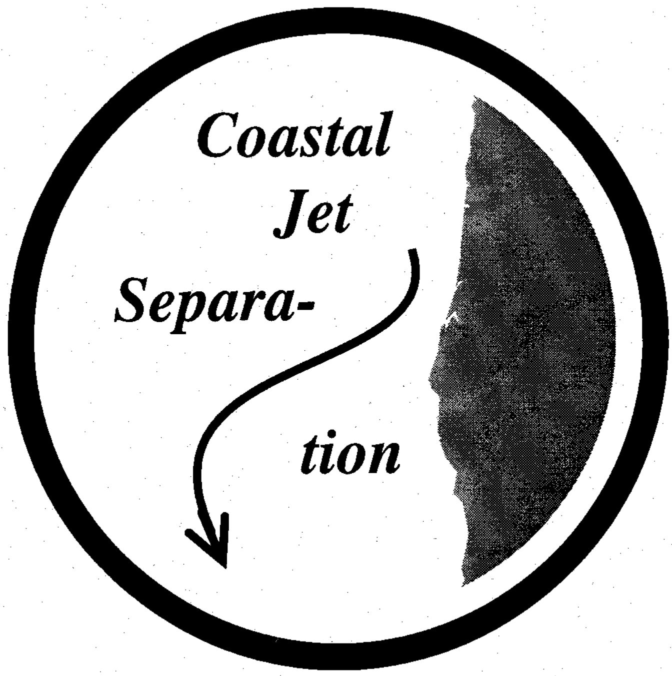
ge of

Oceanic and Atmospheric Sciences



Oregon State University

SeaSoar and CTD Observations During Coastal Jet Separation Cruise W9408A August to September 1994

by

J. A. Barth, R. O'Malley, J. Fleischbein, R. L. Smith and A. Huyer

College of Oceanic & Atmospheric Sciences
Oregon State University
Corvallis, OR 97331–5503

Date Report 162
Reference 96-1
November 1996

SeaSoar and CTD Observations During Coastal Jet Separation Cruise W9408A August to September 1994

J. A. Barth, R. O'Malley, J. Fleischbein, R. L. Smith and A. Huyer

College of Oceanic & Atmospheric Sciences
Oregon State University
Corvallis, OR 97331–5503

Date Report 162
Reference 96-1
November 1996

College of Oceanic and Atmospheric Sciences
Oregon State University

Table of Contents

SeaSoar and CTD Observations During Coastal Jet Separation Cruise W9408A August to September 1994

Introduction

This report summarizes the SeaSoar and CTD observations from *R/V Wecoma* cruise W9408A (23 August to 2 September 1994) conducted as part of the Coastal Jet Separation (CJS) experiment, under funding from the National Science Foundation. The goal of this study is to establish how and why a strong alongshore coastal upwelling jet turns offshore in the vicinity of a coastal promontory, crosses the steep topography of the continental margin and becomes an oceanic jet. Unique aspects of the sampling discussed in this report are: the first use of the OSU SeaSoar vehicles over shallow topography by towing them on a bare cable (without fairing); the first use of dual Sea-Bird CTD sensors where one of the conductivity-temperature sensor pairs is mounted pointing forward through the SeaSoar nose; and post-processing of the SeaSoar conductivity-temperature data using an optimal thermal mass correction, while allowing the time constant to be weakly proportional to the observed lag between temperature and conductivity.

Participants on the cruise are listed in Table 1. Major activities during the cruise are summarized in Table 2. The ship's track during each of the SeaSoar tows is shown in Figure 1. SeaSoar Tows 1 and 2, offshore of the continental shelf break in water deeper than 200 m, were carried out to test the ability to fly SeaSoar on a bare cable from a trawl winch. Tow 3 was designed to sample the separating coastal upwelling jet and the tow legs were positioned by using satellite sea surface temperature maps available before sailing. Tow 4 was conducted with SeaSoar towed on a long, faired cable and was intended to sample the deep structure of the separating jet and to cross it roughly orthogonally in order to make transport estimates. Tows 5 and 6 were again conducted with SeaSoar towed on a bare cable with the inshore part of each leg over shallow bottom topography.

In addition to the SeaSoar and CTD results presented here, velocity measurements were made using a shipborne Acoustic Doppler Current Profiler and are reported in Pierce *et al.* (1996). Three satellite-tracked surface drifters of the WOCE holey-sock design, drogued at 15 m, were released during the SeaSoar mapping (Barth and Smith, 1996). Lex van Geen (LDEO) joined the cruise to collect discrete water samples, from surface waters while underway and from deeper in the water column using CTD/rosette casts, for the analysis of cadmium, phosphate and silicate.

To accomplish the goals of the CJS project, SeaSoar needed to be towed over the mid- and outer continental shelf in water as shallow as 50 m. In these conditions, towing SeaSoar on a

Table 1: W9408A cruise participants with their institution and primary responsibility.

Jack Barth	OSU	Chief Scientist; SeaSoar
Robert Smith	OSU	Co-Chief Scientist; SeaSoar
Jane Huyer	OSU	Co-Chief Scientist; SeaSoar
Jane Fleischbein	OSU	Technician; SeaSoar
Robert O'Malley	OSU	Technician; SeaSoar
Steve Pierce	OSU	Technician; SeaSoar/ADCP
R. Kipp Shearman	OSU	Graduate Student; SeaSoar
Marc Willis	OSU	Marine Technician
Mike Hill	OSU	Marine Technician
Tim Holt	OSU	Marine Technician
Alexander Van Geen	LDEO	Co-Chief Scientist, cadmium sampling

Table 2: Major activities during W9408A (all times UTC).

Start	Stop	Activity	Duration (hrs)	Parameters Measured*
8/23 1700		Depart Newport		
8/23 2000	8/23 2230	CTD on NH line (44° 39.1' N)		
8/23 2349	8/24 0334	Tow SeaSoar on bare cable (**Tow 1**)	4	p,t1,c1,t2,c2,tr,fl
8/24 0400	8/24 1248	Tow SeaSoar on bare cable (**Tow 2**)	9	p,t1,c1,t2,c2,tr,fl
8/24 1730	8/25 0430	CTD on FM line (43° 13.0' N)		
8/25 0443	8/27 1815	Tow SeaSoar on bare cable (**Tow 3**)	62	p,t1,c1,t2,c2,tr,fl
8/25 0853	8/25 0950	Deploy 3 surface drifters during Tow 3		
8/27 2202	8/29 0152	Tow SeaSoar on faired cable (**Tow 4**)	28	p,t1,c1,t2,c2,tr,fl
8/29 0445	8/29 1500	CTD on CR line (41° 54.0' N)		
8/29 1638	9/01 0338	Tow SeaSoar on bare cable (**Tow 5**)	59	p,t1,c1,t2,c2
9/01 0400	9/01 1200	CTD inshore		
9/01 1226	9/02 0430	Tow SeaSoar on bare cable (**Tow 6**)	16	p,t1,c1,t2,c2
9/02 0430	9/02 1430	Transit to Newport		
9/02 1530		Docked at Newport		

* pressure (p), temperature (t), conductivity (c), transmission (tr), fluorescence (fl)
1 = primary sensor, 2 = secondary sensor

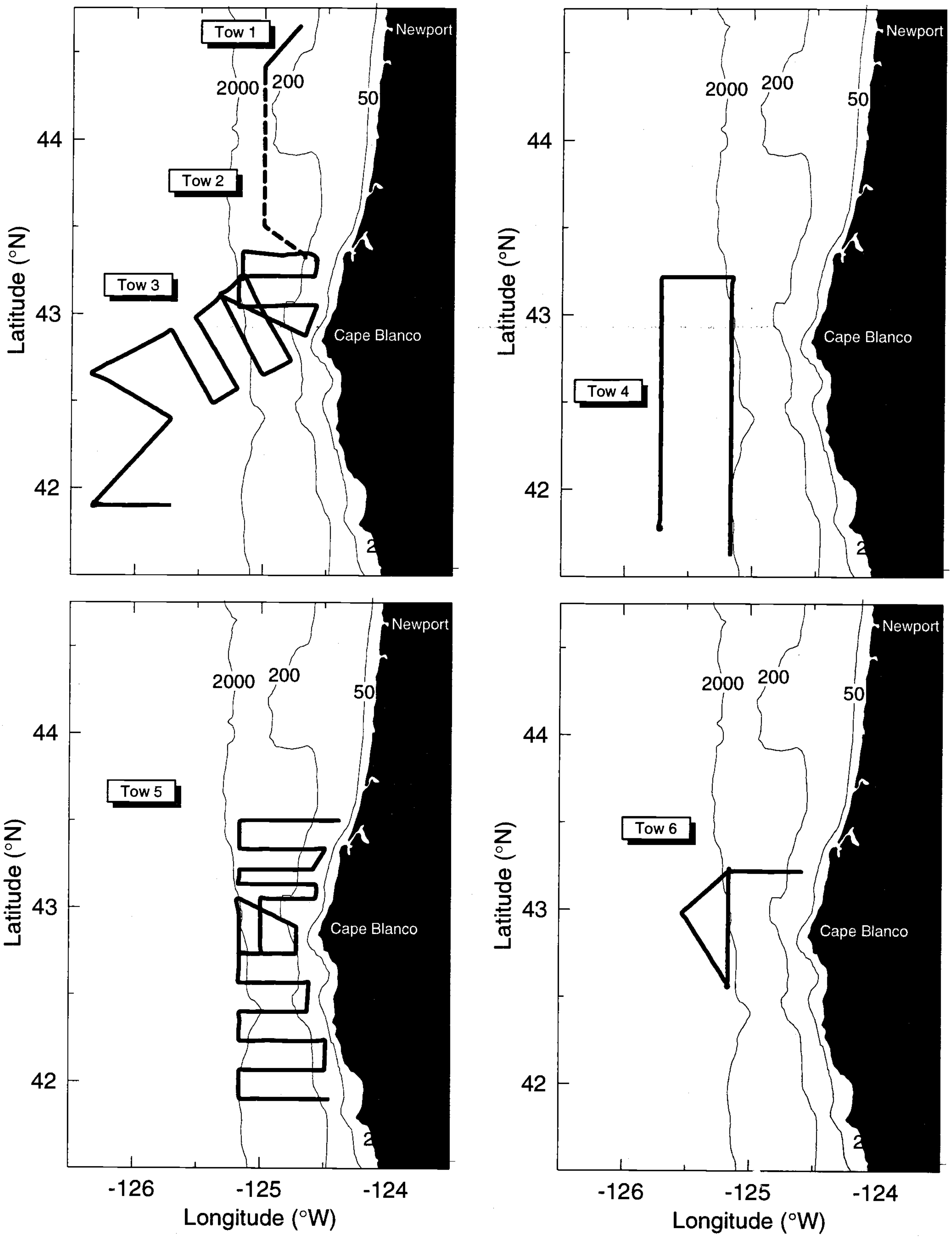


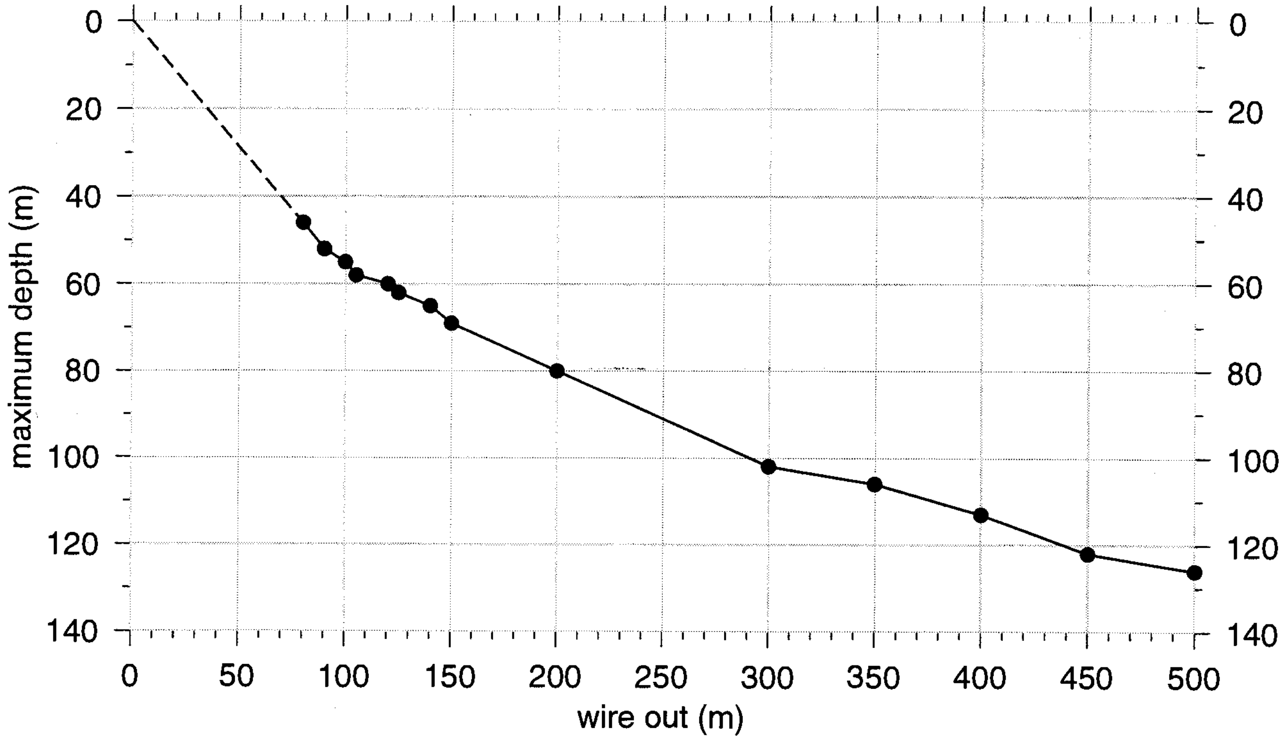
Figure 1: Ship's track during the SeaSoar tows of W9408A. Bottom topography in meters.

faired cable, as in all previous OSU SeaSoar projects, was deemed unsafe because the faired cable cannot be brought in quickly as the ship enters shallow water. This is because careful handling of the fairing is required as the cable spools on and off the dedicated winch. During W9408A, we towed SeaSoar using 940 m (3000 feet) of unfaired ("bare") 5/16", 7-conductor hydrographic cable using Wecoma's trawl winch with level wind and built-in tensiometer. The amount of cable spooled out was adjusted to achieve varying maximum sampling depths (Figure 2, top) and to follow the initial safety guideline that cable out be roughly equal to water depth to avoid collision of the vehicle with the bottom in case of loss of ship's power. As we gained experience flying SeaSoar in shallow water, this safety constraint was relaxed. The maximum depth obtainable with the present SeaSoar vehicle configuration – standard bomb weight mounted below and a 25-cm pathlength transmissometer mounted on top – regardless of cable length, was approximately 125 m.

The overall response of the vehicle while towed on the bare cable was excellent, particularly the rapid response to an up signal at the bottom of the trajectory, a desirable characteristic for avoiding bottom obstacles. Cable tensions during bare-cable towing were always less than 1000 kg. The bottom depth was measured using the ship's 12-kHz echosounder and monitored visually from line scan recorder output. Cable length and SeaSoar flight controller settings were adjusted to allow the vehicle to come no closer than 10-15 m of the bottom. Using the ship's echosounder for bottom detection allows sufficient time for the SeaSoar operator to command wings up in response to an oncoming bottom obstacle. For example, this lead time is approximately 30 s using a cable length of 100 m sampling to a maximum depth of 55 m, an echosounder located 20 m forward from the ship's stern, and a ship speed of 4 m s^{-1} (8 knots).

The bare-cable profiling pattern (Figure 2, bottom) gave very high resolution in the horizontal ranging from 1/3 to 1 km through one full cycle – at the mid-depth of each profile the horizontal resolution is half that, or 167-500 m. While towing alongshore in shallow water in regions of coastal upwelling and high biological productivity and where property gradients are mostly in the cross-shore direction (e.g., hours 5-6.5, Figure 2, bottom), we found that operating the SeaSoar in a "pop-up" mode, where the entire water column is only sampled occasionally with the remaining time being spent at depth, helped reduce biological fouling of the sensors (see also the discussion on Post-Processing of SeaSoar Data below). After turning cross-shore in shallow water where property gradients are strong cross-shore, we again resumed high-spatial-resolution sampling.

After establishing our ability during Tows 1 and 2 to fly SeaSoar on a bare cable, we conducted Tow 3 including cross-shore sections onto the mid-shelf and sampling offshore



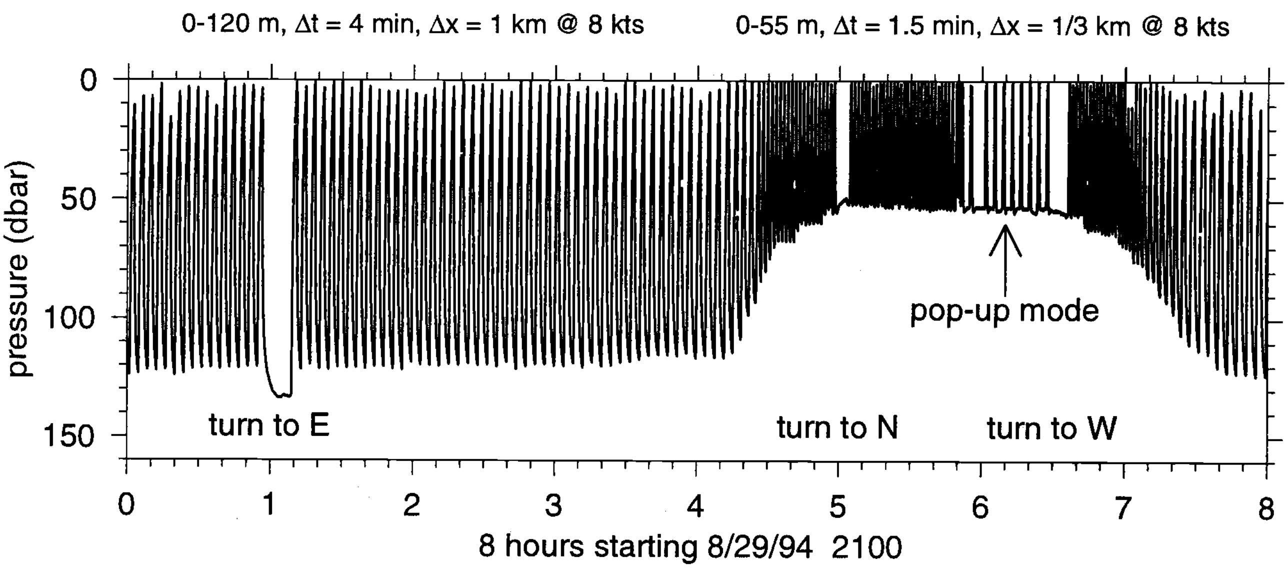


Figure 2: (top) Maximum depth obtained towing SeaSoar with a variable-length, bare 5/16" hydrographic cable. The dashed line connects the origin to the first data point. (bottom) A pressure trace showing the SeaSoar flight path over 8 hours during W9408A.

where the coastal upwelling jet was observed to separate from the coast. Tow 4 was conducted by towing SeaSoar with a faired cable, as in previous OSU SeaSoar projects, in order to sample the deep structure of the separating jet. Maximum depth obtainable with the faired cable and SeaSoar loaded as in Tows 1-3 (standard bomb weight below, transmissometer on top) was approximately 280 m and cable tensions remained less than 2000 kg. We returned to bare-cable towing during Tows 5 and 6 to sample inshore to the mid-shelf; during these tows the SeaSoar did not carry a fluorometer or a transmissometer.

A second novel aspect of the SeaSoar sampling carried out during W9408A, involved a new placement of one of the Sea-Bird T/C sensor pairs in the SeaSoar nose. Previously, both T/C sensor pair ducts had their inlet and outlet ports plumbed through the sides of the SeaSoar nose (Huyer *et al.*, 1993). In an effort to improve sensor performance, specifically to stabilize the time-dependent lags between T and C measurements used in producing quality salinity measurements (Huyer *et al.*, 1993; and see Post-Processing of SeaSoar Data below), one sensor pair was remounted pointing forward through a hole in the SeaSoar nose (Figure 3). This eliminated the need for any additional plumbing on the Sea-Bird T/C duct and exposed the conductivity cell to a better flushing with ambient seawater. This configuration was used during SeaSoar Tows 5 and 6 and the results, detailed below, were excellent. While clogging of the forward-pointing sensors was more frequent than with the sideways-plumbed sensors, it only happened occasionally (quantified in Post-Processing of SeaSoar Data below) and the duct usually cleared after one descending profile so that data from the forward-pointing sensor pair was usable on the next uptrace. Through a combination of swapping in data from the unclogged, sideways-plumbed sensors and by reducing clogging during shallow N-S transects using a pop-up profiling mode (see above), high-quality CTD data were obtained for all profiles during W9408A.

Conventional CTD casts were made along the Newport (NH), Five Mile Point (FM) and Crescent City (CR) hydrographic lines, inshore near Coos Bay, and at the start or end of many of the SeaSoar tows (Figure 4, Table 3). These casts were made using a SBE 9/11-plus CTD equipped with dual temperature and conductivity sensors, a SeaTech fluorometer and a 25-cm pathlength SeaTech transmissometer. Water samples were collected at various depths for CTD calibration and for chemical analysis by Lex van Geen (LDEO).

Winds were generally upwelling favorable during the cruise as measured from the ship (Figure 5, top). Data from the underway 5-m T and C sensors was not recorded properly in the Wecoma MIDAS system due to a programming error in storing the T and C values. Independently of MIDAS, the Wecoma's realtime navigation and data display program saves approximately 3 days of history data from the underway system. When it was realized that

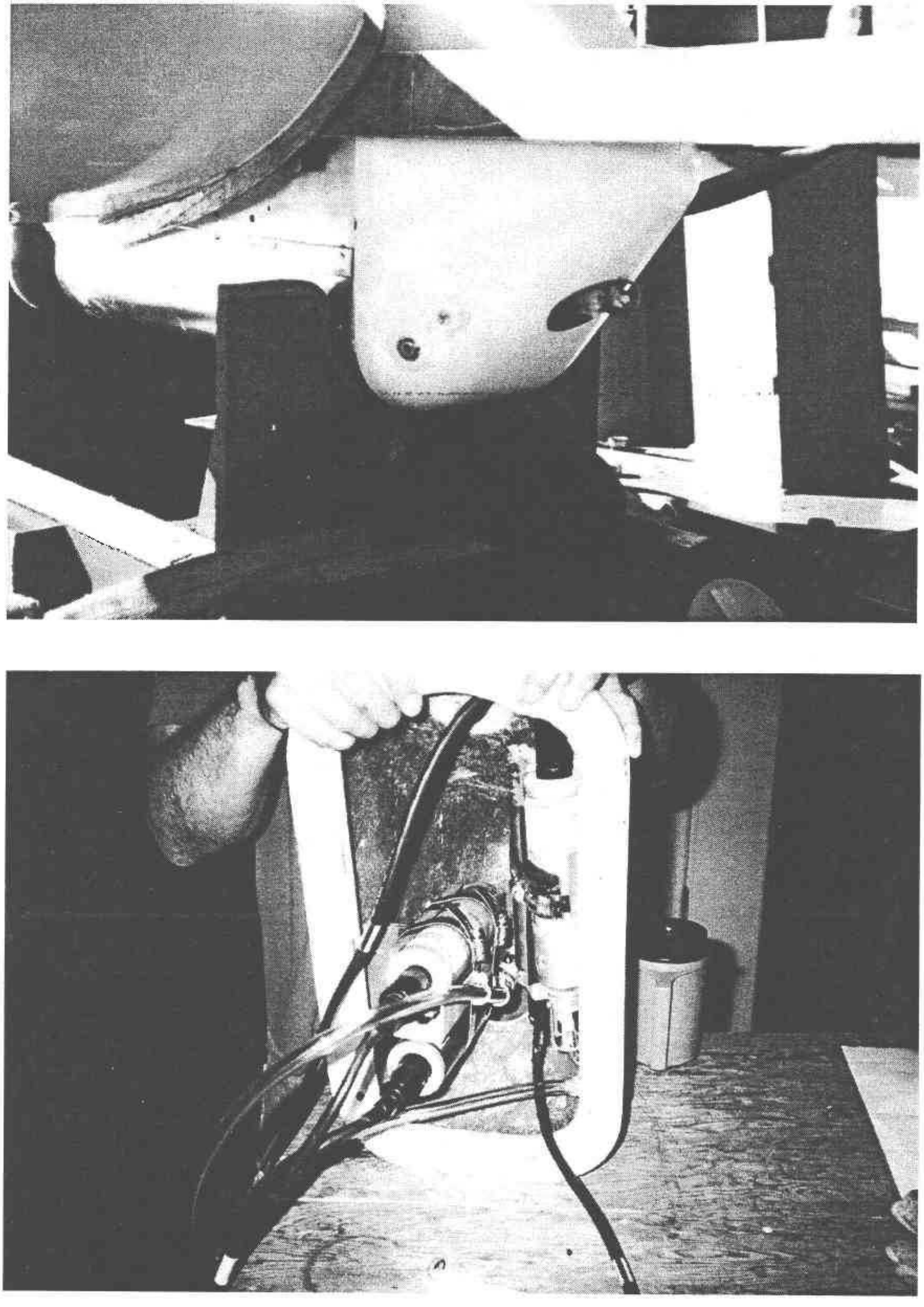


Figure 3: (top) Front view of SeaSoar equipped with dual Sea-Bird T/C sensors where one pair points forward through an opening in SeaSoar's nose and a second pair is plumbed through the starboard side of the nose. (bottom) View into detached SeaSoar nose showing T/C sensor pairs.

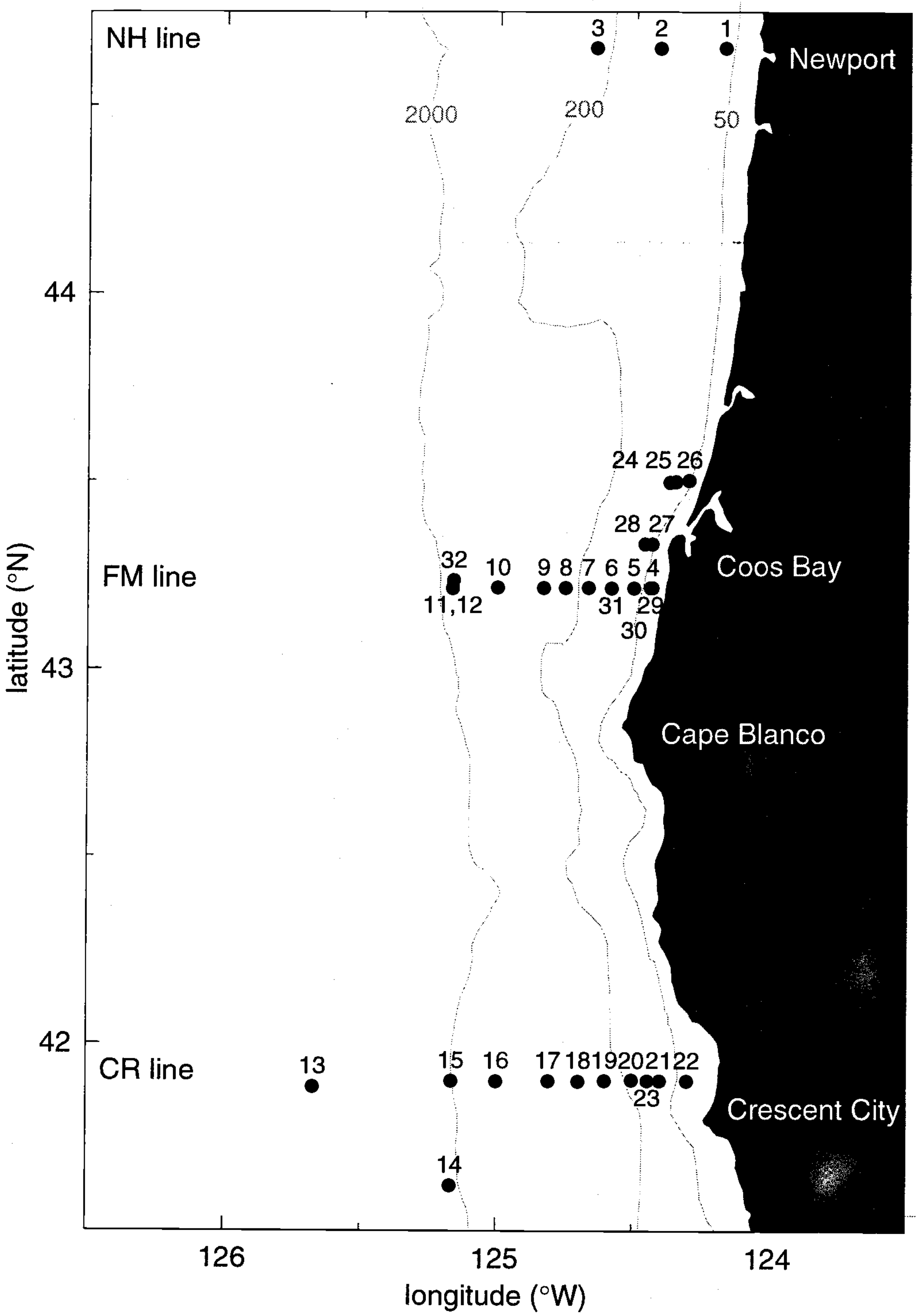


Figure 4: CTD station locations for W9408A.

Table 3: Summary of CTD stations during W9408A.

Station No.	Name	Date 1994	Time UTC	Latitude °N	Longitude °W	Cast Depth(m)	Wind Dir(°T)	Wind Spd(kts)	Atm. P. (mbar)
1	NH-5	23 Aug	1935	44 39.1'	-124 10.6'	51	350	20	1019.1
2	NH-15	23 Aug	2109	44 39.1'	-124 24.9'	81	350	25	1019.1
3	NH-25	23 Aug	2238	44 39.1'	-125 38.9'	276	–	–	–
4	FM-1	24 Aug	1728	43 13.0'	-124 26.0'	30	340	16	1020.5
5	FM-3	24 Aug	1829	43 12.9'	-124 30.1'	56	000	17	1021.2
6	FM-4	24 Aug	1931	43 13.0'	-124 35.1'	79	010	15	1021.5
7	FM-5	24 Aug	2036	43 13.0'	-124 40.1'	159	010	22	1021.2
8	FM-6	24 Aug	2130	43 13.0'	-124 45.1'	315	010	24	1020.9
9	FM-7	24 Aug	2231	43 13.0'	-124 50.0'	336	010	25	1019.8
10	FM-8	25 Aug	0005	43 13.0'	-125 00.1'	501	350	27	1020.8
11	FM-9	25 Aug	0149	43 13.0'	-125 10.0'	501	355	25	1020.1
12	FM-9	25 Aug	0347	43 12.9'	-125 10.0'	200	–	–	–
13	post t3	27 Aug	1147	41 53.0'	-125 40.4'	502	345	7	1015.7
14	post t4	29 Aug	0210	41 37.3'	-125 10.1'	1006	335	17	1020.4
15	CR-8	29 Aug	0453	41 54.0'	-125 09.9'	1006	340	20	1020.0
16	CR-7	29 Aug	0641	41 53.9'	-125 00.0'	811	345	21	1021.0
17	CR-6	29 Aug	0844	41 54.0'	-124 48.5'	690	350	25	1019.9
18	CR-5	29 Aug	1017	41 53.9'	-124 42.0'	651	350	25	1020.8
19	CR-4	29 Aug	1138	41 54.0'	-124 36.1'	502	345	24	1020.1
20	CR-3	29 Aug	1257	41 54.1'	-124 30.1'	130	020	13	1020.2
21	CR-2	29 Aug	1354	41 54.0'	-124 24.0'	61	015	6	1020.5
22	CR-1	29 Aug	1444	41 54.0'	-124 18.0'	35	020	5	1020.6
23	pre t5	29 Aug	1604	41 54.0'	-124 26.7'	85	355	18	1020.8
24	post t5	1 Sep	0358	43 29.8'	-124 22.3'	92	010	7	1017.0
25	TM-2	1 Sep	0435	43 29.9'	-124 21.0'	90	010	12	1016.5
26	TM-1	1 Sep	0518	43 30.1'	-124 18.1'	55	360	10	1017.0
27	AR-1	1 Sep	0641	43 20.0'	-124 26.1'	51	065	6	1017.2
28	AR-2	1 Sep	0713	43 20.0'	-124 27.7'	73	–	6	1017.2
29	FM-1	1 Sep	0822	43 13.0'	-124 26.4'	36	010	6	1017.5
30	FM-3	1 Sep	0856	43 13.0'	-124 30.0'	50	000	7	1017.3
31	FM-4	1 Sep	0944	43 12.9'	-124 35.0'	76	000	10	1017.2
32	post t6	2 Sep	0442	43 14.2'	-125 09.8'	250	350	20	1017.2

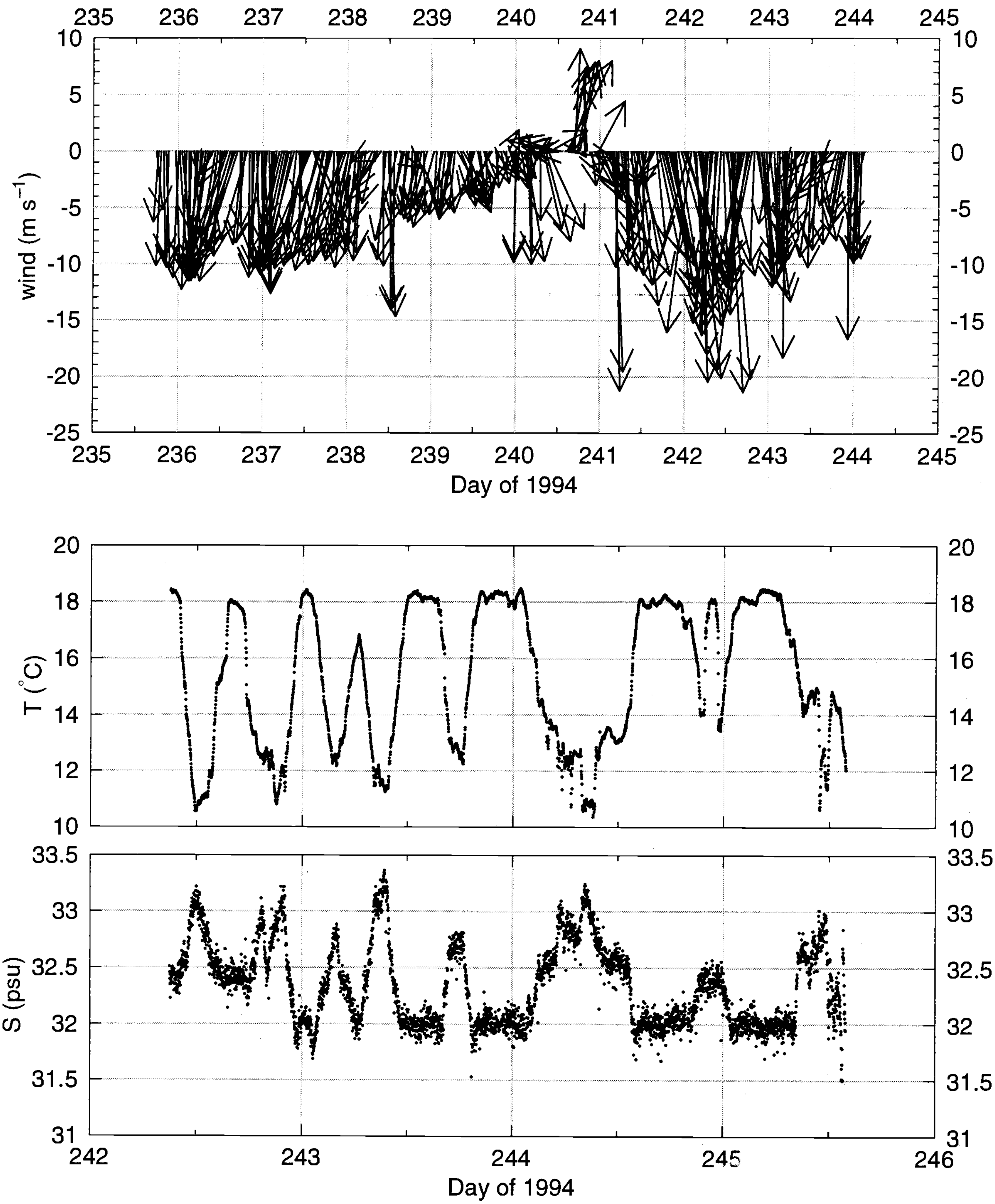


Figure 5: (top) Shipboard winds during W9408A and (bottom) 5-m temperature and salinity from the flow-through system onboard Wecoma. Note that underway T and S data are only available after day 242.375.

the MIDAS system was not recording T and C correctly, these history files were used to recover 3 days of underway T and C data. When the underway 5-m conductivity signal was compared with shallow SeaSoar values an offset in the measured conductivity (and hence salinity), apparently due to a ground fault problem with the conductivity cell, was discovered. The salinity and temperature of the 5-m underway data was corrected to match the shallow (3.5-7.5 m depth) SeaSoar values for S and T. The SeaSoar T and C sensors used the manufacturer's most recent calibration values and were calibrated with bottle salt samples drawn from the 5-m flow-through system (see below). The final result is calibrated 5-m T and S data obtained from the underway flow-through system for day 242.375 through 245.578 (Figure 5, bottom).

CTD Data Acquisition, Calibration and Data Processing

All CTD/rosette casts were made with an SBE 9/11-plus CTD system equipped with dual ducted temperature and conductivity sensors (Table 4). In addition to the CTD casts made along transects, CTD casts were made to monitor the calibration of the SeaSoar CTD data. These calibration casts were made immediately before and after most SeaSoar tows, with as little delay as possible. A total of 32 CTD casts were made, with maximum sampling depths ranging from 30 to 1006 m (Table 3). Raw 24 Hz CTD data were acquired on an IBM-compatible PC using the SEASAVE module of SEASOFT version 4.009 (Anon., 1992); temperature and conductivity data were recorded from both pumped sensor ducts.

At each station a few salinity samples were collected from Niskin bottles at two or more depths for *in situ* calibration of the conductivity sensors; CTD values at the same depth (calculated from the most recent manufacturer's pre-cruise calibration) were recorded both by the PC and manually on the station log sheets. Samples were analysed on a Guildline Autosal 8400A Salinometer that was standardized with IAPSO Standard Water at the beginning and end of each batch of 24 samples. Sample conductivities were calculated using the sample salinity value with the CTD temperature and pressure values; a value of 42.914 mmho cm^{-1} for conductivity of standard seawater at 15°C (Culkin and Smith, 1980) was used to convert the measured sample conductivity ratios to conductivity. Analysis of the sample and CTD conductivity differences showed no conductivity corrections were needed for the primary sensors (Table 5).

CTD data were processed on an IBM-compatible PC using applicable SEASOFT modules. Data from the primary sensors were used for final processing for all CTD stations. The DATCNV module of SEASOFT was used with the pre-cruise calibration constants to calculate 24 Hz values of pressure, temperature and conductivity from the raw frequencies. When

Table 4: Instruments and sensors used during W9408A for CTD, SeaSoar and underway salinity sampling, and date of most recent manufacturer's pre-cruise calibration.

System (Instrument)	Sensor	SN	Pre-Cruise Calibration
CTD/Rosette			
(SBE 9/11 plus, SN 0258)	P	50506	30 Nov 93
	T1	1371	17 Feb 94
	T2	1367	17 Feb 94
	C1	830	19 May 94
	C2	519	19 May 94
SeaSoar Tows 1, 2, 3, 4			
(SBE 9/11 plus, SN 0256)	P	50130	30 Nov 93
(port)	T1	1364	17 Feb 94
(starboard)	T2	1366	17 Feb 94
(port)	C1	1021	23 Nov 93
(starboard)	C2	1070	23 Nov 93
	TRANS	33D	25 May 88
	FL	48	
SeaSoar Tow 5, 6			
(SBE 9/11 plus, SN 0256)	P	50130	30 Nov 93
(forward)	T1	1008	17 Feb 94
(starboard)	T2	997	3 Aug 94
(forward)	C1	1018	3 Aug 94
(starboard)	C2	1054	3 Aug 94
5-m Intake	T	854	17 Feb 94
	C	497	May 94
Transducer Well	T	1093	17 Feb 94

Table 5: Results of *in situ* calibration samples for CTD/Rosette sensor pair S1 for W9408A: Number of samples (N), and the average and standard deviations of the conductivity and salinity differences between the sample values and the corrected CTD data.

Stations	N	Average C1	Std. Dev. C1	Average S1	Std. Dev. S1
W9408A 1-32	62	0.001	0.005	0.001	0.005

necessary, the output data file was edited to remove any spikes and any values inadvertently recorded before the pressure minimum at the beginning of the cast. The CELLTM module was used to correct for the thermal mass of the conductivity cell, assumed to have a thermal anomaly amplitude of 0.03 and a time constant of 9 seconds. Ascending portions of the 24-Hz data file were removed by LOOPEDIT with the minimum velocity set to 0.0 m s^{-1}. The remaining data were averaged to 1 db values using BINAVG. The final processed data files consist of 1 db values of pressure, temperature and conductivity. These processed data files were transferred to a SUN computer where we used standard algorithms (Fofonoff and Millard, 1983) to calculate salinity, potential temperature, density anomaly (sigma-theta), specific volume anomaly, and geopotential anomaly (dynamic height).

SeaSoar Data Acquisition and Preliminary Processing

The Chelsea Instruments SeaSoar vehicle was equipped with a SBE 9/11-plus CTD with dual temperature and conductivity sensors (Table 4). For Tows 1-4, the inlets and outlets of both dual T/C ducts were plumbed through the port (primary) and starboard (secondary) sides of the SeaSoar nose as in previous OSU SeaSoar surveys (Huyer *et al.*, 1993; Kosro *et al.*, 1995). For Tows 5-6 an alternative placement of the primary T/C duct inlet and outlet was tried as previously described (see Figure 3). During Tows 1-4 the SeaSoar also carried two additional instruments: a 25-cm pathlength SeaTech Transmissometer mounted on top of the vehicle; and a SeaTech 300m Fluorometer mounted inside the vehicle, below the SBE 9/11-plus pressure case, with its sensing volume located directly behind a hole in the center of the vehicle's nose (Figure 3, top).

Raw 24-Hz CTD data from the SeaSoar vehicle and GPS position and time data were acquired by an IBM-compatible PC. The acquisition software placed flags in the data stream to mark the collection of hourly salinity samples from the flow-through system, to signal turns between sampling lines and to indicate missing GPS data. The raw data were simultaneously recorded on optical disk by PC and on a Sun SPARC workstation. The PC displayed time series of subsampled temperature (both sensors), conductivity (both sensors) and pressure in real time; it also displayed accumulated temperature data for many hours as a vertical section (color raster). One-second averages of ship's position, CTD temperature (both sensors), conductivity (both sensors), salinity (both sensor pairs), and pressure were calculated on the SPARC workstation, using the most recent manufacturer's calibration (Table 4). Preliminary salinity estimates for each sensor pair were calculated using a fixed offset between temperature and salinity, and a fixed value, $\alpha = 0.045$, for the amplitude and for the time constant, $\tau = 9$, of the thermal mass of the conductivity cell. Time-series and vertical profile plots of the one-second data were made at the end of each hour for science analysis and to monitor data quality. The 1-Hz preliminary data were used to calculate 5-minute average temperature and salinity values in 2 db vertical bins during shallow profiling on a bare cable (Tows 1-3 and 5-6); 12-minute averages were calculated during deep profiling on a faired cable (Tow 4). These gridded values were used for at-sea analysis of the three-dimensional structure of the separating coastal upwelling jet.

SeaSoar Conductivity Calibration

Salinity samples were collected once per hour from a flow-through system in Wecoma's wetlab from 0000 UTC, 24 August until 1400 UTC, 2 September 1994. This system pumps water from the seachest at a depth of 5 m in the ship's hull, through a tank containing SBE temperature and conductivity sensors; samples are drawn from a point just beyond this tank. The 120 ml glass sample bottles were rinsed three times before filling, and closed with screw-on plastic caps with conical polyethylene liners. Samples were further sealed by wrapping parafilm around the base of the cap. Following the end of the cruise, samples were analyzed in Corvallis on a Guildline Autosal salinometer. The salinometer was standardized with IAPSO Standard Water at the beginning and end of each batch of about 24 samples. Time series of these hourly salinity samples and time series of the preliminary SeaSoar data from the 3-7 m depth range (Figure 6) show very similar variations.

For a quantitative comparison between the salinity samples and the SeaSoar data, we selected SeaSoar values that were both within 7 minutes of the time of the salinity sample and within a depth range of 3.0 to 7.9 m. For each salinity sample, we calculated a bottle conductivity using the measured salinity and the temperature from each SeaSoar sensor duct, and then compared this sample conductivity to the directly measured conductivity from the same sensor duct; a few pairs with very large differences were eliminated from the

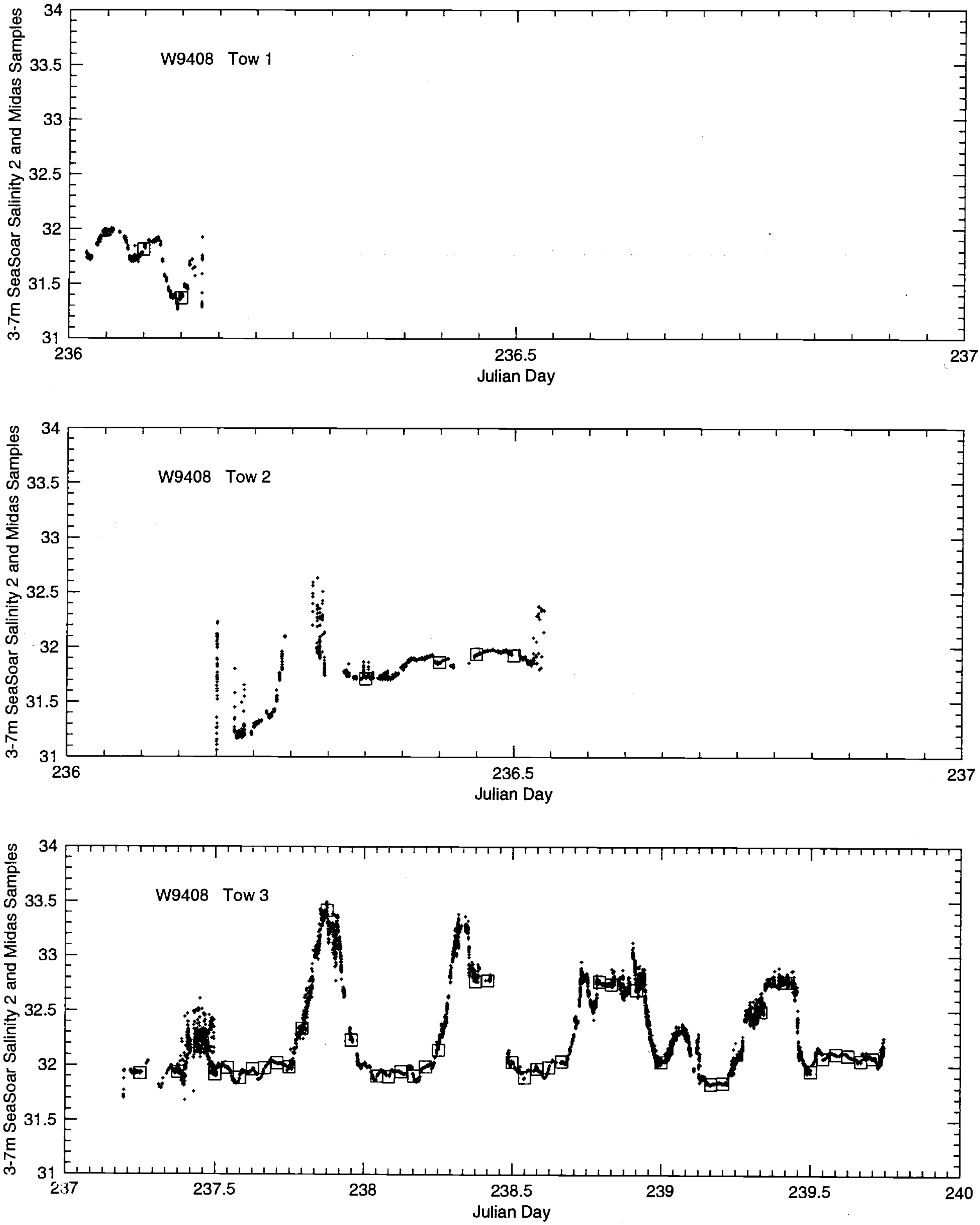


Figure 6: Time series of hourly samples from the ship's 5-m intake (squares) and of preliminary estimates of near-surface (3.0-7.9 m) SeaSoar salinity (dots) from the preferred sensor pair, for Tows 1-6 of W9408A.

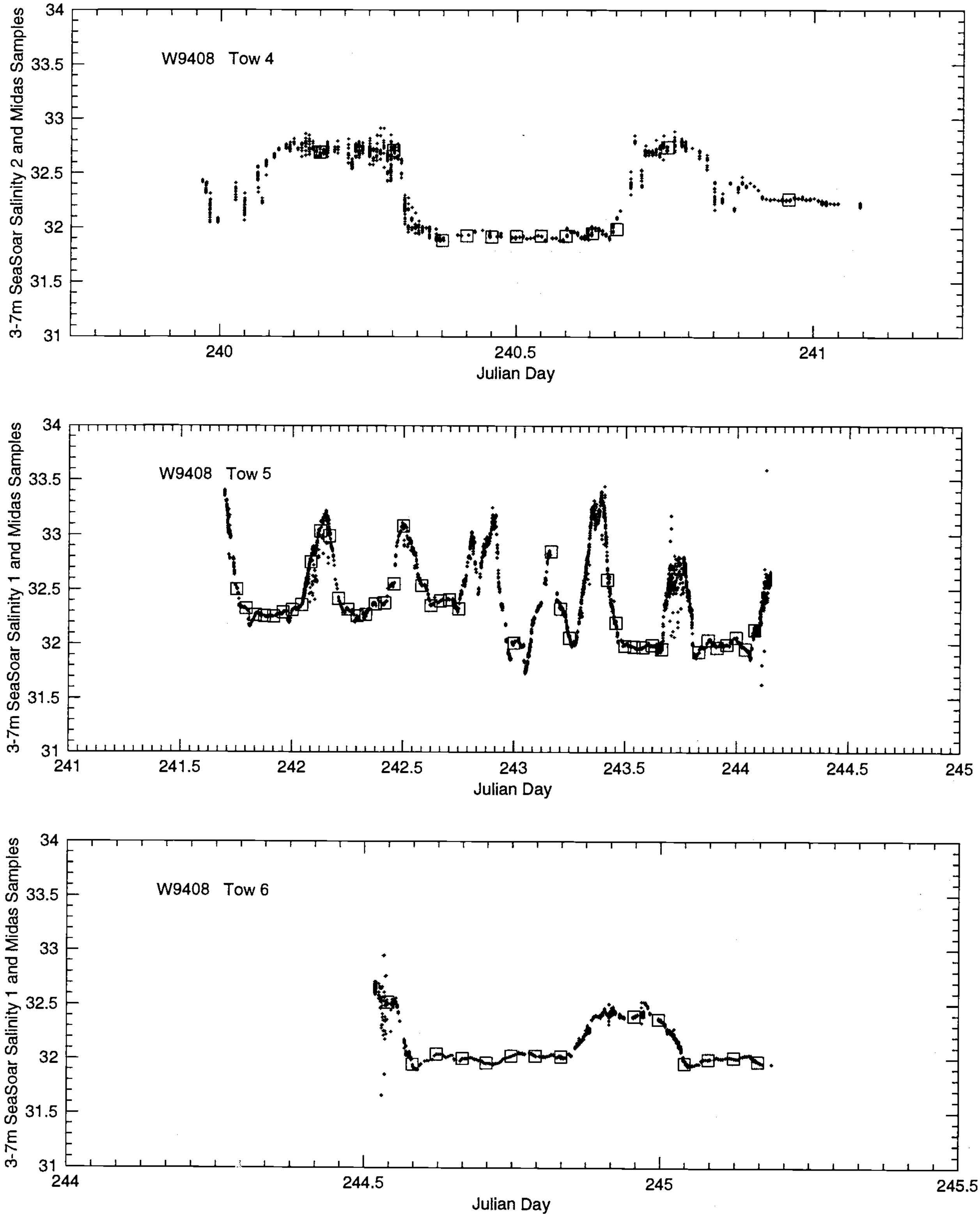


Figure 6: (continued)

comparison. Assuming, as usual, that the measured conductivity should be corrected by a multiplier alone, we calculated the slope (m) of the zero-intercept regression line between the measured conductivity and the sample conductivity separately for each sensor pair and for each SeaSoar tow (Table 6).

Tows 1 and 2 had too few calibration points to be meaningful, and there was no significant difference in the multiplier for the primary sensor pair between Tows 3 and 4, so the data from Tows 1, 2, 3 and 4 were pooled. The primary sensor appeared to be clogged during Tow 2 so data points from Tow 2 were eliminated in the final comparison for the primary sensor. Both the primary and secondary sensors required no conductivity correction (k1 and k2, Table 6) for Tows 1 through 4. During Tows 5 and 6, a systematic offset was noted between the two temperature sensors so the sensors had a post-cruise calibration done in December 1994. After the new calibration data were put into the configuration file, the SeaSoar data were reprocessed and this data were used for the comparison of the SeaSoar conductivity with the bottle samples. Since there was no significant difference in the mean conductivity difference between Tows 5 and 6 for either sensor pair, the data were pooled, and correction factors (k1 and k2) were determined for each sensor (Table 6).

Table 6: Conductivity multipliers (m1 and m2) for primary and secondary sensors, for W9408B, determined from comparison of near-surface SeaSoar data with 5-m intake samples, and the conductivity correction factors (k1 and k2) adopted for reprocessing the SeaSoar conductivity data. Also shown are the average and standard deviations of the salinity differences between the sample values and the corrected SeaSoar data.

						Average		Std Dev	
Tow	N	m1	m2	k1	k2	S1	S2	S1	S2
1	3	–	–	1.00000	1.00000	–	–	–	–
2	0/4	–	1.00006	1.00000	1.00000	–	0.002	–	0.007
3	42/40	1.00012	0.99999	1.00000	1.00000	0.004	0.000	0.009	0.009
4	12	1.00009	0.99995	1.00000	1.00000	0.003	-0.002	0.012	0.011
1-4	56/58	1.00010	0.99998	1.00000	1.00000	0.004	-0.001	0.009	0.009
5	42/39	1.00018	1.00019	1.00021	1.00022	0.006	0.007	0.009	0.008
6	12/11	1.00026	1.00025	1.00021	1.00022	0.009	0.009	0.002	0.003
5-6	56/52	1.00021	1.00022	1.00021	1.00022	0.008	0.008	0.008	0.007

Applying these multipliers to the SeaSoar conductivity data before recalculating salinity allows us to compare the corrected SeaSoar salinity values from both primary and secondary sensor ducts to the sample salinity. The time series of the differences (Figure 7) show reasonable agreement between sample and near-surface SeaSoar data for both sensor pairs during all tows, except sensor pair one in Tow 2.

Post-Processing of SeaSoar Data

Salinity data derived from Sea-Bird ducted temperature and conductivity sensors are subject to errors from three separate sources (Larson, 1992): (1) poor alignment of the 24-Hz temperature and conductivity data, (2) poor compensation for the transfer of heat between the mantle of the conductivity cell and the water flowing through it, and (3) mismatch of the effective time constants of the temperature and conductivity measurements. High-speed pumps, ducted-flow geometry, and sensor design to match response times are hardware measures which help to reduce these errors. Software is then used to align the temperature and conductivity data by some constant offset (typically 1.75 scans); a two-point recursive formula is applied to correct for the thermal mass of the conductivity cell (Lueck, 1990; Lueck and Picklo, 1990). For the results reported here, only the thermal mass correction and the offset between T and C need to be addressed in post-processing.

The primary complication for processing CTD data from SeaSoar is that the flow rate through the sensors might be variable (Huyer *et al.*, 1993). In previous OSU SeaSoar work where the T/C inlet and outlet ducts were both plumbed through the side of the SeaSoar's nose, variable flow rates seemed to be common (e.g., Huyer *et al.*, 1993; Kosro *et al.*, 1995). This same inlet and outlet arrangement was used on Tows 1-4 of this cruise, and we again found the lag of maximum correlation between T and C signals to be quite variable, particularly during descent (Appendix); thus it is necessary to correct for a variable T/C lag. The variable flow rate also impacts the thermal mass correction, where the amplitude and time constant of the correction are inversely proportional to flow rate (Lueck, 1990; Morrison *et al.*, 1994). Biological fouling can also impact the calculated lags between T and C; even when the flow rate is unaffected, partial fouling may lengthen the time response of the thermistor (Kosro *et al.*, 1995).

Because the lateral separation between adjacent SeaSoar profiles is typically small compared to the scale of changes in water-mass characteristics, it is possible to use the T-S plots of consecutive profiles to optimize the thermal mass correction. This was done in a qualitative manner for the earlier data sets (Huyer *et al.*, 1993; Kosro *et al.*, 1995). We have

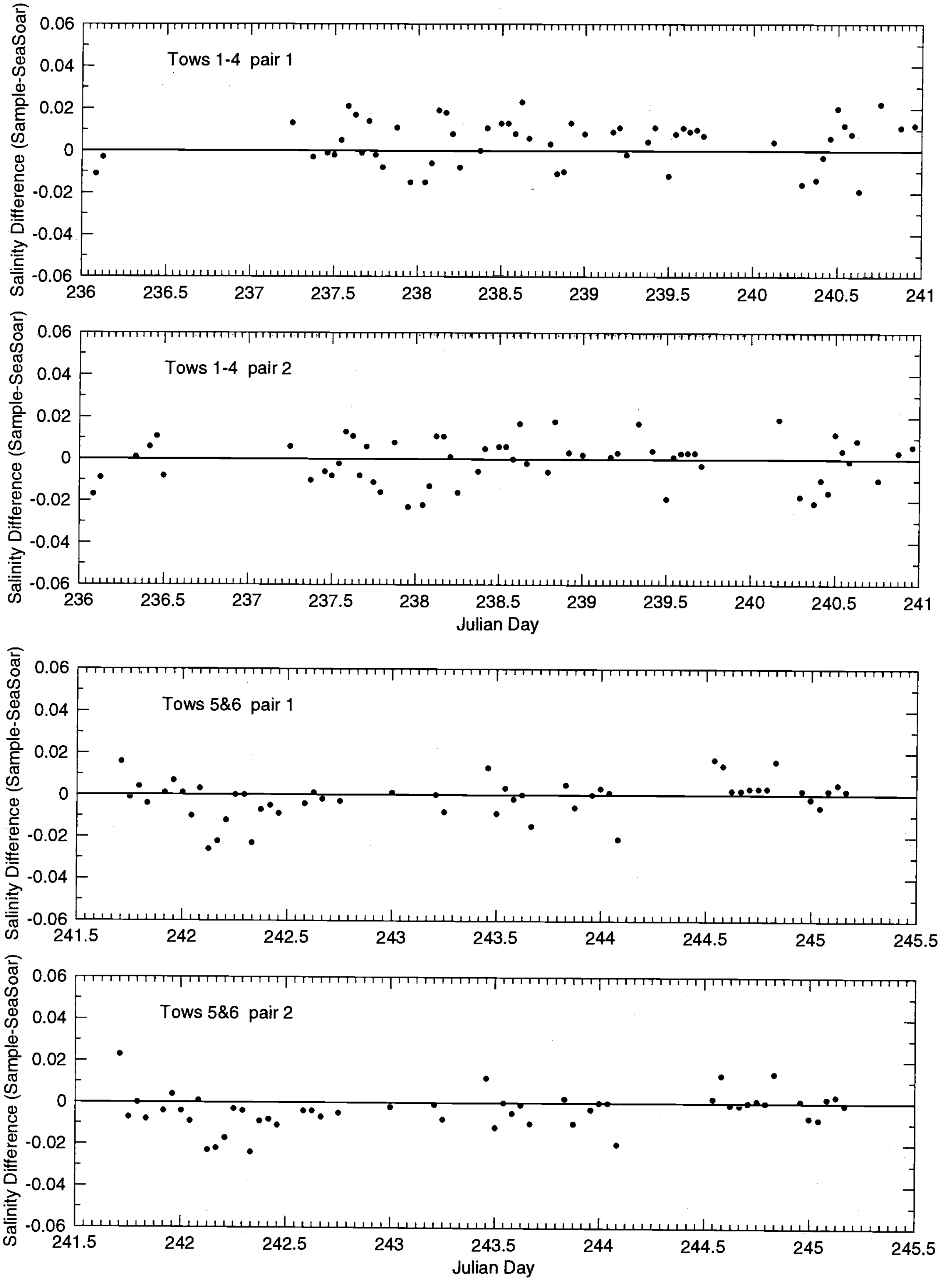


Figure 7: Time series of salinity differences between the 5-m samples and the matching corrected SeaSoar data from both sensor pairs, for Tows 1-6 of W9408A.

now developed a quantitative procedure to choose optimal values of the amplitude (α) and time constant (τ) for the thermal mass correction.

Before the data can be post-processed, three preliminary steps are required: (1) the sensors are calibrated using *in situ* data and/or post-cruise calibrations, (2) the time-series of lags between 24-Hz temperature and conductivity data are computed and cleaned (see below), and (3) optimal values of the thermal mass correction variables are determined. Once these steps are done, the SeaSoar data can be reprocessed. The final calibration values are used for the sensors; the time-series of lags are used to offset the temperature and conductivity signals; and a thermal mass correction is applied to the data, where the thermal mass variables α and τ are calculated from the observed lags. The final data are output as 1-Hz values, using a 24-point boxcar filter.

Use and cleaning of the time-series of lags between first-differenced temperature and conductivity has been described in previous reports (e.g., Huyer *et al.*, 1993). In general, three depth zones are used for the SeaSoar, and lags are calculated in these zones for ascending and descending trajectories. In this survey, the shallow tows on unfaired cable (Tows 1-3, 5, 6) used zones of: 20 to 60 dbar, 60 to 90 dbar, and 90 to 130 dbar. For the deep tow on faired cable (Tow 4) the three zones were: 20 to 120 dbar, 120 to 180 dbar, and 180 to 240 dbar. The time series of lags are then cleaned by discarding outliers from data segments that are very short or have relatively low correlations between T and C, and replacing them with local estimates of the lag based on nearby values. The sensor pair with the least noisy time-series of lags was chosen as the preferred sensor pair for final data processing, and the lags for the preferred sensor pair of each tow are shown in the Appendix. The lags for the forward-pointing sensors used in Tows 5 and 6 are significantly less noisy than those from the sideways-plumbed sensors (Figure 8), and they show essentially no difference between ascending and descending values. We conclude that the flow rate within the T/C duct is much more stable in the forward-pointing configuration.

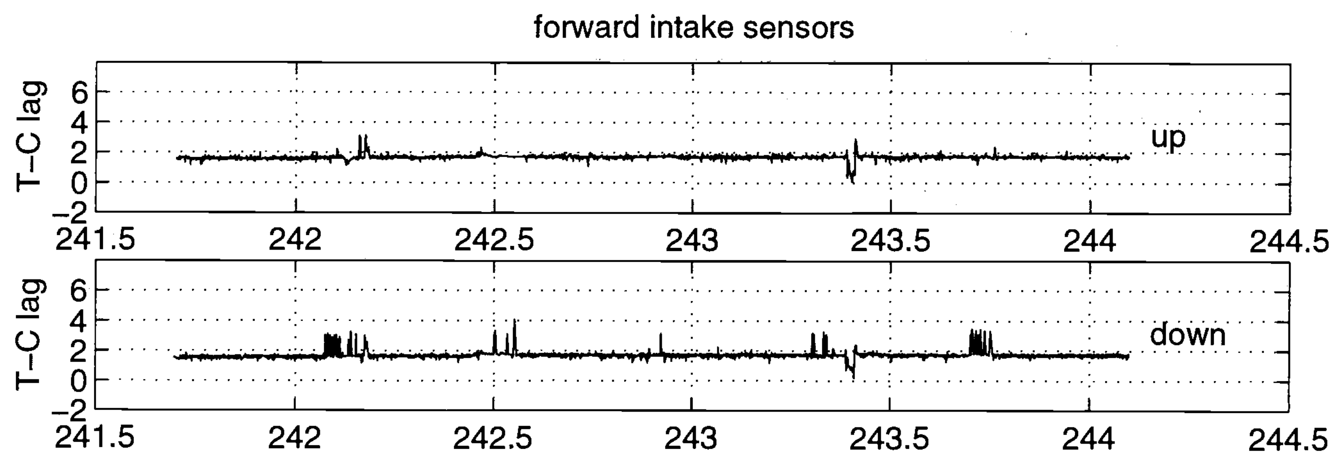
To apply a thermal mass correction we follow Lueck (1990) who presented a two-point recursive formula involving an amplitude (α) and a time constant (τ). We implement this with a recursive algorithm provided by Sea-Bird:

$$\Delta C_n = -bC_{n-1} + a(dC/dT)(T_n - T_{n-1}),$$

where

$$a = 2\alpha/(2 + \beta\Delta t)$$

$$b = 1 - 2a/\alpha$$



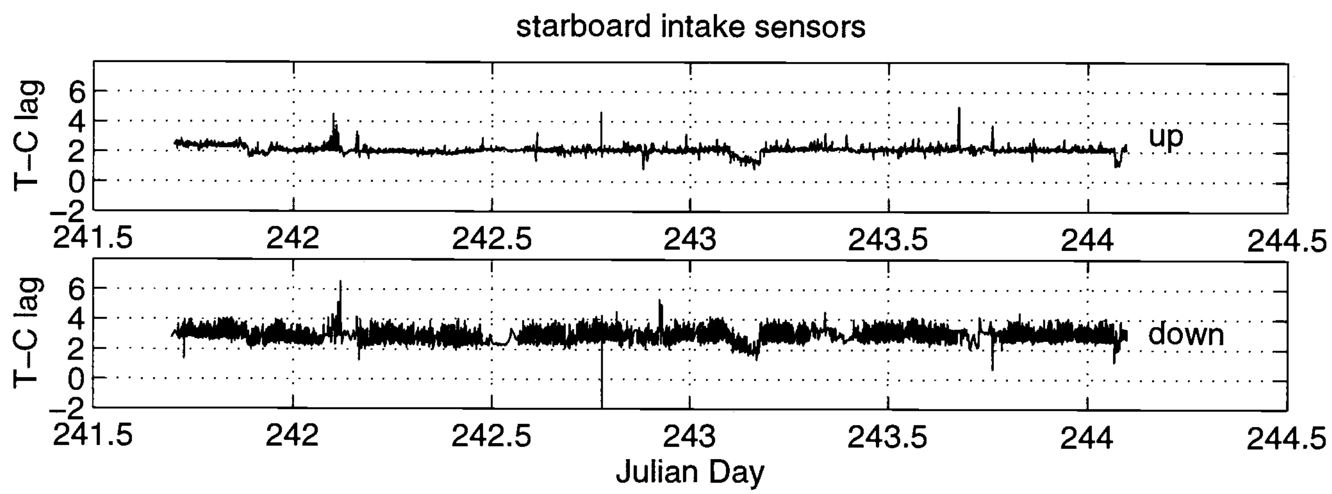


Figure 8: Time series of Tow 5 T-C lags, separately for upcast and downcast data.

$$\beta = 1/\tau$$

$$dC/dT = 0.1(1 + 0.006(T_n - 20)),$$

and ΔC_n is the conductivity correction at time n, C_{n-1} is the conductivity (in S m^{-1}) at the preceding time, T_n and T_{n-1} are the temperatures (°C) at times n and $n-1$, and Δt is the time between scans (1/24 sec).

Lueck suggested that α is inversely proportional to flow rate through the sensor duct, and that τ was weakly proportional to the inverse of the flow rate. Morrison *et al.* (1994) developed this further: α is inversely proportional to the flow rate as before, but now τ is inversely proportional to the square root of the flow rate:

$$\alpha = (0.0264/V) + 0.0135$$

$$\tau = (2.7858/\sqrt{V}) + 7.1499,$$

where V is the flow rate (m s^{-1}). Since our observed T-C lag is also inversely proportional to flow rate, α and τ can instead be posed in terms of the lag: α is now directly proportional to the T-C lag, and τ is directly proportional to the square root of the lag (ξ):

$$\alpha = \alpha_0 + \alpha_1 * \xi$$

$$\tau = \tau_0 + \tau_1 * \sqrt{\xi}.$$

The advantage in doing this is that lag values are readily observable from the data while flow rates are not.

Flow rate is in units of m s^{-1} so that lag can be expressed as:

$$\xi \Delta t = \Delta x / V$$

where Δx is the distance in meters from the temperature probe to the conductivity sensor, and Δt is the sampling interval. If the distance between the thermistor and the middle of the conductivity cell is 0.18 m (Morrison *et al.*, 1994, their figure 2) and the sampling rate is 24 Hz, then we can express the equations of Morrison *et al.* (1994) as:

$$\alpha = 0.0061\xi + 0.0135$$

$$\tau = 1.3403\sqrt{\xi} + 7.1499$$

Suppose we did not correct for the thermal mass of the conductivity cell. During a down trace the cell would be warmer than the water and transferring heat into the water within the conductivity cell; the measured conductivity would then be higher than the conductivity of the surrounding water. If no thermal mass correction is applied, the apparent salinity is too high during descent, and too low during ascent. This has the appearance of a hysteresis loop when plotted on a T-S diagram. If a series of thermal mass corrections are applied, with systematicaly increasing α and τ, the hysteresis loop would diminish until the up-trace lies on top of the down-trace, yielding the best estimates for α and τ. If the thermal mass correction is too strong (α and τ too large, for instance) the hysteresis loop would reappear on the other side, with the apparent salinity now too low during descent.

If we calculate the area (in T-S space) between successive up- and down-traces, then the optimal thermal mass correction is the one which minimizes this area; we would then have the best settings for α and τ. Since α and τ are both proportional to the observed lags but with the possibility of a constant offset, we seek optimal values for the slopes and offsets of α and τ (i.e., for $\alpha_0, \alpha_1, \tau_0, \tau_1$). If we consider the area in T-S space as our function and the slopes and offsets as variables, optimal settings are found by minimizing the function of four variables. There are well established routines for this and we chose to use one from the International Math and Science Library (IMSL) which uses a quasi-Newton method and a finite-difference gradient (routine UMINF).

Test hours were chosen for the two different sensor configurations used on this cruise (see Table 4). Thermal mass corrections were estimated using four test hours for Tows 1-4 (two each from Tow 3 and Tow 4), and five test hours for Tows 5-6 (all from Tow 5). This test data set was then processed with an initial slope and offset for α and τ, and the area in T-S space between successive up- and down-traces was computed for each of the hours, and then summed as a whole. The IMSL routine was used to vary the values for the slopes and offsets until a minimum of the summed area was found. These slopes and offsets which minimized the area for the test data were then applied as the settings for the appropriate tows. These values are summarized in Table 7.

Table 7: Optimized slope and offset values for use in the thermal mass correction.

tow	preferred sensor	α_1	α_0	τ_1	τ_0
1–4	starboard	0.0006	0.043	1.036	7.18
5–6	forward	0.0042	0.014	1.050	7.15

We can compare the results of Morrison *et al.* (1994) with the values reported in Table 7. The values of α_0 and τ_0 for the forward-pointing sensor pair (Tows 5 and 6) essentially match those given in the equations by Morrison *et al.* (1994). The value of τ_0 for the starboard sensor pair (Tows 1-4) also agrees, but α_0 is substantially different. The slope values (α_1 and τ_1) for the forward-pointing sensors are also closer to the values given by Morrison *et al.* (1994) than those for the starboard sensors. This is additional confirmation that the forward-pointing sensors are superior to the sideways-plumbed sensors.

As an example of the very high resolution possible using the superior forward-pointing sensors and the quantitative method for optimizing the thermal mass corrections, Figure 9 shows the T-S diagram for 04:00 hour (UTC) on August 30. The close-up of detail in that figure has solid lines for the upcast data, and dashed lines for the downcast data. The gradient in water-mass characteristics is clearly resolved by successive up- and down-cast traces in the post-processed data.

Using the variable lags (shown in the Appendix) and the thermal mass slopes and offsets (Table 7), the 24-Hz temperature and conductivity data were realigned and corrected, and used to calculate 24-Hz salinity, and these were averaged to yield 1-Hz values stored in hourly files. Reprocessed data were plotted to confirm our choice of the preferred sensor pair, and to see if additional cleaning was required. The forward-pointing sensors used in Tows 5 and 6 were the preferred sensor pair, but they fouled several times in Tow 5. When this happened, the sensors would typically clog as they descended, and then clear before starting their next ascent. In these cases, the data from the alternate sideways-plumbed sensor pair were substituted when applicable. Table 8 summarizes when this took place.

Data Presentation

The final 1-Hz data files contain unfiltered GPS latitude and longitude; pressure; temperature, salinity and σ_t from the preferred sensor pair; date and time (both in decimal year-day and integer year, month, day, hour, minute, second); an integer representing flags (thousands digit of 1 indicates collection of a water sample from 5-m intake, hundreds digit of 1 indicates a ship turn has started, hundreds digit of 2 indicates the SeaSoar has reversed direction, tens digit of 1 indicates missing GPS data filled by linear interpolation, and ones digit indicates port for Tows 1-4 and forward-pointing for Tows 5-6 (0) or starboard (1) intake for the T/C sensor pair); voltage (0-5 volts) from the SeaTech fluorometer (Tows 1-4 only); and voltage (0-5 volts) from the SeaTech transmissometer (Tows 1-4 only). Successive hourly files of the reprocessed 1-Hz average SeaSoar CTD data were joined and clipped to construct data files for each line of Tows 1-6 (Figures 10-13, Table 9).

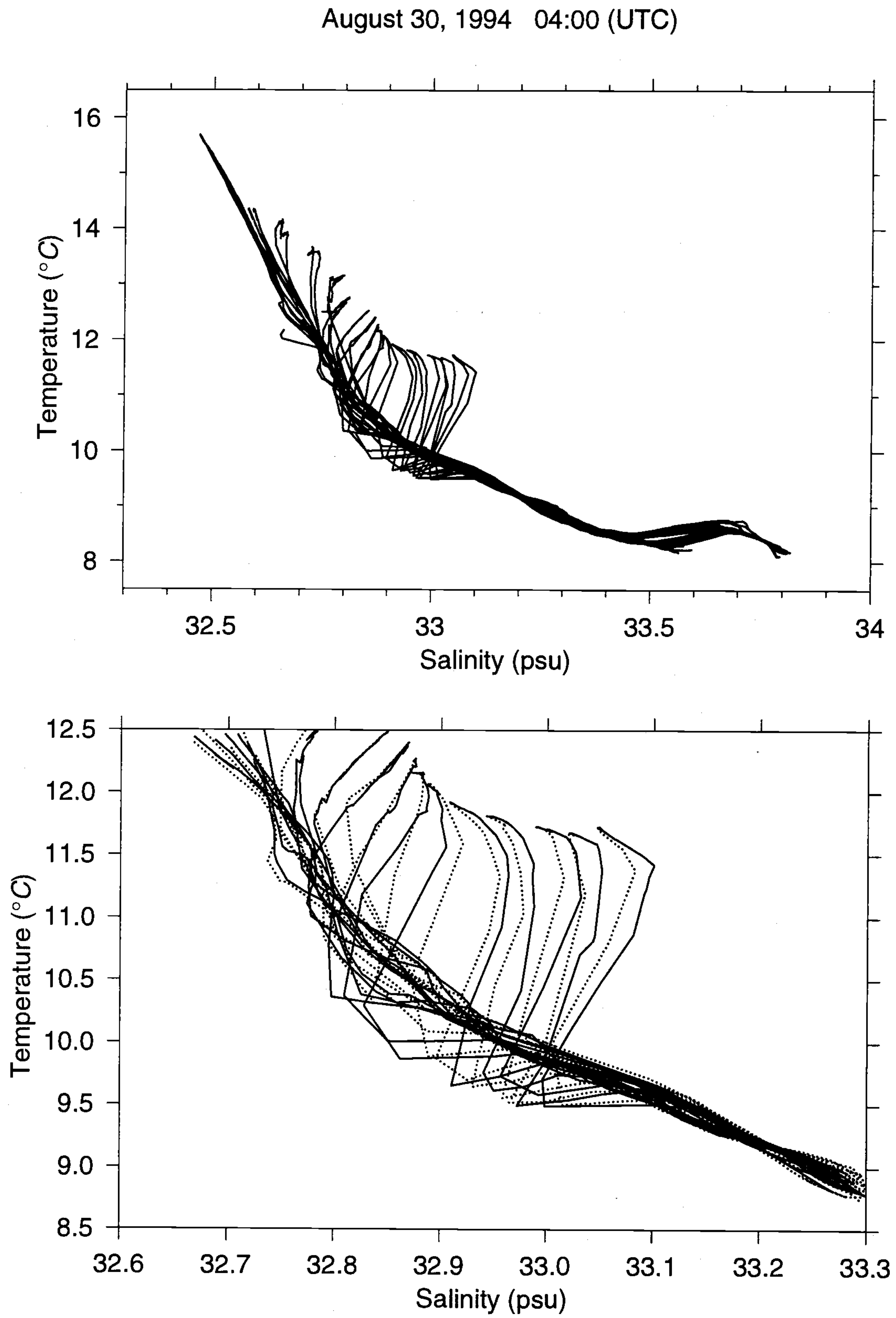


Figure 9: High resolution data from forward-pointing sensor pair with post-processing.

Table 8: Times of forward-pointing sensor clogging in Tow 5 and replaced with data from the starboard sideways-plumbed sensors. At times UTC.

date (yy/mm/dd)	start (hh:mm:ss)	stop (hh:mm:ss)	duration (mm:ss)
94/08/29	17:08:28	17:09:29	01:01
	17:14:23	17:15:23	01:00
94/08/30	01:48:08	01:49:08	01:00
	01:54:41	01:55:41	01:00
	01:56:15	01:57:15	01:00
	02:04:45	02:05:46	01:01
	02:09:25	02:10:25	01:00
	02:10:55	02:11:56	01:00
	02:12:25	02:13:26	01:01
	02:19:52	02:20:53	01:01
	02:22:48	02:23:49	01:01
	02:25:41	02:26:42	01:01
	02:27:07	02:28:07	01:01
	02:32:55	02:33:56	01:01
	02:40:06	02:41:07	01:01
	02:49:20	02:50:21	01:01
	03:12:44	03:13:45	01:01
	03:19:53	03:20:54	01:01
	03:39:22	03:40:22	01:00
	03:48:02	03:49:02	01:00
	03:52:21	03:53:21	01:00
	12:01:04	12:02:05	01:01
	12:04:48	12:05:49	01:01
	12:08:31	12:09:32	01:01
	12:26:42	12:27:43	01:01
	12:30:24	12:31:25	01:01
	12:48:31	12:49:31	01:00
	13:13:53	13:14:53	01:00
	20:44:42	20:45:43	01:01
	22:05:36	22:06:37	01:01
94/08/31	07:17:18	07:18:19	01:01
	07:23:09	07:24:09	01:00
	07:58:31	07:59:32	01:01
	08:08:32	08:09:33	01:01
	09:25:44	09:26:45	01:01
	09:41:29	09:42:30	01:01
	16:50:46	16:51:47	01:01
	16:54:36	16:55:37	01:01
	16:59:43	17:00:44	01:01
	17:10:01	17:11:01	01:00
	17:18:12	17:19:12	01:00
	17:26:13	17:27:13	01:00
	17:41:52	17:42:53	01:01
	18:01:26	18:02:26	01:00
94/09/01	02:44:02	02:45:02	01:00
	02:59:51	03:00:52	01:01
	03:08:02	03:09:03	01:01

In the body of this report, we summarize the results of the conventional CTD casts and the thermohaline data from the SeaSoar tows. For the CTD stations, we provide plots of the vertical profiles of temperature, salinity, σ_t, fluorescence voltage, transmissometer voltage, and listings of observed and calculated variables at standard pressures.

For the SeaSoar observations, we split the tow data into two maps where data from the beginning of Tow 5 is included in both maps to give better spatial coverage. Maps of temperature, salinity and σ_t are shown at 5, 15, 25, 50, 75, 100 and 115 db. These depths were chosen to represent the near-surface (5 db), for comparison with tracks of drifters drogued at 15 m, for comparison with maps of ADCP velocity at the same depths (25, 50, 75, 100 db) (Pierce *et al.*, 1996) and to show the deepest routinely measured level (115 db). Data used in the maps were obtained by linearly interpolating the 1-Hz SeaSoar data in the vertical to the specified map depths. Contour maps are created by gridding the data using zgrid (Crain, 1968, unpublished) where for Map 1 (Map 2) the grid is 32 (31) in the E-W direction and 32 (62) in the N-S direction and any grid point more than four (five) grid spaces from the nearest data point is set to undefined. The differing grid sizes were chosen so that no blank spaces appear in Map 1 near the more widely spaced lines 9-15, but to maintain equal E-W and N-S grid spacing in Map 2.

The maps of dynamic topography show geopotential anomaly in J/kg (m^2s^{-2}) at 5, 15, 25, 50 and 75 db relative to 100 db. On E-W sections where the SeaSoar profiles were shallower than 100 db, dynamic height was calculated using the extrapolation technique described by Reid and Mantyla (1976) where $\Delta D_{p/100}$ is calculated by linear extrapolation from the next offshore pair of stations and $\Delta D_{map\text{-}pressure/100}$ is calculated directly from the SeaSoar CTD data. Along the short, shallow, inshore, N-S SeaSoar lines, the N-S slope of the dynamic height between the deepest common pressure relative to 100 db at the inshore ends of the two E-W lines at either end of the shallow N-S line is assumed to be a constant all along the N-S line. The $\Delta D_{map\text{-}pressure/100}$ is then calculated by integrating directly from the shallow SeaSoar profiles. This method is equivalent to assuming that there is no N-S horizontal shear in the E-W geostrophic velocity near the bottom.

Vertical sections of temperature, salinity and σ_t are shown for each of the SeaSoar lines and summary T-S diagrams are shown for data from Tows 1-4 and for Tows 5-6.

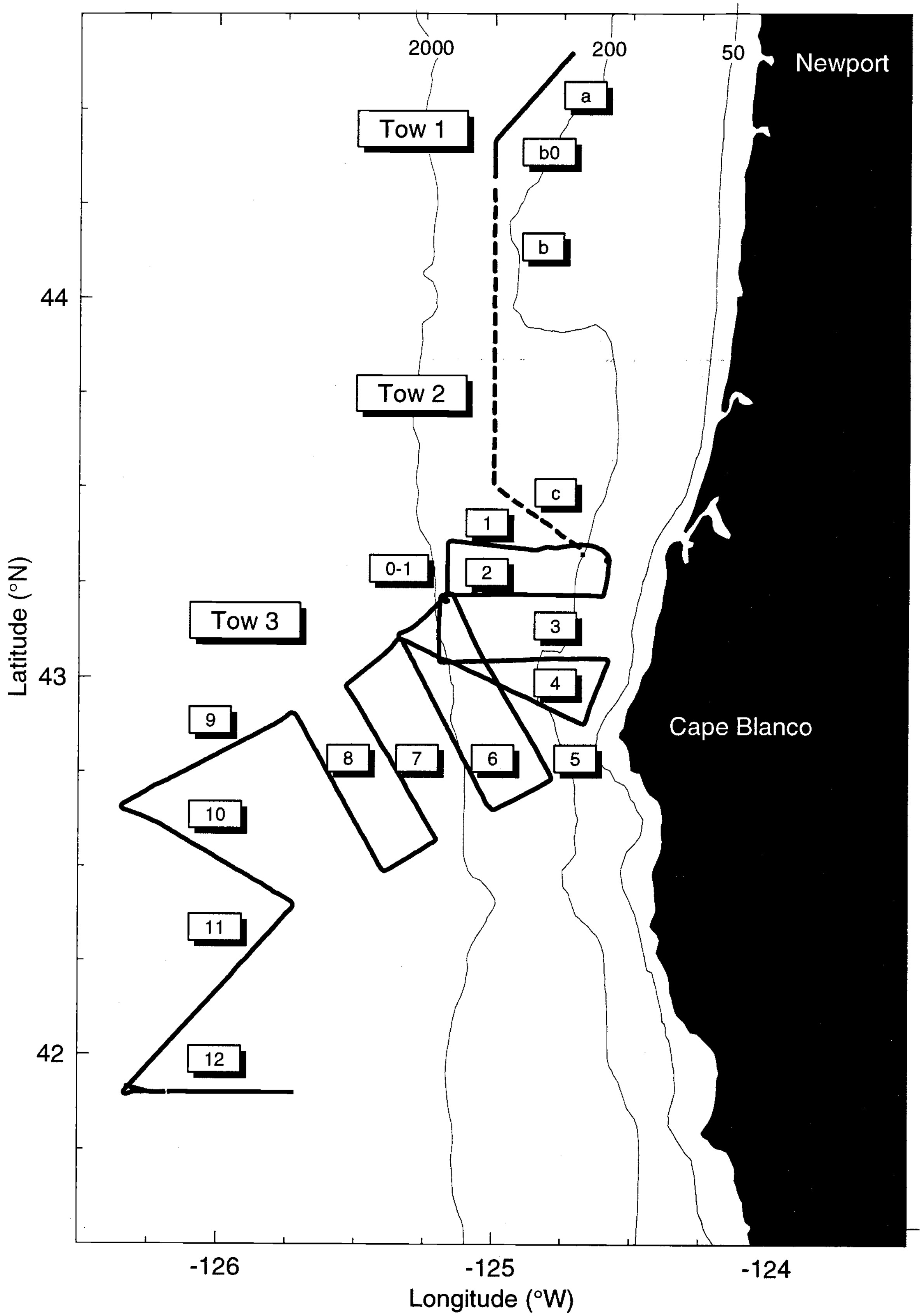


Figure 10: Line names for SeaSoar Tows 1-3 of W9408A.

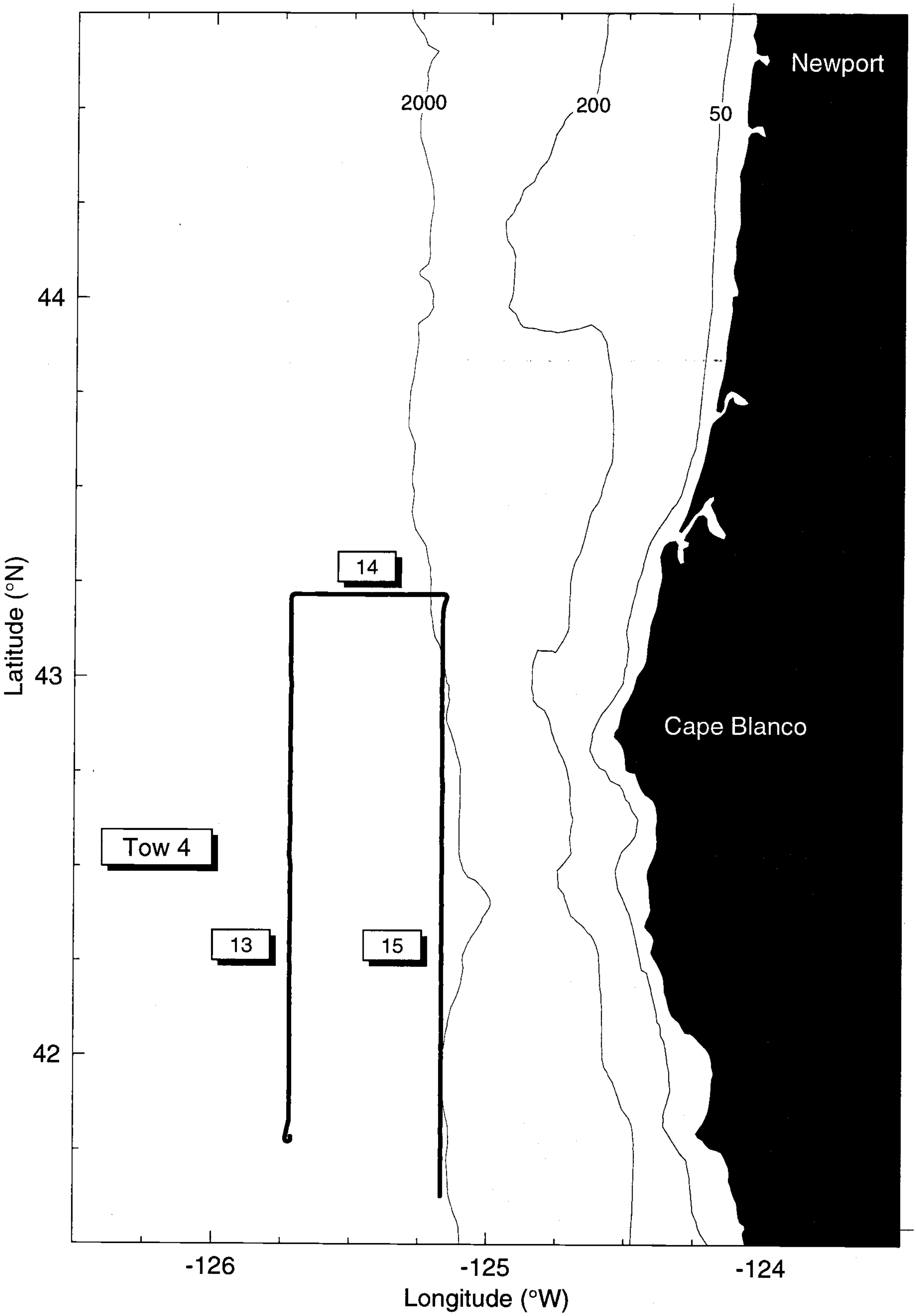


Figure 11: Line names for SeaSoar Tow 4 of W9408A.

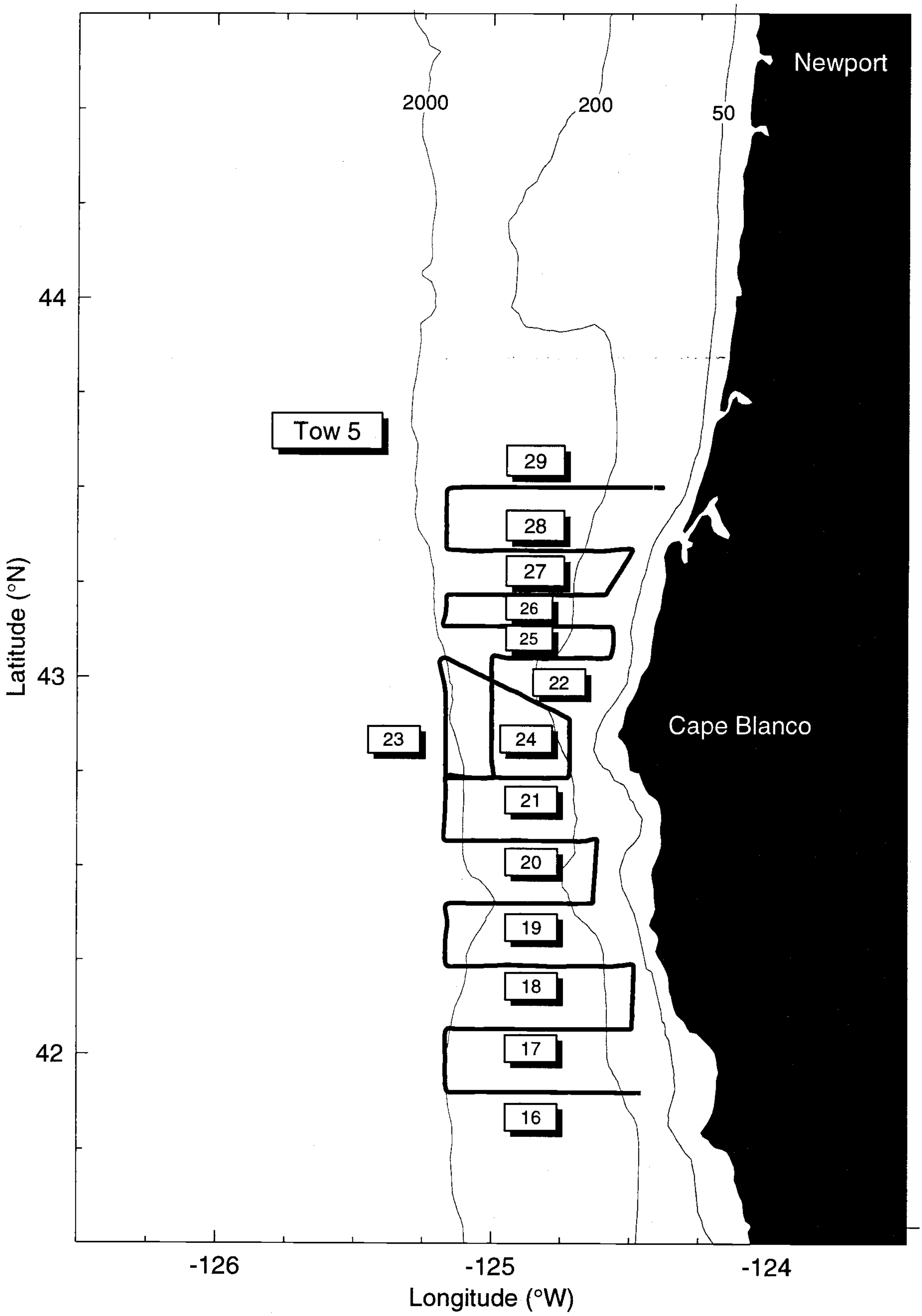


Figure 12: Line names for SeaSoar Tow 5 of W9408A.

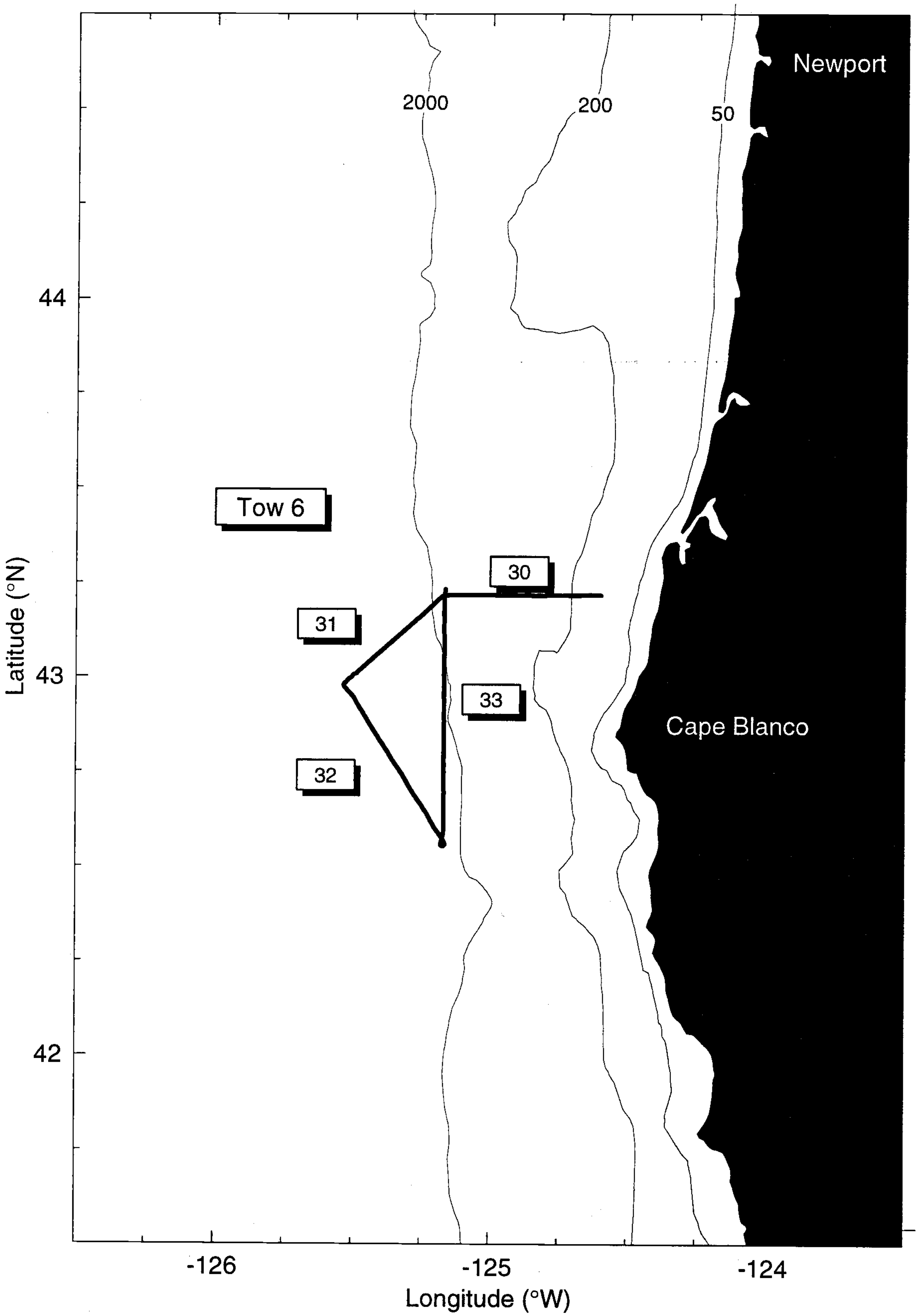


Figure 13: Line names for SeaSoar Tow 6 of W9408A.

Table 9: W9408A Waypoints and Turn Times.

Tow	Waypoint	Line	Latitude (°N)	Longitude (°W)	Turn Times (UTC Year Day)
1	NH-25		44 39.1	124 38.8	235.99236
		a			
	A1		44 25.0	125 0.0	236.11406
		b0			
	recovery				236.14858
2	deployment				236.16667
		b			
	A2		43 30.0	125 0.0	236.44323
		c			
	A3		43 20.0	124 40.0	236.53343
3	FM-9		43 13.0	125 10.0	237.19653
		0-1			
	B1		43 20.0	125 10.0	237.26668
		1			
	B2		43 20.0	124 35.0	237.40106
		1-2			
	B3		43 13.0	124 36.0	237.46374
		2			
	B4		43 13.0	125 10.0	237.60896
		2-3			
	B5		43 3.0	125 10.0	237.66469
		3			
	B6		43 3.0	124 35.0	237.83339
		3-4			
	B7		42 52.5	124 40.0	237.89301
	B5		43 3.0	125 10.0	no turn
		4			
	C6		43 6.0	125 20.0	238.08160
		4-5			
	C3		43 13.0	125 10.0	238.14910
		5			
	C4		42 44.0	124 47.0	238.33302
		5-6			
	C5		42 38.4	125 0.0	238.39498
		6			
	C6		43 6.0	125 20.0	238.56529
		6-7			
	C7		42 58.9	125 31.8	238.63083
		7			
	C8		42 34.0	12[illegible] 12.0	238.79883
		7-8			
	C9		42 29.0	125 23.7	238.84777
		8			
	C10		42 54.3	125 43.1	239.00609

W9408A Waypoints and Turn Times continued.

Tow	Waypoint	Line	Latitude (°N)	Longitude (°W)	Turn Times (UTC Julian Day)
3	C10		42 54.3	125 43.1	239.00609
		9			
	D1		42 40.0	126 20.0	239.18299
		10			
	D2		42 24.0	125 43.1	239.36606
		11			
	D3		41 54.0	126 20.0	239.59054
		12			
	D4		41 54.0	125 43.1	239.76041
4	D4		41 54.0	125 43.1	239.91808
		13			
	E1		43 13.0	125 43.1	240.42291
		14			
	E2		43 13.0	125 10.0	240.55296
		15			
	E3		41 54.0	125 10.0	241.07822
5	F1		41 54.0	124 28.0	241.69306
		16			
	CR-8		41 54.0	125 10.0	241.87027
		16-17			
	F3		42 04.0	125 10.0	241.91979
		17			
	F2		42 04.0	124 28.0	242.08259
		17-18			
	F5		42 14.0	124 29.0	242.14956
		18			
	F4		42 14.0	125 10.0	242.30961
		18-19			
	F7		42 24.0	125 10.0	242.35918
		19			
	F6		42 24.0	124 37.0	242.49523
		19-20			
	F9		42 34.0	124 39.0	242.55606
		20			
	F8		42 34.0	125 10.0	242.68956
		20-21			
	F11		42 44.0	125 10.0	242.74337
		21			
	F10		42 44.0	124 43.0	242.84197
		21-22			
	F12		42 53.5	124 43.0	242.89497
		22			
	B5		43 03.0	125 10.0	243.01163
		23			
	F11		42 44.0	125 10.0	243.11317

W9408A Waypoints and Turn Times continued.

Tow	Waypoint	Line	Latitude (°N)	Longitude (°W)	Turn Times (UTC Julian Day)
5	F11		42 44.0	125 10.0	243.11317
		23-24			
	F13		42 44.0	125 00.0	243.15485
		24			
	F14		43 03.0	125 00.0	243.26567
		25			
	B6		43 03.0	124 34.0	243.36902
		25-26			
	G1		43 08.0	124 34.0	243.39477
		26			
	G2		43 08.0	125 10.0	243.54061
		26-27			
	B4		43 13.0	125 10.0	243.56602
		27			
	B3		43 13.0	124 36.5	243.70751
		27-28			
	B2		43 20.0	124 29.5	243.75531
		28			
	B1		43 20.0	125 10.0	243.91462
		28-29			
	G3		43 30.0	125 10.0	243.96764
		29			
	G4		43 30.0	124 21.0	244.15161
6	H1 (FM-4)		43 13.0	124 35.0	244.51806
		30			
	H2 (FM-9)		43 13.0	125 10.0	244.65897
		31			
	H3		42 58.9	125 31.8	244.77424
		32			
	H4		42 34.0	125 10.0	244.94764
		33			
	H2 (FM-9)		43 13.0	125 10.0	245.18744

Acknowledgements

We are indebted to the OSU Marine Technicians: Marc Willis, Mike Hill and Tim Holt; they were responsible for the highly successful SeaSoar operations. We thank Nordeen Larson of Sea-Bird Electronics for his advise on installing the Sea-Bird sensors in the SeaSoar vehicle and on data processing principles. Steve Pierce contributed valuable assistance in both data collection and in preparation of this report. The officers and crew of the R/V Wecoma performed superbly – only occasionally would they comment on the fact that we insisted on towing the SeaSoar in an E-W direction, invariably in the trough of the prevailing summer swell. Funding for the new placement of the T/C sensors inside the SeaSoar's nose was provided by a supplement from the Ocean Technology Program at the National Science Foundation. This work was funded by the National Science Foundation Grant OCE-9314370.

References

Anonymous, 1992. *CTD Data Acquisition Software, SEASOFT Version 4.xxx.* Sea-Bird Electronics, Inc., Bellevue, Washington, USA.

Barth, J. A. and R. L. Smith, 1996. Coastal ocean circulation off Oregon: Recent observations of spatial and temporal variability. In *Estuarine and Ocean Survival of Northeastern Pacific Salmon, NOAA Technical Memorandum*, NMFS, NWFSC, in press.

Culkin, F. and N. D. Smith, 1980. Determination of the concentration of potassium chloride having the same electrical conductivity, at 15 C and infinite frequency, as standard seawater of salinity 35.000 °/₀₀ (chlorinity 19.37394 °/₀₀). *IEEE Journal of Ocean Engineering*, **OE-5**, 22–23.

Fofonoff, N. P. and R. C. Millard, 1983. *Algorithms for computation of fundamental properties of seawater.* Unesco Technical Papers in Marine Science, 44 53 pp.

Huyer, A., P. M. Kosro, R. O'Malley and J. Fleischbein, 1993. *Seasoar and CTD Observations during a COARE Surveys Cruise, W9211C, 22 January to 22 February 1993.* College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis. Reference 93-2, Data Report 154, October 1993.

Kosro, P. M., J. A. Barth, J. Fleischbein, A. Huyer, R. O'Malley, K. Shearman and R. L. Smith, 1995. *SeaSoar and CTD Observations during EBC Cruises W9306A and W9308B June to September 1993.* College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis. Reference 95-2, Data Report 160, October 1993.

Larson, N., 1992. *Oceanographic CTD Sensors: Principles of Operation, Sources of Error, and Methods for Correcting Data.* Sea-Bird Electronics, Inc., Bellevue, Washington, USA.

Lueck, R., 1990. Thermal inertia of conductivity cells: Theory. *J. Atmos. Oceanic Tech.*, **7**, 741–755.

Lueck, R. and J. J. Picklo, 1990. Thermal inertia of conductivity cells: Observations with a Sea-Bird cell. *J. Atmos. Oceanic Tech.*, **7**, 756–768.

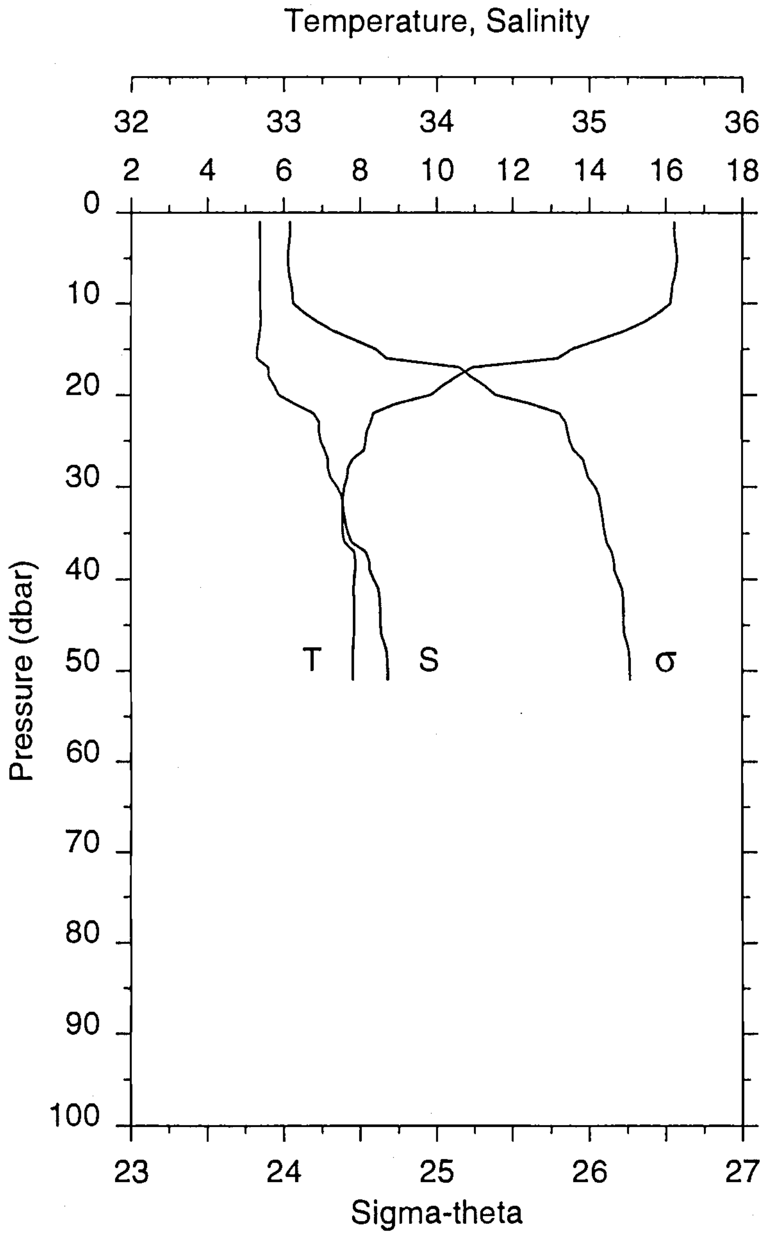
Morrison, J., R. Andersen, N. Larson, E. D'Asaro and T. Boyd, 1994. The correction for thermal-lag effects in Sea-Bird CTD data. *J. Atmos. Oceanic Tech.*, **11**, 1151–1164.

Pierce, S. D., J. A. Barth and R. L. Smith, 1996. *Acoustic Doppler Current Profiler observations during the Coastal Jet Separation project on R/V Wecoma, August 23 to September 2, 1994.* College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis. Reference 95–3, Date Report 161, October 1996.

Reid, J. L. and A. W. Mantyla, 1976. The effect of geostrophic flow upon coastal sea elevations in the northern North Pacific Ocean. *J. Geophys. Res.*, **81**, 3100–3110.

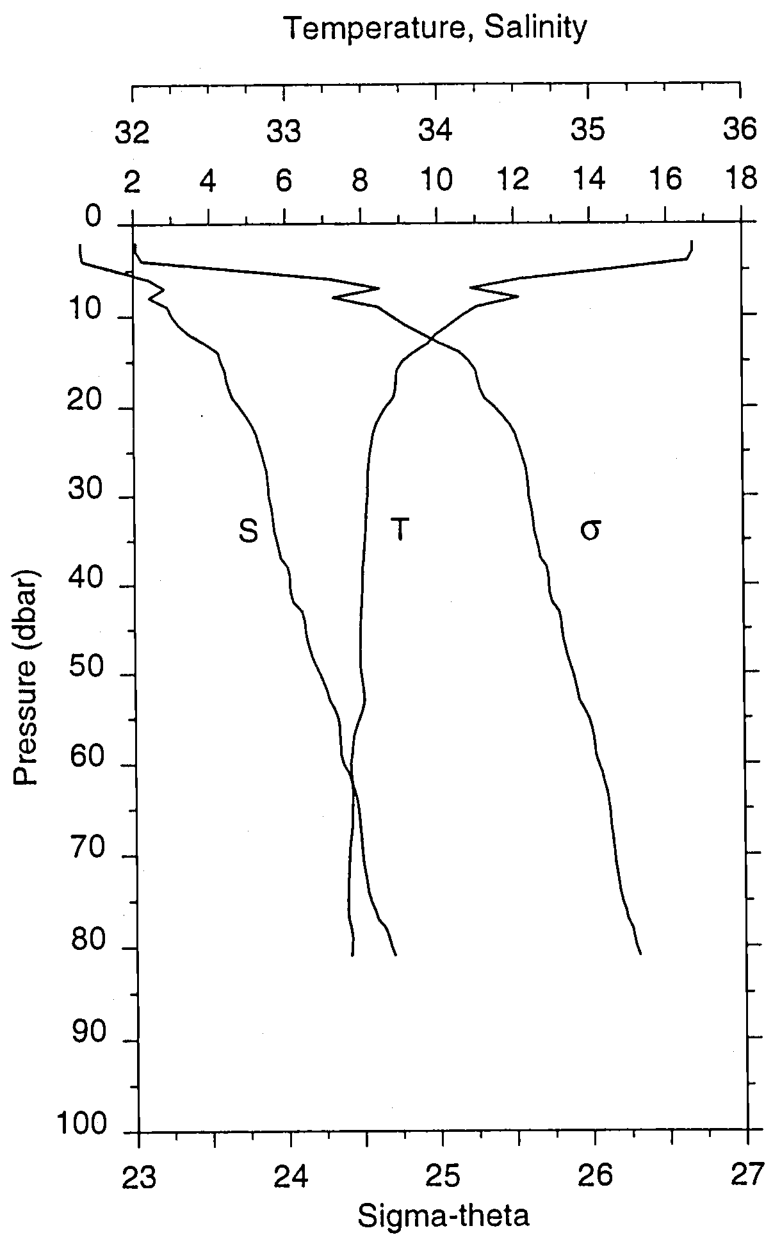
CTD Data

For each station, we present plots of the vertical profiles of temperature, salinity and σ_t, and a listing of the observed and derived variables at standard pressures. Header data includes the CTD Station Number, Latitude (degrees and minutes North), Longitude (degrees and minutes West), Date and Time (UTC), and Bottom Depth (in meters).



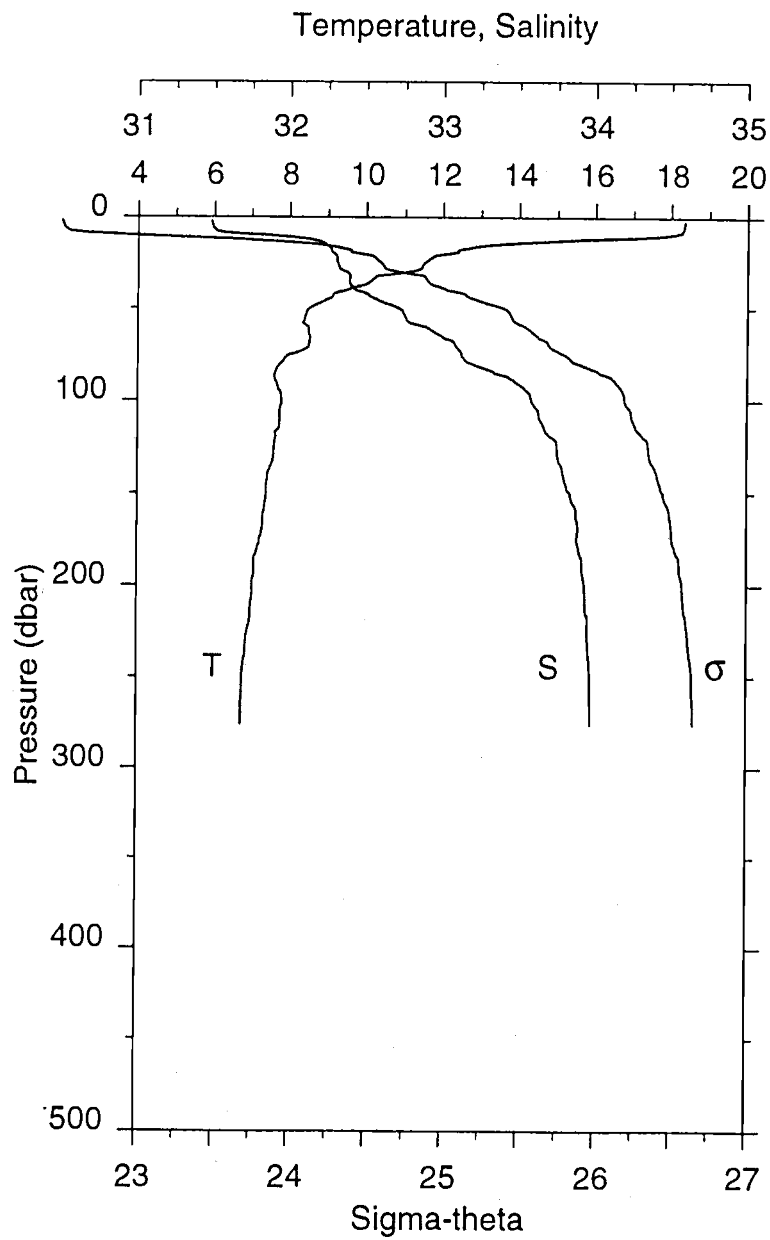
STA: 1 NH-5 LAT: 44 39.1 N LONG: 124 10.7 W
23 AUG 1994 1935 GMT DEPTH 60

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
1	16.223	32.842	16.223	24.039	386.4	0.039
10	16.128	32.846	16.127	24.063	384.3	0.386
20	9.861	32.967	9.858	25.388	258.2	0.712
30	7.600	33.353	7.597	26.039	196.5	0.926
40	7.858	33.590	7.854	26.188	182.5	1.115
50	7.825	33.682	7.821	26.265	175.4	1.294
51	7.825	33.683	7.820	26.266	175.3	1.311



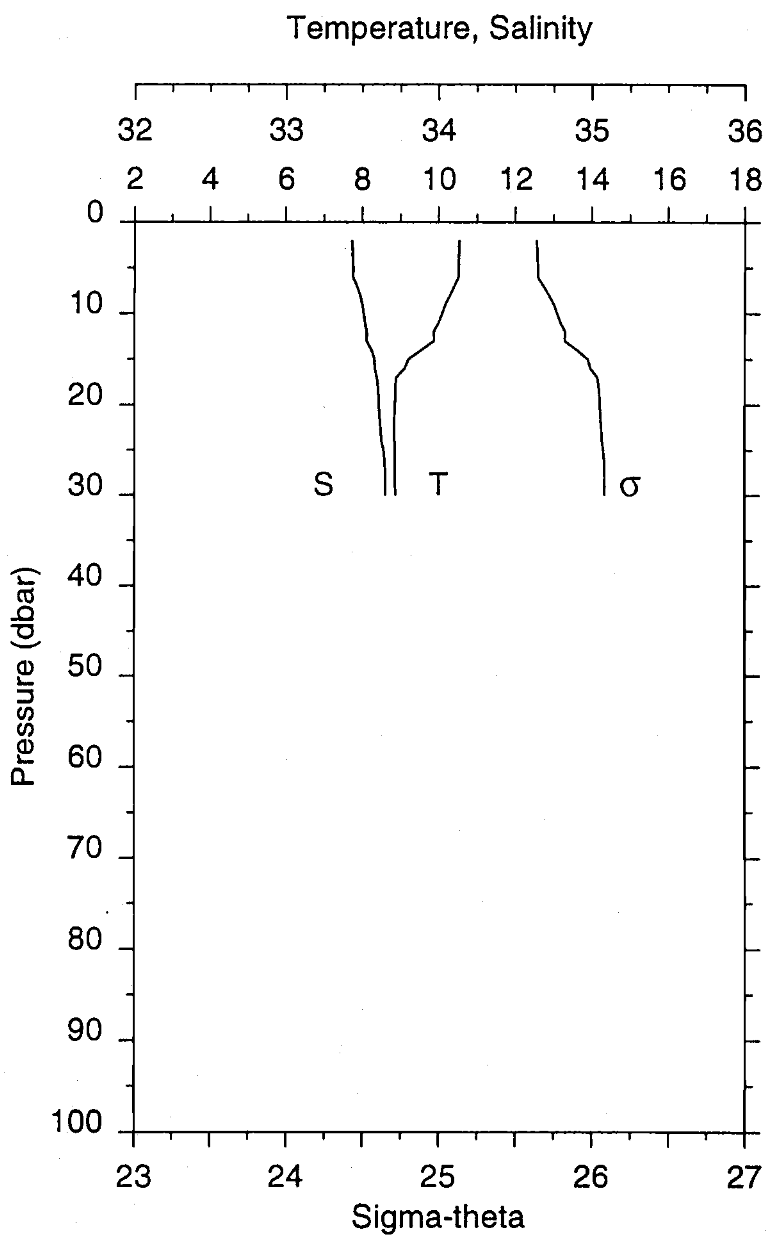
STA: 2 NH-15 LAT: 44 39.1 N LONG: 124 24.9 W
23 AUG 1994 2109 GMT DEPTH 90

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
2	16.704	31.654	16.704	23.017	484.0	0.097
10	10.644	32.252	10.643	24.699	323.6	0.414
20	8.639	32.696	8.637	25.371	259.8	0.698
30	8.146	32.885	8.143	25.592	238.9	0.943
40	7.994	33.023	7.991	25.723	226.7	1.176
50	7.957	33.216	7.952	25.880	211.9	1.395
60	7.660	33.368	7.655	26.043	196.6	1.599
70	7.619	33.492	7.612	26.146	186.9	1.790
80	7.676	33.676	7.669	26.282	174.2	1.971
81	7.655	33.700	7.648	26.305	172.1	1.989



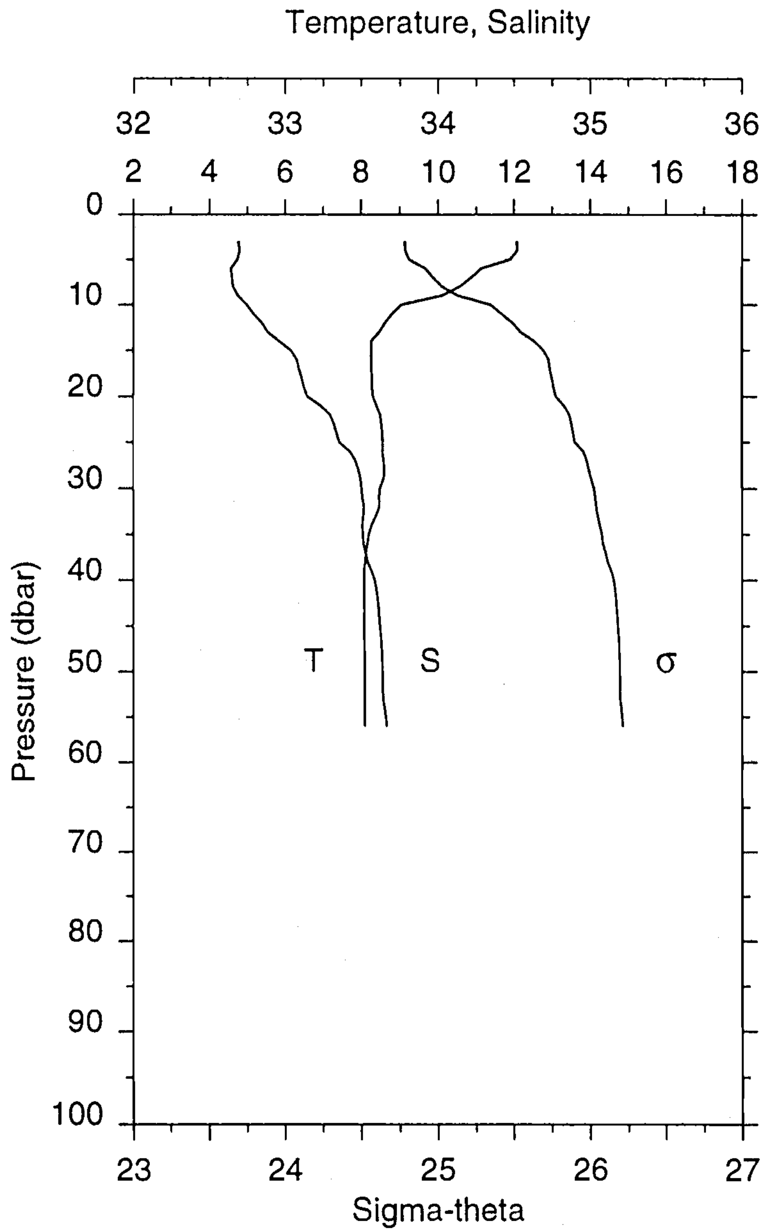
STA: 3 NH-25 LAT: 44 39.1 N LONG: 124 39.0 W
23 AUG 1994 2238 GMT DEPTH 298

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
2	18.342	31.479	18.342	22.496	533.8	0.107
10	17.744	31.865	17.743	22.936	492.0	0.529
20	12.139	32.290	12.136	24.460	346.6	0.919
30	11.067	32.373	11.064	24.719	322.1	1.253
40	9.493	32.428	9.489	25.028	292.9	1.558
50	8.505	32.714	8.500	25.405	257.1	1.832
60	8.496	32.889	8.490	25.544	244.1	2.084
70	8.501	33.082	8.494	25.695	229.9	2.321
80	7.753	33.193	7.746	25.892	211.3	2.542
90	7.638	33.476	7.629	26.131	188.8	2.740
100	7.783	33.581	7.774	26.193	183.1	2.925
110	7.741	33.637	7.730	26.243	178.5	3.105
120	7.643	33.721	7.631	26.323	171.0	3.280
130	7.586	33.753	7.574	26.357	168.0	3.449
140	7.427	33.791	7.414	26.409	163.2	3.615
150	7.397	33.838	7.383	26.451	159.4	3.776
175	7.216	33.881	7.199	26.510	154.1	4.166
200	7.038	33.935	7.020	26.577	148.1	4.543
225	6.903	33.953	6.882	26.611	145.2	4.910
250	6.773	33.970	6.750	26.642	142.6	5.270
275	6.740	33.976	6.715	26.651	142.1	5.626
276	6.739	33.975	6.714	26.651	142.1	5.640



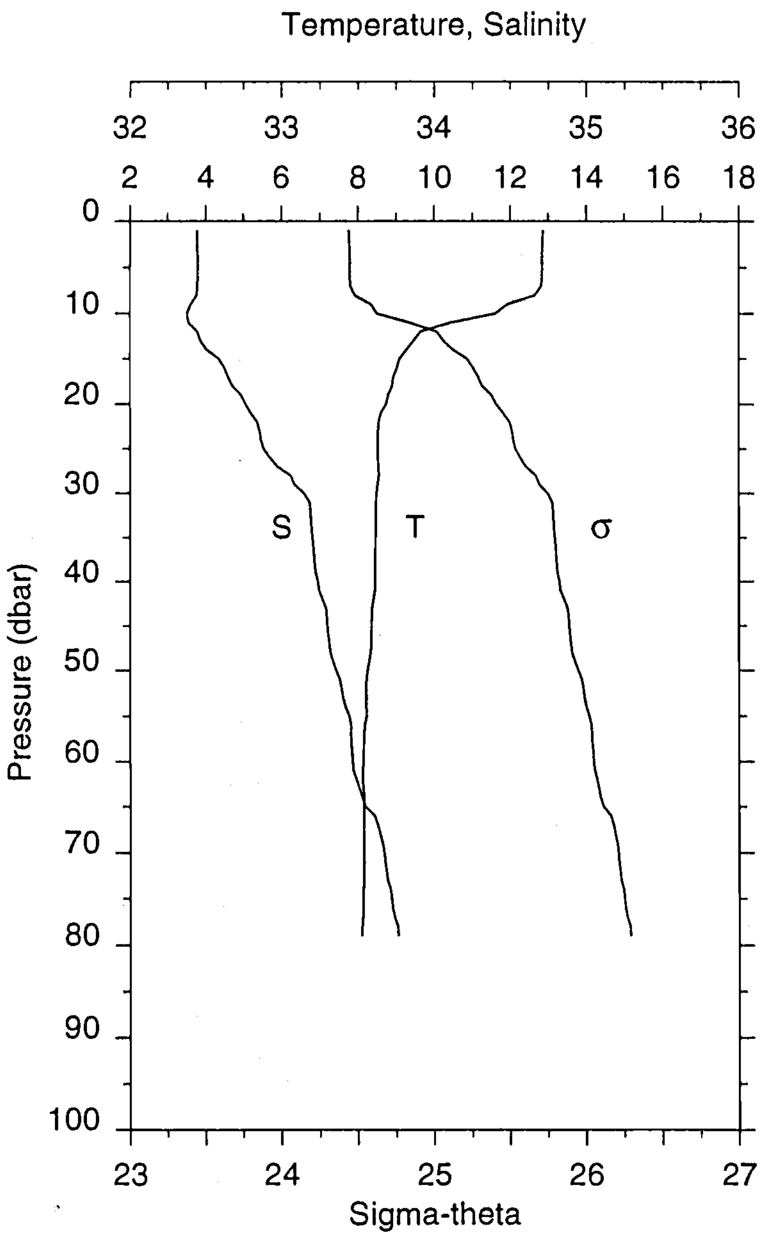
STA: 4 FM-1 LAT: 43 13.1 N LONG: 124 26.0 W
24 AUG 1994 1728 GMT DEPTH 36

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
2	10.541	33.434	10.541	25.637	234.2	0.047
10	10.095	33.510	10.094	25.773	221.4	0.231
20	8.859	33.610	8.857	26.053	195.0	0.437
30	8.871	33.653	8.867	26.085	192.2	0.630



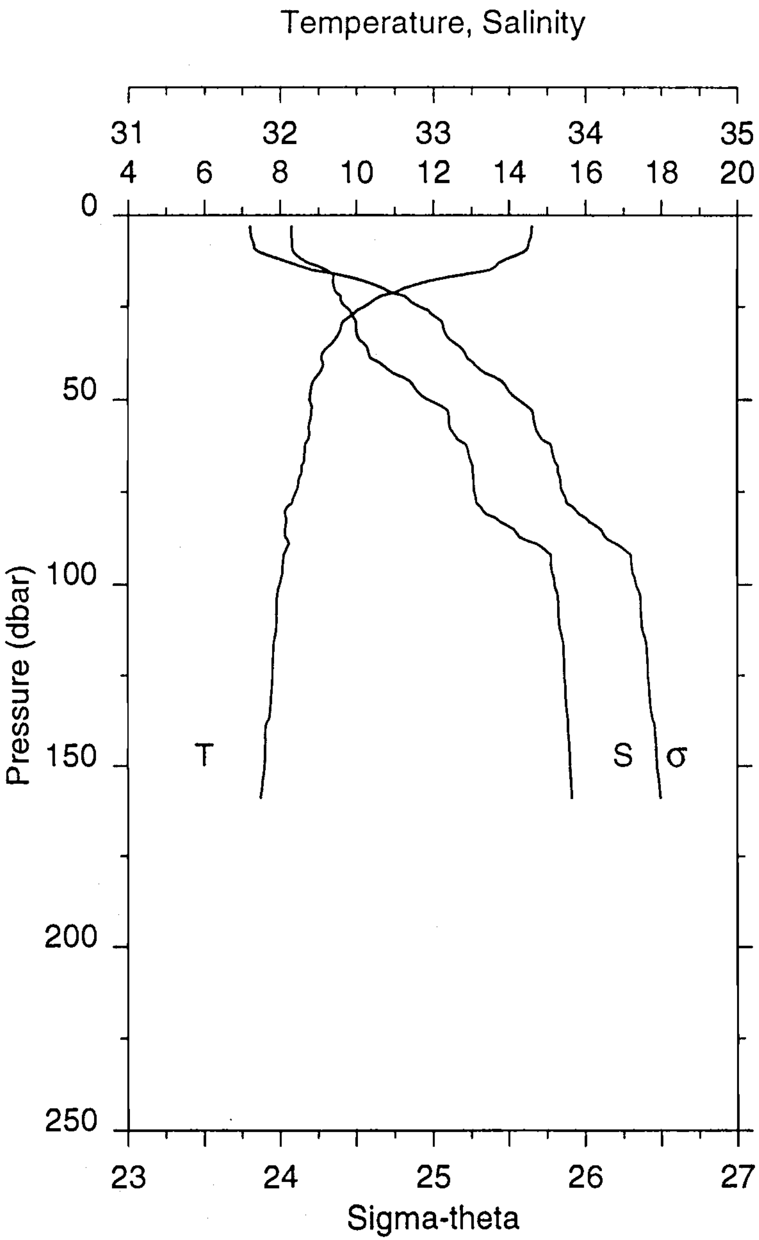
STA: 5 FM-3 LAT: 43 12.9 N LONG: 124 30.1 W
24 AUG 1994 1829 GMT DEPTH 61

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
3	12.073	32.690	12.073	24.783	315.5	0.095
10	9.044	32.746	9.043	25.347	261.9	0.304
20	8.309	33.148	8.308	25.775	221.4	0.539
30	8.491	33.503	8.488	26.026	197.8	0.747
40	8.078	33.589	8.074	26.155	185.6	0.939
50	8.087	33.639	8.082	26.193	182.2	1.123
56	8.094	33.666	8.088	26.214	180.4	1.232



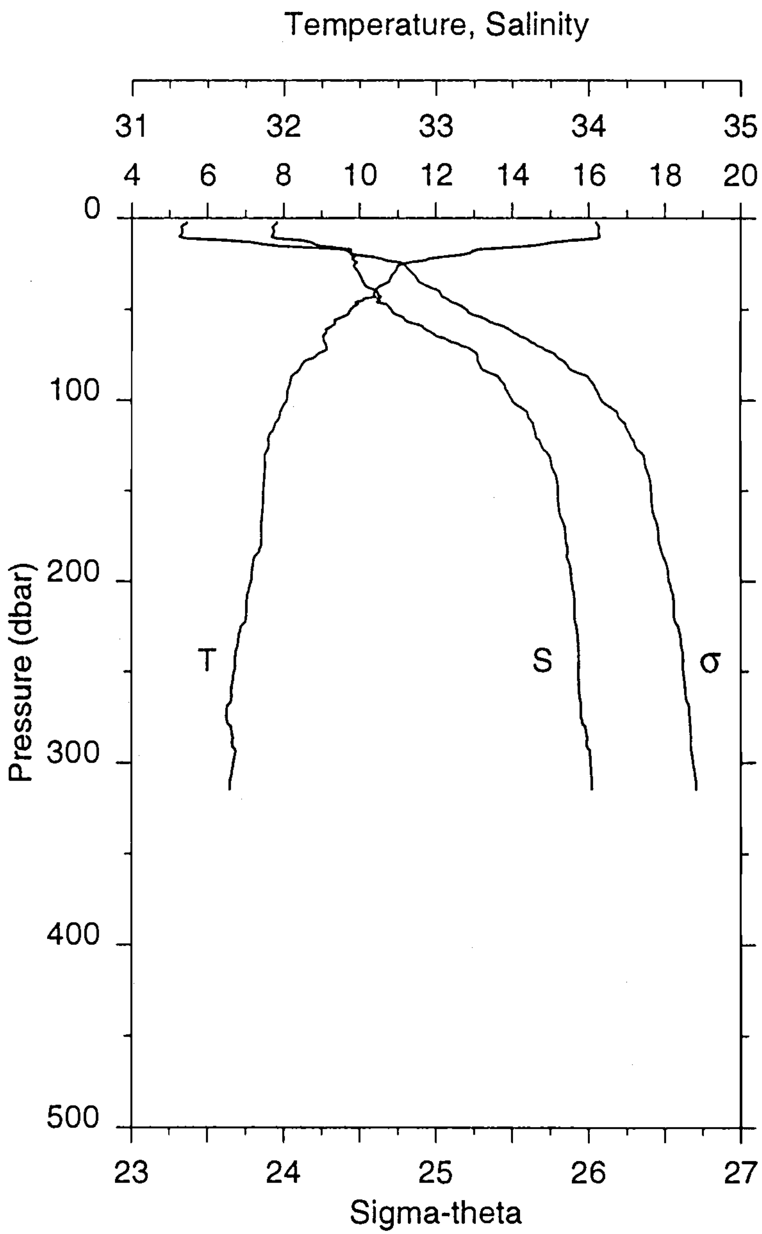
STA: 6 FM-4 LAT: 43 13.1 N LONG: 124 35.1 W
24 AUG 1994 1931 GMT DEPTH 87

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
1	12.863	32.445	12.863	24.442	347.9	0.035
10	11.610	32.377	11.609	24.625	330.7	0.345
20	8.744	32.764	8.742	25.408	256.3	0.626
30	8.485	33.147	8.482	25.747	224.2	0.867
40	8.444	33.237	8.440	25.824	217.1	1.087
50	8.242	33.356	8.237	25.948	205.5	1.299
60	8.133	33.463	8.127	26.048	196.2	1.498
70	8.149	33.670	8.143	26.209	181.1	1.687
79	8.098	33.762	8.090	26.289	173.7	1.847



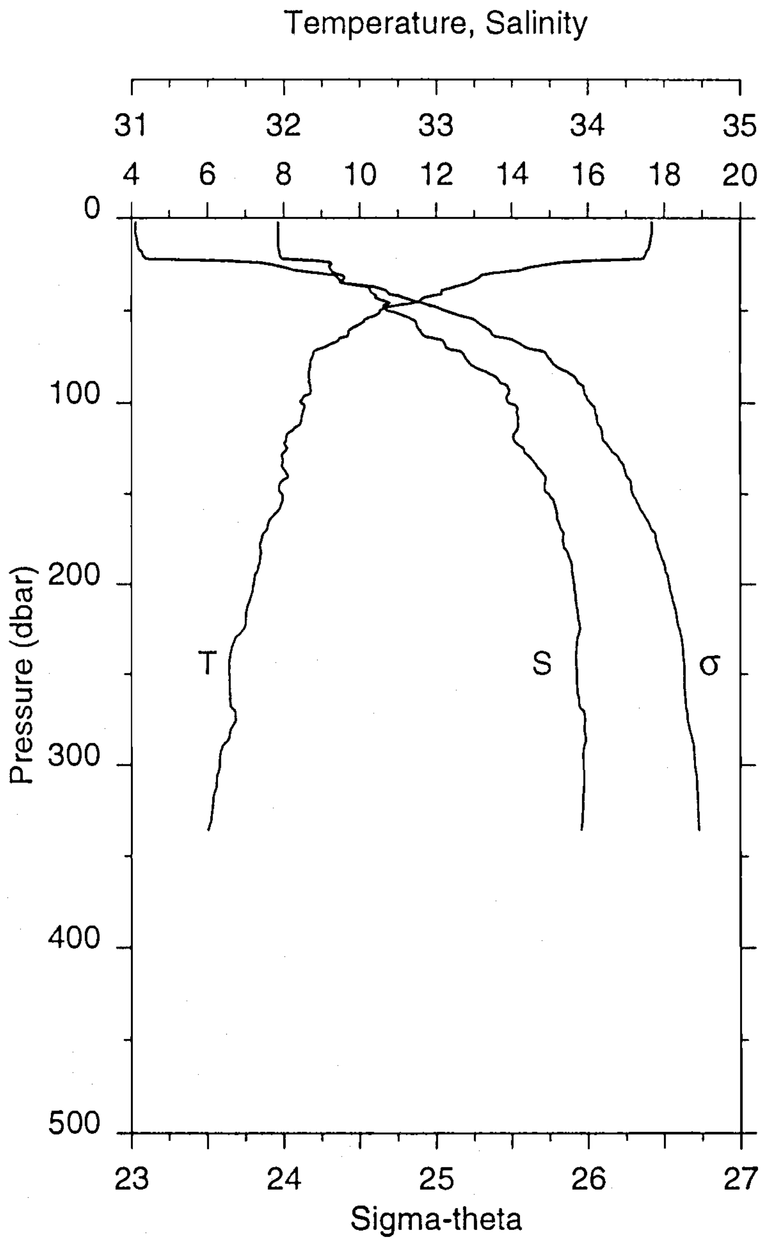
STA: 7 FM-5 LAT: 43 13.1 N LONG: 124 40.1 W
24 AUG 1994 2036 GMT DEPTH 157

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
3	14.600	32.074	14.600	23.803	408.9	0.123
10	14.386	32.087	14.384	23.858	403.8	0.408
20	11.217	32.357	11.215	24.680	325.7	0.774
30	9.612	32.500	9.609	25.065	289.2	1.078
40	9.127	32.649	9.123	25.259	270.9	1.359
50	8.776	32.965	8.770	25.561	242.3	1.615
60	8.773	33.148	8.766	25.704	228.9	1.848
70	8.573	33.261	8.566	25.824	217.7	2.070
80	8.143	33.330	8.135	25.943	206.5	2.283
90	8.189	33.722	8.180	26.243	178.2	2.476
100	7.999	33.801	7.989	26.334	169.7	2.649
110	7.911	33.831	7.900	26.371	166.4	2.816
120	7.823	33.862	7.811	26.408	163.0	2.981
130	7.781	33.872	7.769	26.422	161.9	3.143
140	7.618	33.888	7.605	26.458	158.6	3.304
150	7.592	33.901	7.578	26.473	157.4	3.462
159	7.489	33.911	7.474	26.495	155.4	3.602



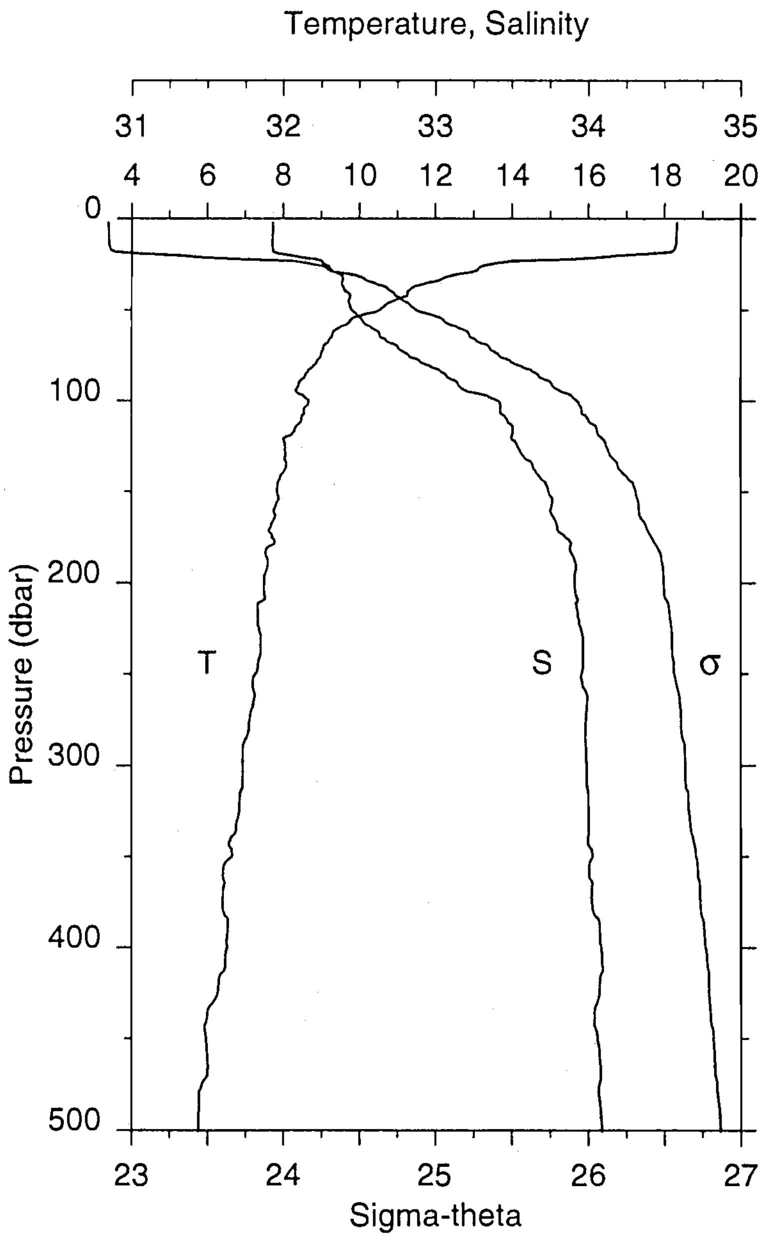
STA: 8 FM-6 LAT: 43 13.1 N LONG: 124 45.1 W
24 AUG 1994 2130 GMT DEPTH 315

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
2	16.195	31.956	16.195	23.364	450.8	0.090
10	16.291	31.917	16.290	23.313	455.9	0.453
20	12.639	32.444	12.636	24.484	344.4	0.844
30	10.891	32.495	10.887	24.846	310.1	1.164
40	10.405	32.616	10.400	25.024	293.4	1.468
50	9.768	32.708	9.762	25.203	276.5	1.754
60	9.209	32.919	9.203	25.458	252.4	2.020
70	9.123	33.165	9.115	25.663	233.0	2.263
80	8.498	33.285	8.490	25.854	215.0	2.485
90	8.178	33.435	8.169	26.020	199.4	2.692
100	8.085	33.501	8.075	26.086	193.3	2.889
110	7.880	33.612	7.869	26.203	182.3	3.075
120	7.613	33.656	7.601	26.276	175.5	3.254
130	7.508	33.738	7.496	26.356	168.0	3.426
140	7.498	33.777	7.484	26.388	165.2	3.593
150	7.467	33.801	7.453	26.411	163.1	3.756
175	7.412	33.850	7.395	26.459	159.0	4.160
200	7.145	33.890	7.126	26.527	152.8	4.549
225	6.877	33.923	6.857	26.590	147.2	5.199
250	6.698	33.935	6.675	26.624	144.2	5.563
275	6.492	33.951	6.467	26.664	140.7	5.919
300	6.675	34.012	6.648	26.688	138.9	6.269
315	6.574	34.020	6.546	26.708	137.1	6.476



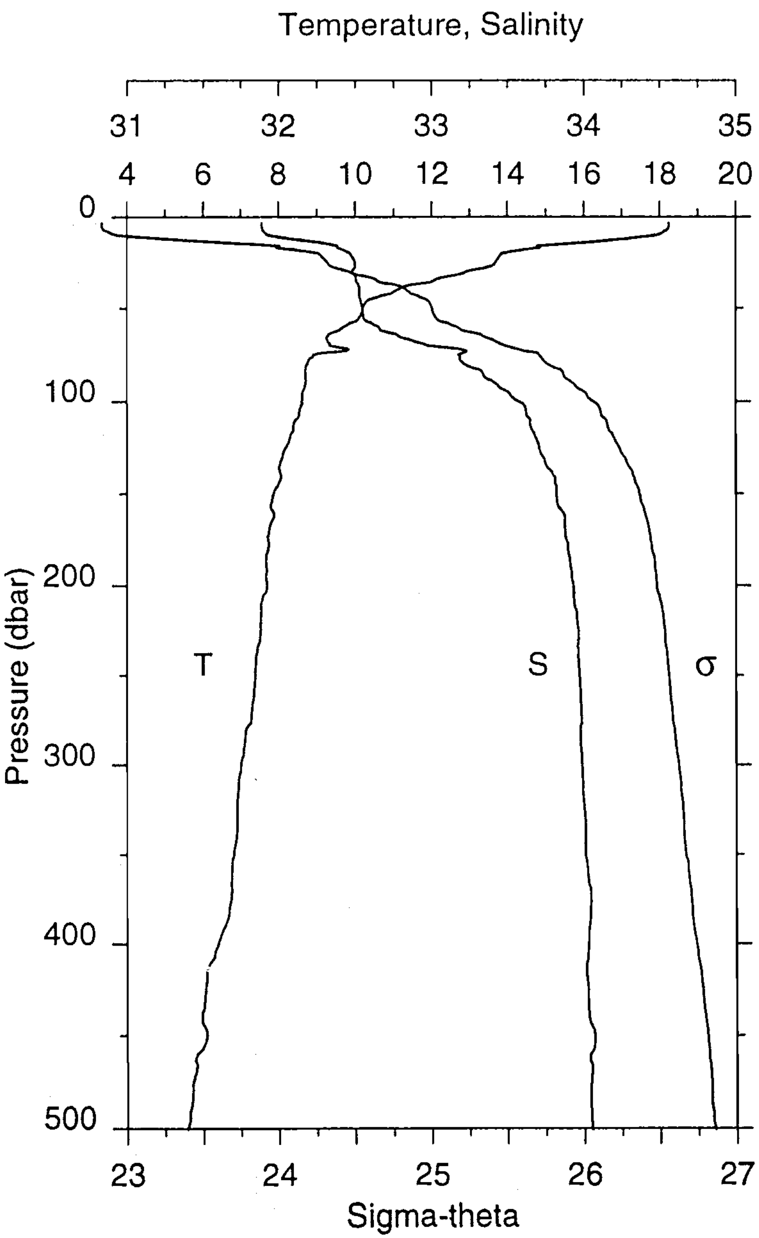
STA: 9 FM-7 LAT: 43 13.1 N LONG: 124 50.0 W
24 AUG 1994 1531 GMT DEPTH 345

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
2	17.666	31.962	17.666	23.028	482.9	0.097
10	17.660	31.962	17.658	23.030	483.0	0.483
20	17.510	31.974	17.507	23.075	479.0	0.965
30	13.401	32.347	13.397	24.260	366.0	1.380
40	12.143	32.578	12.138	24.683	325.9	1.726
50	10.528	32.680	10.522	25.053	290.8	2.034
60	9.771	32.886	9.764	25.341	263.6	2.309
70	9.050	33.064	9.043	25.596	239.4	2.561
80	8.698	33.245	8.690	25.792	220.9	2.788
90	8.700	33.459	8.691	25.960	205.2	3.000
100	8.441	33.481	8.431	26.017	199.9	3.203
110	8.460	33.541	8.449	26.062	195.9	3.400
120	8.065	33.514	8.053	26.099	192.3	3.593
130	7.955	33.624	7.942	26.202	182.8	3.781
140	8.125	33.721	8.111	26.253	178.2	3.961
150	7.964	33.746	7.949	26.297	174.1	4.137
175	7.416	33.838	7.400	26.448	160.0	4.554
200	7.208	33.911	7.190	26.535	152.1	4.944
225	6.941	33.951	6.921	26.604	145.9	5.317
250	6.580	33.929	6.558	26.634	143.2	5.677
275	6.744	33.983	6.719	26.656	141.7	6.033
300	6.321	33.972	6.295	26.703	137.3	6.380
336	6.014	33.958	5.985	26.731	134.9	6.869



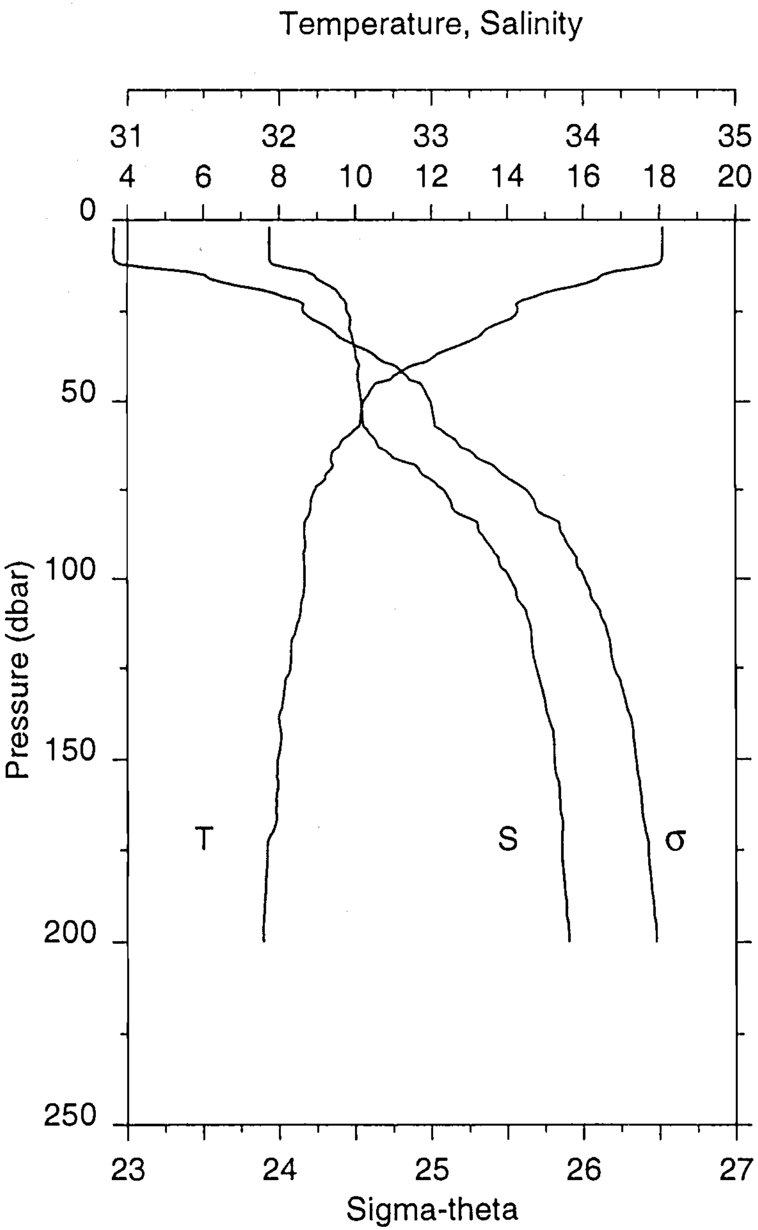
STA: 10 FM-8 LAT: 43 13.1 N LONG: 125 0.2 W
25 AUG 1994 0005 GMT DEPTH 1095

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
2	18.320	31.930	18.320	22.846	500.3	0.100
10	18.309	31.930	18.308	22.849	500.3	0.500
20	16.753	32.056	16.749	23.315	456.0	0.996
30	12.657	32.367	12.653	24.422	350.6	1.380
40	11.262	32.418	11.257	24.721	322.3	1.715
50	10.536	32.452	10.530	24.874	307.8	2.030
60	9.457	32.583	9.451	25.155	281.2	2.323
70	9.060	32.754	9.052	25.352	262.6	2.596
80	8.839	32.934	8.831	25.527	246.1	2.851
90	8.419	33.145	8.410	25.757	224.4	3.086
100	8.676	33.409	8.665	25.925	208.7	3.303
110	8.490	33.468	8.479	25.999	201.8	3.508
120	8.067	33.498	8.055	26.087	193.6	3.706
130	8.077	33.571	8.065	26.142	188.5	3.896
140	7.993	33.663	7.979	26.227	180.5	4.081
150	7.843	33.741	7.829	26.311	172.8	4.256
175	7.701	33.851	7.684	26.417	163.1	4.679
200	7.495	33.913	7.476	26.496	155.9	5.074
225	7.371	33.956	7.350	26.548	151.4	5.458
250	7.271	33.959	7.247	26.565	150.2	5.835
275	7.105	33.985	7.079	26.609	146.3	6.204
300	6.926	33.989	6.899	26.637	144.0	6.567
350	6.637	34.028	6.606	26.706	137.9	7.275
400	6.512	34.084	6.476	26.768	132.8	7.950
450	5.955	34.060	5.916	26.820	128.0	8.602
500	5.759	34.088	5.716	26.868	123.9	9.233
501	5.754	34.088	5.711	26.868	123.9	9.245



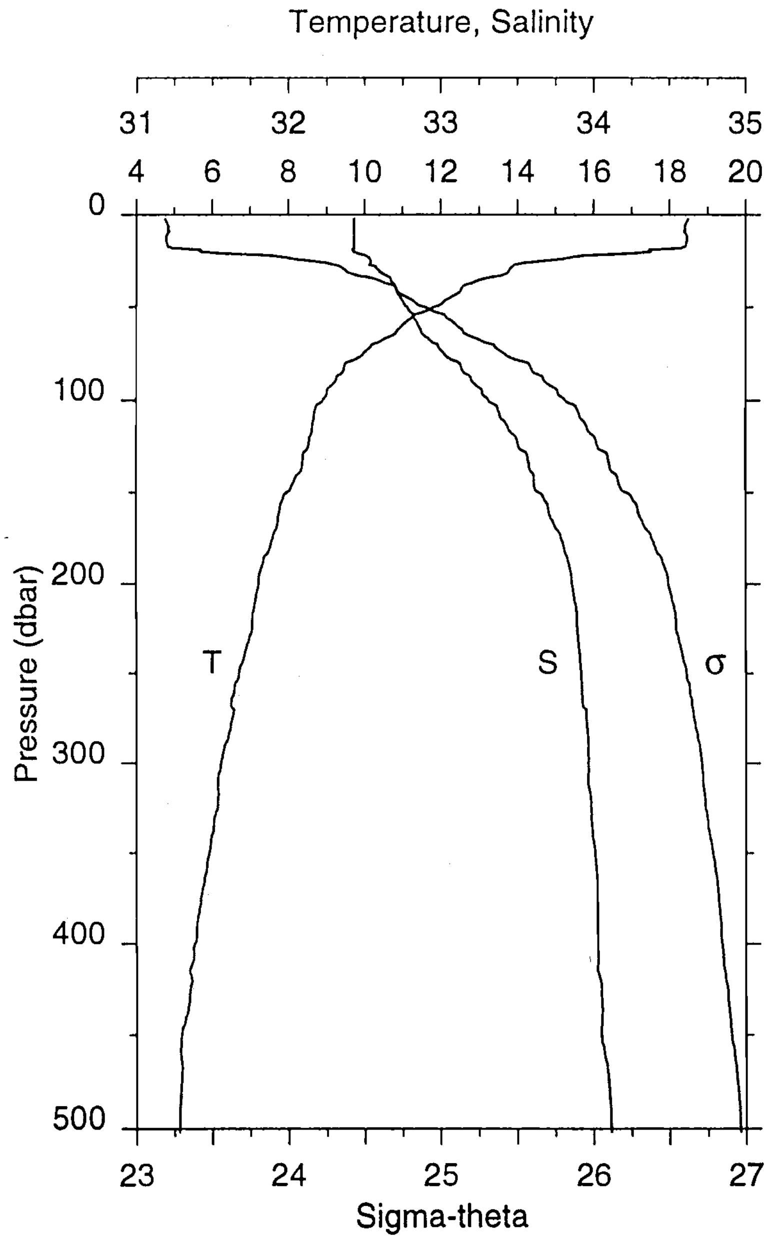
STA: 11 FM-9 LAT: 43 13.1 N LONG: 125 10.1 W
25 AUG 1994 0149 GMT DEPTH 1680

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
3	18.241	31.889	18.240	22.834	501.5	0.150
10	17.945	31.932	17.944	22.939	491.7	0.500
20	13.847	32.469	13.845	24.264	365.4	0.918
30	12.917	32.482	12.913	24.460	346.9	1.277
40	11.101	32.529	11.096	24.836	311.3	1.606
50	10.209	32.548	10.204	25.004	295.4	1.907
60	9.709	32.653	9.703	25.169	279.8	2.199
70	9.339	32.971	9.331	25.478	250.7	2.463
80	8.755	33.219	8.747	25.764	223.6	2.696
90	8.713	33.415	8.703	25.924	208.6	2.911
100	8.608	33.570	8.598	26.062	195.7	3.113
110	8.454	33.650	8.442	26.148	187.7	3.305
120	8.302	33.690	8.290	26.202	182.7	3.490
130	8.102	33.732	8.089	26.265	176.8	3.670
140	8.066	33.800	8.052	26.324	171.4	3.844
150	7.884	33.820	7.869	26.367	167.5	4.013
175	7.734	33.887	7.717	26.441	160.8	4.422
200	7.700	33.931	7.681	26.481	157.4	4.819
225	7.529	33.965	7.507	26.533	152.9	5.206
250	7.378	33.971	7.355	26.559	150.8	5.586
275	7.274	33.983	7.248	26.584	148.8	5.961
300	7.005	33.986	6.977	26.624	145.3	6.328
350	6.805	34.009	6.773	26.669	141.5	7.044
400	6.397	34.030	6.362	26.740	135.3	7.736
450	6.097	34.070	6.058	26.811	129.0	8.395
500	5.592	34.052	5.551	26.859	124.6	9.030
501	5.578	34.053	5.536	26.862	124.3	9.042



STA: 12 FM-9 LAT: 43 12.9 N LONG: 125 10.1 W
25 AUG 1994 0347 GMT DEPTH 1680

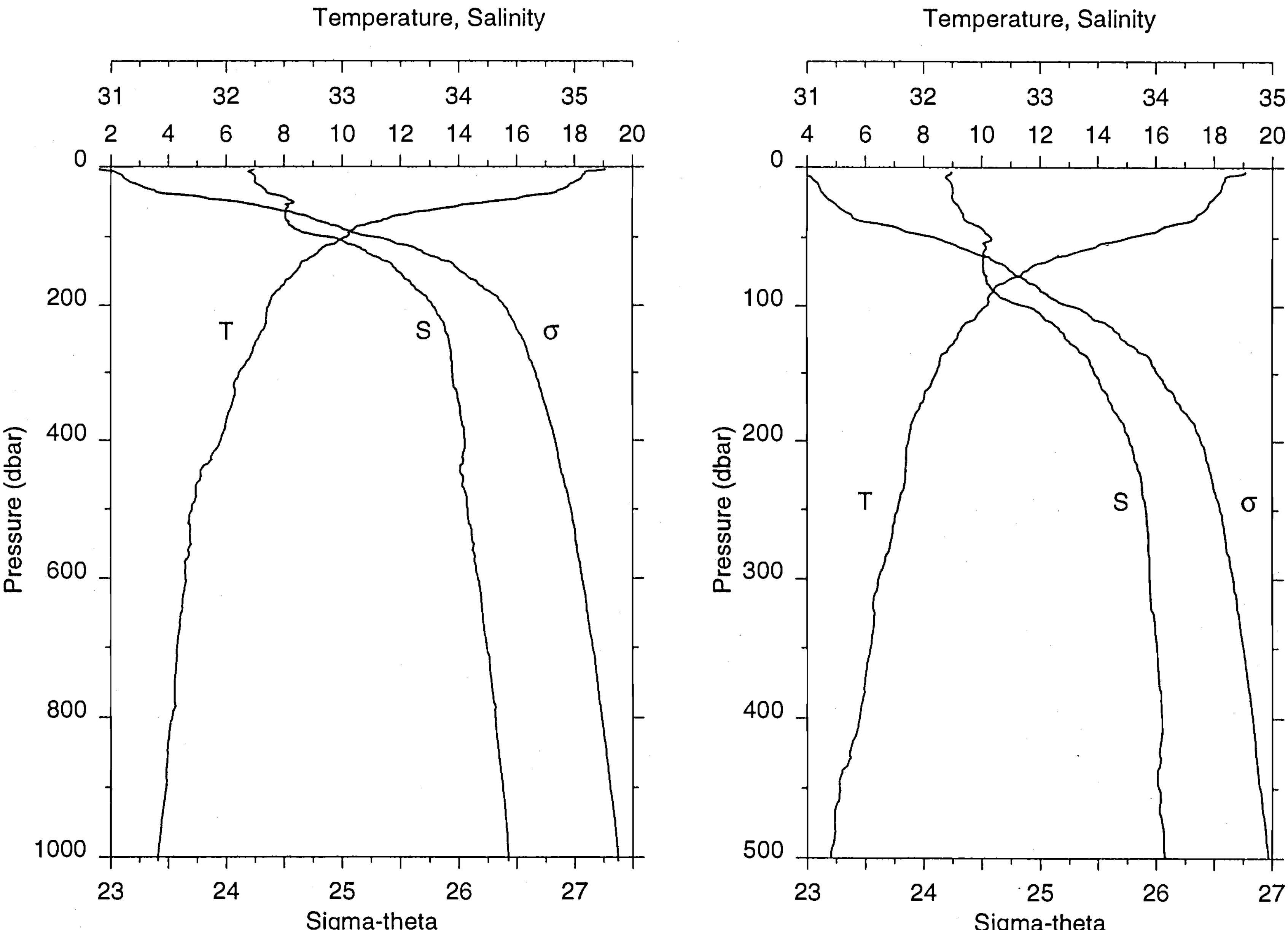
P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
2	18.085	31.937	18.084	22.908	494.4	0.099
10	18.077	31.936	18.075	22.910	494.4	0.494
20	14.954	32.392	14.951	23.973	393.2	0.941
30	13.433	32.462	13.429	24.343	358.1	1.315
40	11.508	32.528	11.503	24.761	318.4	1.655
50	10.227	32.540	10.222	24.995	296.3	1.961
60	9.781	32.619	9.774	25.130	283.5	2.253
70	9.288	32.928	9.281	25.452	253.1	2.522
80	8.829	33.139	8.821	25.690	230.7	2.761
90	8.686	33.370	8.677	25.892	211.6	2.980
100	8.672	33.517	8.661	26.010	200.6	3.186
110	8.554	33.628	8.543	26.115	190.8	3.382
120	8.320	33.667	8.308	26.181	184.6	3.569
130	8.151	33.723	8.138	26.251	178.2	3.751
140	8.000	33.782	7.986	26.320	171.8	3.926
150	7.953	33.810	7.938	26.348	169.3	4.096
175	7.676	33.858	7.659	26.427	162.1	4.511
200	7.577	33.905	7.558	26.478	157.7	4.911



STA: 13 LAT: 41 53.0 N LONG: 125 40.5 W
27 AUG 1994 1147 GMT DEPTH 3000

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
2	18.491	32.431	18.491	23.187	467.7	0.094
10	18.419	32.432	18.417	23.206	466.2	0.466
20	17.516	32.429	17.513	23.422	445.9	0.930
30	13.785	32.594	13.781	24.374	355.2	1.313
40	12.552	32.710	12.546	24.708	323.5	1.651
50	11.820	32.783	11.814	24.902	305.3	1.967
60	10.988	32.858	10.980	25.111	285.5	2.261
70	10.186	32.983	10.178	25.348	263.2	2.538
80	9.493	33.128	9.484	25.576	241.6	2.794
90	9.223	33.207	9.213	25.681	231.7	3.031
100	8.907	33.311	8.897	25.812	219.4	3.256
110	8.661	33.398	8.649	25.919	209.4	3.469
120	8.556	33.492	8.543	26.009	201.1	3.674
130	8.385	33.566	8.372	26.093	193.3	3.872
140	8.243	33.607	8.229	26.146	188.3	4.064
150	7.951	33.646	7.936	26.220	181.4	4.250
175	7.597	33.788	7.580	26.384	166.2	4.683
200	7.221	33.860	7.202	26.493	156.1	5.084
225	7.051	33.894	7.030	26.543	151.7	5.467
250	6.706	33.920	6.683	26.611	145.5	5.838
275	6.517	33.953	6.493	26.662	140.9	6.195
300	6.224	33.967	6.198	26.712	136.4	6.542
350	5.918	34.010	5.889	26.785	129.9	7.210
400	5.540	34.029	5.507	26.846	124.4	7.844
450	5.190	34.051	5.154	26.906	119.1	8.453
500	5.132	34.113	5.092	26.962	114.3	9.033
502	5.129	34.116	5.089	26.964	114.1	9.056

After Tow 3



Temperature, Salinity
31 32 33 34 35
2 4 6 8 10 12 14 16 18 20
0
200
400
600
800
1000
Pressure (dbar)
T
S
σ
23 24 25 26 27
Sigma-theta
Temperature, Salinity
31 32 33 34 35
4 6 8 10 12 14 16 18 20
0
100
200
300
400
500
Pressure (dbar)
T
S
σ
23 24 25 26 27
Sigma-theta

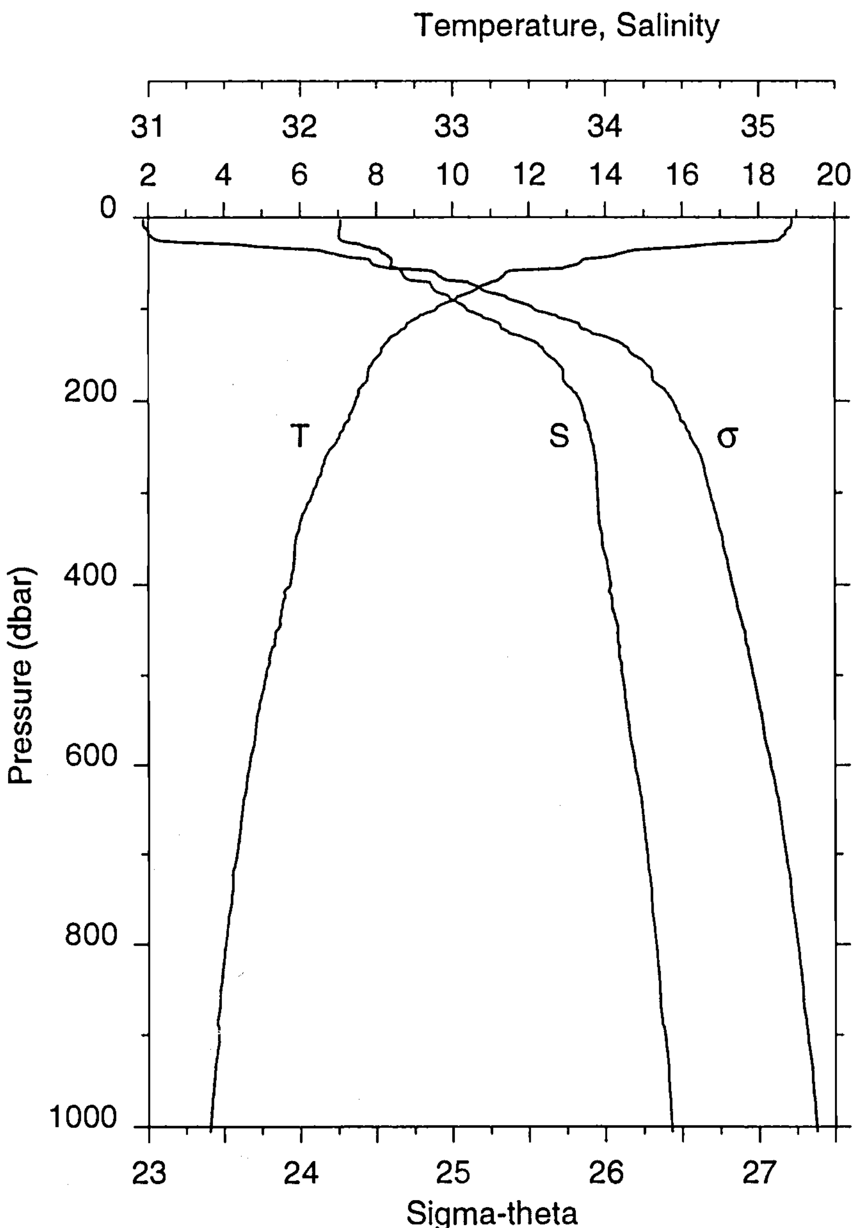
Station 14

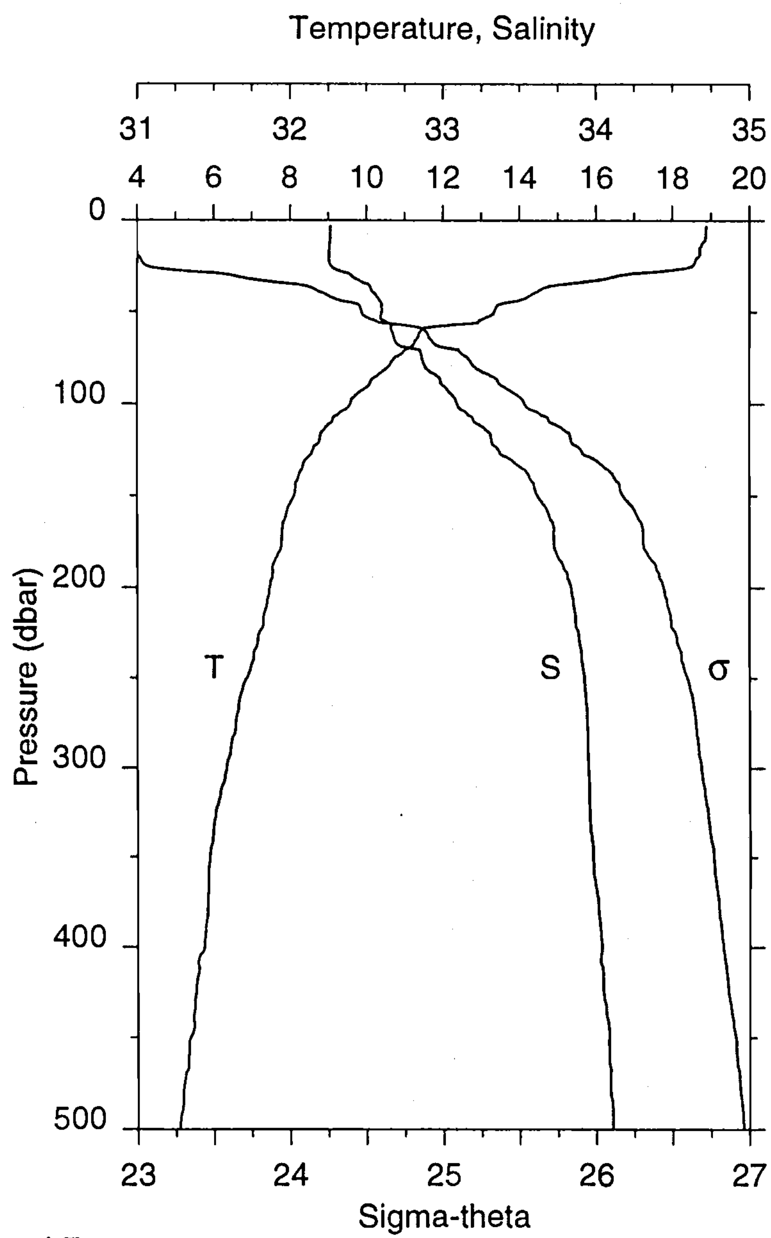
STA: 14 LAT: 41 37.3 N LONG: 125 10.2 W
29 AUG 1994 0210 GMT DEPTH 2750

P	T	S	POT T	SIGMA	SVA	DYN HT
(DB)	(C)		(C)	THETA	(CL/T)	(J/KG)
3	19.060	32.242	19.060	22.900	495.1	0.149
10	18.340	32.228	18.338	23.069	479.2	0.489
20	18.065	32.247	18.062	23.151	471.8	0.964
30	17.691	32.318	17.686	23.296	458.3	1.429
40	16.694	32.426	16.688	23.613	428.2	1.878
50	15.037	32.582	15.029	24.103	381.7	2.283
60	13.339	32.519	13.331	24.407	352.8	2.650
70	11.801	32.510	11.792	24.695	325.5	2.989
80	10.983	32.540	10.973	24.866	309.3	3.307
90	10.384	32.619	10.373	25.031	293.7	3.608
100	10.148	32.881	10.136	25.275	270.7	3.893
110	9.753	33.046	9.741	25.470	252.3	4.152
120	9.202	33.207	9.189	25.685	232.0	4.392
130	8.908	33.313	8.895	25.814	219.8	4.620
140	8.567	33.429	8.552	25.958	206.3	4.833
150	8.432	33.474	8.417	26.014	201.1	5.037

P	T	S	POT T	SIGMA	SVA	DYN HT
(DB)	(C)		(C)	THETA	(CL/T)	(J/KG)
175	7.881	33.625	7.864	26.214	182.3	5.515
200	7.487	33.773	7.468	26.387	166.2	5.947
225	7.381	33.869	7.359	26.478	158.0	6.352
250	7.113	33.915	7.090	26.552	151.3	6.739
275	6.855	33.936	6.830	26.604	146.6	7.110
300	6.453	33.944	6.427	26.664	141.0	7.470
350	6.179	34.009	6.149	26.751	133.3	8.156
400	5.810	34.054	5.776	26.833	126.0	8.804
450	5.107	34.025	5.071	26.894	120.1	9.420
500	4.818	34.078	4.779	26.970	113.2	10.003
600	4.588	34.163	4.542	27.063	105.2	11.094
700	4.299	34.240	4.246	27.156	97.0	12.104
800	4.133	34.315	4.073	27.234	90.4	13.039
900	3.924	34.378	3.857	27.306	84.1	13.909
1000	3.645	34.426	3.572	27.373	78.2	14.716
1006	3.634	34.427	3.561	27.375	78.0	14.763

After Tow 4


Temperature, Salinity
31 32 33 34 35
2 4 6 8 10 12 14 16 18 20
0 200 400 600 800 1000
Pressure (dbar)
T
S
σ
23 24 25 26 27
Sigma-theta

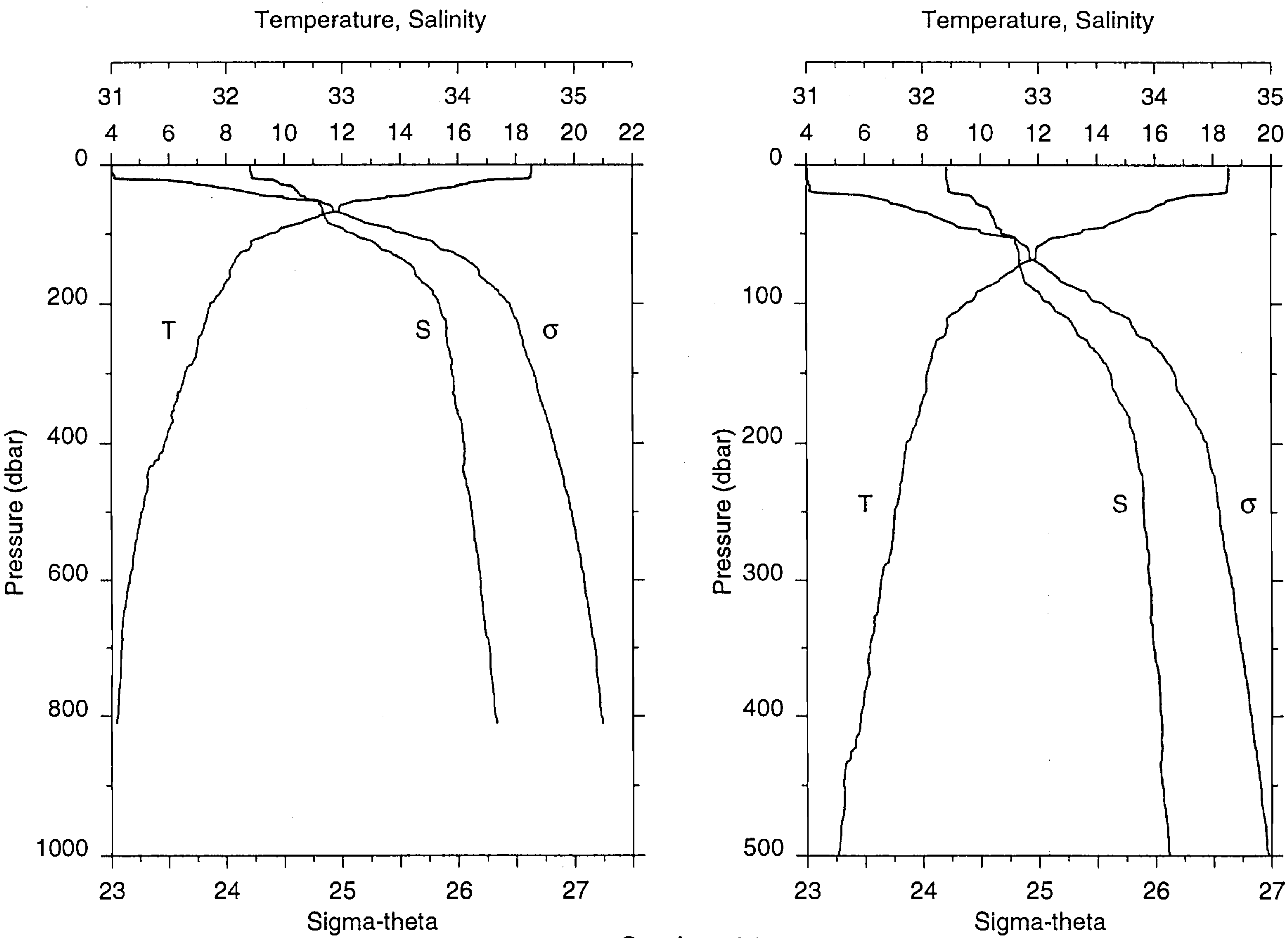

Temperature, Salinity
31 32 33 34 35
4 6 8 10 12 14 16 18 20
0 100 200 300 400 500
Pressure (dbar)
T
S
σ
23 24 25 26 27
Sigma-theta

Station 15

STA: 15 CR-8 LAT: 41 54.0 N LONG: 125 9.9 W
29 AUG 1994 2153 GMT DEPTH 2250

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
3	18.882	32.266	18.881	22.963	489.1	0.147
10	18.854	32.264	18.853	22.969	488.8	0.489
20	18.663	32.257	18.659	23.012	485.0	0.976
30	16.622	32.401	16.617	23.610	428.2	1.446
40	14.355	32.556	14.350	24.227	369.5	1.840
50	13.331	32.600	13.325	24.470	346.5	2.196
60	11.445	32.661	11.437	24.877	307.9	2.528
70	11.127	32.783	11.118	25.029	293.6	2.832
80	10.567	32.885	10.557	25.206	276.9	3.114
90	10.068	32.999	10.058	25.381	260.4	3.382
100	9.579	33.090	9.568	25.532	246.1	3.634
110	9.098	33.204	9.086	25.699	230.4	3.872
120	8.780	33.317	8.767	25.837	217.4	4.093
130	8.434	33.438	8.421	25.985	203.5	4.305
140	8.214	33.565	8.200	26.118	191.0	4.501
150	8.098	33.620	8.083	26.178	185.4	4.689

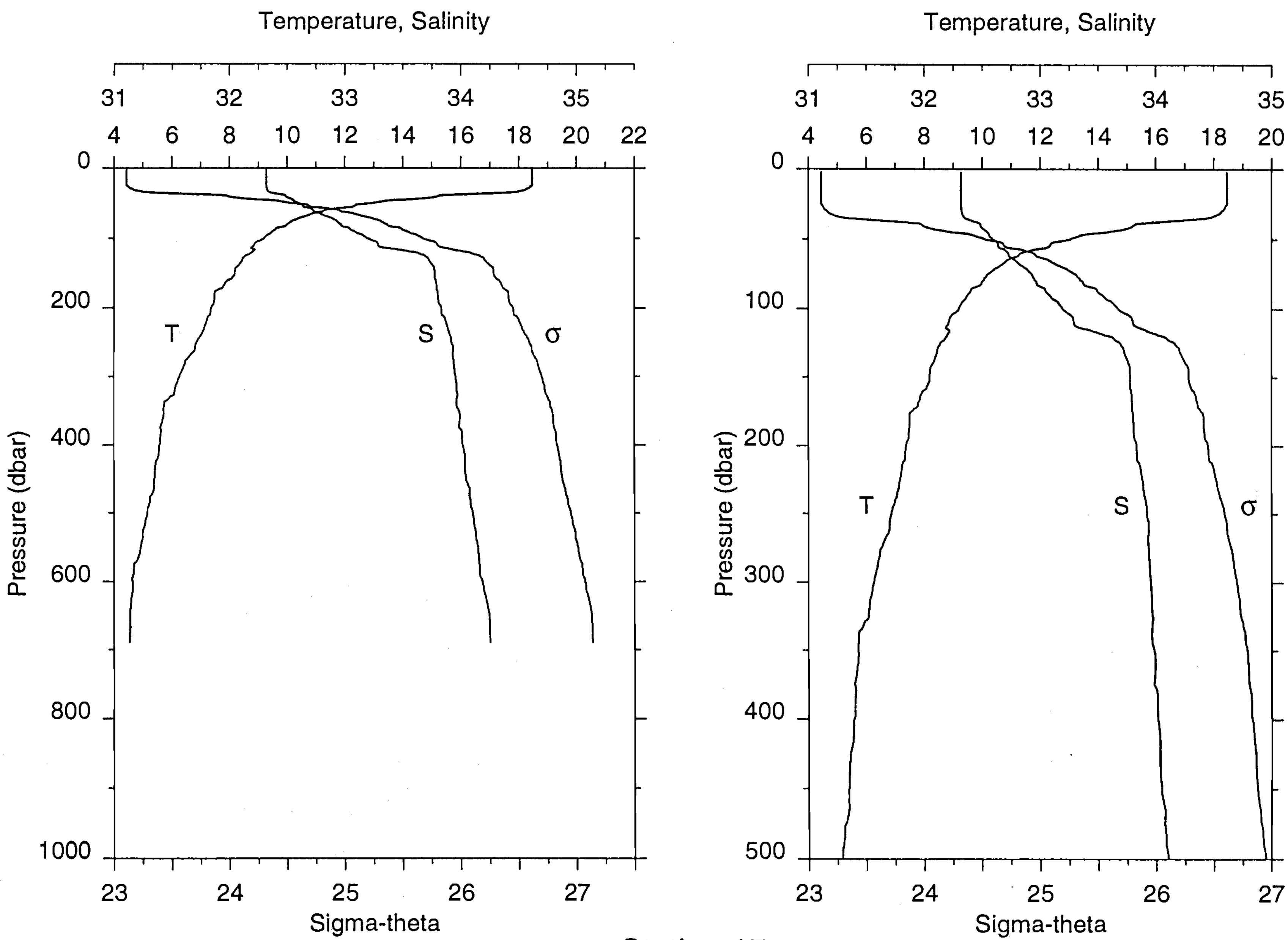
P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
175	7.771	33.725	7.754	26.309	173.4	5.131
200	7.457	33.837	7.438	26.442	161.0	5.549
225	7.179	33.885	7.157	26.519	154.0	5.944
250	6.847	33.924	6.824	26.595	147.0	6.321
275	6.564	33.943	6.540	26.648	142.2	6.681
300	6.337	33.950	6.311	26.683	139.1	7.033
350	5.887	33.980	5.858	26.764	131.8	7.710
400	5.747	34.037	5.714	26.827	126.4	8.356
450	5.379	34.084	5.343	26.909	119.0	8.971
500	5.099	34.110	5.059	26.963	114.2	9.554
600	4.670	34.191	4.624	27.076	104.1	10.645
700	4.324	34.272	4.271	27.179	94.9	11.635
800	4.043	34.329	3.984	27.254	88.3	12.551
900	3.846	34.386	3.780	27.320	82.7	13.406
1000	3.636	34.430	3.564	27.377	77.7	14.206
1006	3.619	34.432	3.546	27.380	77.5	14.252


Temperature, Salinity
31 32 33 34 35
4 6 8 10 12 14 16 18 20 22
Pressure (dbar)
0 200 400 600 800 1000
T
S
σ
23 24 25 26 27
Sigma-theta
Temperature, Salinity
31 32 33 34 35
4 6 8 10 12 14 16 18 20
Pressure (dbar)
0 100 200 300 400 500
T
S
σ
23 24 25 26 27
Sigma-theta

Station 16

STA: 16 CR-7 LAT: 41 54.0 N LONG: 125 0.1 W
29 AUG 1994 0641 GMT DEPTH 850

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
2	18.545	32.208	18.545	23.003	485.3	0.097
10	18.546	32.209	18.544	23.004	485.5	0.485
20	18.439	32.245	18.435	23.058	480.6	0.969
30	16.051	32.519	16.046	23.831	407.1	1.401
40	14.808	32.621	14.802	24.181	373.9	1.790
50	13.305	32.690	13.298	24.546	339.4	2.147
60	11.943	32.818	11.936	24.907	305.0	2.462
70	11.585	32.834	11.577	24.986	297.7	2.765
80	10.843	32.869	10.833	25.146	282.7	3.055
90	10.079	32.966	10.069	25.353	263.1	3.330
100	9.486	33.105	9.475	25.559	243.5	3.584
110	8.892	33.253	8.881	25.769	223.7	3.819
120	8.824	33.329	8.812	25.839	217.2	4.039
130	8.460	33.439	8.446	25.982	203.8	4.249
140	8.307	33.551	8.293	26.093	193.4	4.447
150	8.163	33.620	8.148	26.169	186.3	4.637
175	7.920	33.739	7.903	26.298	174.4	5.092
200	7.437	33.838	7.418	26.446	160.7	5.511
225	7.291	33.896	7.270	26.512	154.8	5.907
250	7.032	33.904	7.009	26.555	151.0	6.290
275	6.928	33.932	6.903	26.591	147.9	6.664
300	6.565	33.951	6.539	26.654	142.0	7.026
350	6.165	33.985	6.135	26.734	134.9	7.719
400	5.843	34.050	5.809	26.826	126.6	8.372
450	5.251	34.057	5.215	26.903	119.4	8.988
500	5.048	34.119	5.008	26.976	112.9	9.570
600	4.628	34.191	4.582	27.081	103.5	10.653
700	4.329	34.268	4.276	27.175	95.3	11.651
800	4.213	34.318	4.153	27.227	91.2	12.585
811	4.186	34.330	4.124	27.241	90.0	12.685

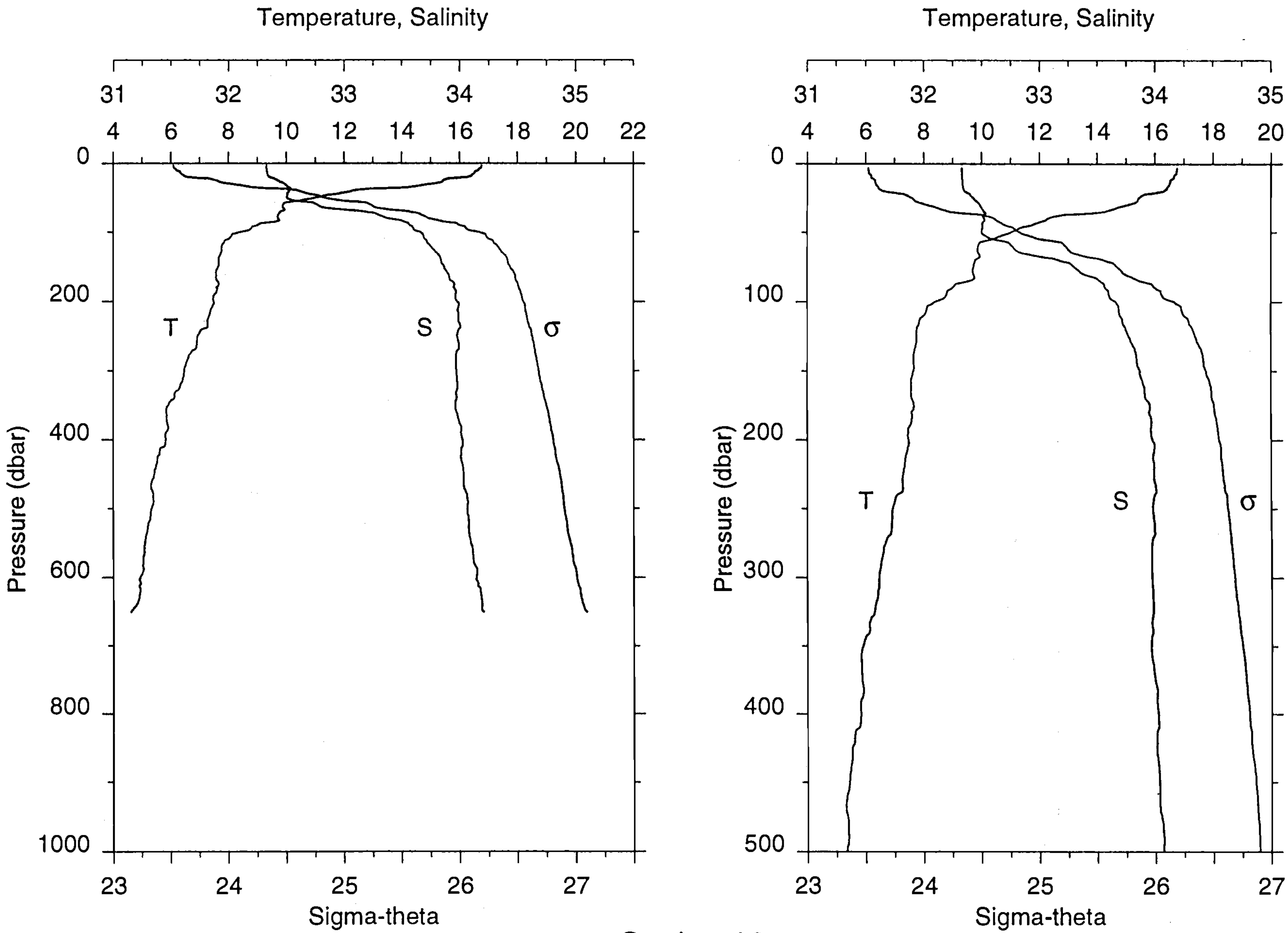


Temperature, Salinity
31
32
33
34
35
4
6
8
10
12
14
16
18
20
22
0
200
400
600
800
1000
Pressure (dbar)
T
S
σ
23
24
25
26
27
Sigma-theta
Temperature, Salinity
31
32
33
34
35
4
6
8
10
12
14
16
18
20
0
100
200
300
400
500
Pressure (dbar)
T
S
σ
23
24
25
26
27
Sigma-theta

Station 17

STA: 17 CR-6 LAT: 41 54.0 N LONG: 124 48.5 W
29 AUG 1994 0844 GMT DEPTH 705

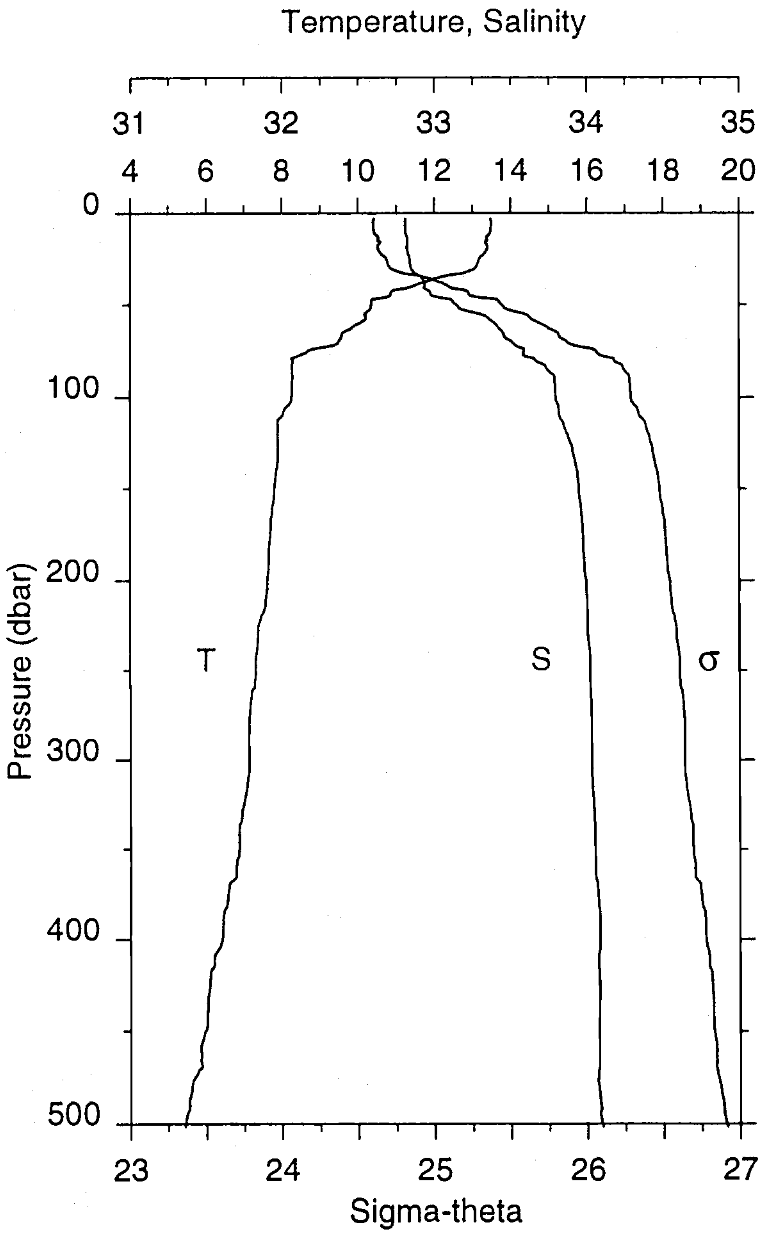
P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
2	18.451	32.320	18.451	23.112	474.9	0.095
10	18.460	32.320	18.459	23.110	475.4	0.475
20	18.459	32.320	18.456	23.110	475.6	0.951
30	18.260	32.327	18.255	23.165	470.7	1.425
40	15.240	32.487	15.234	23.985	392.6	1.867
50	13.025	32.596	13.019	24.528	341.0	2.234
60	11.313	32.728	11.306	24.952	300.7	2.555
70	10.545	32.865	10.537	25.195	277.8	2.845
80	10.011	32.967	10.002	25.365	261.7	3.113
90	9.497	33.083	9.487	25.540	245.2	3.367
100	9.208	33.194	9.198	25.673	232.7	3.605
110	8.852	33.290	8.840	25.805	220.3	3.830
120	8.780	33.615	8.767	26.071	195.3	4.040
130	8.460	33.723	8.447	26.205	182.7	4.228
140	8.295	33.766	8.281	26.263	177.3	4.408
150	8.193	33.776	8.178	26.286	175.2	4.584
175	7.563	33.798	7.546	26.396	165.0	5.011
200	7.370	33.833	7.351	26.451	160.1	5.418
225	7.163	33.884	7.142	26.520	153.9	5.812
250	6.858	33.921	6.835	26.592	147.4	6.189
275	6.503	33.938	6.478	26.652	141.8	6.551
300	6.263	33.955	6.236	26.697	137.8	6.901
350	5.716	33.983	5.686	26.788	129.5	7.570
400	5.571	34.014	5.538	26.831	125.9	8.208
450	5.389	34.046	5.352	26.878	121.9	8.826
500	5.157	34.103	5.117	26.951	115.4	9.420
600	4.640	34.185	4.593	27.075	104.2	10.518
690	4.541	34.251	4.488	27.139	98.9	11.423


Temperature, Salinity
31
32
33
34
35
4
6
8
10
12
14
16
18
20
22
0
200
400
600
800
1000
Pressure (dbar)
T
S
σ
23
24
25
26
27
Sigma-theta
Temperature, Salinity
31
32
33
34
35
4
6
8
10
12
14
16
18
20
0
100
200
300
400
500
Pressure (dbar)
T
S
σ
23
24
25
26
27
Sigma-theta

Station 18

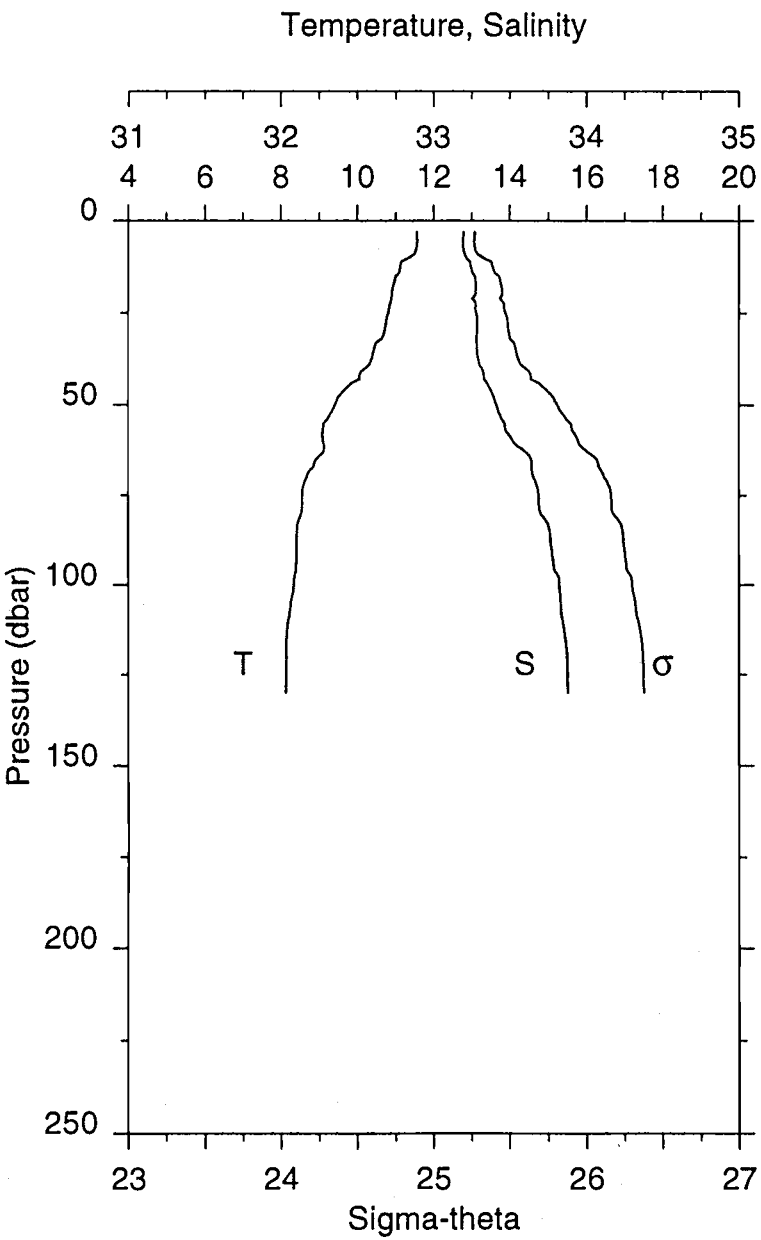
STA: 18 CR-5 LAT: 41 54.0 N LONG: 124 42.0 W
29 AUG 1994 1017 GMT DEPTH 662

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
3	16.764	32.330	16.763	23.522	435.8	0.131
10	16.659	32.331	16.657	23.547	433.5	0.435
20	16.285	32.355	16.282	23.651	424.0	0.864
30	15.030	32.486	15.025	24.030	388.1	1.266
40	12.286	32.526	12.281	24.616	332.3	1.628
50	11.004	32.503	10.998	24.833	311.8	1.951
60	9.889	32.767	9.882	25.229	274.2	2.243
70	9.783	33.162	9.775	25.555	243.4	2.507
80	9.719	33.378	9.710	25.734	226.6	2.740
90	8.996	33.571	8.986	26.002	201.3	2.953
100	8.383	33.663	8.373	26.169	185.5	3.148
110	8.007	33.698	7.997	26.252	177.7	3.328
120	7.768	33.748	7.756	26.326	170.8	3.502
130	7.742	33.802	7.730	26.373	166.5	3.671
140	7.662	33.838	7.648	26.413	162.9	3.835
150	7.648	33.869	7.634	26.439	160.6	3.997
175	7.670	33.956	7.653	26.505	154.8	4.391
200	7.481	33.978	7.462	26.550	150.9	4.772
225	7.292	33.989	7.270	26.586	147.8	5.145
250	6.930	33.980	6.907	26.628	144.0	5.510
275	6.679	33.972	6.654	26.656	141.6	5.866
300	6.466	33.973	6.439	26.685	139.1	6.217
350	5.906	33.962	5.876	26.748	133.4	6.899
400	5.831	34.025	5.797	26.808	128.4	7.552
450	5.429	34.034	5.392	26.864	123.3	8.182
500	5.335	34.067	5.295	26.901	120.3	8.790
600	4.948	34.145	4.900	27.009	110.8	9.946
651	4.599	34.210	4.549	27.099	102.3	10.495



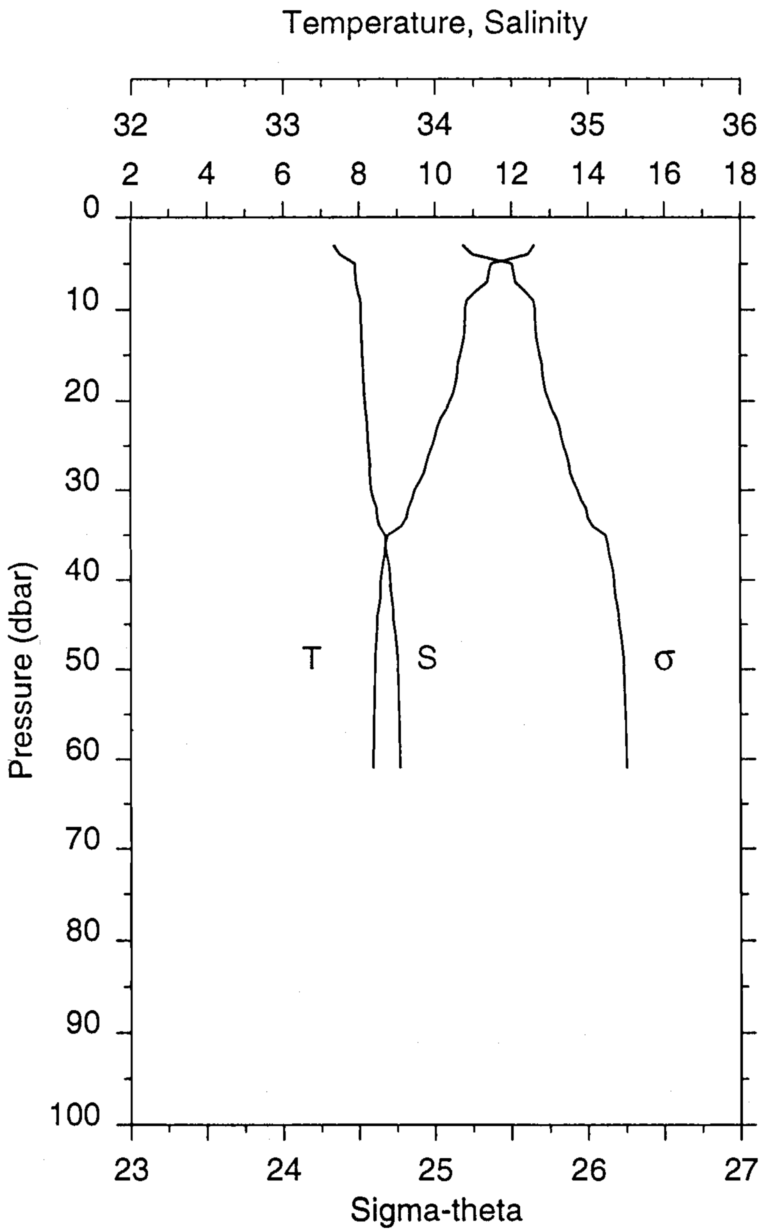
STA: 19 CR-4 LAT: 41 54.0 N LONG: 124 36.1 W
29 AUG 1994 1138 GMT DEPTH 510

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
3	13.464	32.814	13.463	24.609	332.1	0.100
10	13.473	32.813	13.472	24.606	332.6	0.333
20	13.391	32.822	13.388	24.630	330.6	0.663
30	13.081	32.848	13.077	24.711	323.0	0.989
40	11.436	32.938	11.431	25.093	286.8	1.293
50	10.350	33.145	10.344	25.446	253.4	1.562
60	10.033	33.396	10.026	25.695	229.9	1.804
70	9.495	33.508	9.487	25.872	213.2	2.025
80	8.304	33.664	8.296	26.181	183.9	2.223
90	8.288	33.790	8.279	26.283	174.5	2.401
100	8.265	33.798	8.255	26.292	173.8	2.575
110	8.024	33.821	8.013	26.346	168.8	2.746
120	7.894	33.874	7.882	26.407	163.2	2.911
130	7.902	33.910	7.889	26.434	160.8	3.073
140	7.859	33.938	7.845	26.463	158.2	3.233
150	7.813	33.949	7.798	26.479	156.9	3.390
175	7.700	33.976	7.683	26.516	153.7	3.778
200	7.618	33.998	7.598	26.546	151.3	4.160
225	7.376	34.006	7.354	26.587	147.7	4.535
250	7.300	34.022	7.277	26.610	145.9	4.902
275	7.143	34.029	7.117	26.638	143.6	5.264
300	7.125	34.031	7.097	26.642	143.6	5.622
350	6.860	34.052	6.828	26.696	139.1	6.328
400	6.416	34.083	6.381	26.779	131.6	7.002
450	5.961	34.077	5.922	26.833	126.8	7.644
500	5.443	34.094	5.401	26.910	119.5	8.263
502	5.437	34.097	5.396	26.913	119.3	8.287



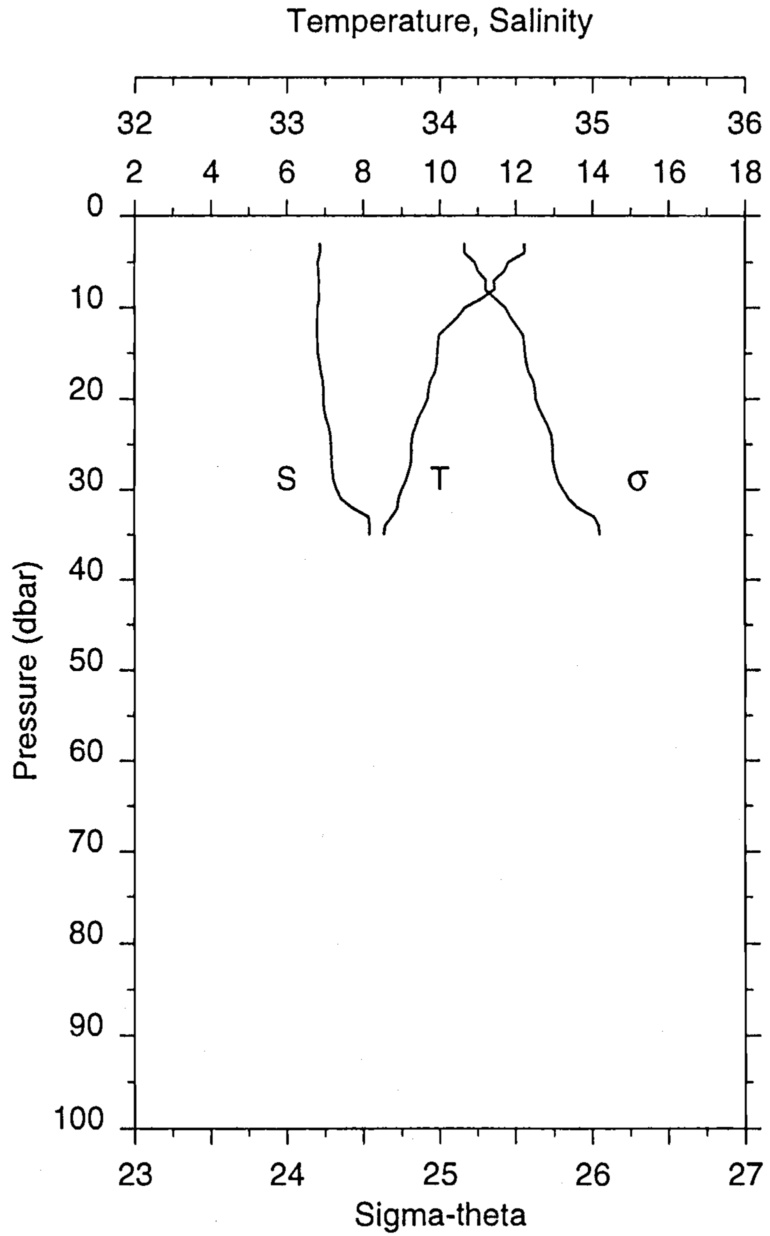
STA: 20 CR-3 LAT: 41 54.1 N LONG: 124 30.1 W
29 AUG 1994 1257 GMT DEPTH 137

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
3	11.561	33.196	11.561	25.270	269.1	0.081
10	11.339	33.216	11.338	25.326	264.0	0.269
20	10.897	33.277	10.895	25.453	252.1	0.524
30	10.707	33.287	10.704	25.494	248.4	0.775
40	10.221	33.317	10.216	25.602	238.4	1.019
50	9.421	33.415	9.416	25.811	218.6	1.247
60	9.114	33.524	9.107	25.946	206.0	1.459
70	8.687	33.655	8.679	26.115	190.1	1.656
80	8.544	33.701	8.536	26.173	184.7	1.842
90	8.424	33.775	8.415	26.250	177.7	2.022
100	8.346	33.823	8.336	26.299	173.1	2.197
110	8.201	33.845	8.190	26.339	169.5	2.369
120	8.145	33.874	8.133	26.370	166.7	2.537
130	8.128	33.880	8.115	26.378	166.2	2.703



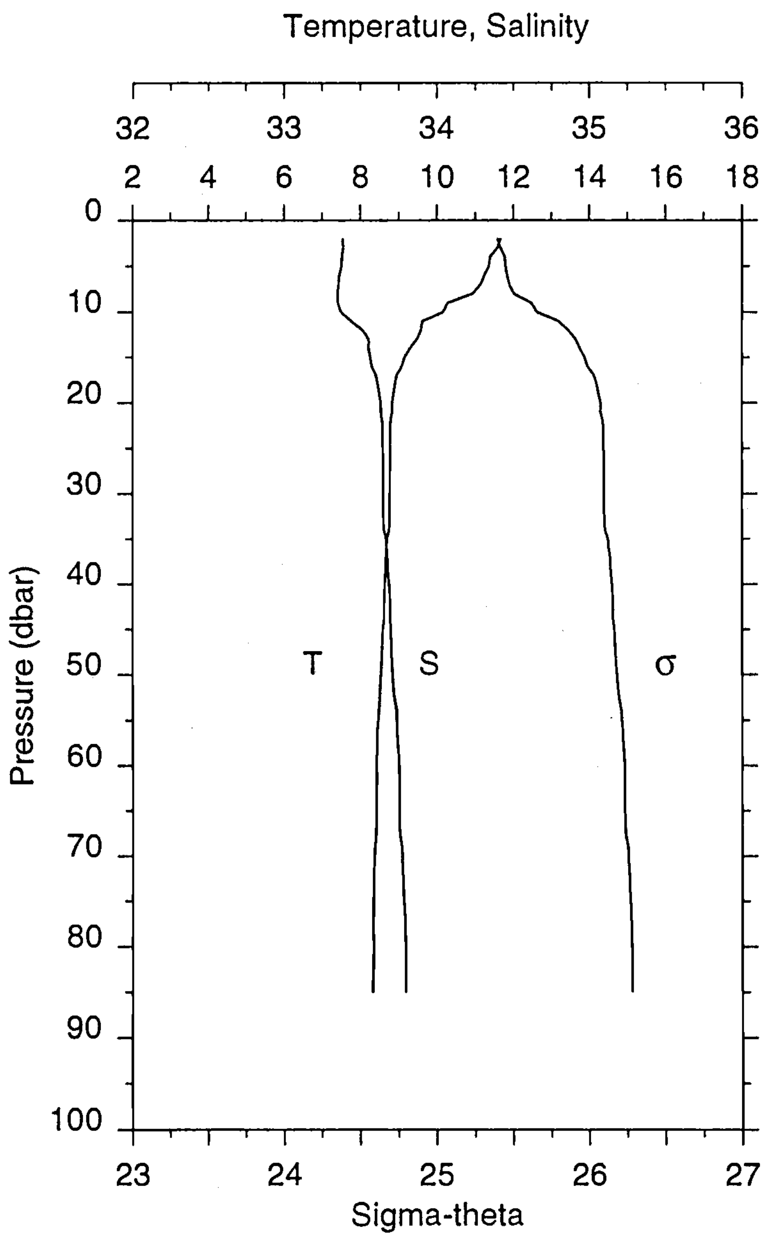
STA: 21 CR-2 LAT: 41 54.0 N LONG: 124 24.0 W
29 AUG 1994 1354 GMT DEPTH 70

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
3	12.600	33.335	12.600	25.183	277.5	0.083
10	10.795	33.514	10.794	25.656	232.6	0.257
20	10.395	33.540	10.393	25.746	224.3	0.487
30	9.471	33.583	9.467	25.934	206.6	0.702
40	8.579	33.707	8.575	26.172	184.1	0.895
50	8.423	33.756	8.418	26.234	178.3	1.076
60	8.377	33.770	8.371	26.252	176.8	1.254
61	8.373	33.770	8.367	26.254	176.7	1.271



STA: 22 CR-1 LAT: 41 54.0 N LONG: 124 18.0 W
29 AUG 1994 1444 GMT DEPTH 41

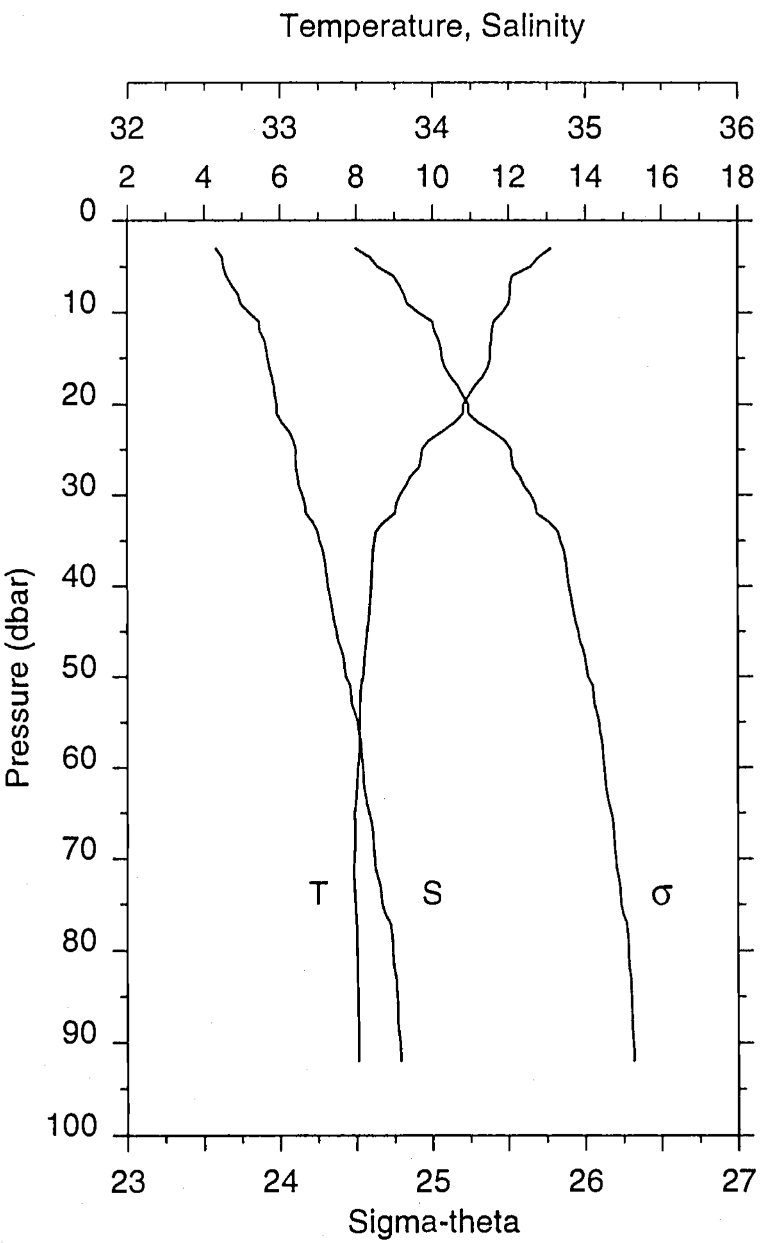
P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
3	12.221	33.217	12.221	25.163	279.3	0.084
10	10.668	33.201	10.667	25.434	253.7	0.272
20	9.687	33.242	9.685	25.632	235.1	0.514
30	9.013	33.330	9.010	25.809	218.4	0.740
35	8.549	33.544	8.545	26.049	195.7	0.843



STA: 23 LAT: 41 54.0 N LONG: 124 26.8 W
29 AUG 1994 1604 GMT DEPTH 94

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
2	11.671	33.384	11.671	25.396	257.1	0.051
10	10.166	33.376	10.165	25.657	232.5	0.250
20	8.836	33.635	8.834	26.076	192.9	0.455
30	8.773	33.651	8.770	26.098	190.9	0.647
40	8.637	33.688	8.632	26.149	186.3	0.836
50	8.533	33.710	8.527	26.182	183.3	1.021
60	8.425	33.753	8.419	26.232	178.7	1.201
70	8.364	33.773	8.357	26.257	176.5	1.380
80	8.338	33.794	8.330	26.278	174.8	1.555
85	8.316	33.794	8.307	26.281	174.5	1.642

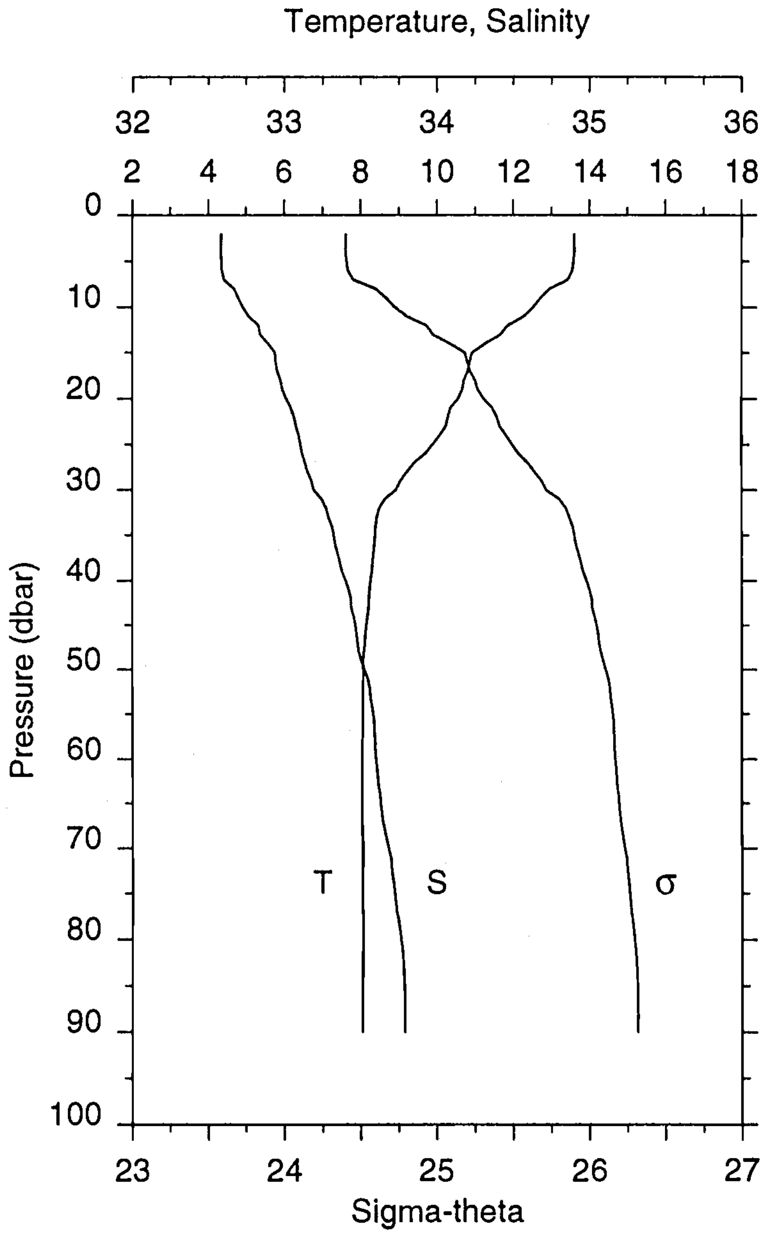
Before Tow 5



STA: 24 LAT: 43 29.8 N LONG: 124 22.3 W
01 SEP 1994 0358 GMT DEPTH 102

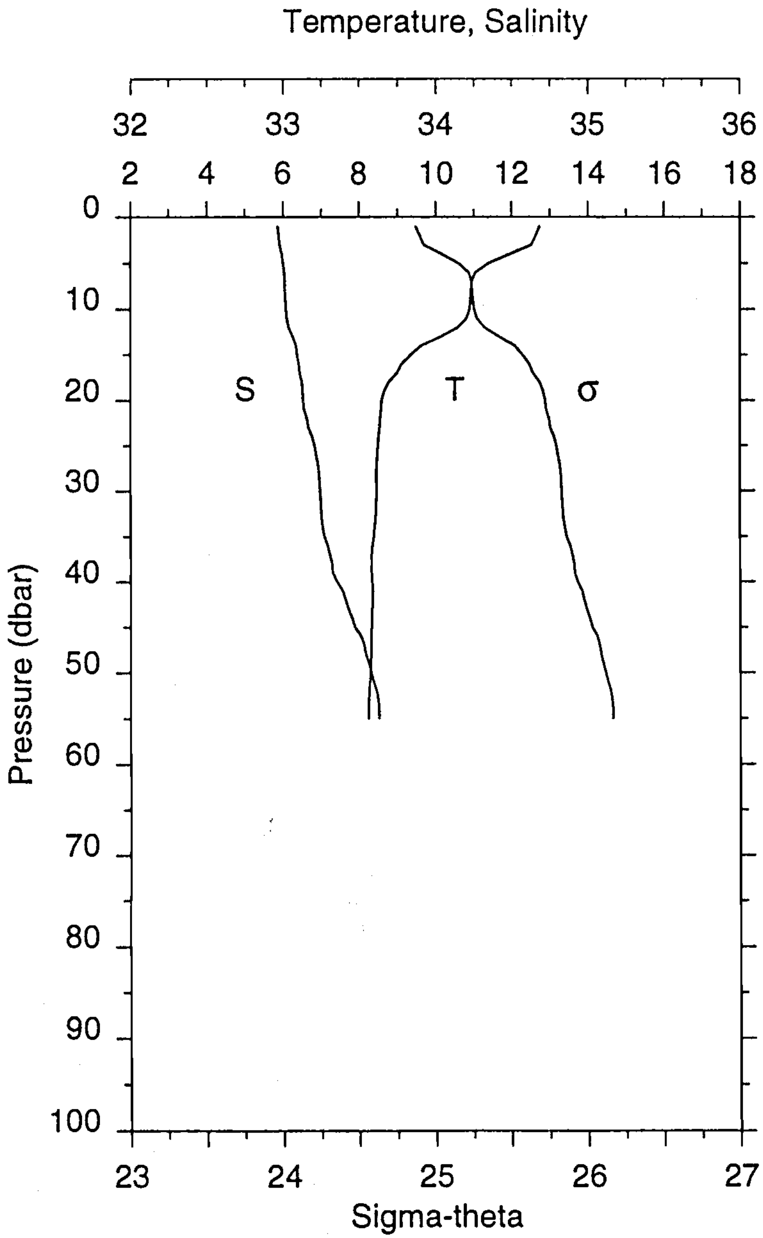
P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
3	13.108	32.576	13.107	24.495	342.9	0.103
10	11.851	32.798	11.850	24.908	303.8	0.327
20	10.817	32.981	10.815	25.237	272.7	0.615
30	9.153	33.150	9.149	25.647	233.8	0.866
40	8.395	33.316	8.391	25.894	210.5	1.085
50	8.183	33.433	8.178	26.018	198.9	1.290
60	8.045	33.543	8.039	26.124	188.9	1.482
70	7.948	33.621	7.941	26.200	181.9	1.668
80	8.018	33.739	8.010	26.283	174.3	1.845
90	8.052	33.786	8.043	26.314	171.4	2.018
92	8.049	33.789	8.040	26.317	171.2	2.053

After Tow 5



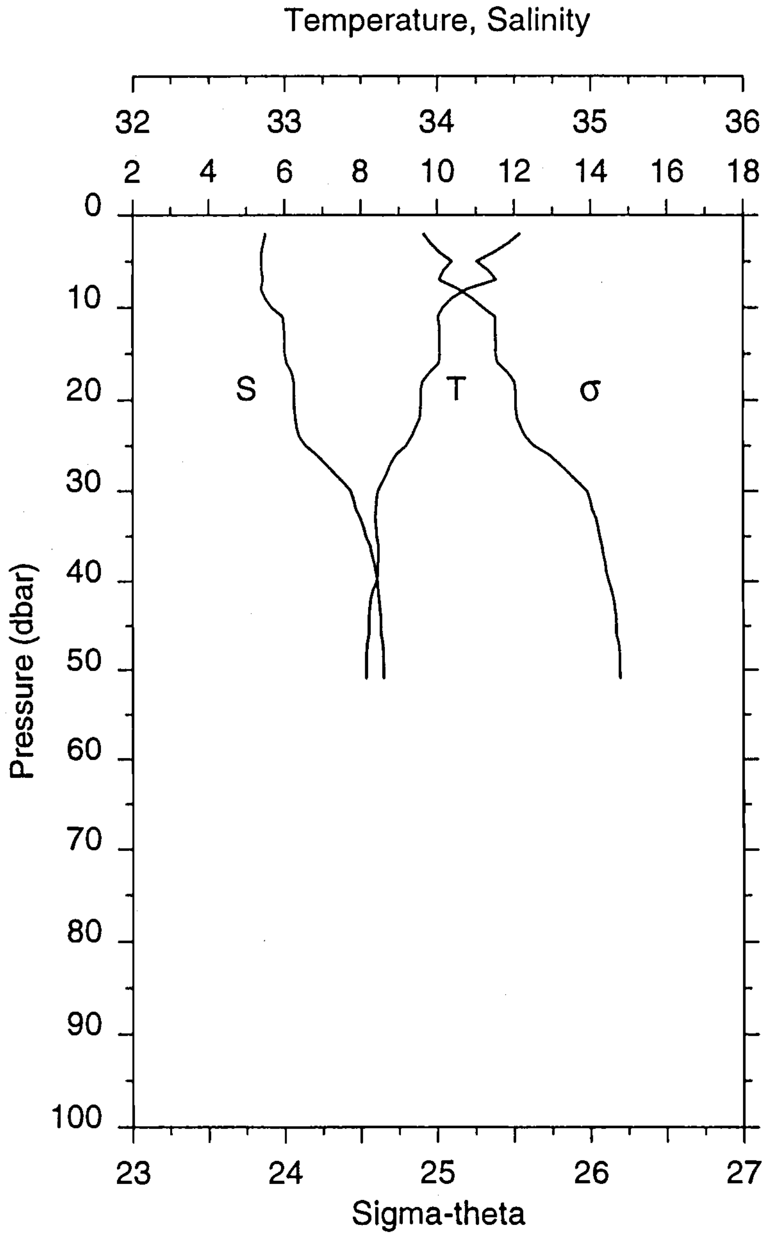
STA: 25 TM-2 LAT: 43 29.9 N LONG: 124 21.0 W
01 SEP 1994 0435 GMT DEPTH 98

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
2	13.602	32.585	13.602	24.403	351.7	0.070
10	12.524	32.730	12.523	24.728	320.9	0.345
20	10.561	33.014	10.559	25.307	266.0	0.631
30	8.933	33.193	8.930	25.715	227.4	0.878
40	8.270	33.404	8.266	25.981	202.2	1.089
50	8.071	33.527	8.066	26.107	190.4	1.285
60	8.045	33.601	8.039	26.170	184.6	1.472
70	8.064	33.685	8.057	26.233	178.8	1.654
80	8.062	33.766	8.054	26.297	172.9	1.830
90	8.046	33.791	8.037	26.319	171.0	2.001



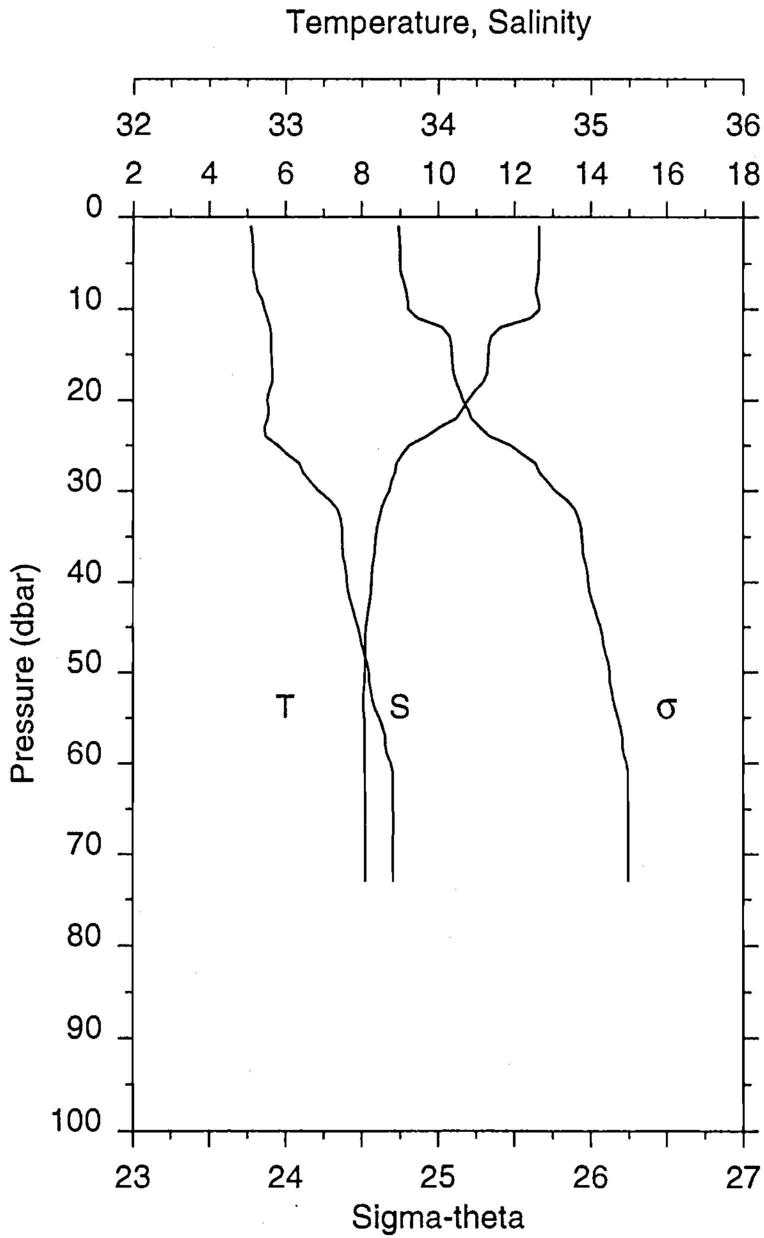
STA: 26 TM-1 LAT: 43 30.1 N LONG: 124 18.1 W
01 SEP 1994 0518 GMT DEPTH 62

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
1	12.737	32.963	12.737	24.867	307.4	0.031
10	10.892	33.019	10.890	25.253	270.9	0.287
20	8.595	33.132	8.593	25.719	226.7	0.532
30	8.457	33.244	8.454	25.827	216.6	0.753
40	8.340	33.355	8.336	25.932	206.8	0.965
50	8.290	33.580	8.285	26.116	189.5	1.163
55	8.240	33.629	8.235	26.163	185.2	1.256



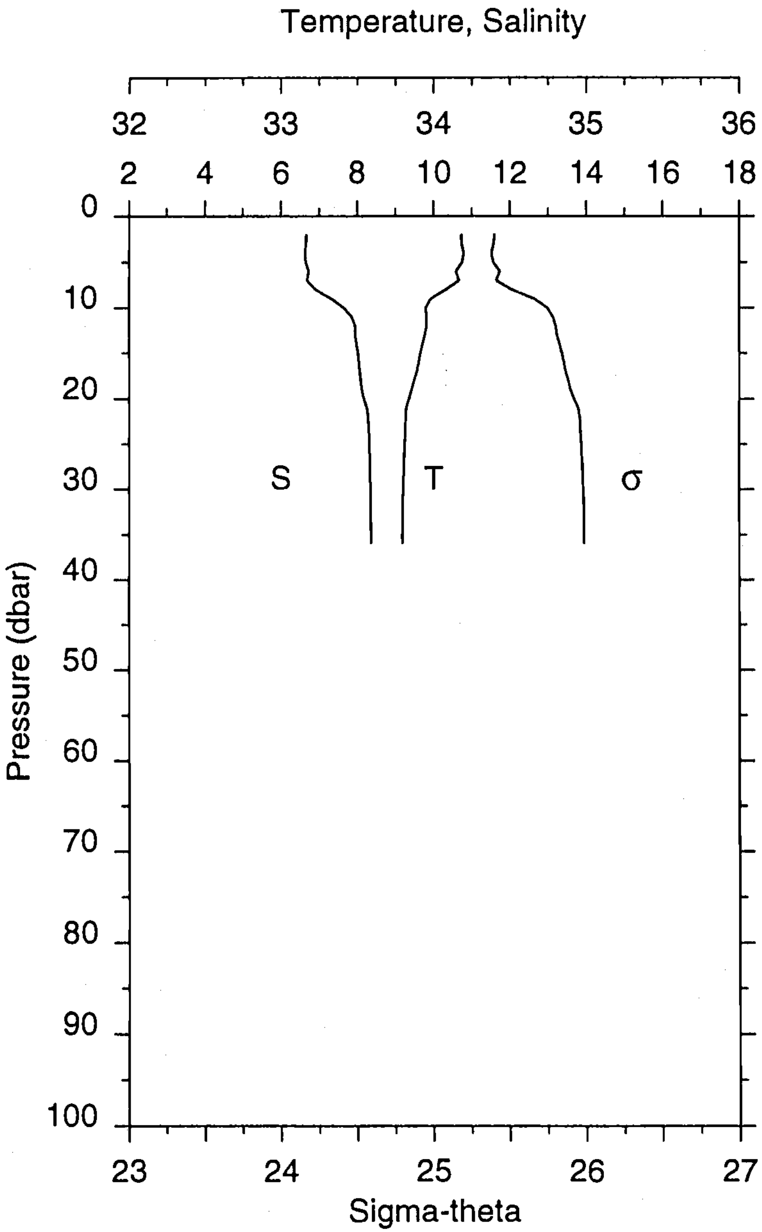
STA: 27 AR-1 LAT: 43 20.0 N LONG: 124 26.1 W
01 SEP 1994 0641 GMT DEPTH 57

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
2	12.153	32.875	12.153	24.911	303.3	0.061
10	10.156	32.915	10.155	25.299	266.6	0.291
20	9.581	33.064	9.579	25.510	246.6	0.546
30	8.459	33.436	8.456	25.978	202.3	0.777
40	8.420	33.610	8.415	26.120	189.0	0.972
50	8.145	33.650	8.140	26.193	182.3	1.156
51	8.139	33.651	8.134	26.195	182.1	1.174



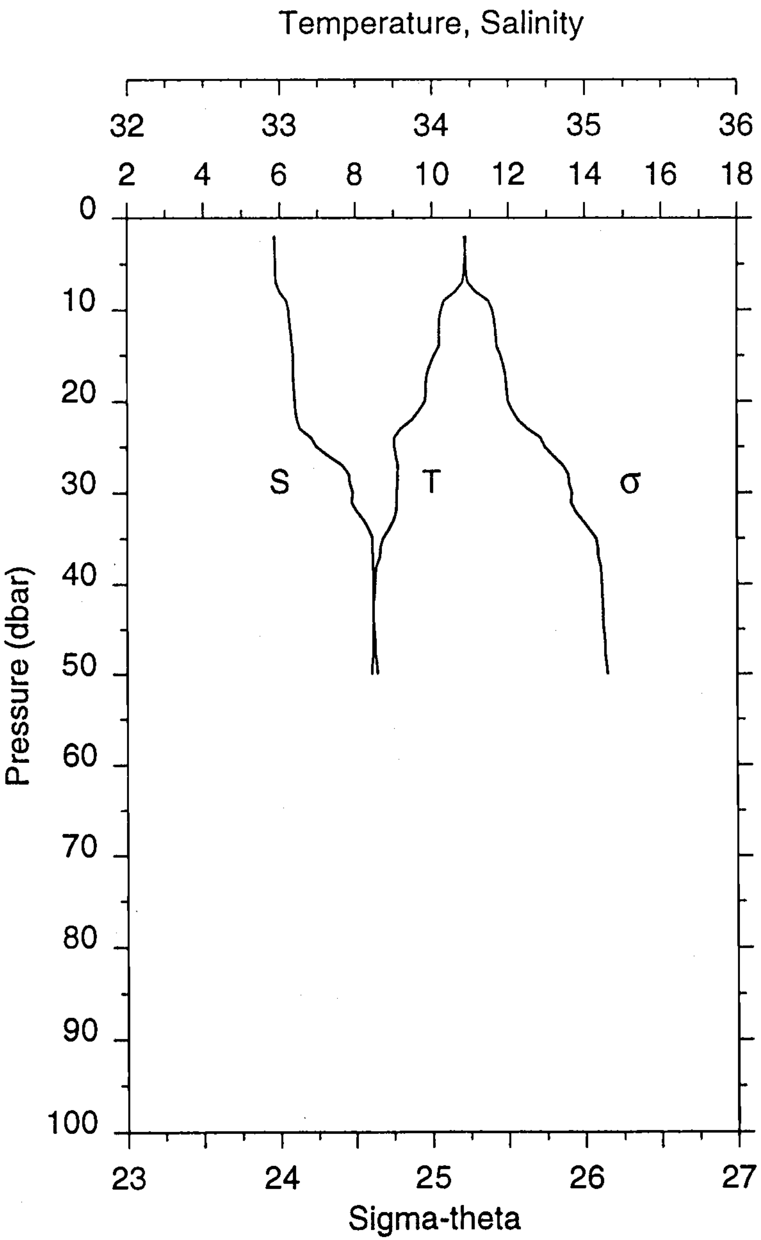
STA: 28 AR-2 LAT: 43 20.0 N LONG: 124 27.8 W
01 SEP 94 0713 GMT DEPTH 80

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
1	12.642	32.771	12.642	24.737	319.8	0.032
10	12.668	32.862	12.666	24.803	313.8	0.318
20	10.790	32.880	10.788	25.163	279.7	0.607
30	8.726	33.221	8.723	25.769	222.2	0.859
40	8.265	33.405	8.261	25.983	202.0	1.066
50	8.084	33.549	8.079	26.123	188.9	1.262
60	8.089	33.690	8.083	26.233	178.6	1.446
70	8.094	33.705	8.088	26.245	177.7	1.624
73	8.095	33.707	8.087	26.246	177.7	1.677



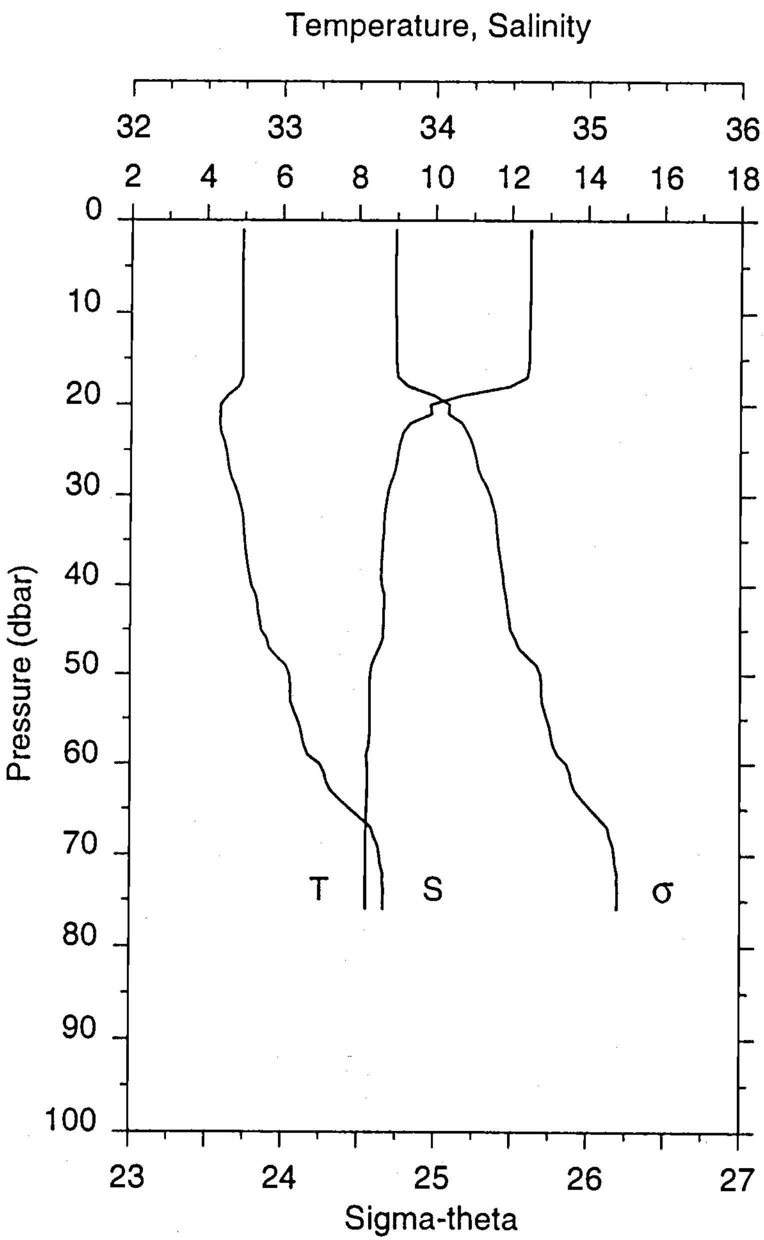
STA: 29 FM-1 LAT: 43 13.1 N LONG: 124 26.4 W
01 SEP 1994 0822 GMT DEPTH 40

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
2	10.726	33.170	10.726	25.400	256.8	0.051
10	9.797	33.412	9.796	25.747	224.0	0.252
20	9.359	33.543	9.357	25.921	207.6	0.467
30	9.204	33.587	9.201	25.980	202.2	0.670
36	9.187	33.591	9.183	25.986	201.7	0.791



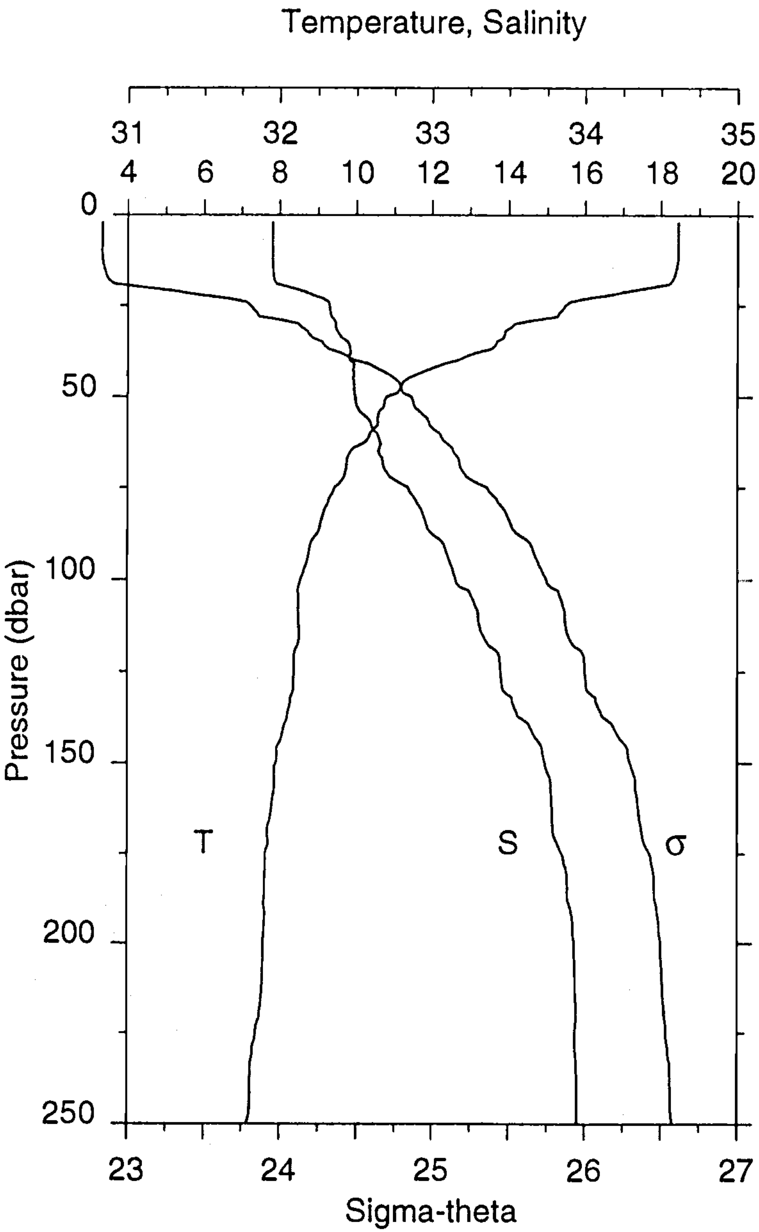
STA: 30 FM-3 LAT: 43 13.1 N LONG: 124 30.0 W
01 SEP 1994 0856 GMT DEPTH 65

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
2	10.890	32.964	10.890	25.210	274.8	0.055
10	10.245	33.060	10.244	25.397	257.2	0.271
20	9.825	33.101	9.822	25.500	247.7	0.523
30	9.093	33.485	9.090	25.918	208.1	0.749
40	8.527	33.619	8.523	26.111	189.9	0.946
50	8.435	33.647	8.430	26.148	186.6	1.135



STA: 31 FM-4 LAT: 43 12.9 N LONG: 124 35.0 W
01 SEP 1994 0944 GMT DEPTH 85

P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
1	12.481	32.735	12.481	24.740	319.6	0.032
10	12.476	32.735	12.475	24.742	319.6	0.320
20	9.876	32.592	9.874	25.093	286.3	0.634
30	8.762	32.710	8.759	25.363	260.8	0.907
40	8.618	32.796	8.614	25.452	252.5	1.163
50	8.321	33.047	8.316	25.694	229.6	1.408
60	8.241	33.249	8.235	25.864	213.6	1.633
70	8.212	33.642	8.205	26.178	184.1	1.831
76	8.210	33.667	8.202	26.197	182.3	1.941

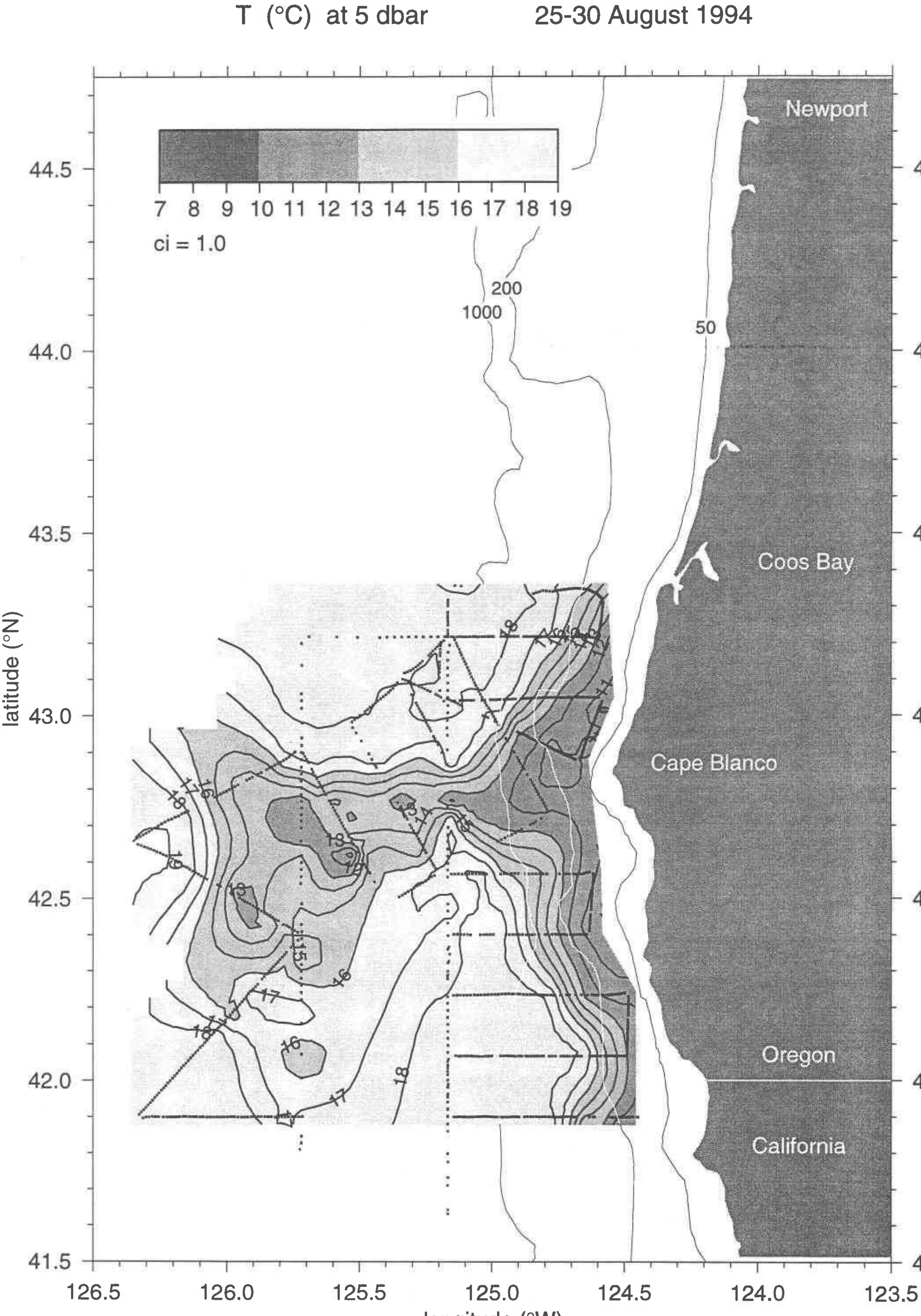


STA: 32 FM-9 LAT: 43 14.2 N LONG: 125 9.9 W
02 SEP 1994 0442 GMT DEPTH 1725

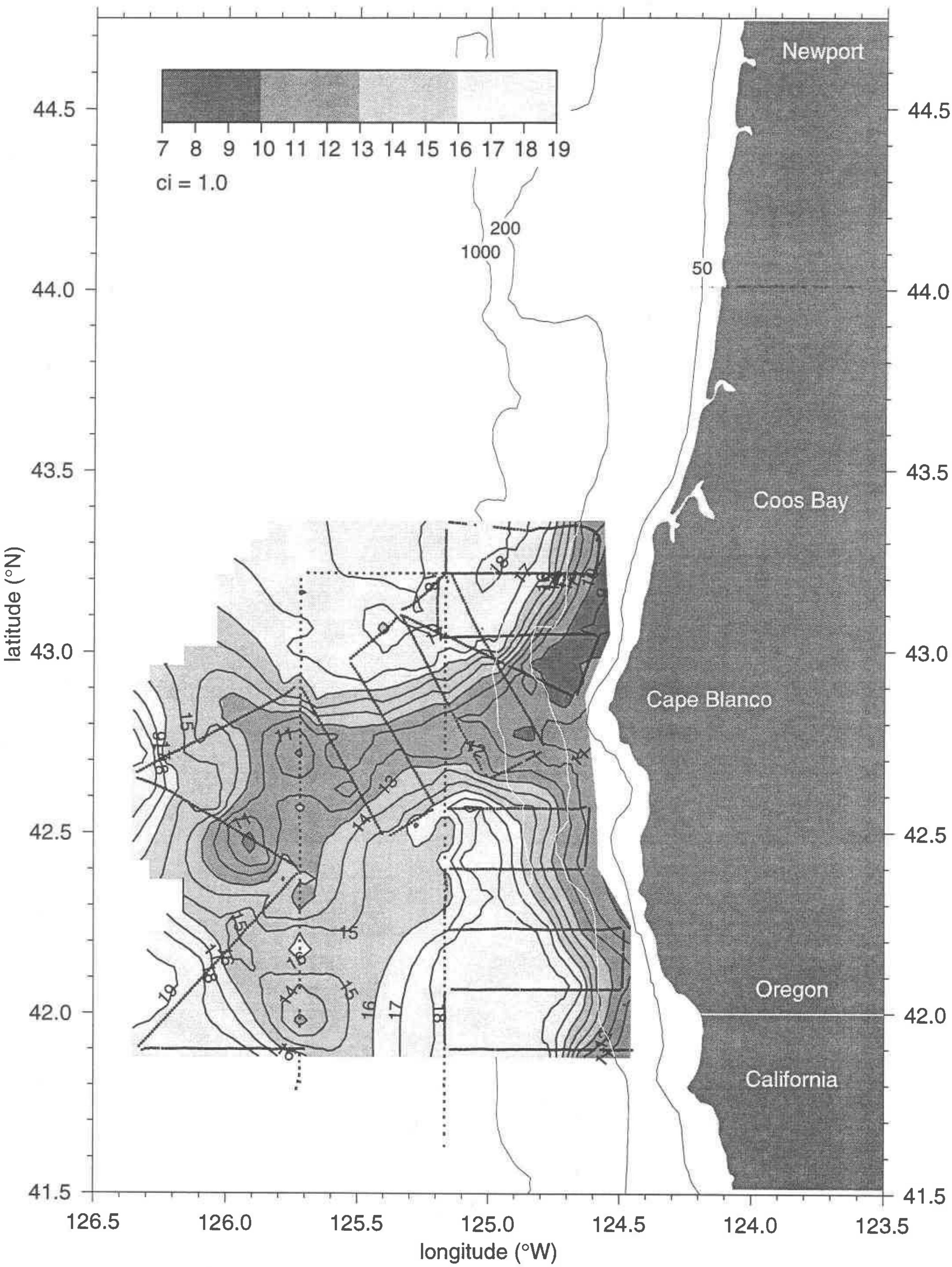
P (DB)	T (C)	S	POT T (C)	SIGMA THETA	SVA (CL/T)	DYN HT (J/KG)
2	18.447	31.953	18.446	22.832	501.6	0.100
10	18.451	31.953	18.449	22.831	502.0	0.502
20	17.682	32.068	17.679	23.106	476.0	1.000
30	14.158	32.367	14.154	24.122	379.2	1.418
40	12.689	32.453	12.684	24.482	345.1	1.783
50	10.790	32.491	10.785	24.861	309.1	2.106
60	10.358	32.634	10.351	25.046	291.6	2.408
70	9.724	32.684	9.716	25.191	277.9	2.691
80	9.217	32.915	9.209	25.453	253.2	2.956
90	8.818	33.072	8.809	25.639	235.7	3.202
100	8.551	33.156	8.541	25.746	225.6	3.433
110	8.500	33.305	8.489	25.870	214.0	3.651
120	8.397	33.434	8.385	25.987	203.1	3.862
130	8.372	33.465	8.359	26.015	200.6	4.064
140	8.119	33.639	8.105	26.190	184.2	4.256
150	7.906	33.738	7.891	26.299	173.9	4.434
175	7.623	33.849	7.606	26.428	162.1	4.856
200	7.571	33.931	7.552	26.500	155.6	5.253
225	7.372	33.938	7.351	26.534	152.7	5.639
250	7.131	33.948	7.108	26.576	149.1	6.015

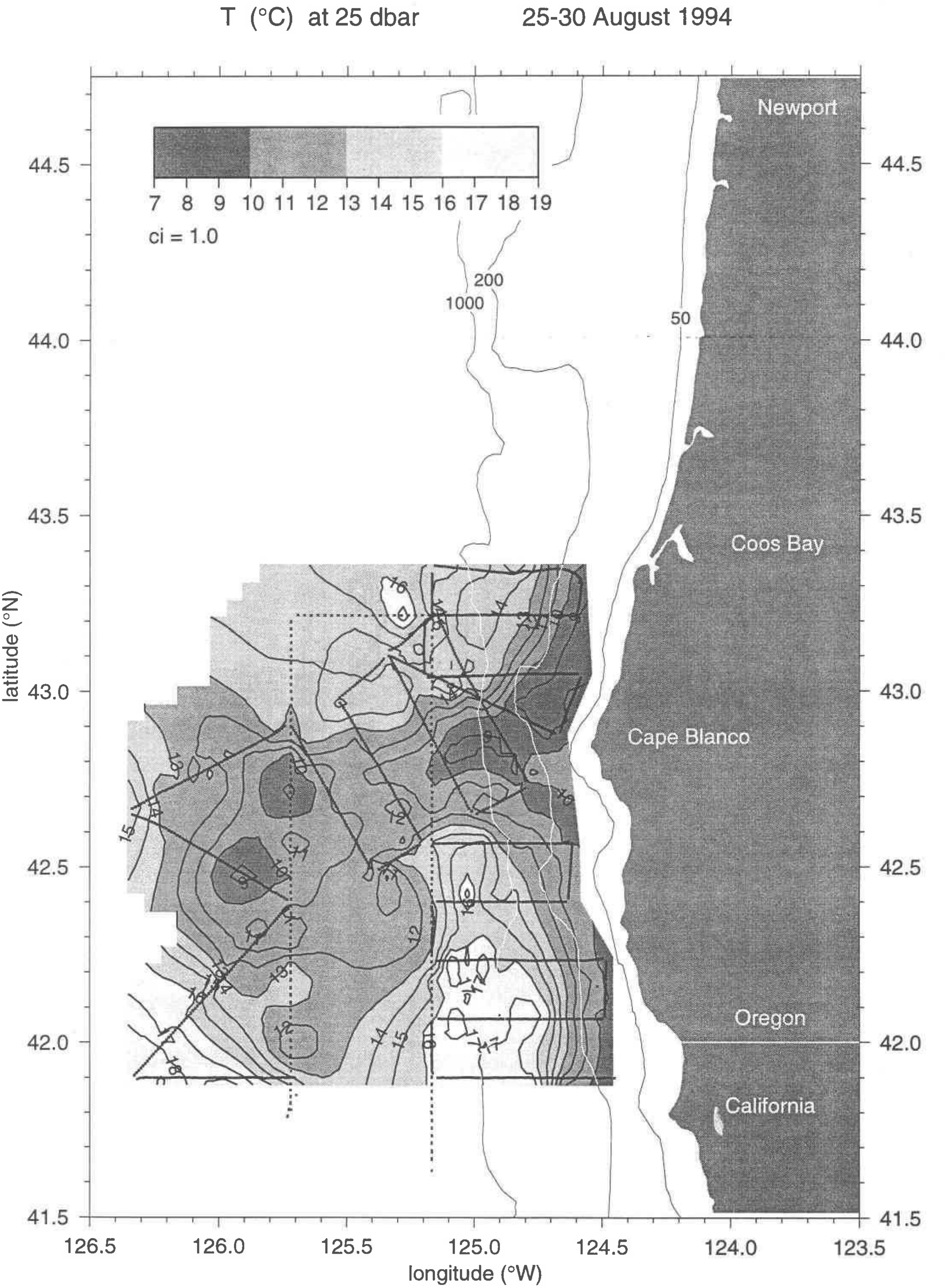
After Tow 6

Maps of Temperature, Salinity, σ_t and Dynamic Topography


T (°C) at 5 dbar
25-30 August 1994
7 8 9 10 11 12 13 14 15 16 17 18 19
ci = 1.0
Newport
Coos Bay
Cape Blanco
Oregon
California
200
1000
50
latitude (°N)
longitude (°W)
44.5
44.0
43.5
43.0
42.5
42.0
41.5
126.5
126.0
125.5
125.0
124.5
124.0
123.5

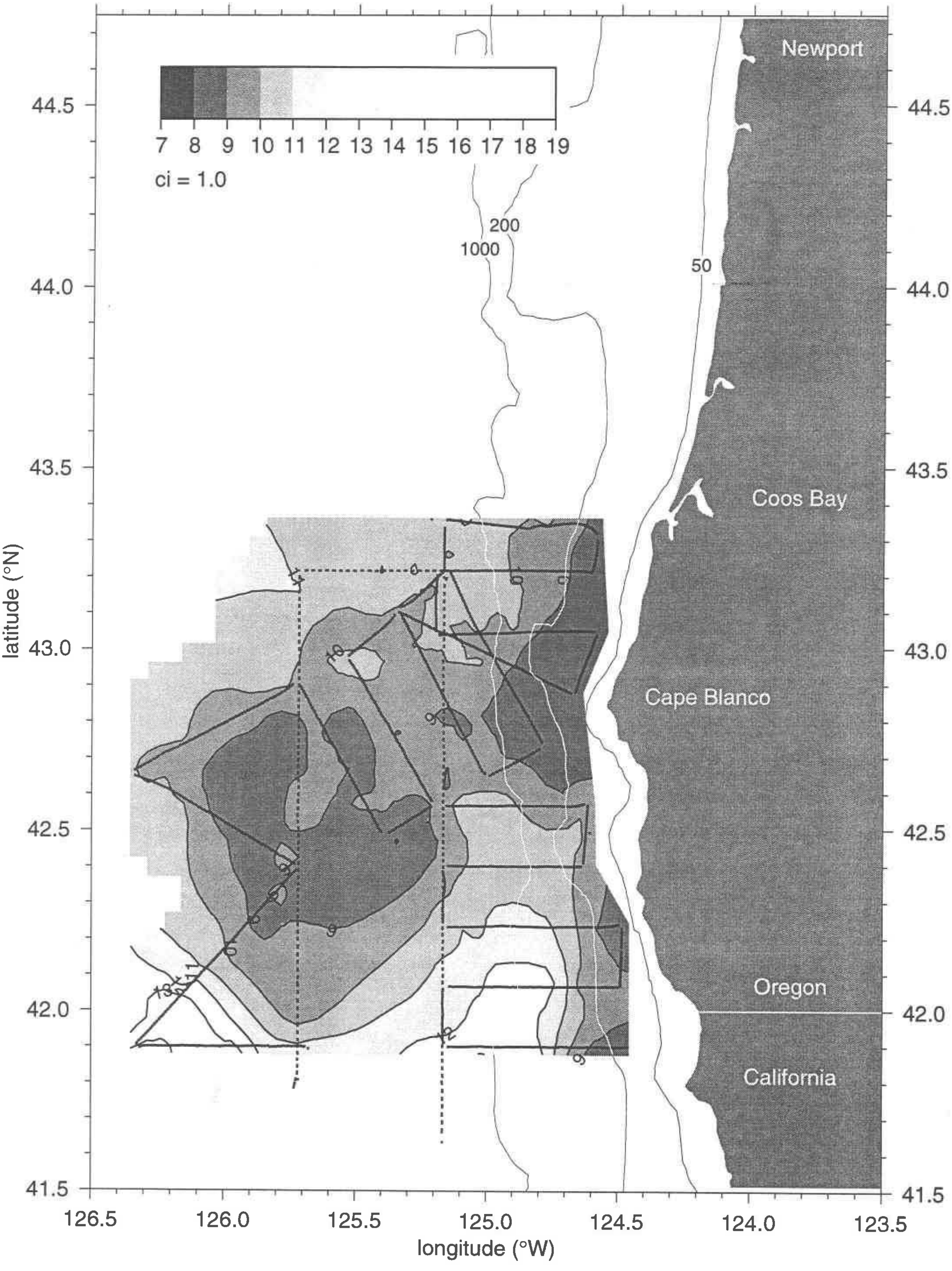
T (°C) at 15 dbar 25-30 August 1994

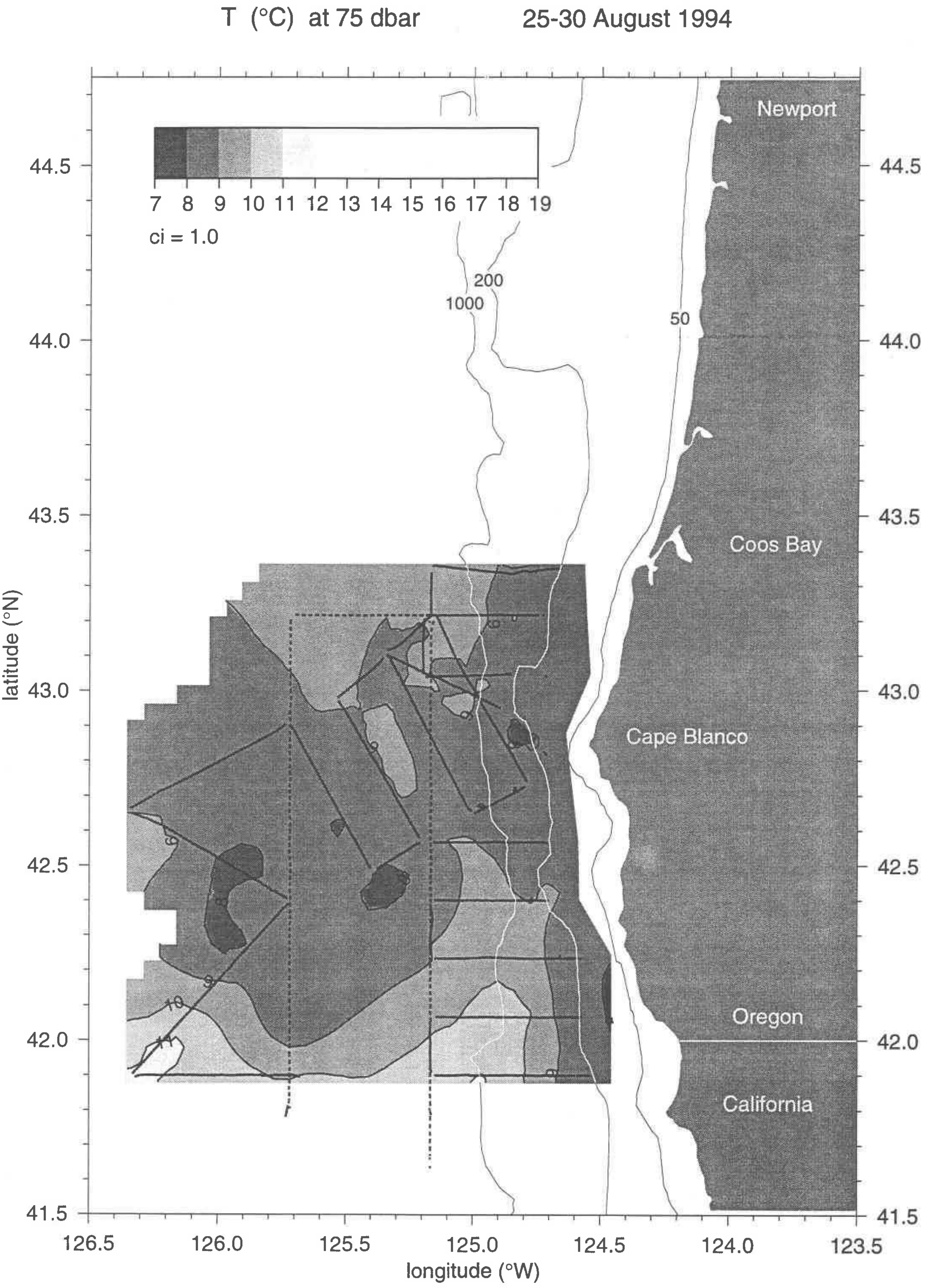


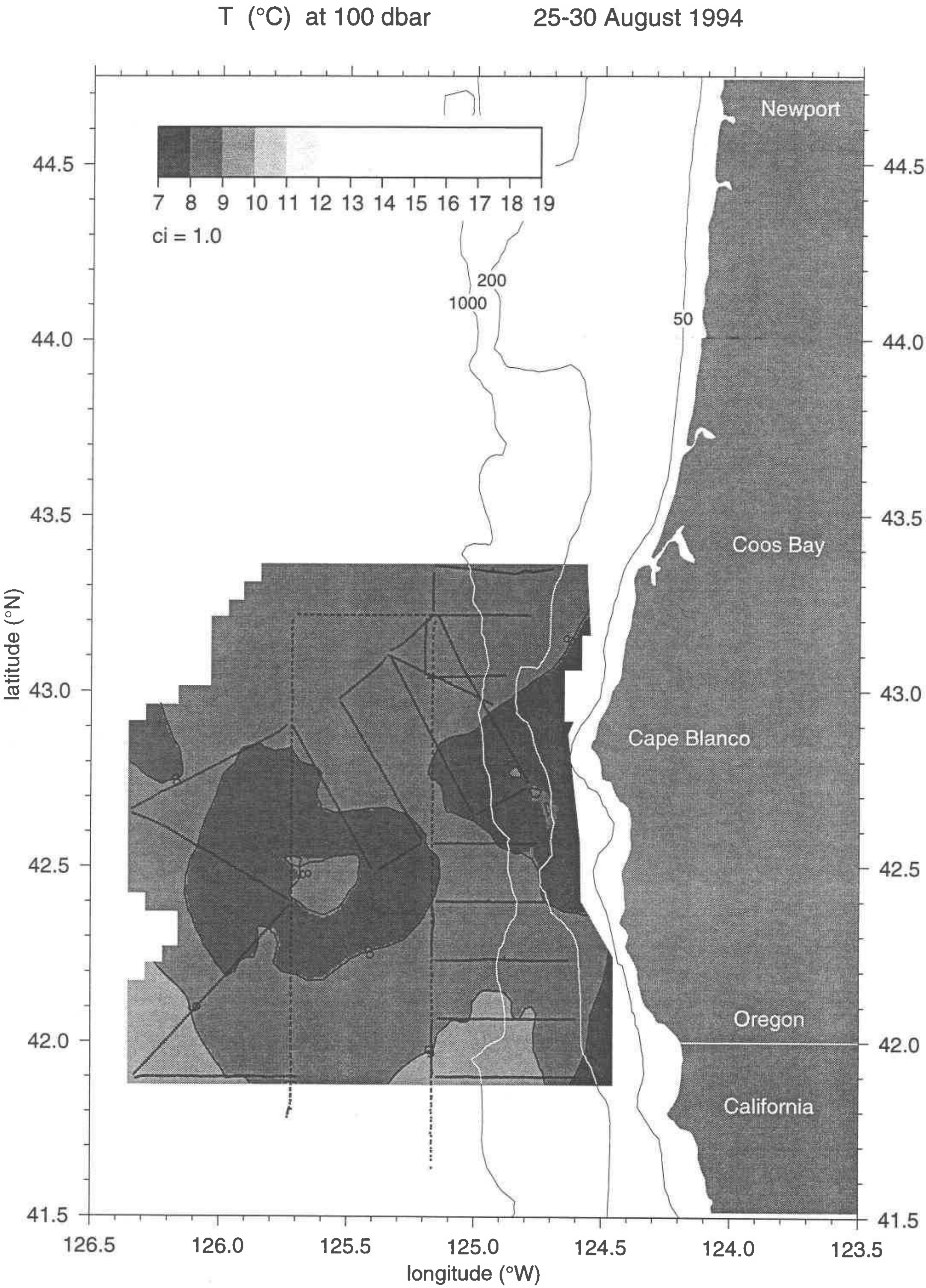


T (°C) at 25 dbar
25-30 August 1994
7 8 9 10 11 12 13 14 15 16 17 18 19
ci = 1.0
Newport
Coos Bay
Cape Blanco
Oregon
California
200
1000
50
latitude (°N)
longitude (°W)
44.5
44.0
43.5
43.0
42.5
42.0
41.5
126.5
126.0
125.5
125.0
124.5
124.0
123.5

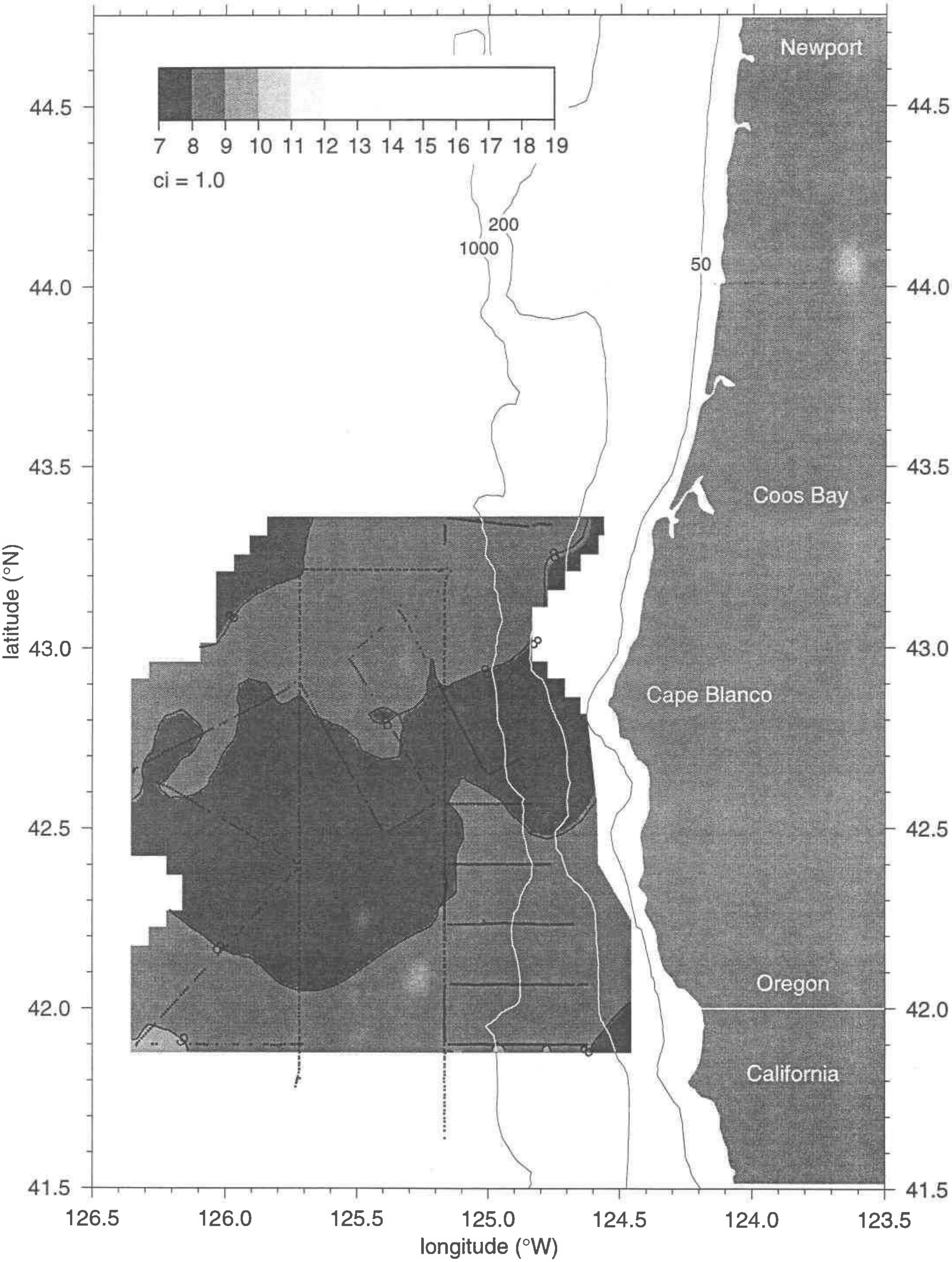
T (°C) at 50 dbar 25-30 August 1994



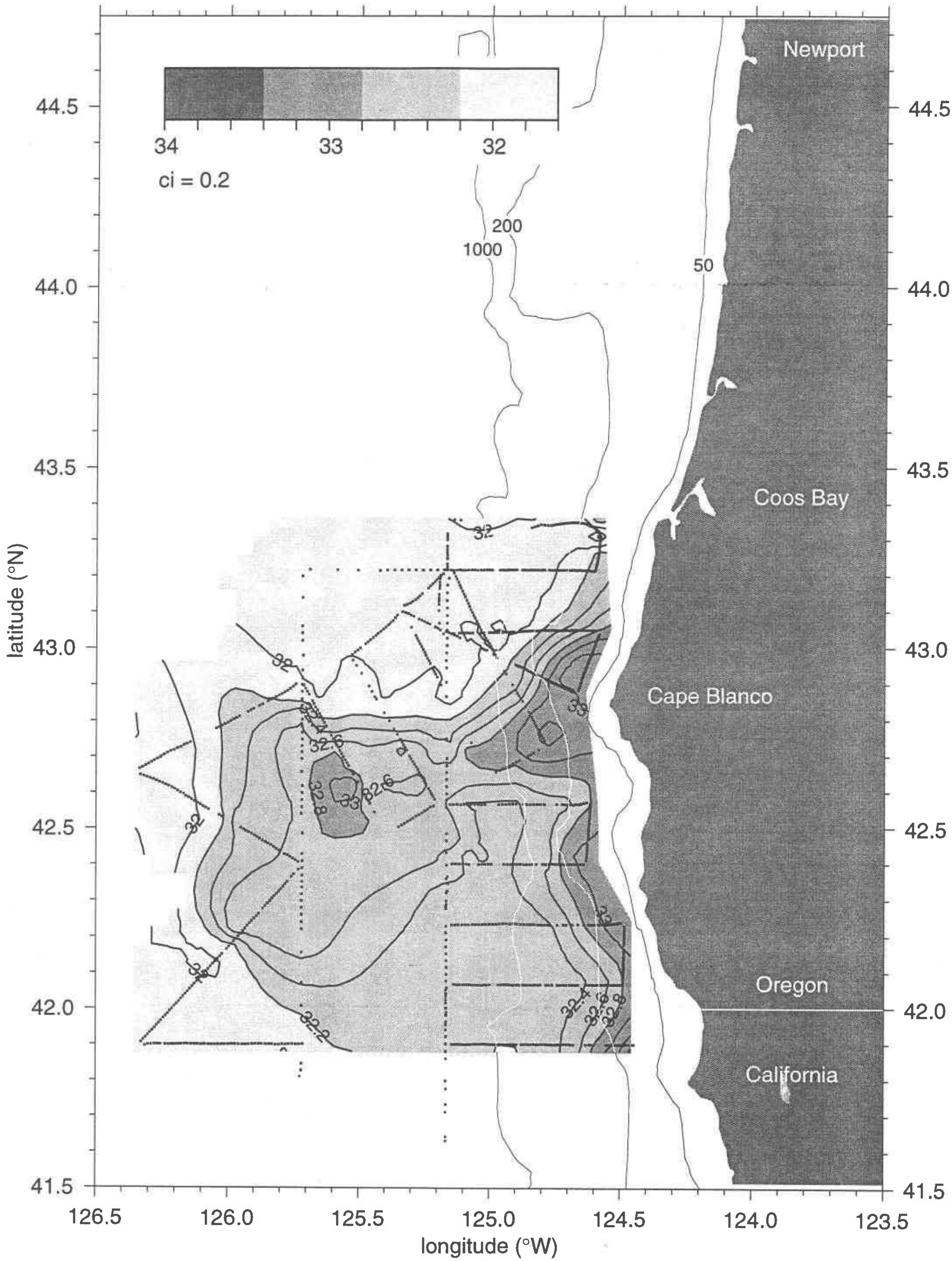

T (°C) at 75 dbar
25-30 August 1994
7 8 9 10 11 12 13 14 15 16 17 18 19
ci = 1.0
Newport
Coos Bay
Cape Blanco
Oregon
California
200
1000
50
44.5
44.0
43.5
43.0
42.5
42.0
41.5
126.5 126.0 125.5 125.0 124.5 124.0 123.5
latitude (°N)
longitude (°W)


T (°C) at 100 dbar
25-30 August 1994
7 8 9 10 11 12 13 14 15 16 17 18 19
ci = 1.0
Newport
Coos Bay
Cape Blanco
Oregon
California
200
1000
50
latitude (°N)
longitude (°W)
44.5
44.0
43.5
43.0
42.5
42.0
41.5
126.5
126.0
125.5
125.0
124.5
124.0
123.5

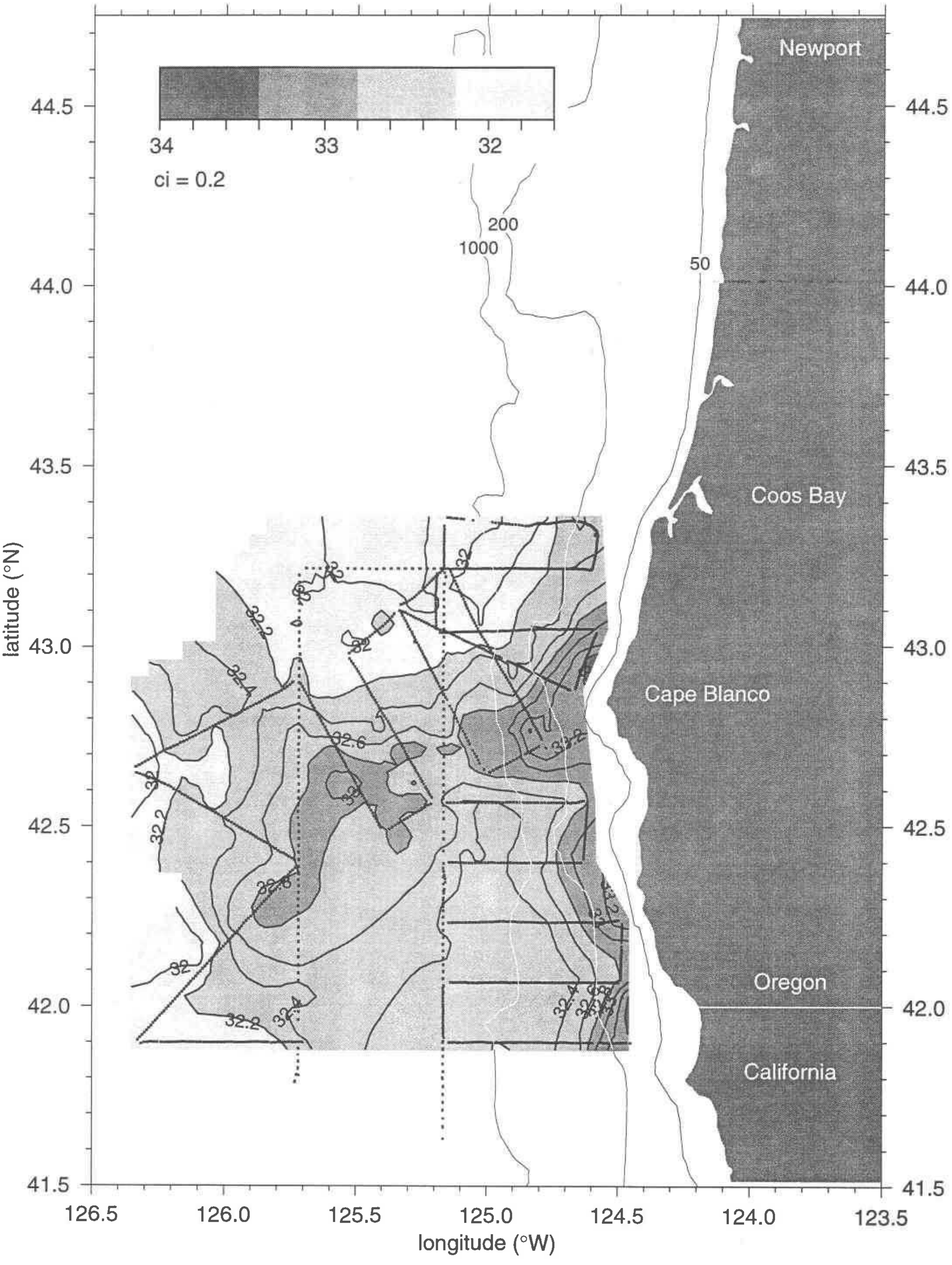
T (°C) at 115 dbar 25-30 August 1994



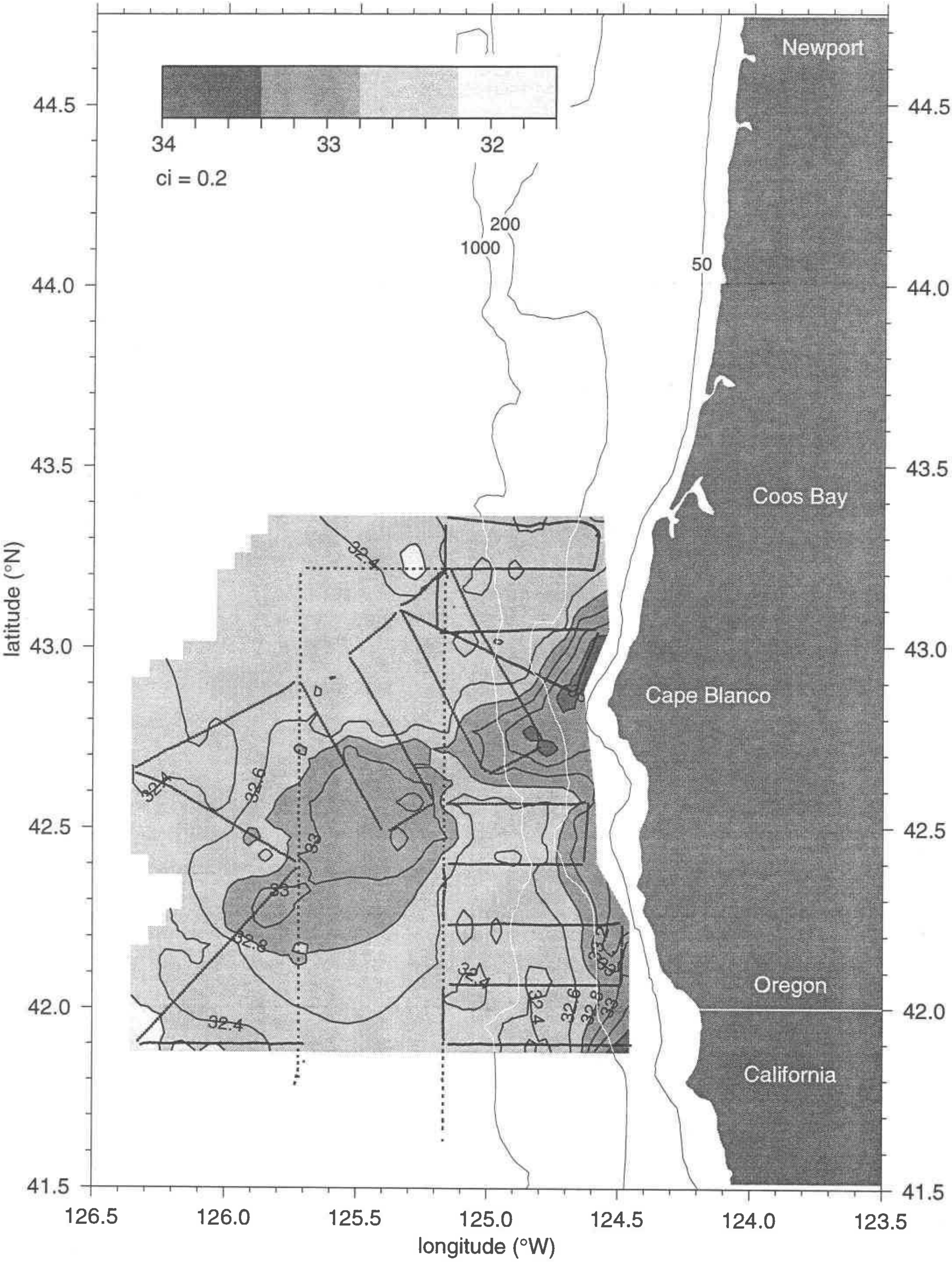
S at 5 dbar 25-30 August 1994



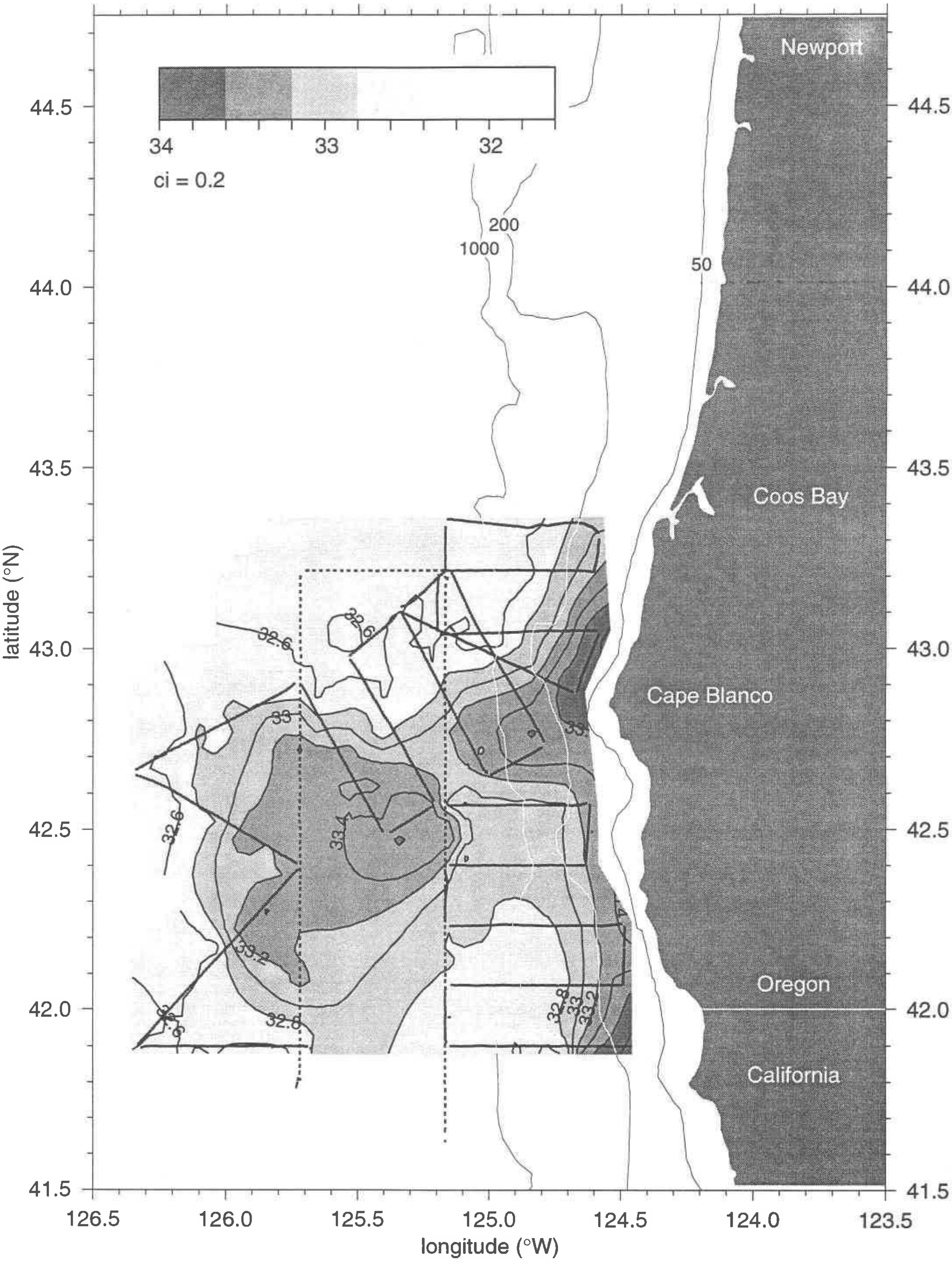
S at 15 dbar 25-30 August 1994

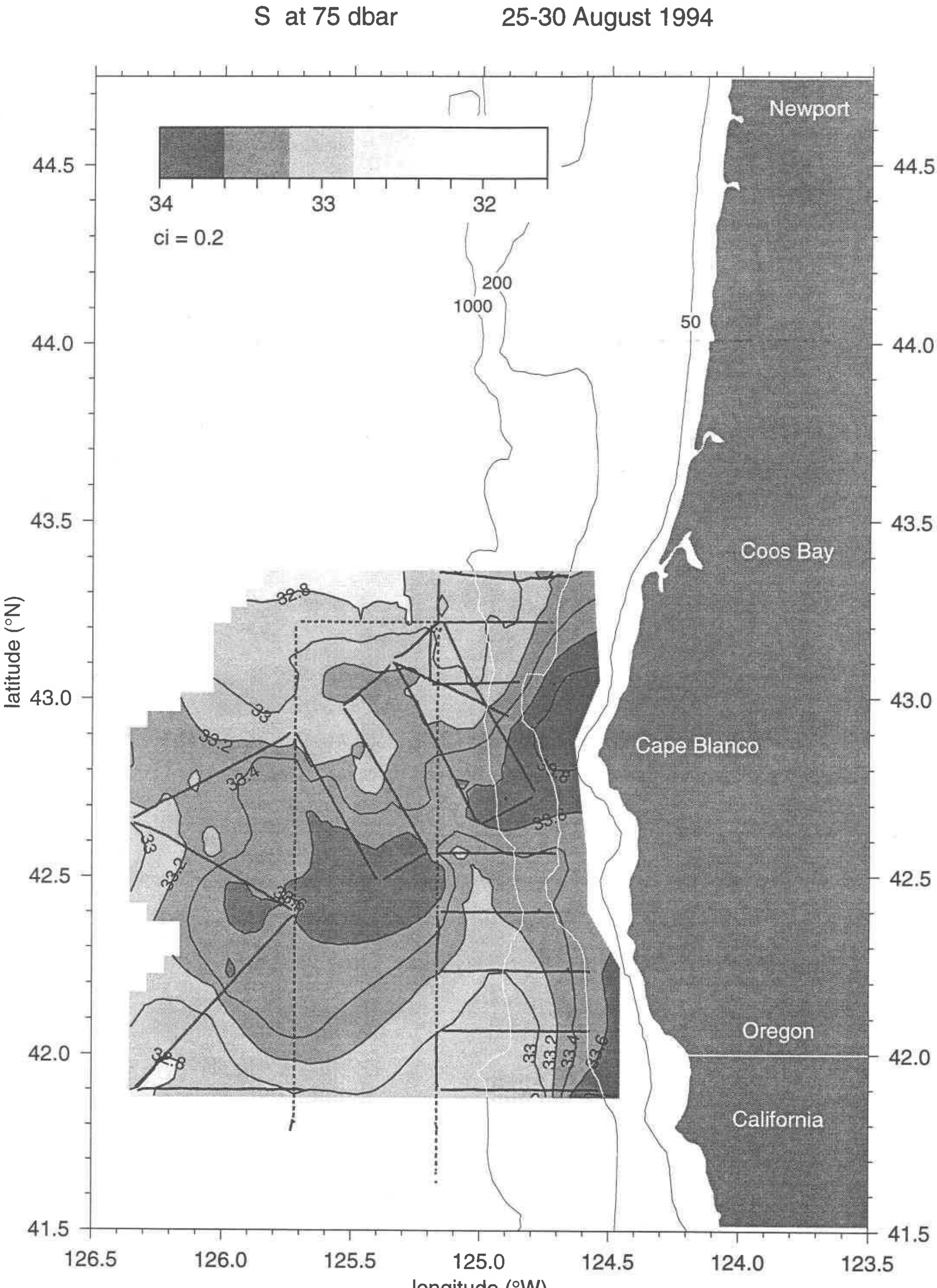


S at 25 dbar 25-30 August 1994



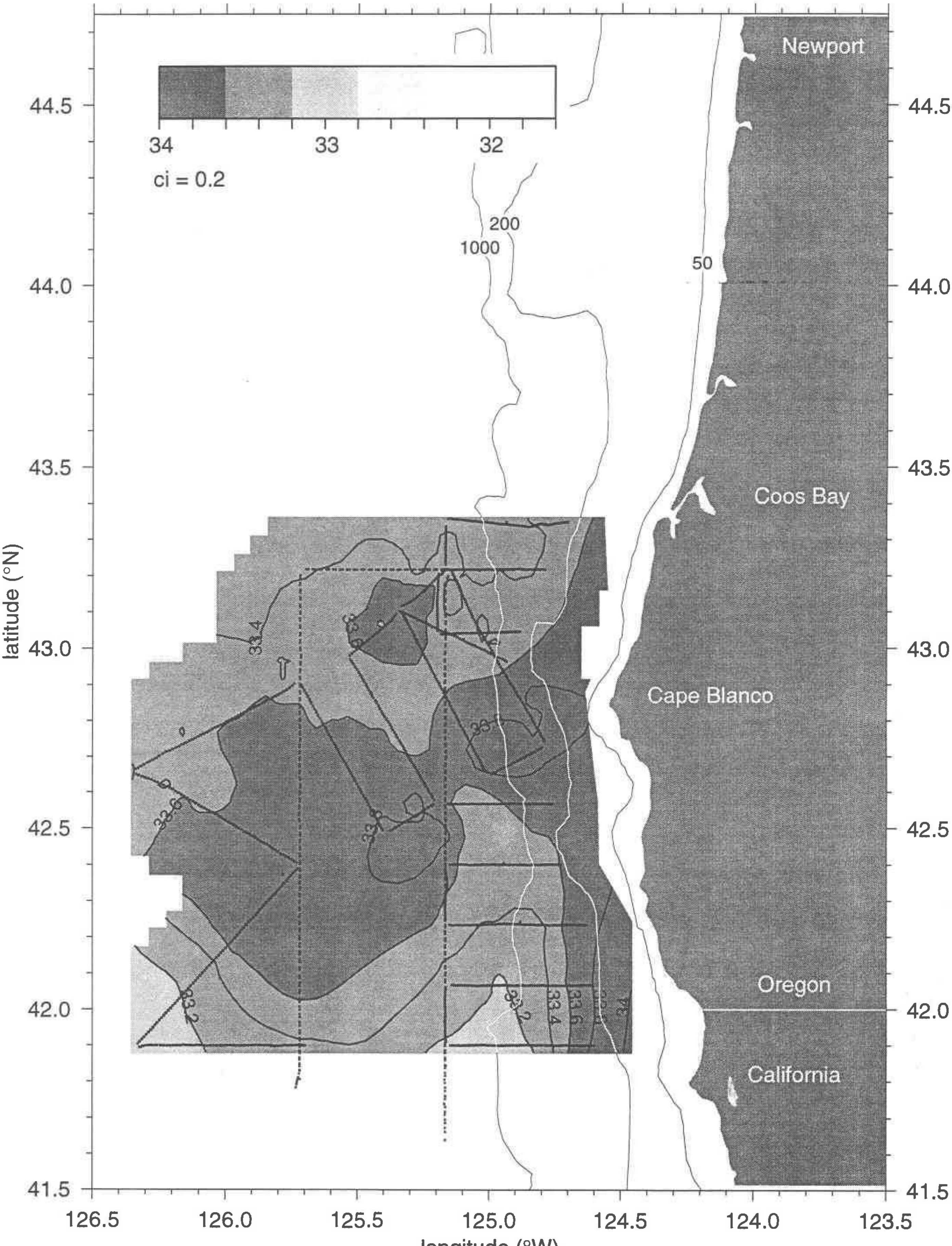
S at 50 dbar 25-30 August 1994



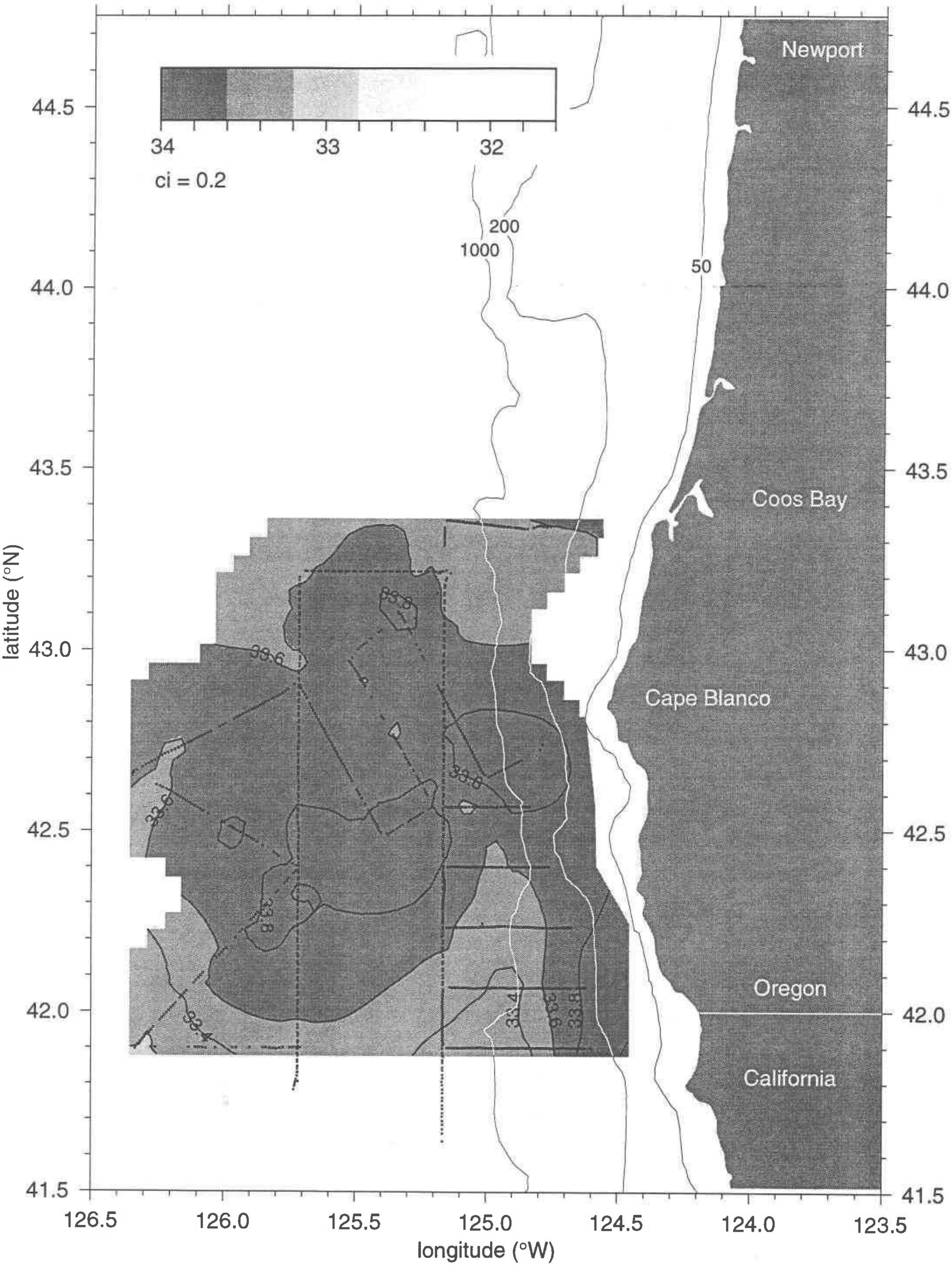


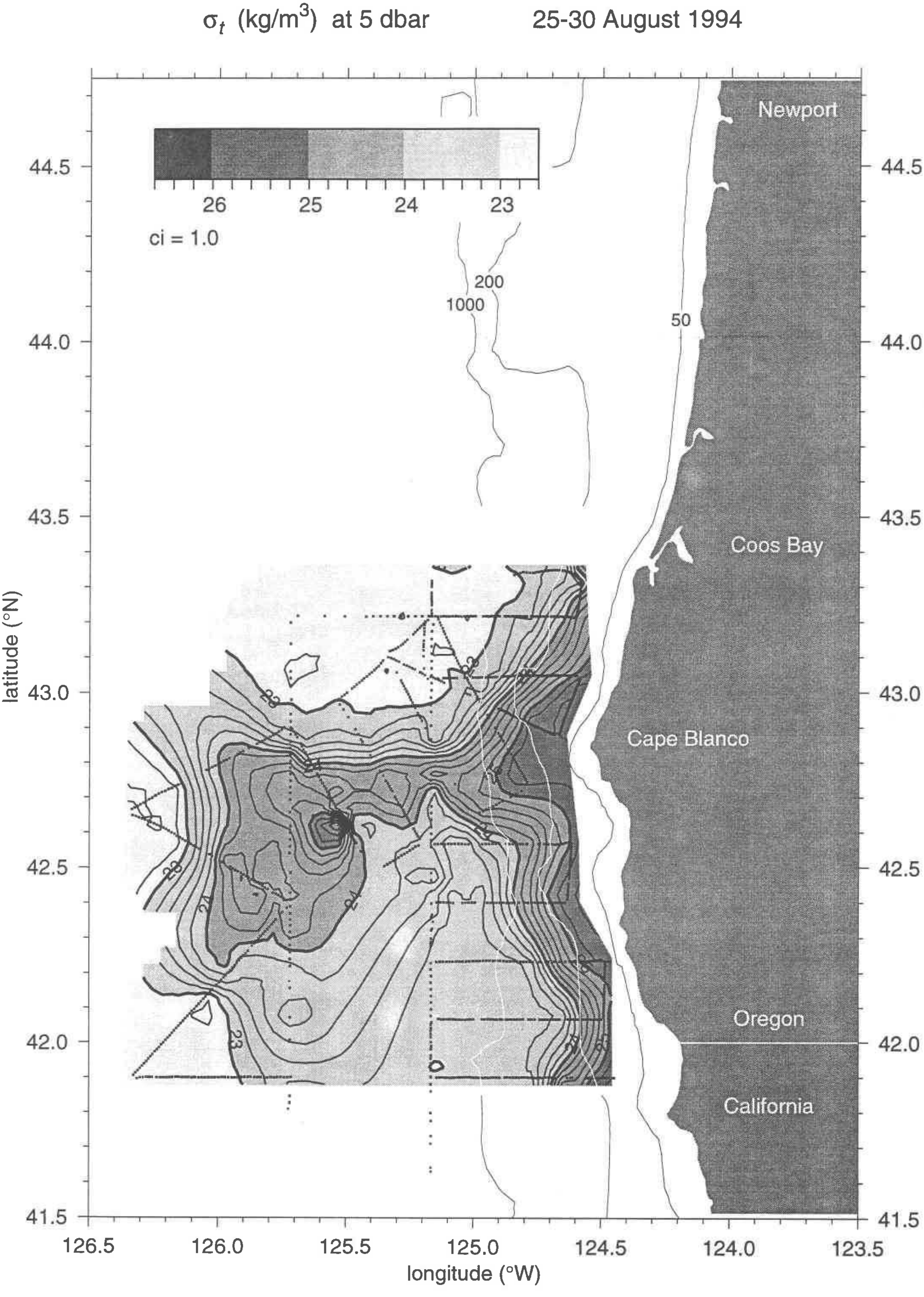
S at 75 dbar
25-30 August 1994
34
33
32
ci = 0.2
Newport
Coos Bay
Cape Blanco
Oregon
California
200
1000
50
32.8
33
33.2
33.4
33.6
33.8
latitude (°N)
longitude (°W)
44.5
44.0
43.5
43.0
42.5
42.0
41.5
126.5
126.0
125.5
125.0
124.5
124.0
123.5

S at 100 dbar 25-30 August 1994

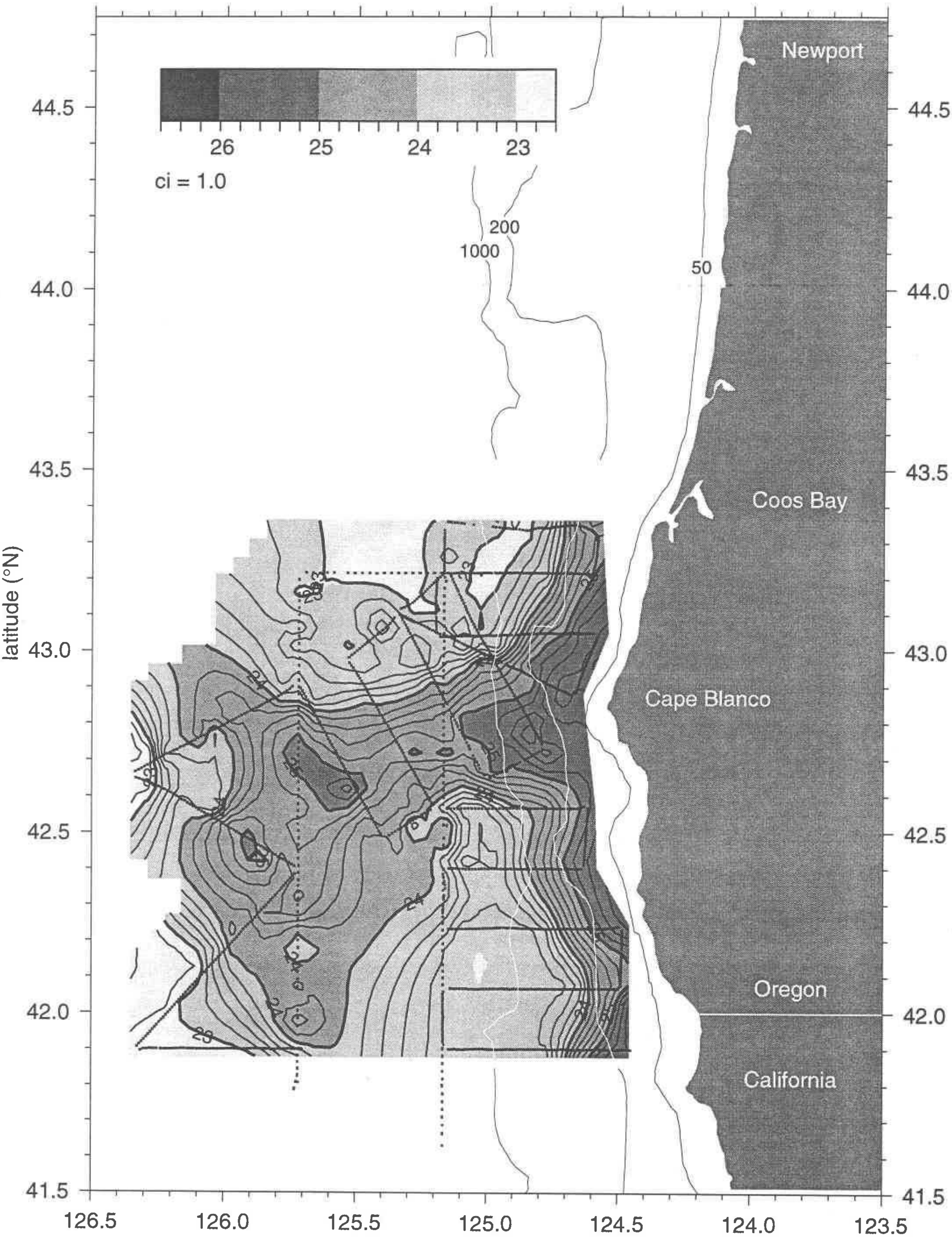


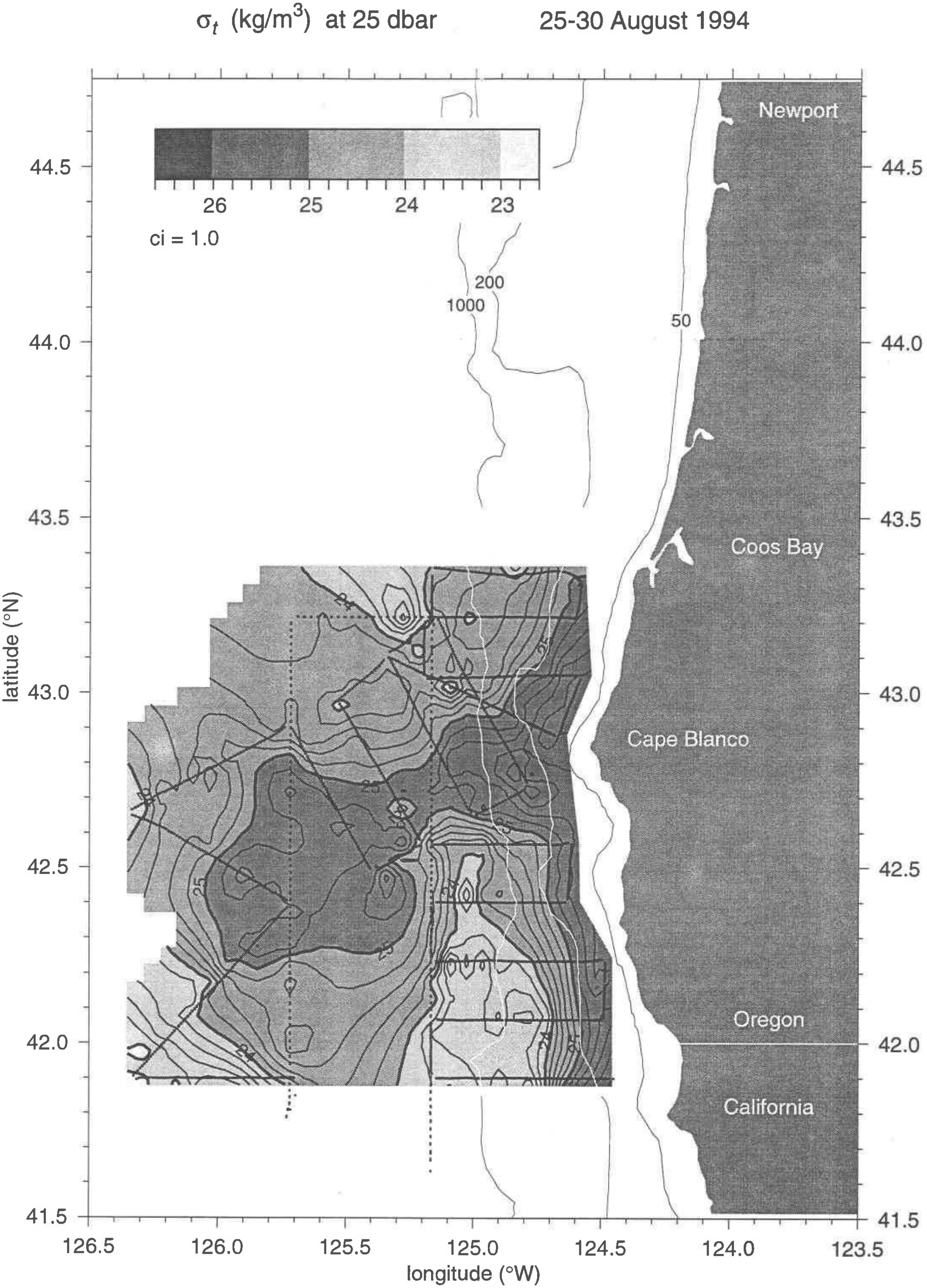
S at 115 dbar 25-30 August 1994




σt (kg/m3) at 5 dbar
25-30 August 1994
26
25
24
23
ci = 1.0
Newport
Coos Bay
Cape Blanco
Oregon
California
200
1000
50
latitude (°N)
longitude (°W)
44.5
44.0
43.5
43.0
42.5
42.0
41.5
126.5
126.0
125.5
125.0
124.5
124.0
123.5

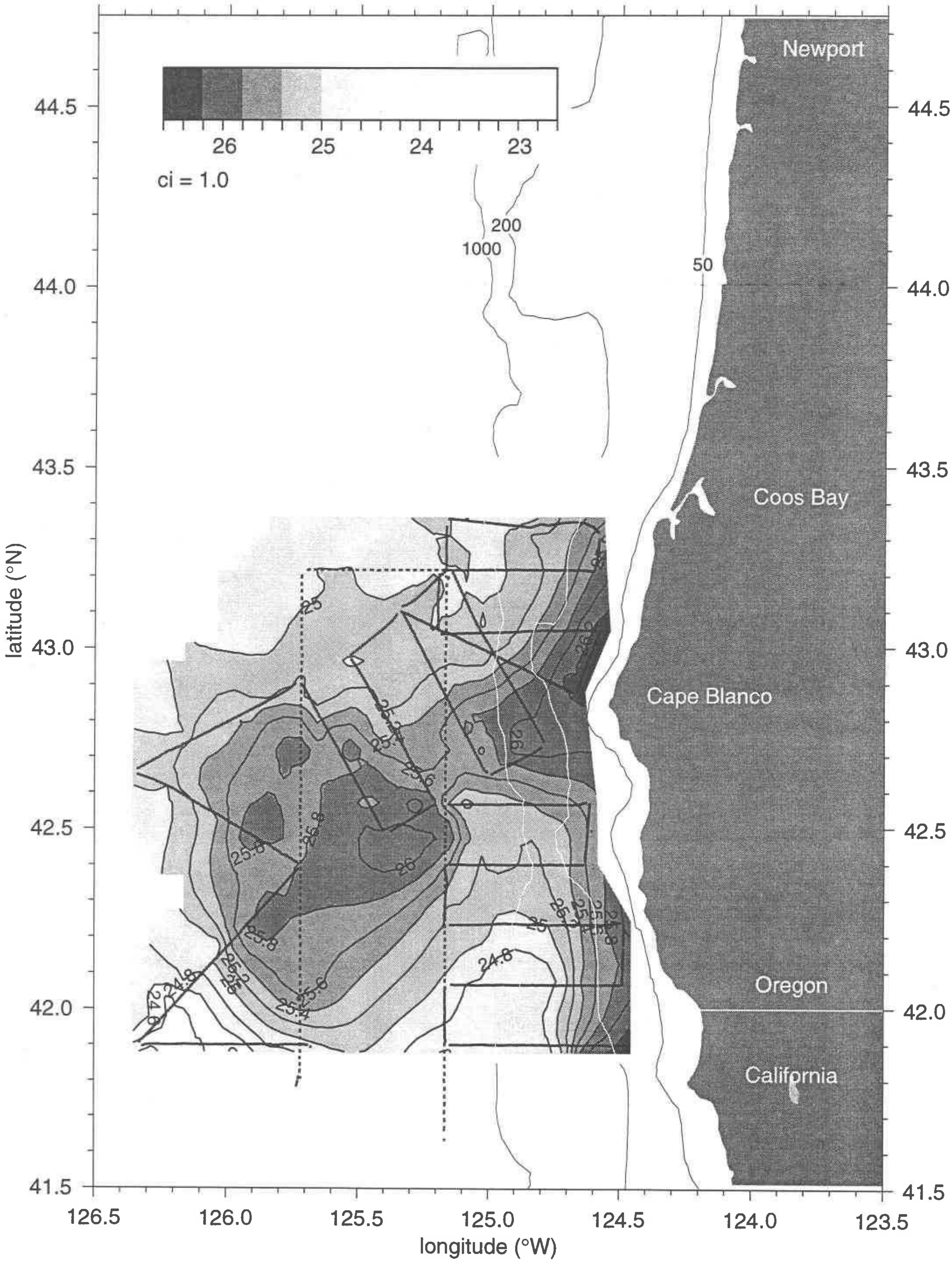
σt (kg/m3) at 15 dbar 25-30 August 1994

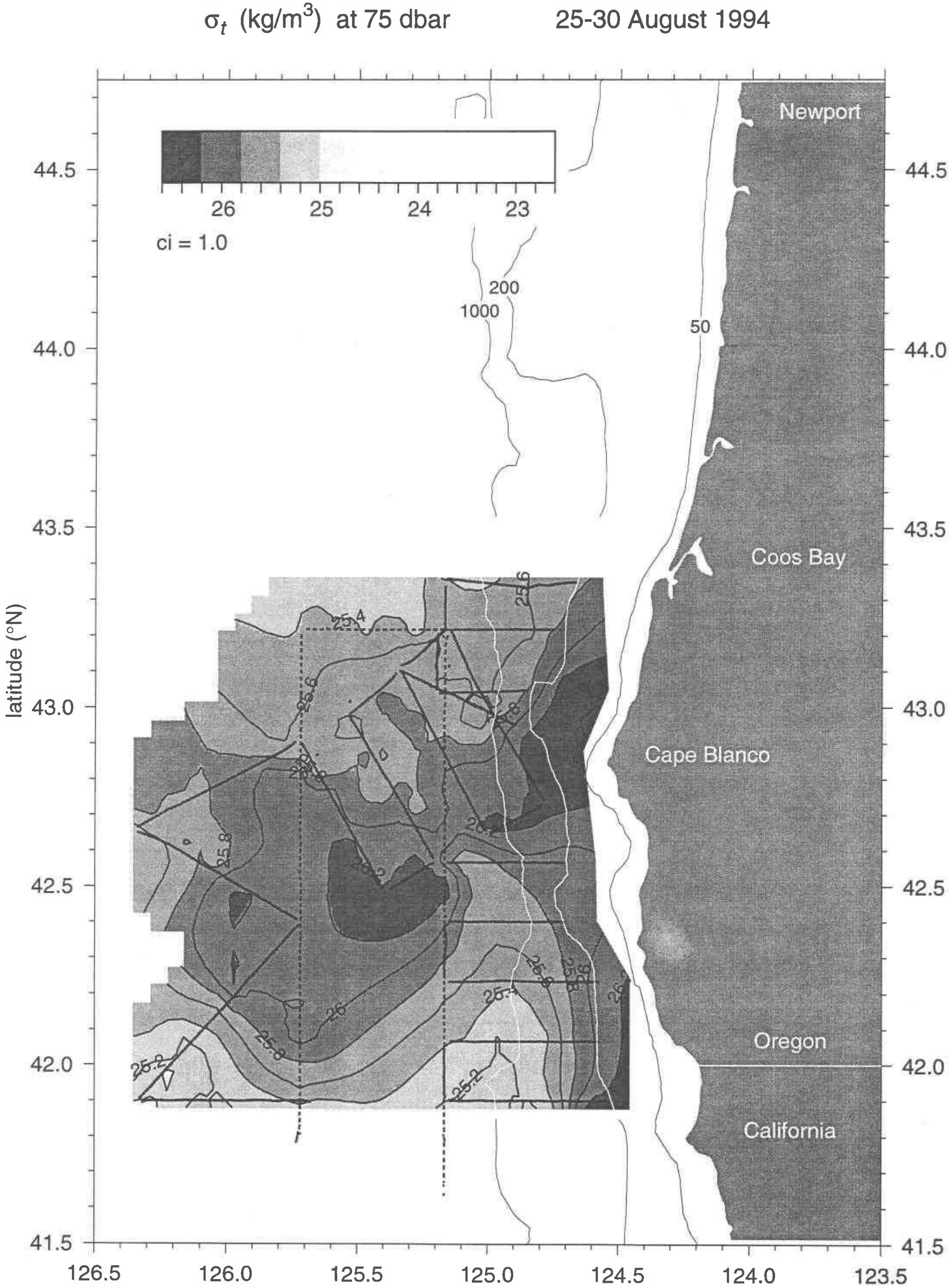




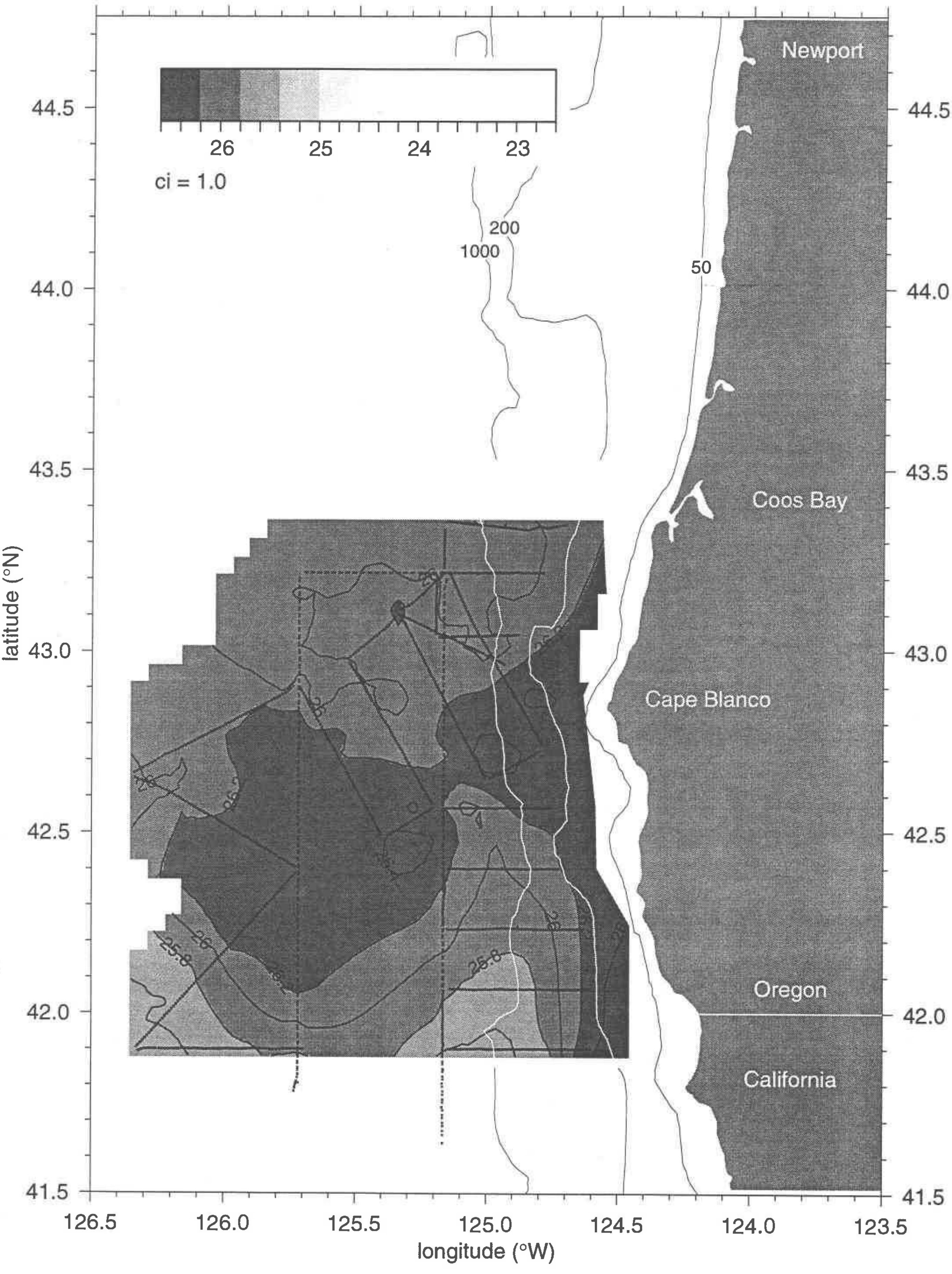
σt (kg/m3) at 25 dbar
25-30 August 1994
26
25
24
23
ci = 1.0
200
1000
50
Newport
Coos Bay
Cape Blanco
Oregon
California
44.5
44.0
43.5
43.0
42.5
42.0
41.5
latitude (°N)
126.5
126.0
125.5
125.0
124.5
124.0
123.5
longitude (°W)

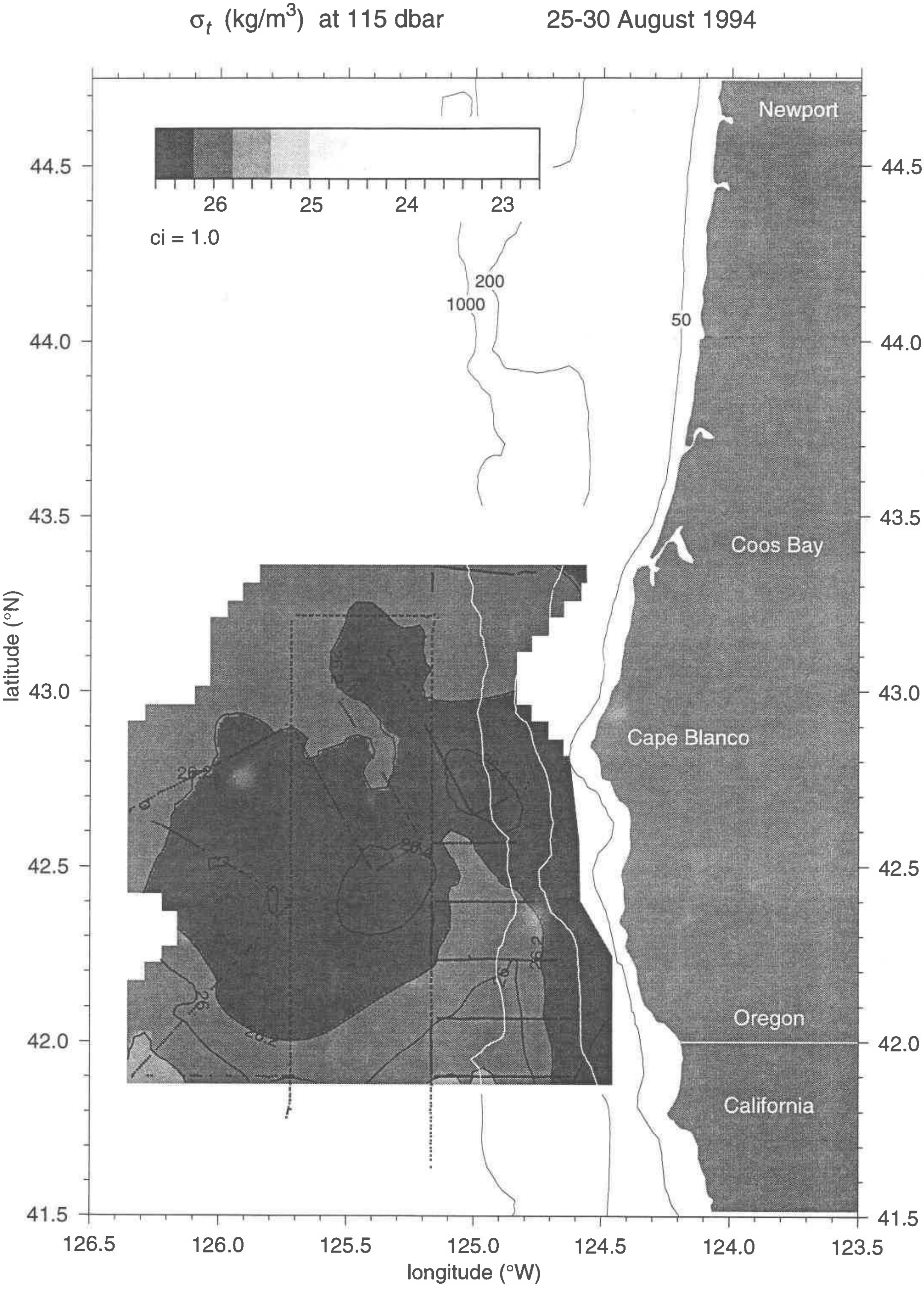
σ_t (kg/m^3) at 50 dbar 25-30 August 1994



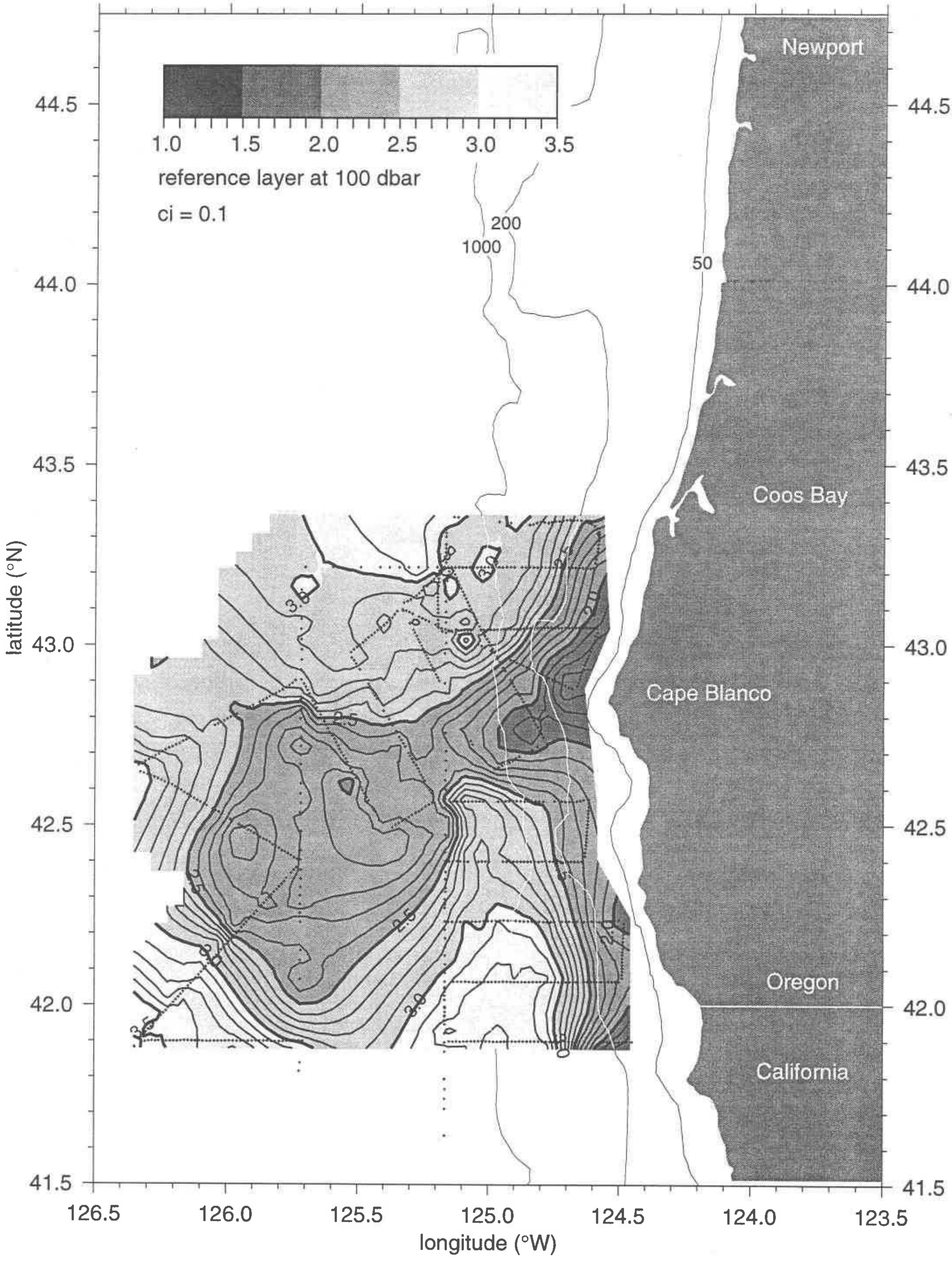

σt (kg/m3) at 75 dbar
25-30 August 1994
26
25
24
23
ci = 1.0
Newport
Coos Bay
Cape Blanco
Oregon
California
200
1000
50
25.4
25.6
25.8
26
26.2
25.2
latitude (°N)
longitude (°W)
44.5
44.0
43.5
43.0
42.5
42.0
41.5
126.5
126.0
125.5
125.0
124.5
124.0
123.5

σ_t (kg/m^3) at 100 dbar 25-30 August 1994

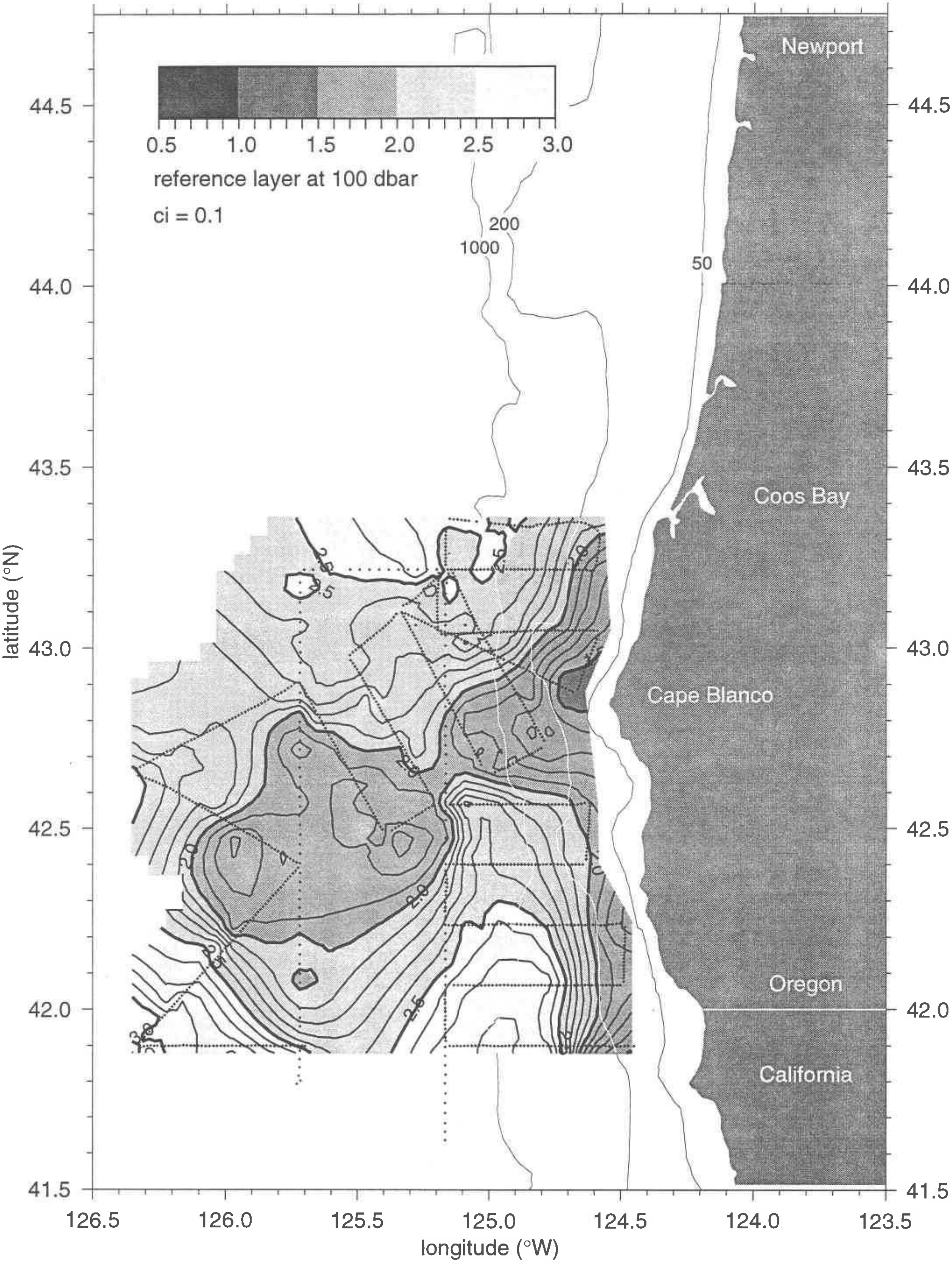


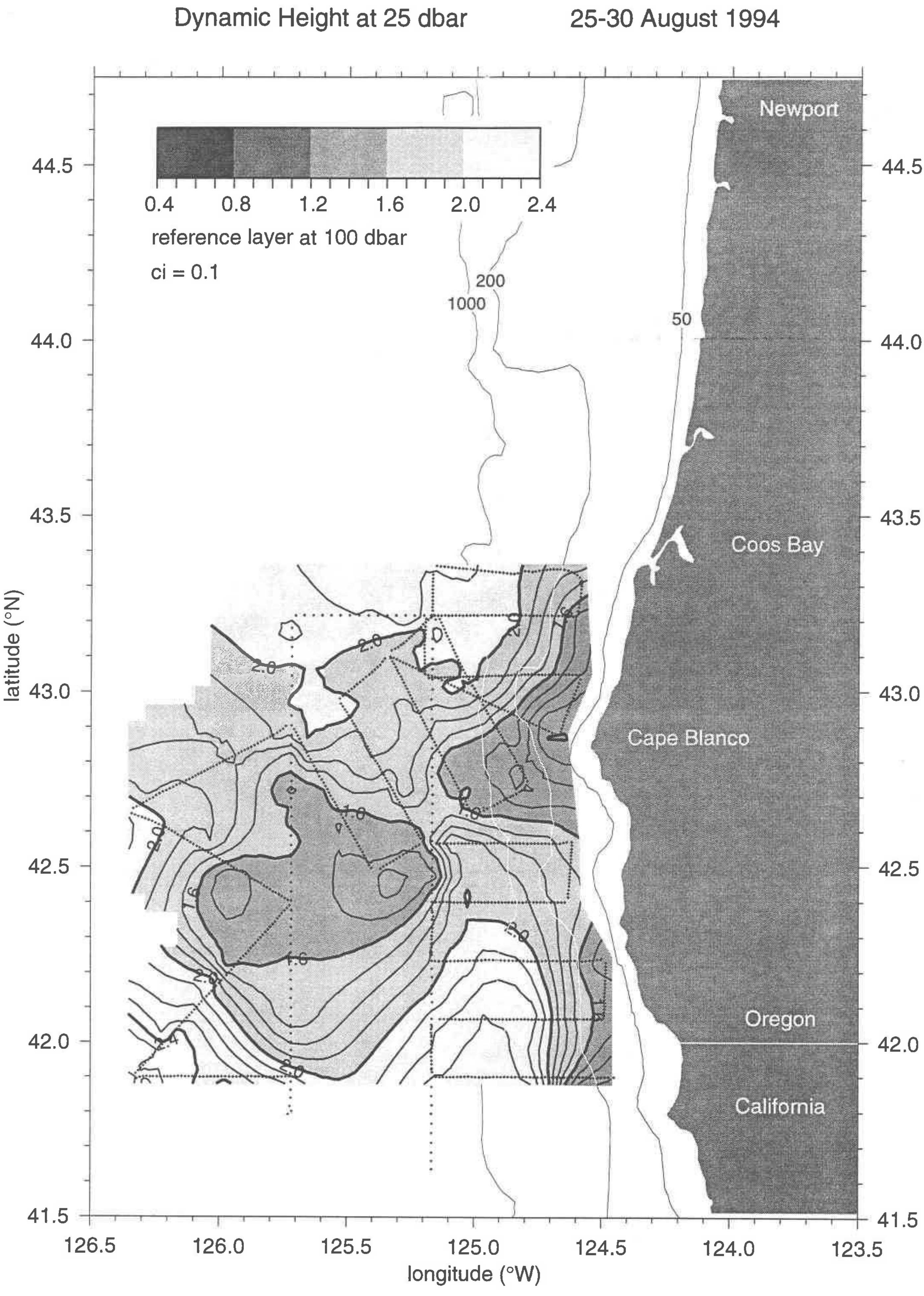

σt (kg/m3) at 115 dbar
25-30 August 1994
26
25
24
23
ci = 1.0
Newport
Coos Bay
Cape Blanco
Oregon
California
200
1000
50
44.5
44.0
43.5
43.0
42.5
42.0
41.5
latitude (°N)
126.5
126.0
125.5
125.0
124.5
124.0
123.5
longitude (°W)

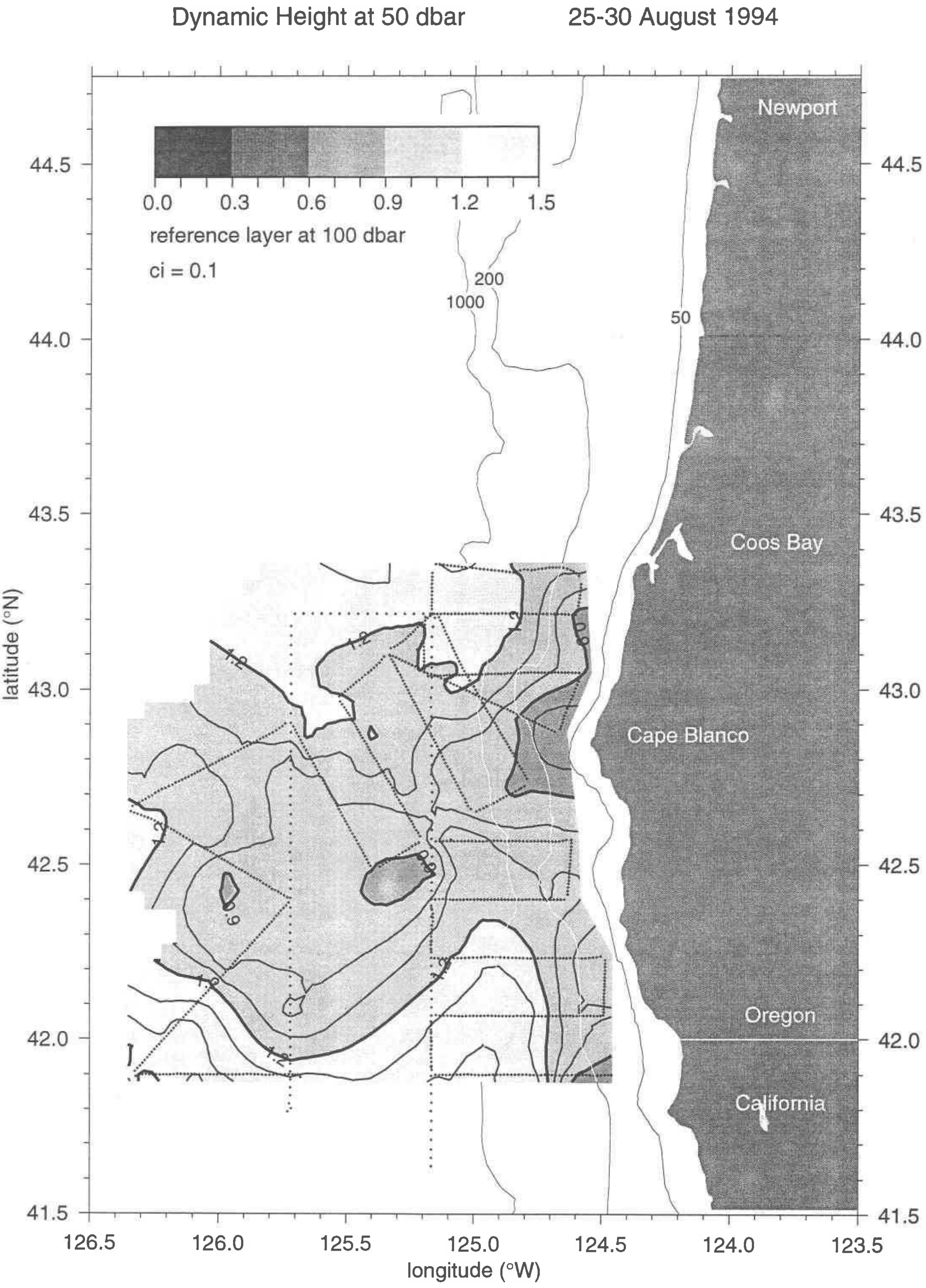
Dynamic Height at 5 dbar 25-30 August 1994

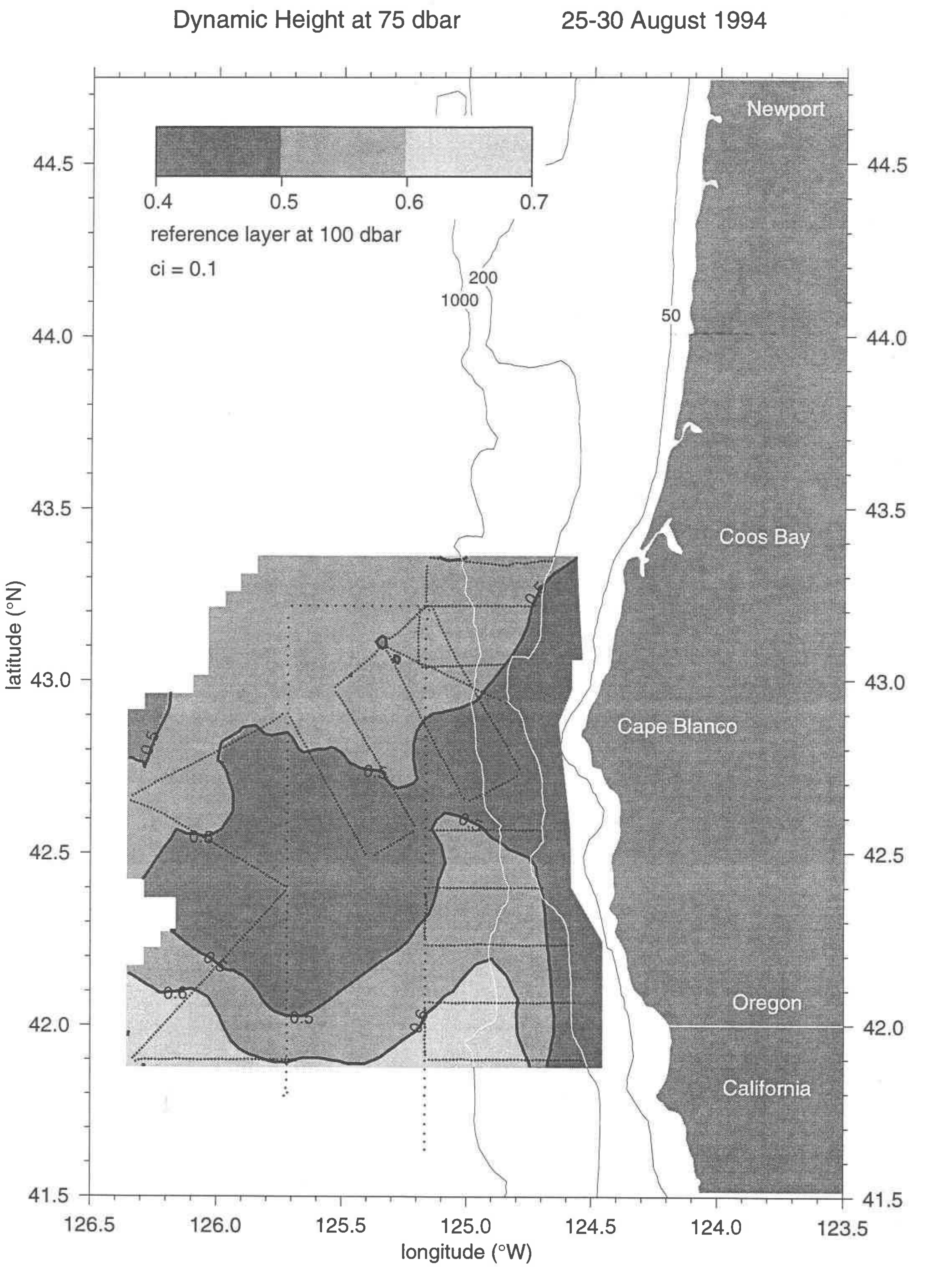


Dynamic Height at 15 dbar 25-30 August 1994

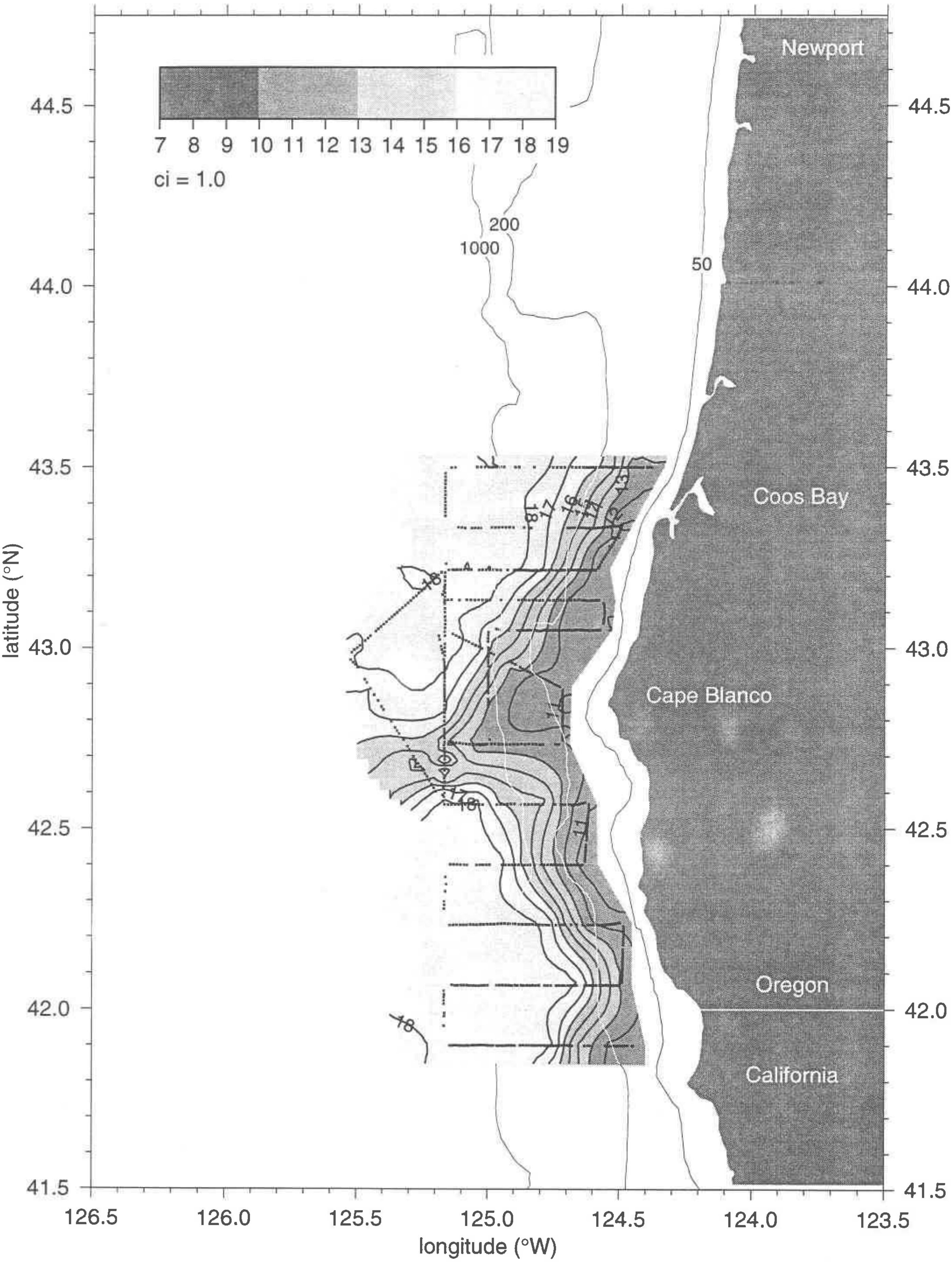


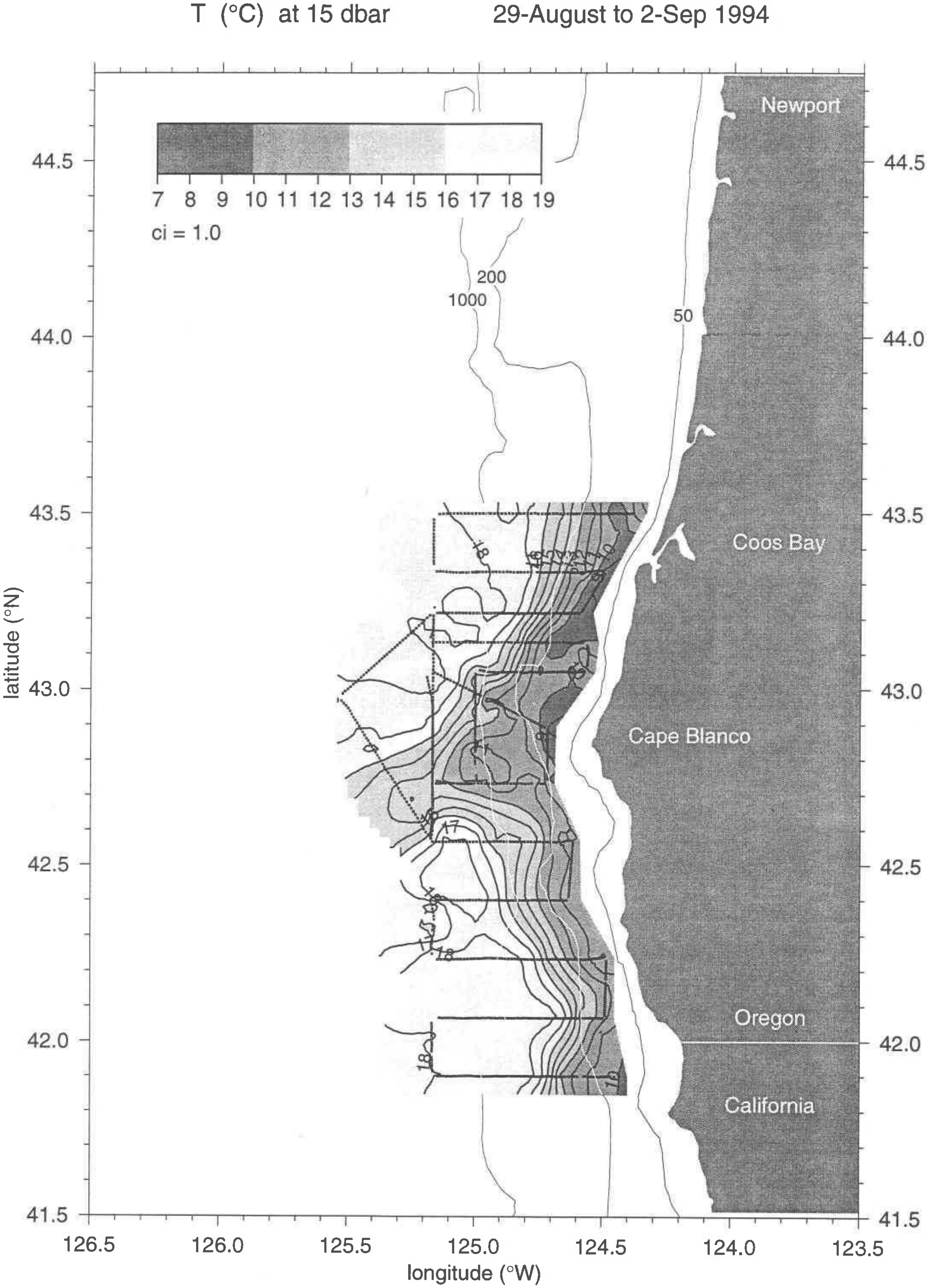

Dynamic Height at 25 dbar
25-30 August 1994
0.4
0.8
1.2
1.6
2.0
2.4
reference layer at 100 dbar
ci = 0.1
200
1000
50
Newport
Coos Bay
Cape Blanco
Oregon
California
latitude (°N)
longitude (°W)
44.5
44.0
43.5
43.0
42.5
42.0
41.5
126.5
126.0
125.5
125.0
124.5
124.0
123.5


Dynamic Height at 50 dbar
25-30 August 1994
0.0
0.3
0.6
0.9
1.2
1.5
reference layer at 100 dbar
ci = 0.1
200
1000
50
Newport
Coos Bay
Cape Blanco
Oregon
California
44.5
44.0
43.5
43.0
42.5
42.0
41.5
latitude (°N)
126.5
126.0
125.5
125.0
124.5
124.0
123.5
longitude (°W)

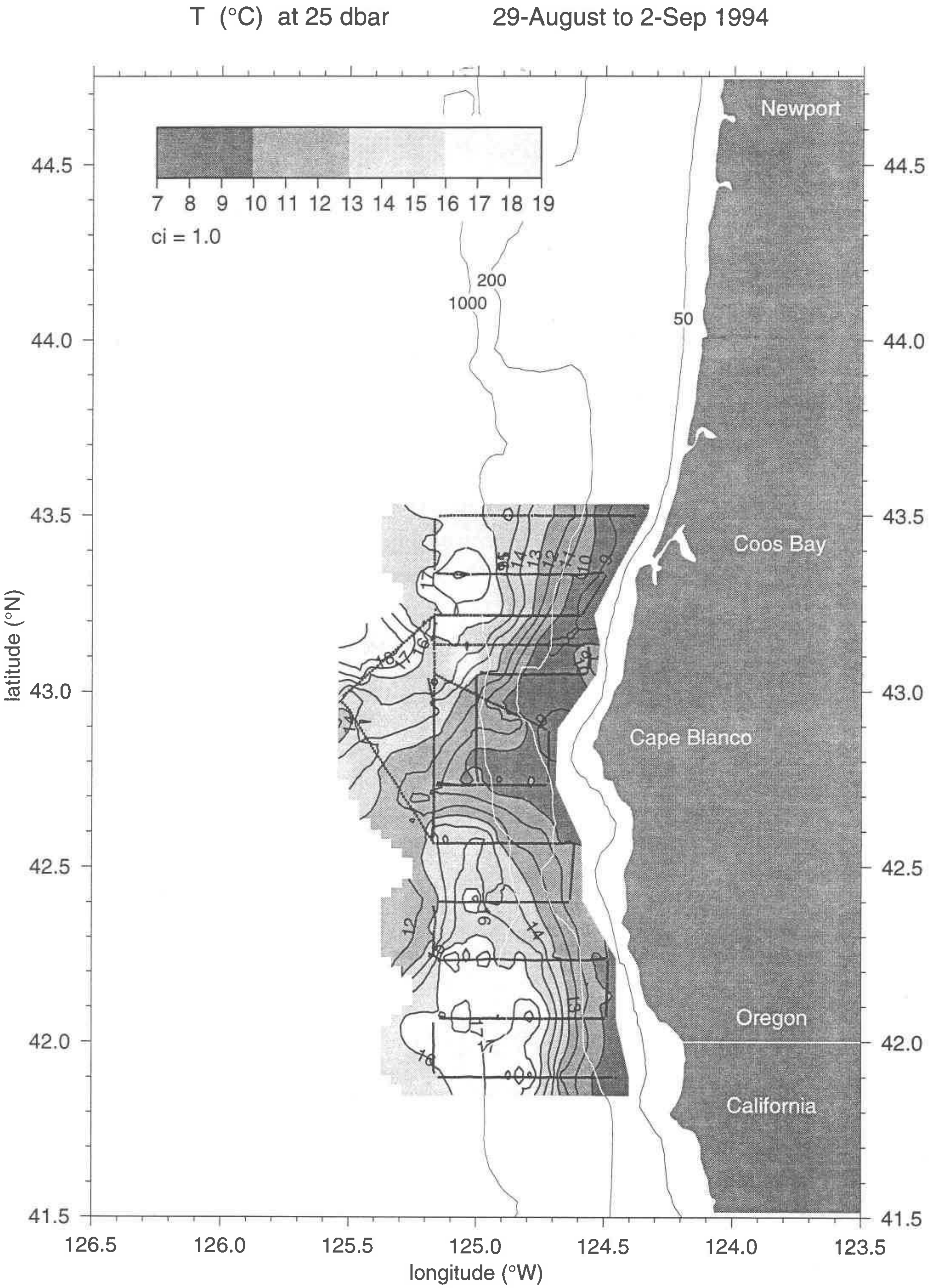

Dynamic Height at 75 dbar
25-30 August 1994
0.4
0.5
0.6
0.7
reference layer at 100 dbar
ci = 0.1
200
1000
50
Newport
Coos Bay
Cape Blanco
Oregon
California
latitude (°N)
longitude (°W)
44.5
44.0
43.5
43.0
42.5
42.0
41.5
126.5
126.0
125.5
125.0
124.5
124.0
123.5

T (°C) at 5 dbar 29-August to 2-Sep 1994

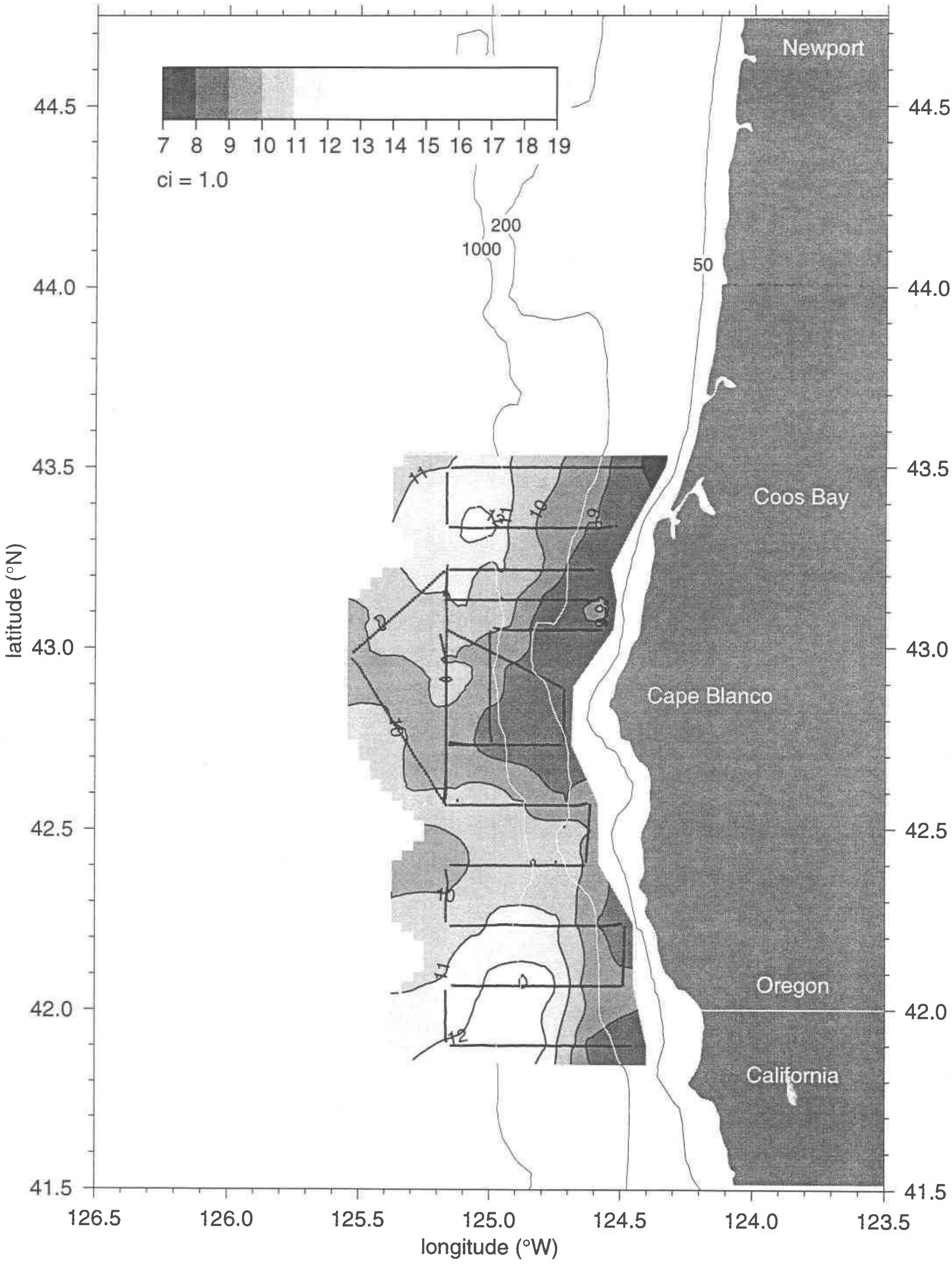




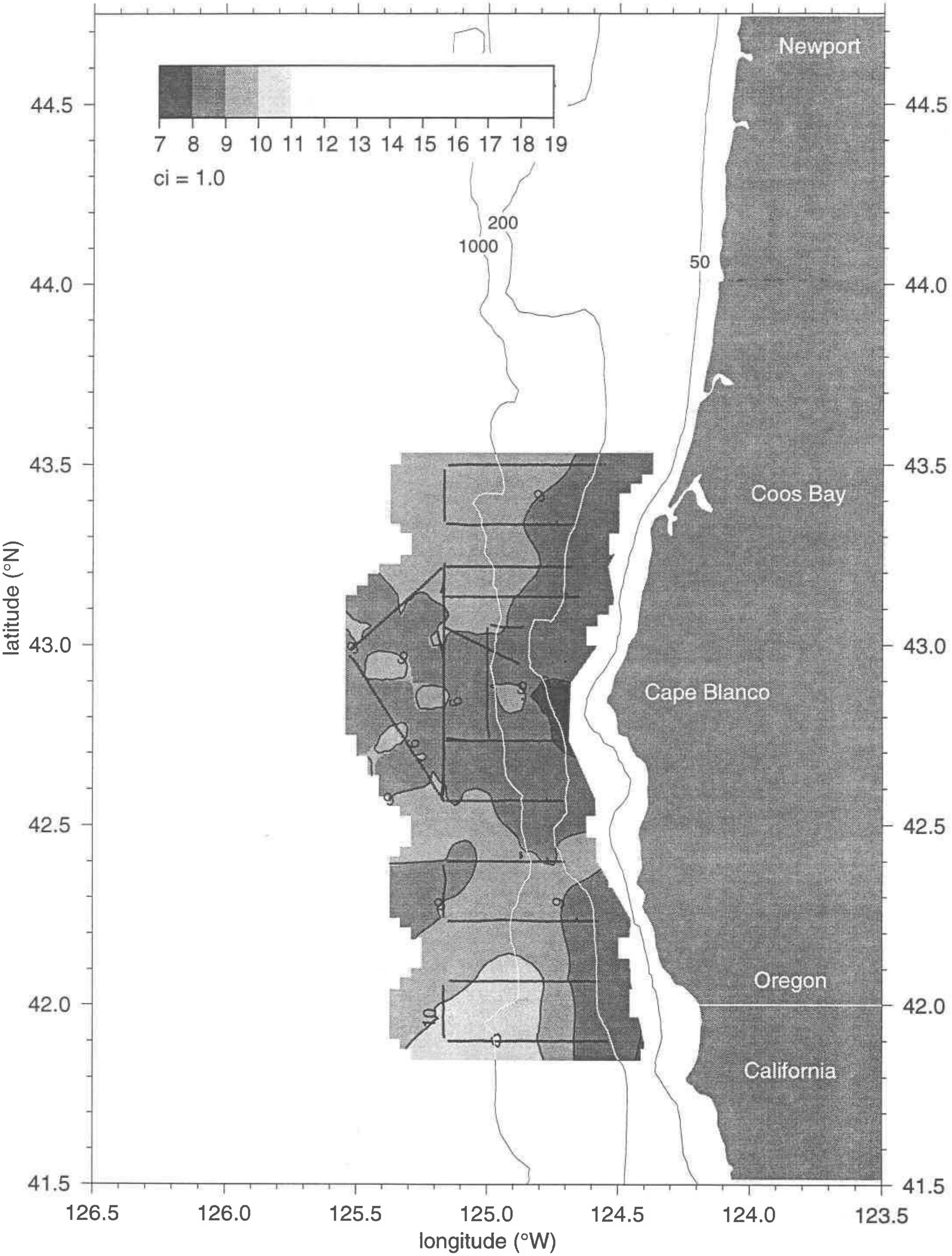
T (°C) at 15 dbar
29-August to 2-Sep 1994
7 8 9 10 11 12 13 14 15 16 17 18 19
ci = 1.0
Newport
Coos Bay
Cape Blanco
Oregon
California
200
1000
50
44.5
44.0
43.5
43.0
42.5
42.0
41.5
126.5
126.0
125.5
125.0
124.5
124.0
123.5
latitude (°N)
longitude (°W)

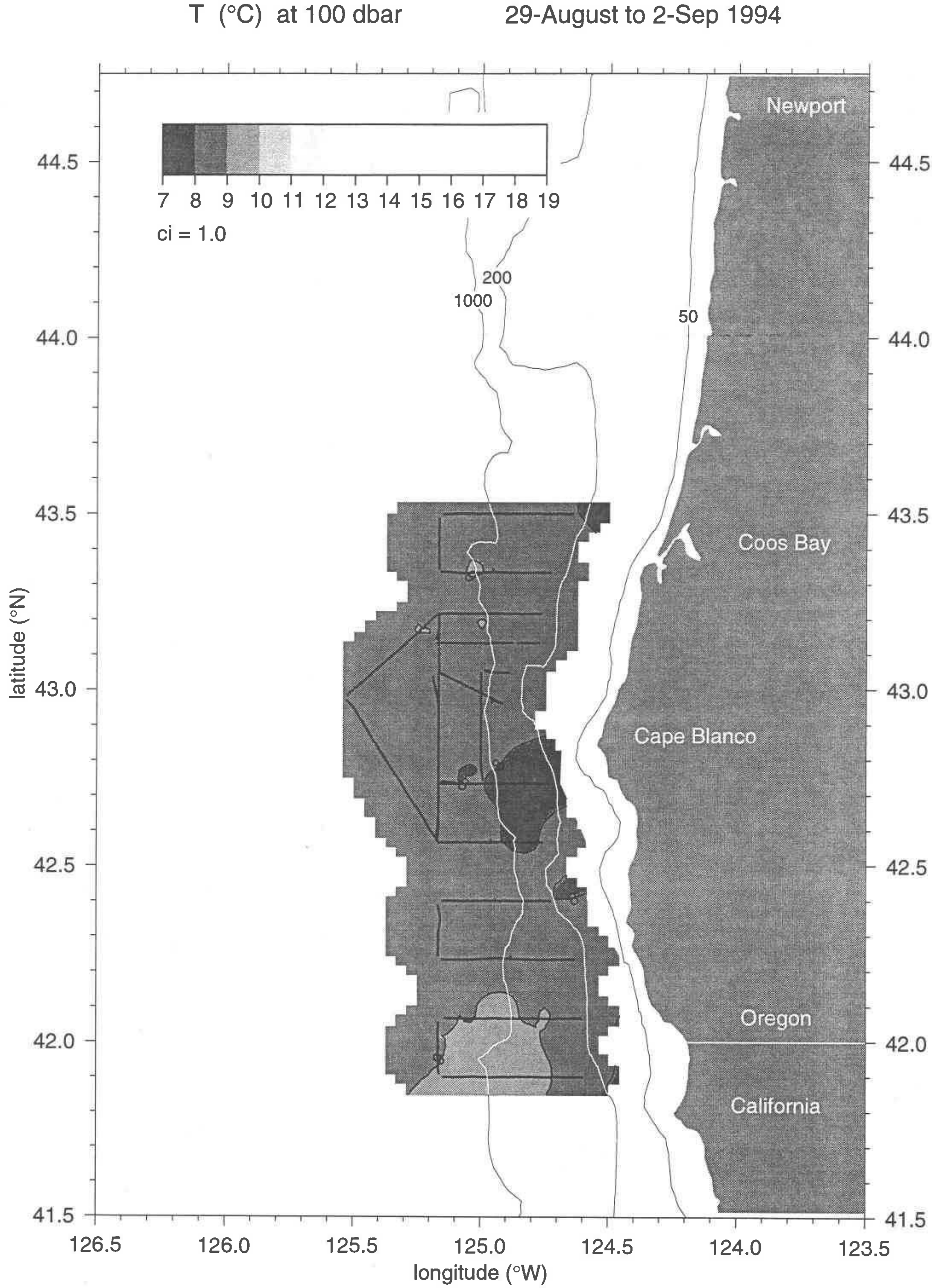

T (°C) at 25 dbar
29-August to 2-Sep 1994
7 8 9 10 11 12 13 14 15 16 17 18 19
ci = 1.0
Newport
Coos Bay
Cape Blanco
Oregon
California
200
1000
50
latitude (°N)
longitude (°W)
44.5
44.0
43.5
43.0
42.5
42.0
41.5
126.5 126.0 125.5 125.0 124.5 124.0 123.5

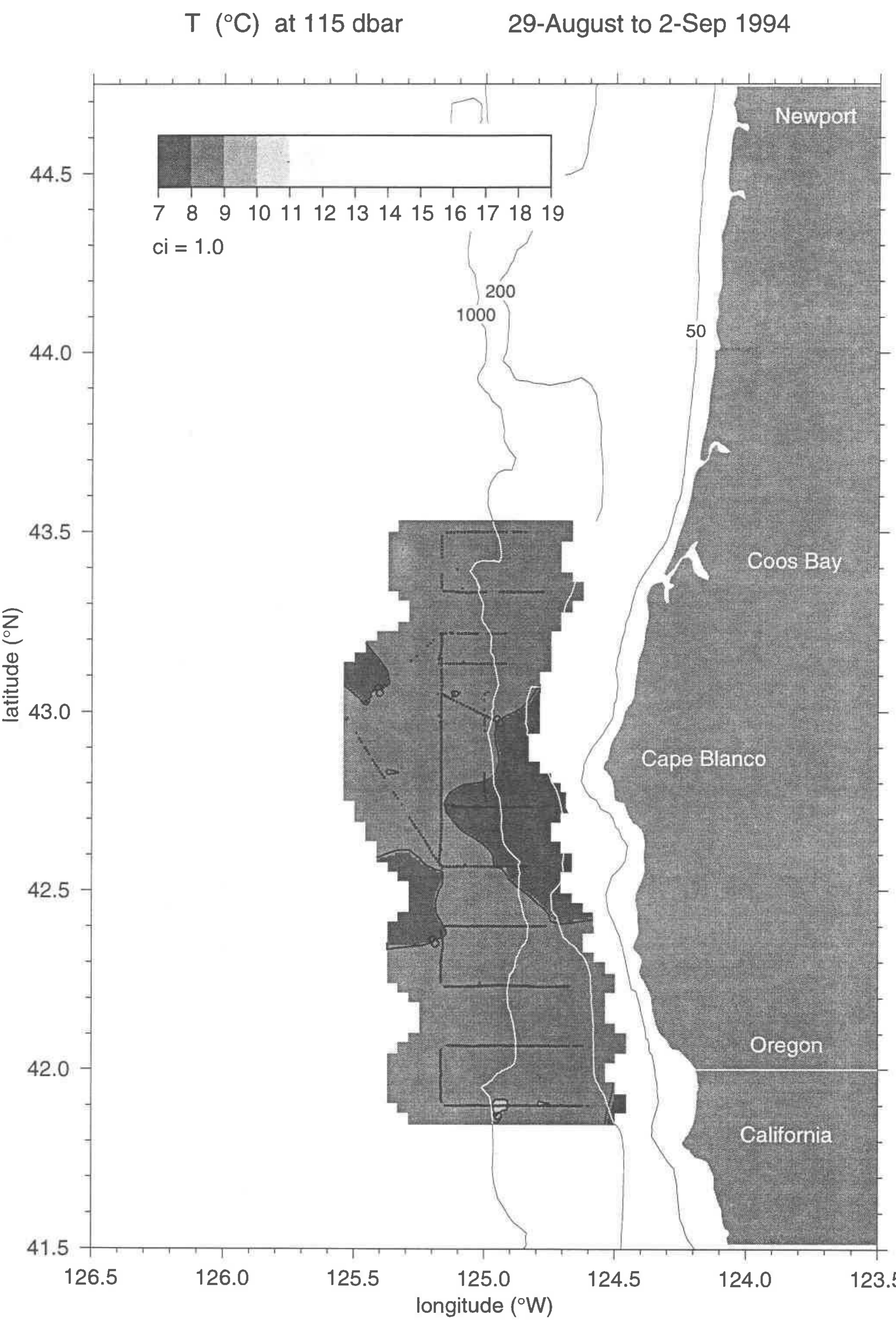
T (°C) at 50 dbar 29-August to 2-Sep 1994



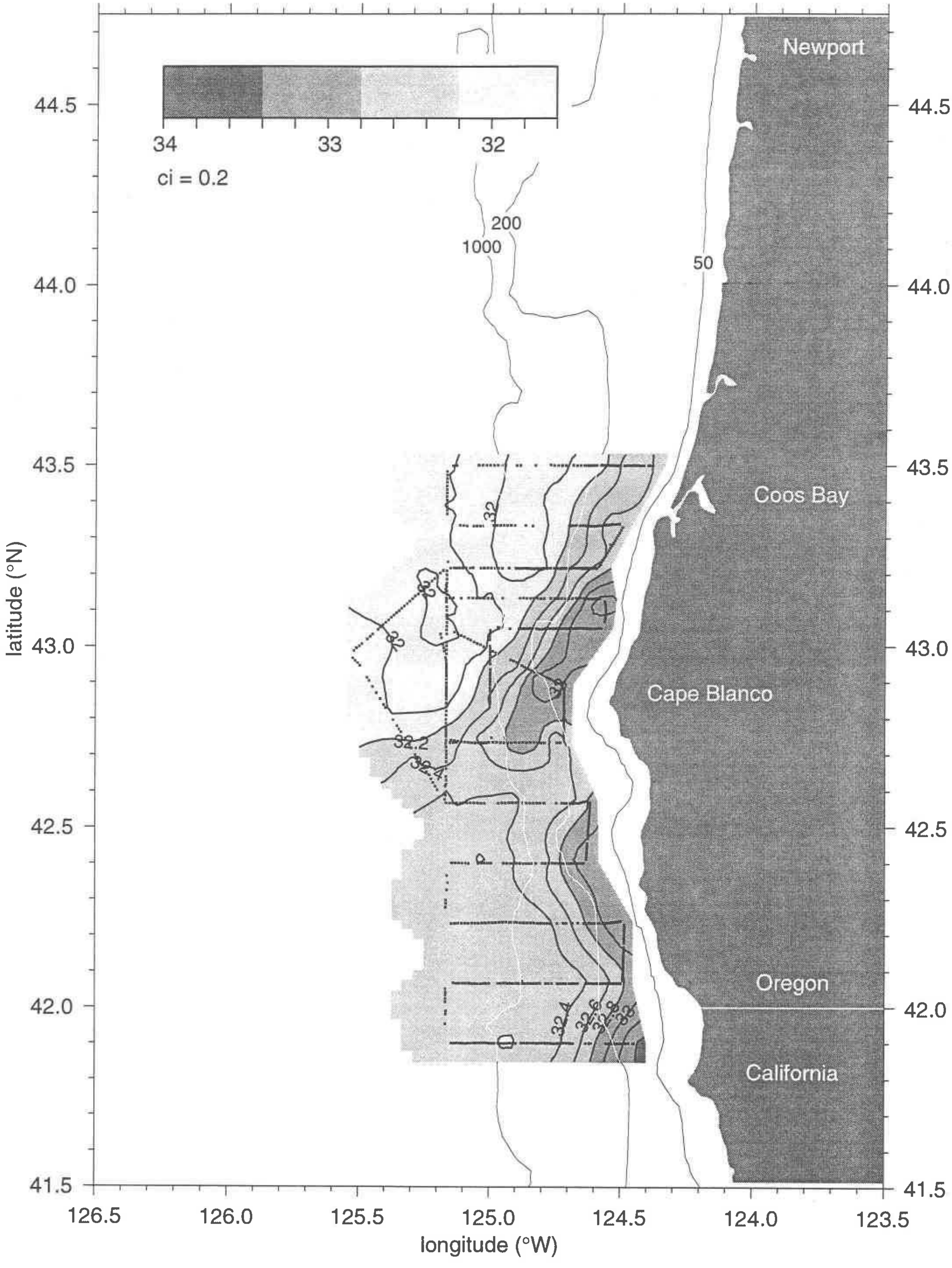
T (°C) at 75 dbar 29-August to 2-Sep 1994



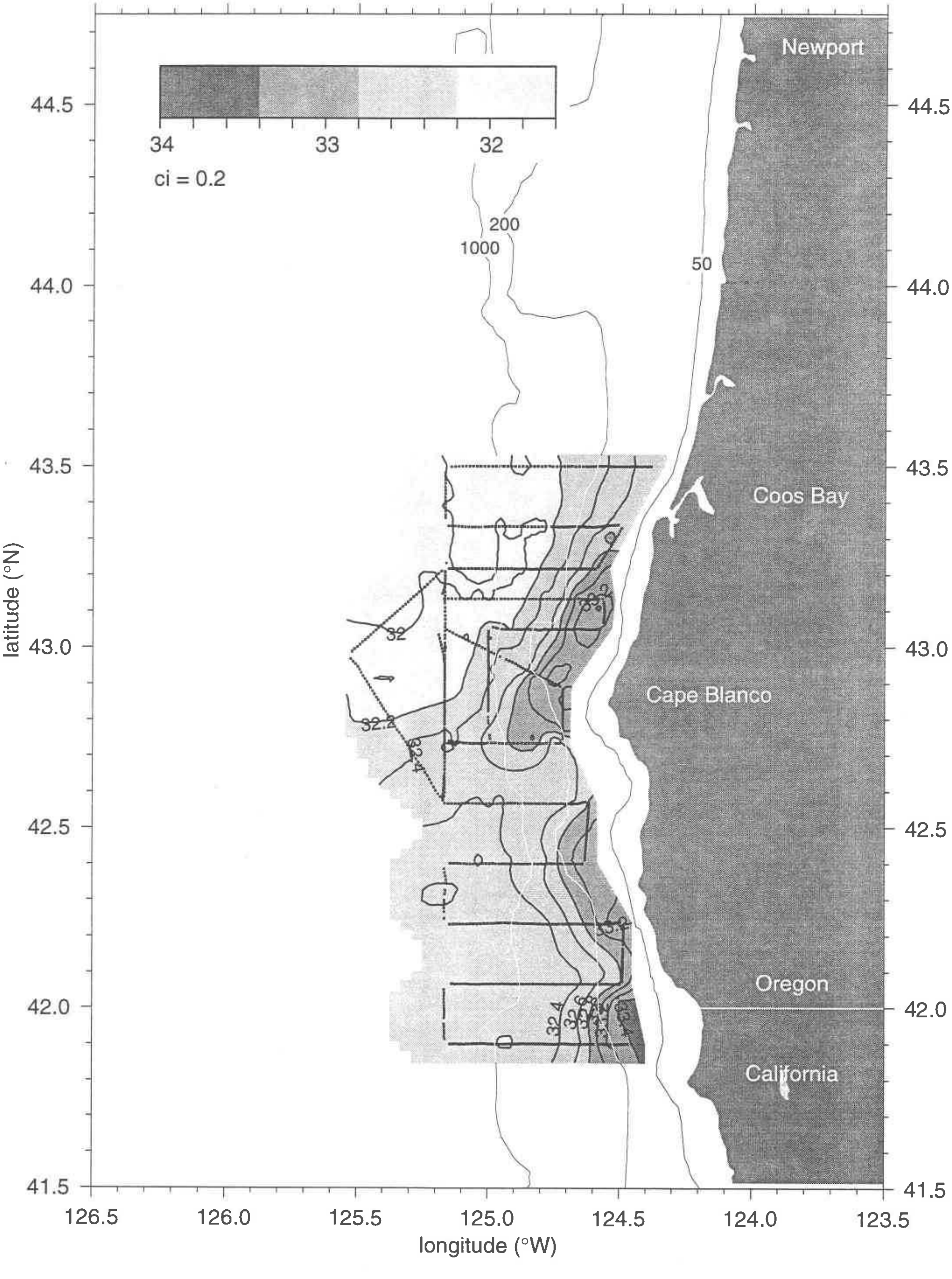

T (°C) at 100 dbar
29-August to 2-Sep 1994
7 8 9 10 11 12 13 14 15 16 17 18 19
ci = 1.0
200
1000
50
Newport
Coos Bay
Cape Blanco
Oregon
California
44.5
44.0
43.5
43.0
42.5
42.0
41.5
latitude (°N)
126.5
126.0
125.5
125.0
124.5
124.0
123.5
longitude (°W)


T (°C) at 115 dbar
29-August to 2-Sep 1994
7 8 9 10 11 12 13 14 15 16 17 18 19
ci = 1.0
Newport
44.5
200
1000
50
44.0
43.5
Coos Bay
latitude (°N)
43.0
Cape Blanco
42.5
Oregon
42.0
California
41.5
126.5 126.0 125.5 125.0 124.5 124.0 123.5
longitude (°W)

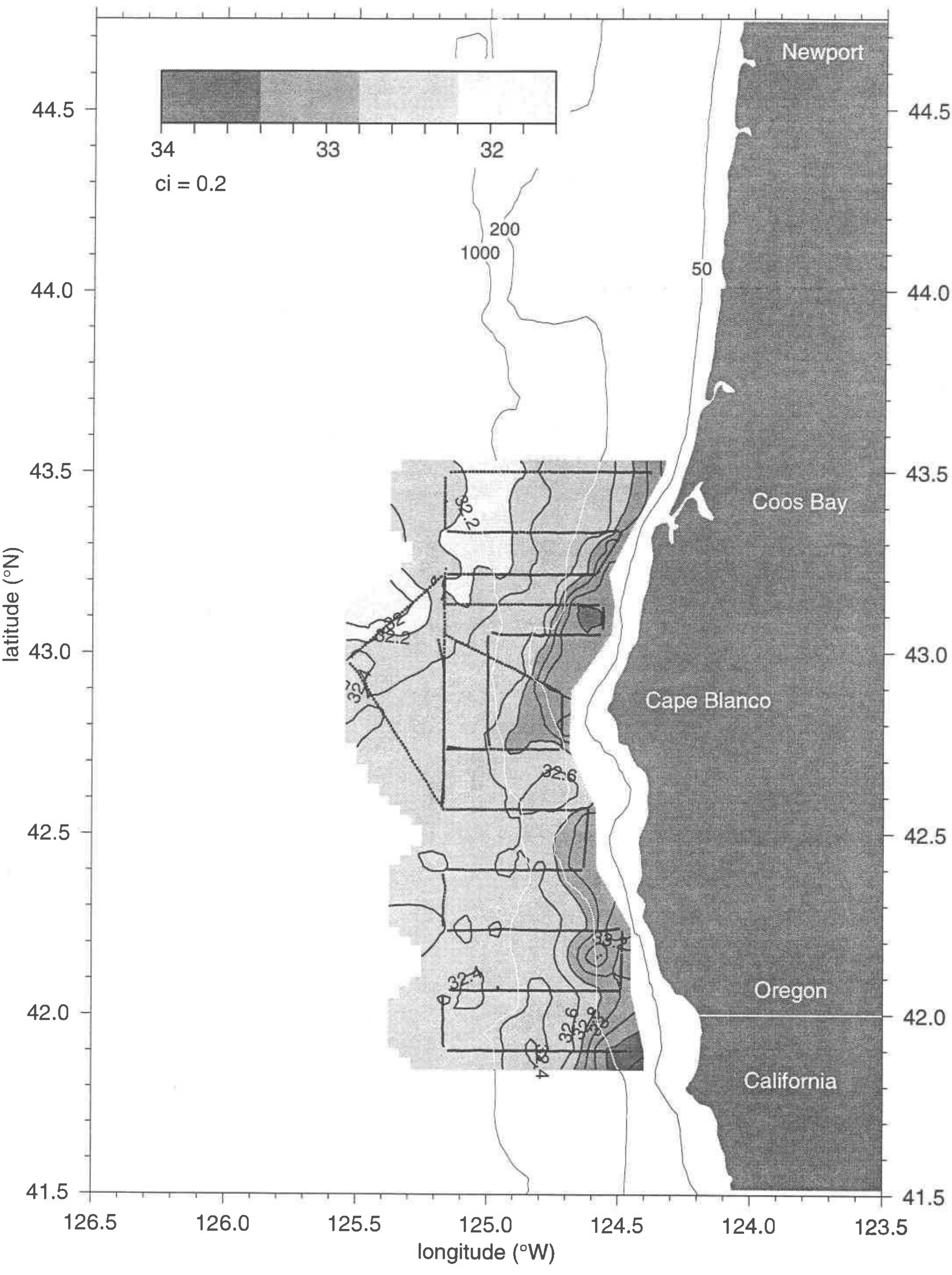
S at 5 dbar 29-August to 2-Sep 1994

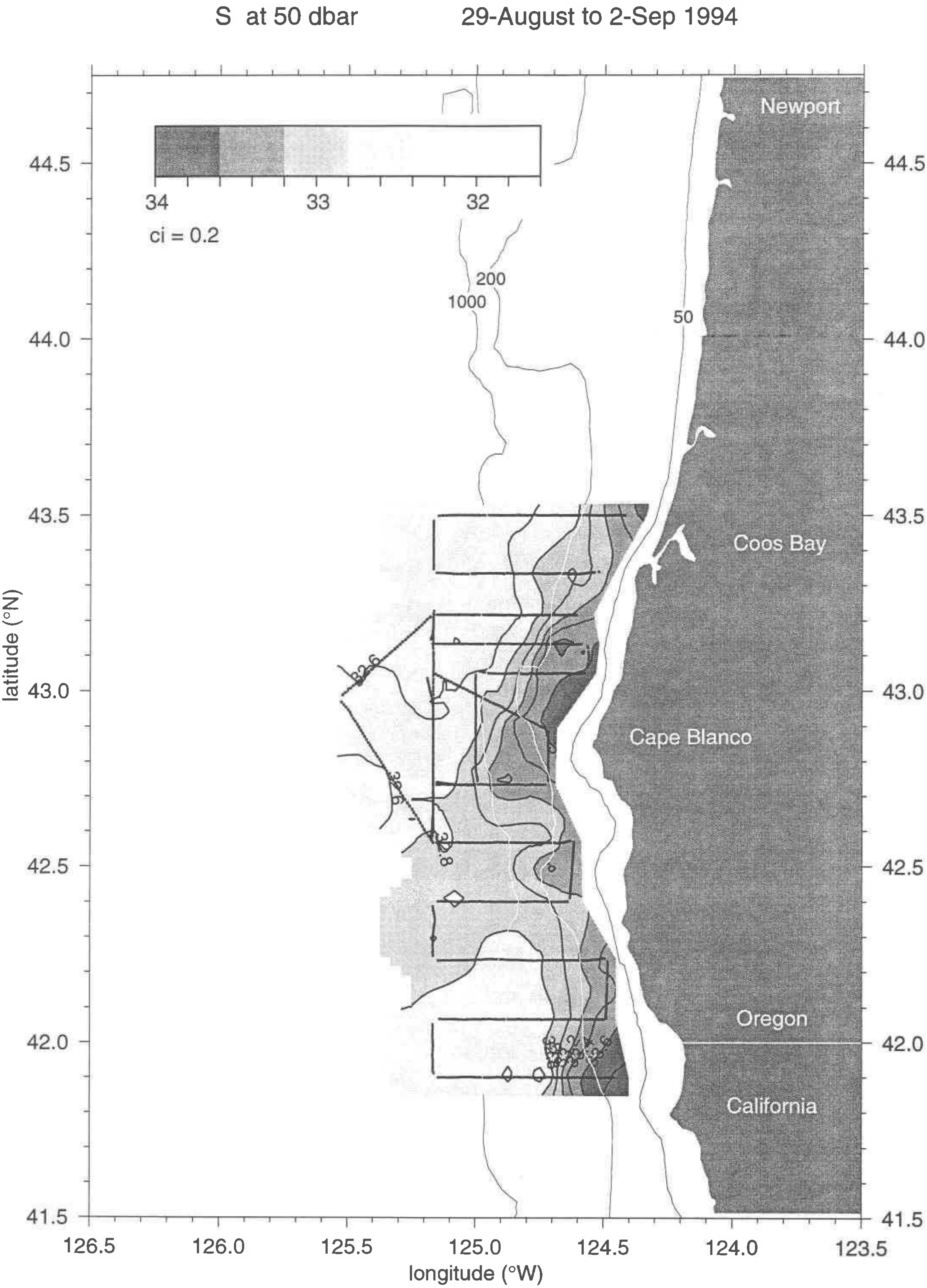


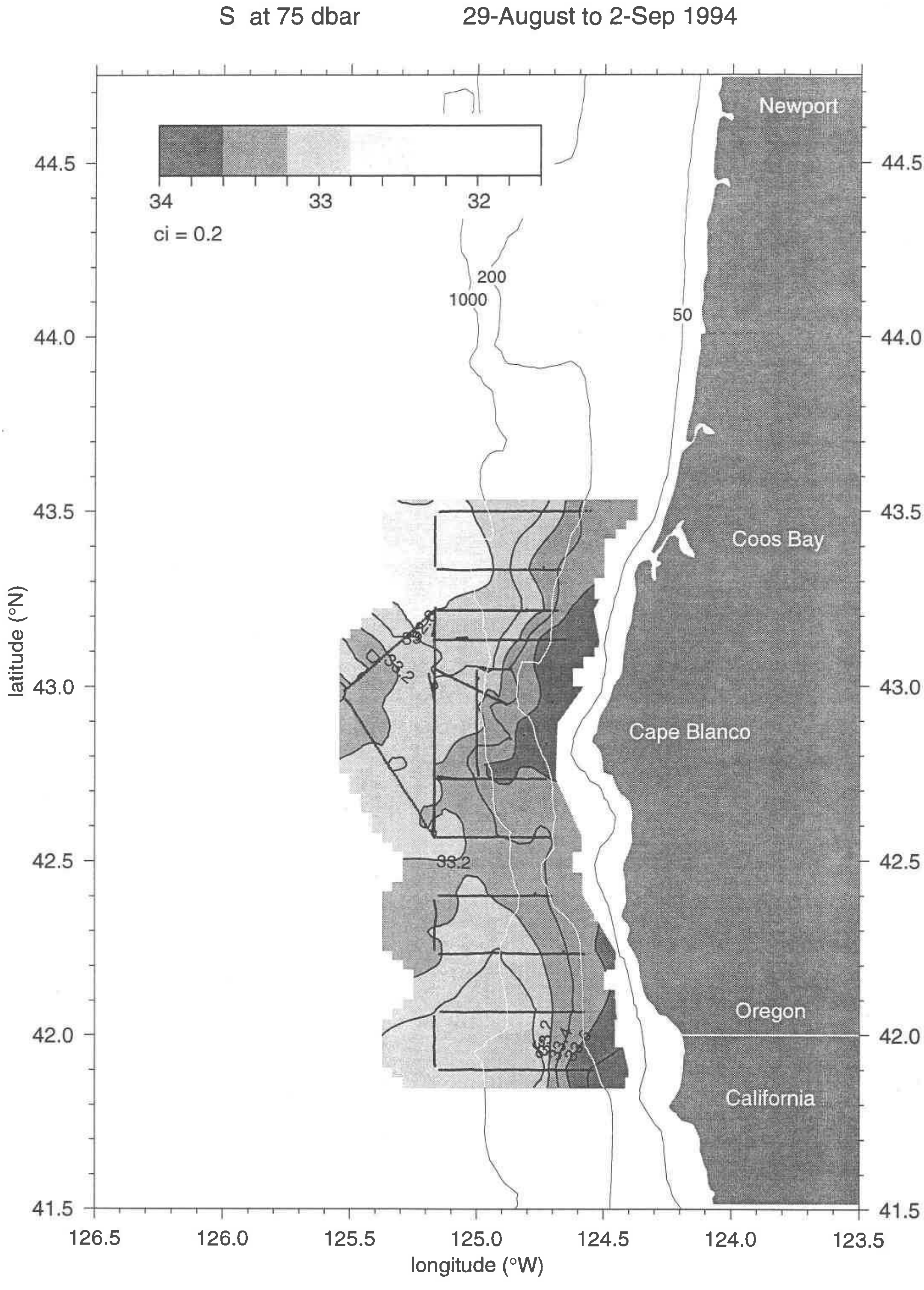
S at 15 dbar 29-August to 2-Sep 1994

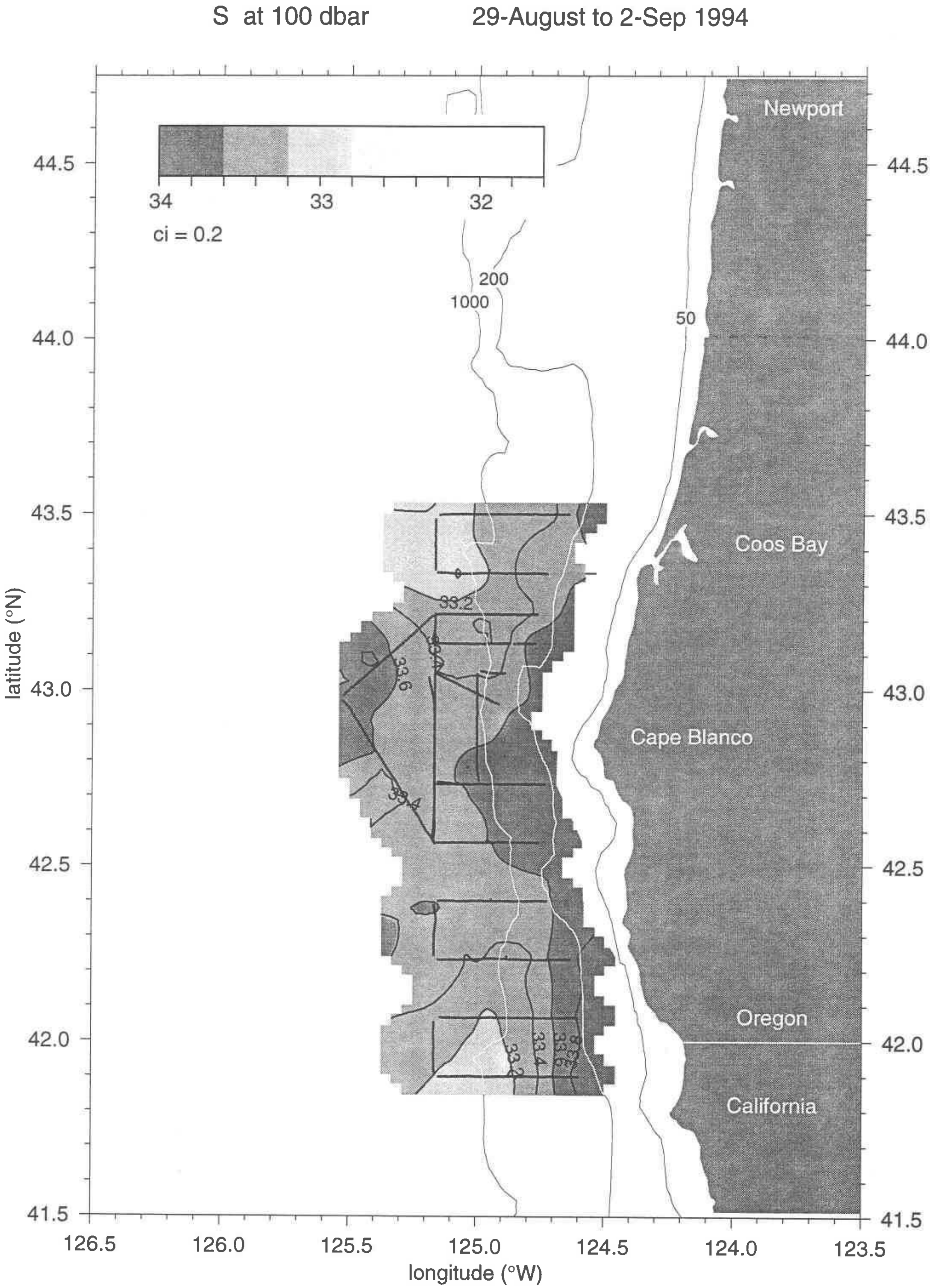


S at 25 dbar 29-August to 2-Sep 1994

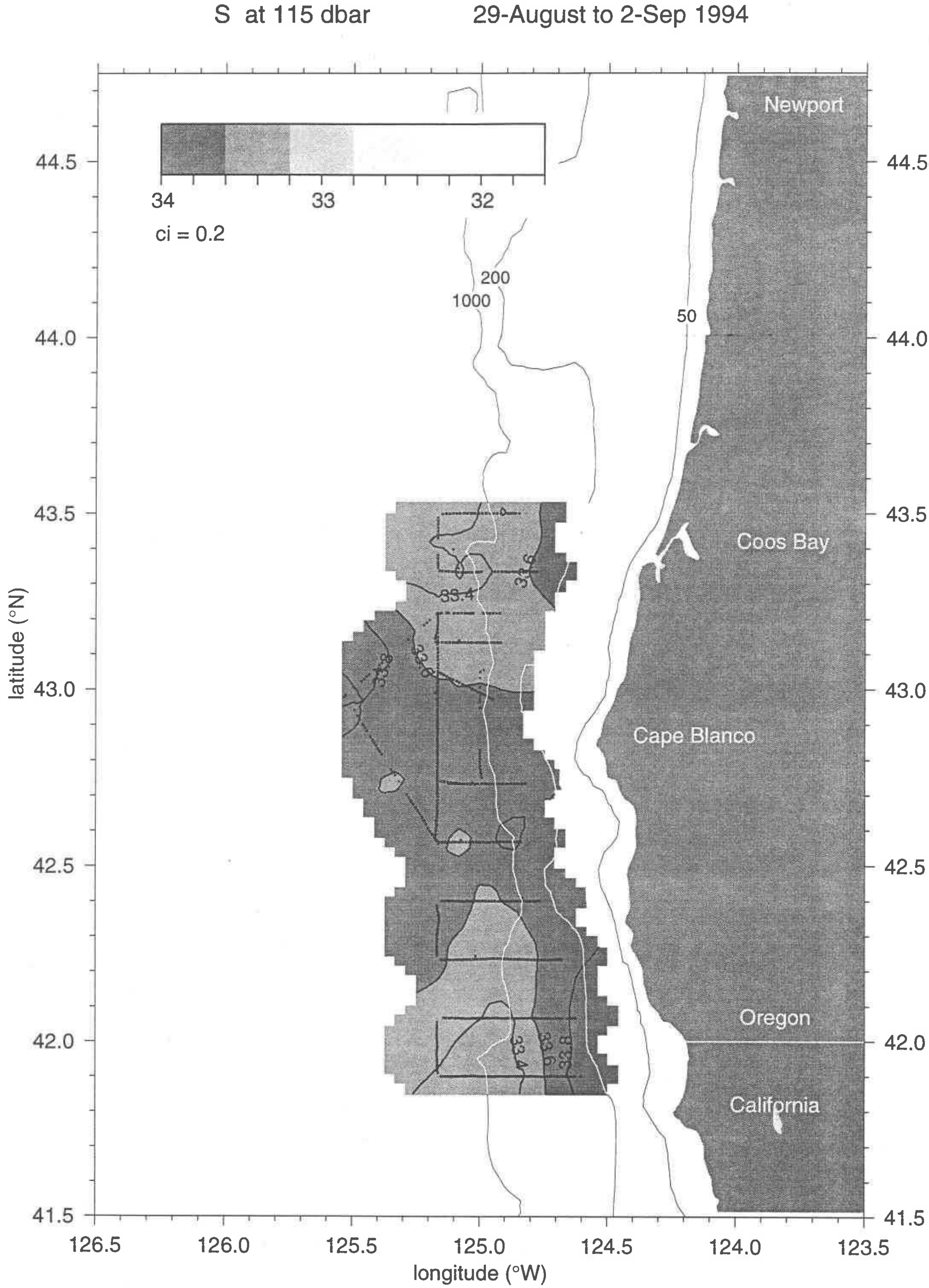



S at 50 dbar
29-August to 2-Sep 1994
34
33
32
ci = 0.2
200
1000
50
Newport
Coos Bay
Cape Blanco
Oregon
California
latitude (°N)
longitude (°W)
44.5
44.0
43.5
43.0
42.5
42.0
41.5
126.5
126.0
125.5
125.0
124.5
124.0
123.5
32.6
32.8


S at 75 dbar
29-August to 2-Sep 1994
34
33
32
ci = 0.2
Newport
Coos Bay
Cape Blanco
Oregon
California
200
1000
50
33.2
33.2
latitude (°N)
longitude (°W)
44.5
44.0
43.5
43.0
42.5
42.0
41.5
126.5
126.0
125.5
125.0
124.5
124.0
123.5

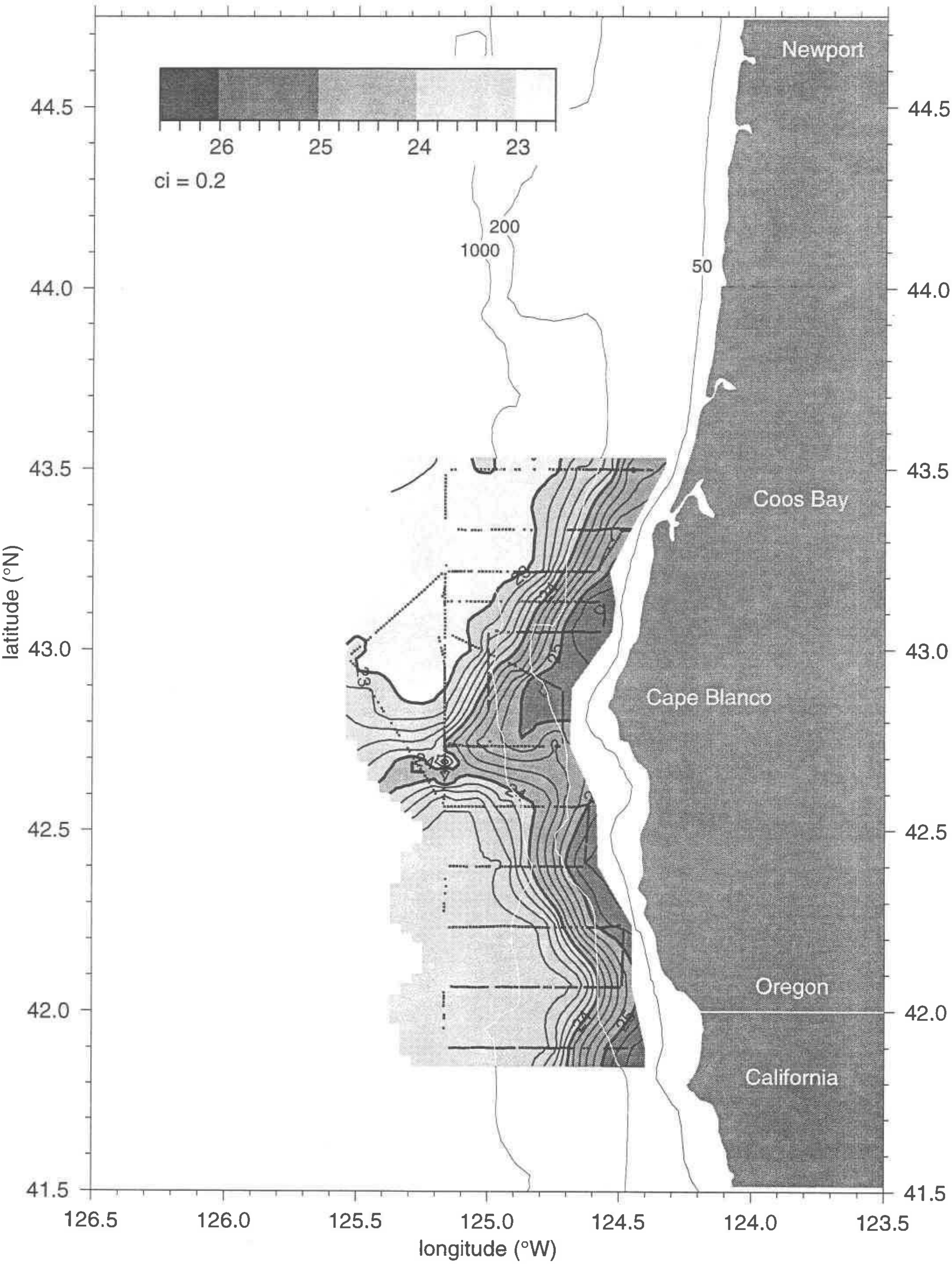


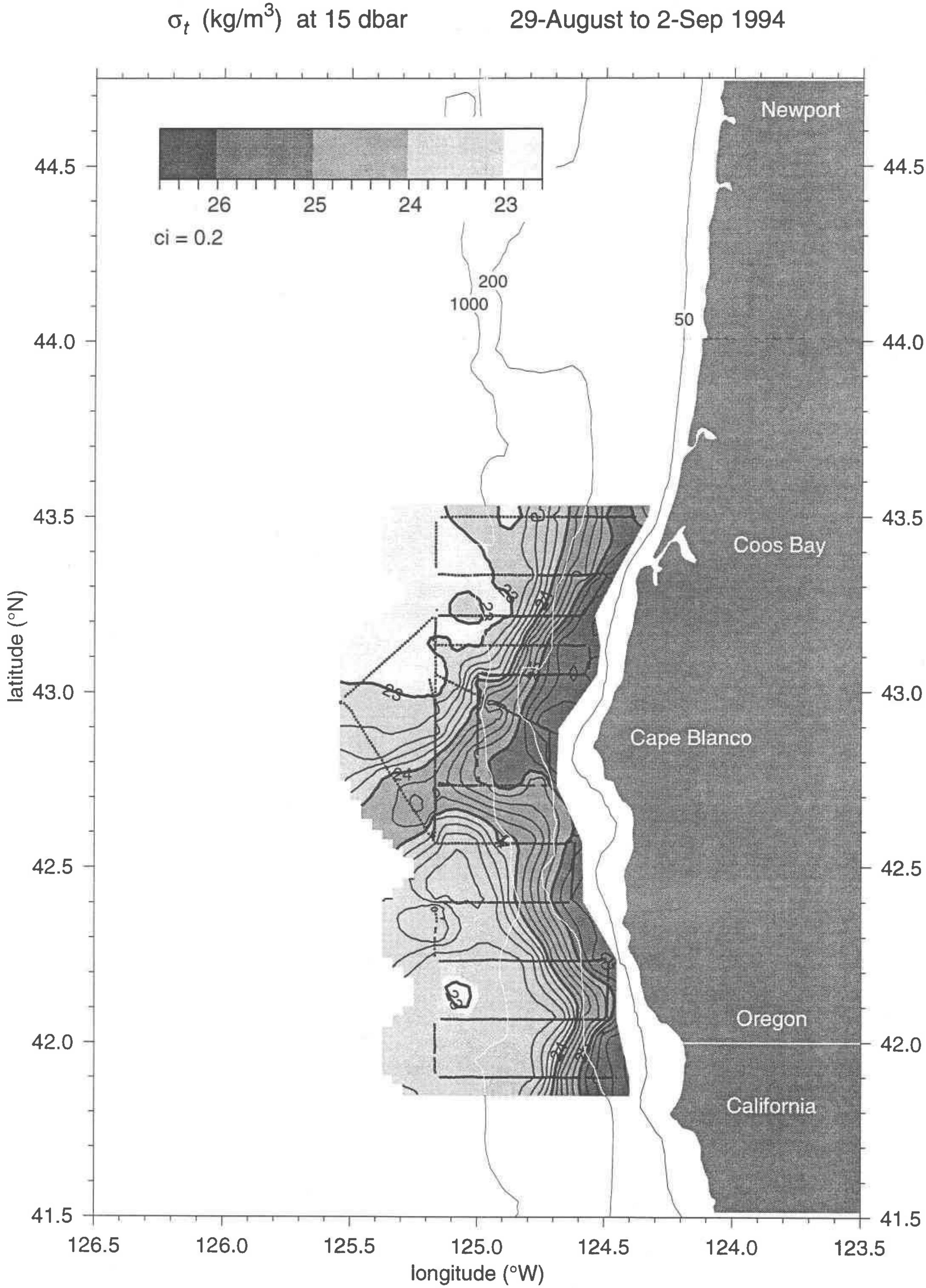
S at 100 dbar
29-August to 2-Sep 1994
34
33
32
ci = 0.2
Newport
Coos Bay
Cape Blanco
Oregon
California
200
1000
50
33.2
33.4
33.6
44.5
44.0
43.5
43.0
42.5
42.0
41.5
126.5
126.0
125.5
125.0
124.5
124.0
123.5
latitude (°N)
longitude (°W)



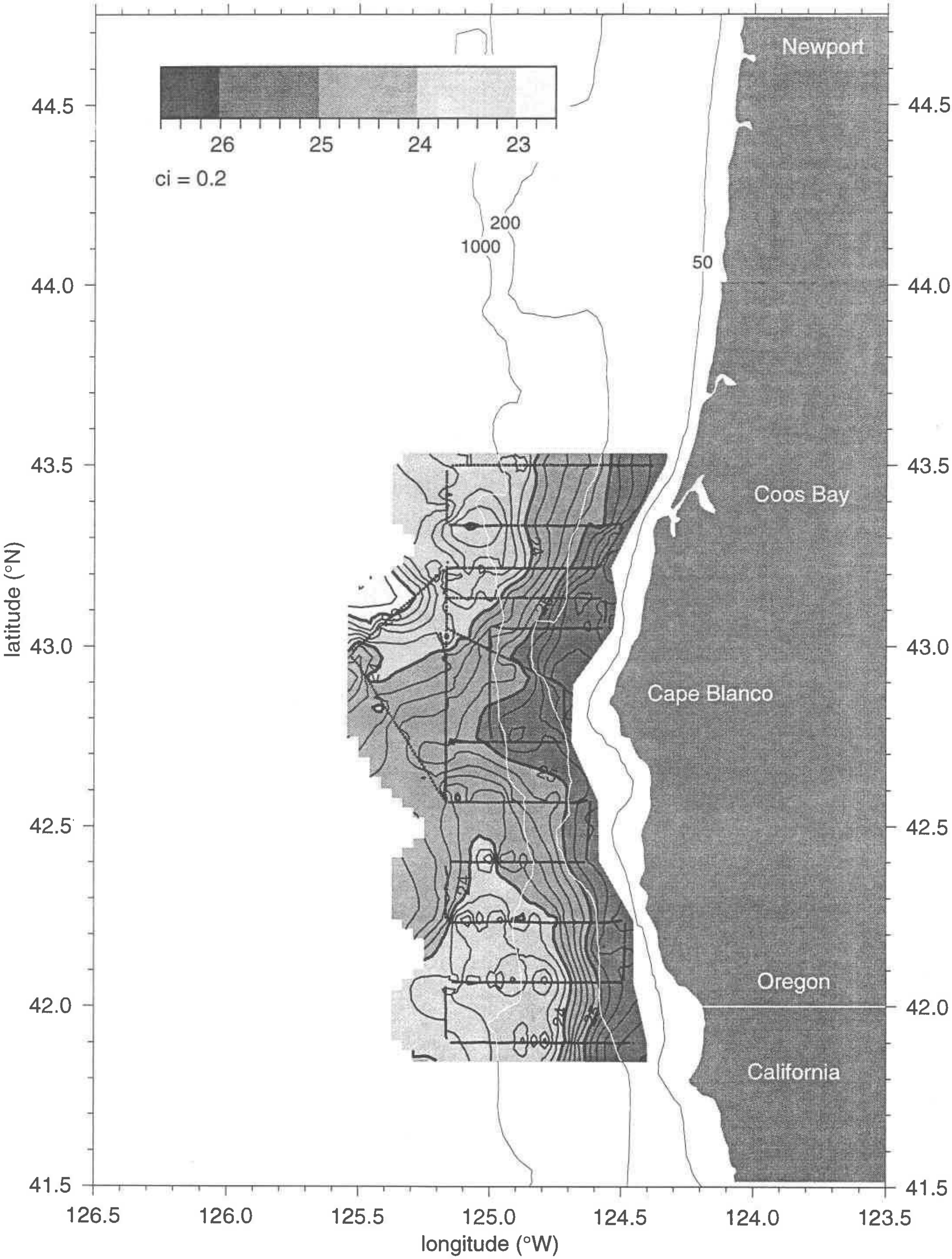
S at 115 dbar
29-August to 2-Sep 1994
34
33
32
ci = 0.2
200
1000
50
Newport
Coos Bay
Cape Blanco
Oregon
California
33.4
33.6
33.8
44.5
44.0
43.5
43.0
42.5
42.0
41.5
126.5
126.0
125.5
125.0
124.5
124.0
123.5
latitude (°N)
longitude (°W)

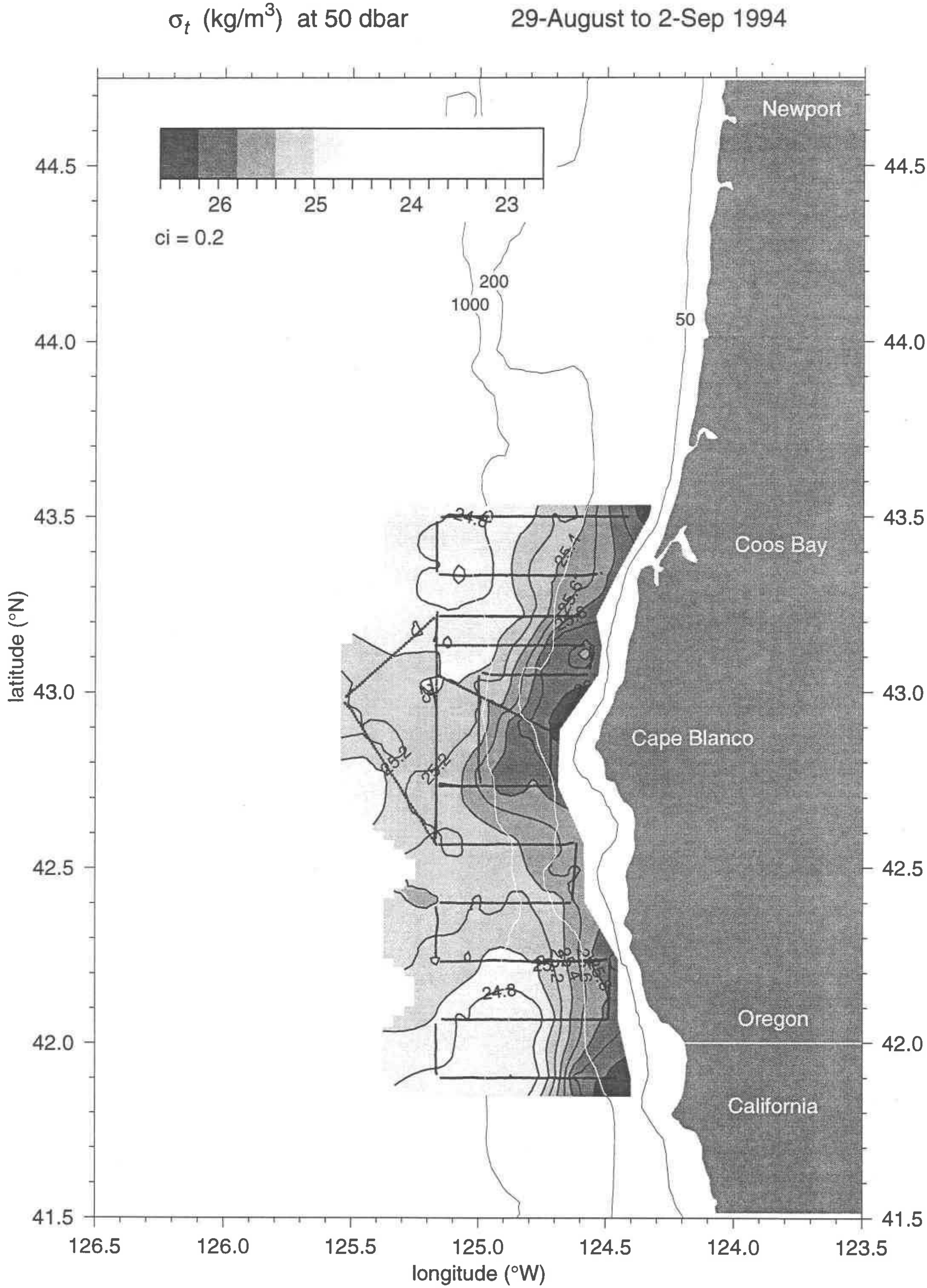
σ_t (kg/m^3) at 5 dbar 29-August to 2-Sep 1994




σt (kg/m3) at 15 dbar
29-August to 2-Sep 1994
26
25
24
23
ci = 0.2
200
1000
50
Newport
Coos Bay
Cape Blanco
Oregon
California
latitude (°N)
44.5
44.0
43.5
43.0
42.5
42.0
41.5
longitude (°W)
126.5
126.0
125.5
125.0
124.5
124.0
123.5

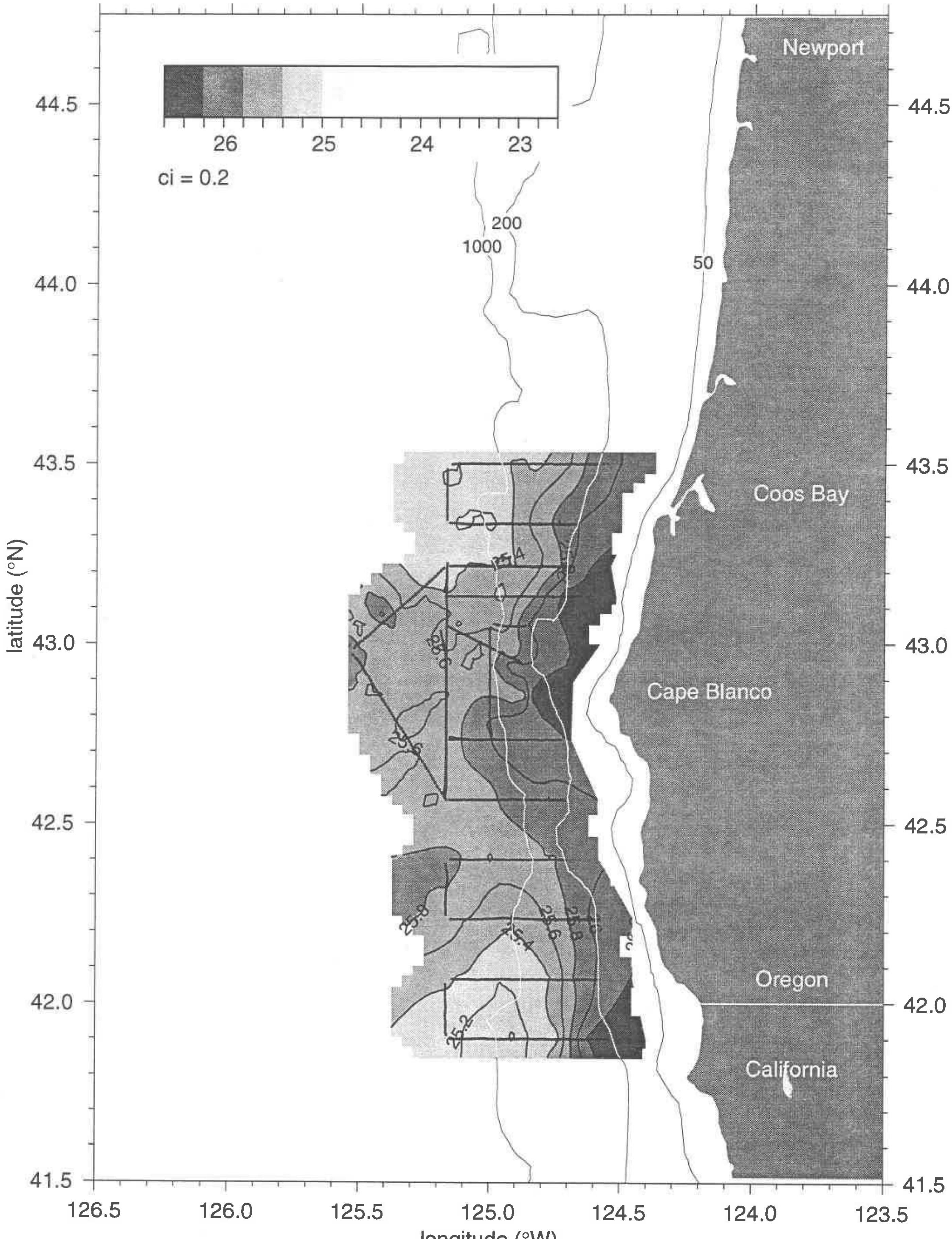
σ_t (kg/m^3) at 25 dbar 29-August to 2-Sep 1994

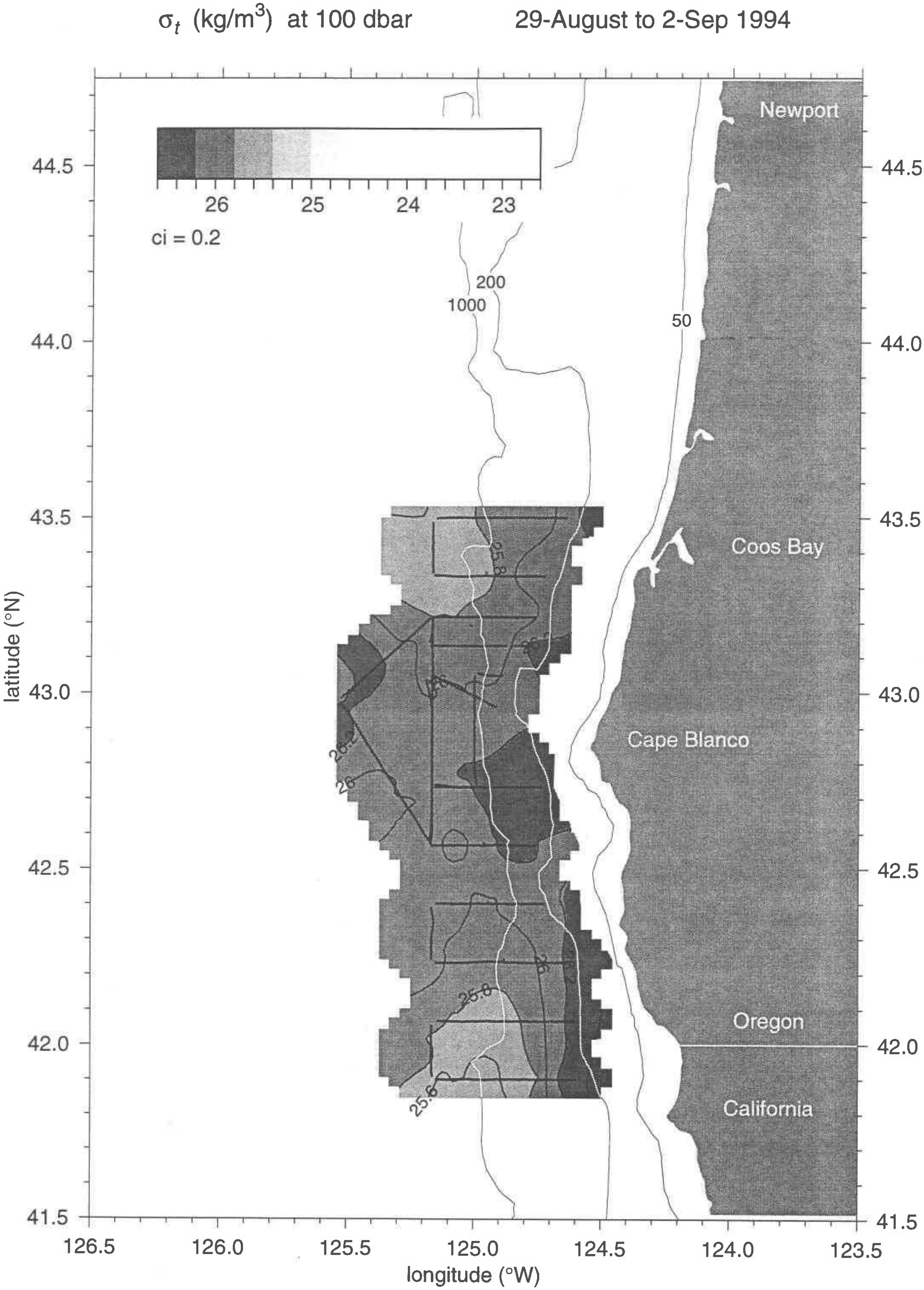




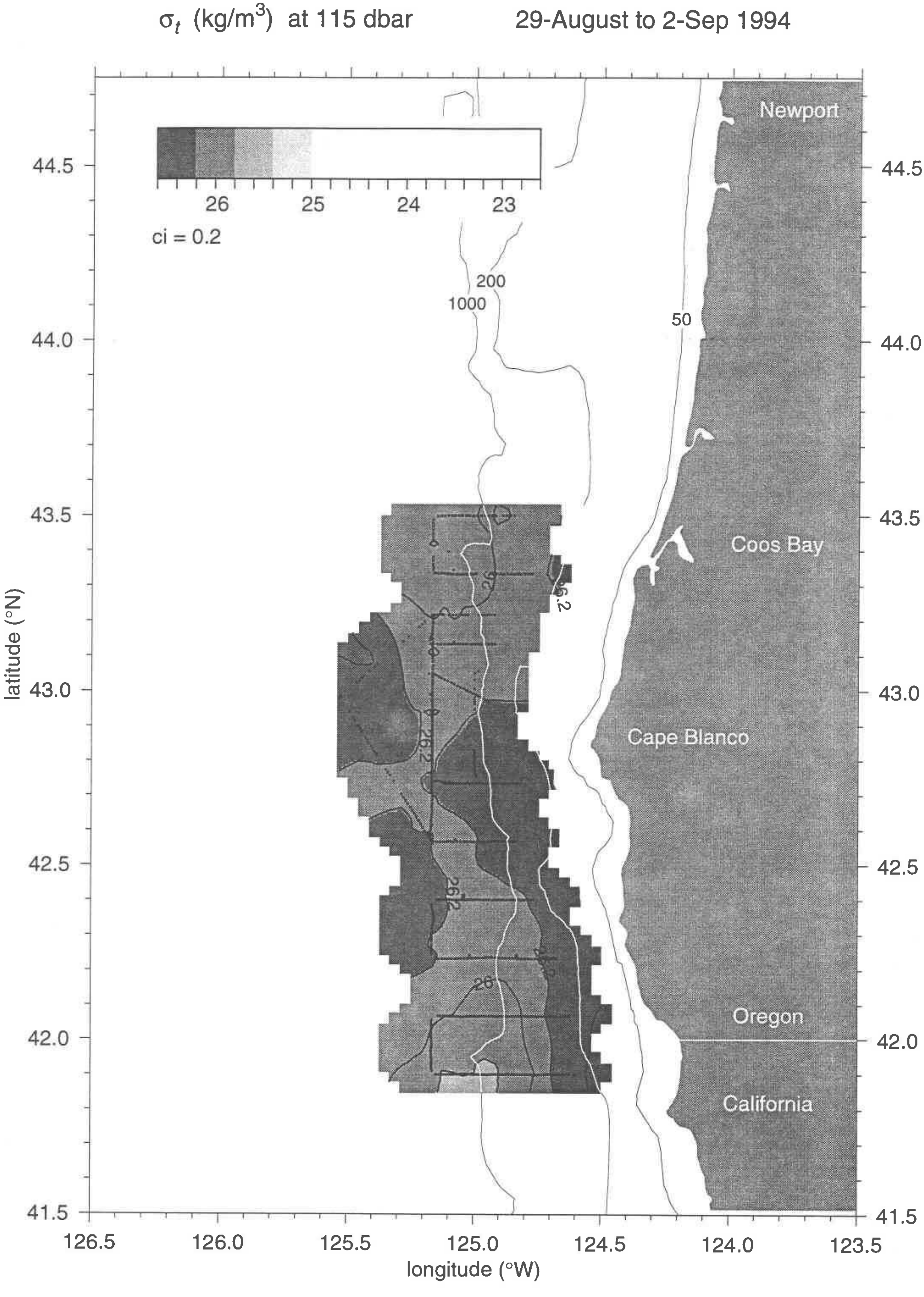
σ_t (kg/m^3) at 50 dbar
29-August to 2-Sep 1994
26
25
24
23
ci = 0.2
200
1000
50
24.8
Newport
Coos Bay
Cape Blanco
Oregon
California
latitude (°N)
longitude (°W)
44.5
44.0
43.5
43.0
42.5
42.0
41.5
126.5
126.0
125.5
125.0
124.5
124.0
123.5

σ_t (kg/m^3) at 75 dbar   29-August to 2-Sep 1994



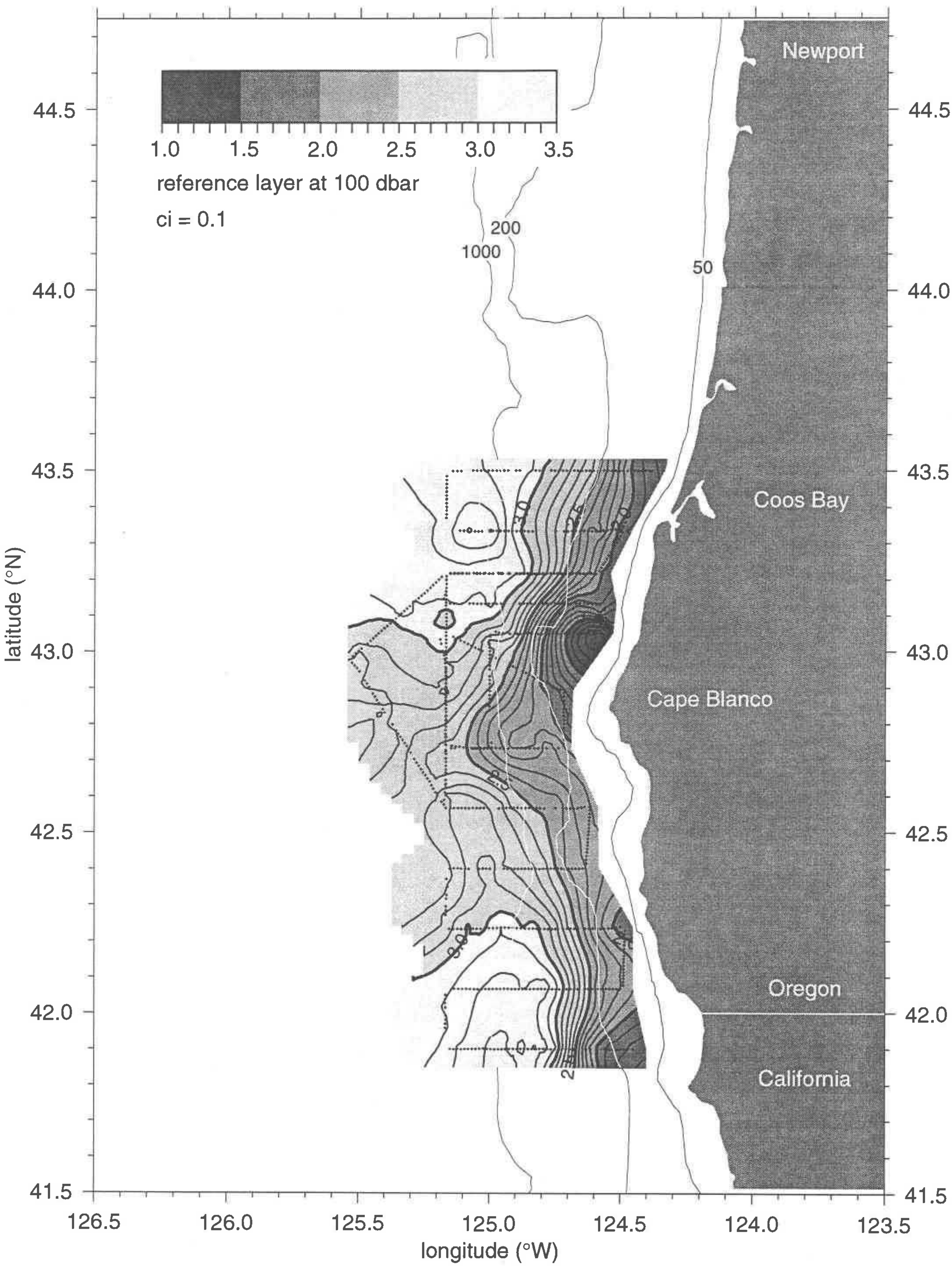


σ_t (kg/m³) at 100 dbar
29-August to 2-Sep 1994
26
25
24
23
ci = 0.2
Newport
Coos Bay
Cape Blanco
Oregon
California
200
1000
50
44.5
44.0
43.5
43.0
42.5
42.0
41.5
latitude (°N)
126.5
126.0
125.5
125.0
124.5
124.0
123.5
longitude (°W)

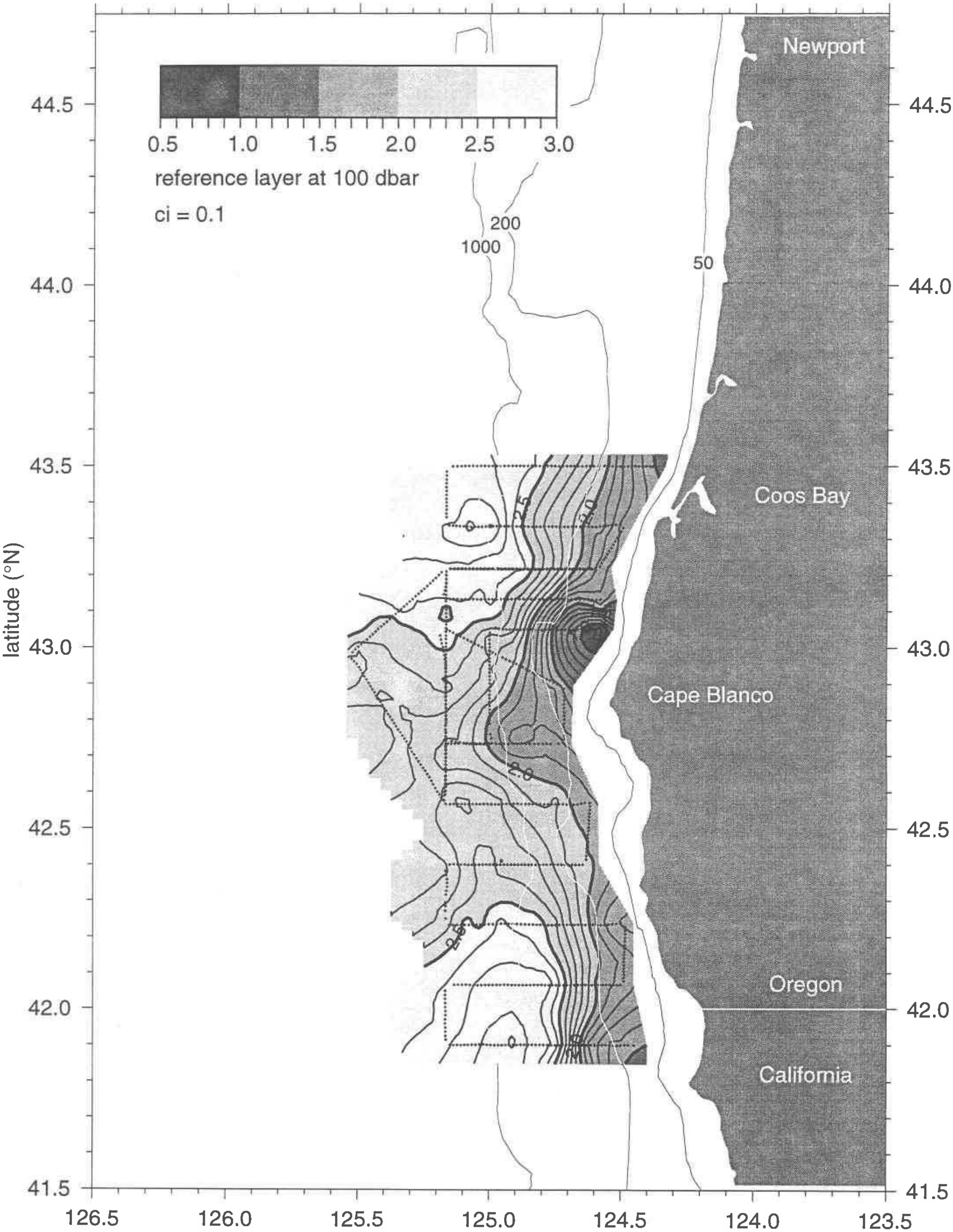


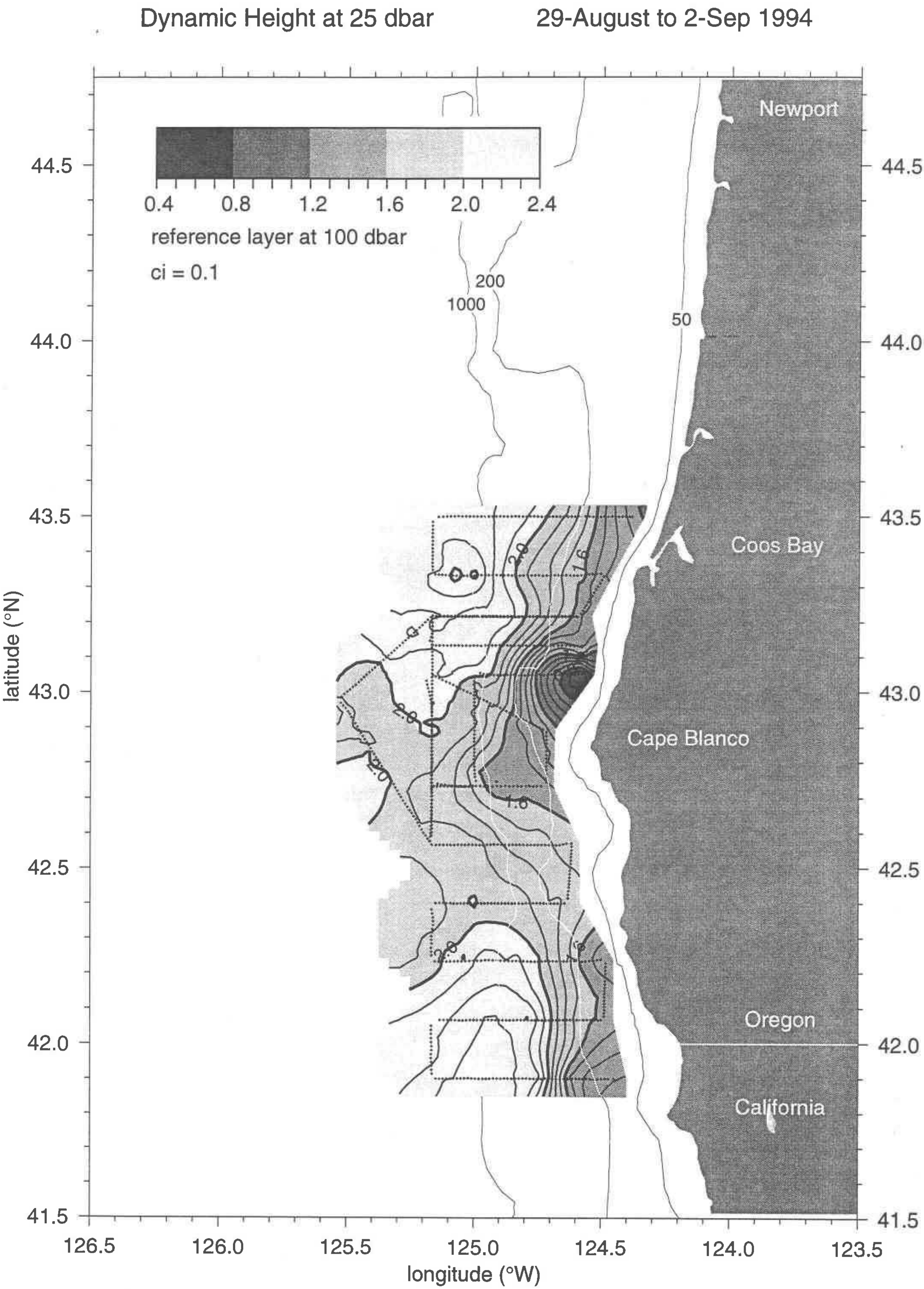
σ_t (kg/m³) at 115 dbar
29-August to 2-Sep 1994
26
25
24
23
ci = 0.2
Newport
44.5
44.0
43.5
43.0
42.5
42.0
41.5
200
1000
50
26
26.2
26.2
26.2
26.2
26
Coos Bay
Cape Blanco
Oregon
California
latitude (°N)
126.5
126.0
125.5
125.0
124.5
124.0
123.5
longitude (°W)

Dynamic Height at 5 dbar 29-August to 2-Sep 1994

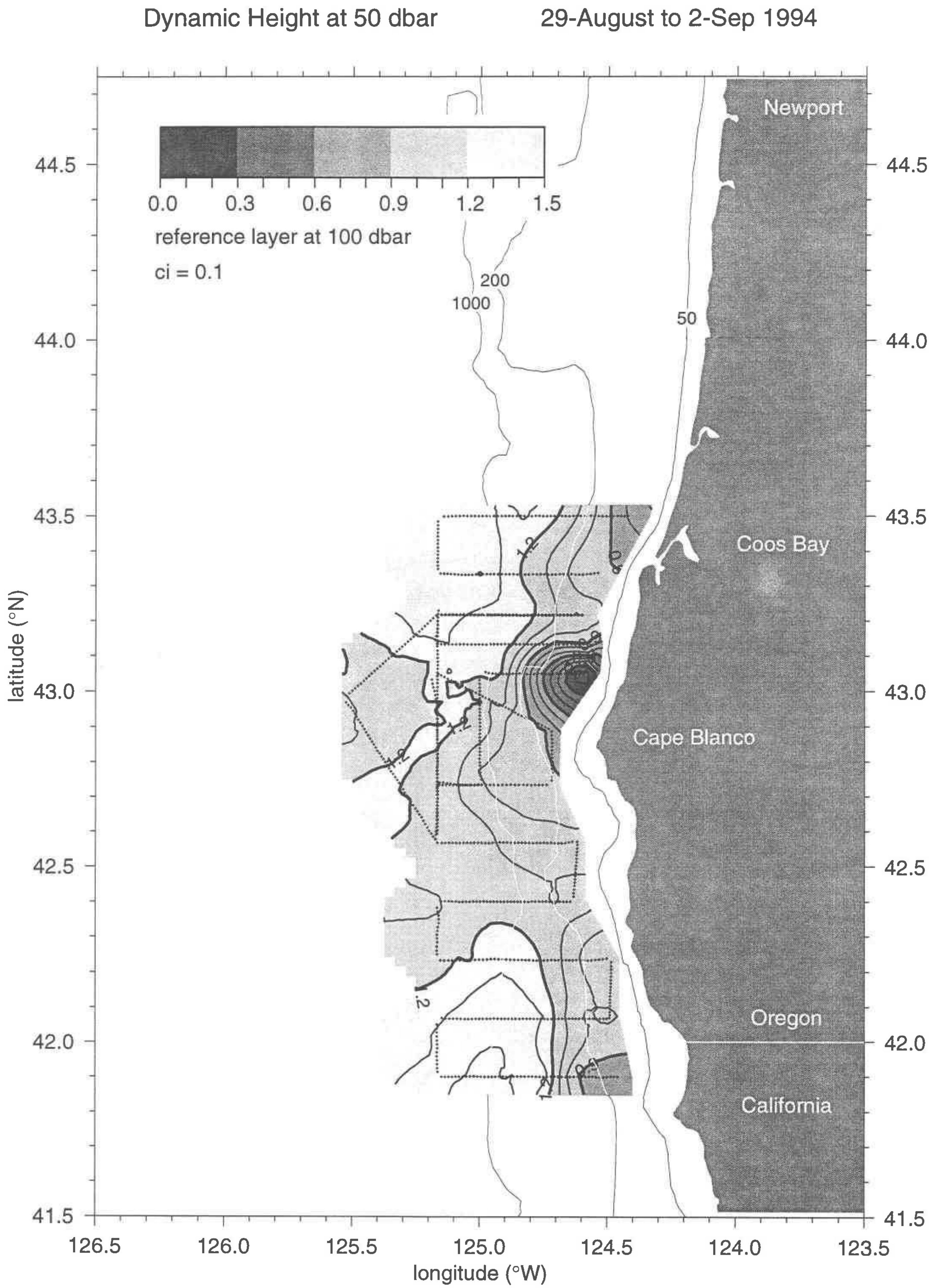


Dynamic Height at 15 dbar 29-August to 2-Sep 1994



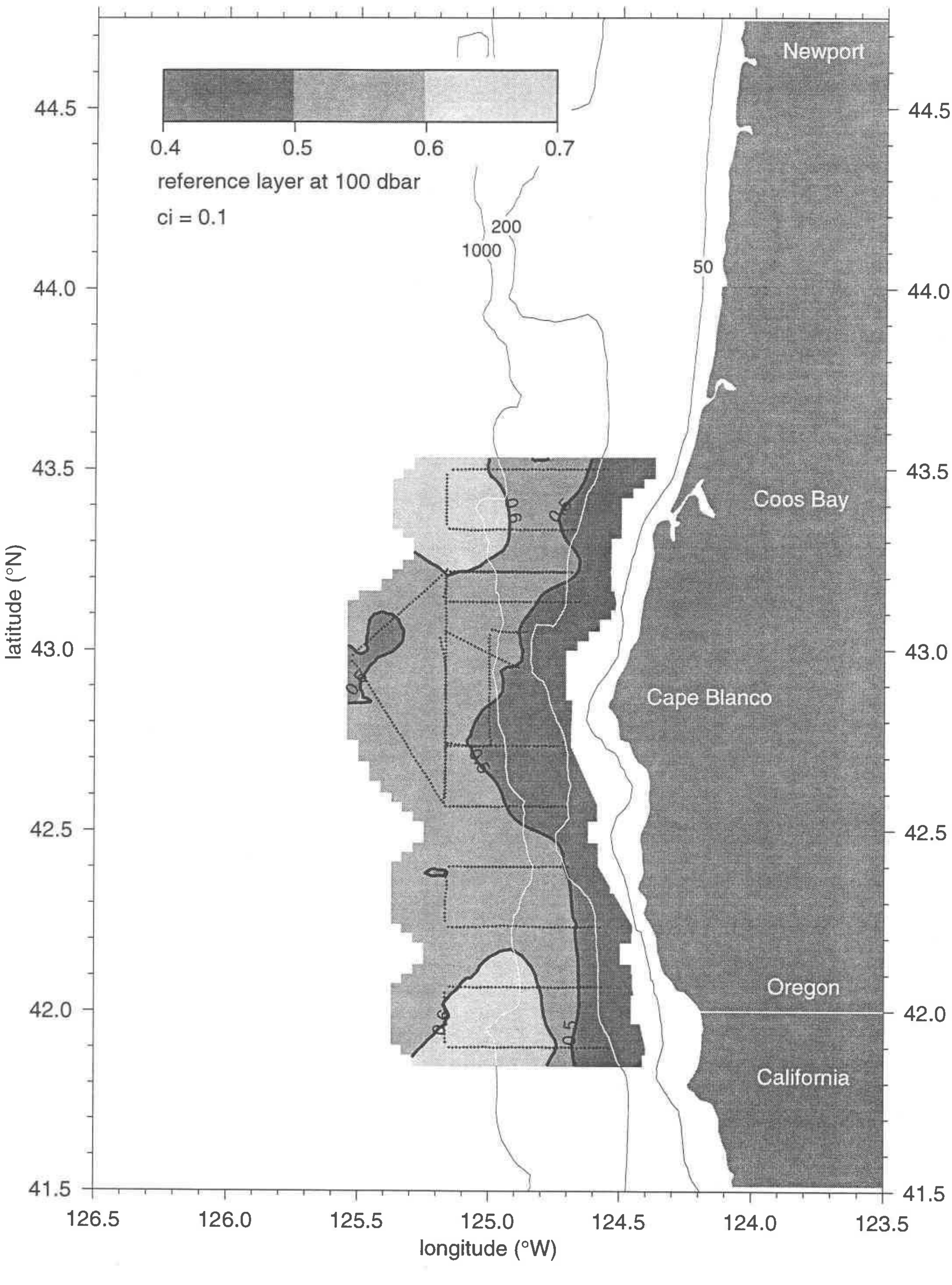


Dynamic Height at 25 dbar
29-August to 2-Sep 1994
0.4
0.8
1.2
1.6
2.0
2.4
reference layer at 100 dbar
ci = 0.1
200
1000
50
Newport
Coos Bay
Cape Blanco
Oregon
California
44.5
44.0
43.5
43.0
42.5
42.0
41.5
latitude (°N)
126.5
126.0
125.5
125.0
124.5
124.0
123.5
longitude (°W)



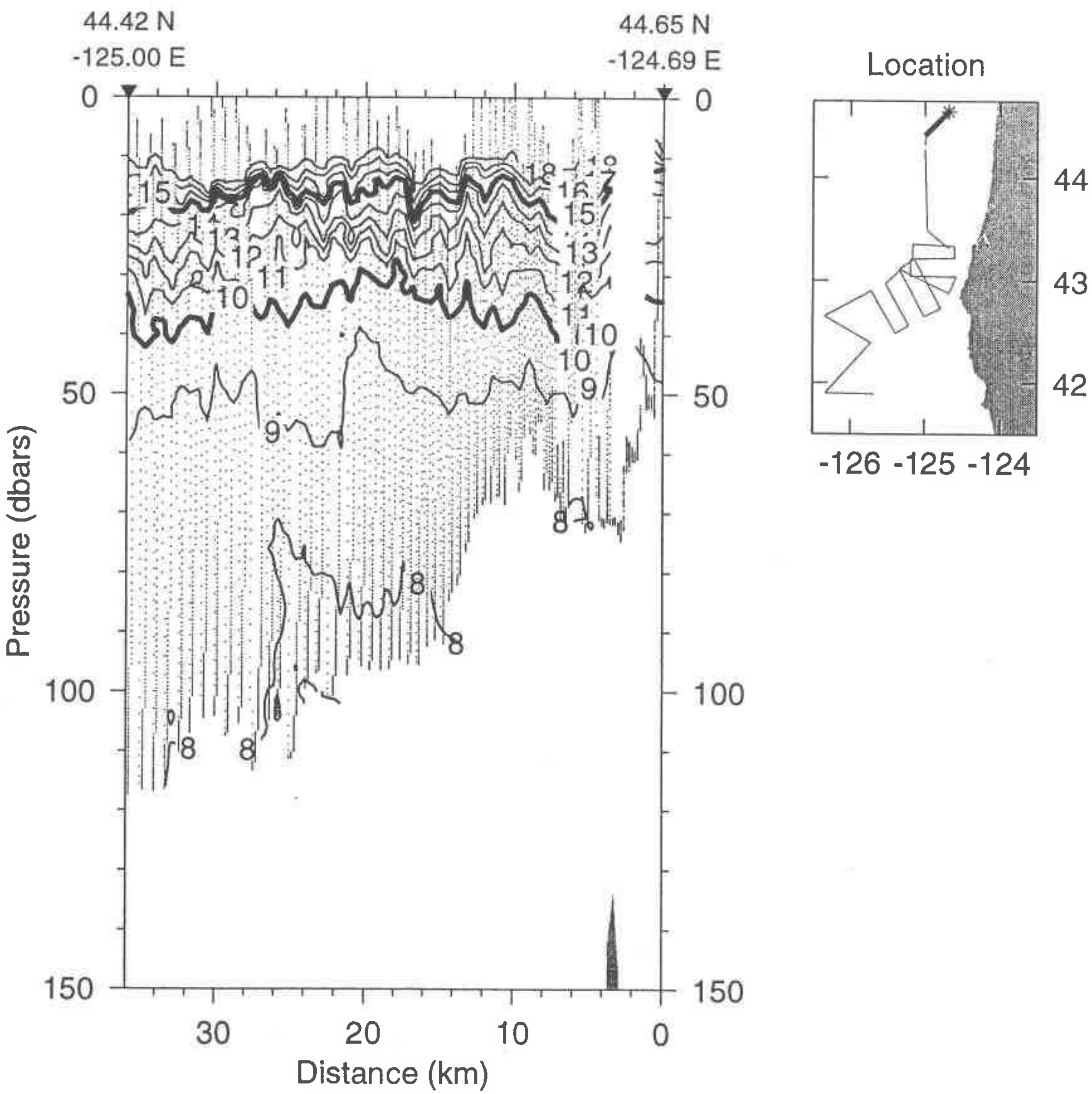
Dynamic Height at 50 dbar
29-August to 2-Sep 1994
0.0
0.3
0.6
0.9
1.2
1.5
reference layer at 100 dbar
ci = 0.1
200
1000
50
Newport
Coos Bay
Cape Blanco
Oregon
California
44.5
44.0
43.5
43.0
42.5
42.0
41.5
latitude (°N)
126.5
126.0
125.5
125.0
124.5
124.0
123.5
longitude (°W)

Dynamic Height at 75 dbar 29-August to 2-Sep 1994

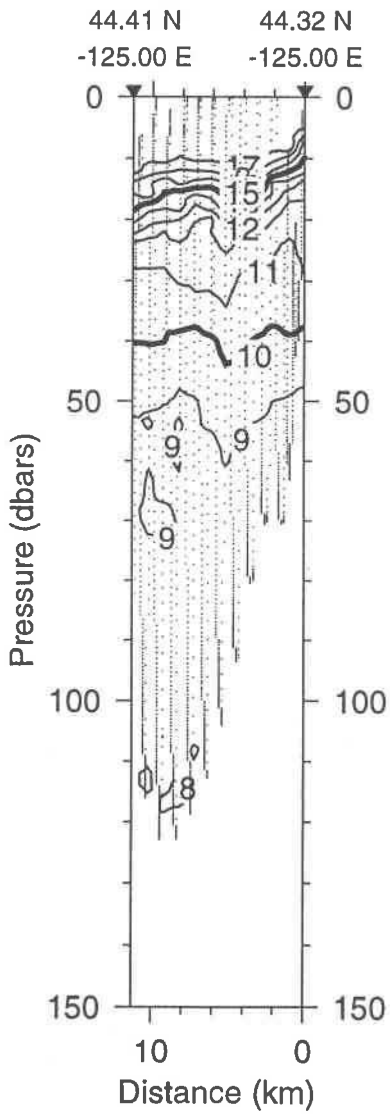


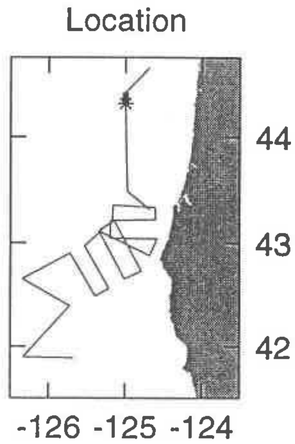
Vertical Sections of Temperature, Salinity and σ_t

Line a Temperature (°C)

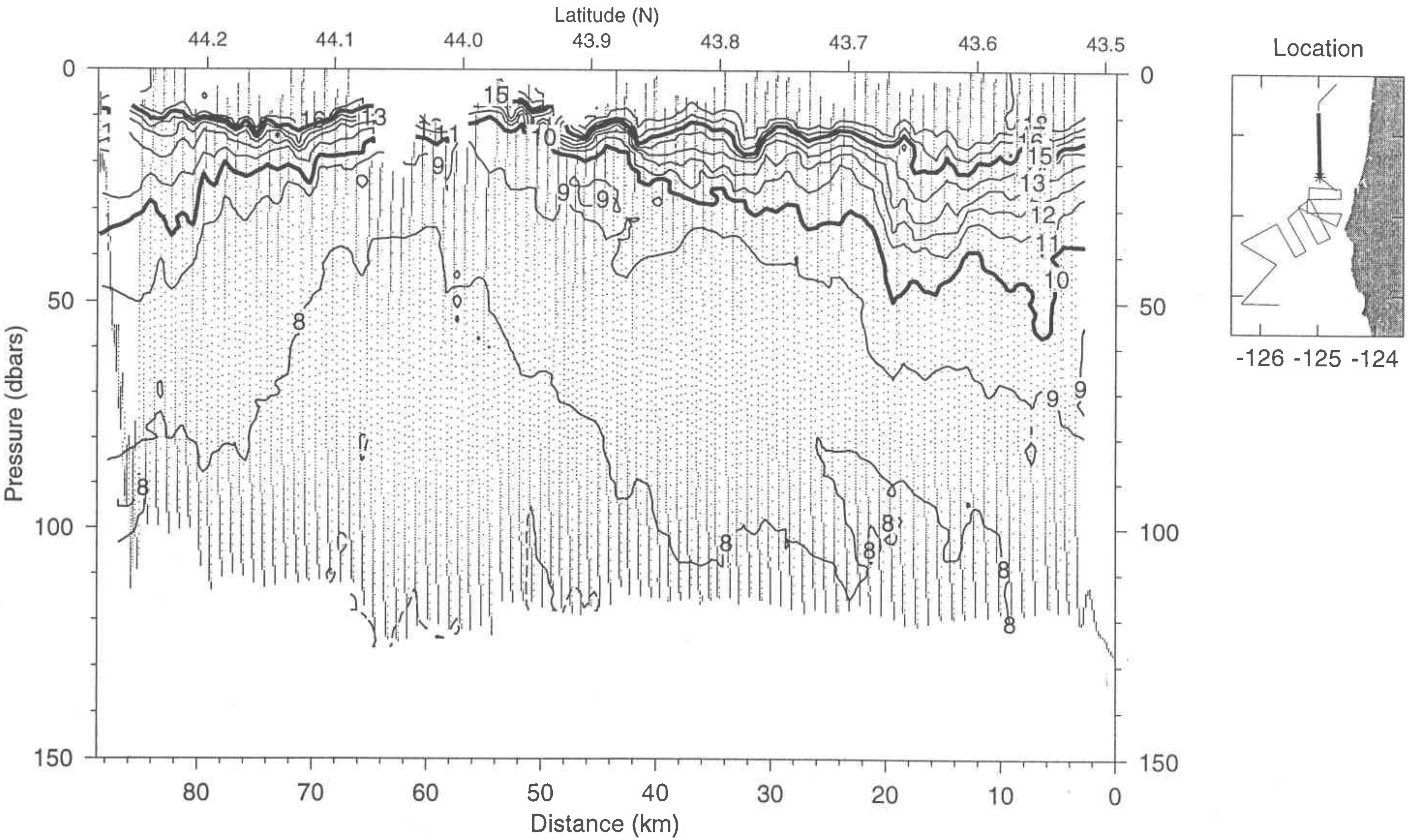


Line b0 Temperature (°C)

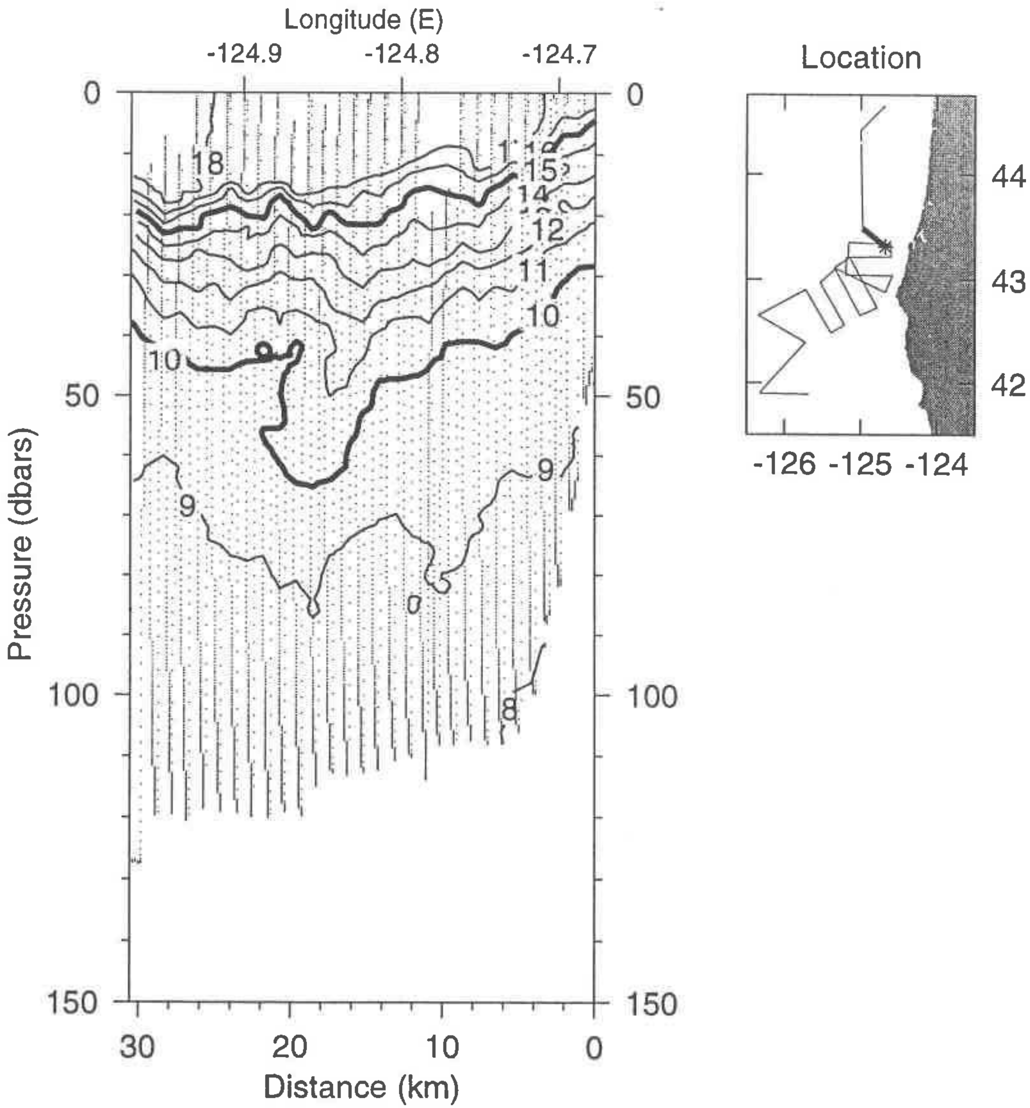




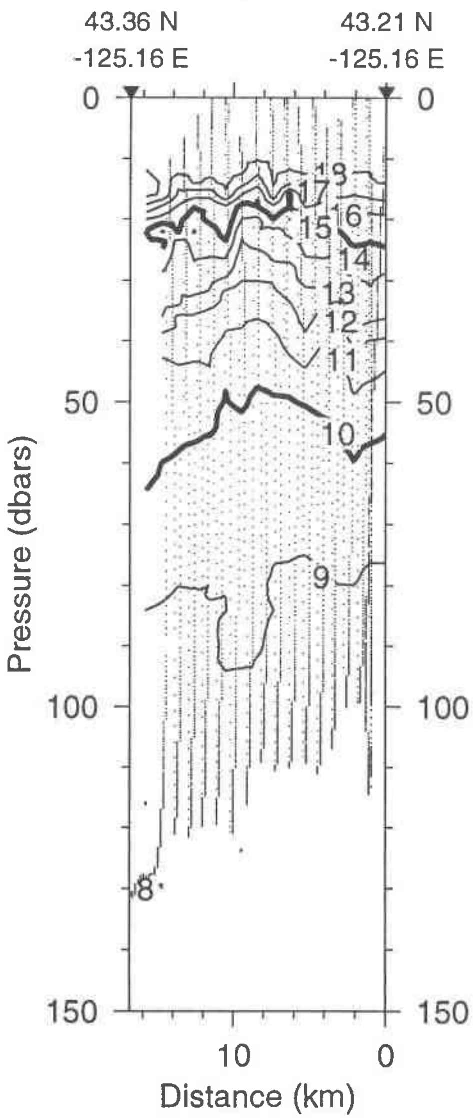
Line b Temperature (°C)

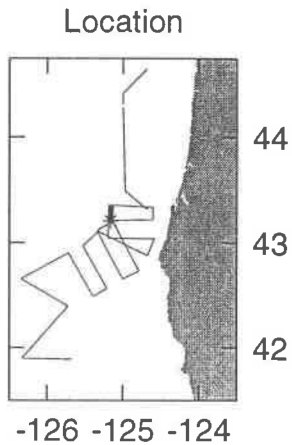


Line c Temperature (°C)

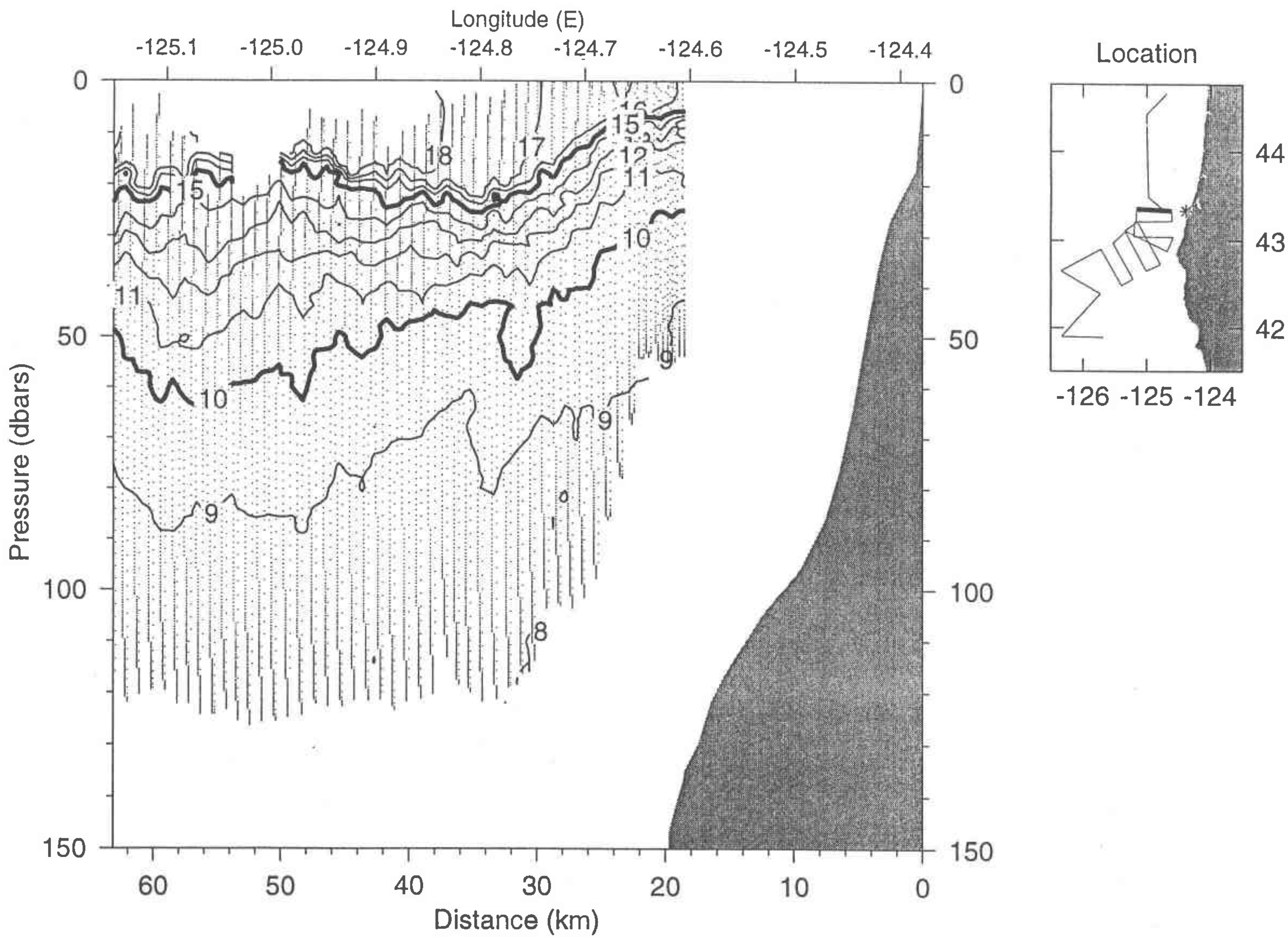


Line 00-01 Temperature (°C)

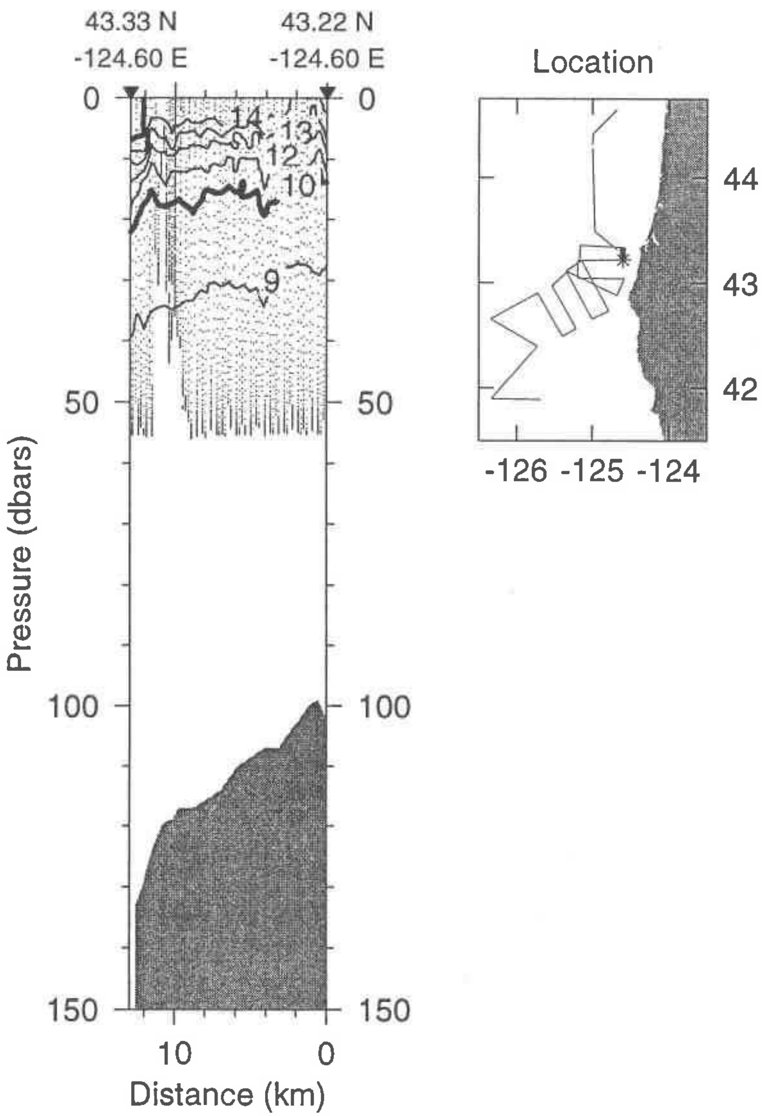




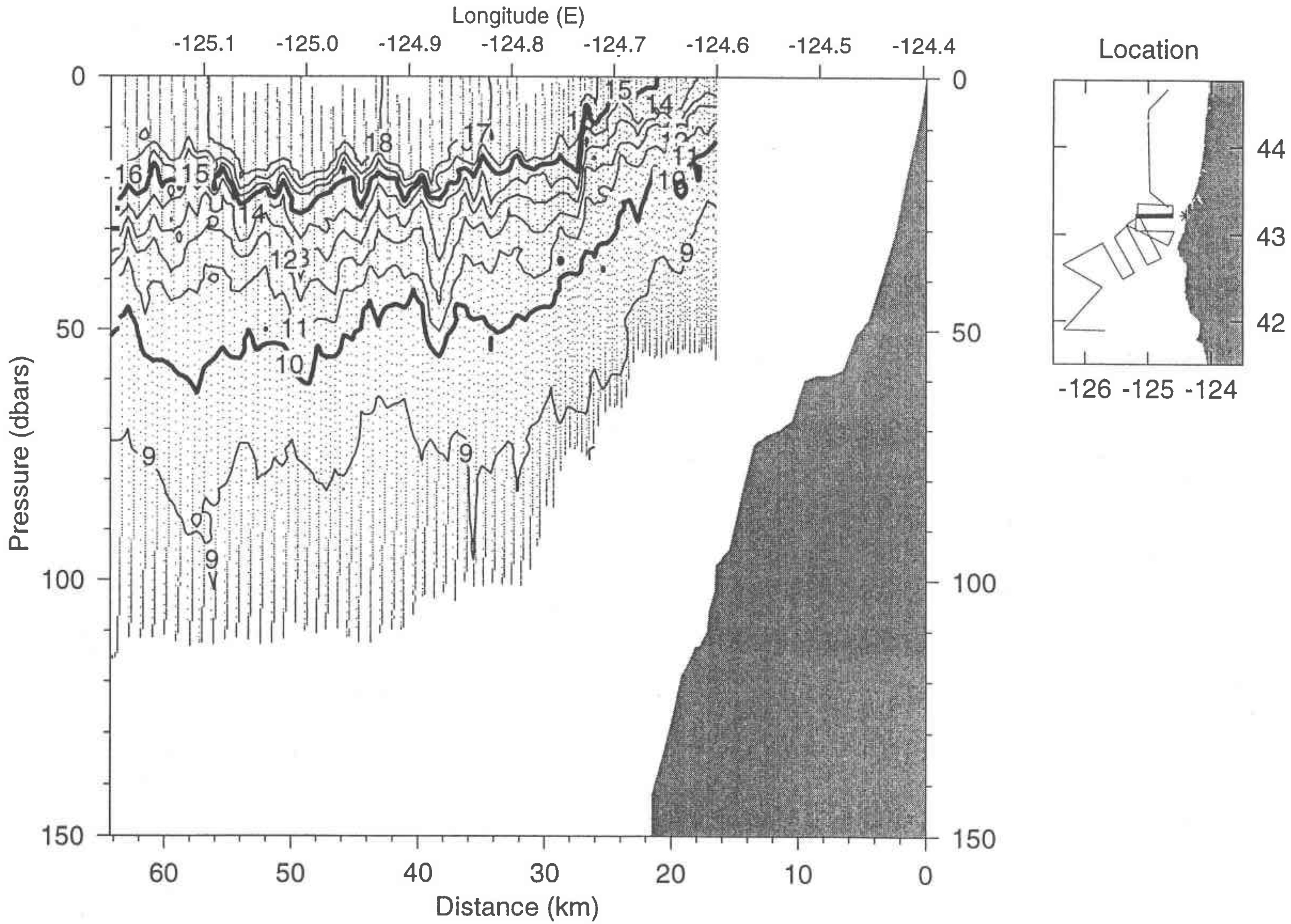
Line 01 Temperature (°C)



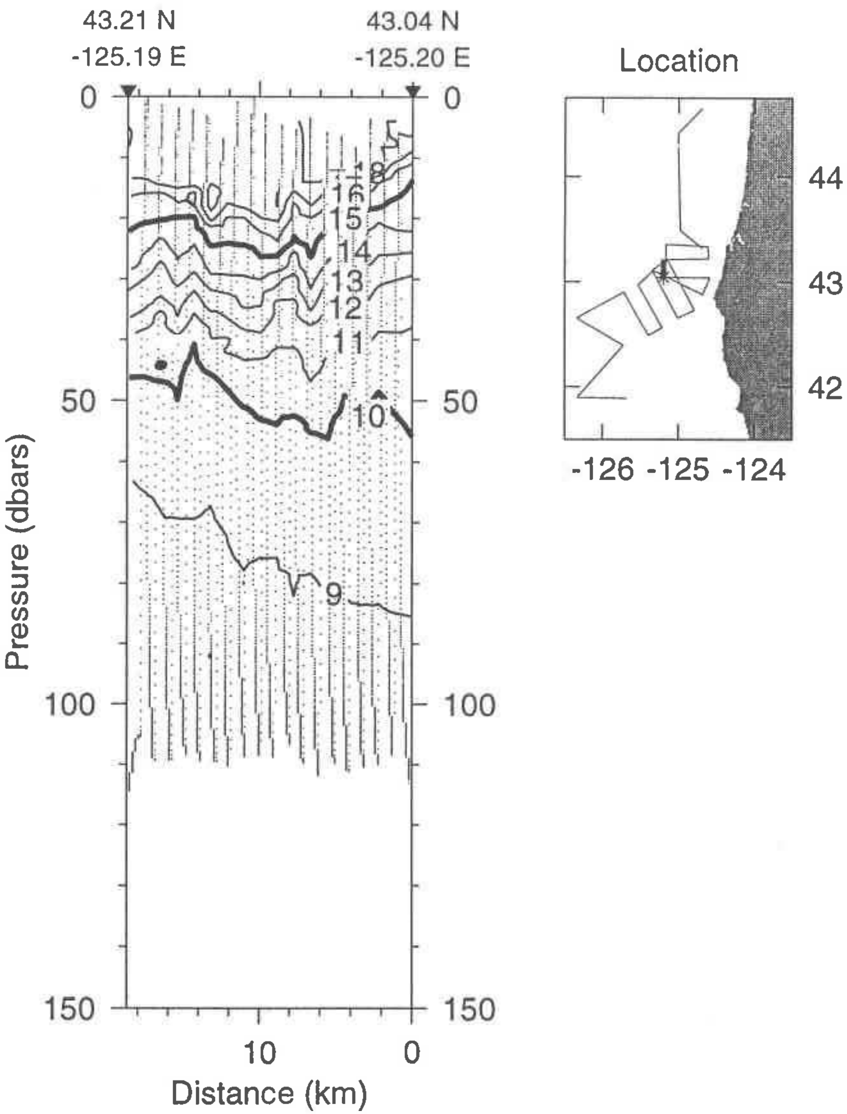
Line 01-02 Temperature (°C)



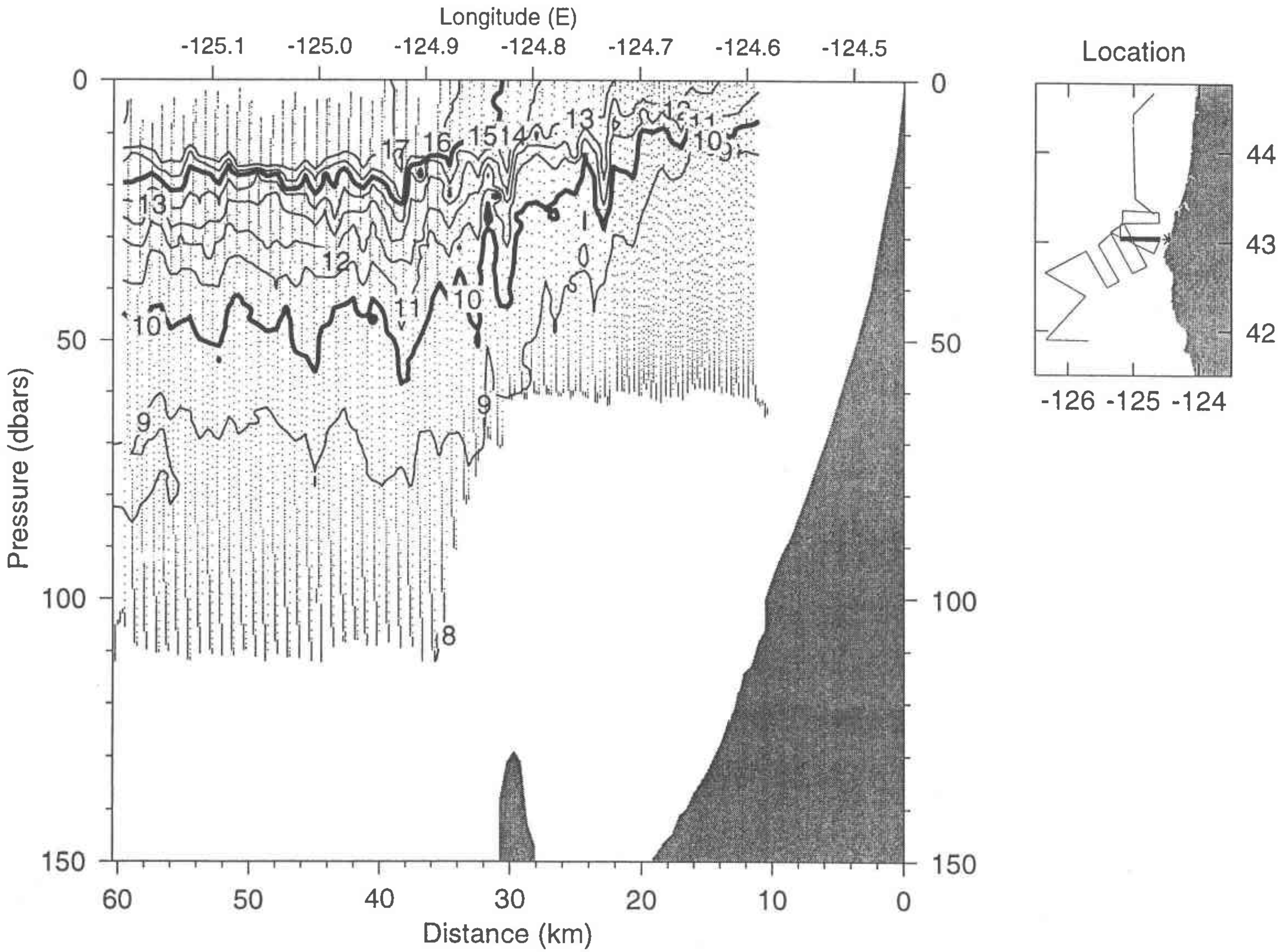
Line 02 Temperature (°C)



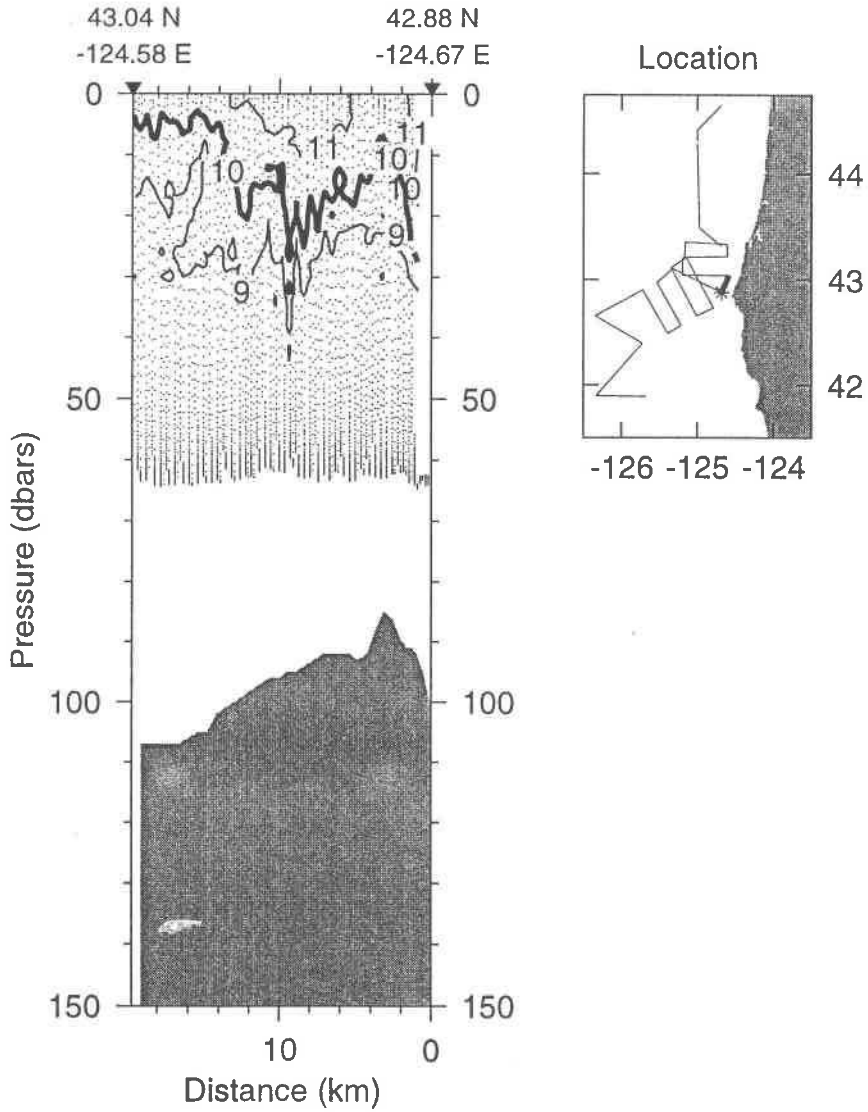
Line 02-03 Temperature (°C)



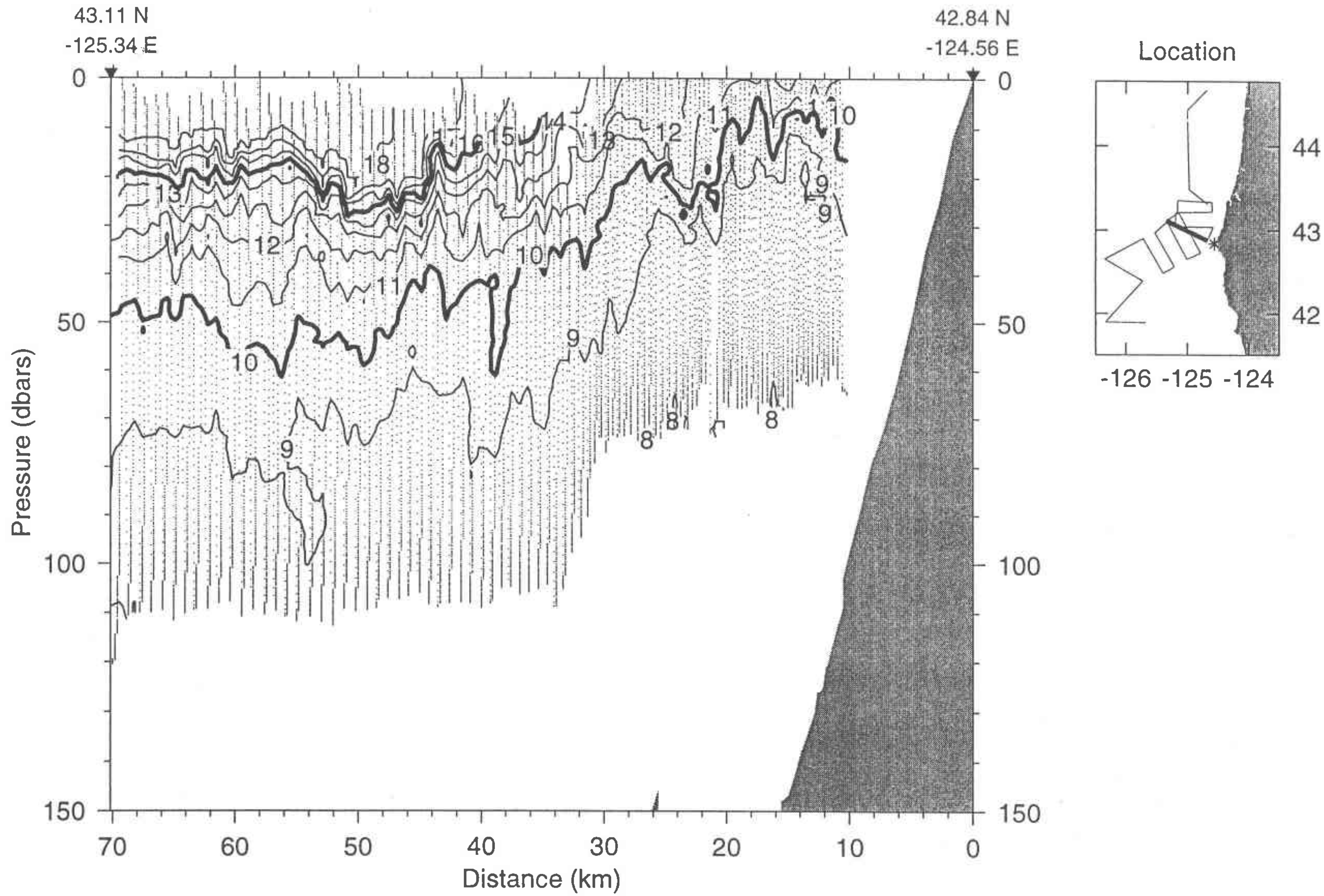
Line 03 Temperature (°C)



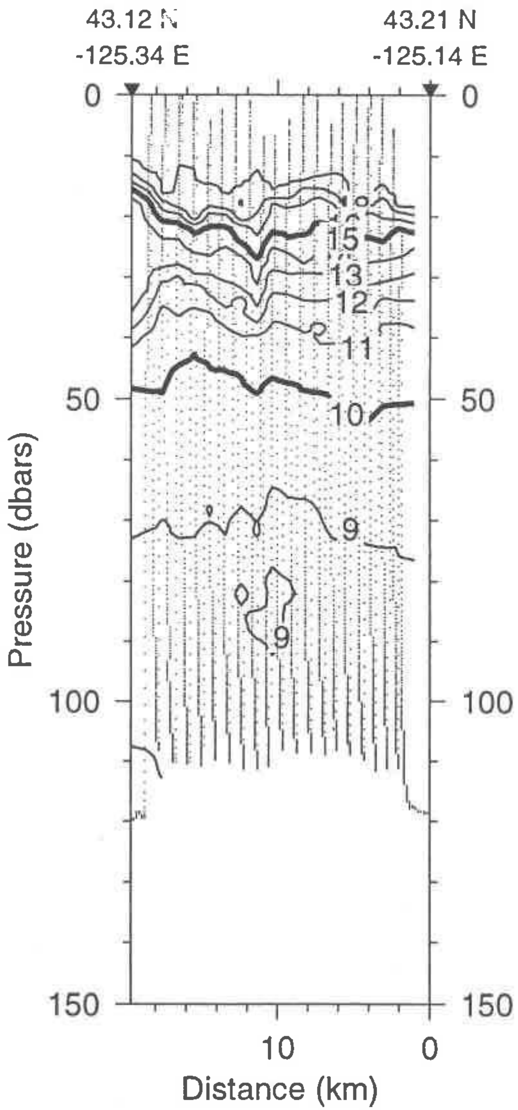
Line 03-04 Temperature (°C)

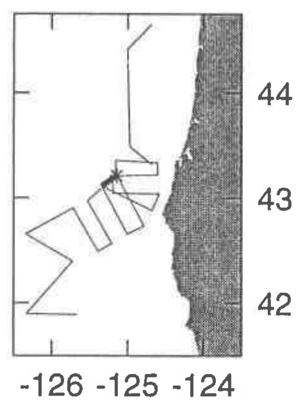


Line 04 Temperature (°C)

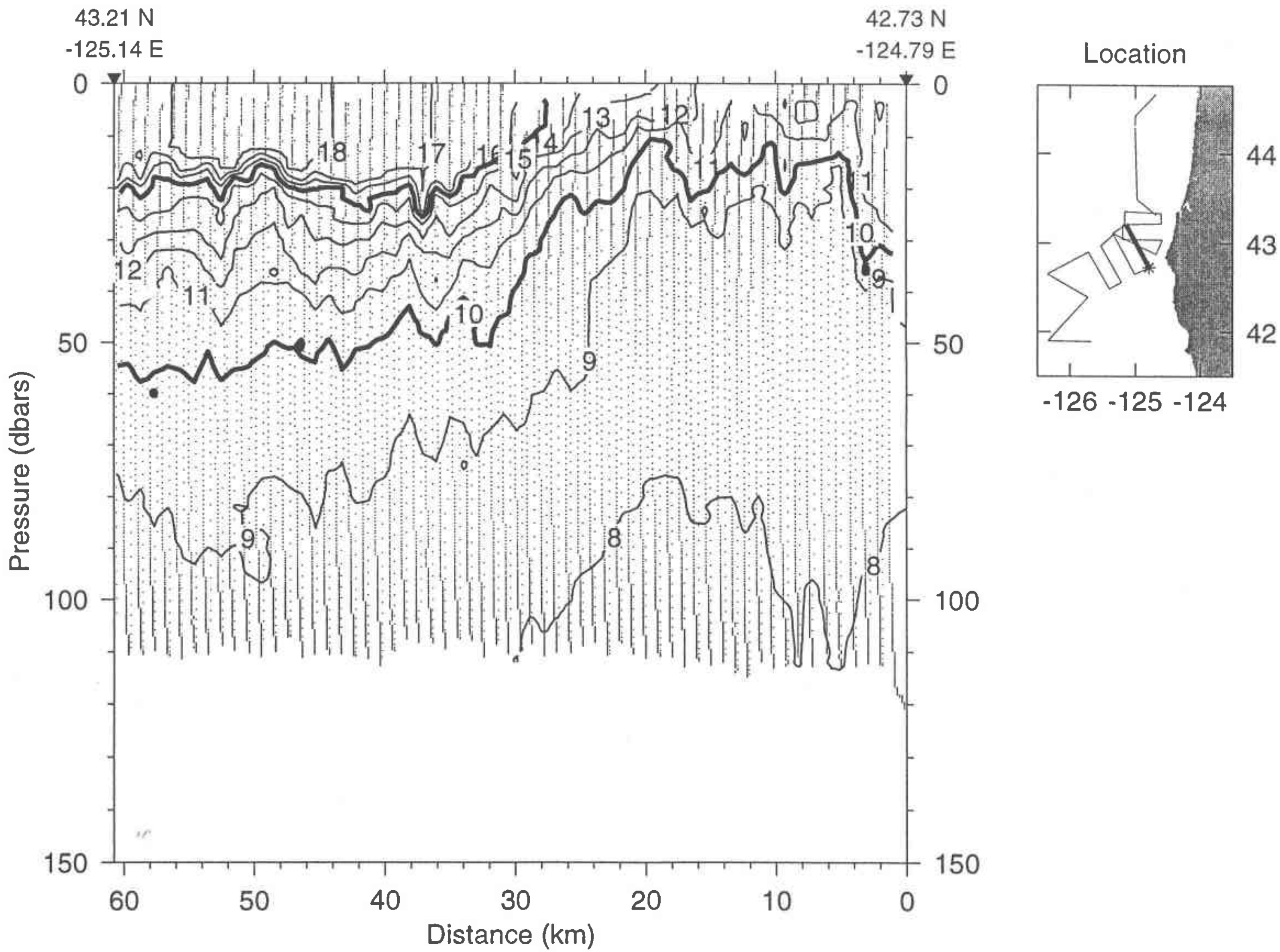


Line 04-05 Temperature (°C)

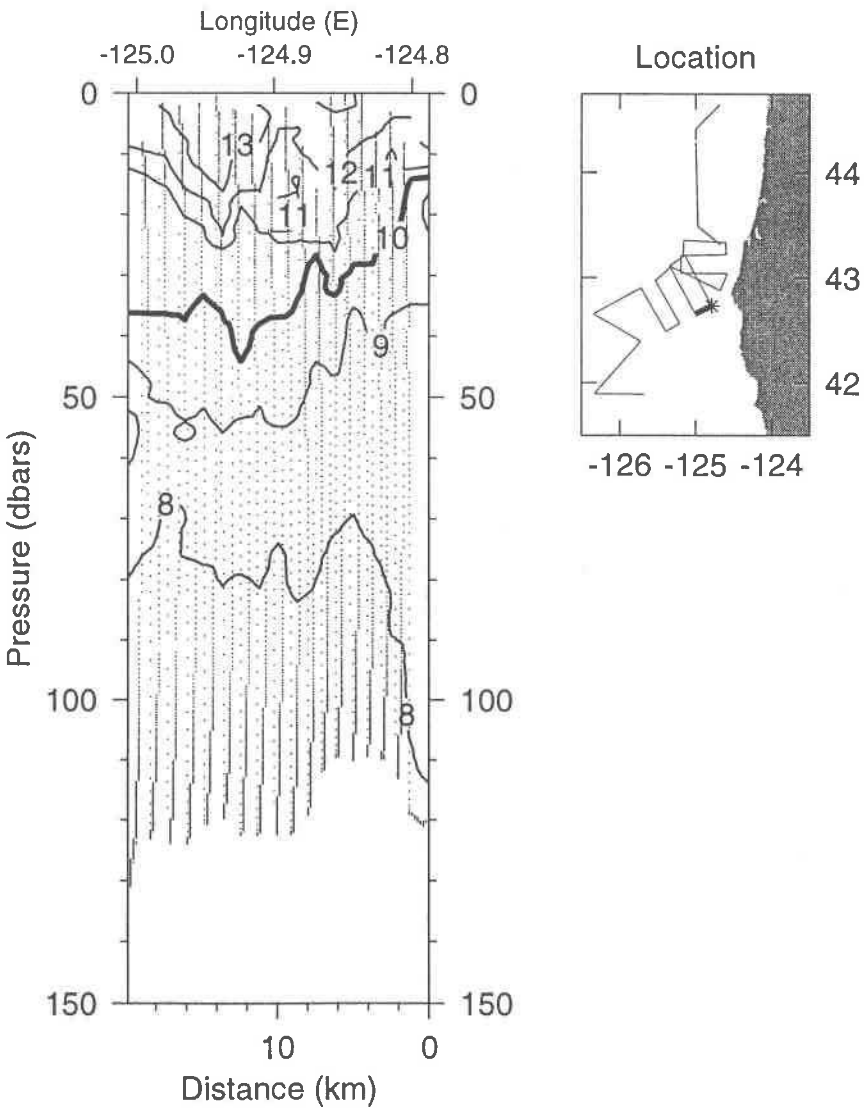




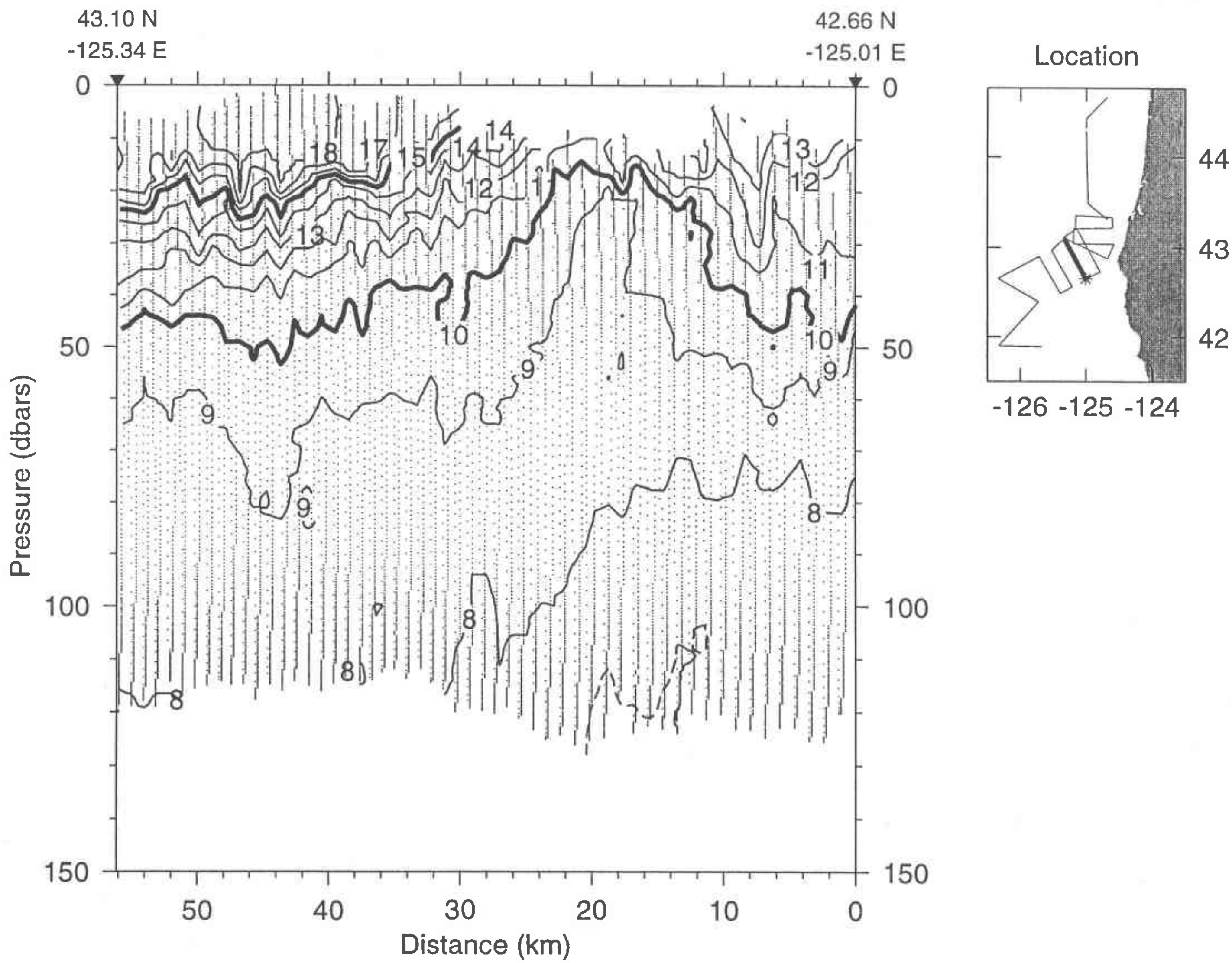
Line 05 Temperature (°C)



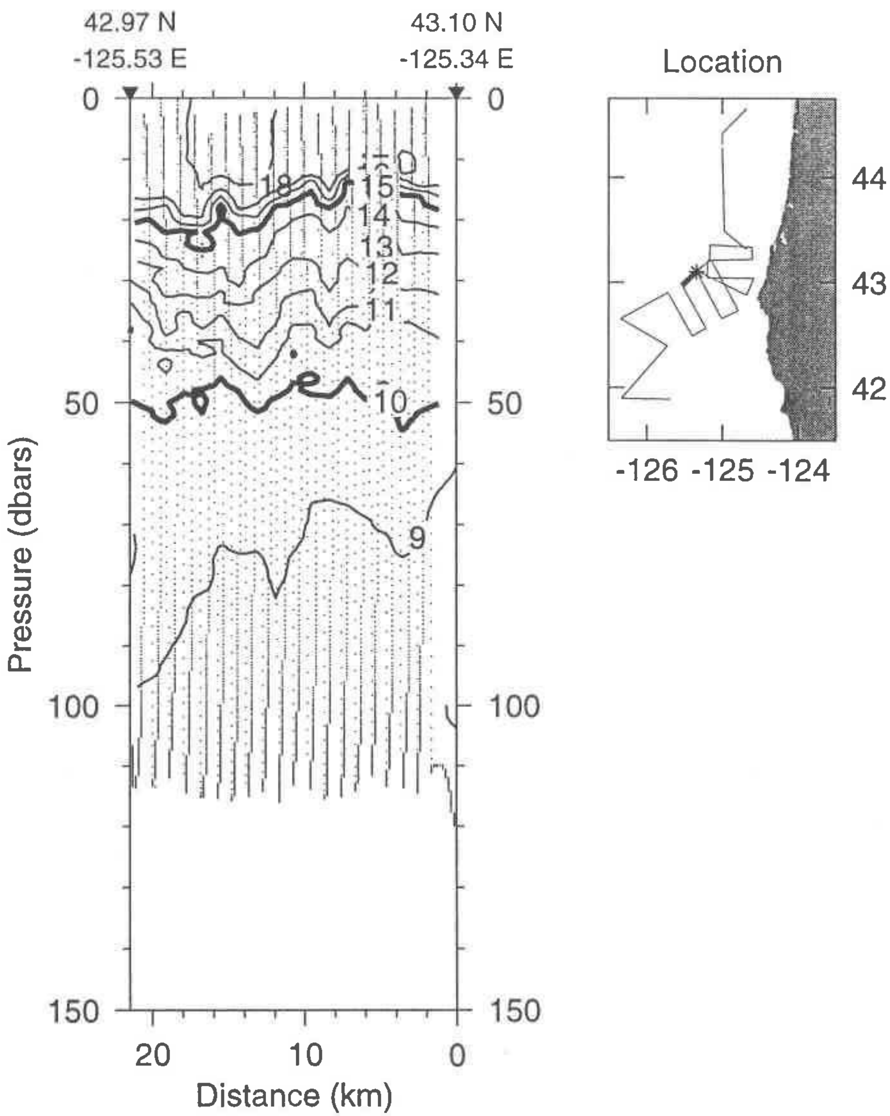
Line 05-06 Temperature (°C)



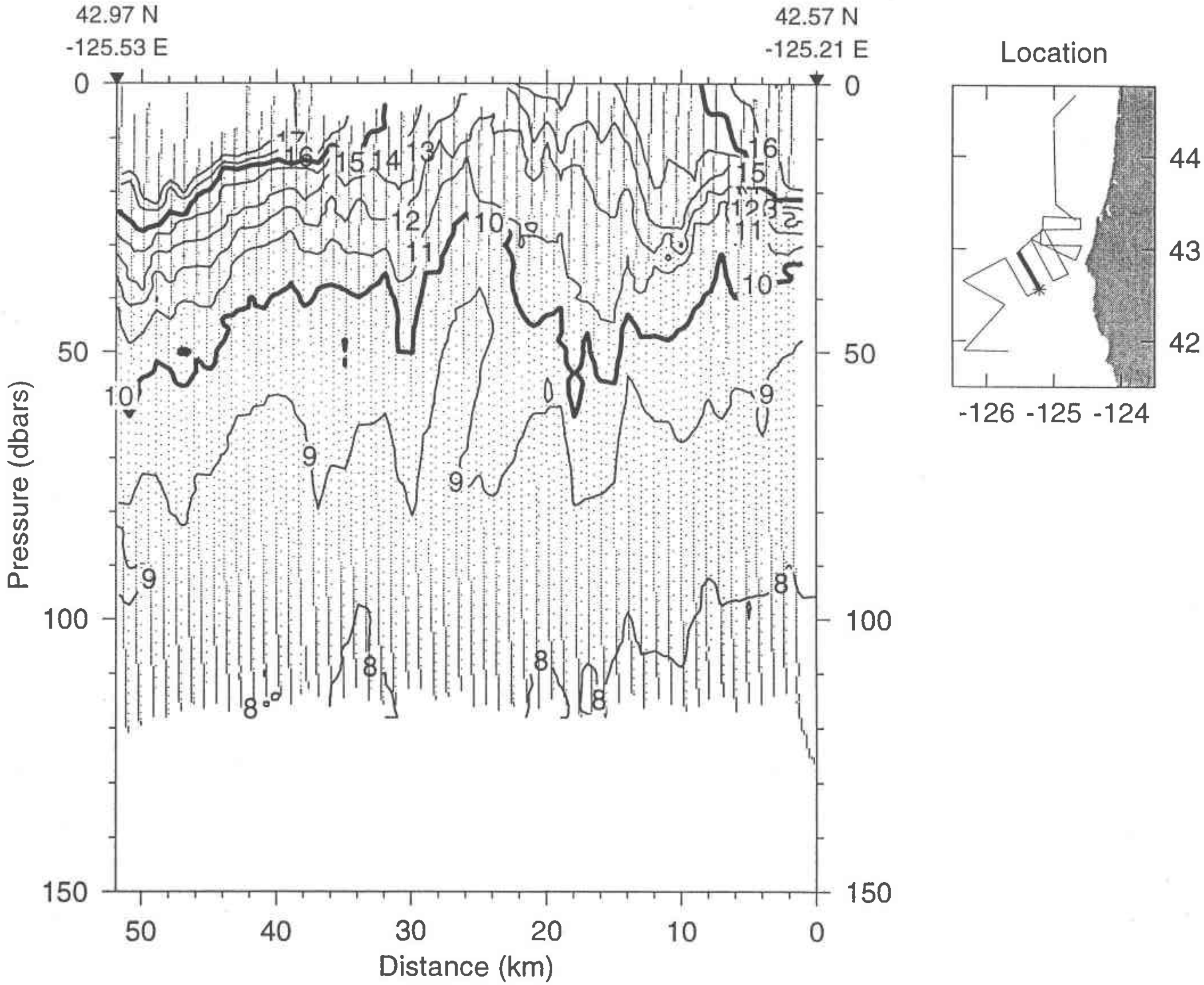
Line 06 Temperature (°C)



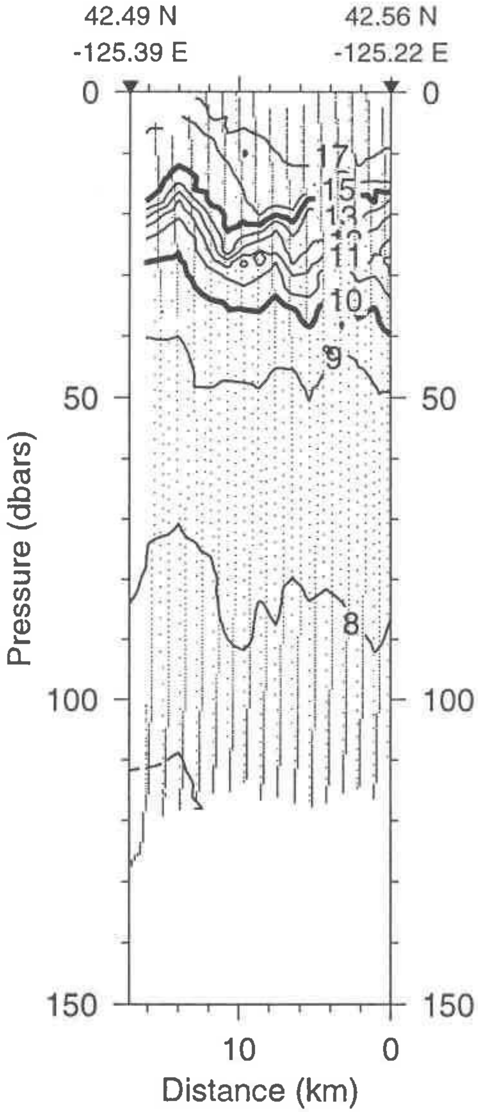
Line 06-07 Temperature (°C)

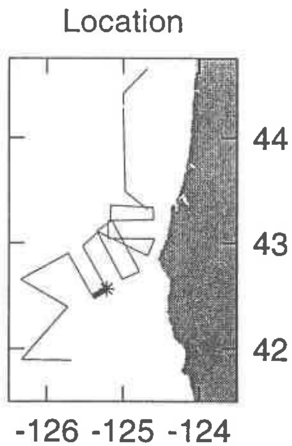


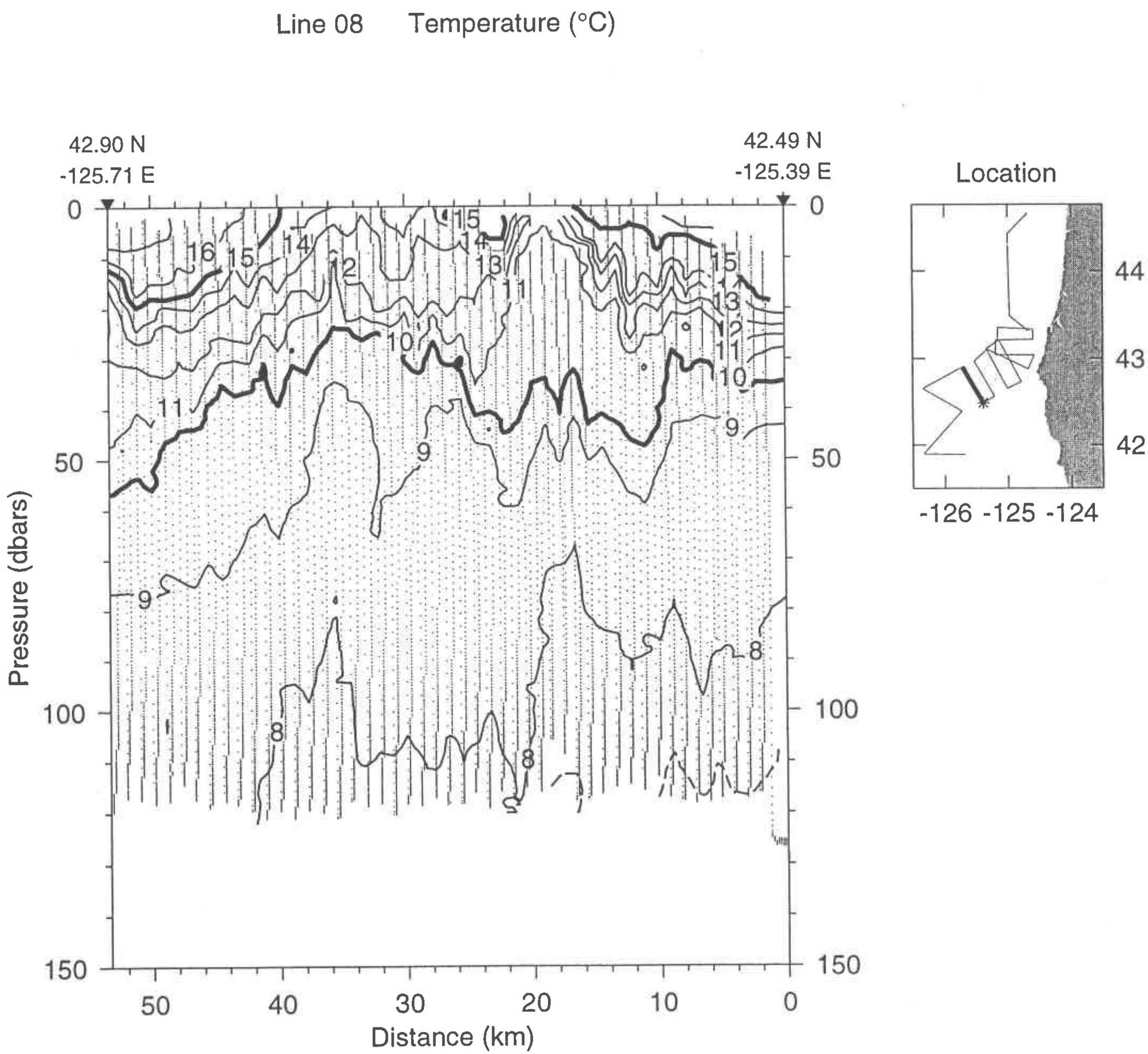
Line 07 Temperature (°C)



Line 07-08 Temperature (°C)

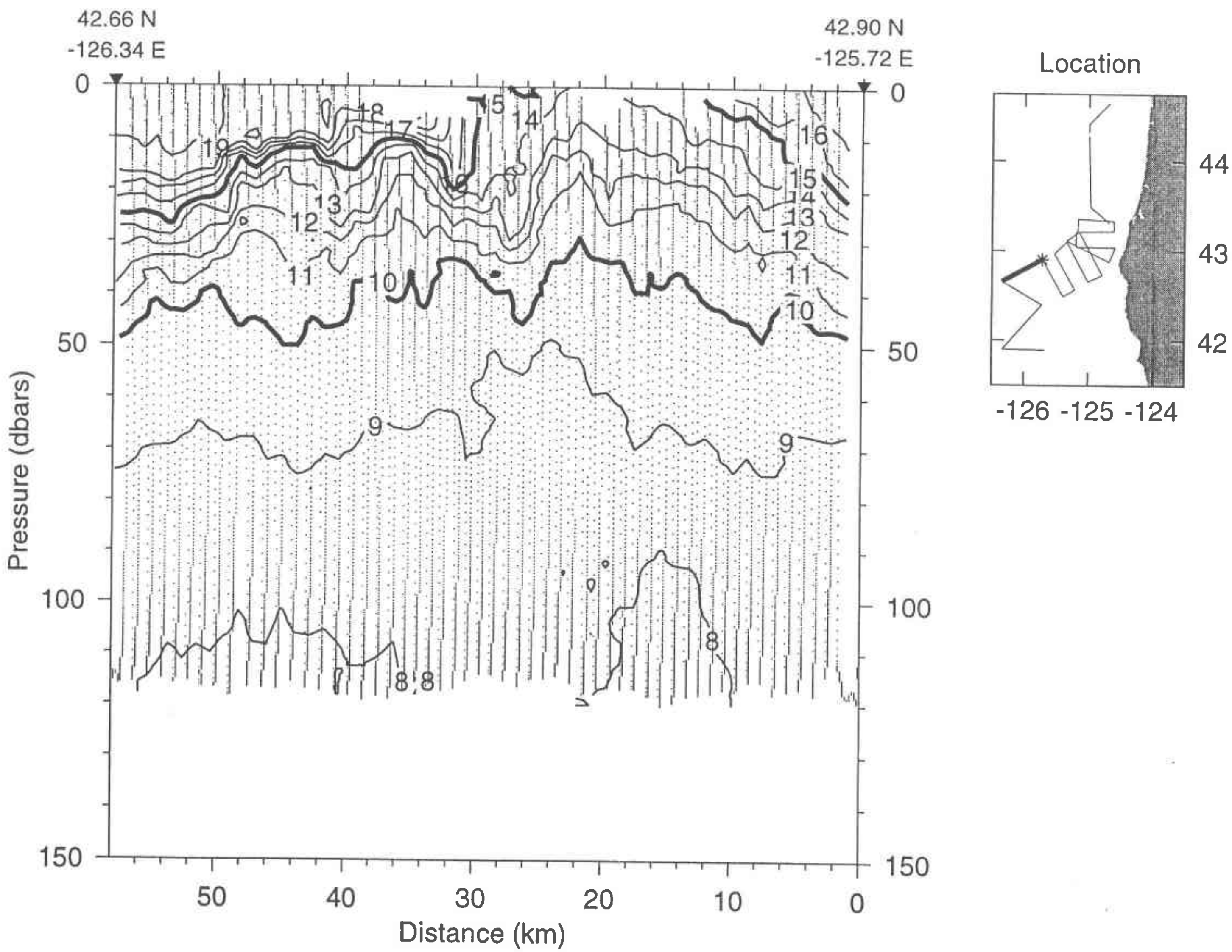




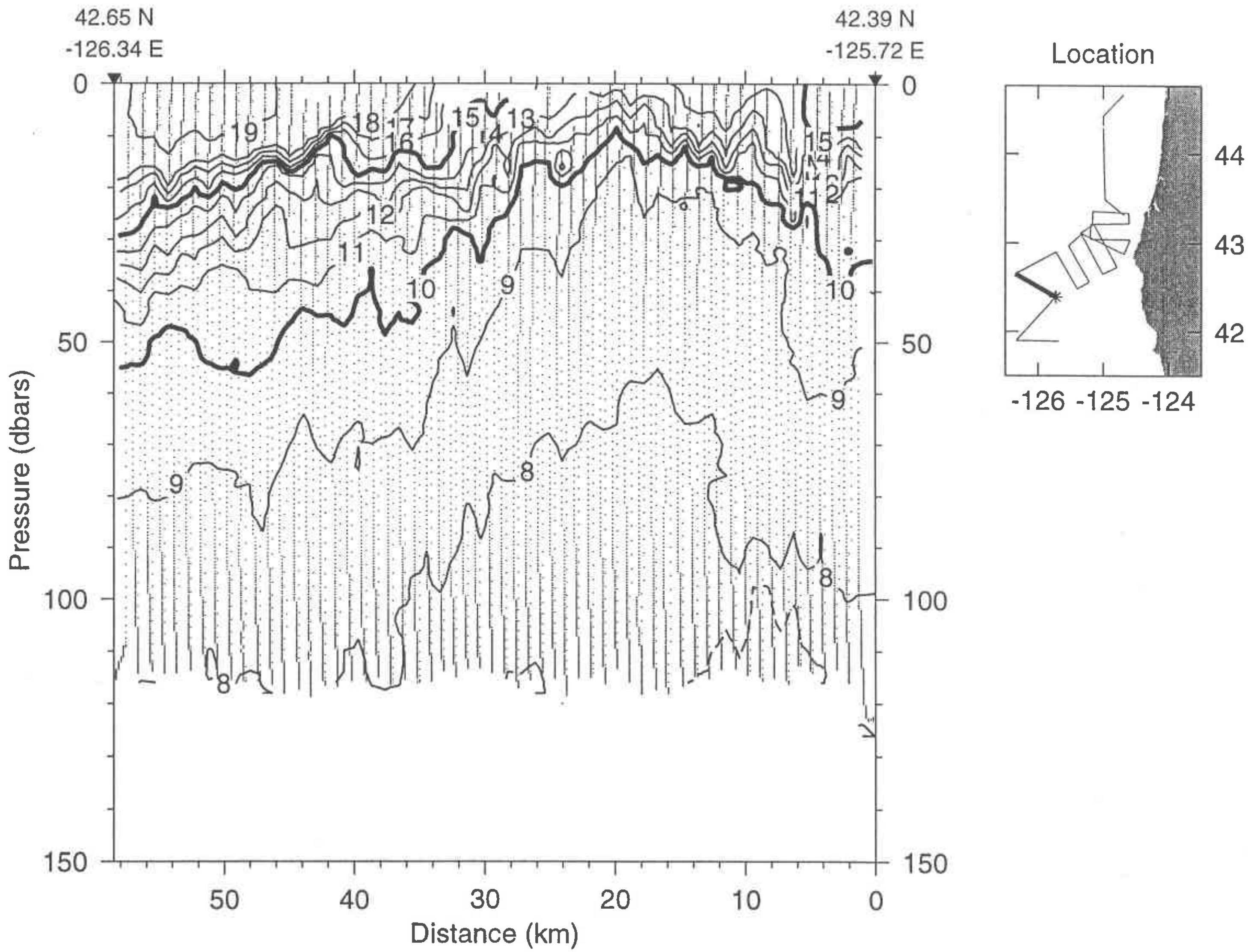


Line 08 Temperature (°C)
42.90 N
-125.71 E
42.49 N
-125.39 E
Location
Pressure (dbars)
Distance (km)
0
50
100
150
50
40
30
20
10
0
16
15
14
13
12
11
10
9
8
-126 -125 -124
44
43
42

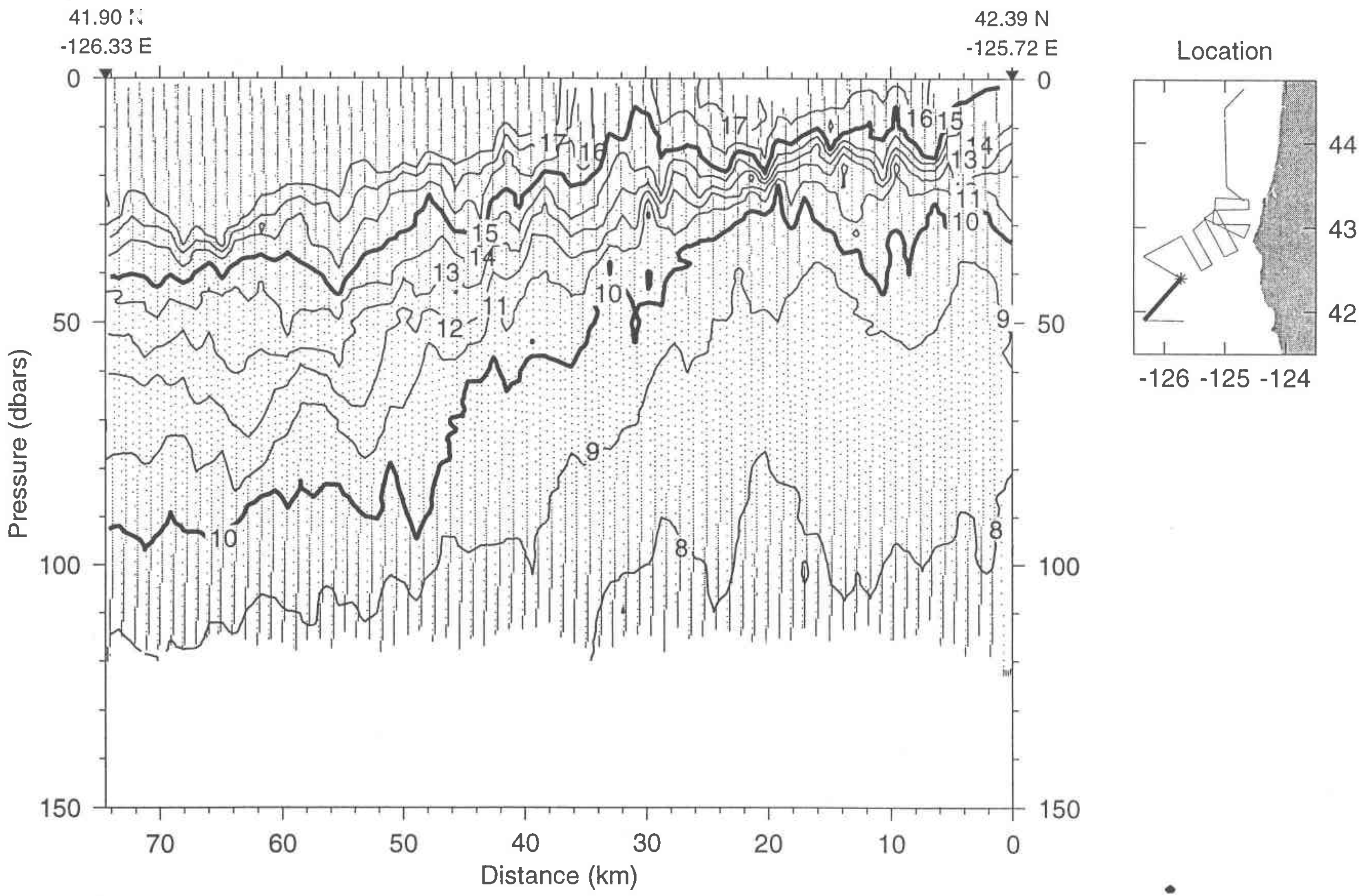
Line 09 Temperature (°C)



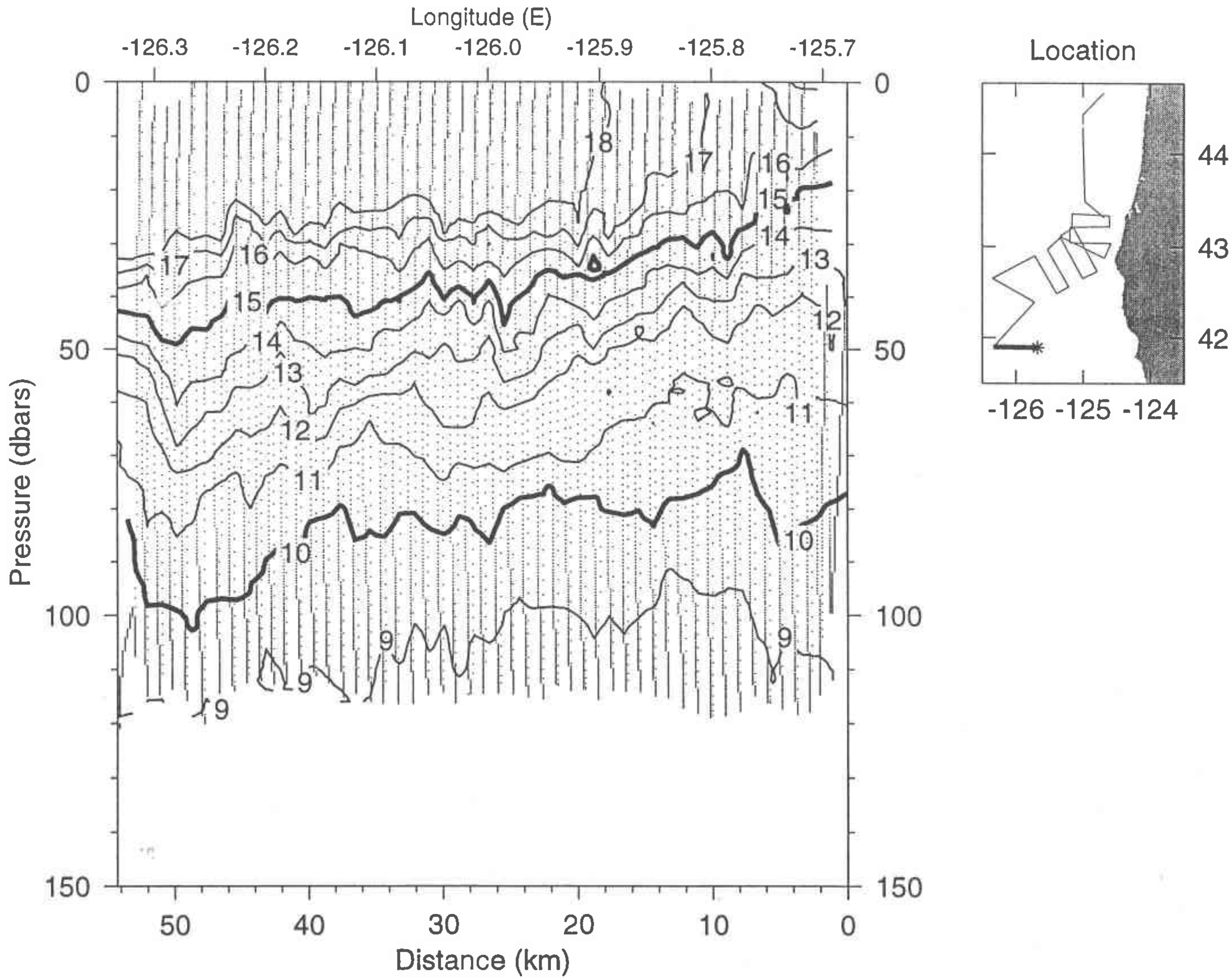
Line 10   Temperature (°C)



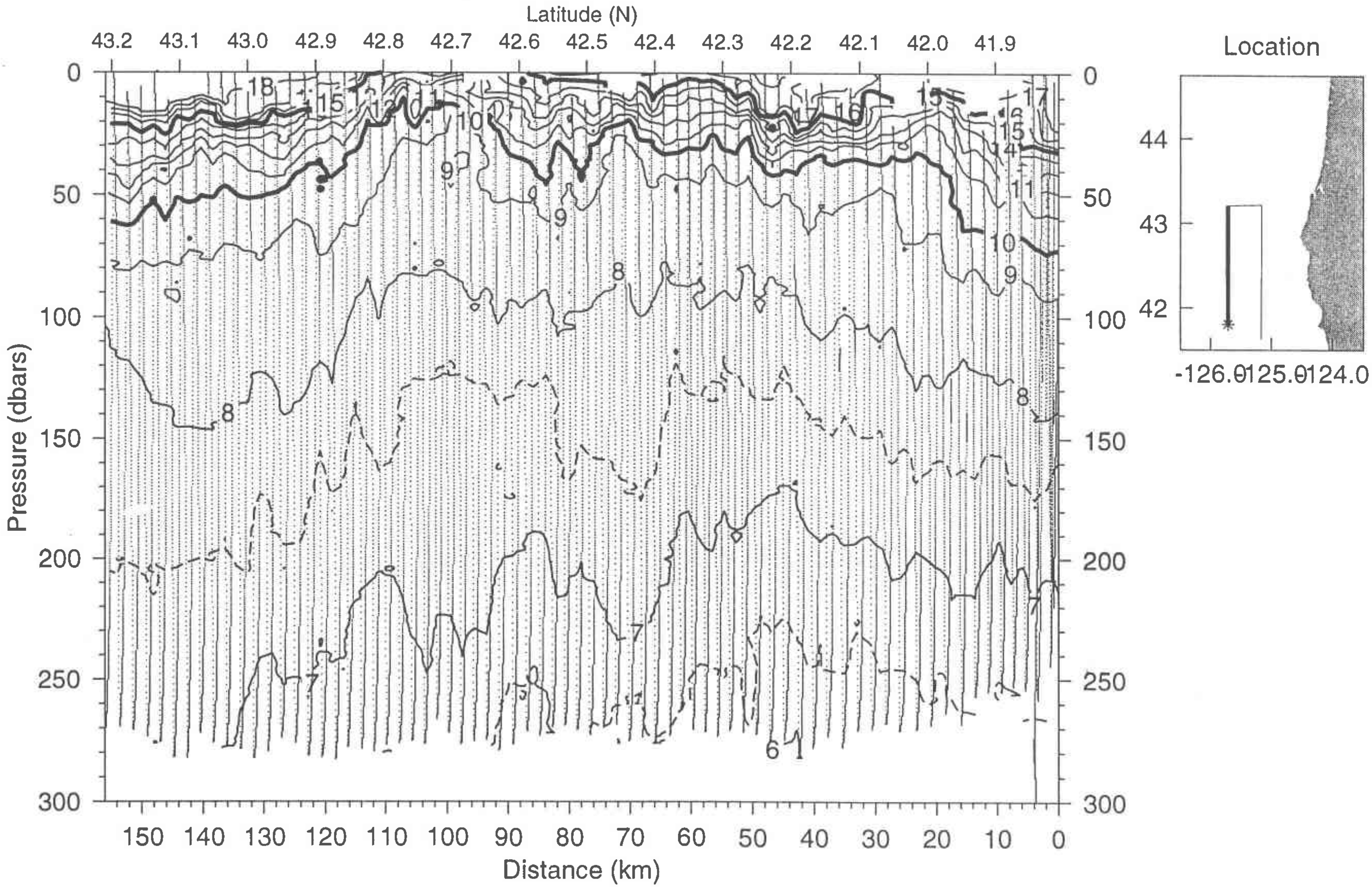
Line 11 Temperature (°C)



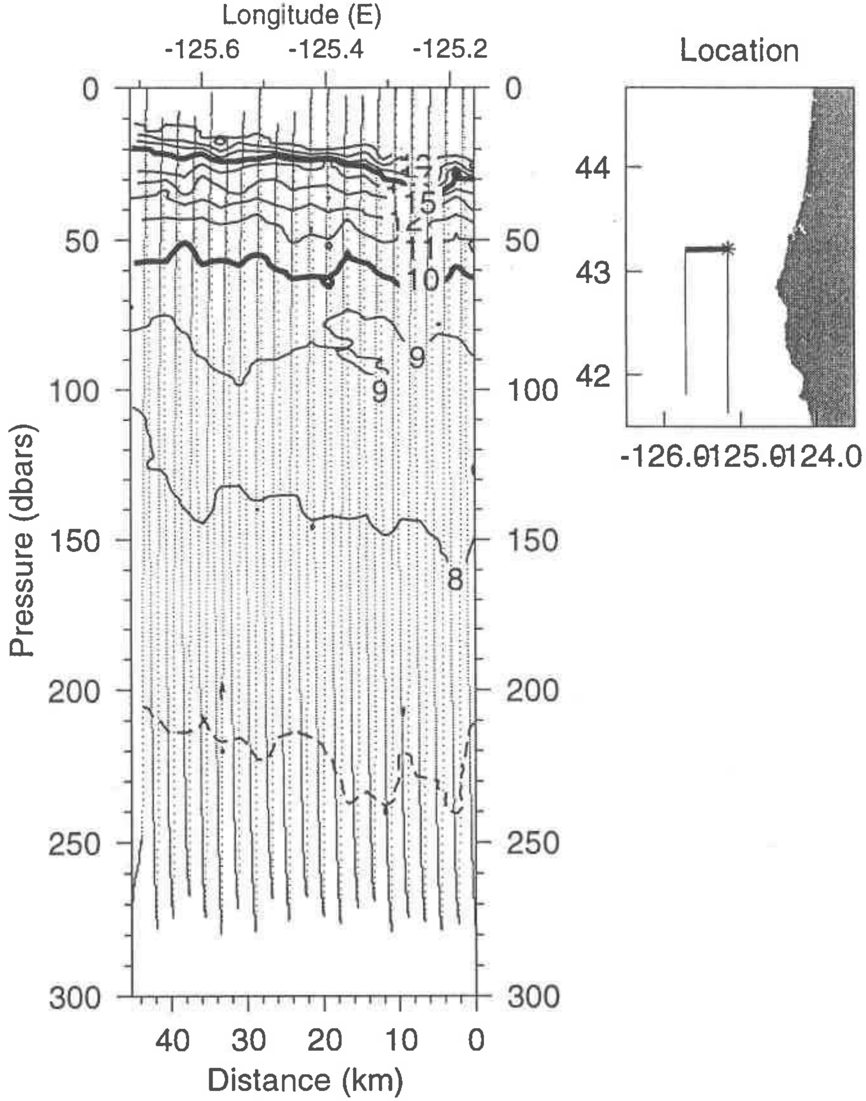
Line 12 Temperature (°C)



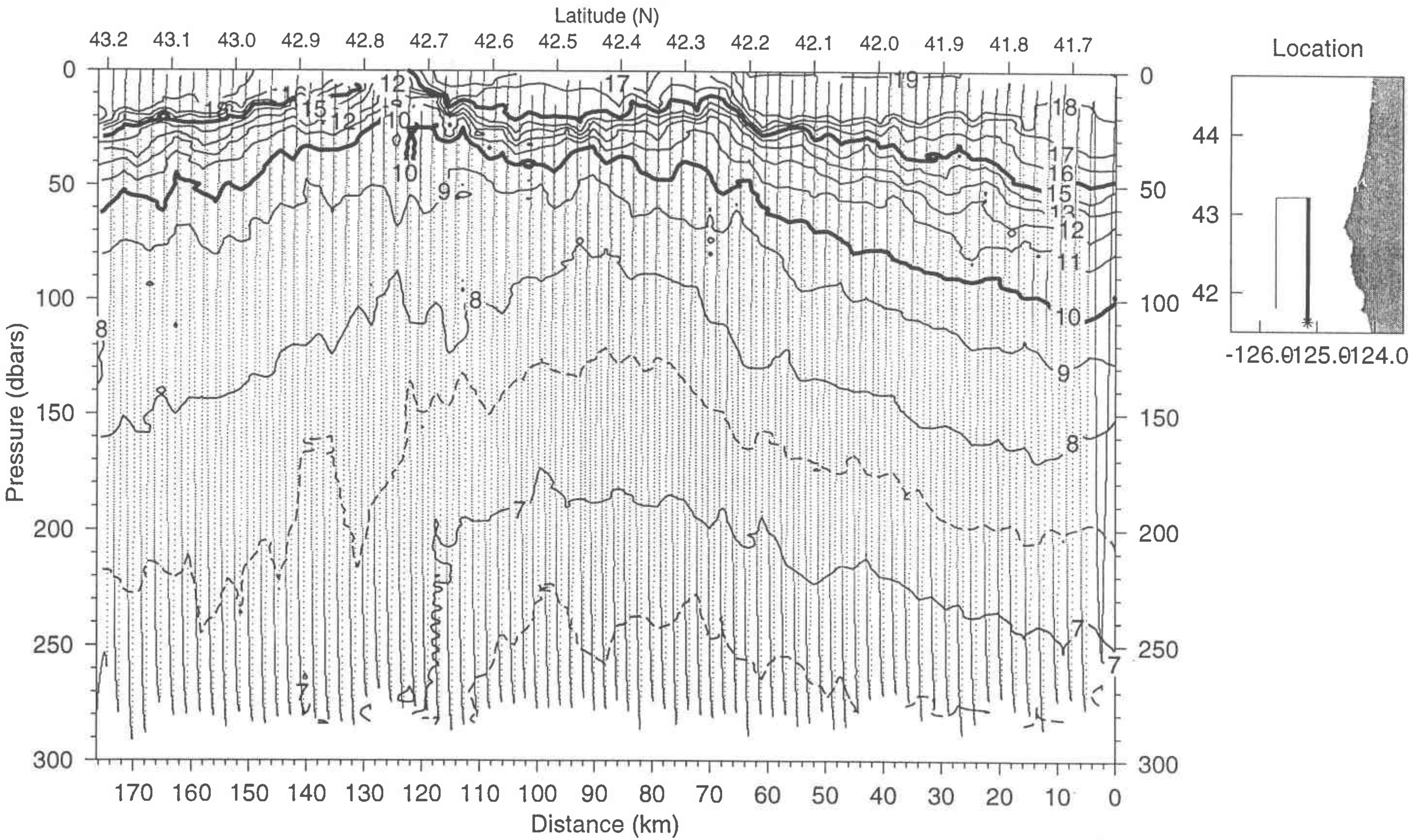
Line 13 Temperature (°C)



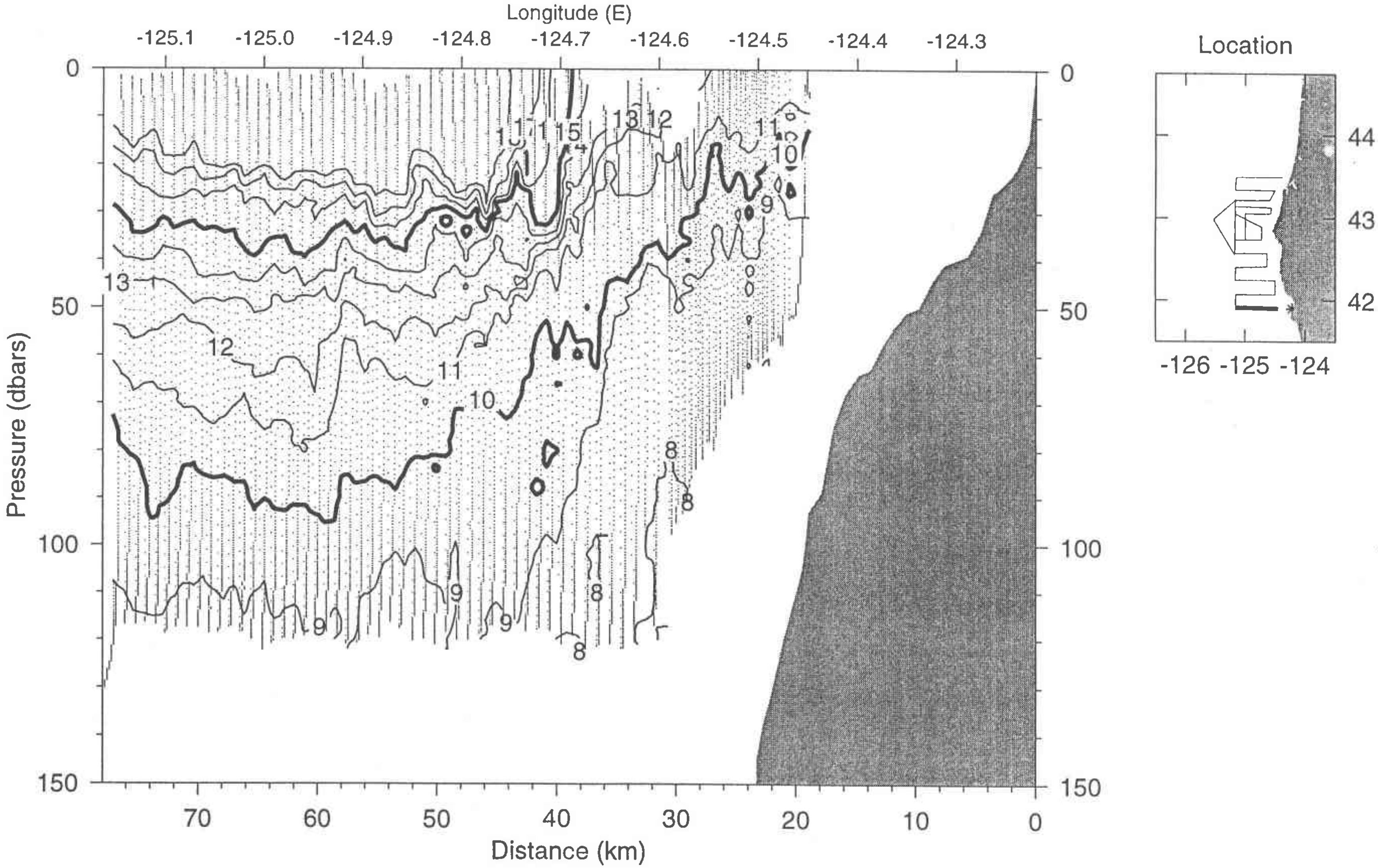
Line 14 Temperature (°C)



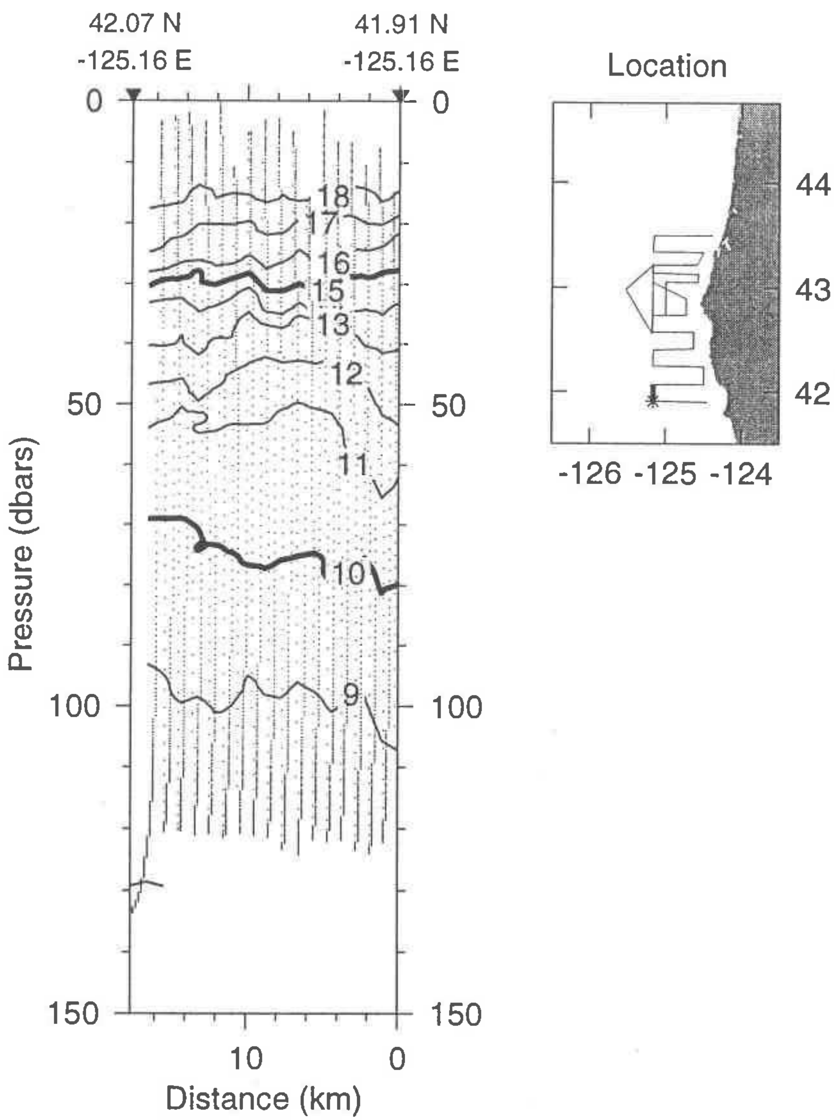
Line 15 Temperature (°C)



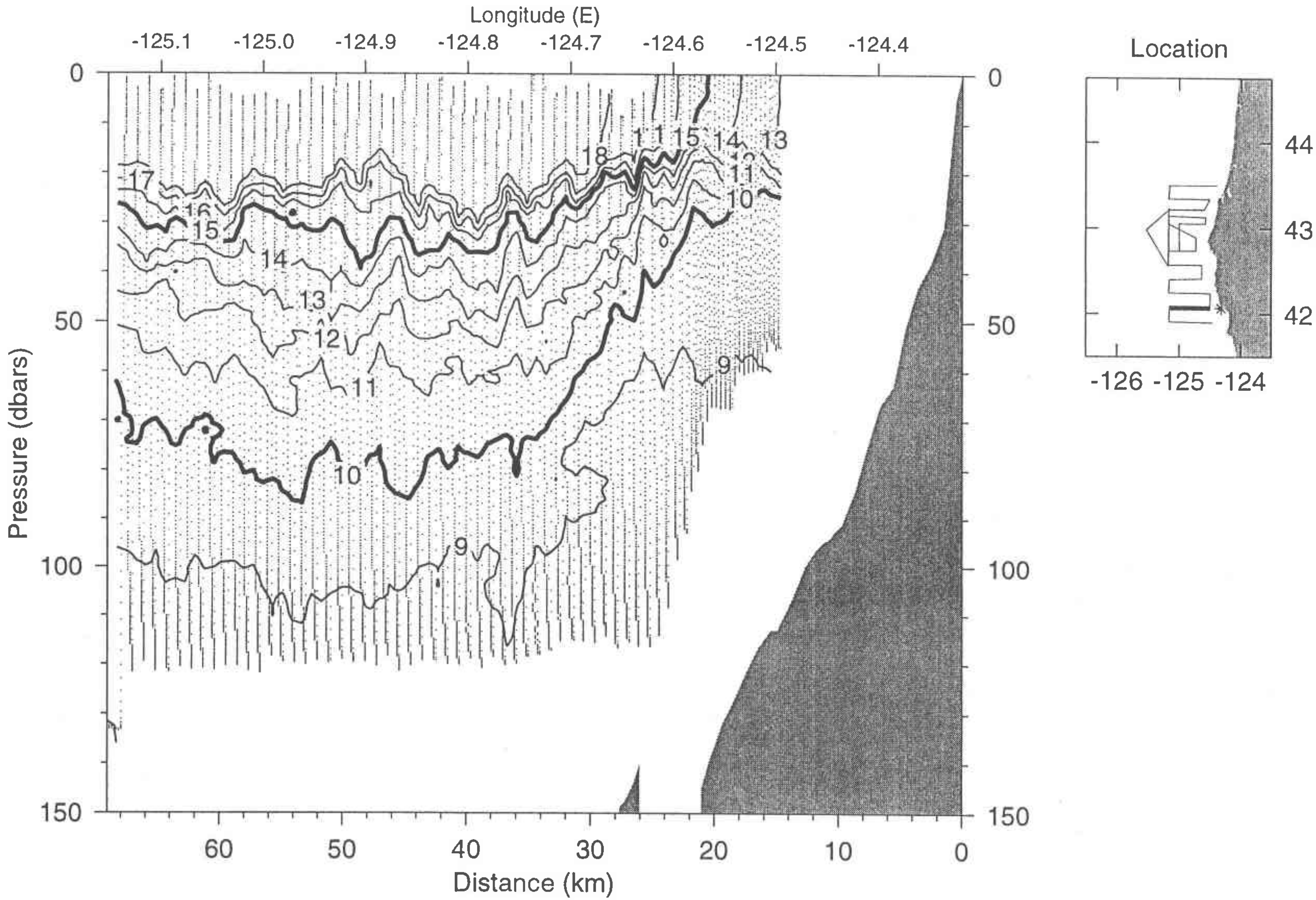
Line 16 Temperature (°C)



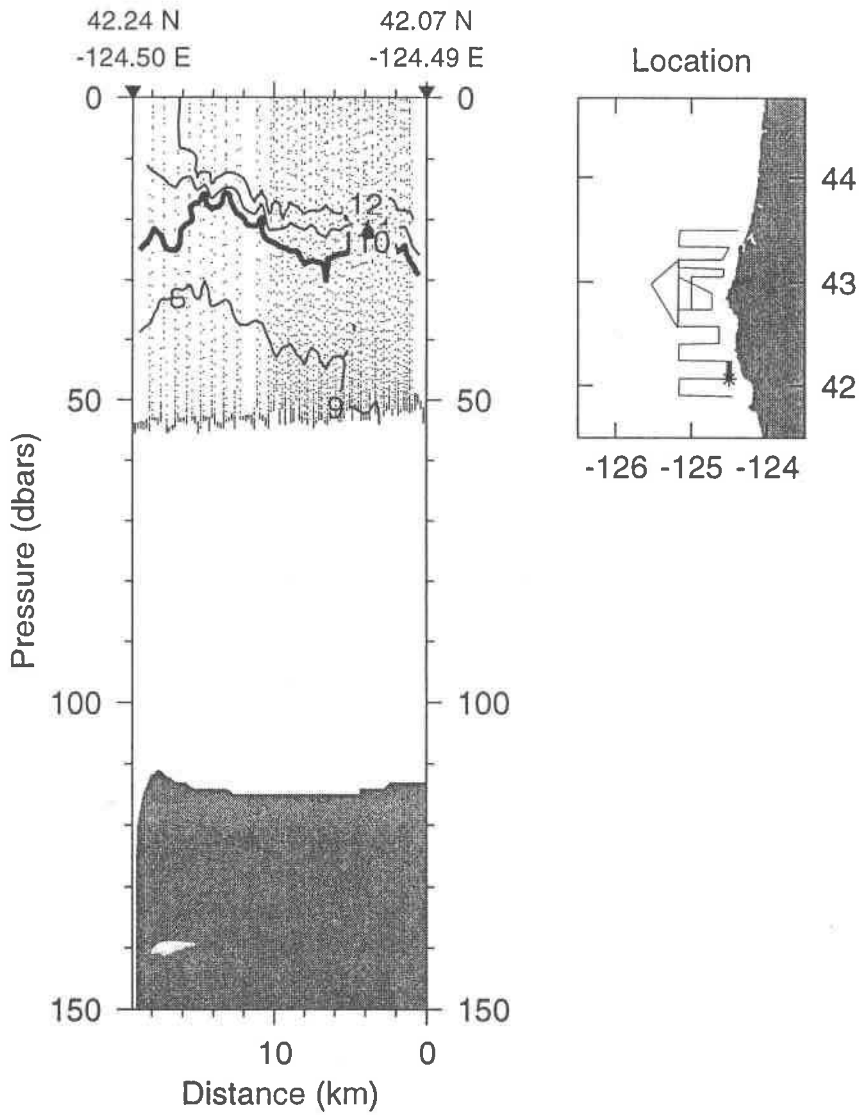
Line 16-17 Temperature (°C)



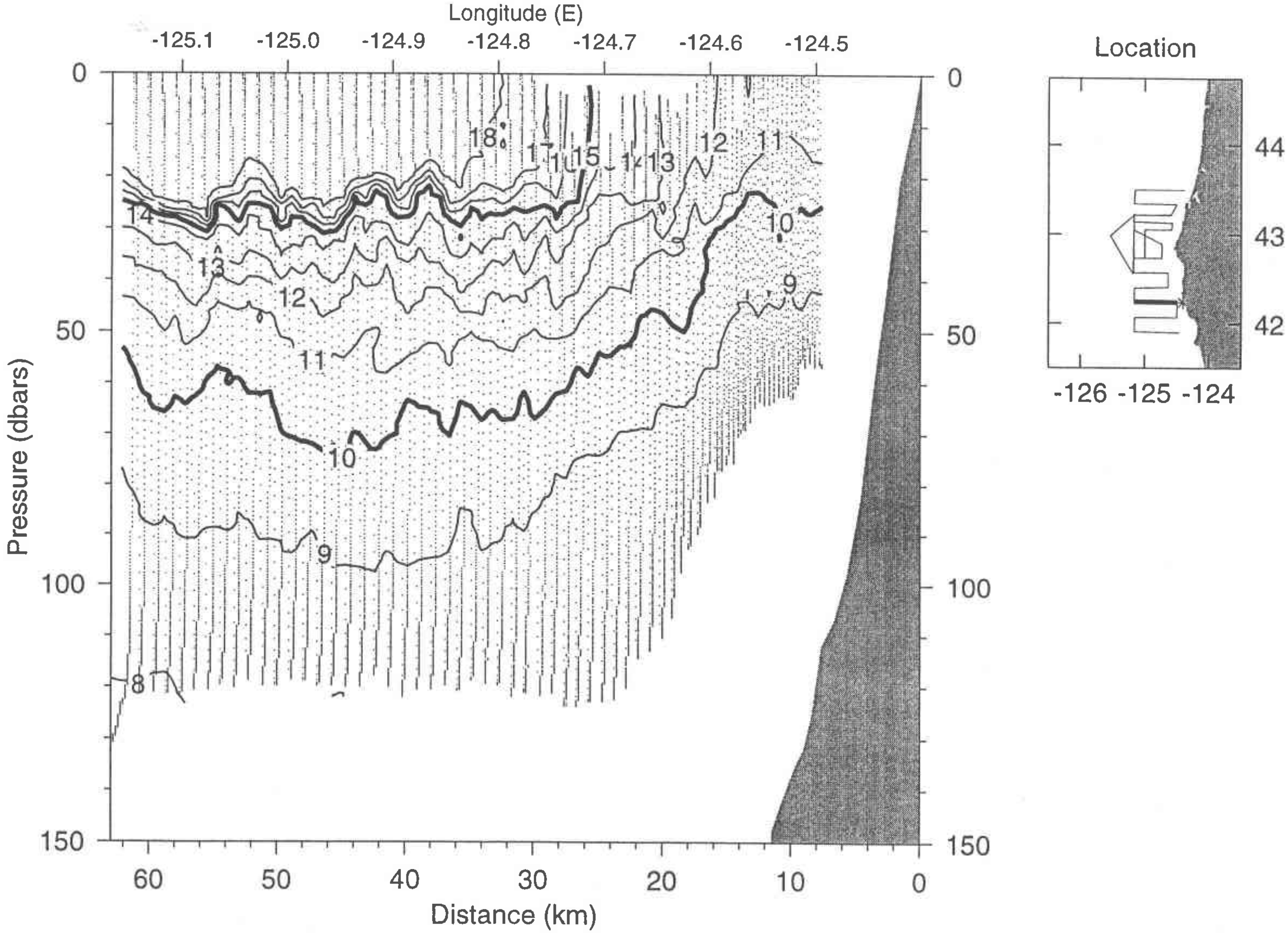
Line 17 Temperature (°C)



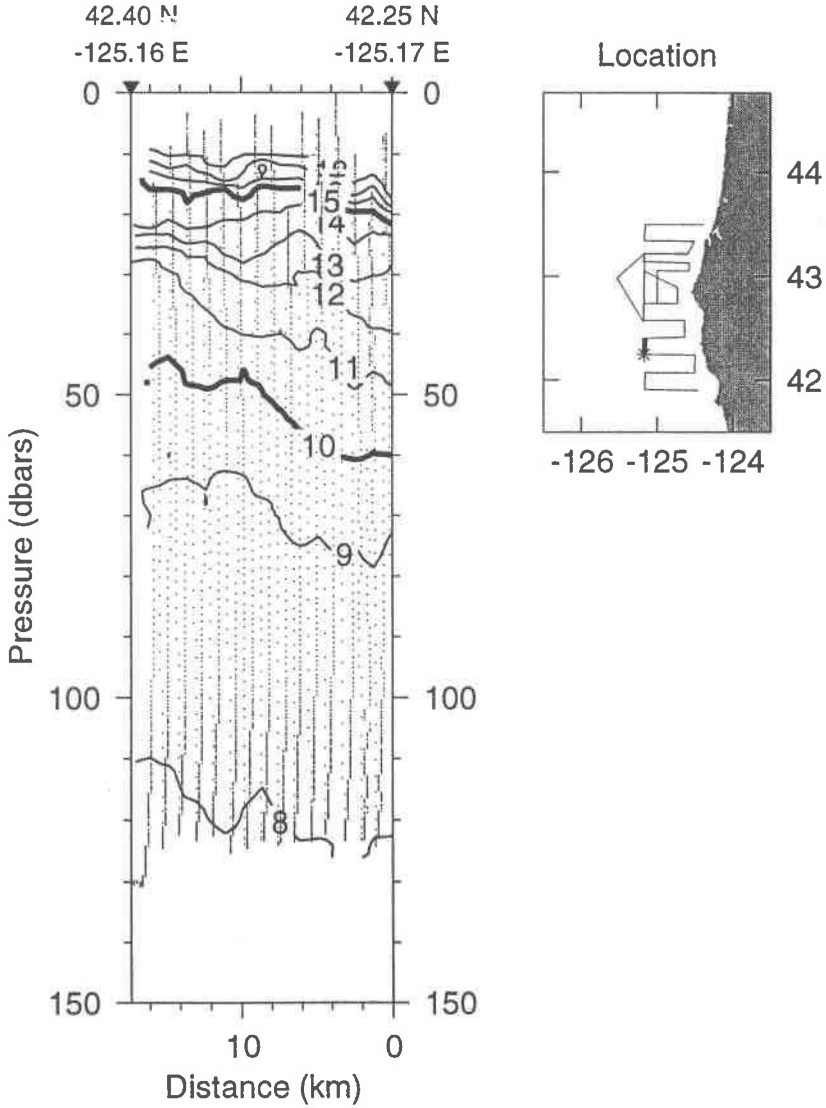
Line 17-18 Temperature (°C)



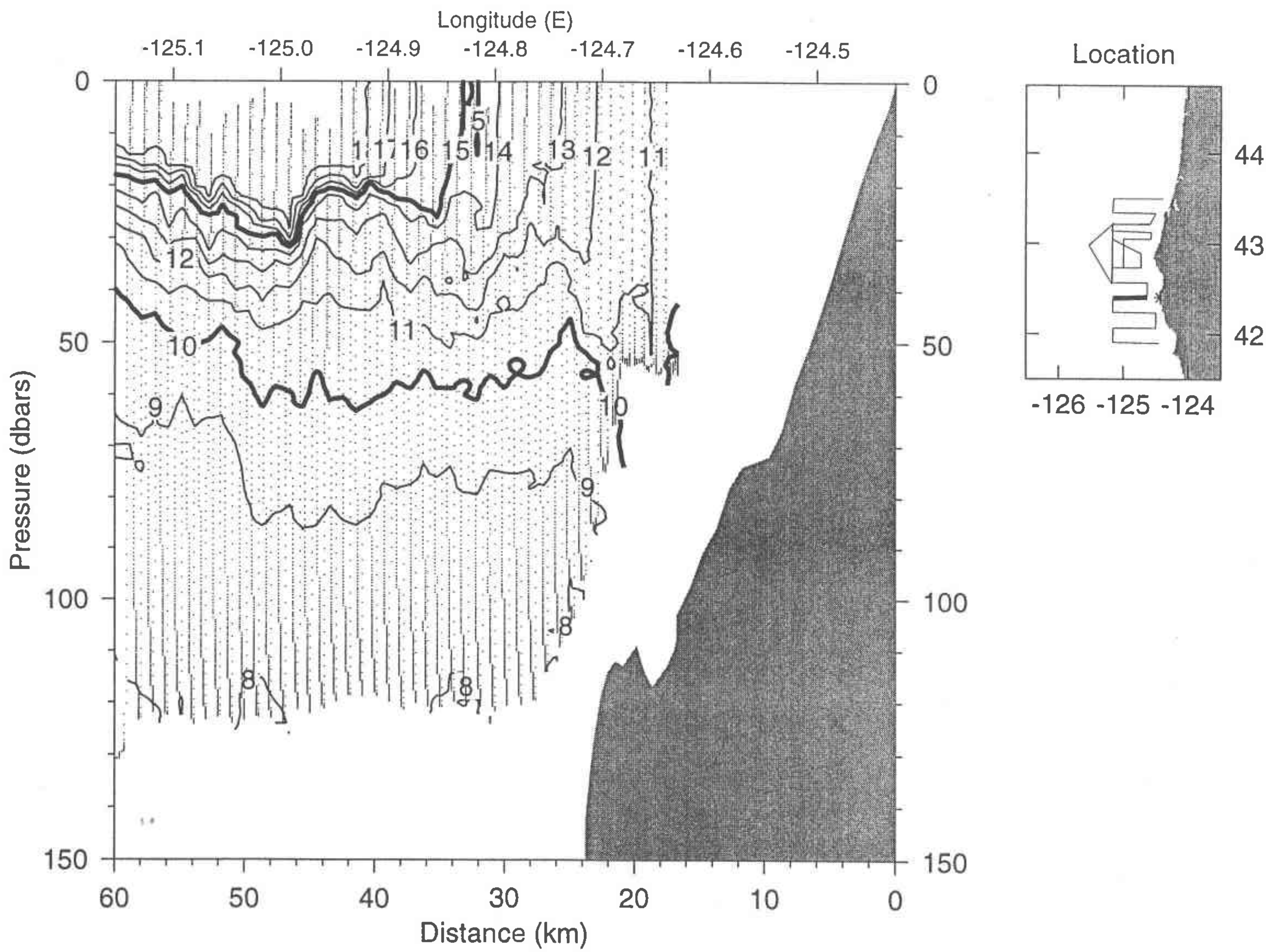
Line 18 Temperature (°C)



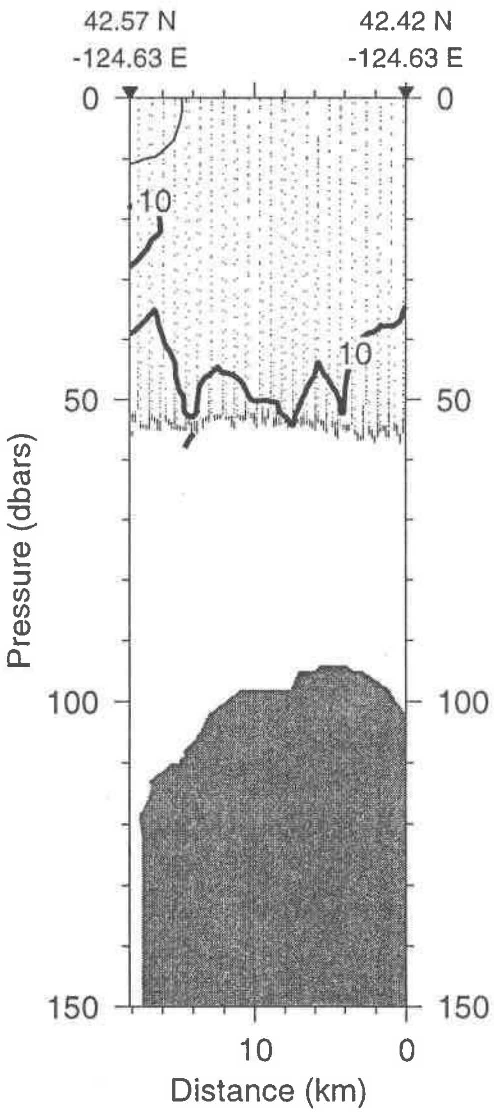
Line 18-19 Temperature (°C)

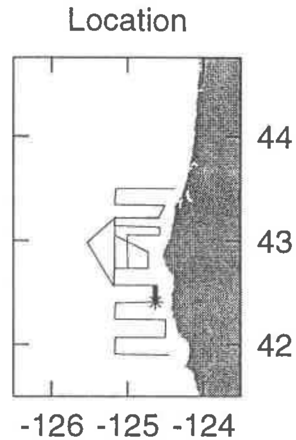


Line 19 Temperature (°C)

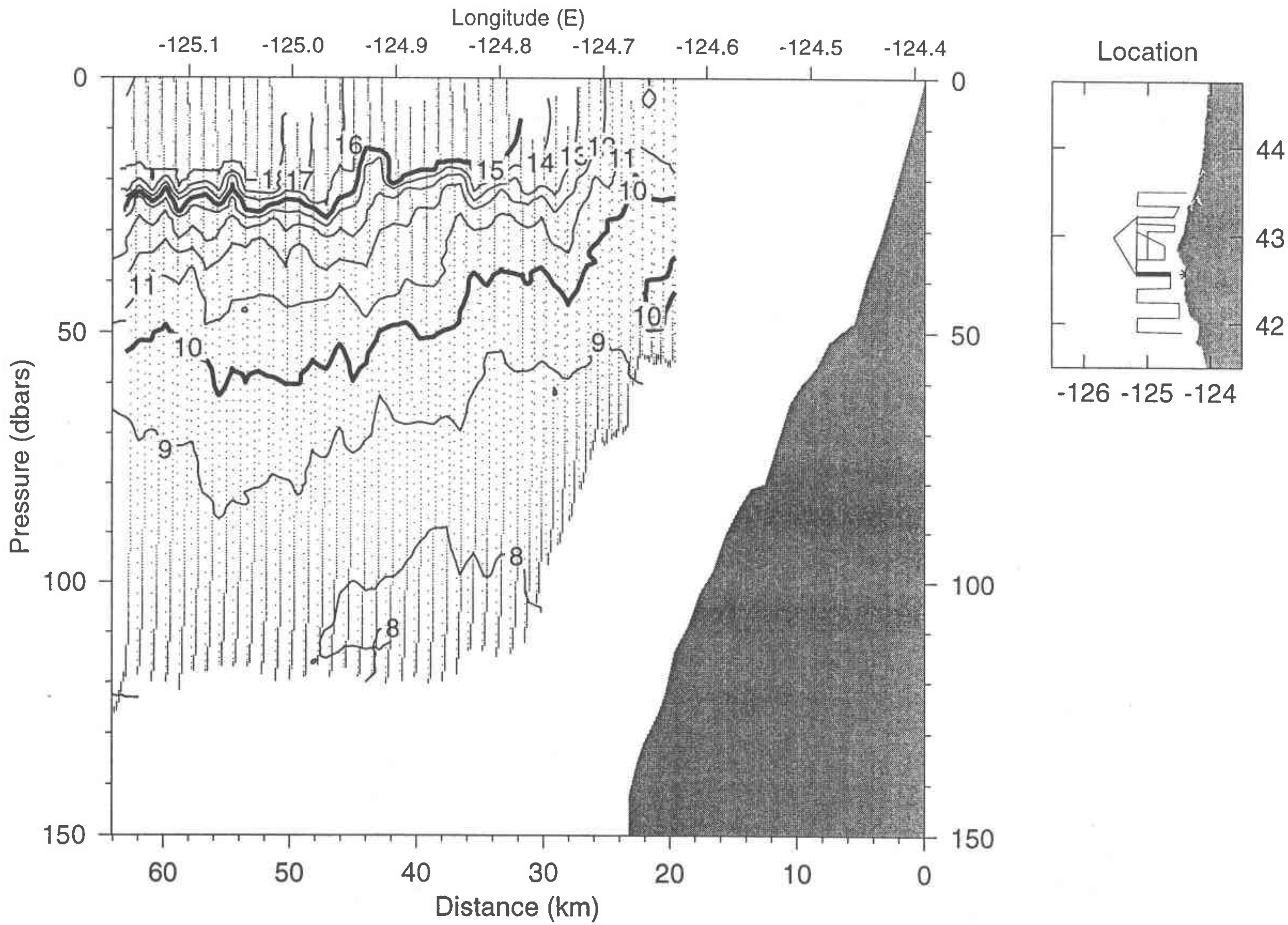


Line 19-20 Temperature (°C)

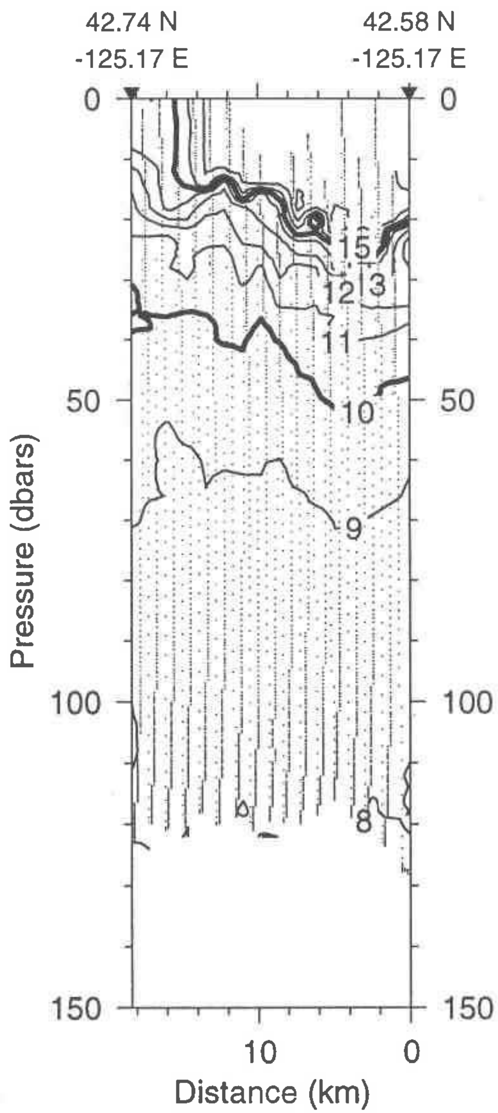




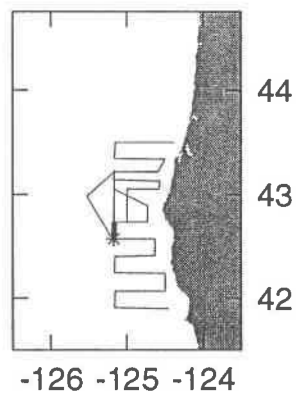
Line 20 Temperature (°C)



Line 20-21 Temperature (°C)



Location



Line 21 Temperature (°C)