09-94    1:49p
DERIVE   EXE        294598 07-09-94    1:54p
FILTER   EXE        284730 07-09-94    2:56p
LOOPEDIT EXE        274546 07-09-94    1:57p
SEACON   EXE        233414 07-09-94    1:46p
SEAPLOT  EXE        432438 07-09-94    2:48p
SEASAVE  EXE        440816 07-09-94    3:04p
SECTION  EXE        321240 07-09-94    1:51p
SPLIT    EXE        274862 07-09-94    1:55p
STRIP    EXE        276332 07-09-94    1:52p
TRANS    EXE        265132 07-09-94    1:50p
PHFIT    EXE         29834 06-11-94    3:08p
OXSAT    EXE         21086 11-18-85   12:33p
SEAPLOT  CFG            58 10-01-94    9:11a
SEAPLOT  PLT           564 10-01-94    9:11a
TERM19   EXE        281672 07-09-94    8:58a
TMODEM   EXE         30544 06-18-94    5:21p
WILDEDIT EXE        296056 07-09-94    1:56p
SBE$ERR  DAT          3118 03-09-94    4:46p
SBE$HELP DAT          3722 03-09-94    4:49p
SBE$MSG  DAT         12468 03-09-94    4:46p
SEACON   HLP          8719 07-08-94    4:25p
SEASAVE  HLP         18624 07-08-94    4:25p
TERM     HLP         24702 06-02-94    1:25p
GPIB     COM         35627 03-09-94    4:46p
MODE     COM          2345 03-09-94    4:46p
DATCNV   CFG           230 10-15-94    1:23p
FILTER   CFG           198 10-15-94    1:24p
BINAVG   CFG            97 10-15-94    1:24p
LOOPEDIT CFG            66 10-15-94    1:24p
ALIGNCTD CFG            77 10-15-94    1:24p
DERIVE   CFG           251 10-15-94    1:26p
DIRECT   LST             0 10-19-94    2:57p
MODULES  DOC         11098 10-19-94    2:57p
```

APPENDIX 2.1: LIST OF CTD STATIONS SUMMARIZED FROM CRUISE DSJ9403

DSJ9403

CAST	DATE	TIME	LATITUDE	LONGITUDE	DEPTH(M)
10	02MAR94	1239	36 43.6	122 00.8	1162
11	02MAR94	1500	36 43.1	122 09.2	1104
12	02MAR94	1735	36 42.5	122 22.5	1400
13	02MAR94	2038	36 42.8	122 34.6	2500
14	03MAR94	0104	36 43.8	122 48.6	2000
15	03MAR94	0405	36 43.2	122 59.6	2900
16	03MAR94	0645	36 43.4	123 11.5	3200
17	03MAR94	0950	36 43.0	123 24.1	3500
18	03MAR94	1315	36 56.6	123 34.4	3500
19	03MAR94	1619	36 56.1	123 22.3	2700
20	03MAR94	1847	36 55.7	123 09.8	2900
21	03MAR94	2137	36 57.1	122 56.9	2200
22	04MAR94	0032	36 56.5	122 46.3	1450
23	04MAR94	0316	36 56.1	122 32.5	800
24	04MAR94	0551	36 56.4	122 20.5	182
25	04MAR94	0713	36 56.1	122 17.5	120
26	04MAR94	1032	37 09.5	122 38.9	104
27	04MAR94	1204	37 08.2	122 44.5	350
28	04MAR94	1408	37 10.3	122 54.7	468
29	04MAR94	1632	37 09.3	123 07.1	1100
30	04MAR94	1851	37 08.5	123 19.2	2200
31	04MAR94	2112	37 09.2	123 31.3	3000
32	04MAR94	2345	37 09.1	123 44.6	3800
33	05MAR94	0315	37 09.3	124 09.4	3700
34	05MAR94	0644	37 09.9	124 33.8	3200
35	05MAR94	1019	37 10.3	124 58.9	4025
36	05MAR94	1352	37 22.7	124 44.5	4000
37	05MAR94	1735	37 22.6	124 20.2	3900
38	05MAR94	2120	37 23.6	123 55.2	4000
39	06MAR94	0043	37 23.6	123 42.3	3000
40	06MAR94	0318	37 23.6	123 29.3	2000
41	06MAR94	0730	37 23.5	123 16.5	1400
42	06MAR94	1010	37 23.5	123 04.8	700
43	06MAR94	1241	37 23.3	122 53.4	210
44	06MAR94	1422	37 22.8	122 48.5	102
45	06MAR94	1656	37 35.7	122 58.9	115
46	06MAR94	1830	37 35.9	123 02.1	350
47	06MAR94	2045	37 39.9	123 15.0	1420
48	06MAR94	2308	37 36.2	123 26.7	2600
49	07MAR94	0150	37 36.3	123 40.0	3500
50	07MAR94	0413	37 35.6	123 52.5	3500
51	07MAR94	0635	37 36.4	124 04.5	3500
52	07MAR94	1000	37 35.8	124 29.4	3800
53	07MAR94	1312	37 49.1	124 39.1	3900
54	07MAR94	1637	37 49.5	124 14.7	3500
55	07MAR94	1905	37 49.5	124 02.1	3650
56	07MAR94	2133	37 49.1	123 50.1	4000
57	08MAR94	0013	37 48.9	123 39.0	3000
58	08MAR94	0248	37 48.9	123 25.8	1300
59	08MAR94	0453	37 49.1	123 19.4	150
60	08MAR94	0612	37 49.0	123 16.4	108
61	08MAR94	0828	38 02.1	123 15.3	111
62	08MAR94	1348	38 01.6	123 31.3	504
63	08MAR94	1530	38 02.3	123 36.8	1500
64	08MAR94	1815	38 02.0	123 48.4	3200
65	08MAR94	2038	38 02.1	124 01.2	3600
66	08MAR94	2252	38 02.8	124 12.6	4000
67	09MAR94	0129	38 02.2	124 26.2	3900

CAST	DATE	TIME	LATITUDE	LONGITUDE	DEPTH(M)
68	09MAR94	0450	38 02.4	124 51.5	3900
69	09MAR94	0740	38 15.6	125 02.3	3900
70	09MAR94	1114	38 14.9	124 38.2	2800
71	09MAR94	1353	38 14.7	124 25.1	3800
72	09MAR94	1625	38 14.7	124 12.5	3700
73	09MAR94	1855	38 15.1	124 00.2	3800
74	09MAR94	2133	38 15.3	123 48.0	2500
75	10MAR94	0009	38 15.6	123 34.9	582
76	10MAR94	0241	38 16.6	123 25.0	180
77	10MAR94	0824	38 15.1	123 35.7	705
78	10MAR94	1035	38 15.6	123 35.7	700
79	10MAR94	1700	38 15.0	123 34.2	539
80	10MAR94	1750	38 13.9	123 33.5	575

APPENDIX 2.2: LIST OF CTD STATIONS SUMMARIZED FROM CRUISE DSJ9406

DSJ9406 SWEEP 1

CAST	DATE	TIME	LATITUDE	LONGITUDE	DEPTH(M)
1	18MAY94	2251	36 46.3	122 09.0	990
3	19MAY94	0227	36 38.7	122 01.1	163
4	19MAY94	0313	36 34.8	122 02.1	641
5	19MAY94	0605	36 35.3	122 08.6	2330
6	19MAY94	0720	36 33.6	122 16.1	2600
7	19MAY94	0845	36 33.6	122 28.5	2700
8	19MAY94	1014	36 33.8	122 40.8	2800
9	19MAY94	1130	36 40.0	122 47.0	2100
10	19MAY94	1245	36 46.3	122 40.7	2264
11	19MAY94	1404	36 40.0	122 34.7	2600
12	19MAY94	1522	36 46.4	122 28.3	2300
13	19MAY94	1636	36 39.8	122 22.4	1940
14	19MAY94	1830	36 42.2	122 06.5	2000
15	19MAY94	2041	36 39.4	121 56.9	70
18	20MAY94	0504	36 52.4	122 00.7	60
19	20MAY94	0613	36 52.7	122 10.2	100
20	20MAY94	0724	36 52.6	122 22.0	958
21	20MAY94	0852	36 52.6	122 34.6	1600
22	20MAY94	1027	36 52.7	122 47.0	2300
23	20MAY94	1207	36 52.6	122 59.3	2700
24	20MAY94	1325	36 59.0	122 53.2	1600
25	20MAY94	1445	37 05.0	122 47.2	720
26	20MAY94	1616	37 04.9	122 34.8	115
27	20MAY94	1735	37 05.0	122 22.5	59
28	20MAY94	2049	36 58.9	122 12.5	46
29	20MAY94	2248	36 57.9	122 16.9	93
30	20MAY94	2333	36 59.1	122 22.6	115
31	21MAY94	0345	36 57.5	122 24.6	246
32	21MAY94	0542	36 57.8	122 34.4	546
33	21MAY94	0823	37 10.8	122 53.3	433
34	21MAY94	0945	37 10.8	123 05.3	780
35	21MAY94	1110	37 10.8	123 17.6	2000
36	21MAY94	1221	37 16.7	123 11.3	1566
37	21MAY94	1333	37 22.3	123 05.5	796
38	21MAY94	1500	37 22.3	122 53.0	192
44	21MAY94	2058	37 16.5	122 29.1	51
45	21MAY94	2242	37 14.9	122 33.4	85
46	21MAY94	2325	37 16.4	122 39.0	95
48	22MAY94	0532	37 14.7	122 58.0	473
49	22MAY94	0742	37 30.8	122 59.4	217
50	22MAY94	0900	37 30.8	123 11.6	1350
51	22MAY94	1030	37 30.8	123 24.1	2430
52	22MAY94	1155	37 30.8	123 36.4	3000
53	22MAY94	1320	37 38.4	123 36.5	3290
54	22MAY94	1448	37 46.2	123 36.3	2630
55	22MAY94	1618	37 46.3	123 24.1	1700
56	22MAY94	1744	37 46.3	123 11.6	114
57	22MAY94	2048	37 39.5	123 02.6	108
58	22MAY94	2338	37 38.1	123 11.8	1050
59	23MAY94	0054	37 44.6	123 08.4	90
61	23MAY94	0545	37 50.5	123 24.4	362
62	23MAY94	0748	38 01.7	123 30.1	145
63	23MAY94	0928	38 01.8	123 42.4	2560
64	23MAY94	1117	38 01.6	123 54.8	3500
65	23MAY94	1250	38 01.7	124 07.1	3660
66	23MAY94	1420	38 09.7	124 07.2	3660
67	23MAY94	1635	38 18.7	123 54.6	3000
68	23MAY94	1809	38 18.6	123 42.2	1300

CAST	DATE	TIME	LATITUDE	LONGITUDE	DEPTH(M)
69	23MAY94	1934	38 18.6	123 30.0	258
70	23MAY94	2104	38 09.9	123 22.2	186
71	24MAY94	2043	37 57.9	122 56.1	53
72	24MAY94	2201	37 54.9	122 51.6	48
73	24MAY94	2250	37 50.9	122 46.1	40
74	25MAY94	0100	37 46.6	122 50.3	53
75	25MAY94	0148	37 41.9	122 54.5	57
76	25MAY94	0421	37 37.3	122 45.0	50

DSJ9406 SWEEP 2

CAST	DATE	TIME	LATITUDE	LONGITUDE	DEPTH(M)
98	26MAY94	2016	36 49.1	122 05.0	105
99	26MAY94	2108	36 50.8	121 58.9	88
100	26MAY94	2327	36 46.0	121 52.8	113
101	27MAY94	0013	36 44.5	121 58.8	320
102	27MAY94	0215	36 41.0	121 53.6	80
103	27MAY94	0259	36 38.4	121 56.6	37
104	27MAY94	0526	36 39.6	121 57.0	83
105	27MAY94	0650	36 40.0	122 10.2	1100
106	27MAY94	0808	36 46.3	122 16.1	841
107	27MAY94	0937	36 40.0	122 22.4	1740
108	27MAY94	1100	36 46.2	122 28.4	2100
109	27MAY94	1220	36 40.0	122 34.7	2375
110	27MAY94	1353	36 46.3	122 40.8	2400
111	27MAY94	1521	36 46.3	122 53.1	2560
112	27MAY94	1638	36 40.1	122 46.9	2740
113	27MAY94	1756	36 33.7	122 40.8	2740
114	27MAY94	1925	36 33.6	122 28.3	2740
115	27MAY94	2130	36 35.0	122 10.7	2300
119	28MAY94	0530	36 45.1	122 09.2	1135
120	28MAY94	0650	36 52.6	122 10.1	100
121	28MAY94	0809	36 52.7	122 22.4	1150
122	28MAY94	0937	36 52.6	122 34.6	1600
123	28MAY94	1109	36 52.7	122 47.1	2300
124	28MAY94	1242	36 52.6	122 59.5	2700
125	28MAY94	1420	36 59.2	122 53.1	1370
126	28MAY94	1603	37 05.2	122 47.0	630
127	28MAY94	1801	37 05.0	122 34.6	114
128	28MAY94	1950	37 04.9	122 22.4	59
129	28MAY94	2106	36 58.9	122 12.5	45
130	28MAY94	2300	36 57.8	122 16.6	91
131	28MAY94	2343	36 59.1	122 22.5	125
133	29MAY94	0530	36 57.4	122 35.1	600
134	29MAY94	0738	37 10.8	122 28.4	70
135	29MAY94	0854	37 10.6	122 40.8	113
137	29MAY94	1107	37 10.7	122 53.2	431
138	29MAY94	1240	37 10.8	123 05.5	860
139	29MAY94	1420	37 16.6	123 11.3	1148
140	29MAY94	1542	37 22.4	123 05.4	787
141	29MAY94	1752	37 22.3	122 52.7	188
142	29MAY94	1915	37 22.3	122 40.7	86
143	29MAY94	1955	37 22.3	122 35.2	67
144	29MAY94	2053	37 16.5	122 29.2	51
145	29MAY94	2241	37 15.5	122 33.0	83

CAST	DATE	TIME	LATITUDE	LONGITUDE	DEPTH (M)
146	29MAY94	2326	37 16.5	122 39.0	93
147	30MAY94	0325	37 16.1	122 49.0	182
148	30MAY94	0519	37 15.6	122 58.3	490
149	30MAY94	0735	37 31.0	122 59.5	215
150	30MAY94	0854	37 30.9	123 11.7	1250
151	30MAY94	1023	37 30.9	123 24.0	2380
152	30MAY94	1150	37 30.8	123 36.3	3100
153	30MAY94	1315	37 38.4	123 36.4	3290
154	30MAY94	1430	37 46.2	123 36.3	2700
155	30MAY94	1606	37 46.1	123 23.9	1500
156	30MAY94	1744	37 46.3	123 11.8	115
157	30MAY94	2108	37 39.7	123 02.5	102
158	30MAY94	2320	37 40.5	123 13.3	1300
159	31MAY94	0018	37 44.4	123 08.1	54
160	31MAY94	0255	37 53.4	123 19.2	79
161	31MAY94	0523	37 53.3	123 29.8	702
162	31MAY94	0645	38 01.7	123 30.2	145
163	31MAY94	0802	38 01.6	123 42.5	2700
164	31MAY94	0928	38 01.7	123 54.7	3475
165	31MAY94	1057	38 01.6	124 06.9	3660
166	31MAY94	1215	38 10.0	124 07.0	3360
167	31MAY94	1330	38 18.5	124 07.2	3570
168	31MAY94	1458	38 18.6	123 54.7	2830
169	31MAY94	1628	38 18.4	123 42.5	1456
170	31MAY94	1756	38 18.4	123 30.1	250
171	31MAY94	1917	38 18.5	123 17.9	109
172	31MAY94	2028	38 10.0	123 22.0	181
173	01JUN94	0028	38 09.1	123 15.1	112
174	01JUN94	0105	38 10.0	123 10.0	90
175	01JUN94	0253	38 08.2	123 03.7	69
176	01JUN94	0405	38 10.8	123 00.5	55
177	01JUN94	0603	38 01.5	123 05.6	62
178	01JUN94	0722	38 01.5	123 17.9	120
179	01JUN94	2045	37 58.1	122 56.1	52
180	01JUN94	2238	37 55.0	122 51.5	47
181	01JUN94	2323	37 50.9	122 46.1	39
182	02JUN94	0110	37 46.5	122 50.6	53
183	02JUN94	0155	37 42.0	122 54.5	55
184	02JUN94	0335	37 37.2	122 45.4	51

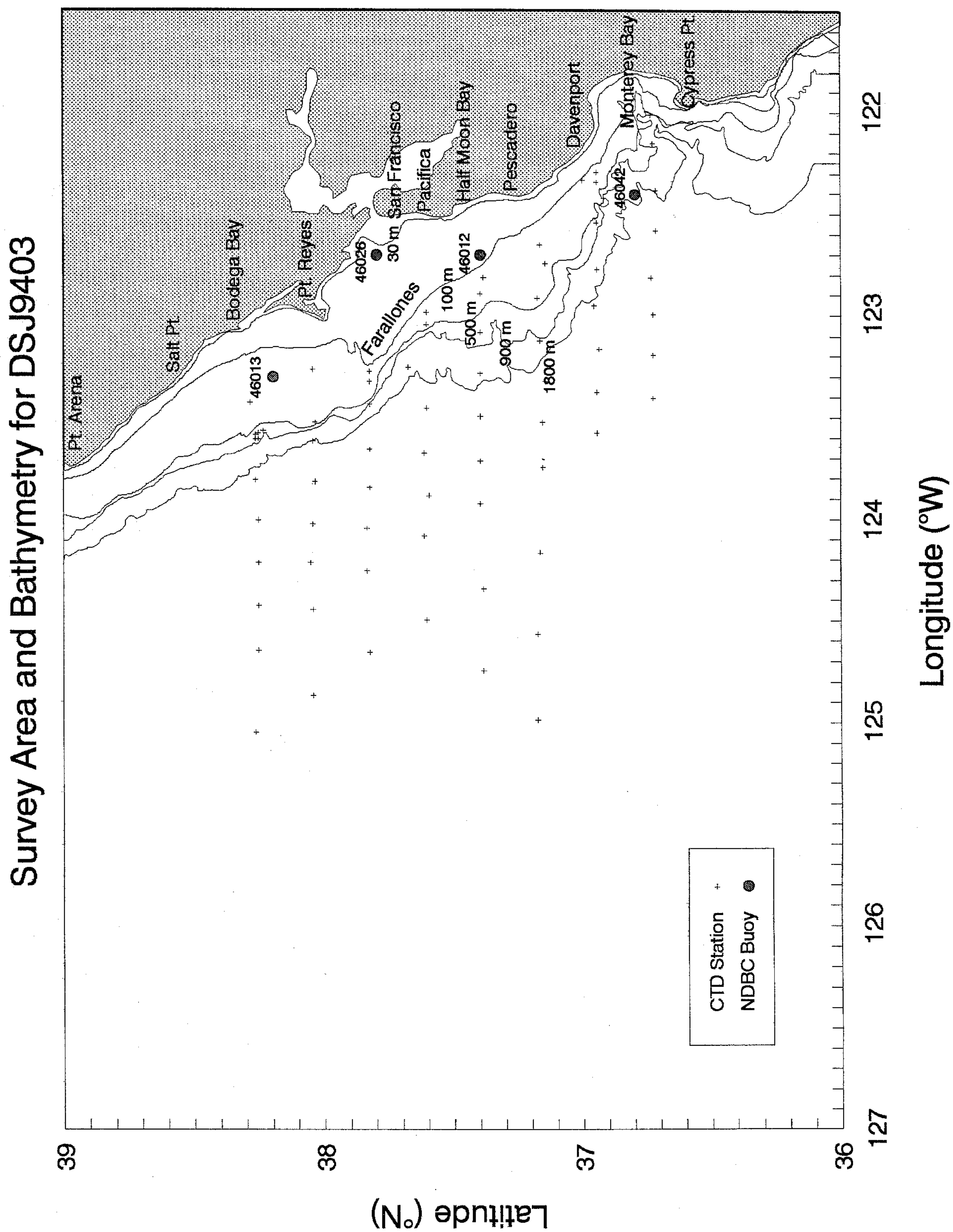
DSJ9406 SWEEP 3

CAST	DATE	TIME	LATITUDE	LONGITUDE	DEPTH (M)
217	11JUN94	2116	36 50.7	121 59.0	88
218	11JUN94	2317	36 45.9	121 53.4	221
219	12JUN94	0005	36 44.4	121 58.7	330
220	12JUN94	0200	36 41.5	121 53.9	82
221	12JUN94	0235	36 38.5	121 51.5	37
222	12JUN94	0510	36 39.5	121 58.4	93
223	12JUN94	0626	36 39.9	122 10.0	1135
224	12JUN94	0800	36 46.3	122 16.1	855
225	12JUN94	0907	36 40.0	122 22.4	1740
226	12JUN94	1037	36 46.3	122 28.4	2100
227	12JUN94	1154	36 40.0	122 34.8	2380
228	12JUN94	1314	36 46.2	122 40.7	2150

CAST	DATE	TIME	LATITUDE	LONGITUDE	DEPTH(M)
229	12JUN94	1431	36 40.0	122 47.2	2740
230	12JUN94	1556	36 33.7	122 41.0	2740
231	12JUN94	1747	36 33.8	122 28.5	2740
232	12JUN94	1925	36 33.7	122 16.3	2560
233	12JUN94	2039	36 35.0	122 10.4	2350
234	13JUN94	0031	36 36.4	122 02.1	650
235	13JUN94	0110	36 38.9	122 03.0	520
236	13JUN94	0310	36 42.3	122 07.8	1850
237	13JUN94	0450	36 47.1	122 10.3	750
238	13JUN94	0557	36 52.6	122 10.0	100
239	13JUN94	0715	36 52.6	122 22.4	906
240	13JUN94	0847	36 52.6	122 34.6	1600
241	13JUN94	1015	36 52.6	122 47.1	2300
242	13JUN94	1141	36 52.7	122 59.3	2700
243	13JUN94	1533	36 59.0	122 52.9	1370
244	13JUN94	1651	37 05.1	122 46.9	638
245	13JUN94	1813	37 05.0	122 34.5	114
246	13JUN94	1925	37 05.0	122 22.3	58
247	13JUN94	2108	36 58.7	122 12.5	46
248	13JUN94	2300	36 57.6	122 15.8	87
249	13JUN94	2354	36 59.0	122 22.6	127
250	14JUN94	0250	36 57.7	122 24.4	220
251	14JUN94	0500	36 57.1	122 34.1	736
252	14JUN94	0725	37 10.7	122 28.6	70
253	14JUN94	0847	37 10.7	122 40.8	113
254	14JUN94	1010	37 10.7	122 53.0	425
255	14JUN94	1147	37 10.7	123 05.3	850
256	14JUN94	1405	37 22.2	123 05.3	808
257	14JUN94	1551	37 22.3	122 52.9	195
258	14JUN94	1707	37 22.2	122 40.8	86
259	14JUN94	1820	37 22.2	122 28.4	30
260	14JUN94	2117	37 16.4	122 29.2	52
263	15JUN94	0525	37 13.1	122 42.0	111
264	15JUN94	0950	37 30.7	122 59.3	215
265	15JUN94	1116	37 30.9	123 11.6	1280
266	15JUN94	1255	37 30.9	123 24.0	2400
267	15JUN94	1445	37 38.6	123 24.0	2370
268	15JUN94	1603	37 46.1	123 24.0	1450
269	15JUN94	1730	37 46.3	123 11.4	111
270	15JUN94	2030	37 53.0	123 30.1	1300
271	15JUN94	2323	37 51.8	123 18.0	106
272	16JUN94	0050	37 44.5	123 08.3	105
273	16JUN94	0304	37 38.7	123 11.2	1050
274	16JUN94	0455	37 39.1	123 02.2	111
275	16JUN94	0936	38 01.6	123 05.6	62
276	16JUN94	1055	38 01.6	123 17.8	119
277	16JUN94	2035	38 09.8	123 22.3	186
278	17JUN94	0041	38 08.8	123 15.6	113
279	17JUN94	0140	38 10.1	123 10.0	90
280	17JUN94	0330	38 08.5	123 03.4	70
281	17JUN94	0445	38 09.9	123 00.1	53
282	17JUN94	0700	38 18.4	123 17.8	109
283	17JUN94	0820	38 18.5	123 30.1	257
284	17JUN94	1008	38 18.5	123 42.4	1460
285	17JUN94	1200	38 18.4	123 54.8	2380
286	17JUN94	1315	38 10.0	123 54.8	3250
287	17JUN94	1433	38 01.6	123 54.9	3470
288	17JUN94	1605	38 01.7	123 42.3	2505
289	17JUN94	1755	38 01.7	123 30.0	148
290	17JUN94	2055	37 58.1	122 56.0	52
291	17JUN94	2220	37 55.0	122 51.5	47
292	17JUN94	2310	37 51.1	122 46.0	38
293	18JUN94	0124	37 46.4	122 50.9	53

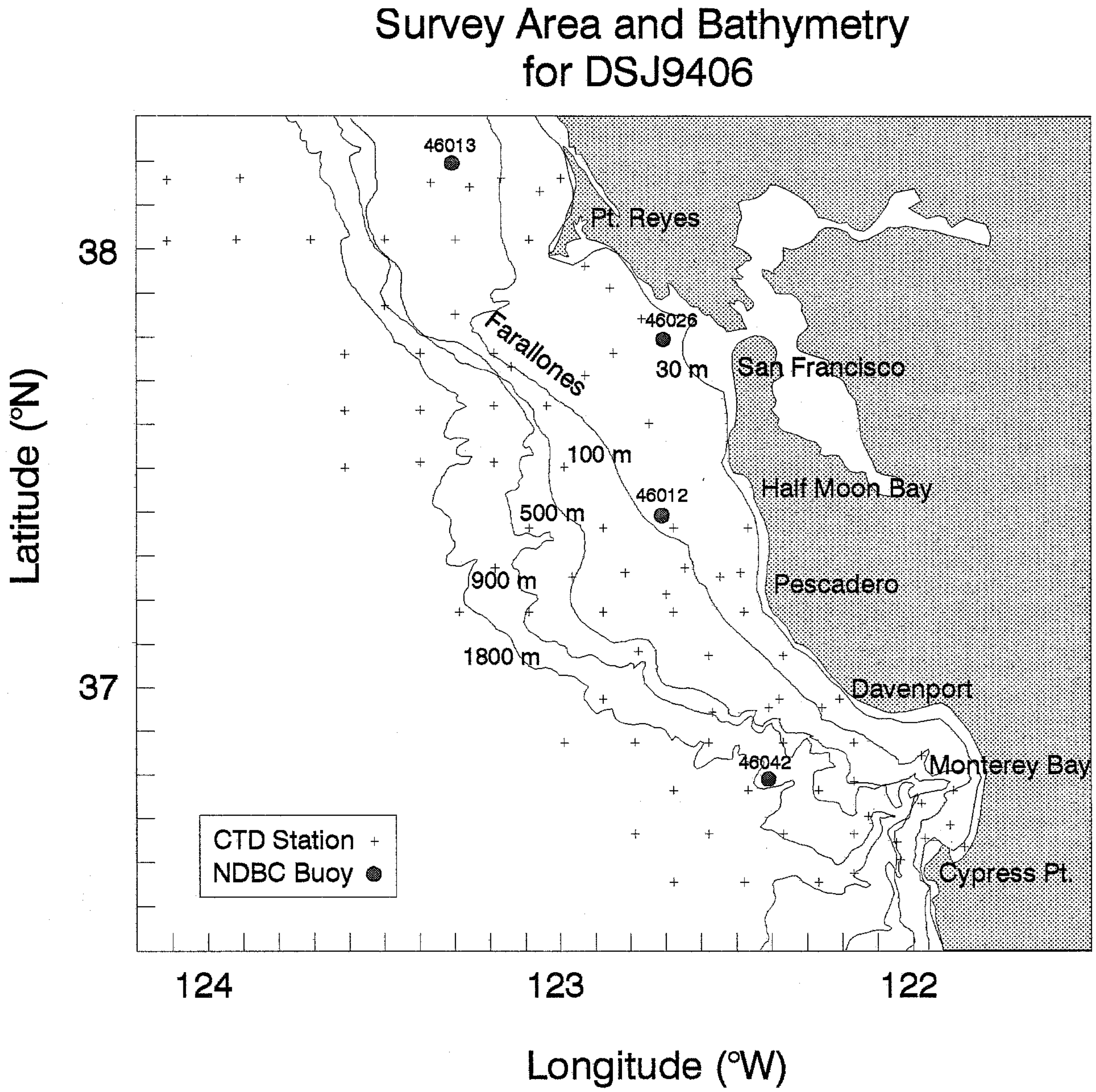
CAST	DATE	TIME	LATITUDE	LONGITUDE	DEPTH(M)
294	18JUN94	0210	37 43.1	122 55.9	53
295	18JUN94	0440	37 36.8	122 44.7	51

APPENDIX 3.1: DSJ9403 CTD STATIONS AND BATHYMETRIC MAP OF SURVEY REGION WITH LOCATIONS OF THE NDBC BUOYS



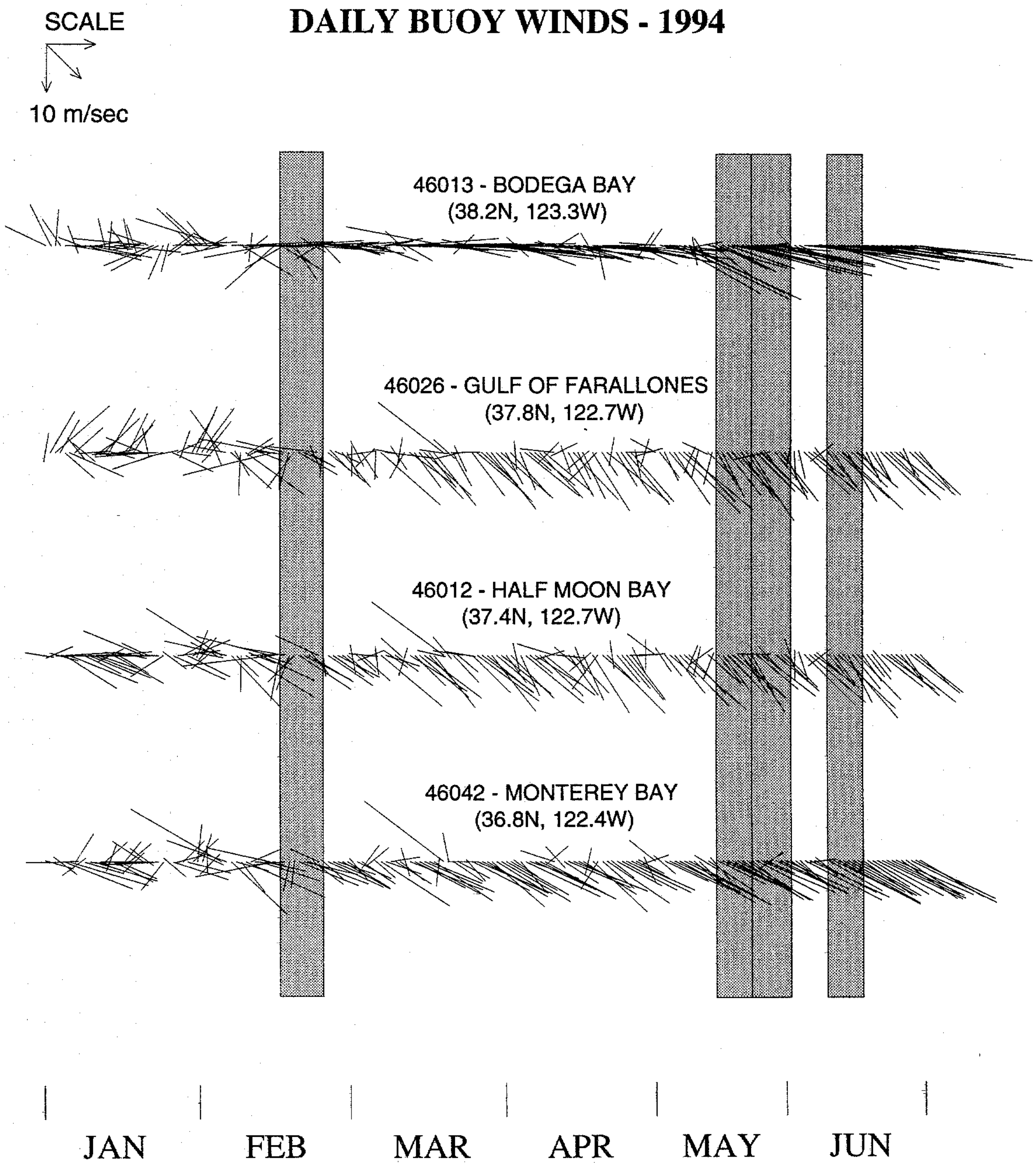
Survey Area and Bathymetry for DSJ9403
Latitude (°N)
Longitude (°W)
39
38
37
36
127
126
125
124
123
122
Pt. Arena
Salt Pt.
Bodega Bay
Pt. Reyes
Farallones
San Francisco
Pacifica
Half Moon Bay
Pescadero
Davenport
Monterey Bay
Cypress Pt.
46013
46026
46012
46042
30 m
100 m
500 m
900 m
1800 m
CTD Station
NDBC Buoy

APPENDIX 3.2: DSJ9406 CTD STATIONS AND BATHYMETRIC MAP OF SURVEY REGION WITH LOCATIONS OF THE NDBC BUOYS

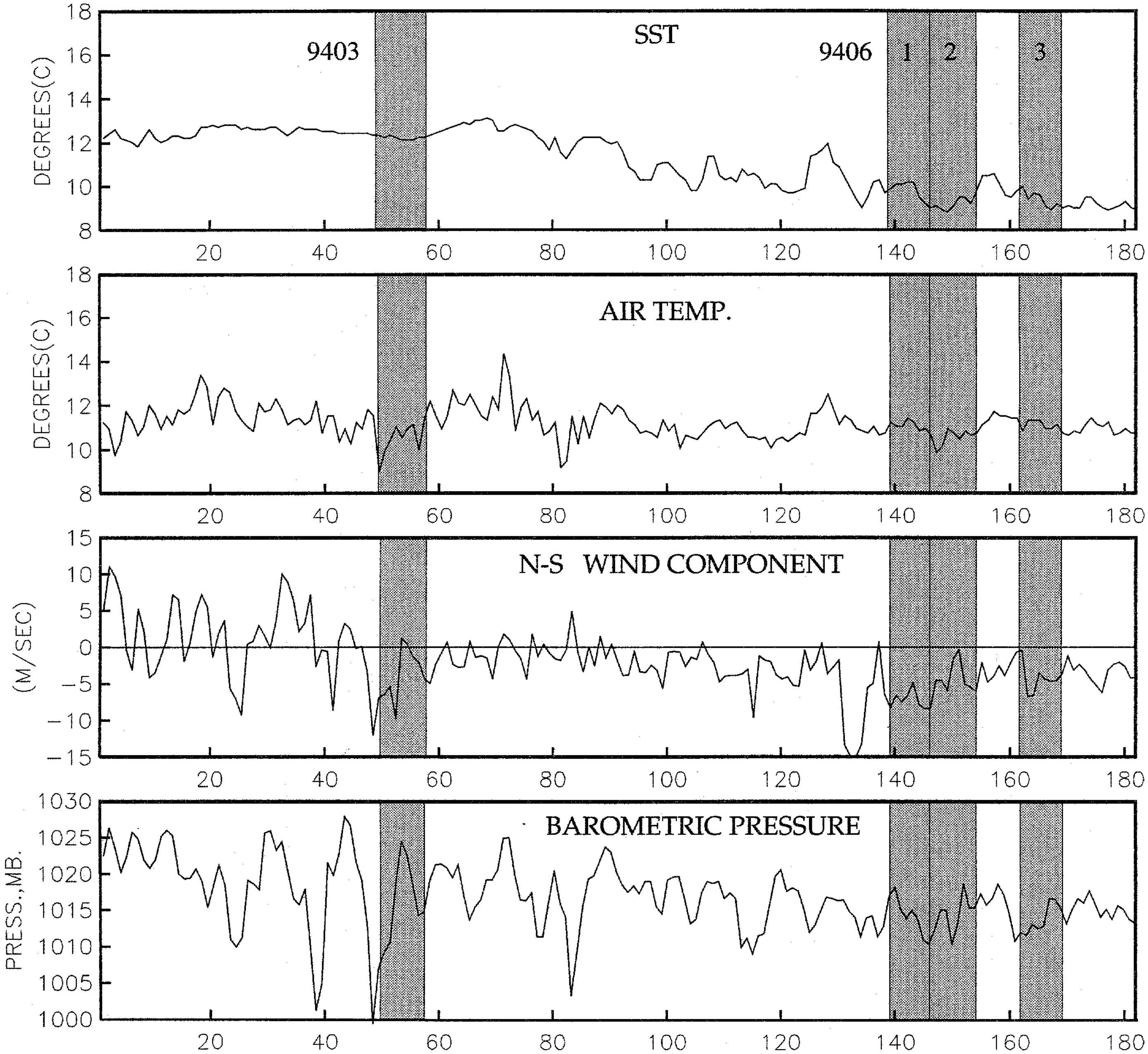

Survey Area and Bathymetry
for DSJ9406
46013
Pt. Reyes
46026
Farallones
30 m
San Francisco
100 m
46012
Half Moon Bay
500 m
900 m
Pescadero
1800 m
Davenport
46042
Monterey Bay
Cypress Pt.
CTD Station
NDBC Buoy
38
37
124
123
122
Latitude (°N)
Longitude (°W)

APPENDIX 4: METEOROLOGICAL TIME SERIES

DAILY BUOY WINDS - 1994

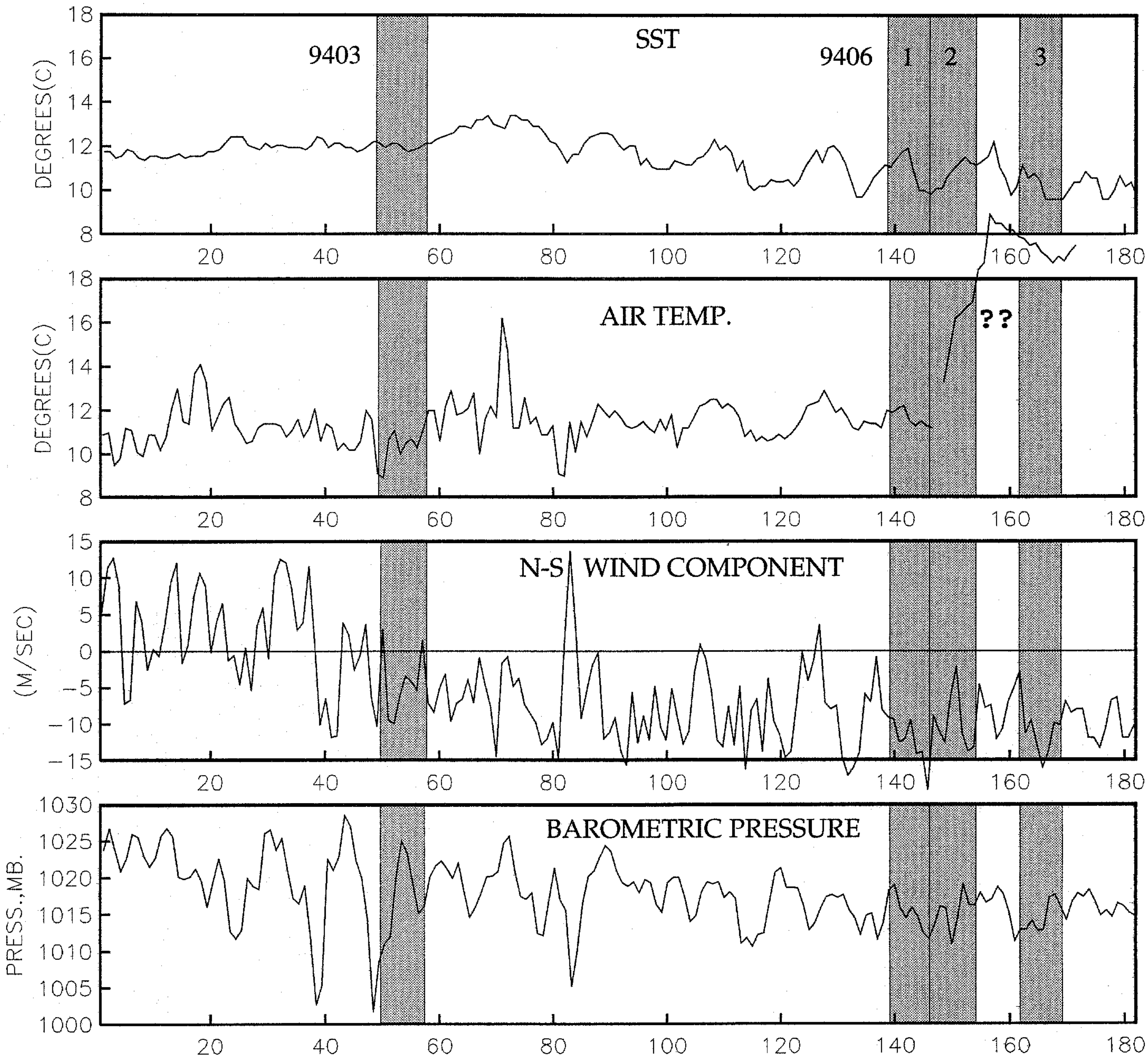


BUOY 46013 - BODEGA BAY (38.2N, 123.3W)



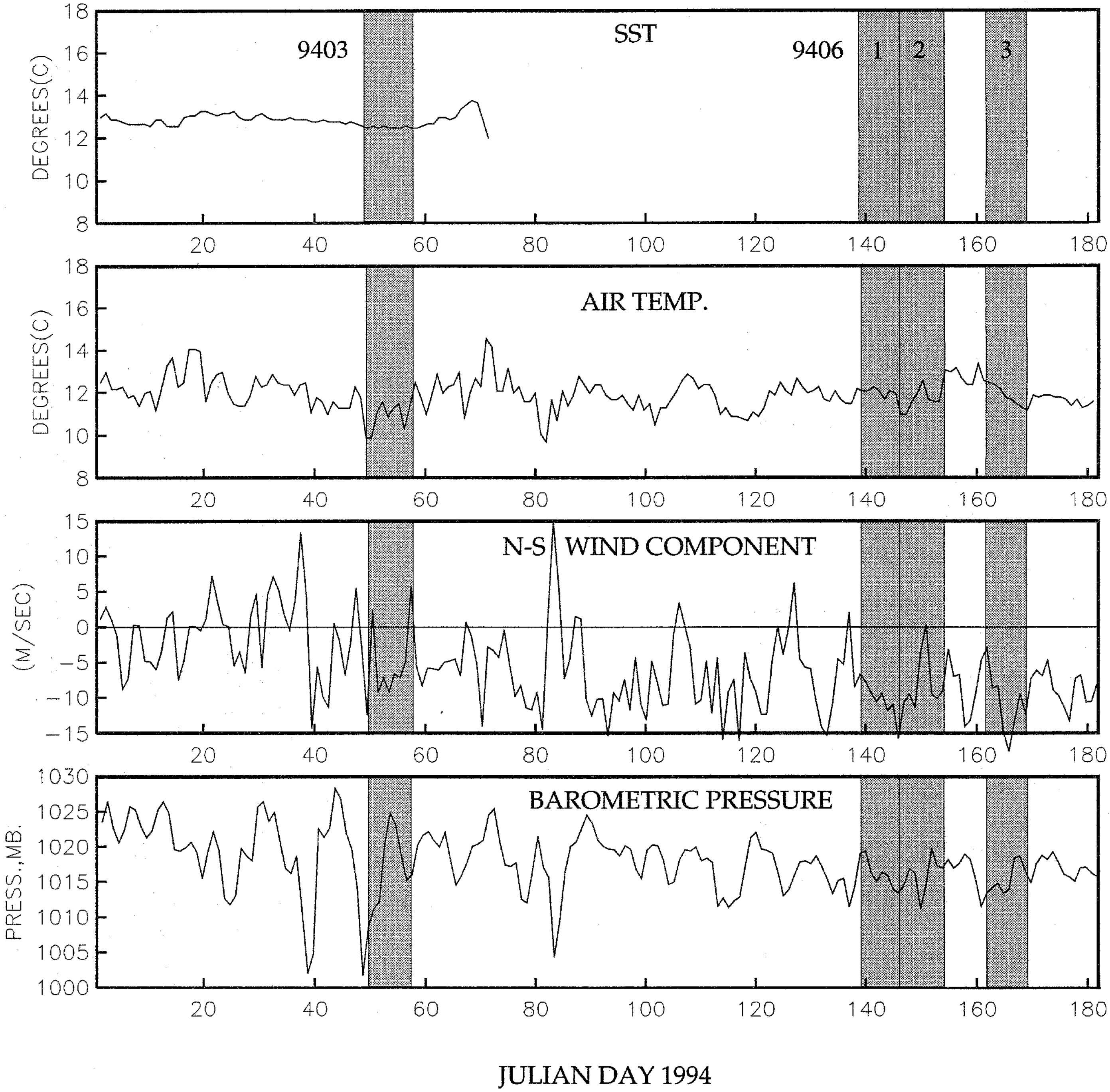
JULIAN DAY 1994

BUOY 46026 - FARALLONES (37.8N, 122.7W)

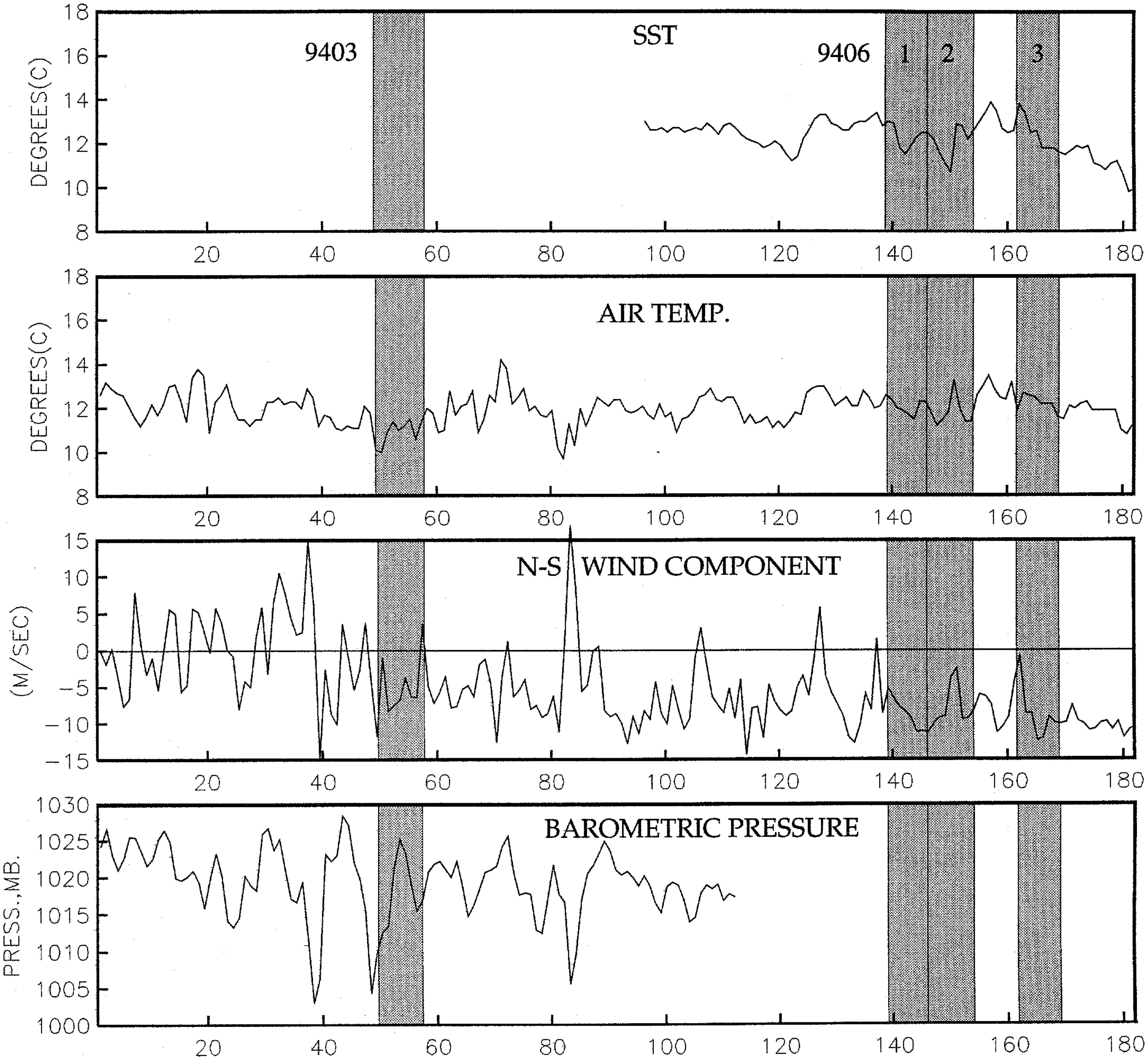


JULIAN DAY 1994

BUOY 46012 - HALF MOON BAY (37.4N, 122.7W)

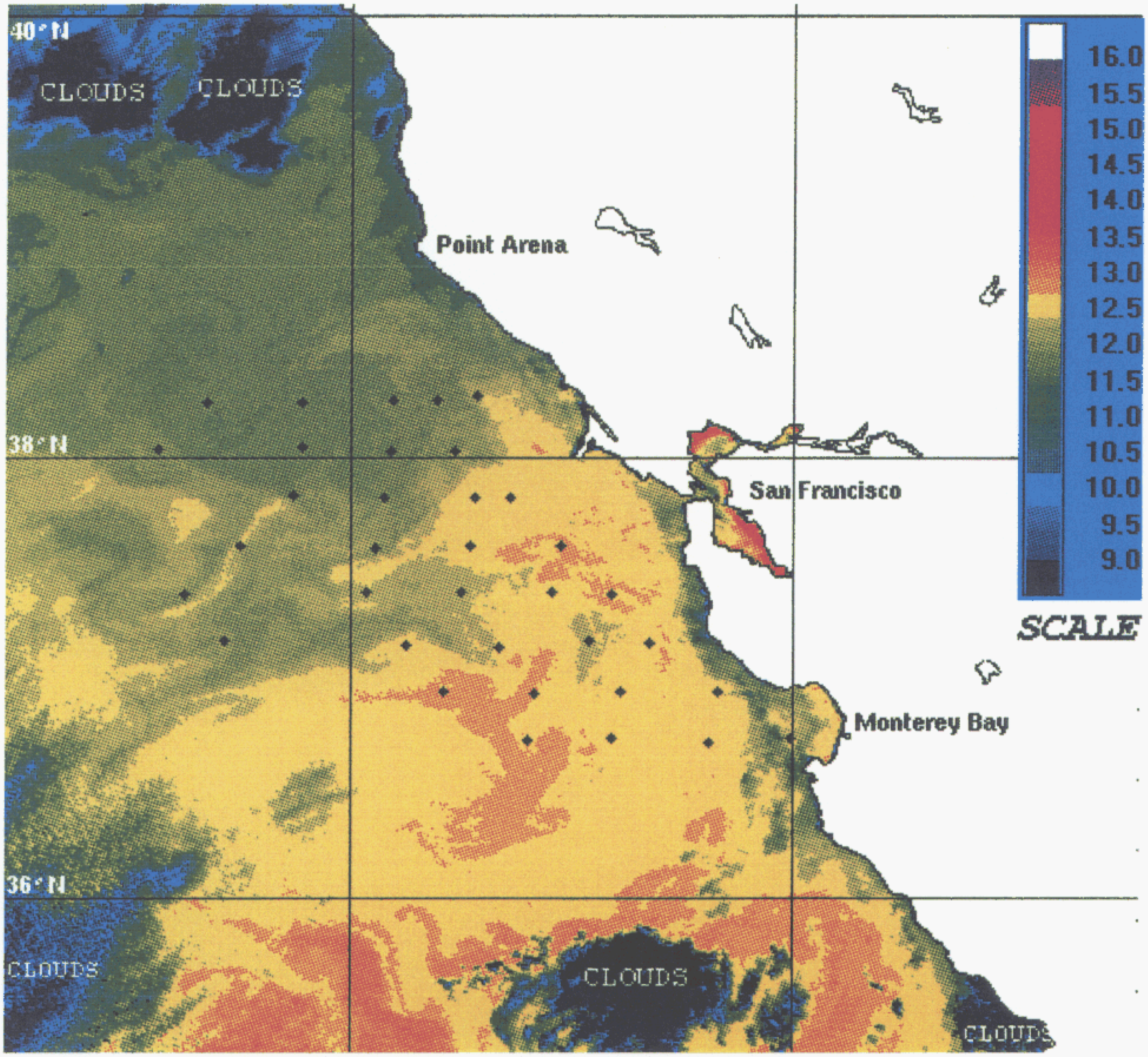


BUOY 46042 - MONTEREY BAY (36.8N, 122.4W)

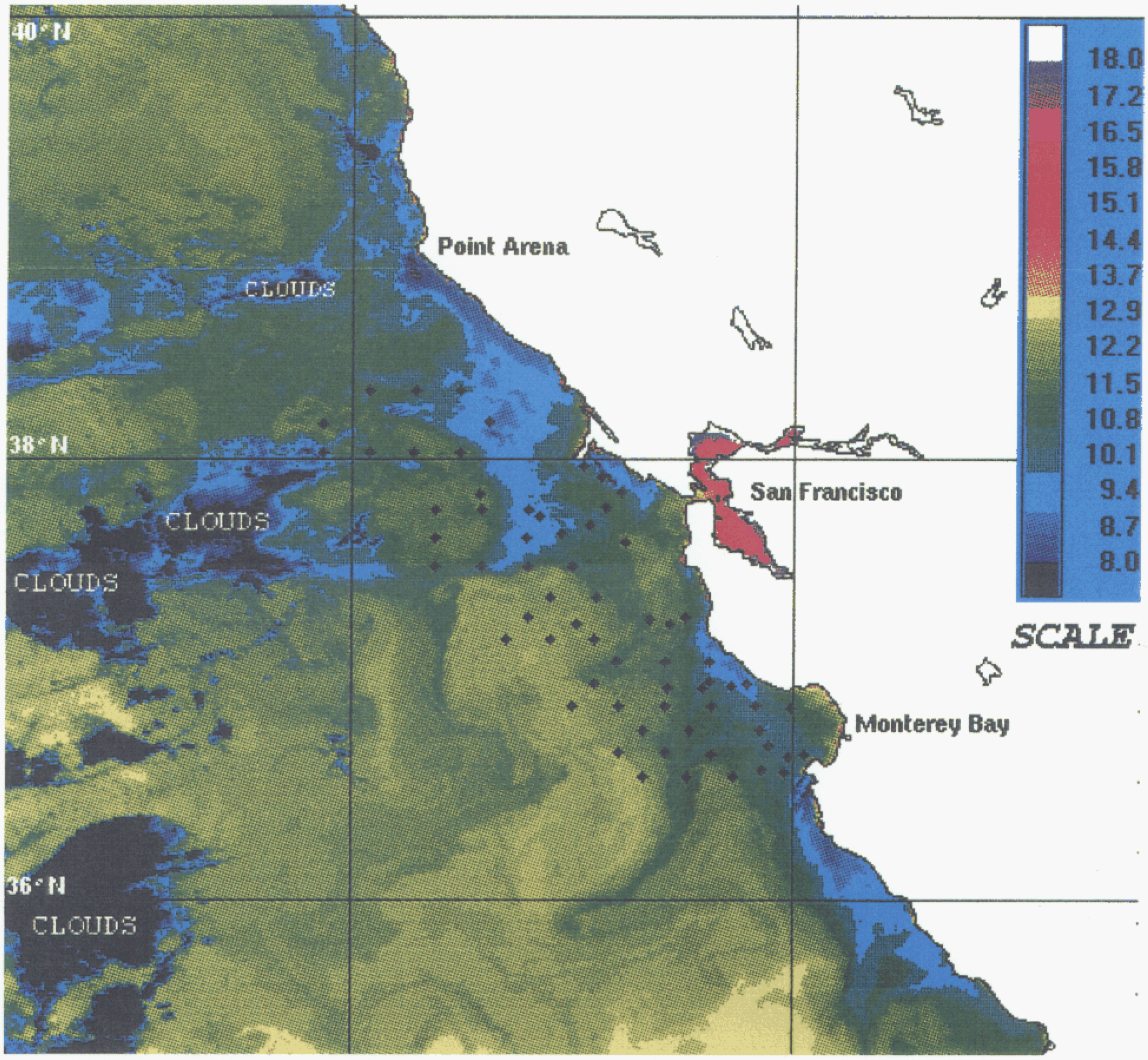


JULIAN DAY 1994

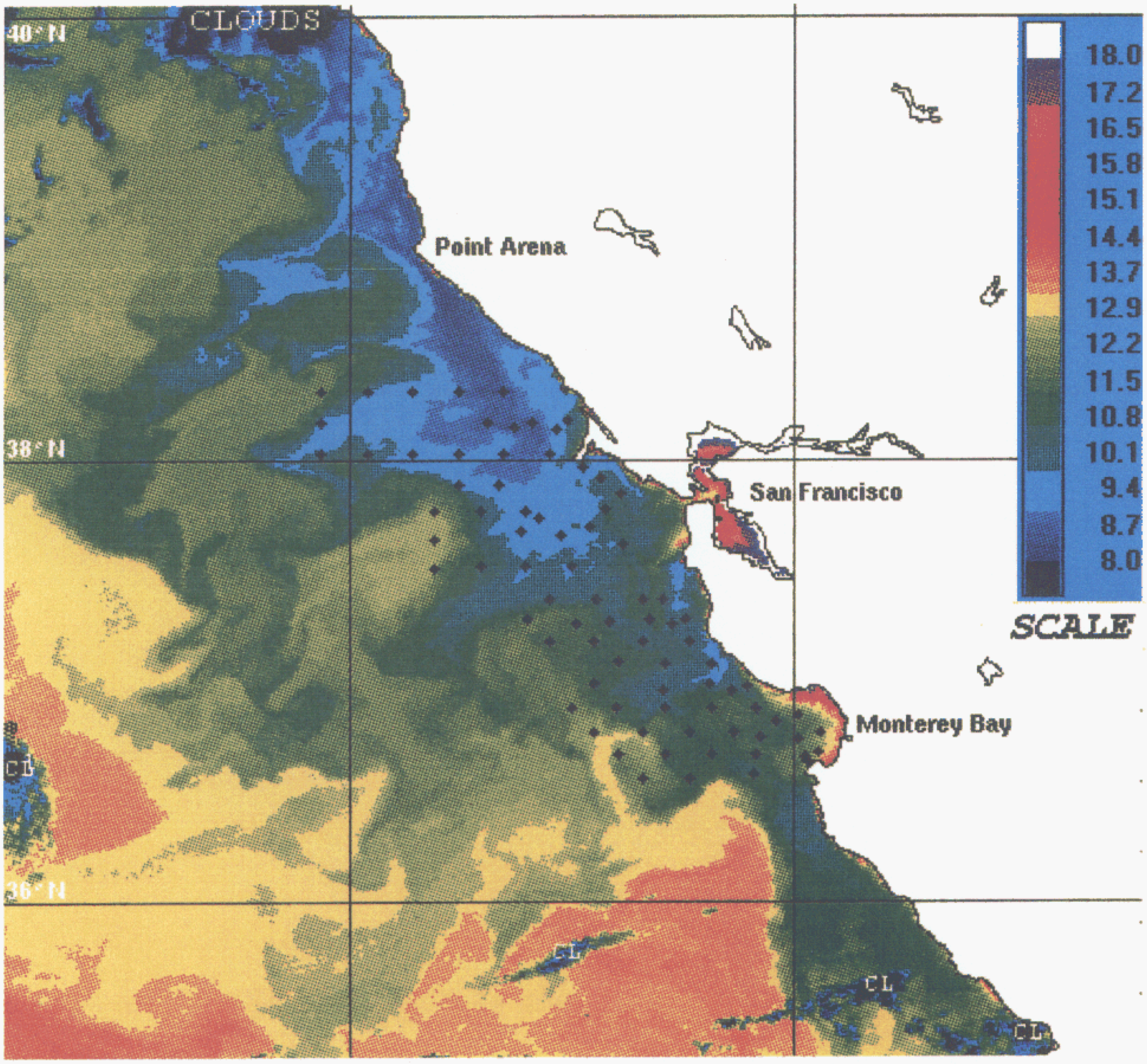
APPENDIX 5: AVHRR SATELLITE IMAGES OF SEA SURFACE TEMPERATURES



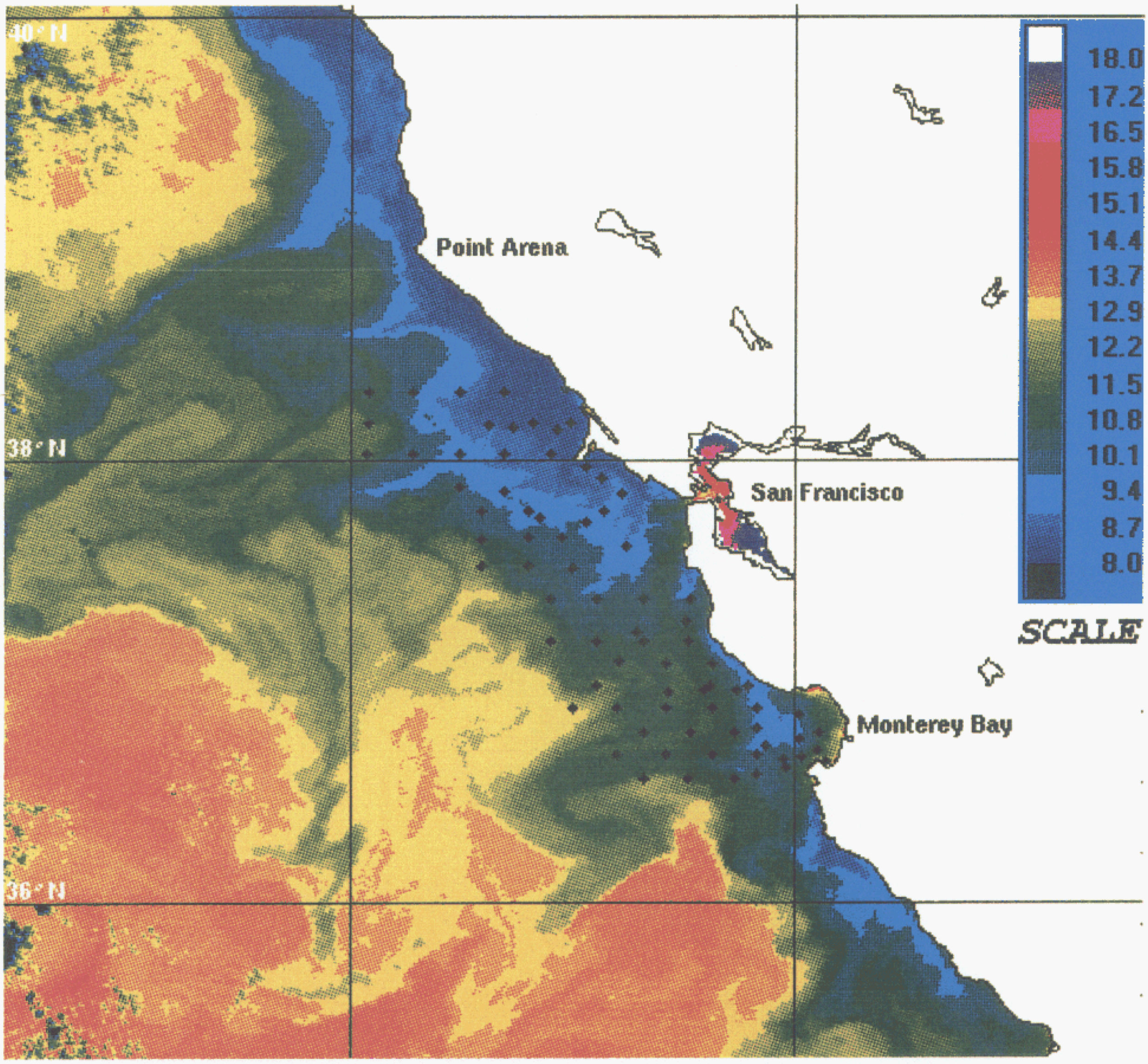
DSJ9403 AVHRR IMAGE FROM MARCH 07, 1994



DSJ9406 SWEEP 1 AVHRR IMAGE FROM MAY 21, 1994

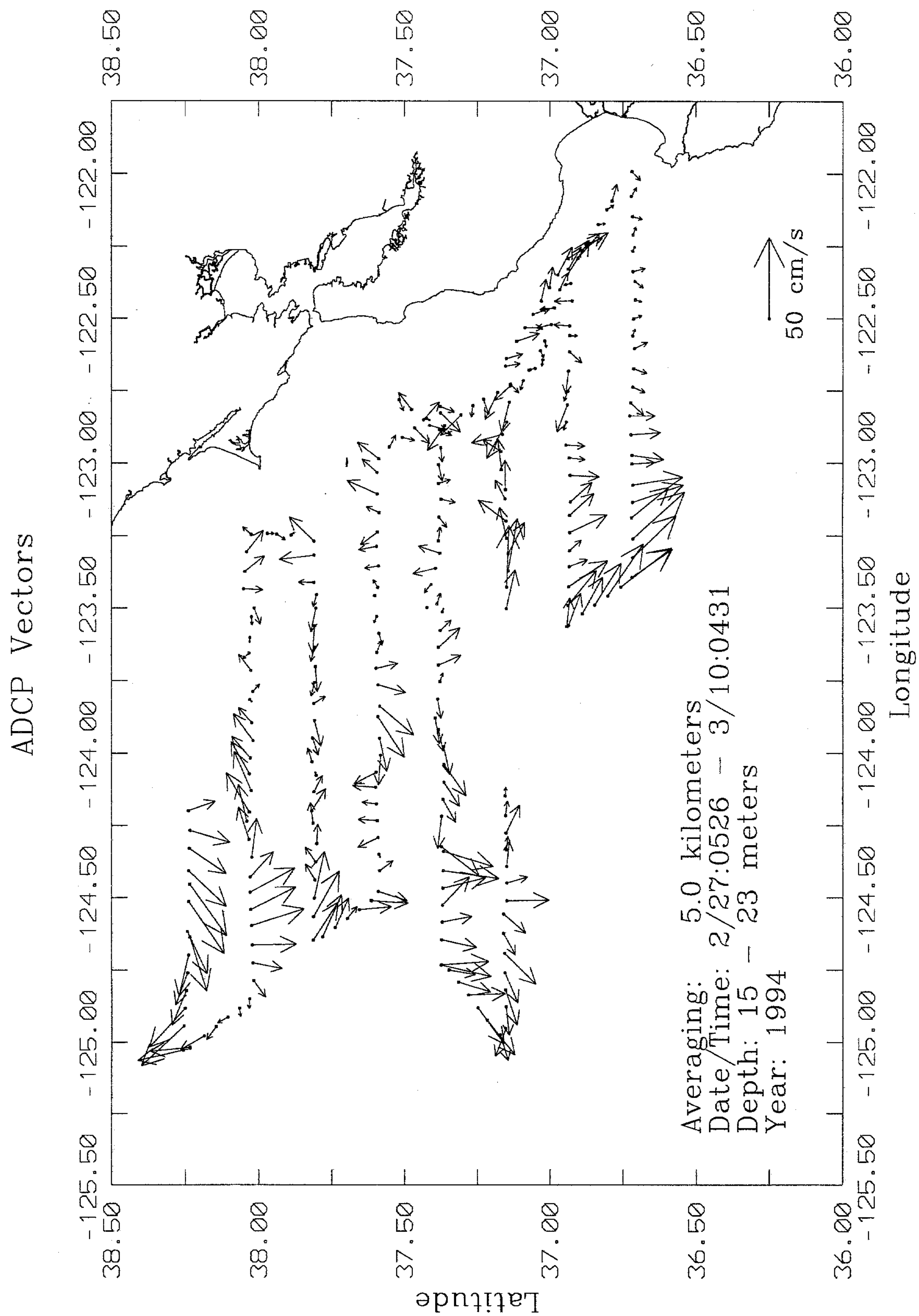


DSJ9406 SWEEP 2 AVHRR IMAGE FROM MAY 29, 1994

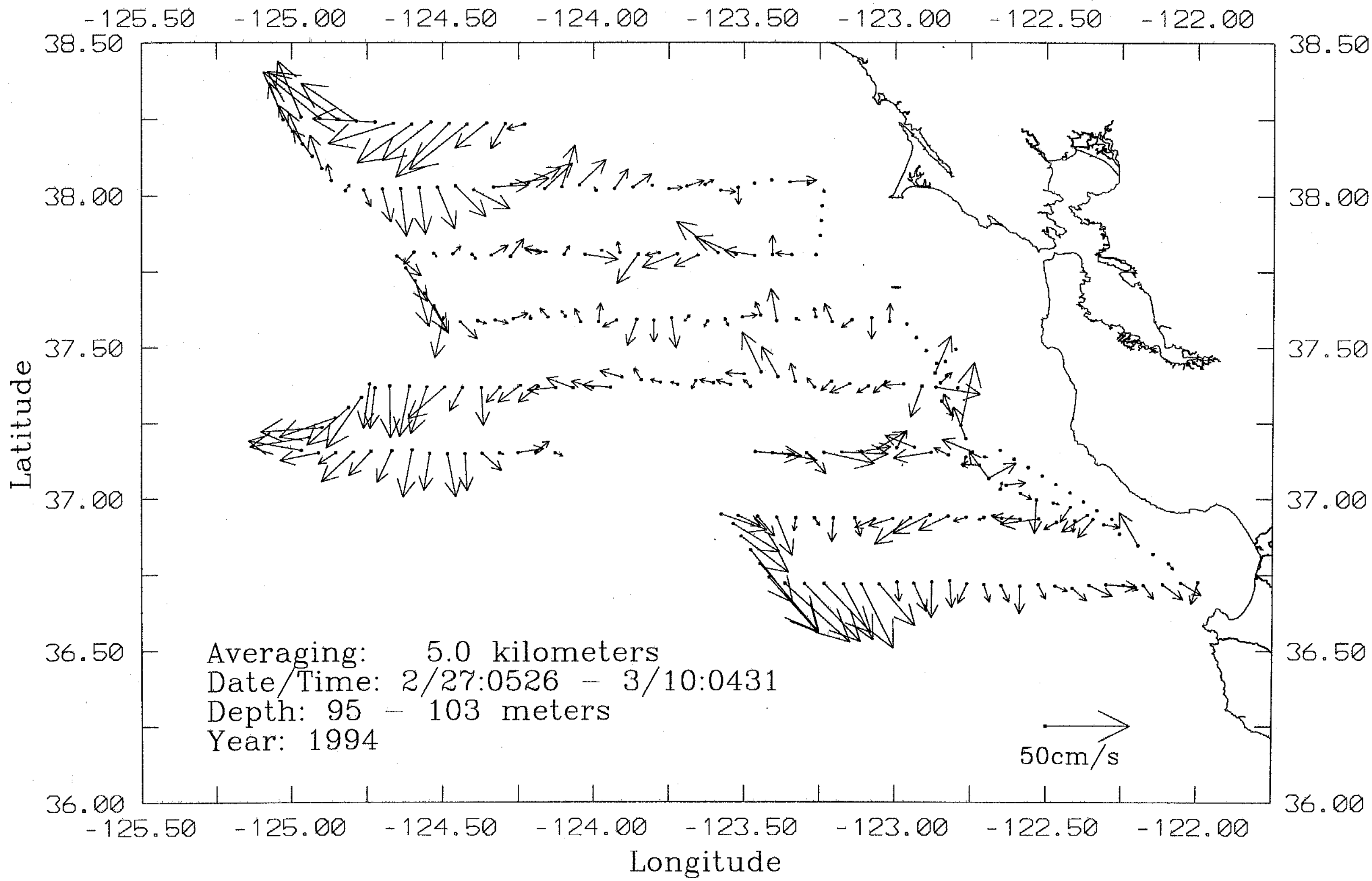


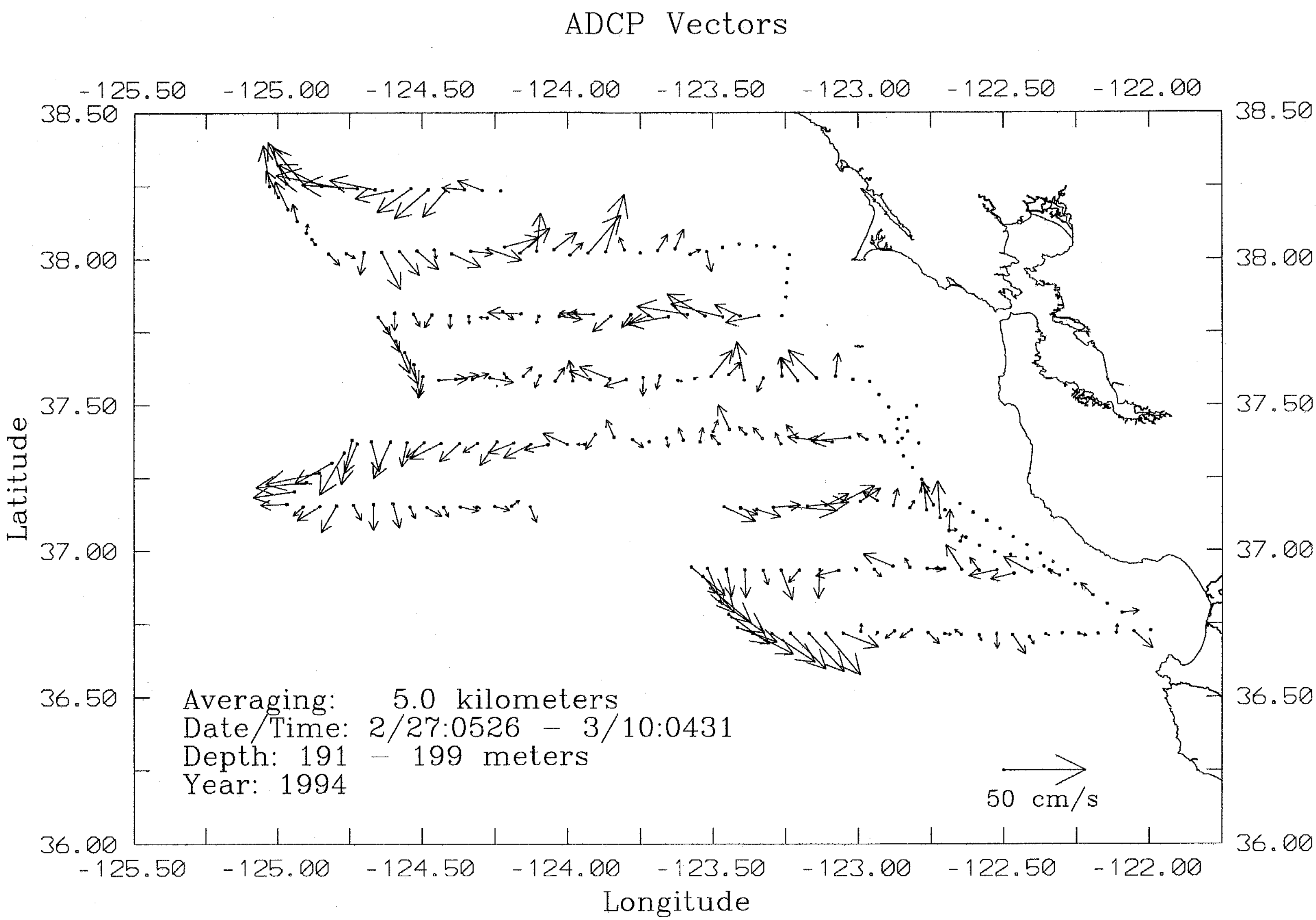
DSJ9406 SWEEP 3 AVHRR IMAGE FROM JUNE 15, 1994

APPENDIX 6: ADCP DATA


ADCP Vectors
Averaging: 5.0 kilometers
Date/Time: 2/27:0526 – 3/10:0431
Depth: 15 – 23 meters
Year: 1994
50 cm/s
Longitude
Latitude
-125.50
-125.00
-124.50
-124.00
-123.50
-123.00
-122.50
-122.00
38.50
38.00
37.50
37.00
36.50
36.00

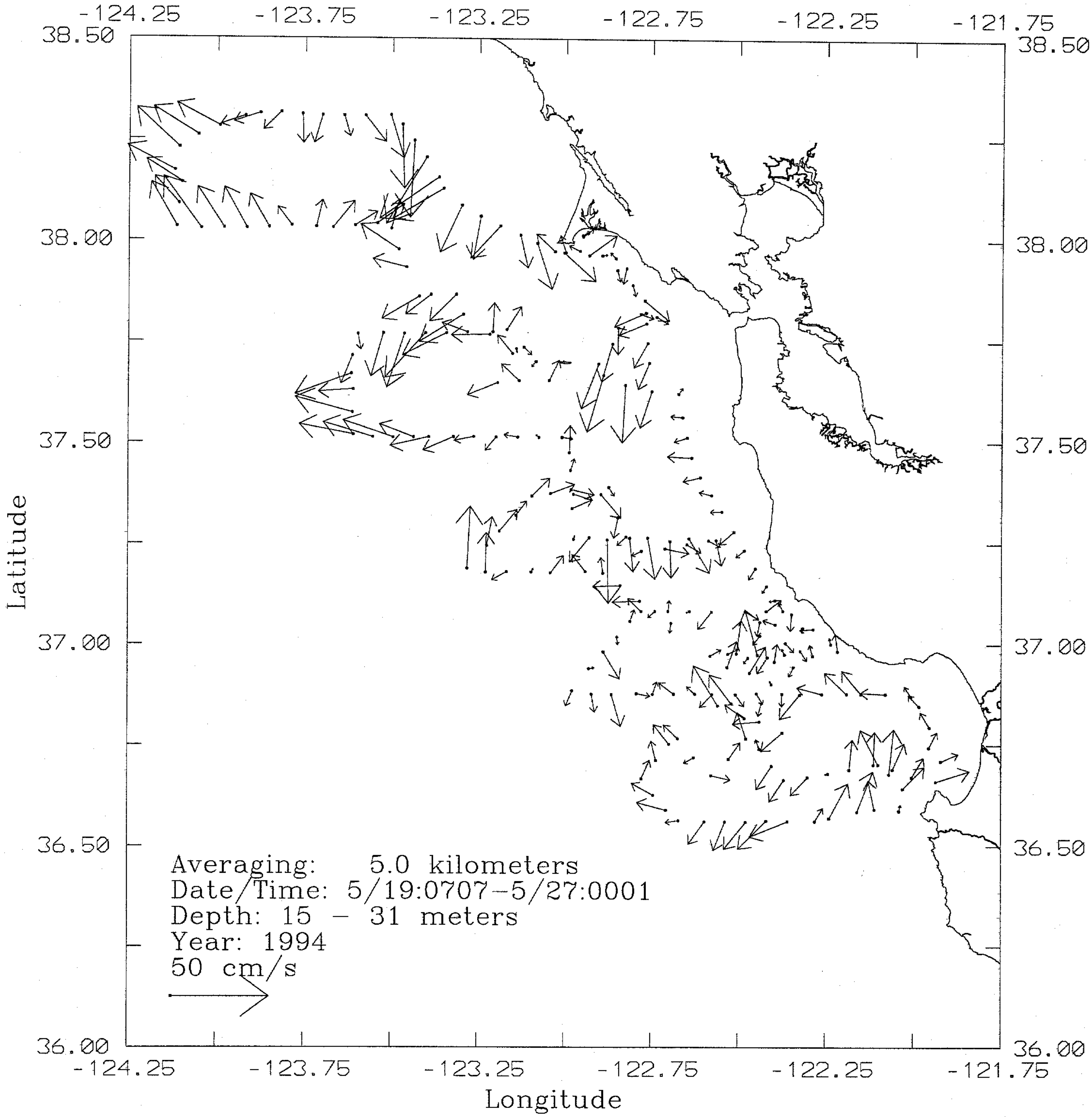
ADCP Vectors

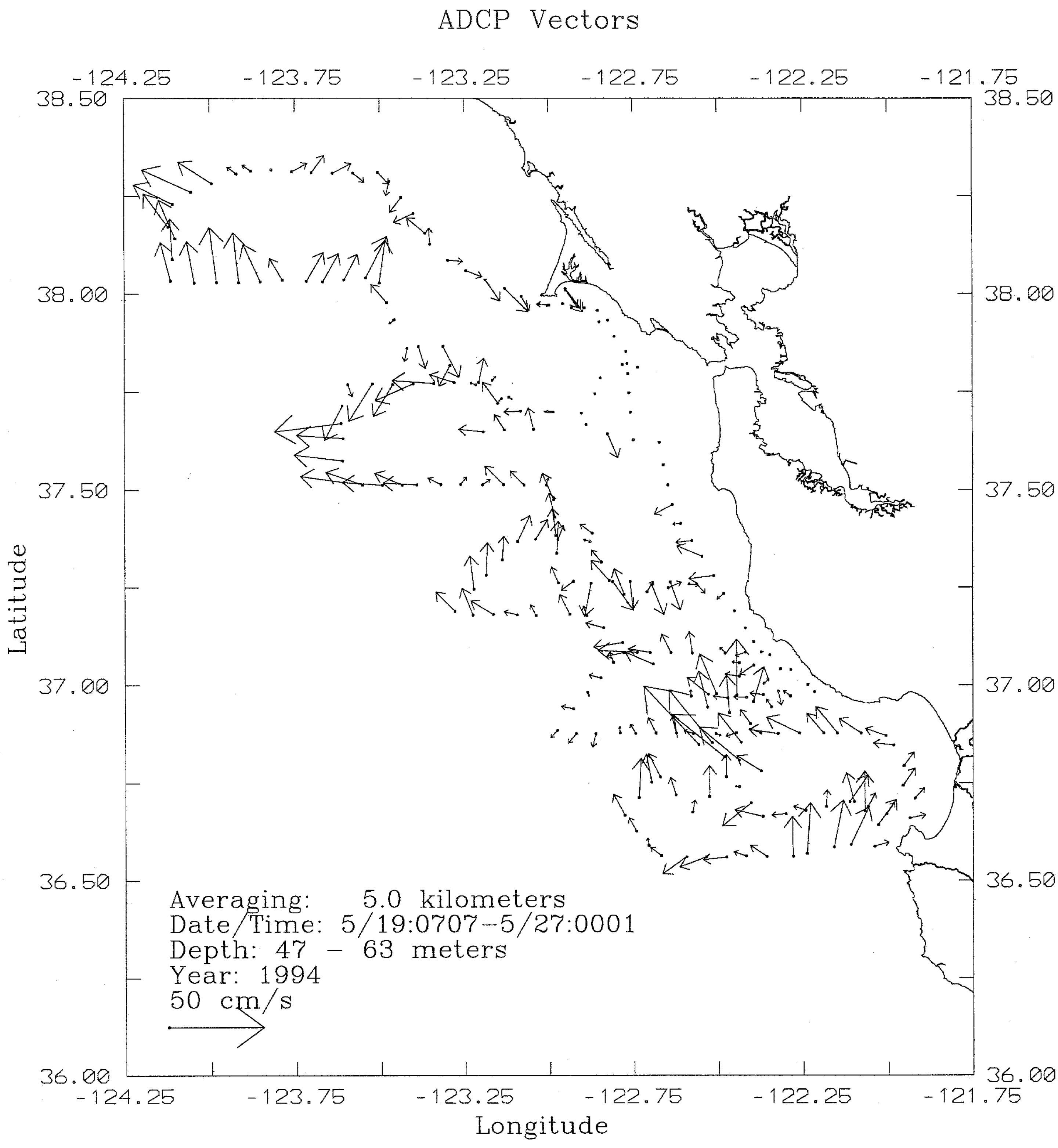


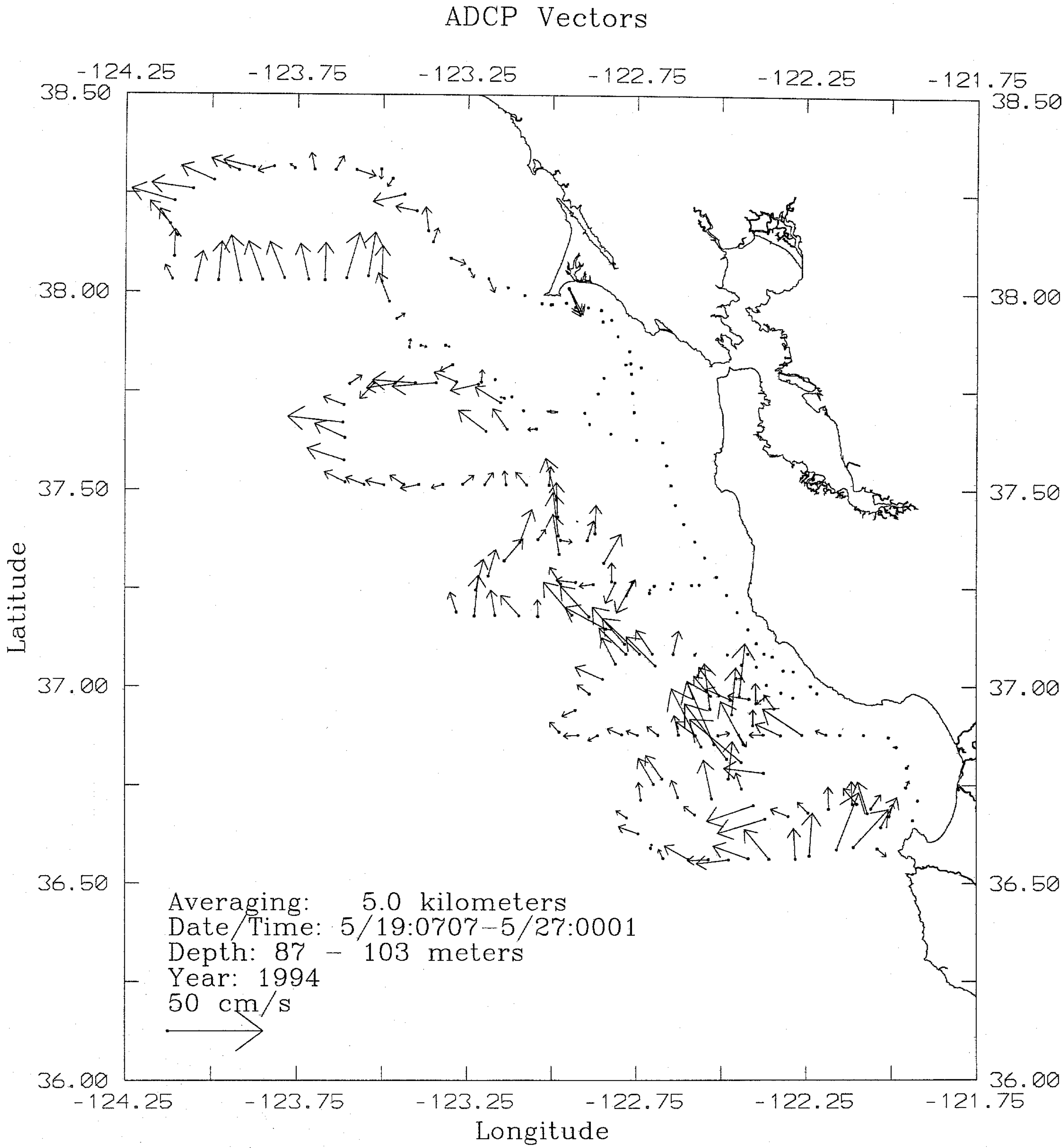


ADCP Vectors
-125.50
-125.00
-124.50
-124.00
-123.50
-123.00
-122.50
-122.00
38.50
38.00
37.50
37.00
36.50
36.00
Latitude
Longitude
Averaging: 5.0 kilometers
Date/Time: 2/27:0526 – 3/10:0431
Depth: 191 – 199 meters
Year: 1994
50 cm/s

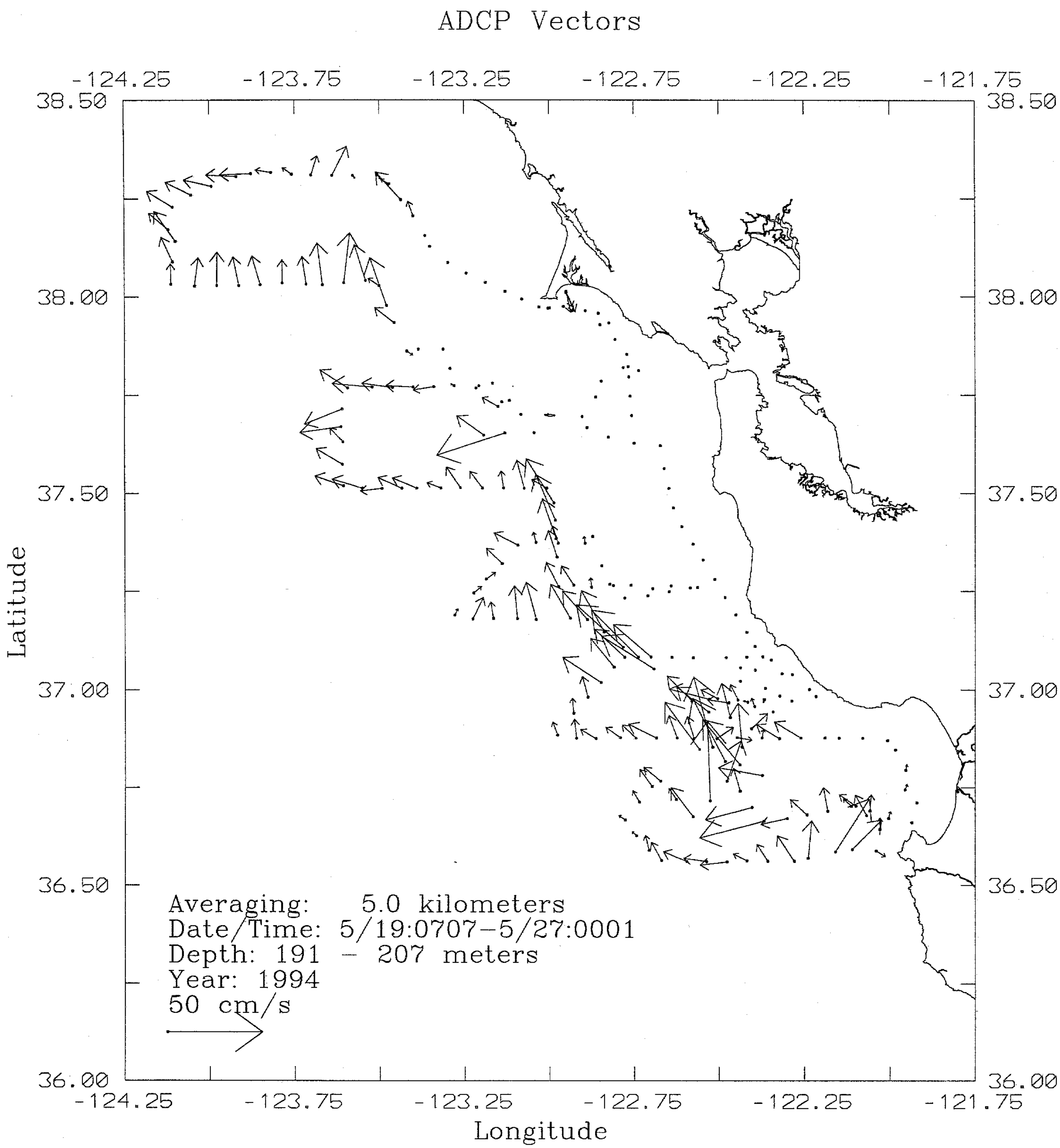
ADCP Vectors

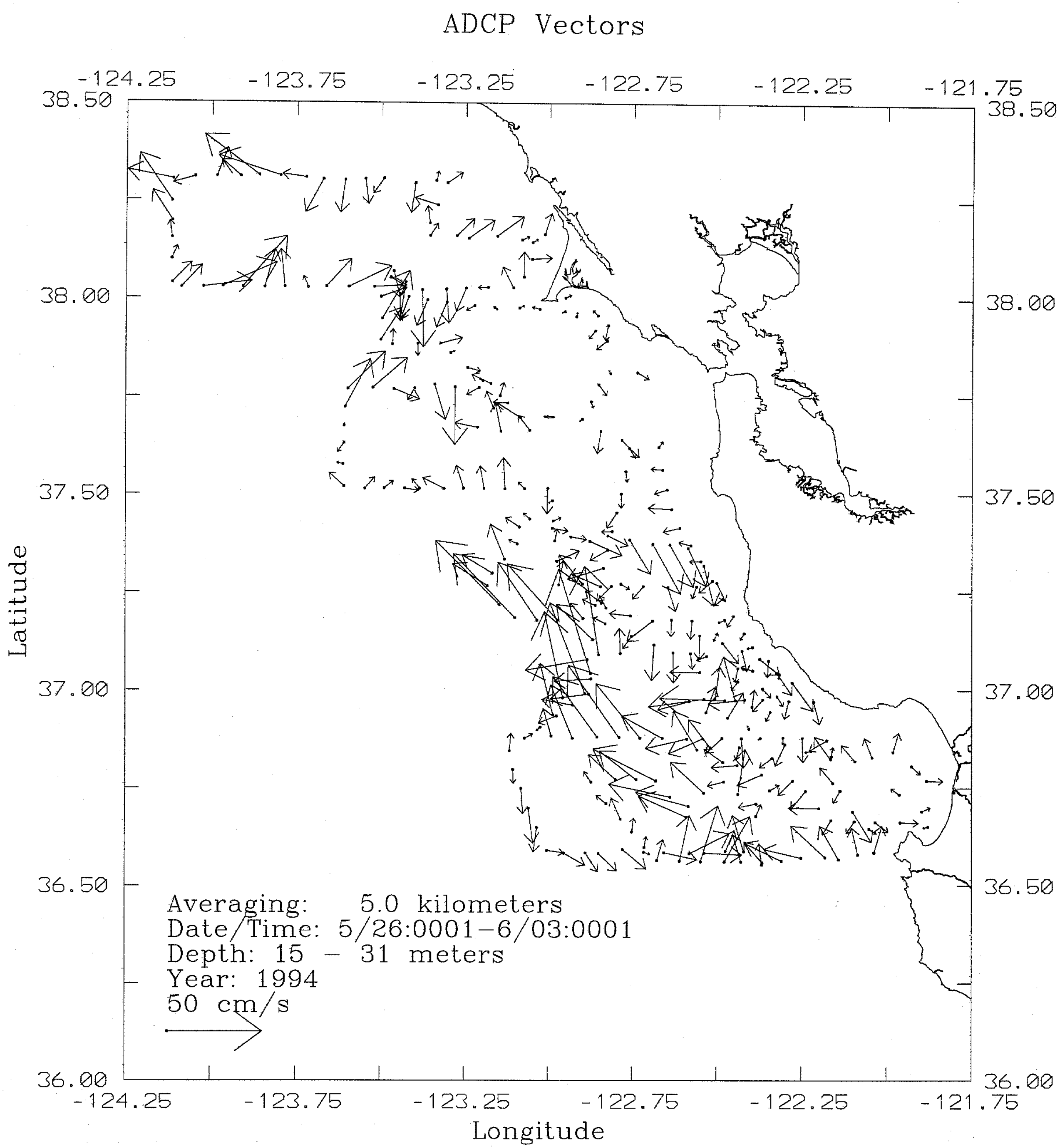


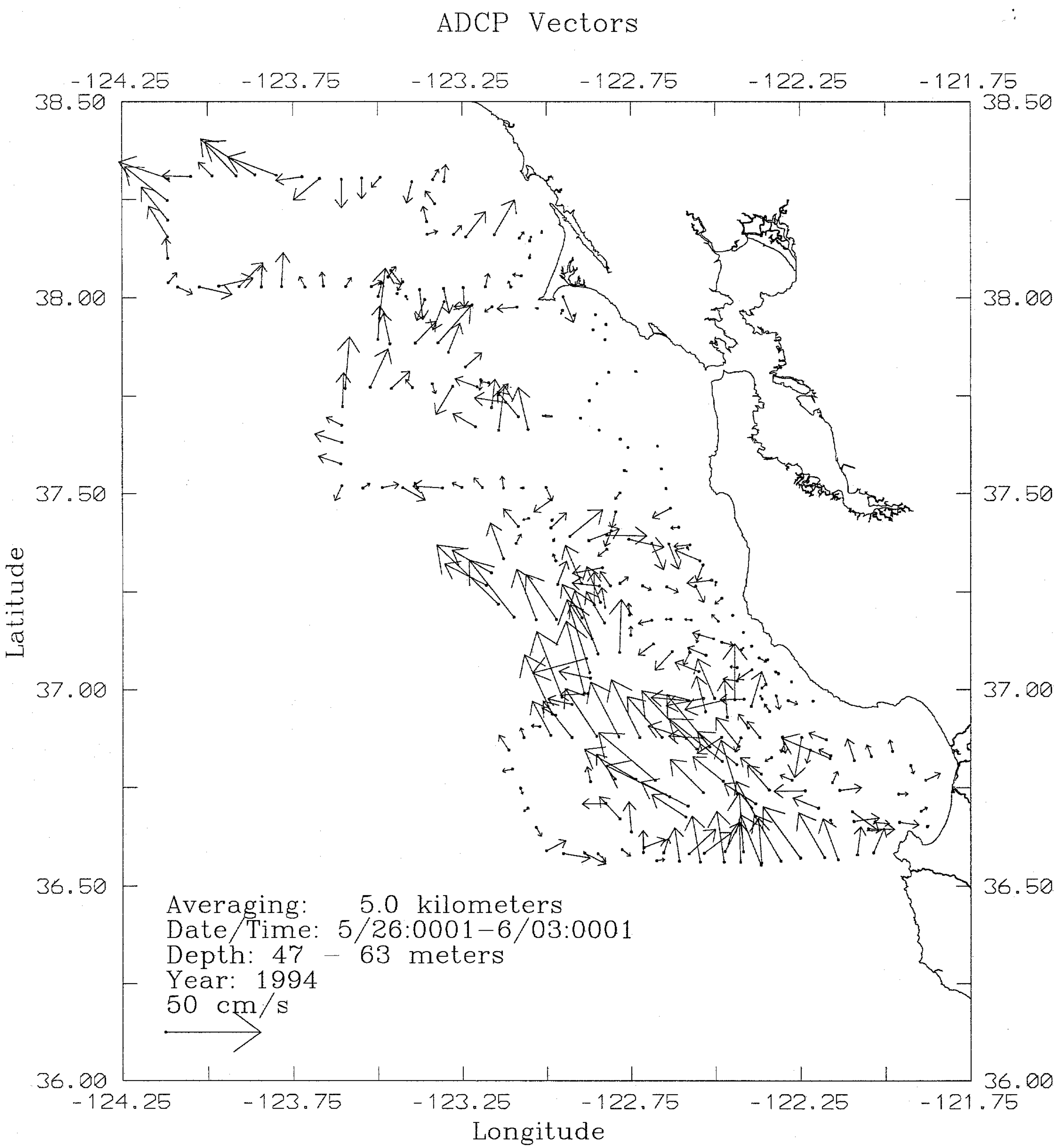

ADCP Vectors
-124.25
-123.75
-123.25
-122.75
-122.25
-121.75
38.50
38.00
37.50
37.00
36.50
36.00
Latitude
Longitude
Averaging: 5.0 kilometers
Date/Time: 5/19:0707-5/27:0001
Depth: 47 - 63 meters
Year: 1994
50 cm/s

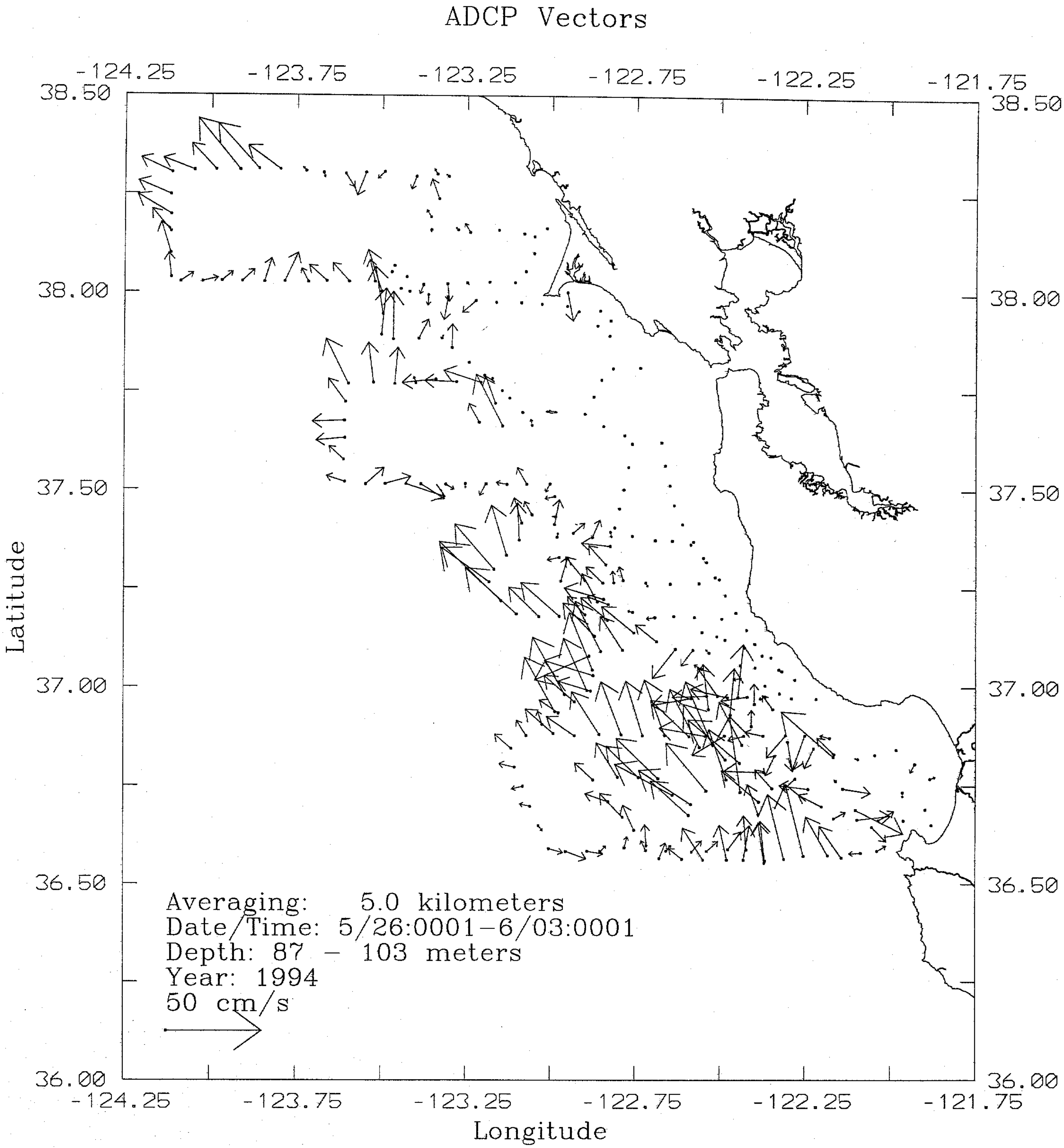


ADCP Vectors
-124.25
-123.75
-123.25
-122.75
-122.25
-121.75
38.50
38.00
37.50
37.00
36.50
36.00
Latitude
Longitude
Averaging: 5.0 kilometers
Date/Time: 5/19:0707-5/27:0001
Depth: 87 - 103 meters
Year: 1994
50 cm/s

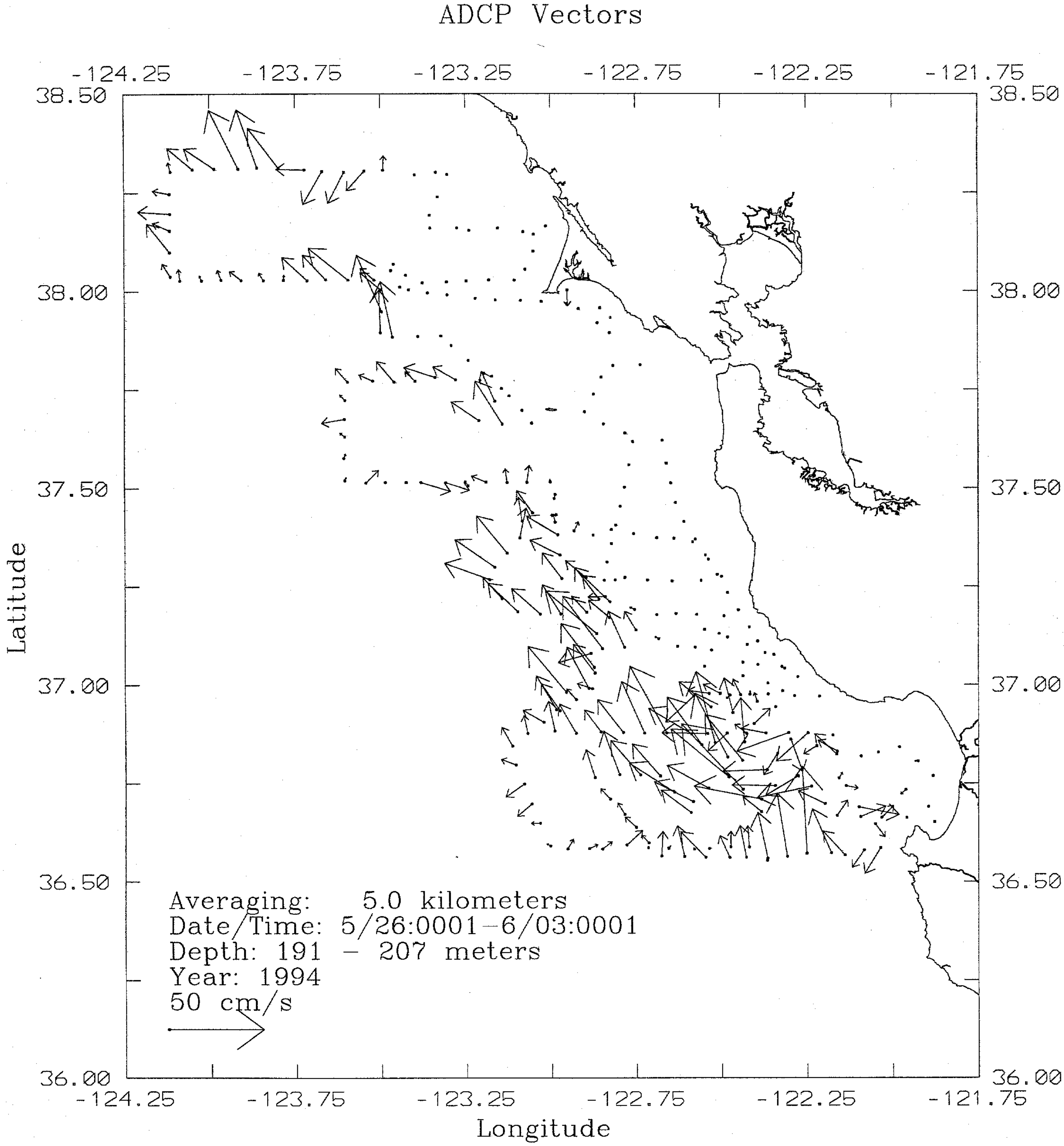

ADCP Vectors
-124.25
-123.75
-123.25
-122.75
-122.25
-121.75
38.50
38.00
37.50
37.00
36.50
36.00
Latitude
Longitude
Averaging: 5.0 kilometers
Date/Time: 5/19:0707-5/27:0001
Depth: 191 - 207 meters
Year: 1994
50 cm/s


ADCP Vectors
-124.25
-123.75
-123.25
-122.75
-122.25
-121.75
38.50
38.00
37.50
37.00
36.50
36.00
Latitude
Longitude
Averaging: 5.0 kilometers
Date/Time: 5/26:0001-6/03:0001
Depth: 15 - 31 meters
Year: 1994
50 cm/s

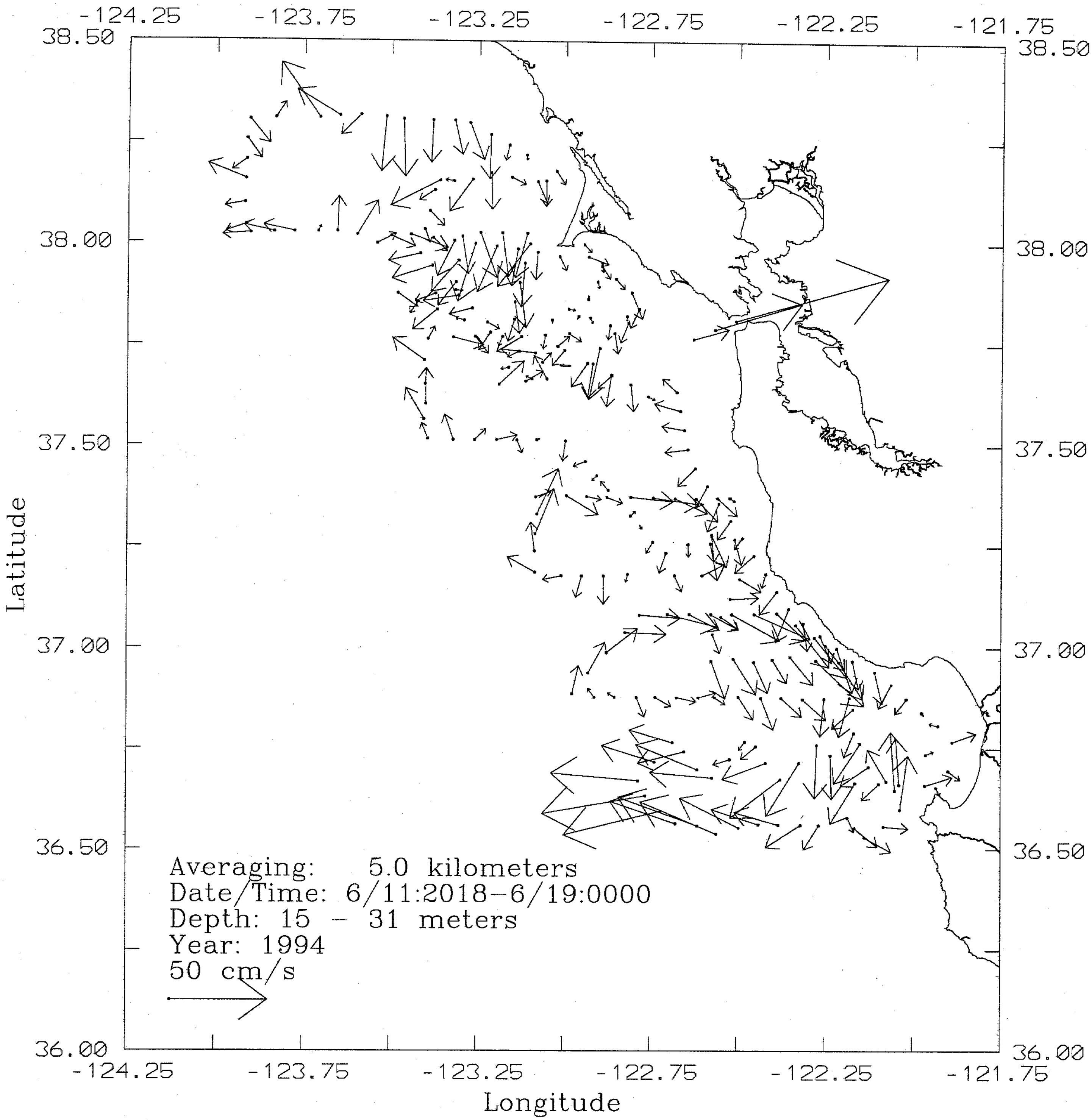

ADCP Vectors
-124.25
-123.75
-123.25
-122.75
-122.25
-121.75
38.50
38.00
37.50
37.00
36.50
36.00
Latitude
Longitude
Averaging: 5.0 kilometers
Date/Time: 5/26:0001-6/03:0001
Depth: 47 - 63 meters
Year: 1994
50 cm/s



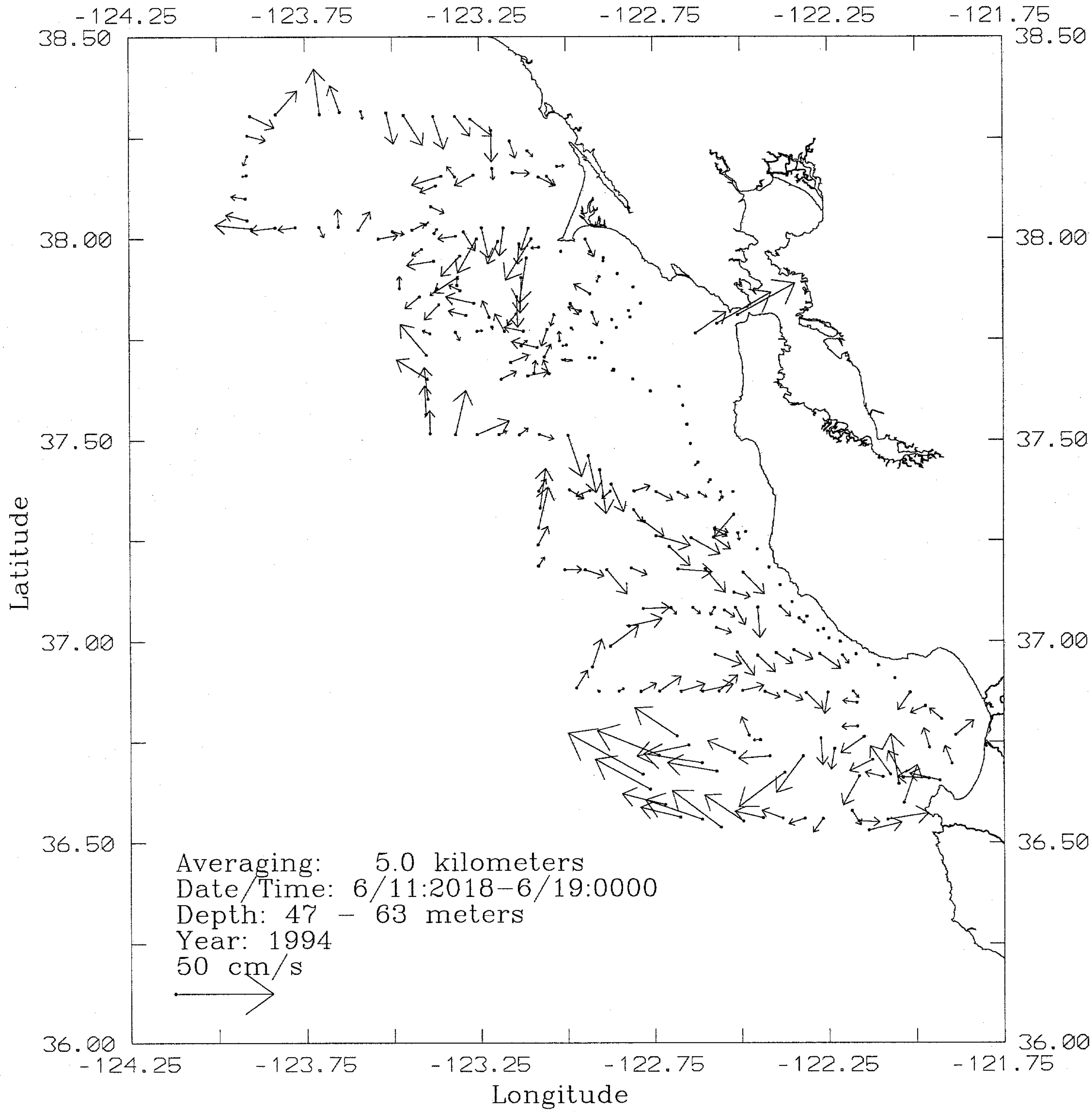
ADCP Vectors
-124.25
-123.75
-123.25
-122.75
-122.25
-121.75
38.50
38.00
37.50
37.00
36.50
36.00
Latitude
Longitude
Averaging: 5.0 kilometers
Date/Time: 5/26:0001-6/03:0001
Depth: 87 - 103 meters
Year: 1994
50 cm/s

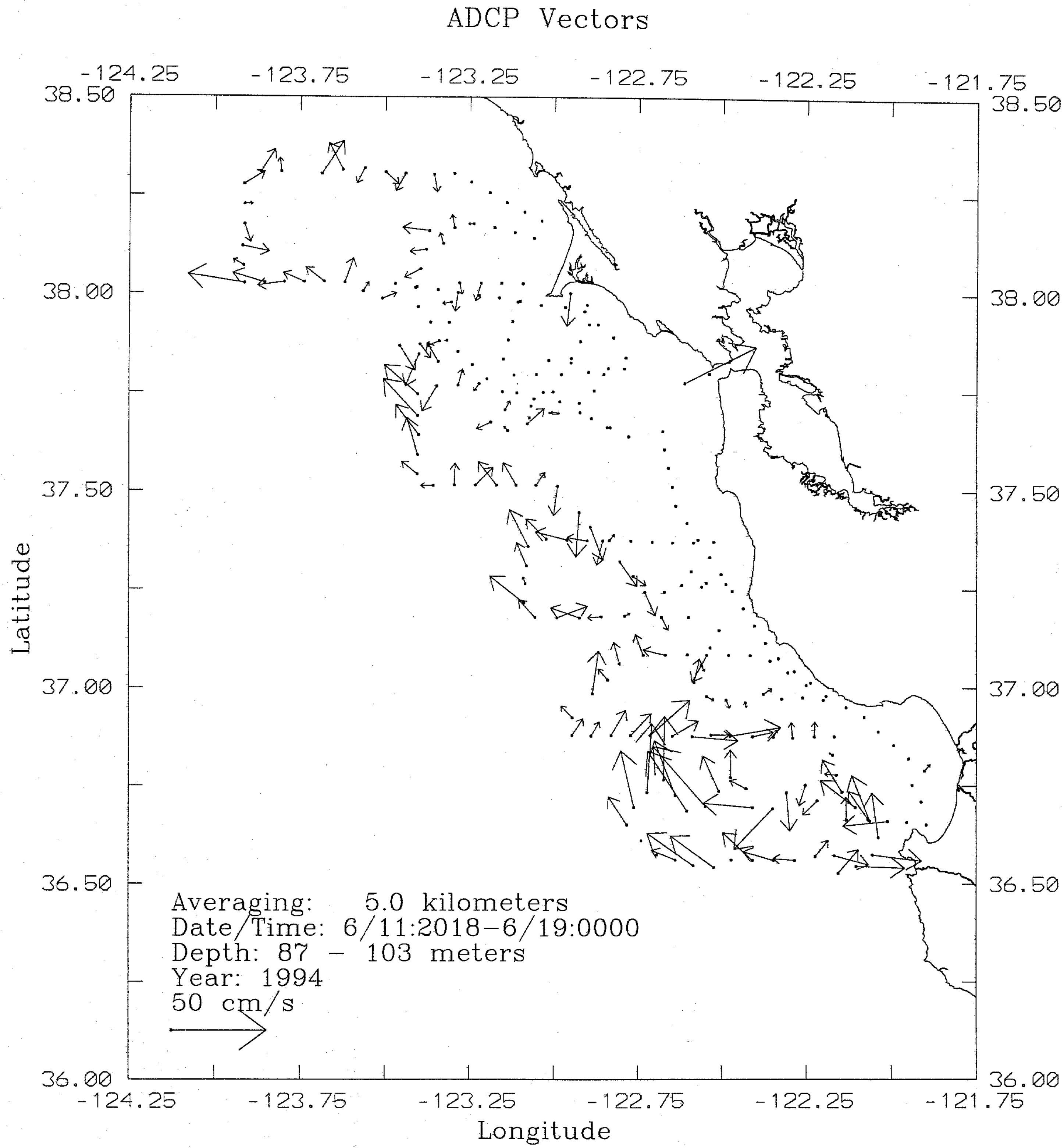

ADCP Vectors
-124.25
-123.75
-123.25
-122.75
-122.25
-121.75
38.50
38.00
37.50
37.00
36.50
36.00
Latitude
Longitude
Averaging: 5.0 kilometers
Date/Time: 5/26:0001-6/03:0001
Depth: 191 - 207 meters
Year: 1994
50 cm/s

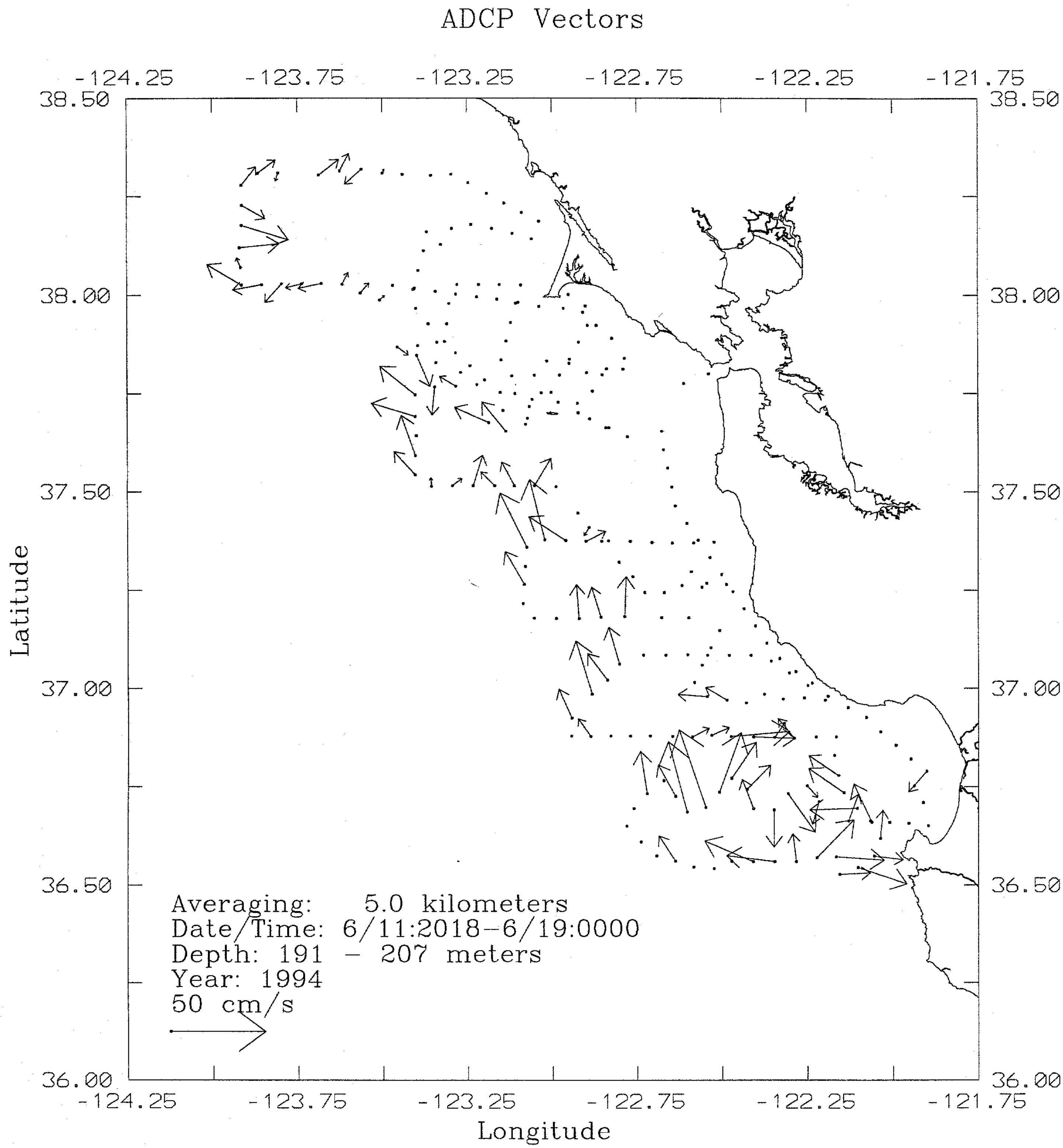
ADCP Vectors



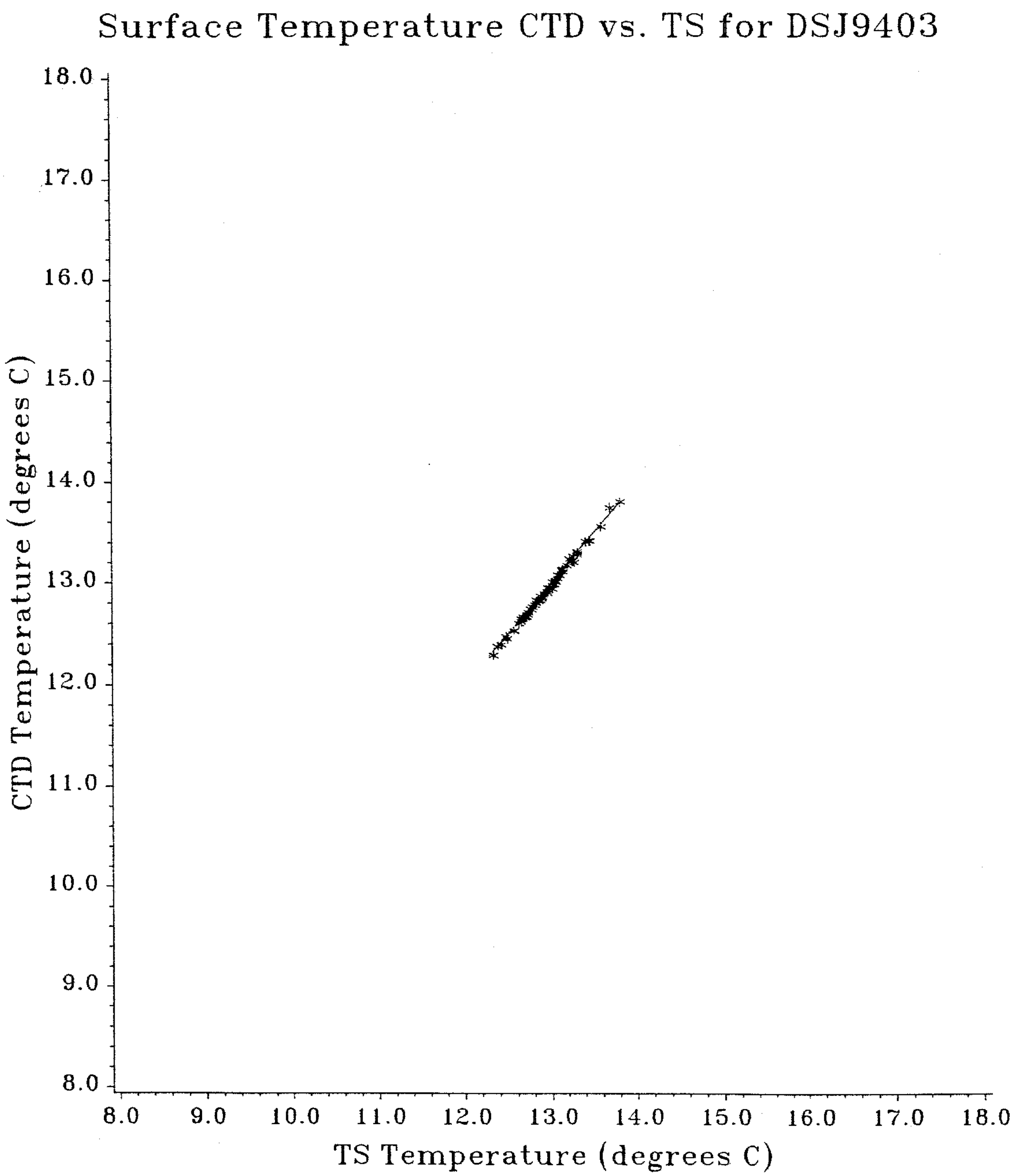
ADCP Vectors



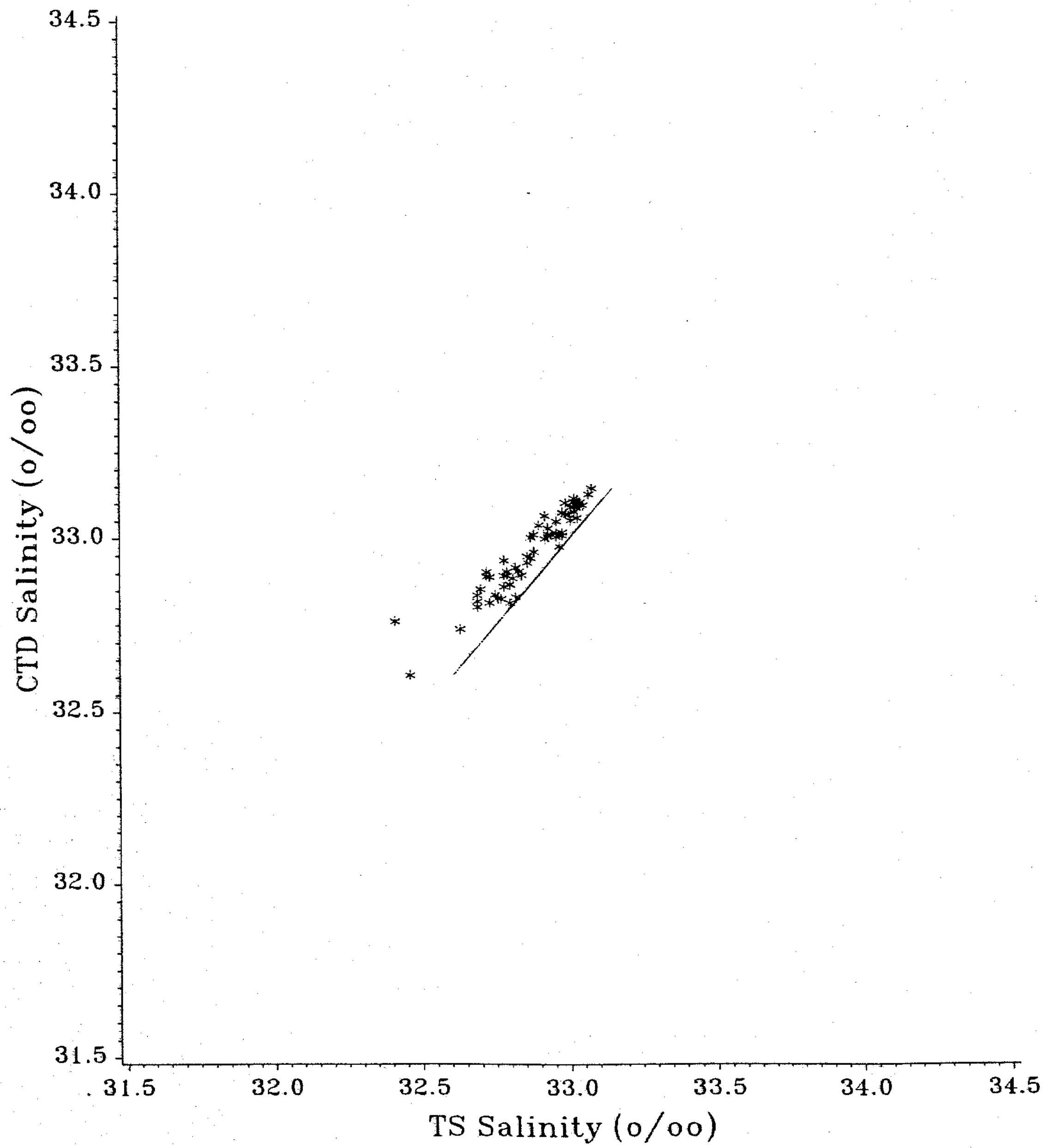

ADCP Vectors
-124.25
-123.75
-123.25
-122.75
-122.25
-121.75
38.50
38.00
37.50
37.00
36.50
36.00
Latitude
Longitude
Averaging: 5.0 kilometers
Date/Time: 6/11:2018-6/19:0000
Depth: 87 - 103 meters
Year: 1994
50 cm/s

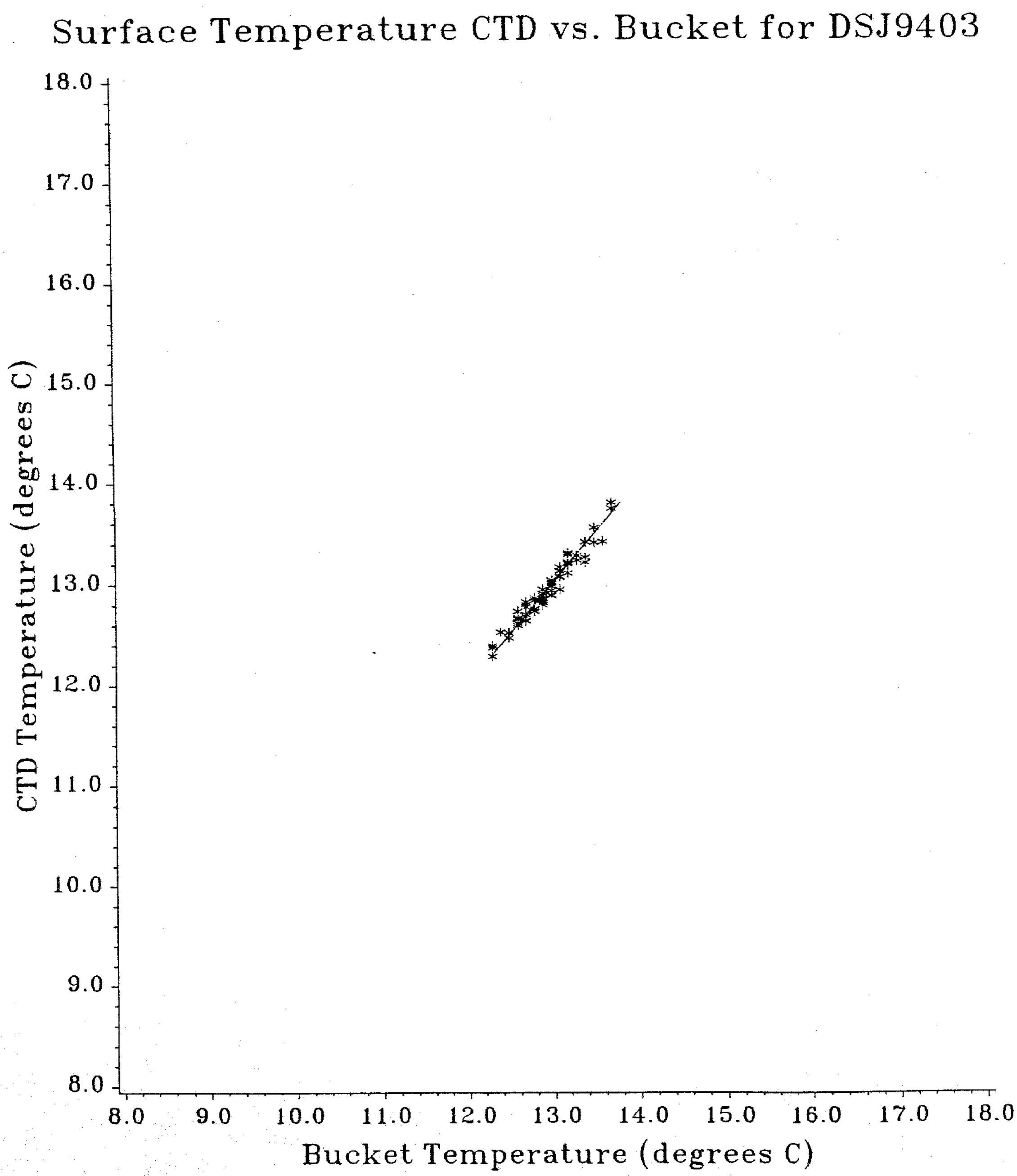

ADCP Vectors
-124.25
-123.75
-123.25
-122.75
-122.25
-121.75
38.50
38.00
37.50
37.00
36.50
36.00
Latitude
Longitude
Averaging: 5.0 kilometers
Date/Time: 6/11:2018-6/19:0000
Depth: 191 - 207 meters
Year: 1994
50 cm/s

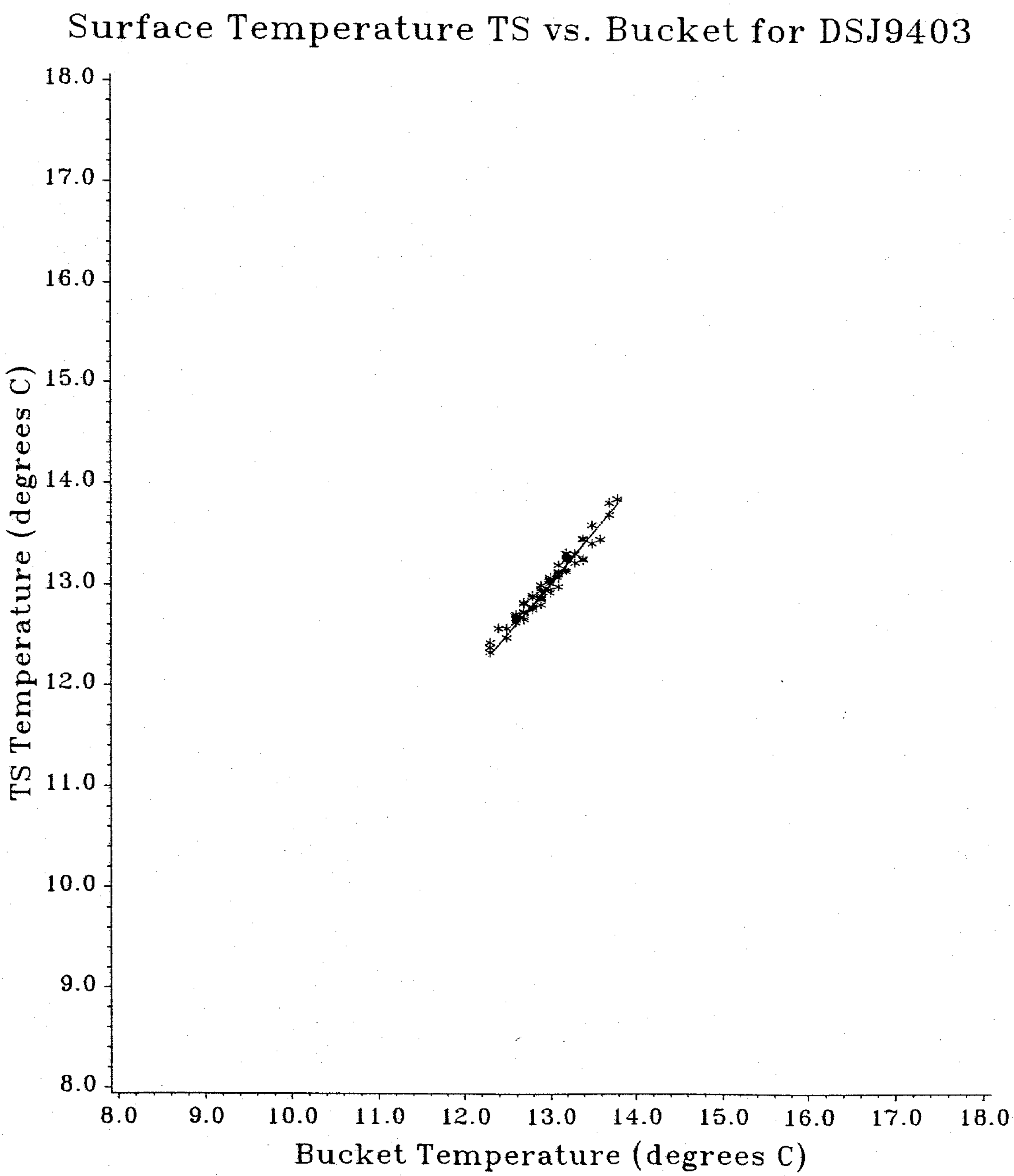
APPENDIX 7.1: REGRESSION COMPARISONS OF CTD, TS, AND BUCKET FOR DSJ9403


Surface Temperature CTD vs. TS for DSJ9403
CTD Temperature (degrees C)
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
TS Temperature (degrees C)

Surface Salinity CTD vs. TS for DSJ9403



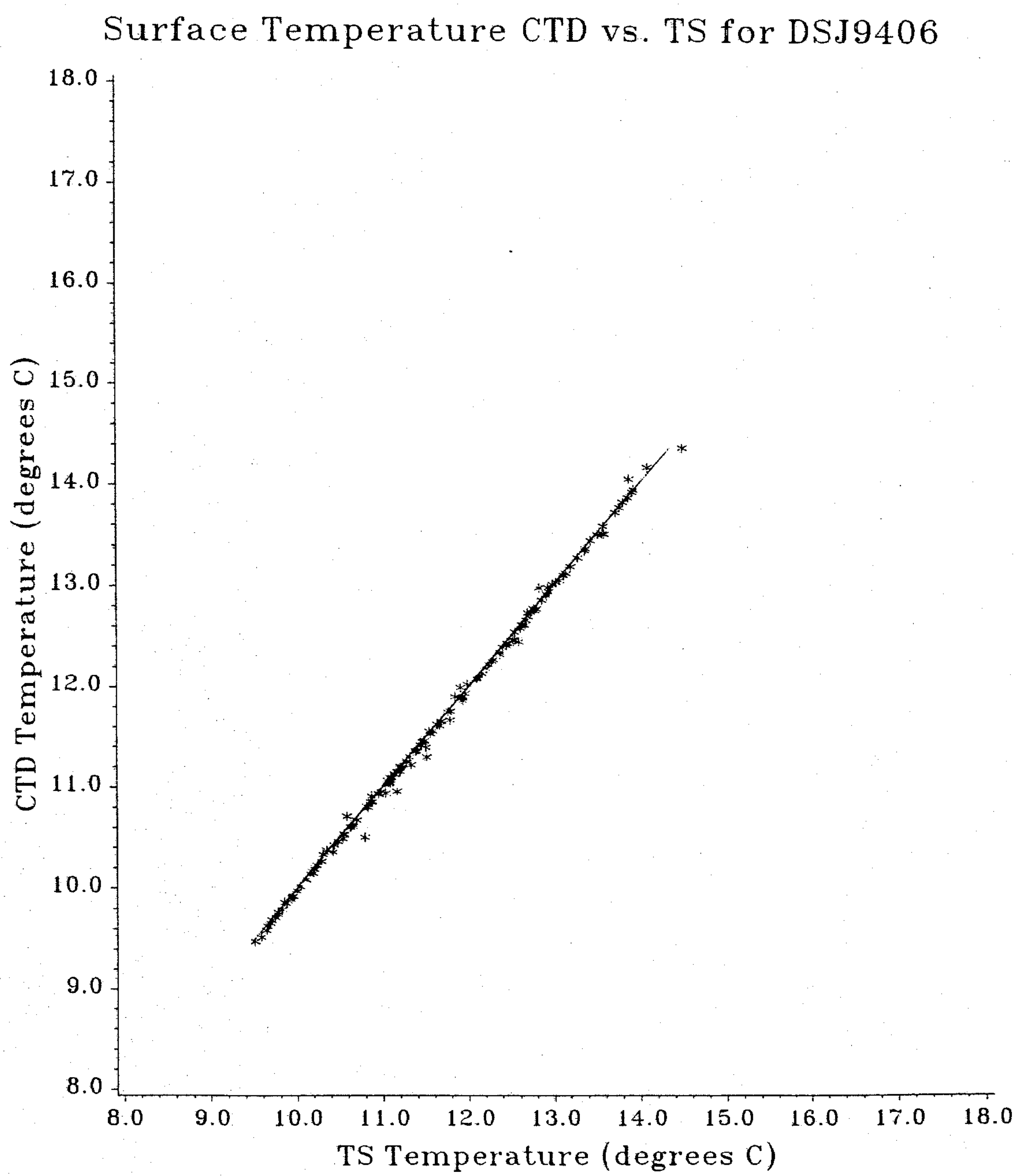

Surface Temperature CTD vs. Bucket for DSJ9403
CTD Temperature (degrees C)
Bucket Temperature (degrees C)
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0



Surface Temperature TS vs. Bucket for DSJ9403
TS Temperature (degrees C)
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
Bucket Temperature (degrees C)

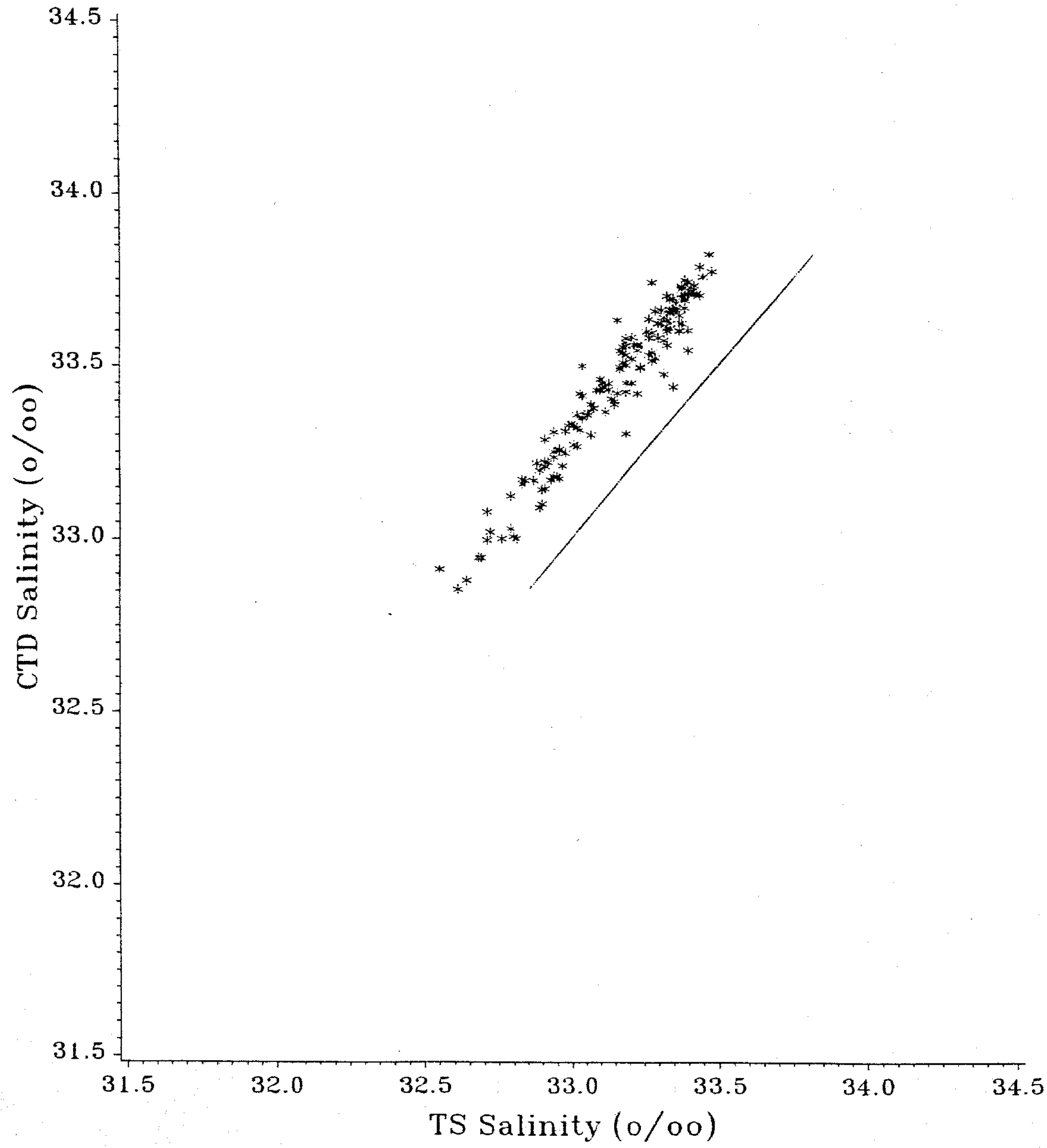
APPENDIX 7.2: REGRESSION COMPARISONS OF CTD, TS, AND BUCKET FOR DSJ9406

CTD Casts 1-215

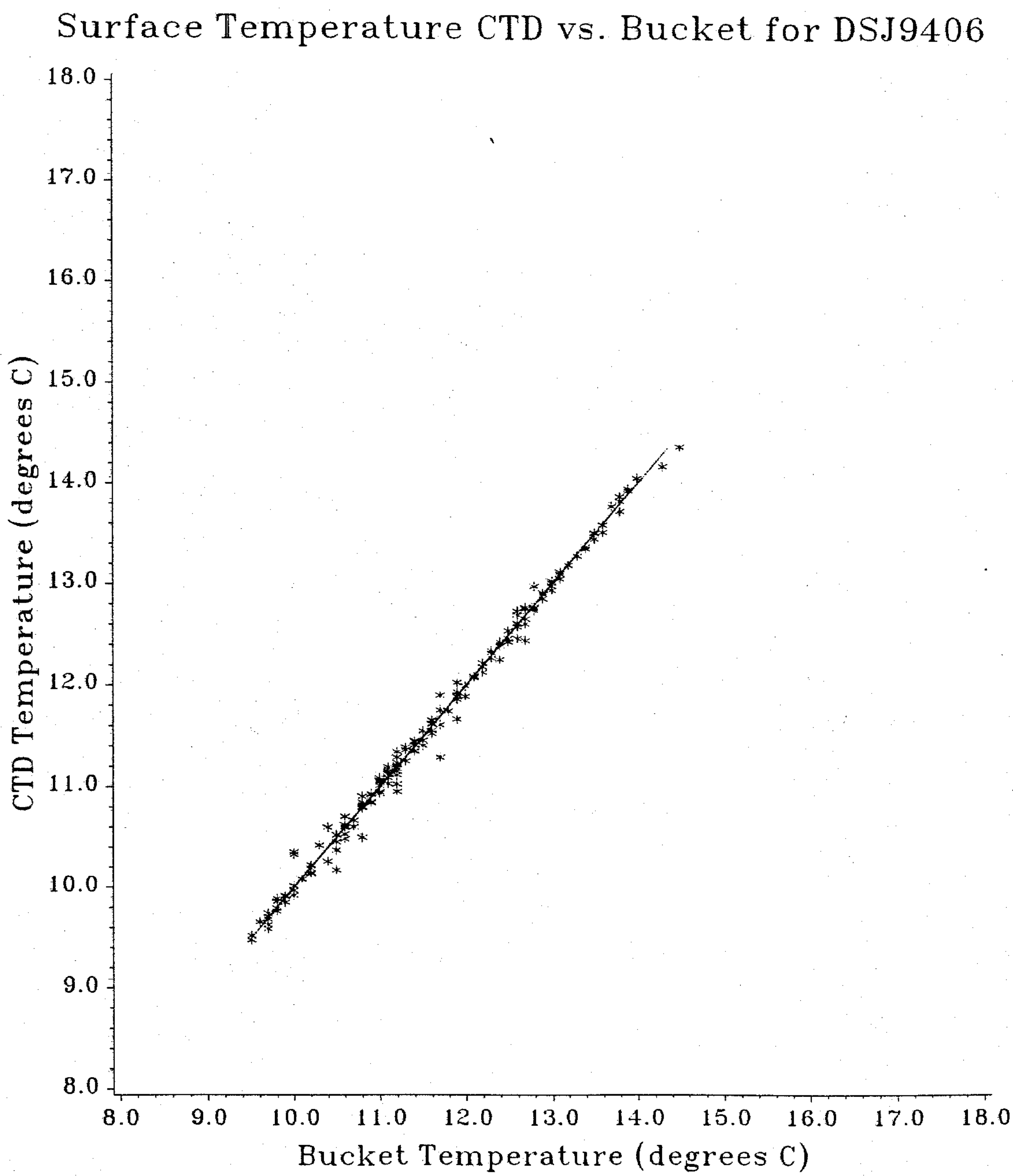


CTD Casts 1-215

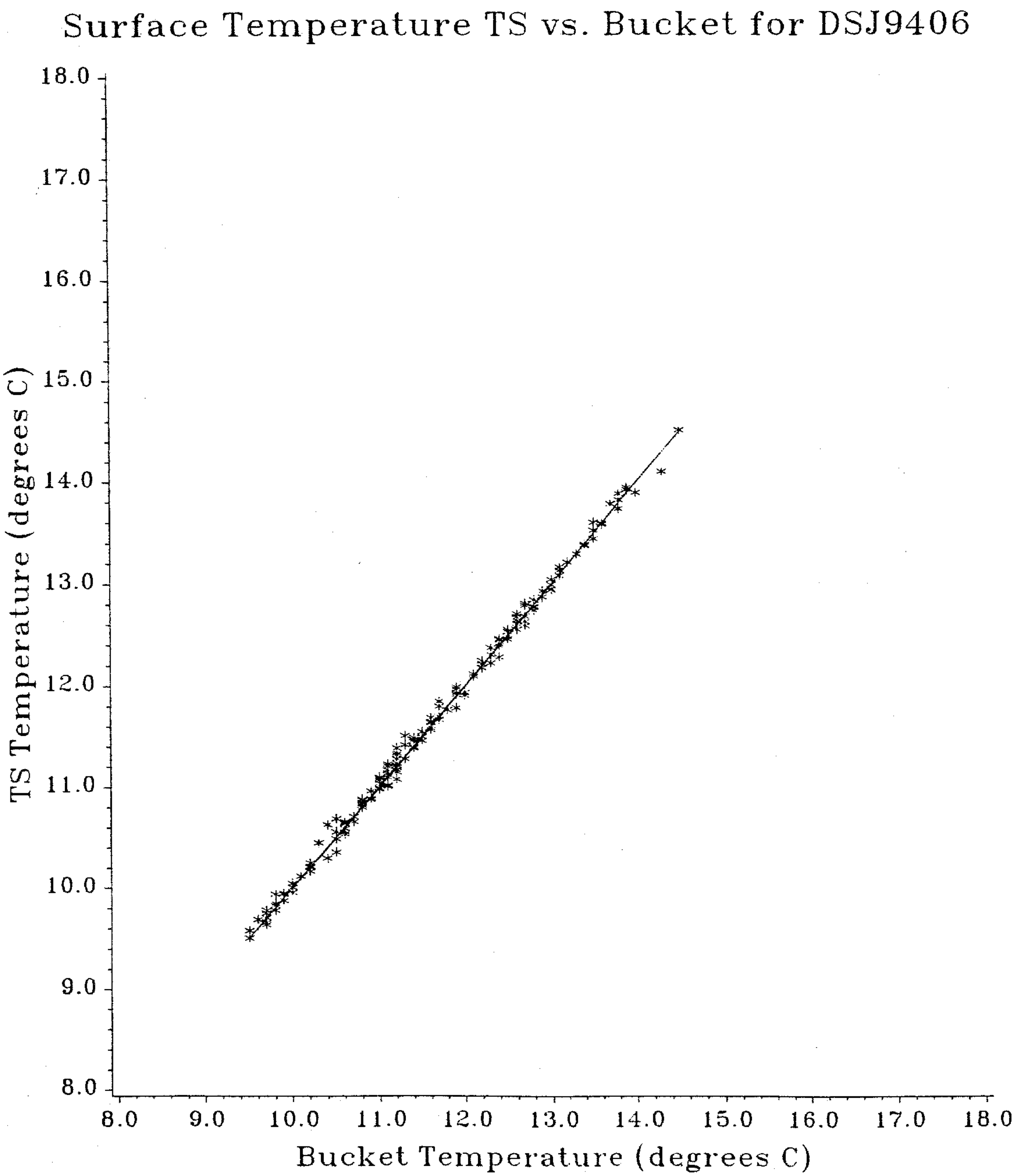
Surface Salinity CTD vs. TS for DSJ9406



CTD Casts 1-215

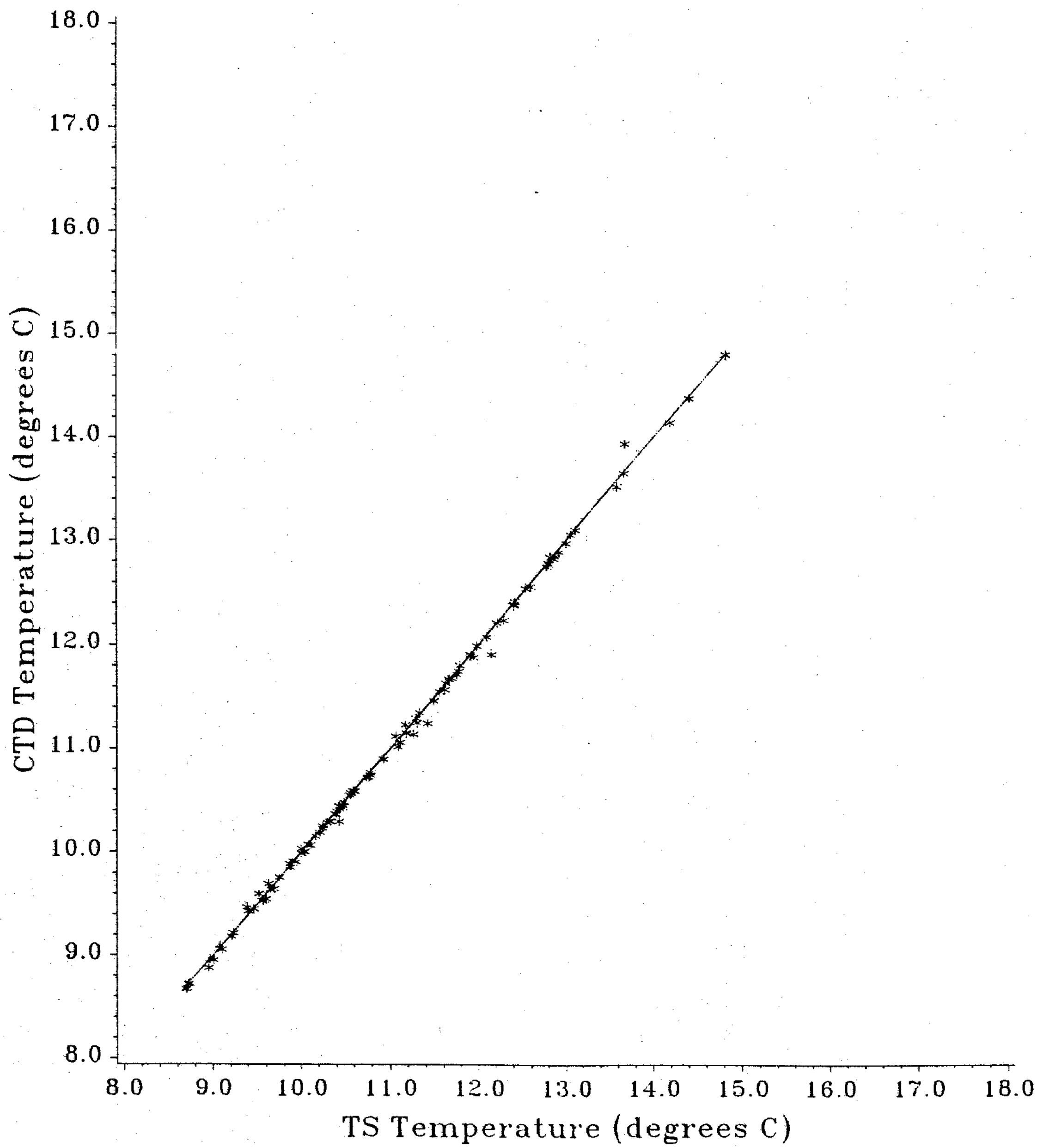


CTD Casts 1-215

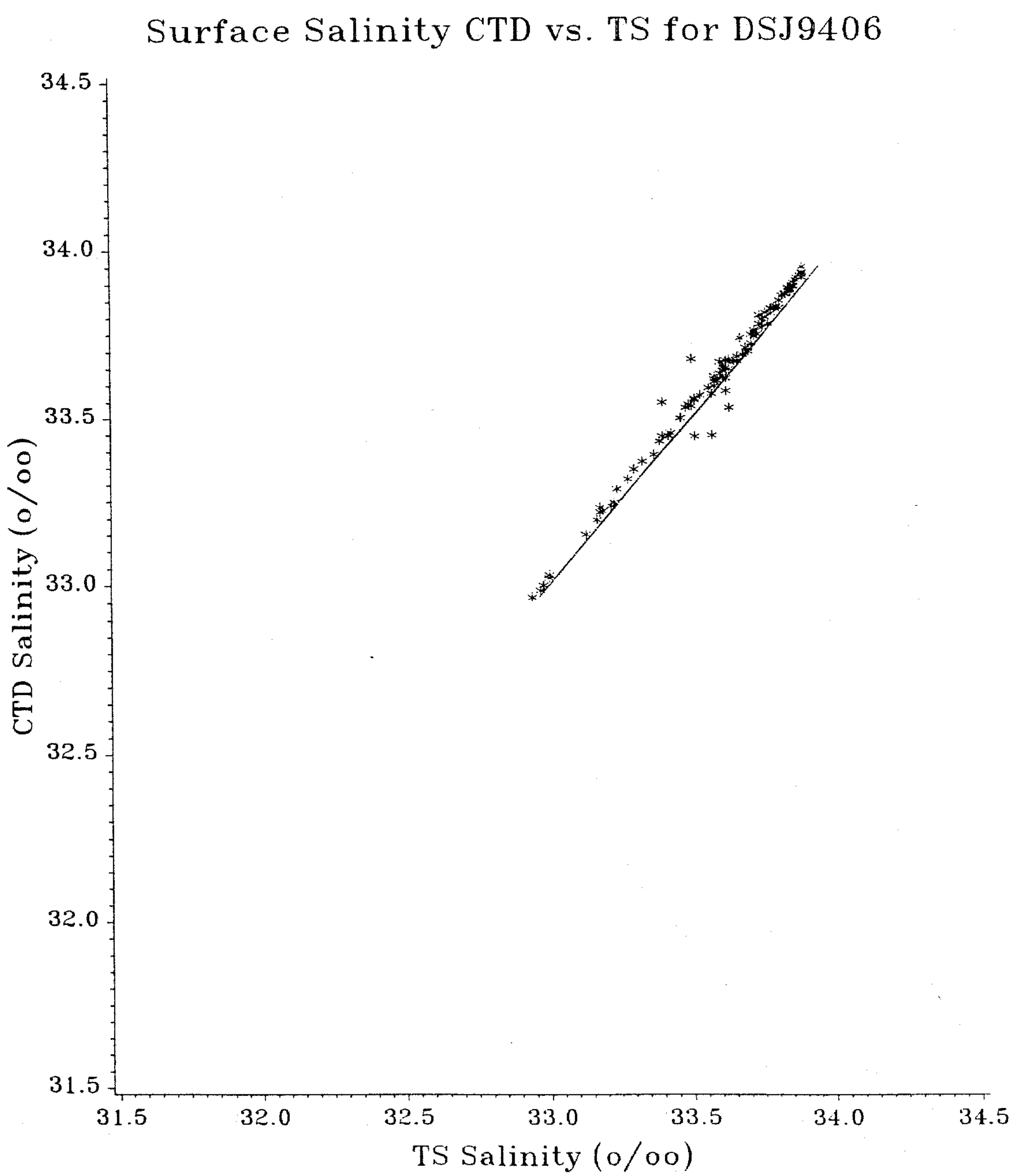


CTD Casts 217-295

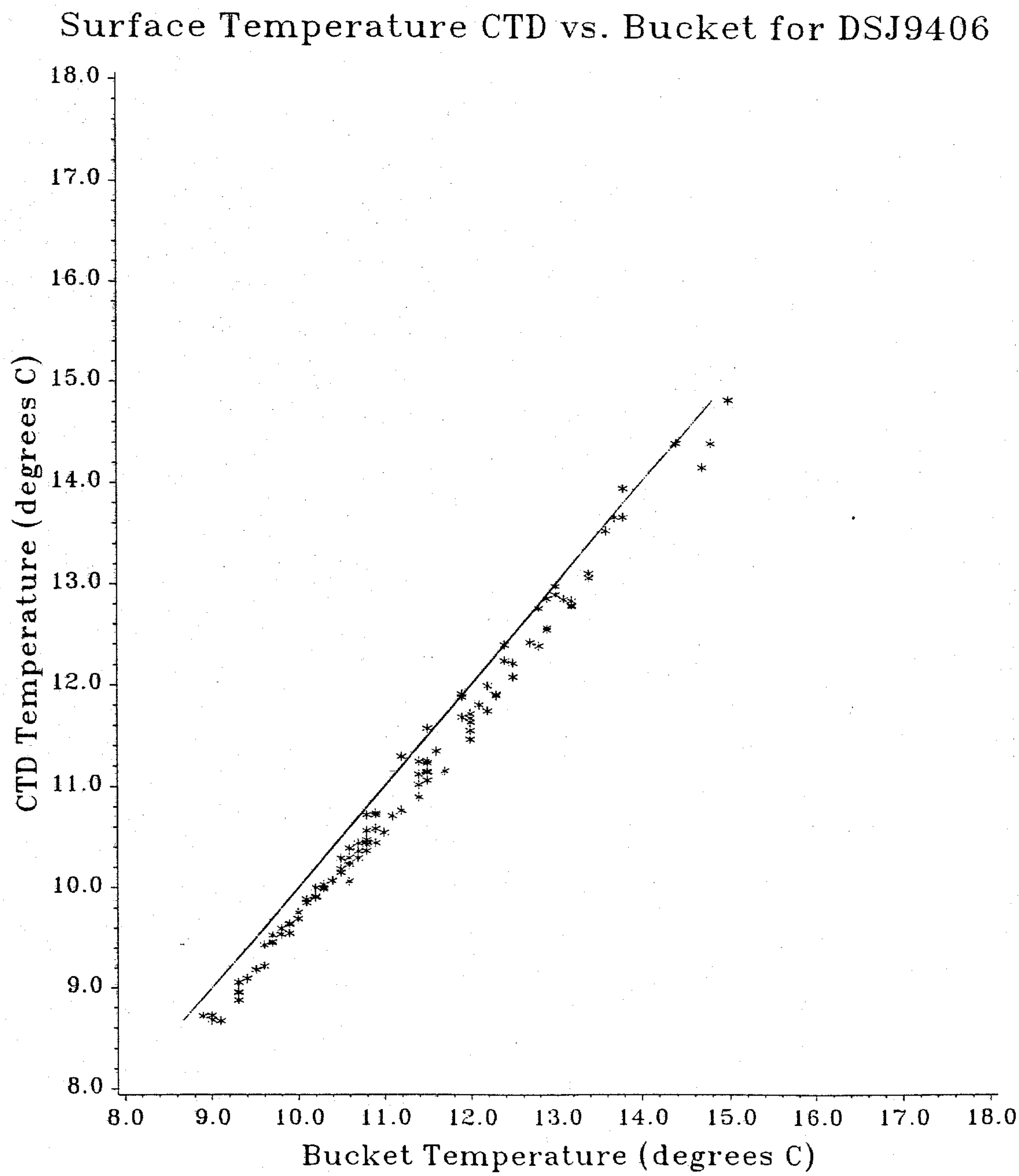
Surface Temperature CTD vs. TS for DSJ9406



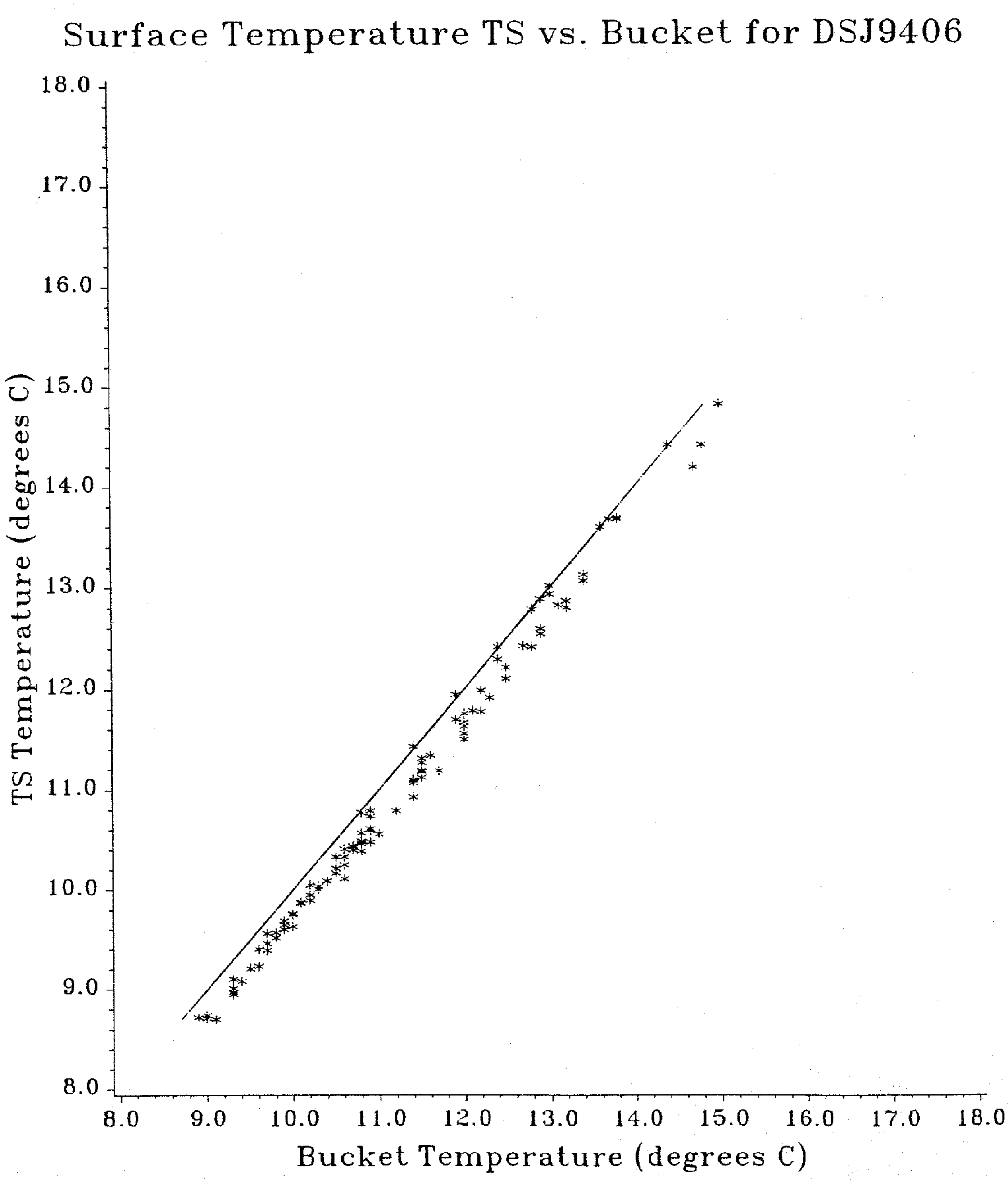
CTD Casts 217-295



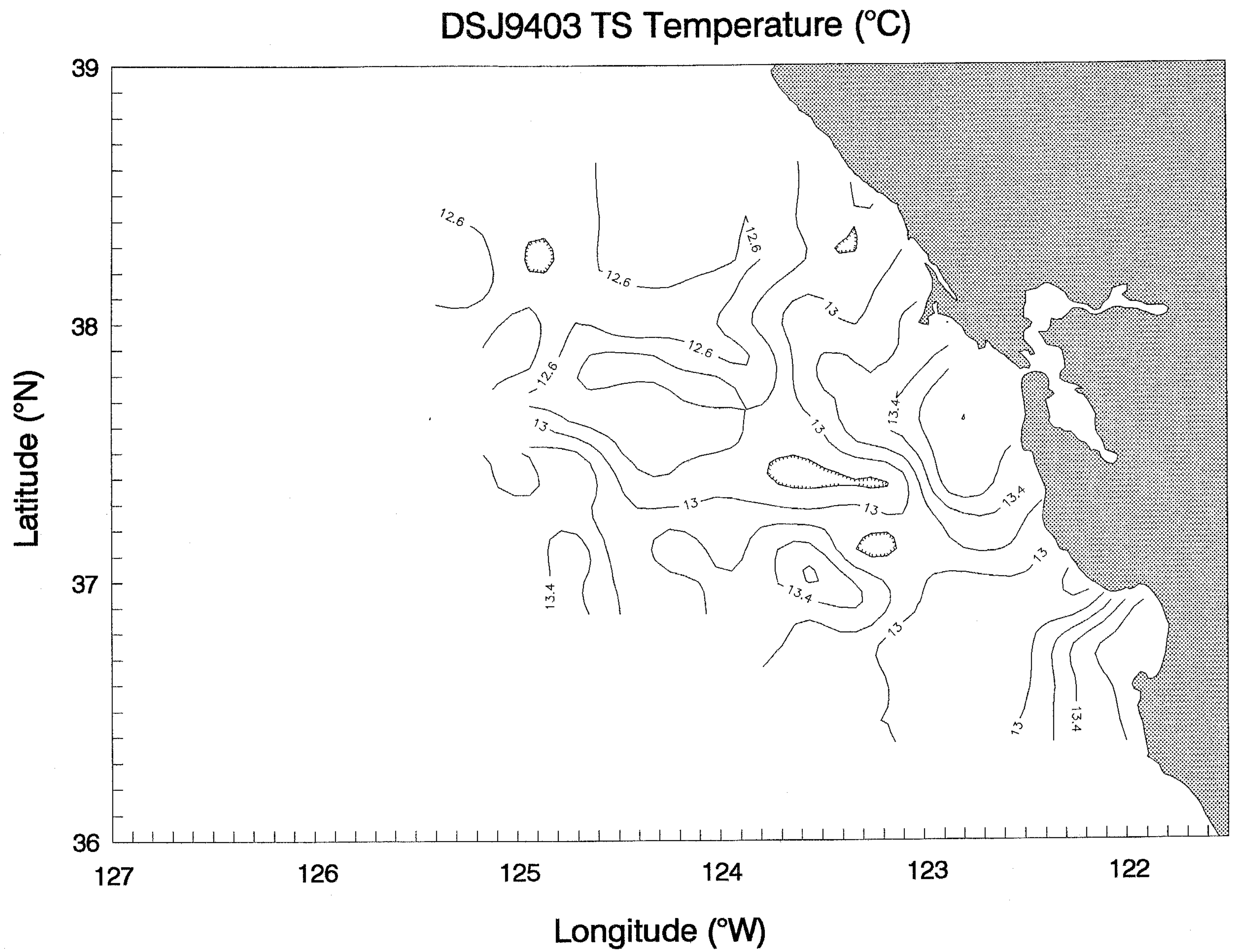
CTD Casts 217-295



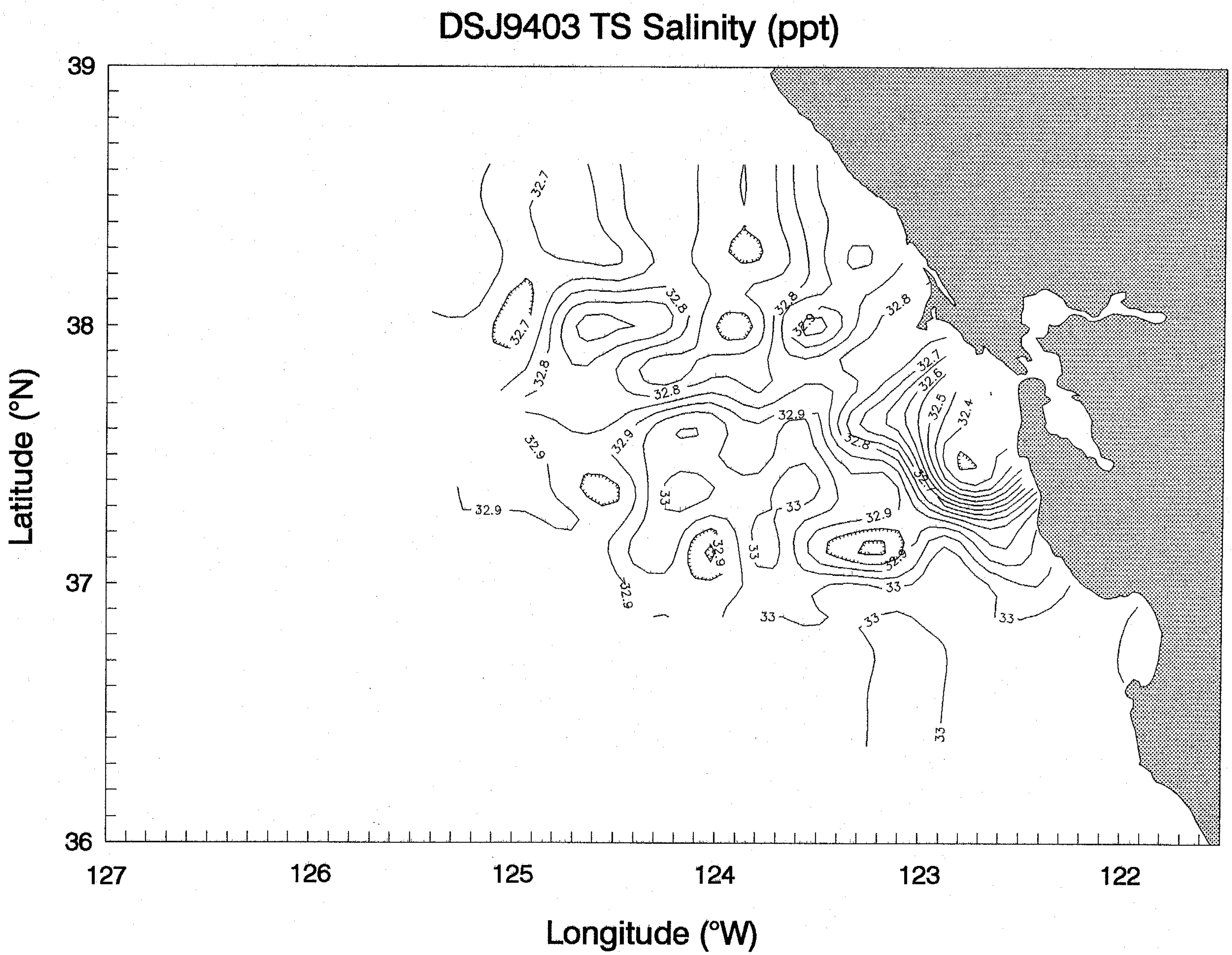
CTD Casts 217-295



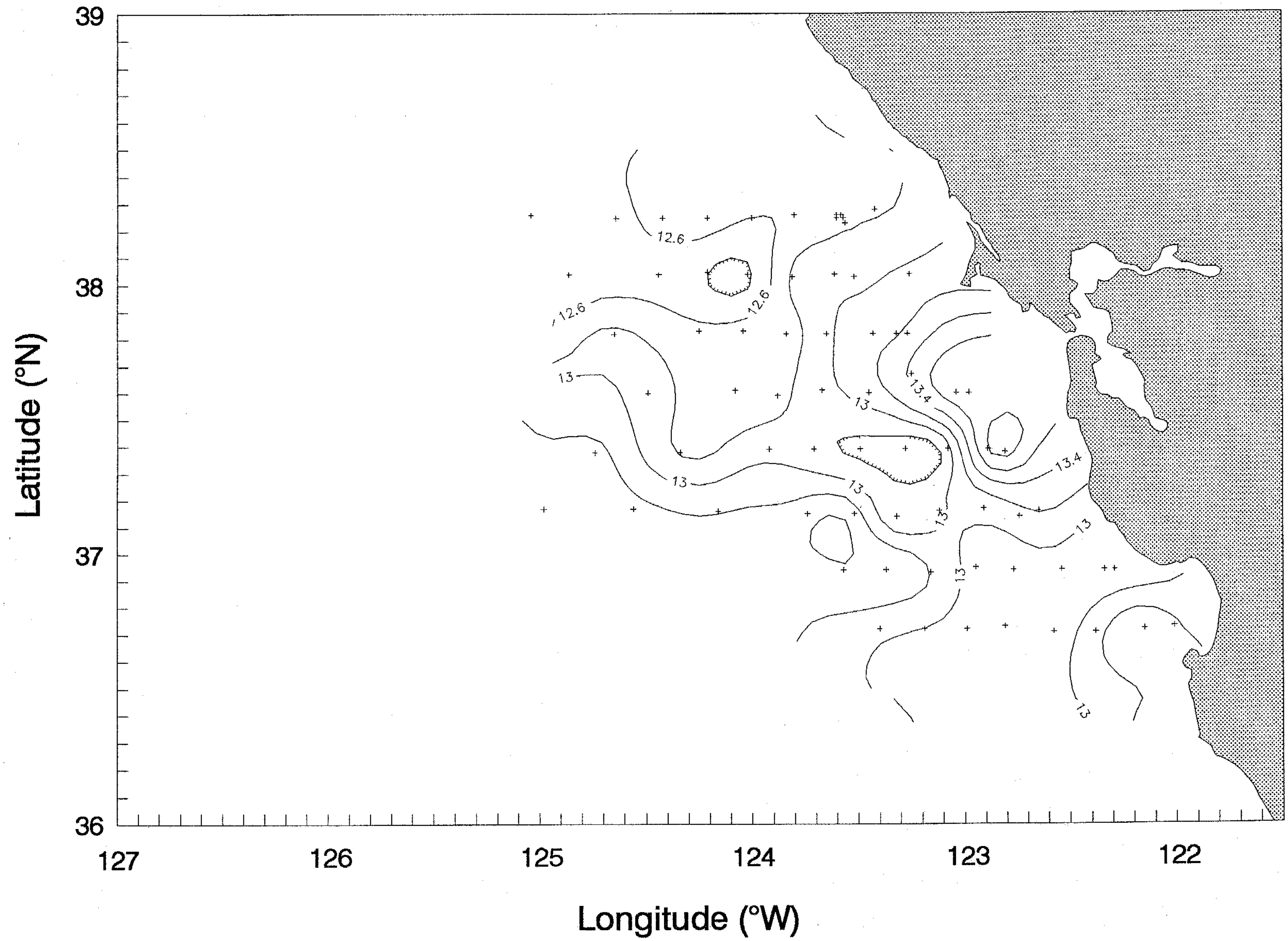
APPENDIX 8.1: HORIZONTAL MAPS OF CTD AND TS FOR DSJ9403



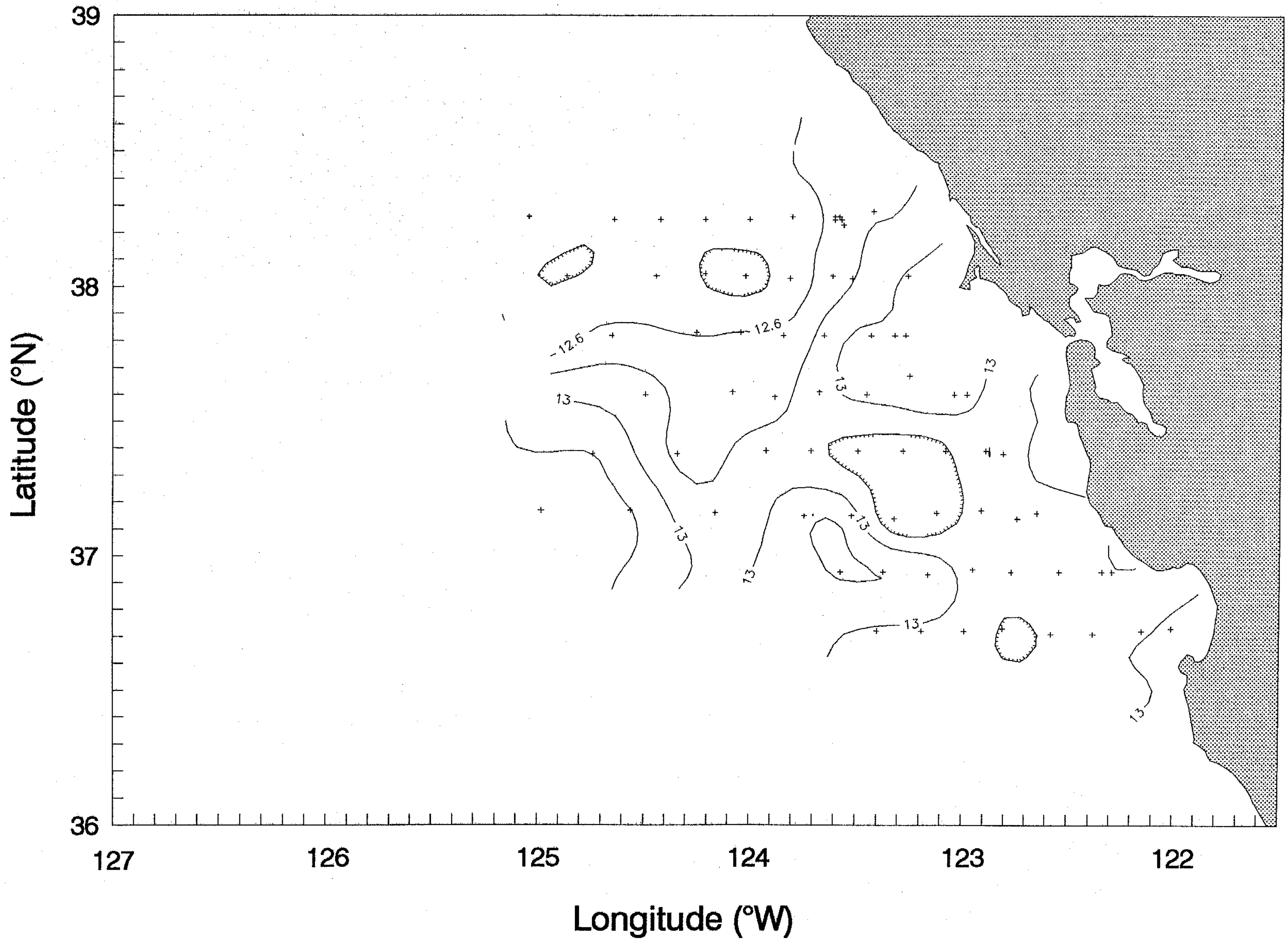
DSJ9403 TS Temperature (°C)
Latitude (°N)
Longitude (°W)
39
38
37
36
127
126
125
124
123
122
12.6
13
13.4


DSJ9403 TS Salinity (ppt)
Latitude (°N)
Longitude (°W)
39
38
37
36
127
126
125
124
123
122
32.4
32.5
32.6
32.7
32.8
32.9
33

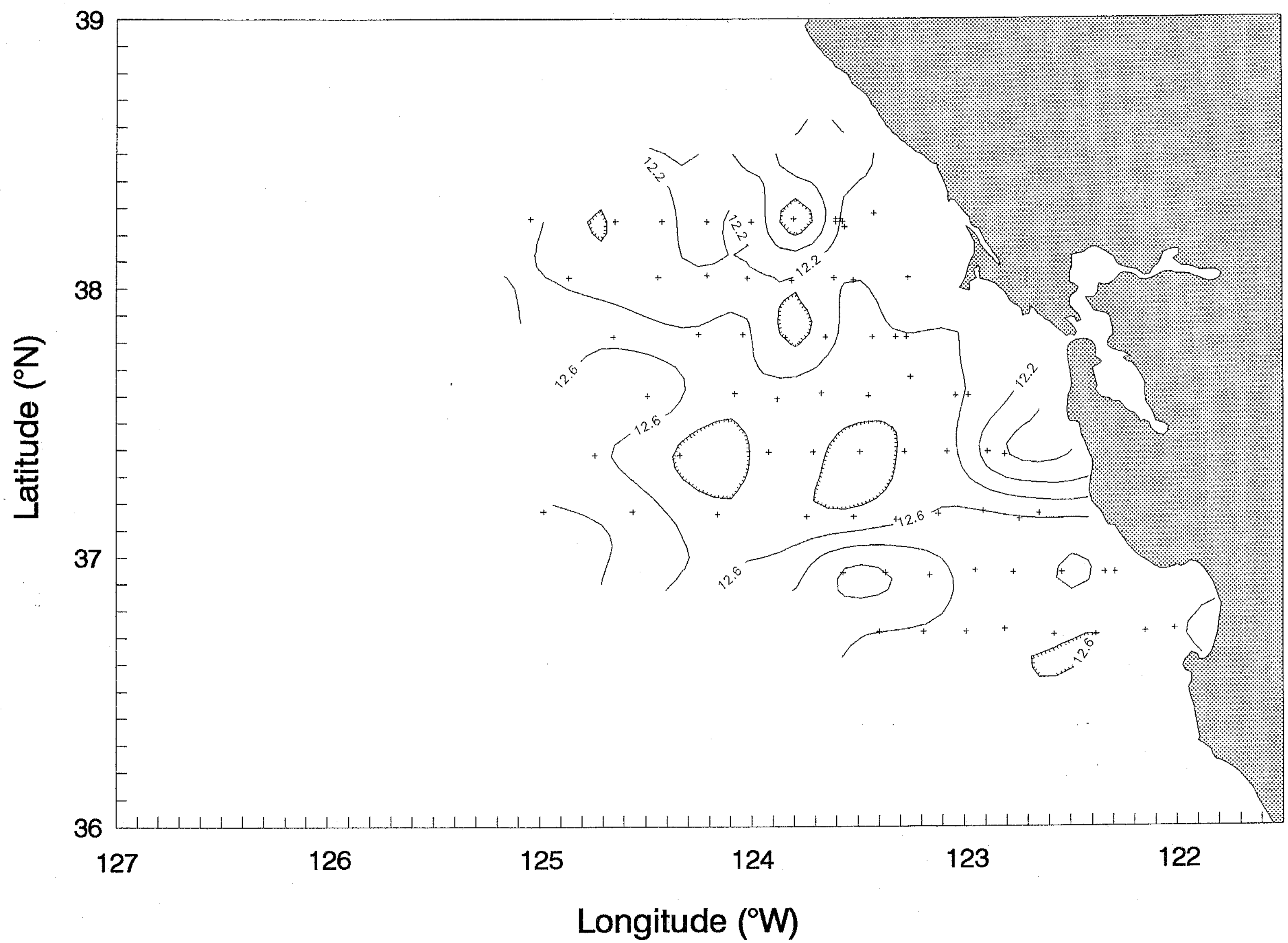
DSJ9403 Temperature (°C) at 2 m



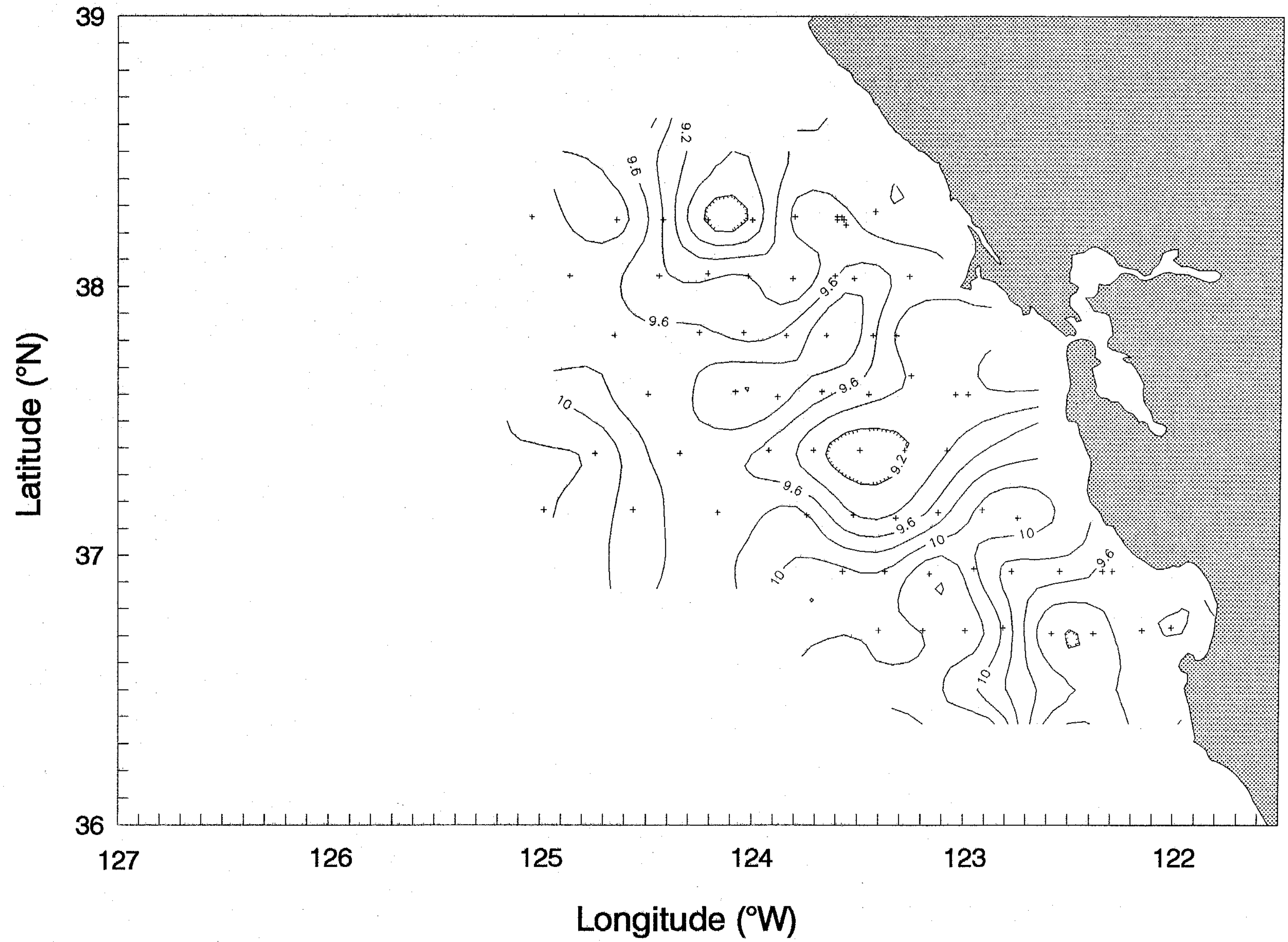
DSJ9403 Temperature (°C) at 10 m

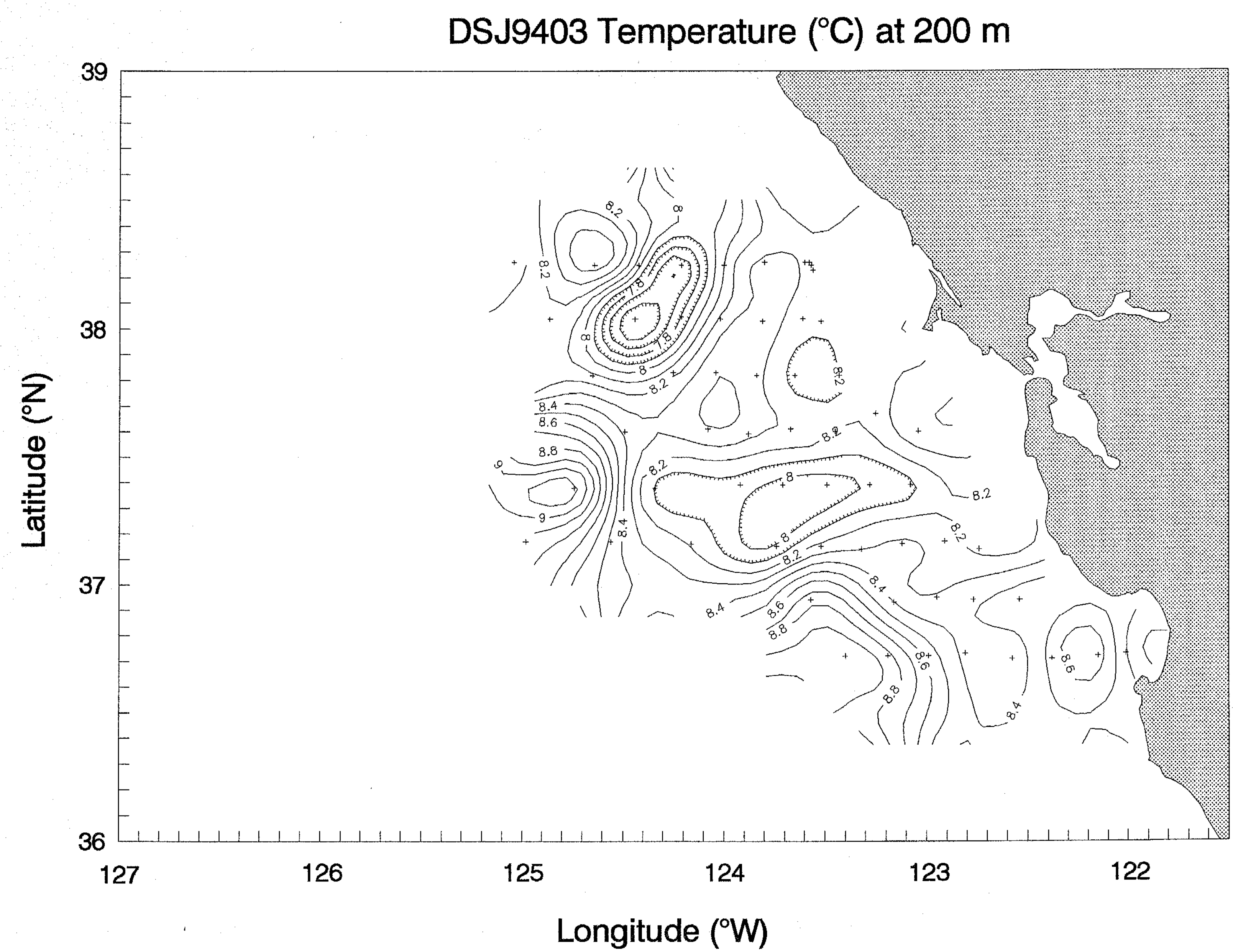


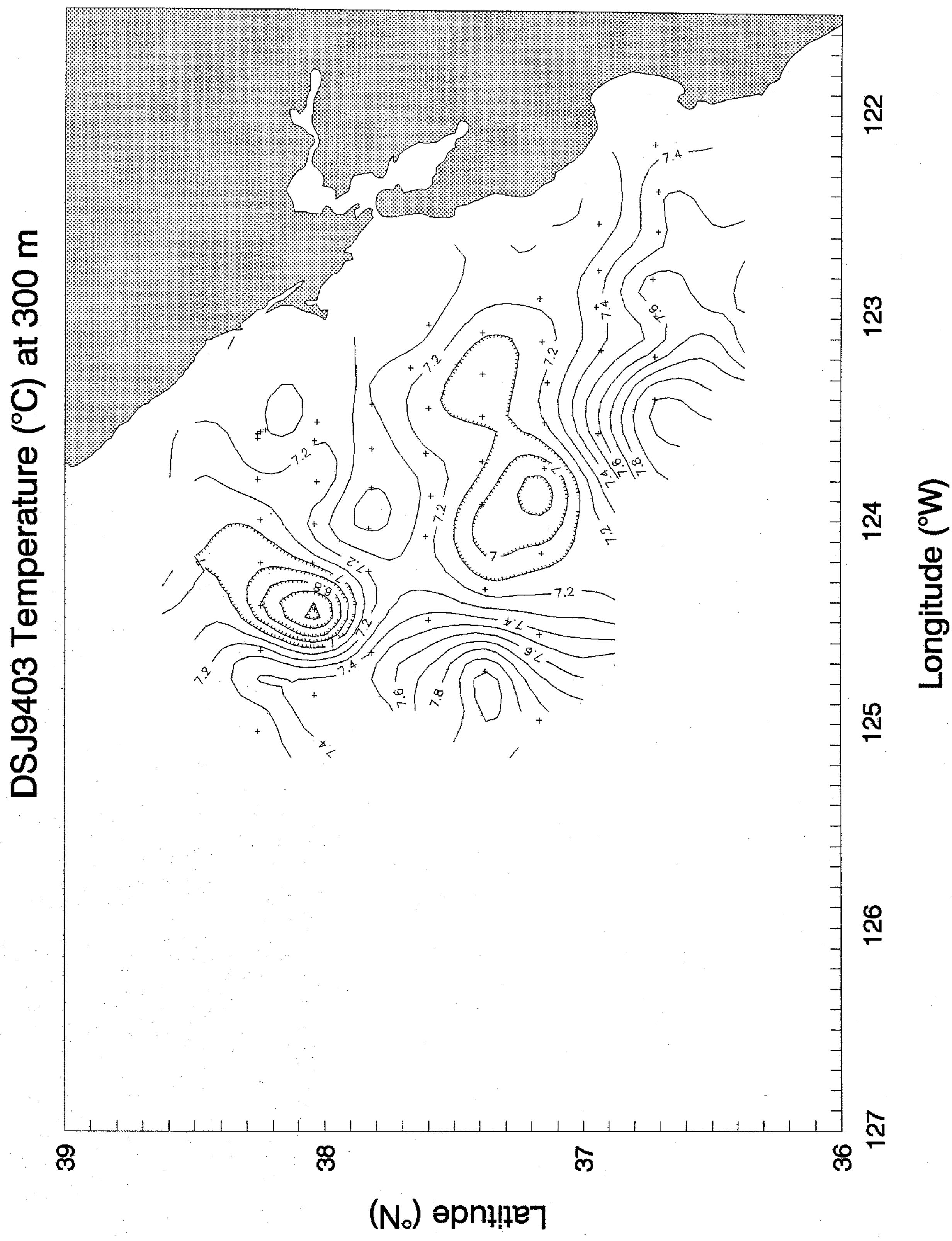
DSJ9403 Temperature (°C) at 30 m

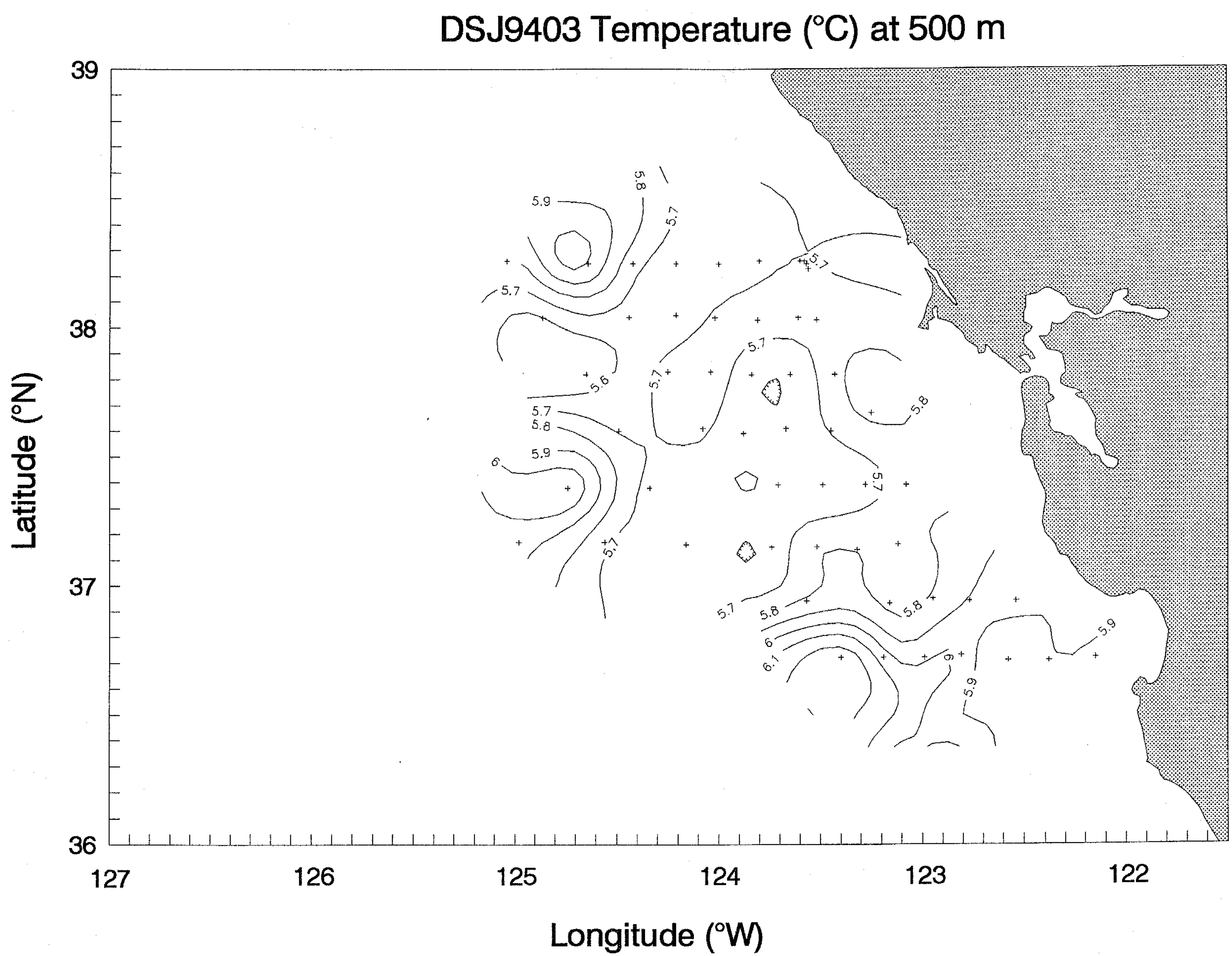


DSJ9403 Temperature (°C) at 100 m

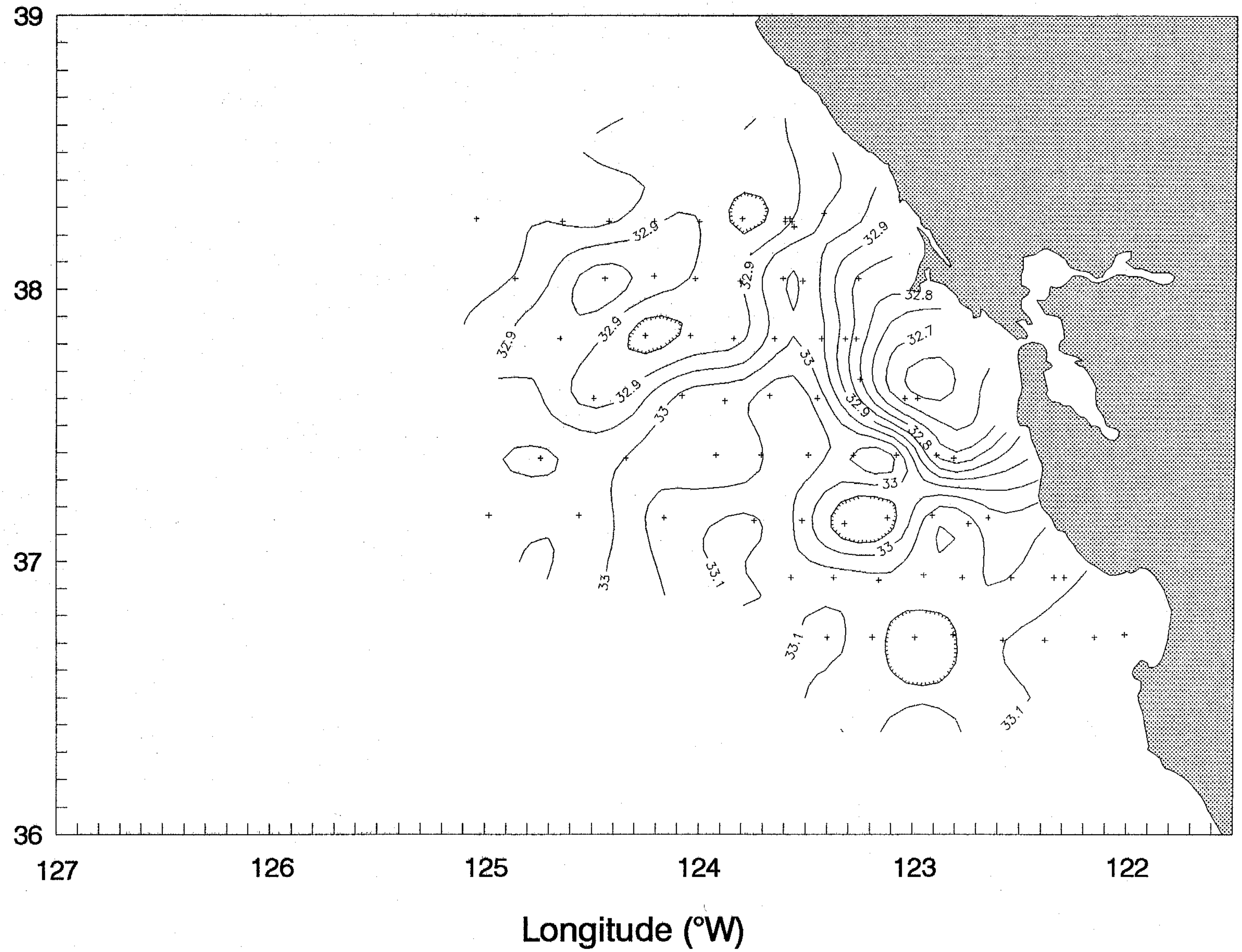



DSJ9403 Temperature (°C) at 200 m
39
38
37
36
127
126
125
124
123
122
Latitude (°N)
Longitude (°W)
8.2
8
7.8
8.4
8.6
8.8
9

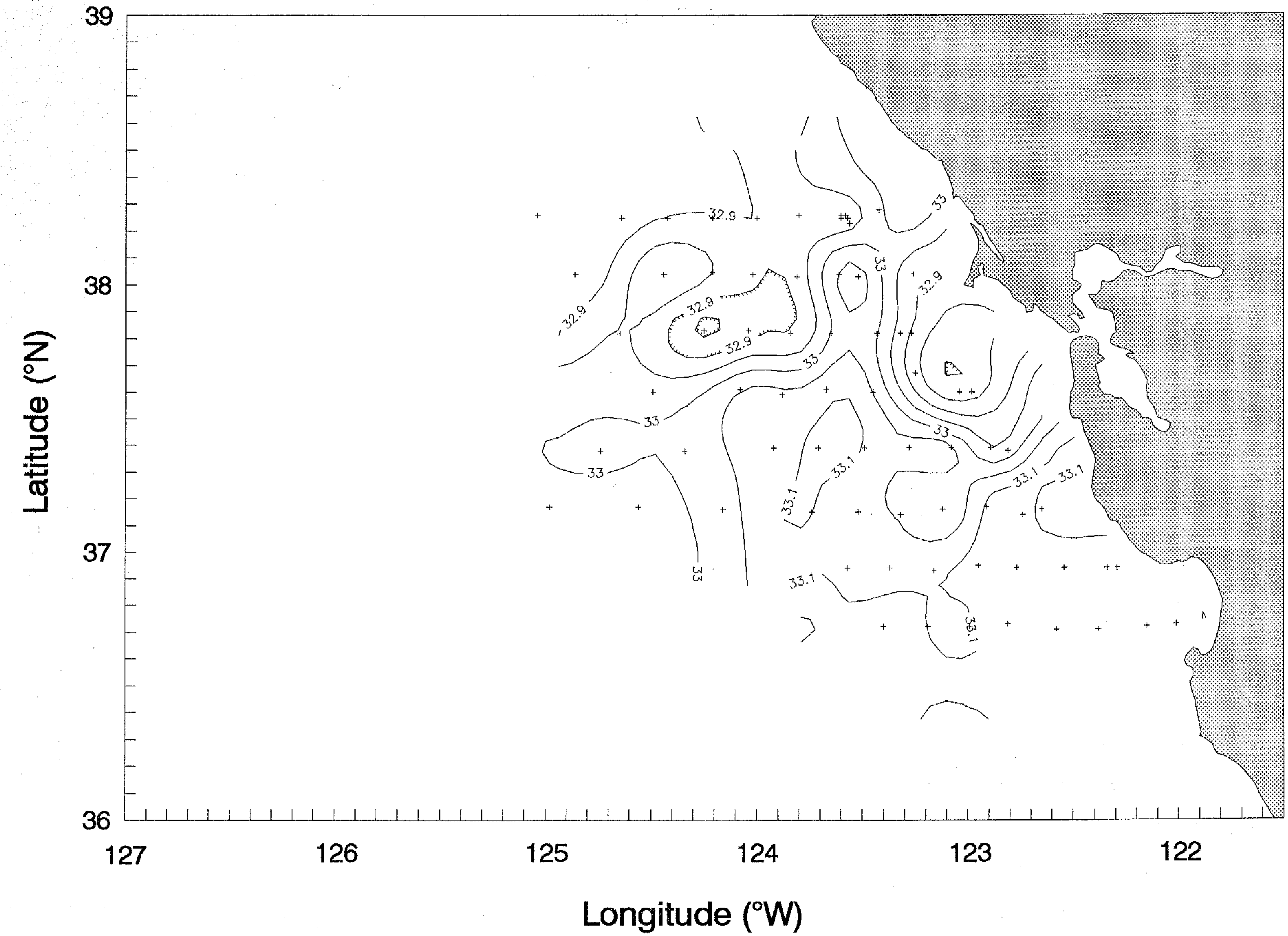

DSJ9403 Temperature (°C) at 300 m
Longitude (°W)
Latitude (°N)
122
123
124
125
126
127
39
38
37
36
7.2
7.4
7.6
7.8
7
6.8

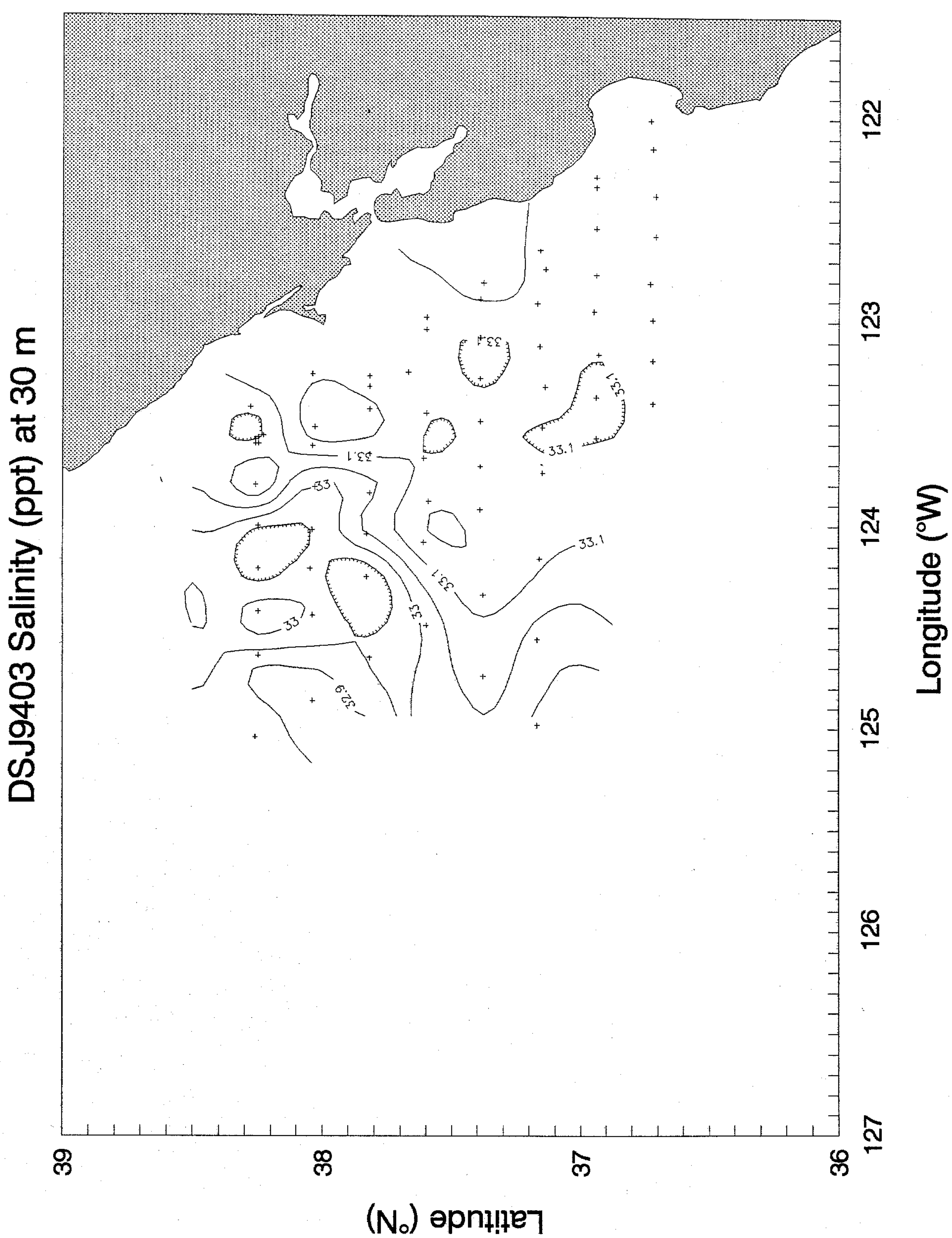

DSJ9403 Temperature (°C) at 500 m
39
38
37
36
127
126
125
124
123
122
Latitude (°N)
Longitude (°W)
5.6
5.7
5.8
5.9
6
6.1

DSJ9403 Salinity (ppt) at 2 m

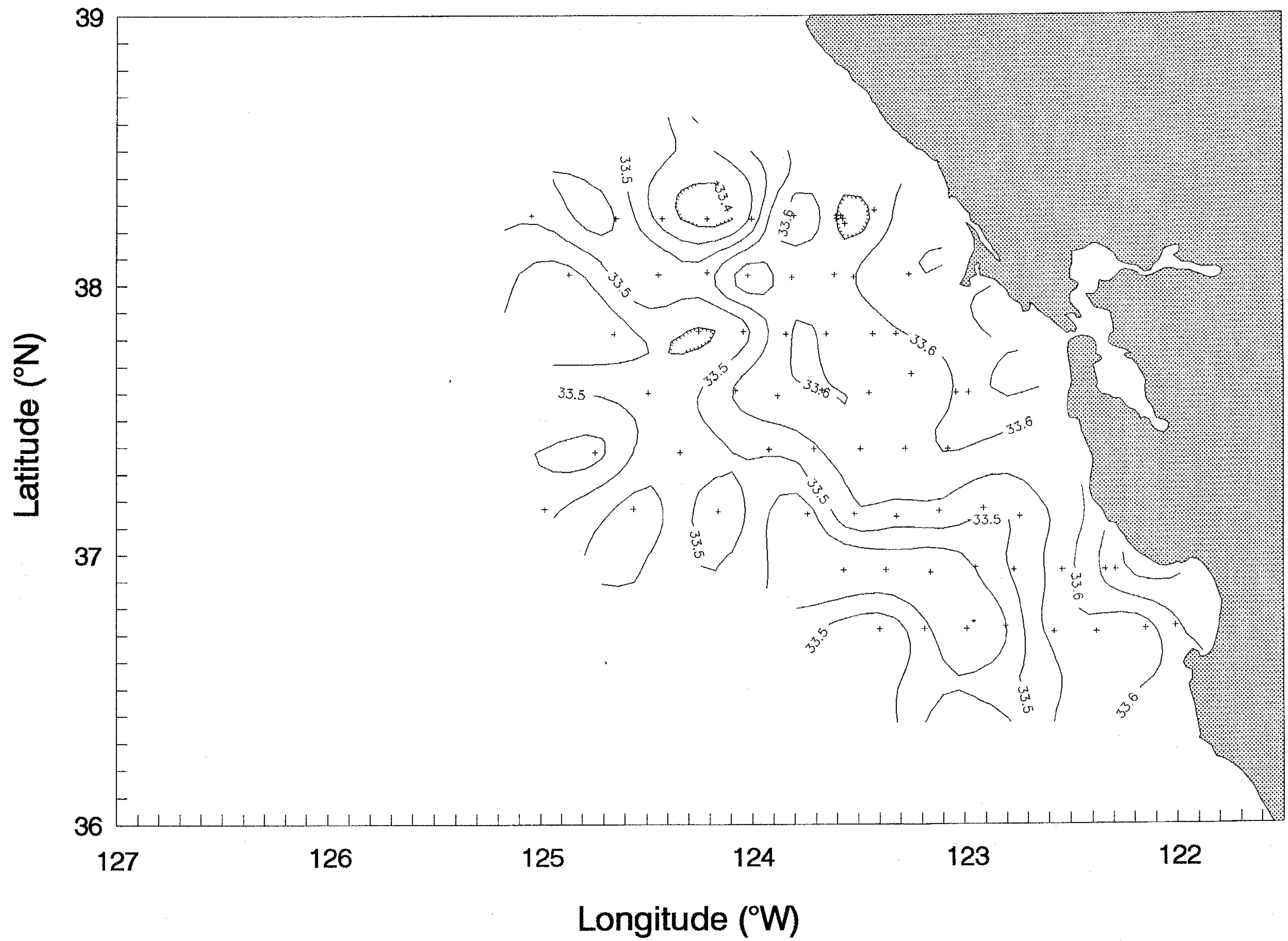


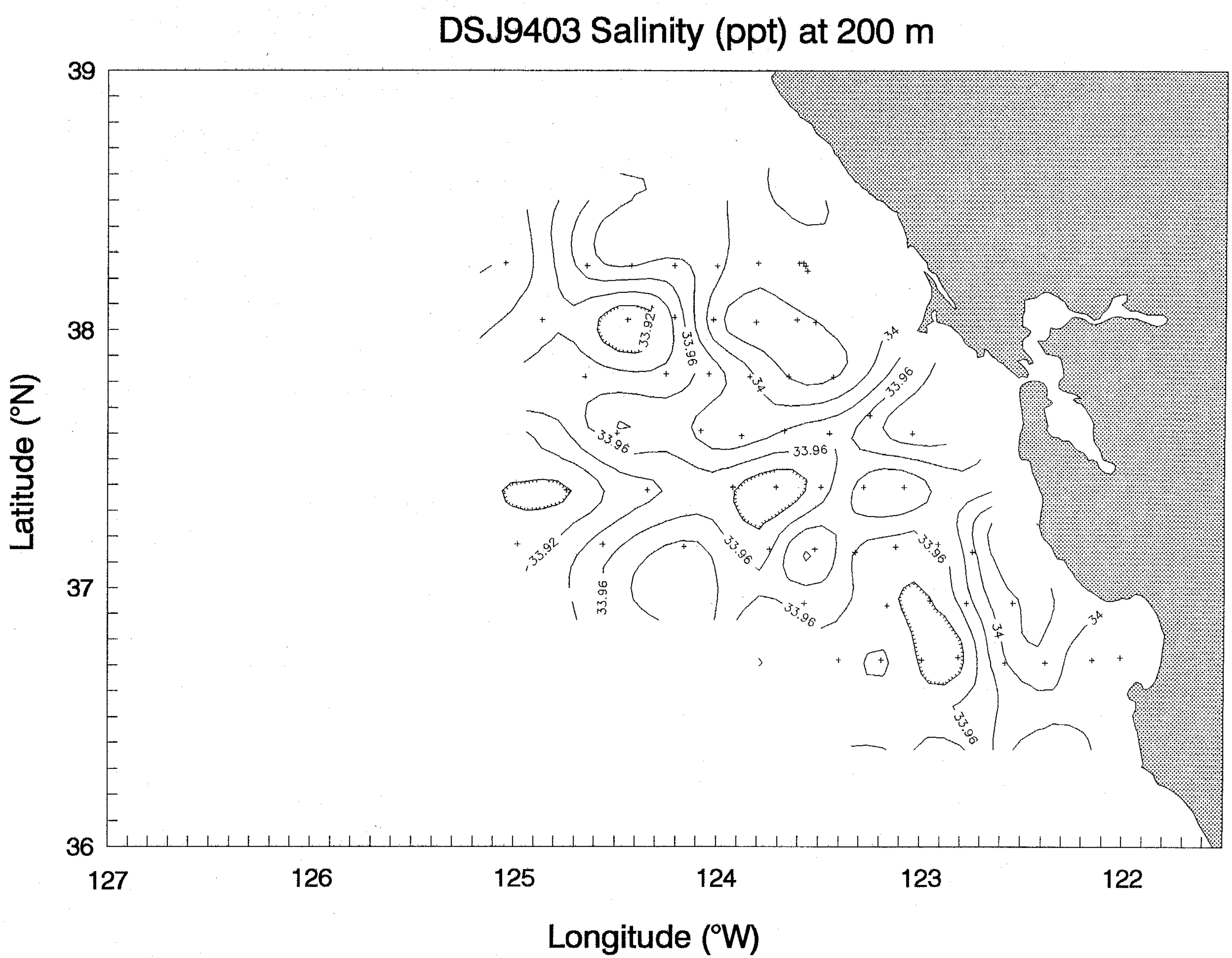
DSJ9403 Salinity (ppt) at 10 m



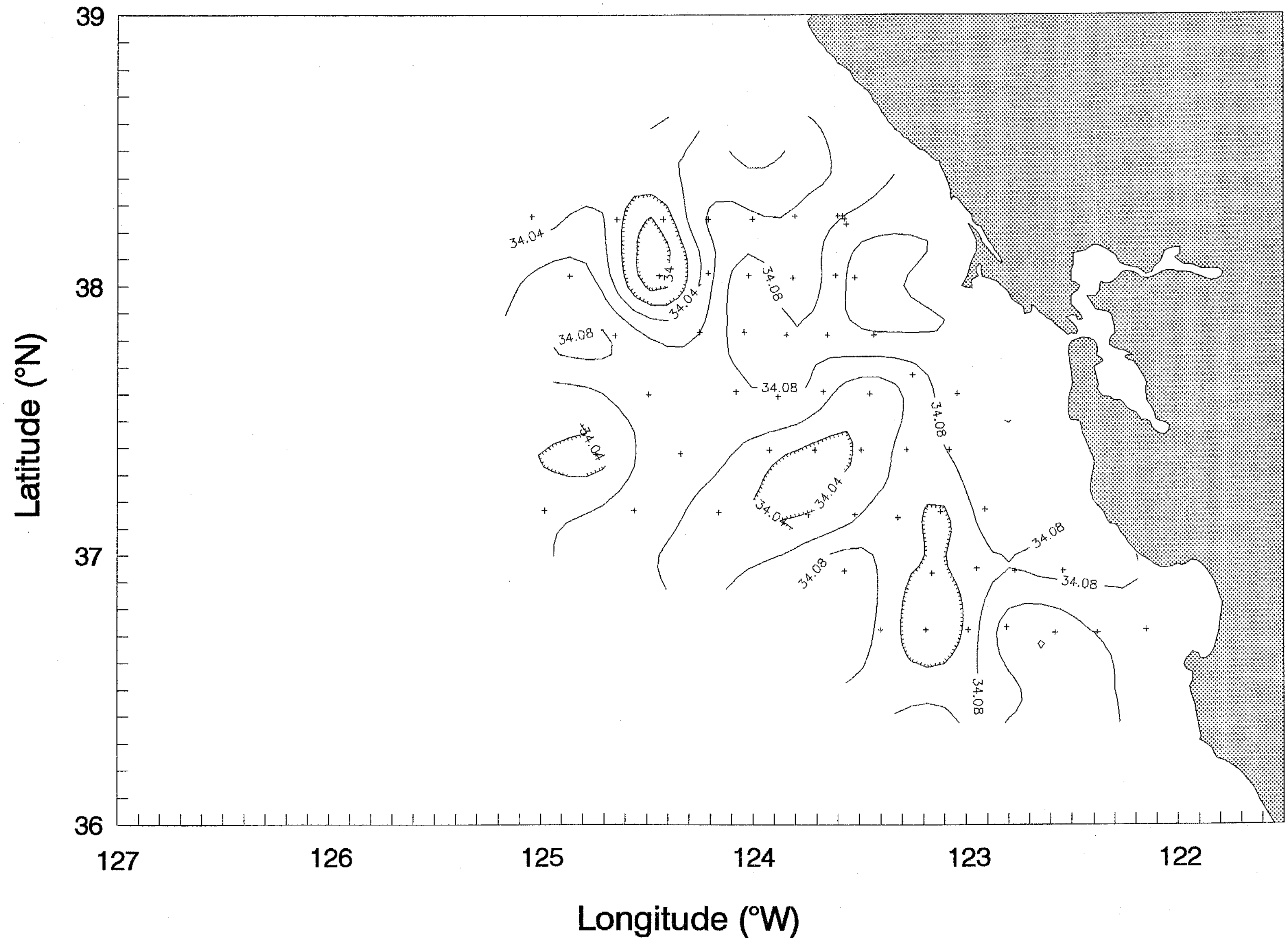

DSJ9403 Salinity (ppt) at 30 m
Longitude (°W)
Latitude (°N)
39
38
37
36
127
126
125
124
123
122
33
33.1
33.4
32.9

DSJ9403 Salinity (ppt) at 100 m

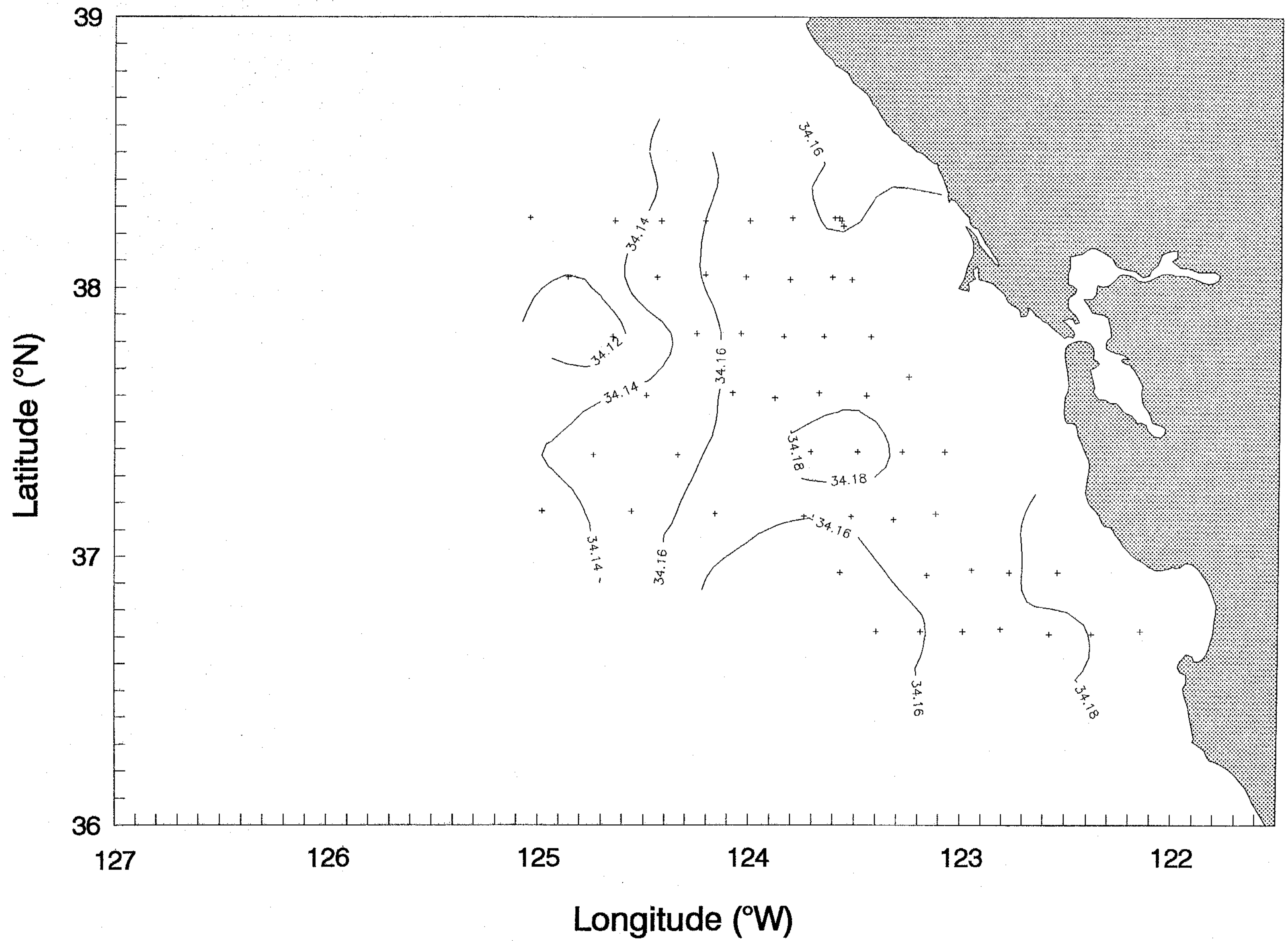



DSJ9403 Salinity (ppt) at 200 m
Latitude (°N)
Longitude (°W)
39
38
37
36
127
126
125
124
123
122
33.92
33.96
34

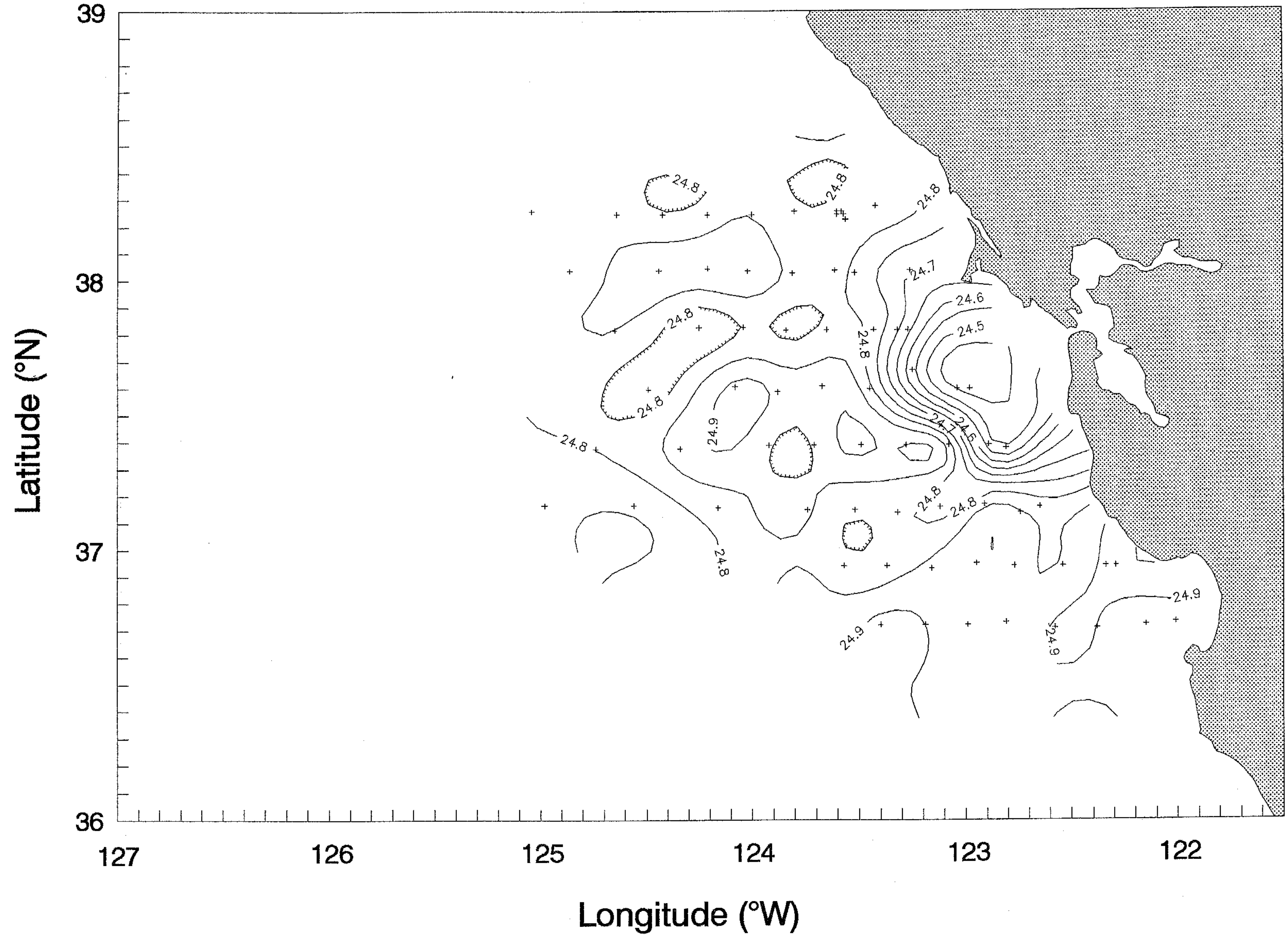
DSJ9403 Salinity (ppt) at 300 m

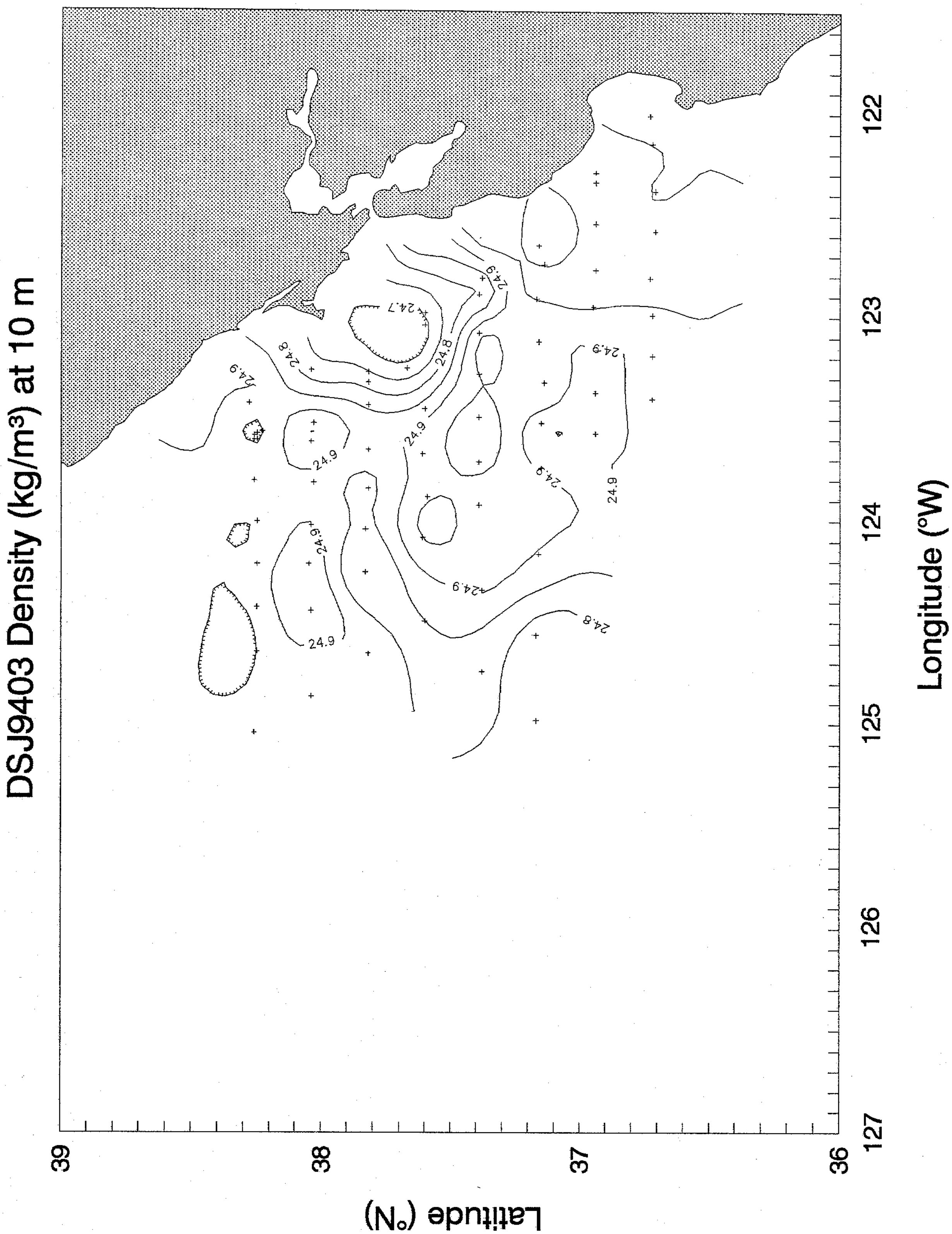


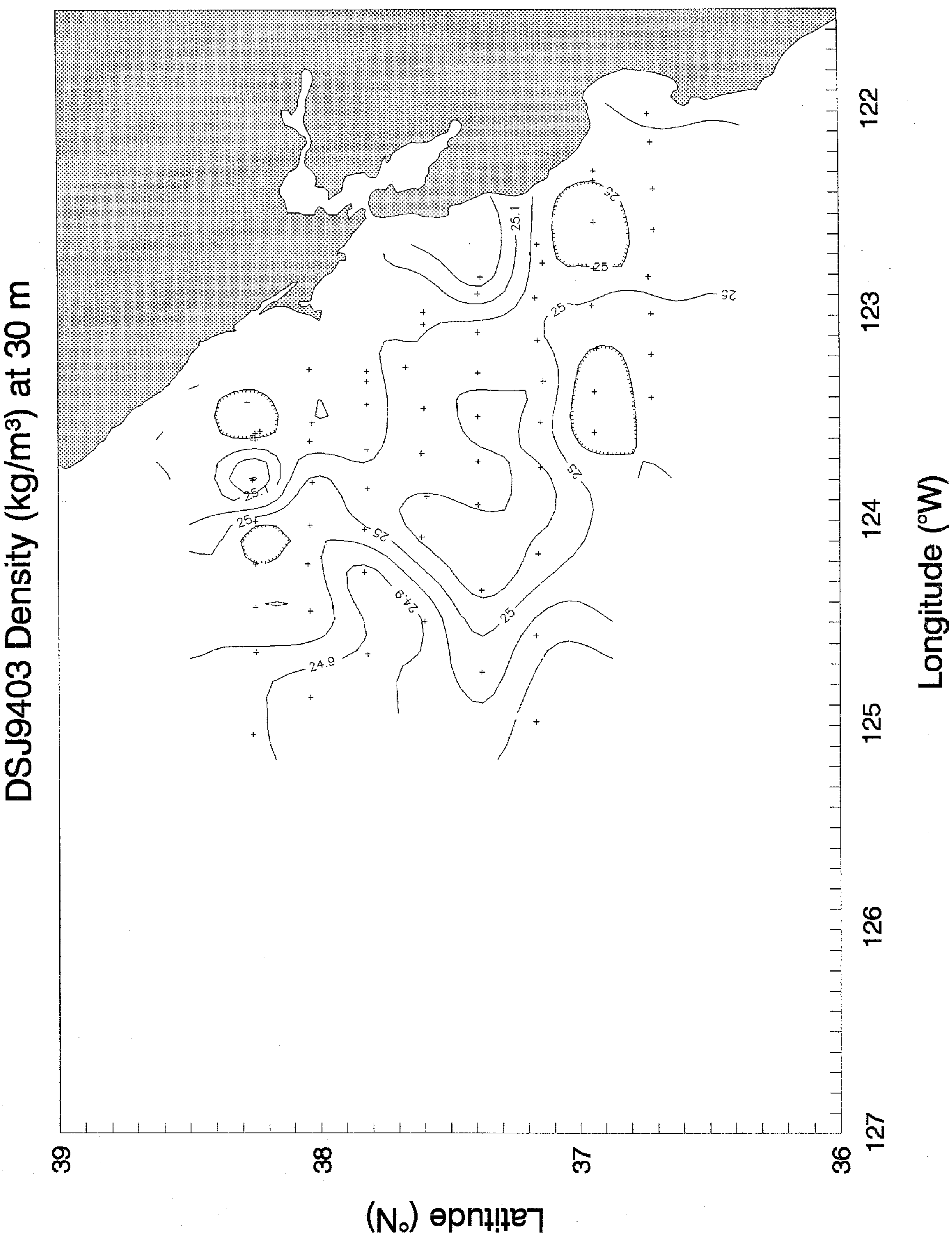
DSJ9403 Salinity (ppt) at 500 m



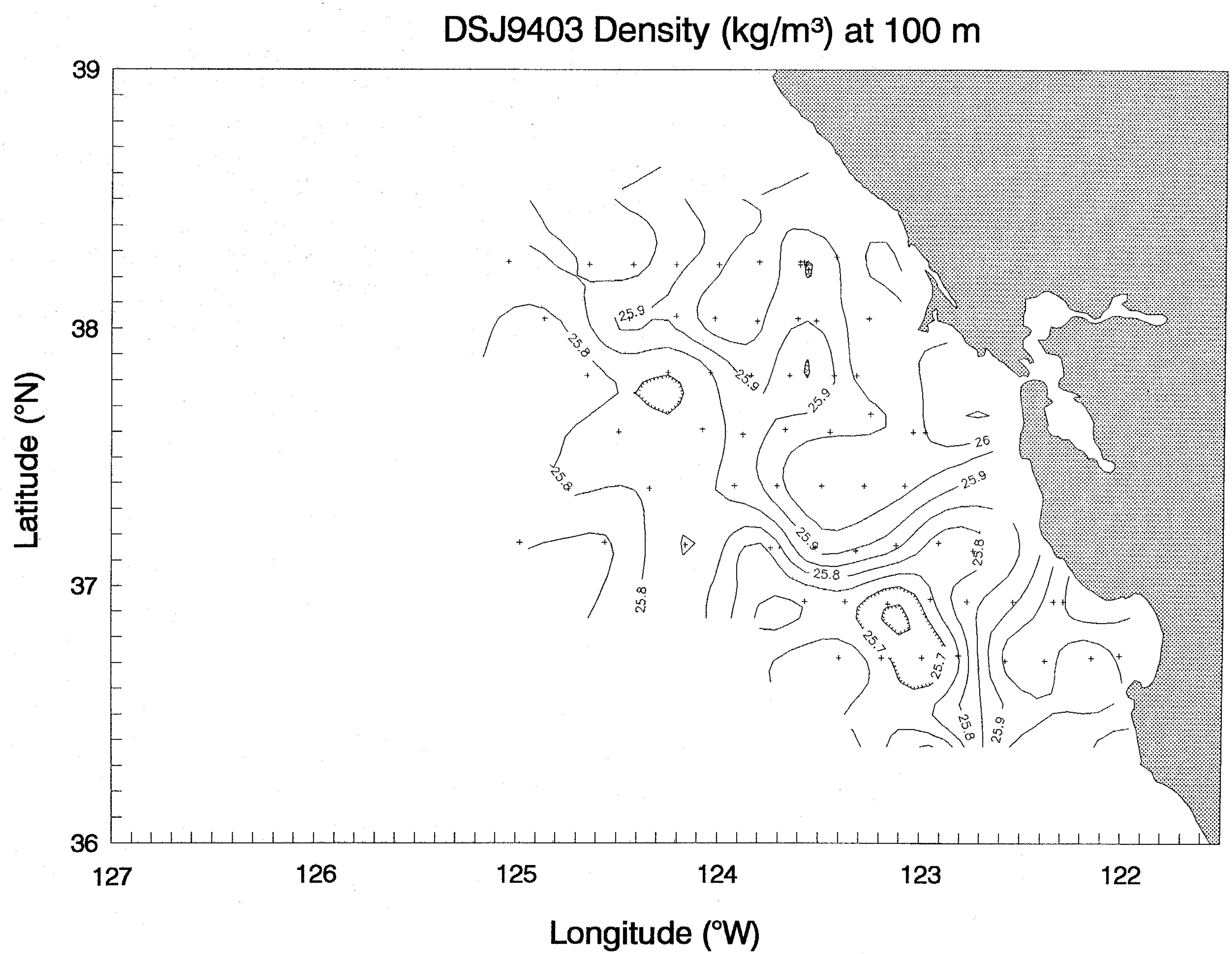
DSJ9403 Density (kg/m³) at 2 m



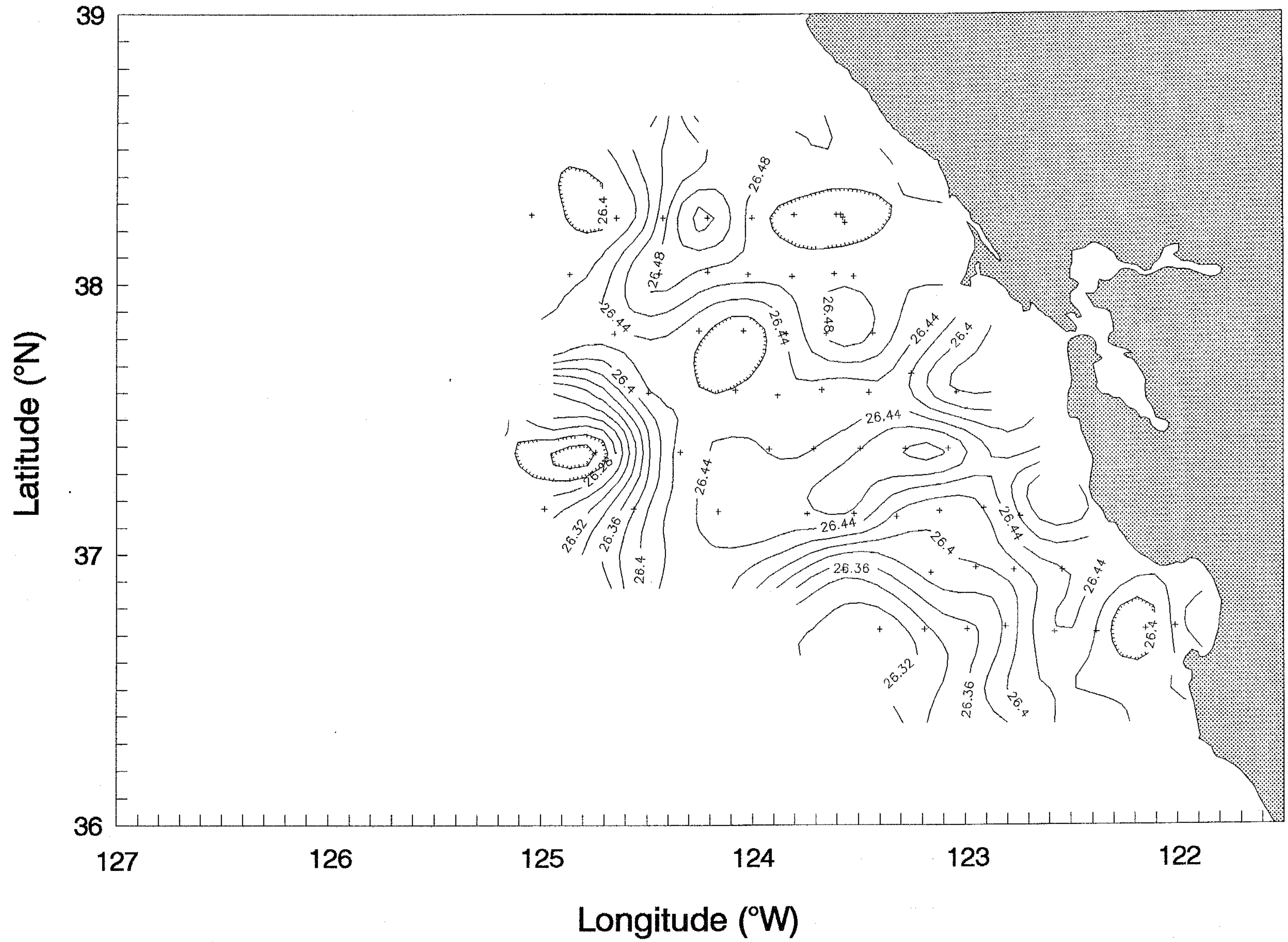

DSJ9403 Density (kg/m³) at 10 m
Longitude (°W)
Latitude (°N)
122
123
124
125
126
127
39
38
37
36
24.7
24.8
24.9



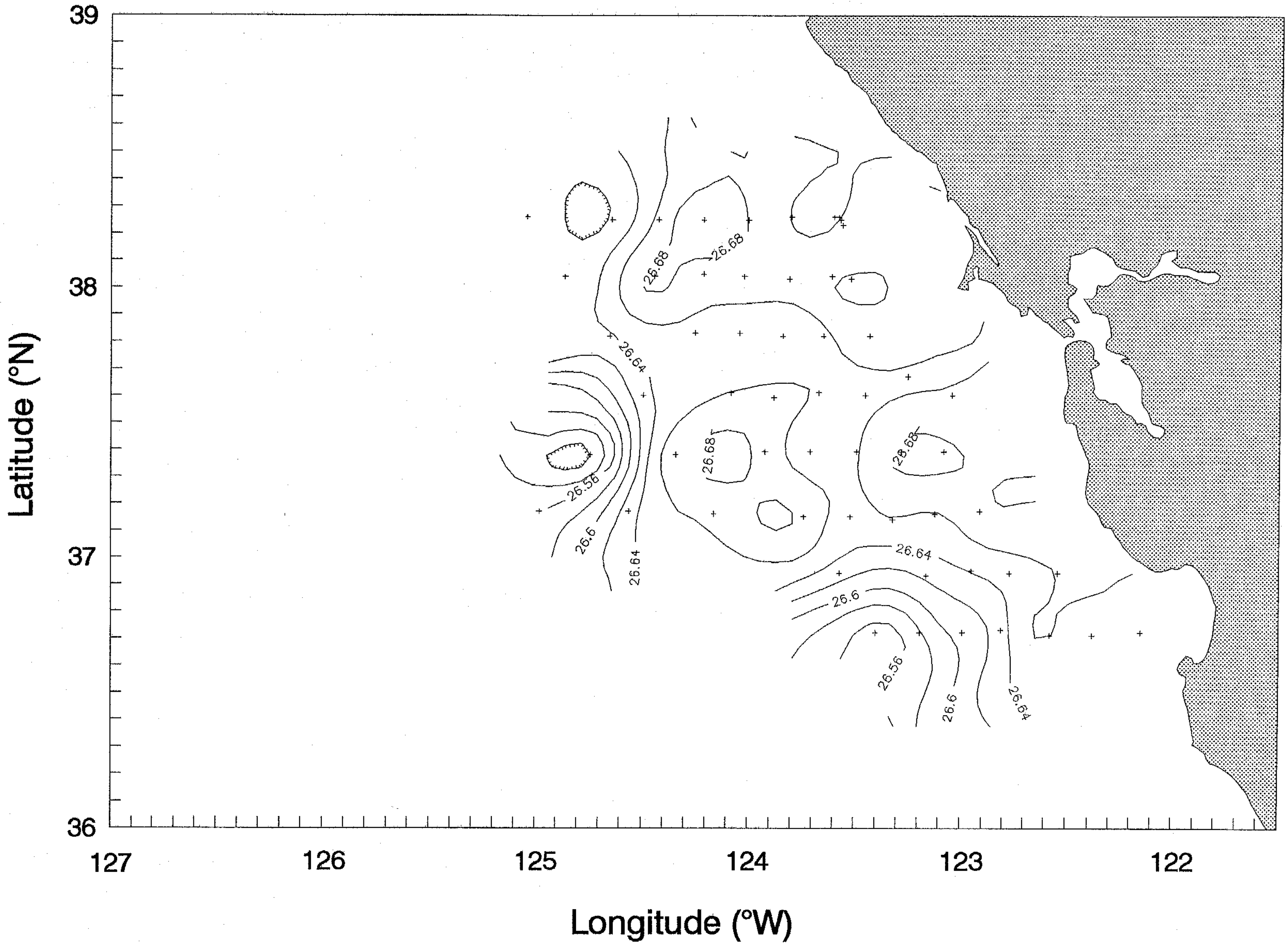
DSJ9403 Density (kg/m³) at 30 m
Longitude (°W)
Latitude (°N)
122
123
124
125
126
127
39
38
37
36
25
25.1
24.9


DSJ9403 Density (kg/m³) at 100 m
Latitude (°N)
Longitude (°W)
39
38
37
36
127
126
125
124
123
122
25.7
25.8
25.9
26

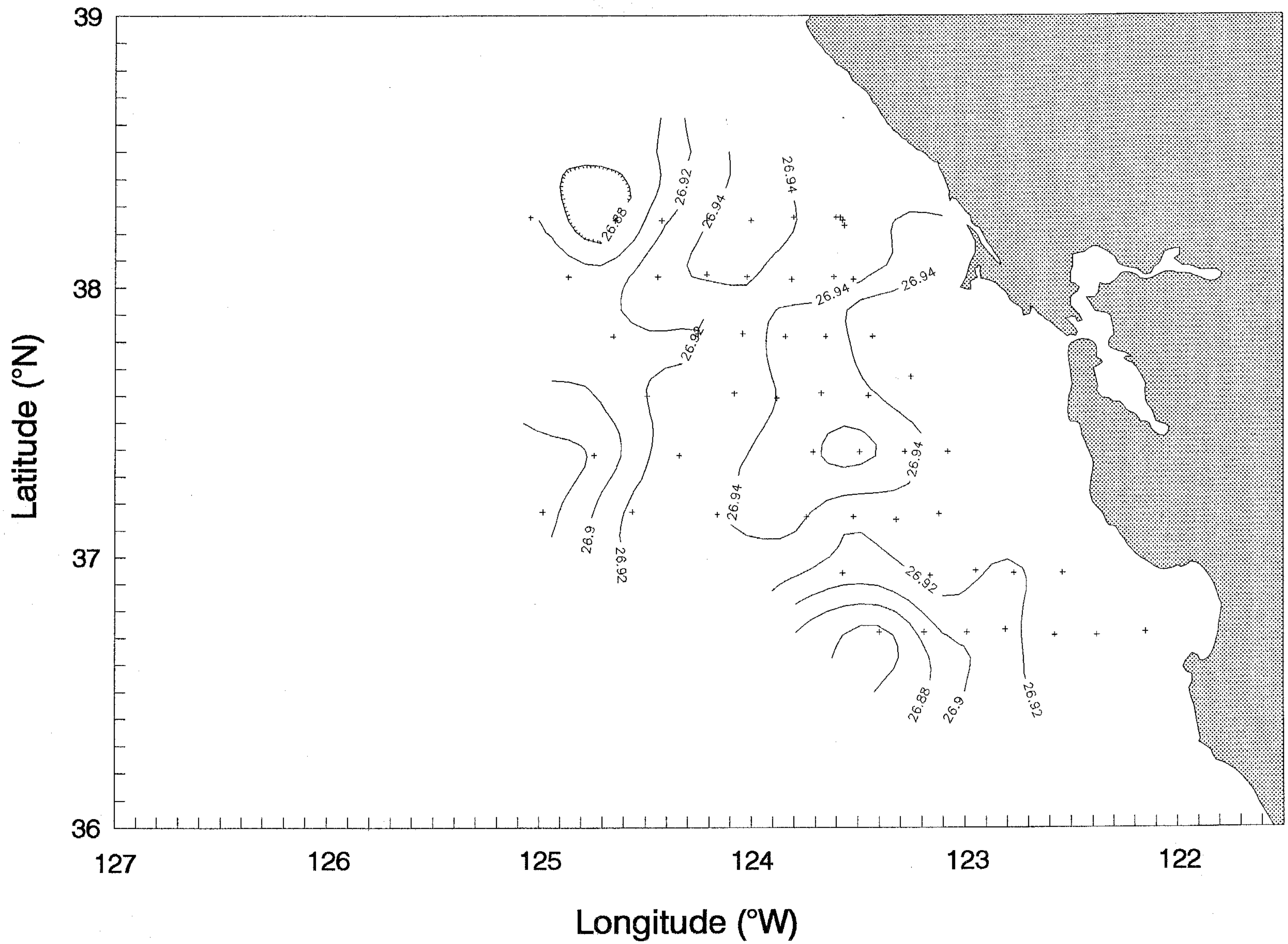
DSJ9403 Density (kg/m³) at 200 m



DSJ9403 Density (kg/m³) at 300 m

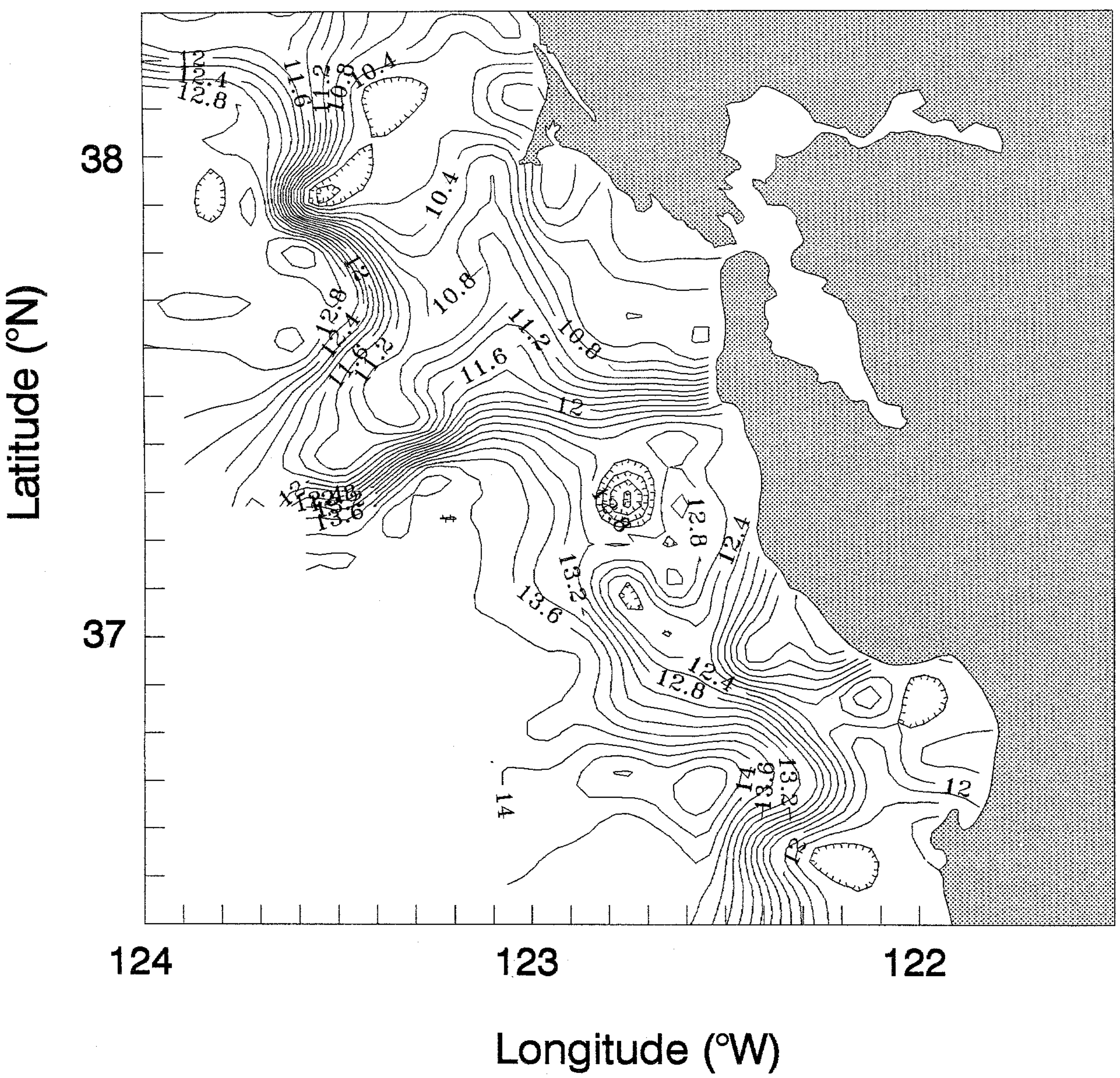


DSJ9403 Density (kg/m³) at 500 m

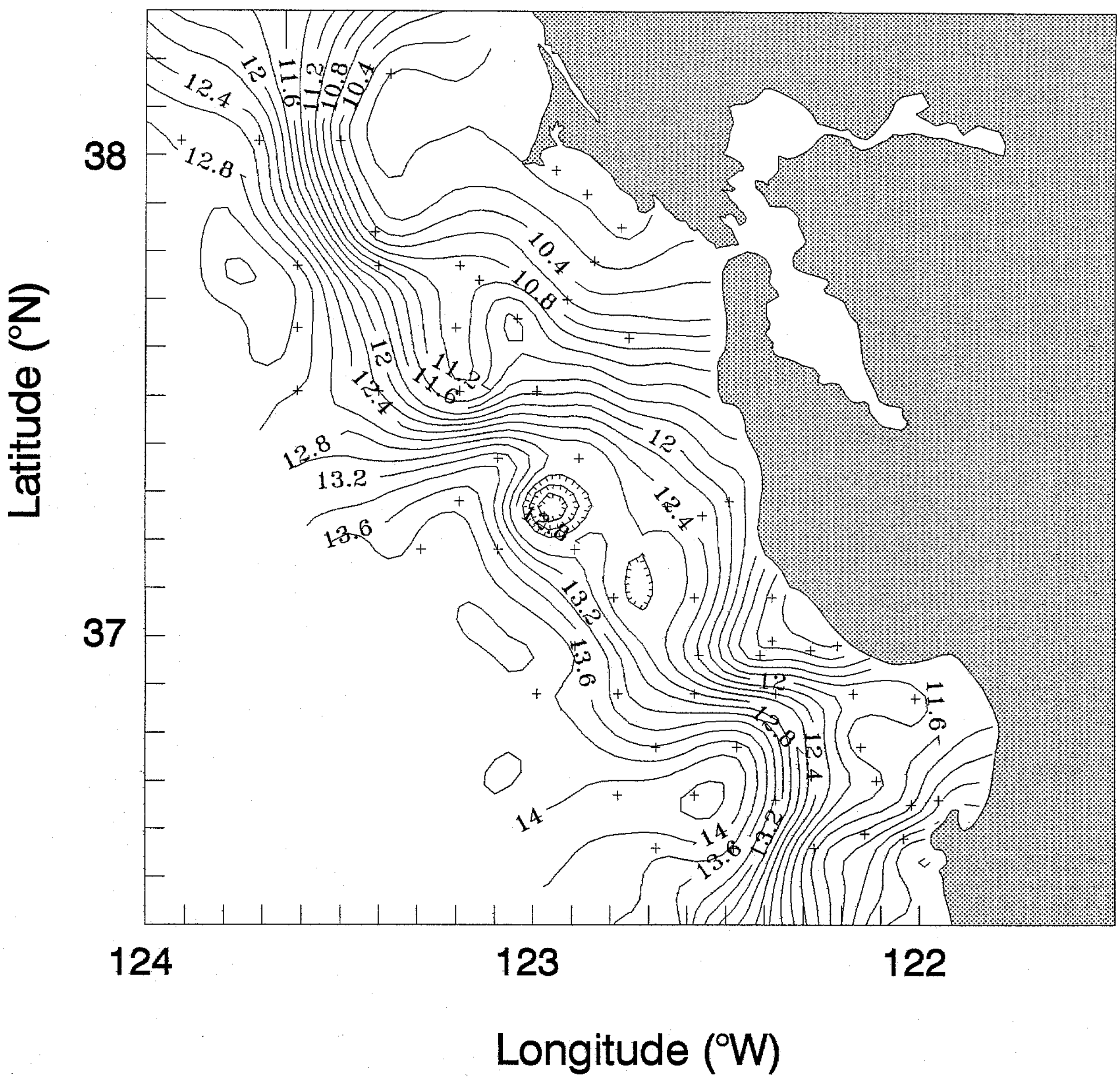


APPENDIX 8.2: HORIZONTAL MAPS OF CTD AND TS FOR DSJ9406, SWEEP 1

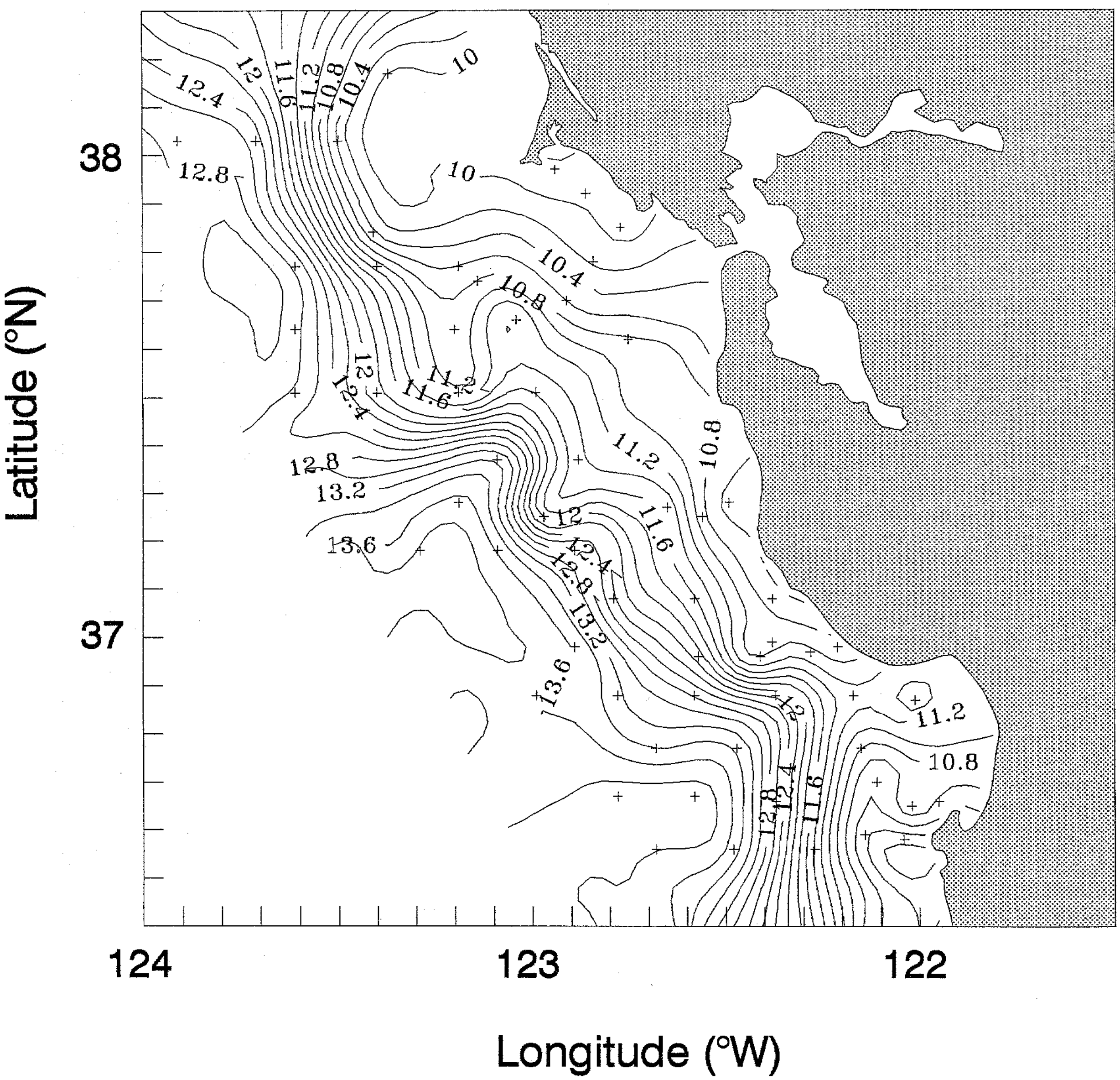
DSJ9406 Sweep 1
TS Temperature (°C)



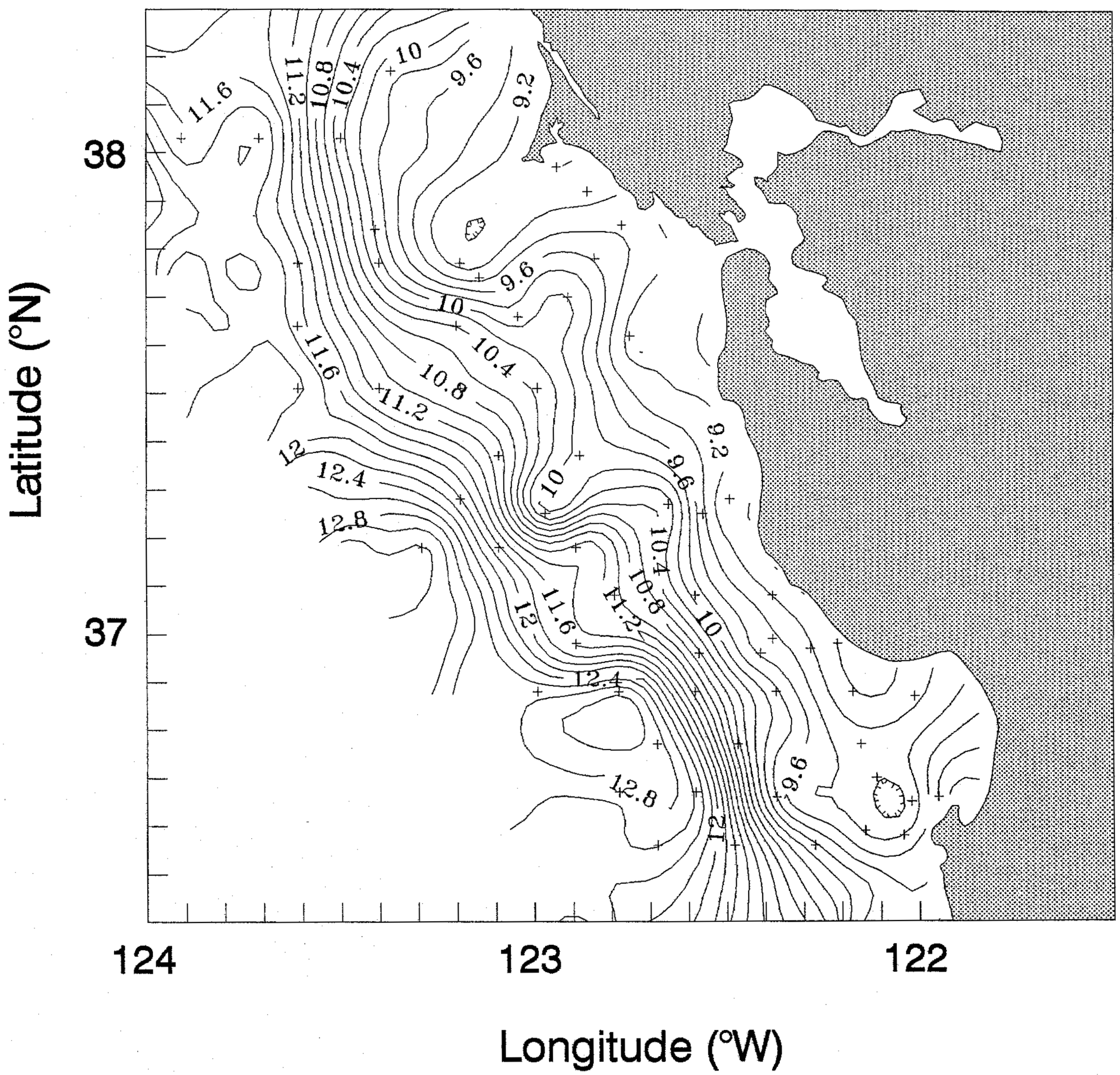
DSJ9406 Sweep 1
Temperature (°C) at 2 m

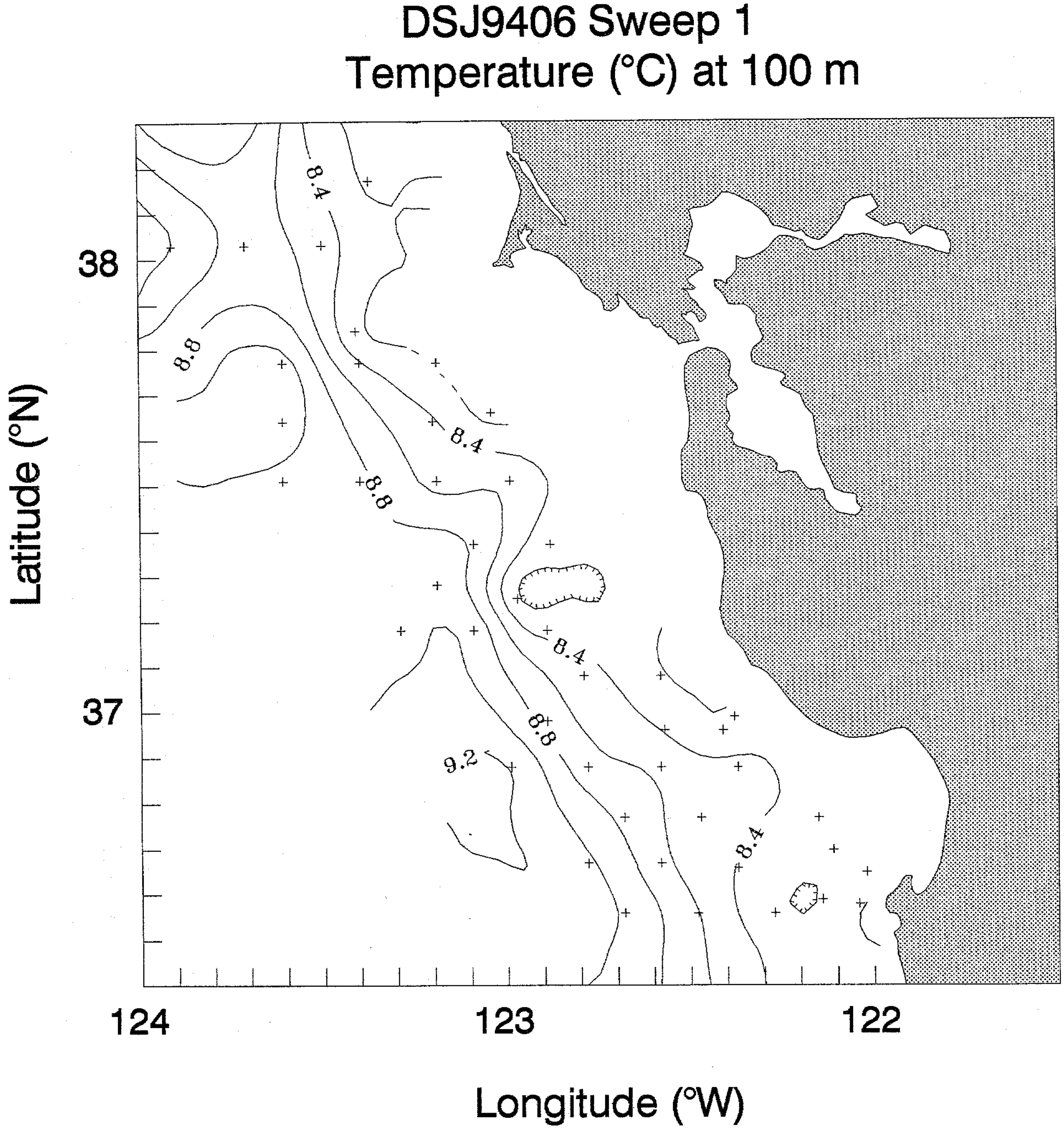


DSJ9406 Sweep 1
Temperature (°C) at 10 m

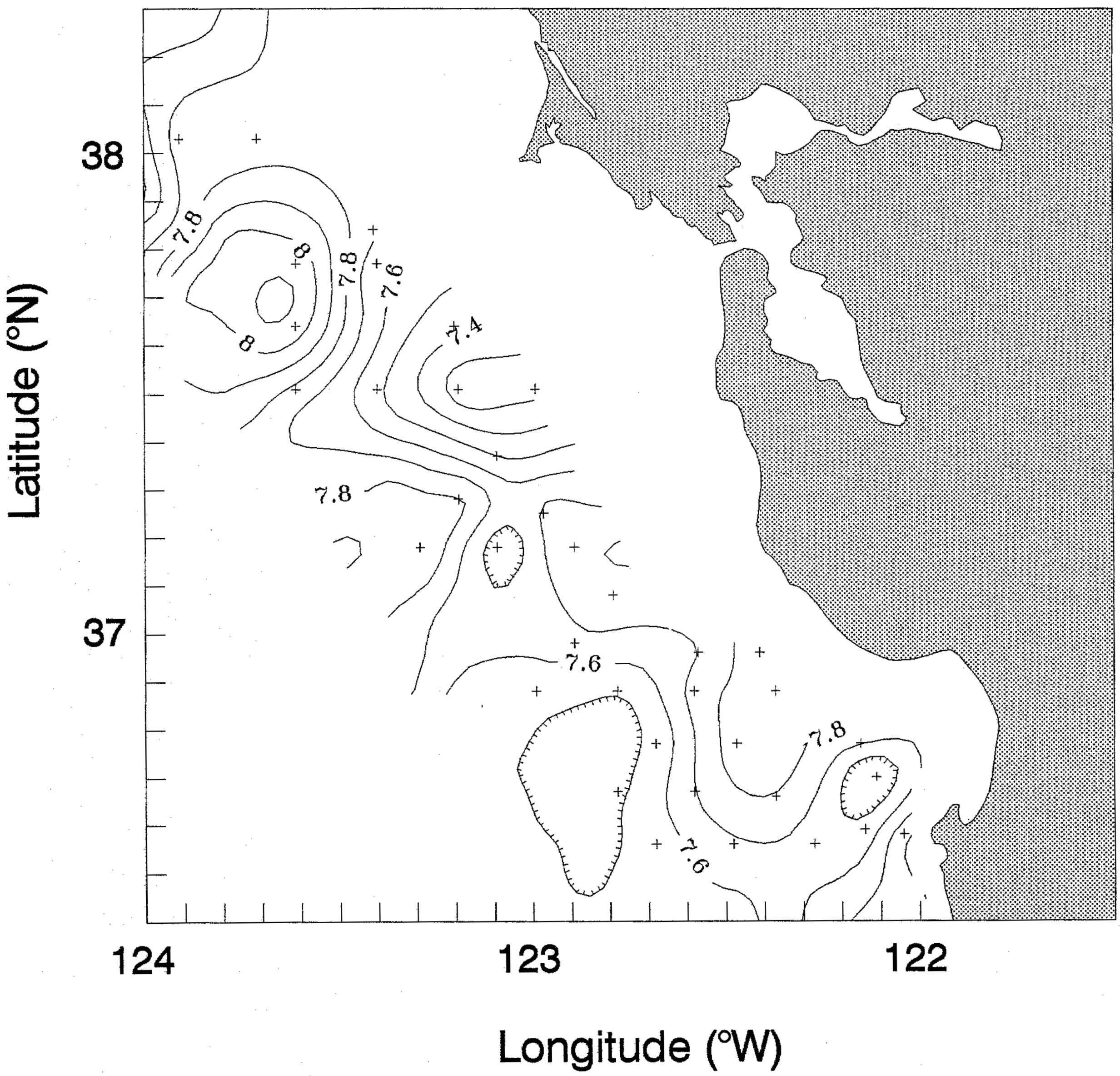


DSJ9406 Sweep 1
Temperature (°C) at 30 m

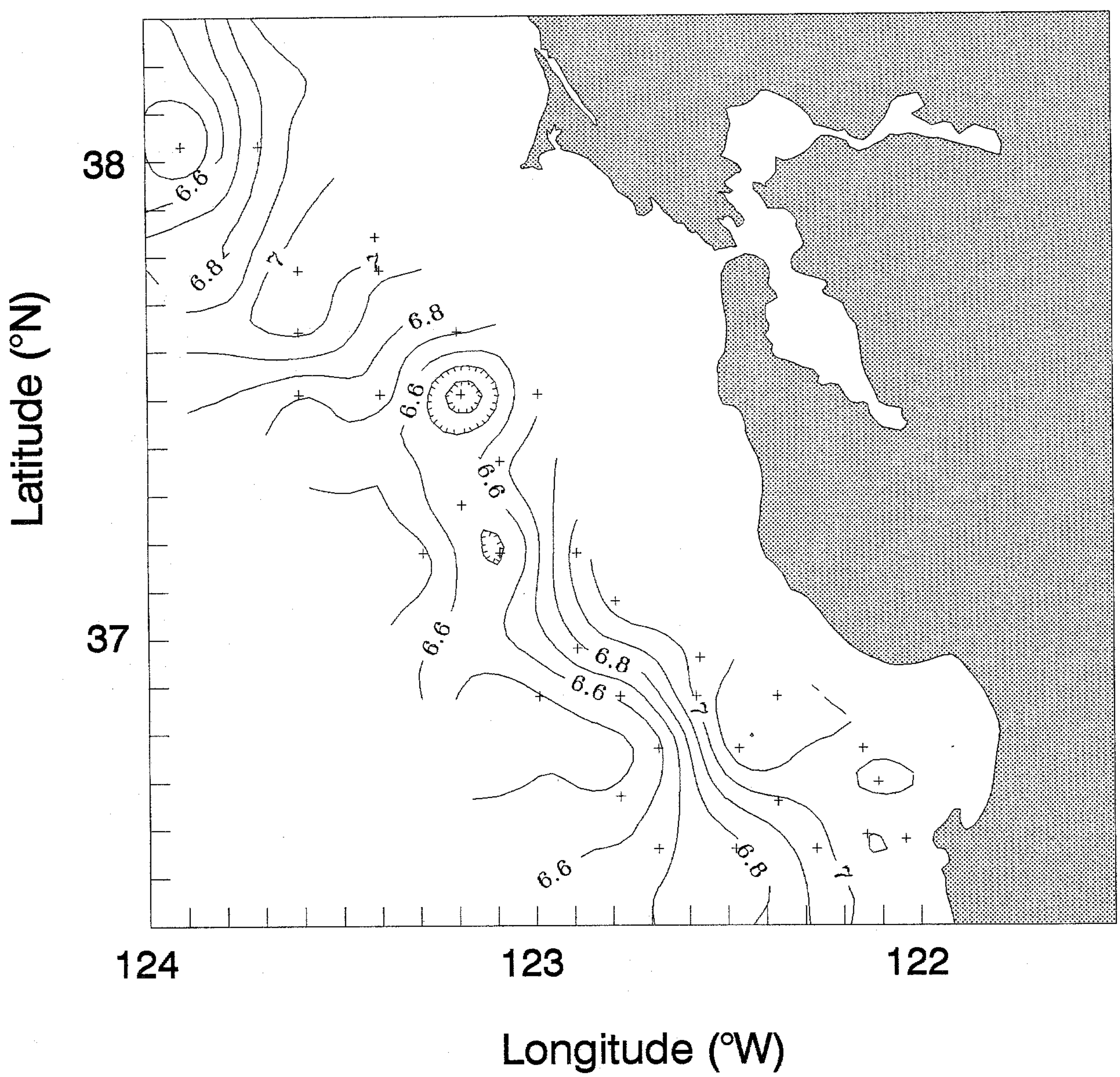



DSJ9406 Sweep 1
Temperature (°C) at 100 m
8.4
8.8
8.4
8.8
8.4
8.8
9.2
8.4
38
37
124
123
122
Latitude (°N)
Longitude (°W)

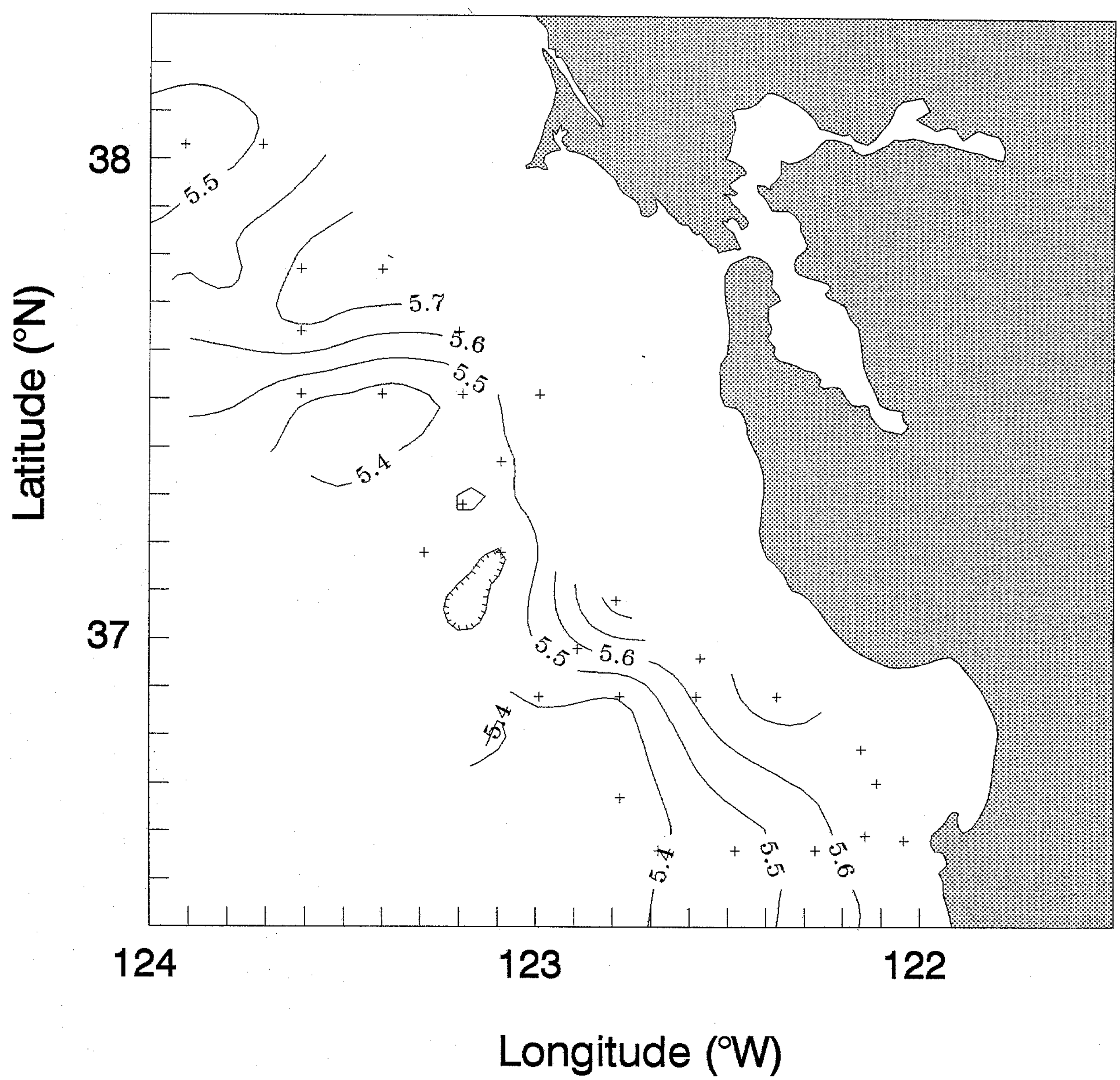
DSJ9406 Sweep 1
Temperature (°C) at 200 m



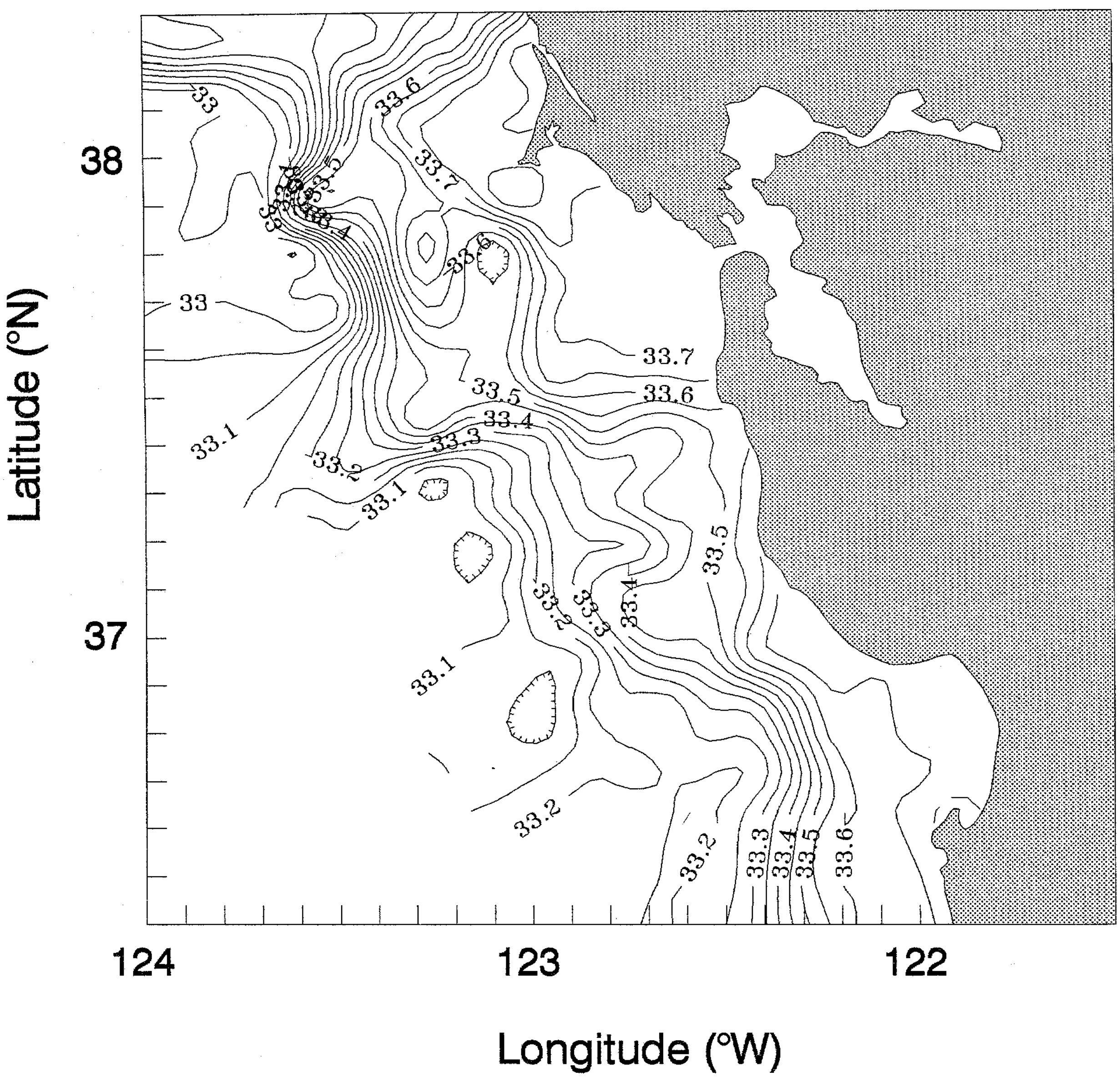
DSJ9406 Sweep 1
Temperature (°C) at 300 m



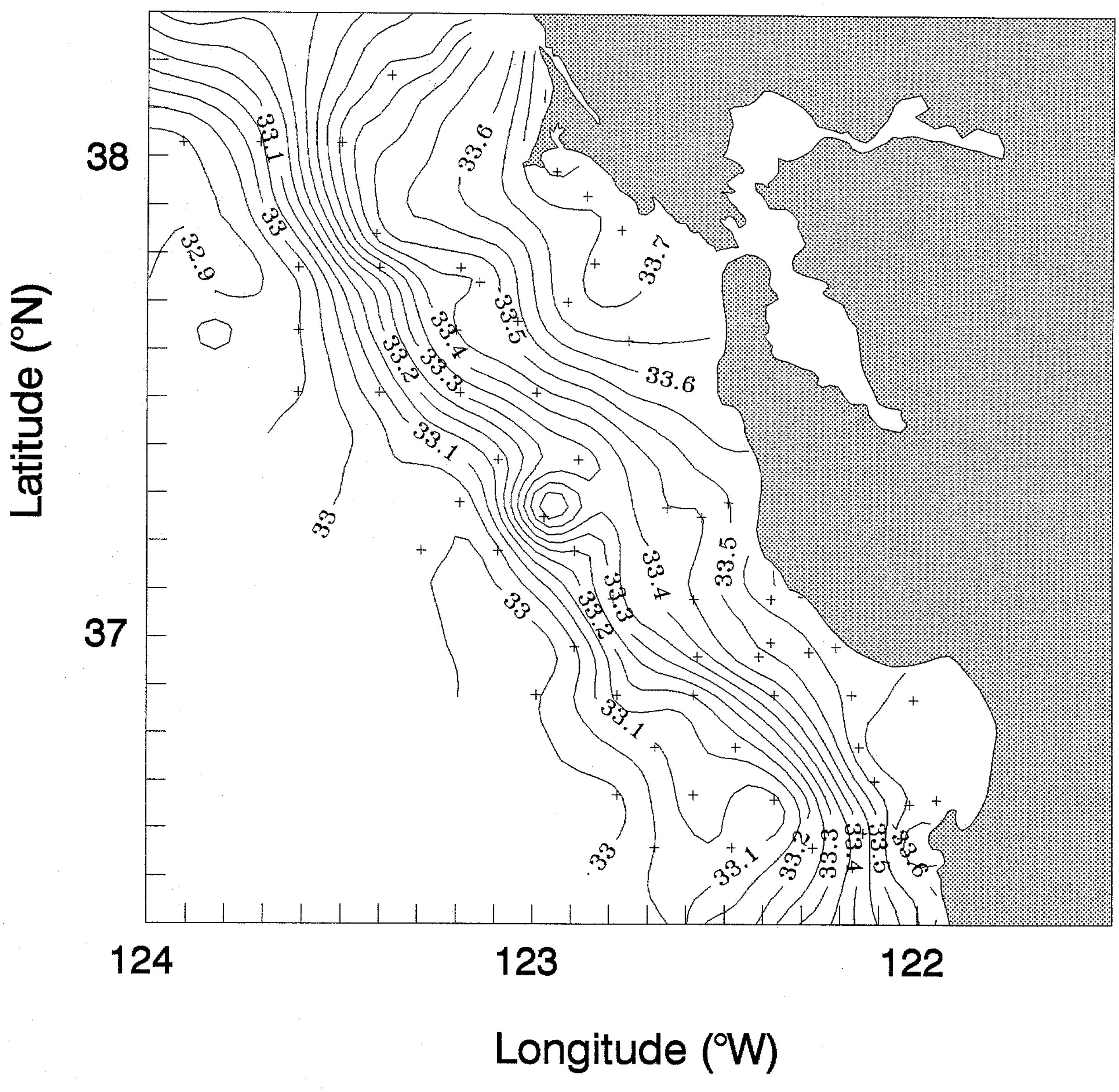
DSJ9406 Sweep 1
Temperature (°C) at 500 m



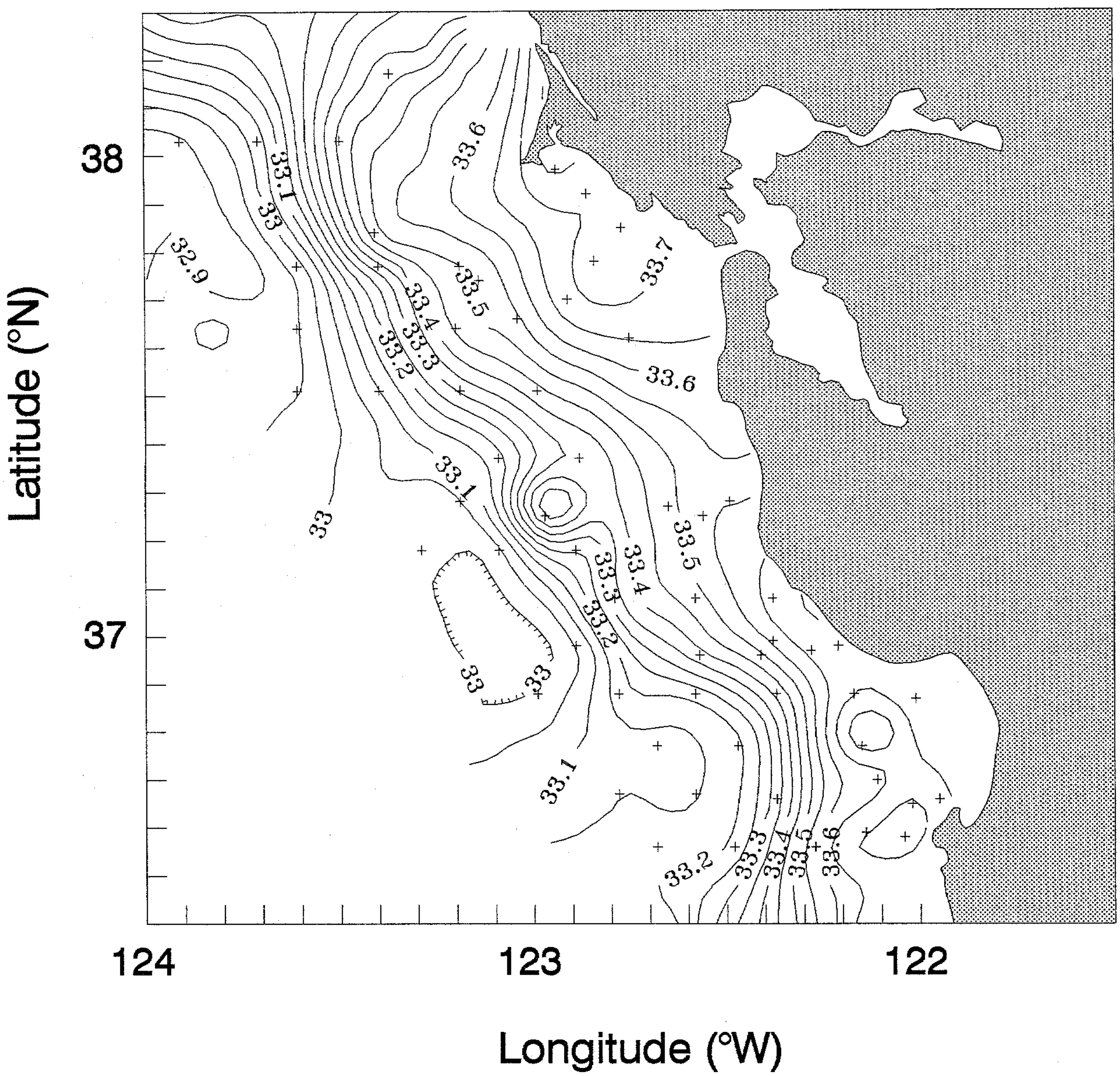
DSJ9406 Sweep 1
TS Salinity (ppt)



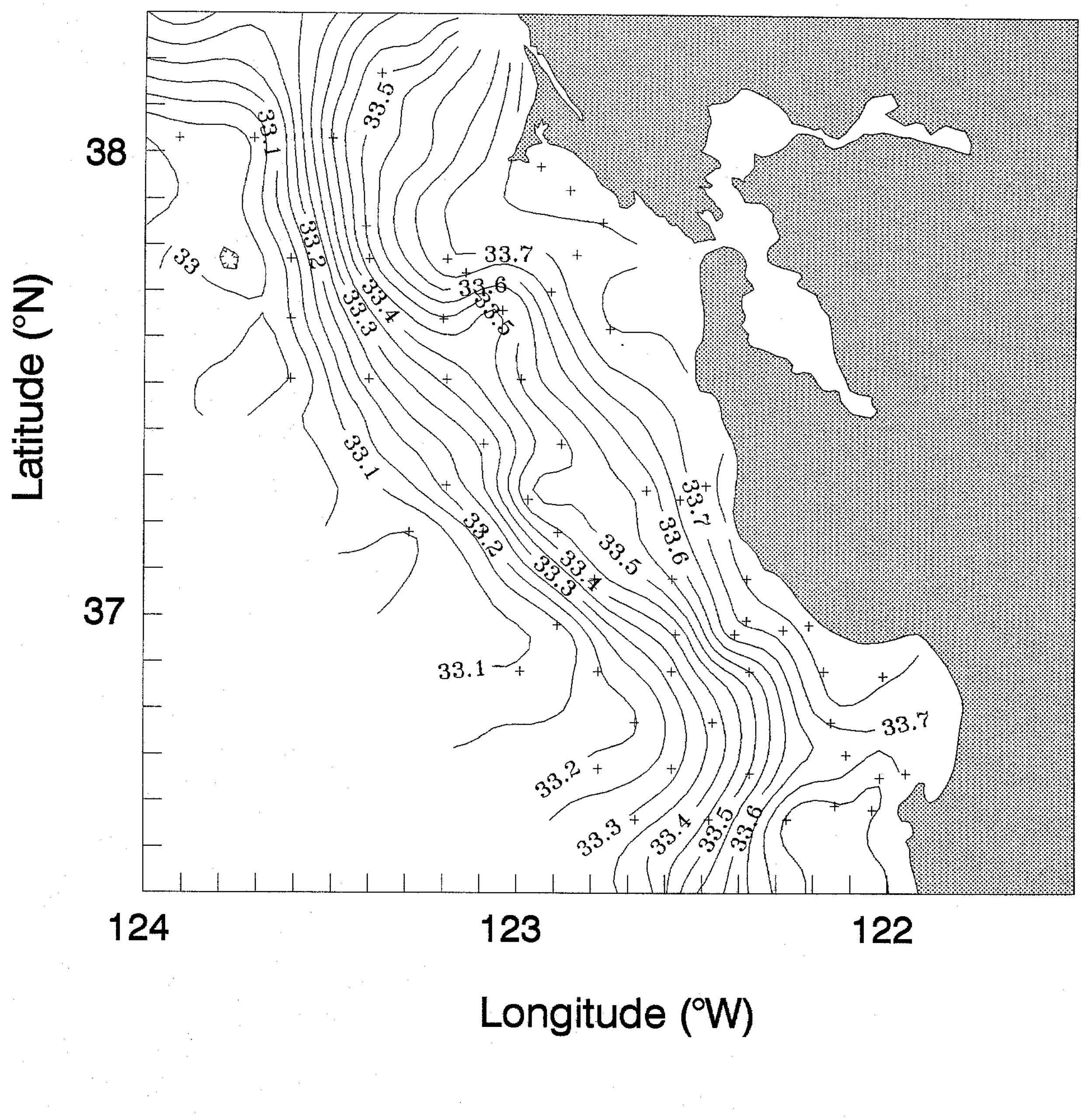
DSJ9406 Sweep 1
Salinity (ppt) at 2 m

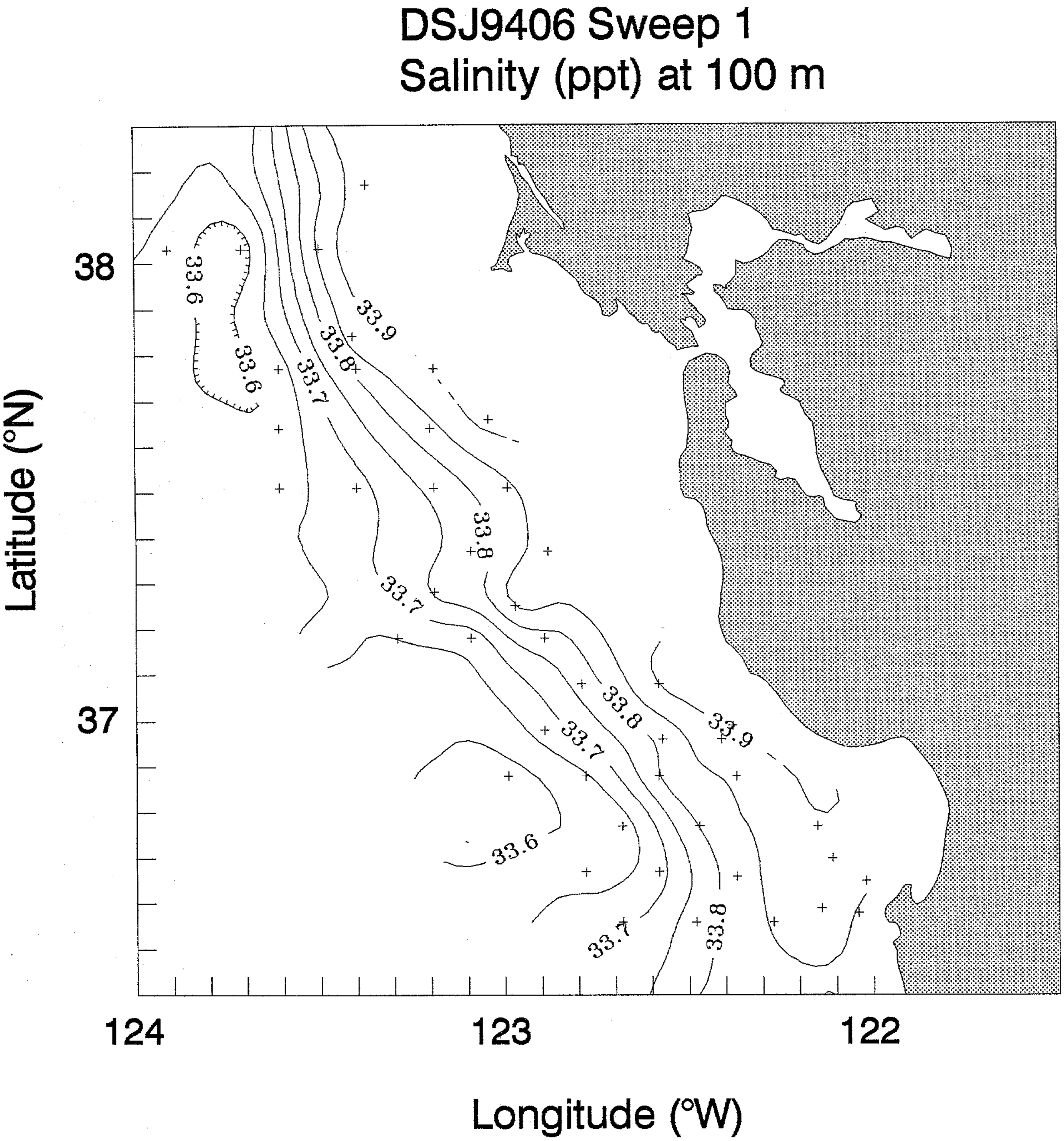


DSJ9406 Sweep 1
Salinity (ppt) at 10 m



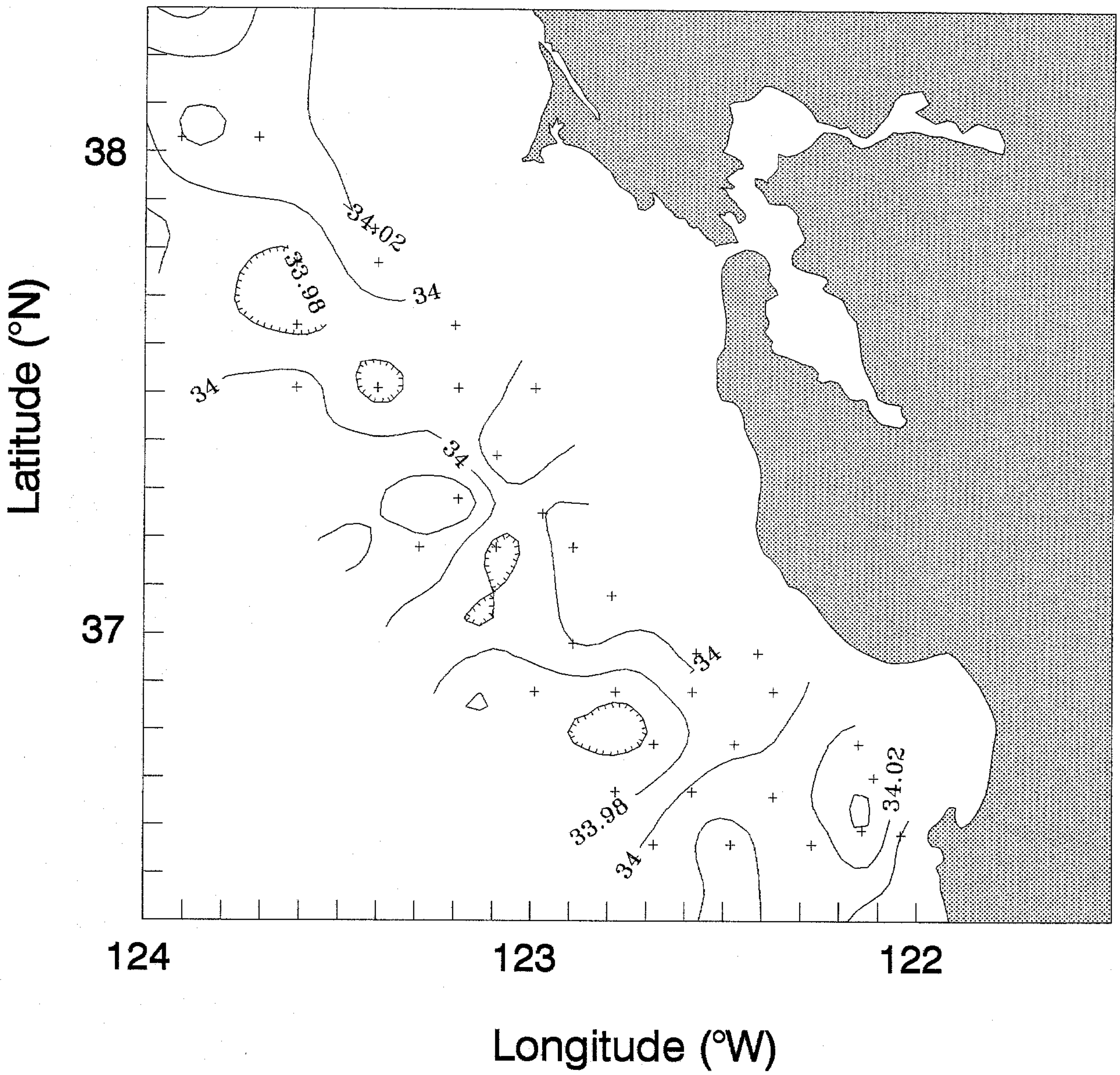
DSJ9406 Sweep 1
Salinity (ppt) at 30 m



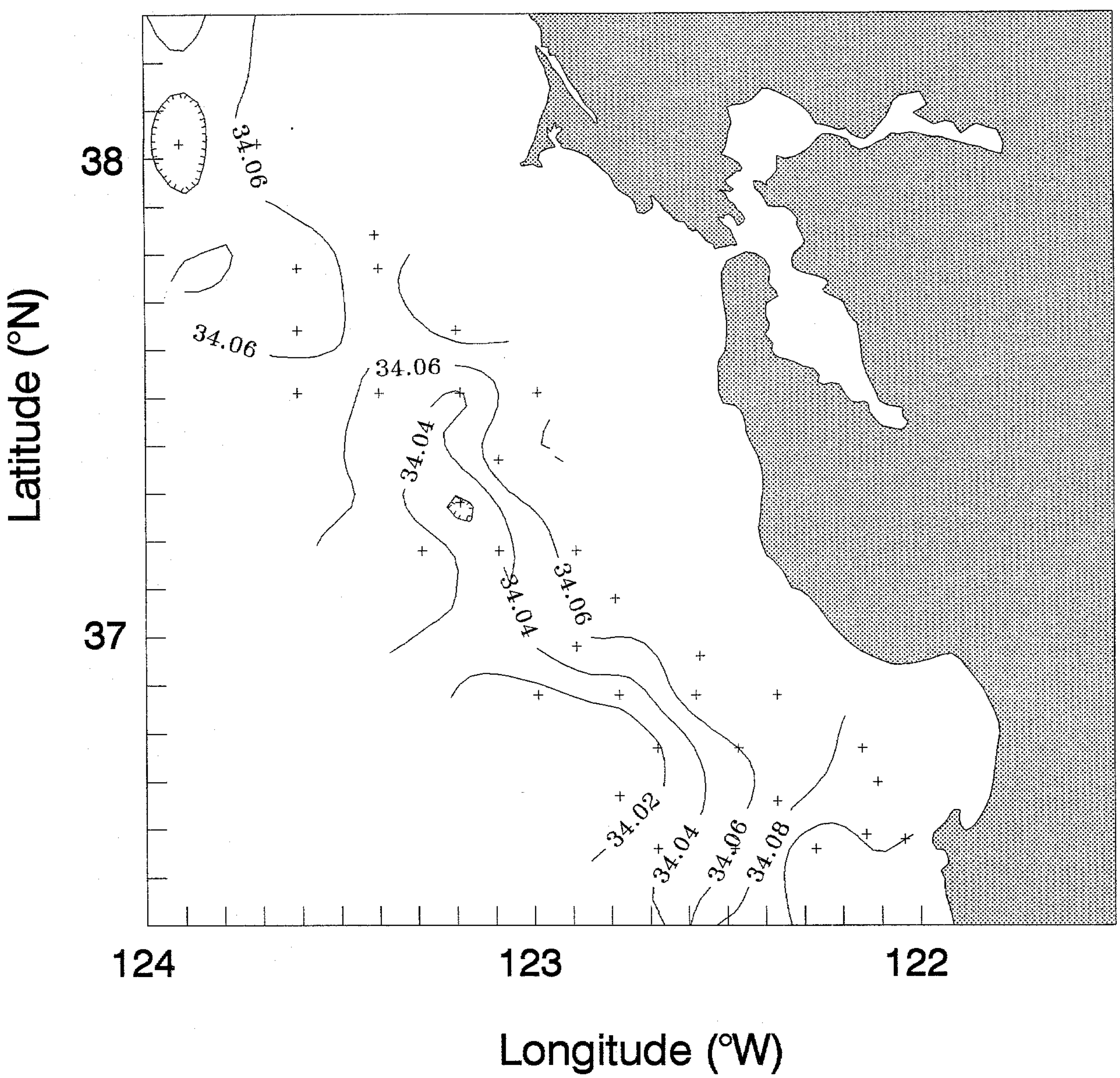


DSJ9406 Sweep 1
Salinity (ppt) at 100 m
Latitude (°N)
38
37
124
123
122
Longitude (°W)
33.6
33.7
33.8
33.9

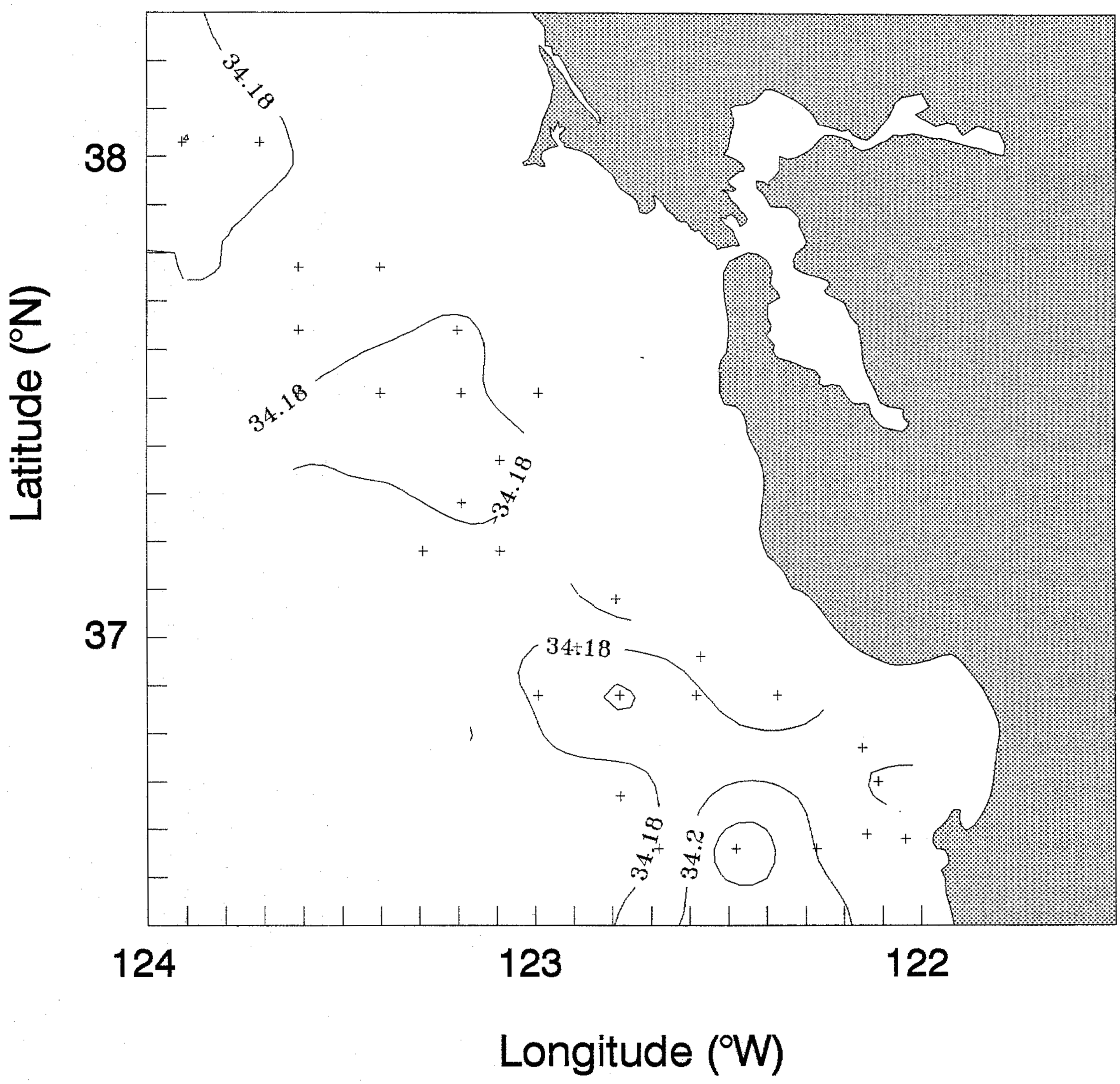
DSJ9406 Sweep 1
Salinity (ppt) at 200 m

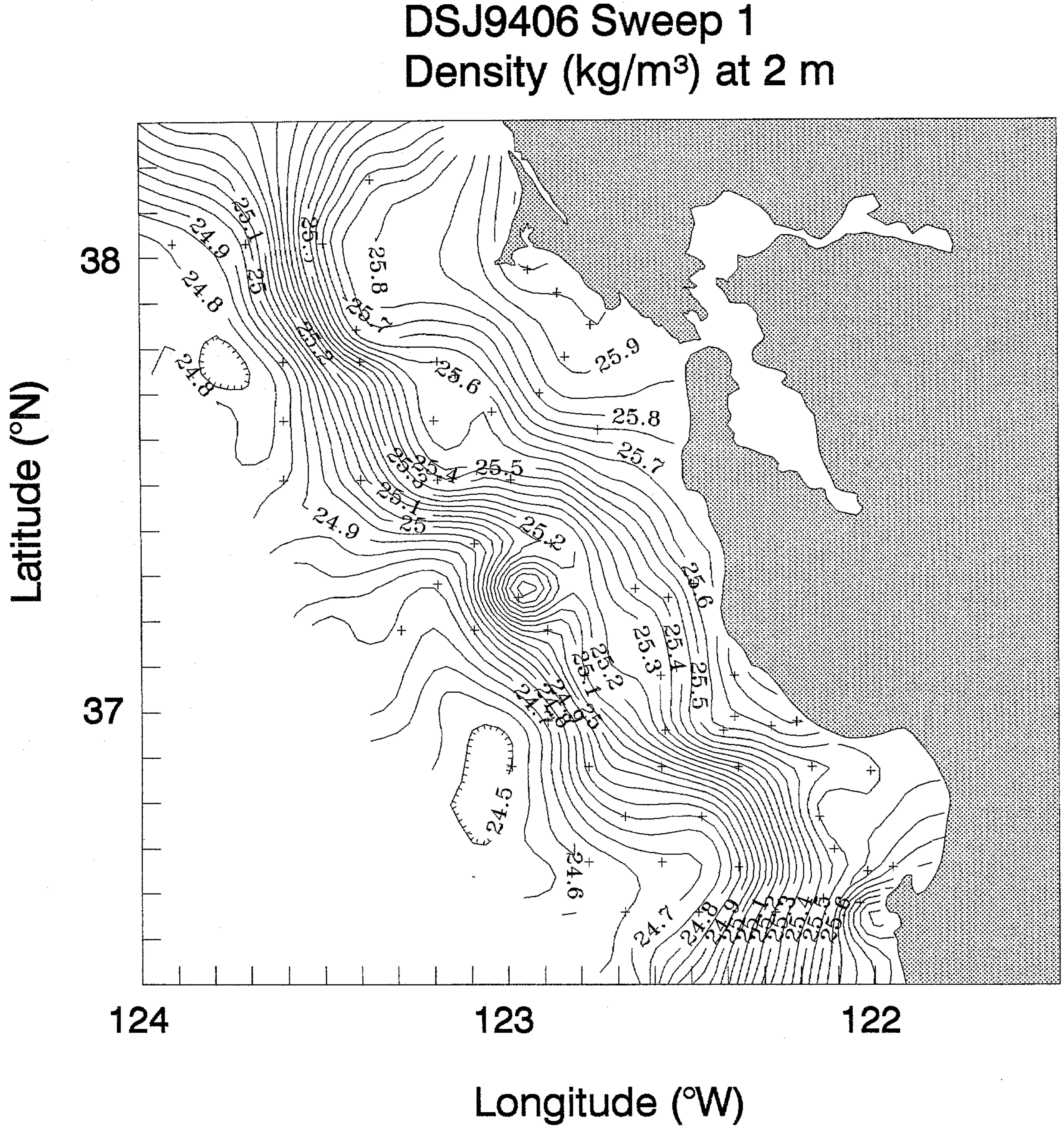


DSJ9406 Sweep 1
Salinity (ppt) at 300 m

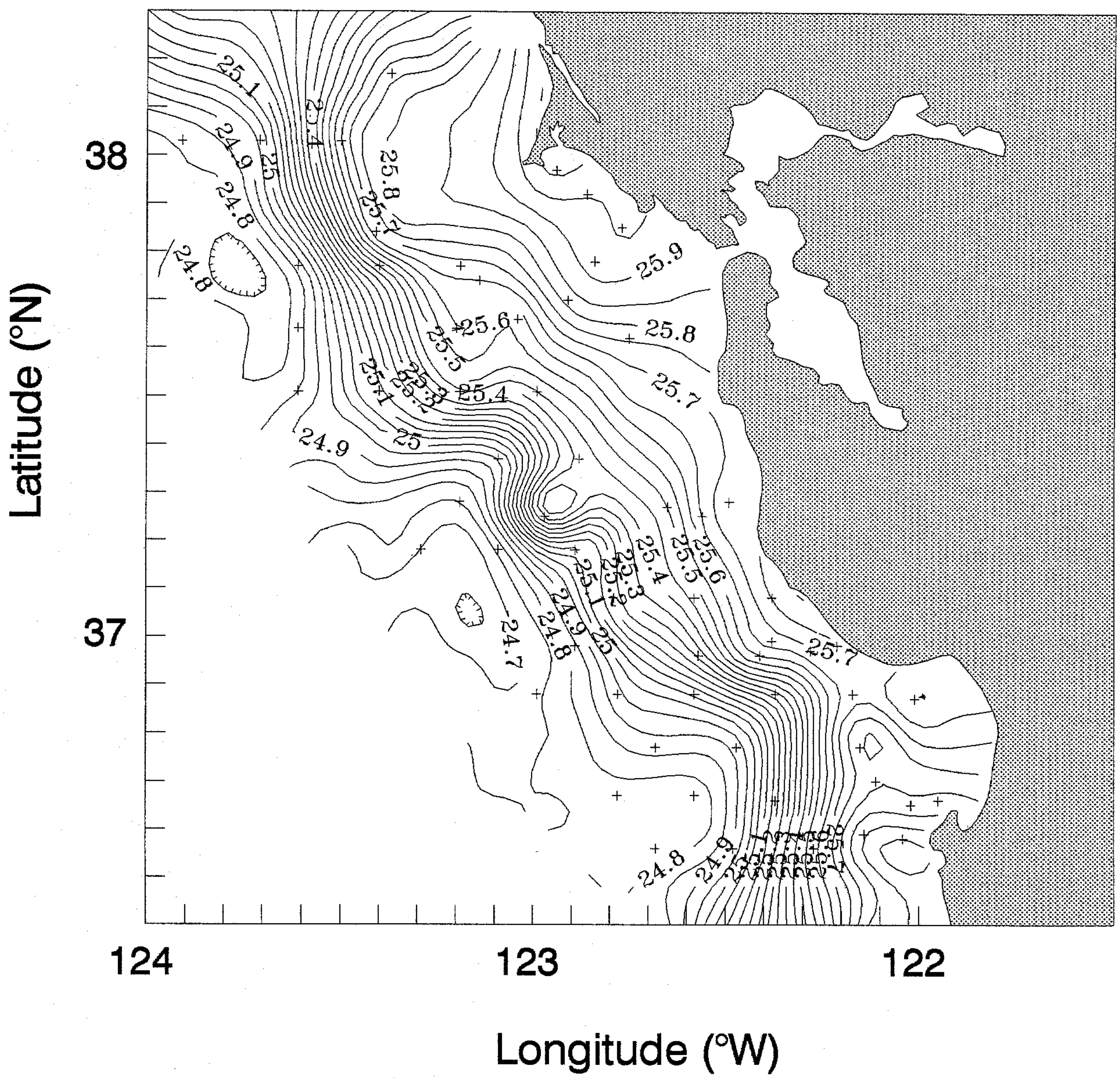


DSJ9406 Sweep 1
Salinity (ppt) at 500 m

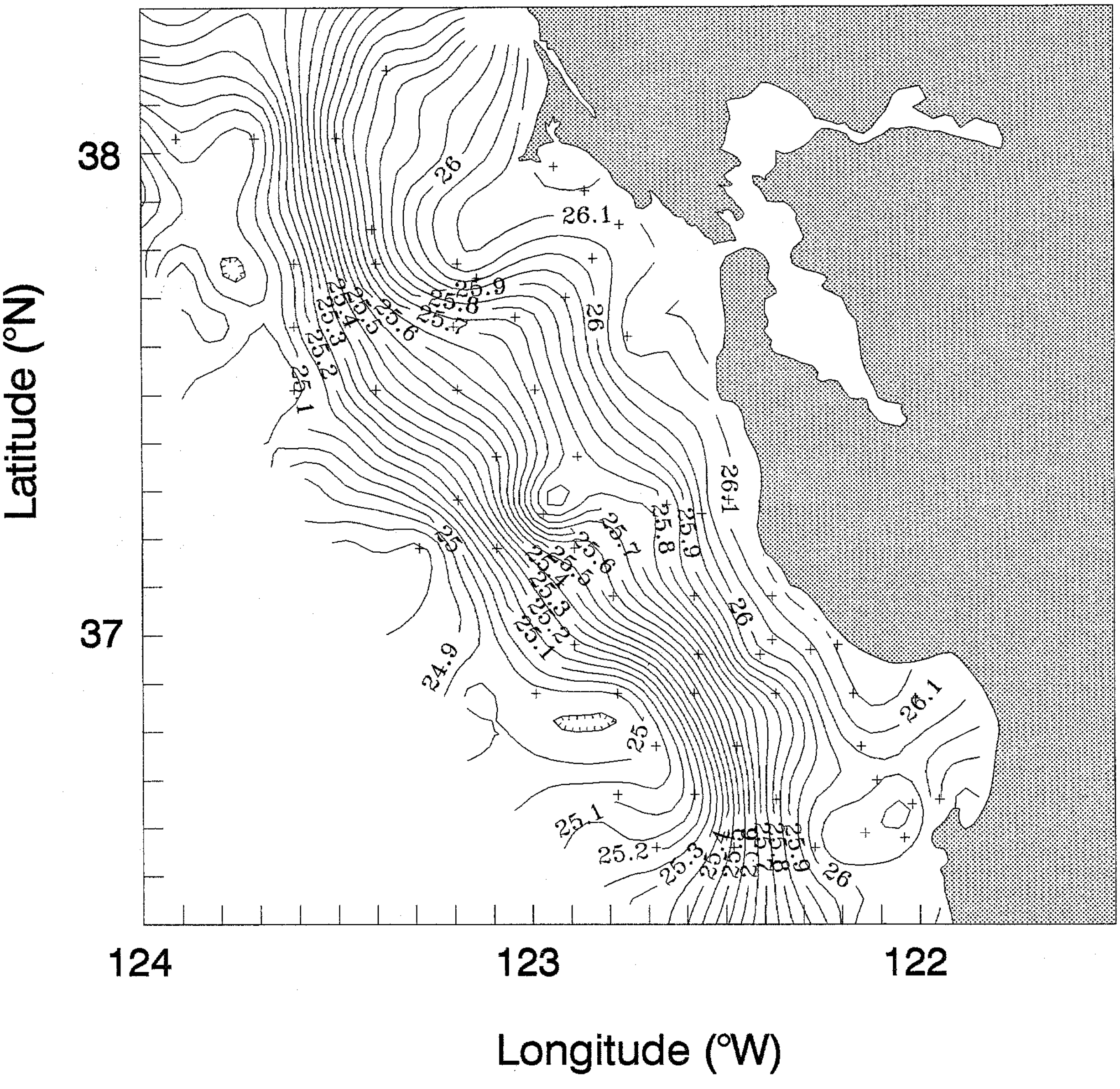



DSJ9406 Sweep 1
Density (kg/m³) at 2 m
Latitude (°N)
38
37
Longitude (°W)
124
123
122

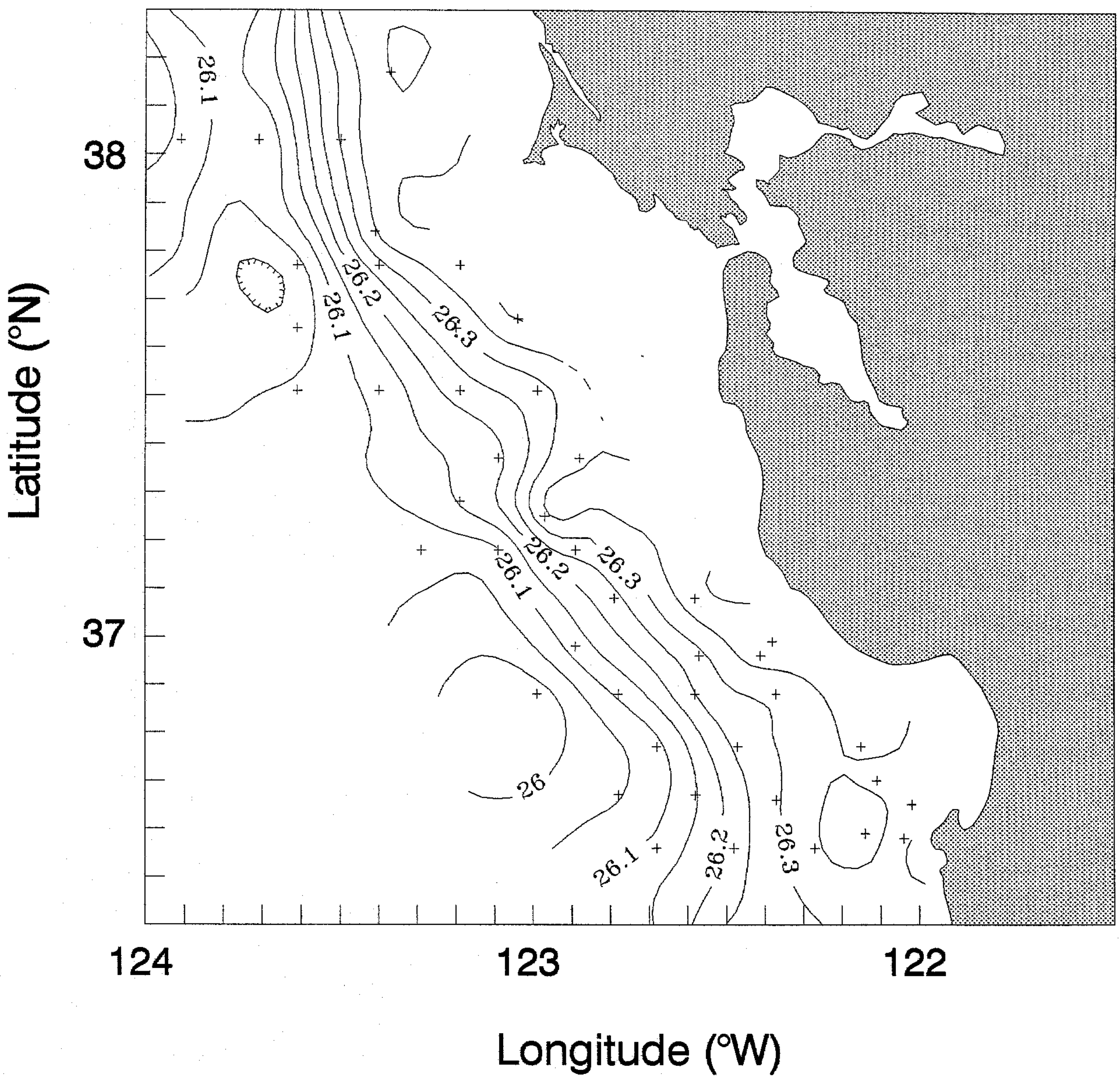
DSJ9406 Sweep 1
Density (kg/m³) at 10 m

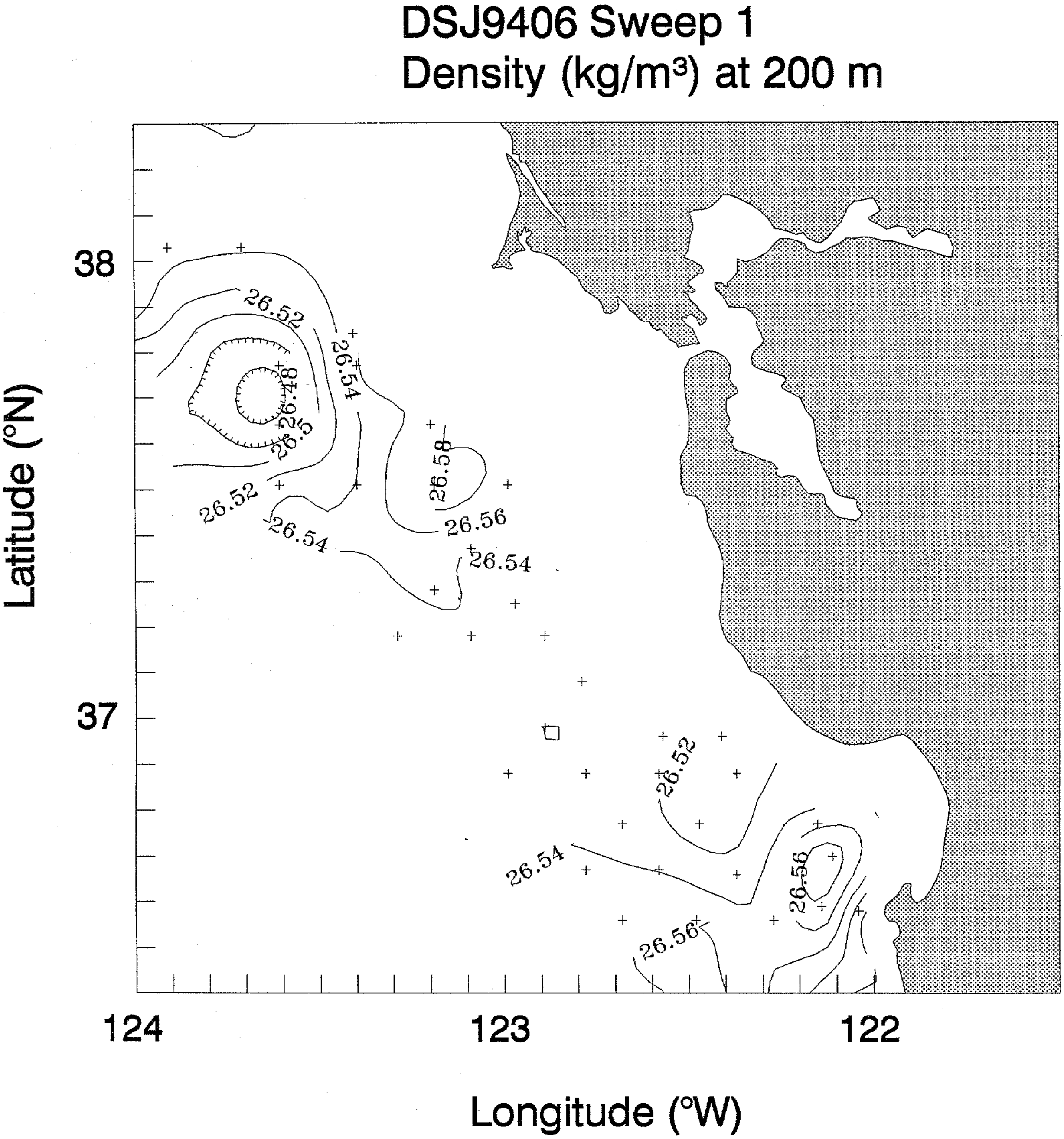


DSJ9406 Sweep 1
Density (kg/m³) at 30 m

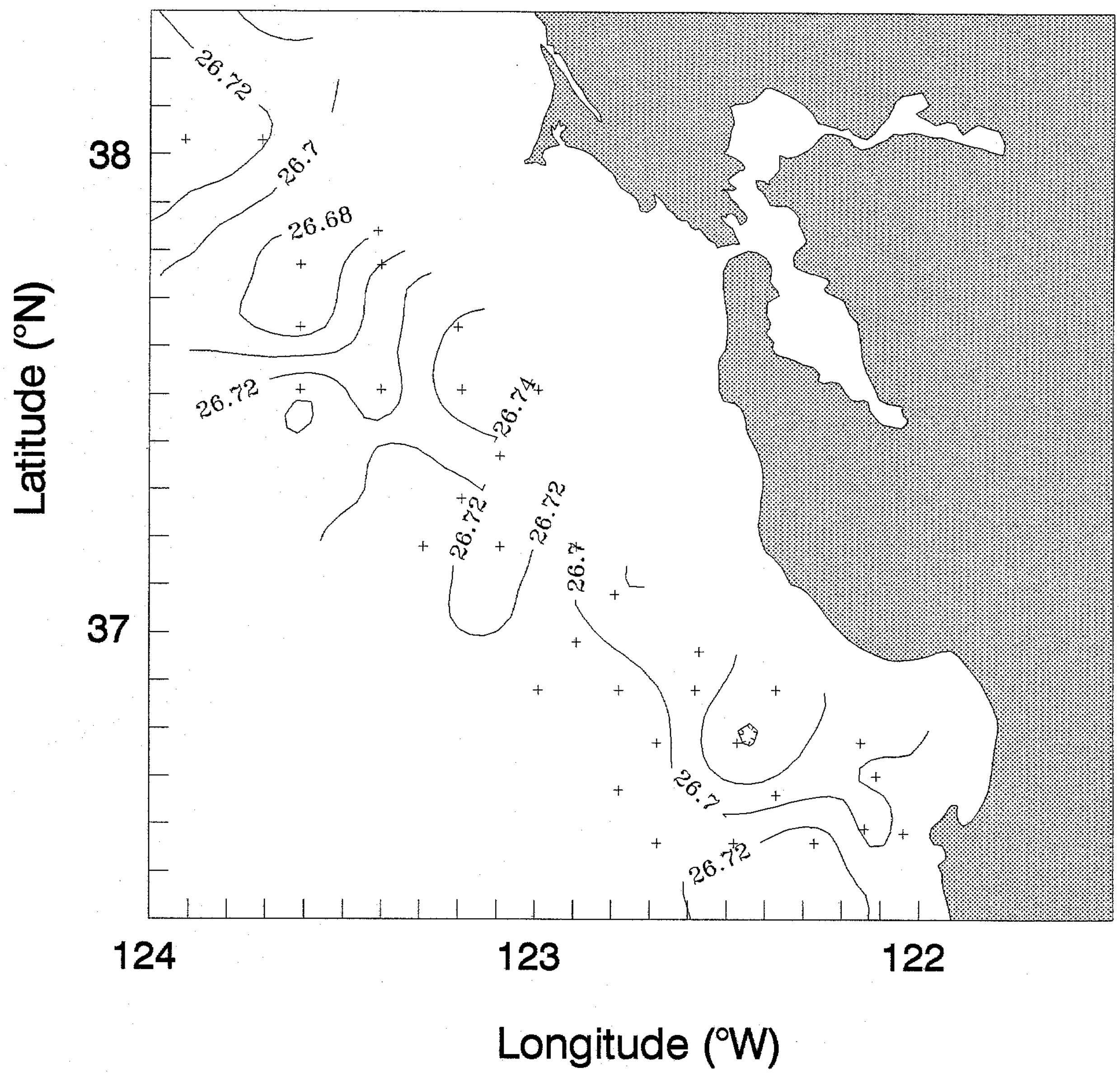


DSJ9406 Sweep 1
Density (kg/m³) at 100 m

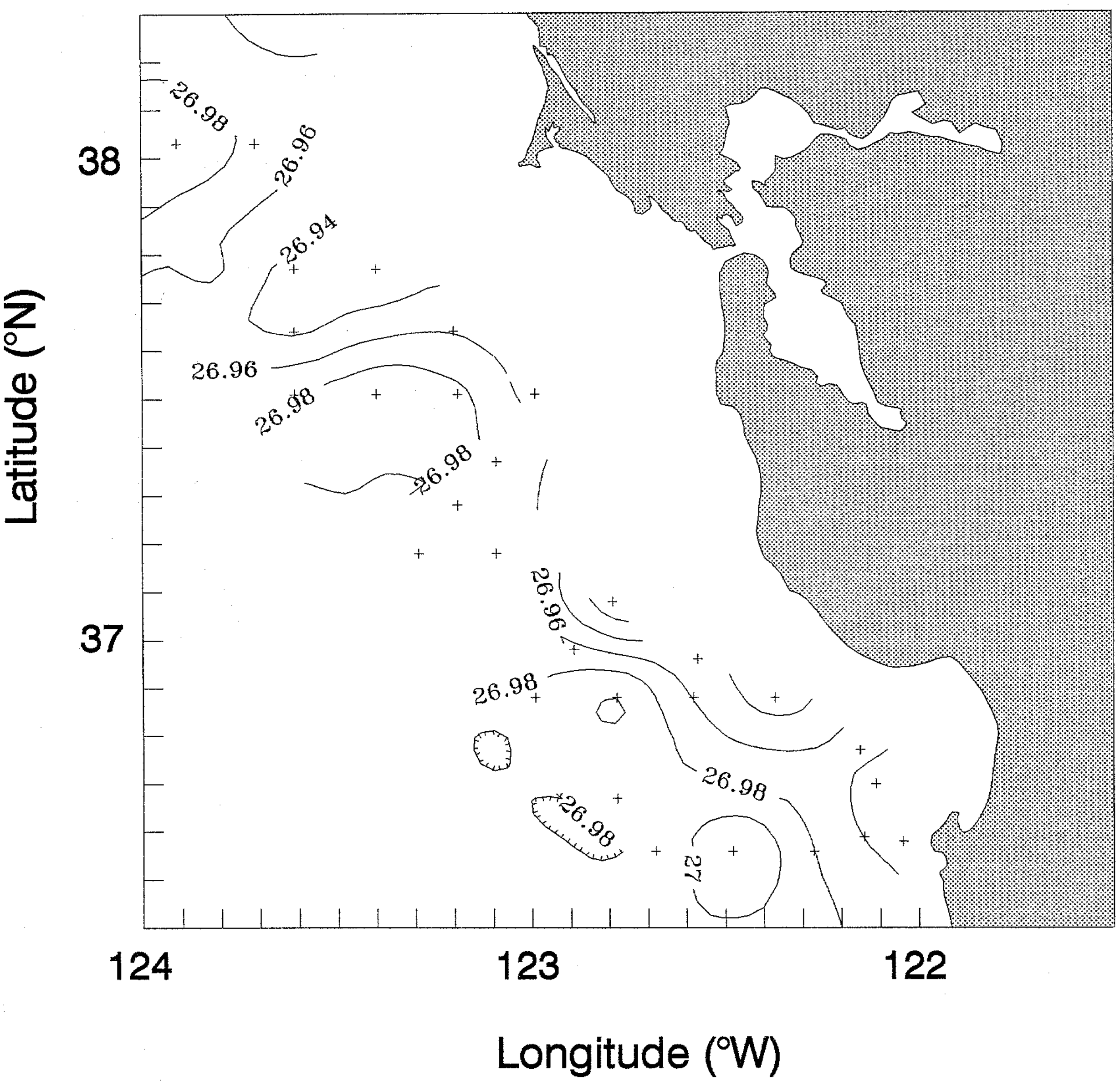



DSJ9406 Sweep 1
Density (kg/m³) at 200 m
38
37
124
123
122
Latitude (°N)
Longitude (°W)
26.52
26.54
26.48
26.5
26.58
26.56
26.54
26.52
26.54
26.52
26.54
26.56
26.56

DSJ9406 Sweep 1
Density (kg/m³) at 300 m

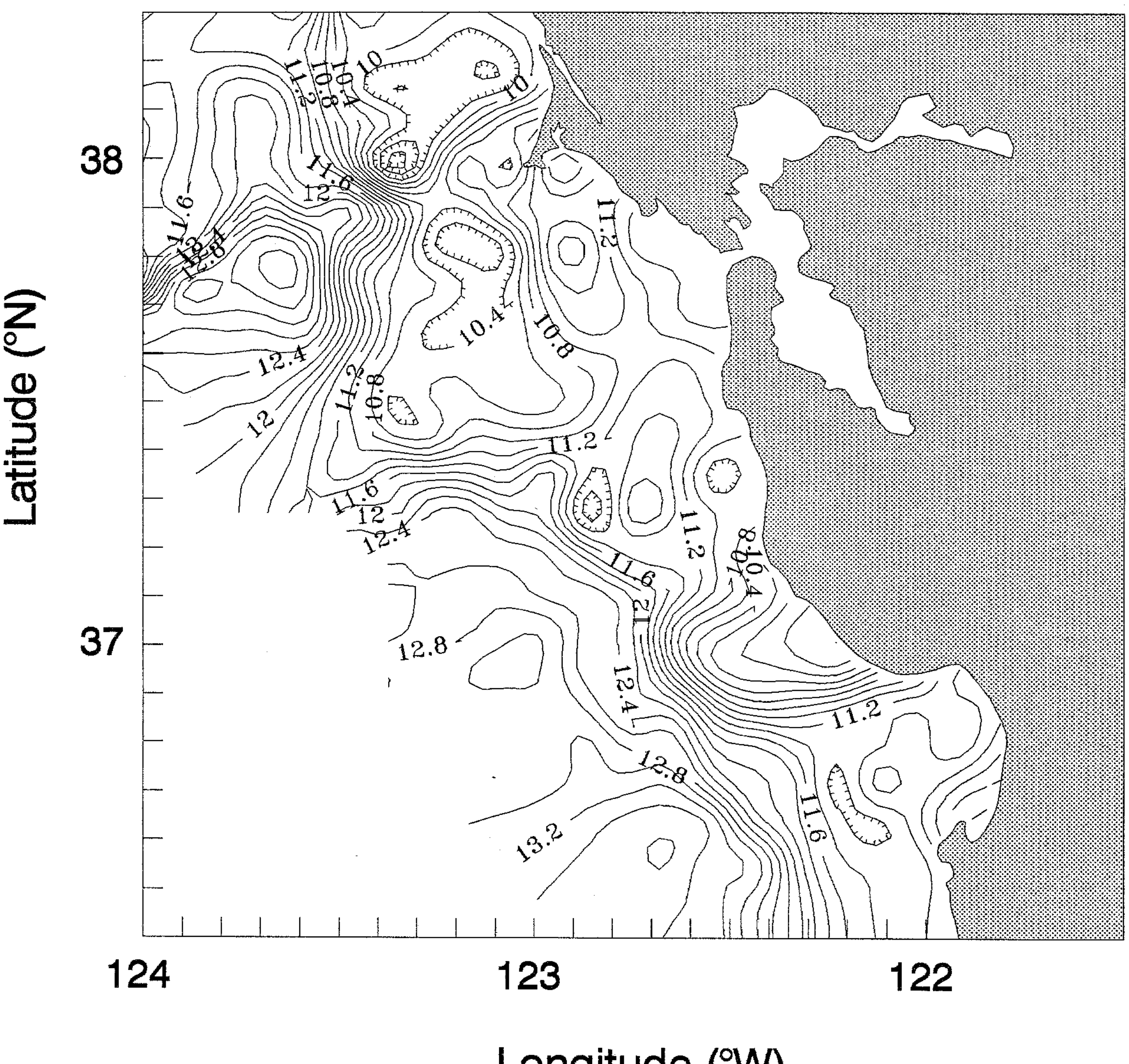


DSJ9406 Sweep 1
Density (kg/m³) at 500 m

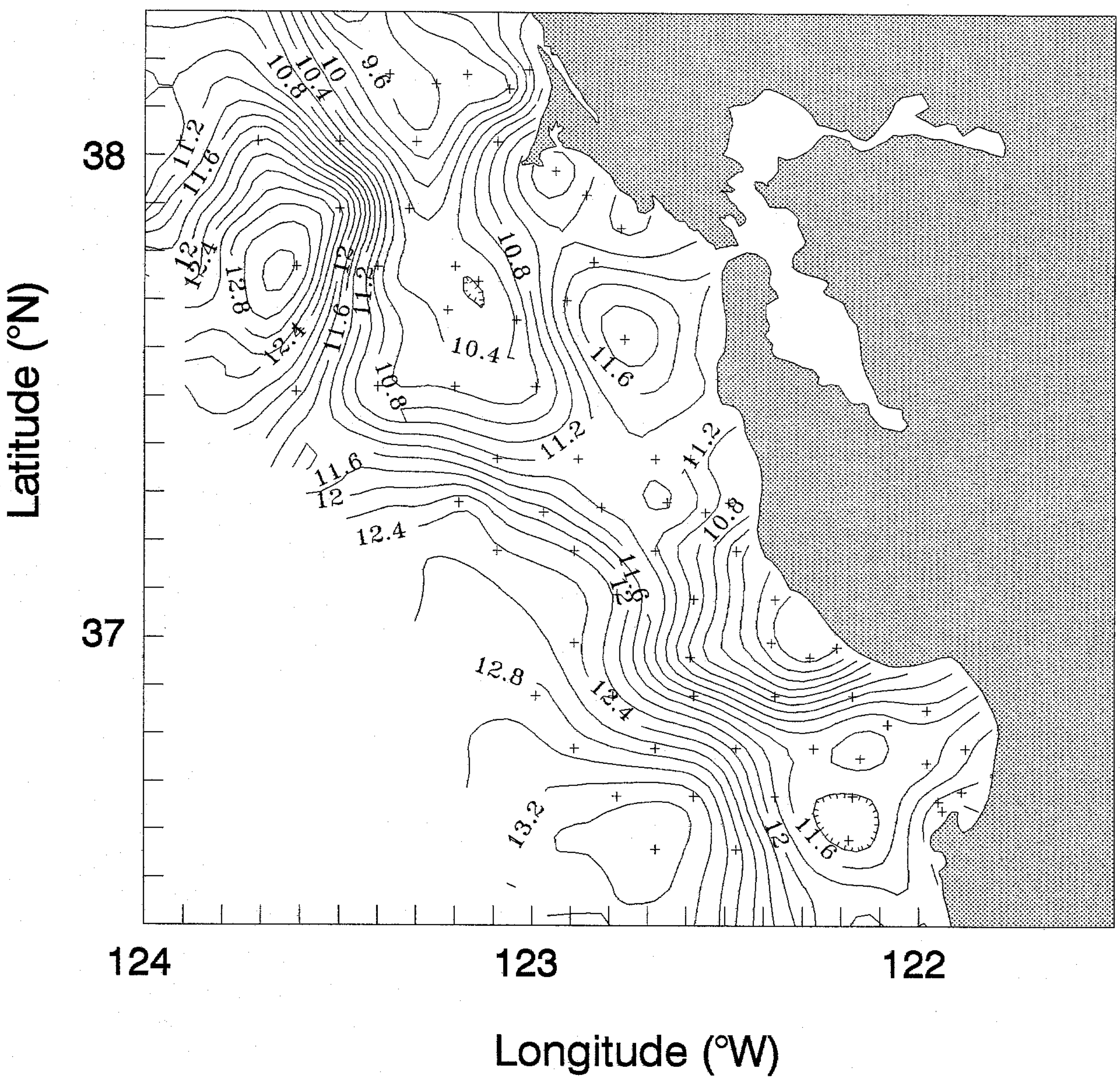


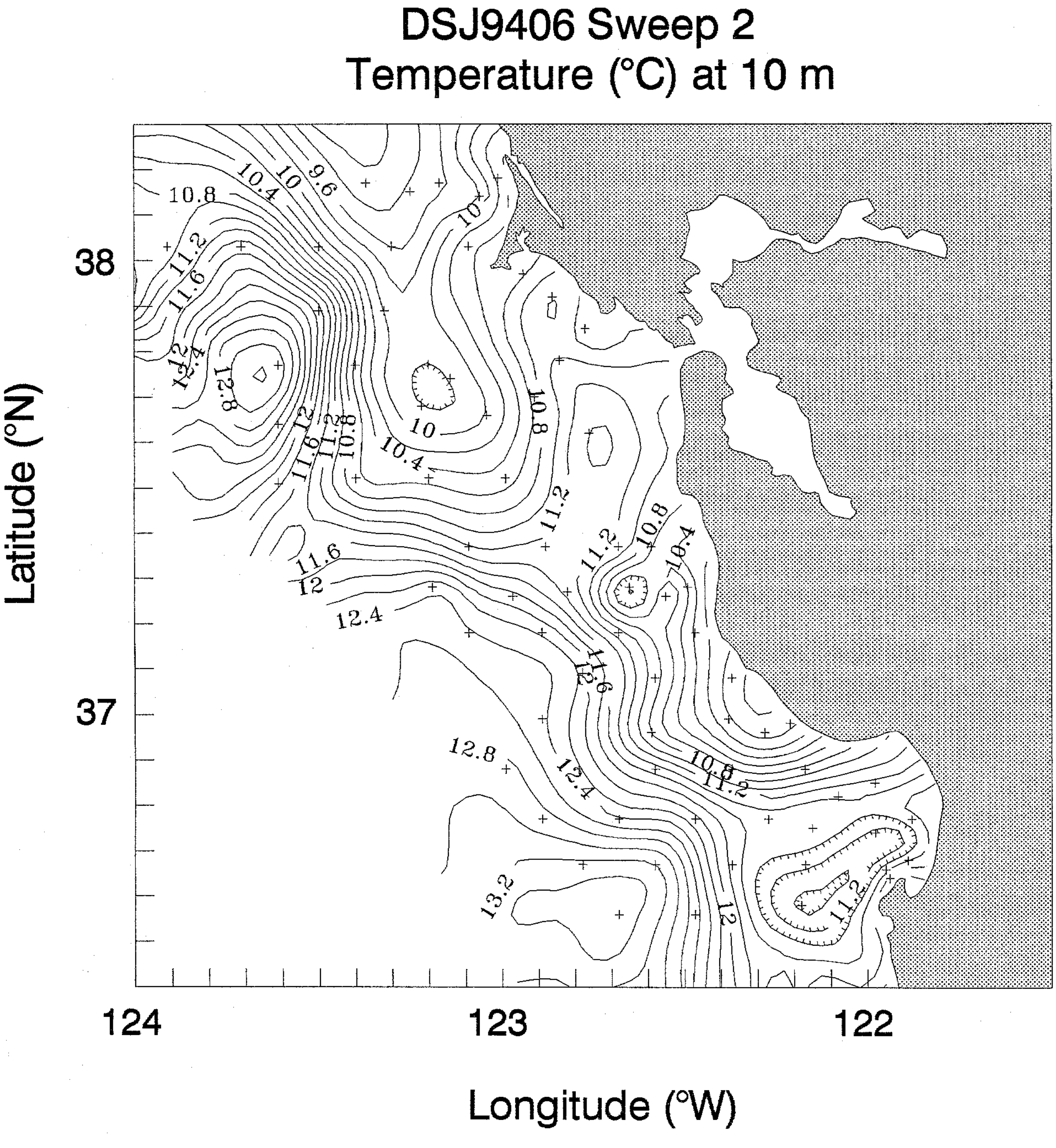
APPENDIX 8.3: HORIZONTAL MAPS OF CTD AND TS FOR DSJ9406, SWEEP 2

DSJ9406 Sweep 2
TS Temperature (°C)

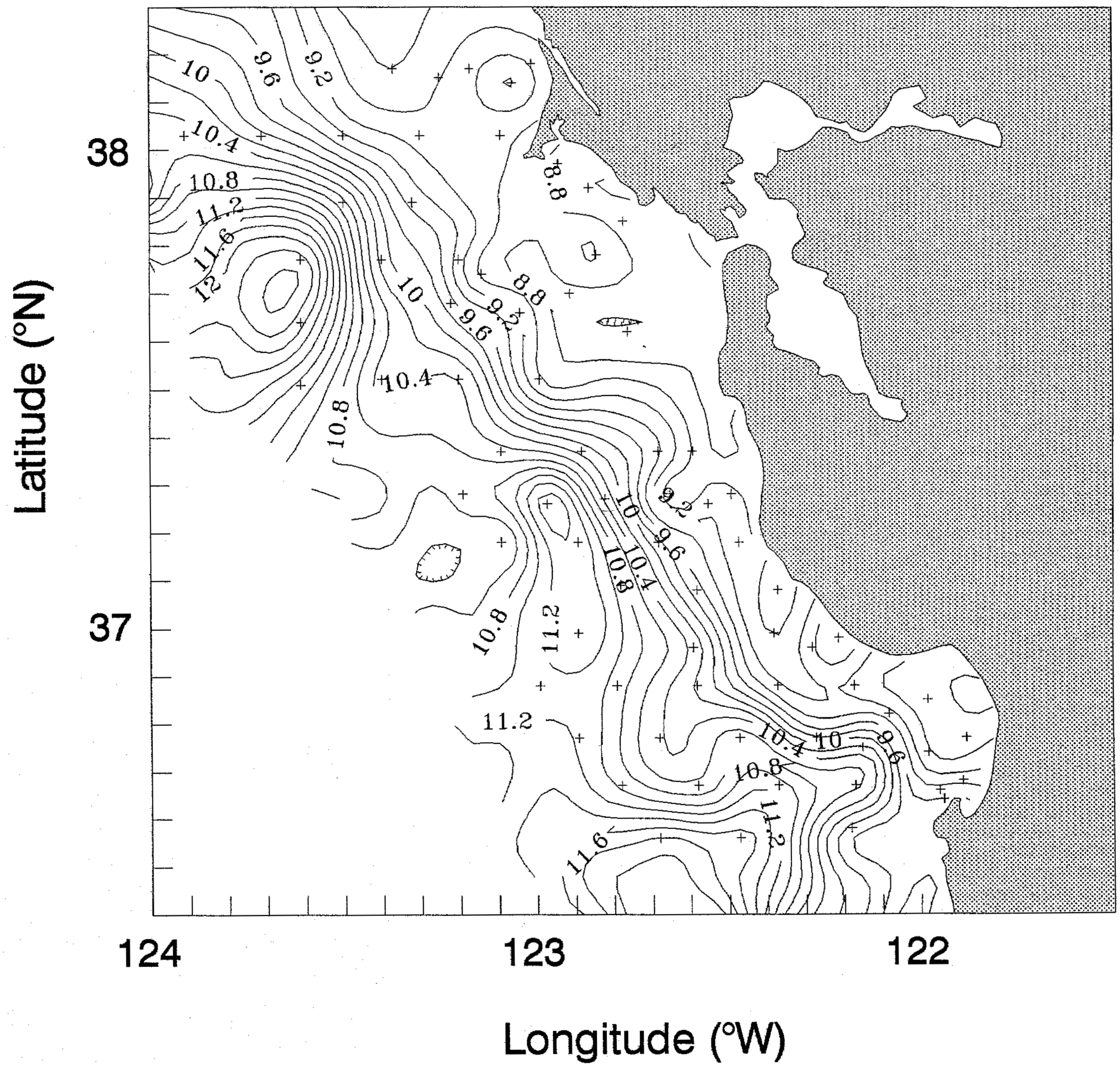


DSJ9406 Sweep 2
Temperature (°C) at 2 m

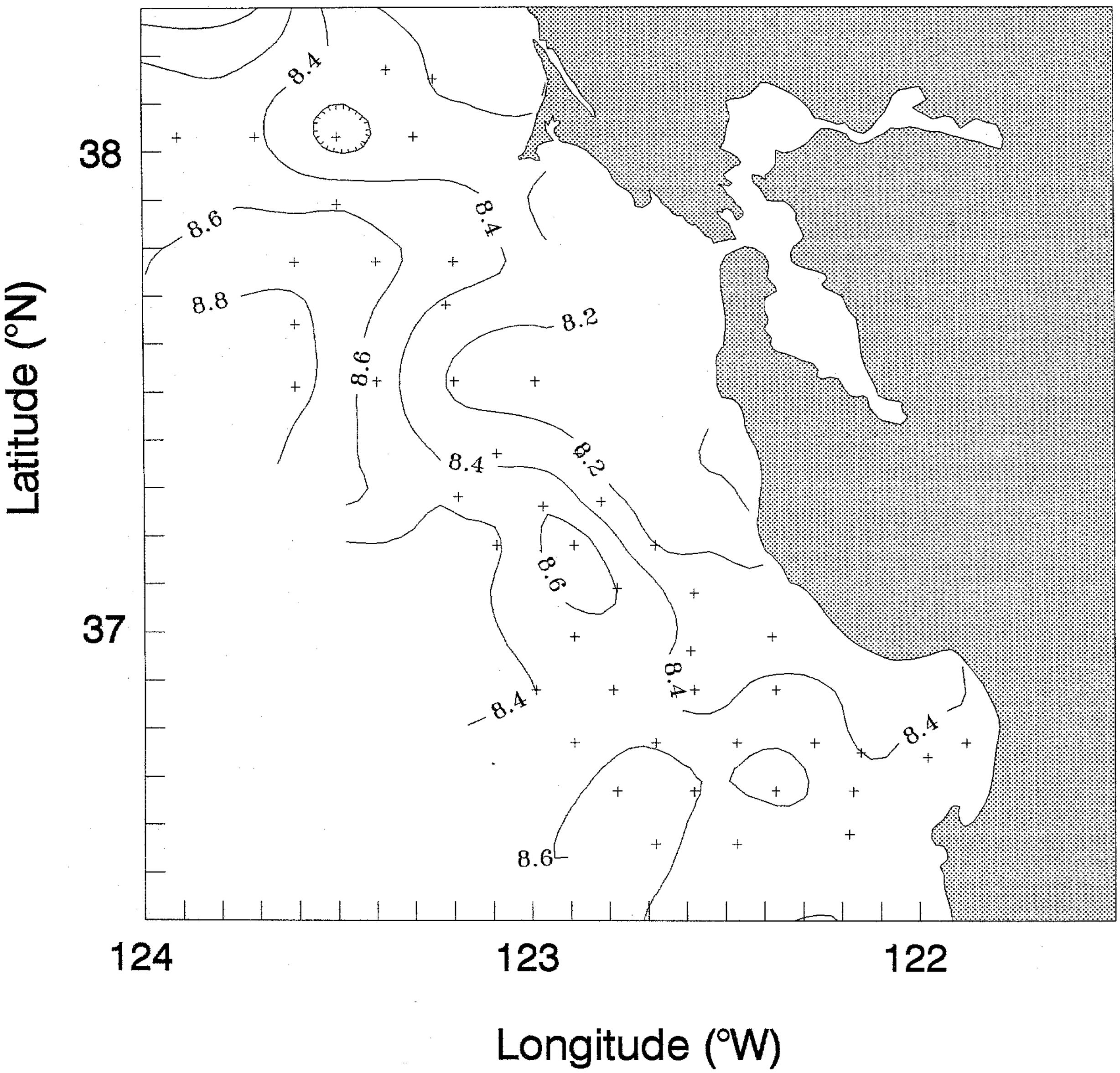



DSJ9406 Sweep 2
Temperature (°C) at 10 m
Latitude (°N)
38
37
124
123
122
Longitude (°W)

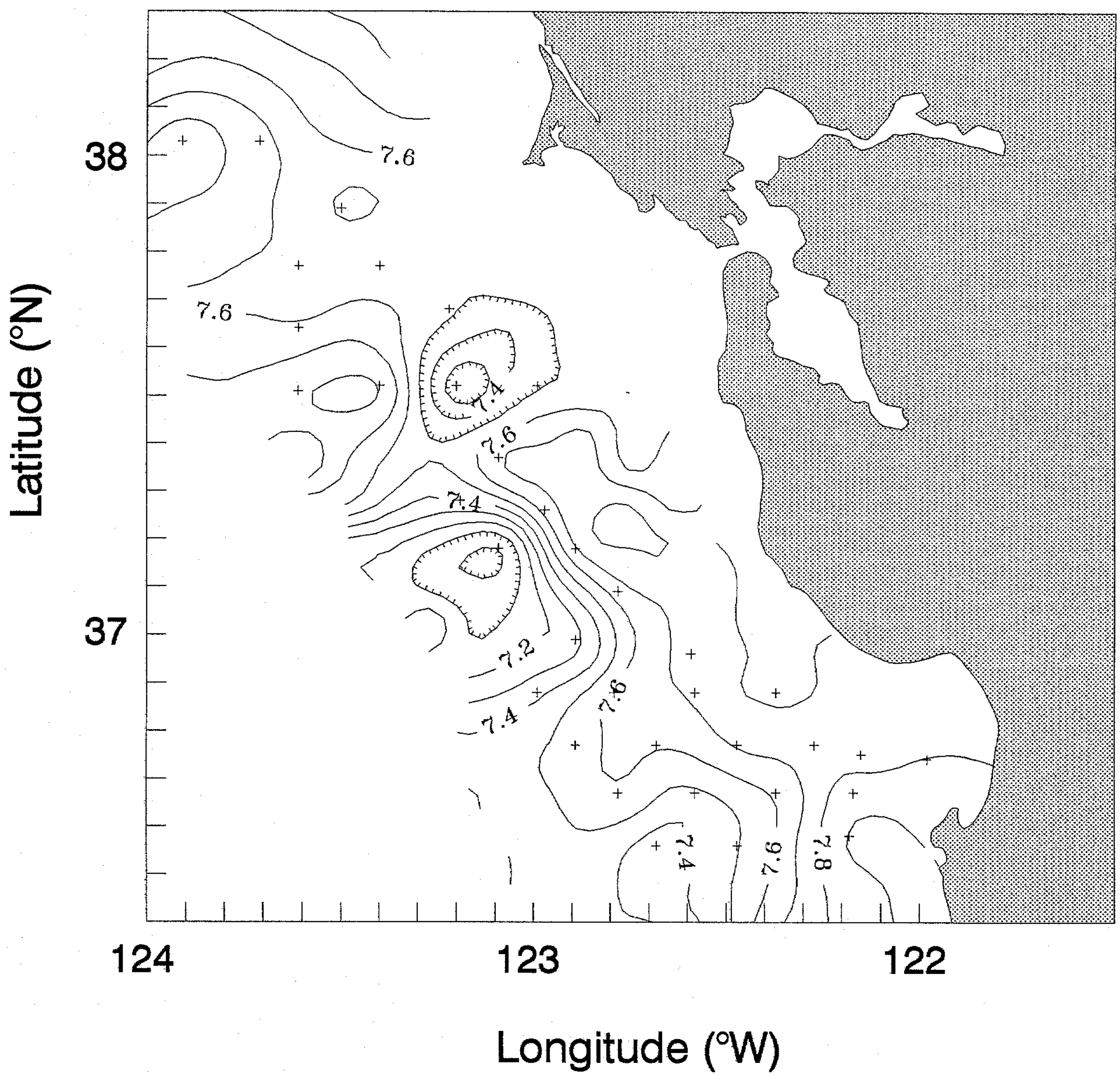
DSJ9406 Sweep 2
Temperature (°C) at 30 m



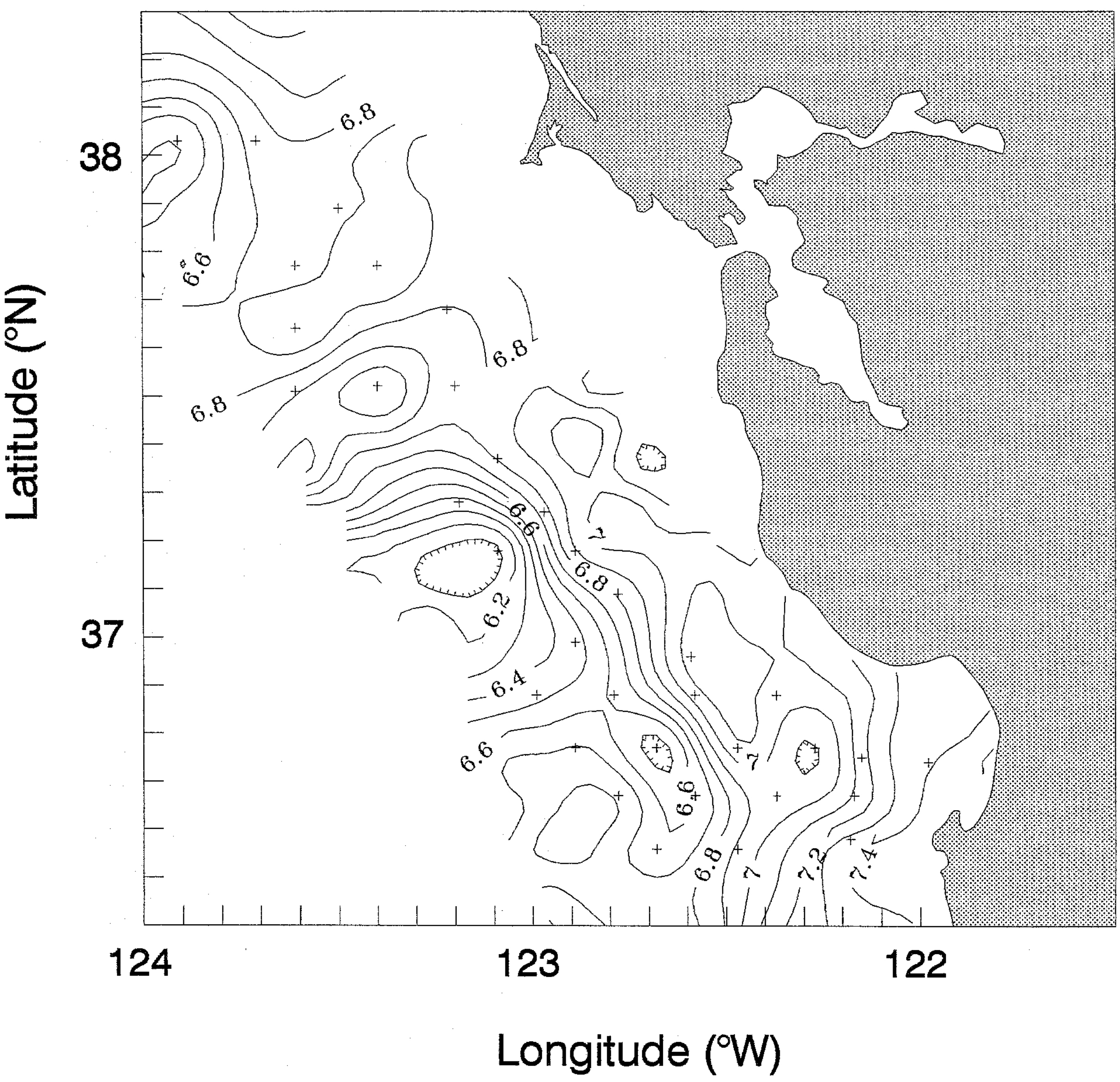
DSJ9406 Sweep 2
Temperature (°C) at 100 m



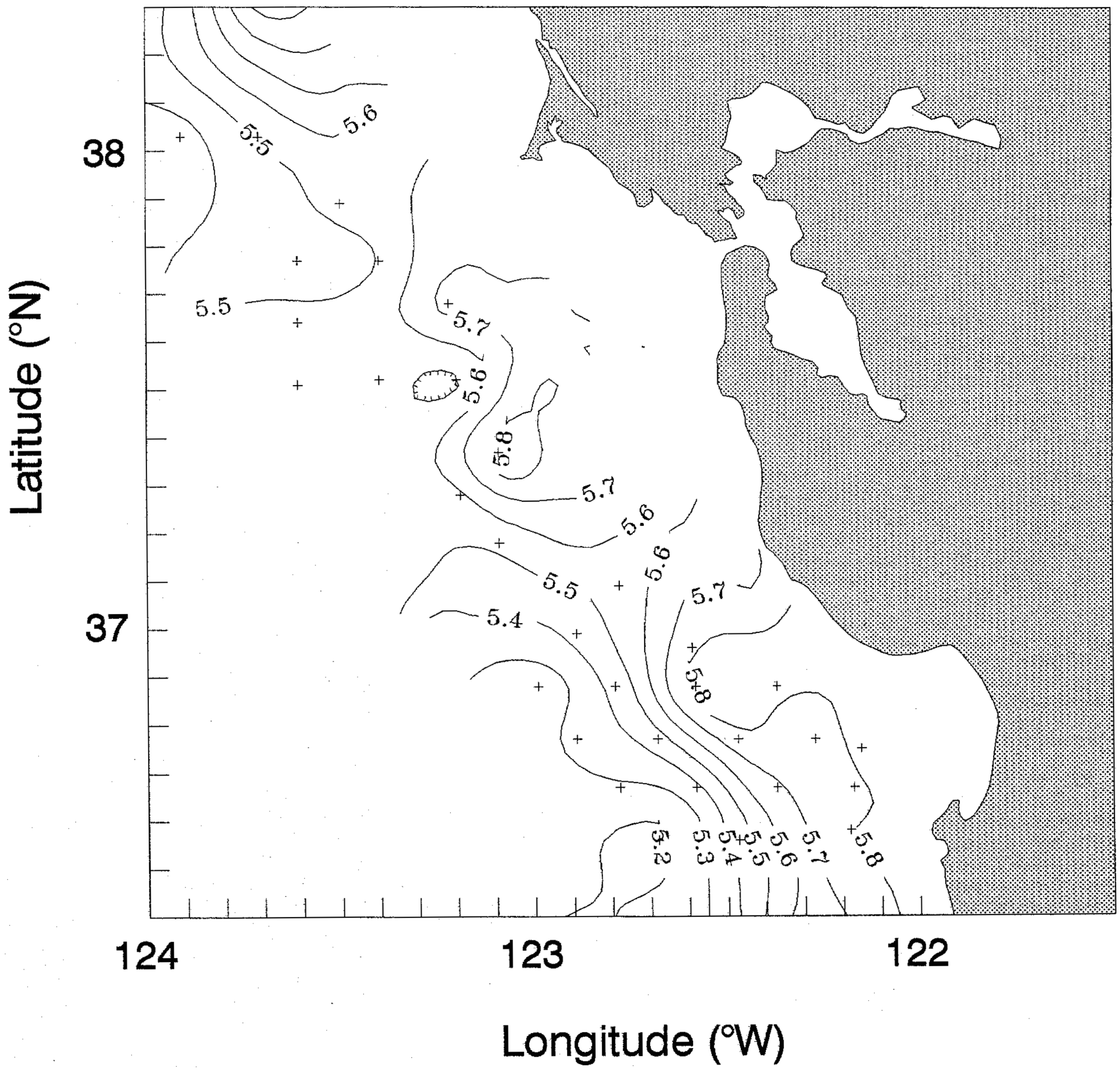
DSJ9406 Sweep 2
Temperature (°C) at 200 m



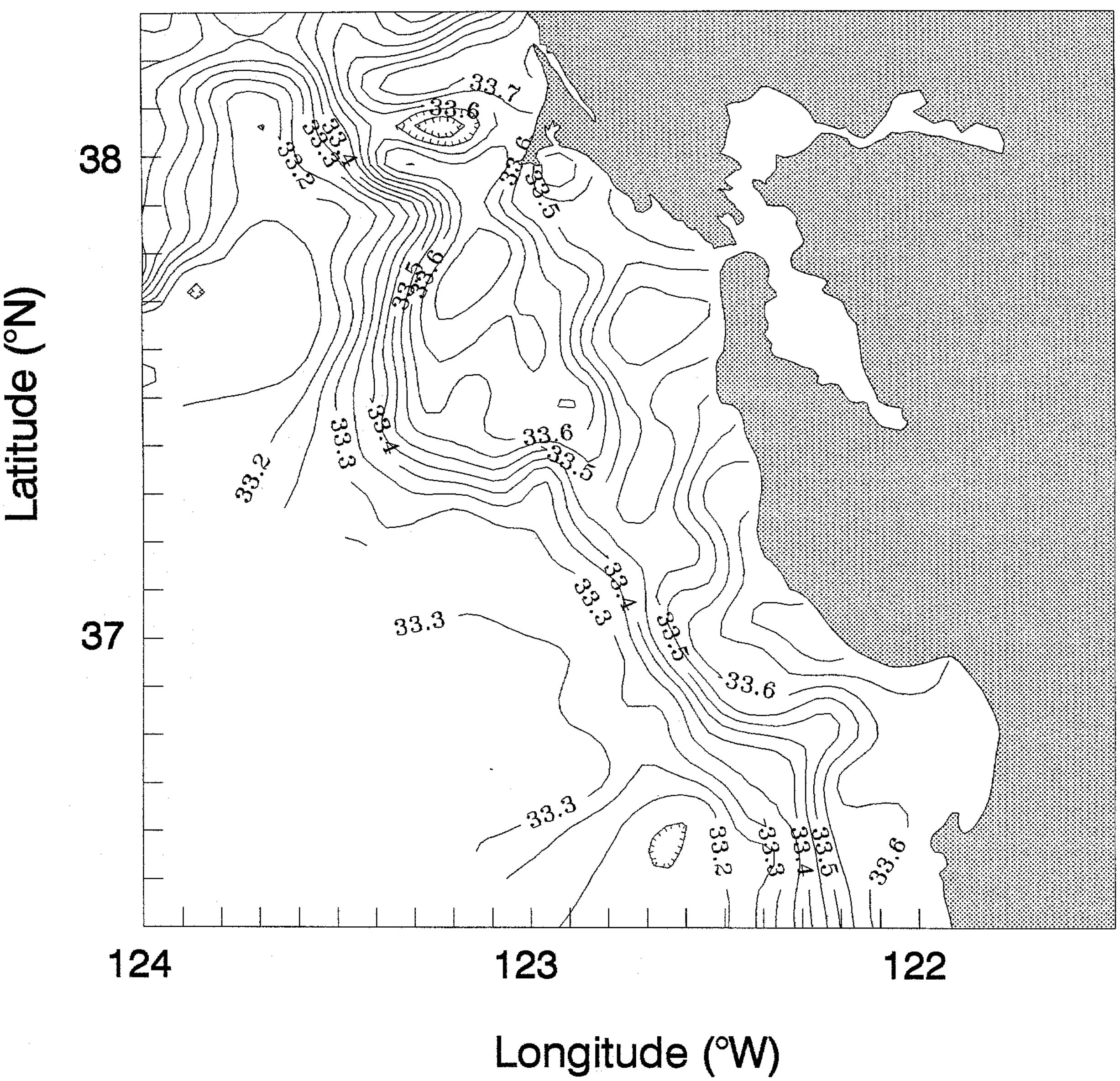
DSJ9406 Sweep 2
Temperature (°C) at 300 m

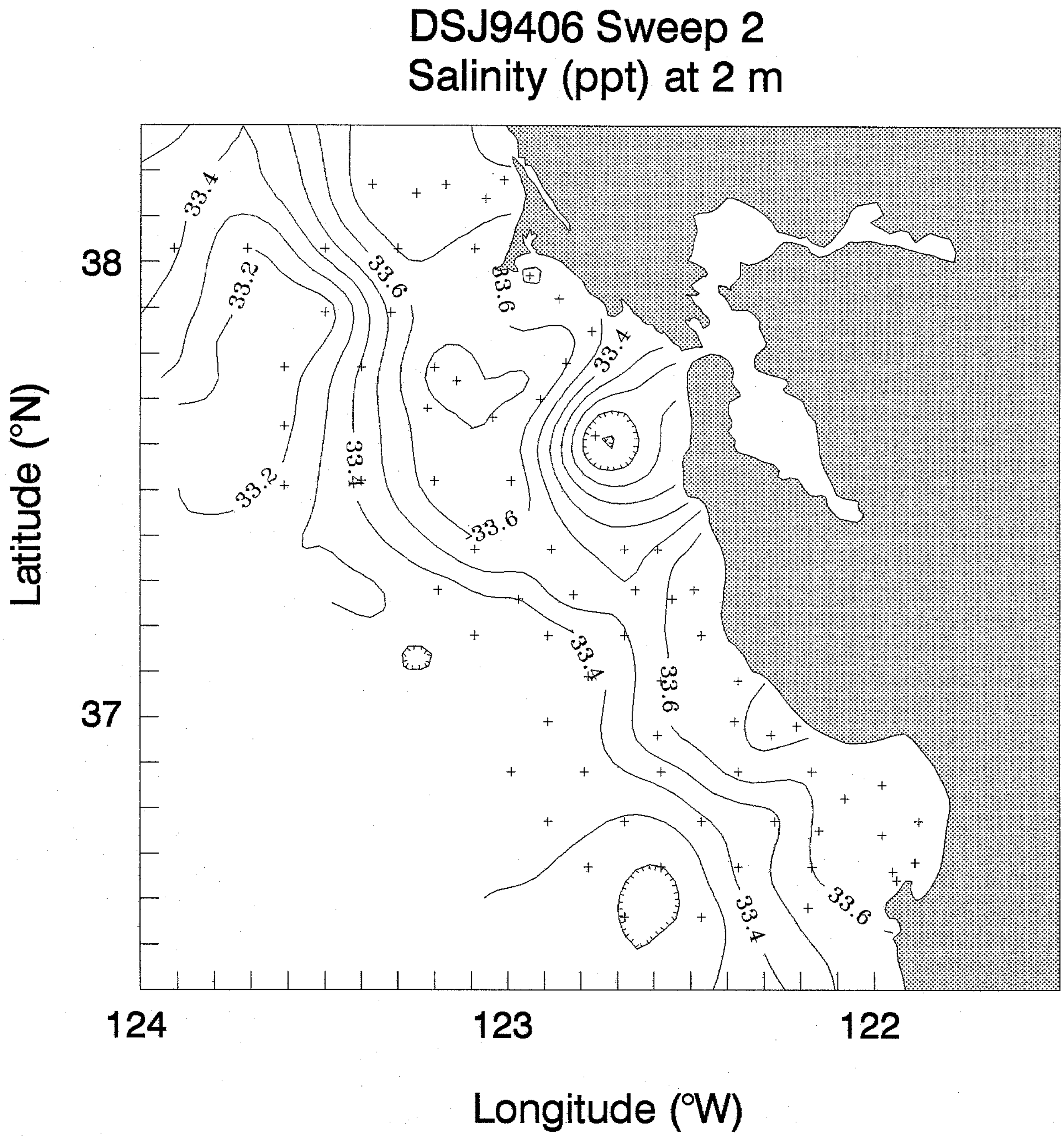


DSJ9406 Sweep 2
Temperature (°C) at 500 m

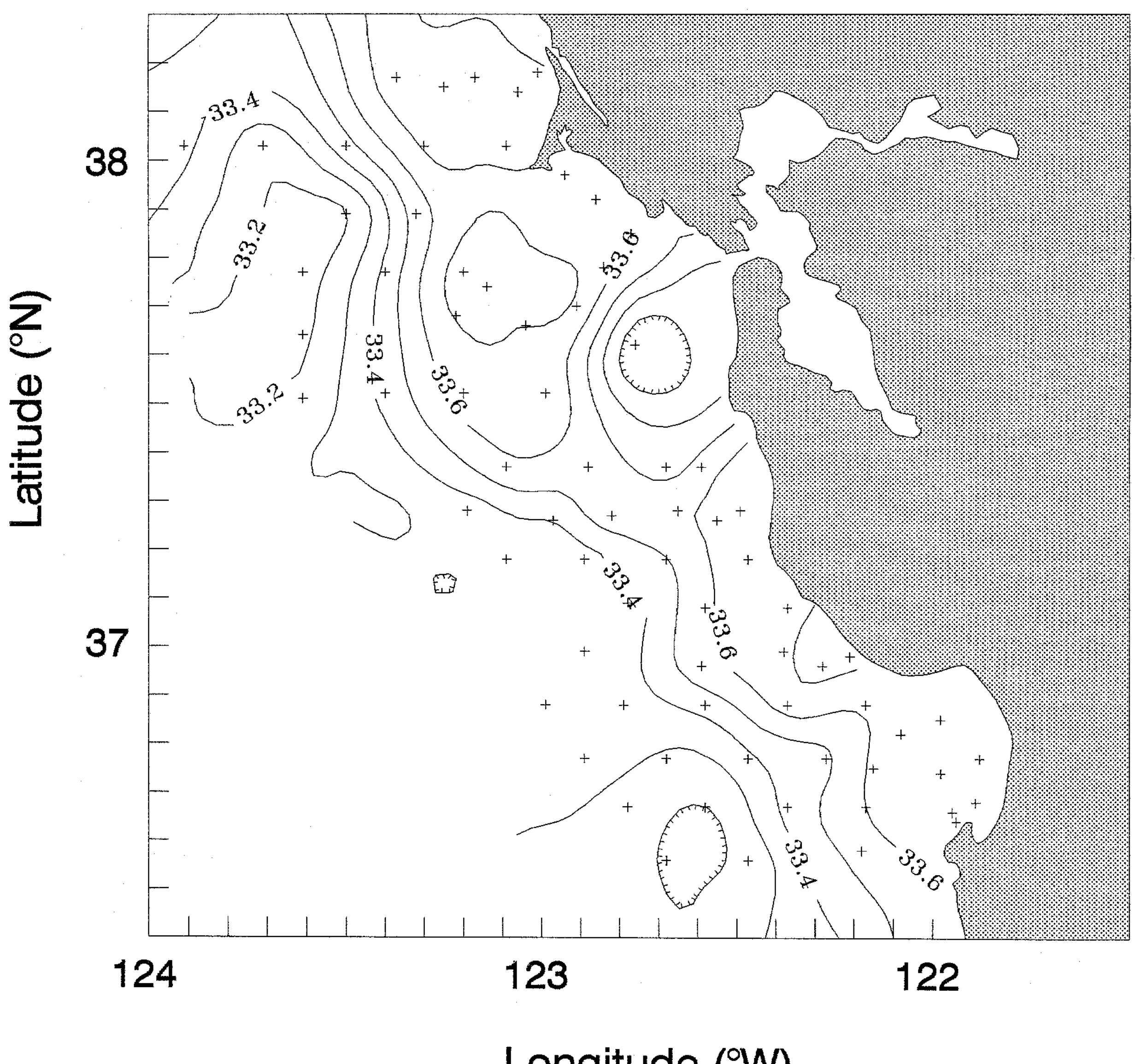


DSJ9406 Sweep 2
TS Salinity (ppt)

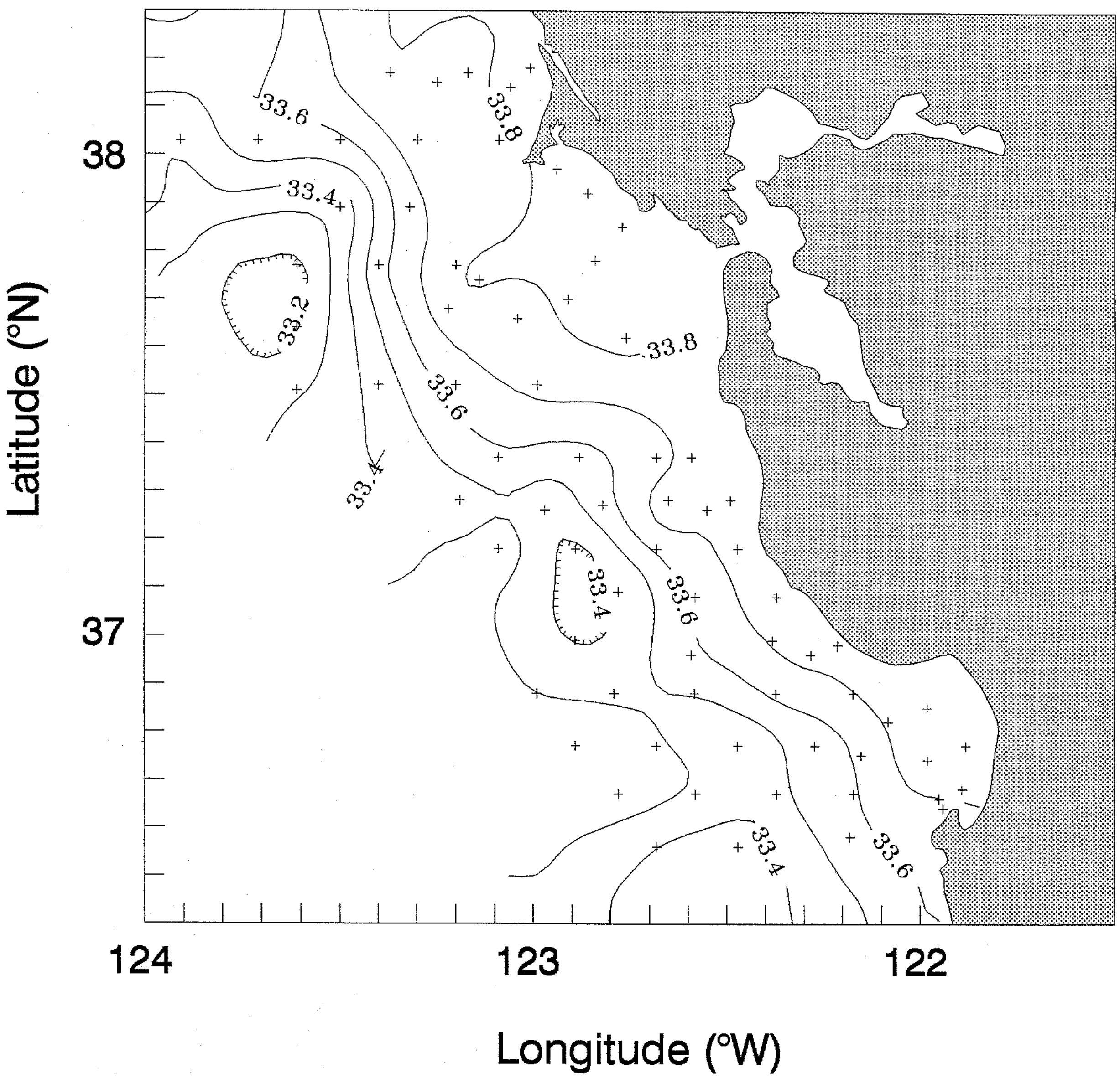



DSJ9406 Sweep 2
Salinity (ppt) at 2 m
Latitude (°N)
Longitude (°W)
38
37
124
123
122
33.4
33.2
33.6
33.6
33.4
33.4
33.2
33.6
33.4
33.6
33.4
33.6

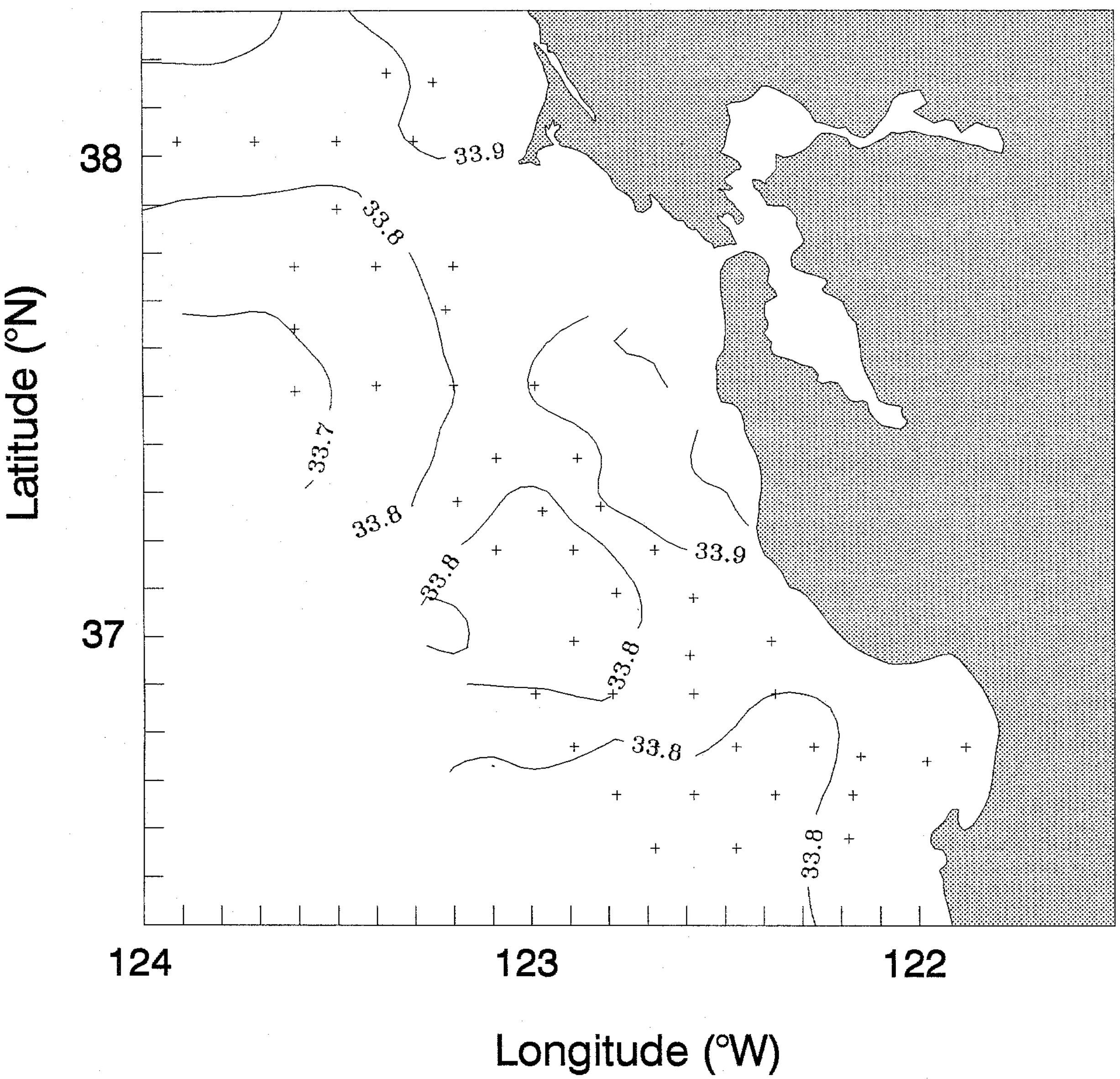
DSJ9406 Sweep 2
Salinity (ppt) at 10 m



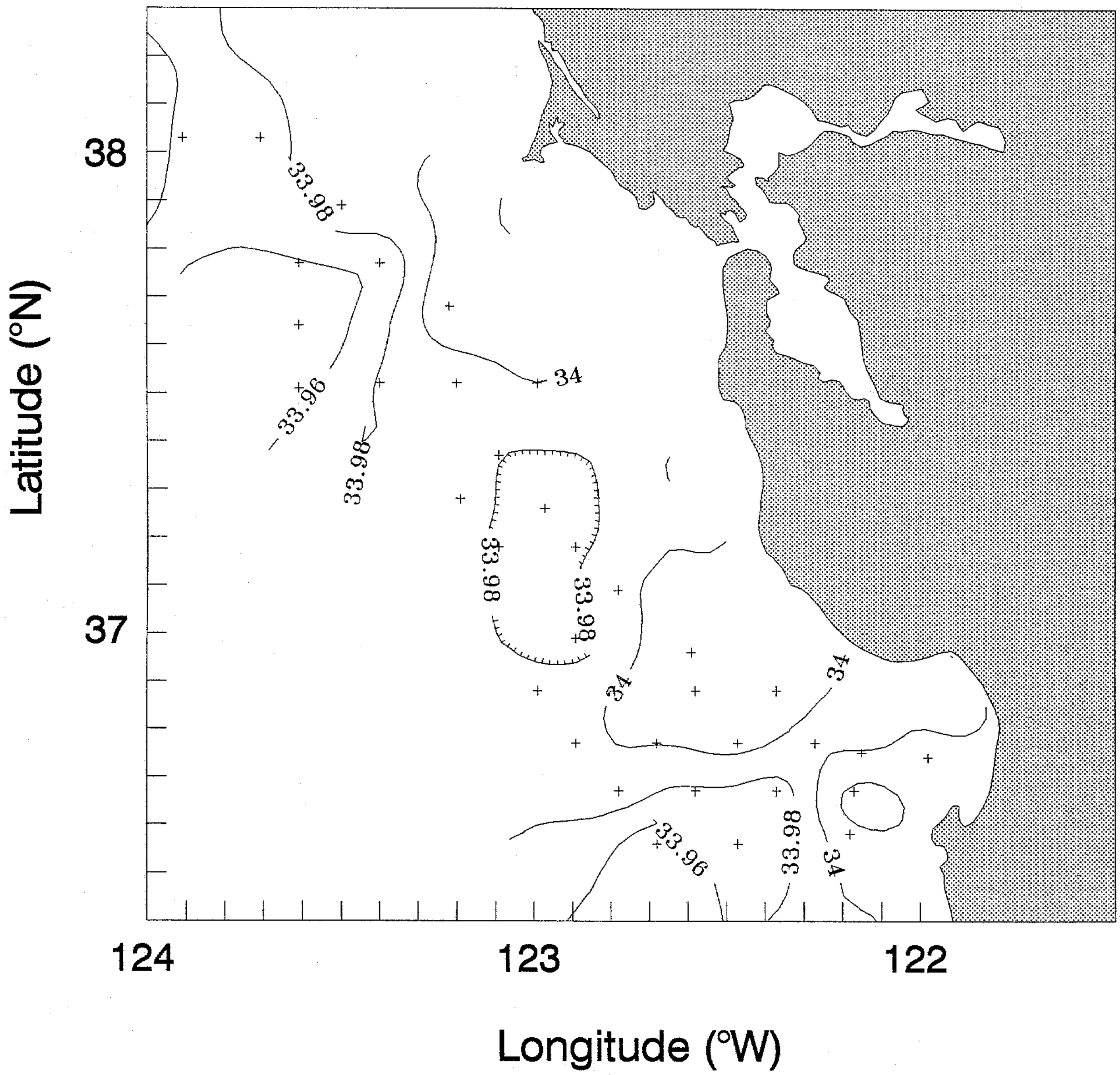
DSJ9406 Sweep 2
Salinity (ppt) at 30 m



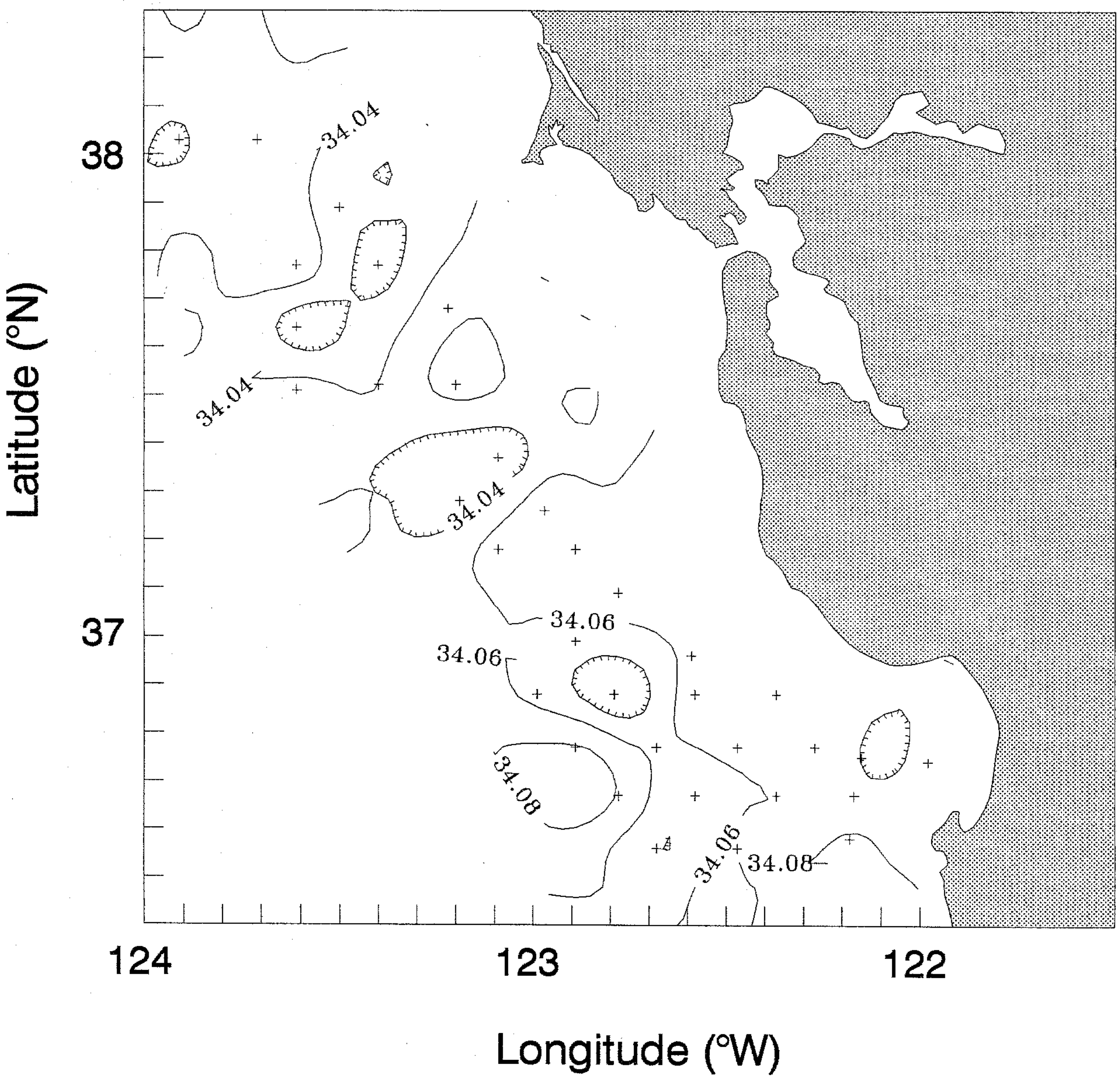
DSJ9406 Sweep 2
Salinity (ppt) at 100 m



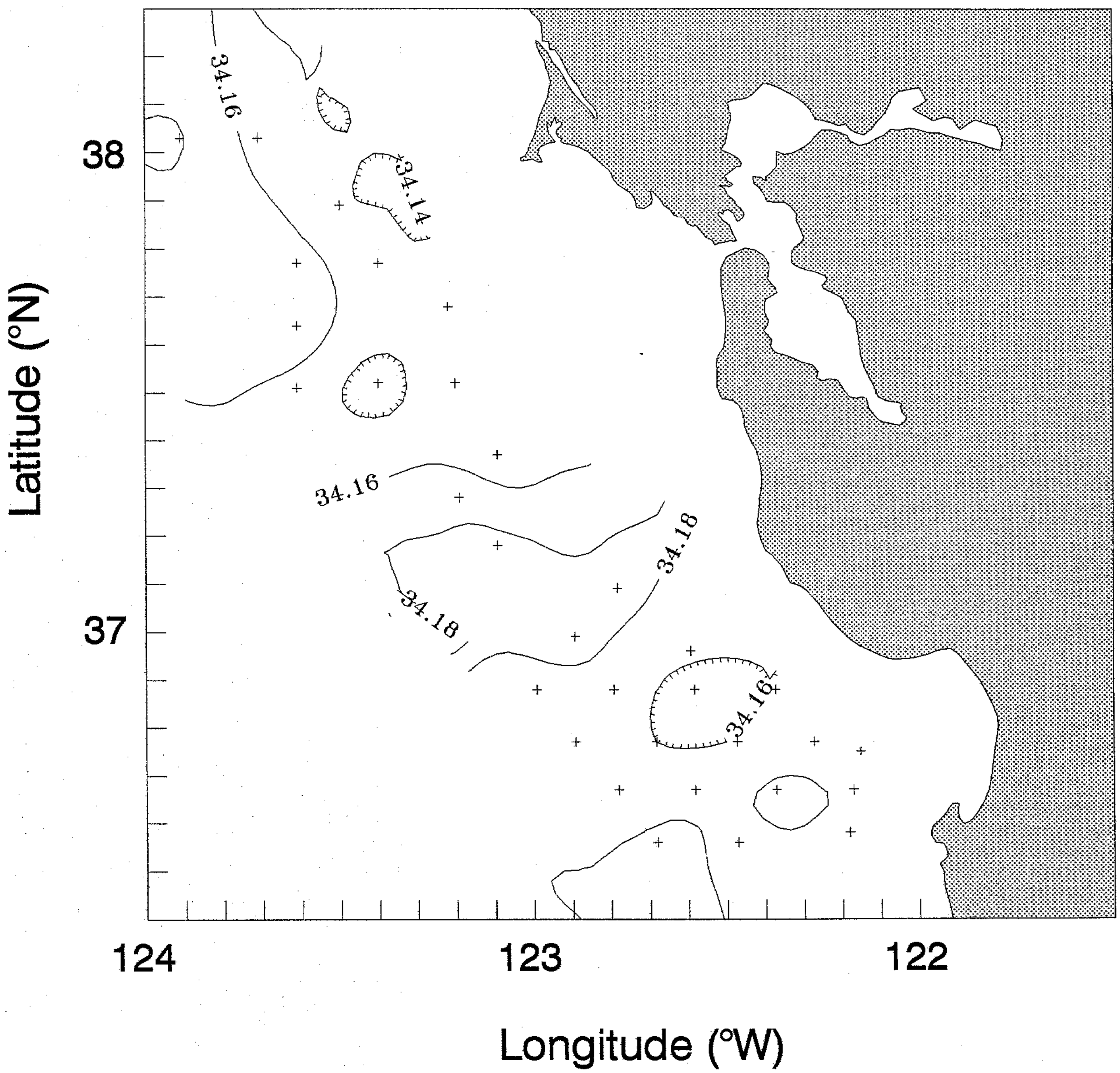
DSJ9406 Sweep 2
Salinity (ppt) at 200 m

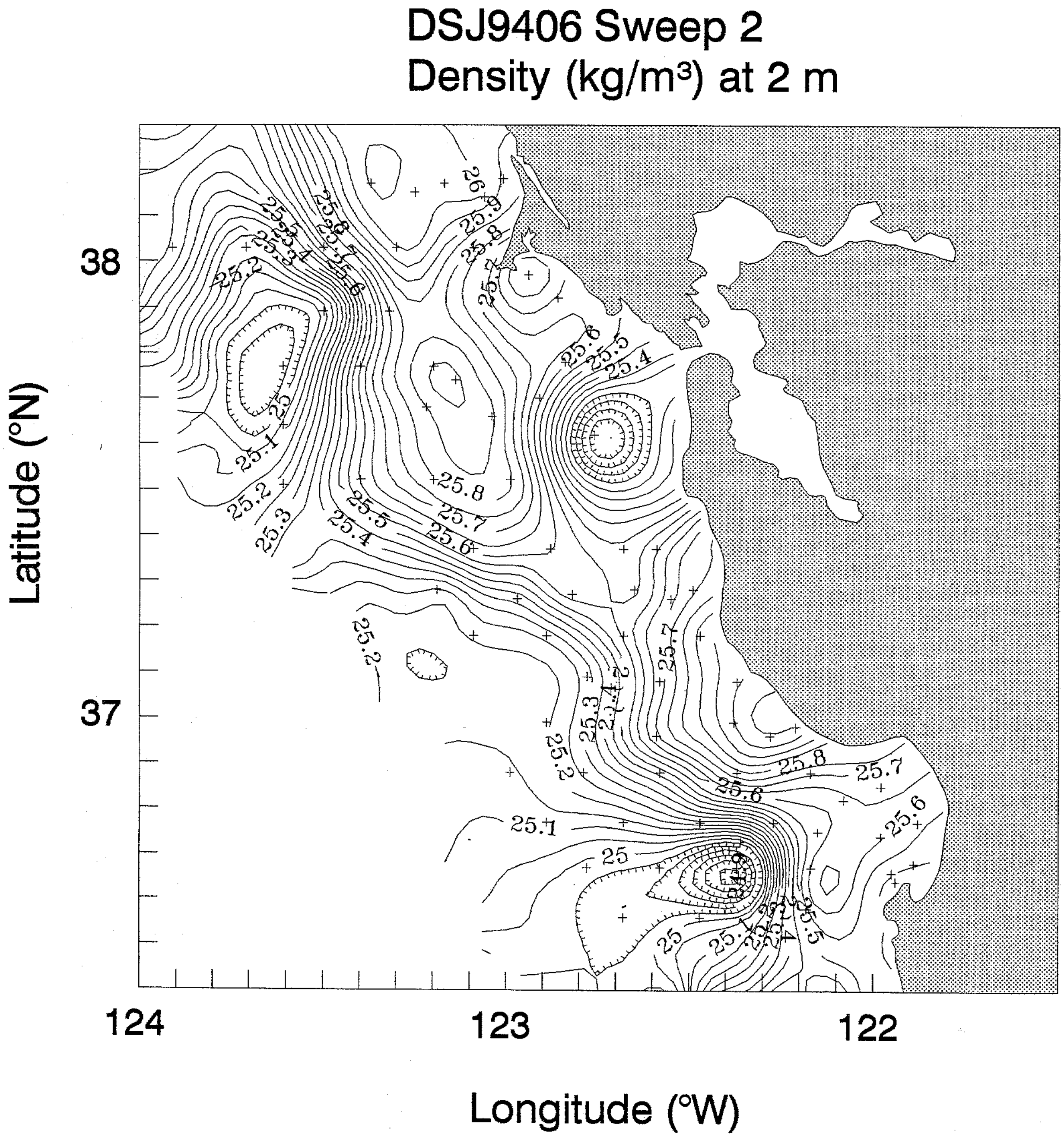


DSJ9406 Sweep 2
Salinity (ppt) at 300 m

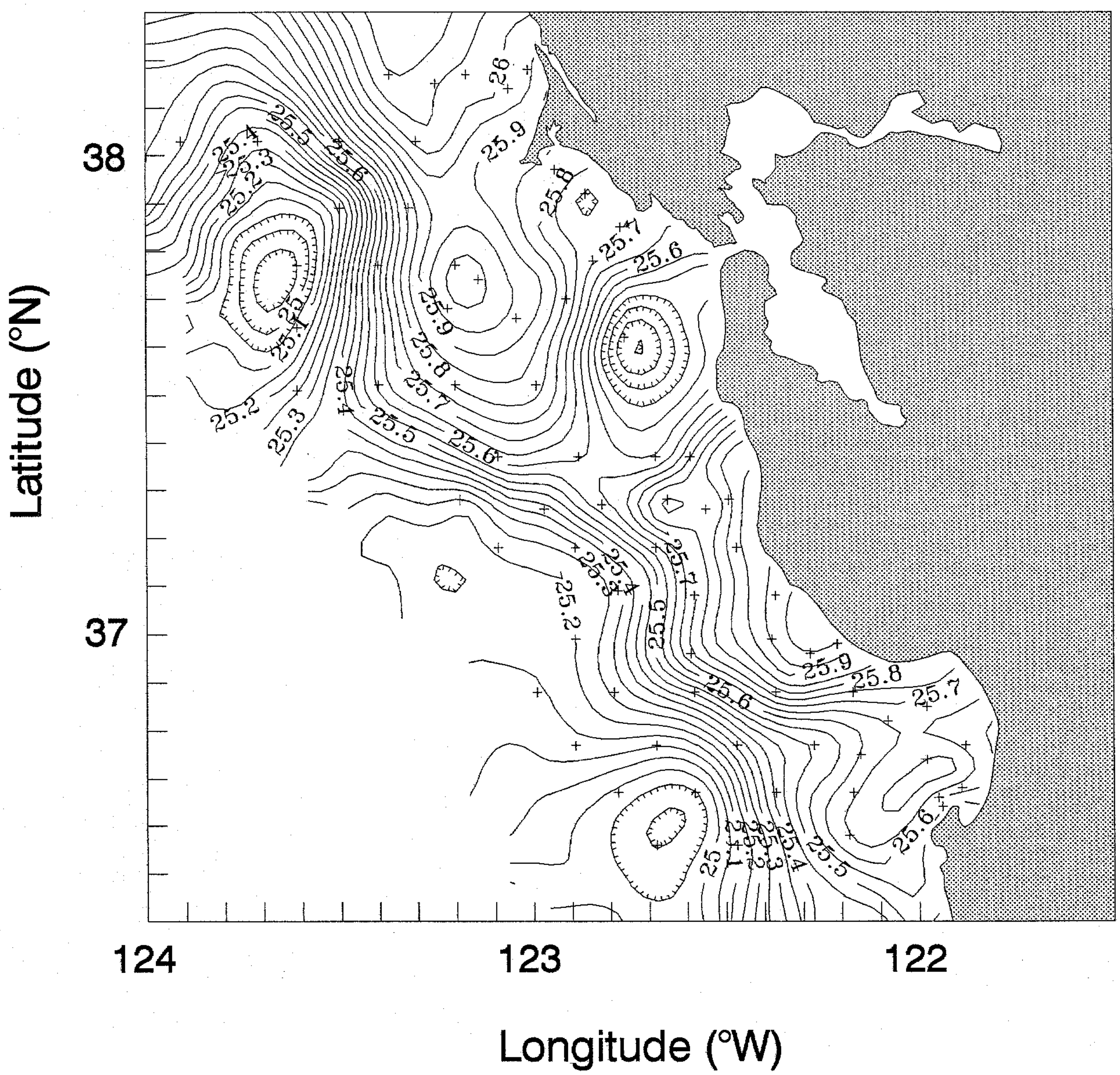


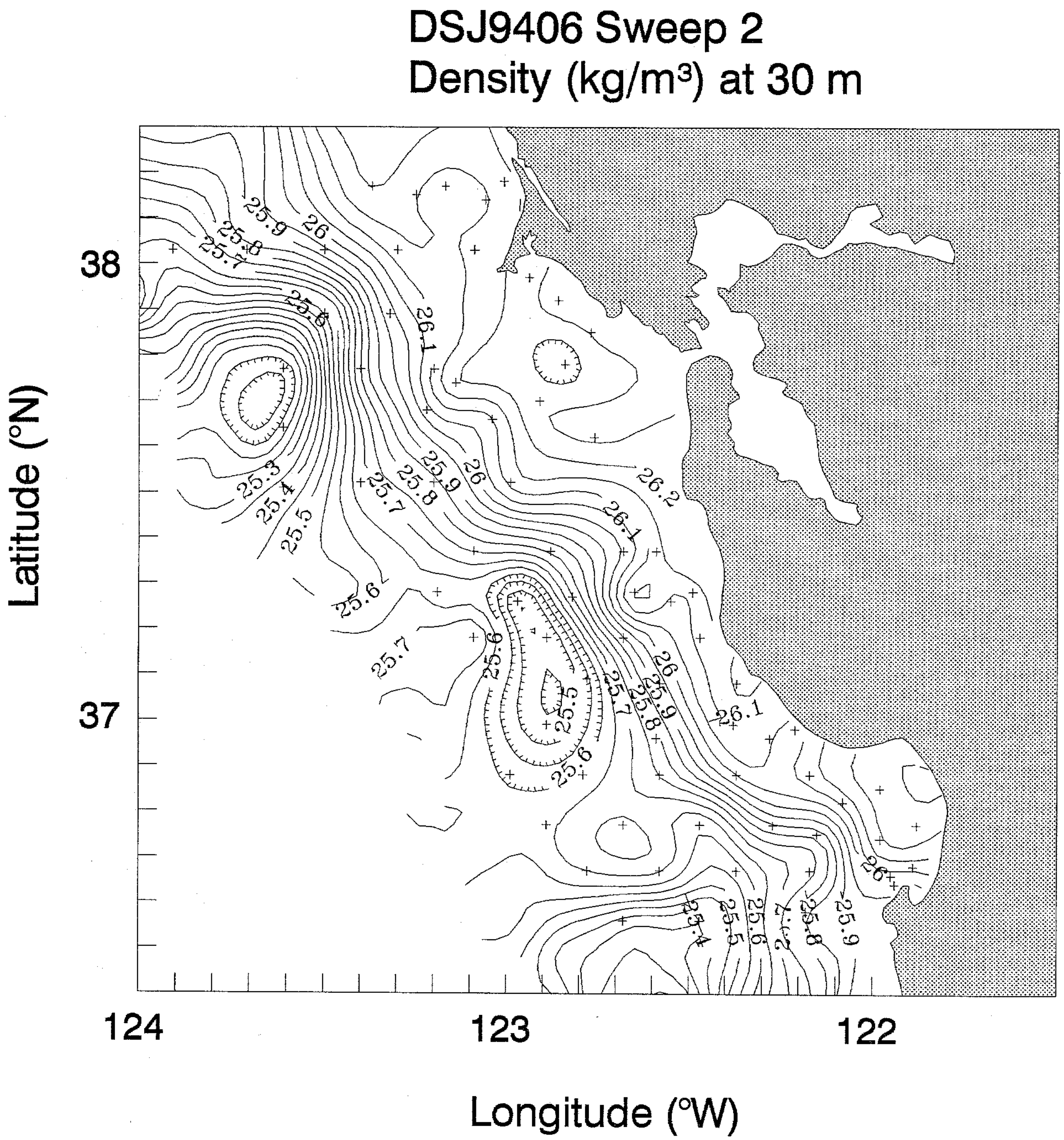
DSJ9406 Sweep 2
Salinity (ppt) at 500 m




DSJ9406 Sweep 2
Density (kg/m³) at 2 m
Latitude (°N)
38
37
124
123
122
Longitude (°W)

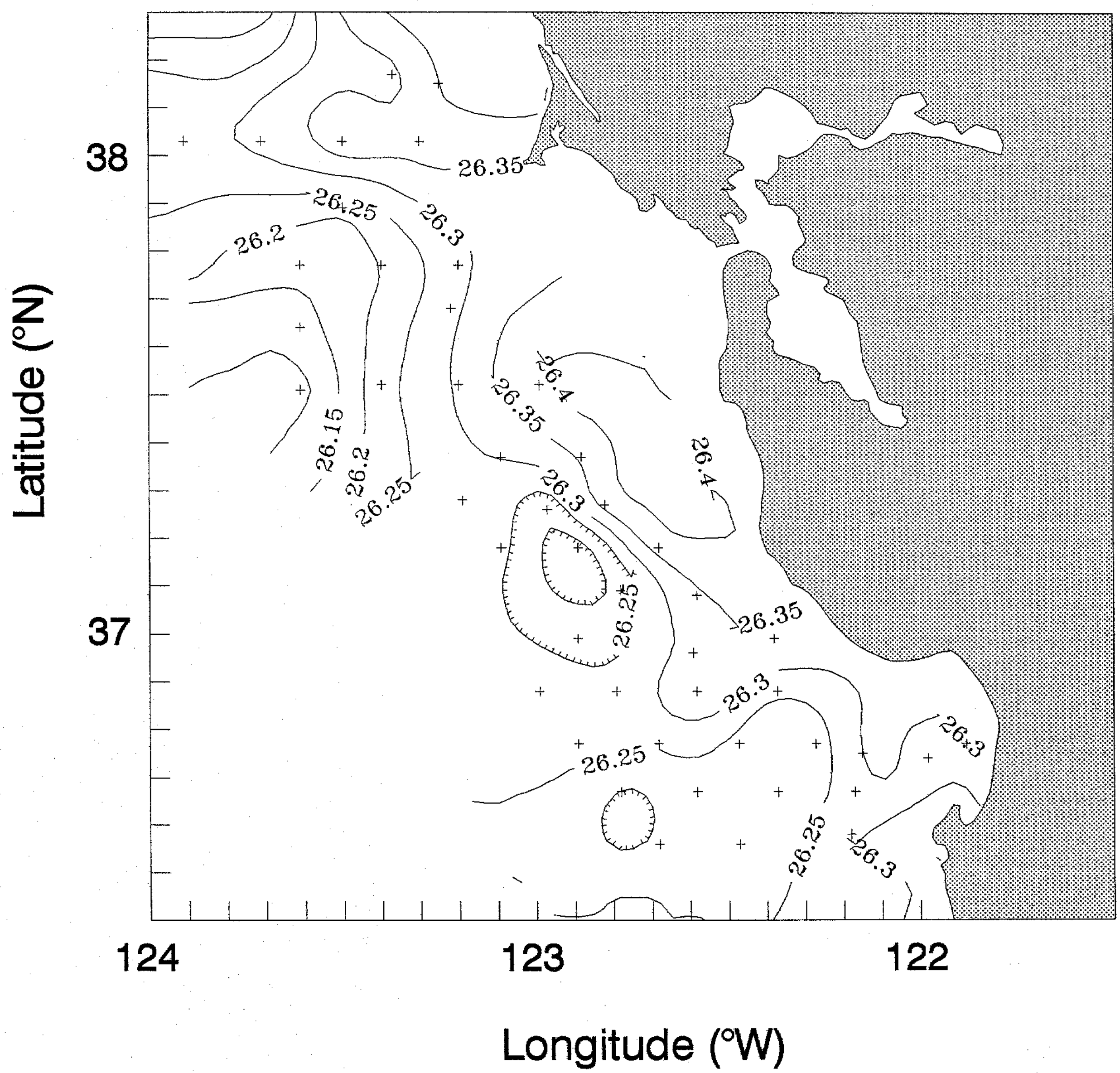
DSJ9406 Sweep 2
Density (kg/m³) at 10 m

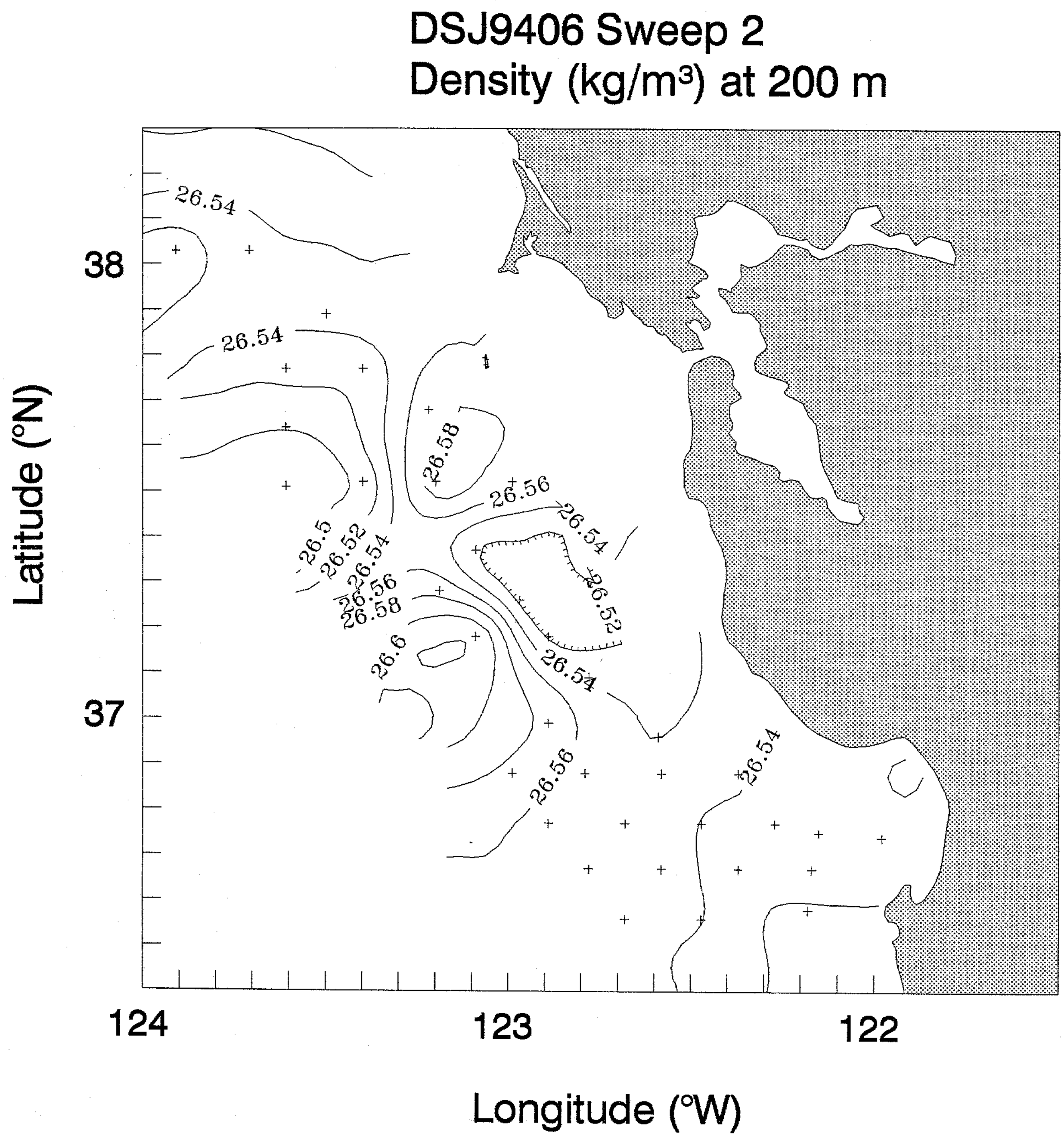




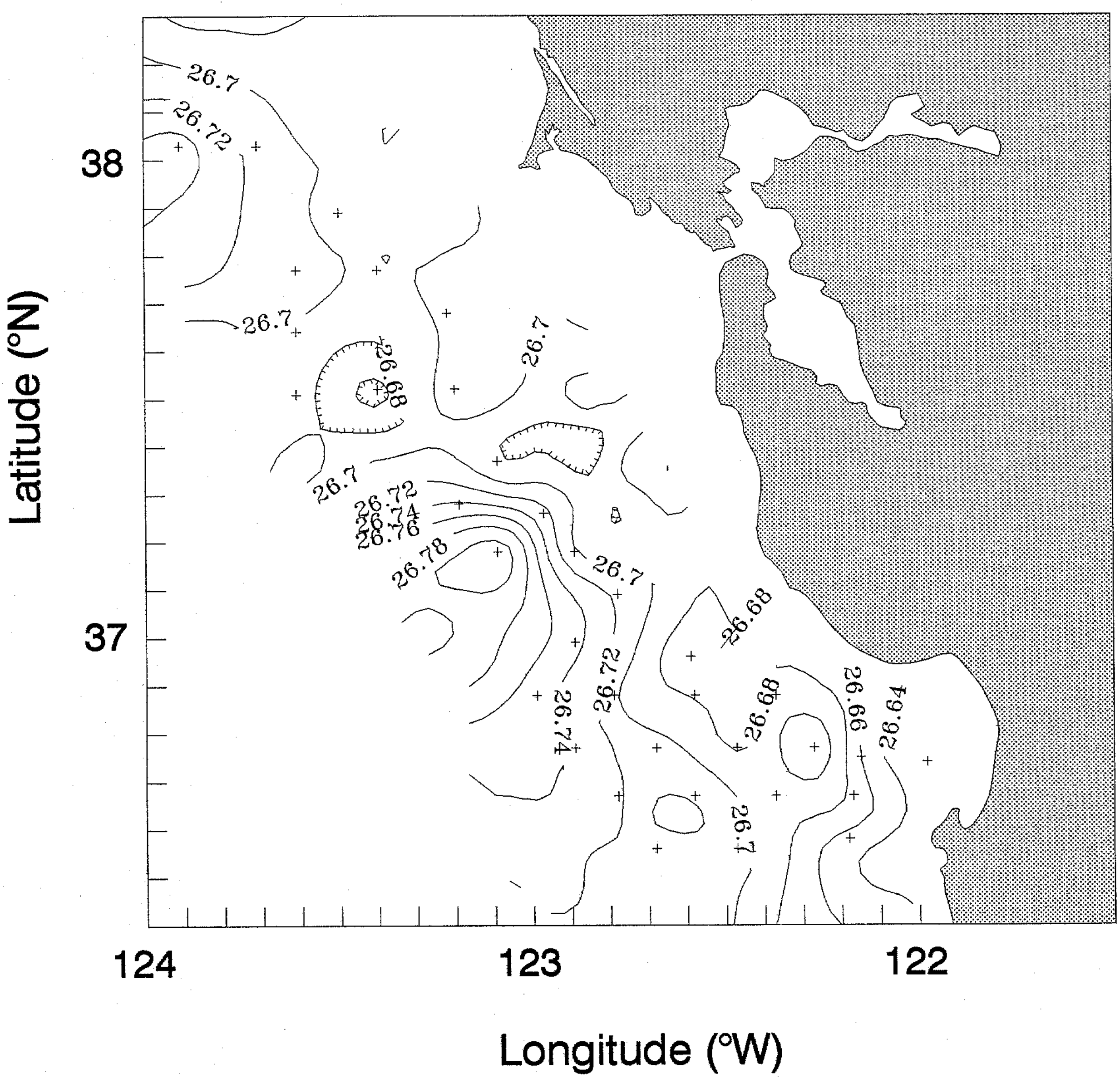
DSJ9406 Sweep 2
Density (kg/m³) at 30 m
Latitude (°N)
38
37
Longitude (°W)
124
123
122

DSJ9406 Sweep 2
Density (kg/m³) at 100 m

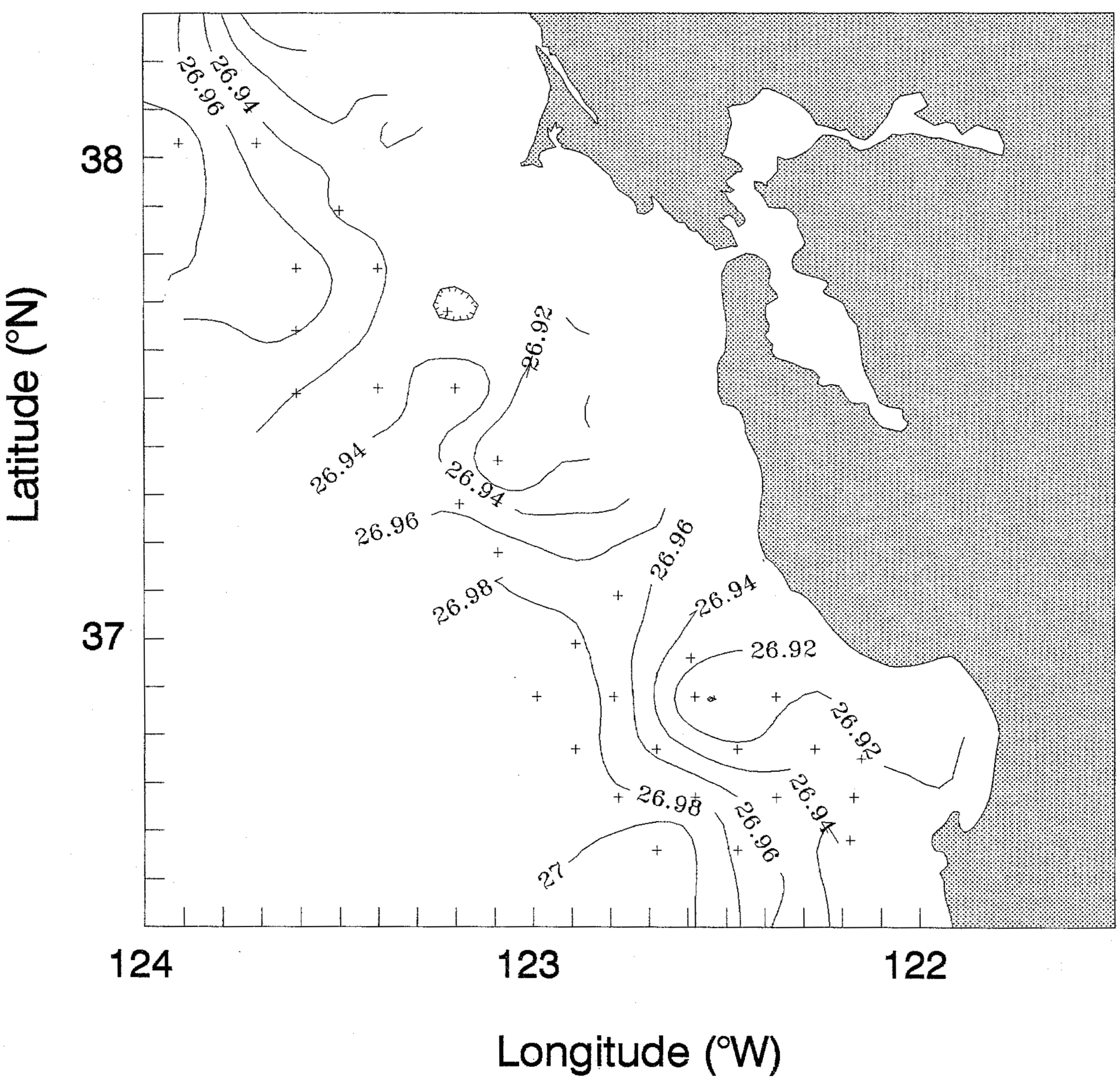



DSJ9406 Sweep 2
Density (kg/m³) at 200 m
26.54
26.54
26.58
26.56
26.54
26.52
26.5
26.52
26.54
26.56
26.56
26.58
26.6
26.54
26.56
26.54
38
37
124
123
122
Latitude (°N)
Longitude (°W)

DSJ9406 Sweep 2
Density (kg/m^3) at 300 m

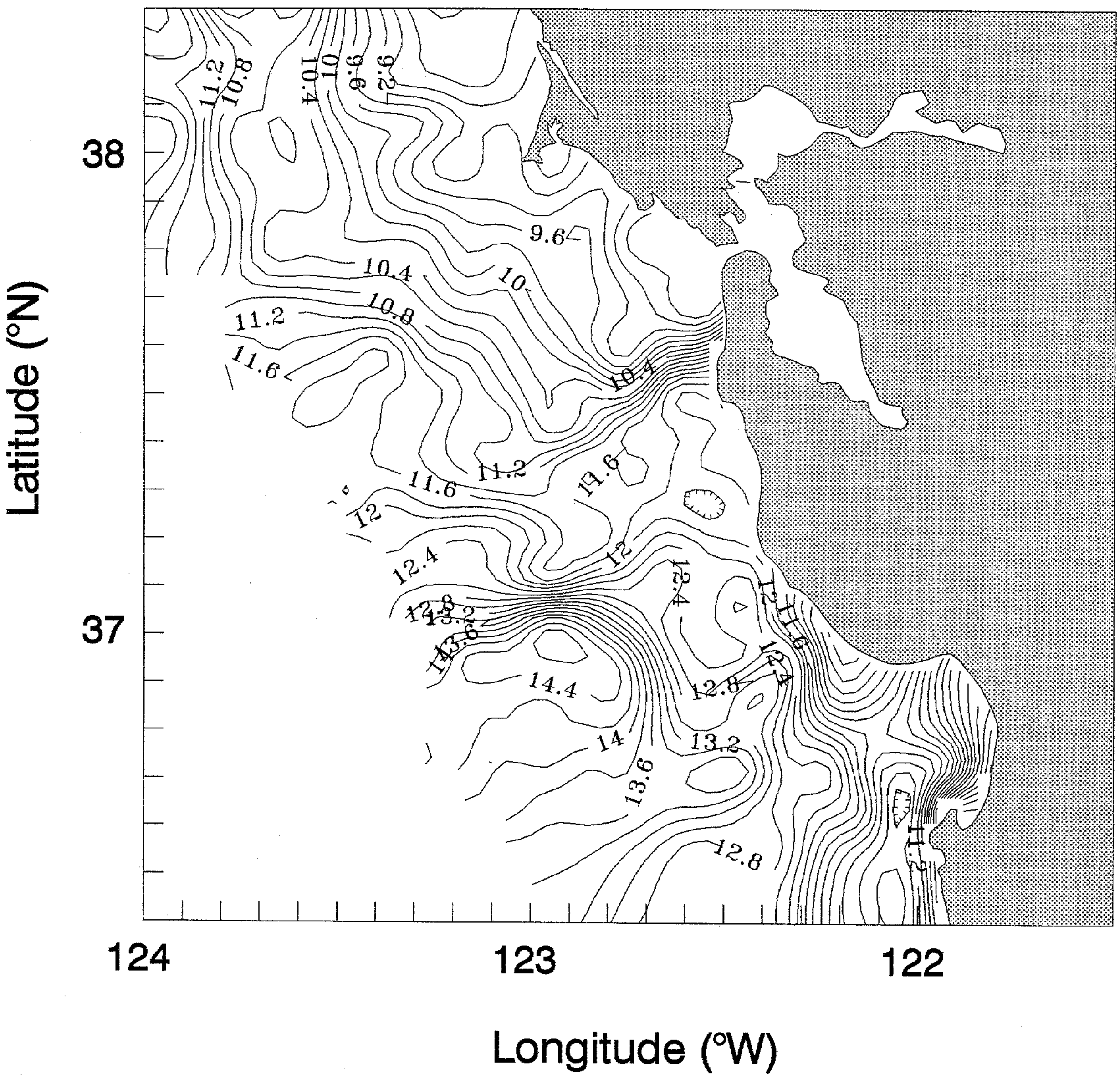


DSJ9406 Sweep 2
Density (kg/m³) at 500 m

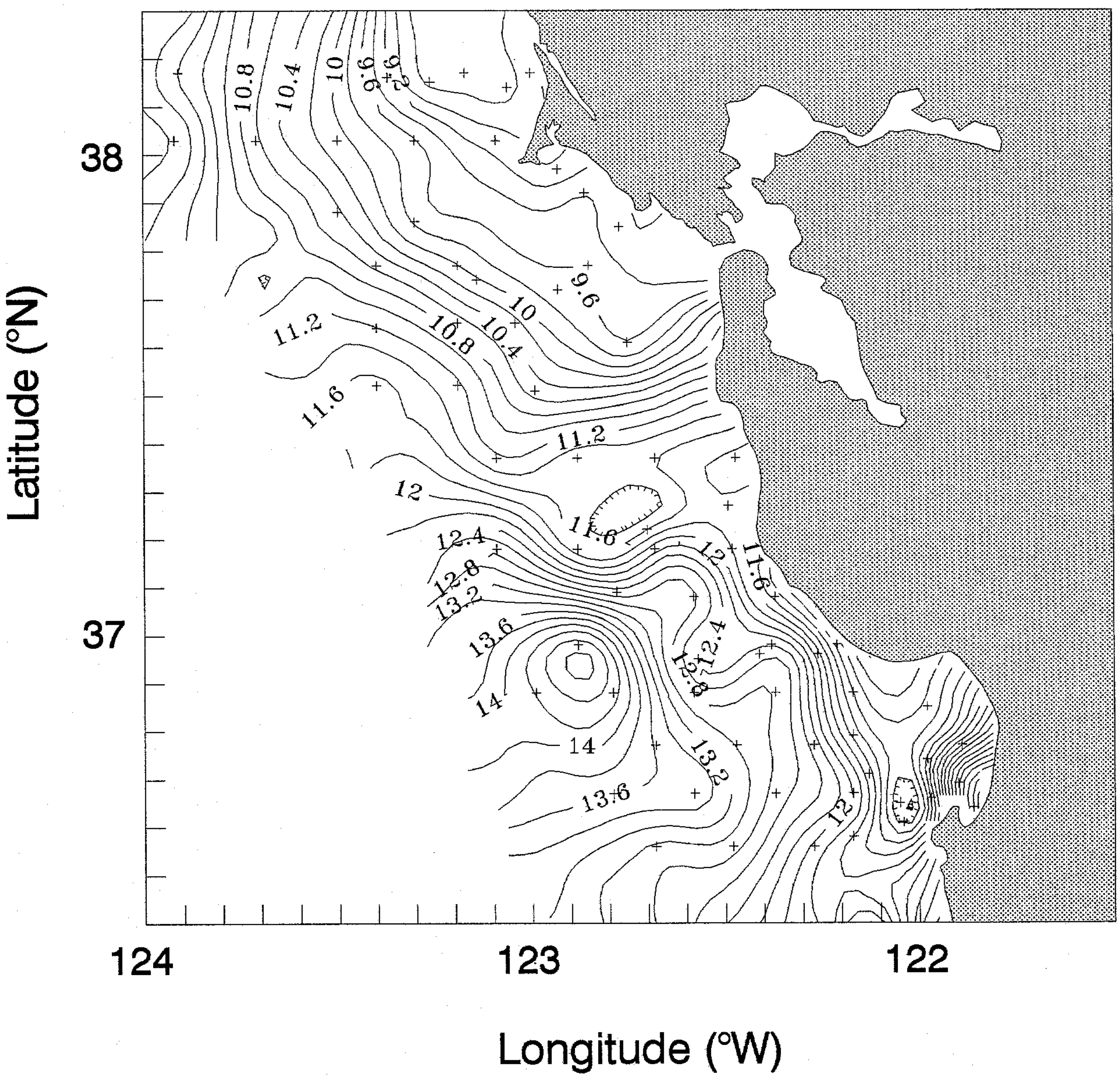


APPENDIX 8.4: HORIZONTAL MAPS OF CTD AND TS FOR DSJ9406, SWEEP 3

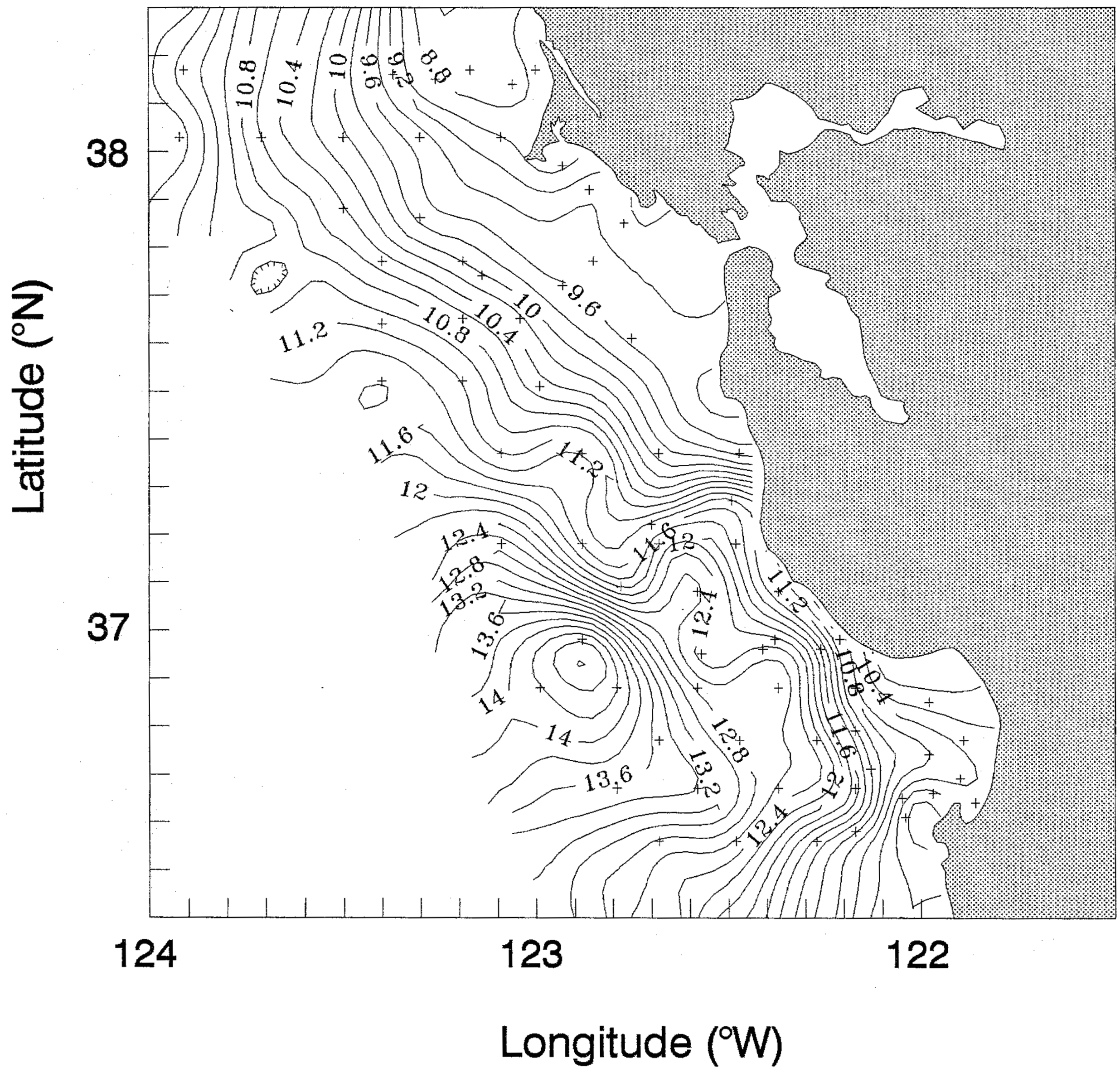
DSJ9406 Sweep 3
TS Temperature (°C)

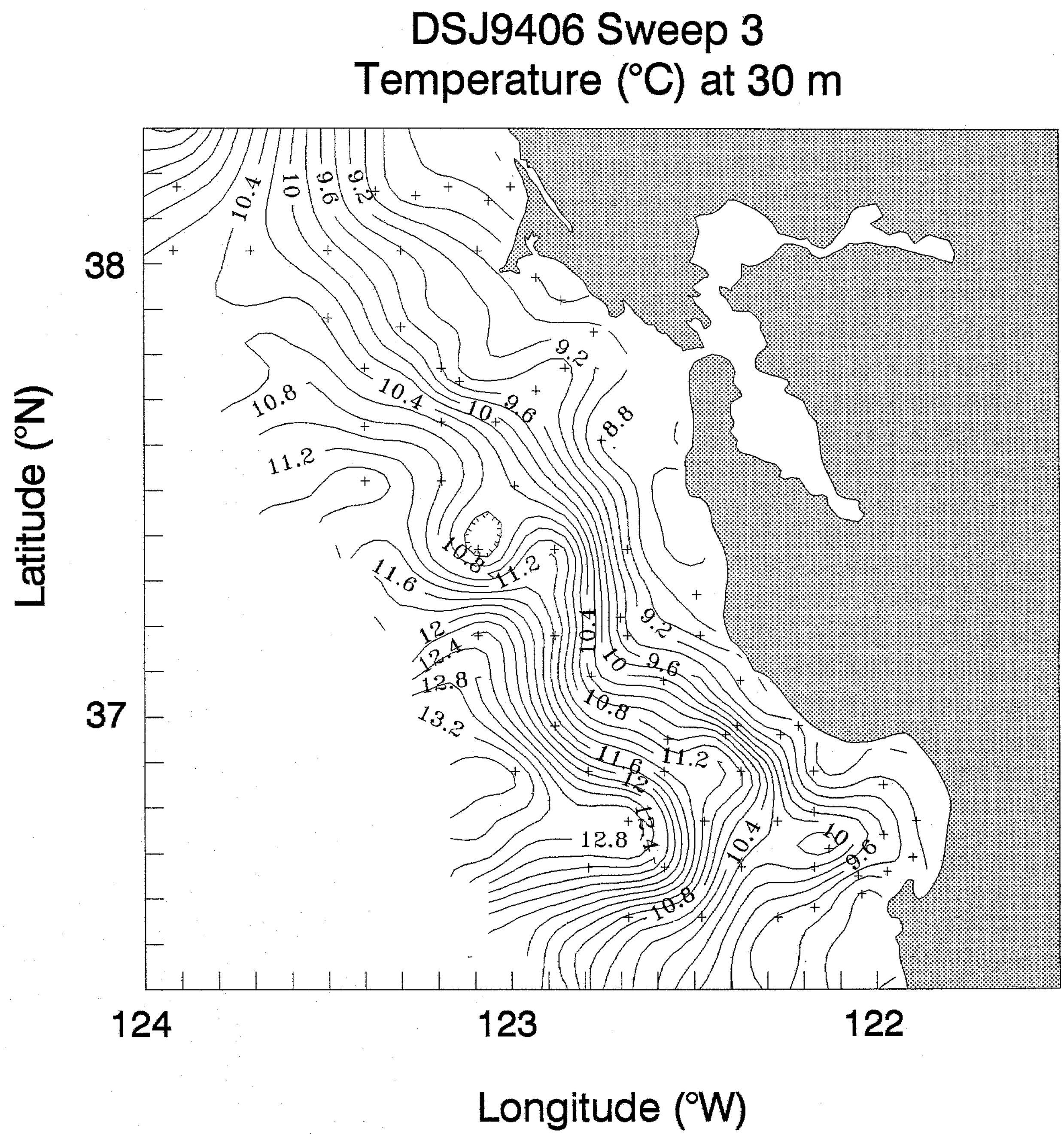


DSJ9406 Sweep 3
Temperature (°C) at 2 m

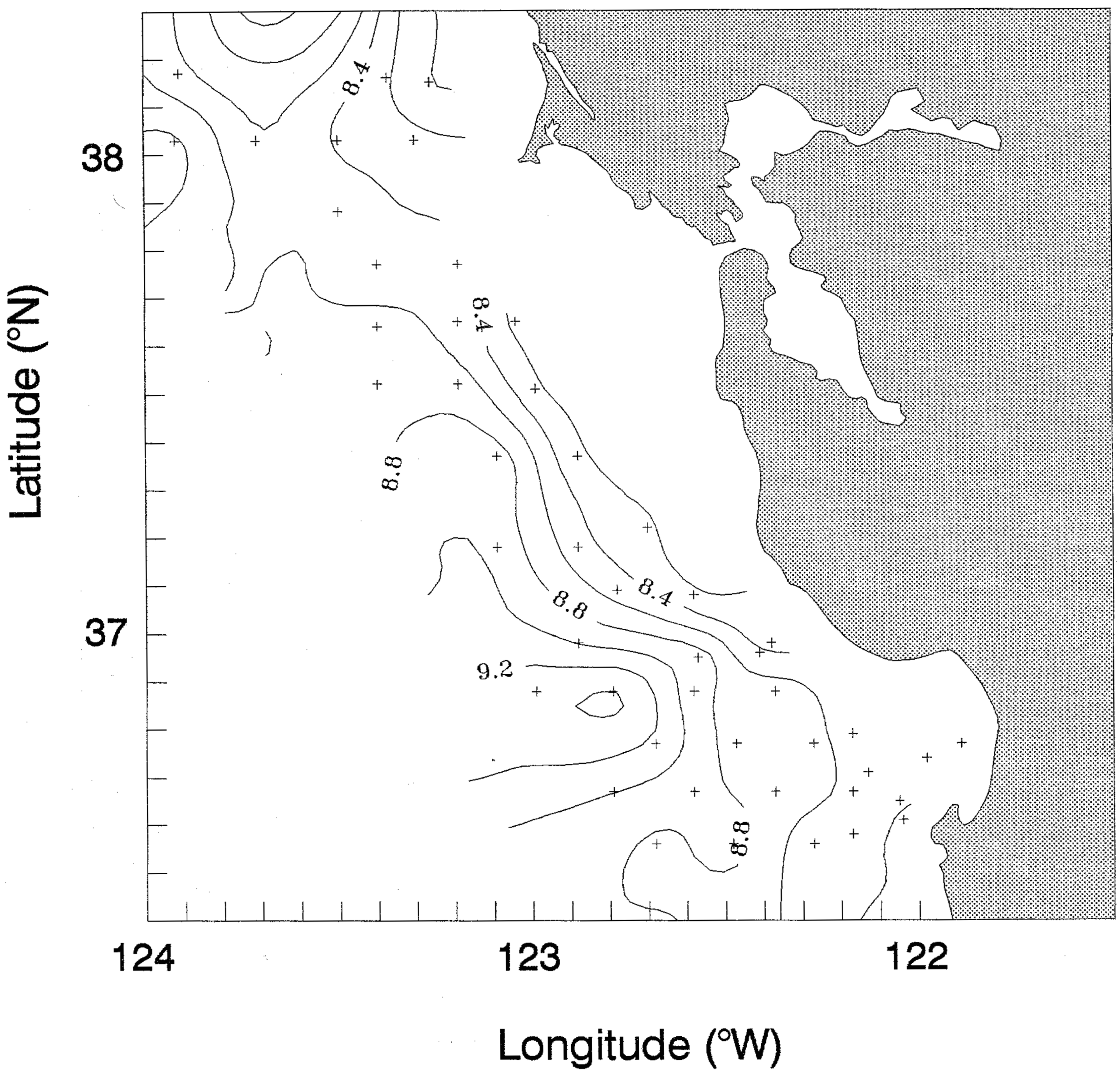


DSJ9406 Sweep 3
Temperature (°C) at 10 m

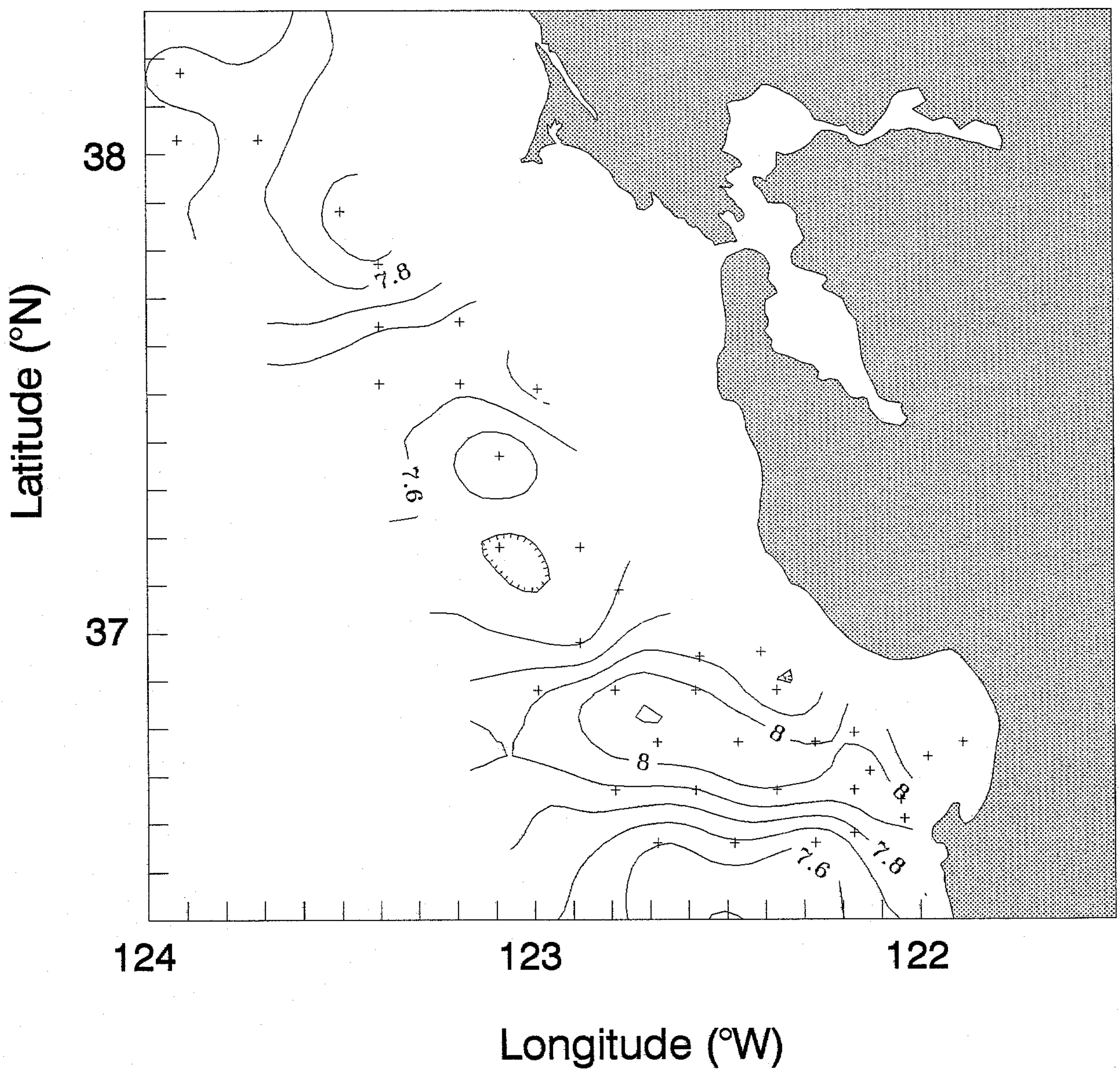



DSJ9406 Sweep 3
Temperature (°C) at 30 m
Latitude (°N)
38
37
124
123
122
Longitude (°W)

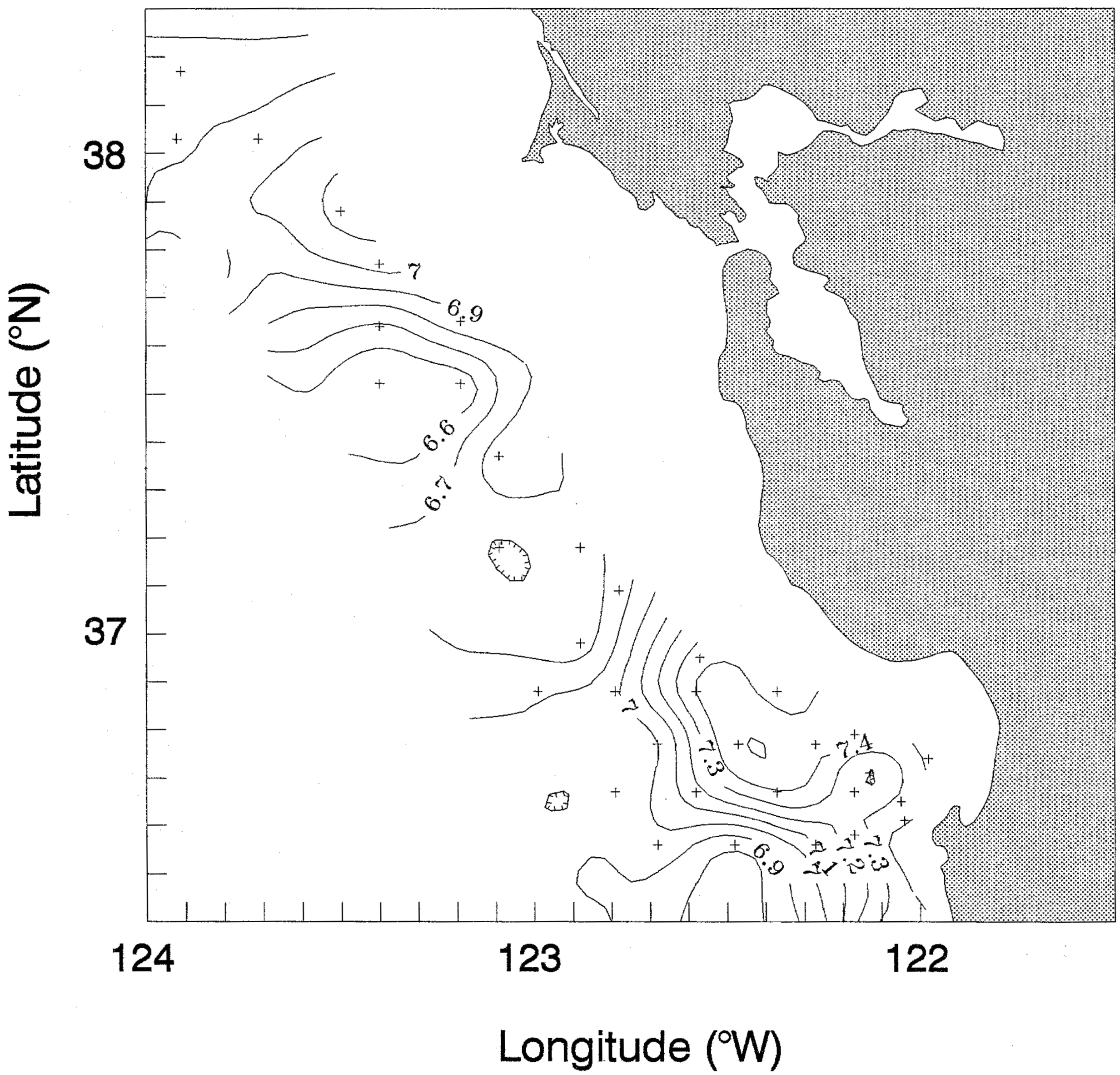
DSJ9406 Sweep 3
Temperature (°C) at 100 m



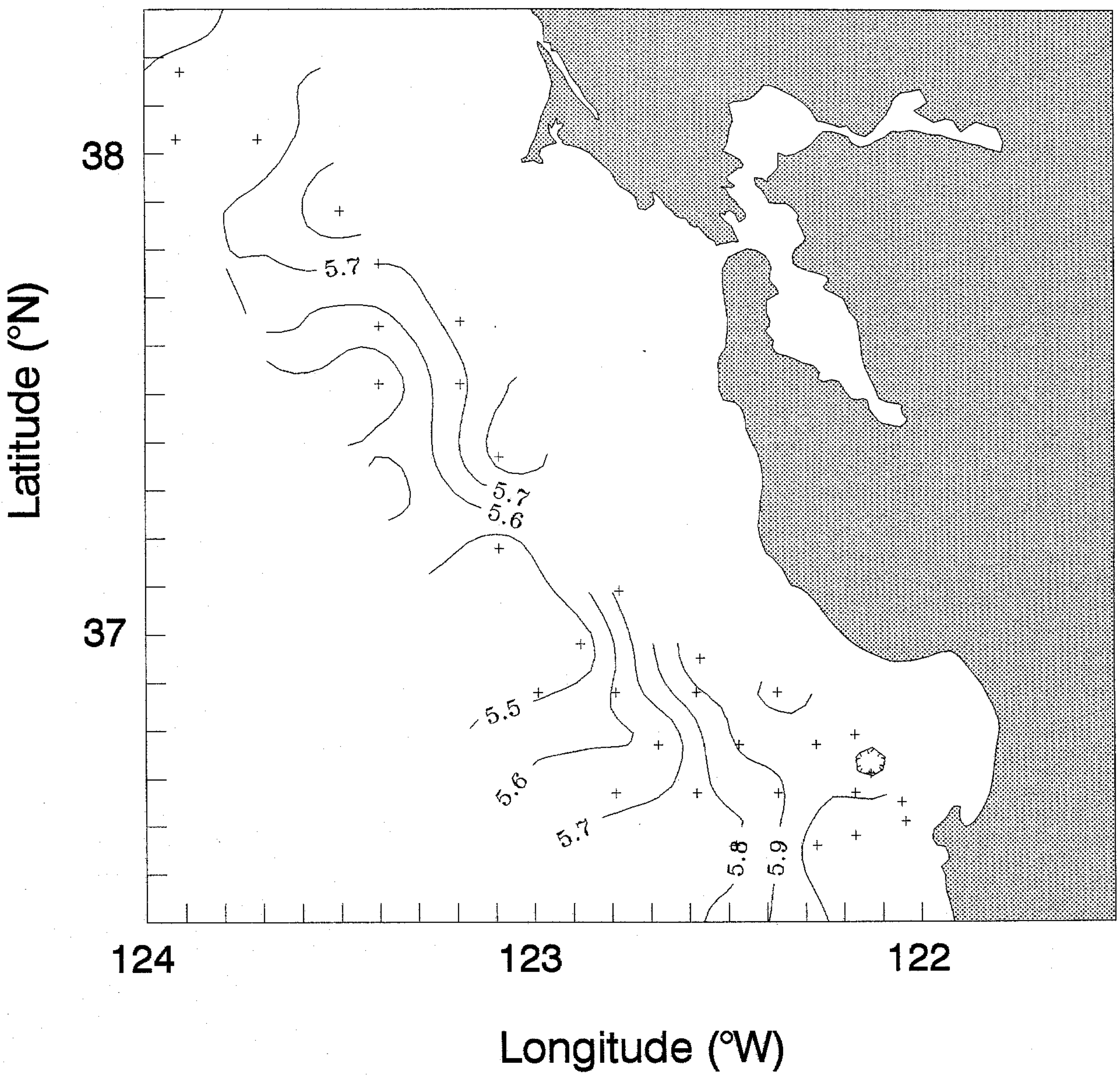
DSJ9406 Sweep 3
Temperature (°C) at 200 m



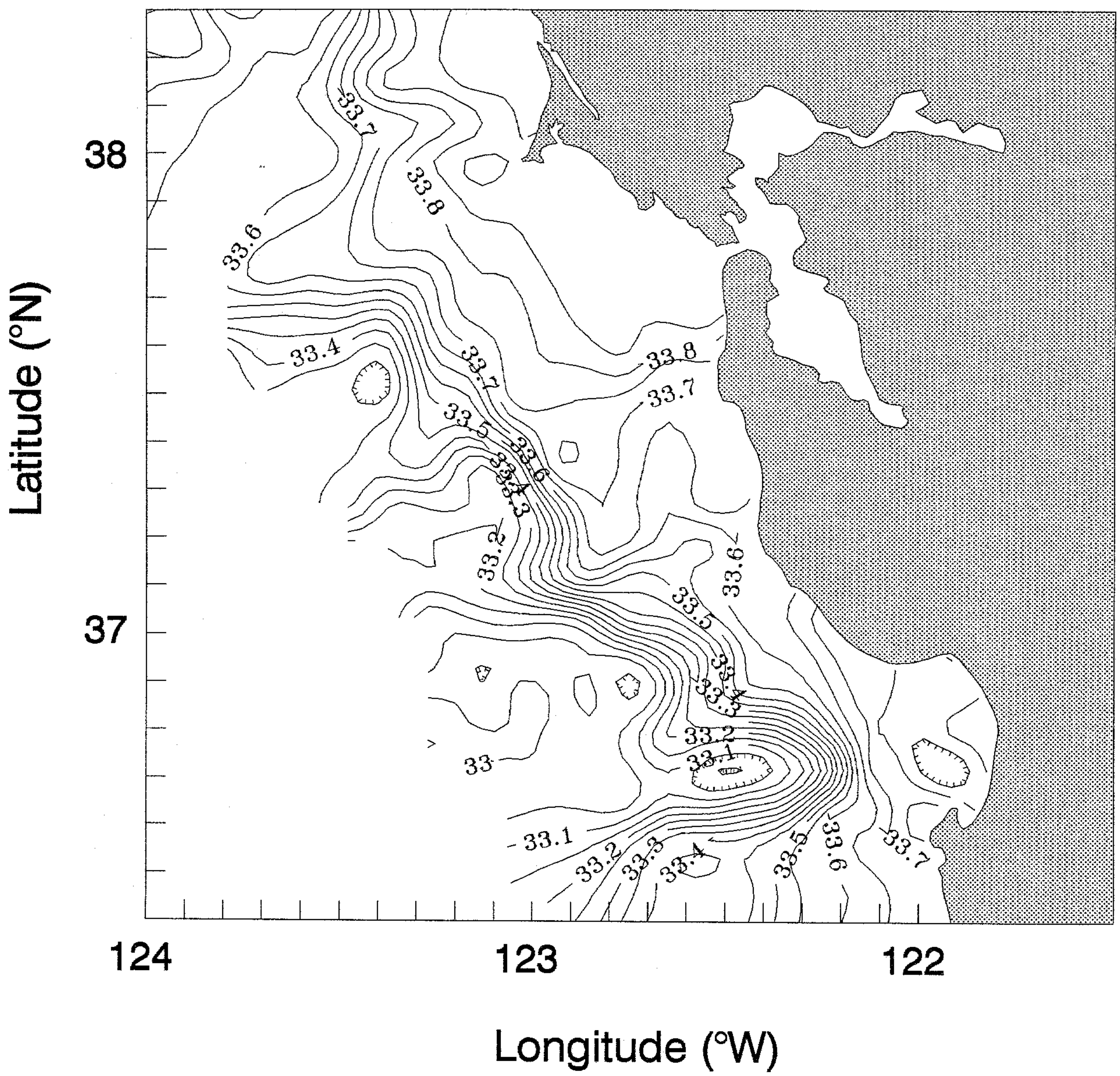
DSJ9406 Sweep 3
Temperature (°C) at 300 m



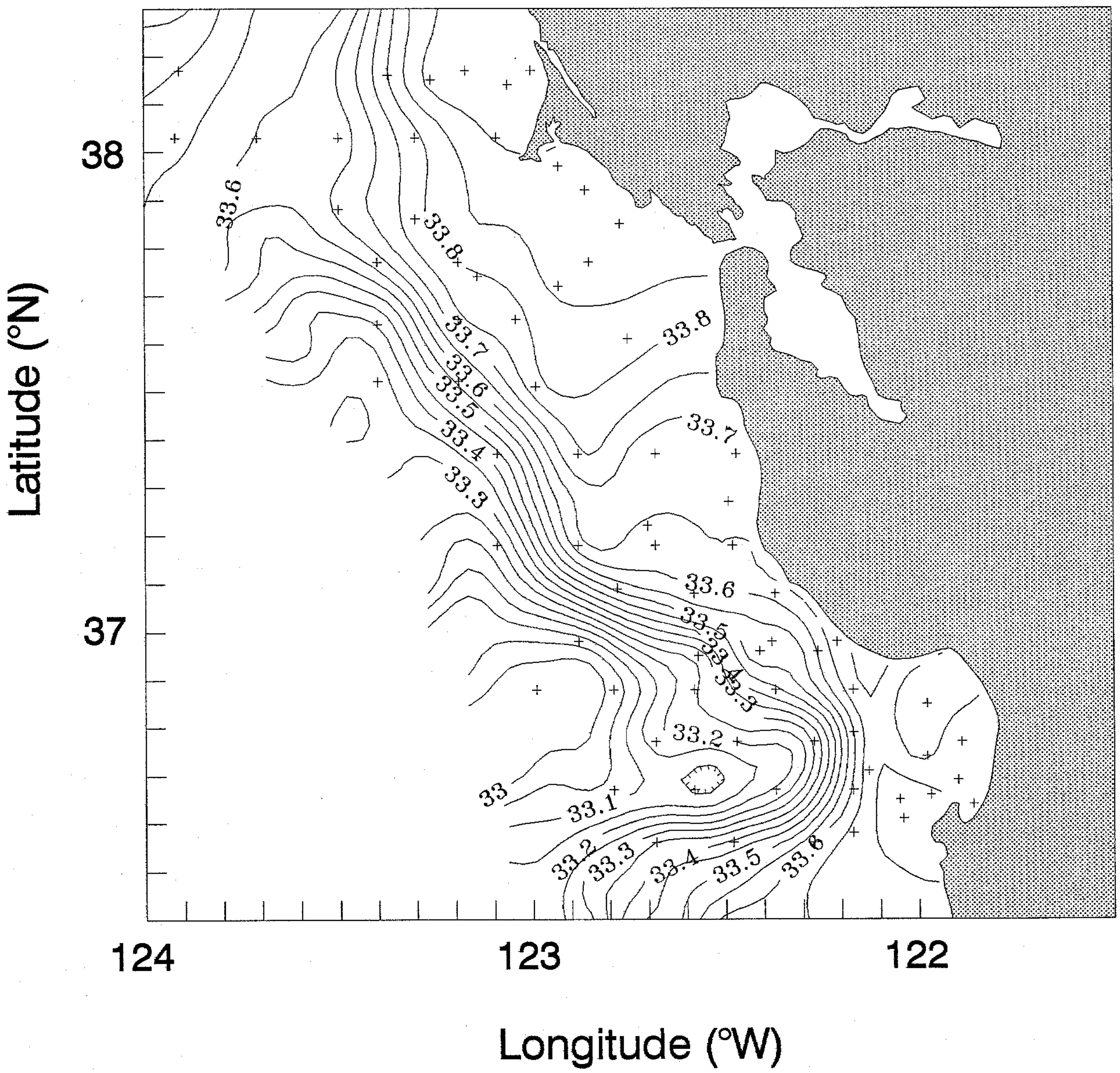
DSJ9406 Sweep 3
Temperature (°C) at 500 m



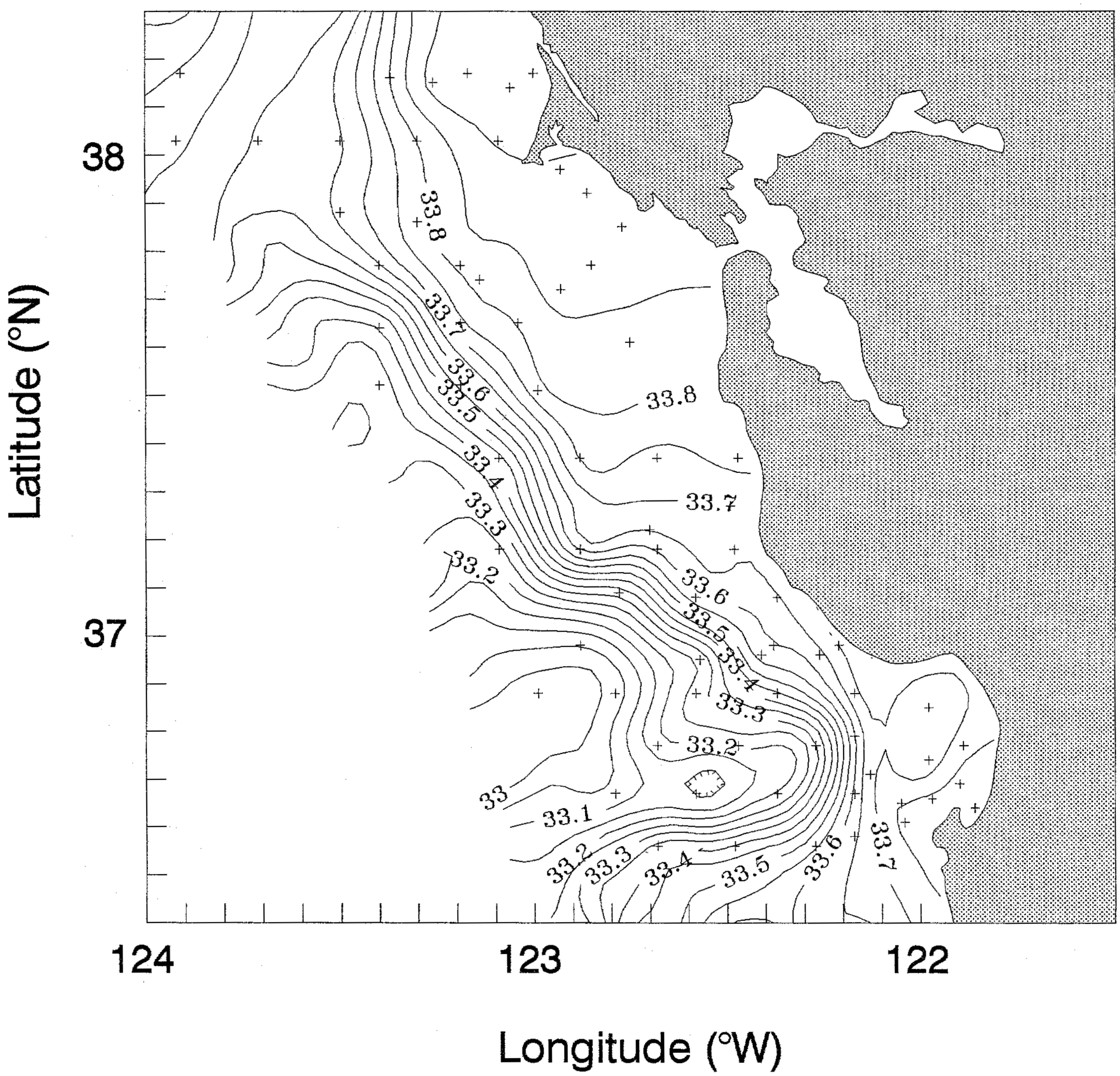
DSJ9406 Sweep 3
TS Salinity (ppt)



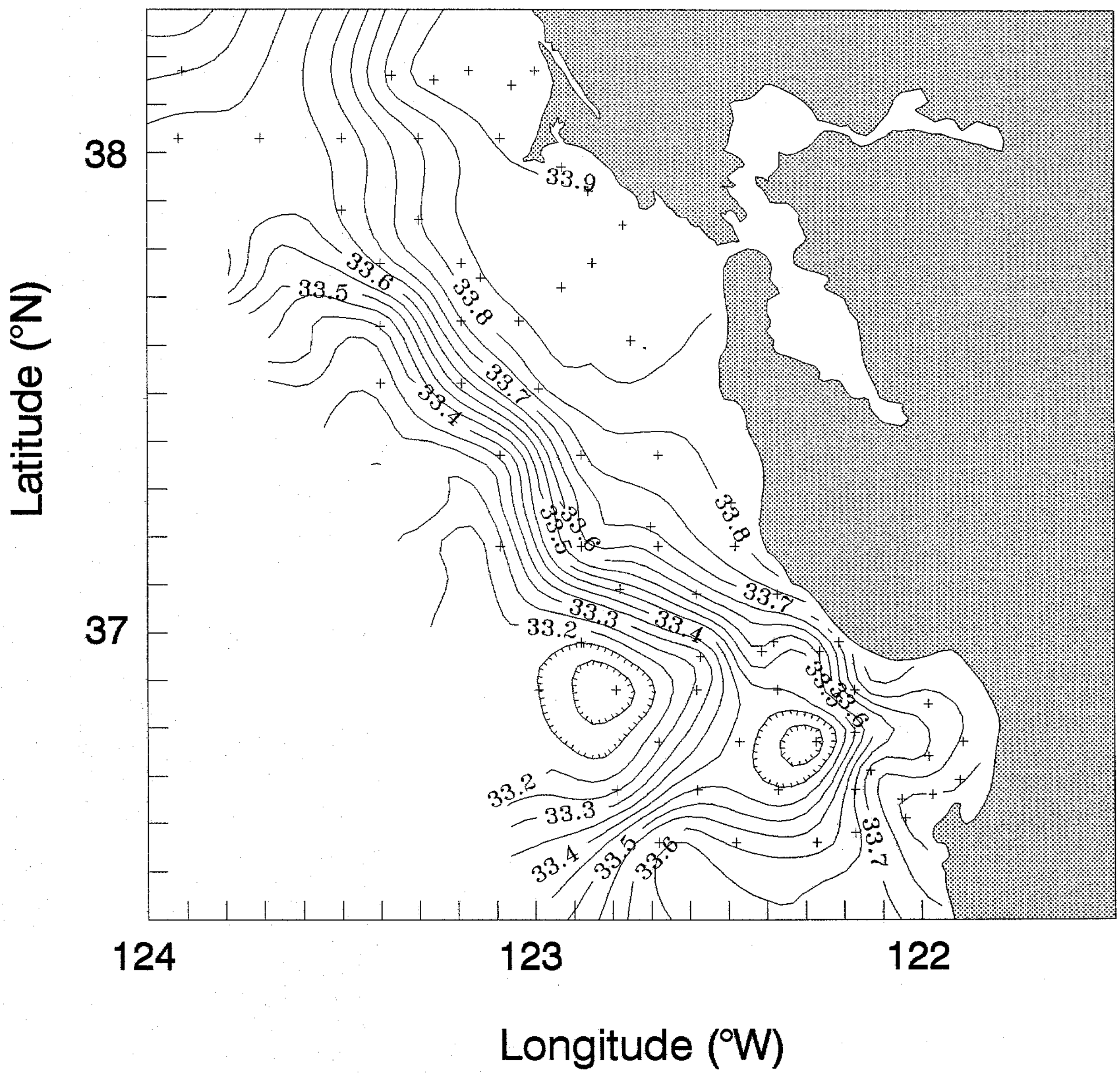
DSJ9406 Sweep 3
Salinity (ppt) at 2 m



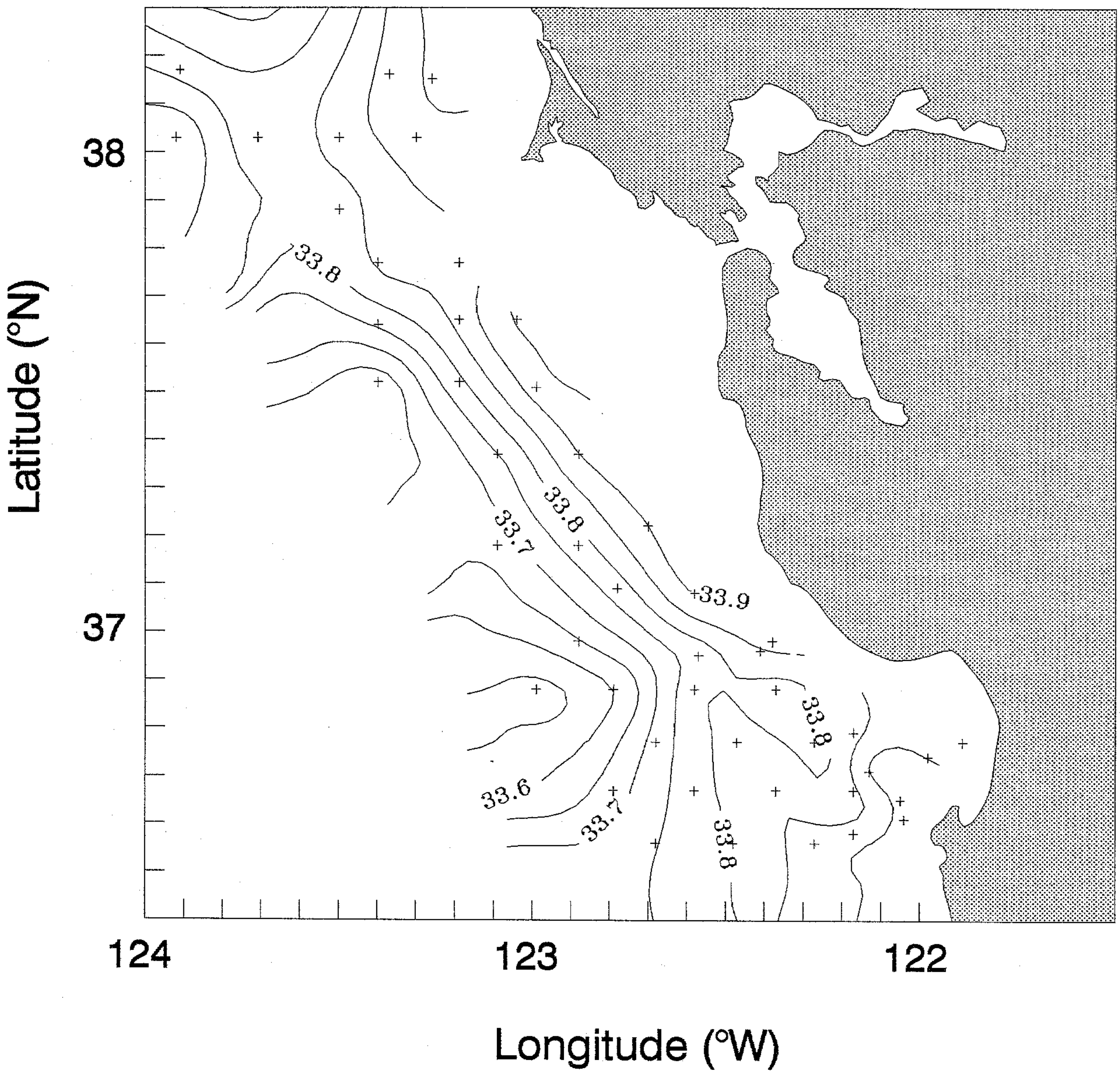
DSJ9406 Sweep 3
Salinity (ppt) at 10 m



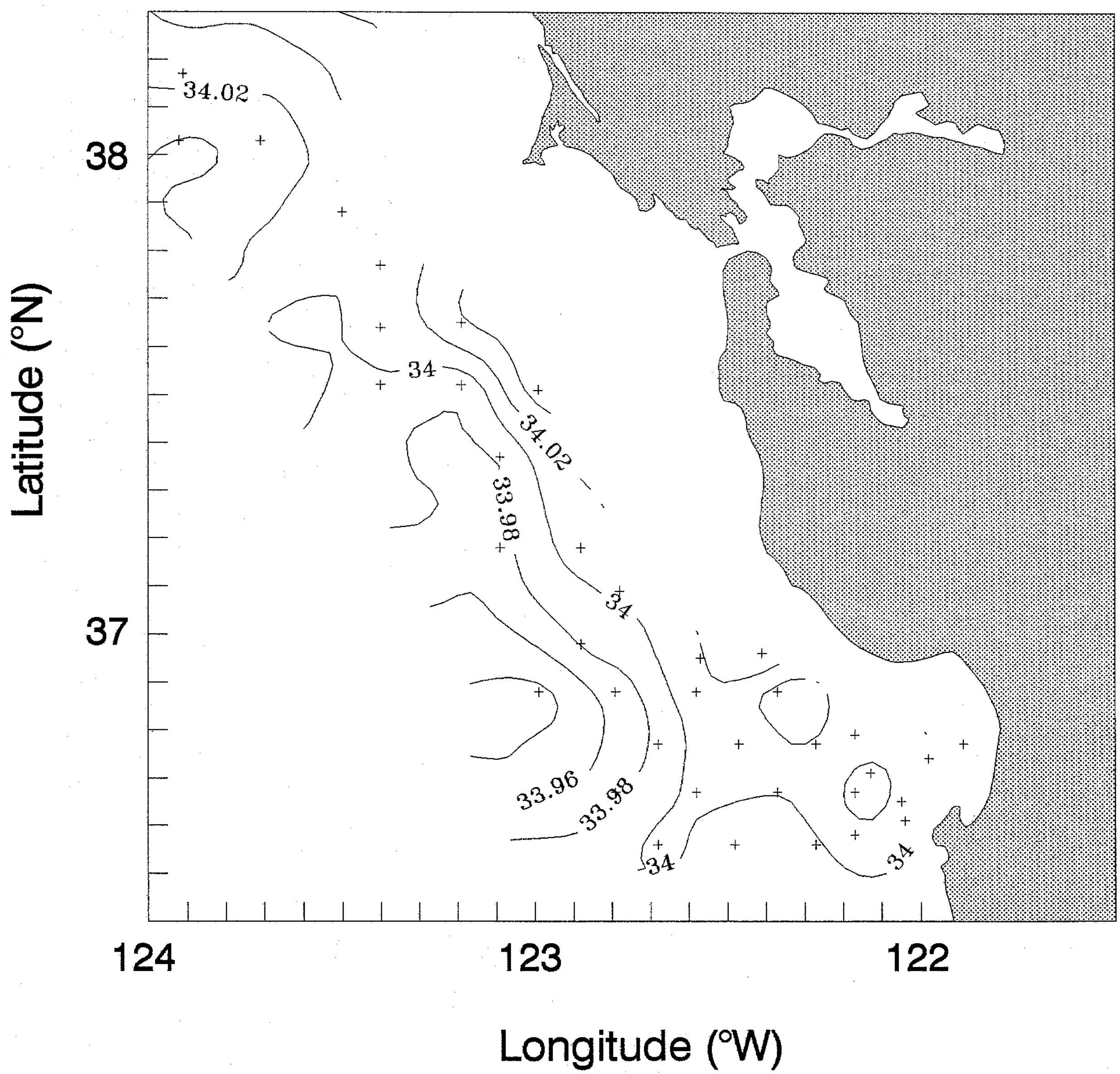
DSJ9406 Sweep 3
Salinity (ppt) at 30 m



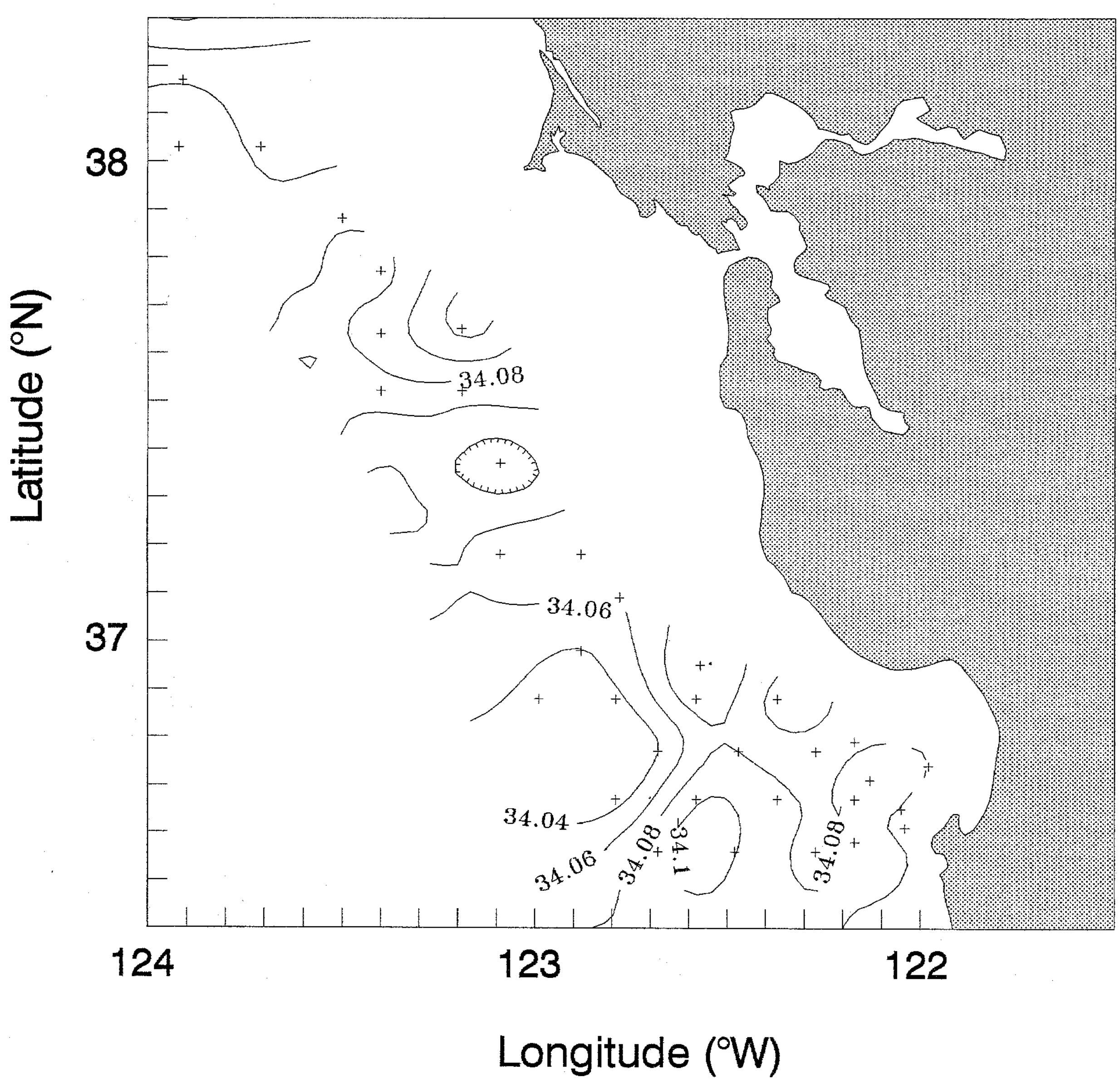
DSJ9406 Sweep 3
Salinity (ppt) at 100 m



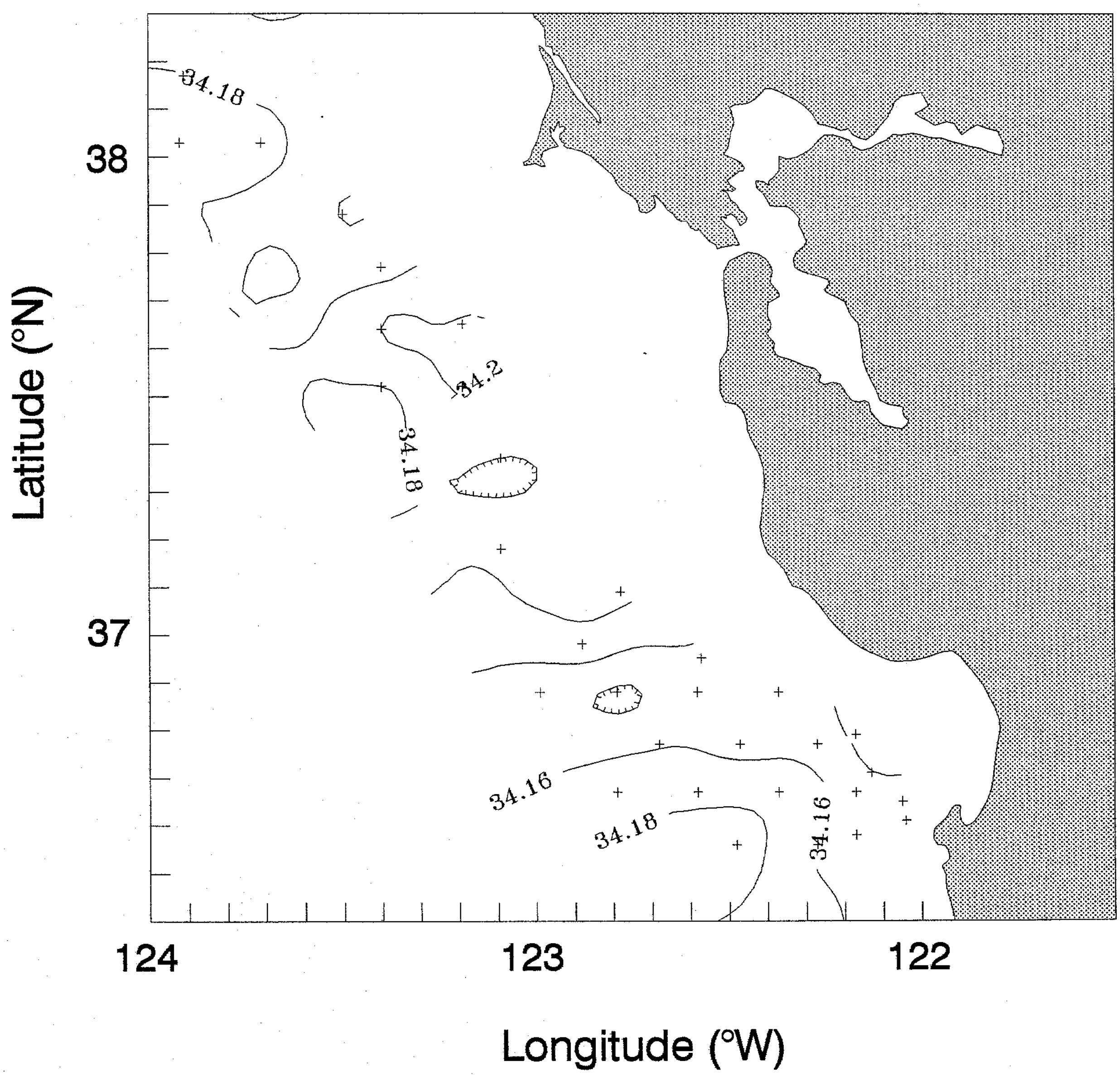
DSJ9406 Sweep 3
Salinity (ppt) at 200 m



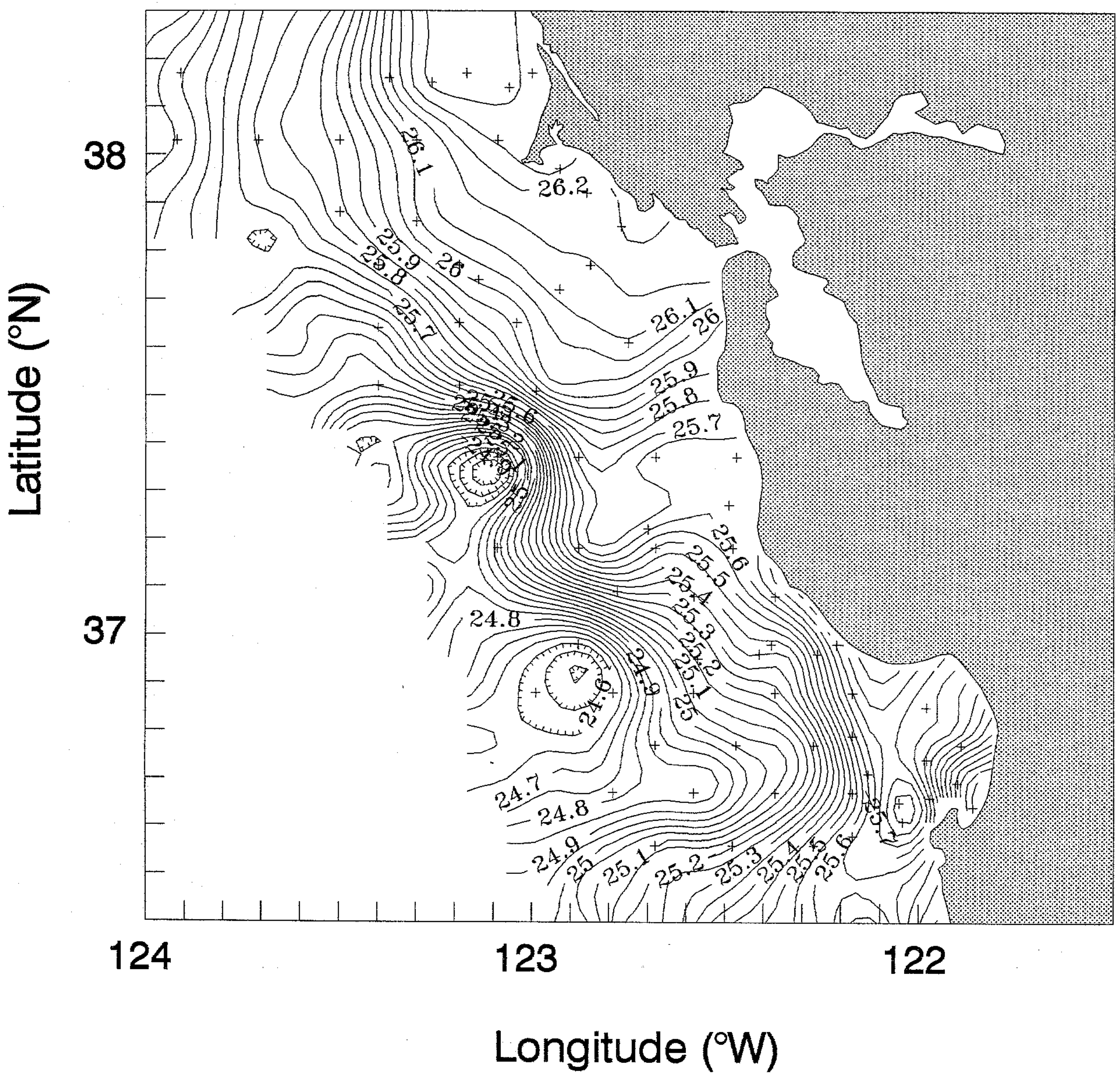
DSJ9406 Sweep 3
Salinity (ppt) at 300 m



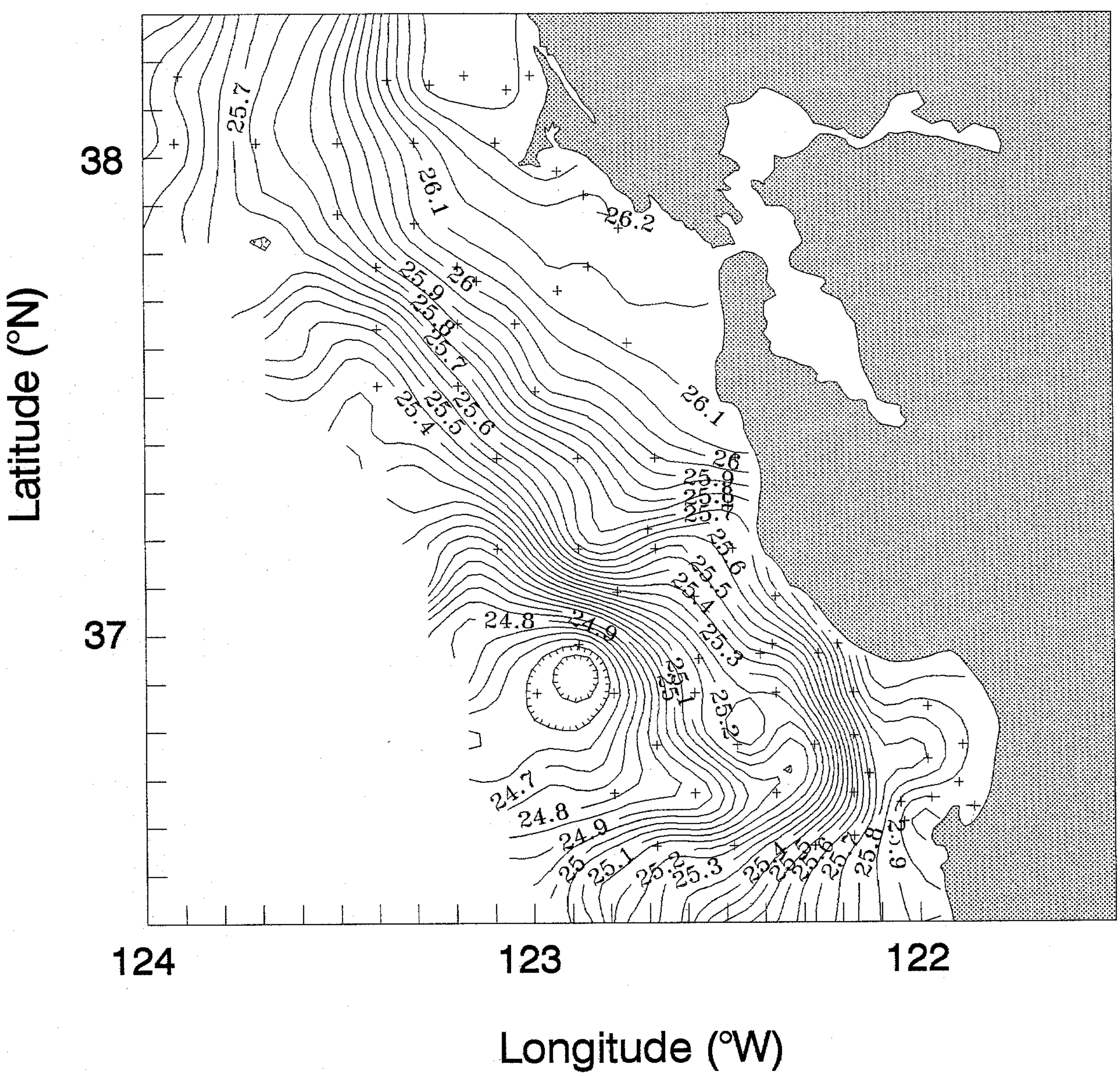
DSJ9406 Sweep 3
Salinity (ppt) at 500 m



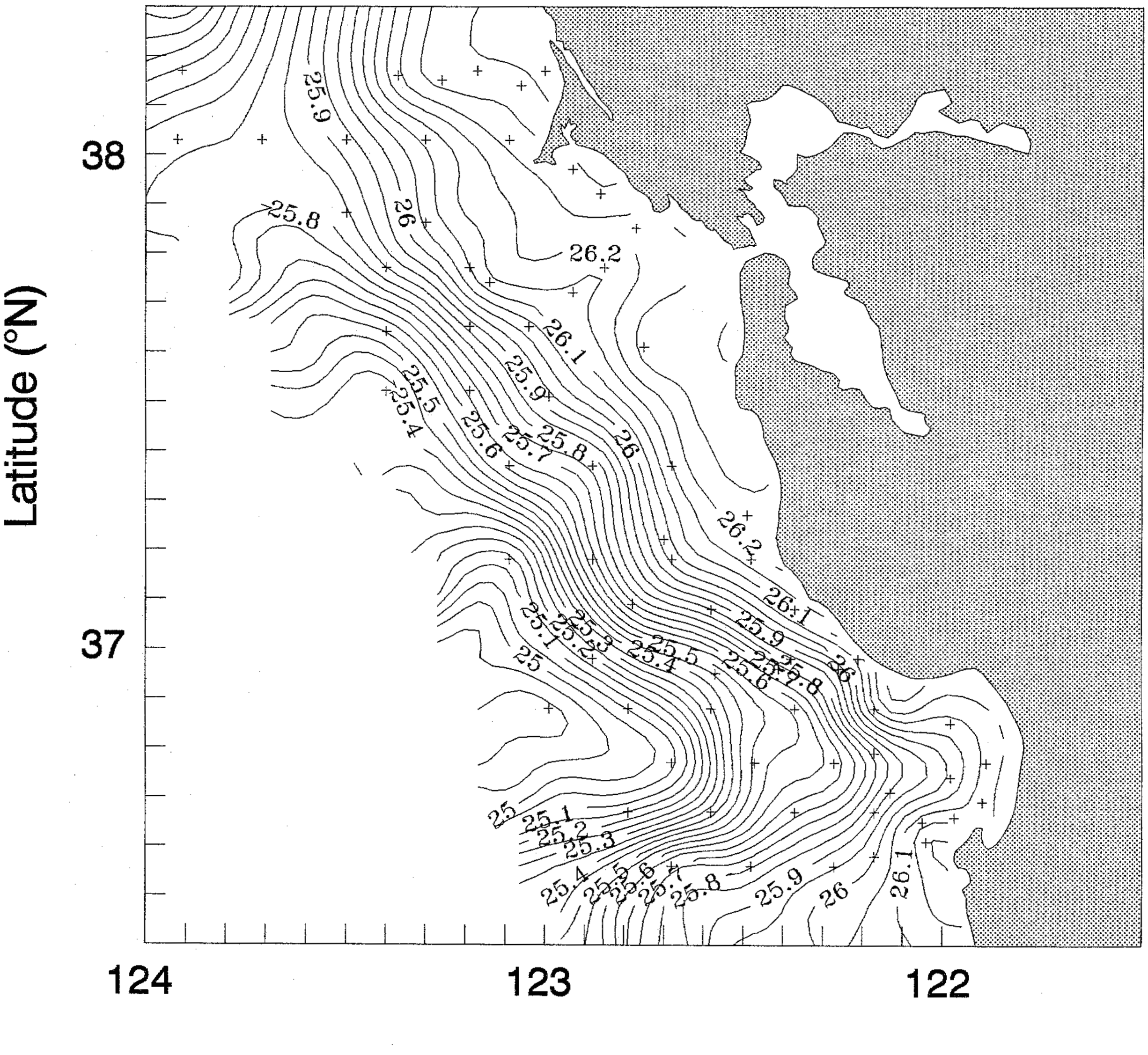
DSJ9406 Sweep 3
Density (kg/m^3) at 2 m



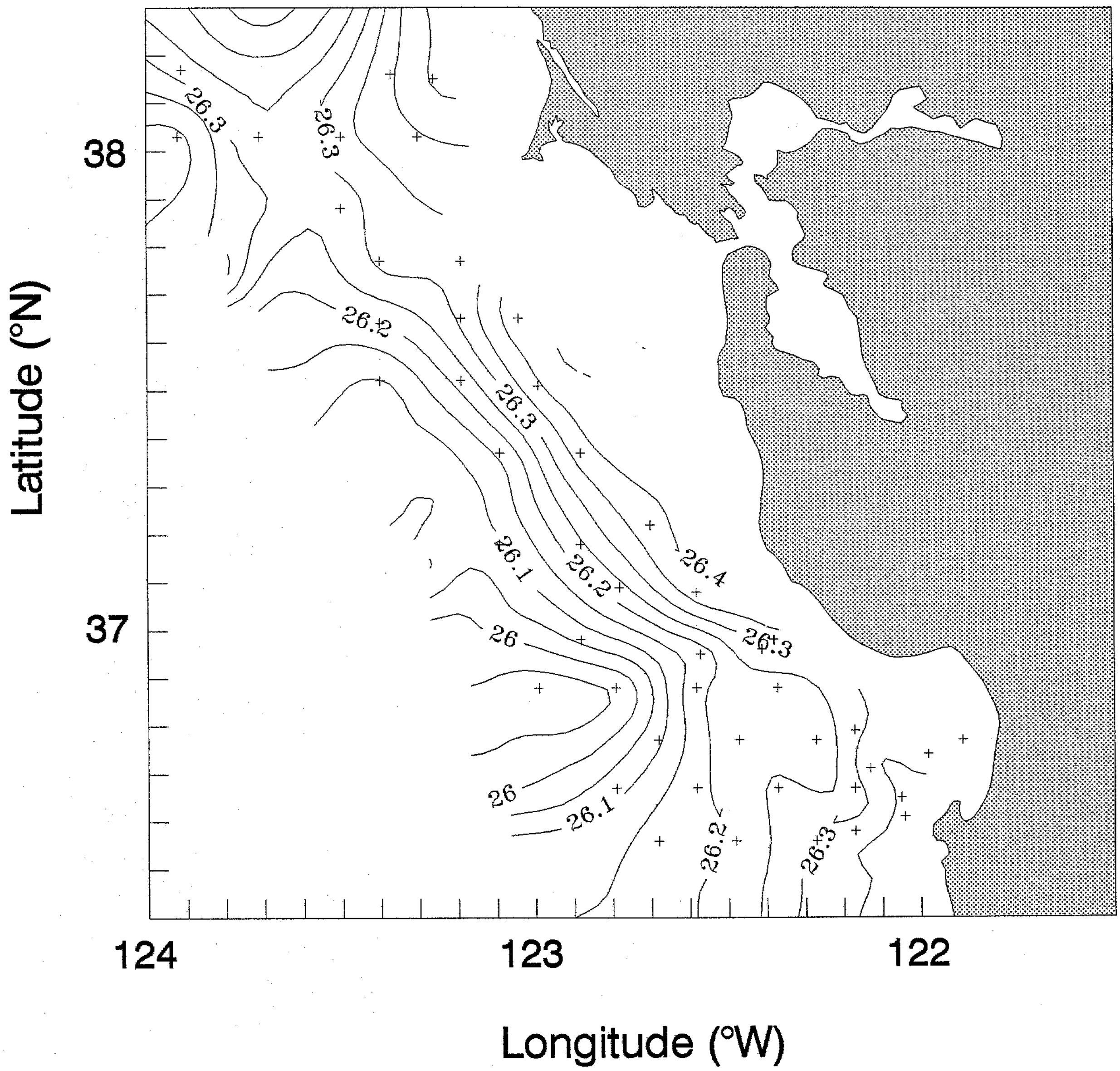
DSJ9406 Sweep 3
Density (kg/m³) at 10 m



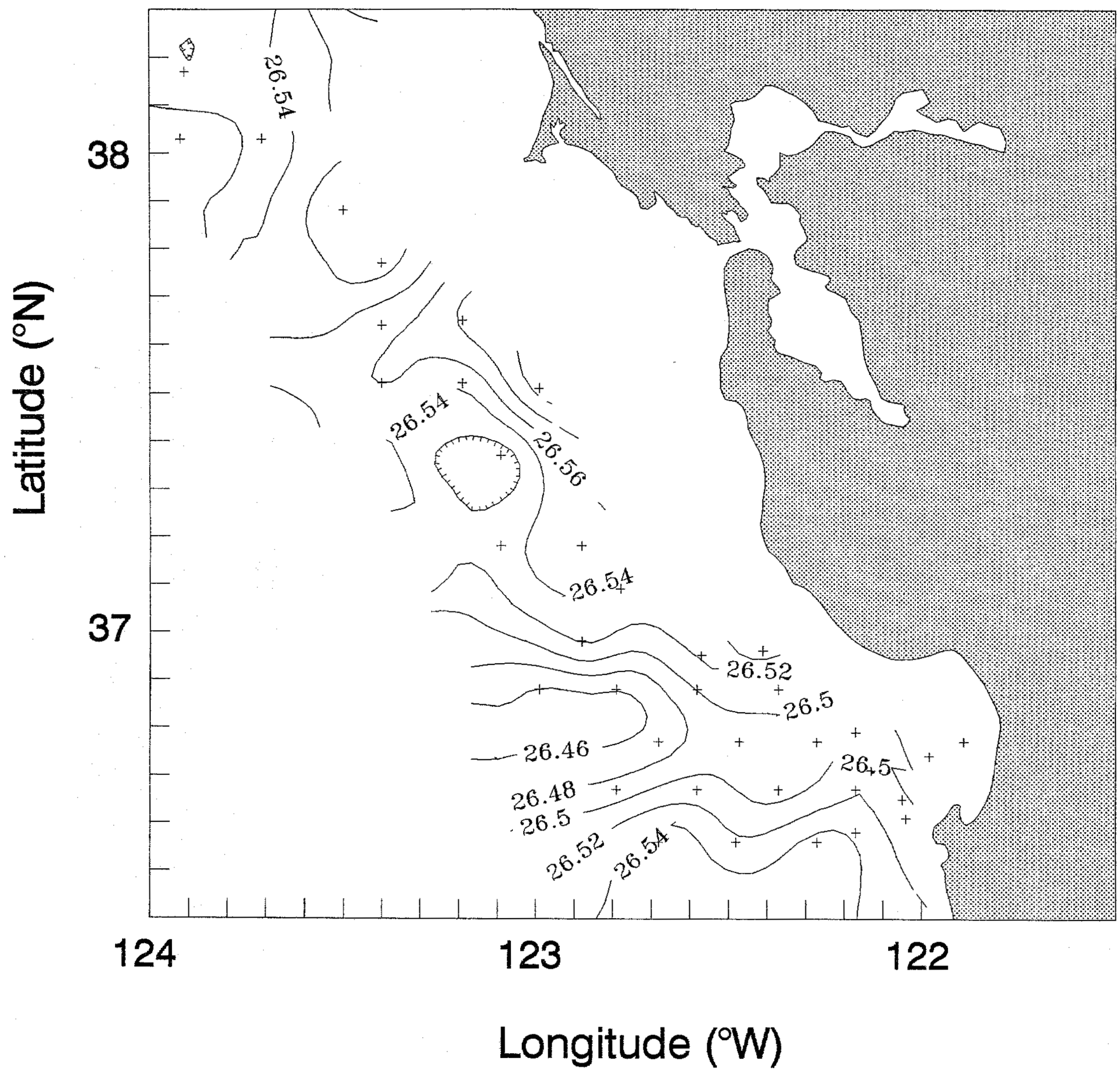
DSJ9406 Sweep 3
Density (kg/m³) at 30 m



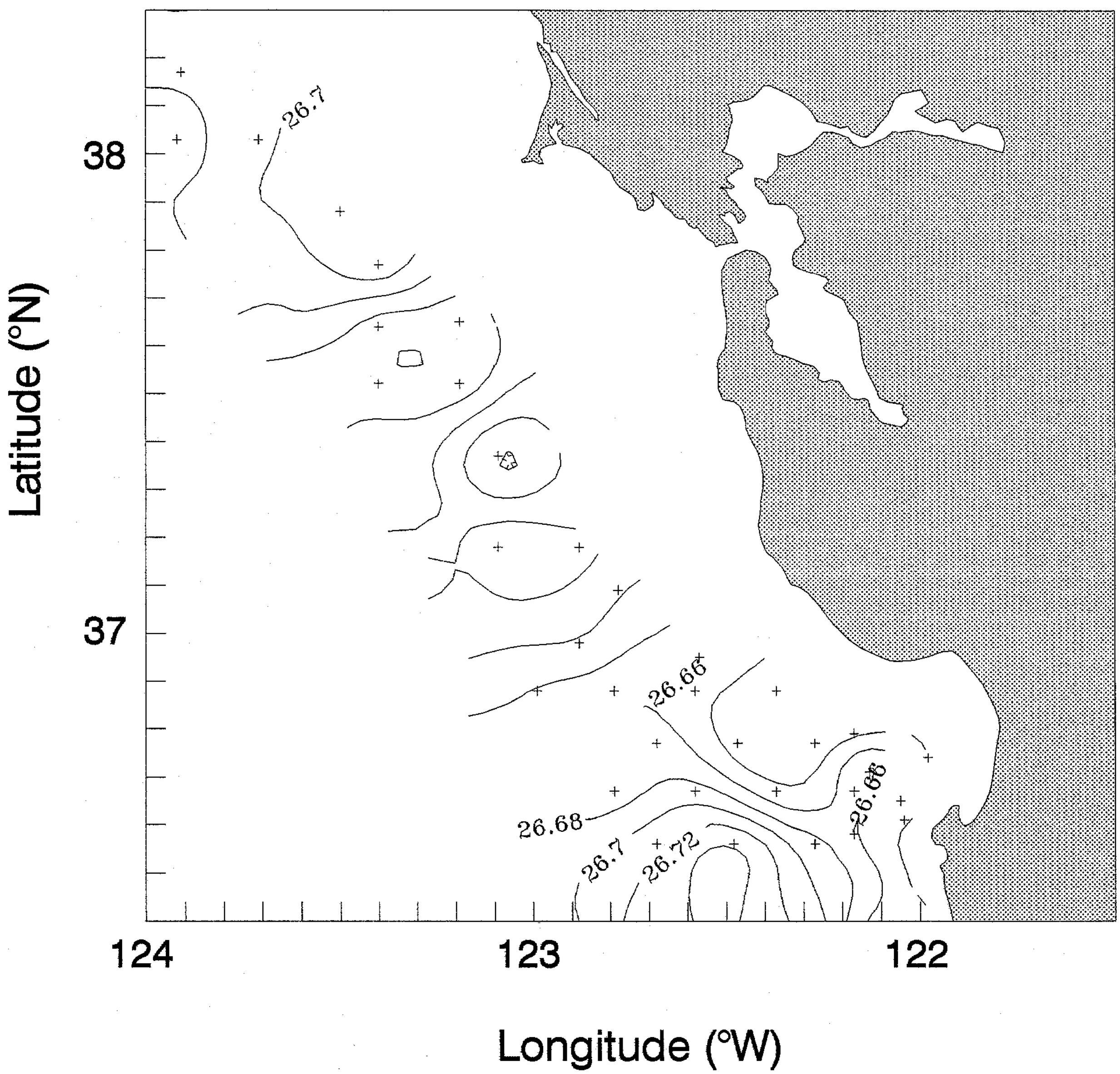
DSJ9406 Sweep 3
Density (kg/m³) at 100 m



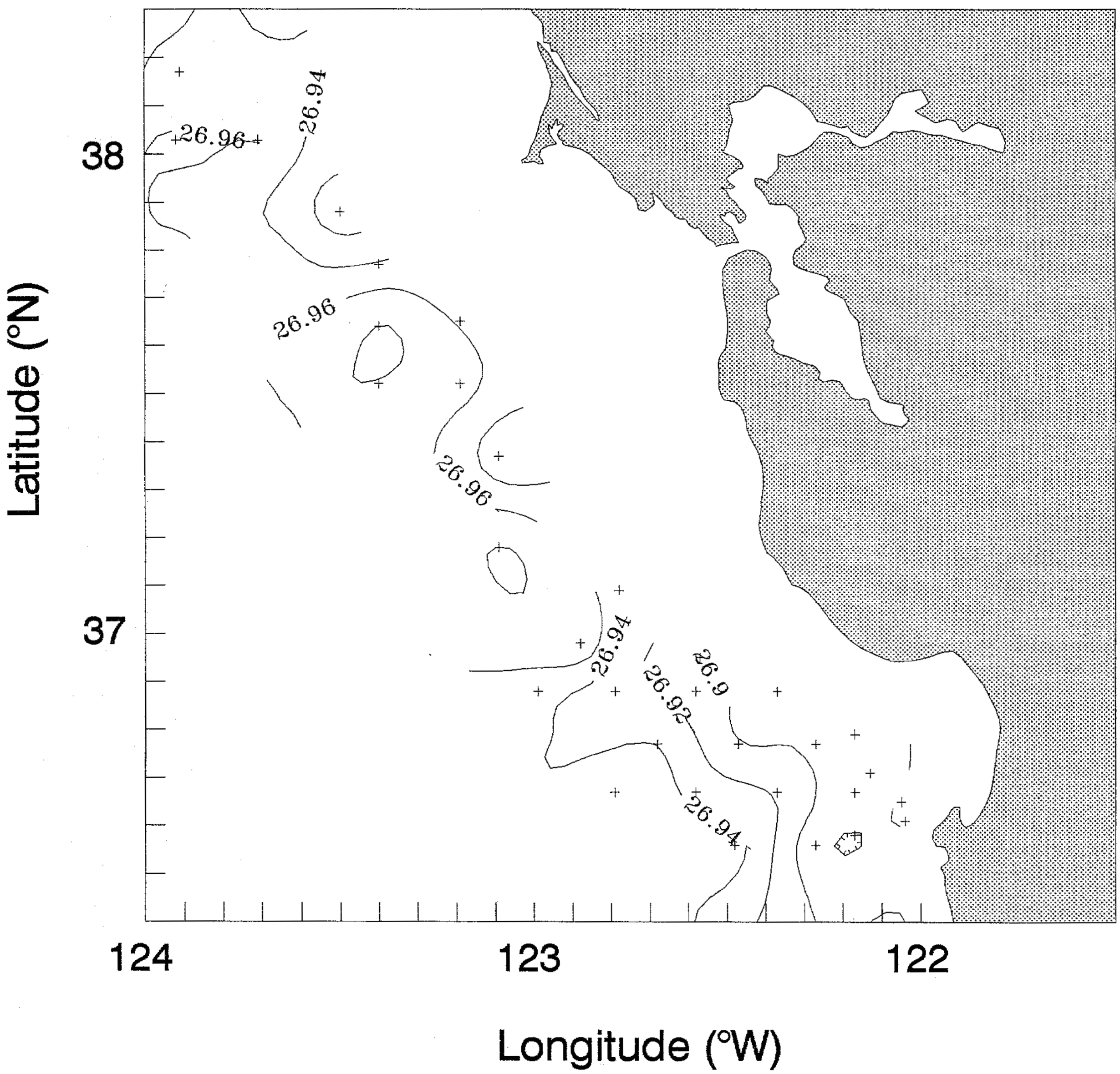
DSJ9406 Sweep 3
Density (kg/m³) at 200 m



DSJ9406 Sweep 3
Density (kg/m³) at 300 m

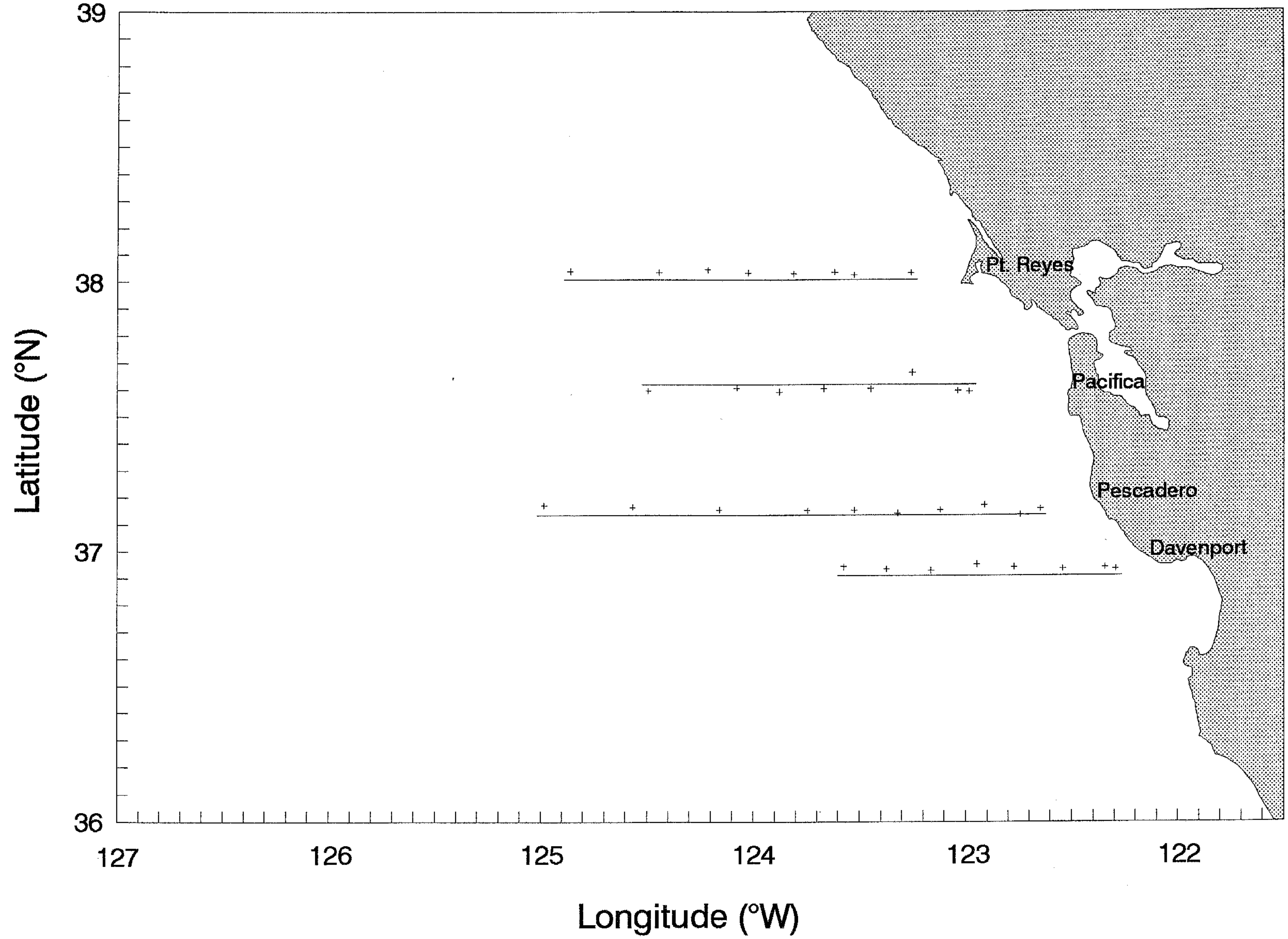


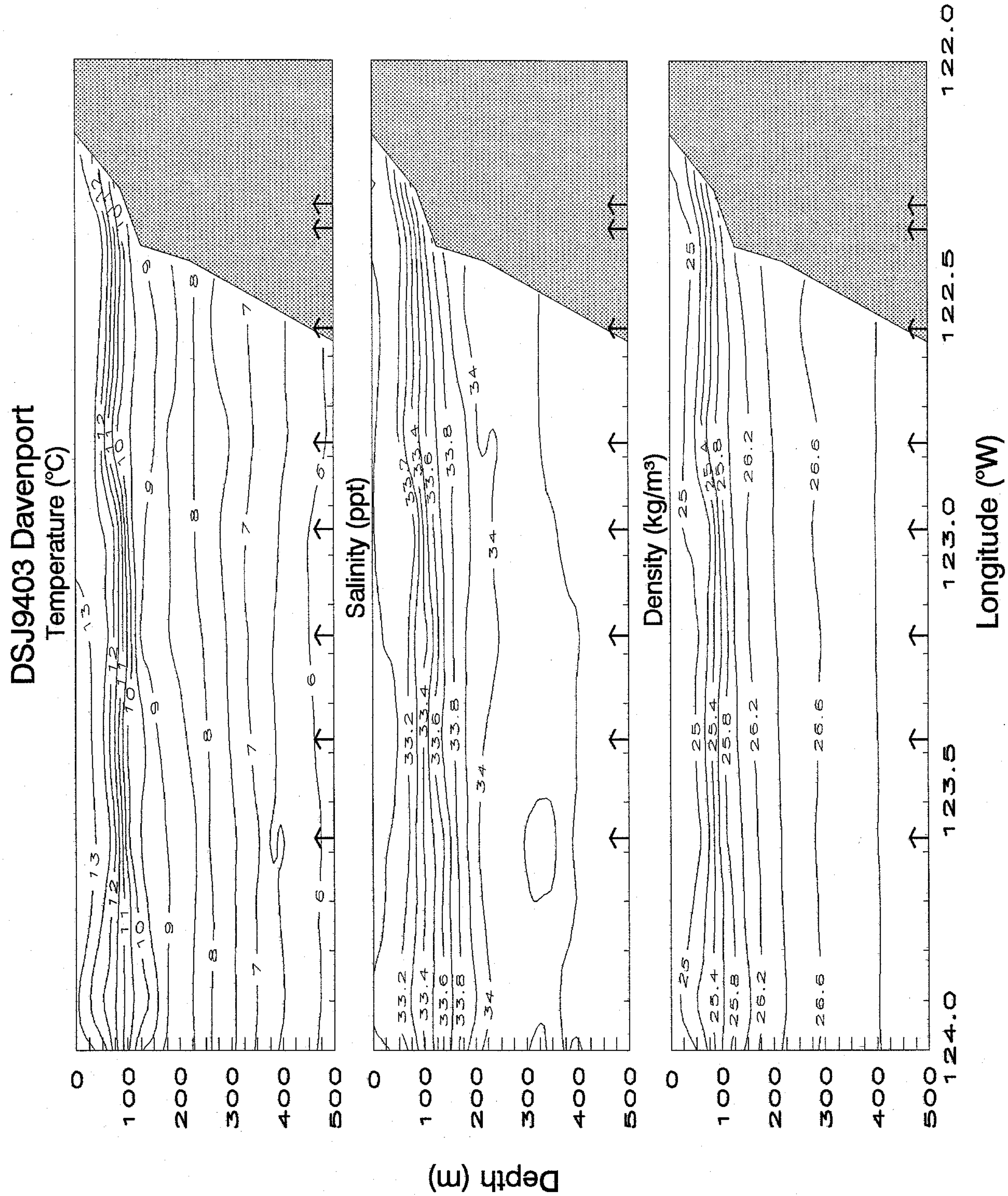
DSJ9406 Sweep 3
Density (kg/m³) at 500 m

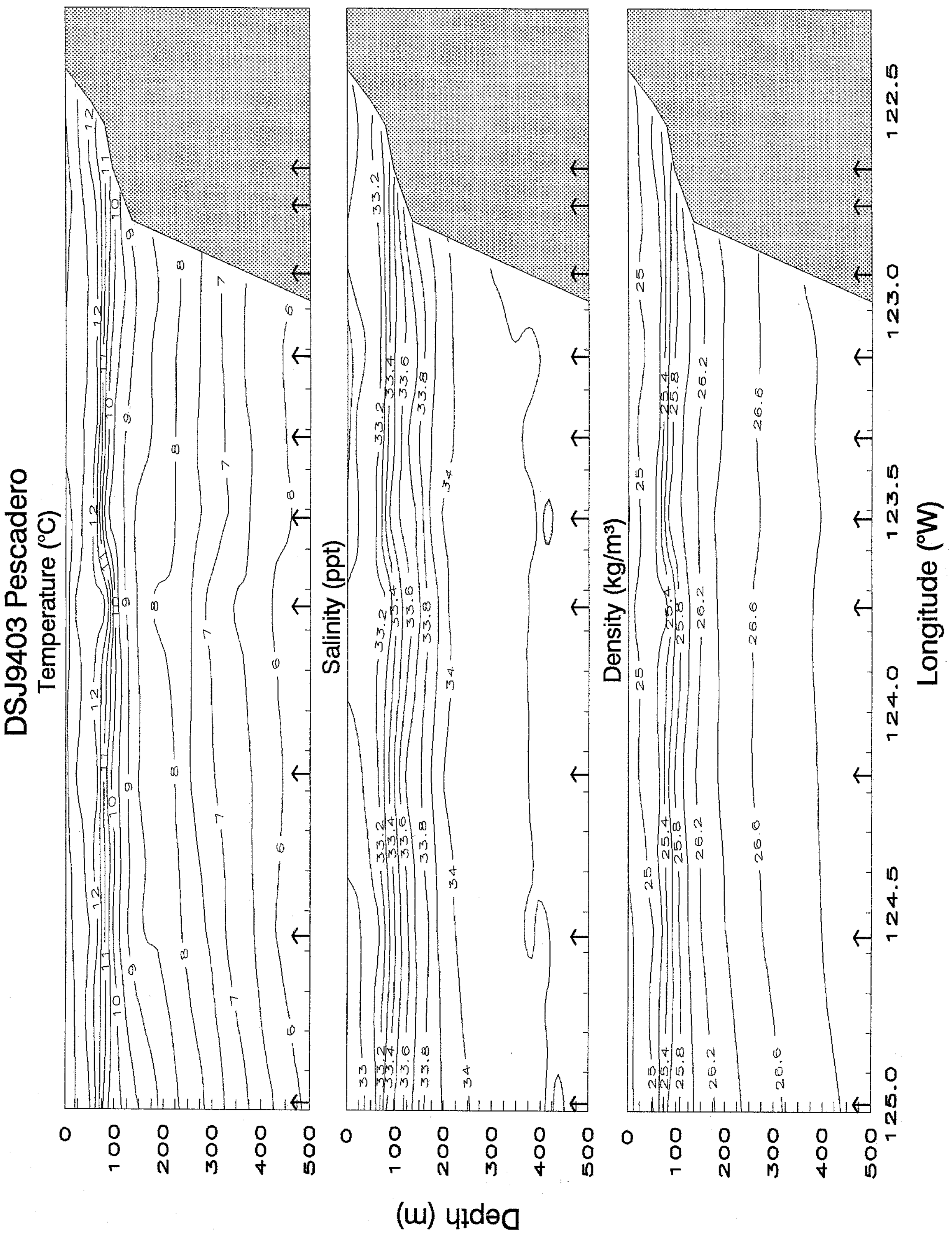


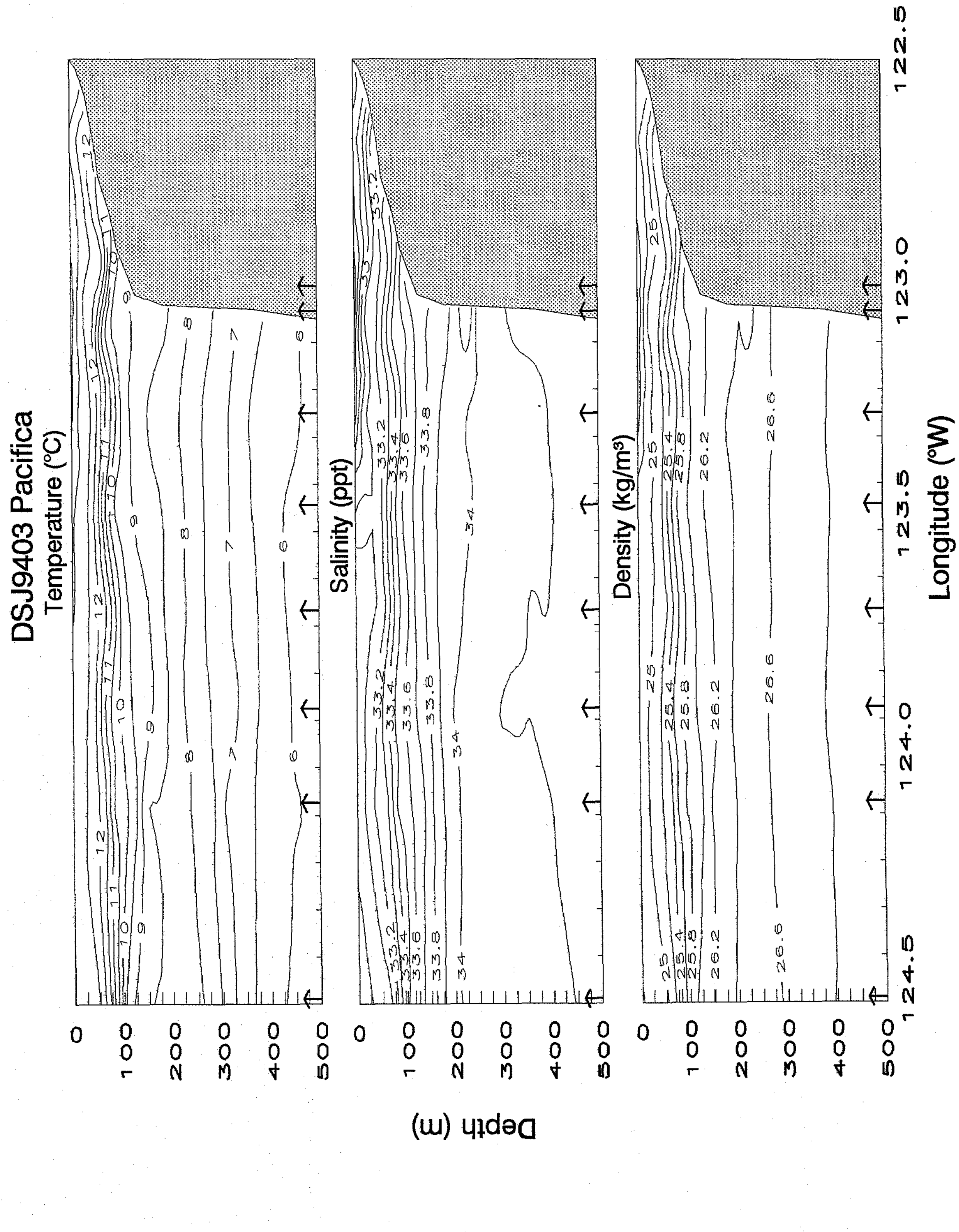
APPENDIX 9.1: VERTICAL TRANSECTS FOR DSJ9403

DSJ9403 Vertical Transect CTD Stations

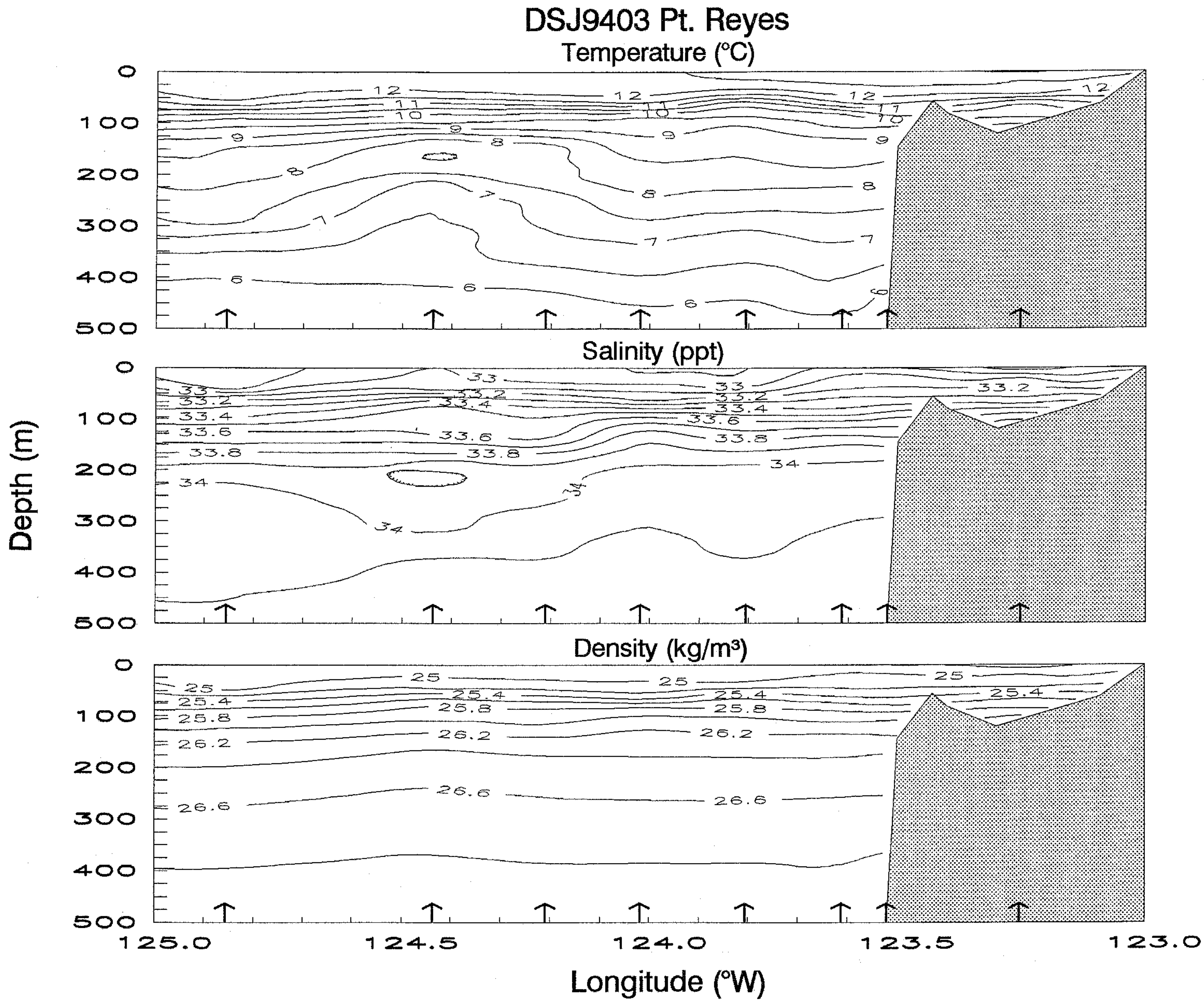



DSJ9403 Davenport
Temperature (°C)
Salinity (ppt)
Density (kg/m³)
Depth (m)
Longitude (°W)
0
100
200
300
400
500
124.0
123.5
123.0
122.5
122.0
13
12
11
10
9
8
7
6
33.2
33.4
33.6
33.8
34
25
25.4
25.8
26.2
26.6


DSJ9403 Pescadero
Temperature (°C)
Salinity (ppt)
Density (kg/m³)
Longitude (°W)
Depth (m)

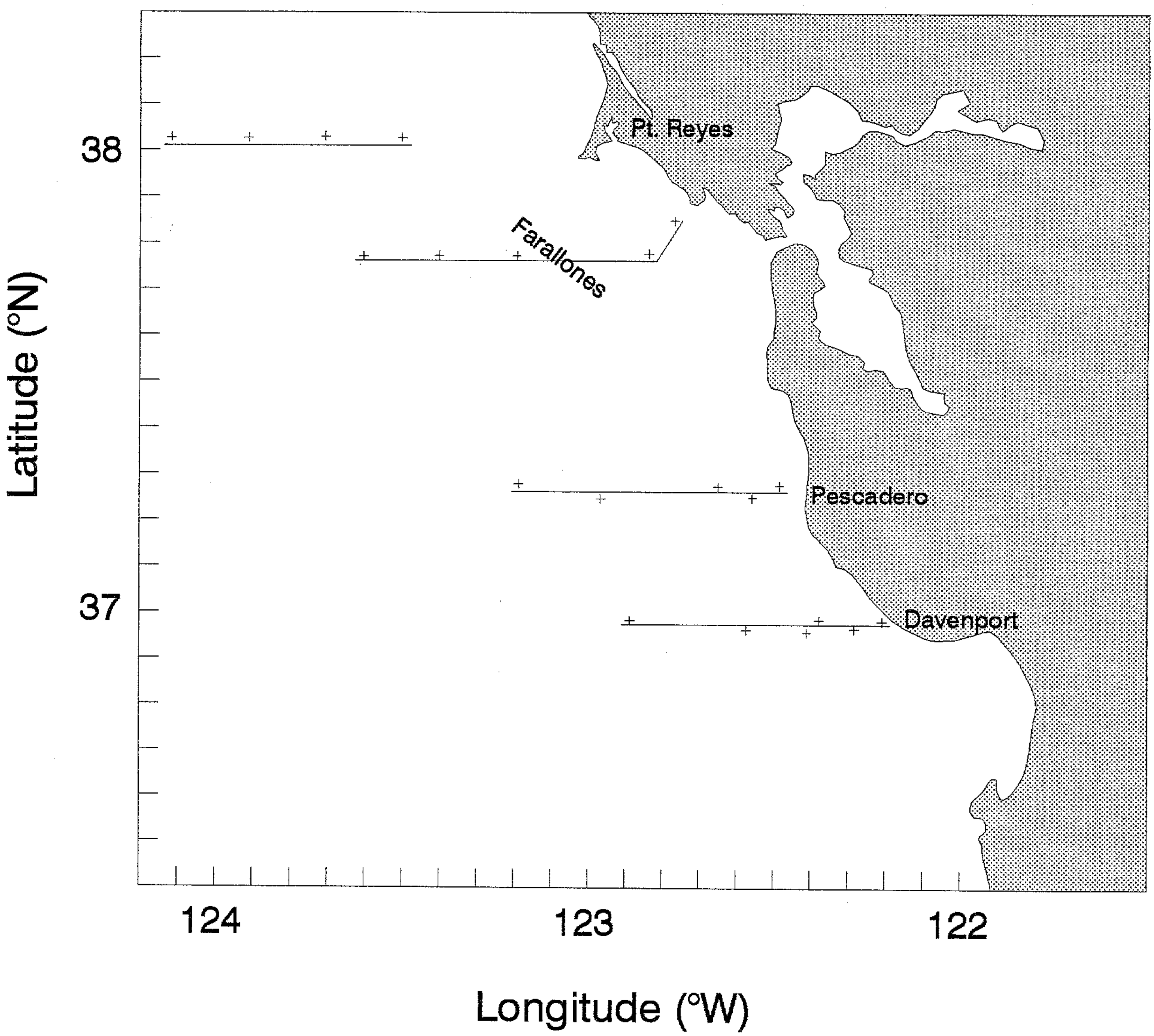


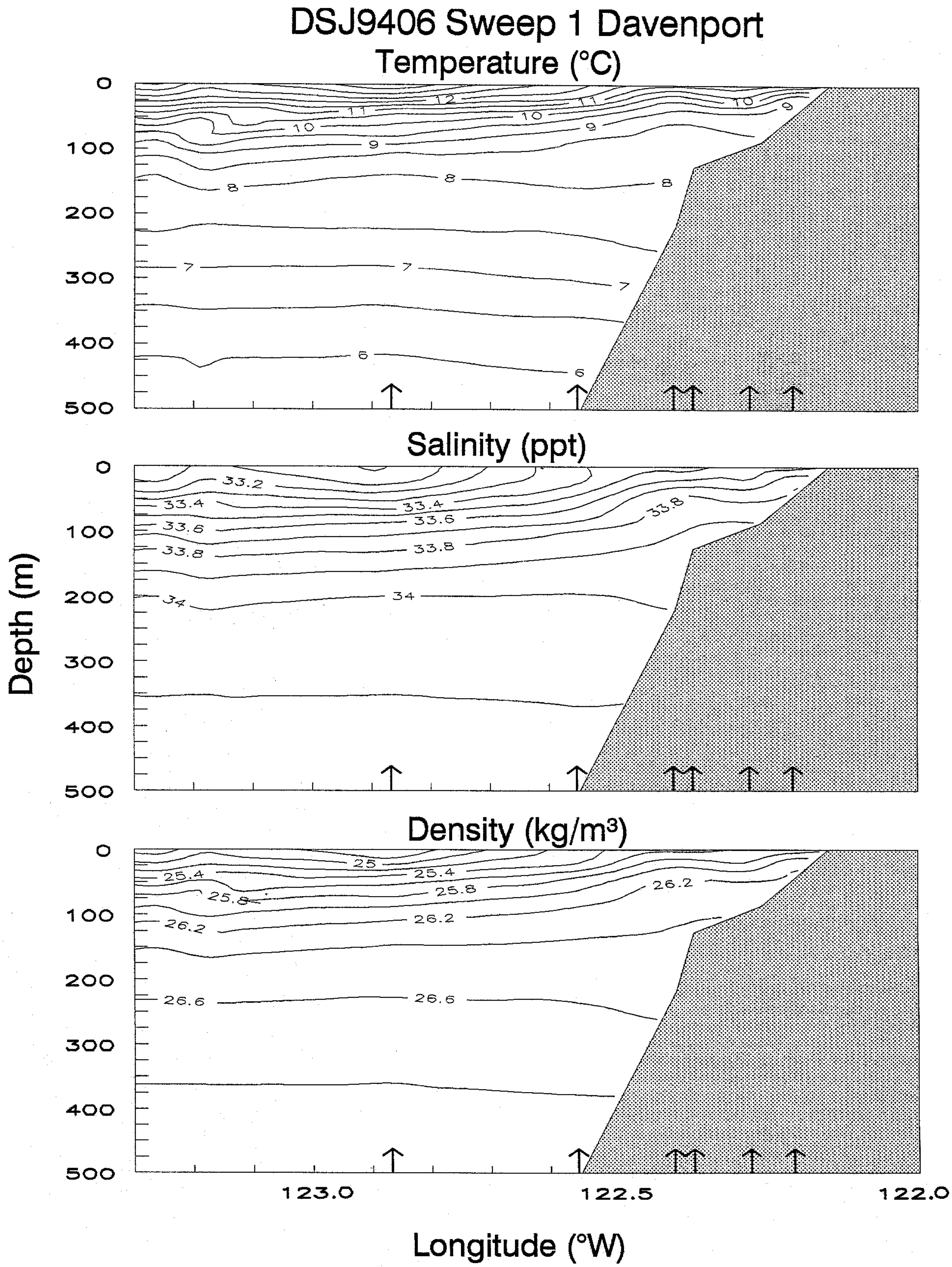
DSJ9403 Pacifica
Temperature (°C)
Salinity (ppt)
Density (kg/m³)
Depth (m)
Longitude (°W)
124.5
124.0
123.5
123.0
122.5
0
100
200
300
400
500


DSJ9403 Pt. Reyes
Temperature (°C)
Salinity (ppt)
Density (kg/m³)
Depth (m)
Longitude (°W)
0
100
200
300
400
500
125.0
124.5
124.0
123.5
123.0
12
11
10
9
8
7
6
33
33.2
33.4
33.6
33.8
34
25
25.4
25.8
26.2
26.6

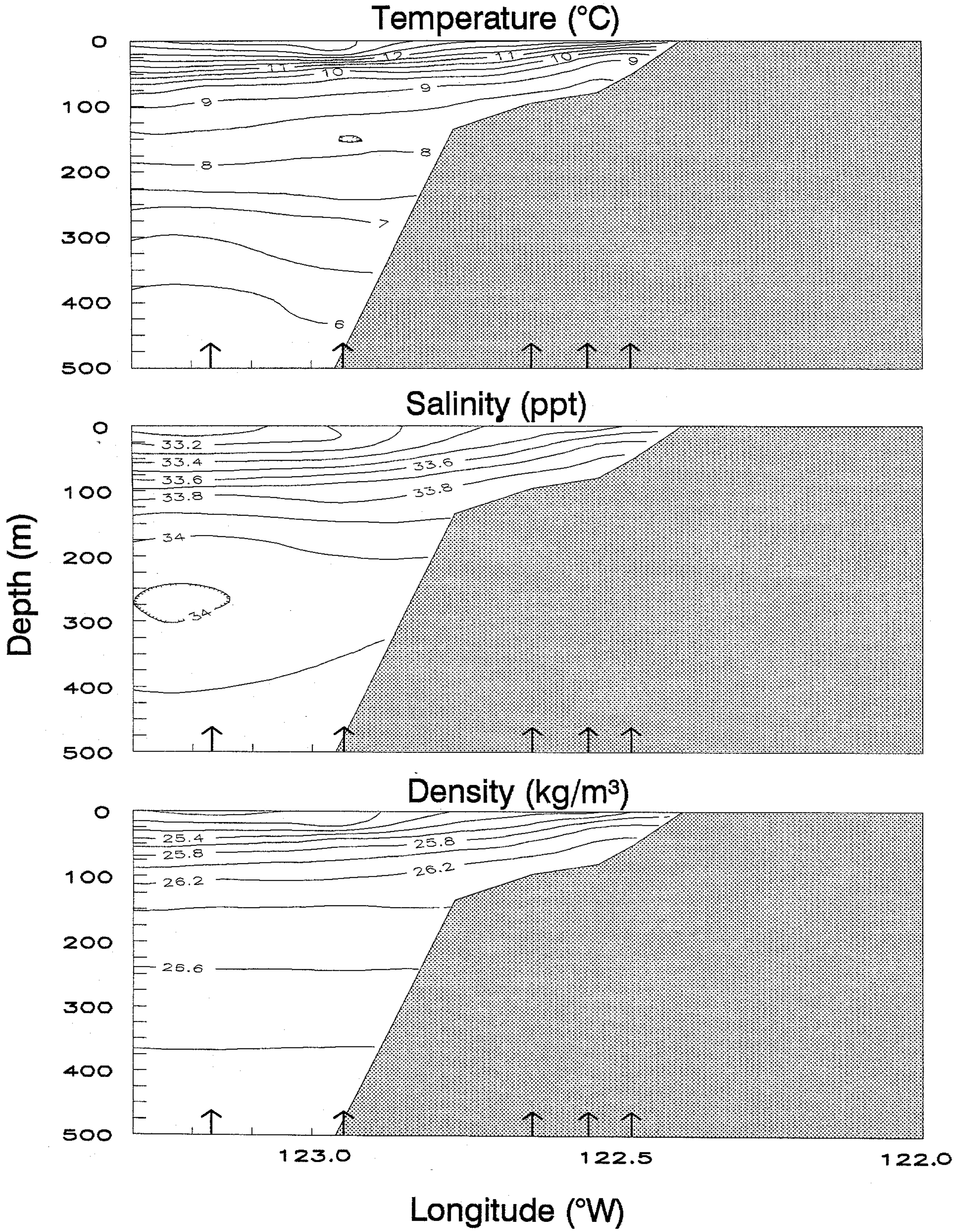
APPENDIX 9.2: VERTICAL TRANSECTS FOR DSJ9406

DSJ9406 Sweep 1
Vertical Transect CTD Stations

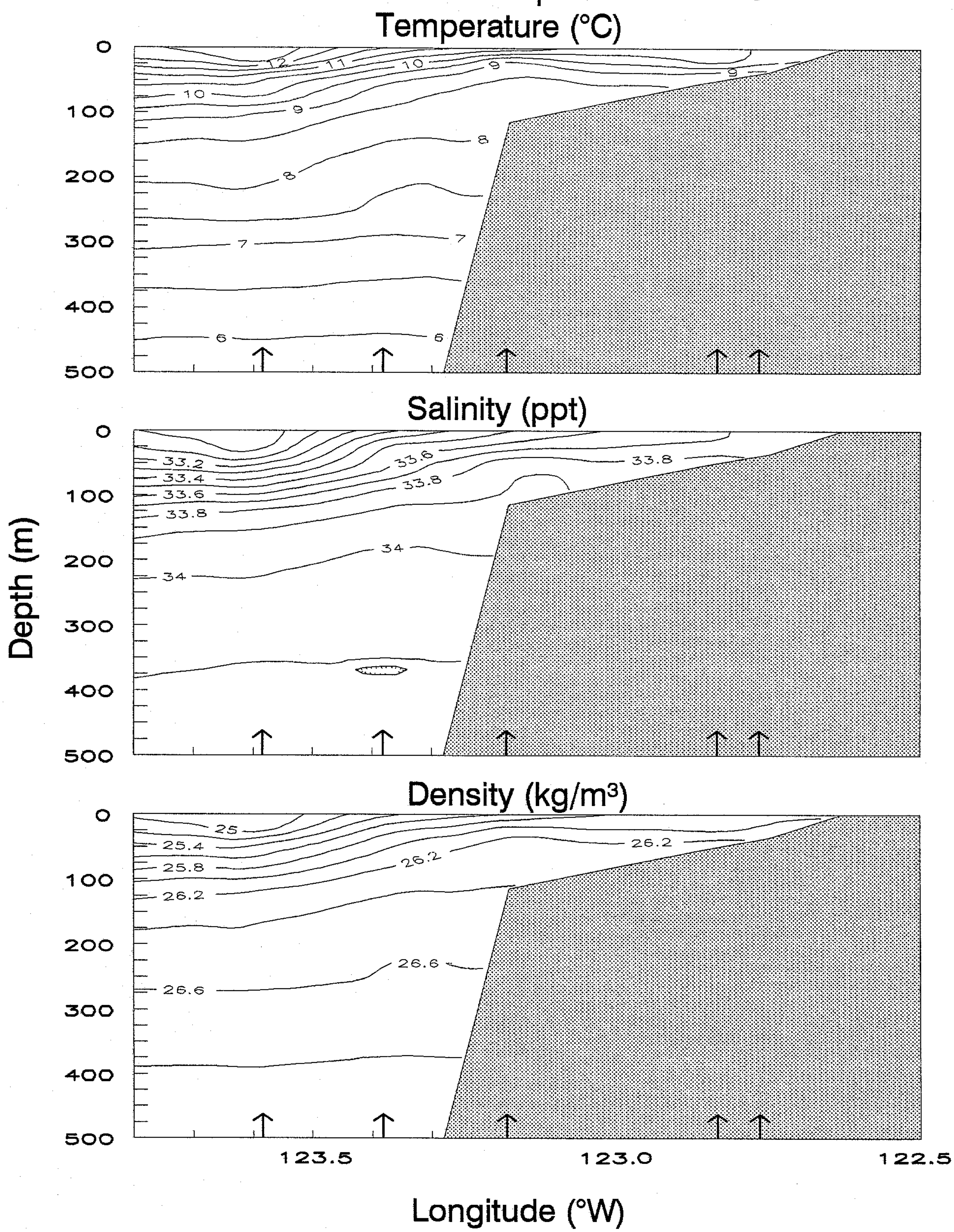


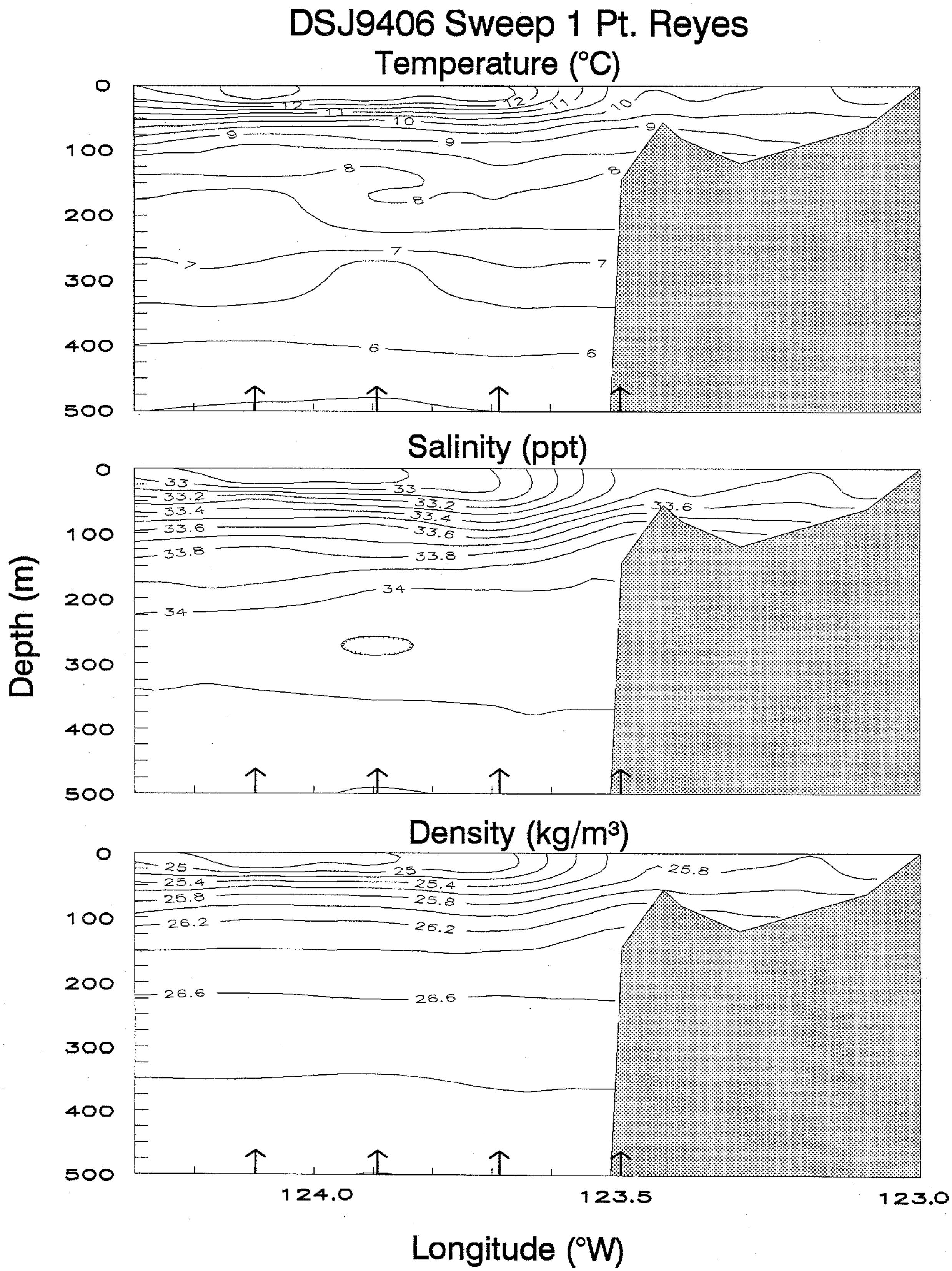

DSJ9406 Sweep 1 Davenport
Temperature (°C)
Salinity (ppt)
Density (kg/m³)
Depth (m)
Longitude (°W)
0
100
200
300
400
500
123.0
122.5
122.0
12
11
10
9
8
7
6
33.2
33.4
33.6
33.8
34
25
25.4
25.8
26.2
26.6

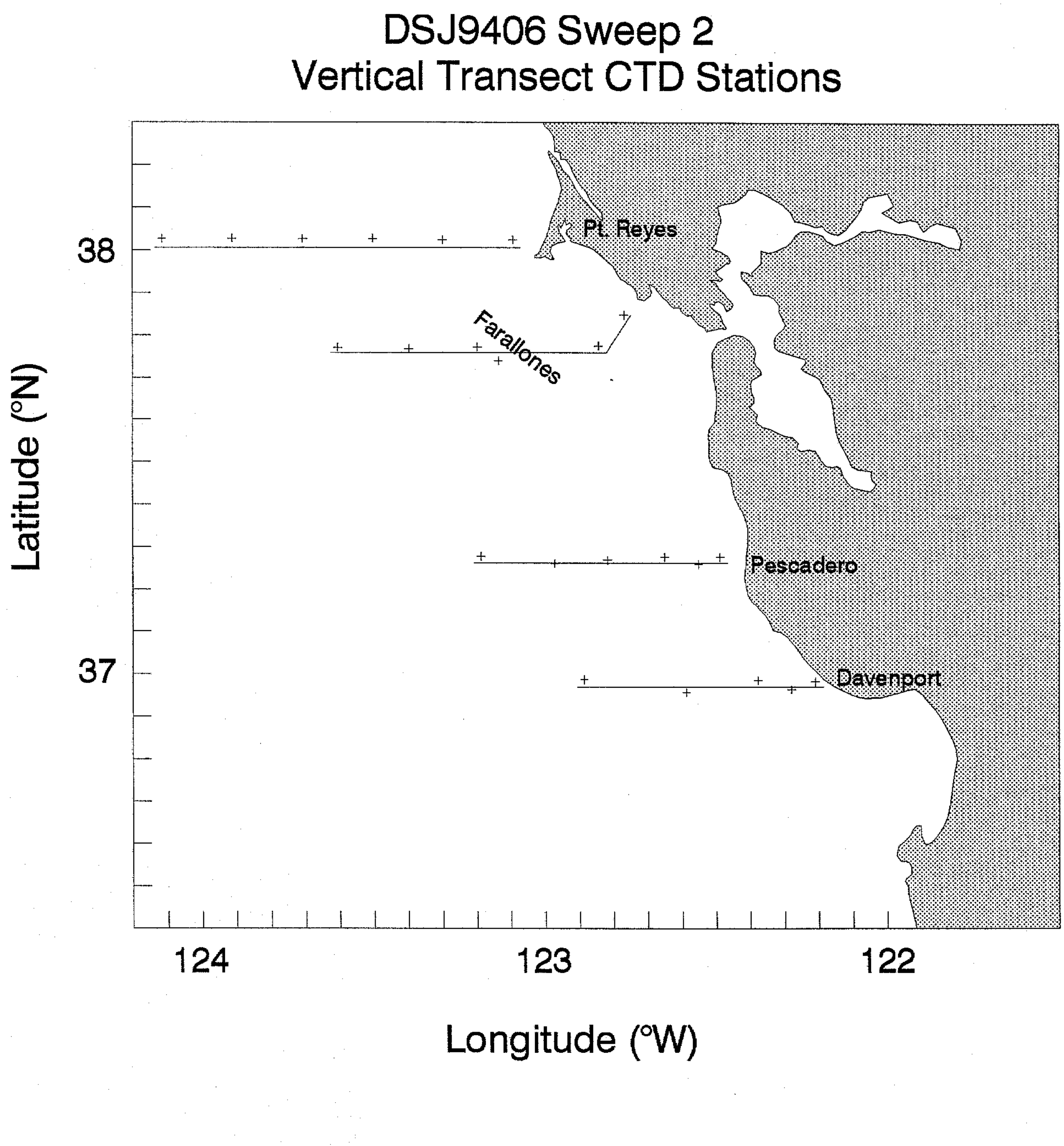
DSJ9406 Sweep 1 Pescadero

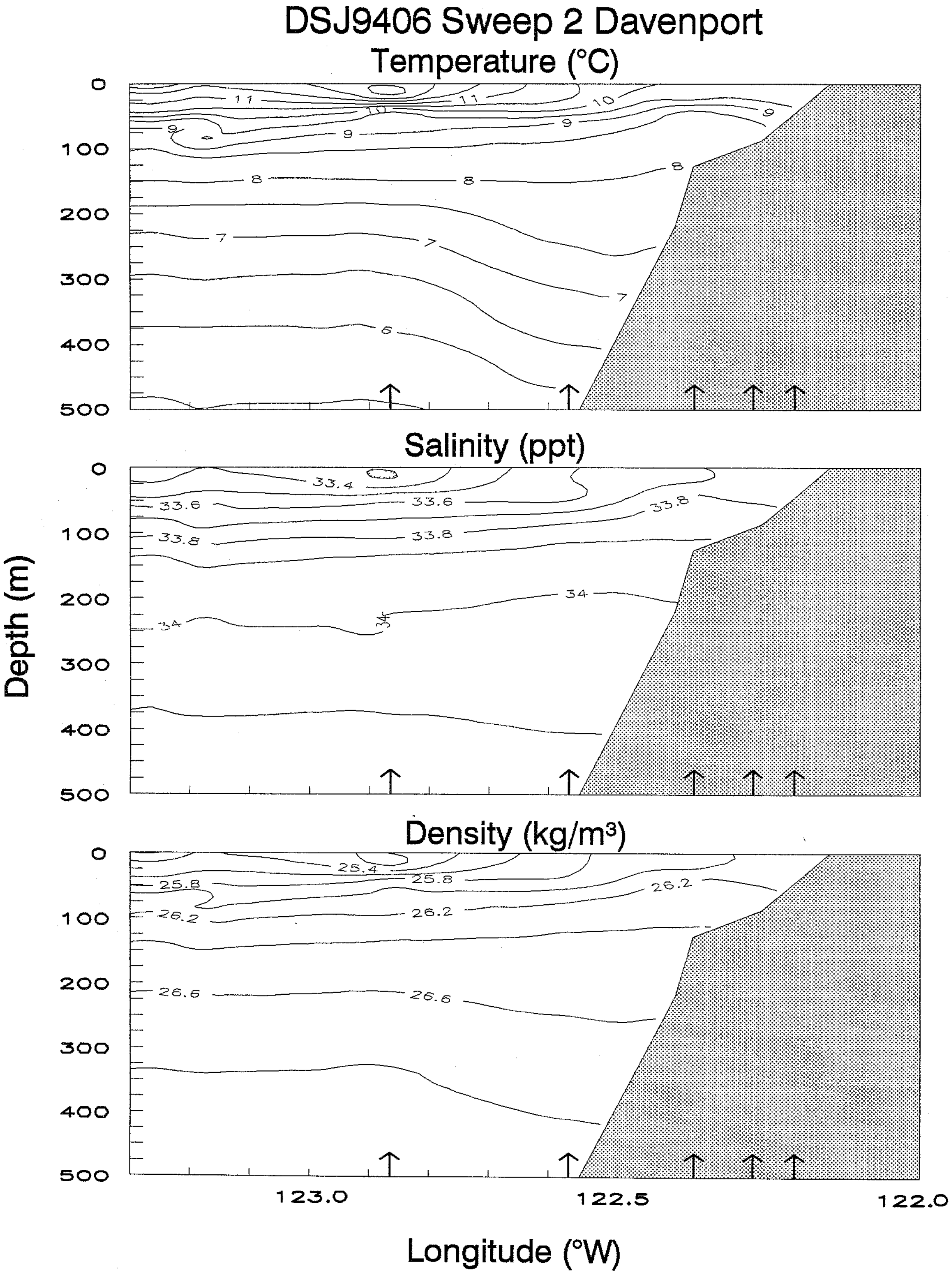


DSJ9406 Sweep 1 Farallones



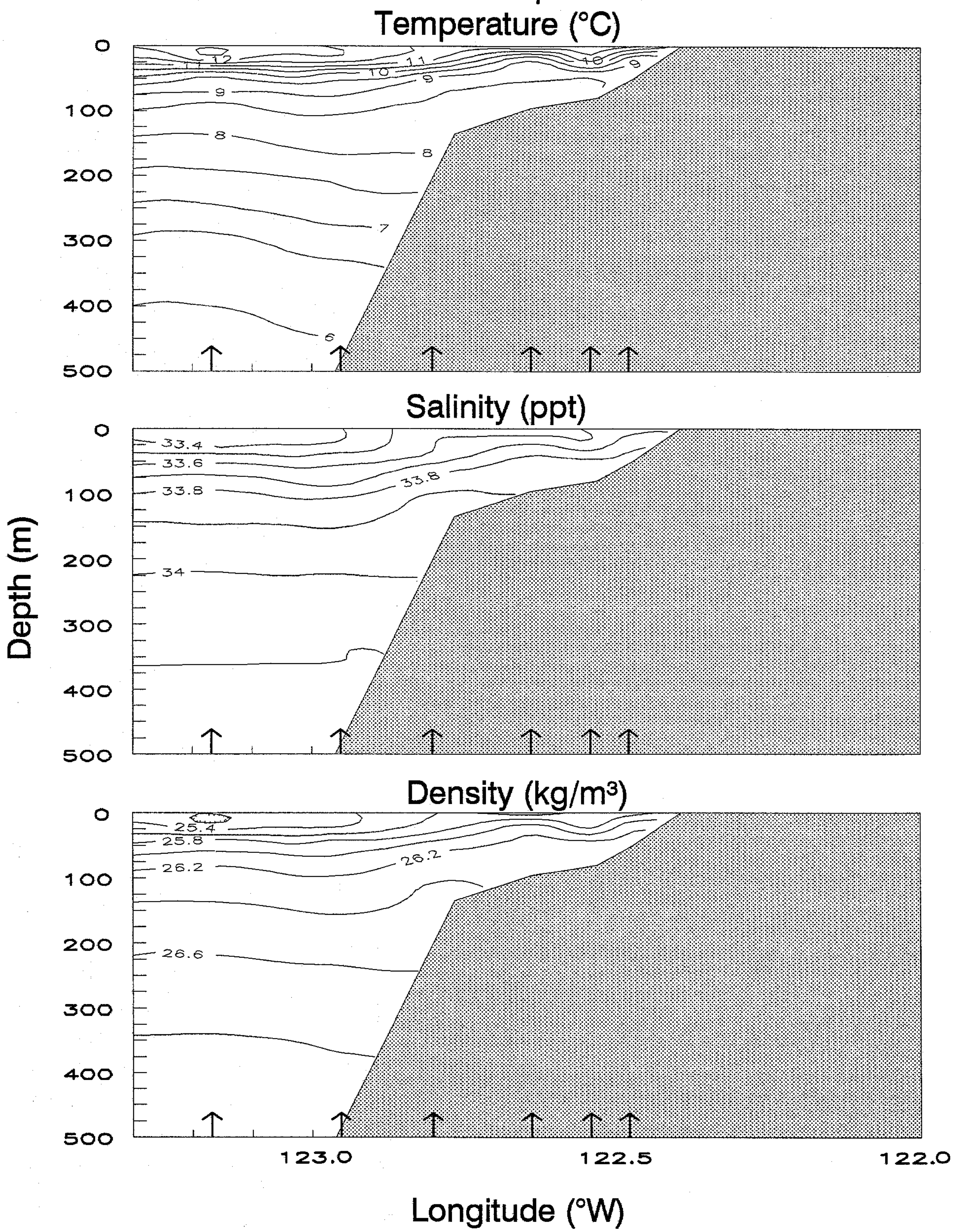

DSJ9406 Sweep 1 Pt. Reyes
Temperature (°C)
Salinity (ppt)
Density (kg/m³)
Depth (m)
Longitude (°W)
0
100
200
300
400
500
124.0
123.5
123.0
12
11
10
9
8
7
6
33
33.2
33.4
33.6
33.8
34
25
25.4
25.8
26.2
26.6

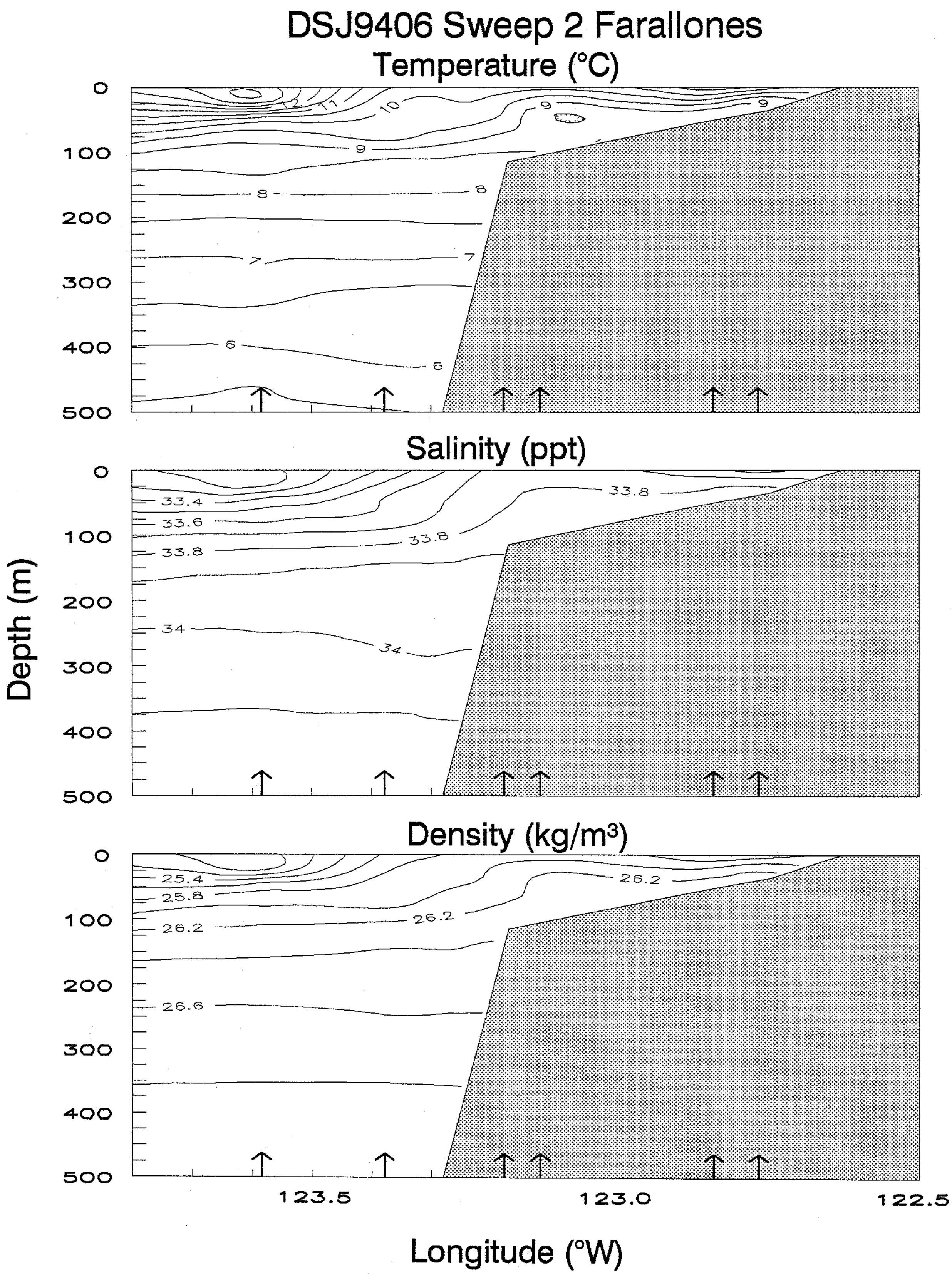

DSJ9406 Sweep 2
Vertical Transect CTD Stations
Pt. Reyes
Farallones
Pescadero
Davenport
38
37
Latitude (°N)
124
123
122
Longitude (°W)



DSJ9406 Sweep 2 Davenport
Temperature (°C)
Salinity (ppt)
Density (kg/m³)
Depth (m)
Longitude (°W)
0
100
200
300
400
500
123.0
122.5
122.0
11
10
9
8
7
6
33.4
33.6
33.8
34
25.4
25.8
26.2
26.6

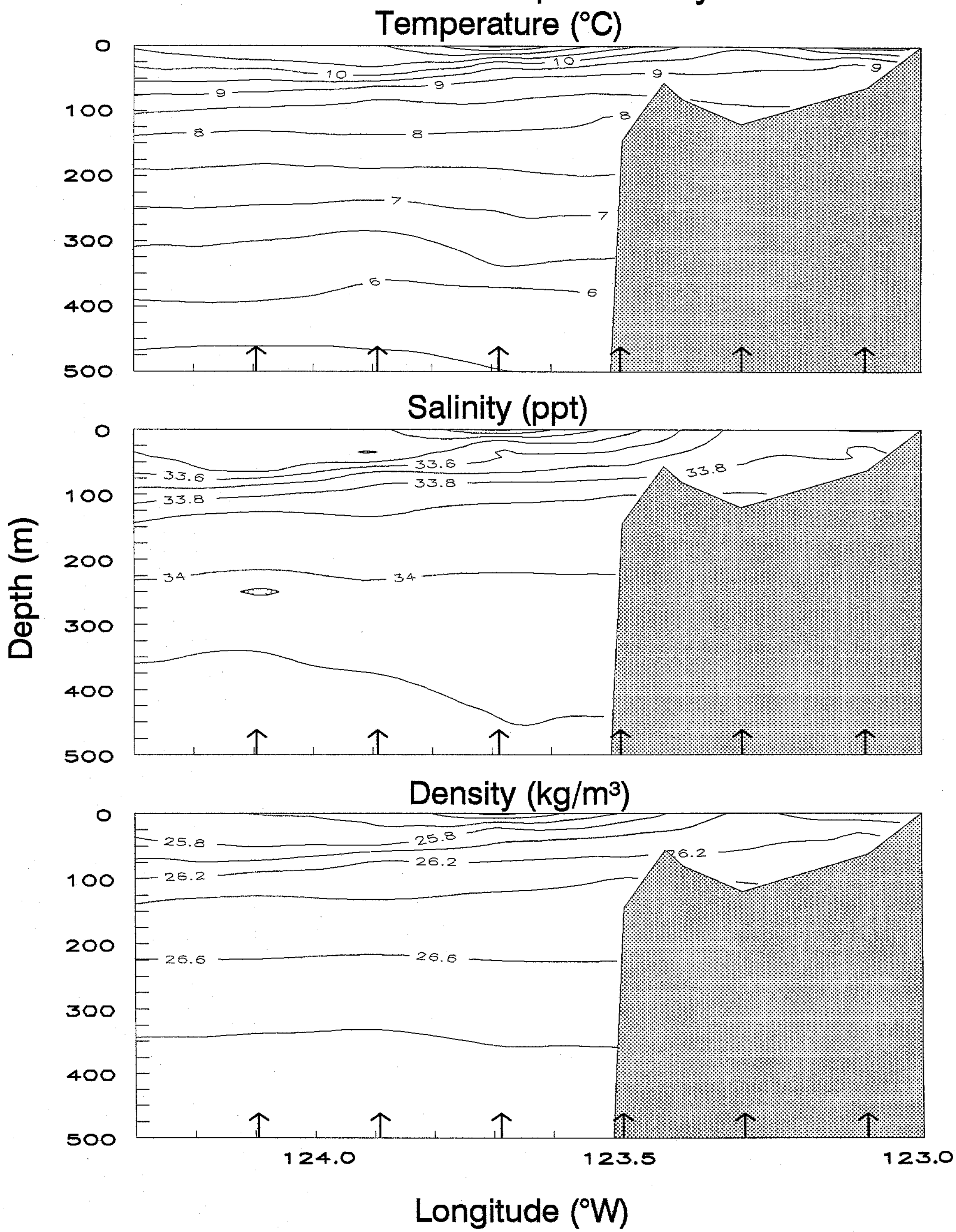
DSJ9406 Sweep 2 Pescadero



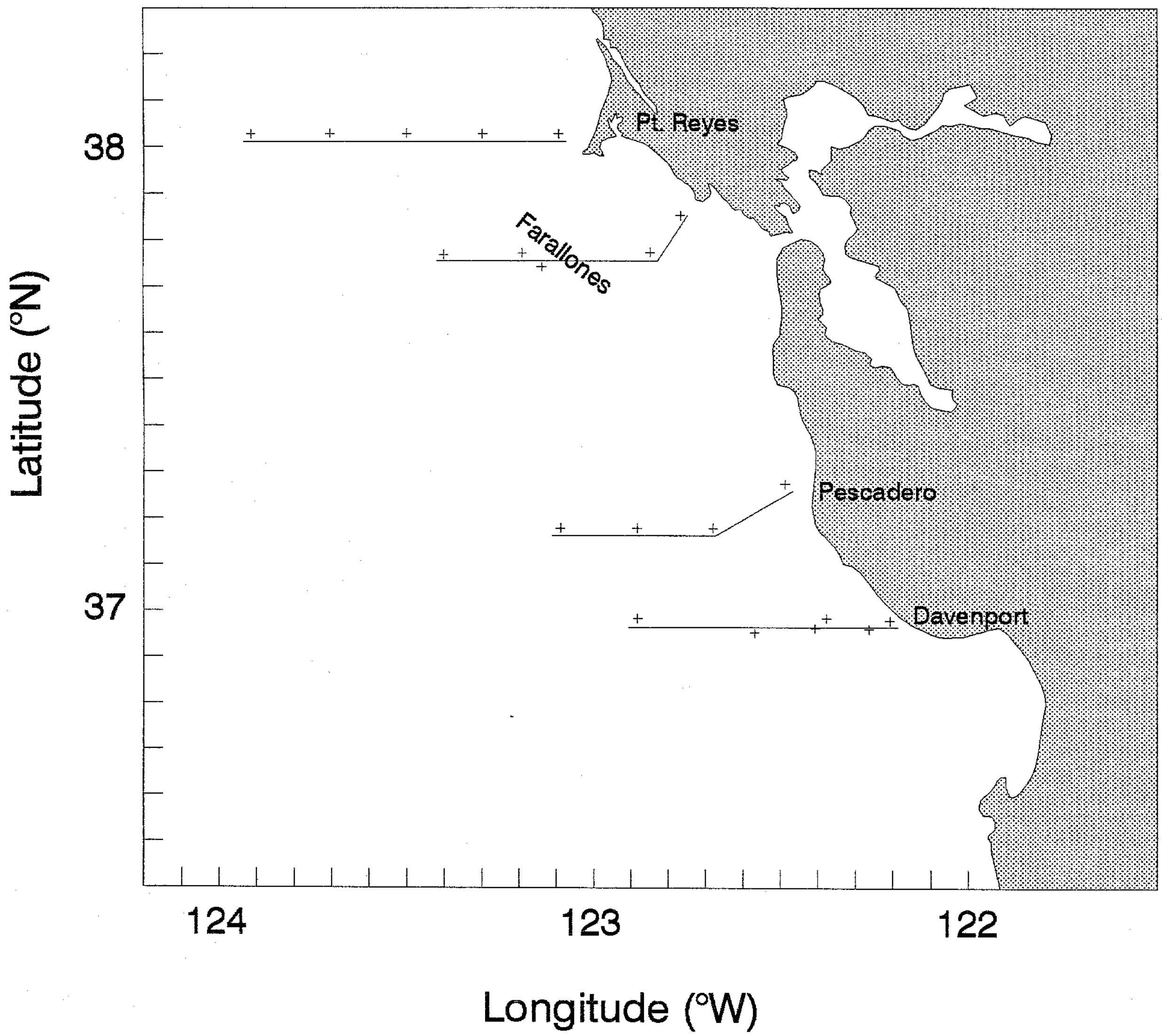


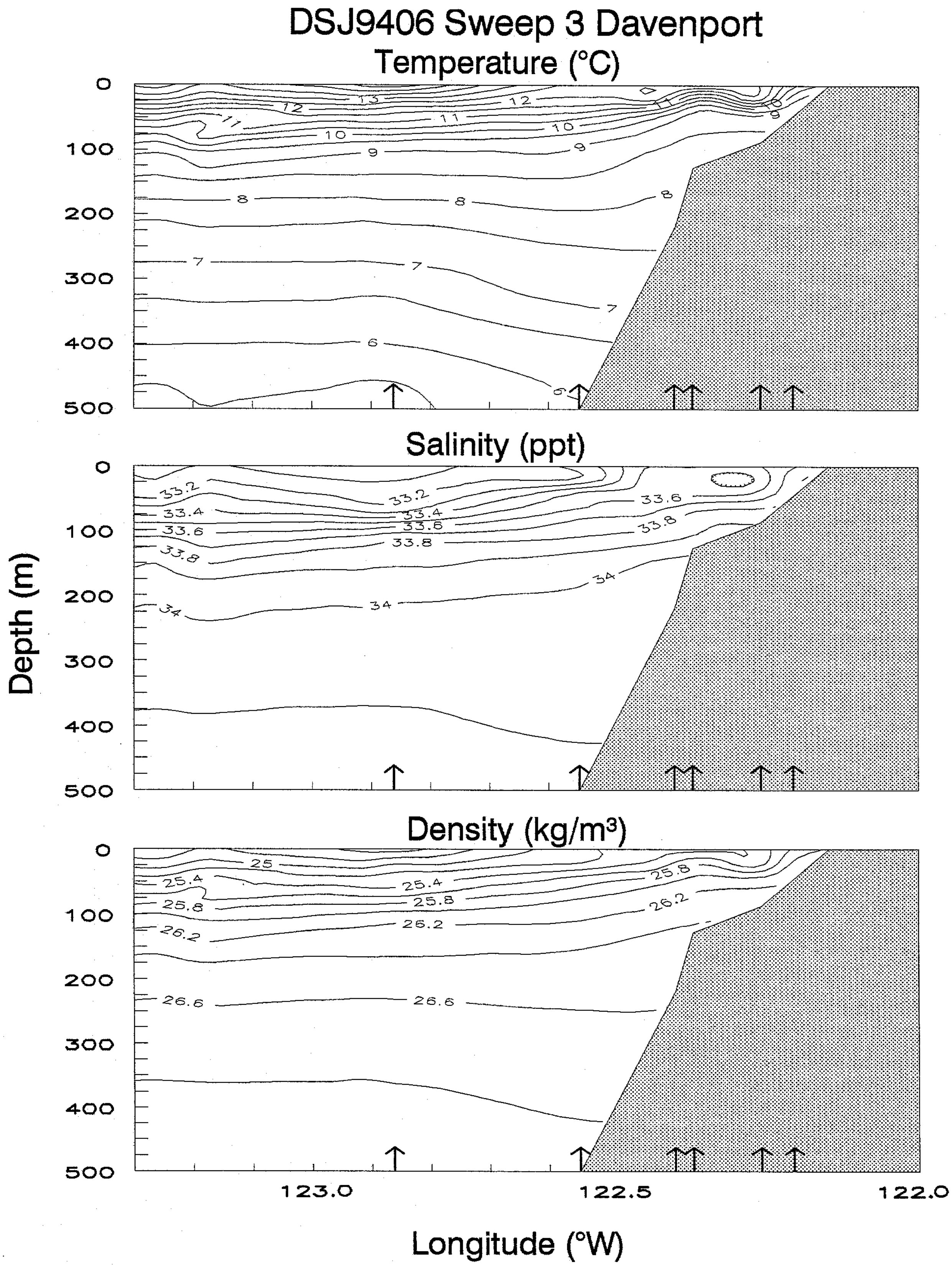
DSJ9406 Sweep 2 Farallones
Temperature (°C)
Salinity (ppt)
Density (kg/m³)
Depth (m)
Longitude (°W)
0
100
200
300
400
500
123.5
123.0
122.5
12
11
10
9
8
7
6
33.4
33.6
33.8
34
25.4
25.8
26.2
26.6

DSJ9406 Sweep 2 Pt. Reyes

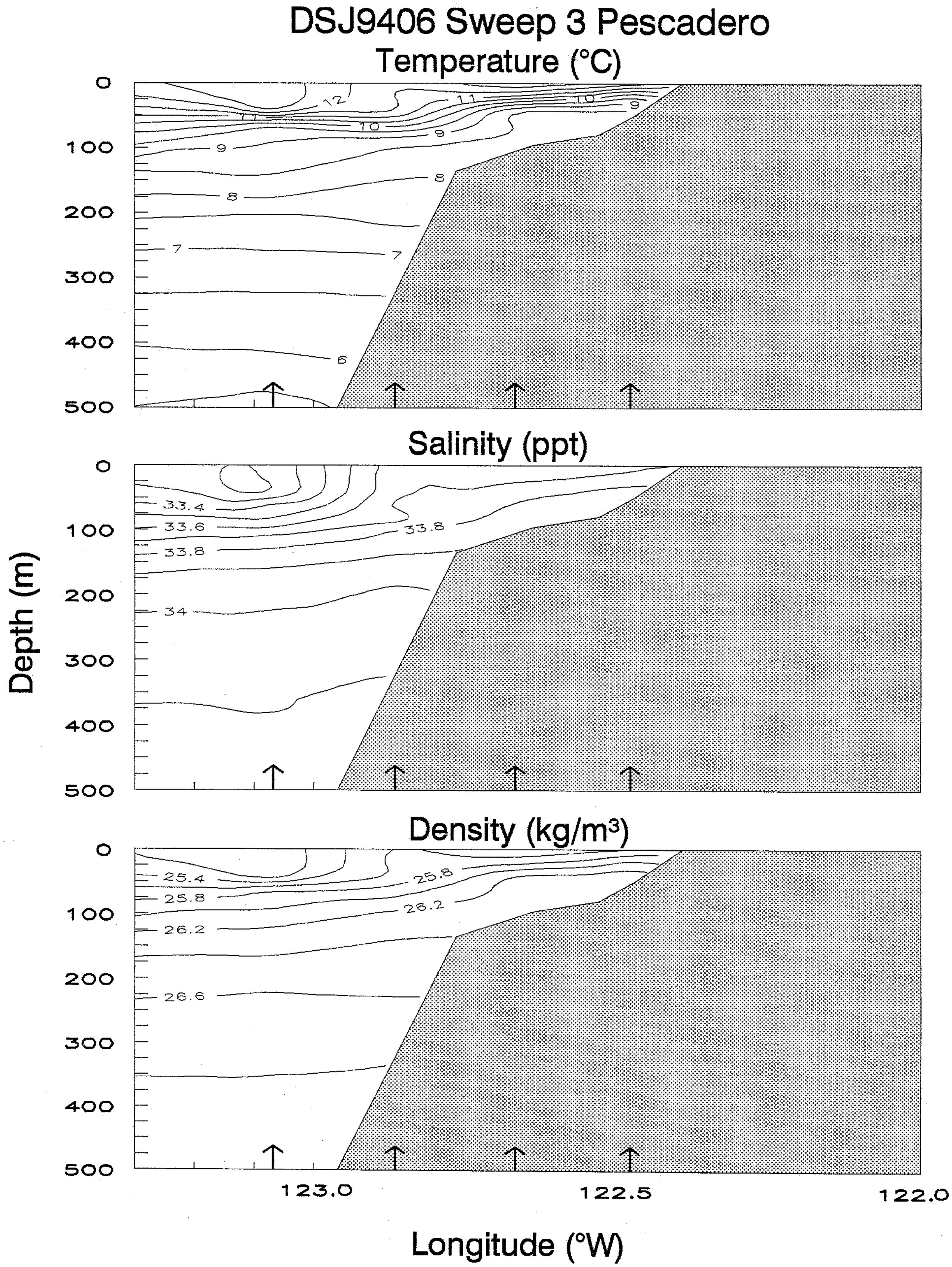


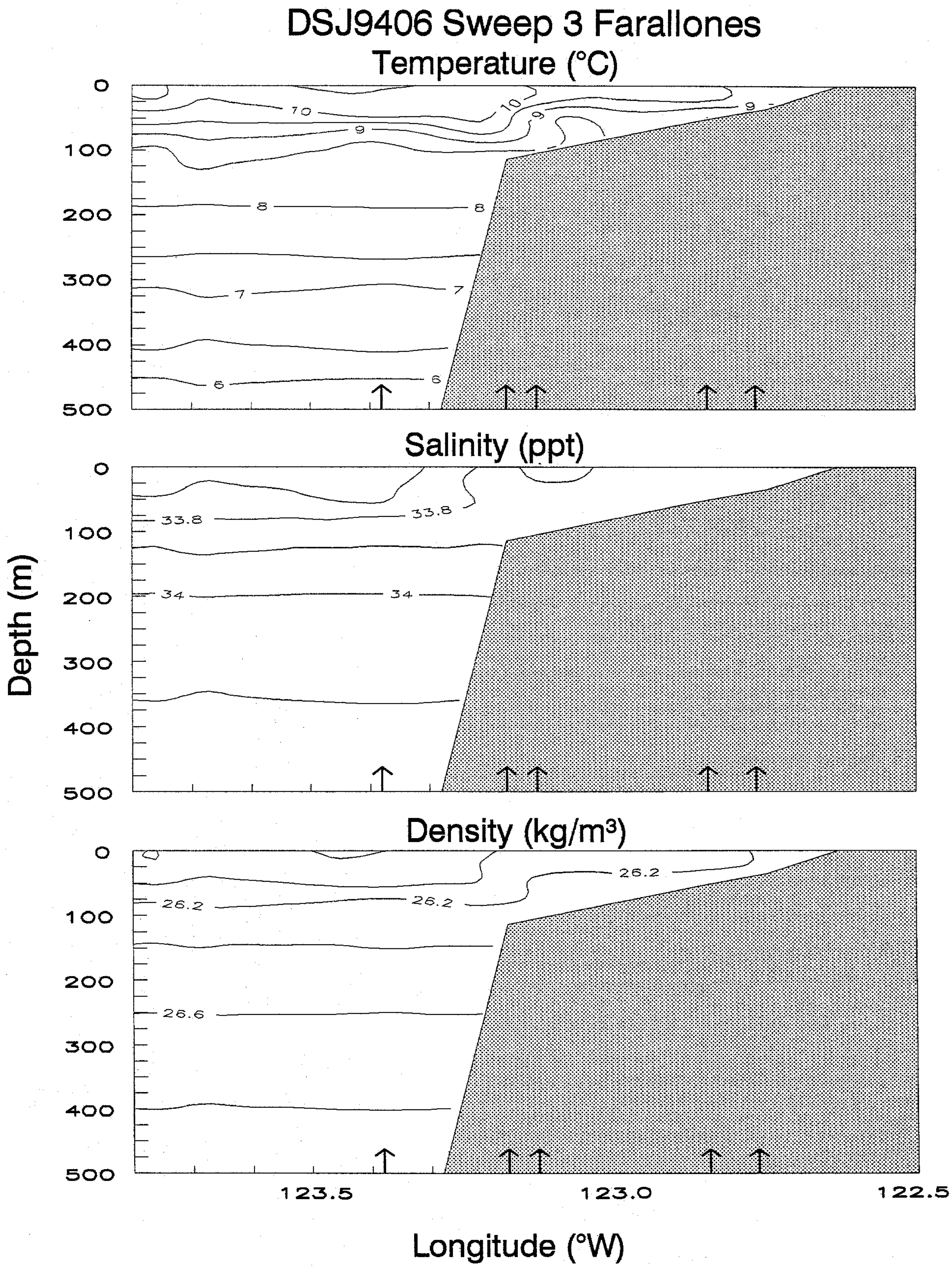
DSJ9406 Sweep 3
Vertical Transect CTD Stations



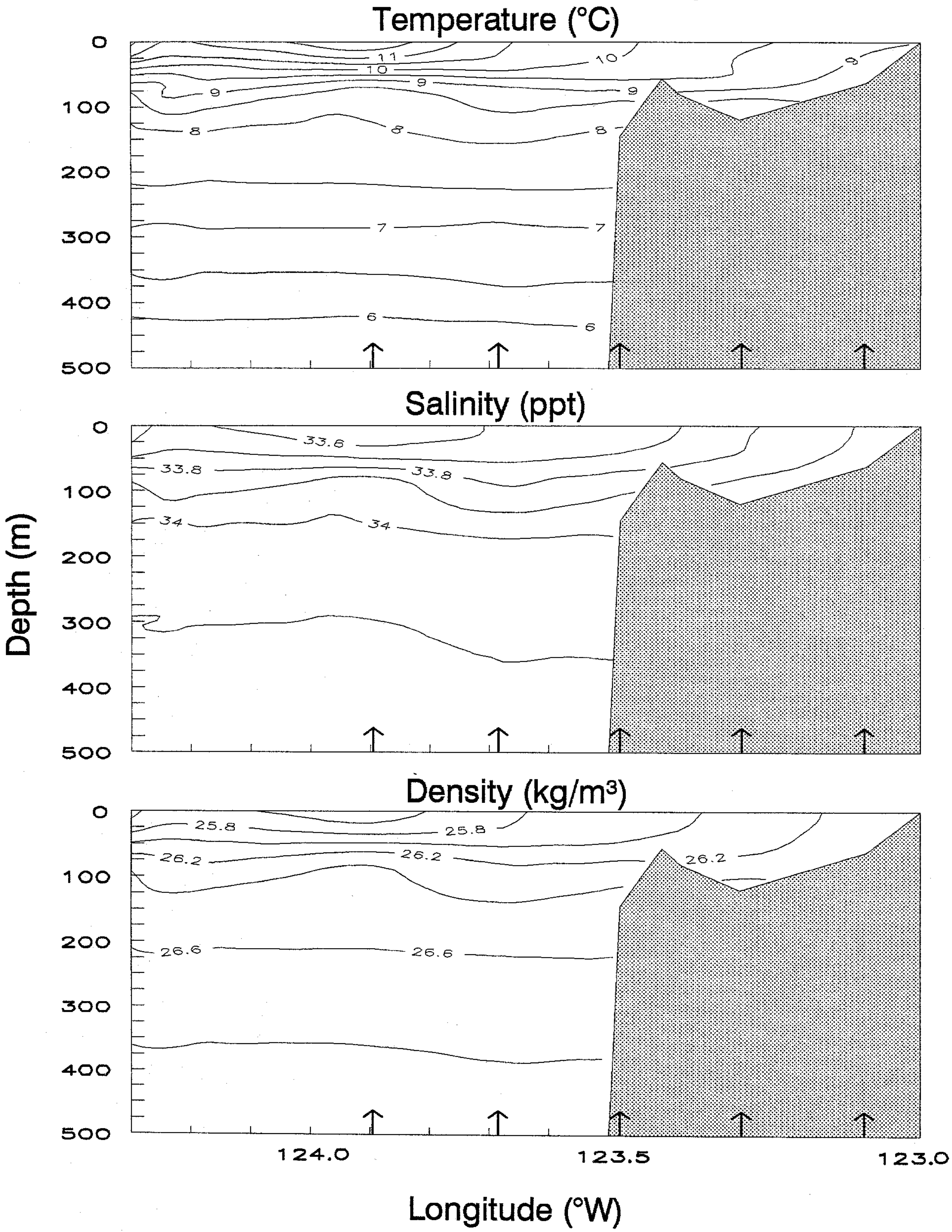


DSJ9406 Sweep 3 Davenport
Temperature (°C)
Salinity (ppt)
Density (kg/m³)
Depth (m)
Longitude (°W)
0
100
200
300
400
500
123.0
122.5
122.0
13
12
11
10
9
8
7
6
33.2
33.4
33.6
33.8
34
25
25.4
25.8
26.2
26.6

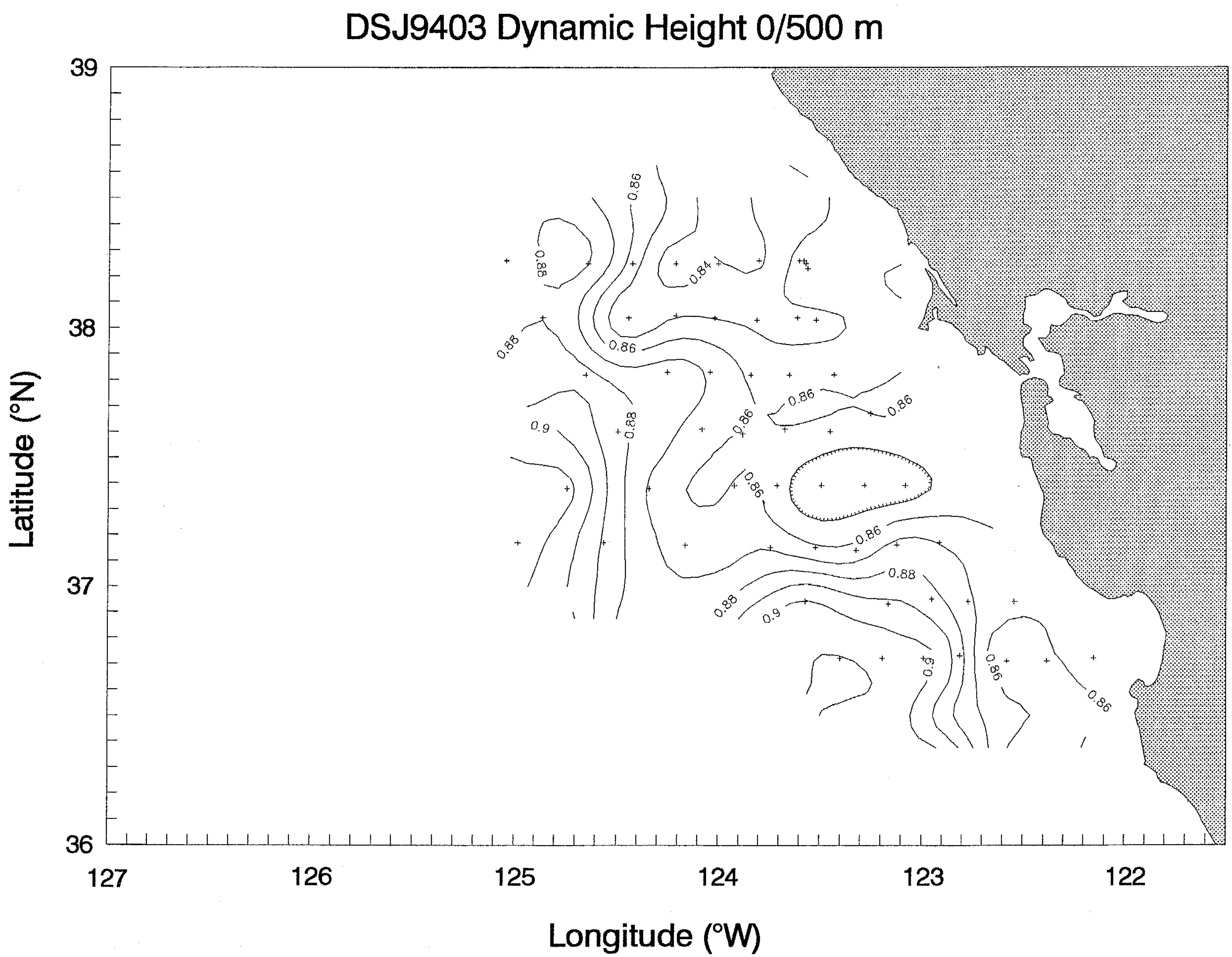

DSJ9406 Sweep 3 Pescadero
Temperature (°C)
12
11
10
9
8
7
6
Salinity (ppt)
33.4
33.6
33.8
34
Density (kg/m³)
25.4
25.8
26.2
26.6
Depth (m)
0
100
200
300
400
500
123.0
122.5
122.0
Longitude (°W)

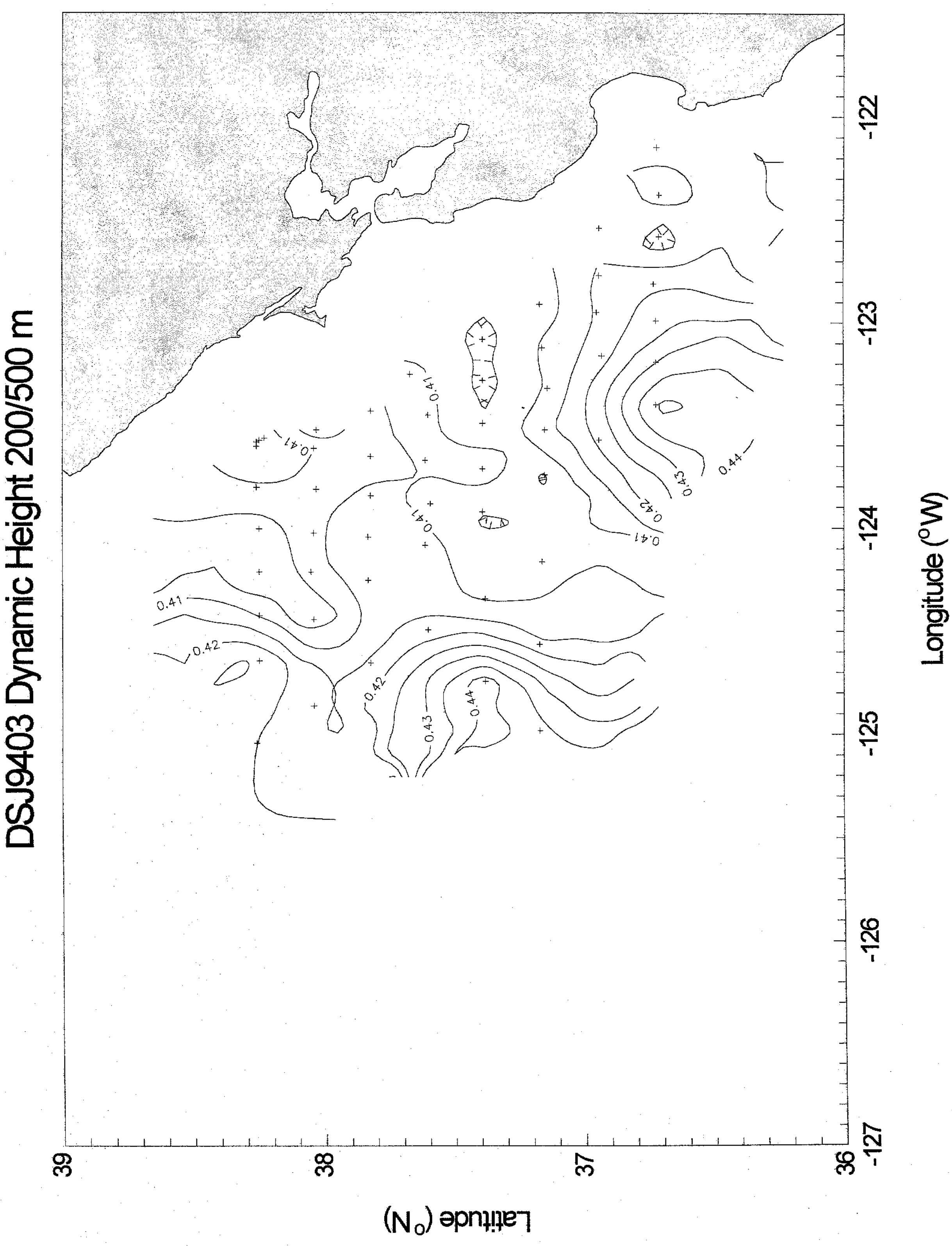

DSJ9406 Sweep 3 Farallones
Temperature (°C)
Salinity (ppt)
Density (kg/m³)
Depth (m)
Longitude (°W)
0
100
200
300
400
500
10
9
8
7
6
33.8
34
26.2
26.6
123.5
123.0
122.5

DSJ9406 Sweep 3 Pt. Reyes



APPENDIX 10.1: DYNAMIC TOPOGRAPHY FOR DSJ9403

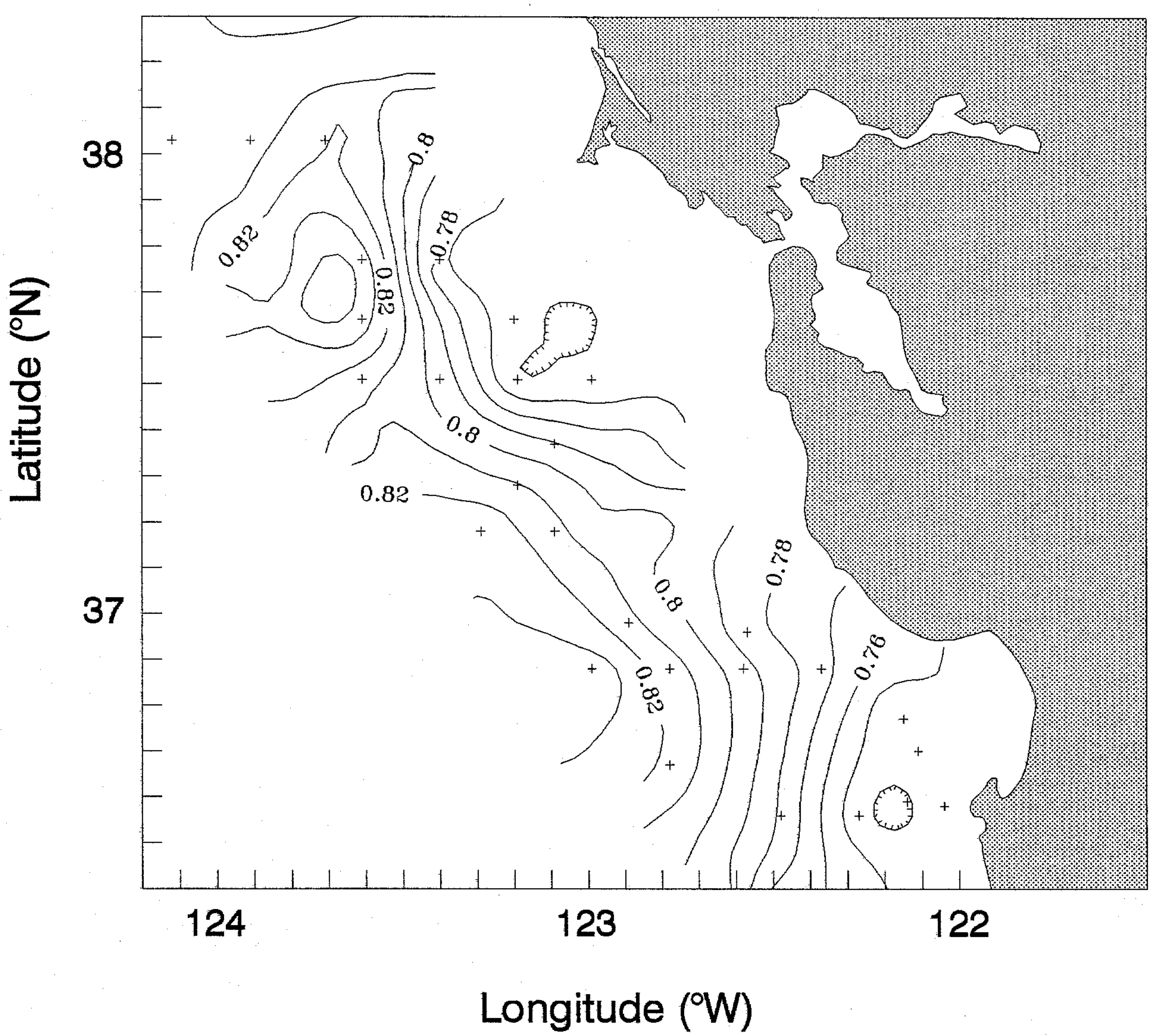

DSJ9403 Dynamic Height 0/500 m
Latitude (°N)
Longitude (°W)
39
38
37
36
127
126
125
124
123
122
0.84
0.86
0.88
0.9

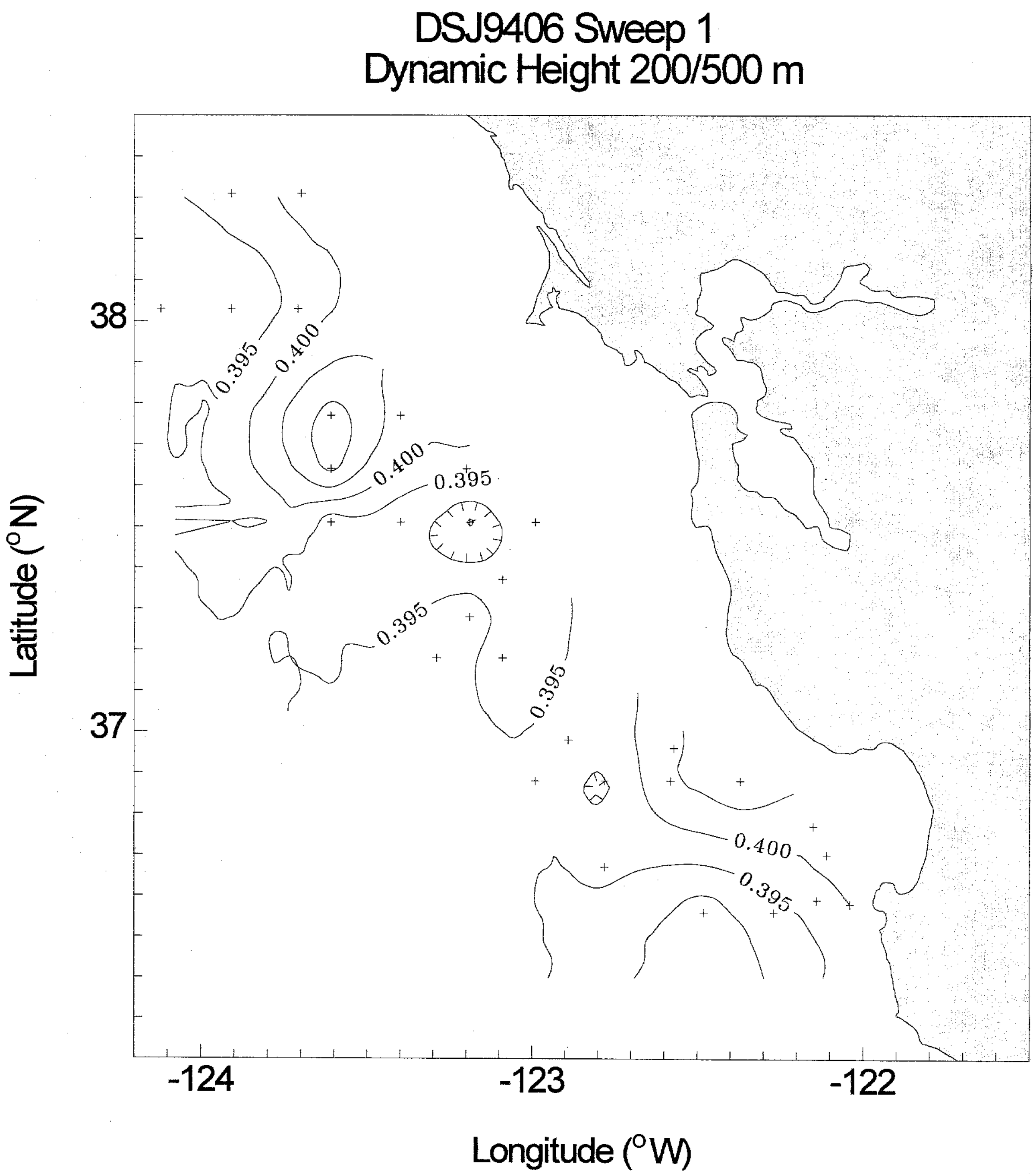


DSJ9403 Dynamic Height 200/500 m
Longitude (°W)
Latitude (°N)
-127
-126
-125
-124
-123
-122
36
37
38
39
0.41
0.42
0.43
0.44

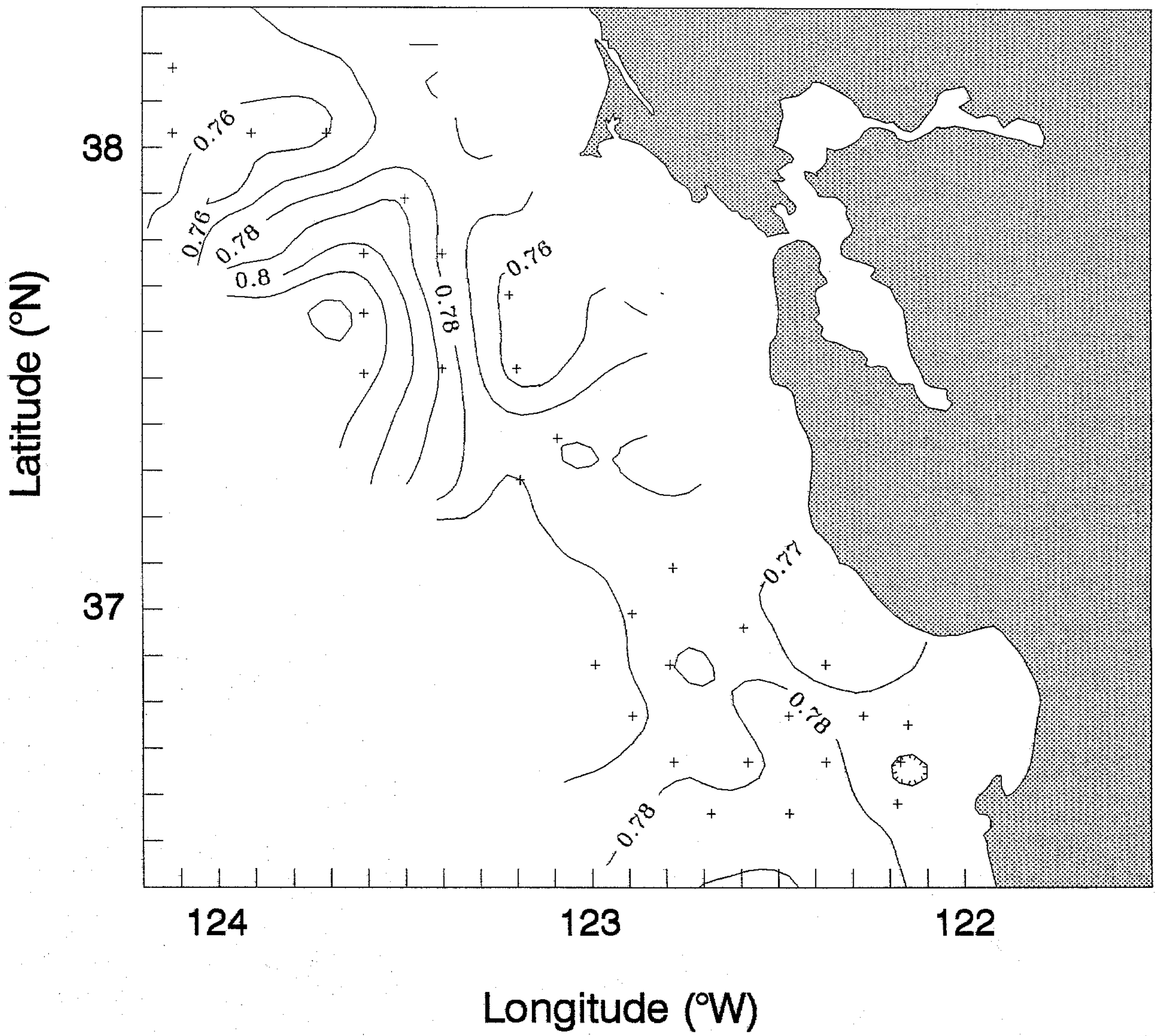
APPENDIX 10.2: DYNAMIC TOPOGRAPHY FOR DSJ9406

DSJ9406 Sweep 1
Dynamic Height 0/500 m

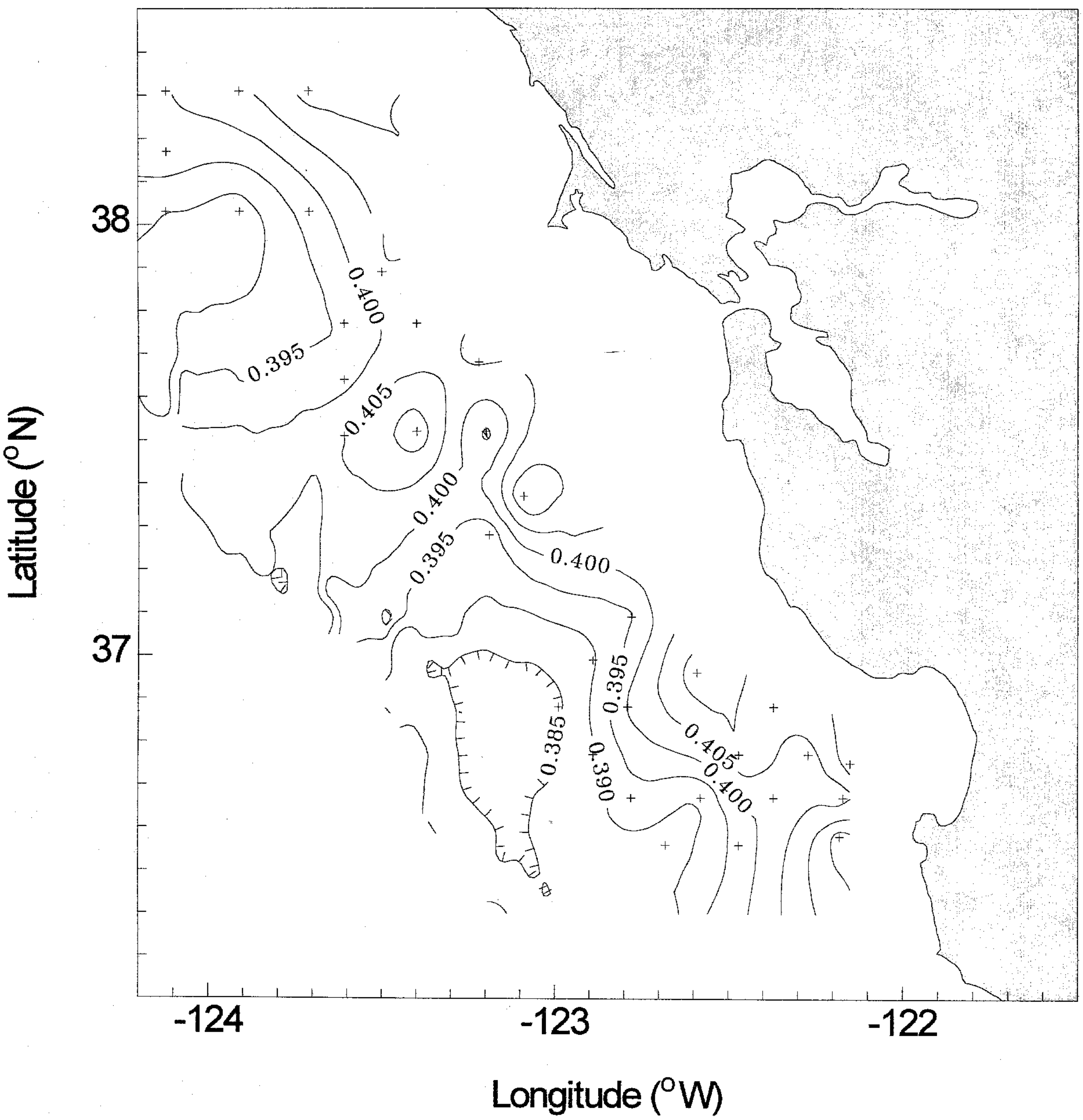


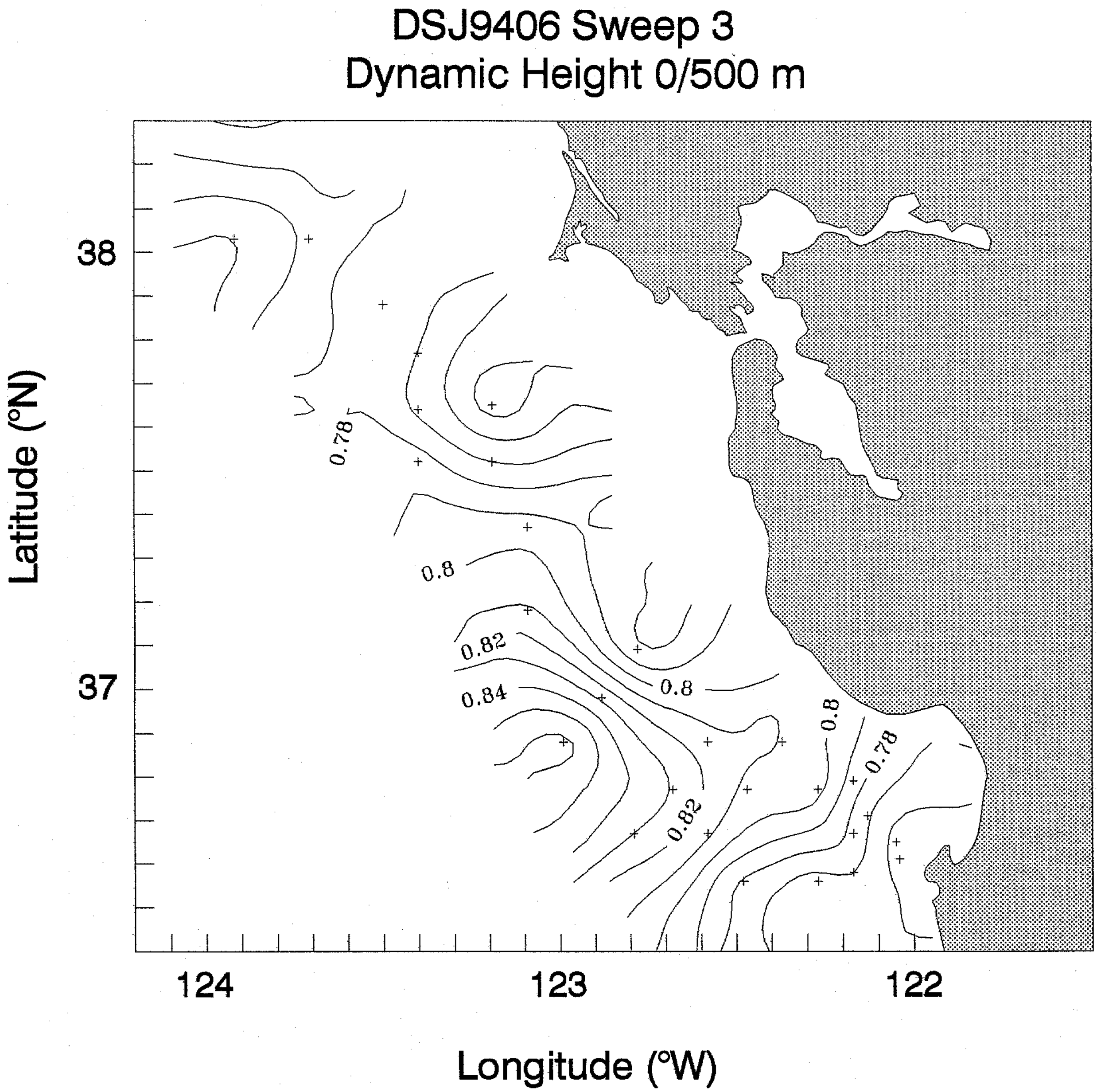

DSJ9406 Sweep 1
Dynamic Height 200/500 m
Latitude (°N)
38
37
Longitude (°W)
-124
-123
-122
0.395
0.400
0.400
0.395
0.395
0.395
0.400
0.395

DSJ9406 Sweep 2
Dynamic Height 0/500 m

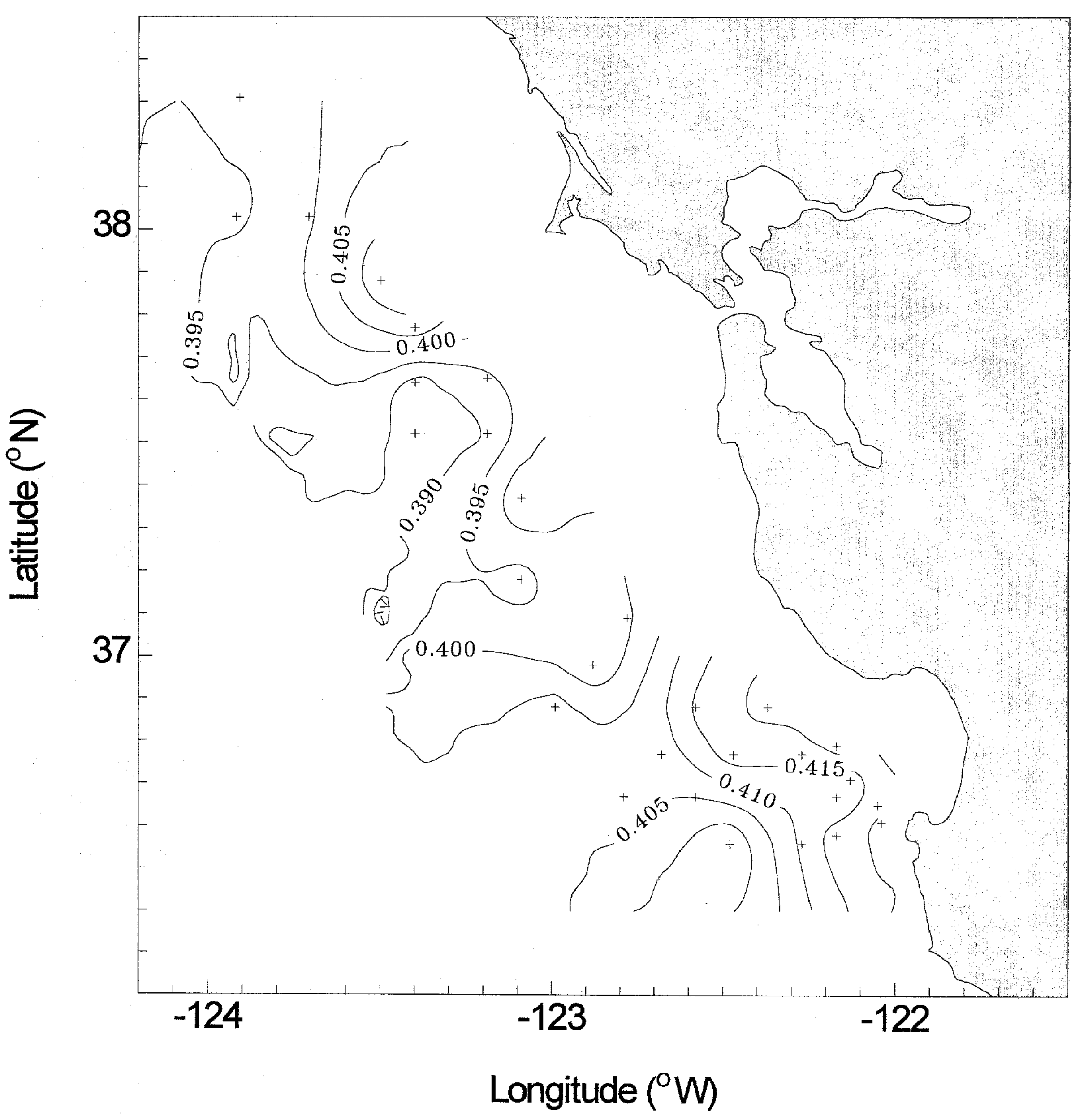


DSJ9406 Sweep 2
Dynamic Height 200/500 m




DSJ9406 Sweep 3
Dynamic Height 0/500 m
38
37
Latitude (°N)
124
123
122
Longitude (°W)
0.78
0.8
0.82
0.84
0.8
0.8
0.78
0.82

DSJ9406 Sweep 3
Dynamic Height 200/500 m



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(October 1994)

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