SEPTEMBER 1997

THE PHYSICAL OCEANOGRAPHY OFF THE CENTRAL CALIFORNIA COAST DURING MAY-JUNE, 1996: A SUMMARY OF CTD DATA FROM PELAGIC JUVENILE ROCKFISH SURVEYS

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NOAA-TM-NMFS-SWFSC-246

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

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Keith M. Sakuma[1]
Franklin B. Schwing[2]
Kenneth Baltz[2]
Dale Roberts[1]
Stephen Ralston[1]

[1]National Marine Fisheries Service, NOAA
Southwest Fisheries Science Center, Tiburon Laboratory
3150 Paradise Drive
Tiburon, California 94920-1211

[2]National Marine Fisheries Service, NOAA
Southwest Fisheries Science Center, Pacific Fisheries Environmental Laboratory
1352 Lighthouse Avenue
Pacific Grove, California 93950-2097

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U.S. DEPARTMENT OF COMMERCE
William M. Daley, Secretary
National Oceanic and Atmospheric Administration
D. James Baker, Under Secretary for Oceans and Atmosphere
National Marine Fisheries Service
Rolland A. Schmitten, Assistant Administrator for Fisheries

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ABSTRACT

Hydrographic conditions during three periods of approximately ten days each from mid-May through mid-June 1996 in the coastal ocean bounded by Cypress Pt. (36°35'N) and Pt. Reyes, California (38°10'N), and from the coast to about 75 km offshore, are summarized in a series of horizontal maps and vertical sections. A total of 244 standard conductivity-temperature-depth (CTD) casts were obtained during the NOAA R/V *David Starr Jordan* cruise DSJ9606 over the course of three consecutive sweeps of the region. Data products contained in this report include (1) a master list of CTD stations during the cruise; (2) surface meteorological time series from the region's four National Data Buoy Center (NDBC) meteorological buoys; (3) horizontal maps of sea surface temperatures from AVHRR (Channel 4) satellite images; (4) 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; (5) temperature, salinity and σ_θ along four cross-shelf vertical transects; (6) horizontal maps of chlorophyll a at 10 m and integrated from the surface to 150 m; and (7) dynamic height topography (0/500 m and 200/500 m) in the survey region.

INTRODUCTION

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

Since 1983, the National Marine Fisheries (NMFS) Southwest Fisheries Science Center's (SWFSC) Tiburon Laboratory has worked on developing a recruitment index for rockfish within the hydrographic region off central California. Annual juvenile rockfish surveys aboard the National Oceanic and Atmospheric Administration (NOAA) research vessel (R/V) *David Starr Jordan* (DSJ) have provided information regarding distributional and abundance patterns of young-of-the-year pelagic juveniles in the area between Monterey Bay and Pt. Reyes (latitude 36°30'-38°10'N) (Wyllie Echeverria et al. 1990). Results of this research show a complex pattern in the spatial distribution of pre-recruits of a variety of commercially significant species (e.g., widow rockfish, *S. entomelas*; chilipepper, *S. goodei*; yellowtail rockfish, *S. flavidus*; and bocaccio, *S. paucispinis*). Moreover, extreme interannual fluctuations in abundance have occurred, with combined back-transformed mean $\log_e$ catches ranging from 0.1-78.6 juvenile rockfish/tow (Adams 1995[1]).

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

This report summarizes results obtained from the CTD data collected in 1996. 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), 1991 (DSJ9102 and DSJ9105), 1992 (DSJ9203 and DSJ9206), 1993 (DSJ9304 and DSJ9307), 1994 (DSJ9403 and DSJ9406), and 1995 (DSJ9506) have been published (Schwing et al. 1990; Johnson et al. 1992; Sakuma et al. 1994a; Sakuma et al. 1994b; Sakuma et al. 1995a; Sakuma et al. 1995b, Sakuma et al. 1996). A companion volume (Schwing and Ralston 1990[2]) 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).

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

[2]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.

MATERIALS AND METHODS

Meteorological Data

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

Annual climatologies and variance were determined for SST and the alongshore wind component at each buoy with a biharmonic analysis of all daily mean data over the buoy's entire operating period. These operating periods were 1981 to 1996 for buoy 46013, 1982 to 1996 for buoy 46026, 1980 to 1996 for buoy 46012, and 1987 to 1996 for buoy 46042. The annual cycles were estimated by a least squares regression of the data to an annual and semiannual harmonic signal of the form

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

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

Sea Surface Temperature Data from AVHRR Satellite Imagery

AVHRR (Advanced Very High Resolution Radiometer) satellite images were transmitted to the NOAA R/V 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 are checked for excessive cloud/fog cover and if clear enough are then calibrated into radiances from the satellite sensor's channels. These radiances are then converted into sea surface temperatures. A cloud masking routine is run on each image file, and then the images are partitioned into different geographic regions along the West Coast. This yields a high resolution (1.1 km) 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 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. Once an image is received, the CCOAST or WIM software was used to decompress, display and manipulate the satellite image in order to discern sea surface temperature gradients and areas of upwelling and mesoscale eddy activity. All images which were clear or relatively clear of clouds/fog were saved on a PC computer and stored at the NMFS SWFSC Tiburon Laboratory and at the NMFS SWFSC PFEL as part of the Oceanographic database system.

Juvenile Rockfish Survey Design

Annual cruises aboard the NOAA R/V DSJ began in 1983 and have been conducted during late spring (April-June), a time when most pelagic-stage juvenile rockfishes are identifiable to species, but prior to their settling to nearshore and benthic habitats. Throughout this time, a standard haul consisted of a 15-minute nighttime tow of a large midwater trawl set to a depth of 30 m.

Additional tows were made at other depths (i.e., 10 and 100 m) as allowed by constraints imposed by time and bottom bathymetry.

In 1986, the sampling design was altered to permit three consecutive "sweeps" through a study area bounded by Cypress Pt. (36°35'N) and Pt. Reyes (38°10'N), California, and from the coast to about 75 km offshore. Five or six stations along a transect were sampled each night and seven transects were completed for each sweep. Starting in 1987, a CTD cast was conducted at each trawl station occupied. In addition, daytime activities were restructured to permit sampling of a new grid of standard CTD stations (Appendix 2). Standard CTD stations were specific locations where CTD casts were scheduled and repeated for each sweep of each cruise. CTD cast locations that were only specific to a particular sweep during a cruise were considered as additional CTD stations. Although each sweep typically lasts approximately ten days (seven nights of scheduled work plus three nights of additional discretionary sampling), adverse weather conditions can extend the duration of a sweep. Logistical constraints can also restrict the number of casts completed. Discretionary sampling typically was focused on specific bathymetric features, such as Cordell Bank or Pioneer Canyon, or devoted to the intense study of oceanic features or processes that may be key to successful recruitment. CTD casts conducted during discretionary sampling were considered additional stations and not included in the grid of standard CTD stations used in this report.

Collection of CTD Data at Sea

All CTD data from the 1996 juvenile rockfish survey presented in this report were collected with two Sea-Bird Electronics, Inc., SEACAT-SBE-19 profilers[3]. These particular units were rated to a depth of 600 m and contained 256K of memory. Both CTDs were also equipped with WETStar model WS3-030 miniature fluorometers. Four data channels were used to record pressure (0.05% of full scale range [50-5,000 psia]), temperature (0.01 °C from -5 to +35 °C), conductivity (0.001 S/m from 0 to 7 S/m), and fluorometer voltage at a baud rate of 9,600. Dual casts using both units yielded similar profile data for temperature and salinity. The tempurature and conductivity sensors of 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, temperature, and fluorometer 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 520 m of cable was let out 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), (9) bucket salinity (salinity of a bucket sample of surface water using a hand-held portable salinometer), and (10) bottom depth in meters. In addition, a water sample from 10 m was collected once a day (using a Nisken bottle attached to the hydrographic winch cable) for later use in calibrating the WETStar fluorometer dsta. Position fixes were obtained using the Global Positioning System (GPS). Collection information recorded on the data sheets were eventually entered into data files on a personal computer.

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

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[3]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.

An additional source of hydrographic data was the vessel's Sea-Bird Electronics, Inc., thermosalinometer (TS) unit, which provided a continuous data stream of surface temperature and salinity. These data were logged by the vessel's scientific computer system and transferred to a personal computer 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 files to ASCII files. This was accomplished using programs supplied by Sea-Bird Electronics, Inc., in SEASOFT menu-driven release Version 4.216[4]. All files were batch-processed through the SEASOFT modules DATCNV, FILTER, ALIGNCTD, LOOPEDIT, BINAVG, and DERIVE (refer to footnote 4 and past Technical Memorandums, e.g., Sakuma et al. 1995b, for more information) and output as ASCII files macros. All data were averaged into two-meter depth bins. Each CTD ASCII file was subsequently manually edited to remove large outliers (i.e., data spikes) in salinity and/or density, which sometimes occurred near the surface and at the thermocline. Comparisons were made between CTD temperature and salinity from the two-meter depth bin, TS temperature and salinity, bucket temperature, and bucket salinity at each CTD station using a simple regression to check for data outliers and any blatant calibration problems (Appendix 5).

Processed hydrographic data were summarized, by sweep, in a series of horizontal maps and vertical sections. Although additional CTD casts were completed during DSJ9606, only casts from the grid of standard CTD stations and those casts which provided a relatively continuous sampling track within a specific sweep were included in the data summary for the horizontal maps (Appendix 6). This was done in an attempt to generate a relatively synoptic representation of each individual sweep and to spatially standardize hydrographic comparisons among sweeps. Vertical sections from the three sweeps of DSJ9606 were also spatially standardized (Appendix 7). However, the Farallones transect line was less synoptic than the Pt. Reyes, Pescadero, and Davenport transect lines, because casts were combined over a 2- to 3-day time period instead of the more usual 24-hour period. In addition, the Farallones transect line does not follow a straight course, which may lead to some distortion of the vertical section contours nearshore. All contouring of CTD data for horizontal maps and vertical sections was done using SURFER FOR WINDOWS graphics software[5], 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).

To better assess the upper water masses at the mesoscale level, the depths, salinities, and thickness between two density surfaces were extracted from the CTD data files and contour plots using gray shading in concert with lines of constant salinity, depth, and thickness were generated for each sweep of DSJ9606. Dates and locations of each CTD cast were merged with the depth, density and salinity data for plotting purposes. The two density surfaces chosen were the 25.8 σ_θ and the 26.2 σ_θ isopycnal. These two density surfaces were chosen as they consistently occupied the upper 100 meters of water depth. Salinity units were based on the Practical Salinity Scale, and the software application used to extract, compute, and plot the data was MATLAB version 4.2c.1[6] for UNIX.

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[4]CTD Data Acquisition software, SEASOFT Version 4.216, October 1995, 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.

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

[6]MATLAB, The Mathworks Inc., 24 Prime Park Way, Natick, Massachusetts 01760-1500, USA. Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

To better assess the surface layer mixing over the cruise survey region, the mixed layer depth was extracted from the processed CTD data and contour plotted using gray shading in concert with lines of constant mixed layer depths. Dates and locations of each CTD cast were merged with the density, temperature, and salinity data for plotting purposes. The mixed layer depth was determined using the same criteria used by NOAA's National Oceanographic Data Center for determining the mixed layer depth at mid-latitudes for the global ocean. The criteria used to compute the mixed layer depth was based on a fixed temperature difference in °C. This fixed temperature criteria was: Δt = 0.5°C, where Δt was the temperature difference in °C between the ocean surface and the bottom of the mixed layer. The plotted mixed layer depths were considered the water depth at the bottom of the diurnal mixed layer over its daily cycle. MATLAB version 4.2c.1[6] was the software application used to compute and plot the mixed layer depths.

The TS raw data were edited to provide a nearly continuous sampling track for each sweep of DSJ9606. However, there appeared to be a consistent offset between salinity recorded by the TS and salinity recorded by the CTD at 2-m depth for the entire cruise (Appendix 5). Because the CTD was calibrated annually by the manufacturer, and because problems occurred with the TS unit in the past during DSJ9203, DSJ9304, and DSJ9406, TS salinity values were considered less reliable and, when necessary, were adjusted using a regression comparison with the CTD. That is,

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

where TS' is the adjusted thermosalinometer value (either temperature or salinity), TS is the unadjusted value, and α and β are the intercept and slope parameters of the regression of 2-m CTD data (temperature or salinity) on the corresponding TS value. TS data were subsequently contoured using SURFER FOR WINDOWS[5].

The WETStar fluorometer data was calibrated using 36 Niskin bottle samples collected at 10 m. A 274-ml sample was removed from the Niskin bottle and filtered through a 25 μm Watman GF/F glass filter. The filters were placed in scintillation vials containing 10 ml of 90% acetone and stored in a freezer aboard ship. Immediately after the cruise, the filtered samples were analyzed at the Monterey Bay Aquarium Research Institute (MBARI) (P.O. Box 628, Moss Landing, California 95039) using a benchtop analog fluorometer to measure chlorophyll concentrations. The calibration equation used to convert the WETStar fluorometer data to estimates of chlorophyll concentration was:

$$Y_{sample}\ (\mu g/l) = (1.59 \times F_{sample}) - 0.223$$

where Y_{sample} is the estimated concentration of chlorophyll in a particular sample and F_{sample} is the WETStar fluorometer value. The converted data were then summarized for each sweep by contouring the chlorophyll concentration at 10 m and the integrated total chlorophyll from the surface to 150 m using SURFER FOR WINDOWS[5] (Appendix 8).

Dynamic height was calculated for stations occupied during DSJ9606 using a 500-db base. CTD casts conducted in areas with bottom depths less than 500 m were not included in this analysis. The dynamic height topography of the 0-db surface relative to the 500-db surface and the 200-db surface relative to the 500-db surface for the three sweeps of DSJ9606 were output from the DERIVE module of SEASOFT Version 4.216[4] and these data were gridded in SURFER FOR WINDOWS[5]. A 0.01 contour interval was chosen for the 0 db surface relative to the 500-db surface maps and a 0.005 contour interval for the 200-db surface relative to the 500-db surface (Appendix 9).

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

RESULTS

Data Products

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

Appendix 1: List of CTD Stations Summarized from Cruise DSJ9606

The station list includes, from left to right, CTD cast number (only acceptable casts included), date, local military time, latitude and longitude (degrees, minutes), and station bottom depth. Cruise DSJ9606, Sweep 1 (May 18-May 25) includes 74 standard stations (casts 4-78), Sweep 2 (May 26-June 2) includes 77 standard stations (casts 82-159), and Sweep 3 (June 10-19) includes 93 standard stations (casts 228-322).

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

The locations of the standard CTD stations for DSJ9606 along with the locations of the NDBC buoys, the place names, and the bottom bathymetry of the survey areas are shown.

Appendix 3: Meteorological Time Series

Wind vectors and SST and alongshore wind time series are presented for January-June 1996 for the four NOAA NDBC buoys located within the survey region. The first figure in this section summarizes the daily-averaged wind velocities (m/s) in stick vector form. Vectors point in the direction toward which the daily-mean wind was blowing; a vector pointing toward the south-southeast (bottom right of page) represents an upwelling-favorable wind. The scaling vector to the left of each series represents a 10 m/s wind blowing alongshore at each location, from the principal component analysis. The times of the three sweeps are shaded.

The following figures show the January-June 1996 time series of daily-averaged buoy SST and alongshore wind plotted against the climatology. In each plot, the bold solid line represents the daily-mean values of the parameter. The bold dotted line represents the biharmonic fit to the climatology derived from daily data over the operating period of the buoy to date. The gray shaded envelope about the biharmonic fit line is ±1 standard error of the daily values on each Julian day. Negative values denote southward (upwelling-favorable) winds. The "PCA direction" legends on the alongshore wind plots represent the direction of the alongshore wind relative to north, which was derived from a principal component analysis.

Appendix 4: AVHRR Satellite Images of 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 each of the three sweeps during DSJ9606. Each image represents a single pass during the afternoon hours, local time. The temperature color spectrum ranges from 9-17°C. Areas experiencing upwelling appear as blue and dark blue, whereas areas with warmer water appear as orange and red. Cloud cover and/or fog appear as white.

Appendix 5: 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:

Sweep 1

CTD temperature versus TS temperature,
CTDtemp. = TStemp. x 0.9903 + 0.0737
$R^2 = 0.9897$
CTD temperature versus bucket temperature,
CTDtemp. = buckettemp. x 0.9580 + 0.3623
$R^2 = 0.9811$
TS temperature versus bucket temperature,
TStemp. = buckettemp. x 0.9602 + 0.3834
$R^2 = 0.9764$
CTD salinity versus TS salinity,
CTDsal. = TSsal. x 0.8731 + 4.3445
$R^2 = 0.7816$
CTD salinity versus bucket salinity,
CTDsal. = bucketsal. x 0.9070 + 3.0505
$R^2 = 0.8908$
TS salinity versus bucket salinity,
TSsal. = bucketsal. x 0.7939 + 6.6842
$R^2 = 0.6933$

Sweep 2

CTD temperature versus TS temperature,
CTDtemp. = TStemp. x 0.9989 - 0.0283
$R^2 = 0.9974$
CTD temperature versus bucket temperature,
CTDtemp. = buckettemp. x 1.0029 - 0.2059
$R^2 = 0.9910$
TS temperature versus bucket temperature,
TStemp. = buckettemp. x 1.0037 - 0.1753
$R^2 = 0.9931$
CTD salinity versus TS salinity,
CTDsal. = TSsal. x 0.9266 + 2.6146
$R^2 = 0.7665$
CTD salinity versus bucket salinity,
CTDsal. = bucketsal. x 0.7474 + 8.4352
$R^2 = 0.6084$
TS salinity versus bucket salinity,
TSsal. = bucketsal. x 0.8062 + 6.2942
$R^2 = 0.7985$

Sweep 3

CTD temperature versus TS temperature,
CTDtemp. = TStemp. x 1.0025 - 0.0622
$R^2 = 0.9995$

CTD temperature versus bucket temperature,
CTDtemp. = buckettemp. x 1.0150 - 0.3513
$R^2 = 0.9927$
TS temperature versus bucket temperature,
TStemp. = buckettemp. x 1.0120 - 0.2837
$R^2 = 0.9928$
CTD salinity versus TS salinity,
CTDsal. = TSsal. x 1.0001 + 0.1507
$R^2 = 0.7096$
CTD salinity versus bucket salinity,
CTDsal. = bucketsal. x 0.8593 + 4.6487
$R^2 = 0.6943$
TS salinity versus bucket salinity,
TSsal. = bucketsal. x 0.7324 + 8.7940
$R^2 = 0.7139$

Appendix 6: Horizontal Maps of CTD and TS

a) Maps of TS temperature and salinity

Maps of surface temperature (°C) and salinity obtained from the vessel's TS continuous profiling unit are presented for each sweep of DSJ9606. 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 0.1 for salinity. They are included to provide some verification of hydrographic spatial patterns inferred from the CTD data. The 2-m CTD and surface TS maps display good 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, 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 3). The 30-m depth was contoured to coincide with the standard midwater trawl depth during the surveys. The contour intervals are 0.2°C, 0.1, and 0.1 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, and 0.02 kg/m^3.

c) Maps of mixed layer depths

Mixed layer depths (m) were estimated from the vertical temperature gradients for each CTD cast, defined as the depth at which the temperature was 0.5°C lower than the 2-m depth, and contoured by sweep. The contour interval is 5 m; lighter shading denotes a deeper mixed layer.

d) Maps of depth and salinity on isopycnal surfaces

The depth of, and salinity on, the 25.8 and 26.2 sigma-theta isopycnal surfaces are contoured for each sweep. The contour intervals are 5 m and 0.04 ppt, with lighter shading denoting greater depths and lower salinities.

Appendix 7: Vertical sections

Vertical sections of temperature, salinity and density are presented for four cross-shelf transects off Pt. Reyes, the Farallones, Pescadero, and Davenport for DSJ9606. Station maps denote the location of each transect and the offshore extent of stations (marked by a +) used to generate plots for each sweep. The locations of CTD casts used in generating the vertical sections are shown on each section by a ◆. The contour intervals are 0.5°C for temperature, 0.1 for salinity, and 0.2 kg/m^3 for density.

Appendix 8: Horizontal Maps of Chlorophyll a

Horizontal maps of chlorophyll a at 10 m and integrated from the surface to 150 m are presented for the three sweeps of DSJ9606. Contour intervals are 0.5 mg/m^3 for the 10-m contour map and 10 mg/m^2 for the integrated (0-150 m) map. The locations of the CTD casts used in generating the horizontal contours are shown by a + symbol.

Appendix 9: Dynamic Height Topography

Horizontal maps of dynamic height (0/500 m and 200/500 m) are presented for the three sweeps of DSJ9606. 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.

Synopsis of Meteorological and Hydrographic Conditions

The seasonal pattern of winds observed in 1996 at the area's four NDBC buoys correspond to the long-term climatology of west coast buoys. In this edition of the juvenile rockfish survey report, we include the long-term climatologies of alongshore wind and SST at each buoy. Wind vectors align strongly with the local coastline. Winter winds in 1996 were highly variable over short time scales, a consequence of a series of strong winter storms that crossed the coast. In the mean, the winter winds were poleward and stronger than normal. Summer winds were predominantly upwelling favorable. One notable event in 1996 was a coast-wide wind reversal in mid-May, immediately prior to the groundfish survey, that produced poleward winds for a brief period. Otherwise the winds during the survey were upwelling favorable and significantly stronger than normal. Overall, winds during 1996 were more upwelling favorable than during 1995, and featured much stronger-than-usual southward velocities.

Moderate La Niña conditions developed in the tropical Pacific in about September 1995 and influenced the California Current region through 1996. Usually, La Niña (e.g., 1989) effects include cooler-than-average SSTs throughout this region (Murphree and Reynolds 1995). During 1995-1996 however, much of the eastern North Pacific Ocean, including the area adjacent to California, was 1-2°C warmer than normal (National Centers for Environmental Prediction [NCEP] 1996; Schwing et al. In press). Corresponding surface wind anomalies off the U.S. west coast were counterclockwise (NCEP 1996) and sea level was anomalously high, suggesting that Ekman pumping (divergence in the surface Ekman layer) was weaker than normal. This implies greater coastal upwelling but decreased open ocean upwelling, which led to relatively warm offshore SSTs. The atypical extratropical response to the 1995-1997 La Niña may have been due to an unusual distribution of atmospheric heating anomalies in the tropical Pacific, which led to anomalous sea level pressure and wind and the warm ocean conditions (Schwing et al. In press). Tropical atmosphere and ocean anomalies appeared in early 1997 that indicated an emerging El Niño.

Buoy SSTs reflect both the large-scale anomaly patterns seen throughout the north Pacific (NCEP 1996; Schwing et al. In press), and the changes in wind forcing over time. SSTs were warmer than normal in early 1996. Unusually cool SSTs, which are related to the anomalously strong upwelling-favorable wind conditions, commenced in late April and predominated for most of the summer, including Sweeps 2 and 3. SSTs at the onset of Sweep 1, on the other hand, warmed in response to the mid-May wind reversal. Thus while very warm surface waters resided just offshore of the survey region, strong coastal upwelling resulted in cool nearshore SSTs.

Ocean conditions off central California during May-June 1996 were cooler and more saline than average (Lynn et al. 1982), and suggest the greatest coastal upwelling rates since 1991. Upper layer temperatures were 9-10°C, 2-4°C warmer than measured during the same period in 1992 and 0.4-0.6 higher than seen during that ENSO event. Near-surface salinities exceeded 34.0 at upwelling centers. Upwelling also appeared to increase over the course of the survey's three sweeps, based on wind and CTD observations. As in the 1995 survey and in March-April 1996 (Schwing et al. In press), high levels of winter precipitation led to considerable freshwater input from San Francisco Bay; salinities of 32.5-33.0 were found confined to the upper 10 m seaward of the Golden Gate.

For a given density, water below the mixed layer was warmer and saltier (more "spicy") in 1996 than the mean of the previous ten years (Figure 1), which suggests the region featured a greater percentage of subtropical water at this time. This may be due to increased transport by the California Countercurrent in recent times, or may be a remnant of the multi-year ENSO event. An analysis of the previous ten years of CTD data from the groundfish surveys (Figure 2) reveals that the character of the region's water in 1996 was similar to that seen in the late 1980's (e.g., warmer and saltier on constant density surfaces than the mean). Mid-level water during the ENSO years appeared less spicy than in 1996, and is attributed to an onshore displacement of the core of the California Current during the event (Lynn et al. 1995). The groundfish surveys do not extend far enough offshore to determine the position of the Current relative to the long-term mean, but it may have been displaced westward in 1996, allowing a greater northward flow of subtropical water.

No unusual circulation features were evident off central California; geostrophic currents were very similar to those in previous years. The strongest feature in the geostrophic flow was an upwelling jet off Pt. Reyes that meandered generally southward during all three sweeps, although the magnitude of this current was much weaker than in 1995. A second relatively strong flow was an anticyclonic circulation associated with a recurring warm surface feature west of Monterey Bay, as seen in the AVHRR images and described in detail by Rosenfeld et al. (1994). Dynamic heights near the surface (relative to 500 db) continued to be depressed by 10 dyn. cm and greater relative to those during the 1992-1994 ENSO and were typically 2-5 dyn. cm lower than 1995 heights. Although the 200/500-db heights were very similar to those in the previous year, the dynamic signature of the Undercurrent off Monterey Bay in 1996 was noticeably stronger than usual.

ACKNOWLEDGEMENTS

The authors greatly acknowledge the officers and crew of the NOAA R/V *David Starr Jordan* and the researchers who participated in the juvenile rockfish survey cruise. Special thanks to Tom Murphree (Department of Meteorology, Naval Postgraduate School, Monterey, California) for his assistance with the synopsis of hydrographic conditions. Thanks also to Brian Jarvis for his continued maintenance of the CTDs. Additional thanks to David Woodbury, Michael Embury, and Mike Kelly (MBARI) for the workup of the chlorophyll samples and to Francisco Chavez (MBARI) for the use of his laboratory.

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TABLES

Table 1. Mean ocean temperature, salinity, and density at selected depths from all CTD casts during May-June 1987-1996 pelagic juvenile rockfish surveys (1990-1996 for depths greater than 200 m).

	Temperature (^{0}C)		Salinity		Density (kg/m^3)	
Depth (m)	Mean	Std.Dev.	Mean	Std. Dev.	Mean	Std. Dev.
10	11.66	1.5541	33.44	0.3510	25.43	0.5200
30	10.42	1.2922	33.55	0.3084	25.74	0.4426
50	9.70	0.9480	33.62	0.3353	25.92	0.3838
100	8.86	0.4926	33.82	0.1806	26.22	0.1987
200	7.93	0.3437	34.02	0.0555	26.52	0.0704
300	7.09	0.3460	34.09	0.0561	26.69	0.0540
400	6.35	0.3069	34.14	0.0408	26.83	0.0422
500	5.69	0.2440	34.19	0.0303	26.96	0.0342

Table 2. Mean ocean temperature, salinity, and density at selected depths from all CTD casts during May-June 1996 pelagic juvenile rockfish surveys.

Depth (m)	Temperature (^{0}C)	Salinity	Density (kg/m^3)
10	11.16	33.56	25.62
30	10.19	33.69	25.89
50	9.61	33.74	26.03
100	8.84	33.91	26.29
200	7.90	34.06	26.55
300	7.08	34.12	26.71
400	6.38	34.16	26.85
500	5.78	34.21	26.96

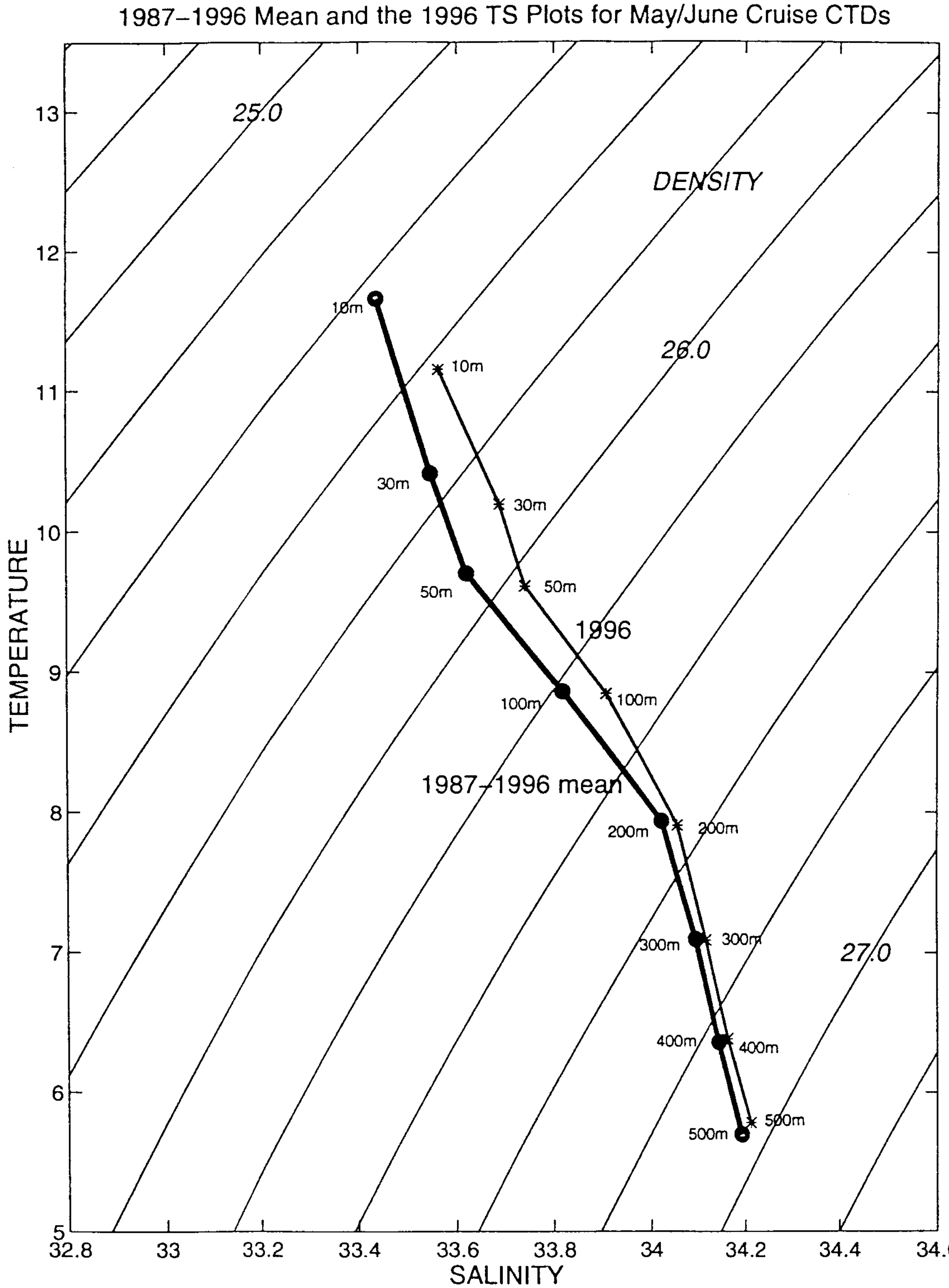


Figure 1. Relationship of mean CTD temperature and salinity from the May-June 1996 juvenile rockfish survey off central California. Asterisks connected by thin line are 1996 mean values at 10, 30, 50, 100, 200, 300, 400, and 500 m. Solid dots connected by bold line are mean of all CTD casts from 1987-1996 cruises.

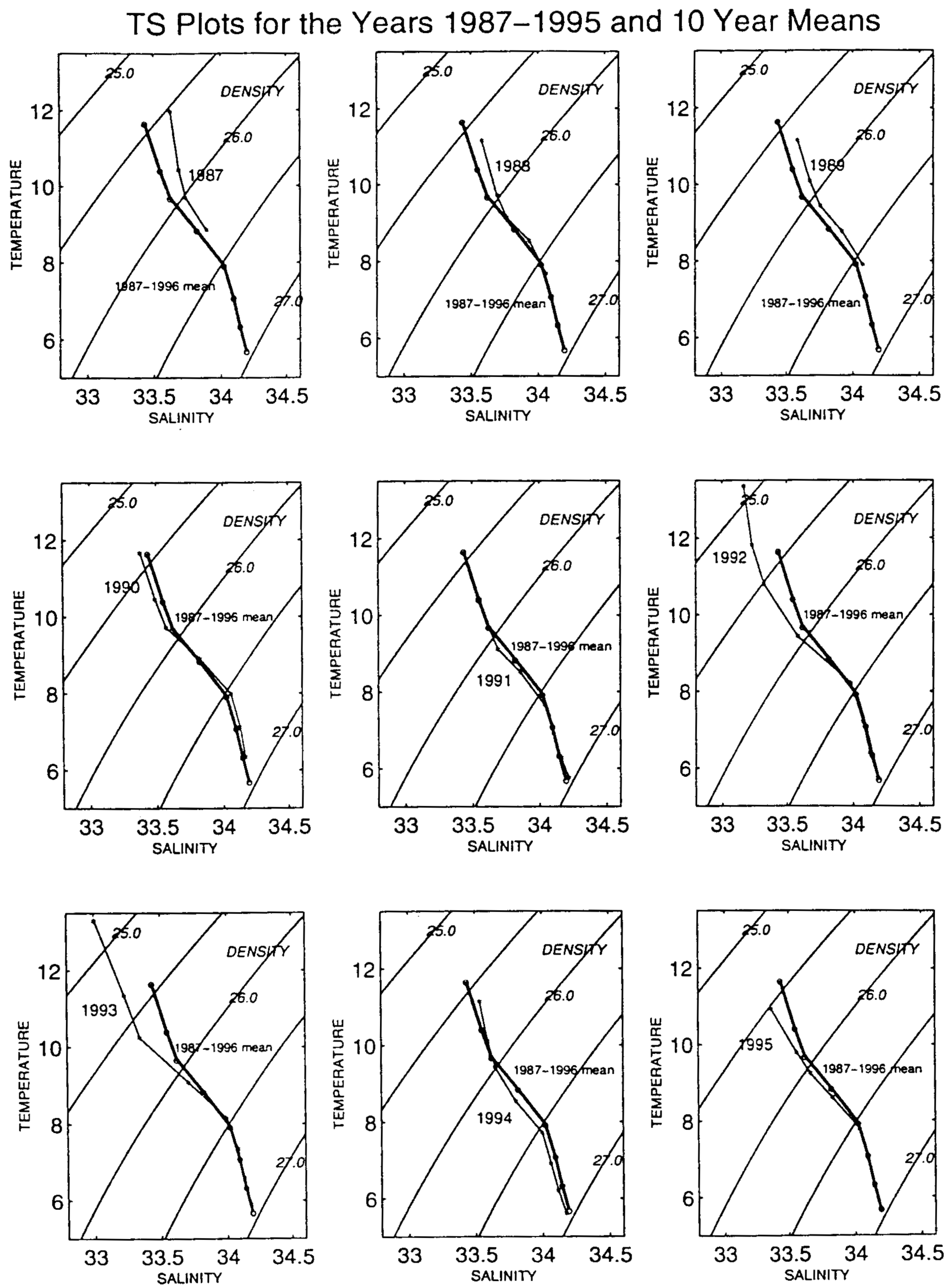


Figure 2. As for Figure 1, for individual May-June juvenile rockfish surveys during 1987-1995. 1987 CTD data extended only to 100 m; 1988 and 1989 data extended only to 200 m.

APPENDIX 1: LIST OF CTD STATIONS SUMMARIZED FROM CRUISE DSJ9606

DSJ9606 Sweep 1

CAST	DATE	TIME	LATITUDE	LONGITUDE	DEPTH(M)
4	18MAY96	0232	36 43.1	121 53.7	82
5	18MAY96	0316	36 38.4	121 51.5	38
6	18MAY96	0517	36 39.8	121 58.2	96
7	18MAY96	0630	36 40.0	122 10.0	1000
8	18MAY96	0740	36 46.3	122 16.1	872
9	18MAY96	0900	36 40.0	122 22.3	1793
10	18MAY96	1020	36 46.3	122 28.4	2159
11	18MAY96	1130	36 40.0	122 34.7	2139
12	18MAY96	1255	36 46.3	122 40.8	2169
13	18MAY96	1420	36 40.1	122 47.1	2800
14	18MAY96	1545	36 33.8	122 40.8	1500
15	18MAY96	1705	36 33.6	122 28.3	1500
16	18MAY96	1820	36 33.7	122 16.1	1530
17	18MAY96	2030	36 35.0	122 10.4	2333
18	19MAY96	0105	36 35.4	122 01.0	220
19	19MAY96	0146	36 38.8	122 03.0	805
20	19MAY96	0358	36 41.5	122 05.0	1830
21	19MAY96	0535	36 46.9	122 10.7	620
22	19MAY96	0925	36 52.6	122 10.1	99
23	19MAY96	1050	36 52.6	122 22.2	1085
24	19MAY96	1220	36 52.8	122 34.7	1548
25	19MAY96	1355	36 52.7	122 47.0	2285
26	19MAY96	1525	36 52.6	122 59.4	2700
27	19MAY96	1632	36 58.9	122 59.3	2141
28	19MAY96	1800	36 58.9	122 46.9	1195
29	19MAY96	2028	36 58.7	122 35.7	440
30	20MAY96	0020	36 58.7	122 25.1	207
31	20MAY96	0050	36 59.0	122 22.6	125
32	20MAY96	0245	36 59.9	122 18.8	89
33	20MAY96	0408	37 00.1	122 14.3	50
34	20MAY96	0605	37 10.6	122 28.4	70
35	20MAY96	0720	37 10.6	122 40.6	111
36	20MAY96	0840	37 10.8	122 53.0	411
37	20MAY96	1010	37 10.8	123 05.3	842
38	20MAY96	1130	37 16.4	123 11.3	1175
39	20MAY96	1243	37 22.4	123 05.4	760
40	20MAY96	1410	37 22.3	122 52.9	193
41	20MAY96	1523	37 22.3	122 40.7	87
42	20MAY96	1636	37 22.3	122 28.3	32
43	20MAY96	2030	37 16.5	122 29.2	54
44	20MAY96	2319	37 15.4	122 33.1	84
45	20MAY96	2357	37 16.6	122 39.1	99
46	21MAY96	0330	37 16.9	122 50.6	217
47	21MAY96	0505	37 17.8	123 00.1	695
48	21MAY96	0647	37 30.9	122 59.1	199
49	21MAY96	0805	37 30.8	123 11.7	753
50	21MAY96	0946	37 30.7	123 23.9	1325
51	21MAY96	1121	37 30.7	123 36.5	2250
52	21MAY96	1233	37 38.3	123 36.4	3220
53	21MAY96	1348	37 46.1	123 36.4	2950
54	21MAY96	1519	37 46.1	123 24.0	1400
55	21MAY96	1650	37 46.1	123 11.2	110
56	21MAY96	2031	37 39.3	123 03.0	107
57	21MAY96	2322	37 38.3	123 12.3	560
58	22MAY96	0035	37 44.6	123 08.5	94

CAST	DATE	TIME	LATITUDE	LONGITUDE	DEPTH(M)
60	22MAY96	2100	37 57.6	122 56.2	54
61	22MAY96	2222	37 55.1	122 51.1	49
62	22MAY96	2320	37 50.9	122 45.7	40
63	23MAY96	0150	37 46.1	122 50.7	55
64	23MAY96	0240	37 41.7	122 54.9	55
65	24MAY96	2134	38 10.0	123 17.1	120
66	25MAY96	0020	38 08.3	123 20.3	144
67	25MAY96	0132	38 10.4	123 10.5	93
68	25MAY96	0323	38 08.5	123 03.8	72
69	25MAY96	0435	38 09.7	122 59.8	54
70	25MAY96	0647	38 18.4	123 17.8	106
71	25MAY96	0812	38 18.5	123 30.2	254
72	25MAY96	0930	38 18.5	123 42.4	1530
73	25MAY96	1122	38 18.4	123 54.6	2790
74	25MAY96	1243	38 09.8	123 54.1	3522
75	25MAY96	1458	38 01.5	123 42.2	2700
76	25MAY96	1635	38 01.5	123 30.1	145
77	25MAY96	1746	38 01.6	123 17.8	119
78	25MAY96	1900	38 01.7	123 05.5	64

DSJ9606 Sweep 2

CAST	DATE	TIME	LATITUDE	LONGITUDE	DEPTH(M)
82	26MAY96	2125	36 58.8	122 38.6	431
83	27MAY96	0058	36 57.1	122 23.0	460
84	27MAY96	0140	36 59.2	122 22.7	120
85	27MAY96	0348	36 57.0	122 15.7	89
86	27MAY96	0520	36 58.0	122 12.0	57
87	27MAY96	0715	37 04.8	122 22.4	60
88	27MAY96	0845	37 04.9	122 34.6	112
89	27MAY96	1020	37 05.0	122 47.2	650
90	27MAY96	1140	36 59.0	122 53.1	750
91	27MAY96	1308	36 52.6	122 47.3	2300
92	27MAY96	1455	36 52.6	122 34.7	1600
93	27MAY96	1626	36 52.7	122 22.3	823
94	27MAY96	1753	36 52.7	122 10.1	99
95	27MAY96	1910	36 53.0	121 56.0	38
96	27MAY96	2035	36 50.6	121 59.0	90
97	27MAY96	2325	36 45.7	121 50.7	43
98	28MAY96	0023	36 44.5	121 58.7	330
99	28MAY96	0208	36 41.6	121 53.6	80
100	28MAY96	0242	36 38.5	121 51.6	40
101	28MAY96	0505	36 40.1	121 56.7	90
102	28MAY96	0625	36 40.1	122 10.1	1068
103	28MAY96	0745	36 46.3	122 16.2	800
104	28MAY96	0905	36 39.9	122 22.3	860
105	28MAY96	1045	36 46.3	122 28.5	1147
106	28MAY96	1205	36 40.1	122 34.7	2350
107	28MAY96	1345	36 46.5	122 40.8	2200
108	28MAY96	1525	36 40.2	122 47.1	2800
109	28MAY96	1650	36 33.5	122 40.9	2800
110	28MAY96	1816	36 33.7	122 28.6	2700
111	28MAY96	1955	36 33.7	122 16.4	2400
112	28MAY96	2101	36 35.1	122 10.7	2333

CAST	DATE	TIME	LATITUDE	LONGITUDE	DEPTH(M)
113	29MAY96	0052	36 33.5	122 01.7	475
114	29MAY96	0158	36 38.8	122 03.1	850
115	29MAY96	0433	36 41.6	122 05.6	1800
116	29MAY96	0955	37 10.7	122 28.5	72
117	29MAY96	1120	37 10.7	122 40.8	112
118	29MAY96	1255	37 10.7	122 53.0	410
119	29MAY96	1435	37 10.9	123 05.3	830
120	29MAY96	1620	37 16.6	123 11.2	1100
121	29MAY96	2033	37 16.6	122 58.9	500
122	29MAY96	2318	37 14.9	122 47.4	165
123	30MAY96	0023	37 16.8	122 39.5	95
124	30MAY96	0223	37 15.0	122 32.7	85
125	30MAY96	0335	37 15.5	122 28.2	45
126	30MAY96	0800	37 30.8	122 59.6	210
127	30MAY96	0933	37 30.8	123 11.6	1500
128	30MAY96	1120	37 30.6	123 24.1	2470
129	30MAY96	1310	37 30.7	123 36.4	3001
130	30MAY96	1440	37 38.5	123 36.3	3300
131	30MAY96	1620	37 46.2	123 36.4	3000
132	30MAY96	1755	37 46.3	123 24.1	1440
133	30MAY96	1922	37 46.3	123 11.7	112
134	30MAY96	2000	37 44.7	123 08.1	75
135	30MAY96	2105	37 39.4	123 02.5	100
136	30MAY96	2352	37 38.3	123 11.3	1375
138	31MAY96	0435	37 51.5	123 17.9	100
139	31MAY96	0635	38 01.7	123 30.1	140
140	31MAY96	0755	38 01.6	123 42.8	1375
141	31MAY96	0925	38 01.6	123 54.9	1900
142	31MAY96	1127	38 10.1	124 07.1	1975
143	31MAY96	1323	38 18.4	123 54.8	2800
144	31MAY96	1445	38 18.5	123 42.4	1585
145	31MAY96	1615	38 18.7	123 30.1	245
146	31MAY96	1730	38 18.5	123 17.9	107
147	31MAY96	2055	38 09.9	123 21.9	175
148	01JUN96	0036	38 08.3	123 15.3	112
149	01JUN96	0125	38 10.3	123 10.2	91
150	01JUN96	0315	38 08.1	123 04.3	60
151	01JUN96	0430	38 08.9	122 59.5	48
152	01JUN96	0805	38 01.5	123 05.6	65
153	01JUN96	1015	38 01.6	123 17.9	118
154	01JUN96	2042	37 58.1	122 55.9	54
155	01JUN96	2210	37 55.1	122 51.4	49
156	01JUN96	2300	37 51.0	122 46.0	41
157	02JUN96	0050	37 47.5	122 53.5	58
158	02JUN96	0135	37 42.1	122 54.6	58
159	02JUN96	0330	37 36.8	122 45.2	52

DSJ9606 Sweep 3

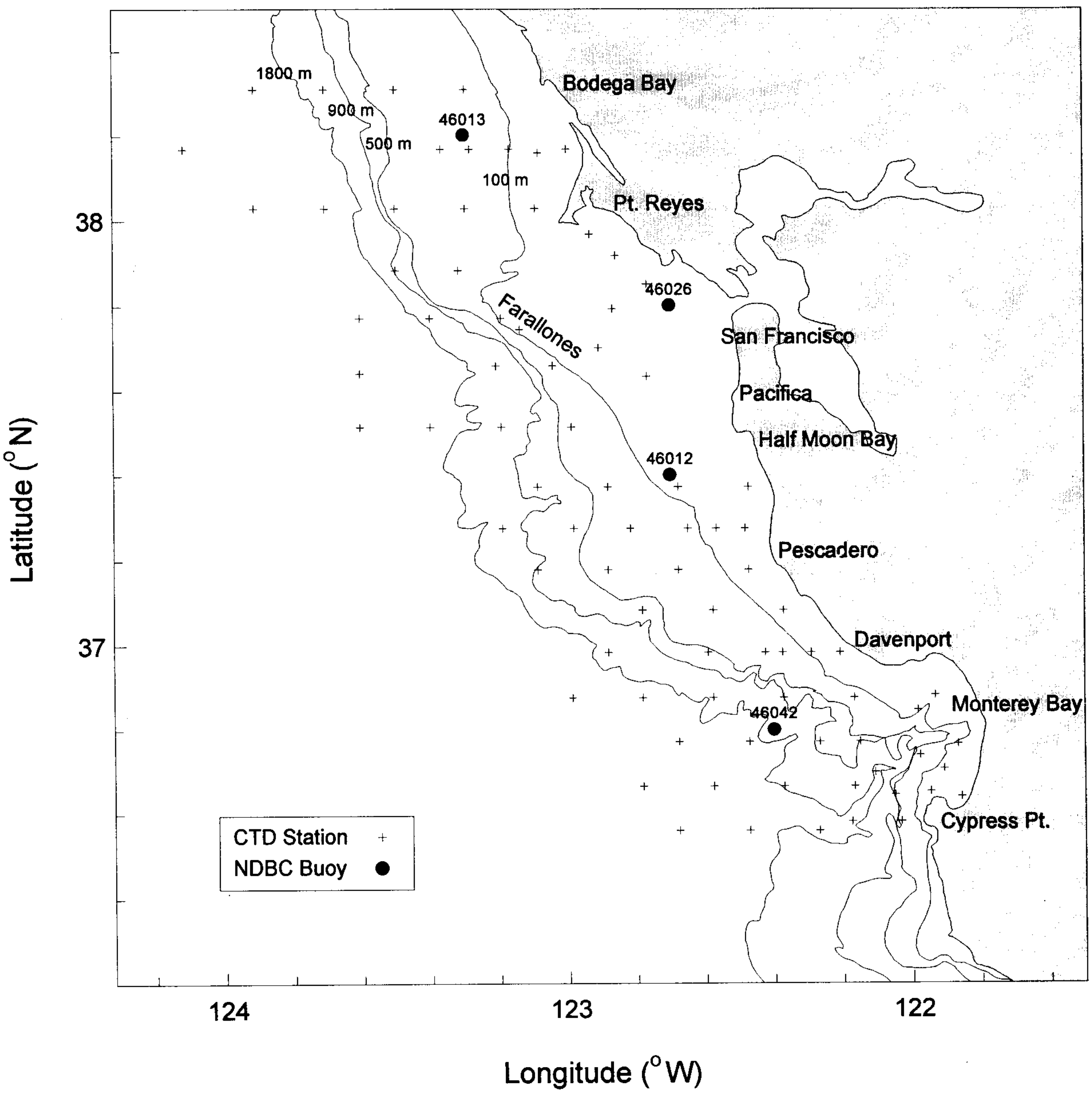
CAST	DATE	TIME	LATITUDE	LONGITUDE	DEPTH(M)
228	10JUN96	1915	36 52.6	121 56.1	46
229	10JUN96	2107	36 50.6	121 59.0	79
230	10JUN96	2333	36 45.4	121 50.3	37
231	11JUN96	0030	36 44.4	121 58.6	280

CAST	DATE	TIME	LATITUDE	LONGITUDE	DEPTH(M)
232	11JUN96	0214	36 41.2	121 53.4	79
233	11JUN96	0244	36 38.5	121 51.8	44
235	11JUN96	0456	36 39.5	121 56.9	84
236	11JUN96	0619	36 40.0	122 09.8	1000
237	11JUN96	0750	36 44.2	122 16.0	861
238	11JUN96	0910	36 40.0	122 22.4	1170
239	11JUN96	1037	36 46.3	122 28.5	2099
240	11JUN96	1155	36 40.0	122 34.8	2375
241	11JUN96	1325	36 46.3	122 40.8	2100
242	11JUN96	1450	36 40.0	122 47.0	2800
243	11JUN96	1608	36 33.7	122 40.7	2750
244	11JUN96	1740	36 33.8	122 28.4	2700
245	11JUN96	1916	36 33.7	122 16.3	2500
246	11JUN96	2049	36 35.0	122 10.7	2500
247	12JUN96	0054	36 36.2	122 02.5	775
248	12JUN96	0138	36 38.8	122 03.2	1000
249	12JUN96	0338	36 43.4	122 06.2	1920
250	12JUN96	0516	36 47.1	122 10.1	820
251	12JUN96	0618	36 52.4	122 09.7	100
252	12JUN96	0742	36 52.6	122 22.2	1150
253	12JUN96	0920	36 52.6	122 34.6	1756
254	12JUN96	1055	36 52.6	122 47.0	2928
255	12JUN96	1235	36 52.7	122 59.4	2700
256	12JUN96	1420	36 59.1	122 53.2	1375
257	12JUN96	1540	37 05.1	122 47.1	625
258	12JUN96	1715	37 05.0	122 34.6	114
259	12JUN96	1829	37 05.0	122 22.2	60
260	12JUN96	2046	36 59.1	122 35.5	406
261	13JUN96	0103	36 57.2	122 24.4	280
262	13JUN96	0139	36 59.0	122 22.6	125
263	13JUN96	0328	36 58.1	122 16.1	87
264	13JUN96	0435	36 57.9	122 11.8	55
265	13JUN96	0655	37 10.7	122 28.5	70
266	13JUN96	0810	37 10.7	122 40.9	115
267	13JUN96	2234	37 16.5	122 58.7	550
268	14JUN96	0102	37 15.1	122 47.0	168
269	14JUN96	0202	37 16.6	122 39.1	96
270	14JUN96	0334	37 15.2	122 34.5	87
271	14JUN96	0715	37 30.8	122 59.3	212
272	14JUN96	0845	37 30.8	123 11.6	1281
273	14JUN96	1035	37 30.9	123 24.1	2379
274	14JUN96	1315	37 38.4	123 36.3	3200
275	14JUN96	1505	37 46.2	123 36.2	3000
276	14JUN96	1645	37 46.2	123 24.0	1450
277	14JUN96	1809	37 46.3	123 11.6	111
278	15JUN96	2051	37 58.0	122 56.1	55
279	15JUN96	2248	37 55.0	122 51.5	50
280	15JUN96	2338	37 51.0	122 46.1	42
281	16JUN96	0141	37 47.0	122 51.2	56
282	16JUN96	0231	37 42.1	122 54.9	57
283	16JUN96	0416	37 37.7	122 45.7	53
284	16JUN96	0825	38 01.6	123 05.6	63
285	16JUN96	0940	38 01.6	123 17.9	118
286	16JUN96	1100	38 01.6	123 30.2	150
287	16JUN96	1225	38 01.8	123 42.4	2515
288	16JUN96	1407	38 01.7	123 54.8	3100
289	16JUN96	1543	38 01.6	124 07.1	3670
290	16JUN96	1640	38 01.6	124 12.9	3770
291	16JUN96	2109	37 53.0	123 29.7	1600

CAST	DATE	TIME	LATITUDE	LONGITUDE	DEPTH(M)
292	16JUN96	2352	37 52.1	123 17.7	107
293	17JUN96	0111	37 44.8	123 08.8	105
294	17JUN96	0325	37 37.9	123 10.9	1000
295	17JUN96	0740	37 51.0	122 46.0	40
296	17JUN96	0945	37 55.0	122 51.0	47
297	17JUN96	1055	37 57.0	122 59.1	60
298	17JUN96	1325	37 54.5	122 54.3	59
299	17JUN96	1415	37 55.5	122 56.6	61
300	17JUN96	1520	37 56.0	122 53.1	51
301	17JUN96	1605	37 57.1	122 55.0	53
302	17JUN96	1655	37 58.2	122 56.9	59
303	17JUN96	1811	37 57.3	122 51.6	43
304	17JUN96	1905	37 58.9	122 53.1	42
305	17JUN96	2000	37 59.3	122 53.9	41
307	17JUN96	2136	37 57.3	122 51.5	44
308	17JUN96	2228	37 59.0	122 53.1	42
309	17JUN96	2317	38 00.0	122 54.9	34
310	18JUN96	0028	37 56.0	122 52.9	51
311	18JUN96	0117	37 56.9	122 54.9	56
312	18JUN96	0210	37 58.3	122 57.0	59
313	18JUN96	0309	37 54.5	122 54.2	59
314	18JUN96	0405	37 55.5	122 56.4	60
315	18JUN96	0520	37 56.4	122 58.5	60
316	18JUN96	1607	37 59.9	123 04.8	60
317	18JUN96	1730	38 05.5	123 05.2	69
318	18JUN96	2212	38 10.0	123 22.1	180
319	19JUN96	0023	38 08.5	123 15.6	116
320	19JUN96	0108	38 10.1	123 10.2	96
321	19JUN96	0259	38 07.9	123 03.6	76
322	19JUN96	0423	38 09.4	122 59.7	53

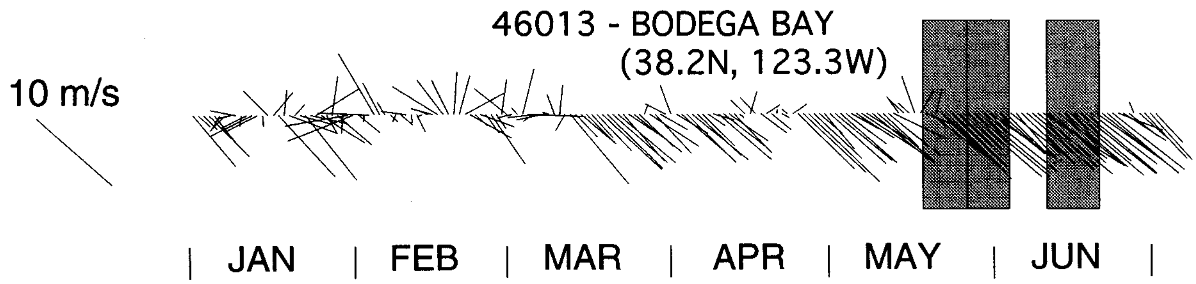
APPENDIX 2: DSJ9606 CTD STATIONS AND BATHYMETRIC MAP OF SURVEY REGION WITH LOCATIONS OF THE NDBC BUOYS

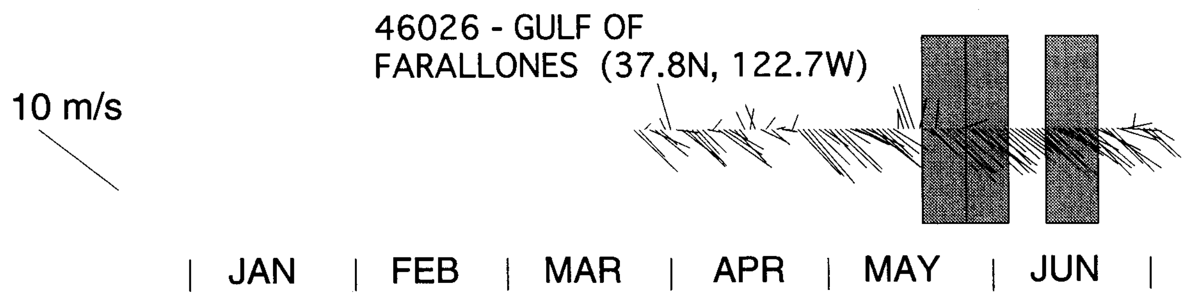
Standard CTD Station Locations

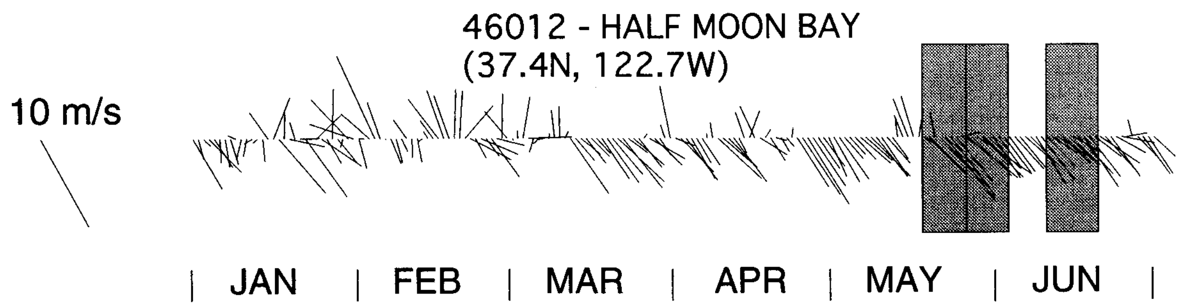


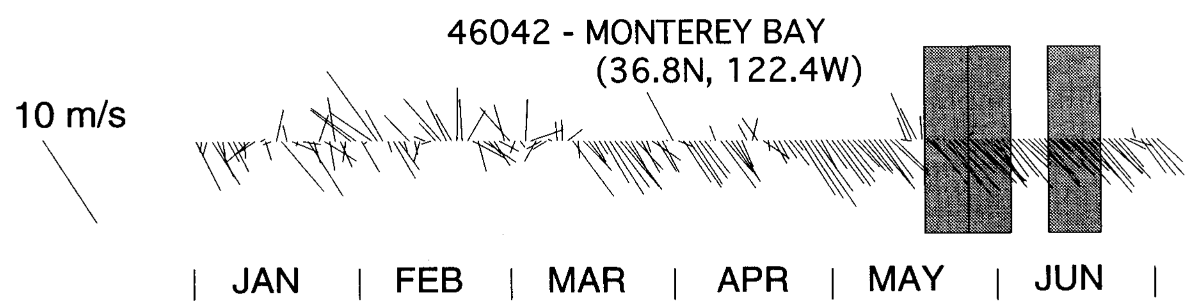
APPENDIX 3: METEOROLOGICAL TIME SERIES

DAILY BUOY WINDS - 1996



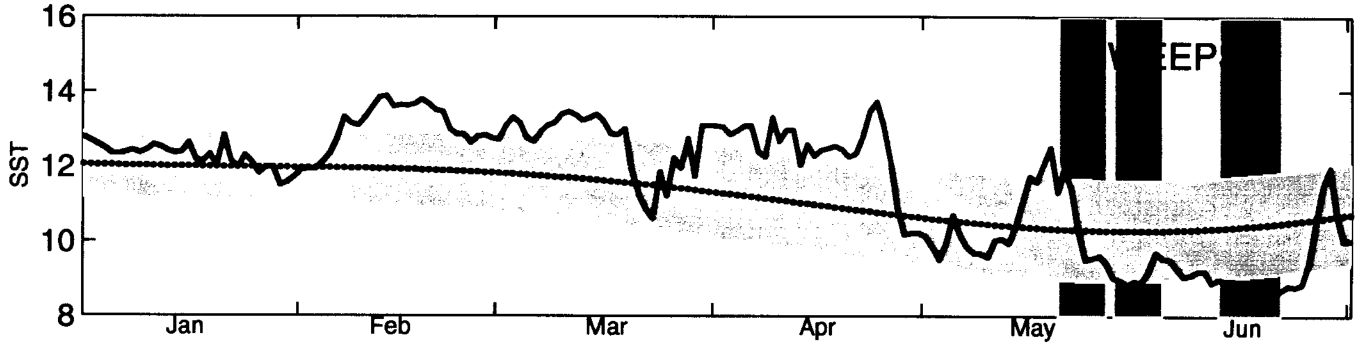




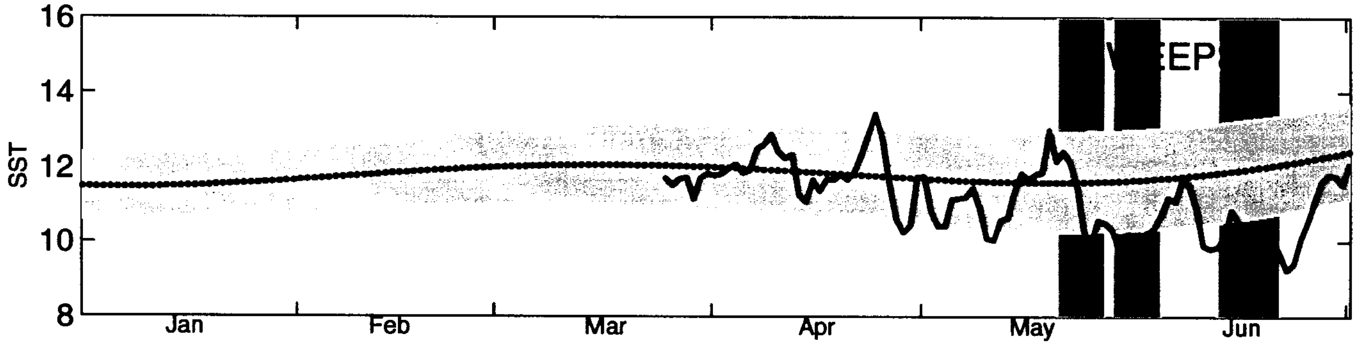


Sea Surface Temperatures 1996

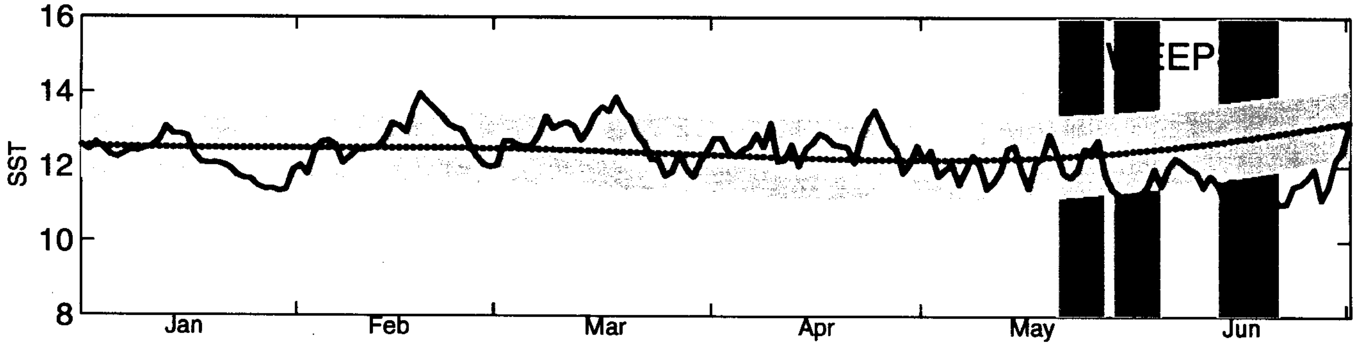
Buoy 46013 ~ (Bodega, CA)



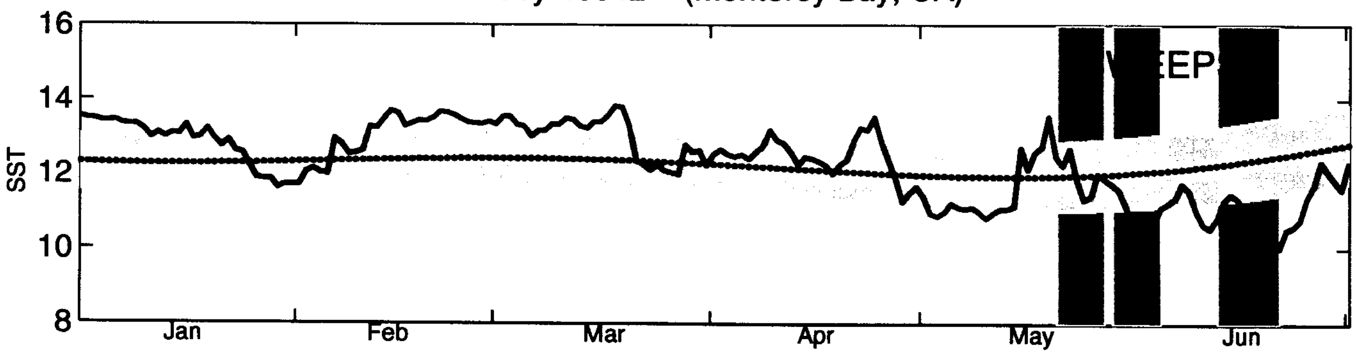
Buoy 46026 ~ (Gulf of the Farallones)



Buoy 46012 ~ (Half Moon Bay, CA)

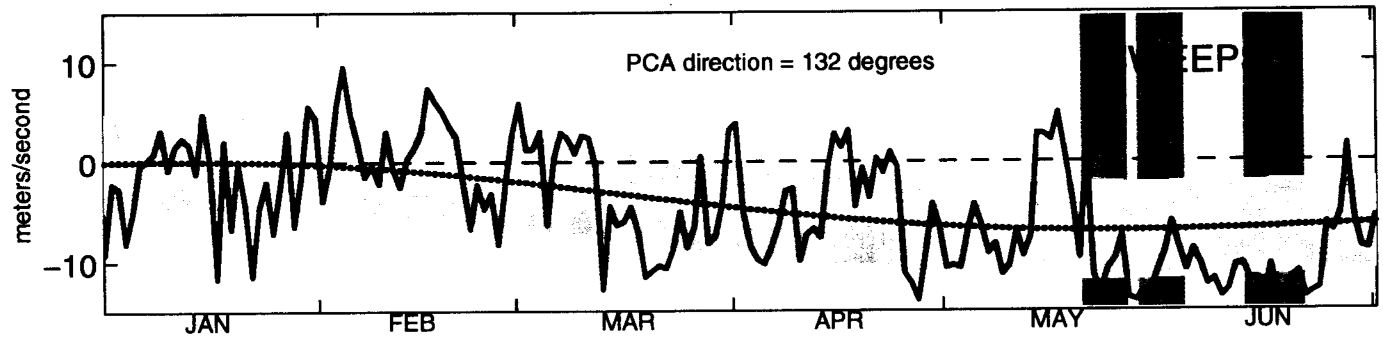


Buoy 46042 ~ (Monterey Bay, CA)

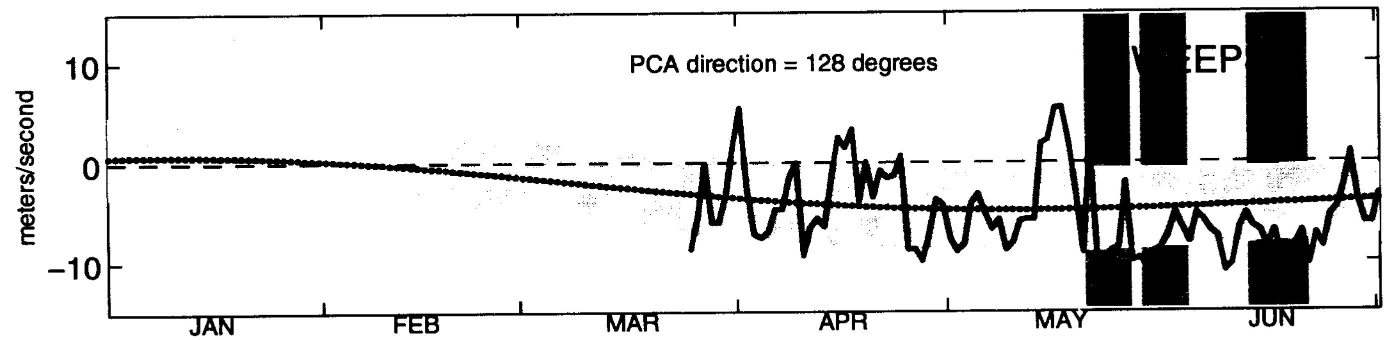


Alongshore Winds 1996

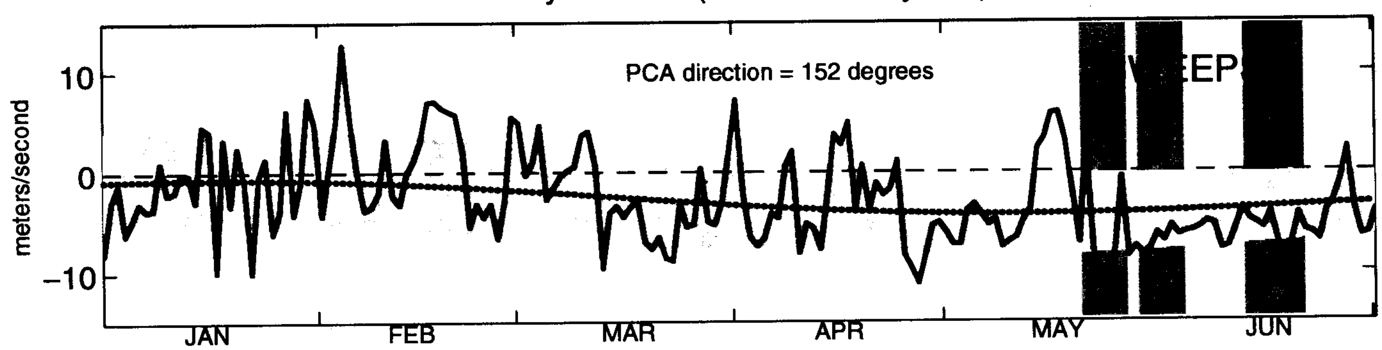
Buoy 46013 ~ (Bodega, CA)



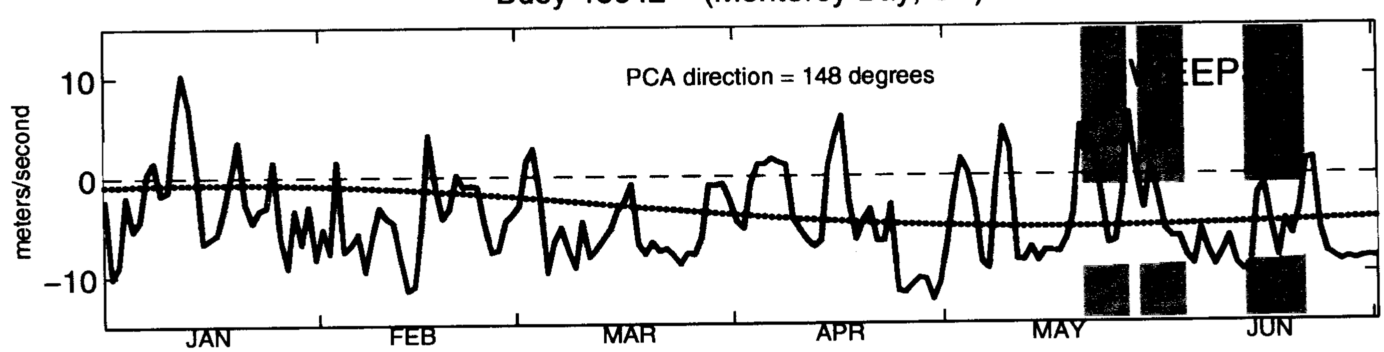
Buoy 46026 ~ (Gulf of the Farallones)



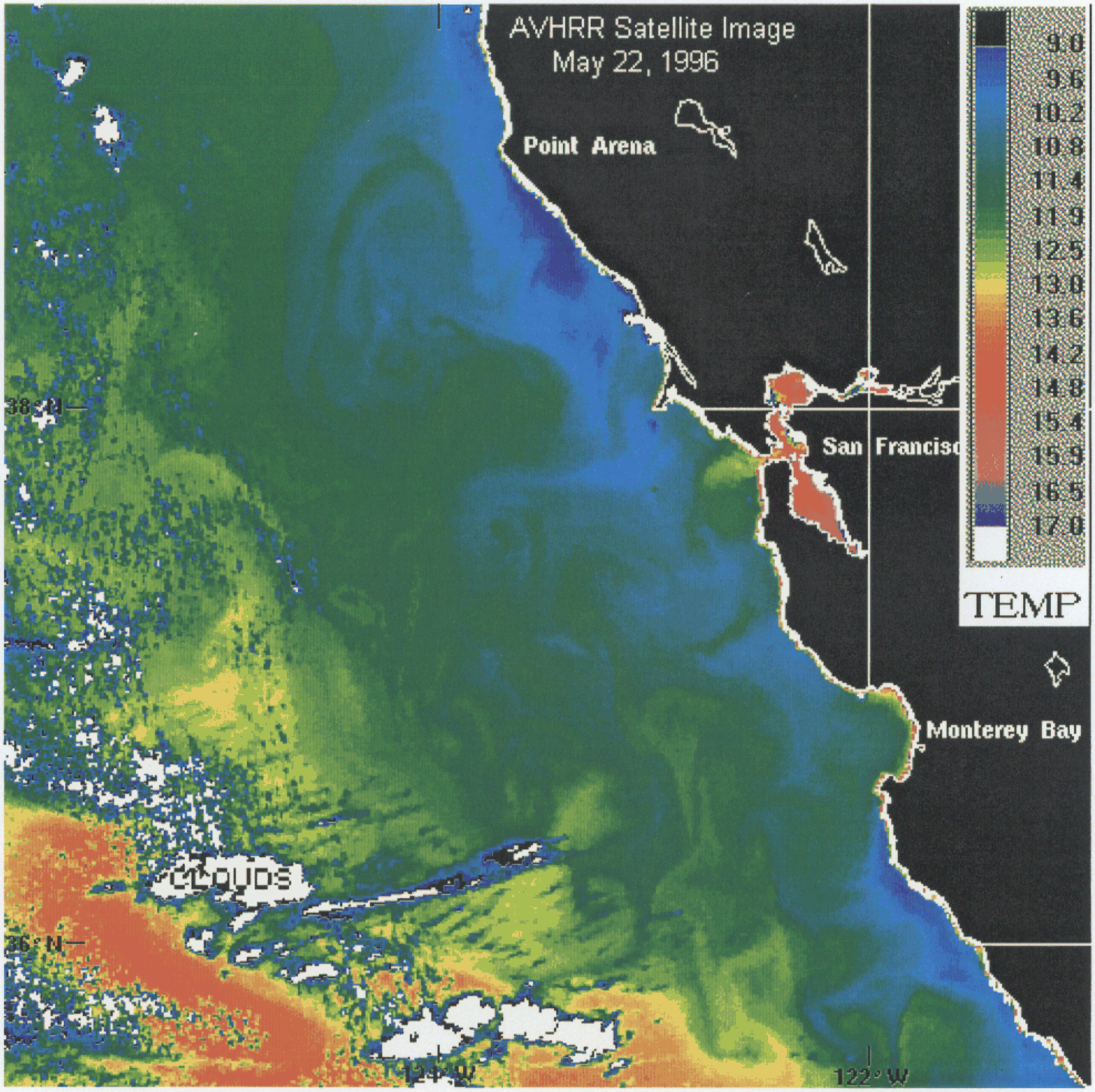
Buoy 46012 ~ (Half Moon Bay, CA)

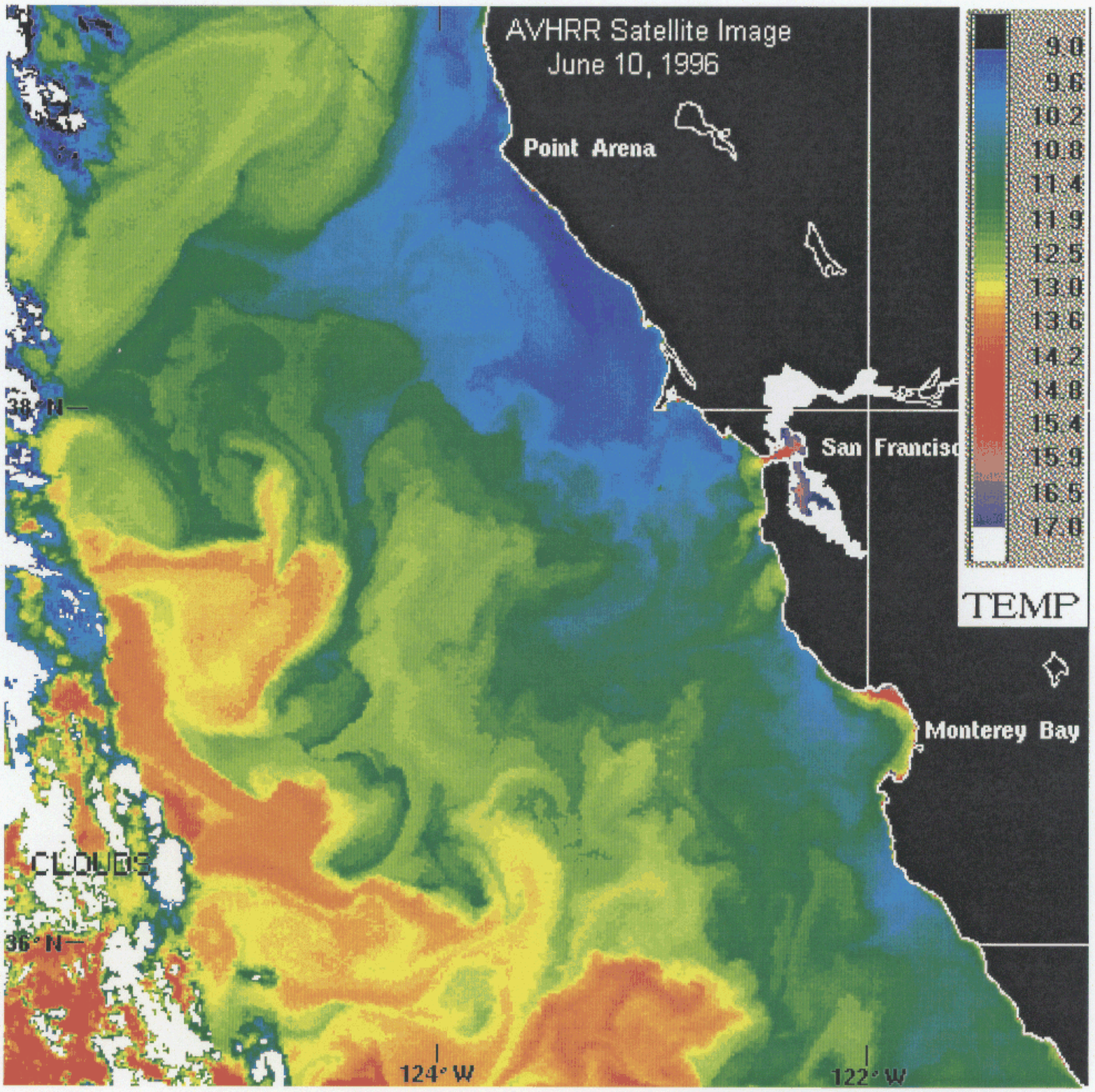


Buoy 46042 ~ (Monterey Bay, CA)

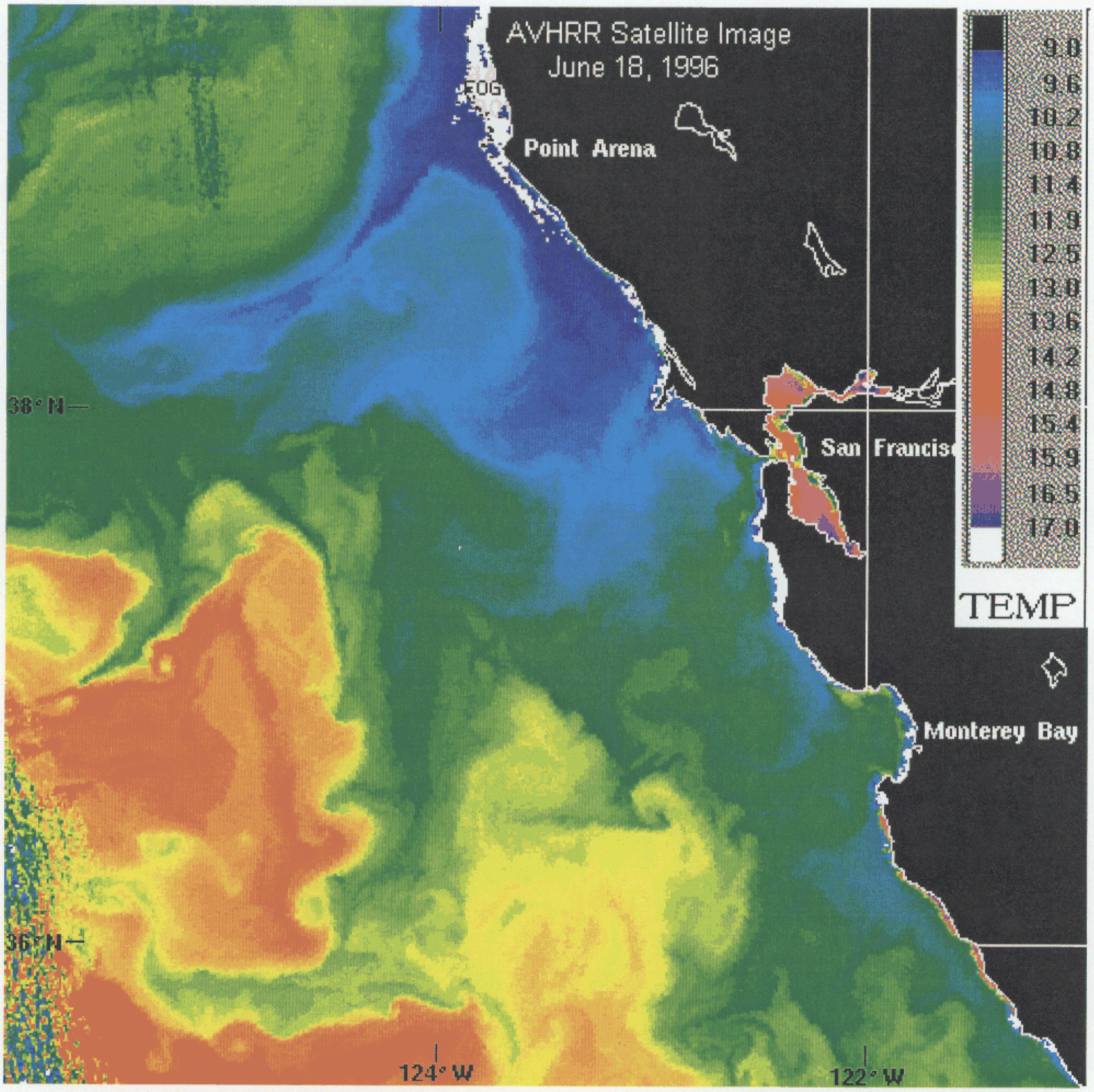


APPENDIX 4: AVHRR SATELLITE IMAGES OF SEA SURFACE TEMPERATURES


AVHRR Satellite Image
May 22, 1996
Point Arena
San Francisco
Monterey Bay
CLOUDS
38° N
36° N
124° W
122° W
9.0
9.6
10.2
10.8
11.4
11.9
12.5
13.0
13.6
14.2
14.8
15.4
15.9
16.5
17.0
TEMP



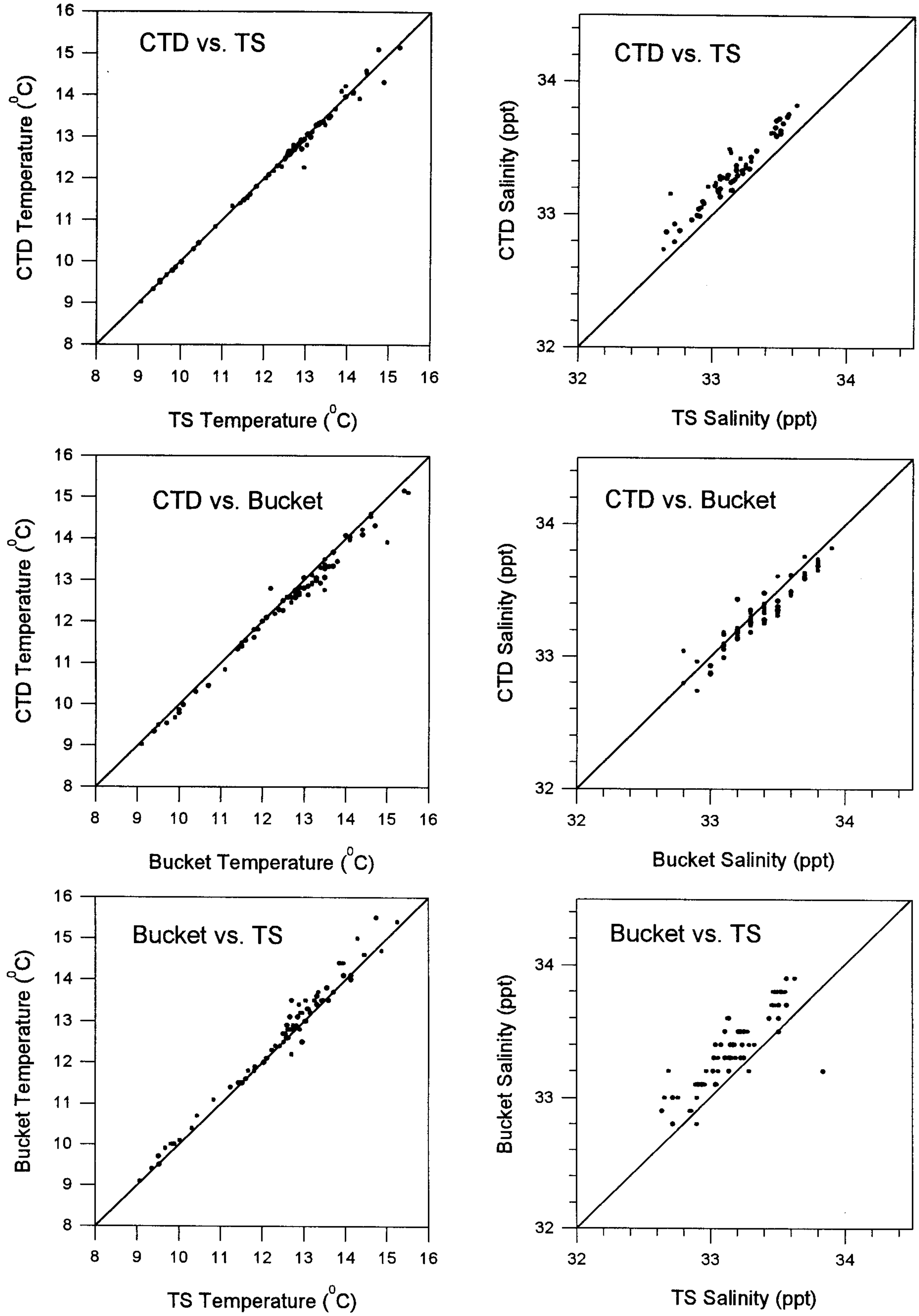
AVHRR Satellite Image
June 10, 1996
Point Arena
San Francisco
Monterey Bay
CLOUDS
38° N
36° N
124° W
122° W
9.0
9.6
10.2
10.8
11.4
11.9
12.5
13.0
13.6
14.2
14.8
15.4
15.9
16.5
17.0
TEMP



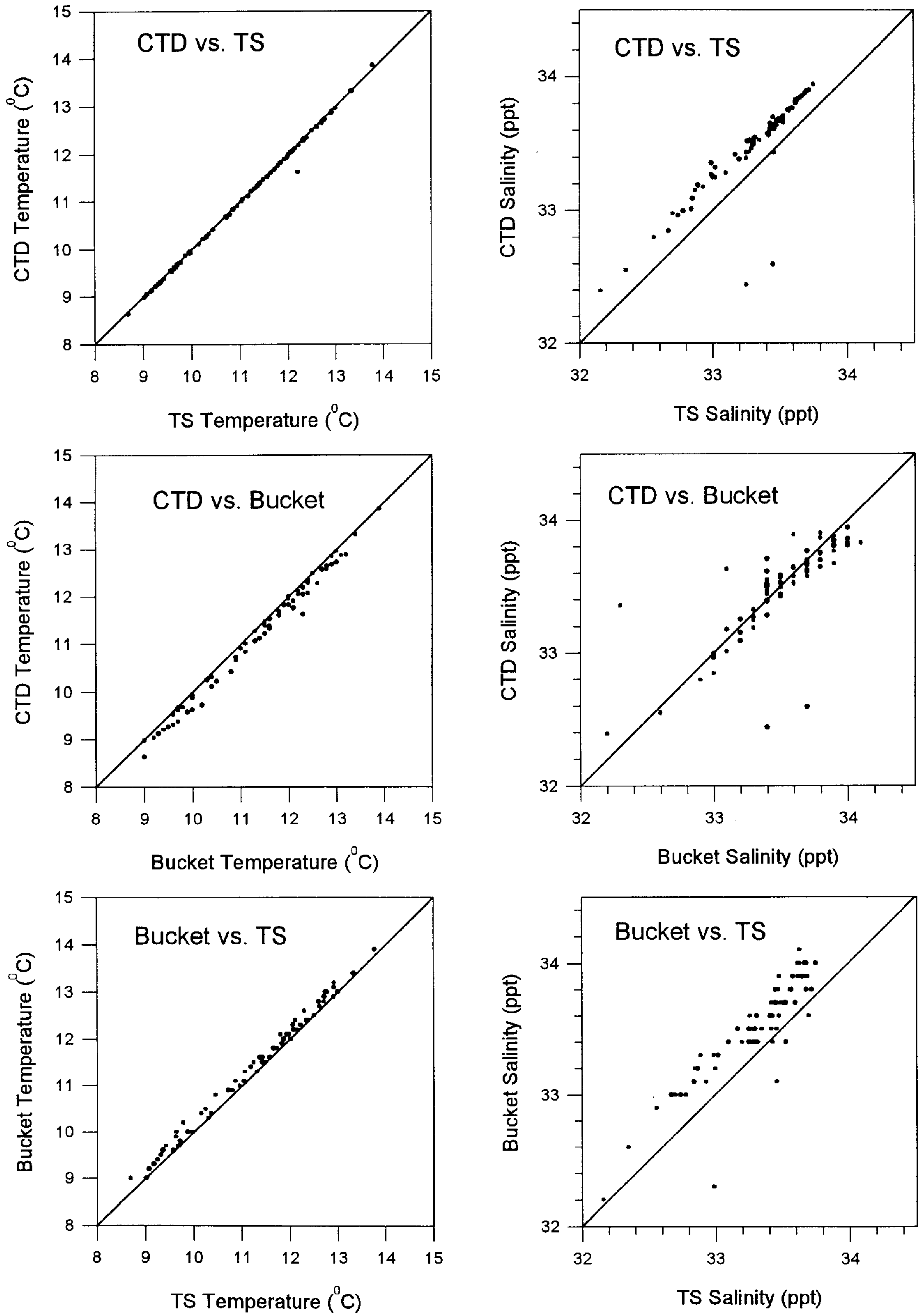
AVHRR Satellite Image
June 18, 1996
FOG
Point Arena
San Francisc
Monterey Bay
38° N
36° N
124° W
122° W
9.0
9.6
10.2
10.8
11.4
11.9
12.5
13.0
13.6
14.2
14.8
15.4
15.9
16.5
17.0
TEMP

APPENDIX 5: REGRESSION COMPARISONS OF CTD, TS, AND BUCKET FOR DSJ9606

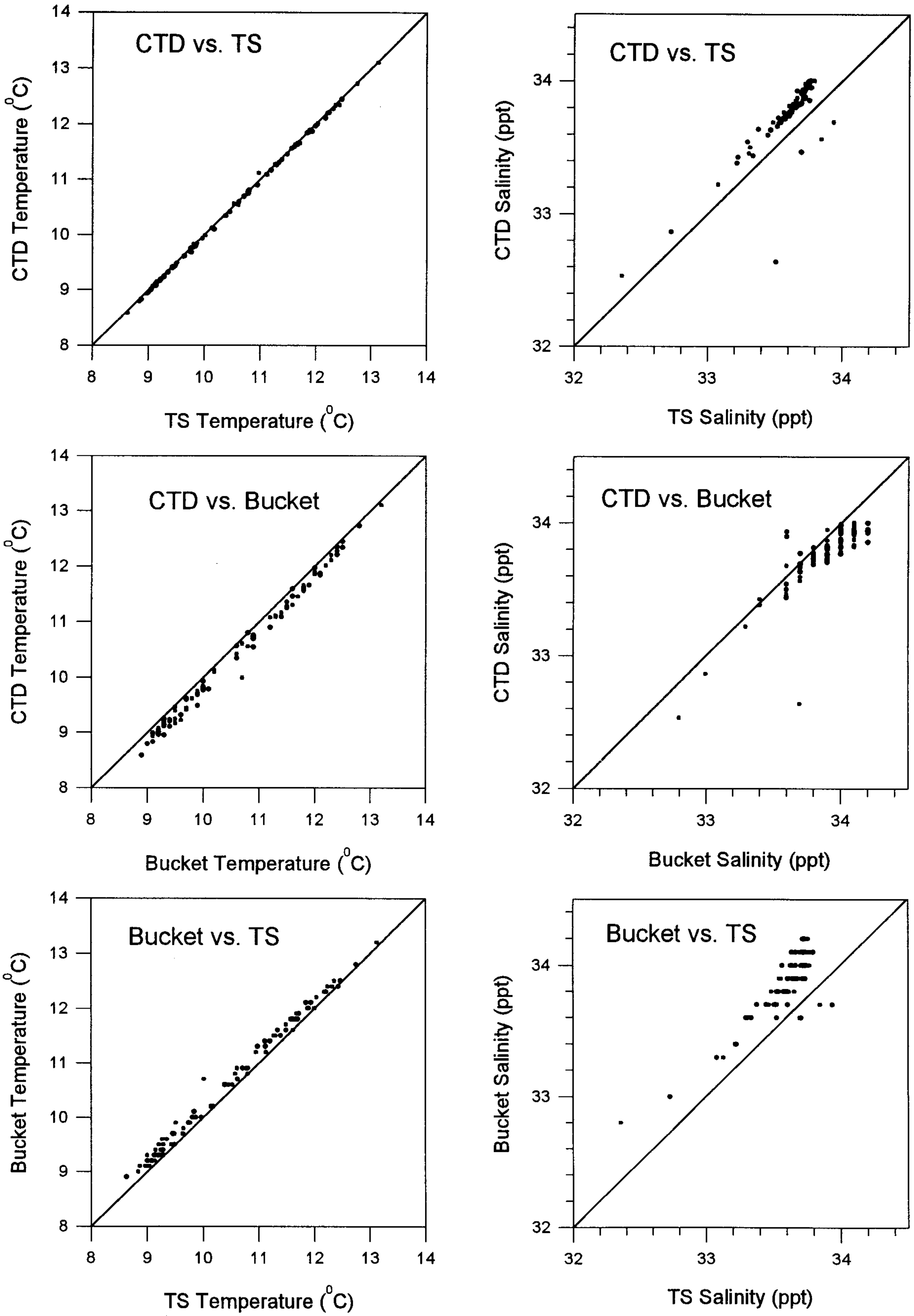
DSJ9606 Sweep 1



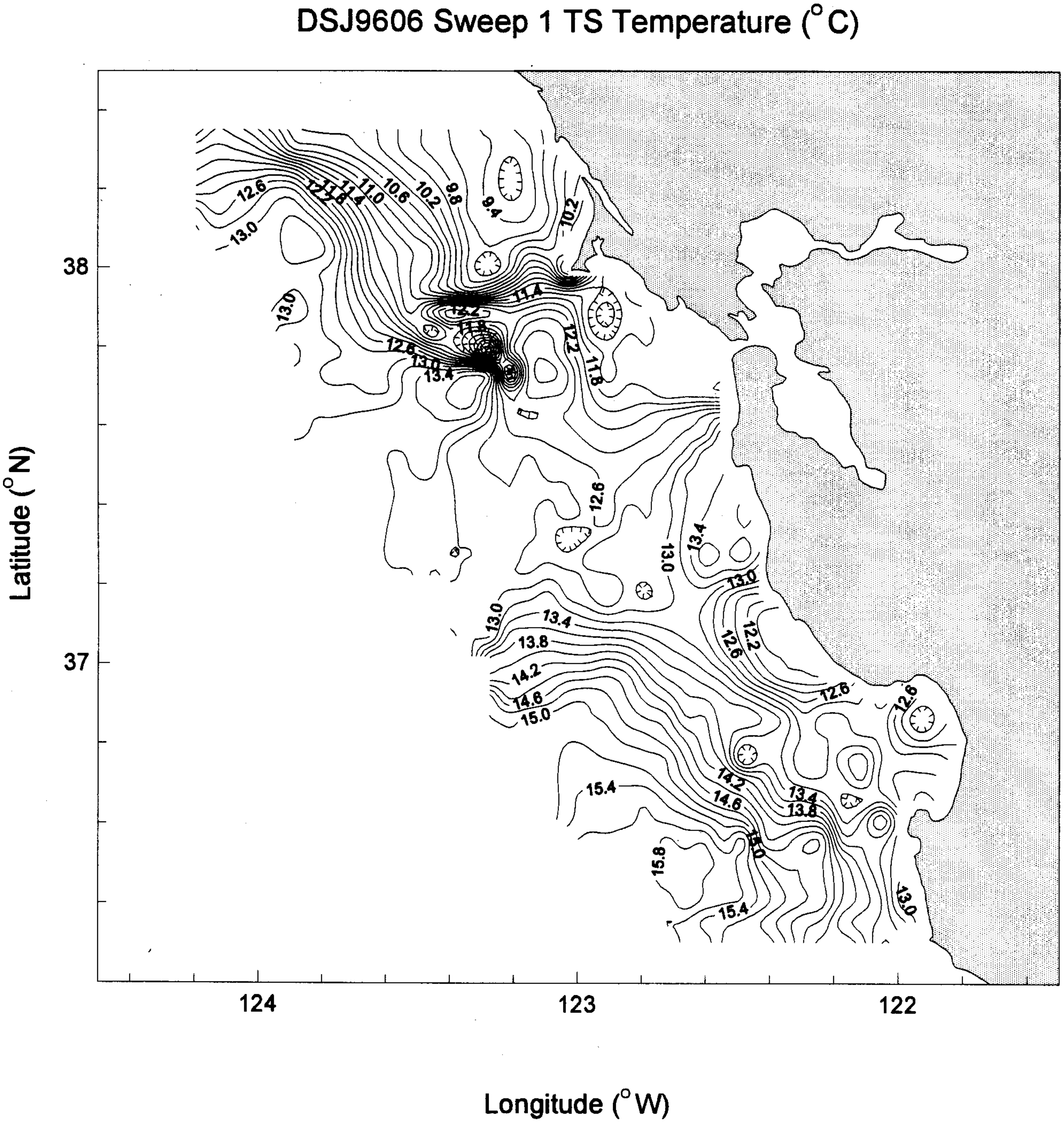
DSJ9606 Sweep 2



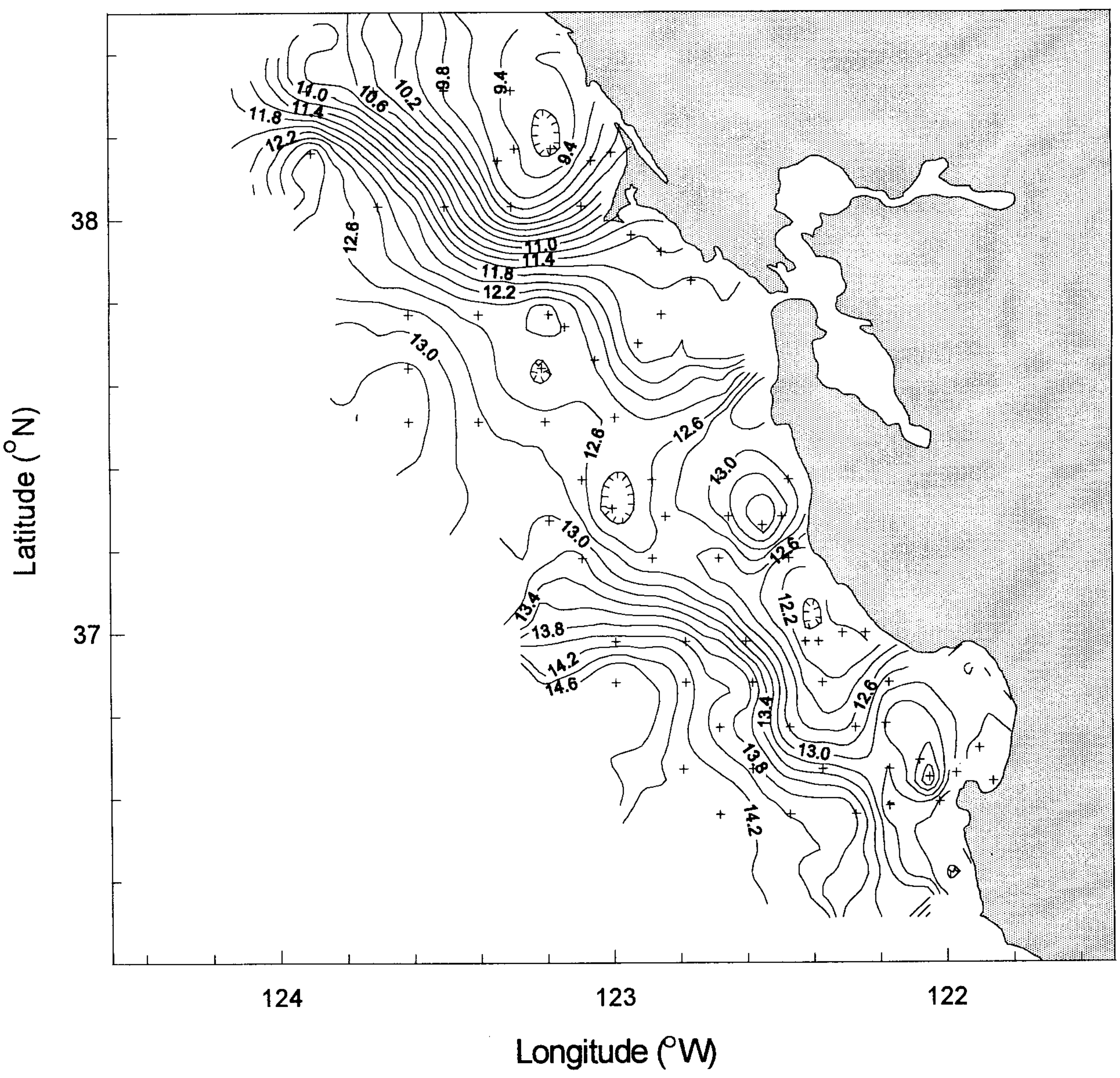
DSJ9606 Sweep 3



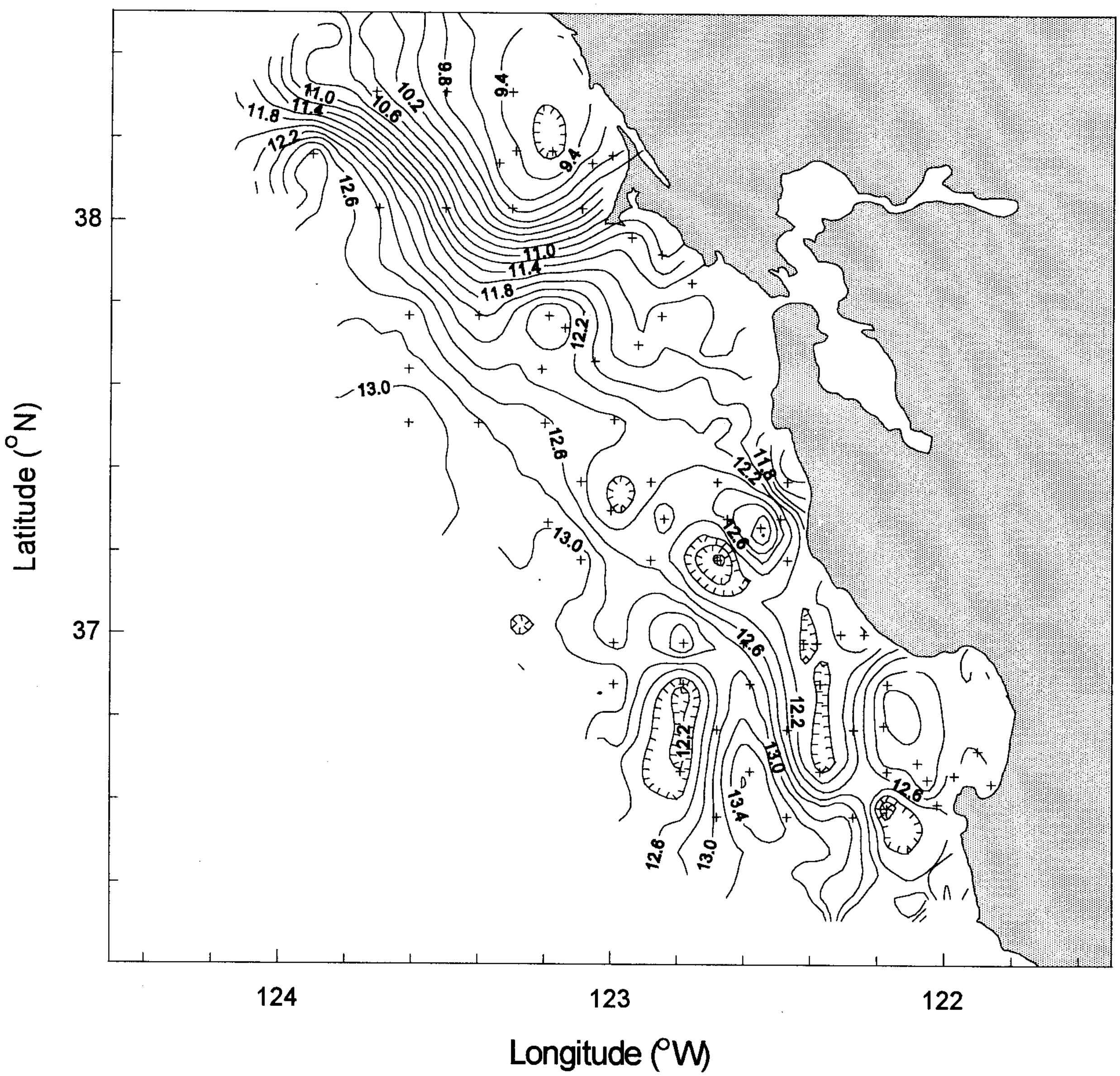
APPENDIX 6.1: HORIZONTAL MAPS OF CTD AND TS FOR DSJ9606, SWEEP 1


DSJ9606 Sweep 1 TS Temperature (°C)
Latitude (°N)
Longitude (°W)
38
37
124
123
122

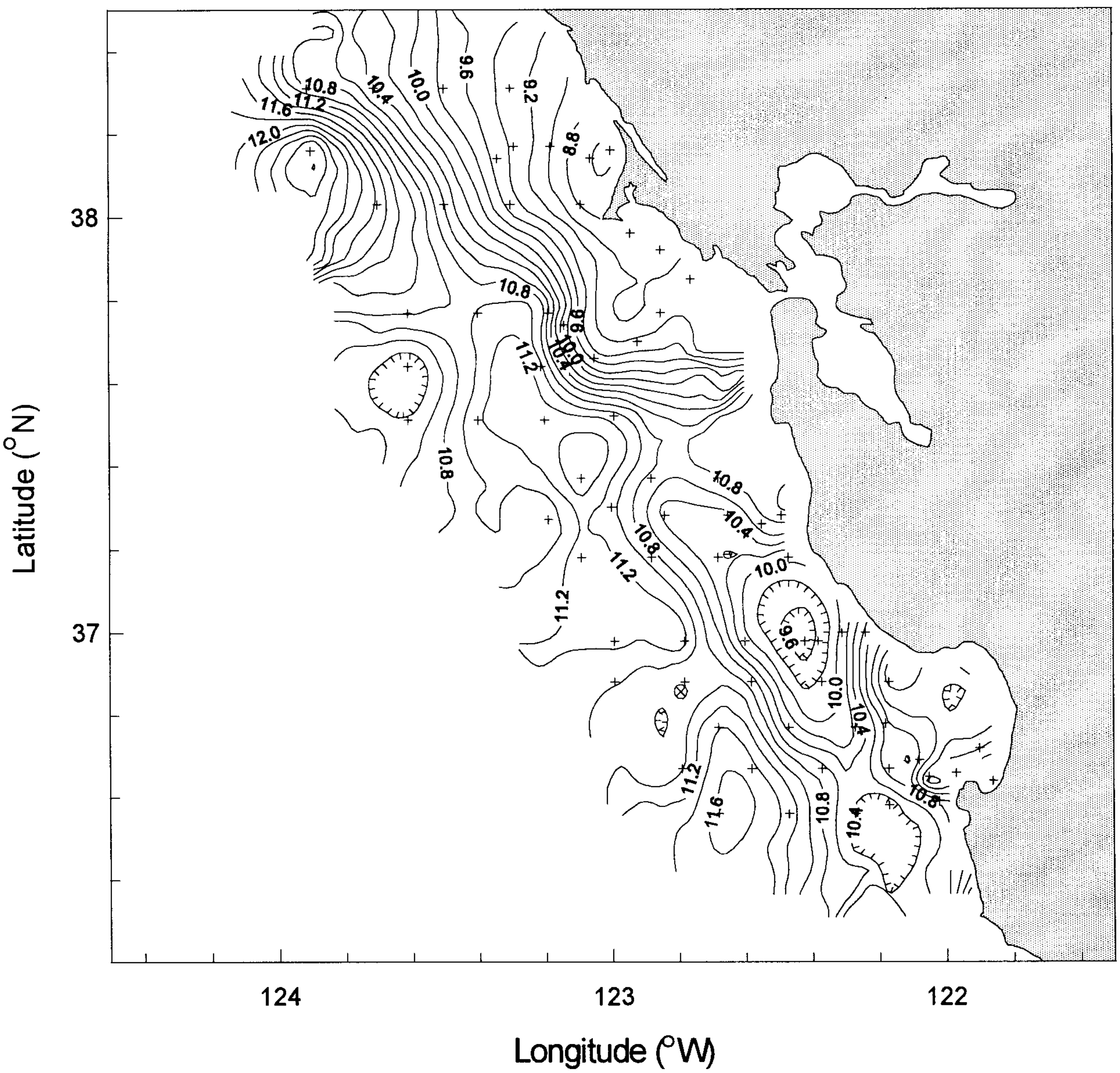
DSJ9606 Sweep 1 Temperature (°C) at 2 m

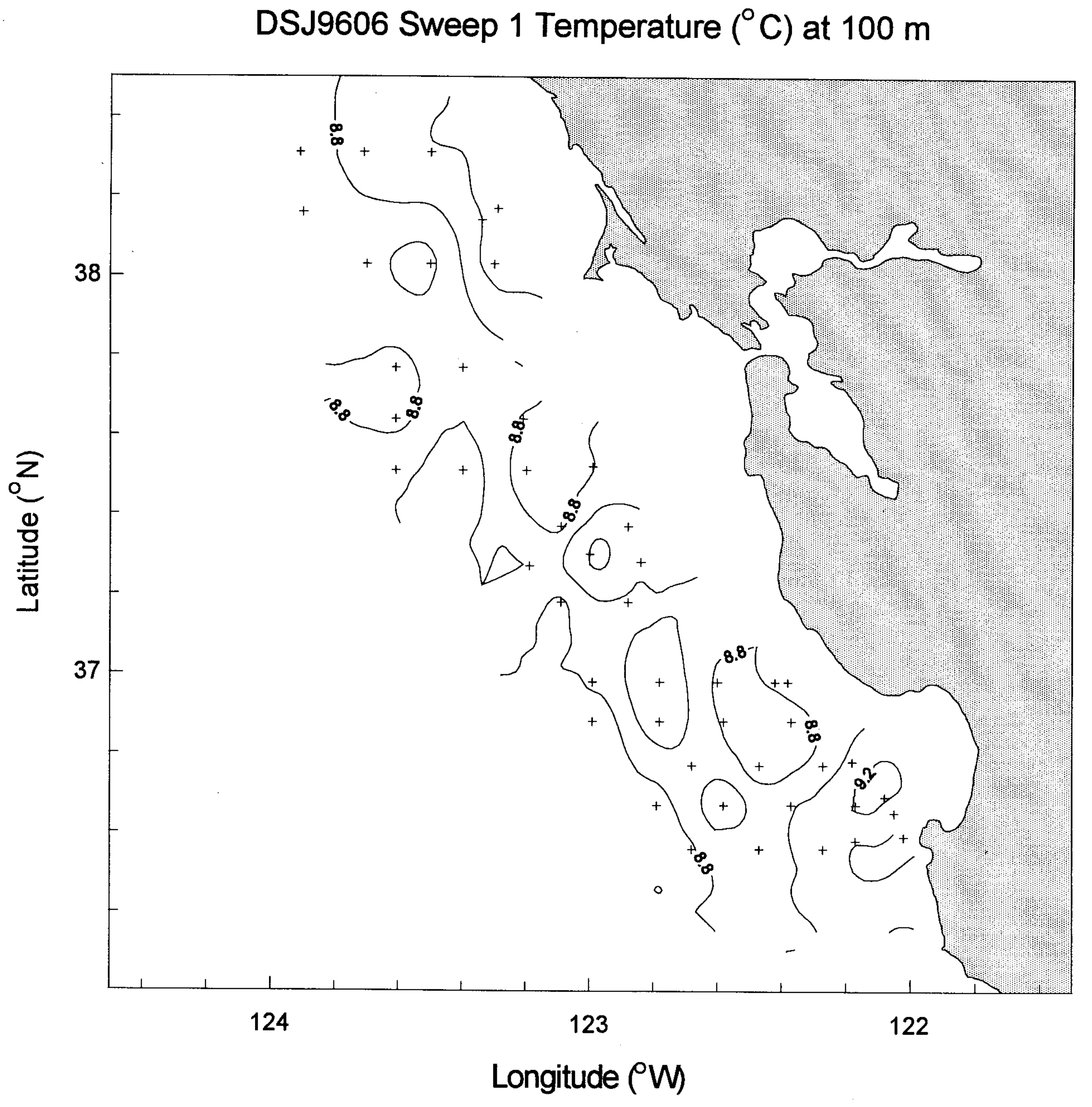


DSJ9606 Sweep 1 Temperature (°C) at 10 m

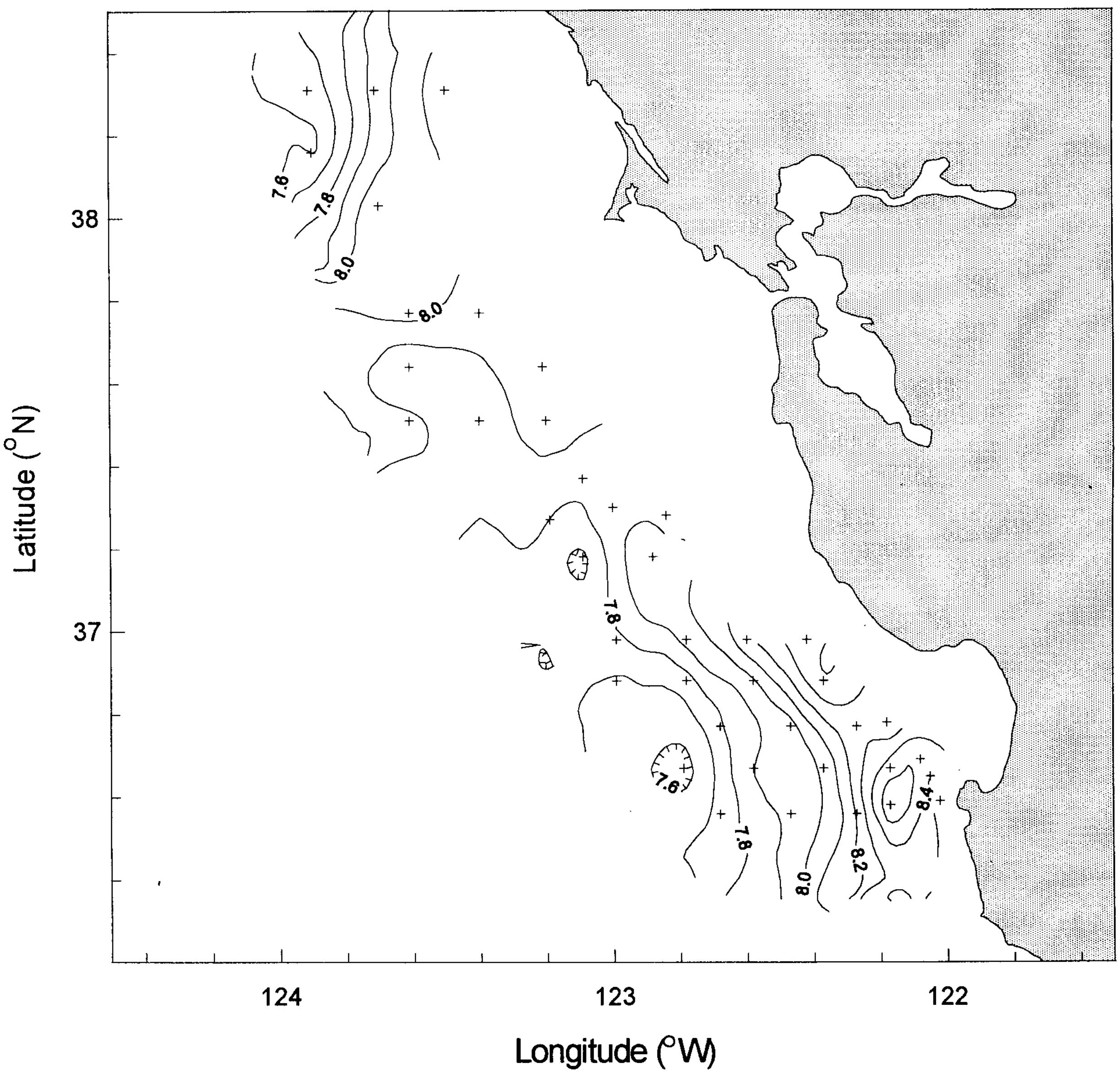


DSJ9606 Sweep 1 Temperature (°C) at 30 m

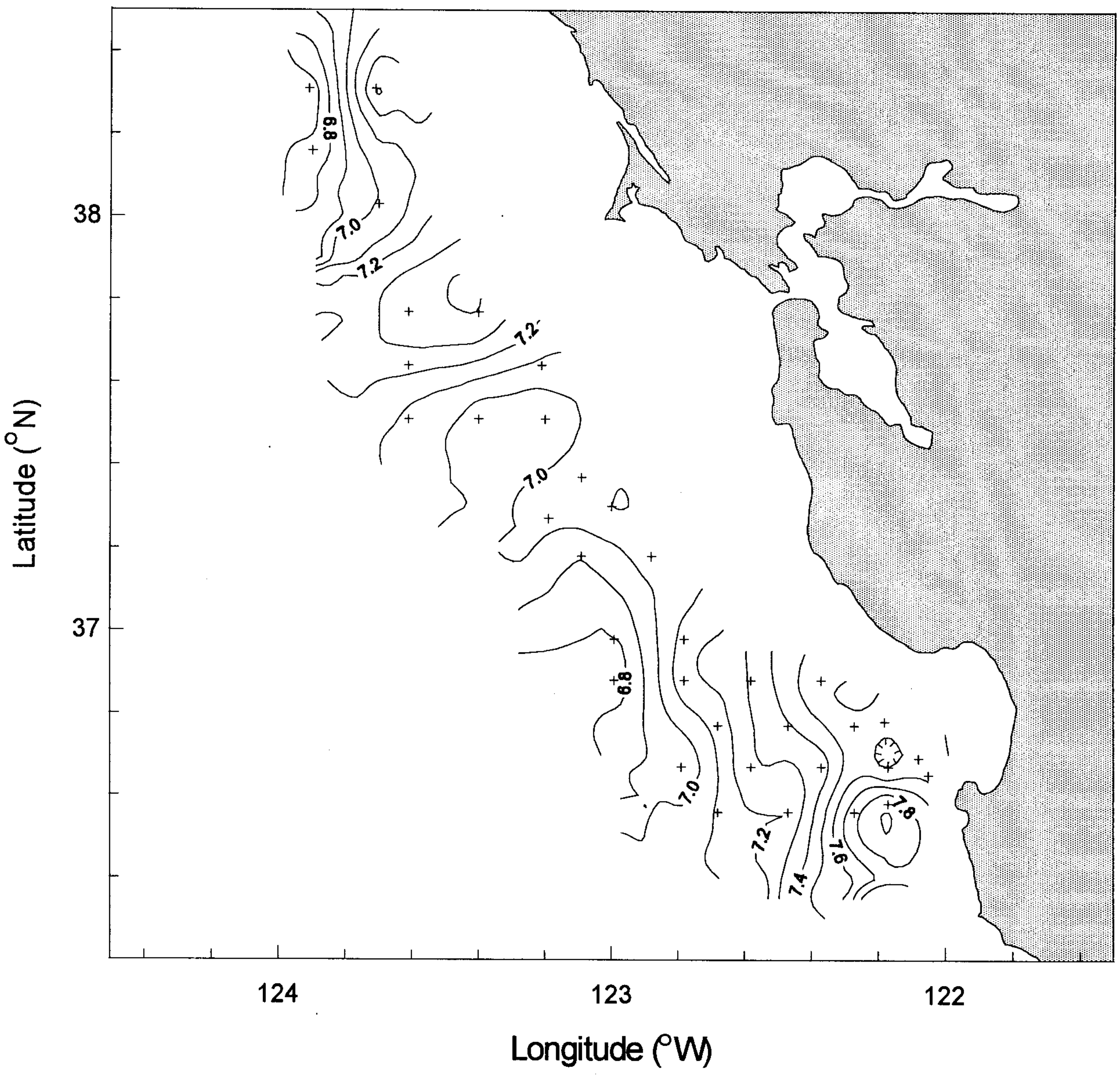



DSJ9606 Sweep 1 Temperature (°C) at 100 m
38
37
Latitude (°N)
124
123
122
Longitude (°W)
8.8
9.2

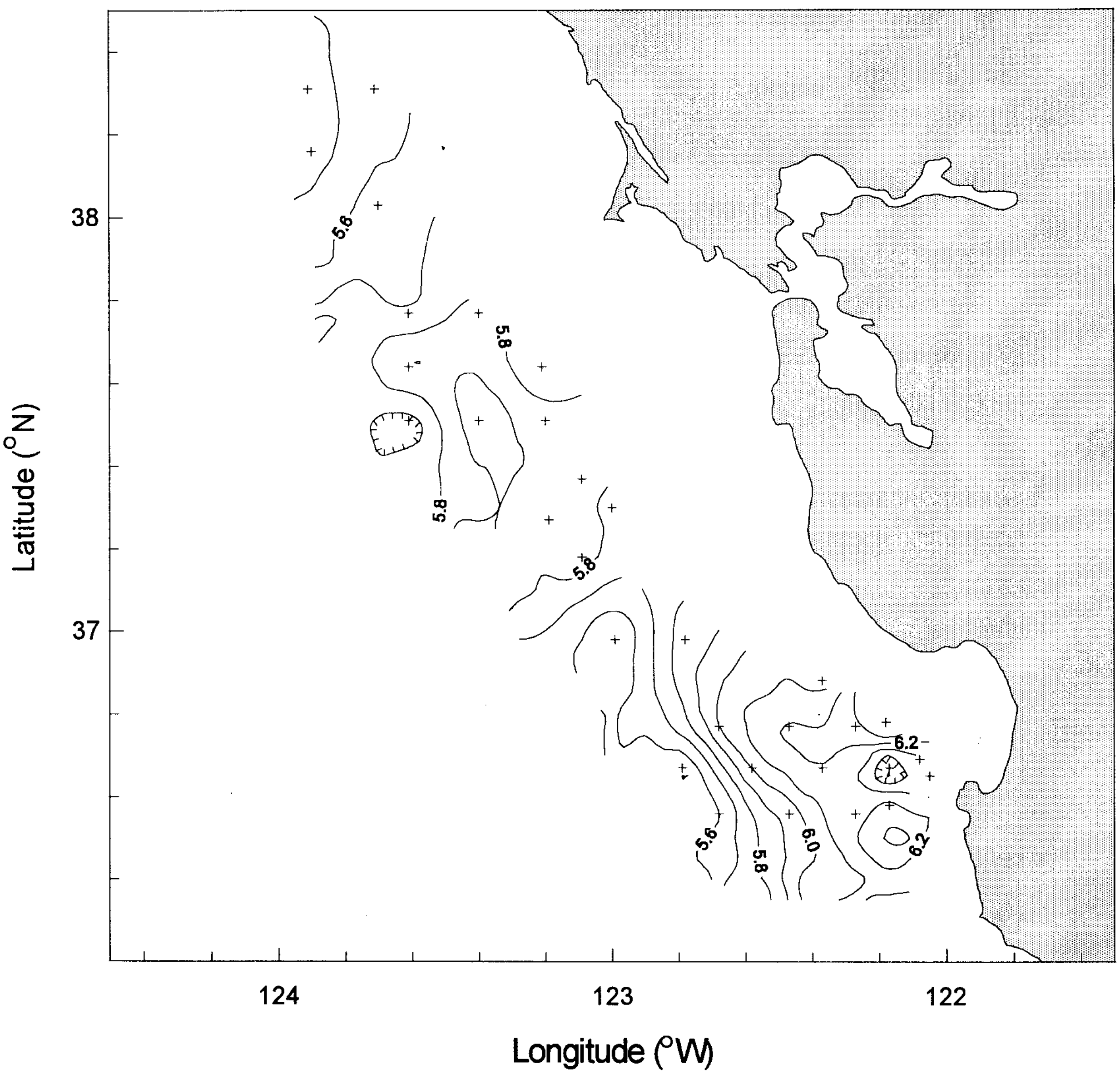
DSJ9606 Sweep 1 Temperature (°C) at 200 m



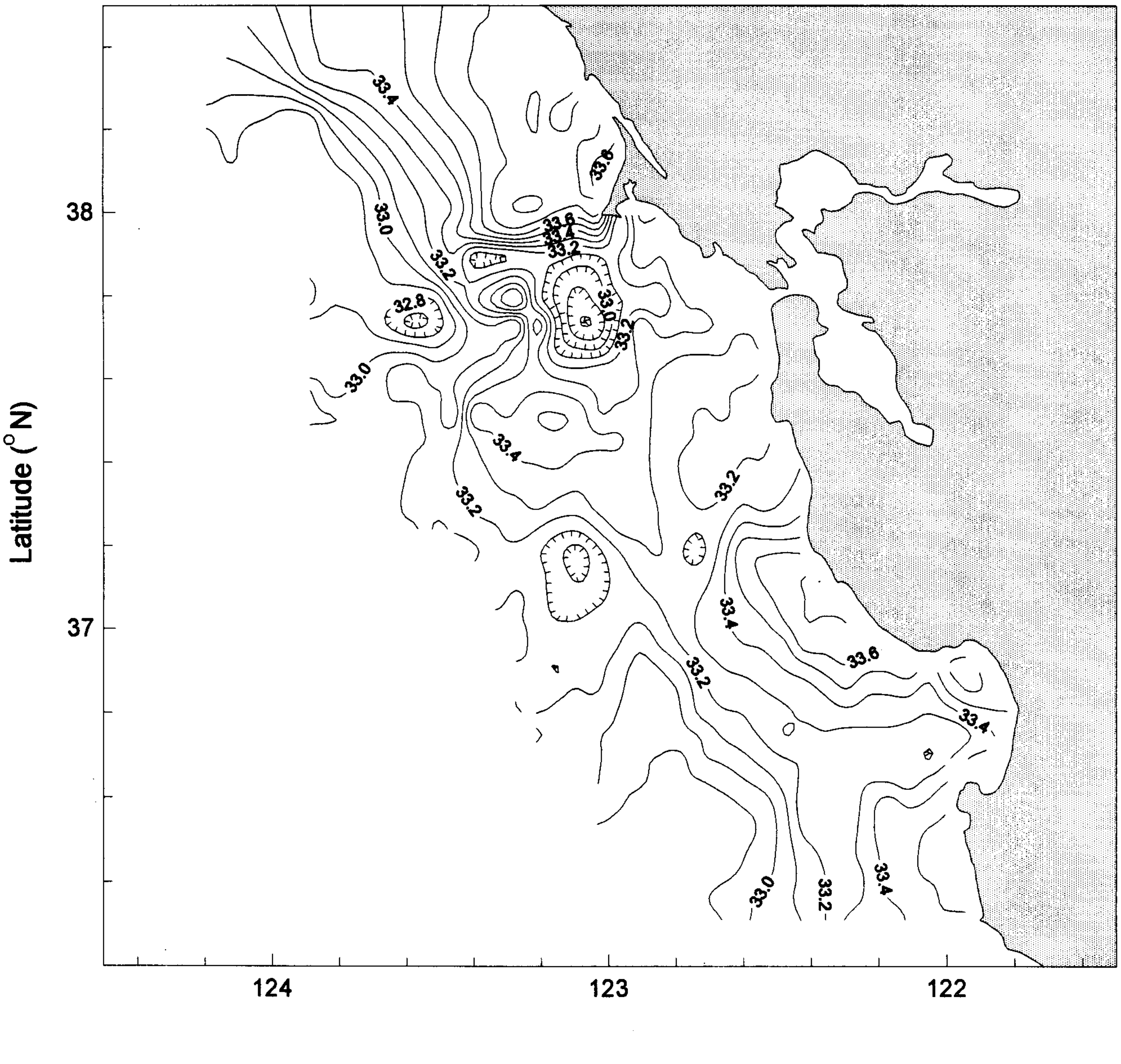
DSJ9606 Sweep 1 Temperature (°C) at 300 m



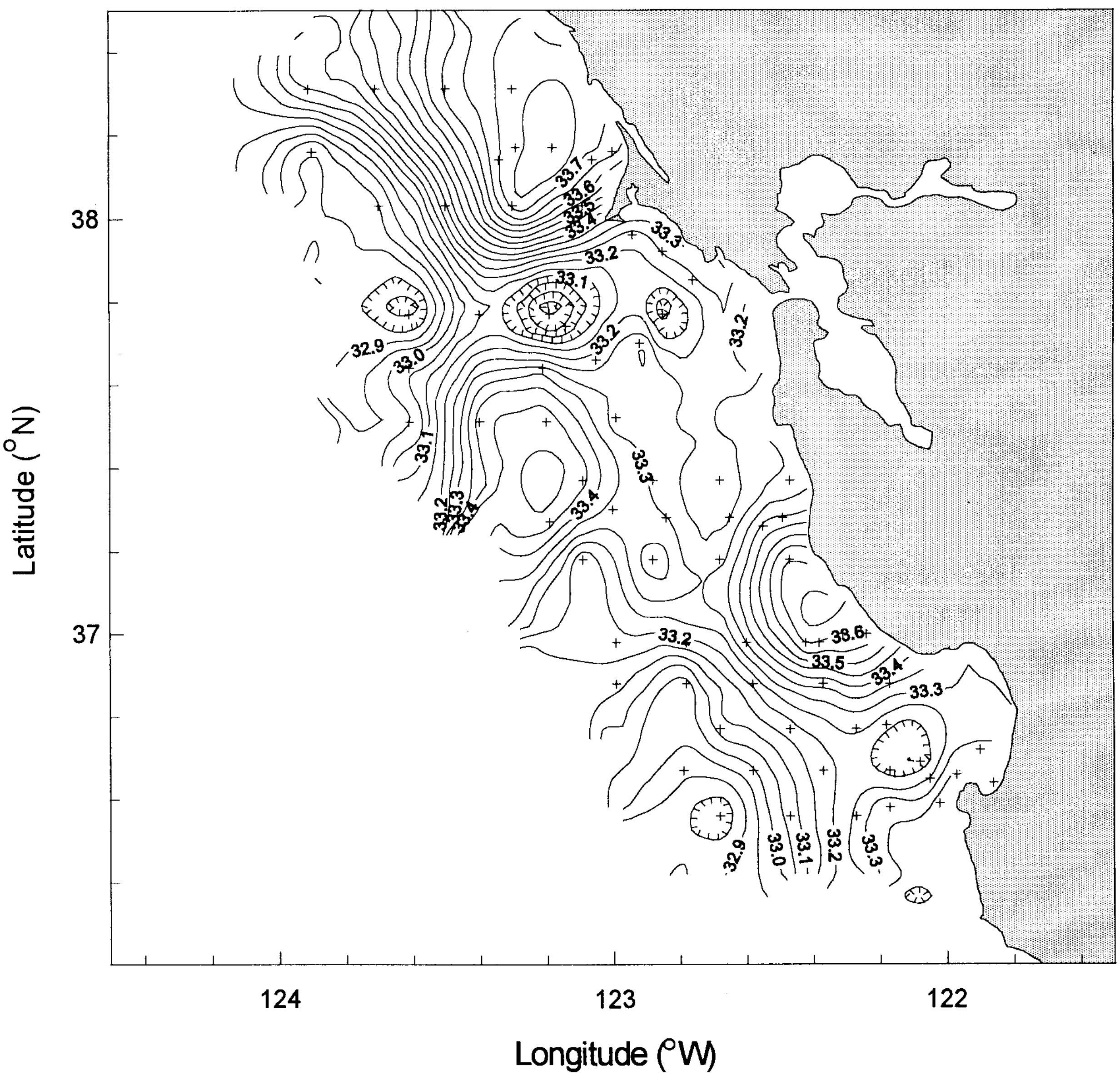
DSJ9606 Sweep 1 Temperature (°C) at 500 m



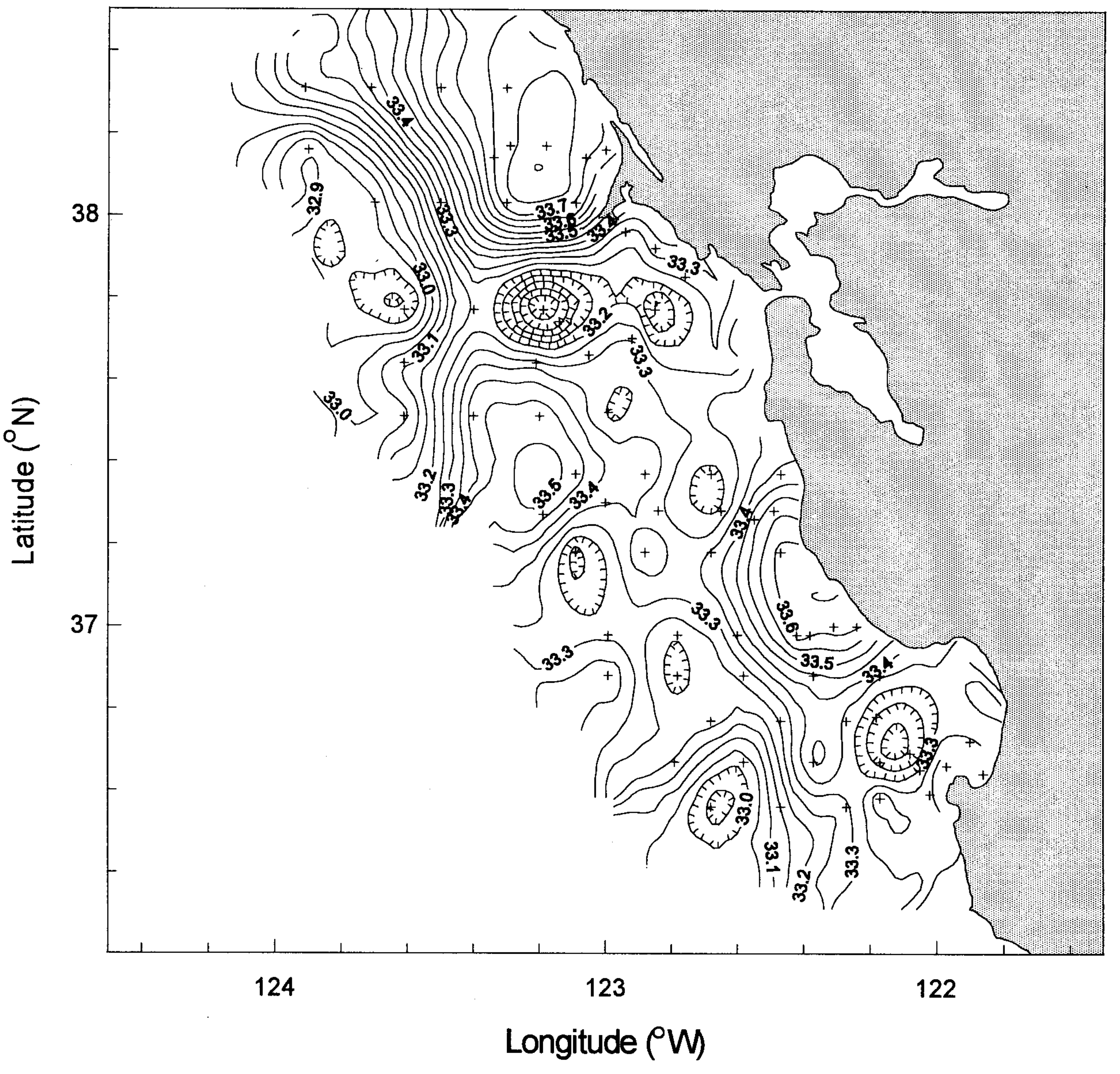
DSJ9606 Sweep 1 TS Salinity



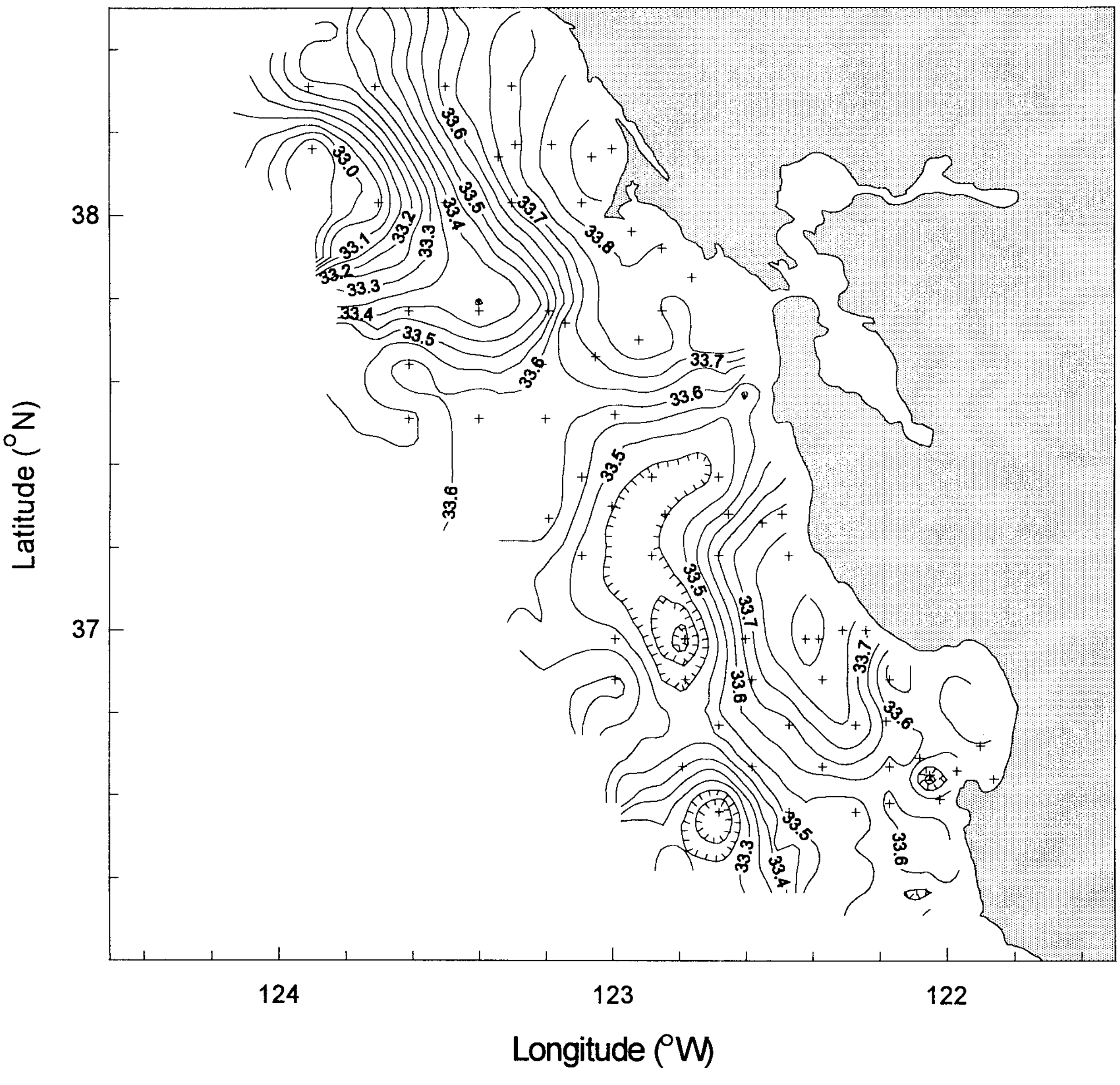
DSJ9606 Sweep 1 Salinity (ppt) at 2 m

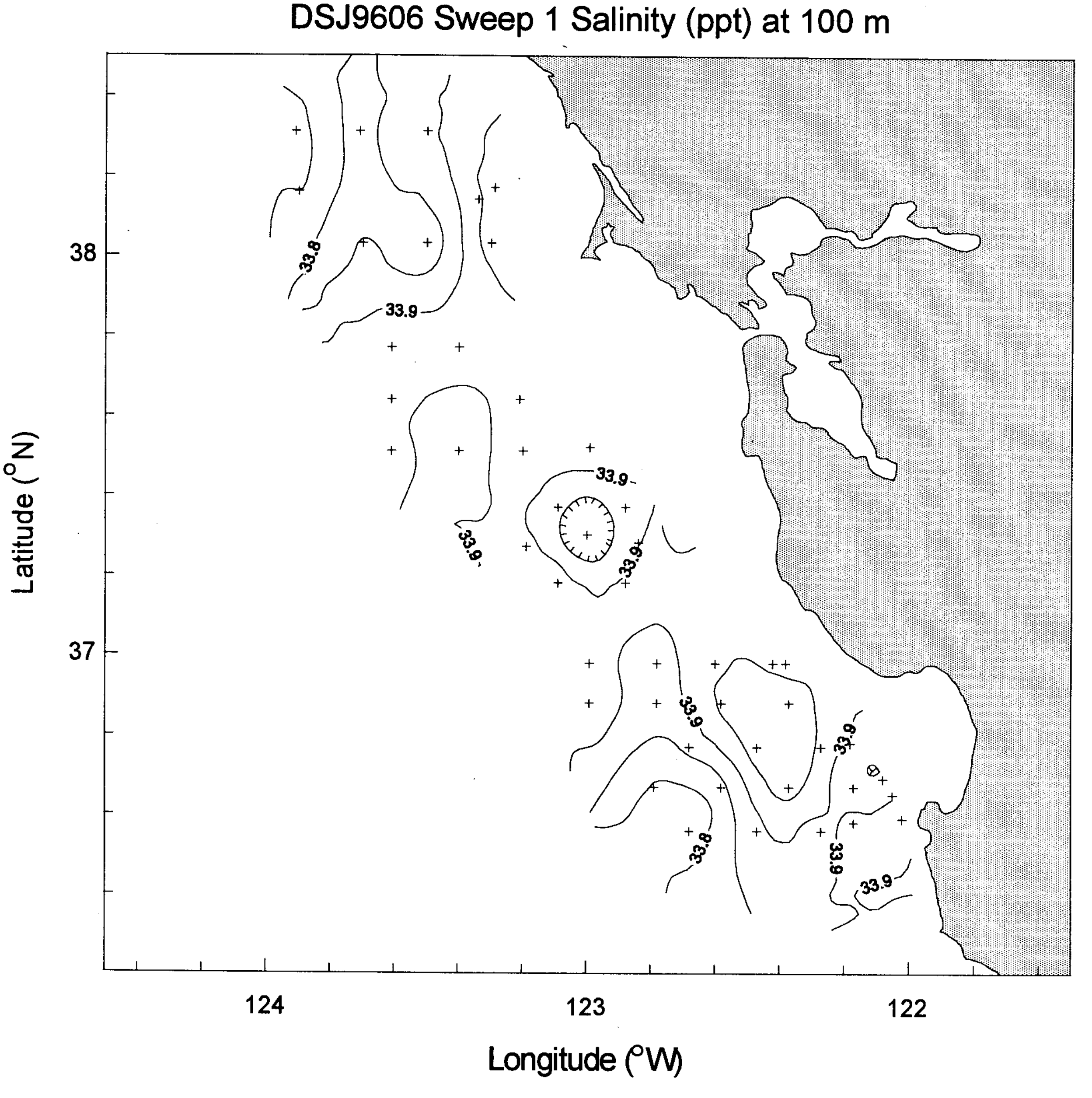


DSJ9606 Sweep 1 Salinity (ppt) at 10 m

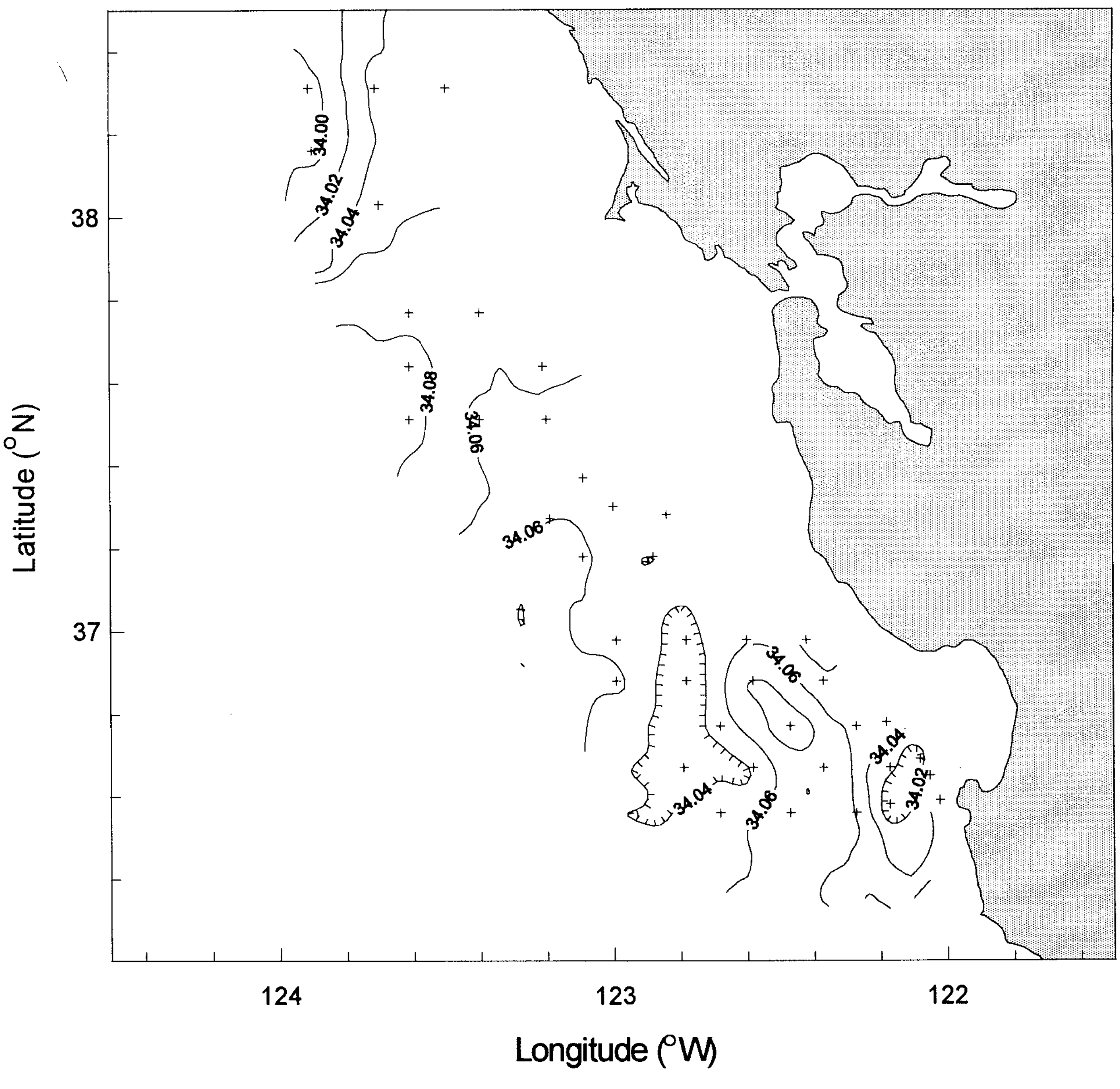


DSJ9606 Sweep 1 Salinity (ppt) at 30 m

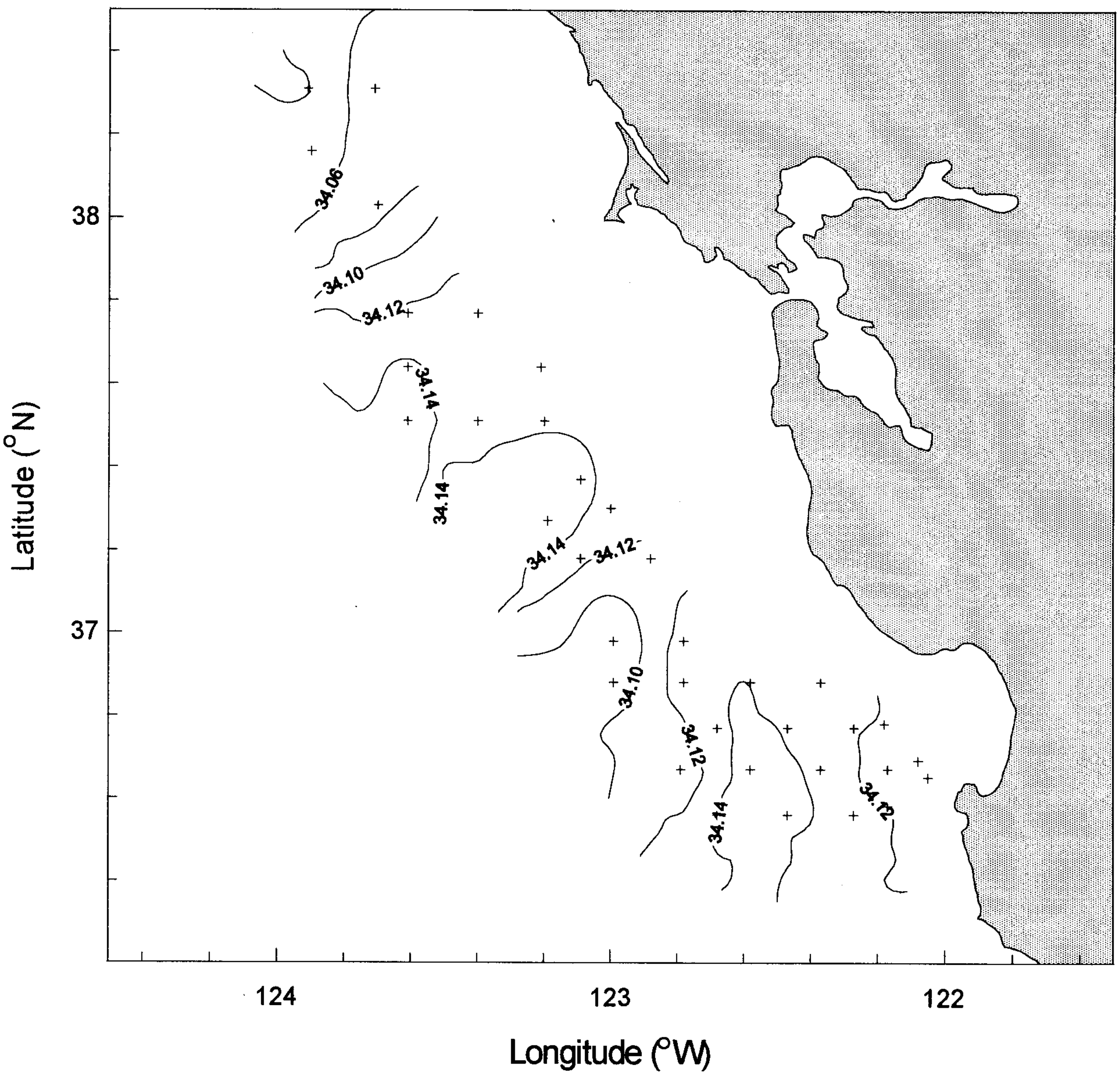



DSJ9606 Sweep 1 Salinity (ppt) at 100 m
38
37
Latitude (°N)
124
123
122
Longitude (°W)
33.8
33.9

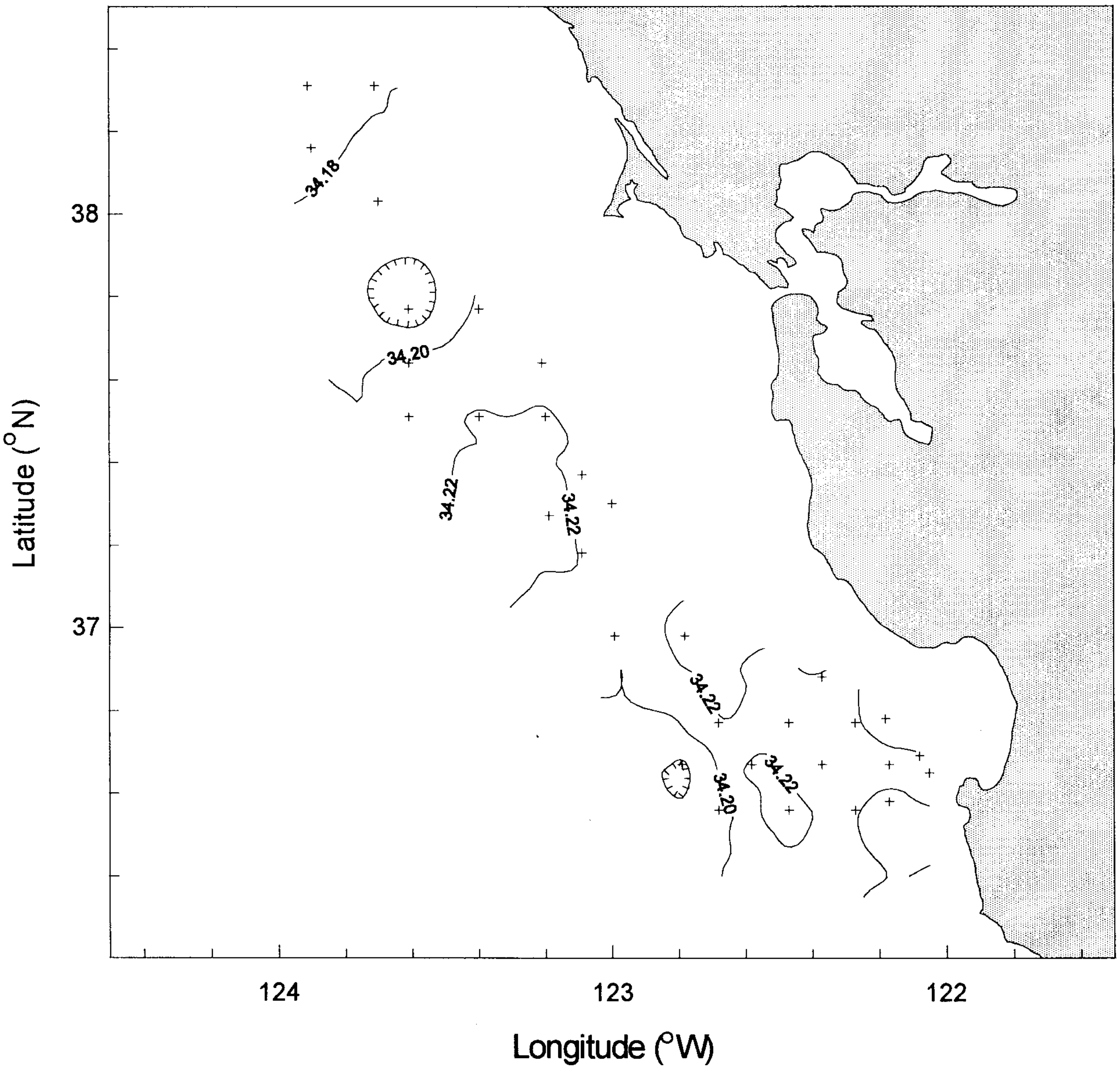
DSJ9606 Sweep 1 Salinity (ppt) at 200 m



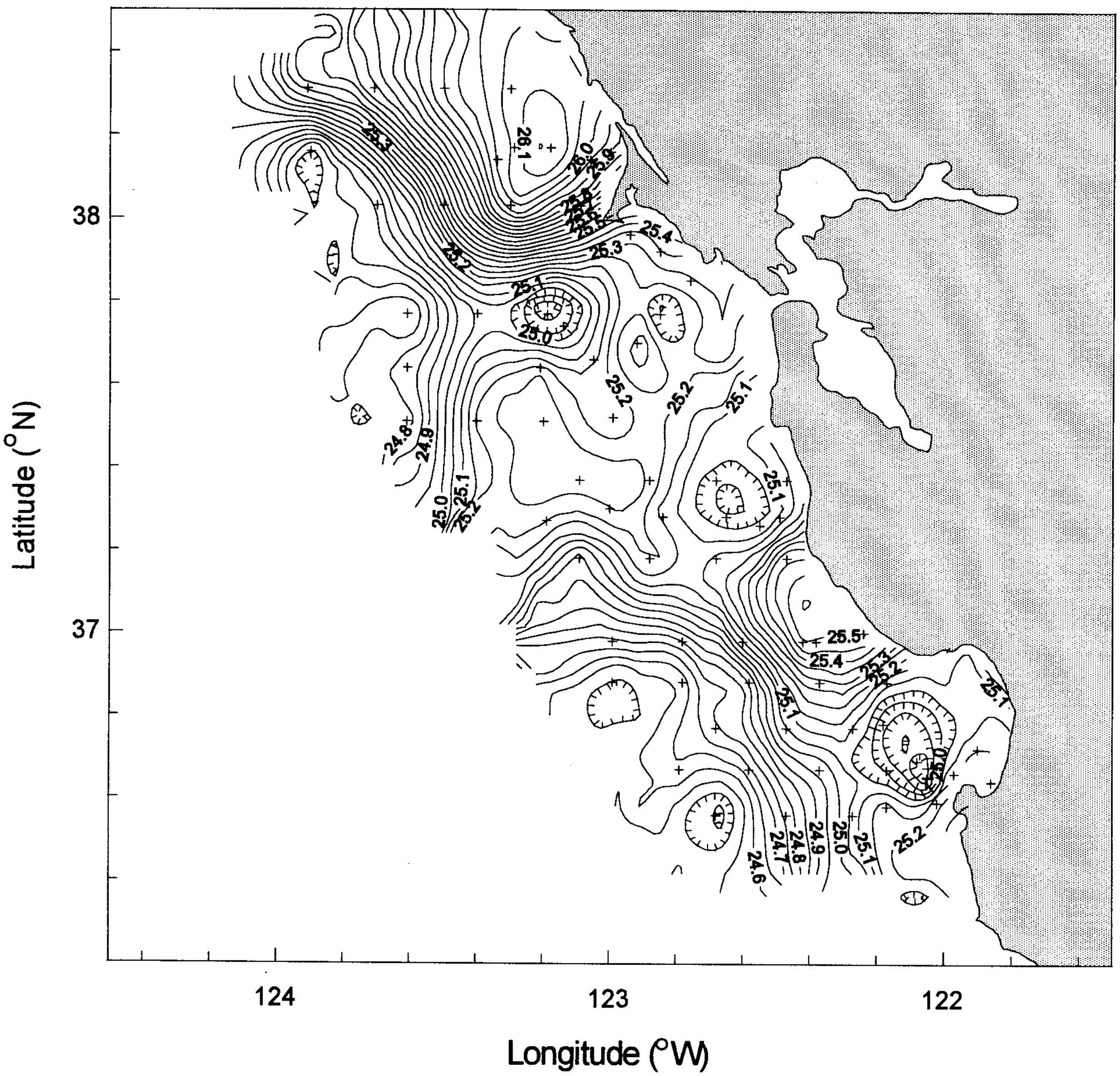
DSJ9606 Sweep 1 Salinity (ppt) at 300 m



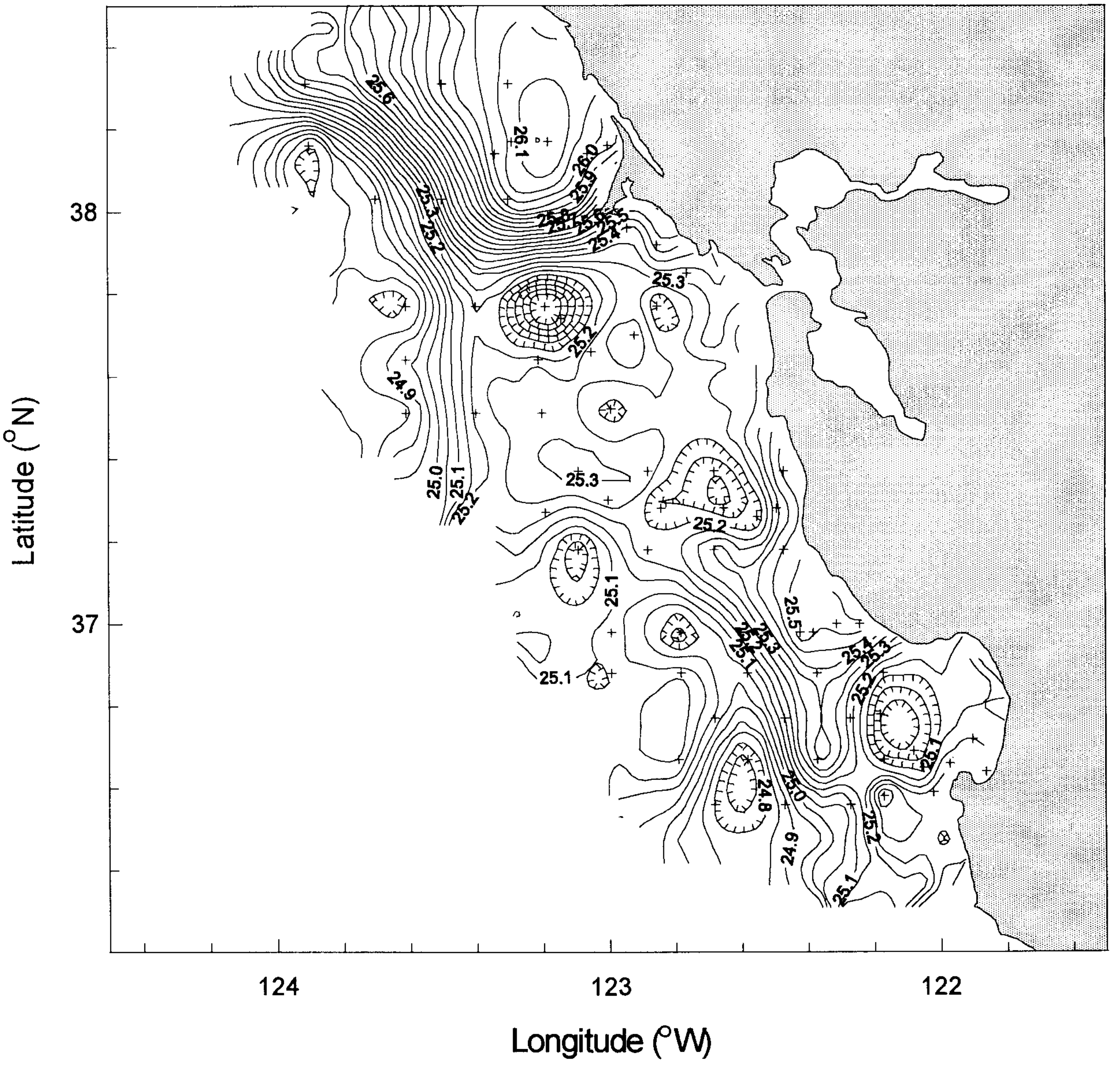
DSJ9606 Sweep 1 Salinity (ppt) at 500 m



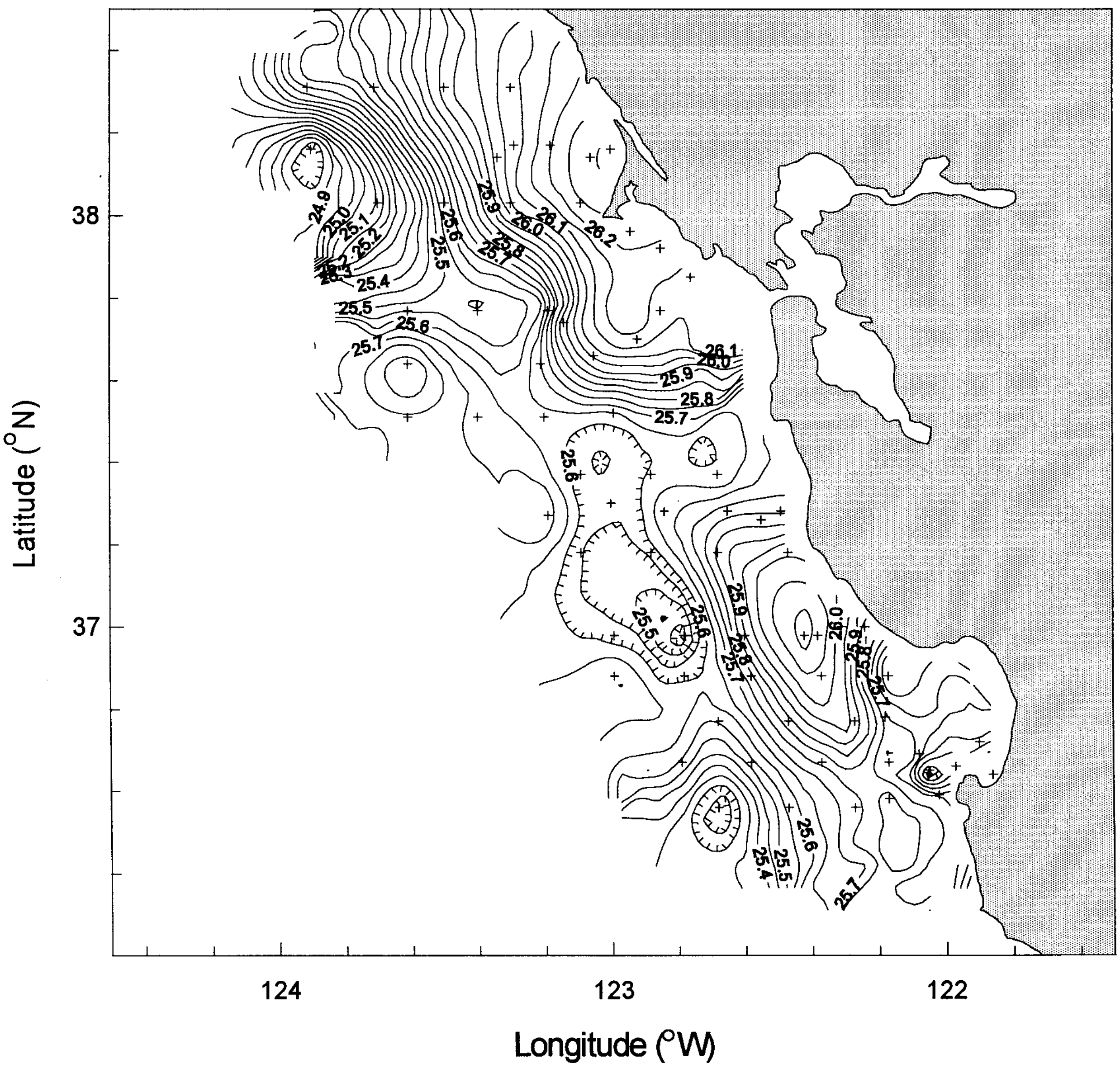
DSJ9606 Sweep 1 Density (kg/m^3) at 2 m

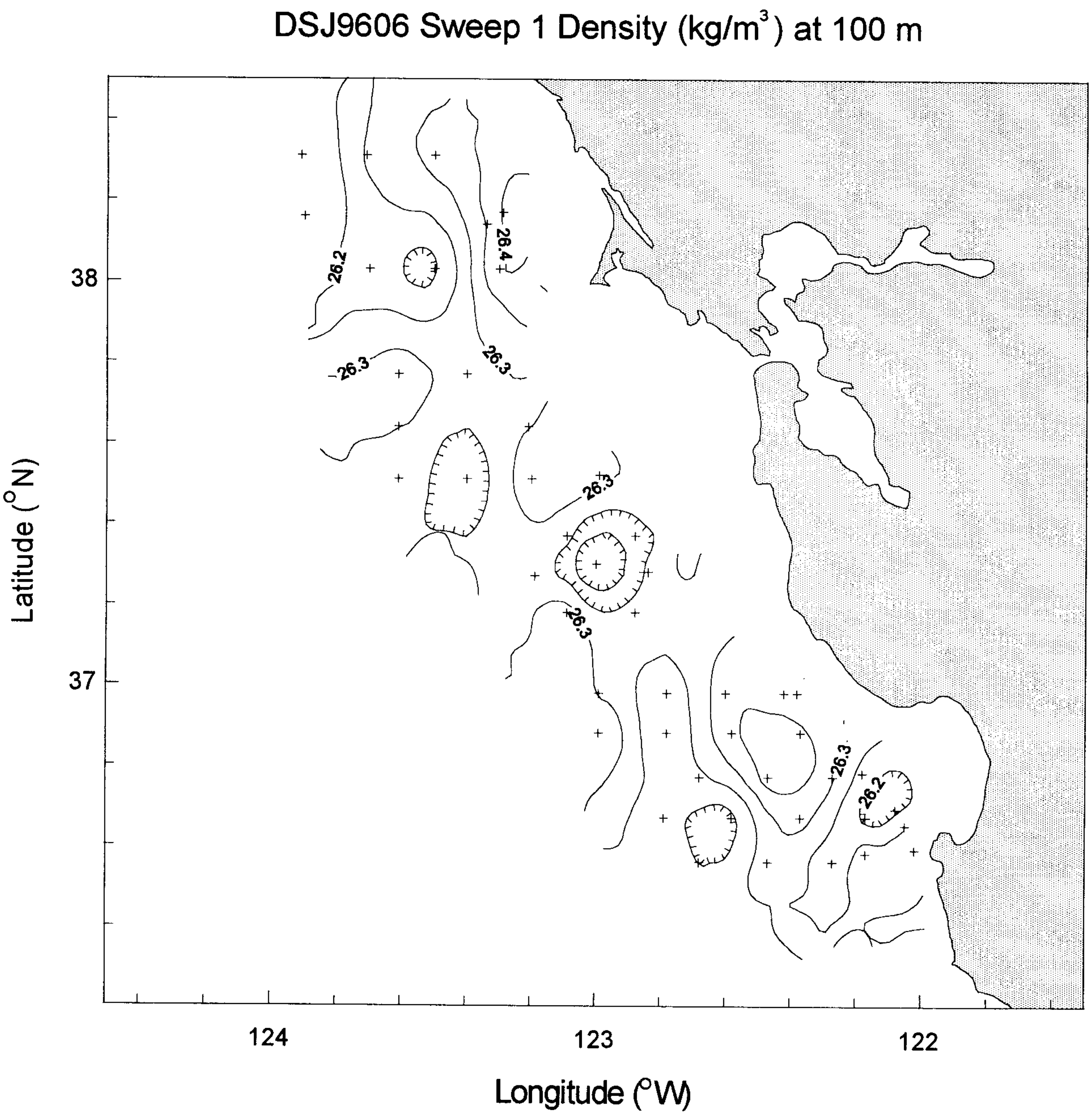


DSJ9606 Sweep 1 Density (kg/m³) at 10 m

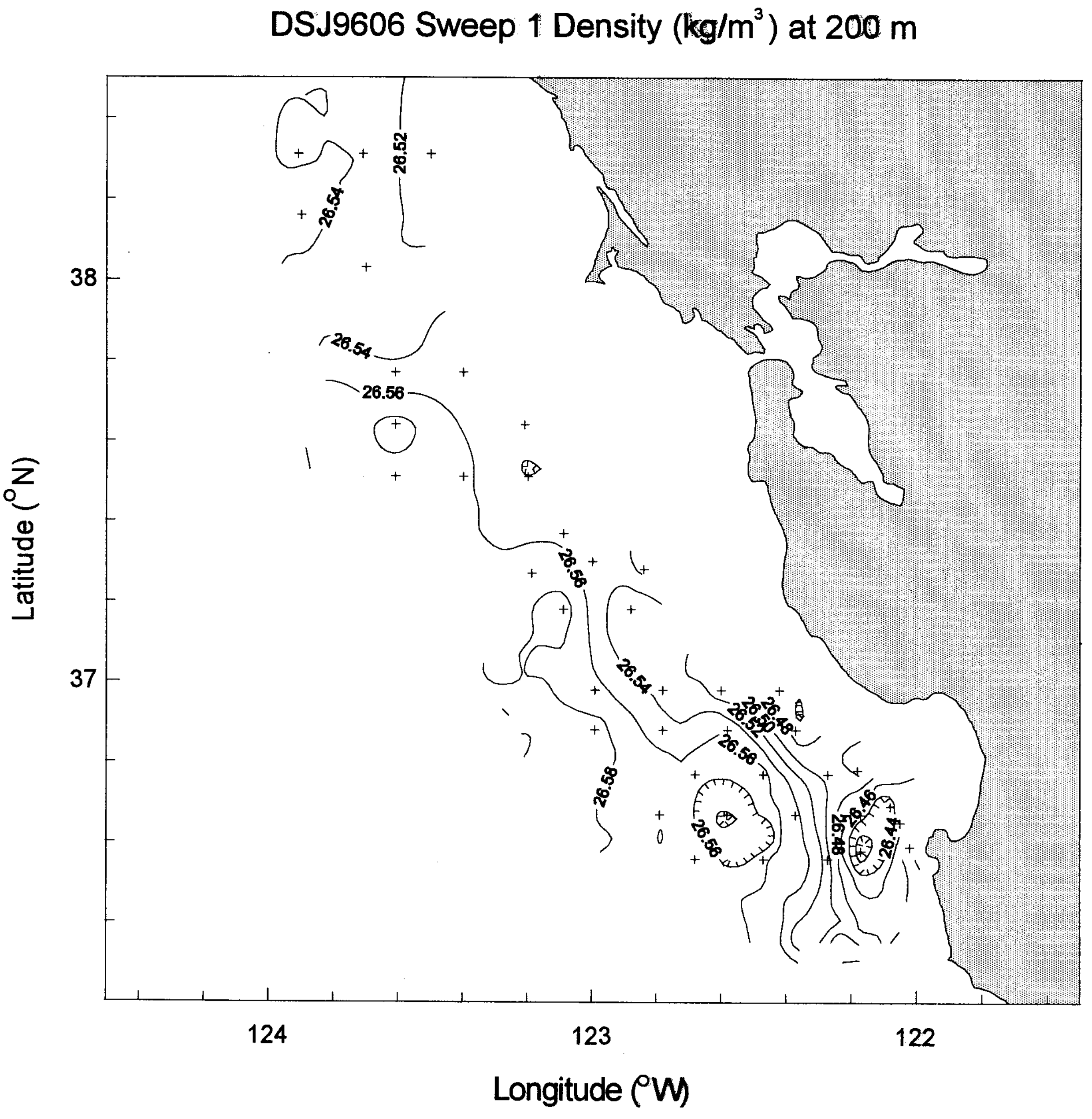


DSJ9606 Sweep 1 Density (kg/m^3) at 30 m

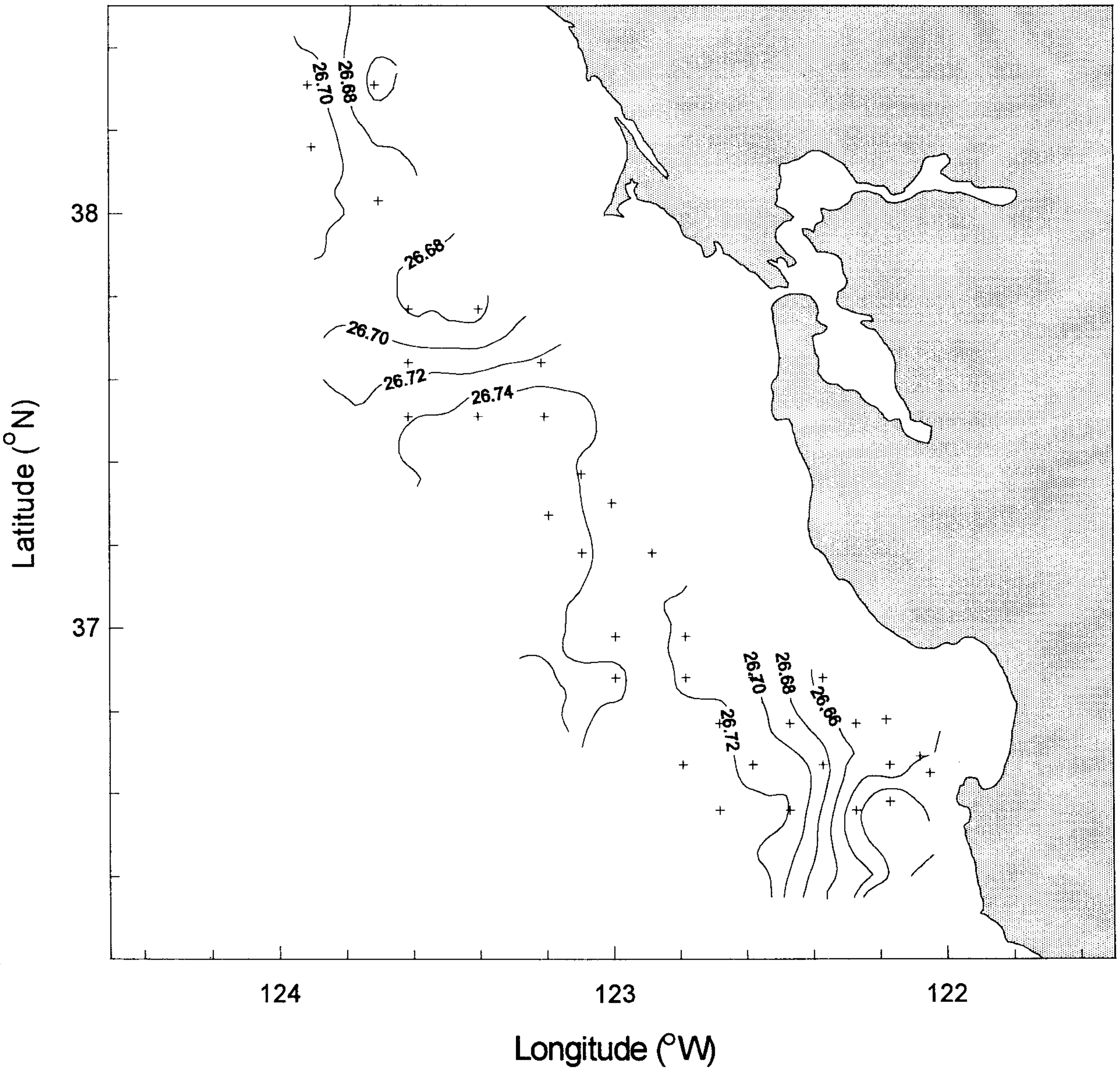


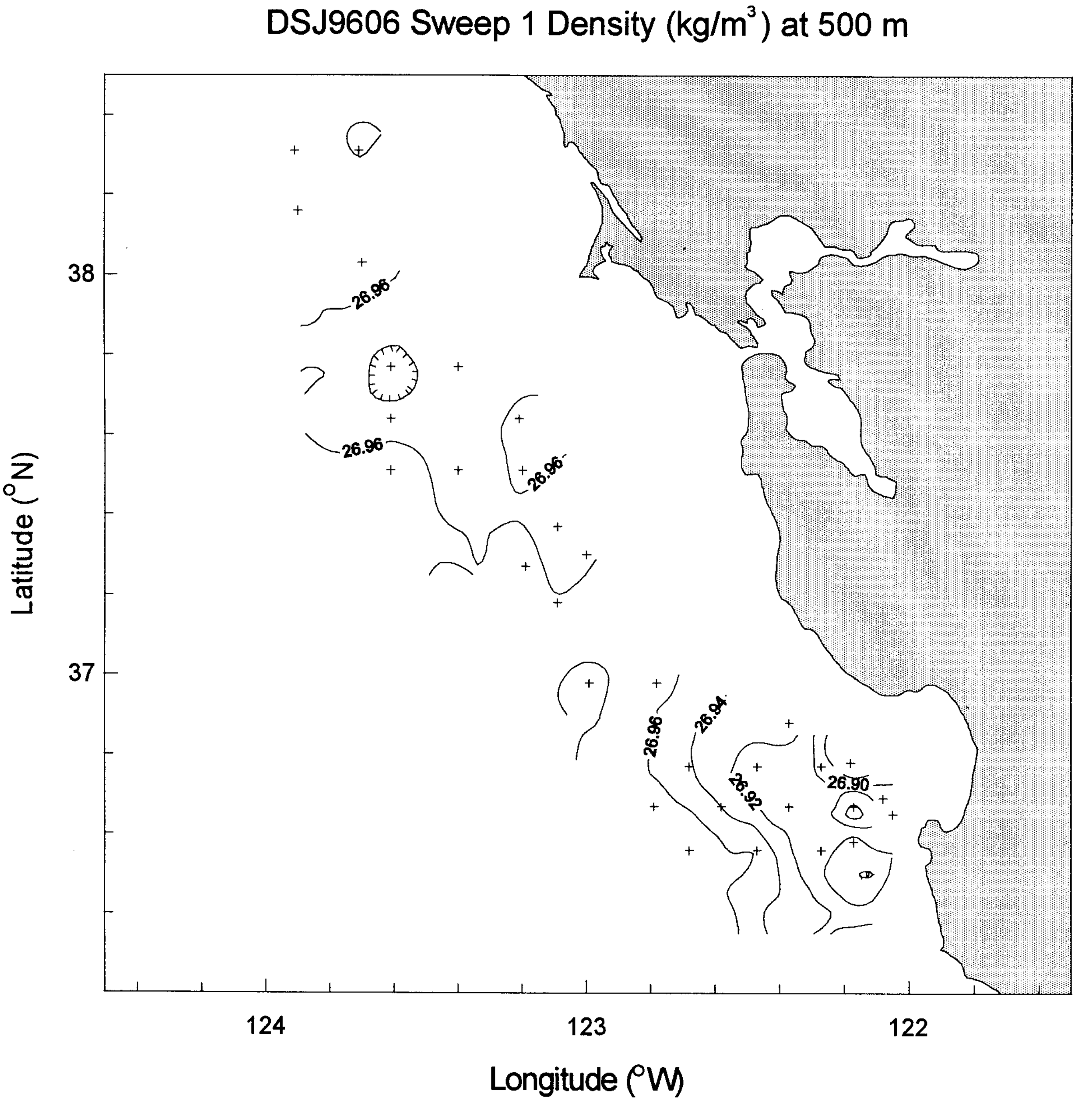


DSJ9606 Sweep 1 Density (kg/m³) at 100 m
Latitude (°N)
38
37
124
123
122
Longitude (°W)
26.2
26.4
26.3
26.3
26.3
26.3
26.3
26.3
26.2

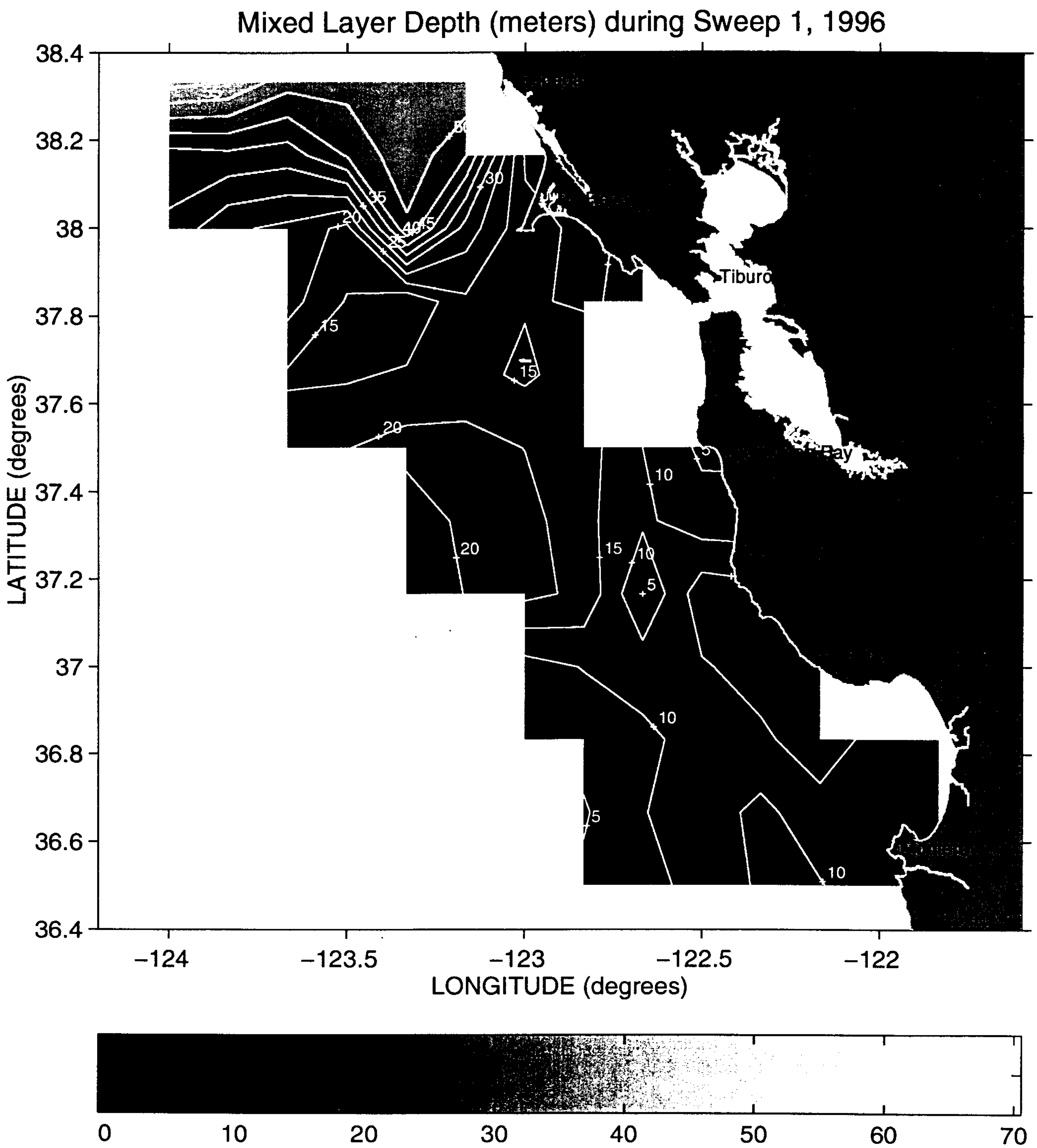

DSJ9606 Sweep 1 Density (kg/m³) at 200 m
26.52
26.54
26.54
26.58
26.56
26.54
26.58
26.56
26.48
26.46
26.44
38
37
124
123
122
Latitude (°N)
Longitude (°W)

DSJ9606 Sweep 1 Density (kg/m^3) at 300 m

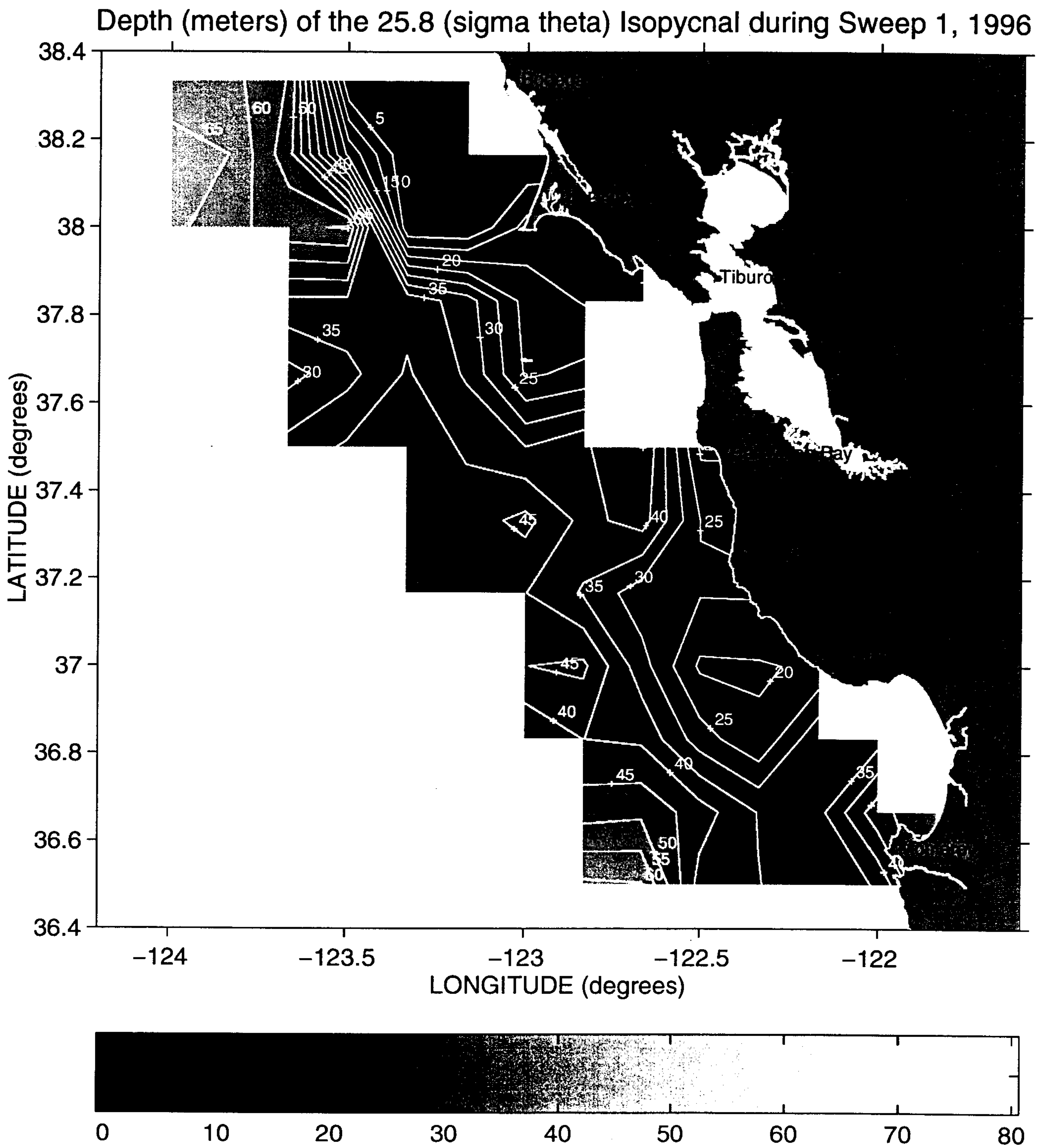




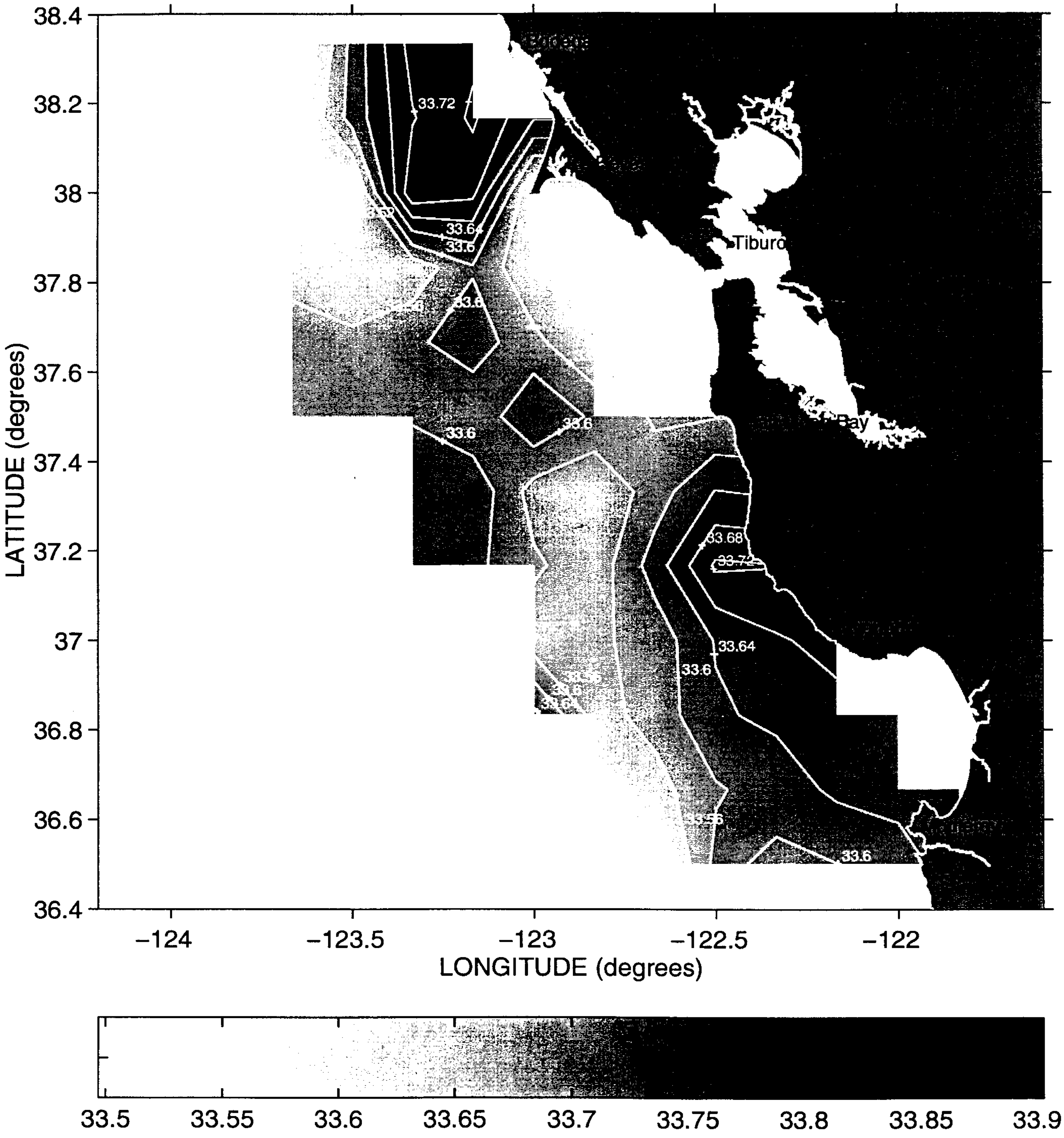
DSJ9606 Sweep 1 Density (kg/m³) at 500 m
38
37
Latitude (°N)
124
123
122
Longitude (°W)
26.96
26.96
26.96
26.96
26.94
26.92
26.90

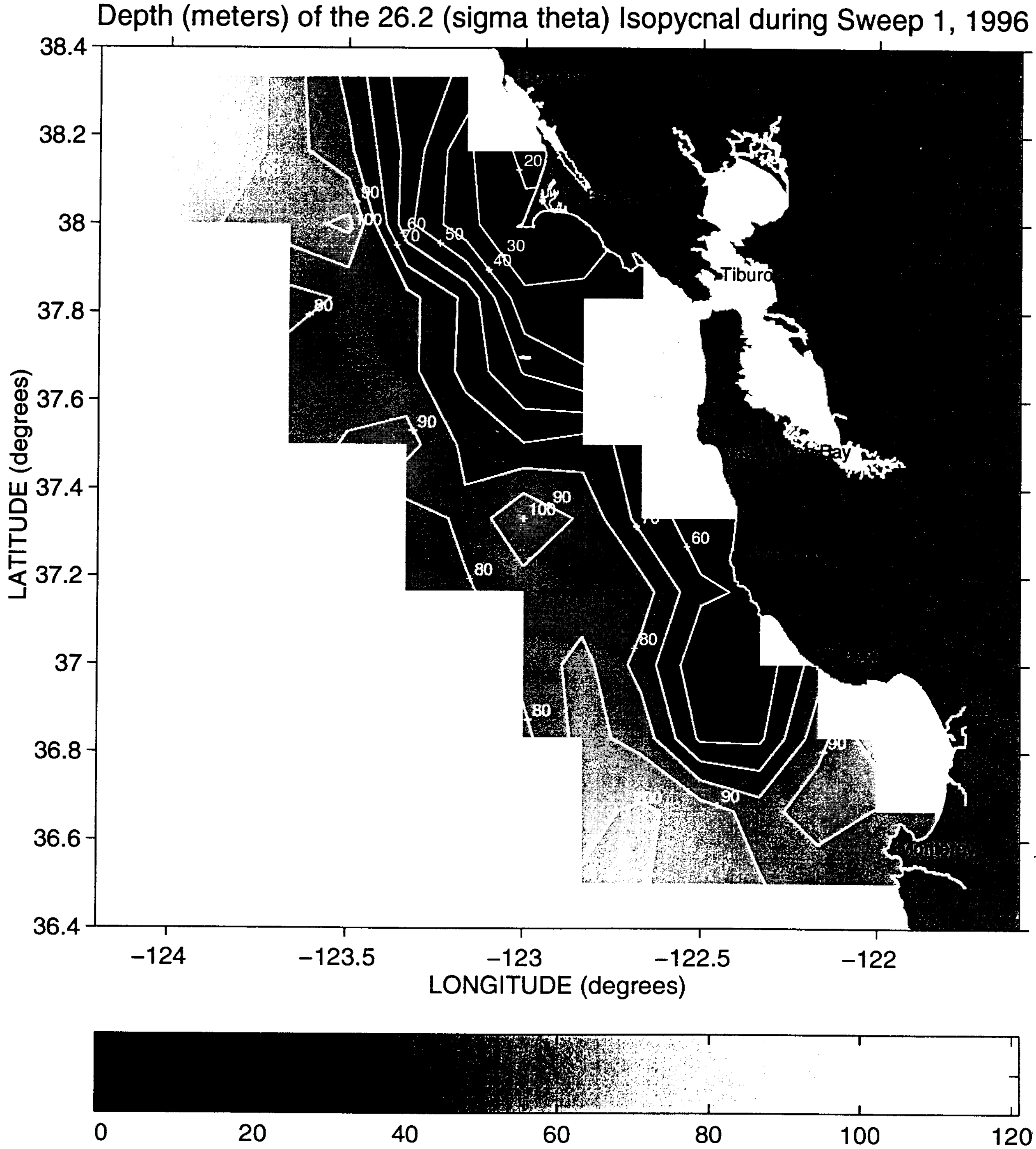


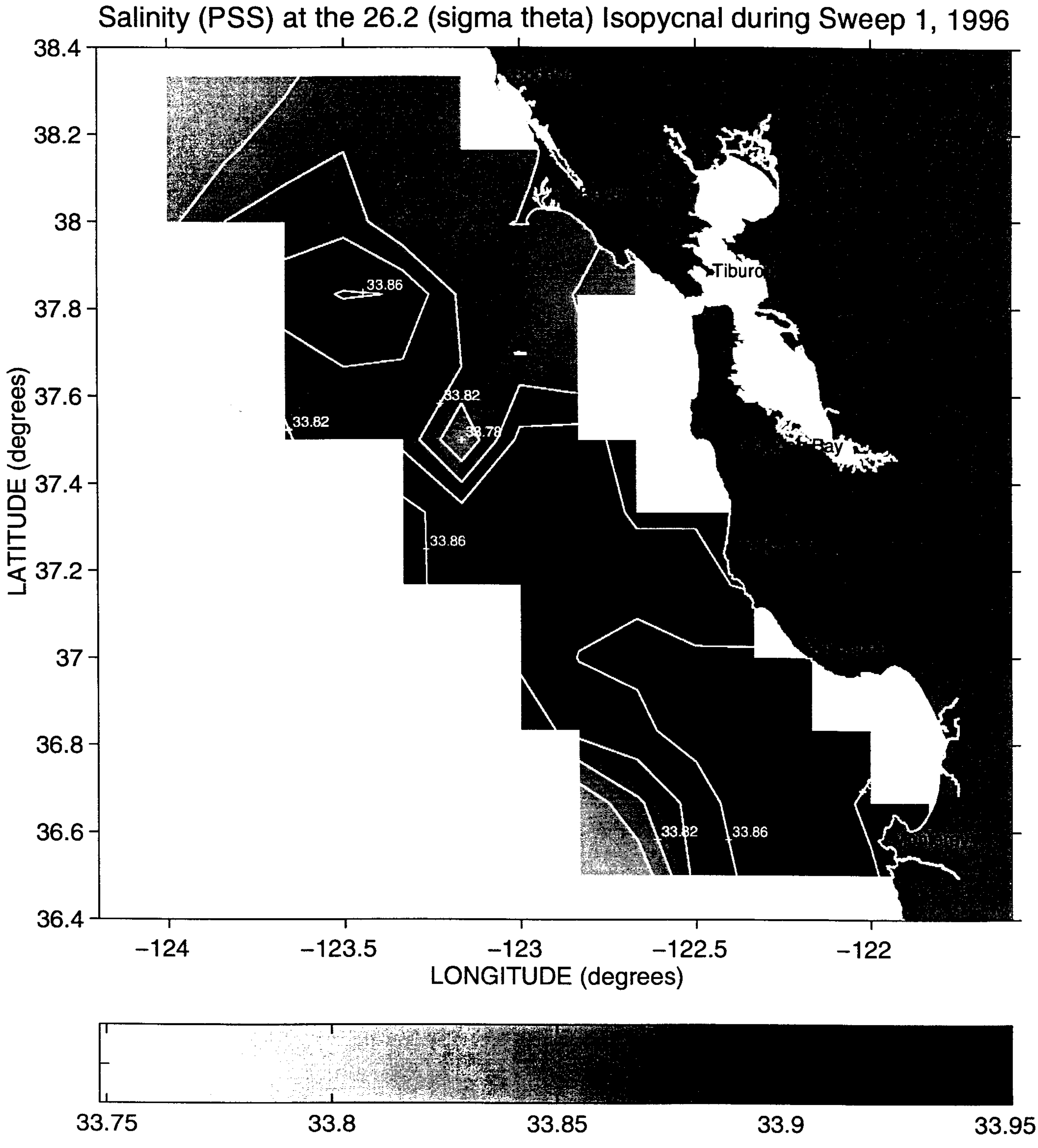
Mixed Layer Depth (meters) during Sweep 1, 1996
38.4
38.2
38
37.8
37.6
37.4
37.2
37
36.8
36.6
36.4
LATITUDE (degrees)
-124
-123.5
-123
-122.5
-122
LONGITUDE (degrees)
Tiburo
Bay
0
10
20
30
40
50
60
70


Depth (meters) of the 25.8 (sigma theta) Isopycnal during Sweep 1, 1996
38.4
38.2
38
37.8
37.6
37.4
37.2
37
36.8
36.6
36.4
LATITUDE (degrees)
-124
-123.5
-123
-122.5
-122
LONGITUDE (degrees)
Tiburo
Bay
0
10
20
30
40
50
60
70
80

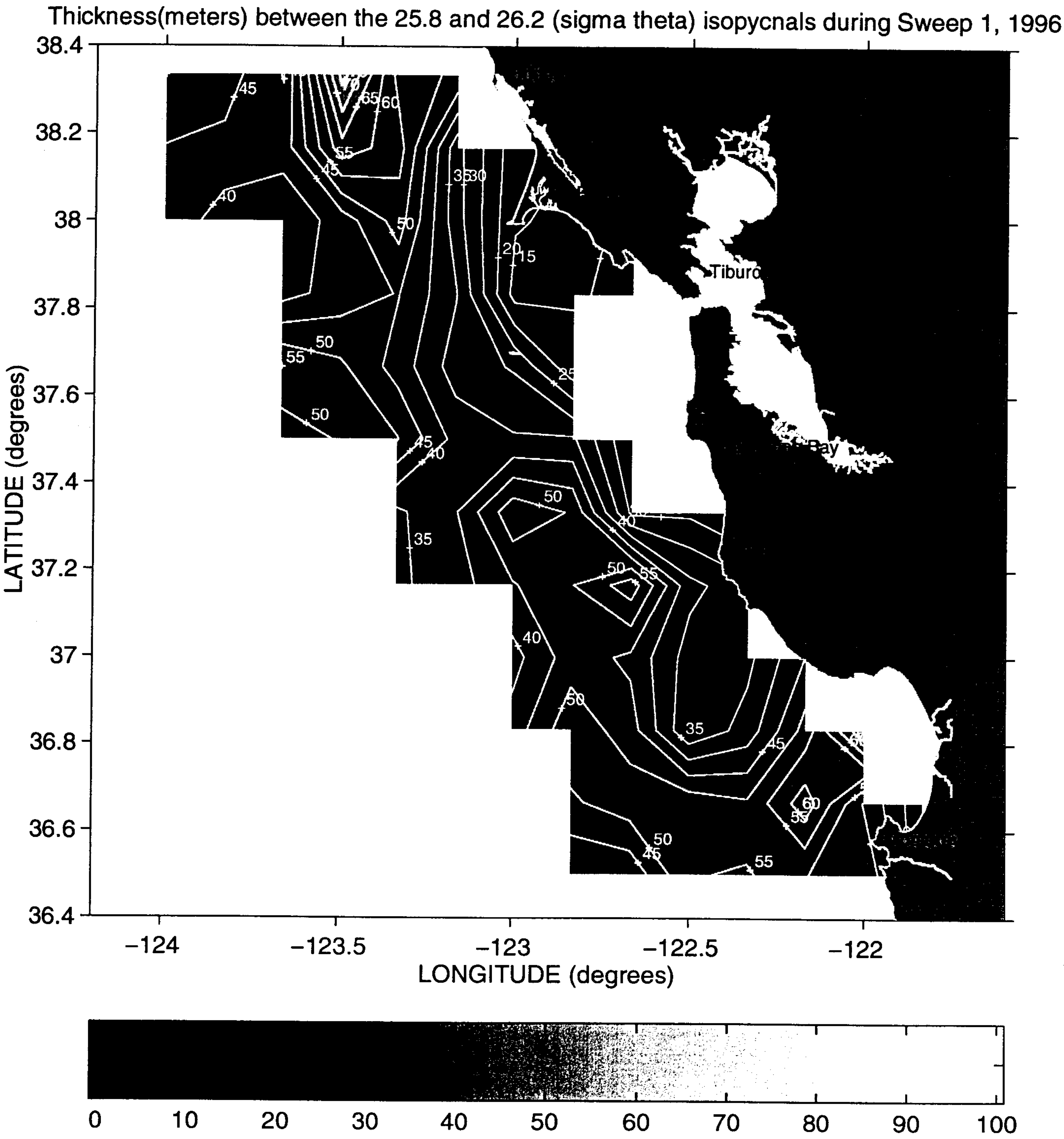
Salinity (PSS) at the 25.8 (sigma theta) Isopycnal during Sweep 1, 1996




Depth (meters) of the 26.2 (sigma theta) Isopycnal during Sweep 1, 1996
38.4
38.2
38
37.8
37.6
37.4
37.2
37
36.8
36.6
36.4
LATITUDE (degrees)
-124
-123.5
-123
-122.5
-122
LONGITUDE (degrees)
Tiburo
Bay
20
30
40
50
60
70
80
90
100
0
20
40
60
80
100
120



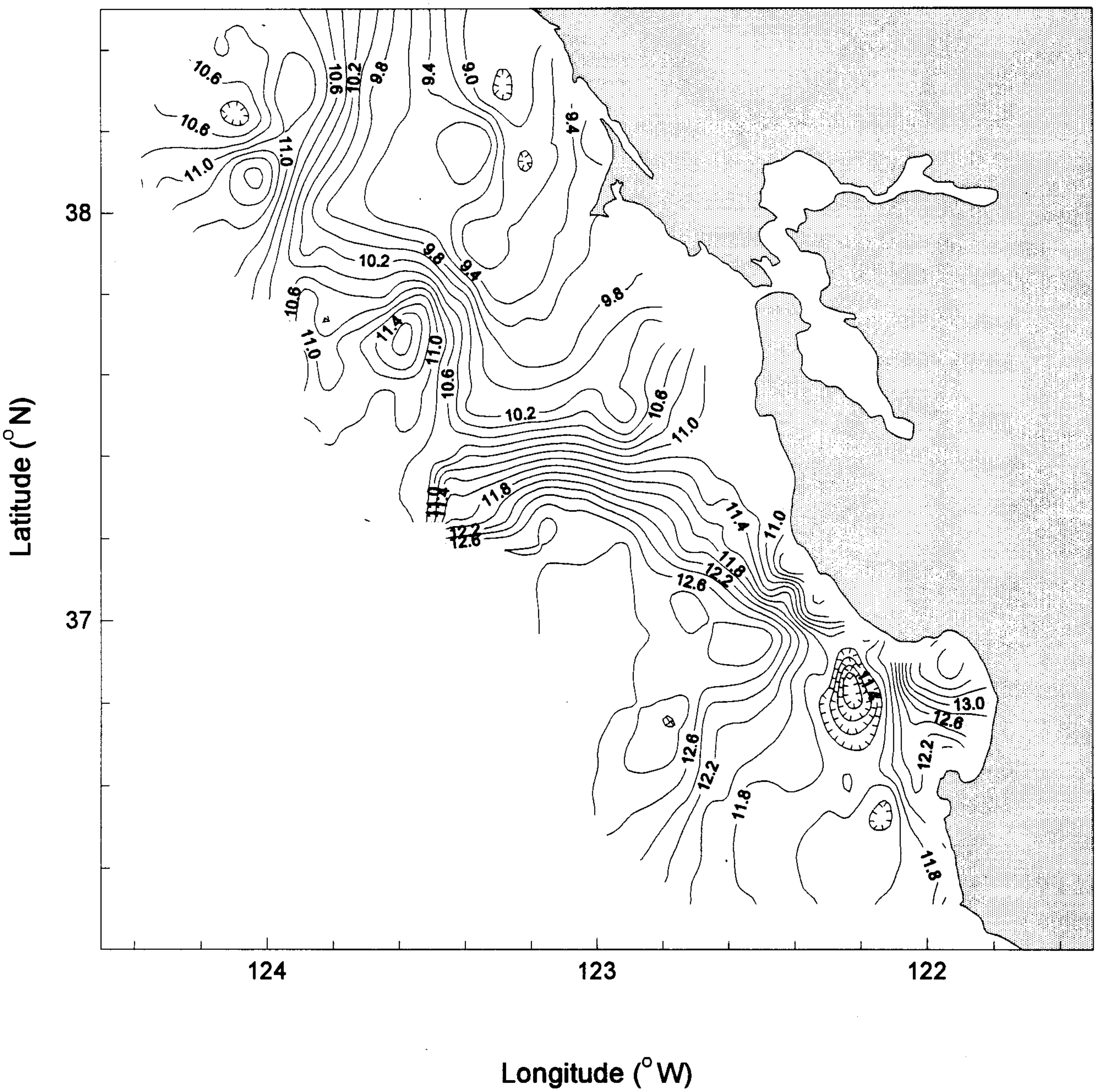
Salinity (PSS) at the 26.2 (sigma theta) Isopycnal during Sweep 1, 1996
38.4
38.2
38
37.8
37.6
37.4
37.2
37
36.8
36.6
36.4
LATITUDE (degrees)
−124
−123.5
−123
−122.5
−122
LONGITUDE (degrees)
33.86
33.82
33.82
33.78
33.86
33.82
33.86
Tiburo
Bay
33.75
33.8
33.85
33.9
33.95



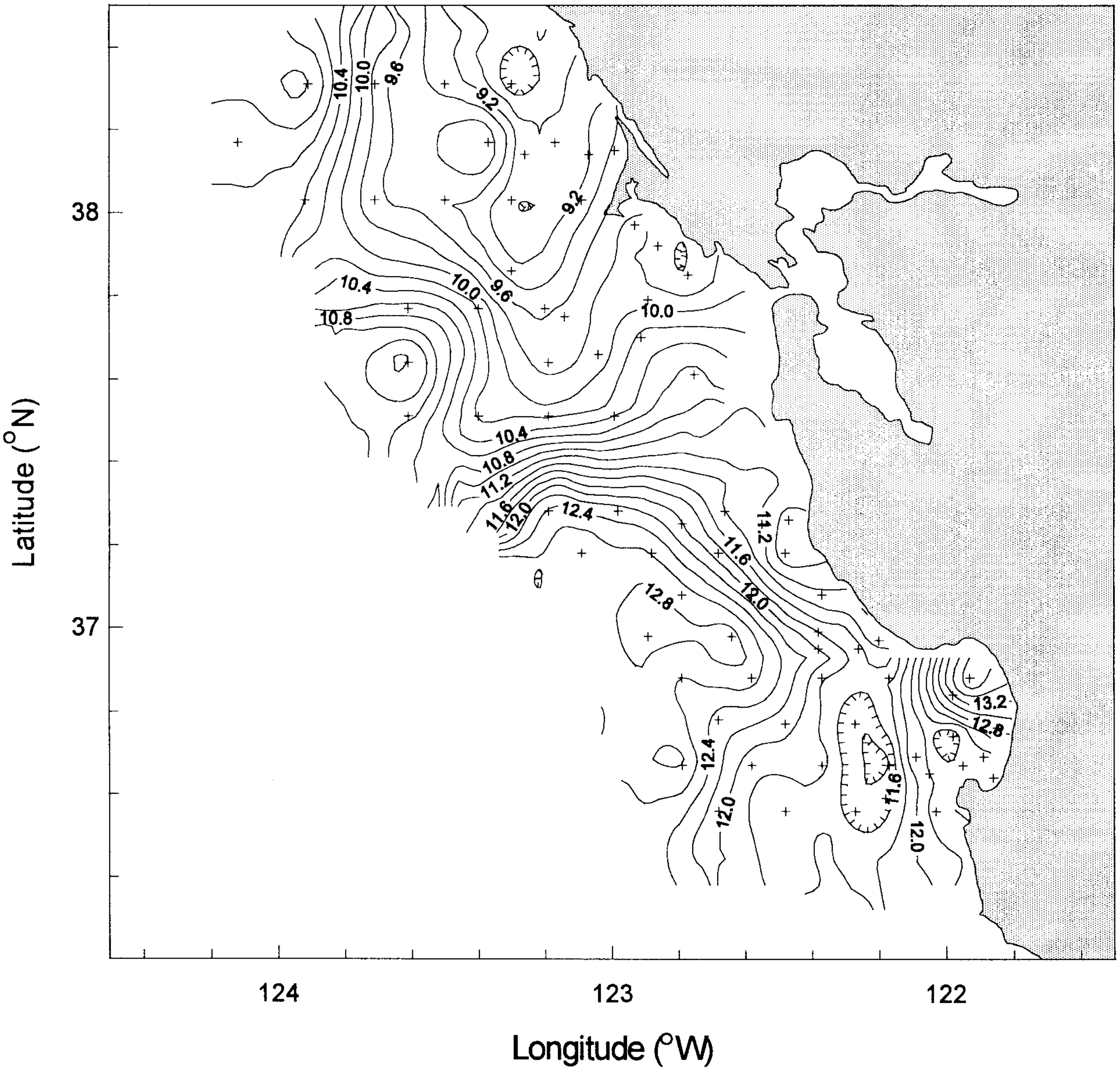
Thickness(meters) between the 25.8 and 26.2 (sigma theta) isopycnals during Sweep 1, 1996
LATITUDE (degrees)
LONGITUDE (degrees)
Tiburo
Bay
0 10 20 30 40 50 60 70 80 90 100

APPENDIX 6.2: HORIZONTAL MAPS OF CTD AND TS FOR DSJ9606, SWEEP 2

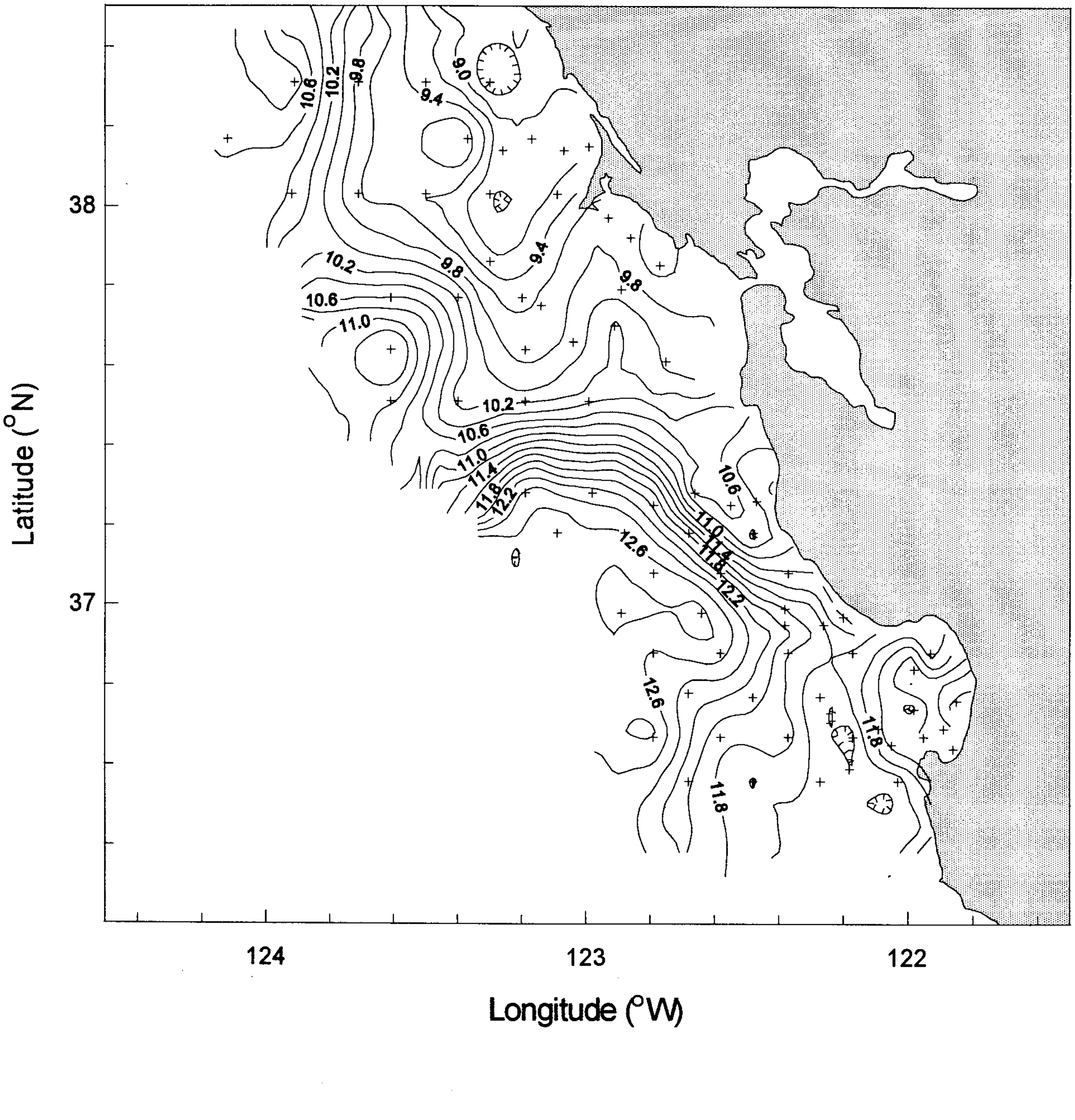
DSJ9606 Sweep 2 TS Temperature (°C)

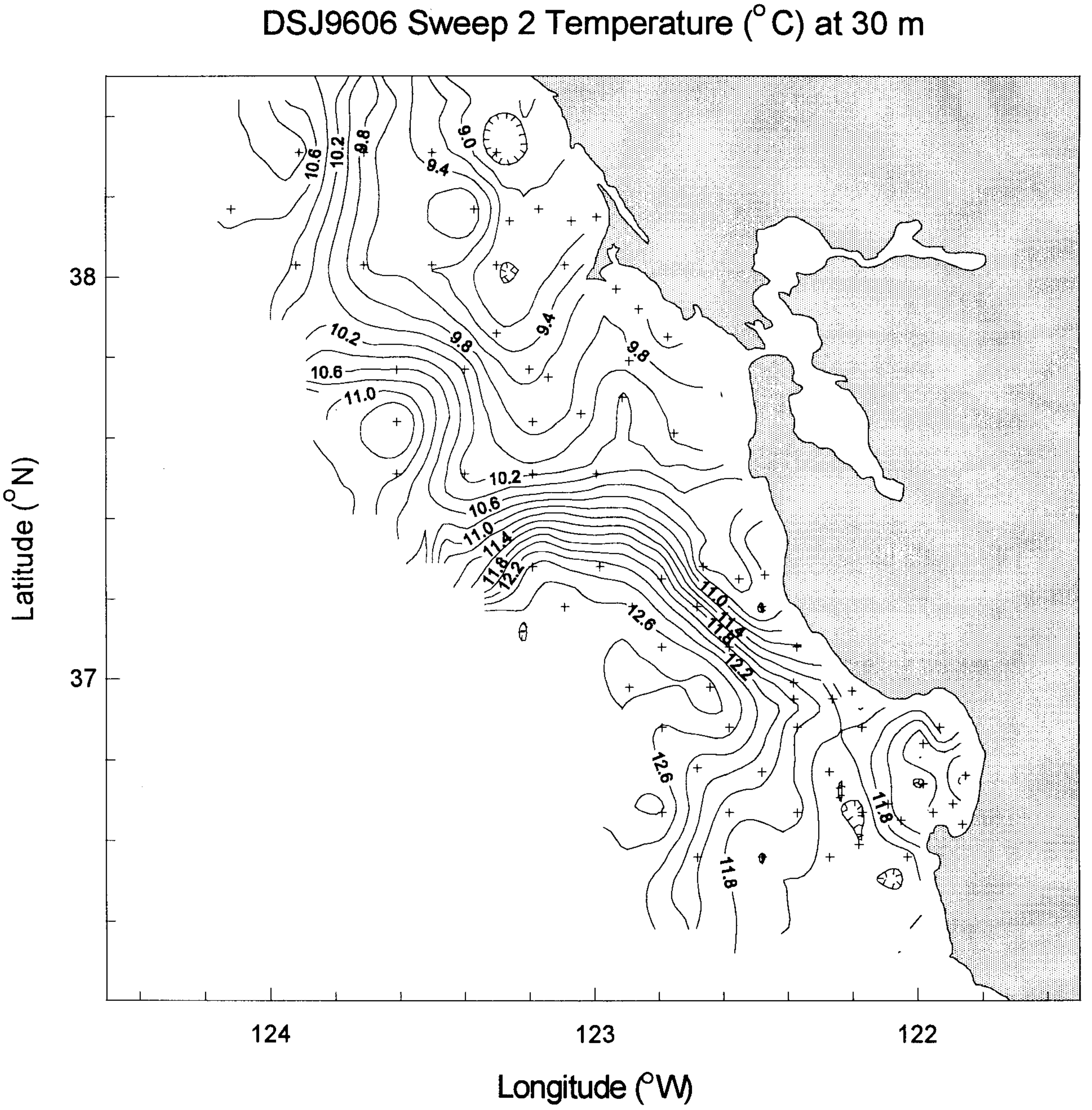


DSJ9606 Sweep 2 Temperature (°C) at 2 m



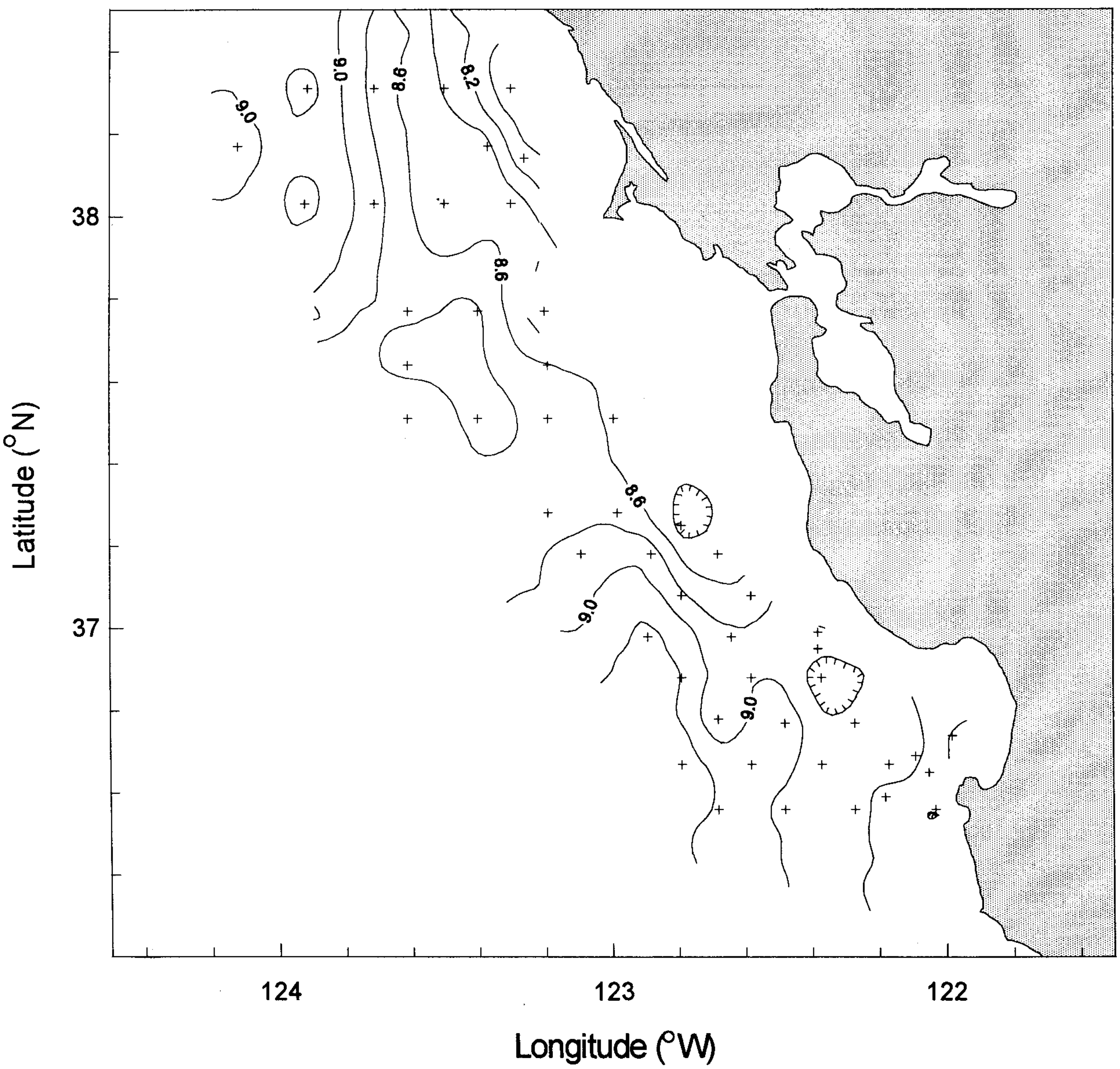
DSJ9606 Sweep 2 Temperature (°C) at 10 m



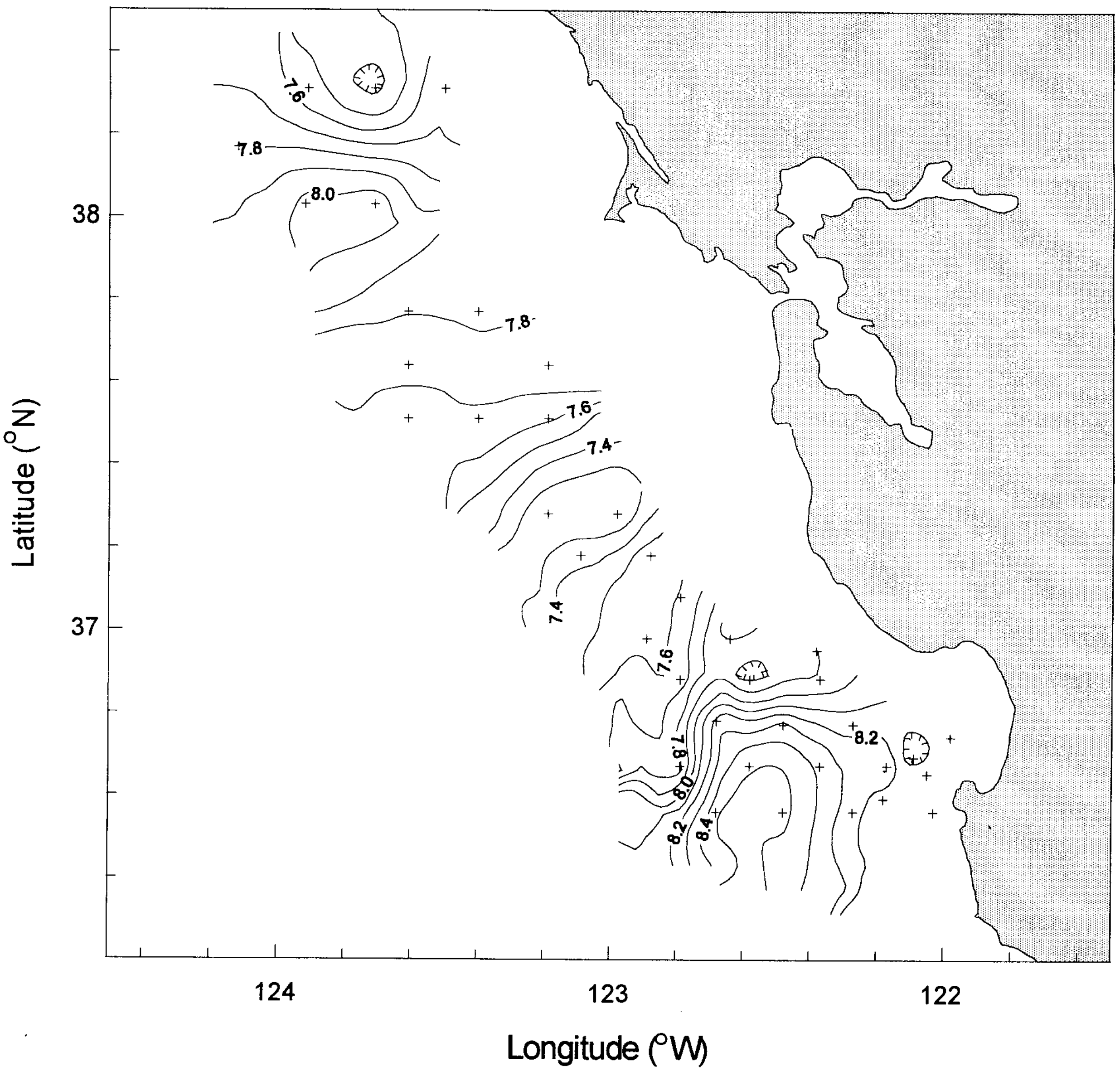


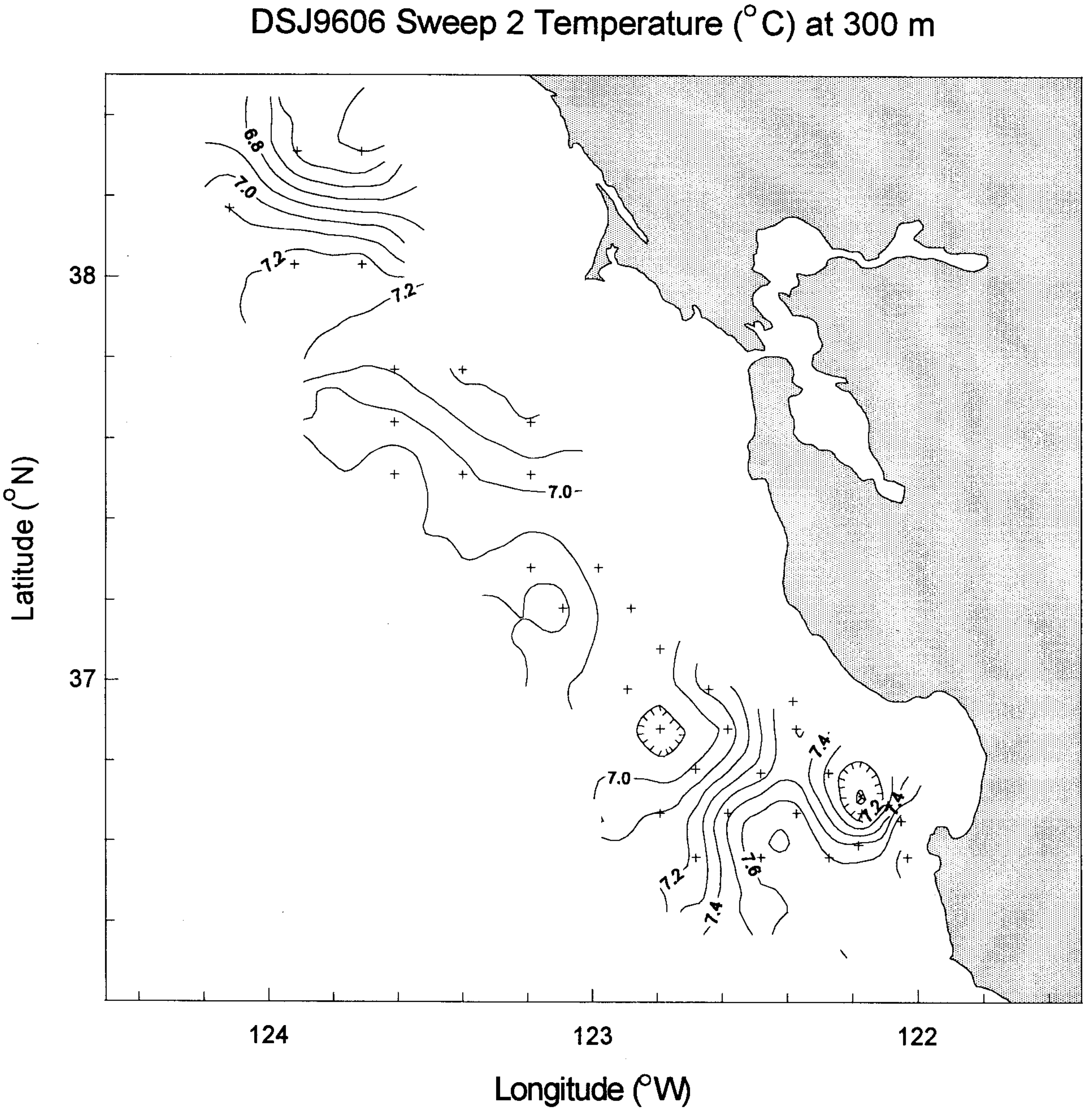
DSJ9606 Sweep 2 Temperature (°C) at 30 m
Latitude (°N)
38
37
124
123
122
Longitude (°W)
10.6
10.2
9.8
9.4
9.0
11.0
10.2
10.6
11.4
11.8
12.2
12.6

DSJ9606 Sweep 2 Temperature (°C) at 100 m

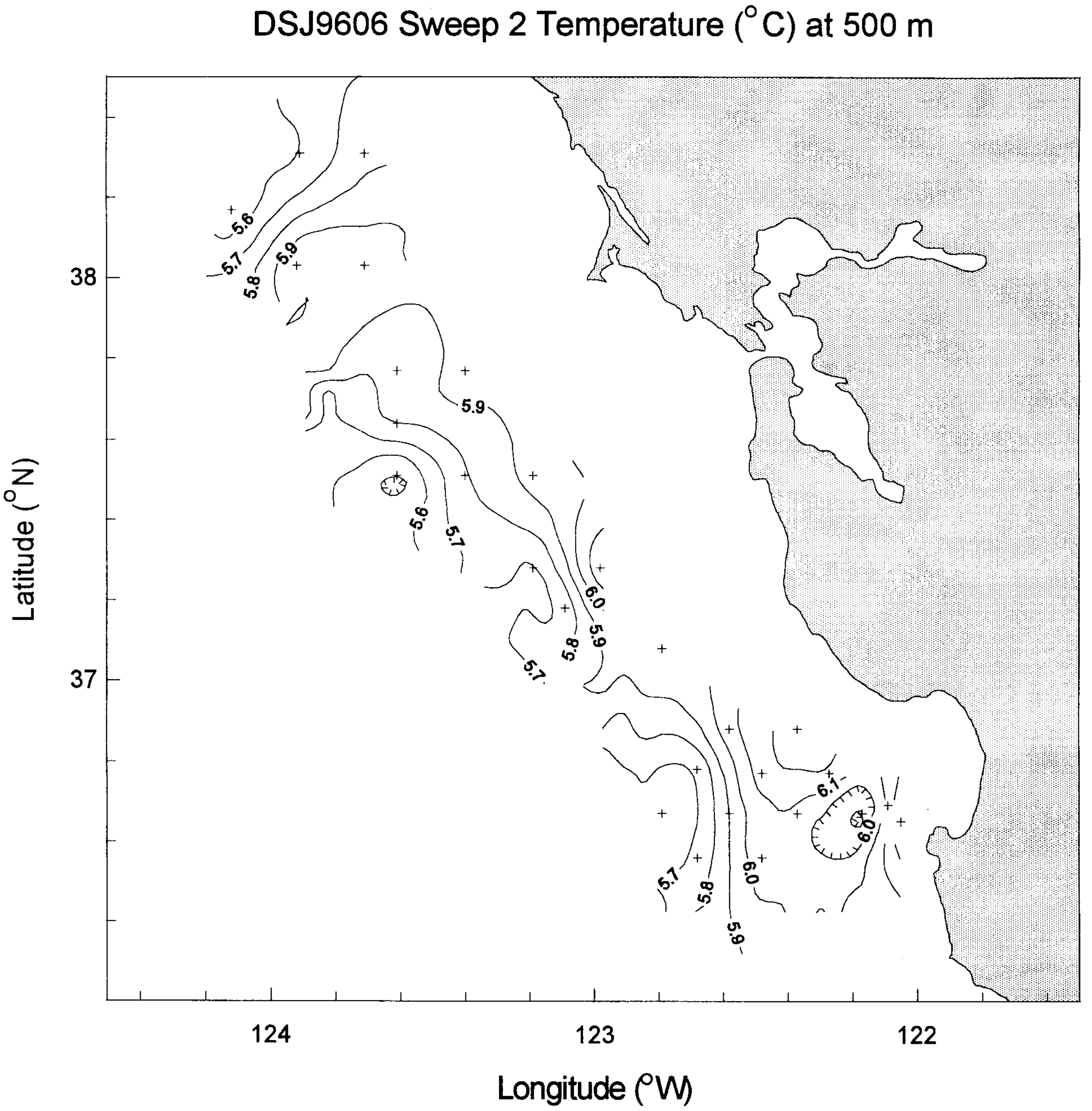


DSJ9606 Sweep 2 Temperature (°C) at 200 m

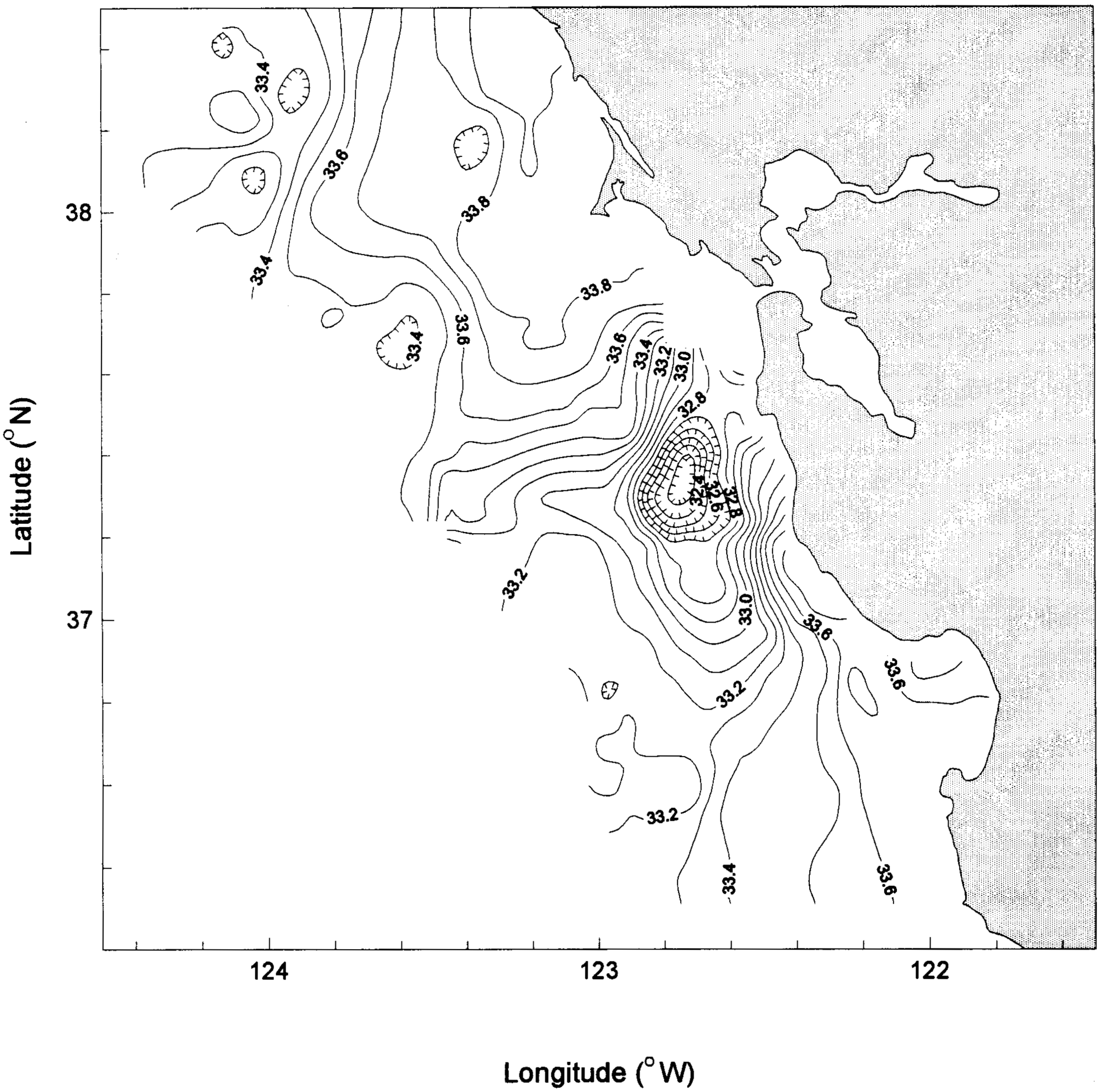


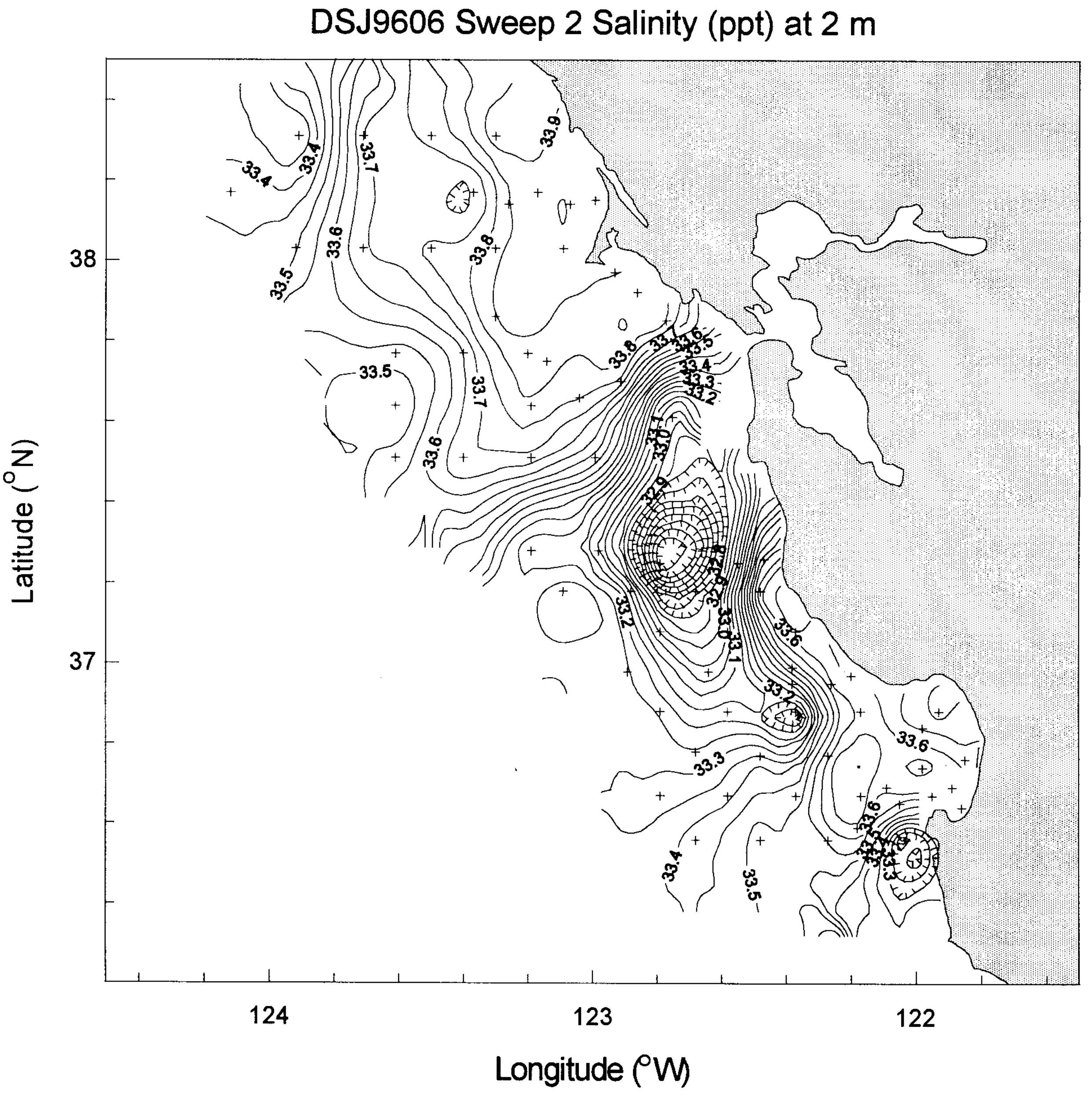


DSJ9606 Sweep 2 Temperature (°C) at 300 m
Latitude (°N)
Longitude (°W)
38
37
124
123
122
6.8
7.0
7.2
7.2
7.0
7.0
7.2
7.4
7.6
7.4
7.2
7.4

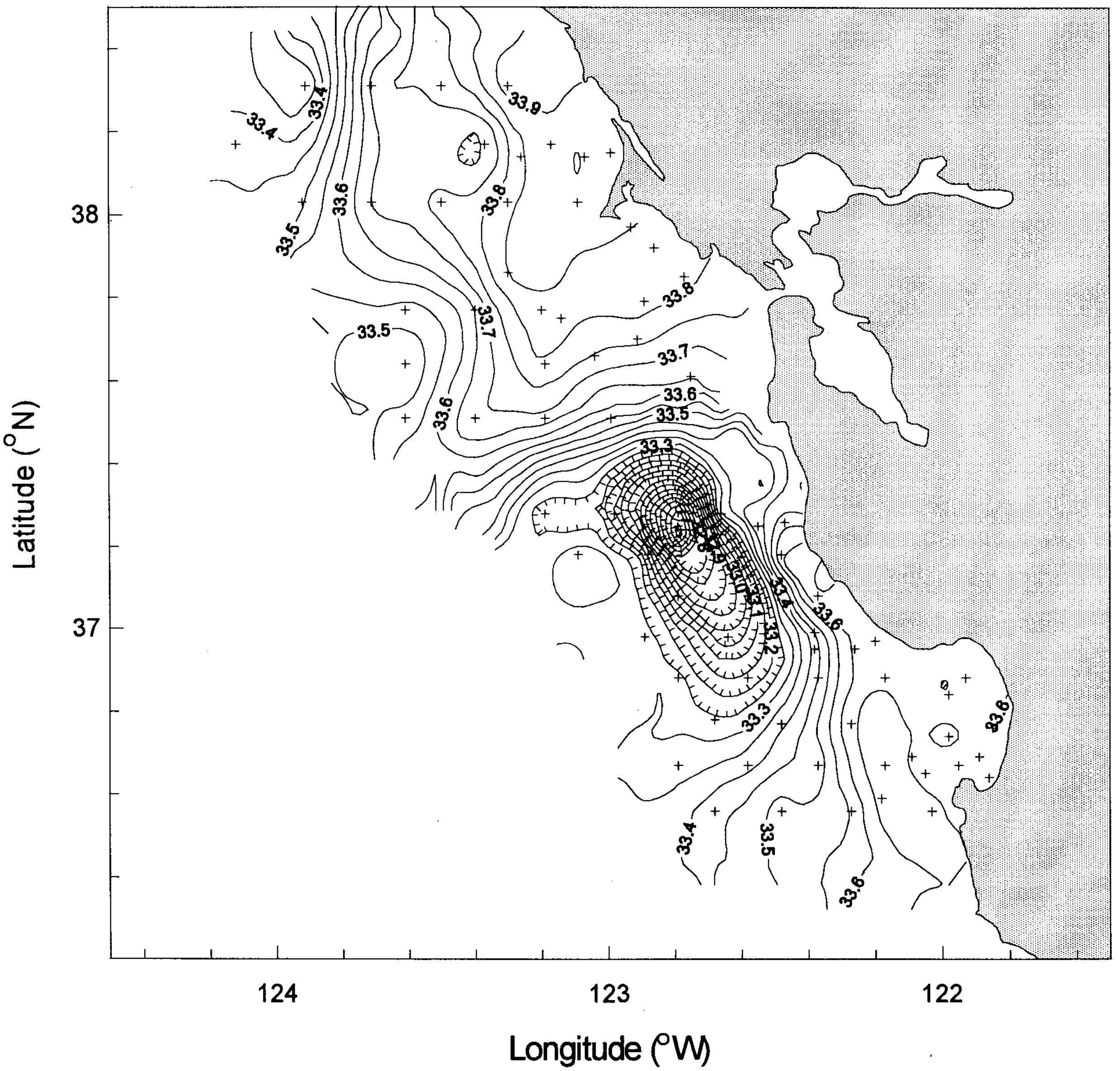

DSJ9606 Sweep 2 Temperature (°C) at 500 m
Latitude (°N)
38
37
124
123
122
Longitude (°W)
5.6
5.7
5.8
5.9
6.0
6.1

DSJ9606 Sweep 2 TS Salinity

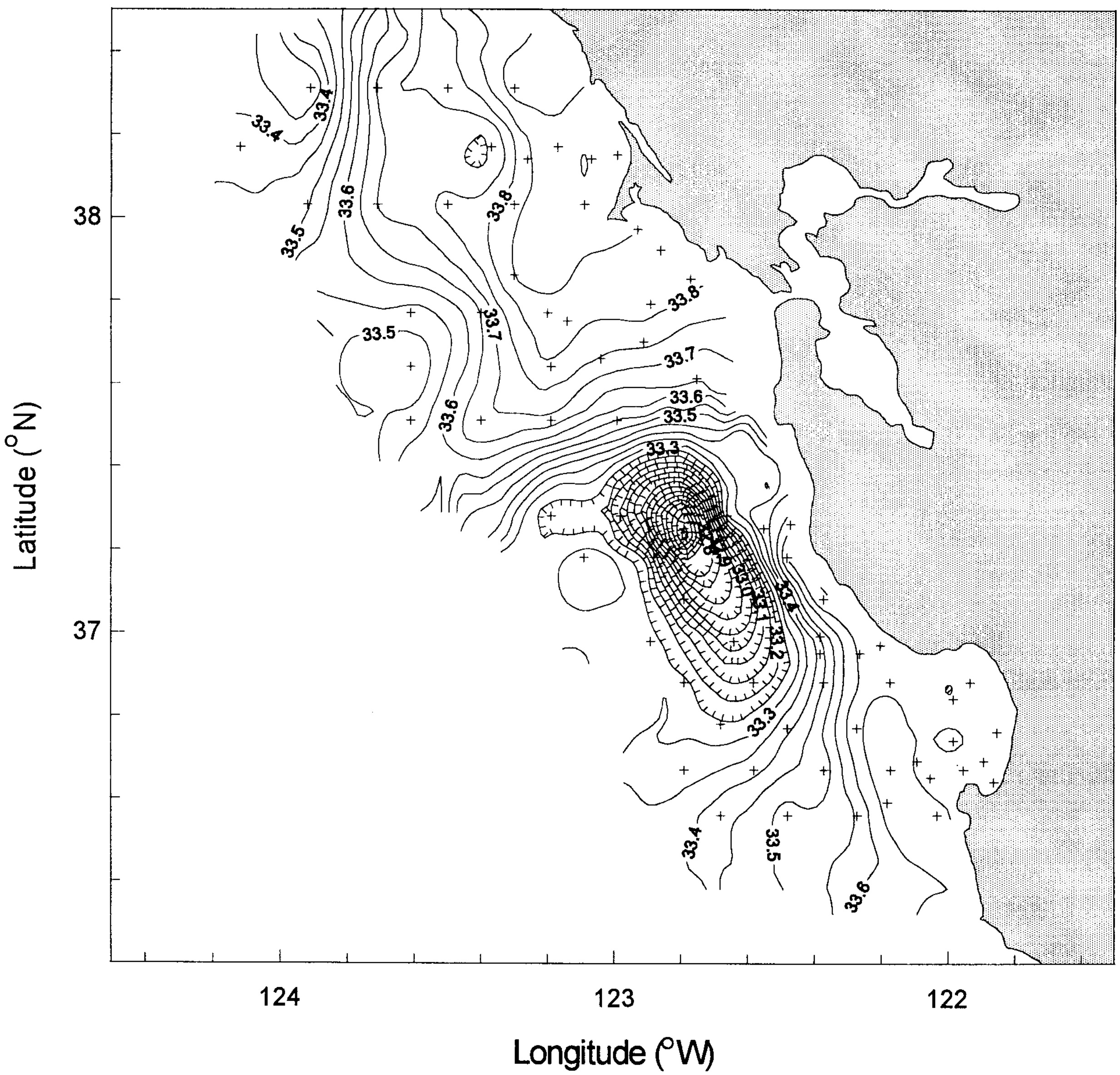



DSJ9606 Sweep 2 Salinity (ppt) at 2 m
38
37
Latitude (°N)
124
123
122
Longitude (°W)

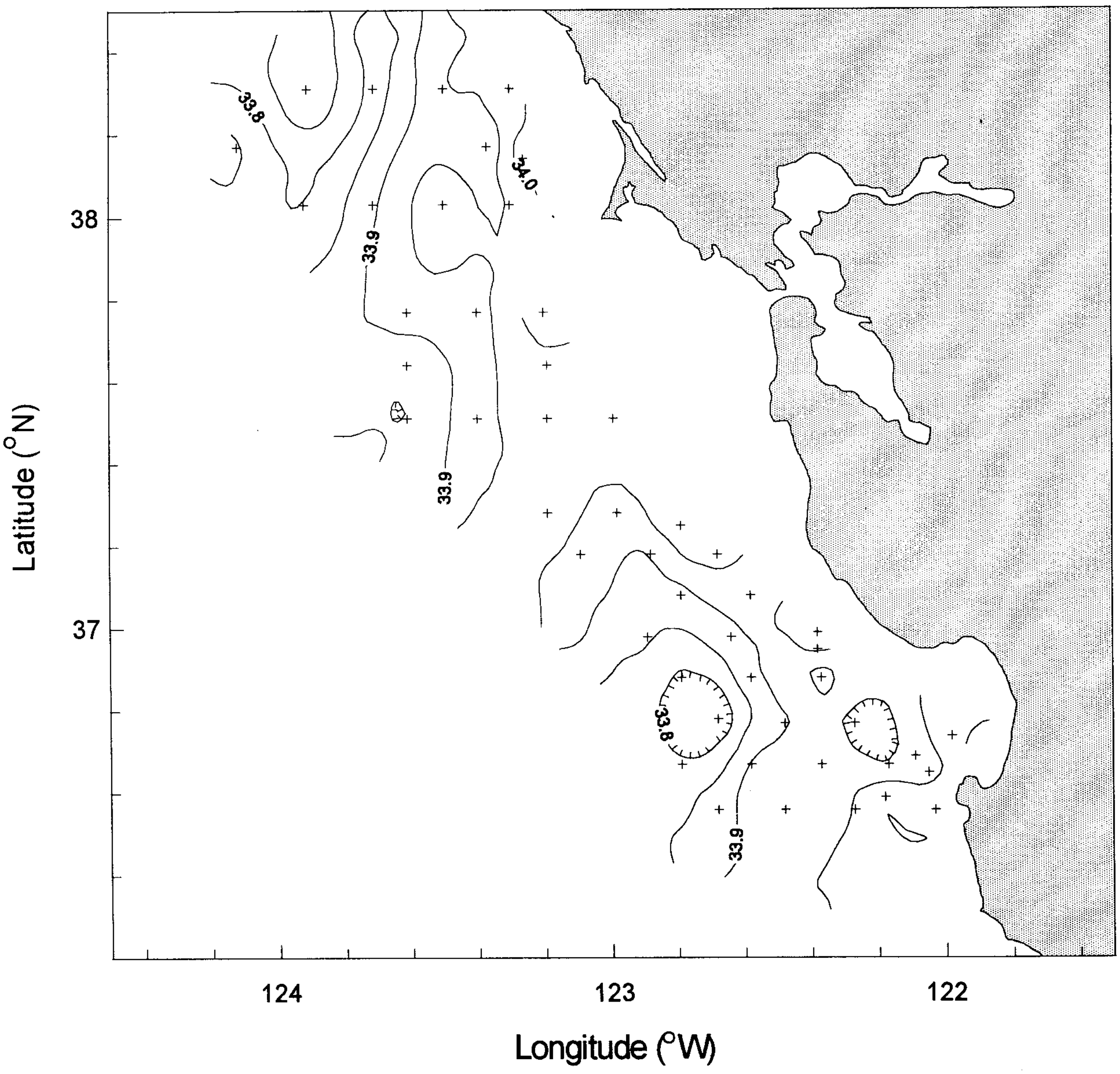
DSJ9606 Sweep 2 Salinity (ppt) at 10 m



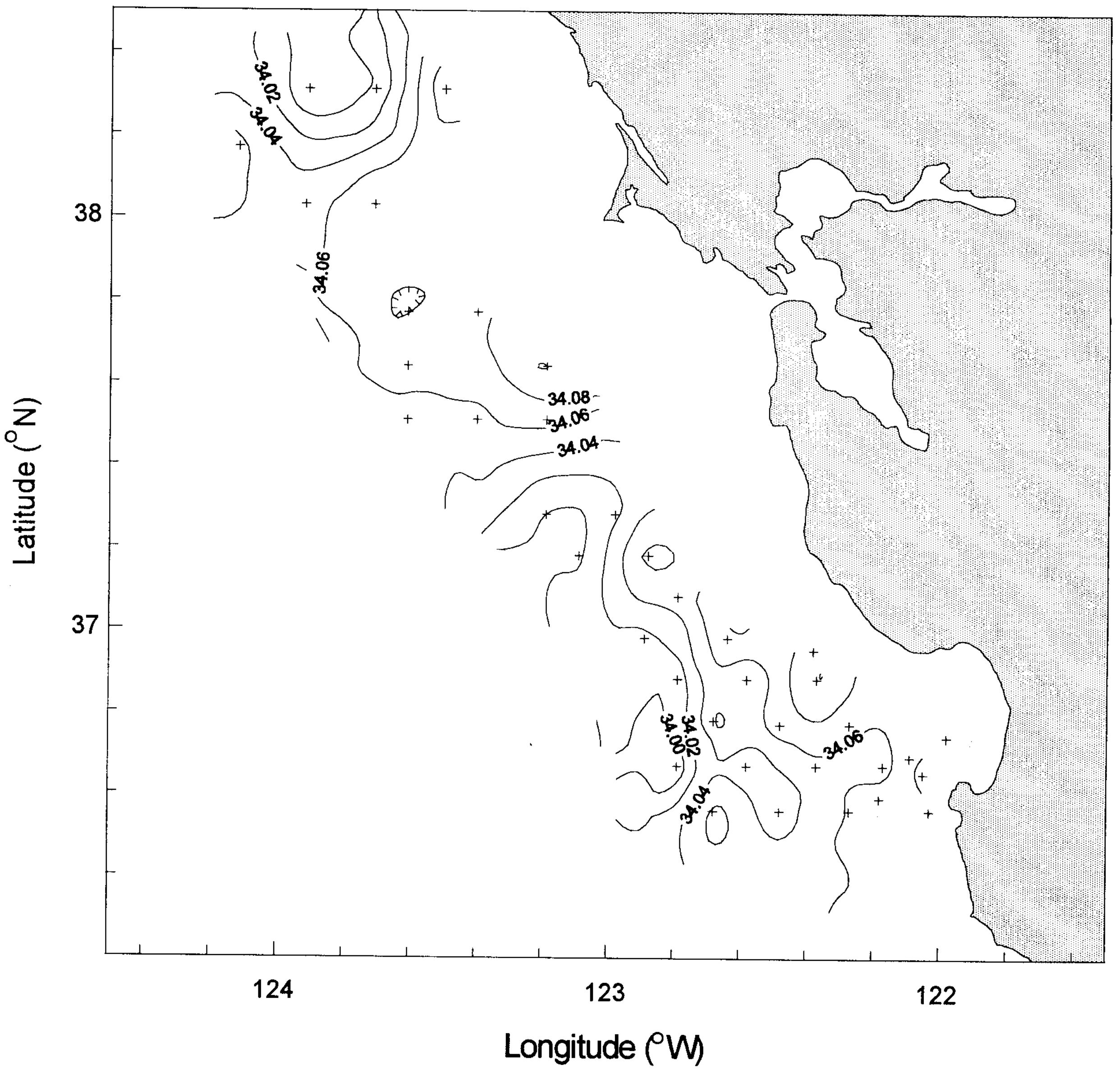
DSJ9606 Sweep 2 Salinity (ppt) at 30 m



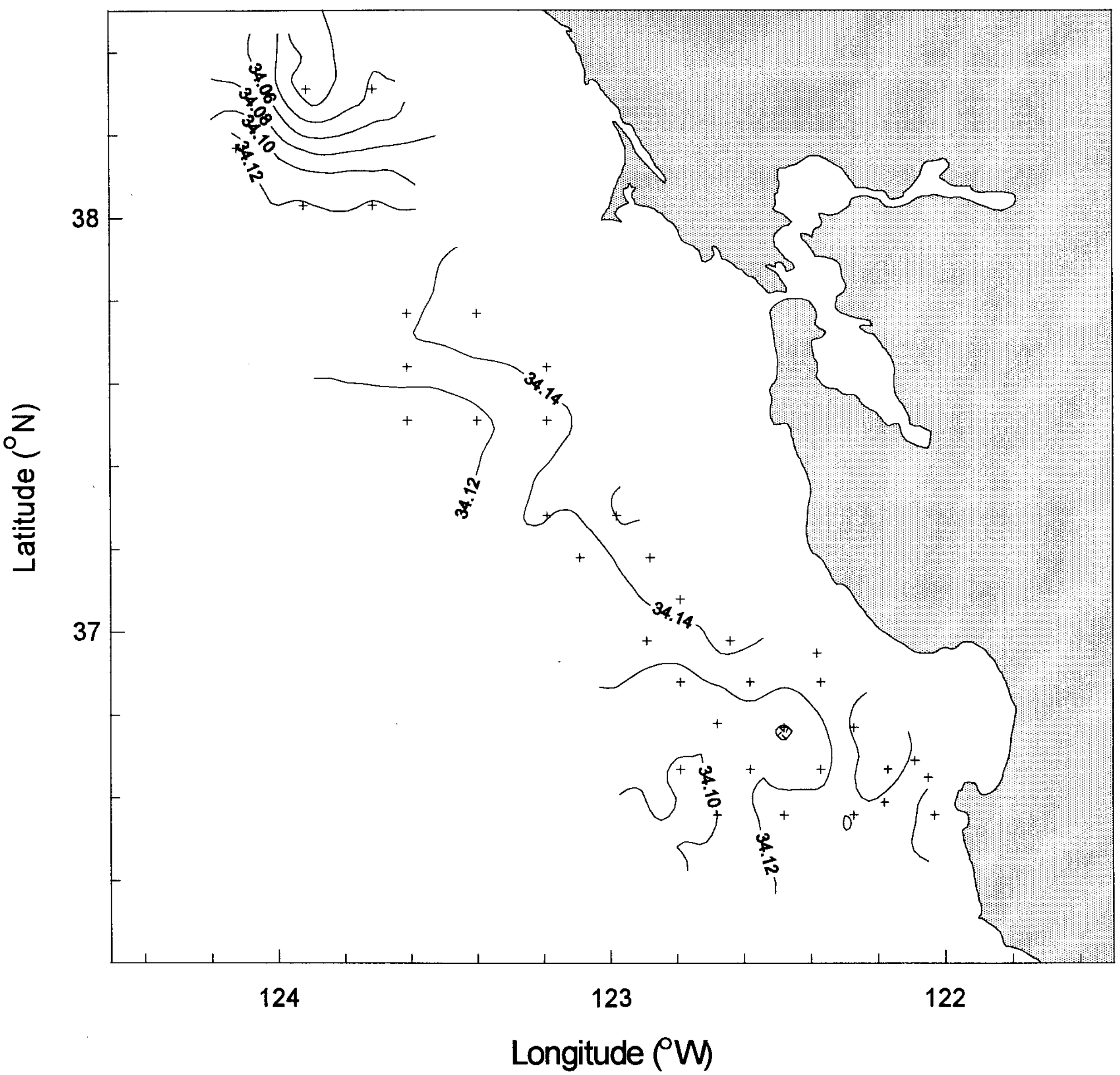
DSJ9606 Sweep 2 Salinity (ppt) at 100 m



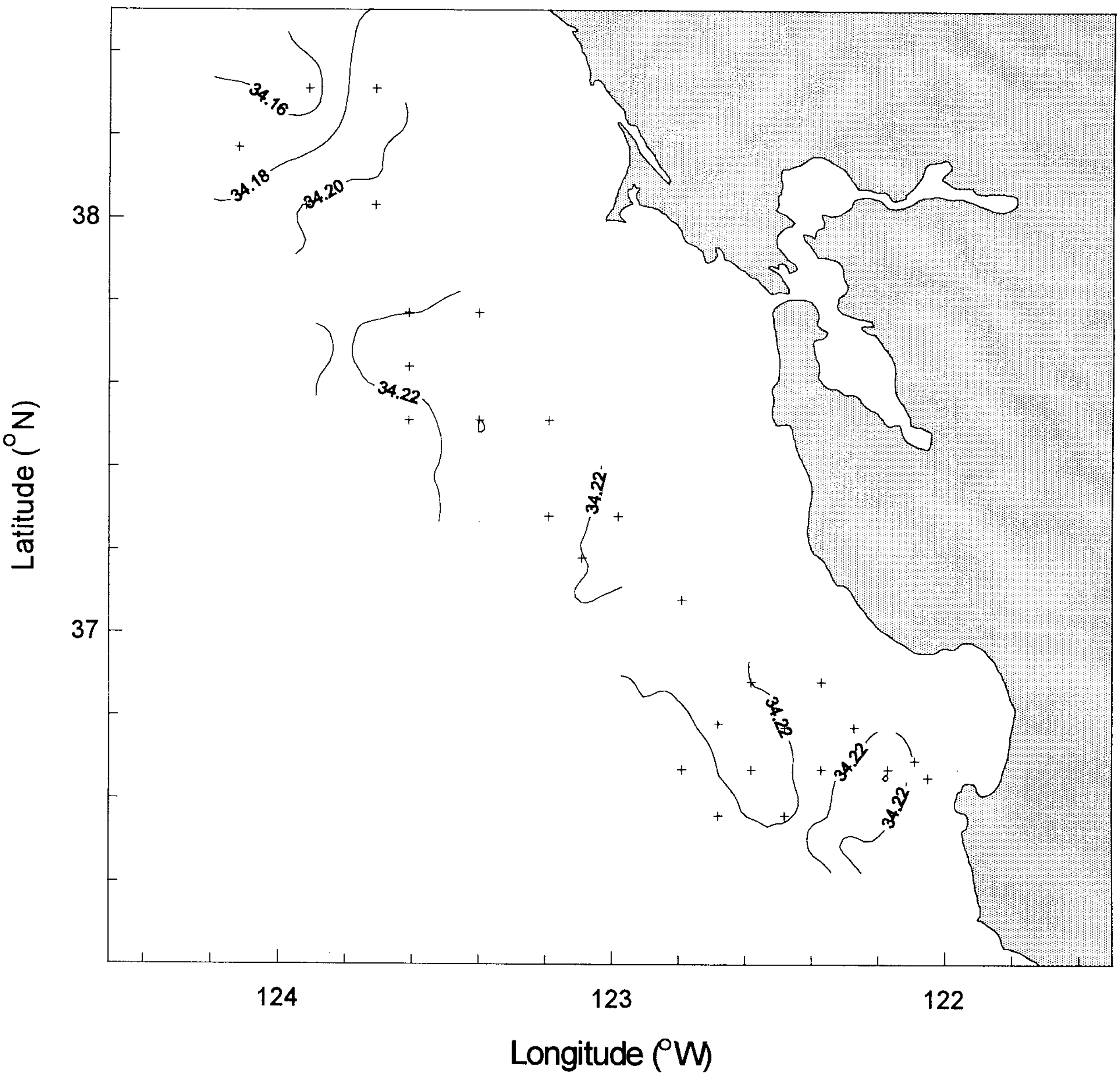
DSJ9606 Sweep 2 Salinity (ppt) at 200 m



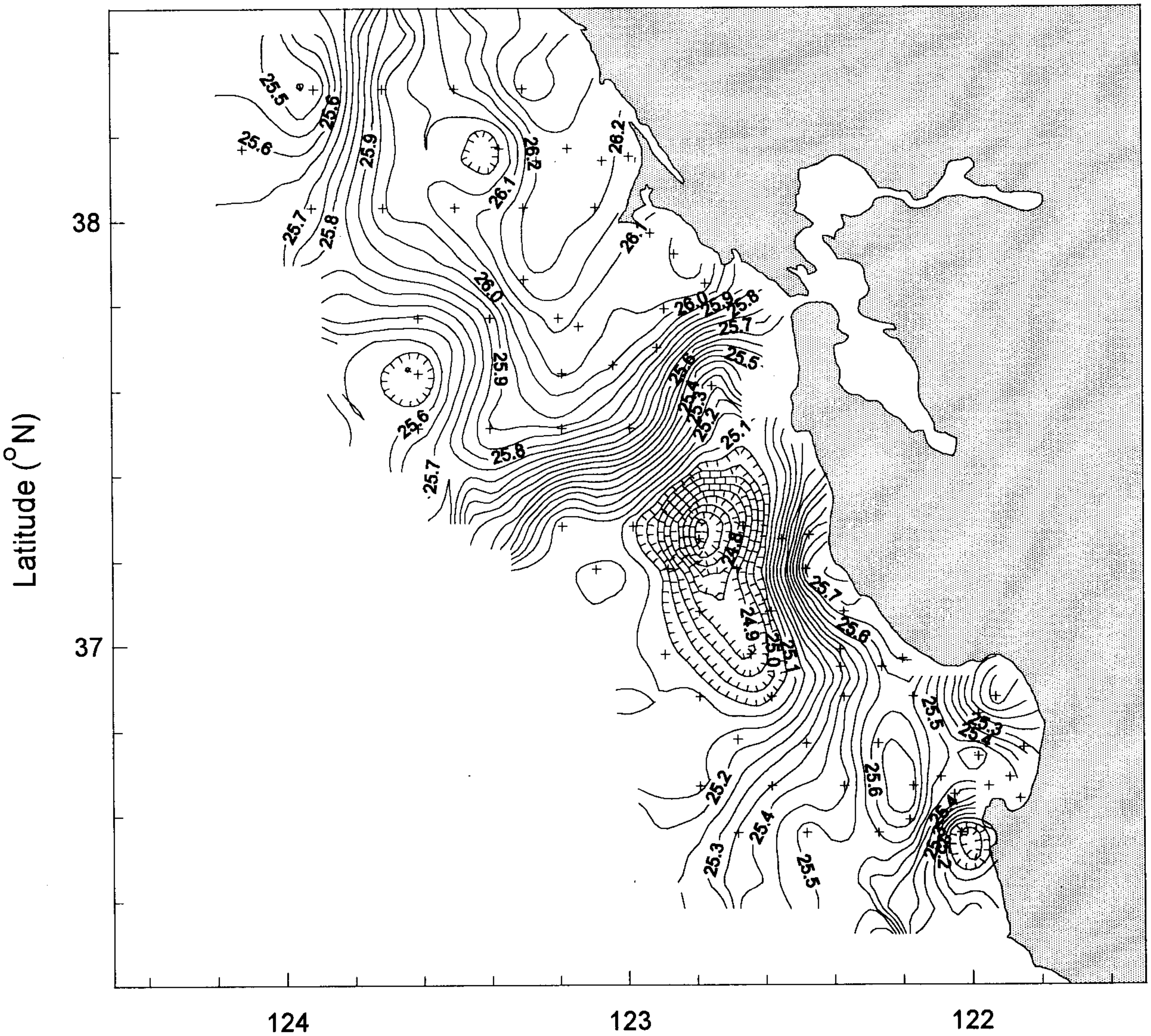
DSJ9606 Sweep 2 Salinity (ppt) at 300 m



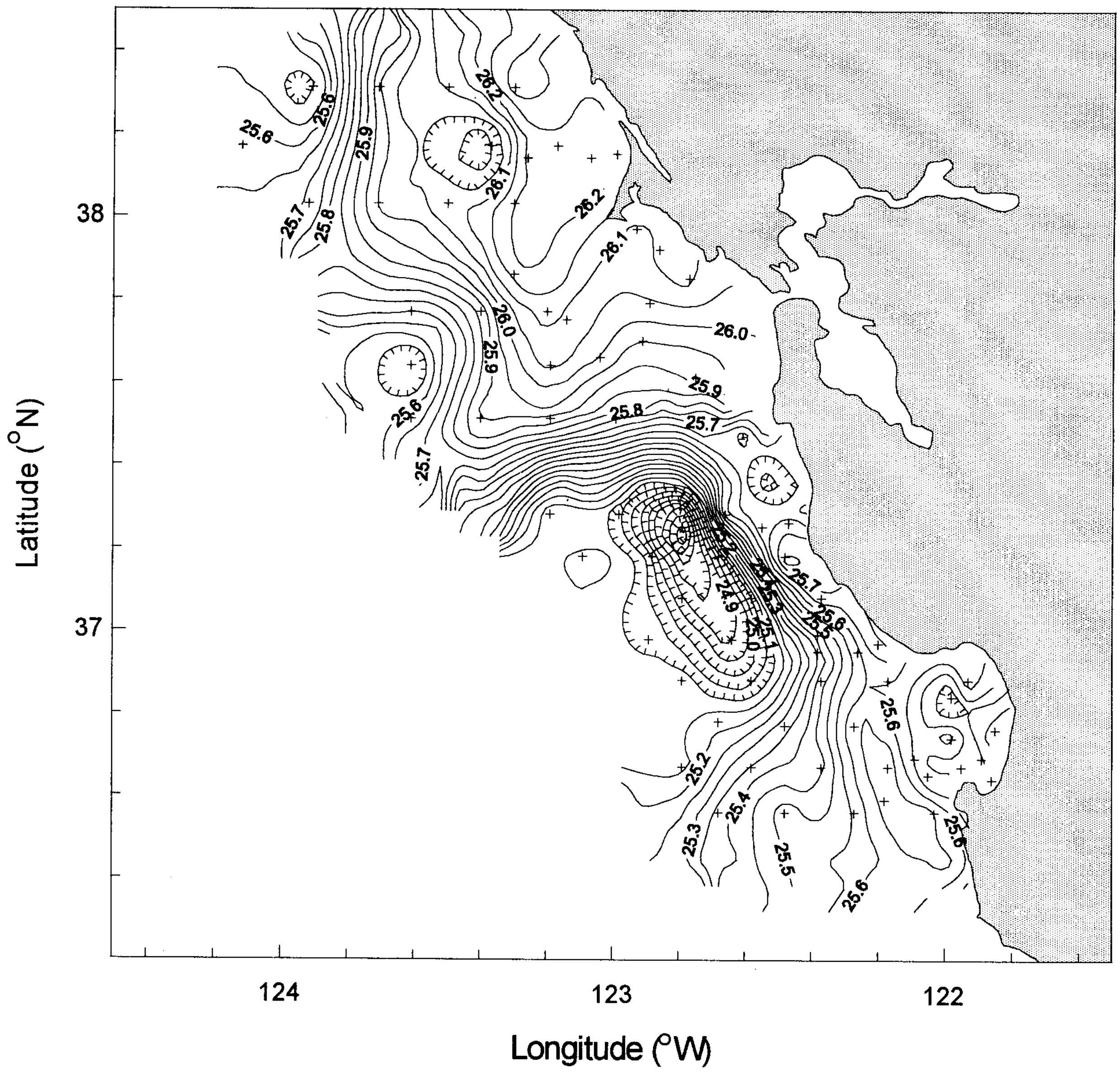
DSJ9606 Sweep 2 Salinity (ppt) at 500 m



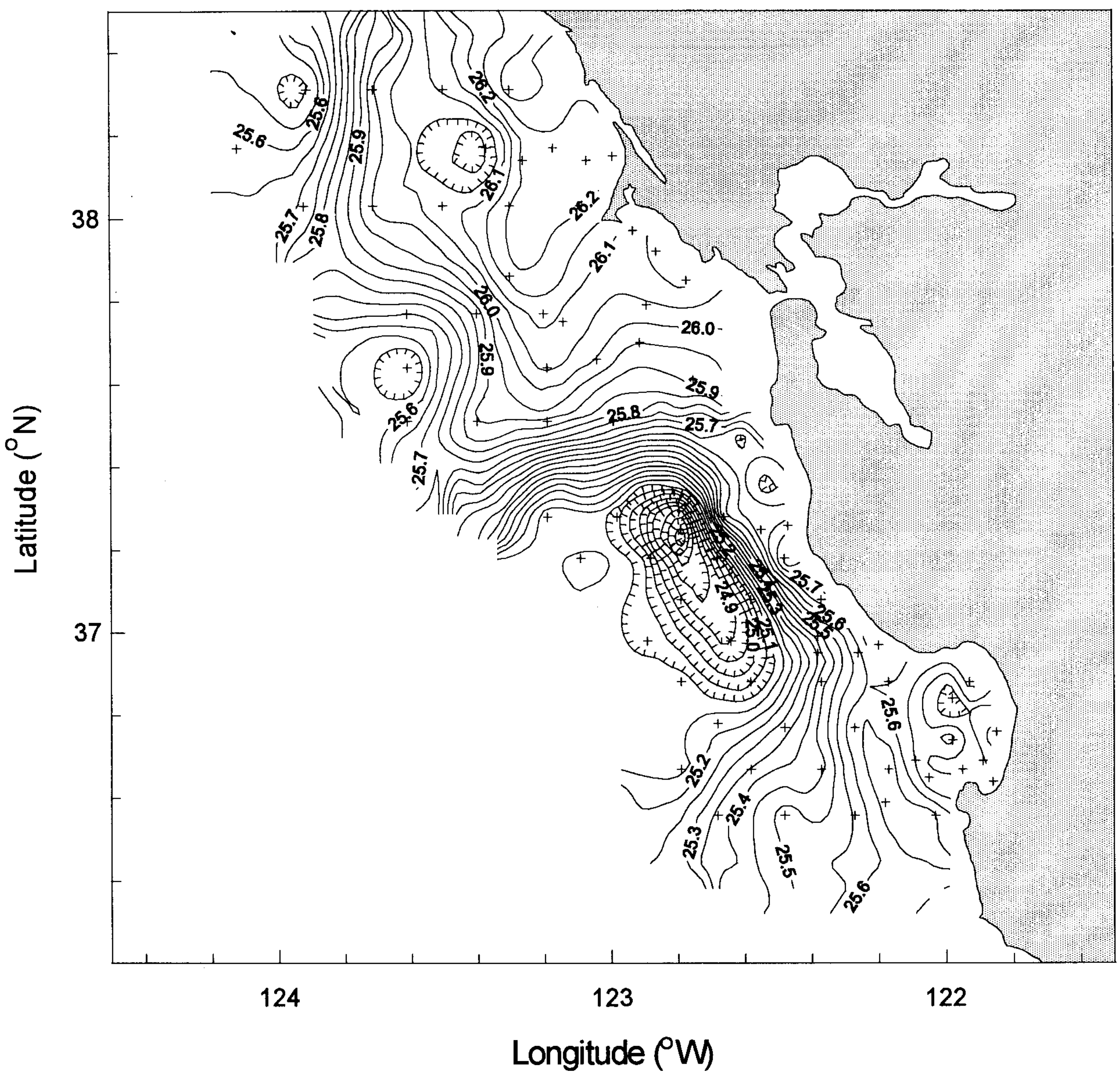
DSJ9606 Sweep 2 Density (kg/m^3) at 2 m



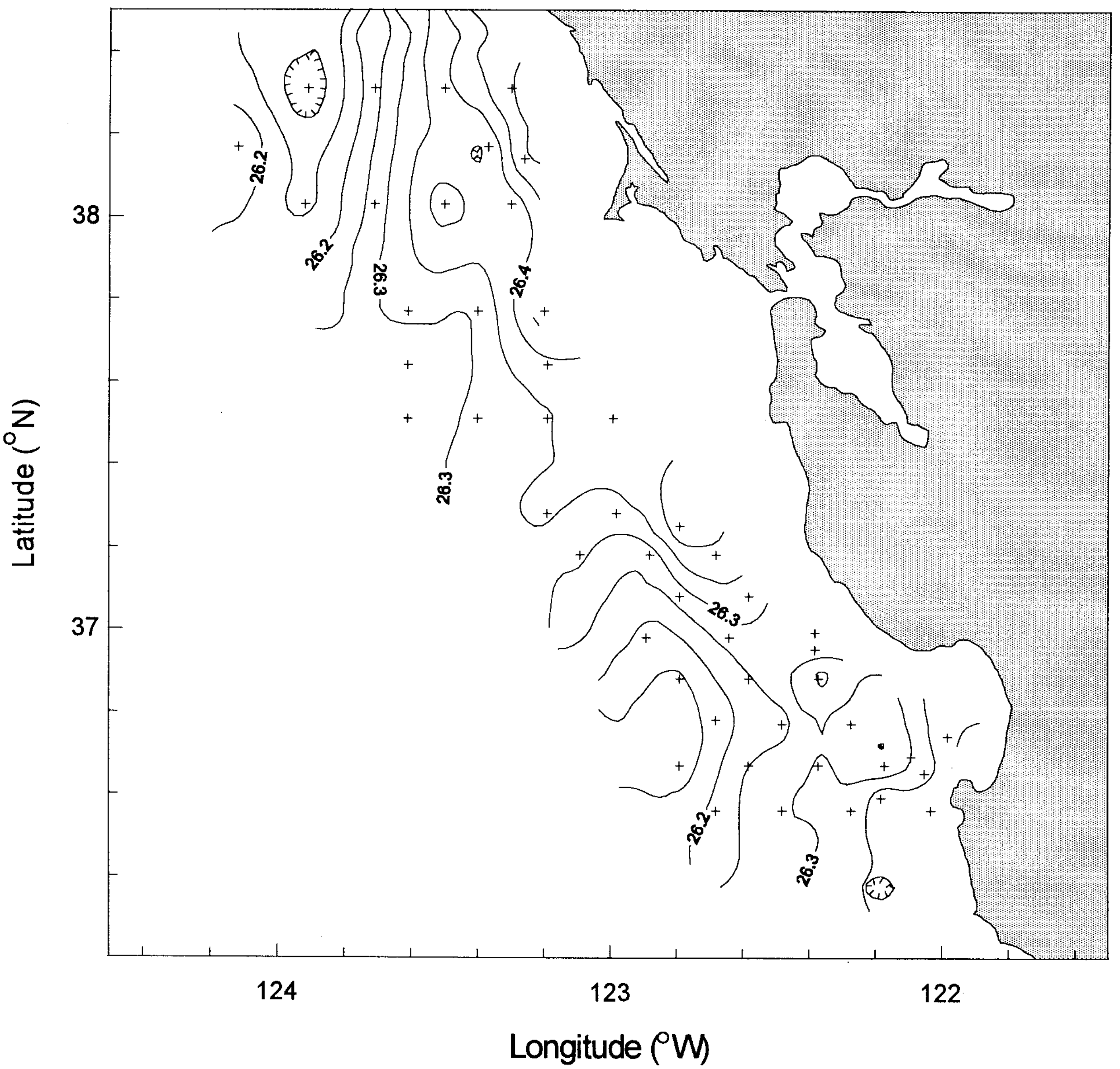
DSJ9606 Sweep 2 Density (kg/m^3) at 10 m



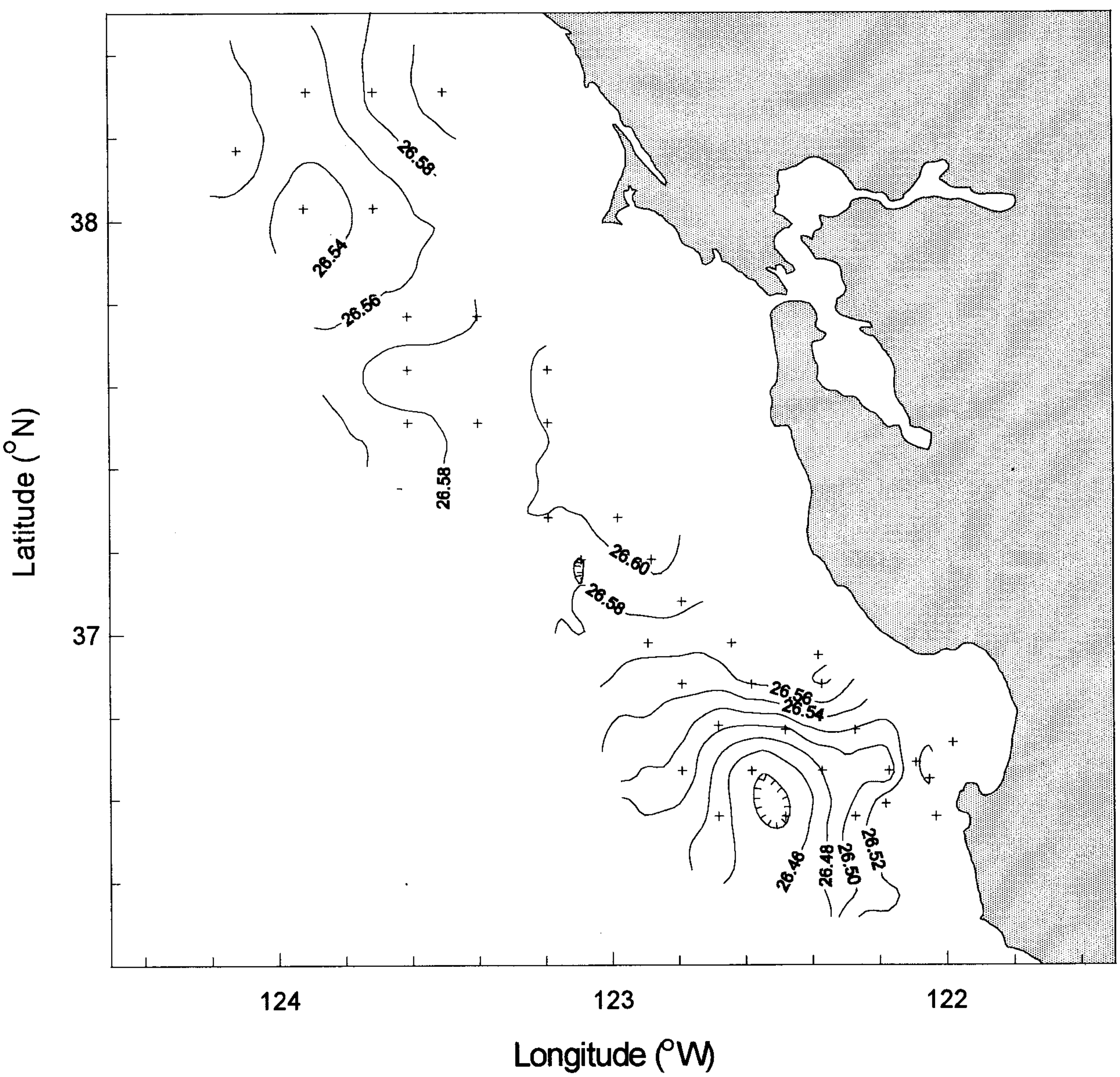
DSJ9606 Sweep 2 Density (kg/m^3) at 30 m



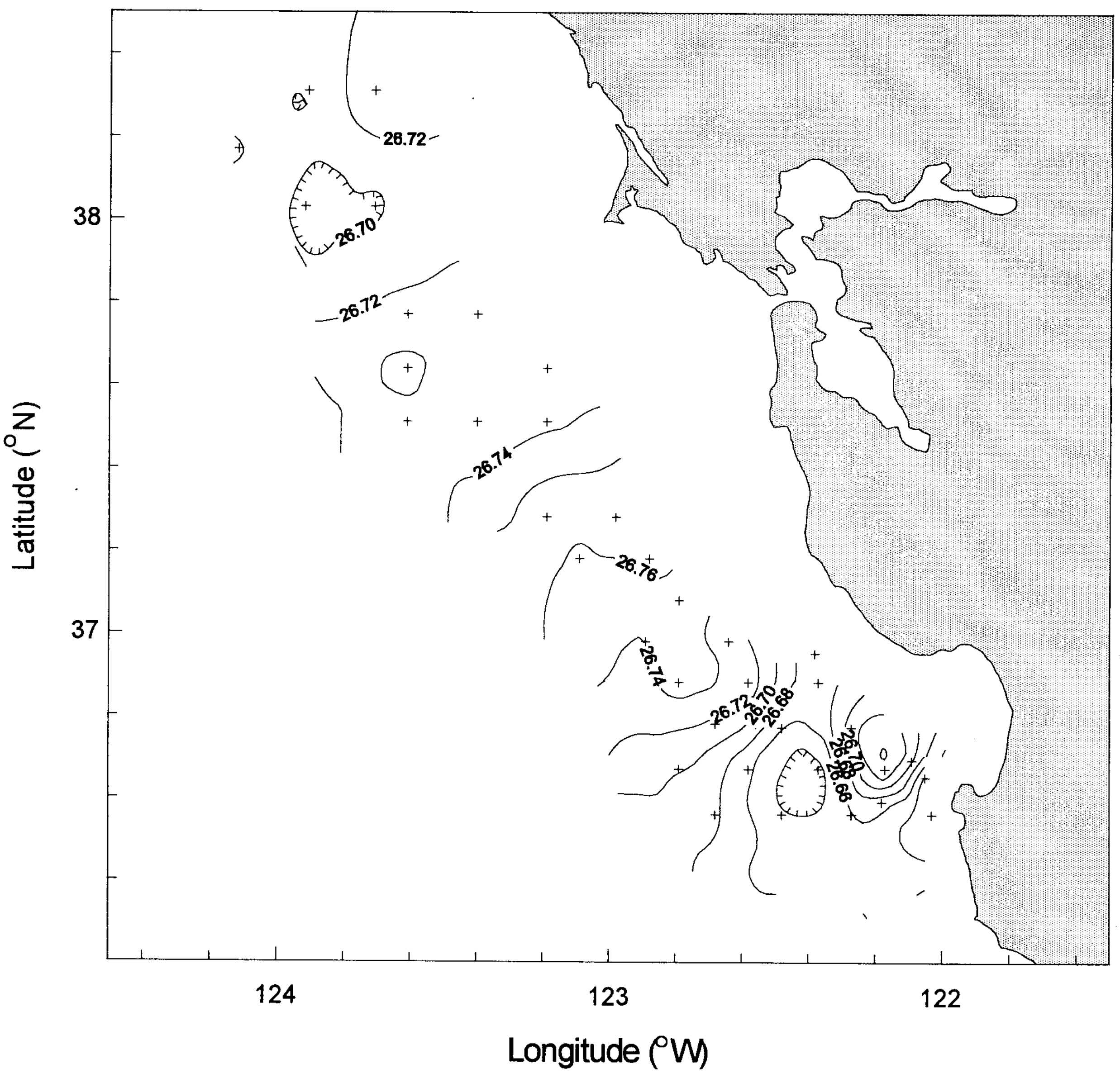
DSJ9606 Sweep 2 Density (kg/m^3) at 100 m



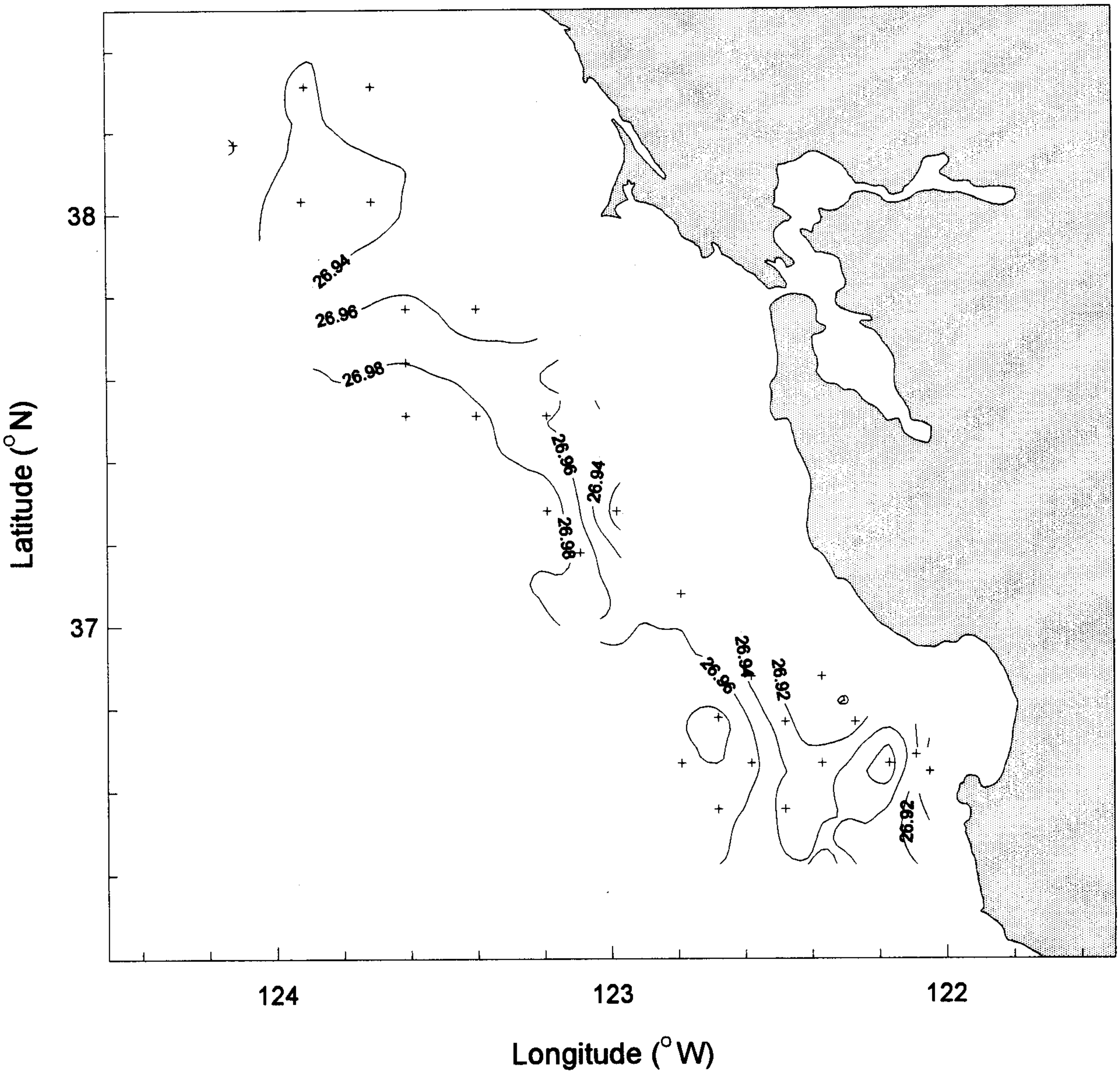
DSJ9606 Sweep 2 Density (kg/m^3) at 200 m

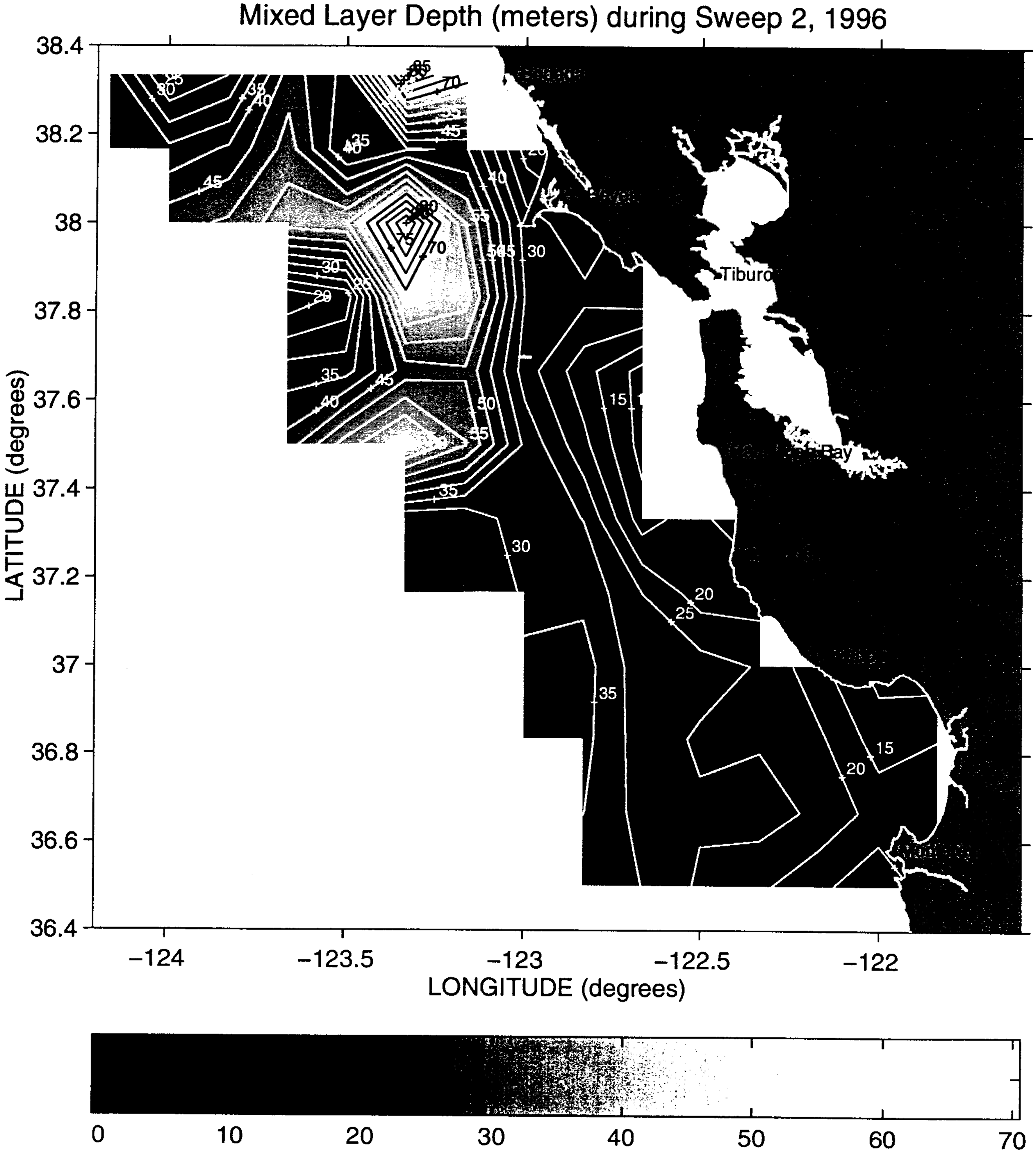


DSJ9606 Sweep 2 Density (kg/m^3) at 300 m

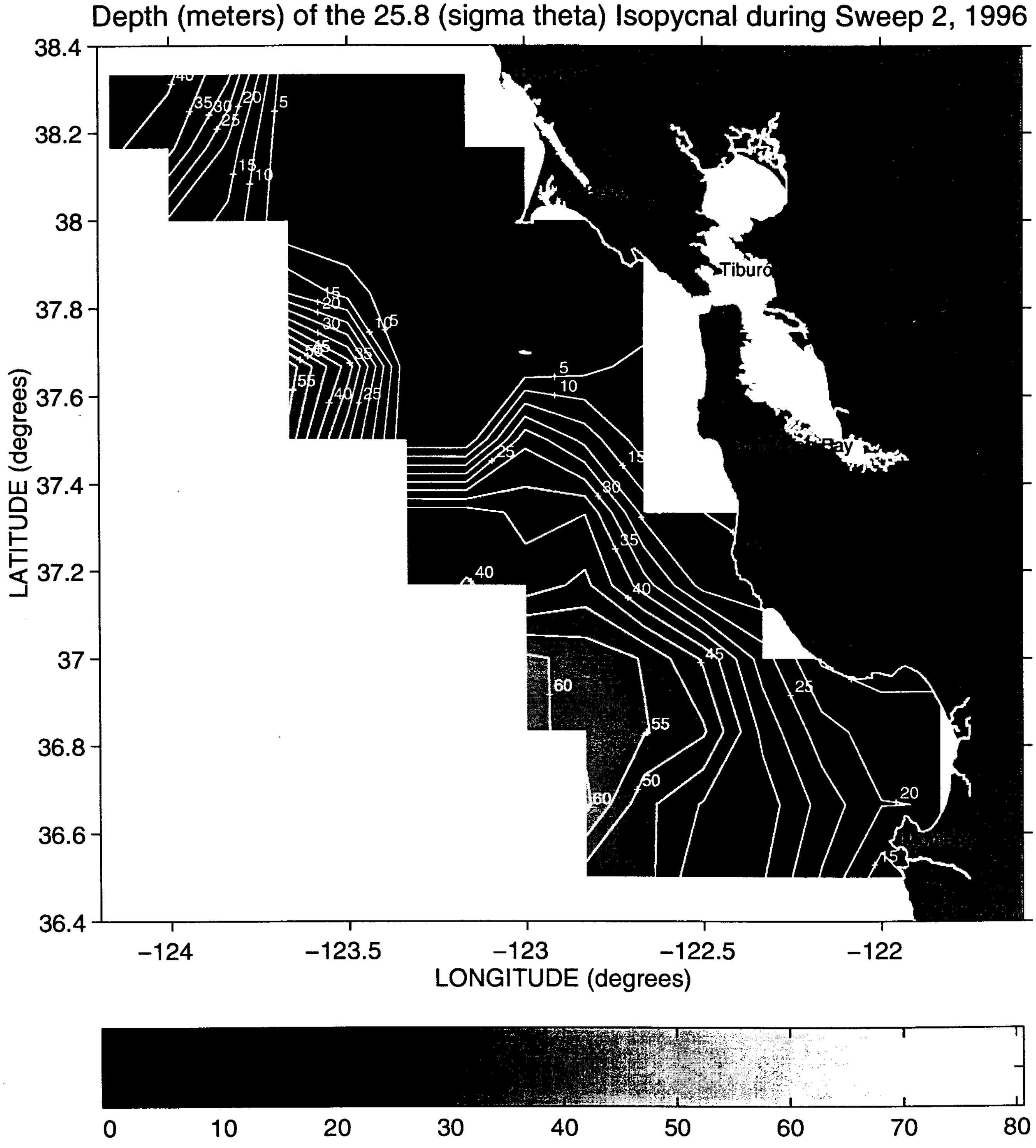


DSJ9606 Sweep 2 Density (kg/m³) at 500 m

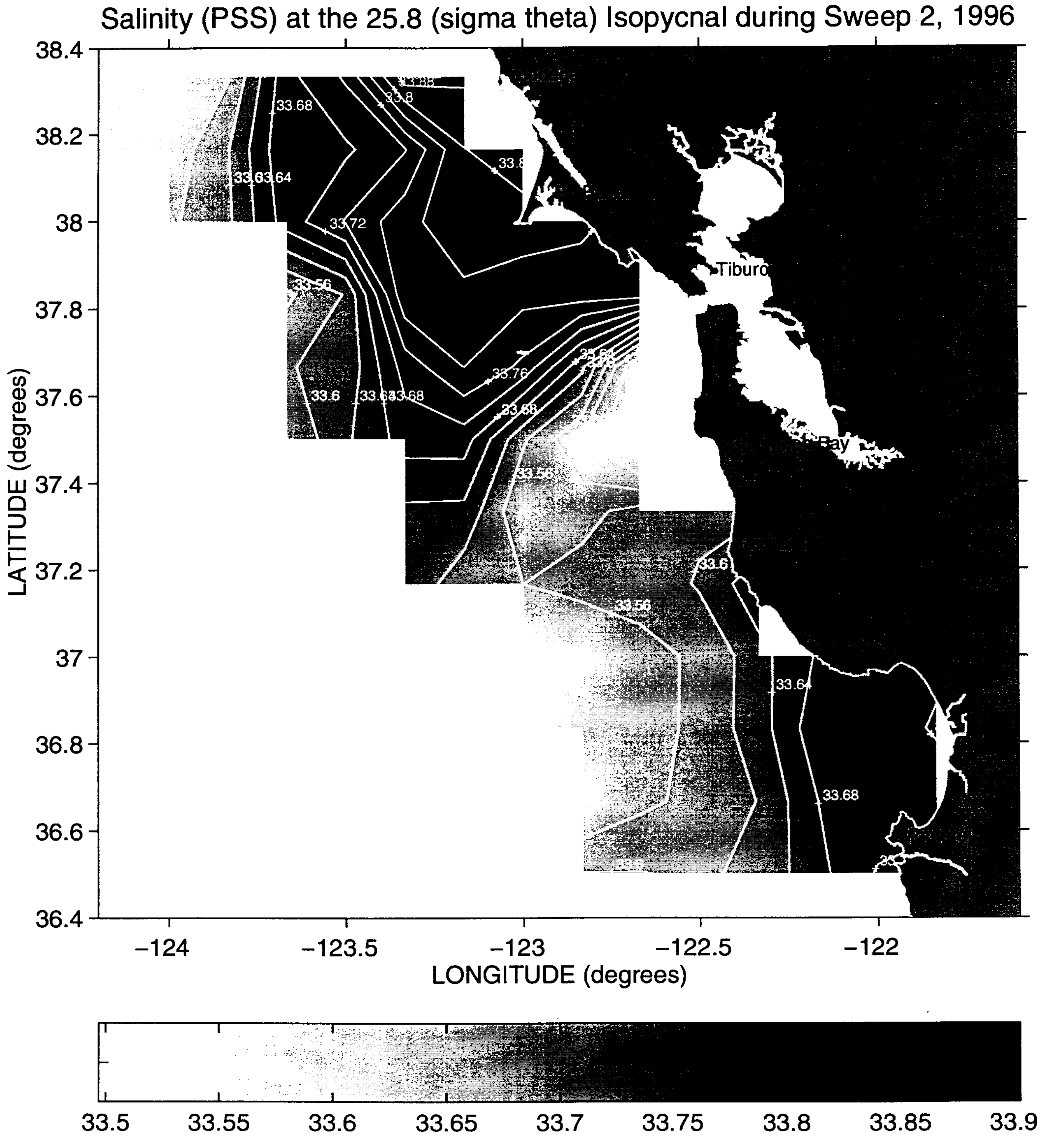


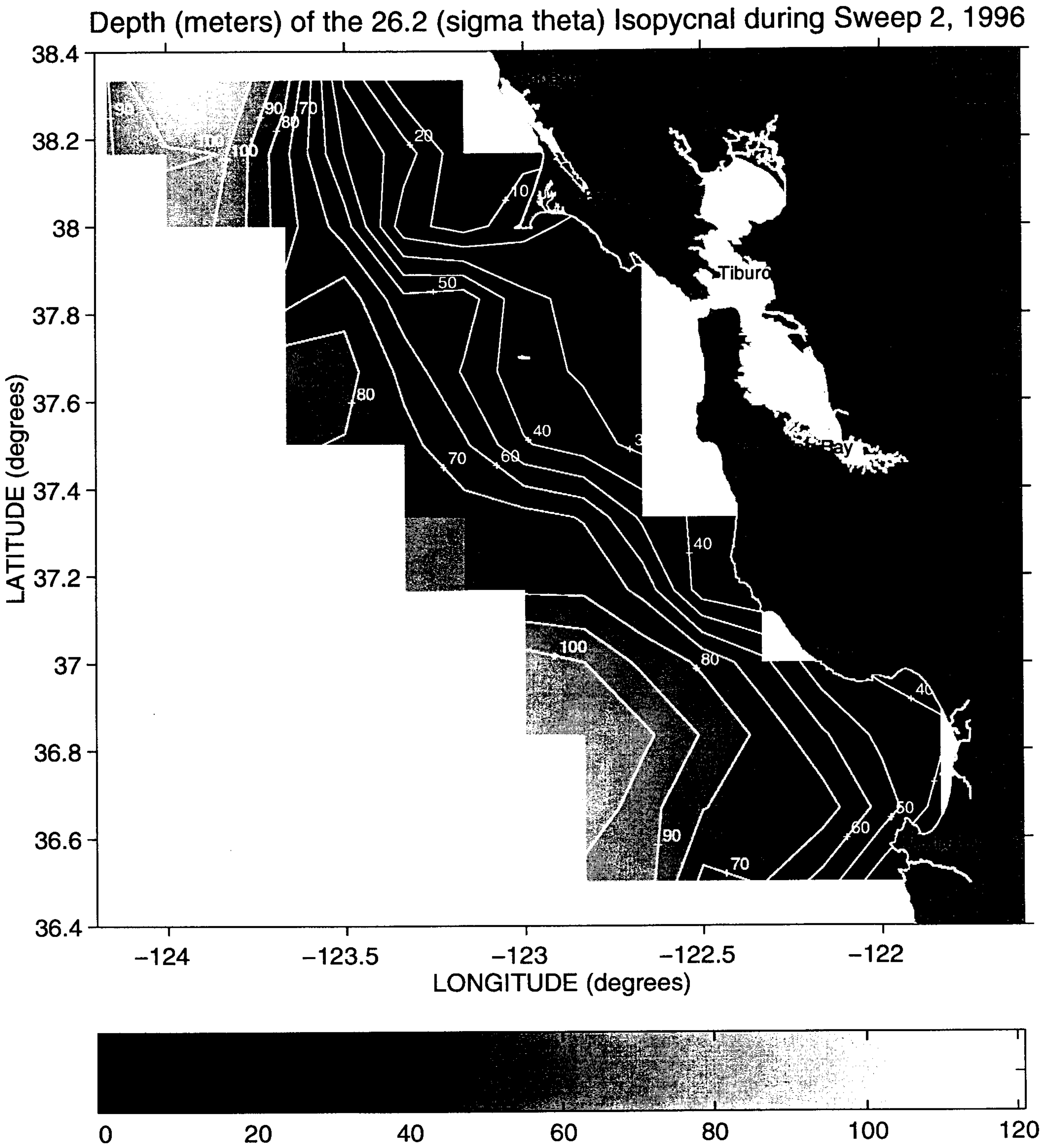


Mixed Layer Depth (meters) during Sweep 2, 1996
LATITUDE (degrees)
LONGITUDE (degrees)
38.4
38.2
38
37.8
37.6
37.4
37.2
37
36.8
36.6
36.4
−124
−123.5
−123
−122.5
−122
Tiburo
0
10
20
30
40
50
60
70

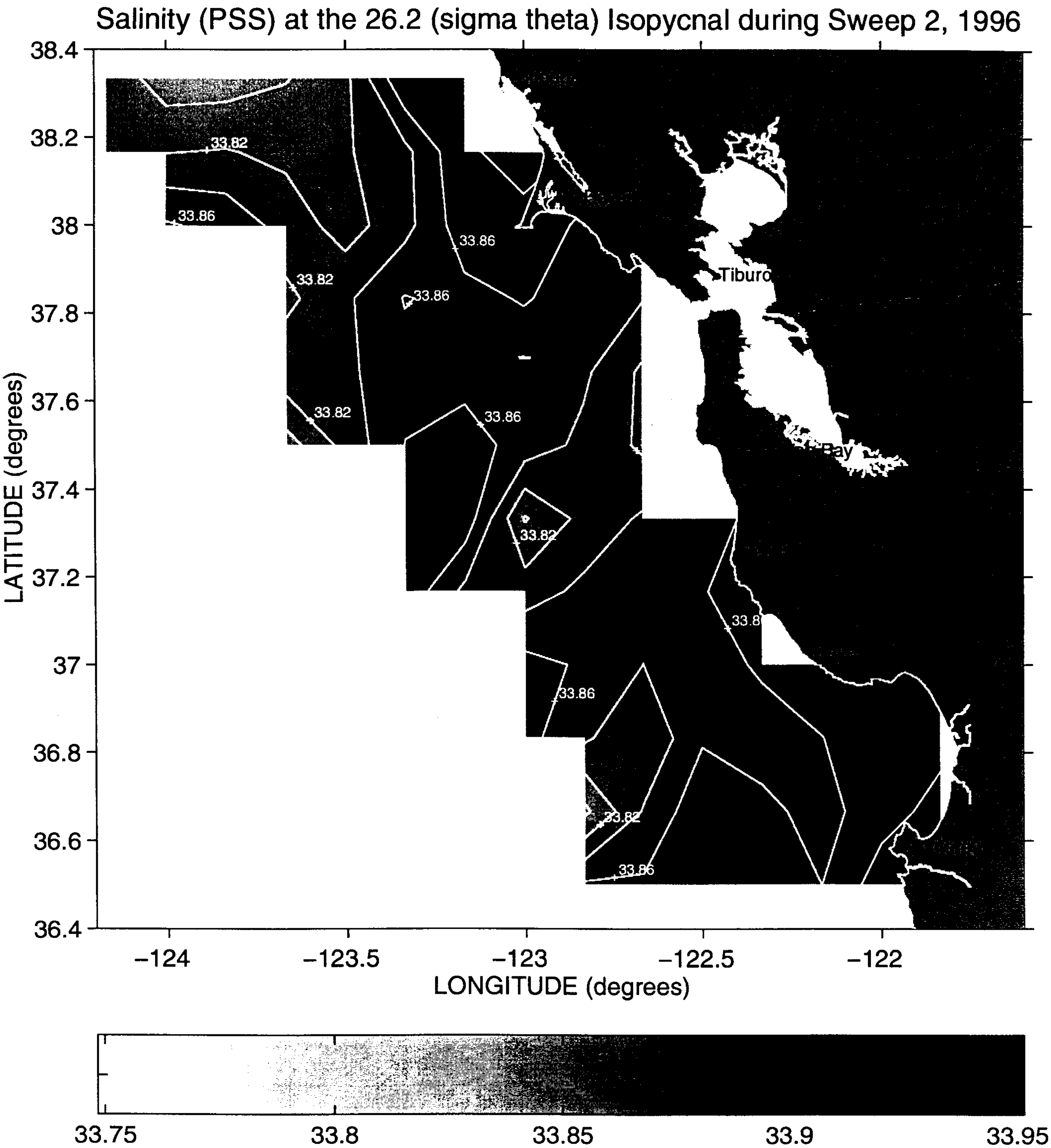


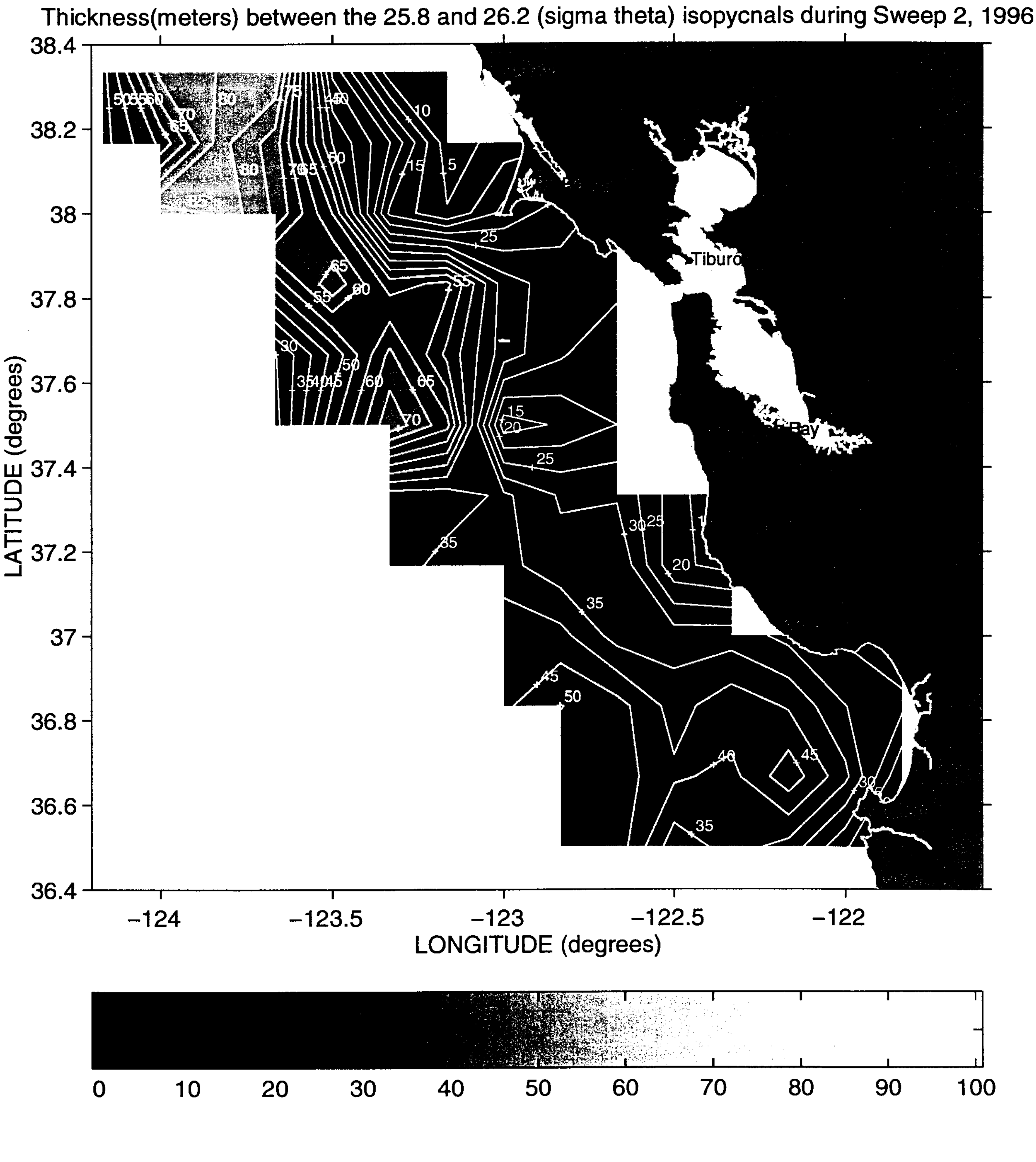
Depth (meters) of the 25.8 (sigma theta) Isopycnal during Sweep 2, 1996
LATITUDE (degrees)
LONGITUDE (degrees)
38.4
38.2
38
37.8
37.6
37.4
37.2
37
36.8
36.6
36.4
-124
-123.5
-123
-122.5
-122
Tiburo
Bay
0
10
20
30
40
50
60
70
80


Salinity (PSS) at the 25.8 (sigma theta) Isopycnal during Sweep 2, 1996
38.4
38.2
38
37.8
37.6
37.4
37.2
37
36.8
36.6
36.4
LATITUDE (degrees)
-124
-123.5
-123
-122.5
-122
LONGITUDE (degrees)
33.68
33.8
33.72
33.56
33.6
33.76
33.64
Tiburo
33.5
33.55
33.6
33.65
33.7
33.75
33.8
33.85
33.9



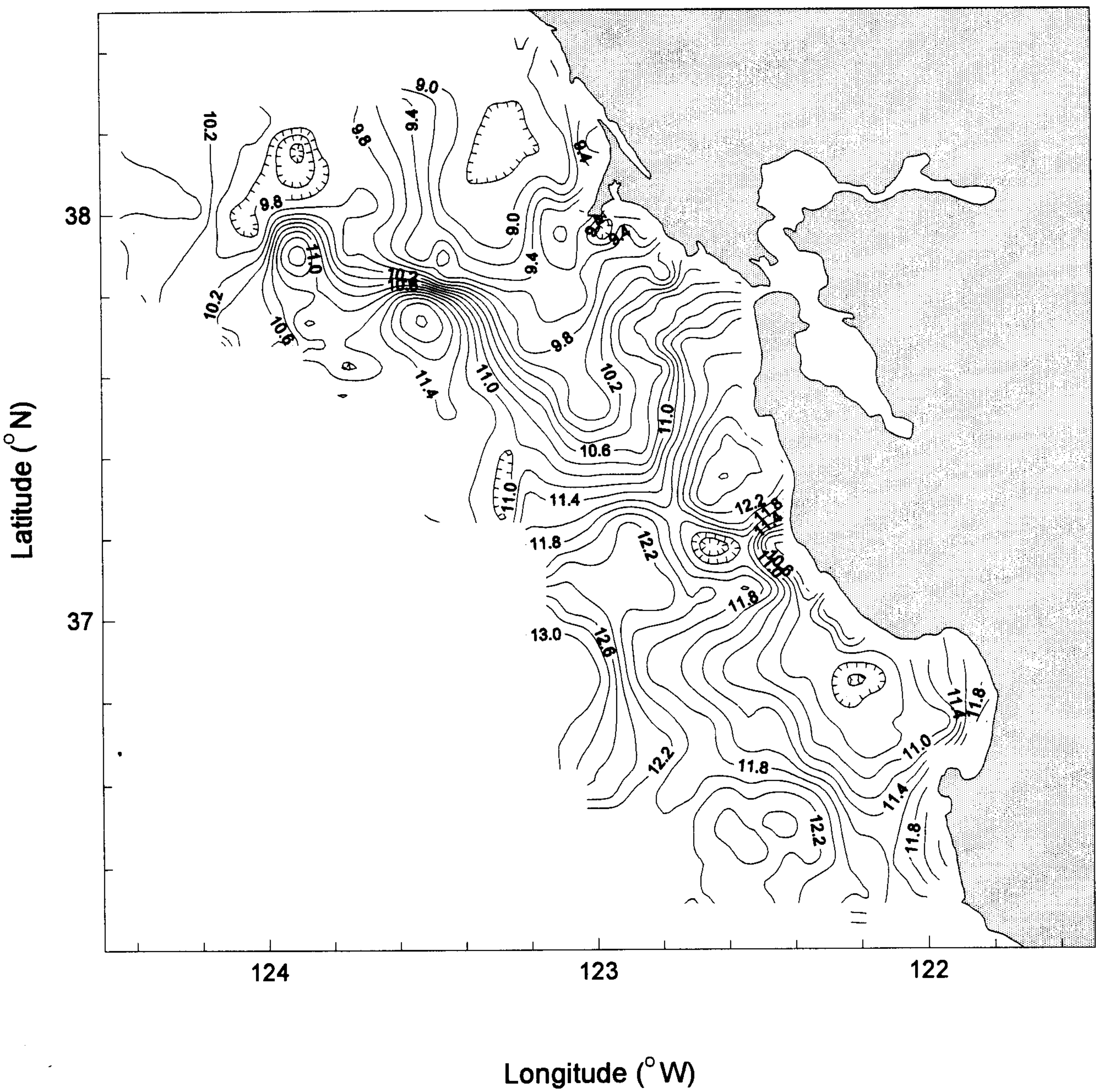
Depth (meters) of the 26.2 (sigma theta) Isopycnal during Sweep 2, 1996
38.4
38.2
38
37.8
37.6
37.4
37.2
37
36.8
36.6
36.4
LATITUDE (degrees)
-124
-123.5
-123
-122.5
-122
LONGITUDE (degrees)
0
20
40
60
80
100
120

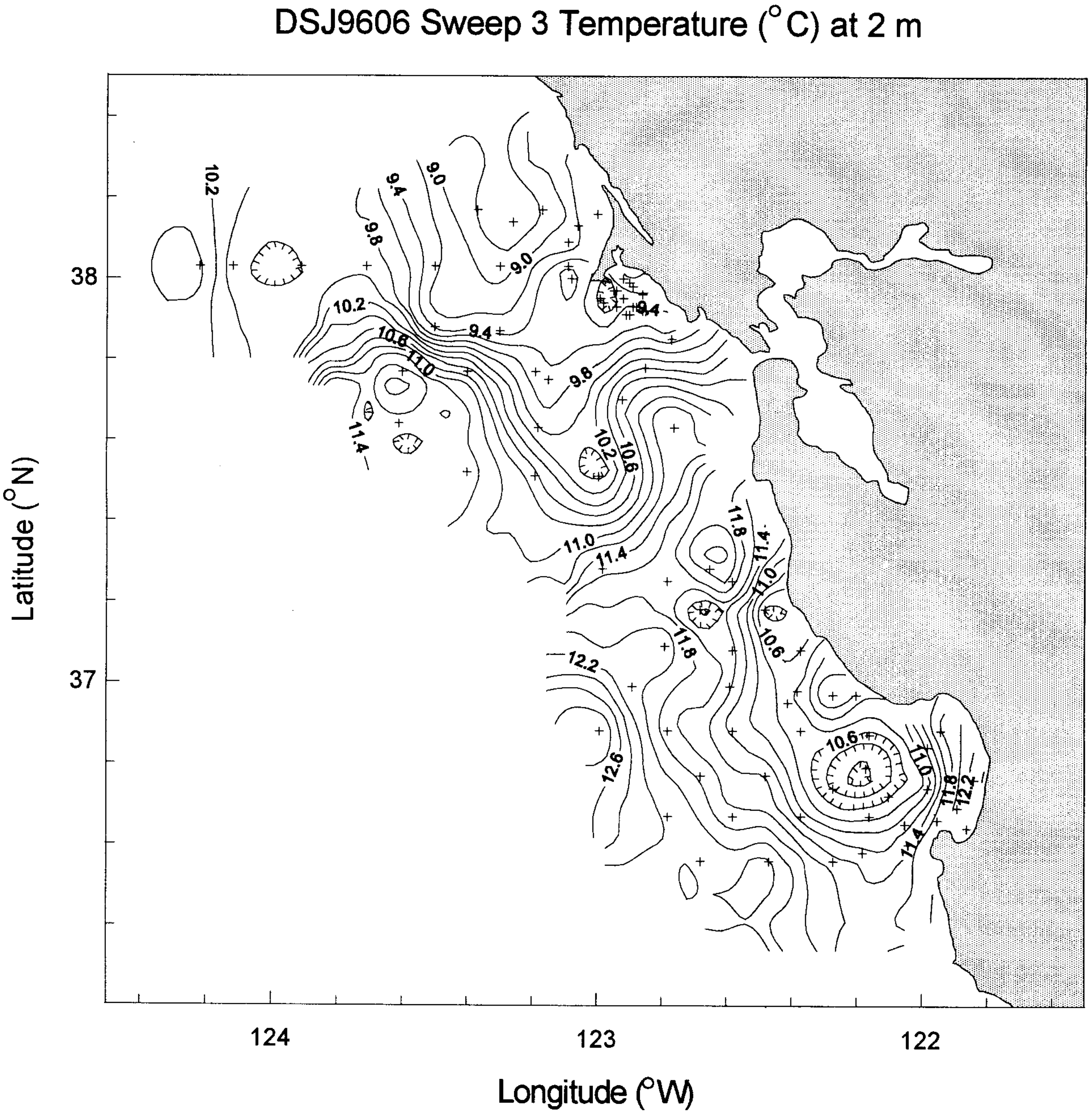

Salinity (PSS) at the 26.2 (sigma theta) Isopycnal during Sweep 2, 1996
38.4
38.2
38
37.8
37.6
37.4
37.2
37
36.8
36.6
36.4
LATITUDE (degrees)
33.82
33.86
33.82
33.86
33.86
33.82
33.86
33.82
33.86
33.82
33.86
Tiburo
Bay
-124
-123.5
-123
-122.5
-122
LONGITUDE (degrees)
33.75
33.8
33.85
33.9
33.95


Thickness(meters) between the 25.8 and 26.2 (sigma theta) isopycnals during Sweep 2, 1996
LATITUDE (degrees)
LONGITUDE (degrees)
38.4
38.2
38
37.8
37.6
37.4
37.2
37
36.8
36.6
36.4
−124
−123.5
−123
−122.5
−122
Tiburo
Bay
0
10
20
30
40
50
60
70
80
90
100

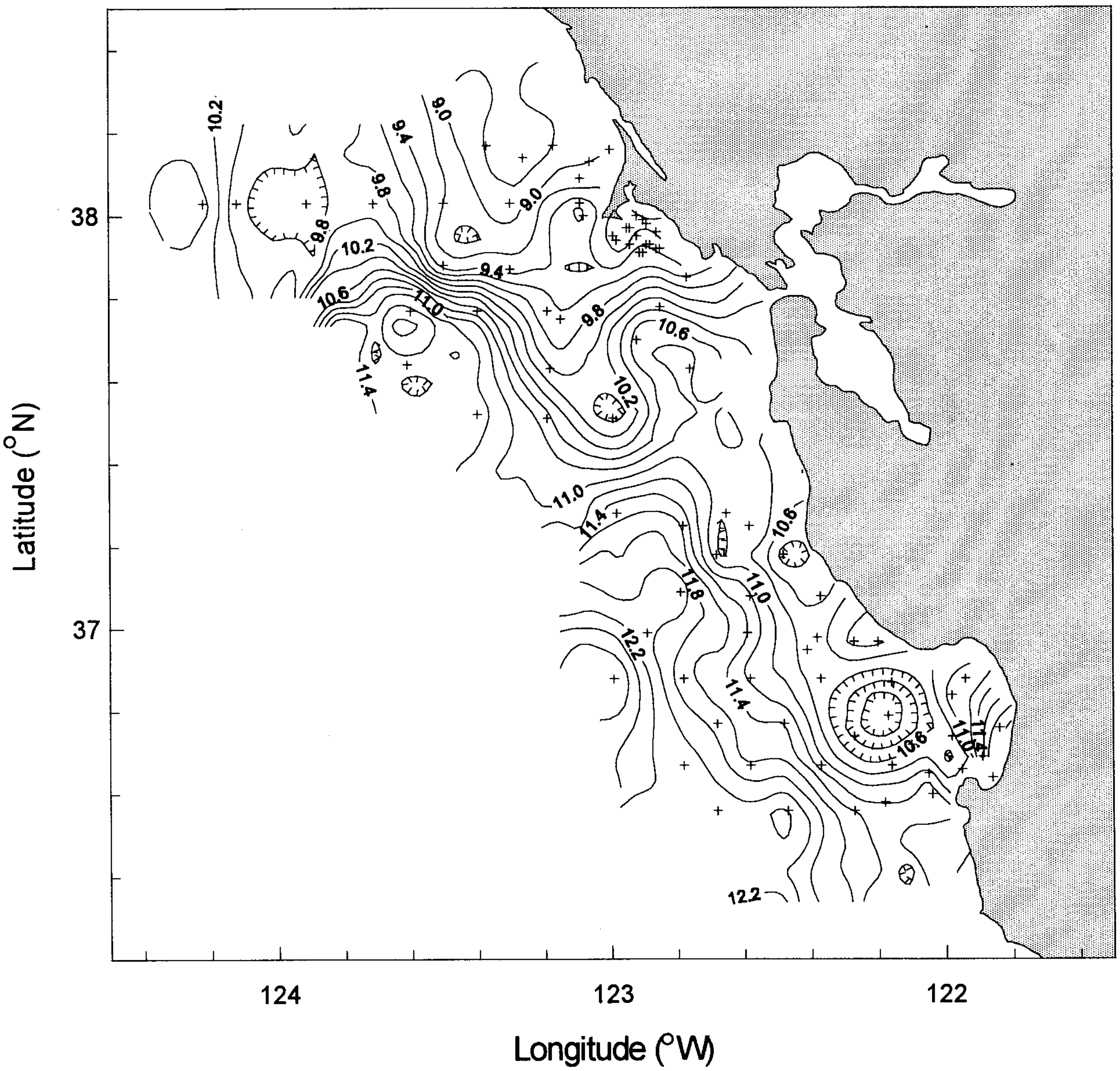
APPENDIX 6.3: HORIZONTAL MAPS OF CTD AND TS FOR DSJ9606, SWEEP 3

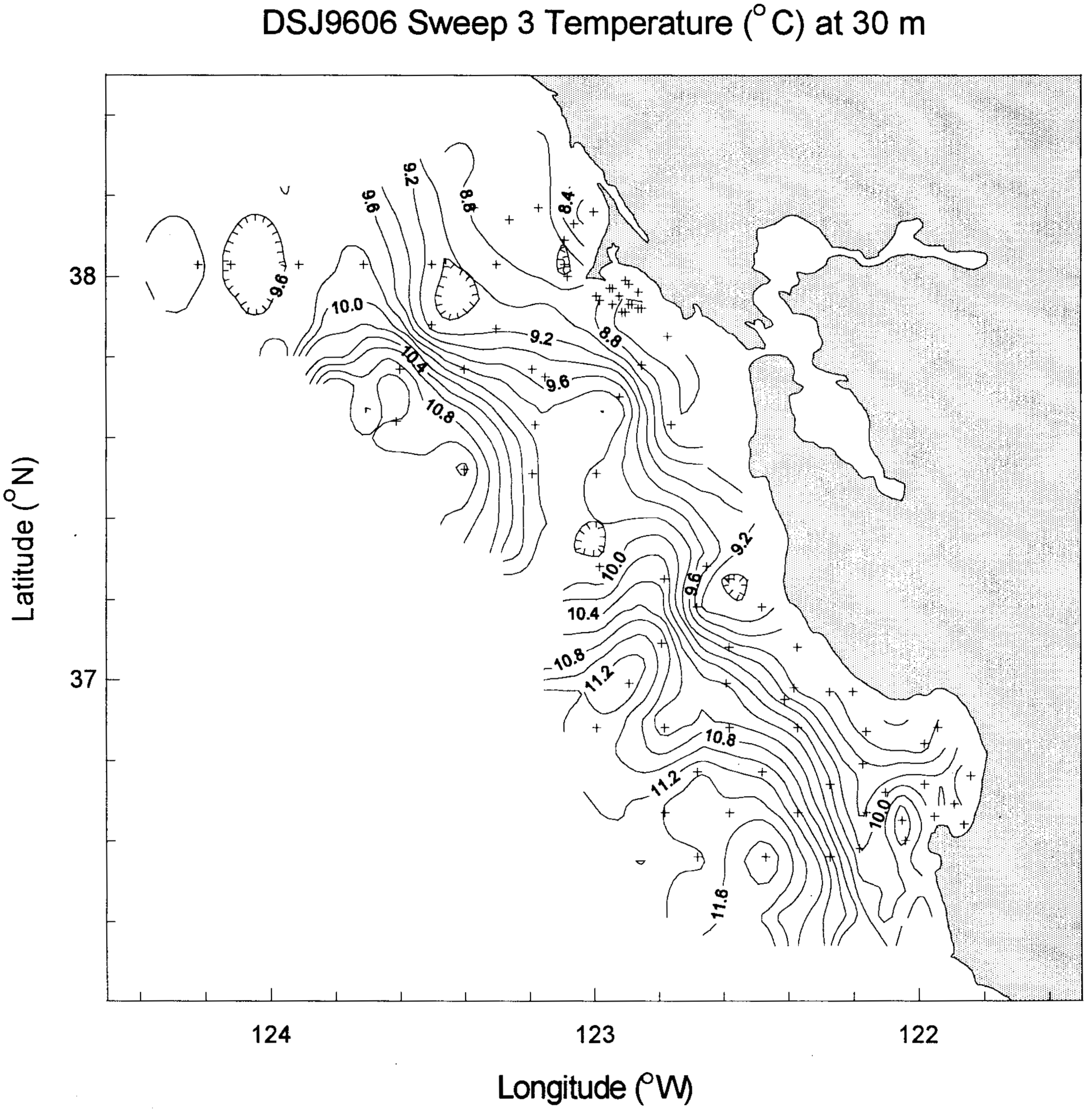
DSJ9606 Sweep 3 TS Temperature (°C)



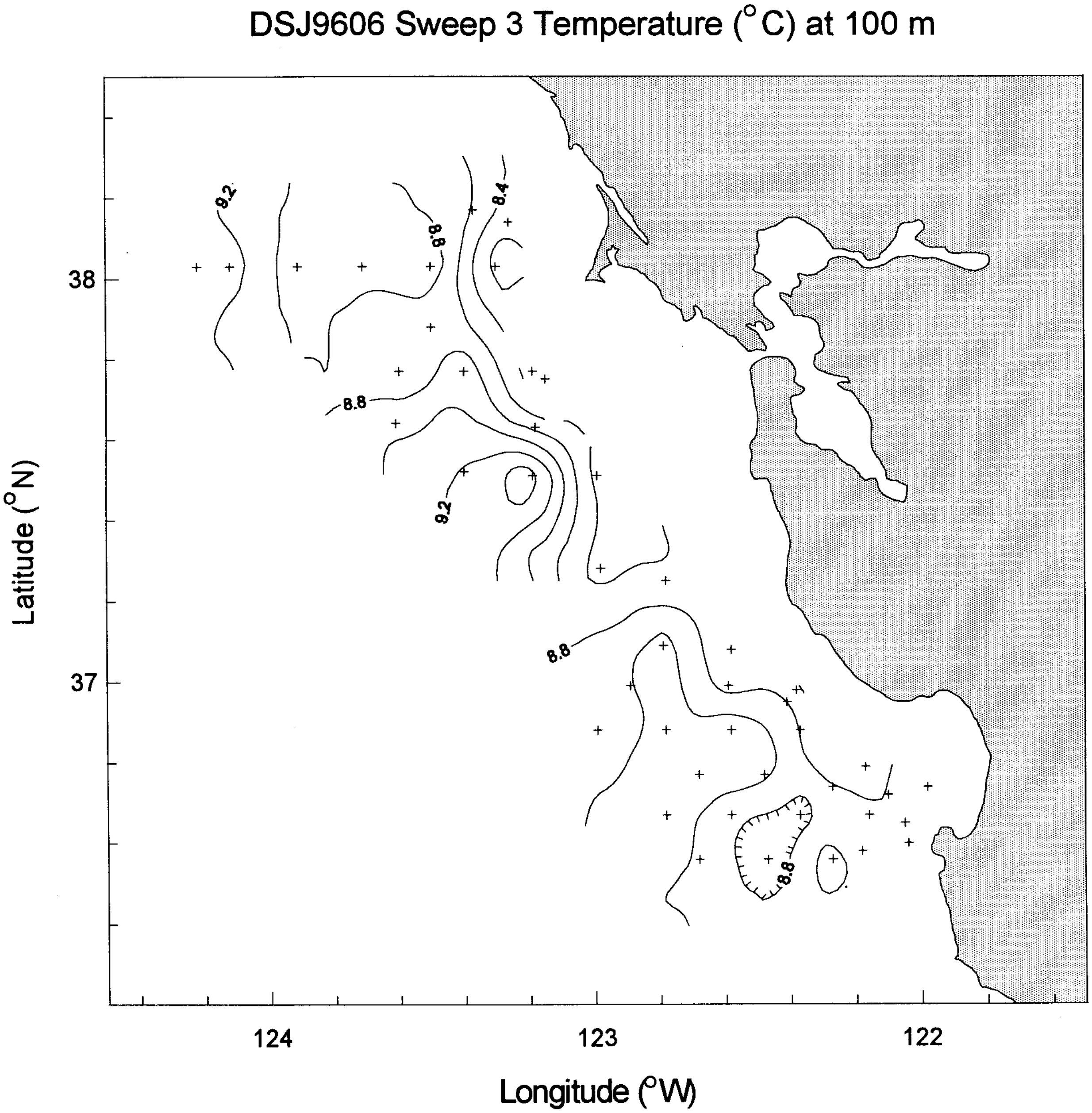

DSJ9606 Sweep 3 Temperature (°C) at 2 m
Latitude (°N)
38
37
124
123
122
Longitude (°W)
10.2
9.4
9.0
9.8
10.6
11.0
11.4
11.8
12.2
12.6

DSJ9606 Sweep 3 Temperature (°C) at 10 m



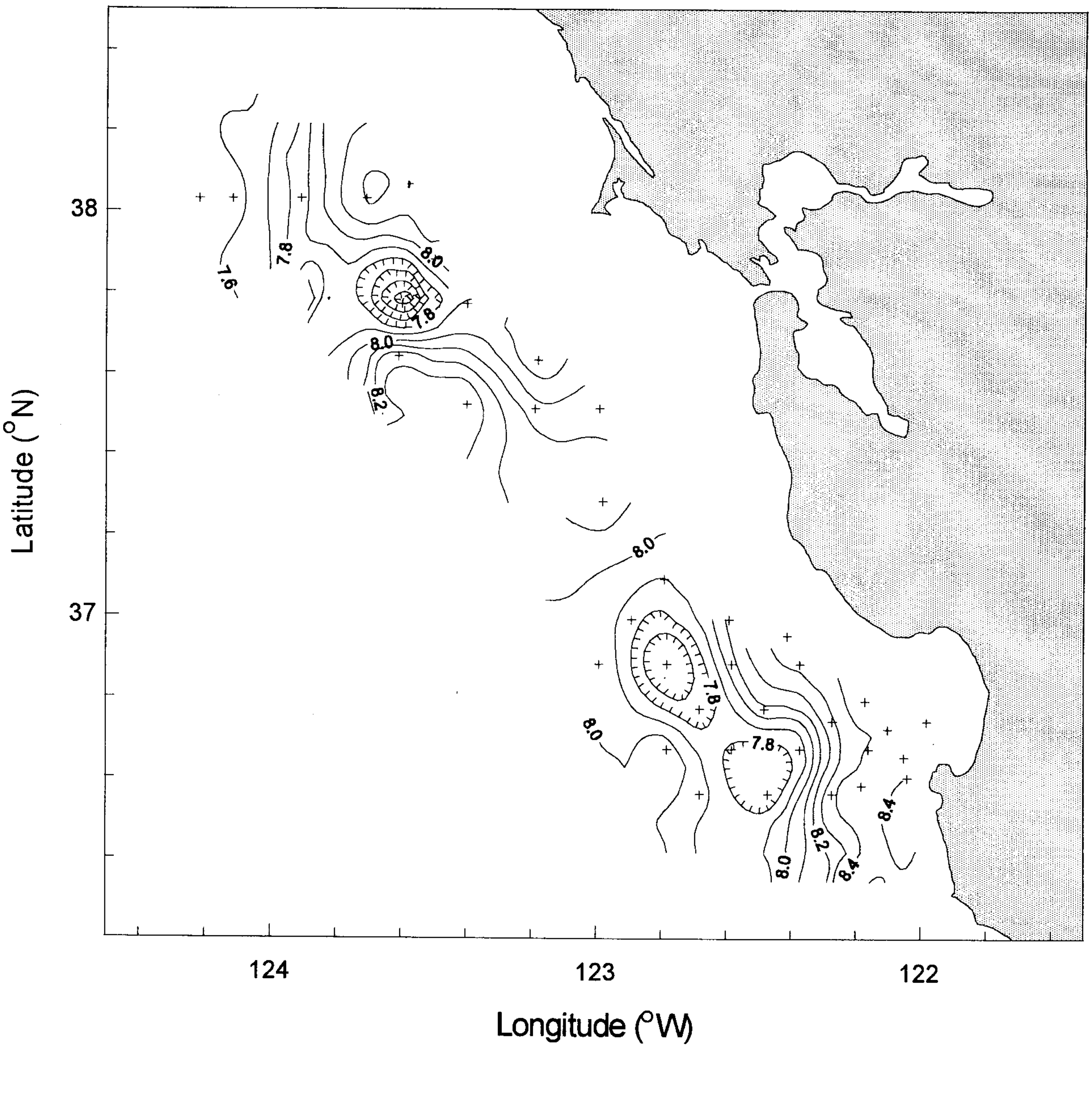


DSJ9606 Sweep 3 Temperature (°C) at 30 m
38
37
Latitude (°N)
124
123
122
Longitude (°W)
9.2
9.6
8.8
8.4
10.0
10.4
10.8
11.2
11.8

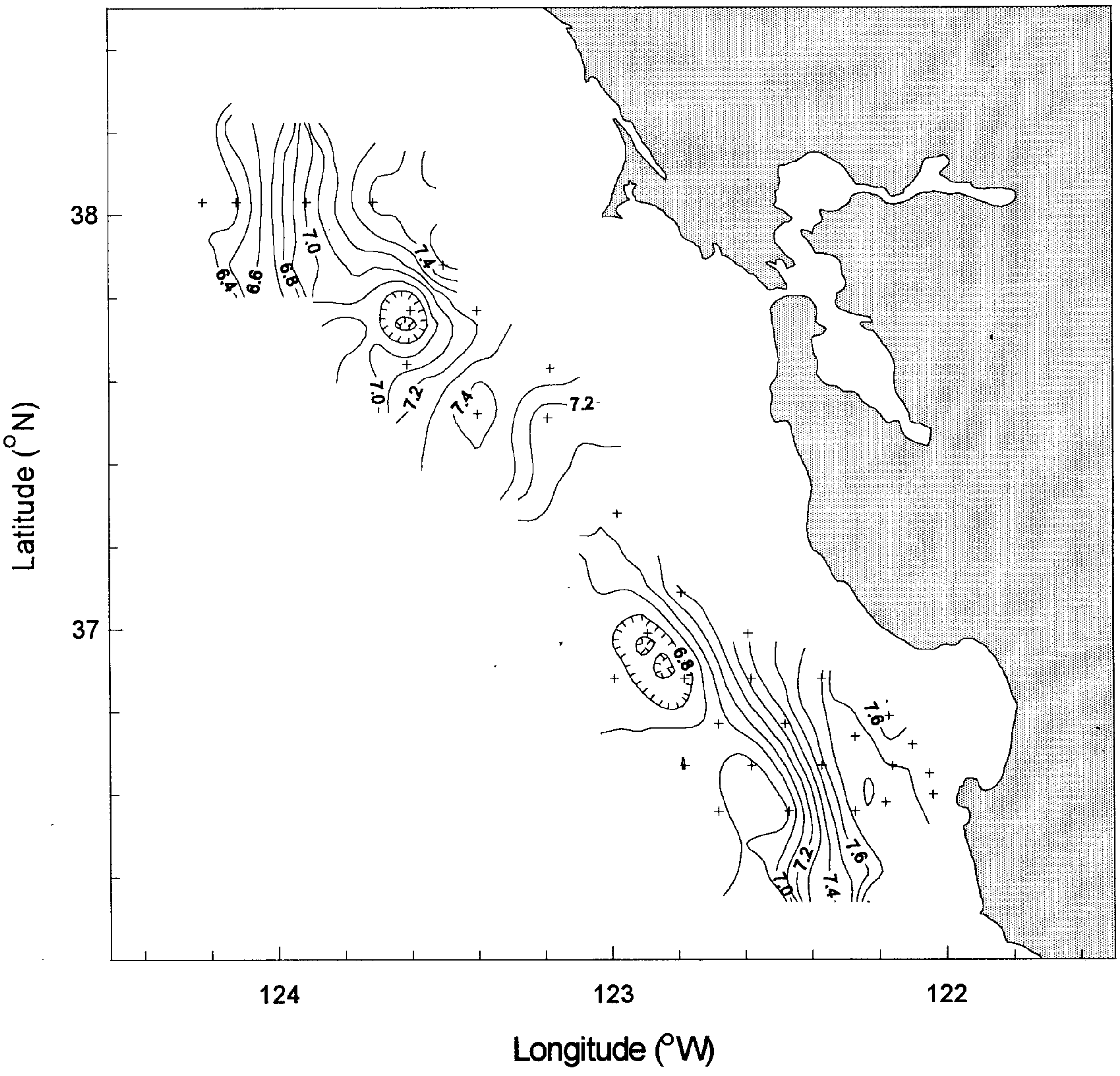


DSJ9606 Sweep 3 Temperature (°C) at 100 m
9.2
8.8
8.4
8.8
9.2
8.8
8.8
38
37
Latitude (°N)
124
123
122
Longitude (°W)

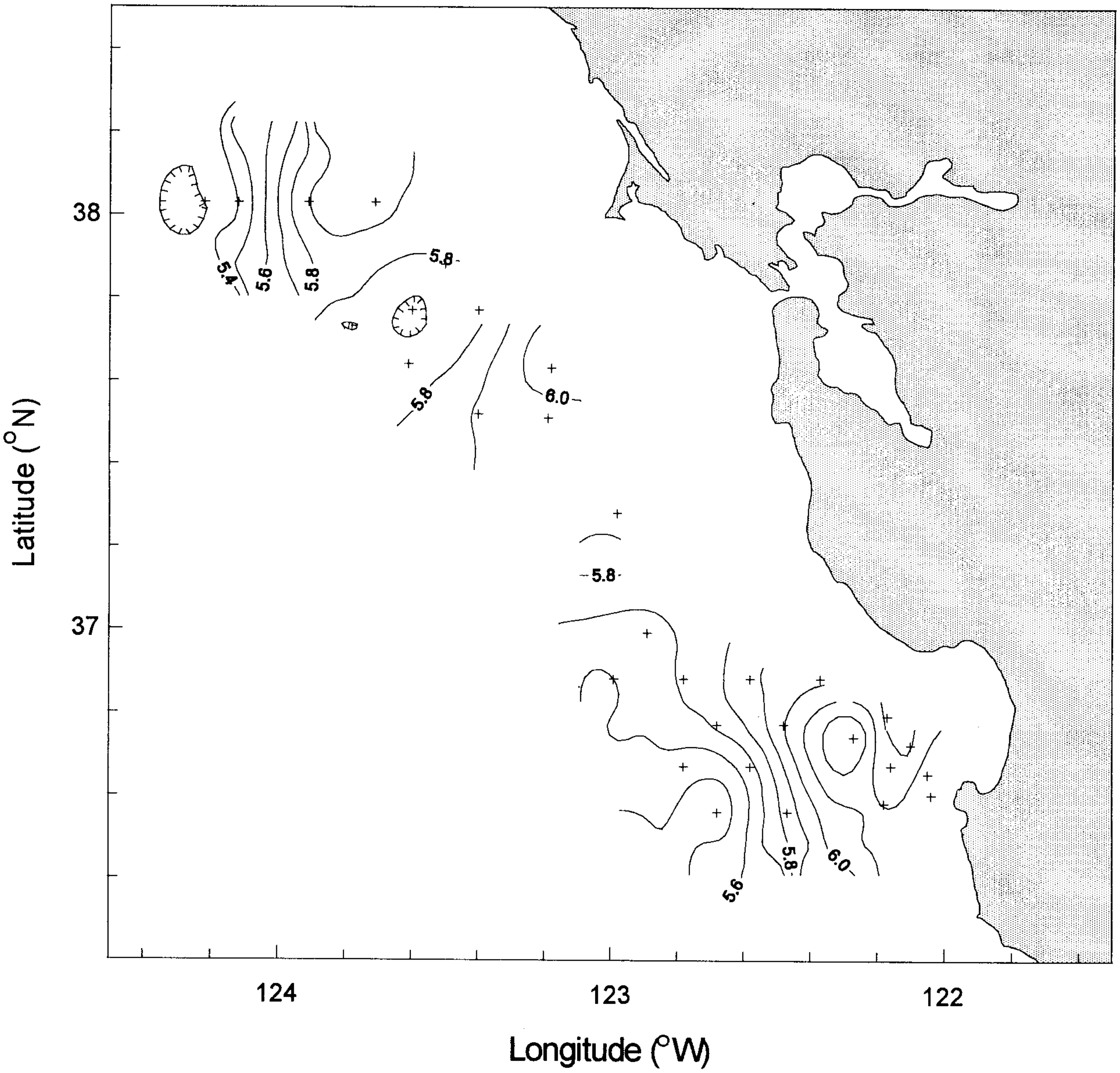
DSJ9606 Sweep 3 Temperature (°C) at 200 m



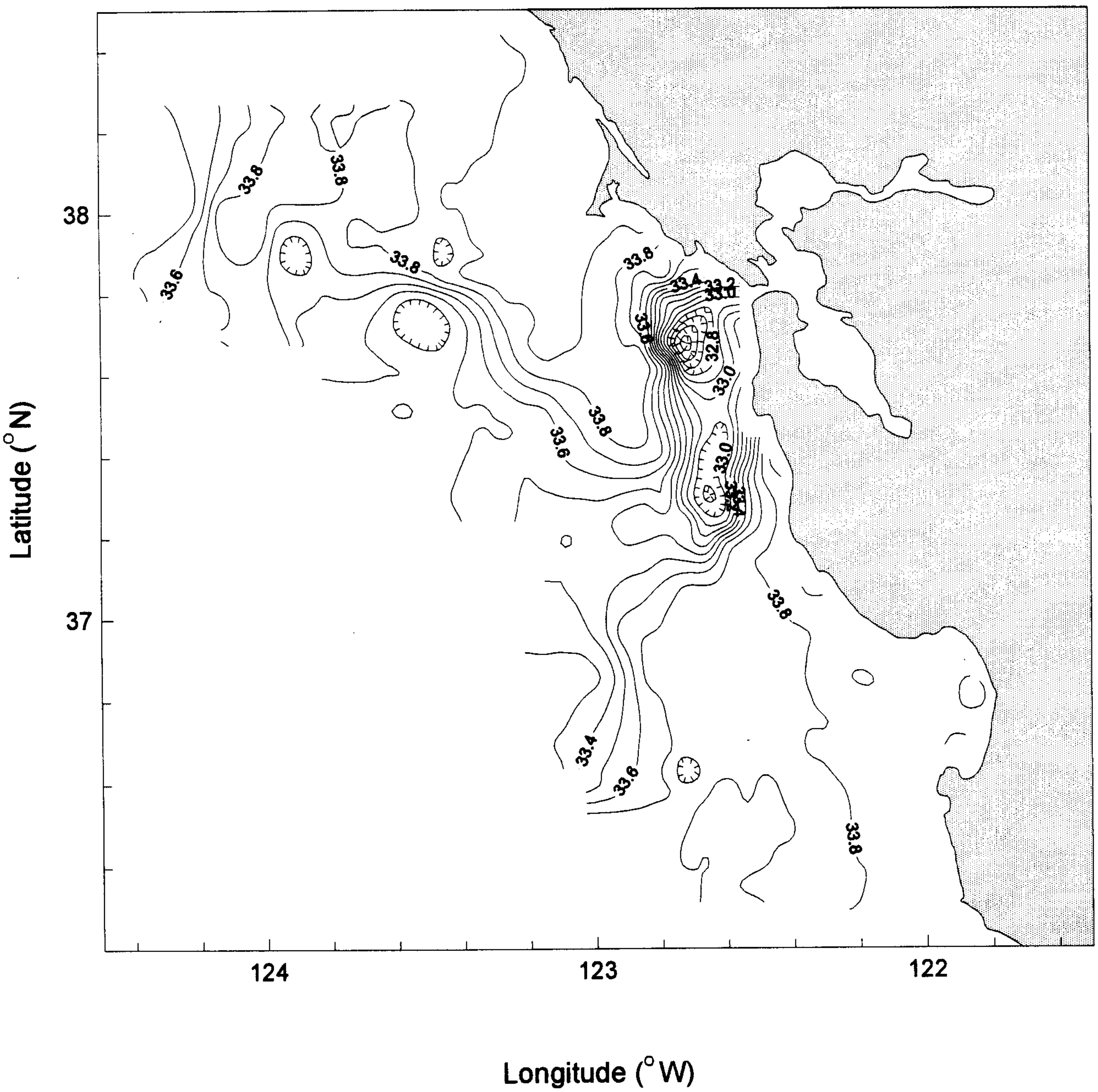
DSJ9606 Sweep 3 Temperature (°C) at 300 m

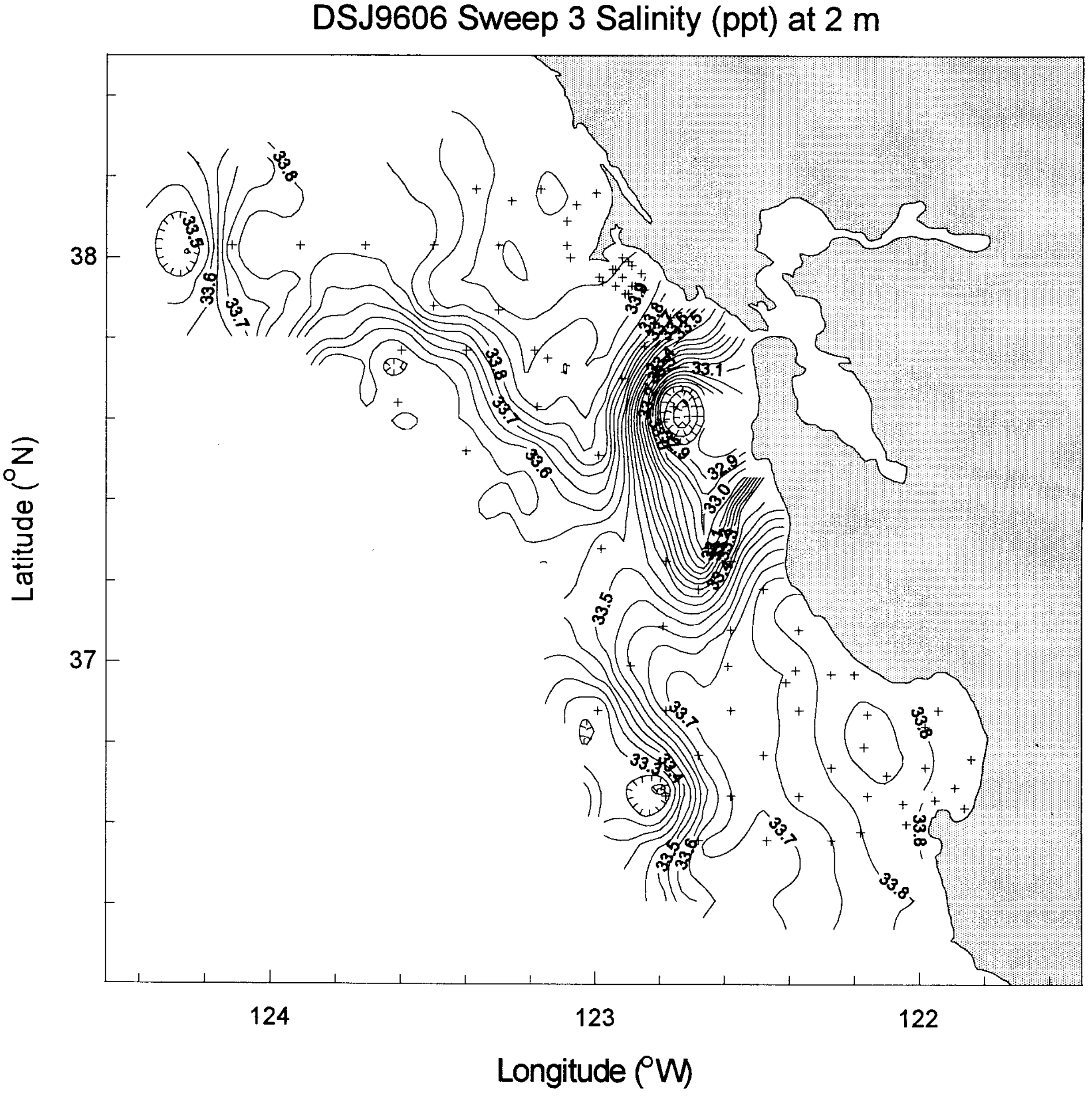


DSJ9606 Sweep 3 Temperature (°C) at 500 m

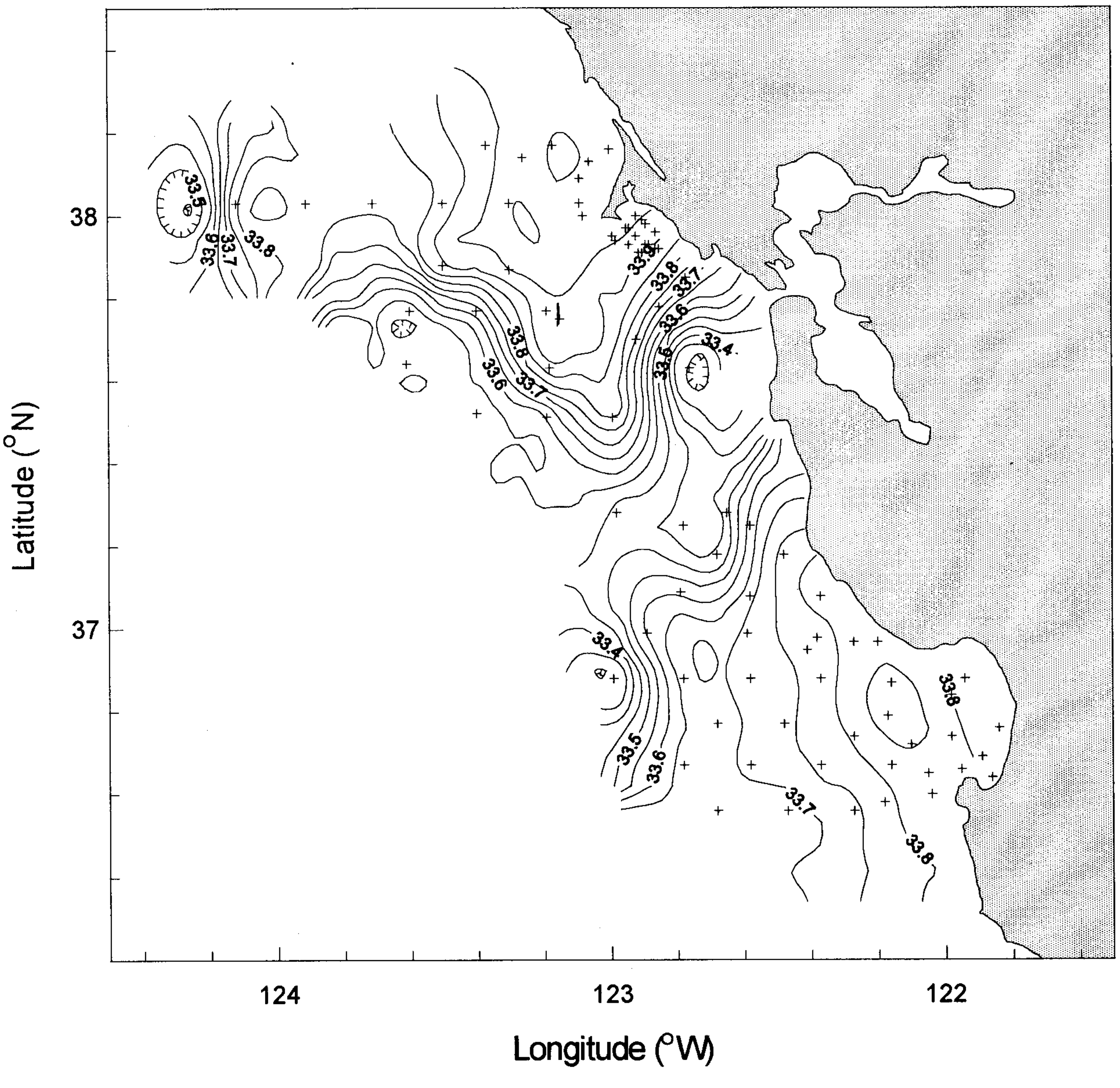


DSJ9606 Sweep 3 TS Salinity

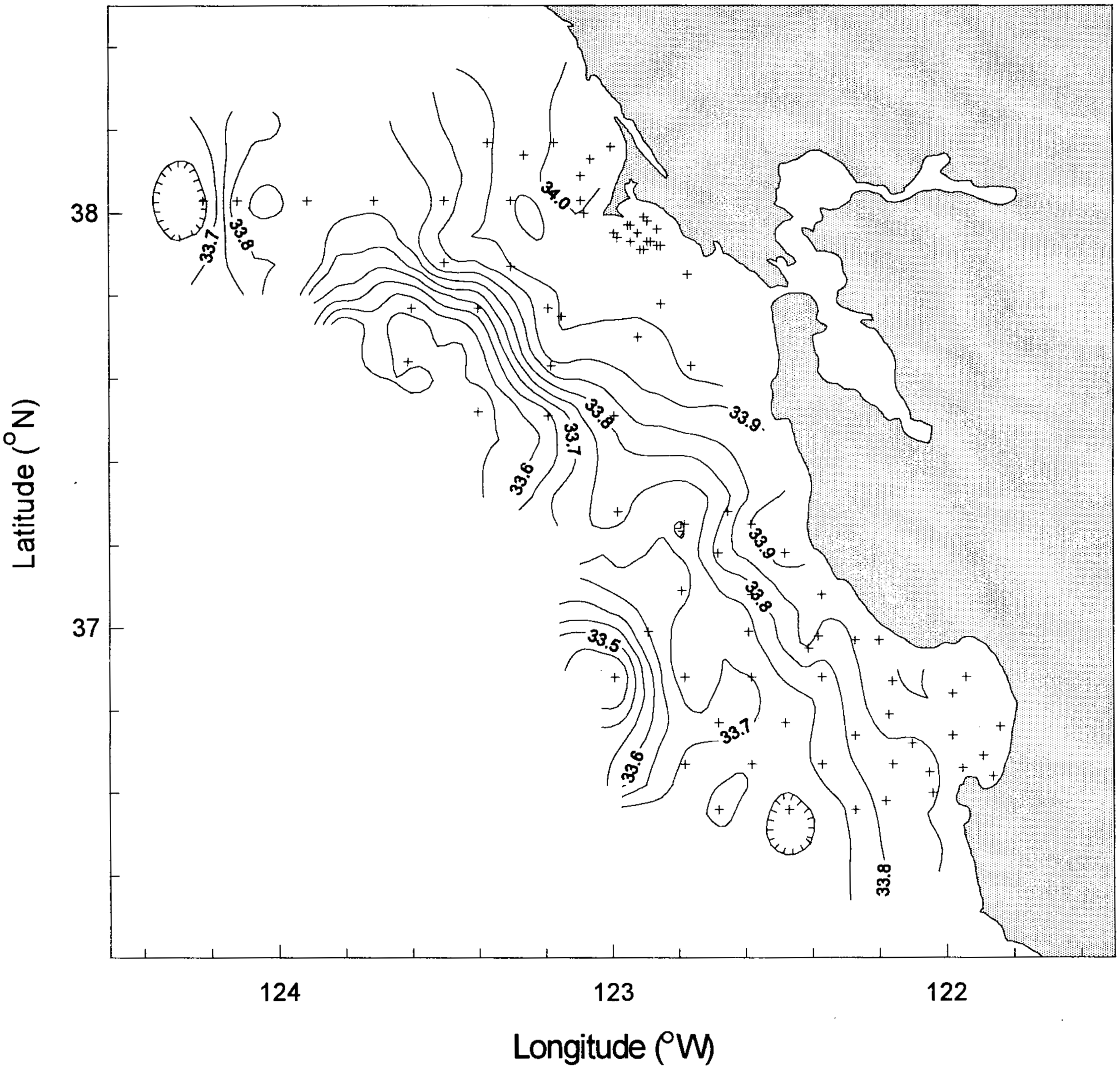


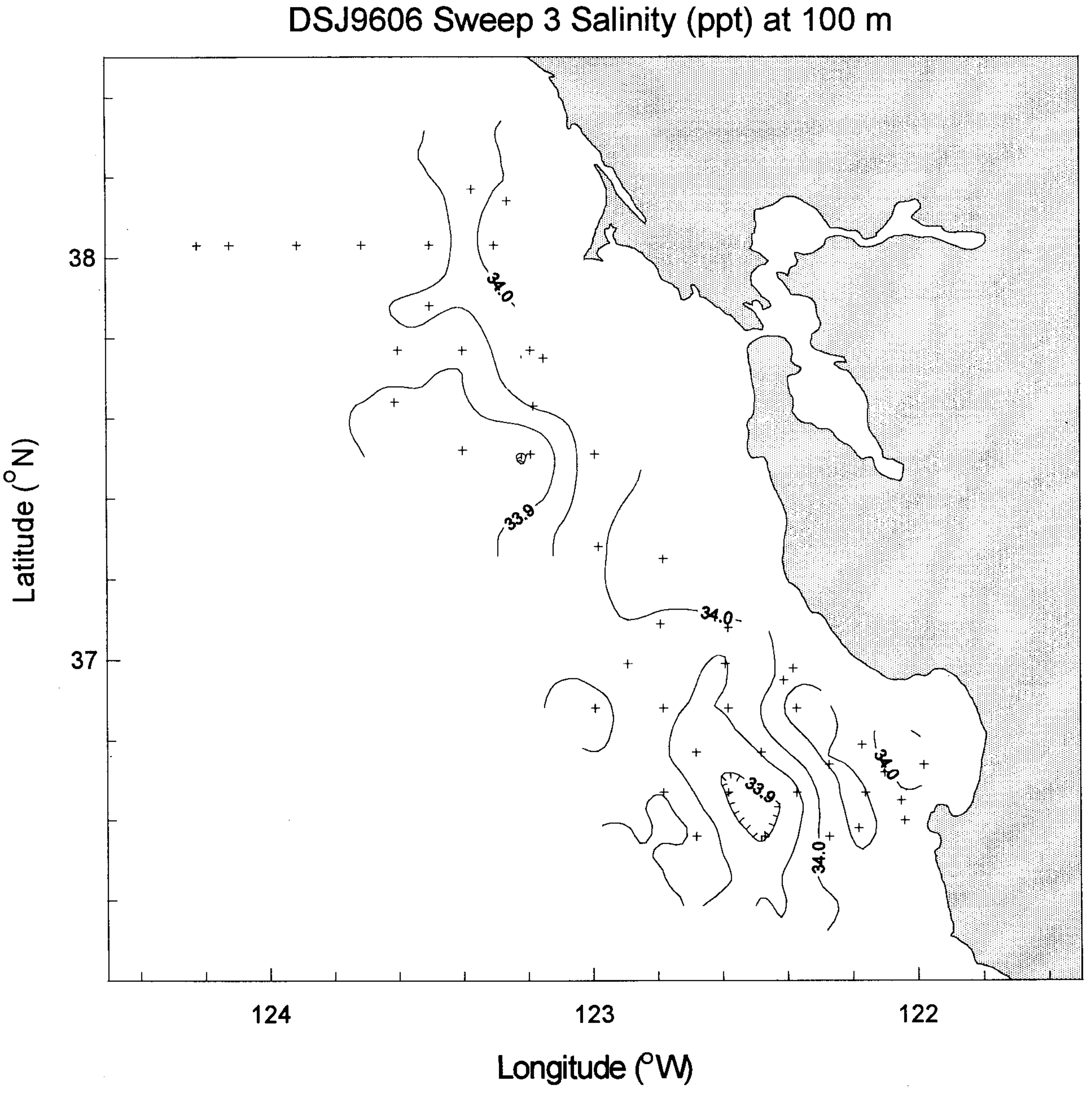

DSJ9606 Sweep 3 Salinity (ppt) at 2 m
Latitude (°N)
Longitude (°W)
38
37
124
123
122
33.8
33.5
33.6
33.7
33.1
32.9
33.0

DSJ9606 Sweep 3 Salinity (ppt) at 10 m

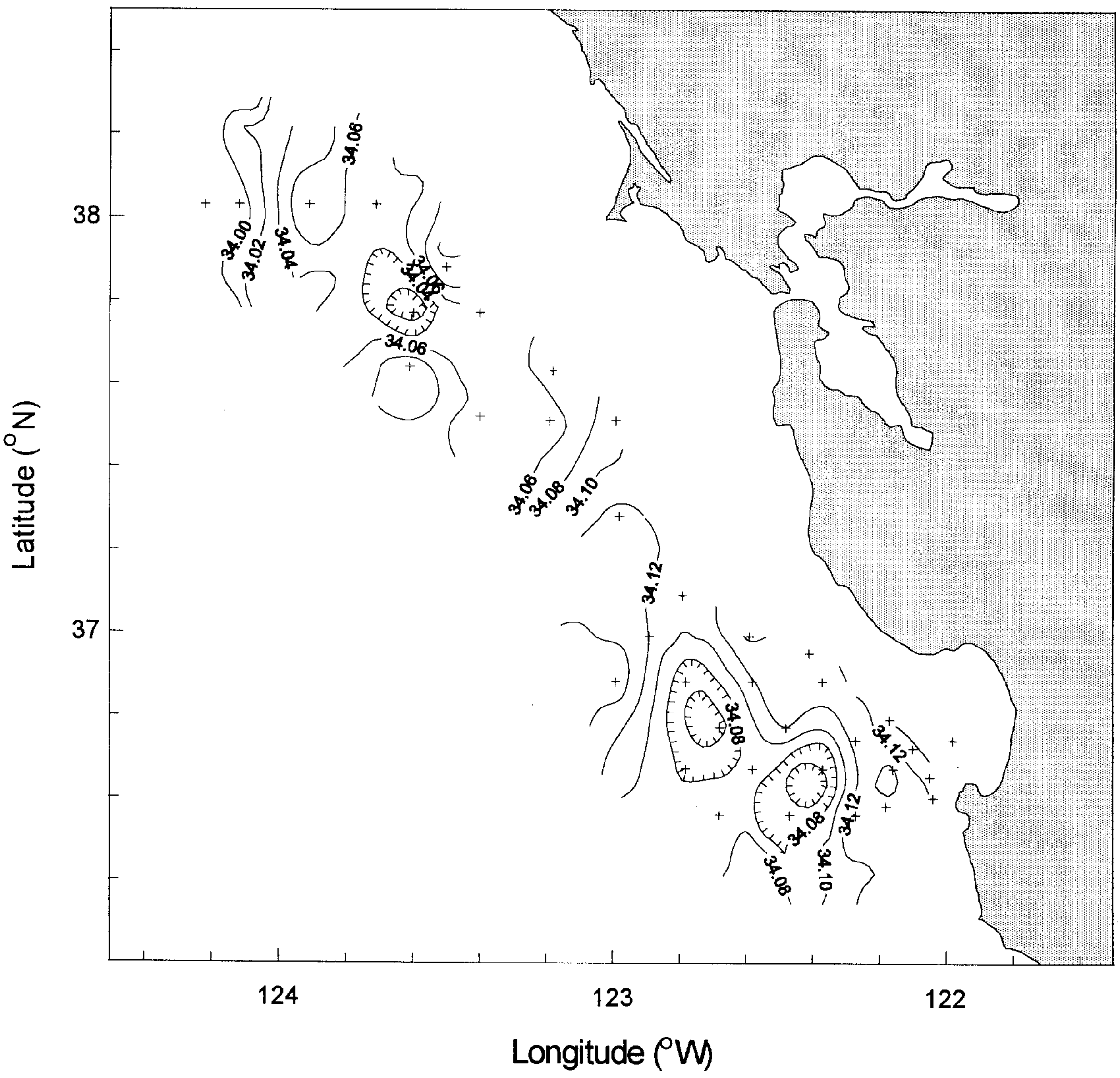


DSJ9606 Sweep 3 Salinity (ppt) at 30 m

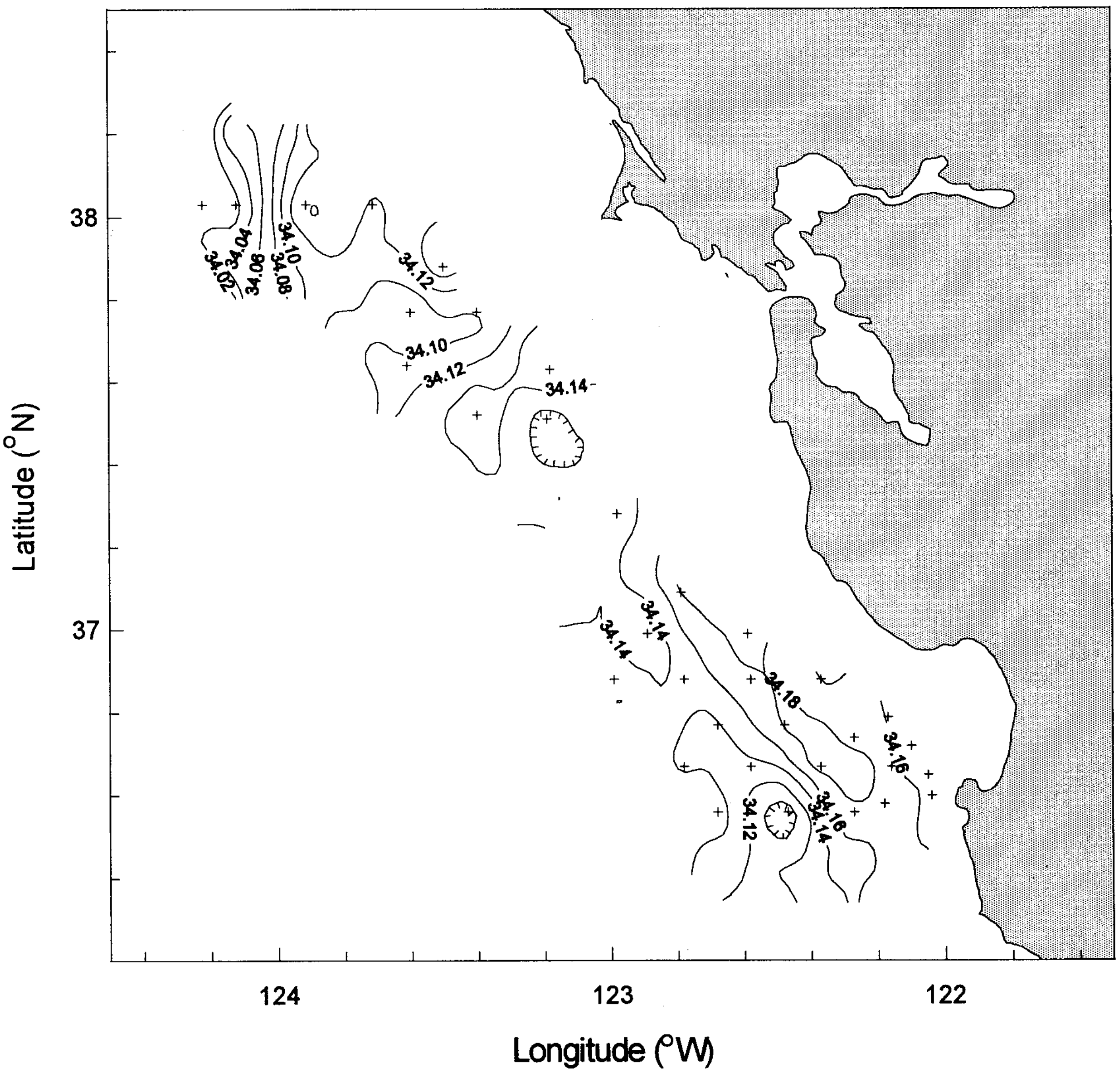



DSJ9606 Sweep 3 Salinity (ppt) at 100 m
Latitude (°N)
38
37
Longitude (°W)
124
123
122
34.0
33.9
34.0
34.0
33.9
34.0
34.0

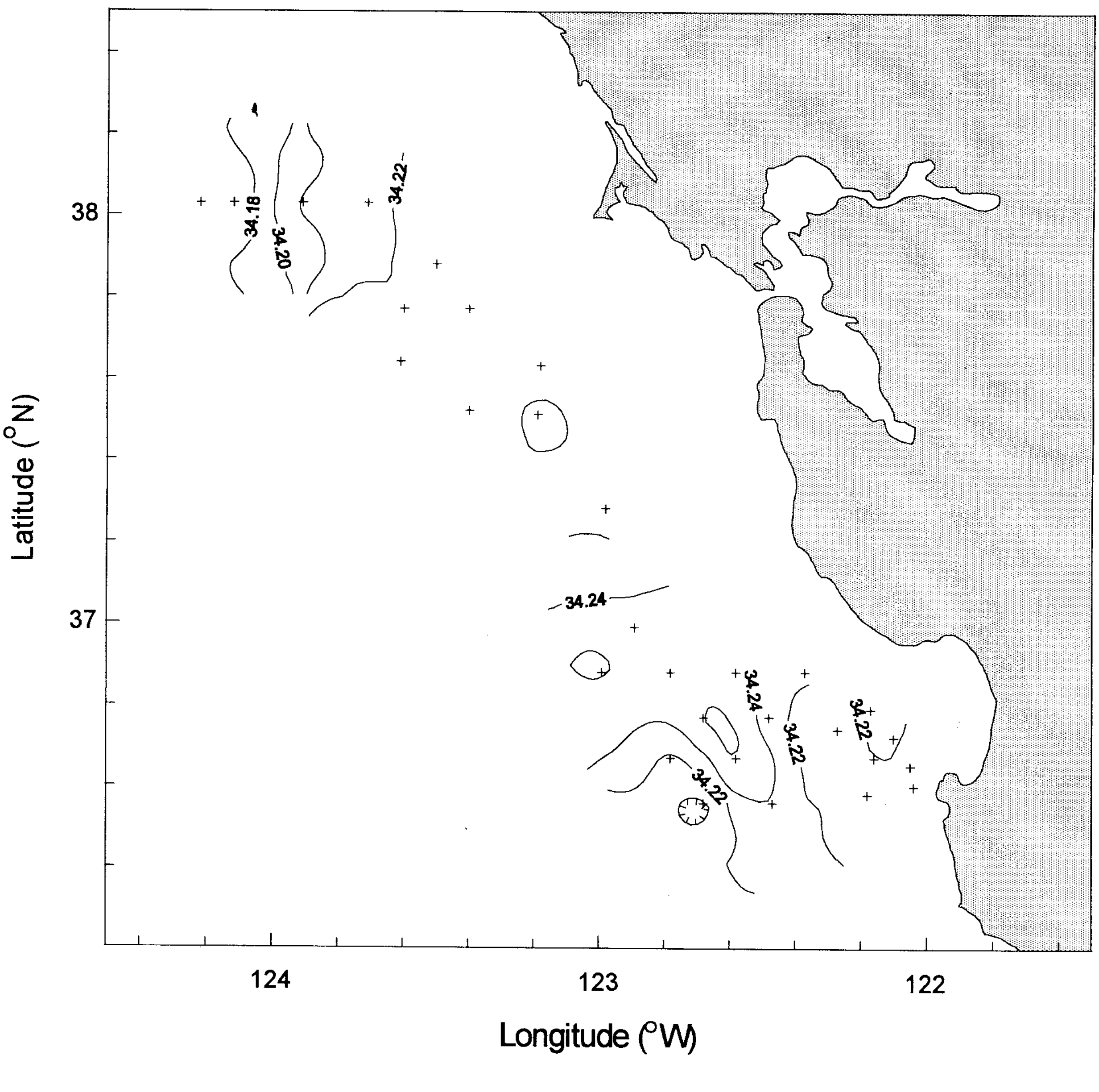
DSJ9606 Sweep 3 Salinity (ppt) at 200 m



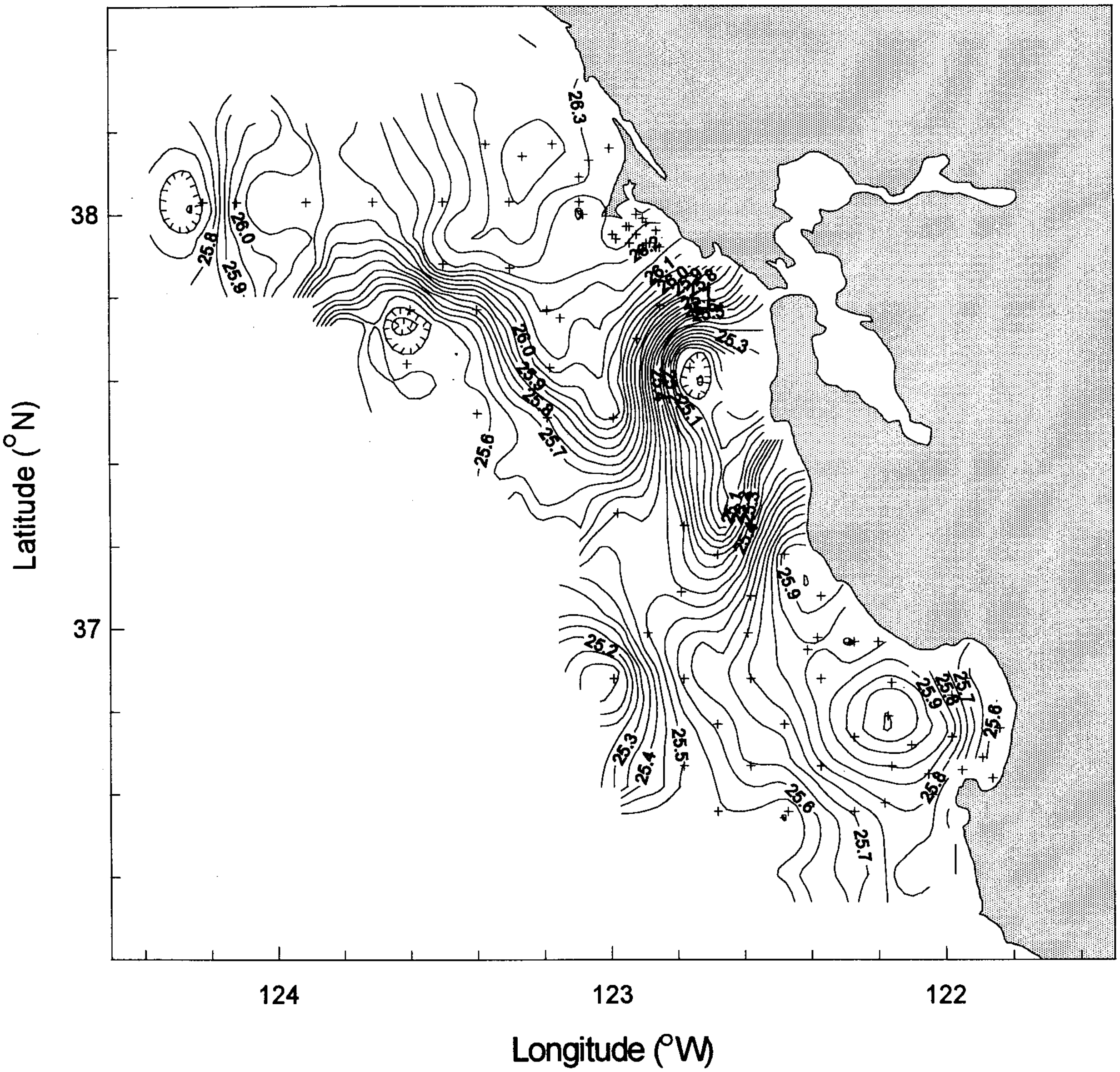
DSJ9606 Sweep 3 Salinity (ppt) at 300 m



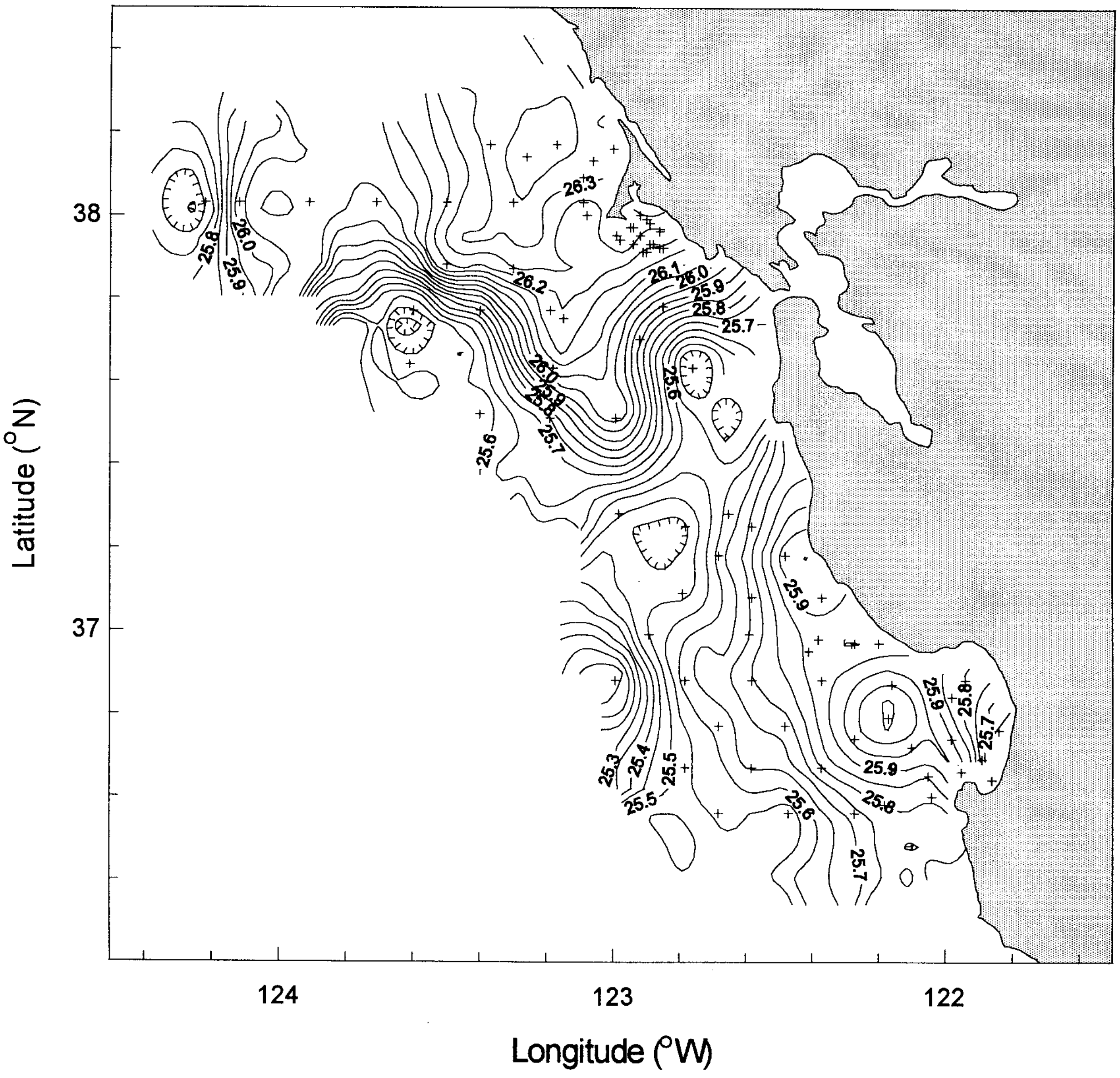
DSJ9606 Sweep 3 Salinity (ppt) at 500 m



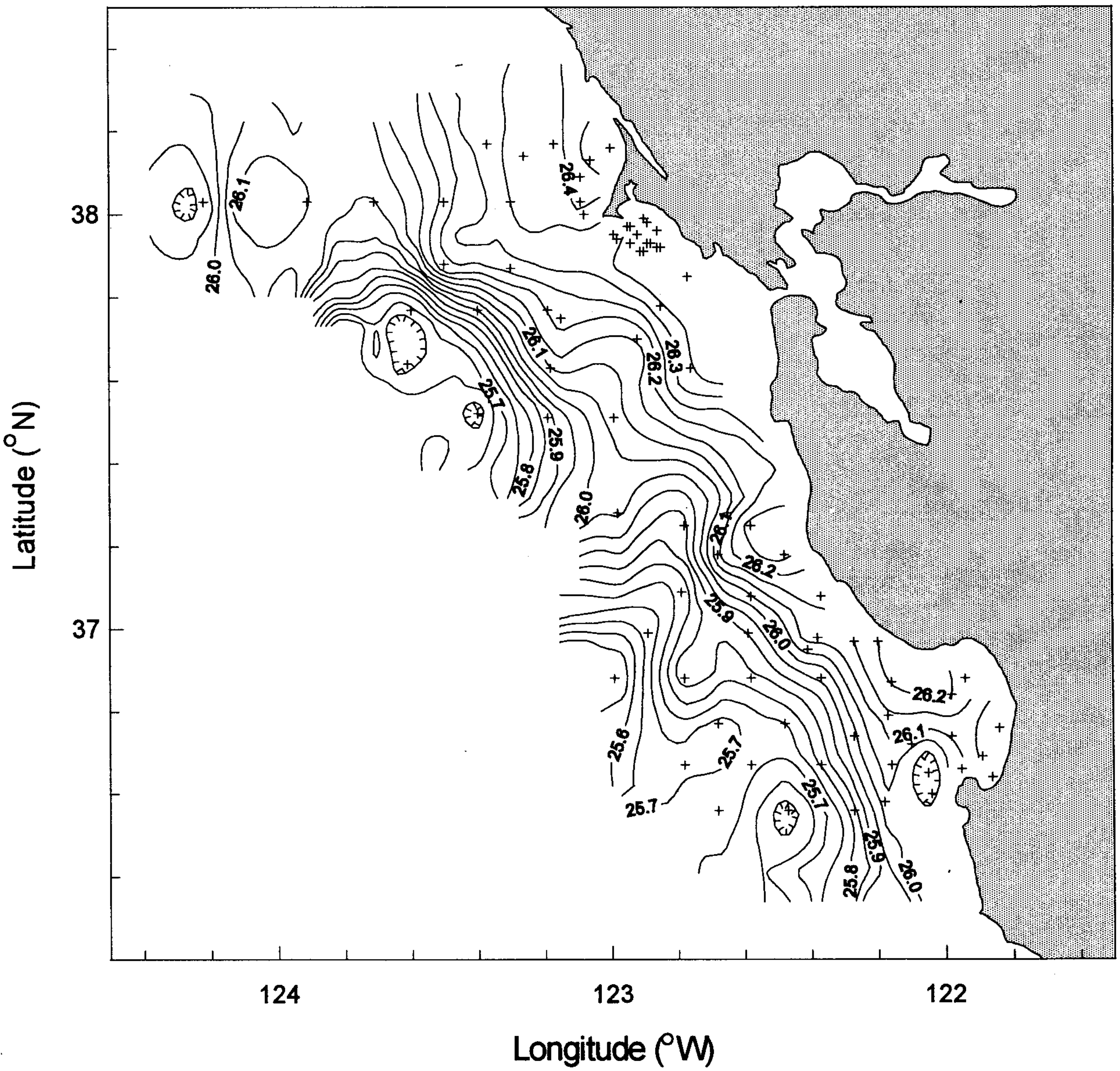
DSJ9606 Sweep 3 Density (kg/m^3) at 2 m



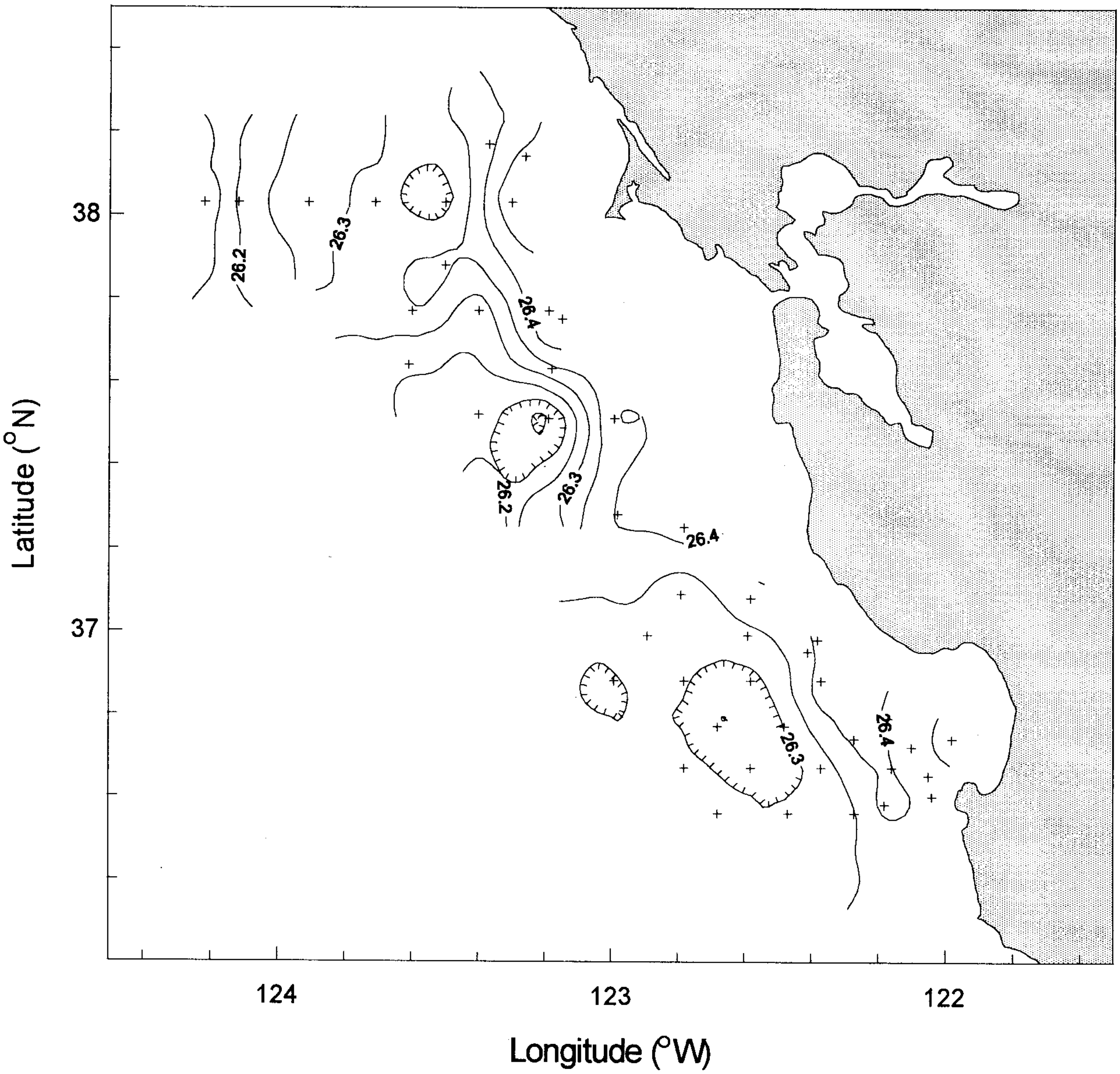
DSJ9606 Sweep 3 Density (kg/m³) at 10 m

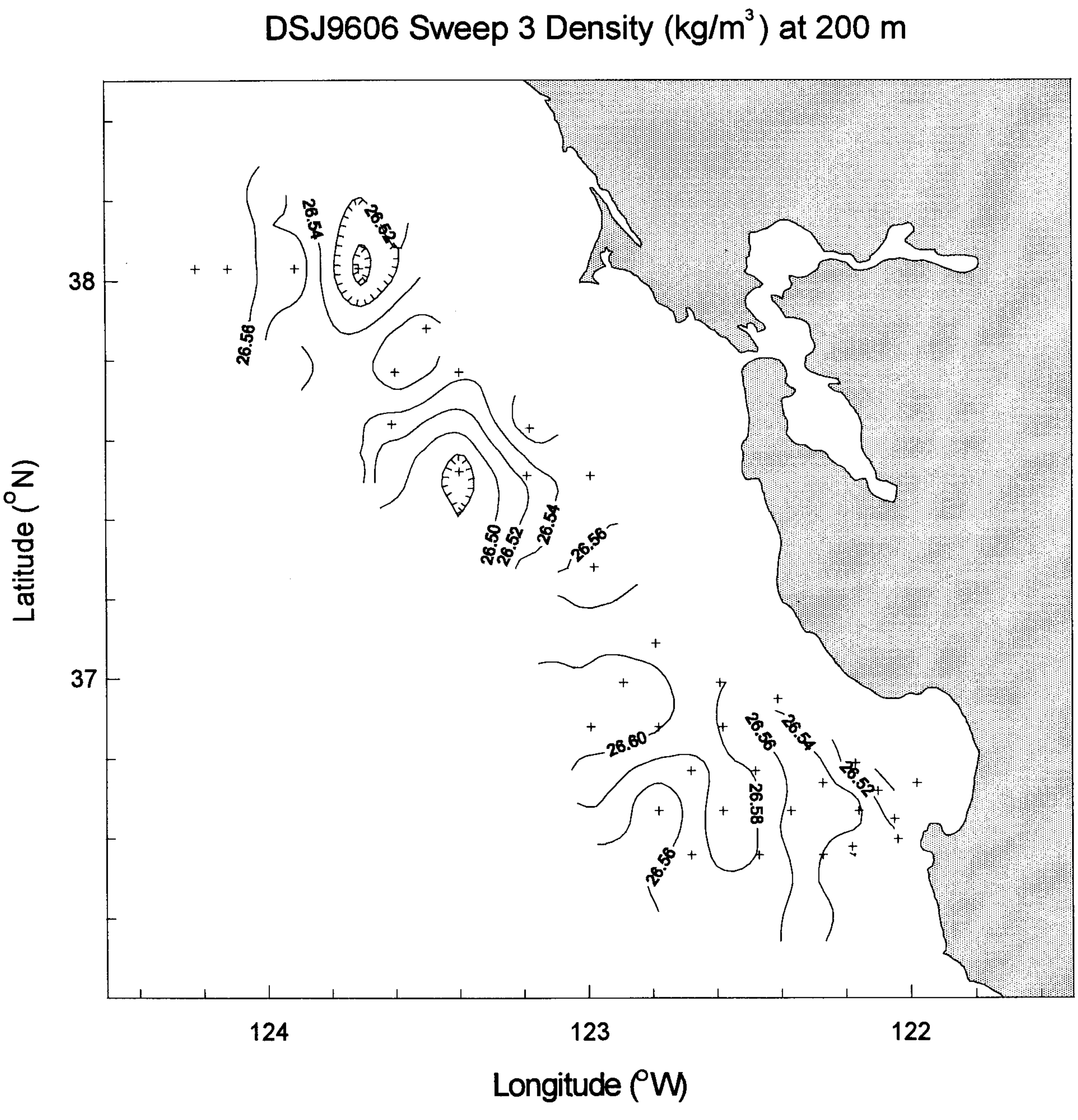


DSJ9606 Sweep 3 Density (kg/m^3) at 30 m

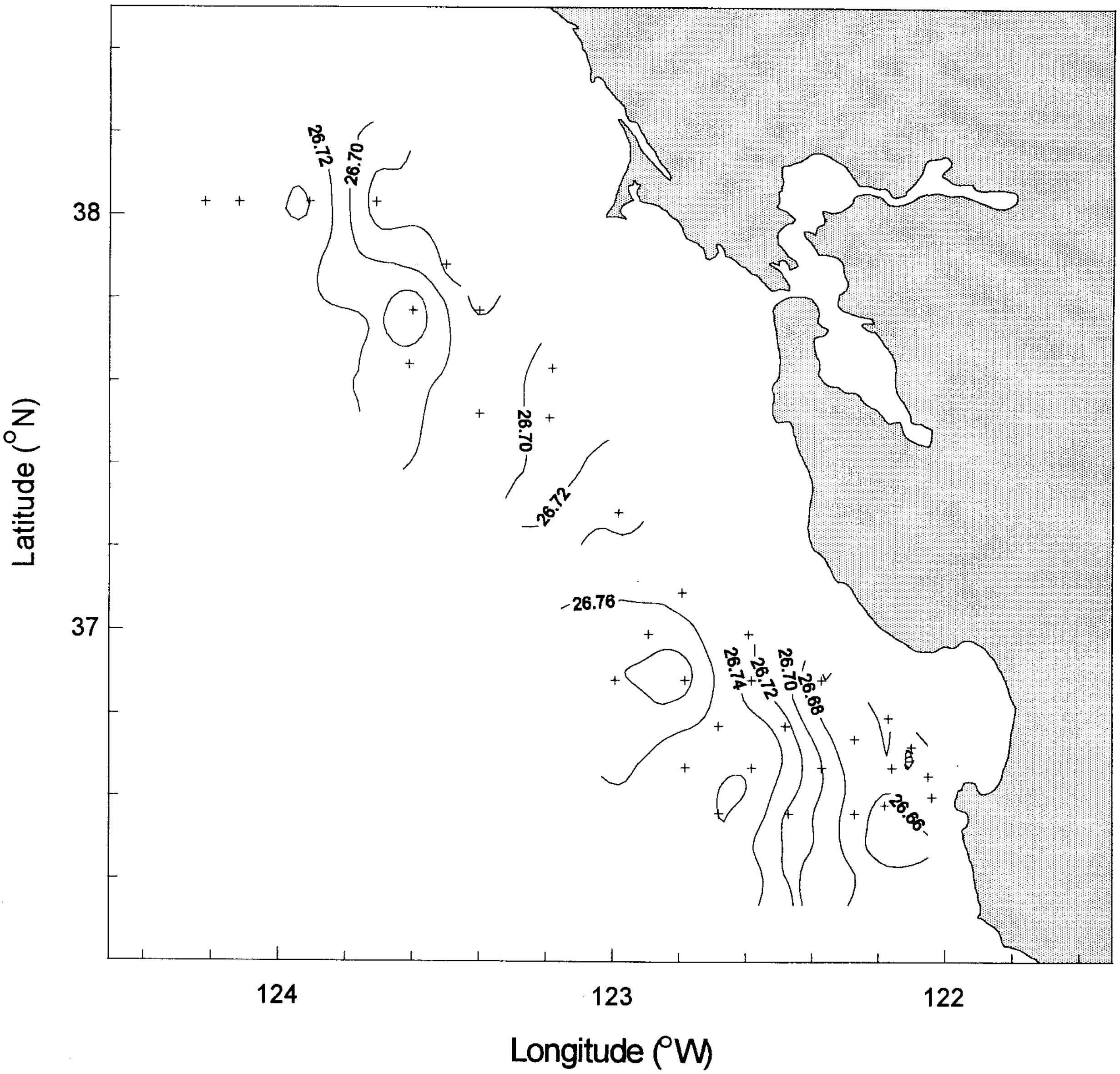


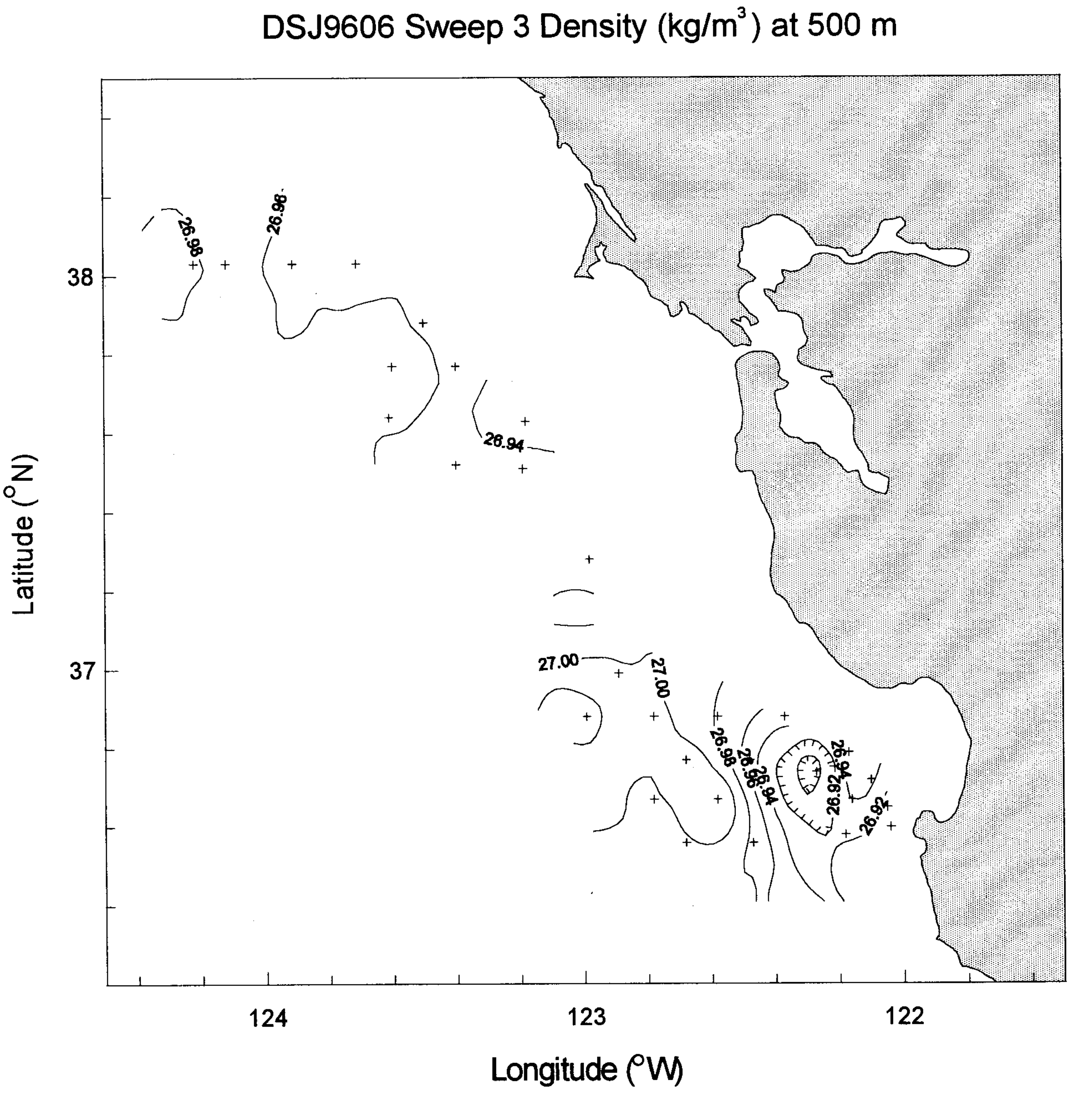
DSJ9606 Sweep 3 Density (kg/m^3) at 100 m



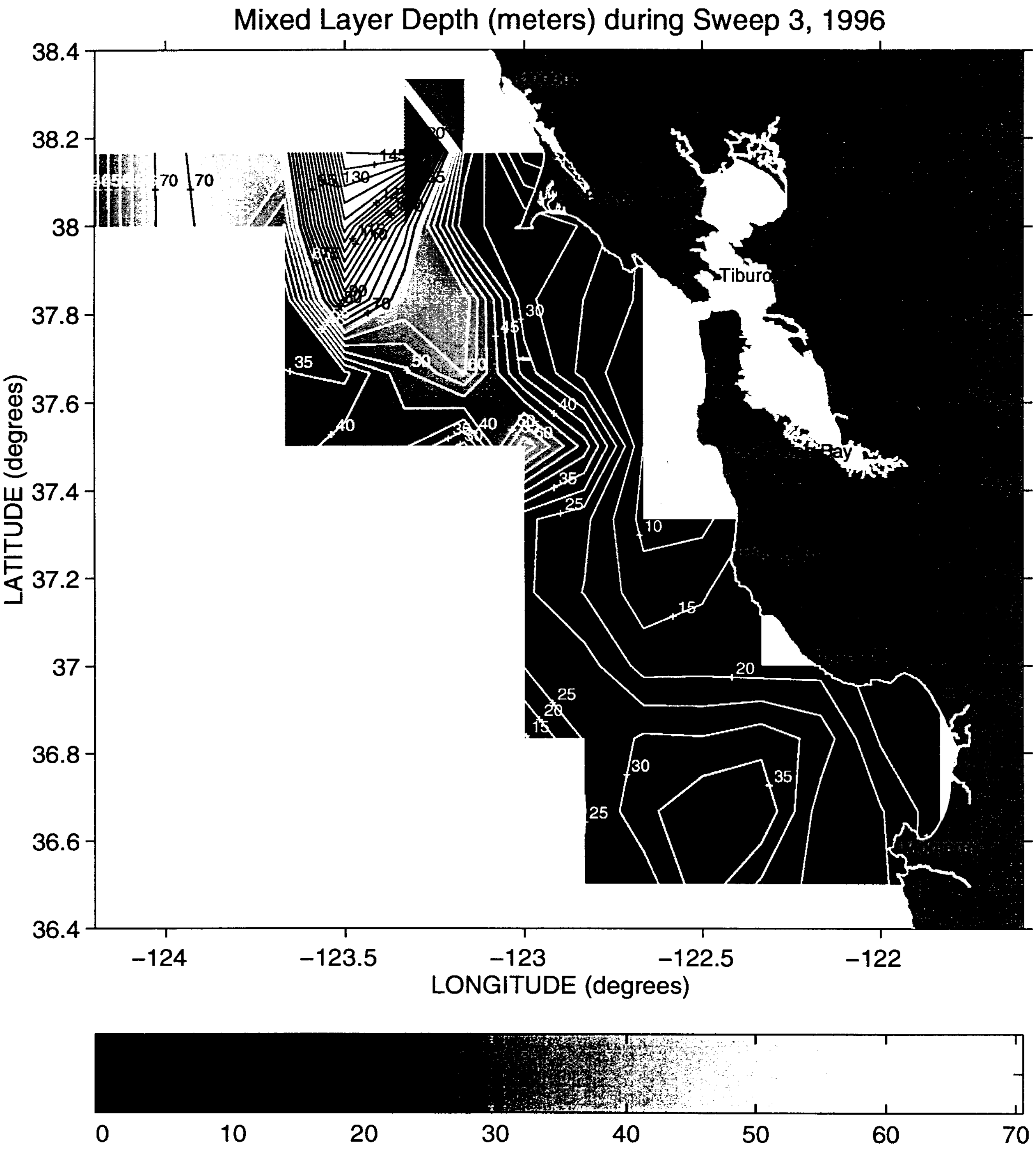

DSJ9606 Sweep 3 Density (kg/m³) at 200 m
26.54
26.62
26.58
26.50
26.52
26.54
26.56
26.60
26.56
26.54
26.52
26.58
26.56
38
37
Latitude (°N)
124
123
122
Longitude (°W)

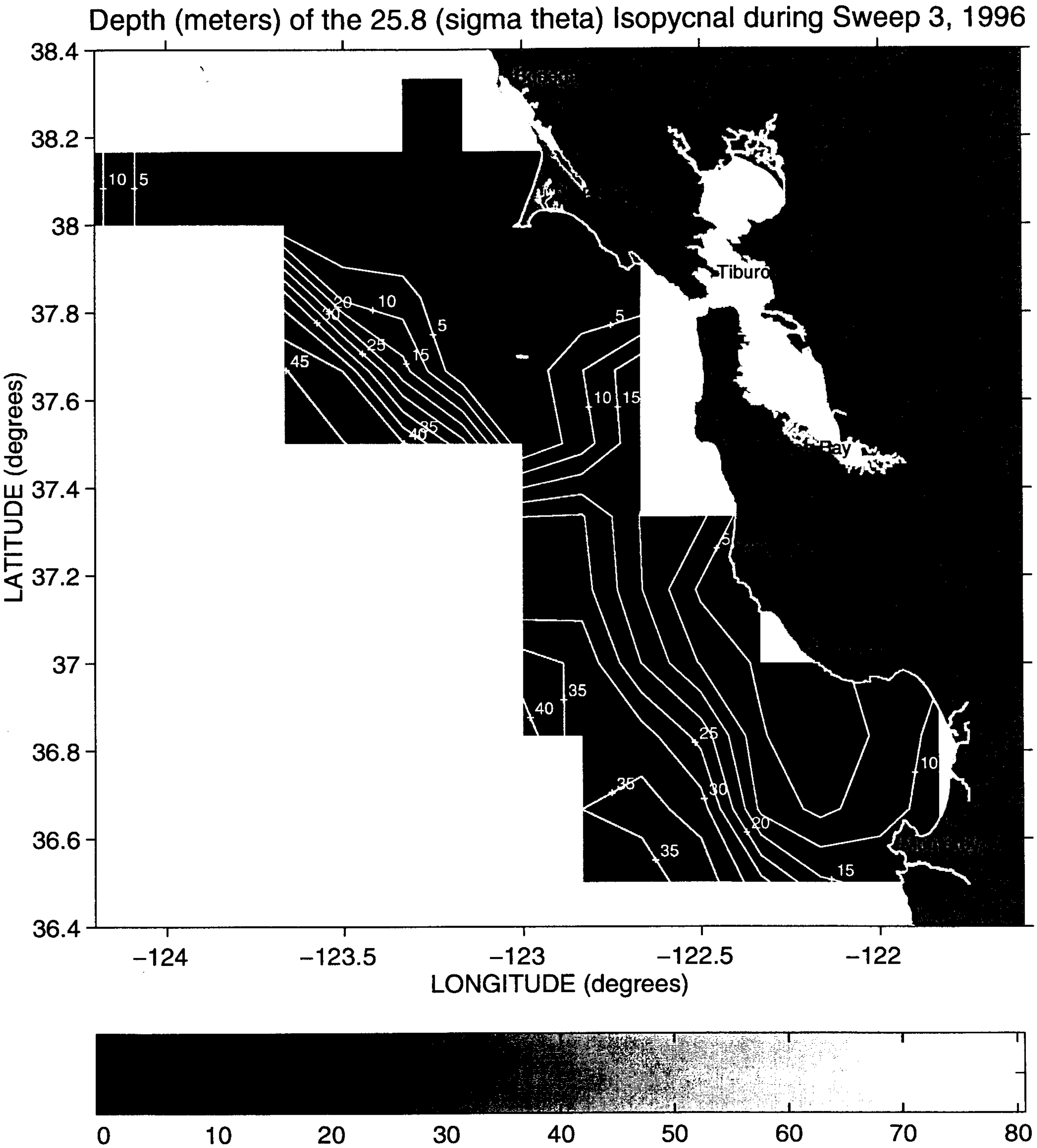
DSJ9606 Sweep 3 Density (kg/m^3) at 300 m

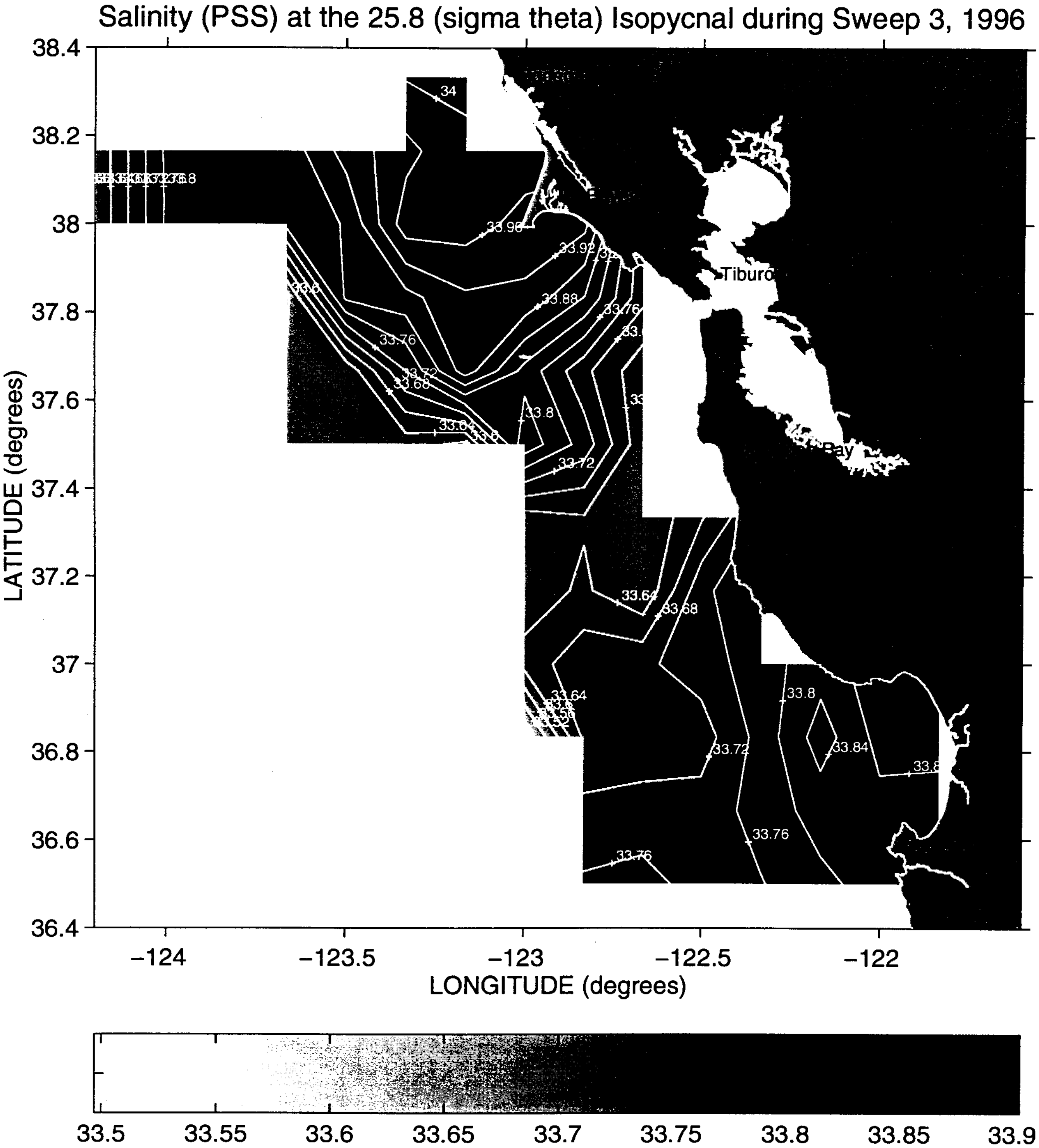


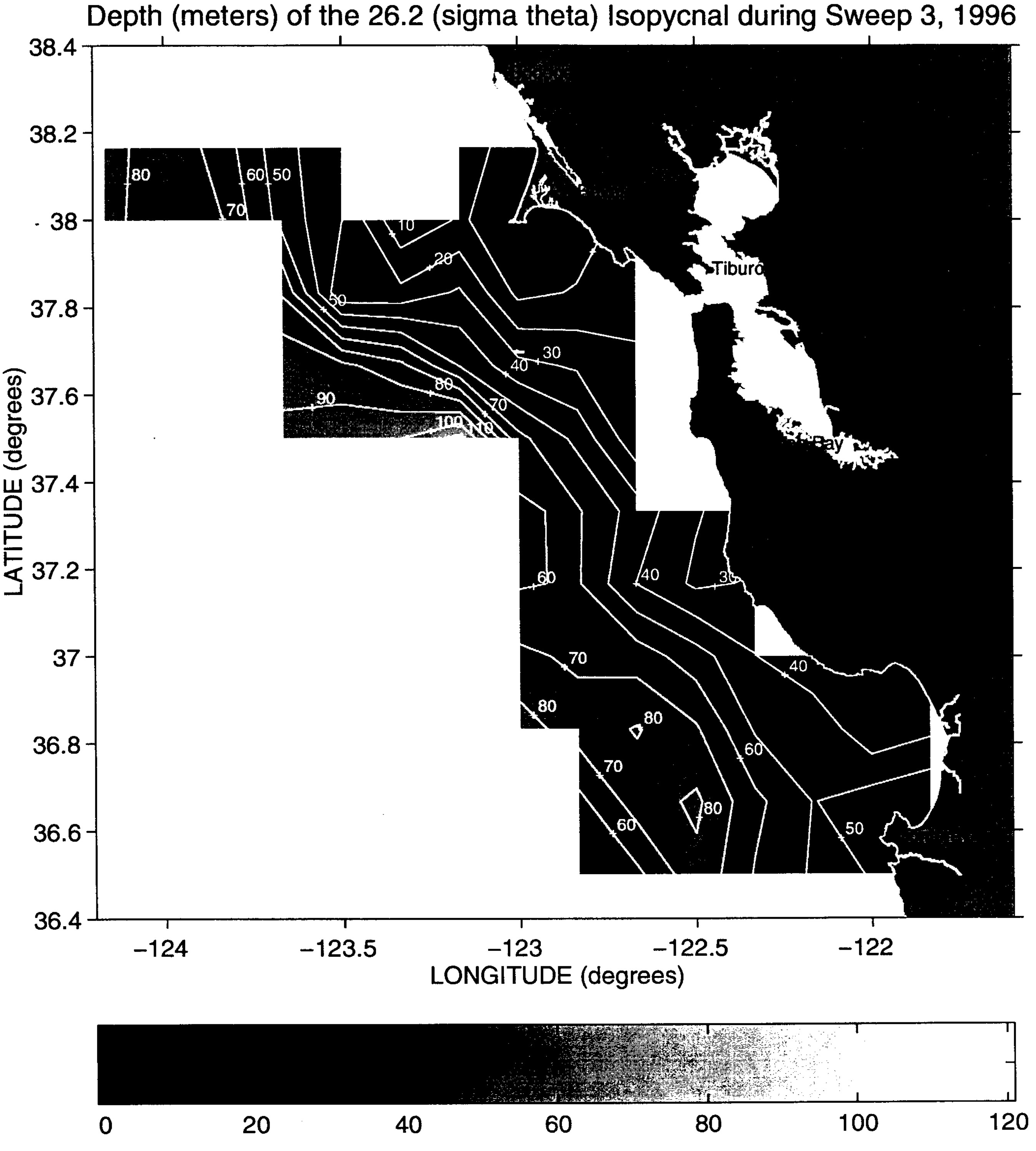


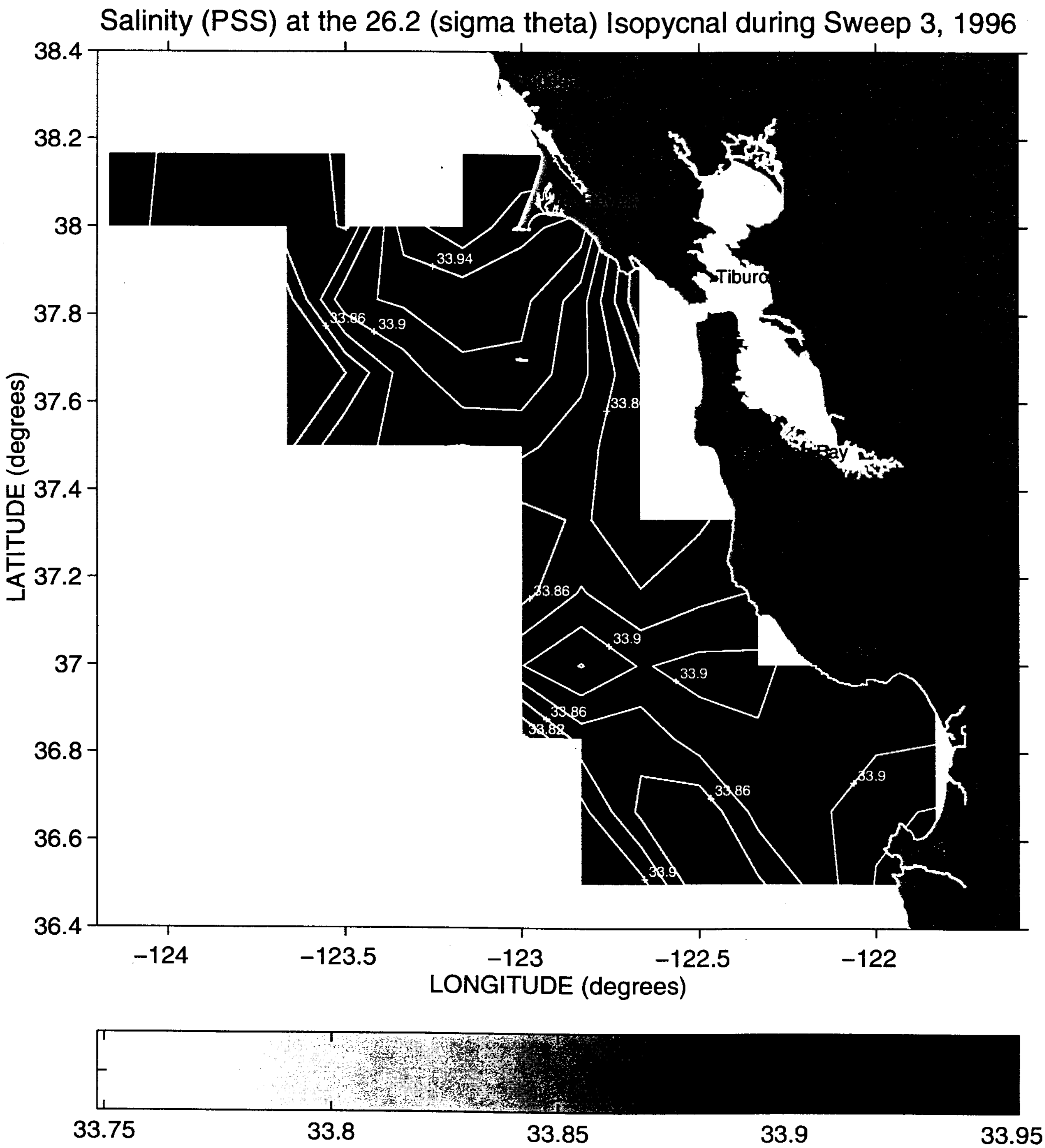
DSJ9606 Sweep 3 Density (kg/m³) at 500 m
26.98
26.96
26.94
27.00
27.00
26.98
26.96
26.94
26.92
26.94
26.92
38
37
Latitude (°N)
124
123
122
Longitude (°W)


Mixed Layer Depth (meters) during Sweep 3, 1996
LATITUDE (degrees)
LONGITUDE (degrees)
38.4
38.2
38
37.8
37.6
37.4
37.2
37
36.8
36.6
36.4
−124
−123.5
−123
−122.5
−122
Tiburo
0
10
20
30
40
50
60
70

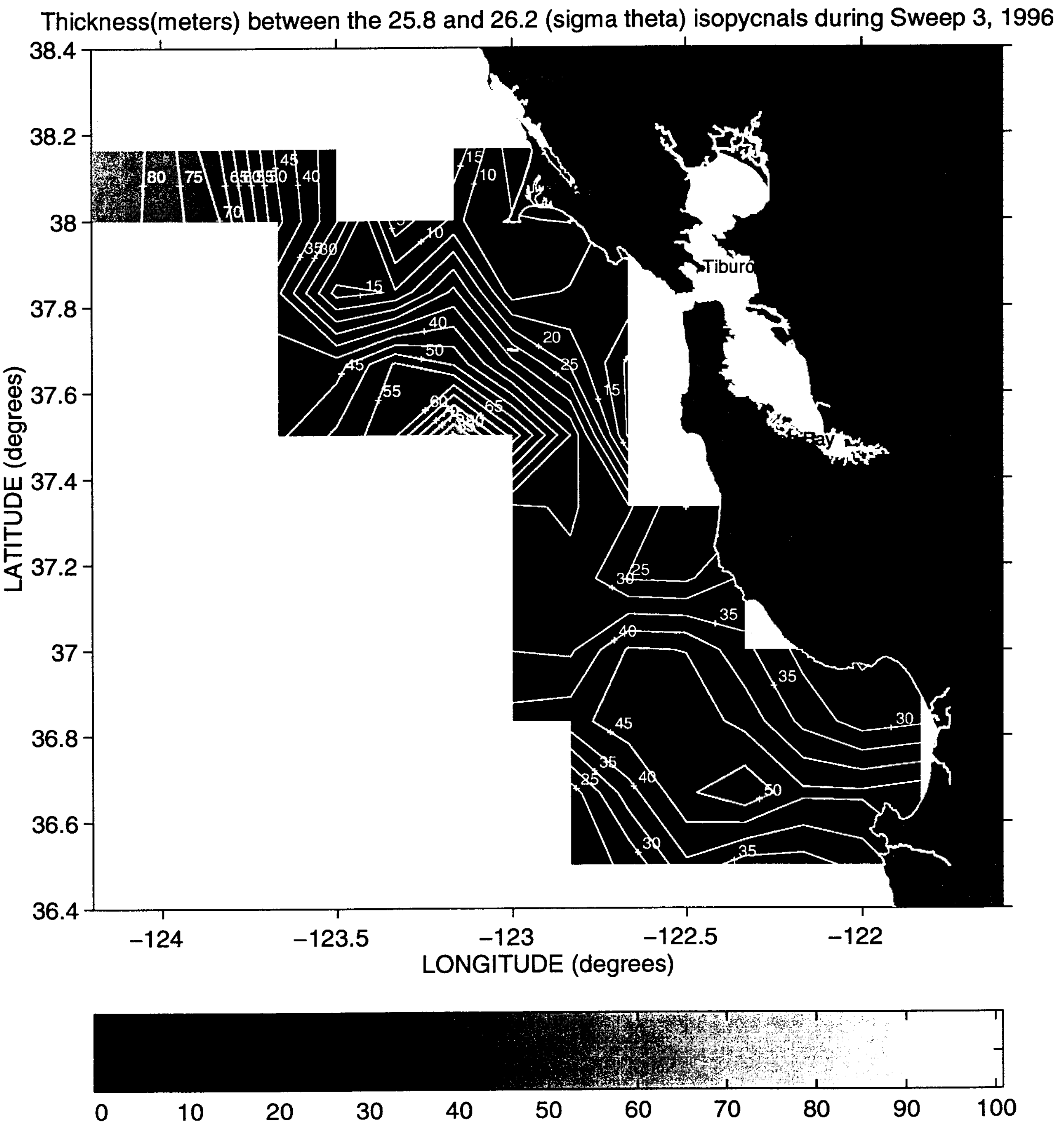

Depth (meters) of the 25.8 (sigma theta) Isopycnal during Sweep 3, 1996
38.4
38.2
38
37.8
37.6
37.4
37.2
37
36.8
36.6
36.4
LATITUDE (degrees)
−124
−123.5
−123
−122.5
−122
LONGITUDE (degrees)
Tiburo
Bay
0
10
20
30
40
50
60
70
80


Salinity (PSS) at the 25.8 (sigma theta) Isopycnal during Sweep 3, 1996
LATITUDE (degrees)
LONGITUDE (degrees)
38.4
38.2
38
37.8
37.6
37.4
37.2
37
36.8
36.6
36.4
−124
−123.5
−123
−122.5
−122
Tiburo
Bay
34
33.96
33.92
33.88
33.76
33.72
33.68
33.64
33.8
33.84
33.5
33.55
33.6
33.65
33.7
33.75
33.85
33.9


Depth (meters) of the 26.2 (sigma theta) Isopycnal during Sweep 3, 1996
LATITUDE (degrees)
LONGITUDE (degrees)
38.4
38.2
38
37.8
37.6
37.4
37.2
37
36.8
36.6
36.4
-124
-123.5
-123
-122.5
-122
Tiburo
Bay
0
20
40
60
80
100
120



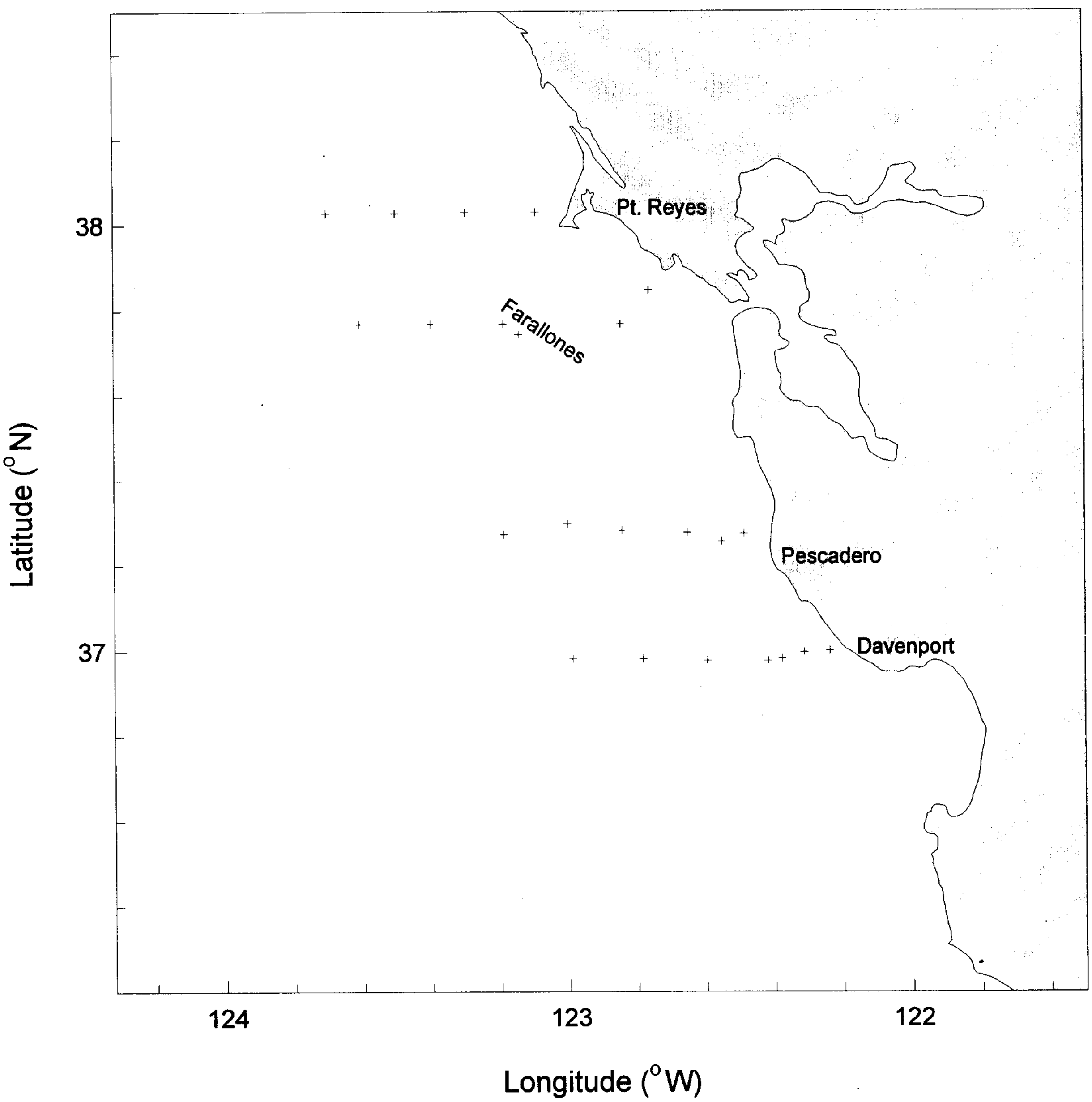
Salinity (PSS) at the 26.2 (sigma theta) Isopycnal during Sweep 3, 1996
38.4
38.2
38
37.8
37.6
37.4
37.2
37
36.8
36.6
36.4
LATITUDE (degrees)
-124
-123.5
-123
-122.5
-122
LONGITUDE (degrees)
33.94
33.86
33.9
33.86
33.9
33.9
33.86
33.82
33.86
33.9
33.9
Tiburo
Bay
33.75
33.8
33.85
33.9
33.95



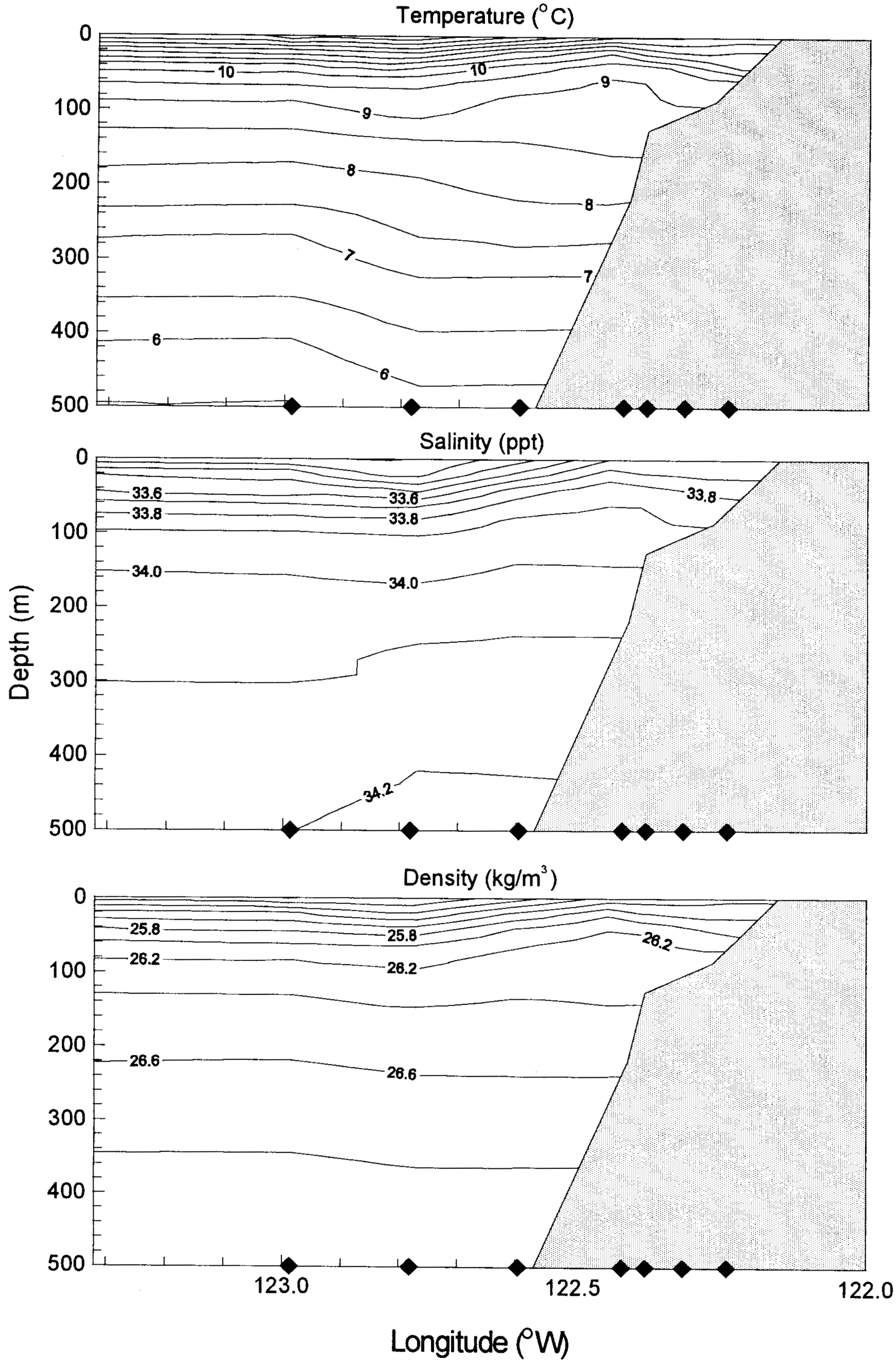
Thickness(meters) between the 25.8 and 26.2 (sigma theta) isopycnals during Sweep 3, 1996
LATITUDE (degrees)
LONGITUDE (degrees)
38.4
38.2
38
37.8
37.6
37.4
37.2
37
36.8
36.6
36.4
-124
-123.5
-123
-122.5
-122
Tiburo
Bay
0
10
20
30
40
50
60
70
80
90
100

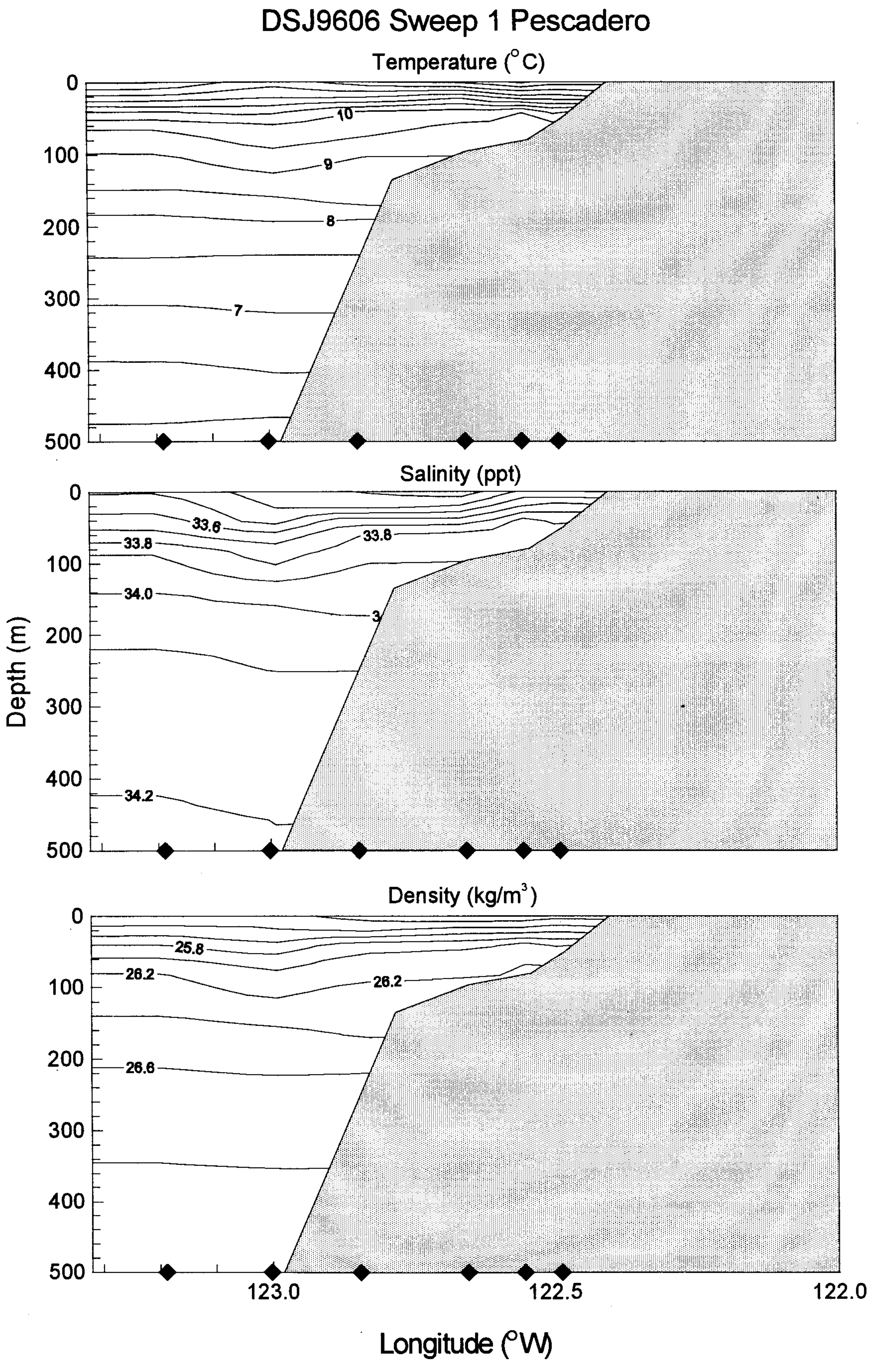
APPENDIX 7: VERTICAL SECTIONS FOR DSJ9606

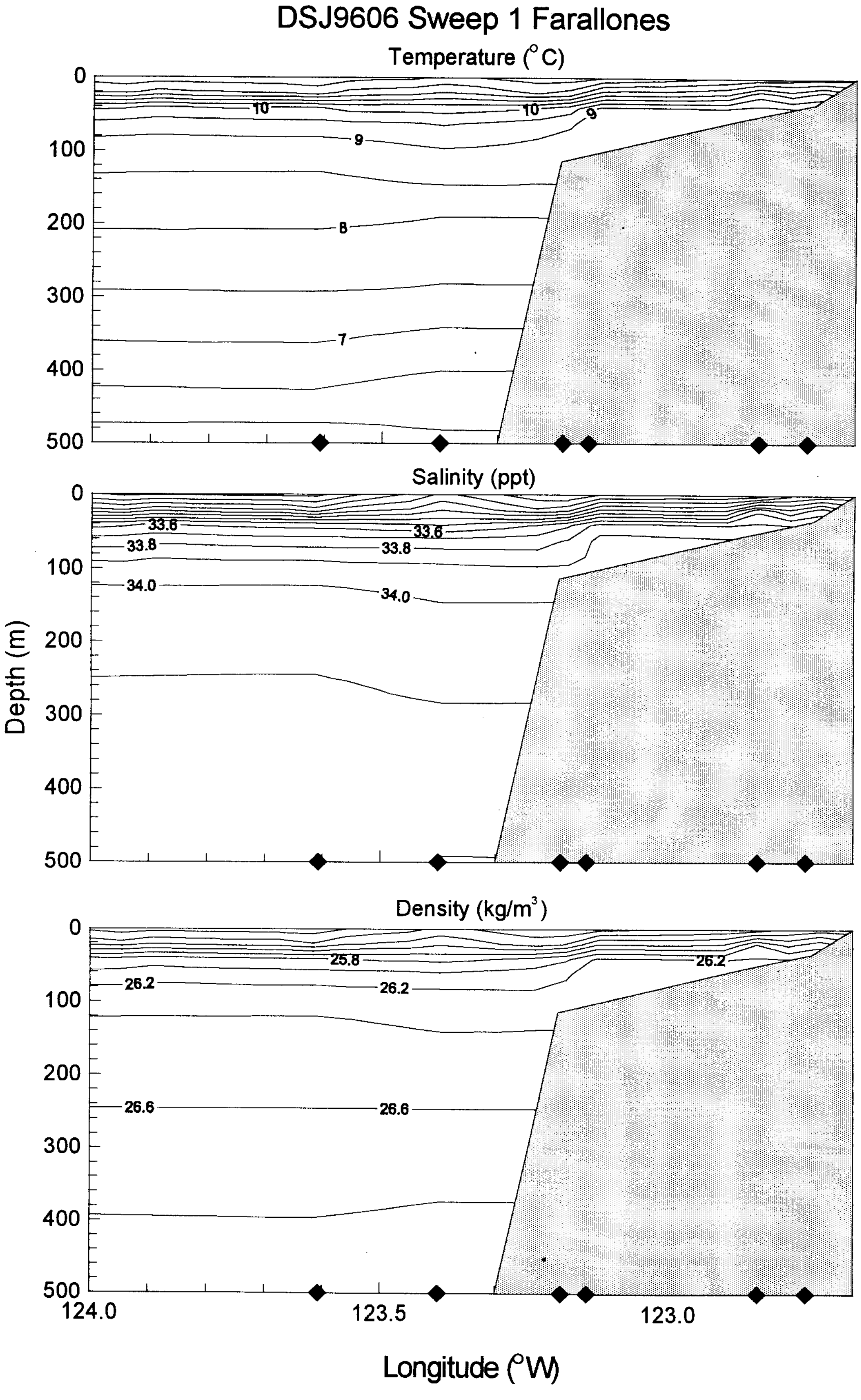
DSJ9606 Sweep 1 Vertical Transect Stations

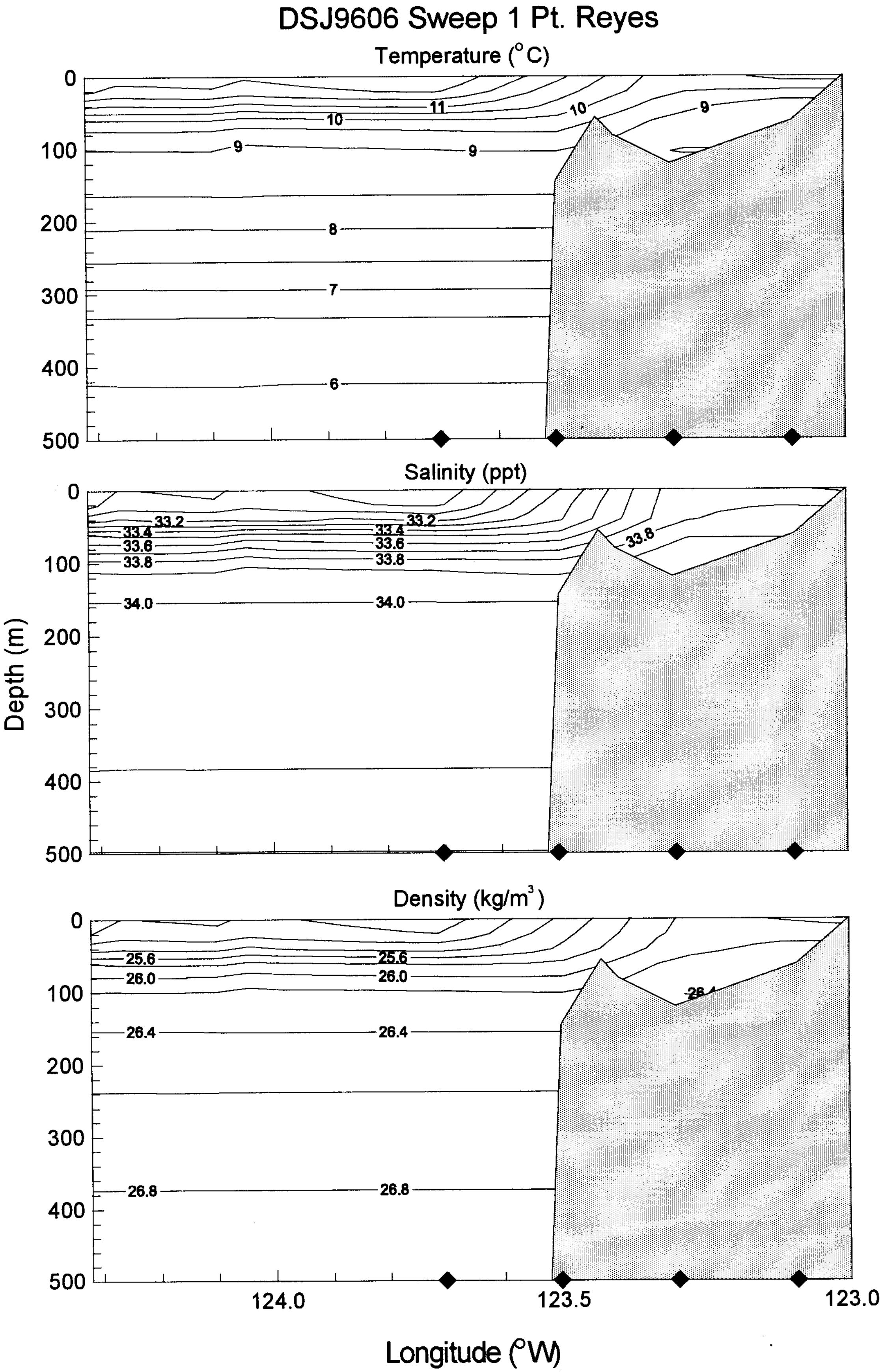


DSJ9606 Sweep 1 Davenport

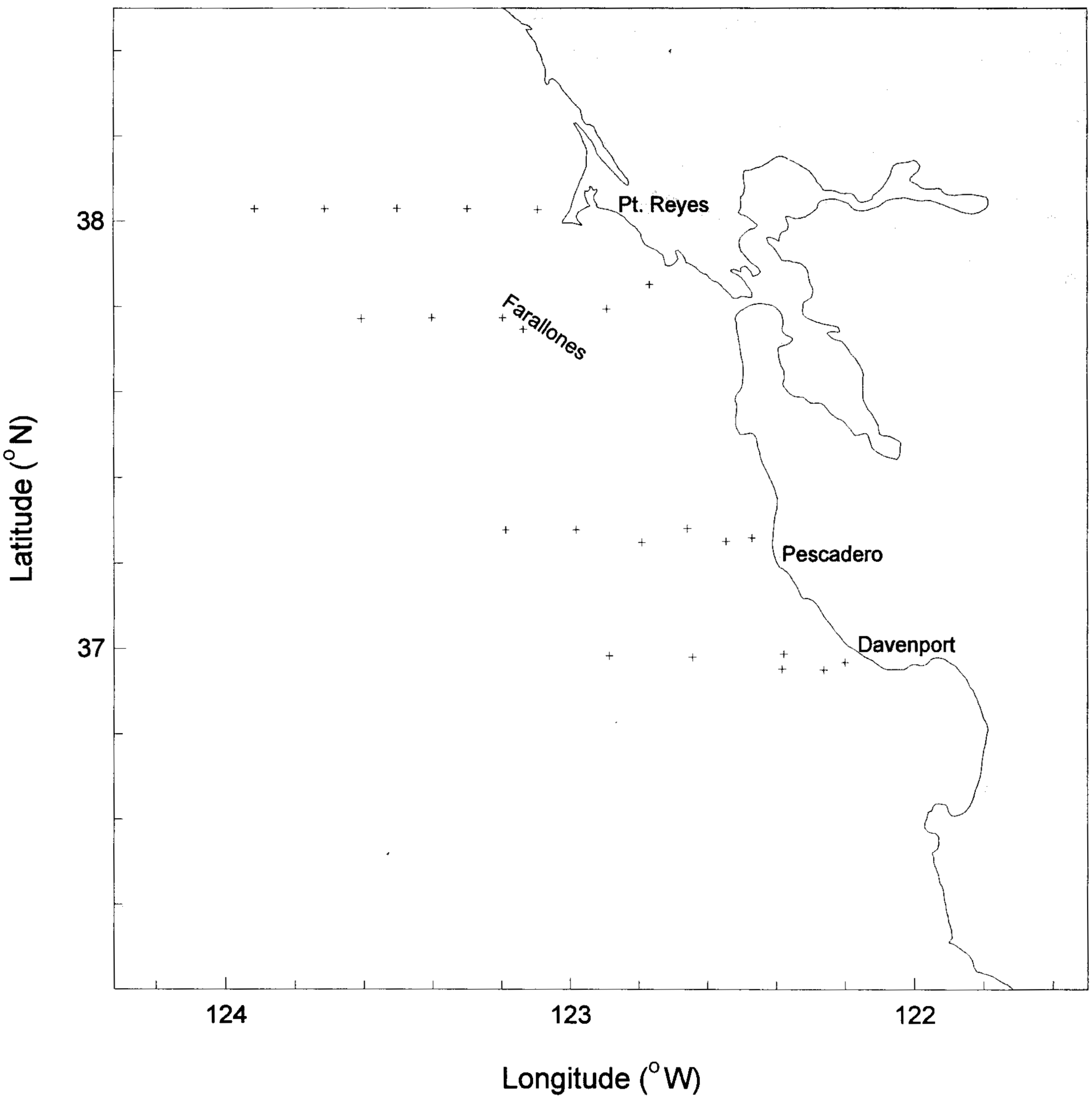


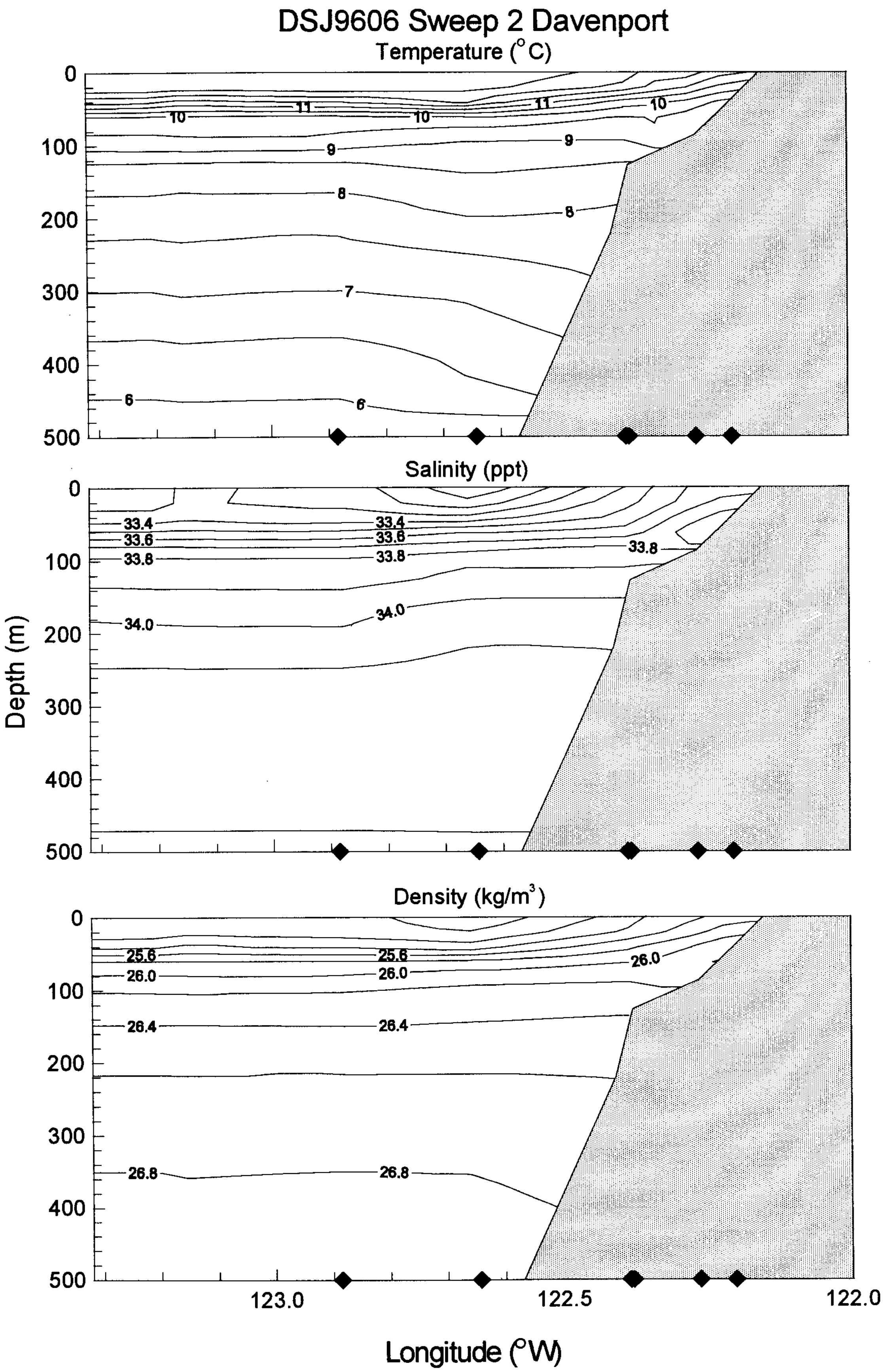

DSJ9606 Sweep 1 Pescadero
Temperature (°C)
10
9
8
7
Salinity (ppt)
33.6
33.8
33.8
34.0
34.2
Density (kg/m³)
25.8
26.2
26.2
26.6
Depth (m)
0
100
200
300
400
500
123.0
122.5
122.0
Longitude (°W)


DSJ9606 Sweep 1 Farallones
Temperature (°C)
Salinity (ppt)
Density (kg/m³)
Depth (m)
Longitude (°W)
0
100
200
300
400
500
10
9
8
7
33.6
33.8
34.0
25.8
26.2
26.6
124.0
123.5
123.0

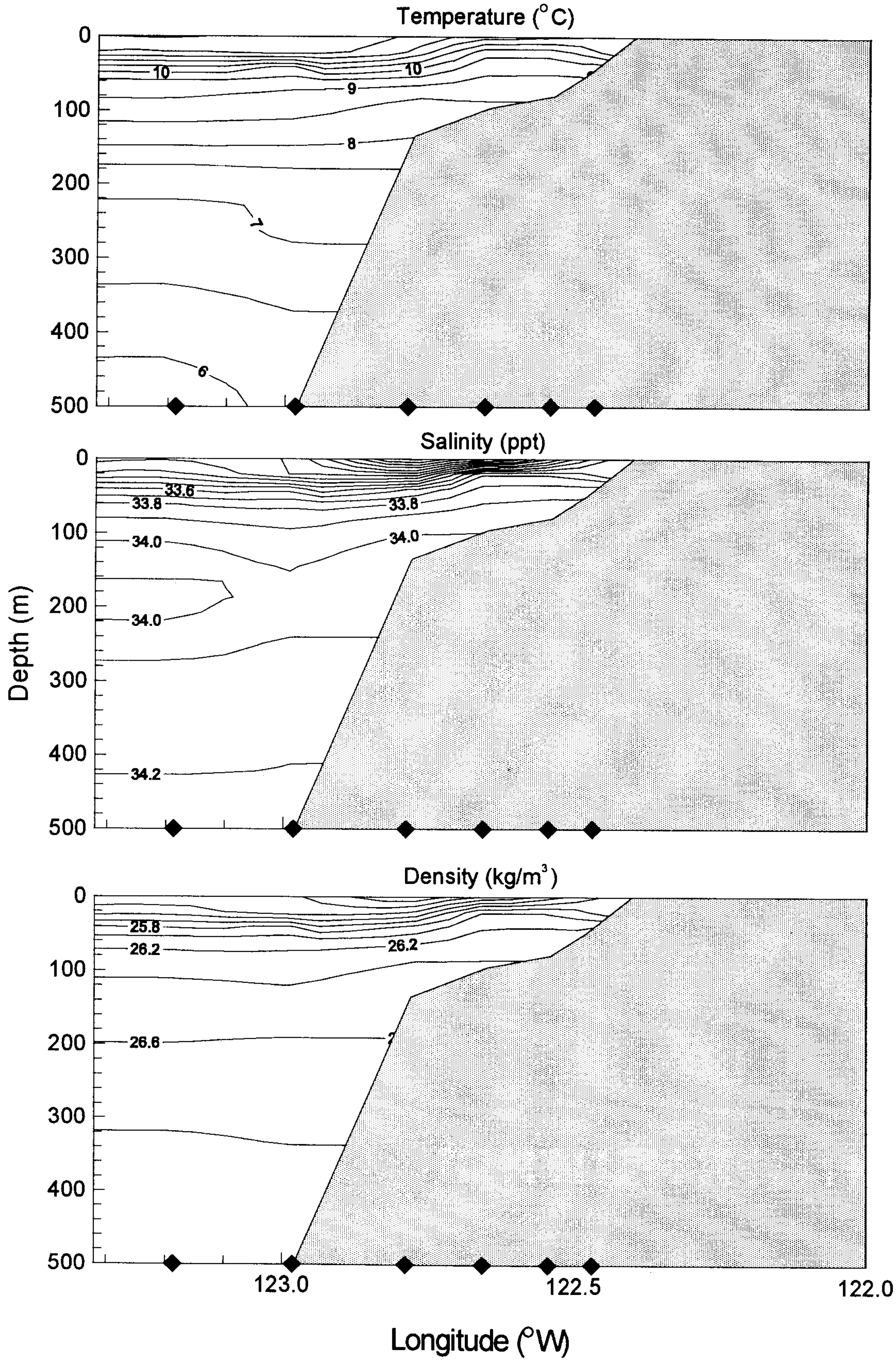

DSJ9606 Sweep 1 Pt. Reyes
Temperature (°C)
Salinity (ppt)
Density (kg/m³)
Depth (m)
Longitude (°W)
124.0
123.5
123.0
0
100
200
300
400
500
11
10
9
8
7
6
33.2
33.4
33.6
33.8
34.0
25.6
26.0
26.4
26.8

DSJ9606 Sweep 2 Vertical Transect Stations

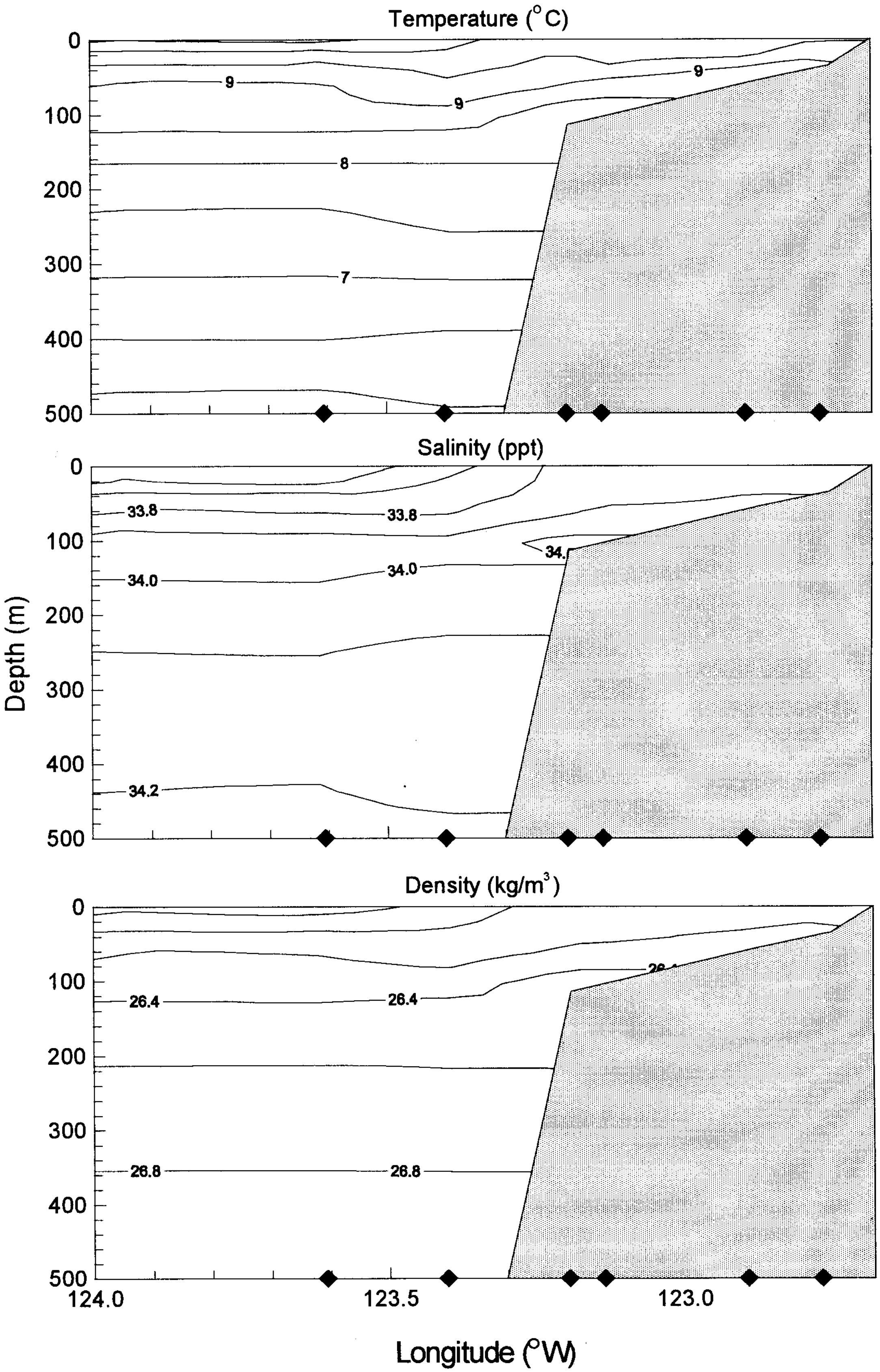


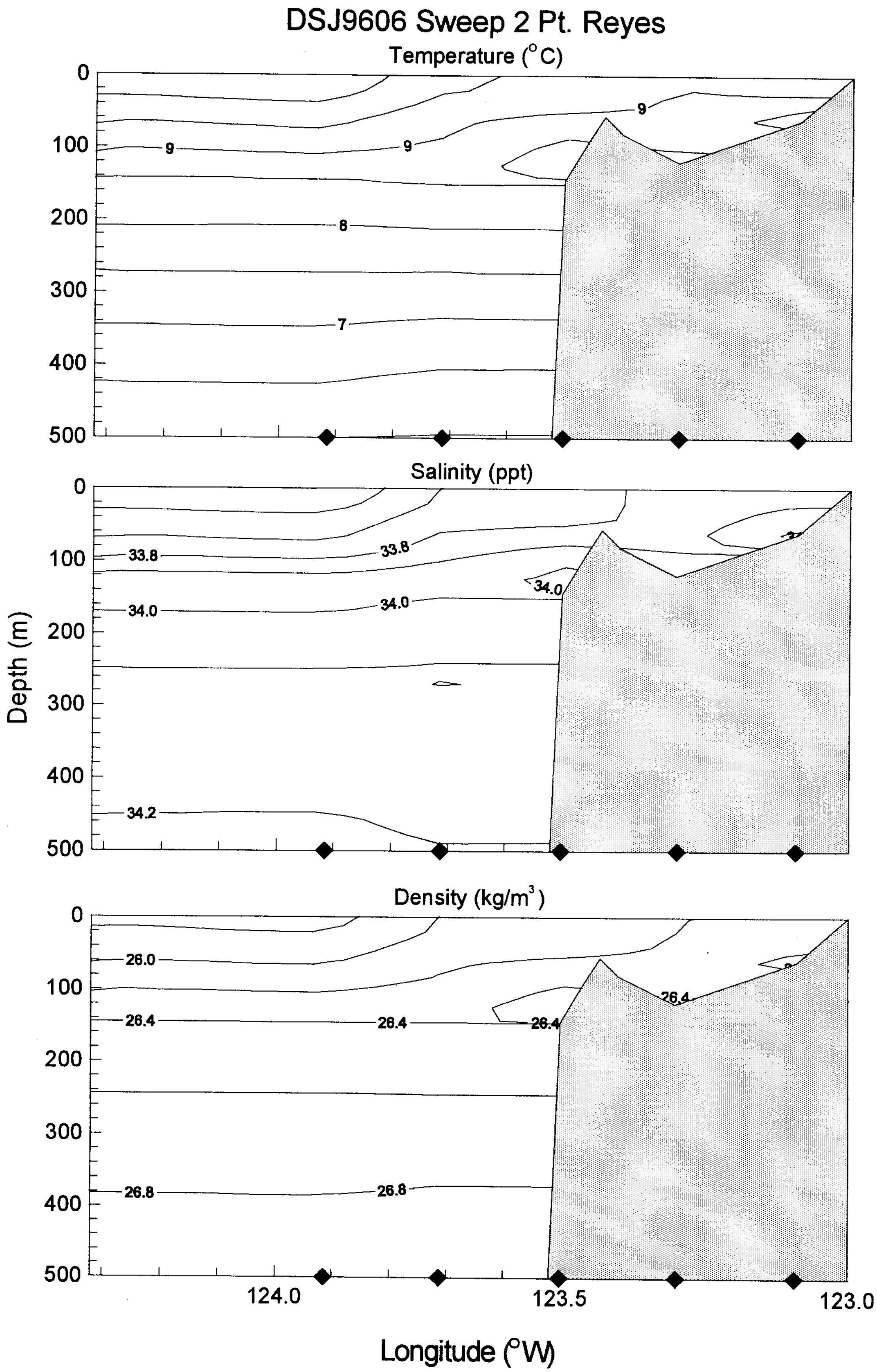

DSJ9606 Sweep 2 Davenport
Temperature (°C)
Salinity (ppt)
Density (kg/m³)
Depth (m)
Longitude (°W)
123.0
122.5
122.0
0
100
200
300
400
500
11
10
9
8
7
6
33.4
33.6
33.8
34.0
25.6
26.0
26.4
26.8

DSJ9606 Sweep 2 Pescadero



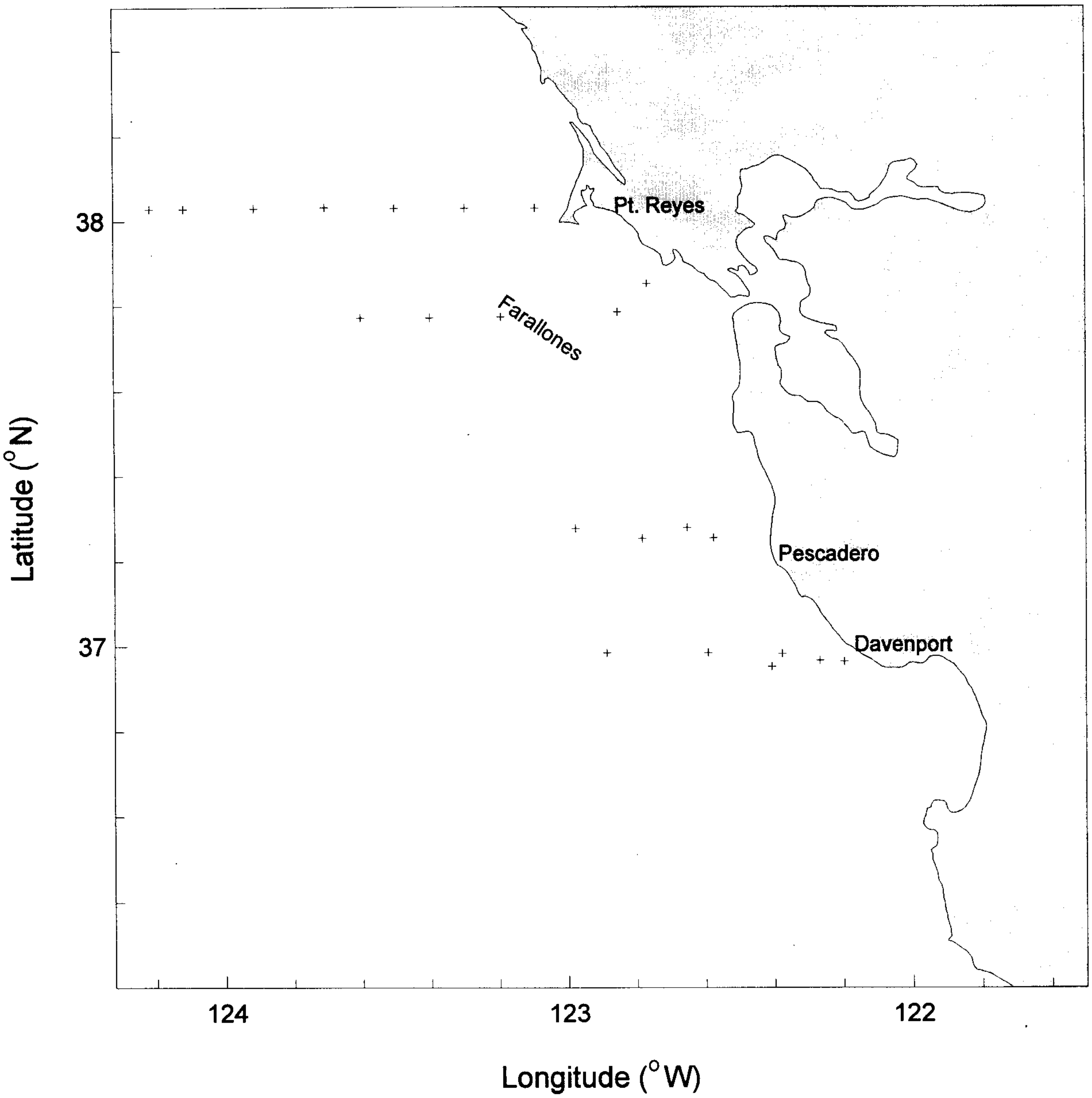
DSJ9606 Sweep 2 Farallones



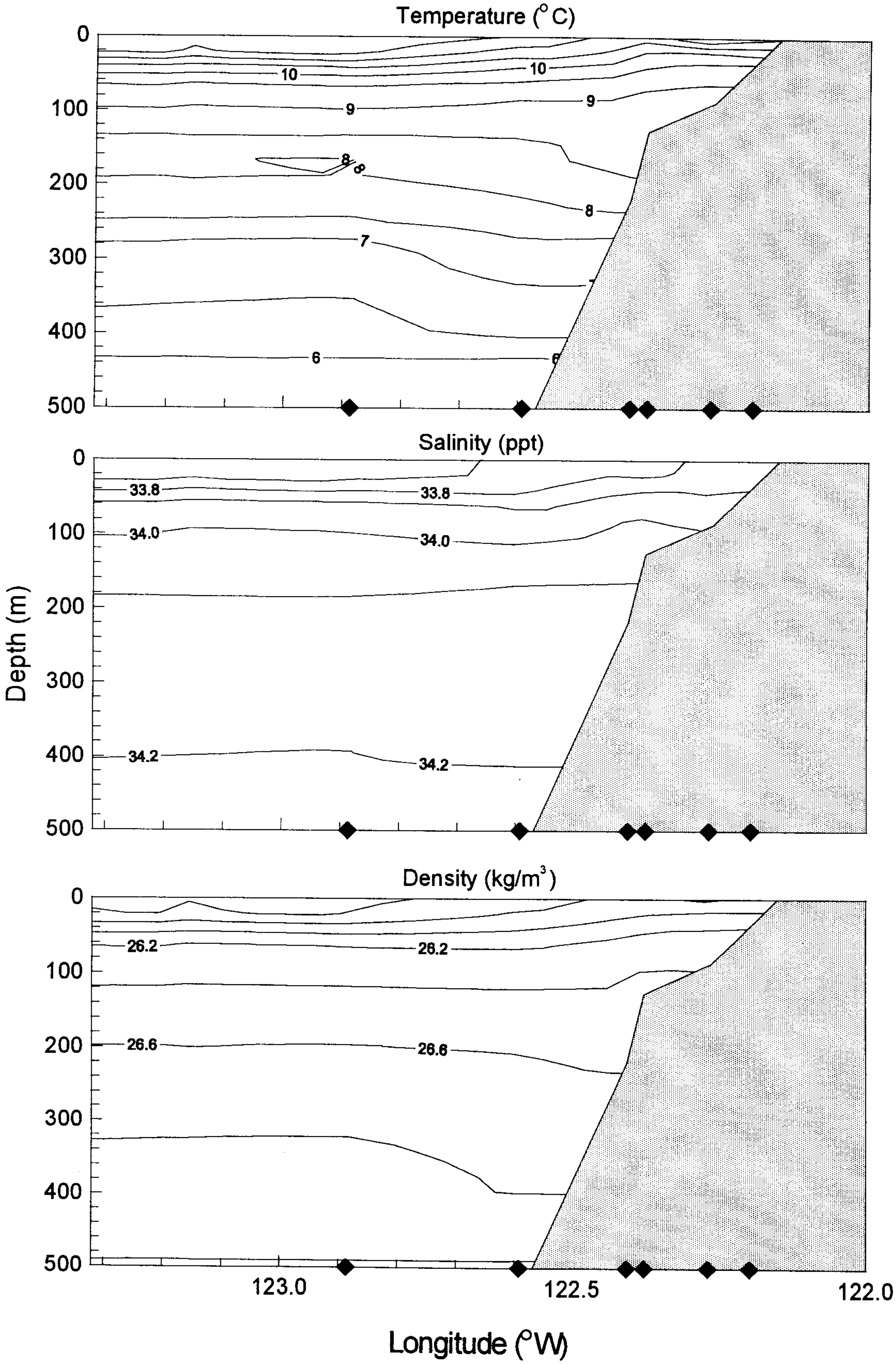


DSJ9606 Sweep 2 Pt. Reyes
Temperature (°C)
9
9
9
8
7
Salinity (ppt)
33.8
33.8
34.0
34.0
34.0
34.2
Density (kg/m³)
26.0
26.4
26.4
26.4
26.4
26.8
26.8
Depth (m)
0
100
200
300
400
500
124.0
123.5
123.0
Longitude (°W)

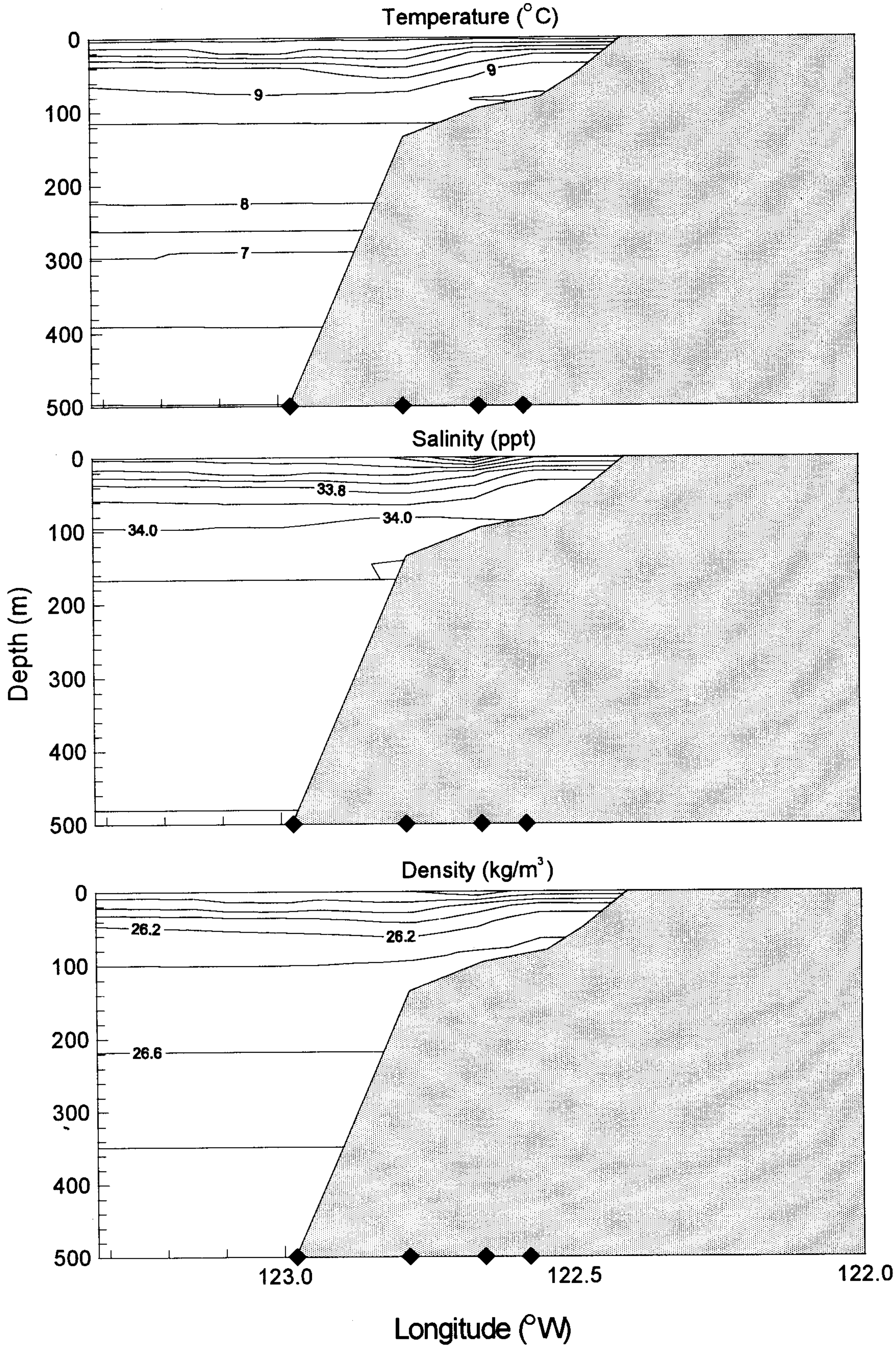
DSJ9606 Sweep 3 Vertical Transect Stations



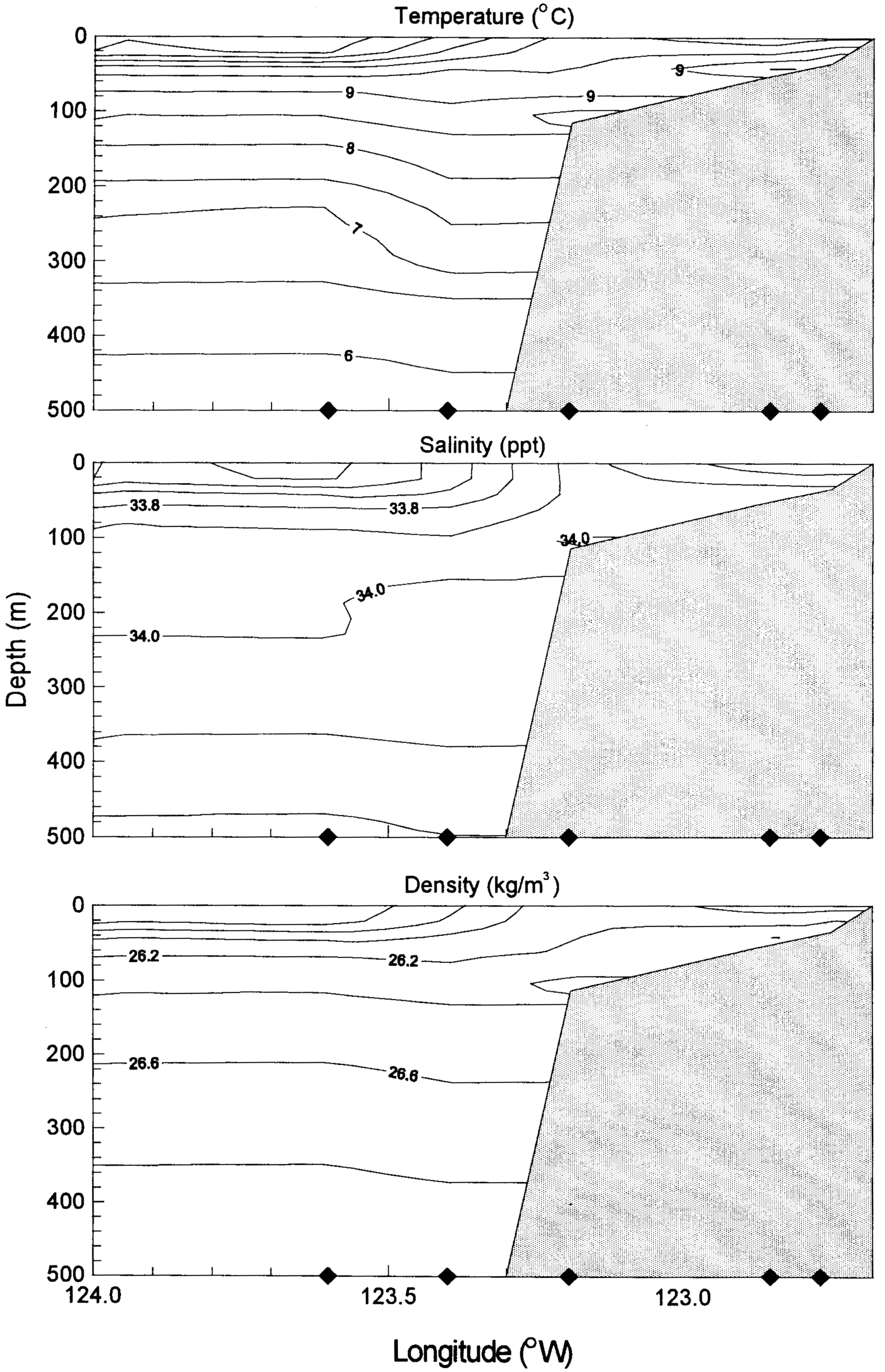
DSJ9606 Sweep 3 Davenport



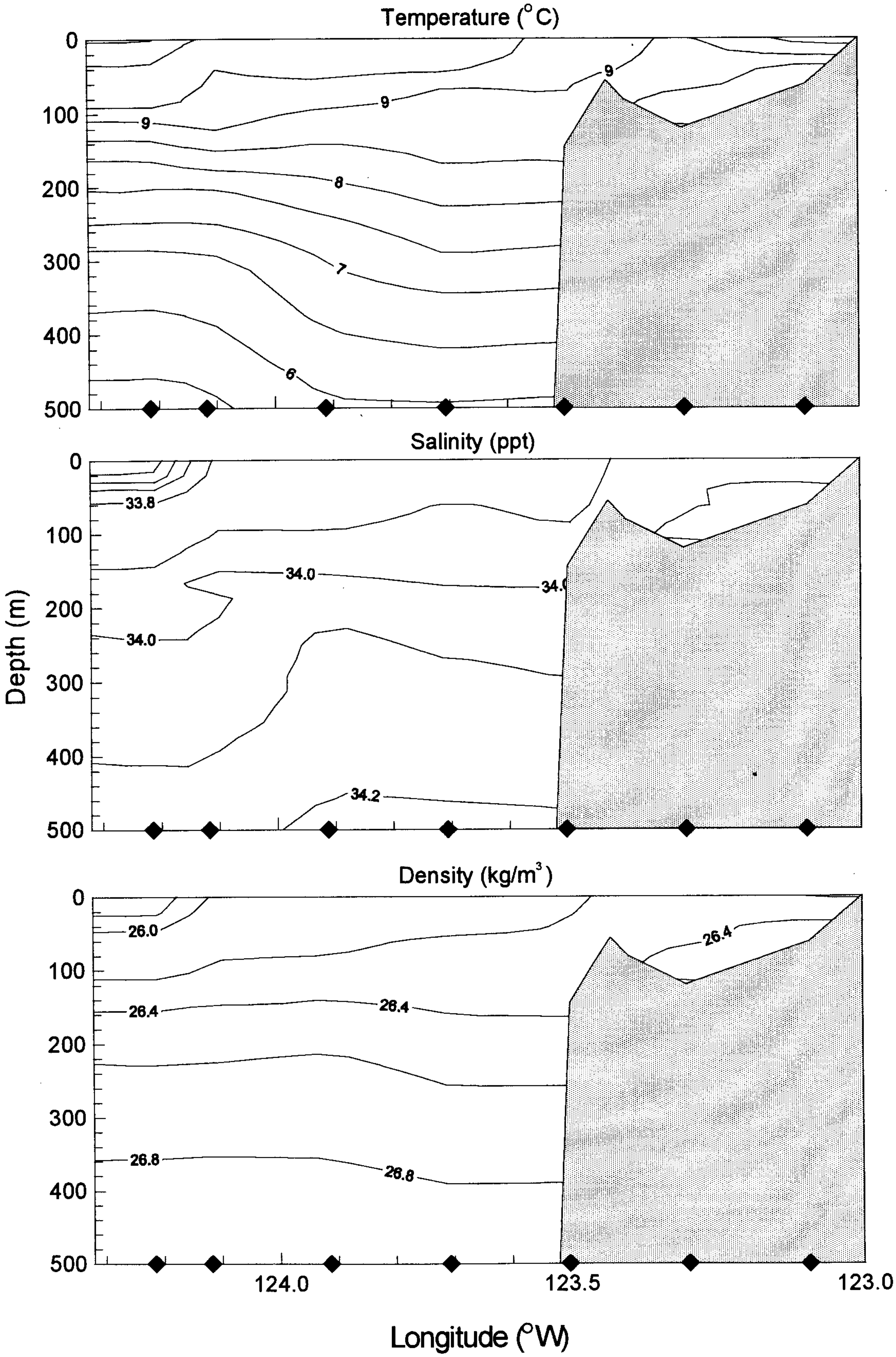
DSJ9606 Sweep 3 Pescadero



DSJ9606 Sweep 3 Farallones

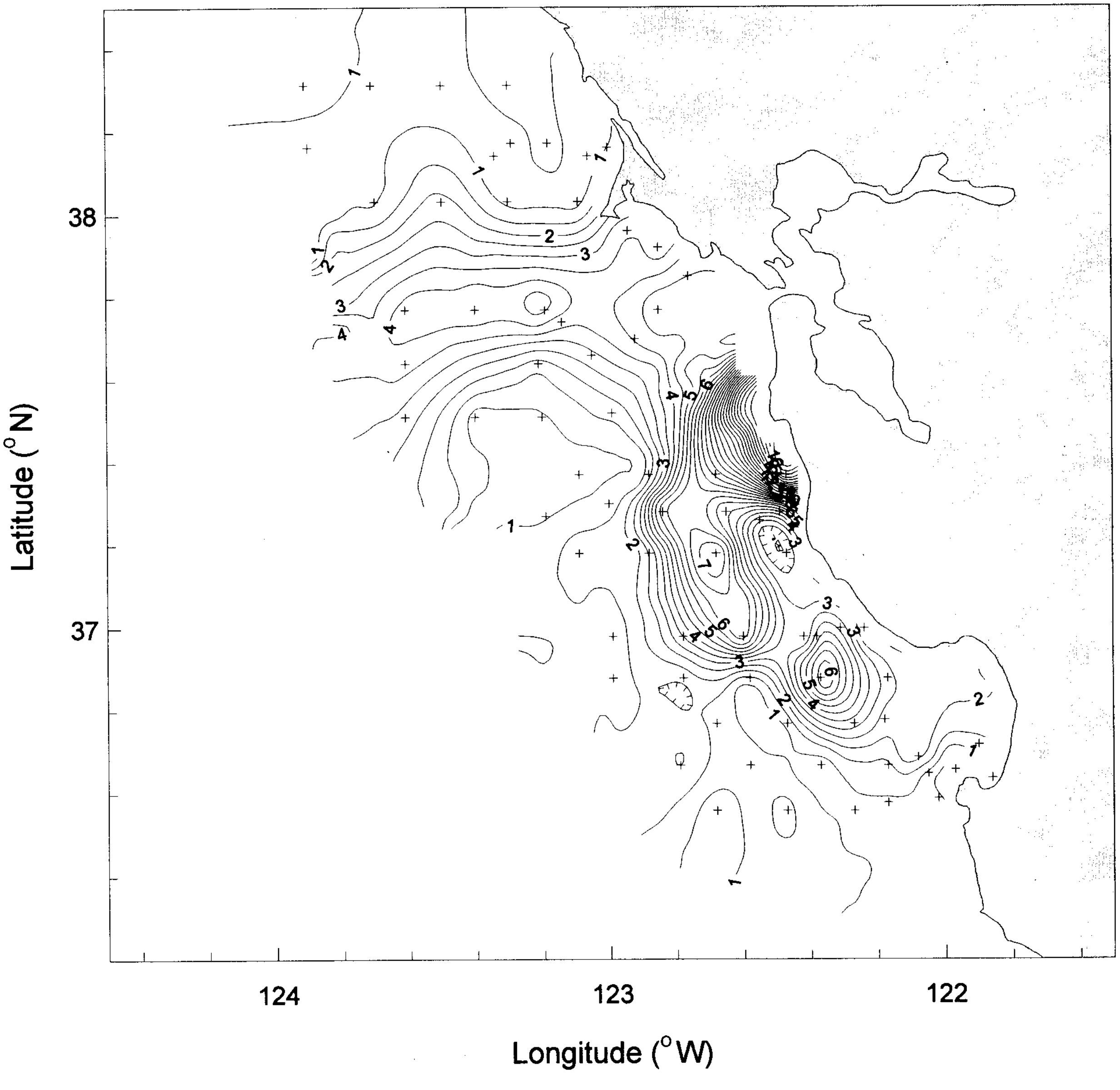


DSJ9606 Sweep 3 Pt. Reyes

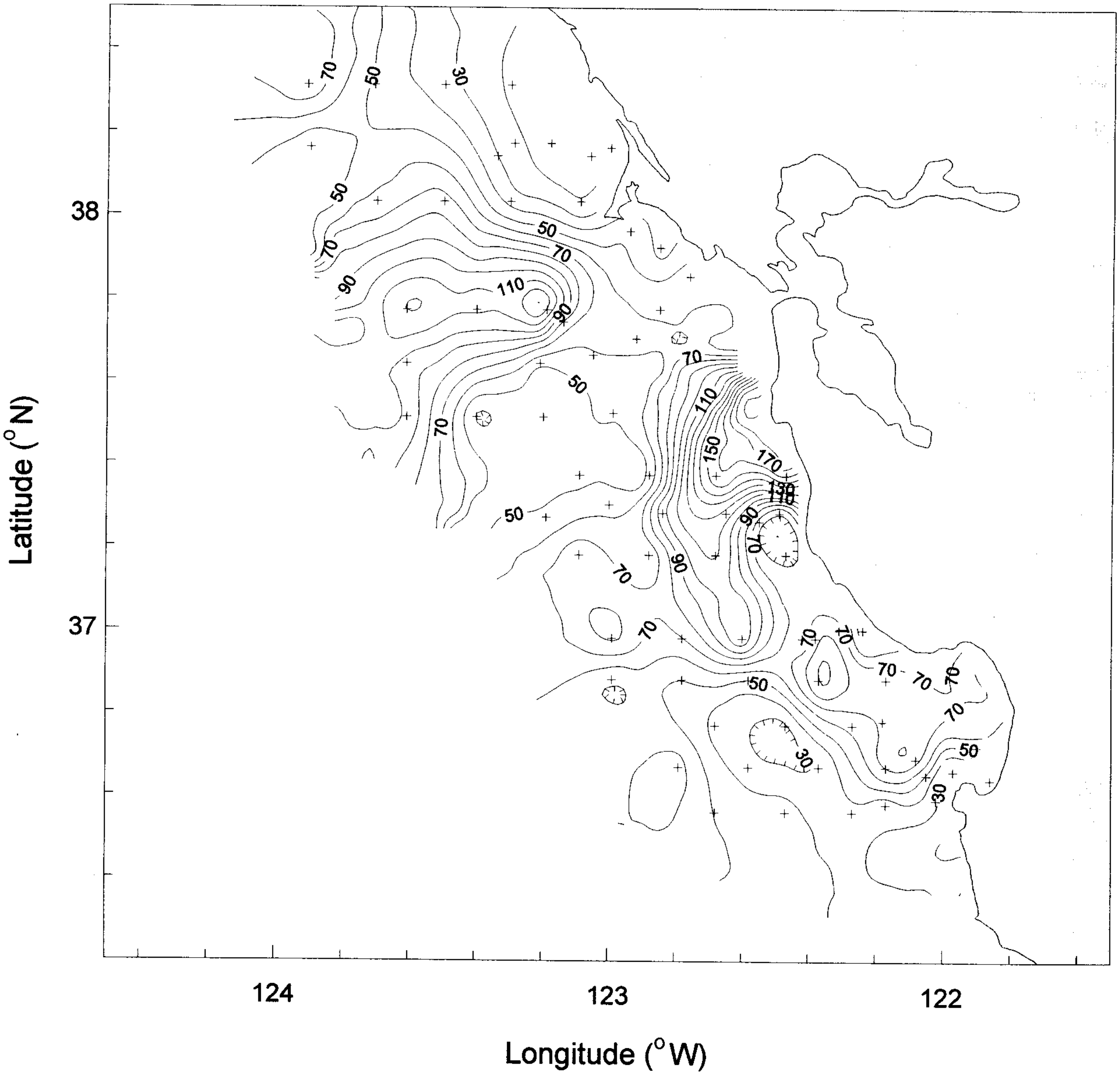


APPENDIX 8: HORIZONTAL MAPS OF CHLOROPHYLL a FOR DSJ9606

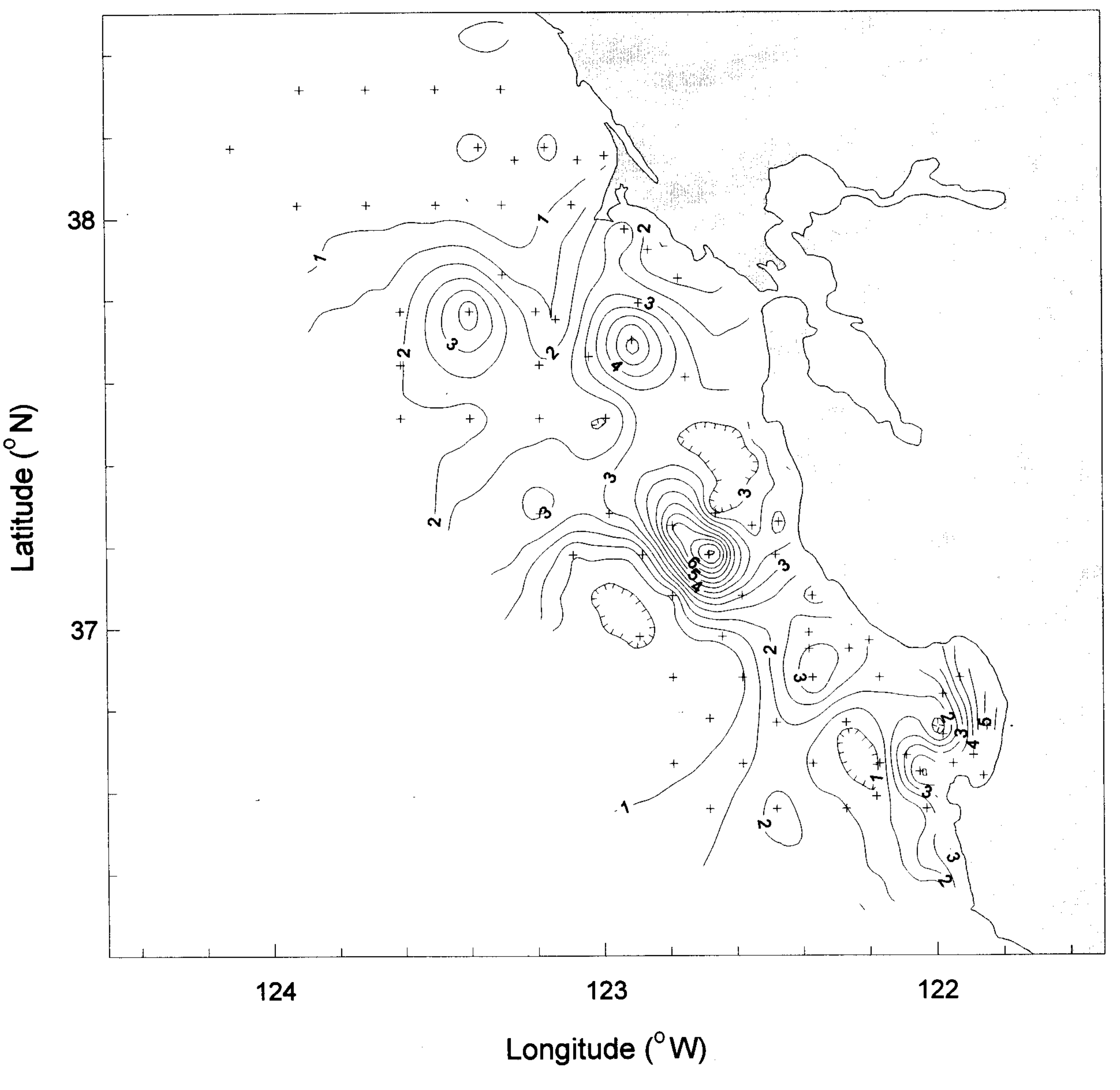
DSJ9606 Sweep 1 Chlorophyll a (mg/m³) at 10 m

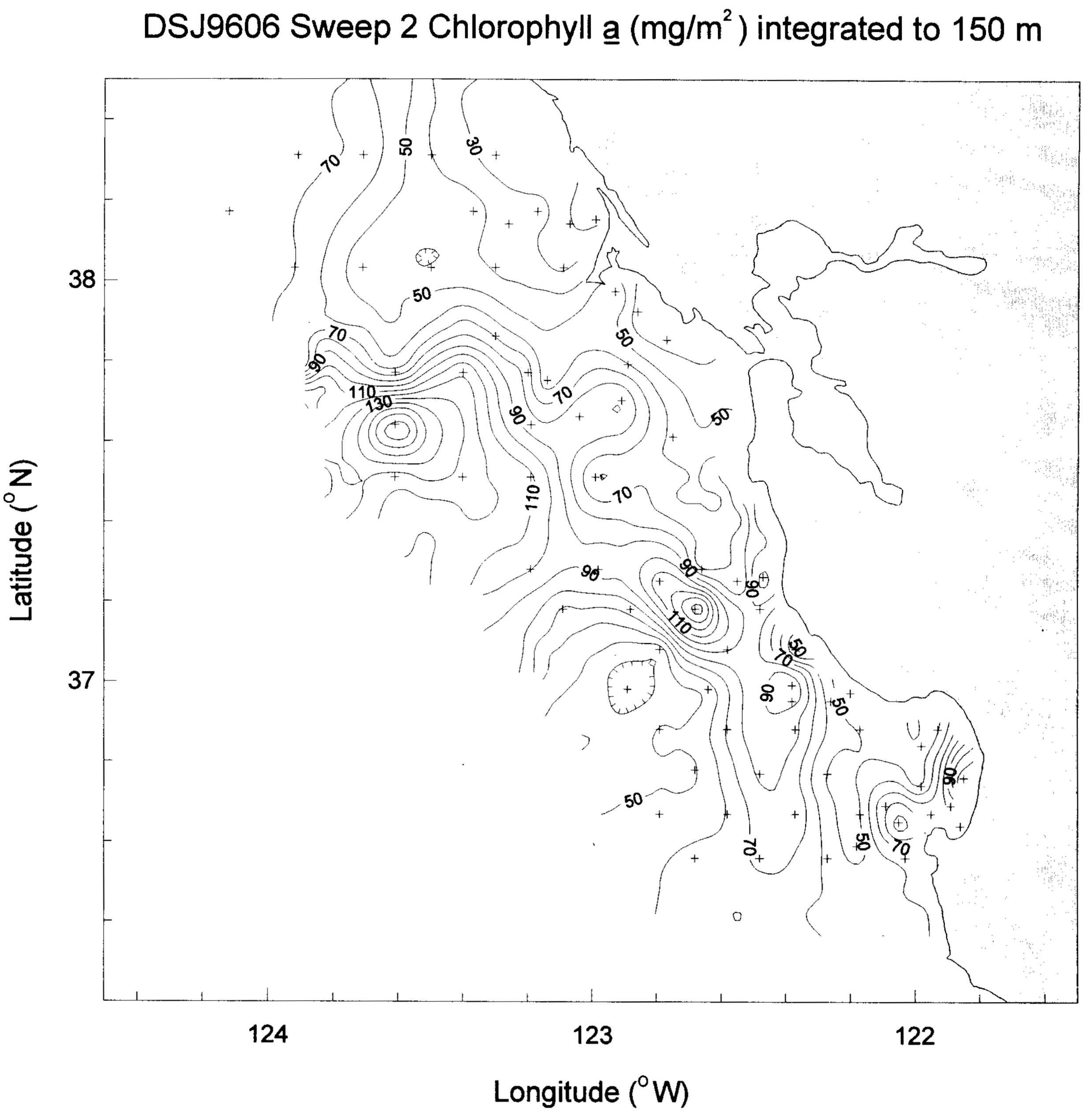


DSJ9606 Sweep 1 Chlorophyll a (mg/m^2) integrated to 150 m

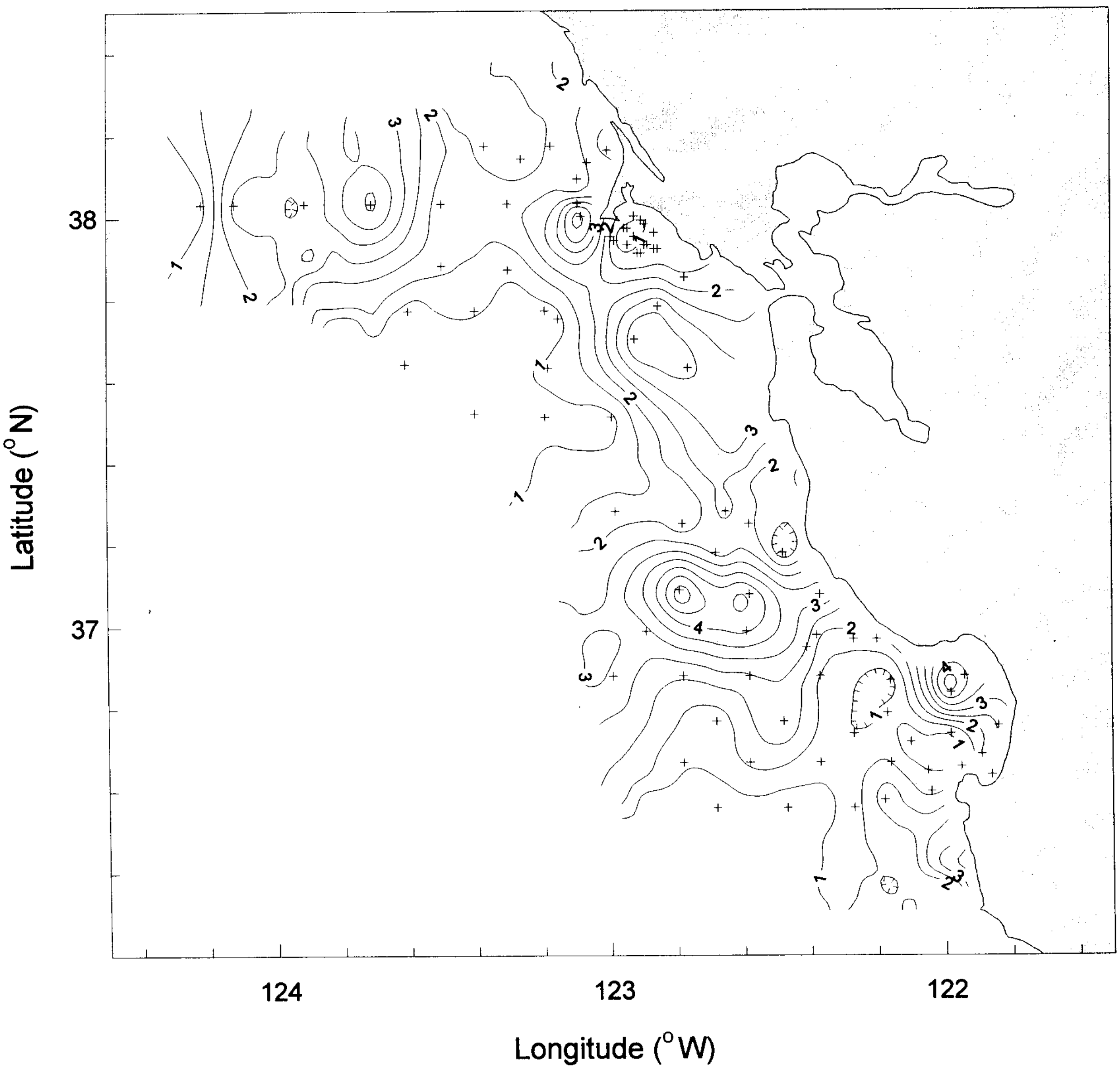


DSJ9606 Sweep 2 Chlorophyll a (mg/m^3) at 10 m

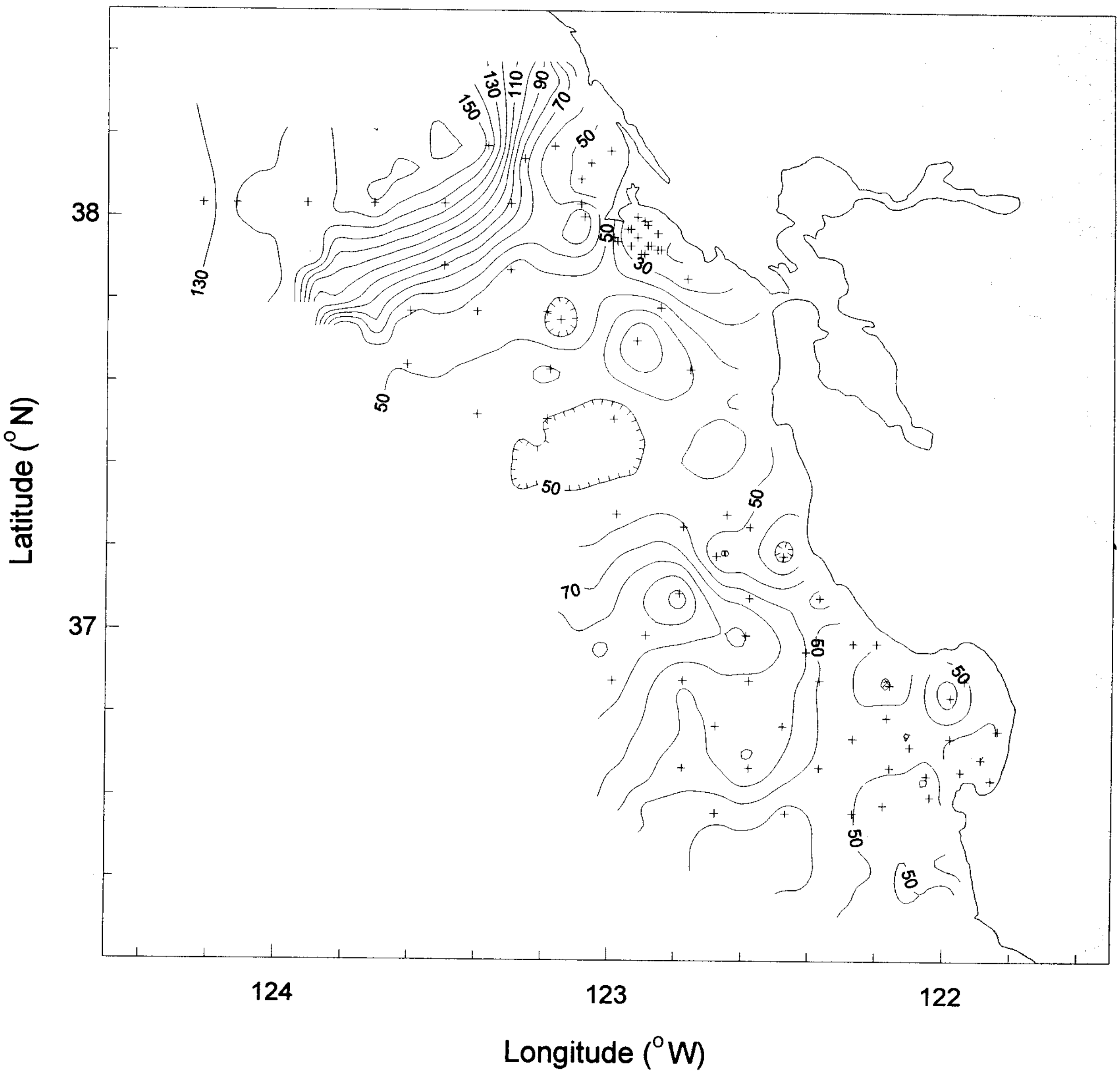



DSJ9606 Sweep 2 Chlorophyll a (mg/m²) integrated to 150 m
Latitude (°N)
38
37
124
123
122
Longitude (°W)

DSJ9606 Sweep 3 Chlorophyll a (mg/m³) at 10 m

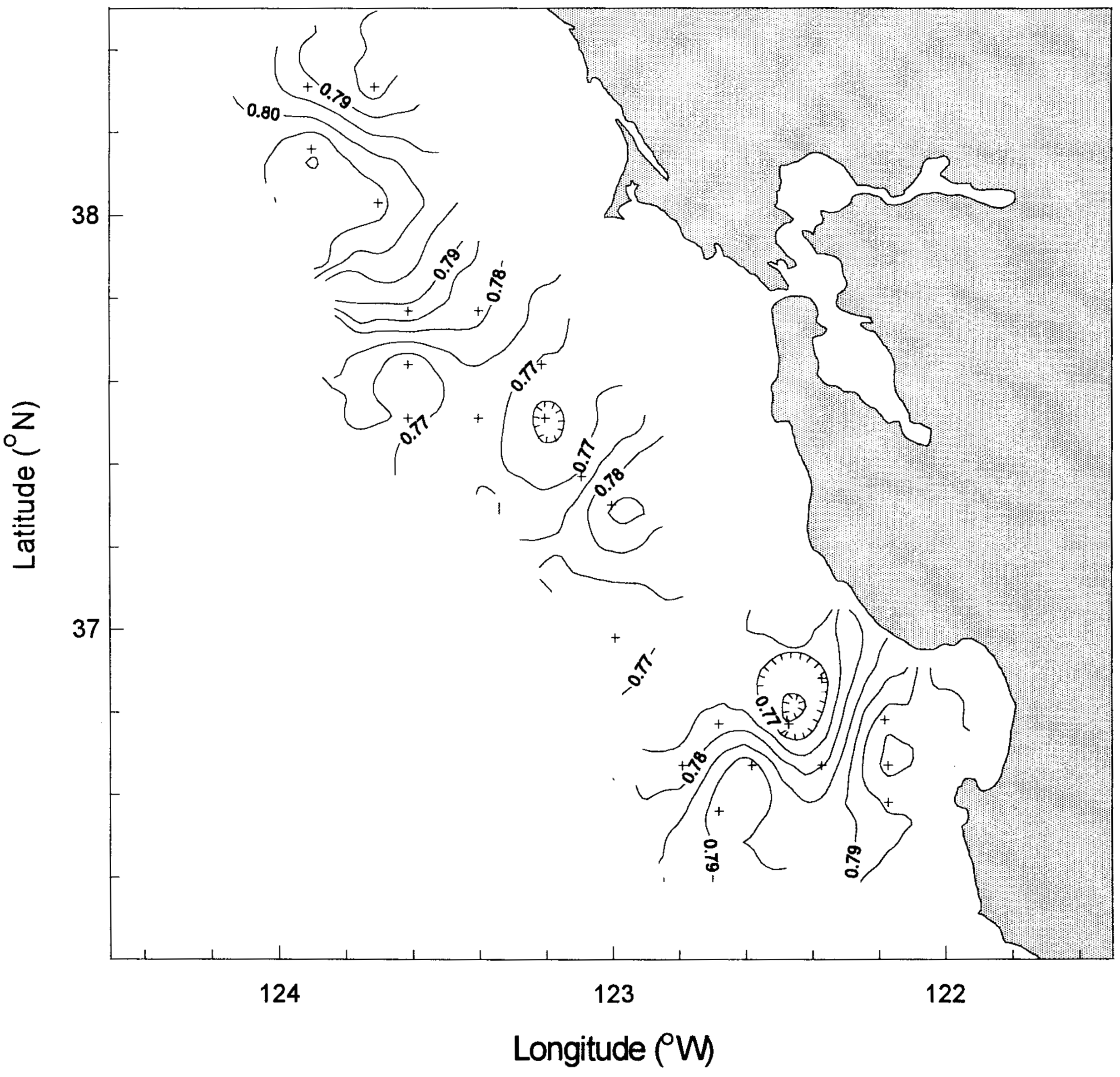


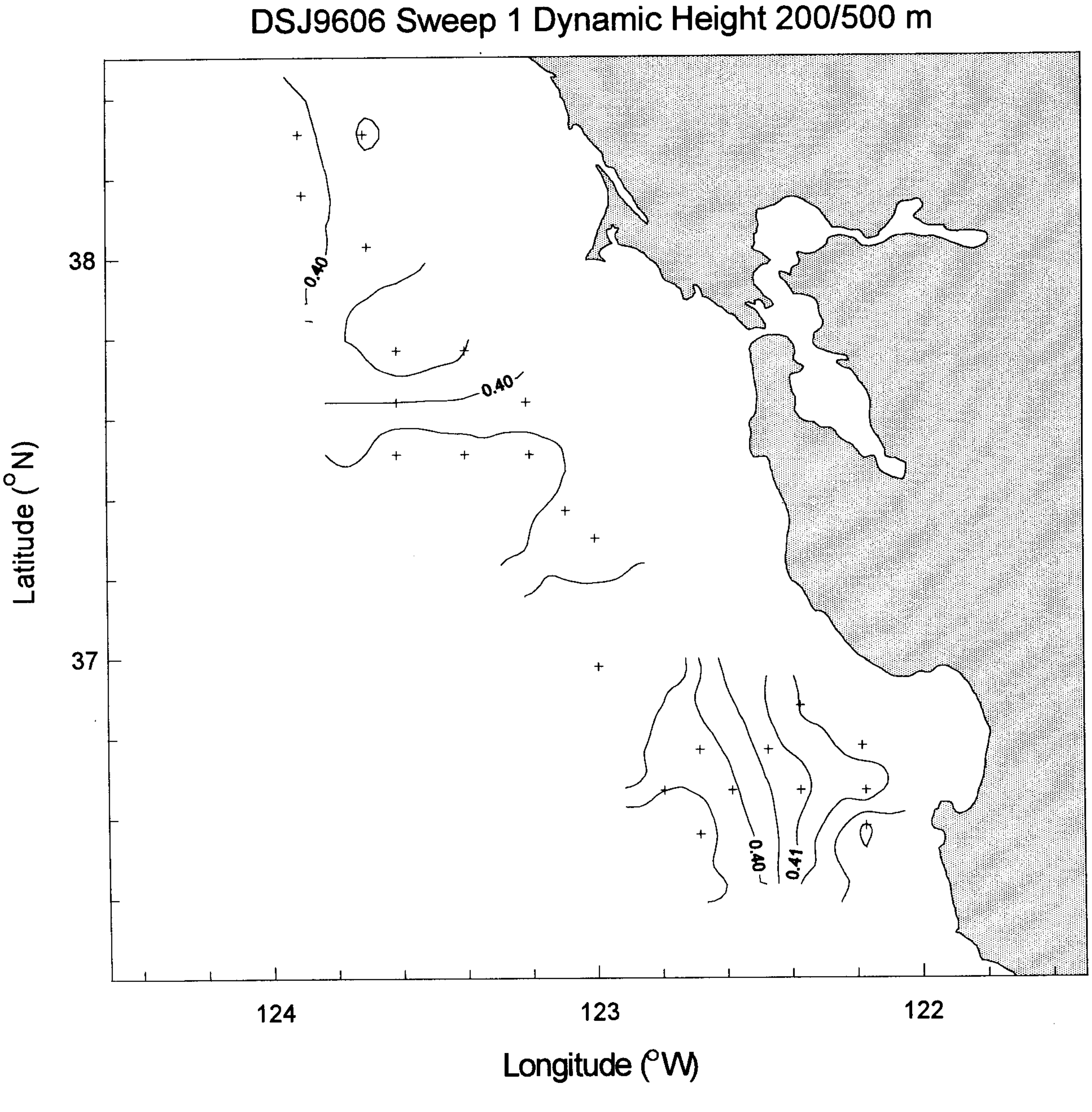
DSJ9606 Sweep 3 Chlorophyll a (mg/m^2) integrated to 150 m



APPENDIX 9: DYNAMIC HEIGHT TOPOGRAPHY FOR DSJ9606

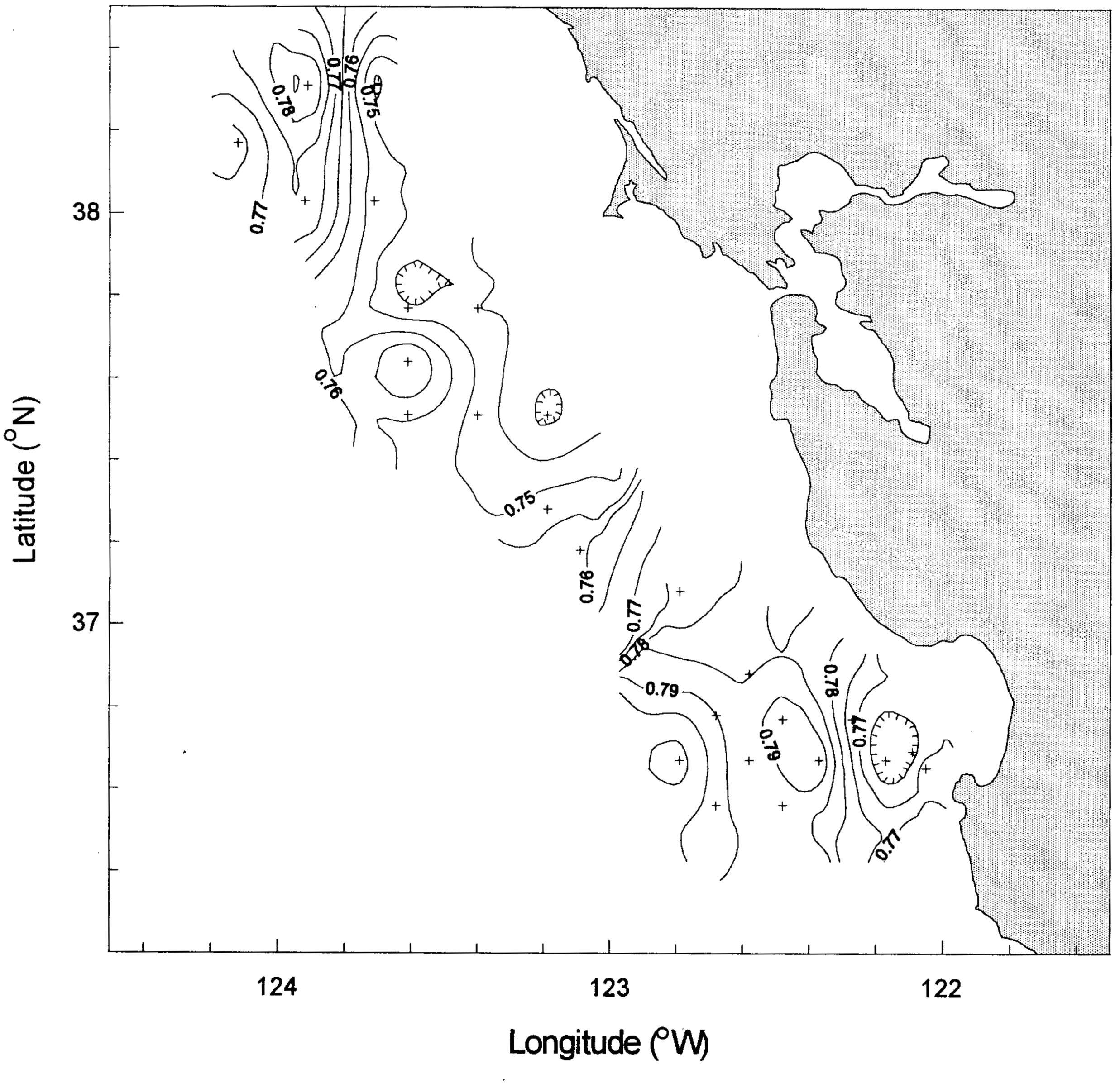
DSJ9606 Sweep 1 Dynamic Height 0/500 m

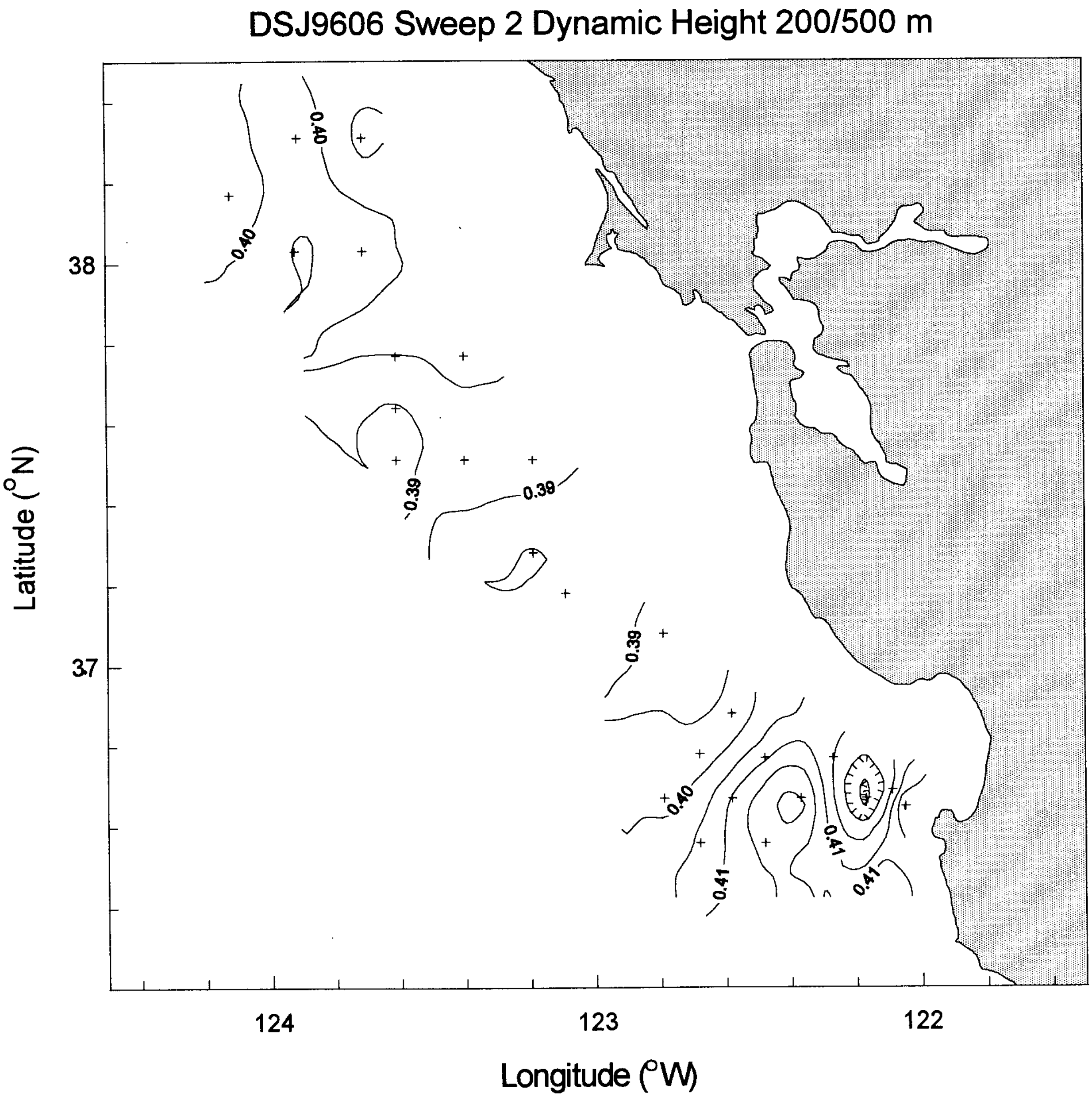




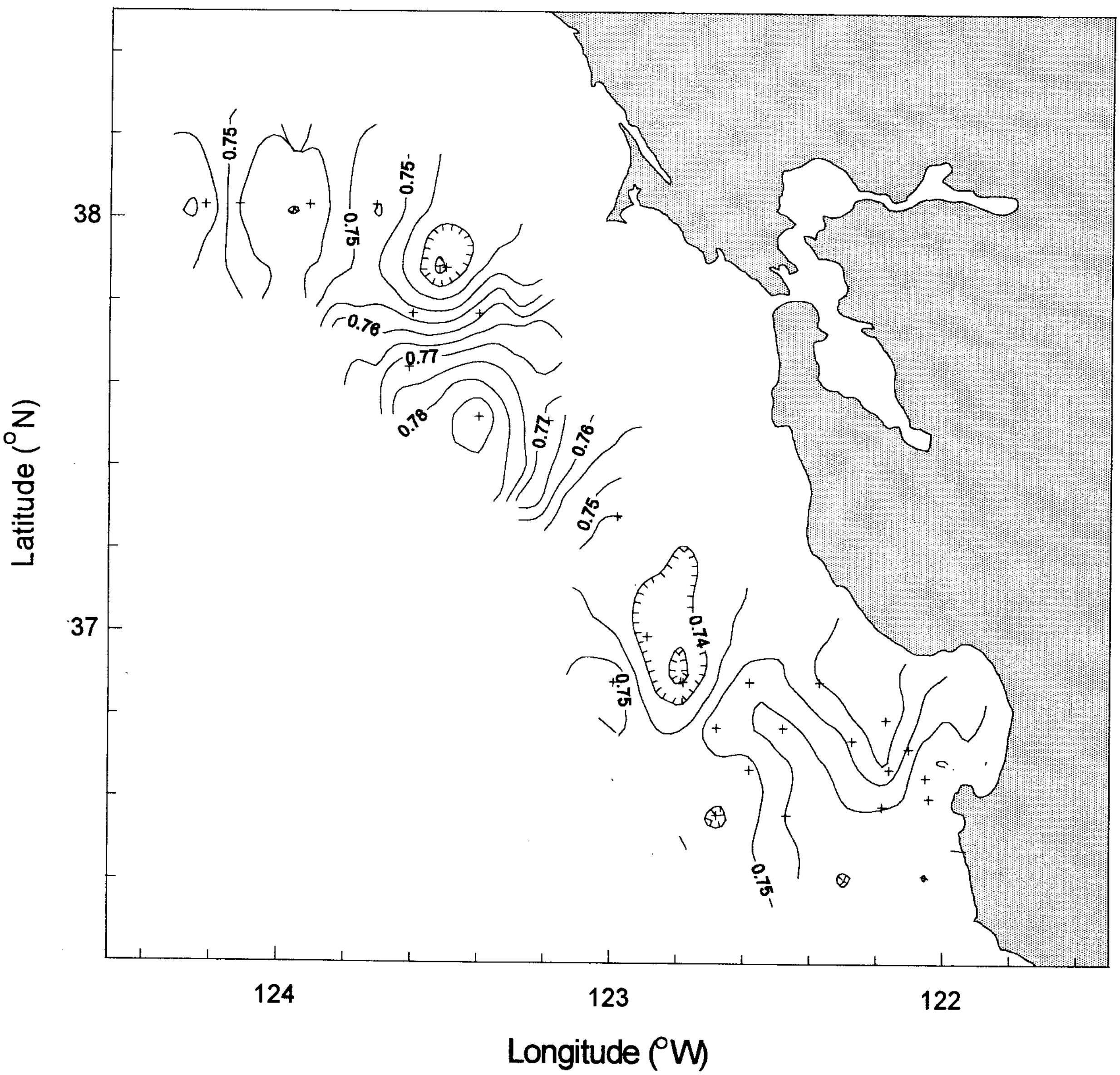
DSJ9606 Sweep 1 Dynamic Height 200/500 m
38
37
Latitude (°N)
124
123
122
Longitude (°W)
0.40
0.40
0.40
0.41

DSJ9606 Sweep 2 Dynamic Height 0/500 m

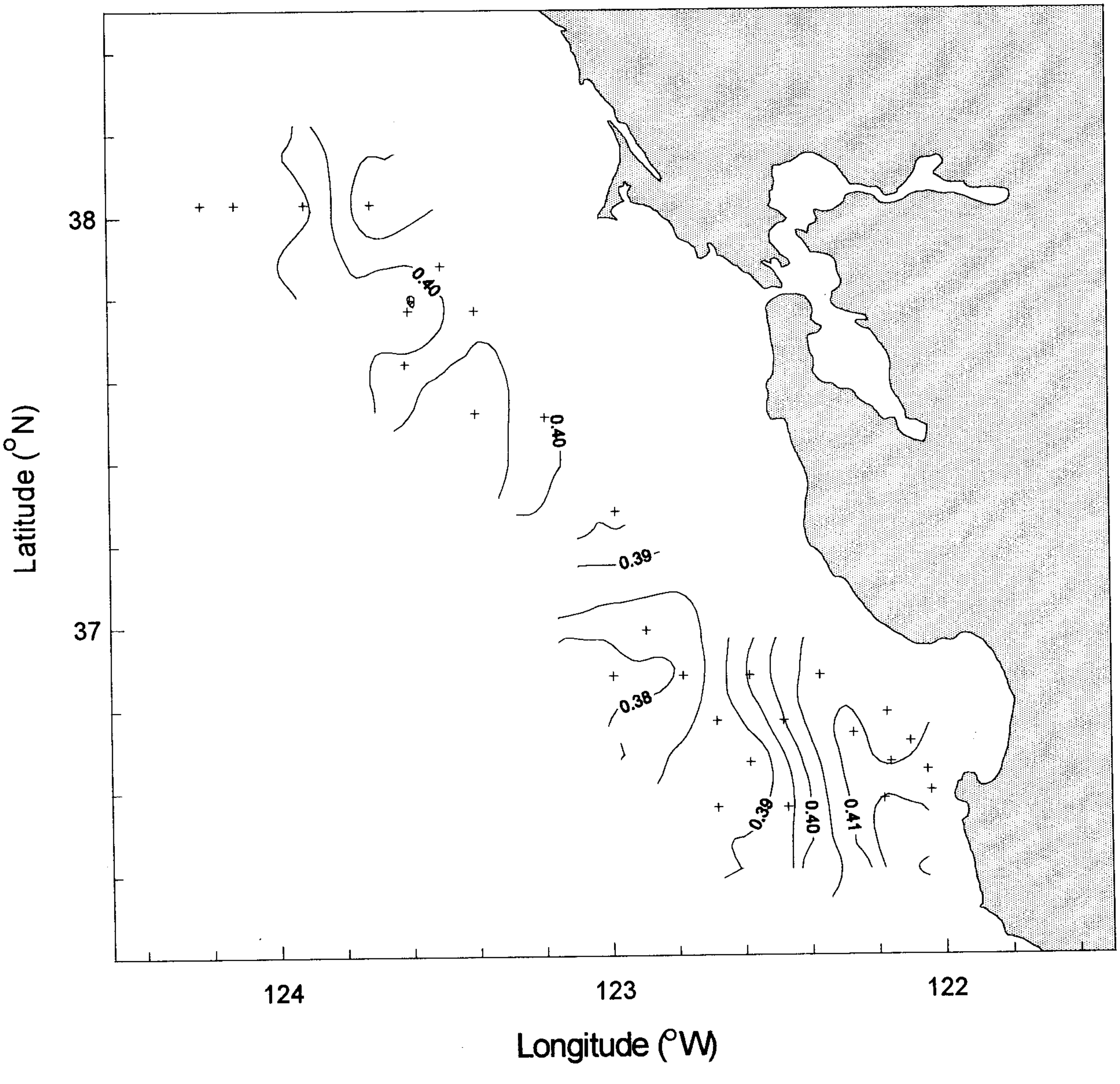



DSJ9606 Sweep 2 Dynamic Height 200/500 m
Latitude (°N)
38
37
124
123
122
Longitude (°W)
0.40
0.40
0.39
0.39
0.39
0.40
0.41
0.41
0.41

DSJ9606 Sweep 3 Dynamic Height 0/500 m



DSJ9606 Sweep 3 Dynamic Height 200/500 m



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M. YOKLAVICH, R. STARR, J. STEGER, H.G. GREENE, F. SCHWING, and C. MALZONE
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