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REPORT OF ECOSYSTEM STUDIES CONDUCTED DURING THE 1997 VAQUITA ABUNDANCE SURVEY ON THE RESEARCH VESSEL *DAVID STARR JORDAN*

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

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8604 La Jolla Shores Drive
La Jolla, California, USA 92037

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U.S. DEPARTMENT OF COMMERCE
Donald L. Evans, Secretary
National Oceanic and Atmospheric Administration
Scott B. Gudes, Acting Under Secretary for Oceans and Atmosphere
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CONTENTS

LIST OF TABLES

LIST OF FIGURES

REPORT OF ECOSYSTEM STUDIES CONDUCTED DURING THE 1997 VAQUITA ABUNDANCE SURVEY ON THE RESEARCH VESSEL *DAVID STARR JORDAN*

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INTRODUCTION

In 1997, the Southwest Fisheries Science Center (SWFSC) conducted a survey designed to estimate the abundance of vaquita, the Gulf of California harbor porpoise (*Phocoena sinus*). This was a joint project between the fisheries agencies of the United States and Mexico.

Two research vessels were used for this survey. The NOAA ship *David Starr Jordan* (hereafter referred to as the *Jordan*) was the primary vessel and the Instituto Nacional de la Pesca of Mexico (INP) research vessel *Buque de Investigacion Pesqueria XI* (or *BIPXI*) assisted in shallower areas around the coastline of the Gulf. A small open boat was used from the *BIPXI* for very shallow waters in the northern Gulf. The seven-week cruise was conducted on the *Jordan* from August 04 to September 19, with additional concurrent work on the *BIPXI* throughout the cruise.

This report describes the types of ecosystem data collected and sampling techniques used, and summarizes the data collected aboard the *Jordan* during the 1997 vaquita abundance survey. A paper regarding the vaquita abundance estimates was published by A. Jaramillo-Legorreta (1999).

OBJECTIVES

The primary objectives of this survey were to estimate the abundance and understand the distribution of vaquita, whose range is restricted to the northern Gulf of California. A secondary objective was to collect ecosystem data to better characterize their environment. Other objectives include acoustic sampling, biopsy sampling and photo-identification of cetaceans.

STUDY AREA AND ITINERARY

The principal study area was the northern section of the Gulf of California (Figure 1), with the southwestern boundary at Punta Final (29° 46'N) and southeastern boundary at Punta Jaguey (30° 48'N) extending to the north 120 nautical miles. The *Jordan's* actual tracklines (Figure 2) were concentrated in the area with the most historical sightings of vaquita. In addition to the predetermined tracklines, five dedicated oceanographic transects were completed, perpendicular to the shoreline, starting in deeper water and working towards the coast (in bold, Figure 2).

The cruise was conducted during two legs on the *Jordan* and daily surveys from the small boat in mild weather conditions.

The itinerary for the *Jordan* was as follows:

Initial Transit to survey area		
Departure	San Diego, California	04 August
Touch & Go	La Paz, Mexico (personnel transfer)	08 August
Arrival	Guaymas, Mexico (fueling of ship)	09 August
Departure	Guaymas, Mexico	10 August
Touch & Go	San Felipe, Mexico (personnel transfer)	12 August
Leg I		
Start of survey	San Felipe, Mexico	12 August
Touch & Go	San Felipe, Mexico (personnel transfer)	31 August
Arrival	Guaymas, Mexico (fueling of ship)	01 September
Departure	Guaymas, Mexico (transit to survey area)	04 September
Arrival	San Felipe, Mexico (personnel transfer)	05 September
Leg II		
Start of survey leg	Northern Gulf survey area	06 September
Arrival	San Felipe, Mexico (disembark scientific party)	19 September
Transit from survey area		
Departure	San Felipe, Mexico	20 September
Arrival	San Diego, California	29 September

METHODS

Oceanography

Temperature, salinity and fluorescence of surface water were measured continuously and recorded in digital form. Seawater was sampled from an intake 3 meters below the surface and analyzed using a Sea-Bird Electronics (SBE) thermosalinograph (Model SBE-21) and a Turner Designs fluorometer (model 10-005R). A Windows[1] data acquisition program (WinDACS; Holland 1993) recorded the data on a computer via serial connections to a Sea-Bird brand, National Marine Electronics Association (NMEA) Interface box (thermosalinograph and position data) and to the fluorometer. The ship's Scientific Computing System (SCS) also collected the thermosalinograph data, as well as information from other navigational and weather sensors. Discrete bucket temperatures, salinity and chlorophyll a samples were collected at regular intervals to verify thermosalinograph readings and calibrate fluorometer levels.

Two consecutive vertical profiles were done each morning before sunrise. The first instrument package, called a "Seapig", consisted of an OS200 CTD (Ocean Sensors, Inc.), a WETStar mini-fluorometer (WET Labs, Inc.) and an AC-3 spectral absorption and attenuation meter (WET Labs, Inc.). The CTD measured conductivity (salinity), temperature and depth, while the mini-fluorometer measured *in situ* chlorophyll fluorescence and the AC-3 measured the absorption coefficient at three wavelengths. The WET Labs instruments were powered by a separate power pack (Ocean Sensors), which was attached to the package frame. The Seapig was lowered and retrieved on a hydrocable at a rate of 1 meter/minute. The WET Labs devices were both connected to a Sea-Bird pump to draw the water across the sensors, whereas the OS200 CTD was not pumped. This package was also used occasionally during the day, as it was quicker to launch and retrieve, thus reducing time on station.

The second instrument package (referred to as CTD) consisted of a Sea-Bird Electronics 911plus CTD, a General Oceanics rosette system, and a Biospherical Instruments PAR sensor (QCD-905L) mounted on the rosette in place of a Niskin sample bottle. The CTD was lowered via a conducting cable to within 5 meters of the bottom in calm weather (10m in rough) and sensors connected to shipboard computers collected data from conductivity (salinity), temperature, pressure (depth) and photosynthetically active radiation (PAR) sensors. Water samples were collected from 11 Niskin bottles on all CTD casts, for ^{14}C-uptake incubations (pre-sunrise only), salinity calibration, and nutrient and phytoplankton pigment analysis.

When weather conditions precluded the visual survey work, cross-shelf oceanographic transects were conducted to more completely study the Gulf's physical habitat. On these "weather days", oceanographic transect lines were 24-30 nautical miles long, and started at the deepest end of the line and continued across the shelf towards shore to 20 meters depth. Each line consisted of three CTD stations with bottles and six to eight Seapig stations.

Sea-Bird CTD cast data were processed using their software package, "SBE Data Processing©, a Windows 95/98/NT program, version 5.25". Standard processing following the manufacturers instructions were used with the pre-cruise calibration coefficients and post-cruise

1 Windows is a registered trademark of the Microsoft Corporation.

calibration adjustments. The OS200 CTD data were compared with Sea-Bird CTD (pumped) data, and only the OS200 pressure was adjusted if necessary. According to the manufacturer's specifications, the accuracy of the OS200 sensors (pressure, temperature and conductivity) is less than that of the Sea-Bird CTD sensors.

Hydrochloric acid (2%) and Micro®-washed General Oceanics Niskin bottles (1.7-liter) were retrofitted with silicon rubber o-rings in the valves and end caps. Silicon rubber tubing was used as the closing mechanism. Niskin bottles numbered 1 (surface) to 11 were tripped at seven variable light depths and four additional depths ≤ 200 m as determined by the "ZEPRED97" program (see below).

Eleven samples from ≤ 200 m were collected for chlorophyll *a* (275 ml each) and nutrient analysis (15 ml each) at each station. Chlorophyll *a* and phaeophytin were determined by the fluorometric technique (Holm-Hansen *et al.* 1965) using a Turner Designs Model 10-005R fluorometer calibrated with purified chlorophyll *a* from Sigma Chemical Company. These data were entered at sea and processed at the SWFSC following the cruise. Nutrient samples were collected and immediately frozen for analysis following the cruise. Two 150 ml salinity samples per CTD cast were also collected and analyzed on a Guildline Instruments AutoSal® salinometer (Model 8400) calibrated during each run with IAPSO[2] standard seawater. These data were used at sea to monitor the accuracy of CTD and thermosalinograph conductivity cells.

Water samples for determination of dissolved inorganic carbon uptake were collected from depths at which irradiance of PAR (photosynthetically active radiation) is a standard fraction (100, 50, 30, 15, 5, 1 and 0.1%) of irradiance just below the sea surface. A program, ZEPRED97, calculated an initial estimate of euphotic zone depth (1% light level) based on historical chlorophyll profiles, according to the spectral model of attenuation by Morel (1988).

Samples for analysis of primary production were drawn into conditioned screw cap "Vitro" glass bottles (150 mls; Wheaton Corporation) rinsed twice with sample water. Radioactively labeled sodium carbonate ($NaH^{14}CO_3$) was added to each sample bottle (10 μCi). The bottles were then incubated inside nickel screens (Perforated Products) in an on-deck seawater-cooled Plexiglas® incubator for 24 hours with natural sunlight as the light source. The screens act as neutral density filters, reducing the light intensity to the same level as that occurring at the depth from which the sample was collected. Two extra samples at the 100% and 0.1% light levels were inoculated with radioactive tracer and filtered immediately without incubation to determine abiotic particulate ^{14}C incorporation (Chavez and Barber 1987). For determination of particulate carbon fixation, the water was filtered onto Whatman GF/F filters at <10 psi of vacuum. The filter was acidified with 0.5 N HCl for 12 hours then immersed in 10 mls of scintillation cocktail (CytoScint ES). These vials were counted on a liquid scintillation counter (Beckman LS6000) following the end of the cruise. The total inorganic carbon activity was determined by adding 1.0 ml of incubated sample water (from the 100% and 30% light levels) to a scintillation vial containing 1 ml of β-phenylethylamine in 20 mls of scintillation cocktail. An average of these two values was used as the total amount of added activity for each station in the calculation of carbon uptake for each sample. Primary productivity data were

2 The International Association for Physical Science of the Ocean (IAPSO) Standard Seawater is manufactured by Ocean Scientific International.

processed after the cruise at the SWFSC.

Sediment Sampling

During the first two weeks of the cruise, box core samples were collected using a 20 x 20 x 50 cm box-corer in several locations. The box corer was lowered from the ship on a hydrocable. Three cylindrical sub samples were collected using 3" polycarbonate liners, varying in length from 30 to 45 cm. These samples were collected by Dr. Victor Camacho-Ibar of the Universidad Autonoma de Baja California, Ensenada, Mexico.

Acoustic Backscatter

An acoustic data acquisition system (ADA) collected 38 kHz and 200 kHz acoustic backscatter data from the ship's Simrad EQ-50 echosounder. Backscatter was digitized and integrated in 5-meter intervals between the depths of 5 and 205 meters. Nominal ping interval was 5 seconds; thirty pings were averaged approximately every two to five minutes to reduce data volume.

RESULTS

Oceanography

In Figure 1, the bathymetry of the survey area is illustrated, as well as the locations of the siz box core samples collected during leg 1. Cruise tracks for the *Jordan* are shown in Figure 2. The total number of oceanographic casts, box cores, and samples collected on the *Jordan* are presented in Table 1.

In Figure 3, the locations of the 51 *Jordan* Sea-Bird CTD casts and 80 Seapig casts are shown. There were five directed transects (shown in bold in Figure 2), which had 34 Seapig casts and 15 Sea-Bird CTD casts. Table 2 is the Sea-Bird CTD cast summary, including temperature, salinity, pigment and productivity values from bottle samples. In general, the CTD water sample salinities agreed with the CTD sensor values to within ±0.01 psu (practical salinity units).

Sea surface temperature (Figure 4) and sea surface salinity (Figure 5) were plotted from along-track thermosalinograph data collected on the *Jordan*.

Thermocline depth (Figure 6) was calculated as the depth of the maximum temperature gradient (in meters) using Sea-Bird and OS200 CTD data. Stratification is presented in Figure 7, as potential energy anomaly Φ in J m^{-2} (Simpson 1981), representing the amount of energy needed to vertically mix the water column to a depth of 100m or to the bottom (if <100m). Values of $\Phi<0$ occurred in noisy OS200 density profiles with spurious density inversions, and represent zero stratification. Although some uncertainty remains in the calibrations of the OS200 temperature and conductivity sensors, such error should not affect the thermocline depth and stratification estimates plotted here.

Nutrient samples (337 total) were analyzed for nitrate + nitrite, ammonium, phosphate, and silicate. Dr. Victor Camacho-Ibar and his colleagues performed the analyses at the Instituto de Investigaciones Oceanológicas, Universidad Autónoma de Baja California Sur in Ensenada, Mexico. Results for nutrient concentrations at the surface and at a depth of 50 meters are shown in Figures 8-11. A duplicate set of samples is in frozen storage at the SWFSC.

Surface chlorophyll concentrations from the *Jordan* are shown in Figure 12 and primary productivity data integrated within the euphotic zone are shown in Figure 13.

All CTD (Sea-Bird and OS200) and sample data will be submitted to NOAA/National Oceanographic Data Center following this publication.

Sediment Sampling

A total of six box core stations were conducted during the first two weeks of the cruise (Figure 1). The cores are stored at the Instituto de Investigaciones Oceanológicas, Universidad Autónoma de Baja California, in Ensenada, Mexico. One 30-cm core has been analyzed by Dr. Victor Camacho-Ibar to determine fatty acids, which are then used as tracers of organic matter sources (Camacho-Ibar, in press).

Acoustic Backscatter

These data have not been yet analyzed. They are archived at the SWFSC.

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Table 1. Summary of data collected aboard the *Jordan*, 04 August- 19 September 1997.

	LEG 1	LEG 2	TOTALS
Sea-Bird CTD casts	27	24	51
Seapig casts (OS200 CTD)	42	38	80
CTD chlorophyll samples	222	183	405
Surface chlorophyll samples	58	47	105
Primary productivity samples	91	63	154
Nutrient samples	188	149	337
Salinity samples	35	19	54
Box cores	6	0	6
Stable Isotope filtered samples	188	149	337

Table 2. *Jordan* 1997 Sea-Bird CTD cast summary: station number, date, time, location, depth of cast, bottle depth, temperature, salinity, phytoplankton pigments; chlorophyll *a* (chl *a*) and phaeophytin (phaeo.), and primary production (prod). Station dates and times are in Pacific Standard Time (Greenwich Mean Time +7 hrs.). Stations where samples were not collected due to equipment malfunction or lack of processing time are blank.

Station	Date	Local Time	Latitude (°N)	Longitude (°W)	Cast depth (m)	Bottle depth (m)	Temp. (°C)	Salinity (psu)	Chl *a* (mg/m^3)	Phaeo. (mg/m^3)	Prod. (mgC/ m^2/day)
2	8/10	1239	27.452	111.332	1008	0	31.28	35.154	0.149	0.058	
						19	30.32	35.178	0.215	0.142	
						38	25.55	35.007	0.982	0.932	
						58	18.32	35.008	0.072	0.159	
						77	16.97	35.043	0.035	0.097	
						100	15.67	34.964	0.005	0.054	
3	8/11	1237	28.265	112.405	209	0	30.73	35.046	0.174	0.078	
						18	30.52	35.027	0.210	0.106	
						39	28.61	34.965	1.037	0.942	
						59	27.97	34.946	0.517	0.650	
						79	24.49	34.970	0.143	0.317	
						99	22.83	34.983	0.058	0.185	
4	8/15	0540	30.775	114.513	23	0	29.76	35.724	0.832	0.410	
						3	29.76	35.724	0.781	0.441	
						2	29.76	35.723	0.852	0.436	
						2	29.75	35.721	0.783	0.442	
						8	29.77	35.721	0.727	0.428	
						13	29.75	35.718	0.886	0.494	
						5	29.75	35.717	0.886	0.448	
						16	29.75	35.714	1.009	0.491	
						16	29.75	35.714	1.057	0.498	
						17	29.72	35.708	1.002	0.507	
						22	29.69	35.700	1.187	0.525	
5	8/16	0459	30.767	114.512	27	0	30.06	36.081	1.753	0.778	123.27
						3	30.05	36.079	1.637	0.673	136.60
						3	30.05	36.076	1.616	0.684	114.81
						4	30.03	36.069	1.650	0.650	64.05
						6	30.03	36.065	1.596	0.723	23.98
						9	30.00	36.057	1.650	0.650	3.43
						13	30.00	36.054	1.623	0.742	0.39
						18	30.00	36.036	1.623	0.769	
						26	29.99	36.018	1.678	0.798	
6	8/17	0448	30.528	114.468	65	0	29.18	35.402	0.209	0.190	6.69
						2	29.19	35.402	0.264	0.182	7.32
						4	29.19	35.402	0.205	0.185	5.67
						6	29.19	35.402	0.229	0.194	7.91
						9	29.18	35.402	0.216	0.206	2.28
						14	29.20	35.401	0.223	0.198	0.66
						21	29.19	35.401	0.226	0.177	0.20

Station	Date	Local Time	Latitude (°N)	Longitude (°W)	Cast depth (m)	Bottle depth (m)	Temp. (°C)	Salinity (psu)	Chl *a* (mg/m^3)	Phaeo. (mg/m^3)	Prod. (mgC/ m^2/day)
6	8/17	0448	30.528	114.468		29	29.17	35.402	0.191	0.166	
						38	28.80	35.406	0.328	0.329	
						49	28.25	35.380	0.431	0.469	
						63	27.29	35.357	0.339	0.394	
7	8/18	0450	30.770	114.240	89	0	29.80	35.346	0.506	0.487	6.90
						4	29.81	35.346	0.539	0.452	9.49
						6	29.81	35.349	0.558	0.505	8.48
						10	29.83	35.420	0.696	0.574	10.92
						18	29.78	35.451	0.757	0.679	6.36
						28	29.67	35.418	0.709	0.561	1.51
						38	29.45	35.384	0.607	0.508	0.24
						48	29.40	35.495	0.682	0.461	
						58	29.43	35.544	0.667	0.479	
						73	29.05	35.563	0.577	0.404	
						87	27.22	35.382	0.285	0.302	
8	8/19	0443	29.925	114.248	103	0	28.78	35.430	0.277	0.215	3.27
						5	28.71	35.430	0.313	0.202	5.03
						9	28.70	35.430	0.290	0.226	4.82
						15	28.58	35.431	0.476	0.404	6.07
						24	28.39	35.400	0.743	0.591	5.94
						38	28.22	35.380	0.715	0.507	0.83
						57	26.56	35.280	0.446	0.480	0.14
						69	25.28	35.281	0.153	0.222	
						79	25.26	35.282	0.156	0.223	
						88	25.24	35.282	0.140	0.226	
						99	25.11	35.285	0.142	0.247	
9	8/20	0447	30.932	114.270	101	0	30.08	35.346	0.193	0.120	2.13
						4	30.03	35.349	0.201	0.120	3.09
						9	29.85	35.332	0.188	0.121	2.36
						14	29.66	35.340	0.249	0.209	1.37
						24	29.60	35.346	0.371	0.318	1.57
						38	27.99	35.258	0.616	0.658	1.04
						56	26.71	35.276	0.270	0.300	0.09
						68	26.01	35.284	0.170	0.215	
						79	25.44	35.285	0.112	0.175	
						89	24.91	35.284	0.080	0.151	
						99	22.66	35.273	0.054	0.173	
10	8/21	0442	30.850	114.325	59	0	29.97	35.366	0.184	0.125	2.55
						3	29.98	35.366	0.204	0.131	2.86
						7	29.98	35.366	0.208	0.146	2.93
						10	29.90	35.362	0.270	0.190	3.02
						19	29.70	35.356	0.685	0.497	3.83
						28	29.58	35.348	0.757	0.614	0.76
						44	29.60	35.464	0.921	0.533	0.31
						54	29.42	35.466	0.955	0.582	

Station	Date	Local Time	Latitude (°N)	Longitude (°W)	Cast depth (m)	Bottle depth (m)	Temp. (°C)	Salinity (psu)	Chl *a* (mg/m^3)	Phaeo. (mg/m^3)	Prod. ($mgC/m^2/day$)
10	8/21	0442	30.850	114.325		59	29.01	35.425	0.798	0.536	
11	8/24	0448	30.505	113.662	95	0	30.89	35.194	0.168	0.084	
						4	30.89	35.195	0.193	0.098	
						8	30.90	35.193	0.195	0.100	
						14	30.12	35.162	0.202	0.135	
						24	28.82	35.140	0.702	0.724	
						38	27.48	35.166	0.558	0.603	
						57	25.45	35.266	0.343	0.418	
						69	23.21	35.288	0.134	0.184	
						79	22.47	35.295	0.087	0.121	
						89	22.09	35.292	0.078	0.134	
						94	21.74	35.295	0.066	0.135	
12	8/24	1154	30.813	113.852	74	0	30.91	35.171	0.216	0.098	15.79
						19	30.53	35.158	0.363	0.182	14.76
						39	29.36	35.156	0.811	0.633	29.27
						59	27.40	35.246	0.187	0.287	11.89
						73	26.04	35.271	0.115	0.218	27.23
13	8/25	0502	30.918	113.330	30	0	30.99	35.250	0.326	0.212	14.56
						3	30.98	35.250	0.333	0.209	21.09
						6	30.98	35.250	0.326	0.221	26.36
						11	30.78	35.225	0.403	0.344	23.18
						17	30.21	35.230	1.309	0.991	37.27
						28	30.09	35.231	1.118	0.704	3.55
						30	29.90	35.238	1.105	0.717	0.73
14	8/25	1154	30.775	113.723	72	0	30.83	35.142	0.251	0.123	
						9	30.62	35.128	0.292	0.163	
						19	30.37	35.115	0.376	0.235	
						29	30.15	35.100	0.421	0.289	
						39	29.82	35.114	0.791	0.663	
						71	27.07	35.253	0.140	0.235	
15	8/26	0503	31.293	114.058	46	0	31.42	35.407	0.305	0.147	4.58
						2	31.41	35.406	0.311	0.149	5.94
						5	31.41	35.406	0.322	0.159	7.21
						8	31.41	35.406	0.307	0.154	4.64
						13	31.36	35.401	0.292	0.154	4.59
						21	31.14	35.396	0.401	0.271	0.72
						32	30.34	35.385	1.187	1.022	0.36
						39	29.69	35.355	0.697	0.568	
						46	29.27	35.370	0.468	0.467	
16	8/26	1107	31.125	114.153	127	0	30.71	35.292	0.229	0.103	
						9	30.69	35.291	0.234	0.104	
						19	30.18	35.266	0.303	0.178	
						29	29.88	35.261	0.549	0.386	
						40	29.25	35.280	1.118	0.777	
						49	27.90	35.280	0.764	0.764	

Station	Date	Local Time	Latitude (°N)	Longitude (°W)	Cast depth (m)	Bottle depth (m)	Temp. (°C)	Salinity (psu)	Chl *a* (mg/m^3)	Phaeo. (mg/m^3)	Prod. ($mgC/m^2/day$)
16	8/26	1107	31.125	114.153		59	26.55	35.283	0.202	0.291	
						69	25.69	35.280	0.079	0.200	
						79	23.91	35.272	0.045	0.119	
						98	19.98	35.240	0.030	0.115	
						126	18.35	35.225	0.031	0.157	
17	8/26	1310	31.252	114.267	40	0	31.34	35.445	0.313	0.136	
						4	31.33	35.445	0.324	0.125	
						9	31.22	35.442	0.343	0.152	
						14	30.51	35.305	0.376	0.189	
						19	30.13	35.278	0.393	0.236	
						24	29.93	35.268	0.530	0.336	
						29	29.85	35.310	1.125	0.706	
						34	29.81	35.330	1.043	0.742	
						38	29.71	35.352	0.982	0.665	
18	8/26	1501	31.377	114.393	23	0	31.70	35.758	0.822	0.293	
						4	31.60	35.760	0.934	0.354	
						9	31.52	35.761	0.886	0.347	
						14	31.17	35.786	1.418	0.597	
						19	30.89	35.859	2.530	1.261	
						23	30.87	35.861	1.425	0.829	
19	8/27	0447	30.442	114.227	97	0	30.47	35.254	0.184	0.099	2.53
						5	30.47	35.255	0.182	0.097	3.74
						9	30.47	35.255	0.199	0.095	3.27
						15	29.75	35.233	0.194	0.113	2.71
						24	29.10	35.161	0.296	0.211	2.56
						37	28.23	35.301	0.573	0.727	0.91
						56	26.29	35.266	0.423	0.452	0.16
						68	25.12	35.287	0.305	0.376	
						79	23.64	35.301	0.219	0.256	
						89	22.38	35.304	0.131	0.147	
						96	21.73	35.290	0.082	0.141	
20	8/27	1151	30.460	114.358	52	0	30.99	35.378	0.163	0.072	
						9	30.73	35.365	0.188	0.092	
						19	29.29	35.314	0.395	0.289	
						29	27.92	35.251	1.200	1.183	
						38	27.69	35.279	0.818	0.829	
						49	27.56	35.333	0.479	0.529	
21	8/28	0459	30.012	114.412	24	0	31.15	35.543	0.241	0.148	3.17
						3	31.14	35.543	0.246	0.140	3.55
						6	31.14	35.543	0.224	0.145	3.31
						9	31.14	35.542	0.210	0.143	2.56
						16	30.76	35.604	0.438	0.301	2.76
						24	30.36	35.678	1.200	0.603	2.49
						24	30.37	35.678	1.187	0.599	0.25
22	8/28	1009	31.108	114.202	121	0	30.80	35.316	0.218	0.115	

Station	Date	Local Time	Latitude (°N)	Longitude (°W)	Cast depth (m)	Bottle depth (m)	Temp. (°C)	Salinity (psu)	Chl *a* (mg/m^3)	Phaeo. (mg/m^3)	Prod. (mgC/ m^2/day)
22	8/28	1009	31.108	114.202		8	30.80	35.316	0.215	0.117	
						19	30.37	35.303	0.207	0.112	
						28	29.80	35.305	0.468	0.407	
						38	28.98	35.307	1.282	1.138	
						48	27.74	35.287	0.675	0.733	
						59	26.12	35.278	0.201	0.226	
						68	24.58	35.268	0.066	0.197	
						80	22.66	35.258	0.040	0.134	
						98	19.92	35.238	0.027	0.119	
						119	17.67	35.212	0.018	0.149	
23	8/28	1214	31.152	114.370	36	0	30.76	35.394	0.511	0.207	
						4	30.76	35.393	0.479	0.205	
						8	30.75	35.395	0.530	0.226	
						14	30.68	35.401	0.601	0.271	
						19	30.66	35.411	0.800	0.367	
						24	30.55	35.503	1.678	0.651	
						29	30.48	35.614	1.678	0.724	
						33	30.51	35.647	1.480	0.719	
24	8/28	1428	31.203	114.543	25	0	31.36	35.939	0.846	0.314	
						4	31.37	35.939	0.768	0.274	
						9	31.37	35.937	0.794	0.280	
						14	31.26	35.960	0.822	0.333	
						19	31.26	35.988	1.009	0.435	
						22	30.87	36.004	1.534	0.600	
						25	31.10	36.580	1.255	0.521	
25	8/29	0445	30.438	114.350	53	0	30.23	35.349	0.135	0.108	1.50
						5	30.23	35.349	0.136	0.112	1.44
						10	30.25	35.349	0.139	0.106	1.34
						16	29.89	35.317	0.139	0.119	1.13
						24	28.77	35.276	0.318	0.421	1.88
						37	27.82	35.327	0.436	0.474	0.82
						51	26.44	35.305	0.343	0.436	0.13
26	8/30	0450	31.010	114.310	82	0	30.64	35.390	0.395	0.265	3.54
						3	30.63	35.389	0.388	0.260	5.18
						6	30.63	35.389	0.378	0.251	5.09
						10	30.64	35.388	0.418	0.277	4.06
						16	30.64	35.387	0.406	0.281	2.96
						25	30.06	35.329	0.517	0.444	0.71
						38	29.58	35.438	0.825	0.656	0.20
						49	29.07	35.356	0.689	0.719	
						59	28.76	35.337	0.764	0.939	
						69	28.33	35.579	0.601	0.421	
						79	25.14	35.283	0.144	0.214	
27	8/30	1200	30.770	114.645	20	0	30.91	36.067	2.141	0.619	
						4	30.90	36.067	1.916	0.605	

Station	Date	Local Time	Latitude (°N)	Longitude (°W)	Cast depth (m)	Bottle depth (m)	Temp. (°C)	Salinity (psu)	Chl *a* (mg/m^3)	Phaeo. (mg/m^3)	Prod. (mgC/ m^2/day)
27	8/30	1200	30.770	114.645		8	30.80	36.218	2.530	0.967	
						14	30.93	36.400	2.093	1.035	
						20	30.94	36.410	1.848	1.051	
28	9/07	0511	31.008	114.317	79	0	30.78	35.743	1.384	0.548	15.35
						4	30.78	35.738	1.357	0.511	27.92
						8	30.79	35.740	1.323	0.508	29.45
						13	30.78	35.743	1.357	0.520	22.95
						22	30.84	35.799	1.630	0.579	-1.00
						33	30.15	35.717	1.705	0.467	3.68
						51	28.30	35.563	0.839	0.261	0.22
						54	27.08	35.491	0.790	0.322	
						59	23.80	35.327	0.348	0.342	
						69	20.69	35.252	0.255	0.466	
						79	19.97	35.243	0.104	0.263	
29	9/07	1156	30.925	114.452	25	0	31.27	35.804	1.050	0.220	
						4	30.74	35.797	1.643	0.353	
						9	30.69	35.800	1.991	0.438	
						14	30.68	35.801	2.128	0.458	
						19	30.67	35.805	1.978	0.424	
						23	30.69	35.826	2.012	0.464	
30	9/08	1205	30.748	114.550	30	0	30.99	35.554	0.481	0.098	
						4	30.85	35.552	0.448	0.105	
						9	30.63	35.561	0.665	0.134	
						14	30.52	35.606	1.125	0.356	
						20	30.26	35.733	2.353	0.592	
						30	29.89	35.626	1.678	0.568	
31	9/09	0452	31.010	114.520	25	0	31.30	36.054	0.732	0.276	22.41
						2	31.29	36.055	0.695	0.289	23.07
						4	31.29	36.054	0.704	0.278	25.60
						7	31.30	36.053	0.727	0.292	17.78
						12	31.26	36.041	0.880	0.344	4.45
						19	31.07	36.046	2.469	0.789	3.95
						25	31.07	36.060	2.325	0.674	0.71
32	9/09	1059	30.792	114.158	179	0	30.80	35.235	0.339	0.139	
						19	30.45	35.180	0.421	0.243	
						29	29.98	35.144	0.543	0.526	
						39	29.18	35.181	0.907	0.915	
						49	28.26	35.257	0.566	0.603	
						59	26.51	35.262	0.253	0.291	
						79	22.01	35.267	0.067	0.168	
						99	19.61	35.236	0.025	0.091	
						124	17.85	35.223	0.016	0.056	
						149	16.56	35.194	0.011	0.064	
						178	15.70	35.170	0.016	0.130	
33	9/09	1325	30.760	114.328	59	0	30.83	35.471	0.380	0.115	

Station	Date	Local Time	Latitude (°N)	Longitude (°W)	Cast depth (m)	Bottle depth (m)	Temp. (°C)	Salinity (psu)	Chl *a* (mg/m^3)	Phaeo. (mg/m^3)	Prod. (mgC/ m^2/day)
33	9/09	1325	30.760	114.328		9	30.69	35.546	0.470	0.161	
						14	29.67	35.424	1.596	0.981	
						19	29.65	35.436	1.337	0.835	
						29	28.45	35.360	0.846	0.618	
						39	28.06	35.366	0.573	0.452	
						49	27.85	35.382	0.474	0.438	
						56	26.62	35.354	0.406	0.489	
34	9/09	1532	30.723	114.508	25	0	30.92	35.534	0.689	0.142	
						5	30.93	35.534	0.564	0.102	
						9	30.68	35.512	0.513	0.142	
						14	30.66	35.548	0.594	0.225	
						18	30.26	35.559	0.818	0.344	
						24	29.84	35.636	2.305	0.750	
35	9/10	0505	30.912	114.585	25	0	31.08	35.844	0.599	0.235	4.12
						3	31.10	35.843	0.586	0.222	7.56
						6	31.07	35.844	0.577	0.205	6.72
						10	31.07	35.845	0.556	0.209	4.75
						16	31.07	35.845	0.551	0.222	2.90
						24	30.83	36.003	2.059	0.628	2.73
						25	30.83	36.003	2.148	0.640	0.33
36	9/10	1153	31.002	114.617	22	0	31.48	36.043	1.214	0.304	
						4	31.41	36.042	1.248	0.307	
						9	31.20	36.046	1.602	0.422	
						13	31.18	36.048	1.746	0.536	
						19	31.16	36.090	2.387	0.613	
						22	31.15	36.101	2.359	0.640	
37	9/11	0455	30.478	114.248	87	0	30.64	35.347	0.236	0.129	2.40
						6	30.61	35.355	0.230	0.135	3.06
						11	30.58	35.361	0.236	0.137	3.15
						18	30.55	35.366	0.253	0.181	2.33
						29	29.53	35.298	0.539	0.501	3.66
						45	28.51	35.309	0.750	0.952	1.69
						67	25.28	35.269	0.140	0.180	0.11
						79	23.25	35.277	0.116	0.172	
						86	20.67	35.259	0.042	0.123	
38	9/11	1223	30.942	114.080	96	0	31.02	35.266	0.268	0.105	
						8	30.94	35.263	0.311	0.115	
						19	30.65	35.245	0.770	0.197	
						29	29.86	35.163	0.519	0.355	
						39	29.38	35.270	1.398	0.967	
						49	28.65	35.399	1.166	0.987	
						59	26.88	35.299	0.328	0.358	
						69	24.58	35.284	0.139	0.180	
						79	21.92	35.271	0.059	0.099	
						89	20.46	35.252	0.030	0.083	

Station	Date	Local Time	Latitude (°N)	Longitude (°W)	Cast depth (m)	Bottle depth (m)	Temp. (°C)	Salinity (psu)	Chl *a* (mg/m^3)	Phaeo. (mg/m^3)	Prod. (mgC/ m^2/day)
38	9/11	1223	30.942	114.080		96	19.95	35.249	0.028	0.094	
39	9/11	1444	30.940	114.285	82	0	31.05	35.398	0.238	0.082	
						8	31.04	35.398	0.237	0.082	
						14	30.79	35.391	0.267	0.106	
						19	29.85	35.330	0.620	0.445	
						29	29.39	35.367	2.012	1.641	
						39	28.64	35.514	0.893	0.754	
						49	27.11	35.483	0.380	0.231	
						59	25.02	35.329	0.226	0.143	
						69	23.57	35.275	0.112	0.108	
						79	22.25	35.264	0.063	0.152	
40	9/11	1700	30.942	114.483	24	0	31.20	35.672	0.627	0.170	
						4	31.21	35.674	0.627	0.173	
						9	31.20	35.669	0.667	0.196	
						14	30.77	35.672	0.813	0.290	
						18	30.47	35.658	3.086	1.112	
						23	30.87	35.914	2.073	0.540	
41	9/12	0448	31.007	114.520	26	0	31.28	35.964	0.907	0.372	16.45
						3	31.27	35.962	0.934	0.372	30.89
						6	31.27	35.961	0.948	0.377	33.69
						9	31.27	35.959	0.907	0.372	21.60
						16	31.28	35.958	0.941	0.375	12.03
						25	31.27	35.959	0.846	0.323	2.04
						25	31.27	35.960	0.846	0.314	0.46
42	9/13	0450	31.072	114.412	25	0	31.17	35.877	1.575	0.449	34.87
						3	31.17	35.879	1.521	0.458	45.71
						6	31.17	35.881	1.534	0.508	51.84
						10	31.19	35.913	1.630	0.441	36.14
						16	31.20	35.930	1.609	0.507	18.12
						25	31.46	36.209	1.957	0.629	3.16
						25	31.45	36.189	1.950	0.645	0.51
43	9/13	1020	30.973	114.088	106	0	30.81	35.313	0.262	0.109	
						9	30.79	35.313	0.262	0.112	
						19	30.29	35.257	0.440	0.226	
						29	29.35	35.213	0.900	0.545	
						39	28.18	35.251	0.907	0.759	
						49	27.04	35.299	0.444	0.372	
						60	25.51	35.308	0.175	0.216	
						68	24.19	35.287	0.124	0.171	
						79	24.20	35.288	0.127	0.168	
						88	24.08	35.281	0.125	0.165	
						105	21.19	35.262	0.054	0.276	
44	9/13	1232	31.117	114.085	89	0	30.81	35.324	0.348	0.130	
						8	30.78	35.321	0.352	0.126	
						19	30.71	35.312	0.468	0.181	

Station	Date	Local Time	Latitude (°N)	Longitude (°W)	Cast depth (m)	Bottle depth (m)	Temp. (°C)	Salinity (psu)	Chl *a* (mg/m^3)	Phaeo. (mg/m^3)	Prod. ($mgC/m^2/day$)
44	9/13	1232	31.117	114.085		28	30.71	35.314	0.487	0.231	
						39	29.21	35.335	1.821	1.630	
						48	28.79	35.358	1.221	0.933	
						59	26.98	35.383	0.444	0.323	
						69	25.39	35.303	0.227	0.236	
						79	25.06	35.292	0.294	0.224	
						89	23.45	35.283	0.084	0.271	
45	9/13	1431	31.265	114.085	48	0	31.09	35.460	0.627	0.213	
						9	31.08	35.463	0.646	0.234	
						19	30.05	35.383	1.384	0.705	
						24	29.00	35.380	1.541	0.769	
						29	29.10	35.376	1.814	0.698	
						39	28.22	35.371	1.057	0.507	
						48	28.20	35.371	1.016	0.502	
46	9/14	1152	30.812	114.617	31	0	31.22	36.070	2.509	0.500	
						4	31.26	36.069	2.250	0.464	
						8	31.10	36.077	3.663	0.400	
						14	31.08	36.083	1.984	0.528	
						19	31.08	36.086	2.012	0.528	
						30	31.08	36.097	2.012	0.675	
47	9/16	0457	31.003	114.412	23	0	30.89	35.628	0.820	0.310	17.14
						3	30.88	35.616	0.846	0.295	26.19
						6	30.88	35.618	0.798	0.316	21.00
						9	30.98	35.727	1.302	0.455	30.80
						15	31.05	35.800	1.916	0.624	20.27
						23	31.07	35.817	1.903	0.665	1.79
						23	31.07	35.813	1.834	0.715	0.59
48	9/16	1154	31.348	114.352	33	0	31.47	35.634	1.759	0.394	
						9	31.29	35.633	3.989	0.987	
						13	31.25	35.629	3.587	0.847	
						19	31.21	35.628	2.687	0.792	
						24	31.21	35.626	2.516	0.631	
						32	31.21	35.626	2.537	0.859	
49	9/17	0446	30.840	114.513	26	0	31.12	35.763	1.616	0.509	26.39
						3	31.15	35.762	1.555	0.470	30.82
						6	31.11	35.762	1.875	0.536	30.40
						10	31.07	35.761	2.100	0.605	21.04
						17	31.07	35.760	2.189	0.581	11.46
						26	31.06	35.756	2.182	0.781	0.82
						26	31.06	35.755	2.012	0.684	0.37
50	9/18	0448	31.205	114.467	32	0	31.21	35.539	0.798	0.343	10.07
						3	31.24	35.554	0.989	0.419	19.38
						6	31.26	35.570	1.152	0.467	28.30
						11	31.18	35.616	1.828	0.648	44.29
						17	31.14	35.636	2.223	0.657	21.81

Station	Date	Local Time	Latitude (°N)	Longitude (°W)	Cast depth (m)	Bottle depth (m)	Temp. (°C)	Salinity (psu)	Chl *a* (mg/m^3)	Phaeo. (mg/m^3)	Prod. (mgC/ m^2/day)
50	9/18	0448	31.205	114.467		27	30.81	35.591	2.182	0.753	2.36
						32	30.74	35.577	1.957	0.803	0.36
51	9/18	1155	31.180	114.558	21	0	31.53	35.867	4.340	1.009	
						4	31.47	35.864	5.996	1.350	
						9	31.35	35.866	5.143	0.917	
						14	31.36	35.887	2.700	0.851	
						18	31.37	35.902	2.182	0.928	
						21	31.37	35.906	2.319	1.114	

Table 3. *Jordan* 1997 Seapig (OS200) CTD cast summary: station number, date, time, location, depth of cast, and the associated Sea-Bird cast, which was performed immediately afterwards. Station dates and times are in Pacific Standard Time (Greenwich Mean Time +7 hrs.).

Station number	Date	Time	Latitude (ºN)	Longitude (ºW)	Cast Depth (m)	Associated Sea-Bird CTD
1	8/7	1309	23.13	110.45	200	1
2	8/10	1208	27.45	111.33	200	2
3	8/11	1218	28.27	112.41	200	3
4	8/15	0523	30.78	114.51	28	4
5	8/16	0442	30.77	114.51	28	5
6	8/16	1208	31.31	114.52	23	
7	8/17	0429	30.53	114.33	51	6
8	8/17	1205	30.72	114.45	37	
9	8/18	0434	30.78	114.24	87	7
10	8/18	1205	30.92	114.65	29	
11	8/19	0428	29.93	114.25	100	8
12	8/19	1209	30.11	114.46	43	
13	8/20	0430	30.94	114.27	100	9
14	8/20	1205	31.24	114.55	24	
15	8/21	0427	30.85	114.33	60	10
16	8/21	1203	30.86	114.52	25	
17	8/22	1202	30.12	114.59	24	
18	8/23	0603	31.26	113.75	24	
19	8/23	1201	30.95	113.99	74	
20	8/24	0432	30.51	113.66	97	11
21	8/24	1208	30.82	113.85	71	12
22	8/25	0447	30.92	113.33	30	13
23	8/25	1208	30.77	113.72	71	14
24	8/26	0449	31.29	114.05	48	15
25	8/26	1158	31.18	114.20	84	
26	8/26	1228	31.21	114.23	53	
27	8/26	1351	31.29	114.31	33	
28	8/26	1425	31.33	114.35	28	
29	8/26	1539	31.42	114.43	17	
30	8/26	1613	31.46	114.47	10	
31	8/27	0430	30.44	114.22	100	19
32	8/27	1208	30.46	114.36	53	20
33	8/28	0446	31.01	114.41	25	21
34	8/28	1057	31.12	114.25	68	
35	8/28	1132	31.13	114.31	36	
36	8/28	1301	31.17	114.43	34	
37	8/28	1343	31.19	114.49	31	
38	8/28	1516	31.22	114.65	20	
39	8/28	1557	31.24	114.66	11	
40	8/29	0429	30.44	114.35	50	25
41	8/30	0433	31.01	114.31	82	26

Station number	Date	Time	Latitude (ºN)	Longitude (ºW)	Cast Depth (m)	Associated Sea-Bird CTD
42	8/30	1147	30.77	114.65	20	27
43	9/6	0621	31.01	114.58	21	
44	9/7	0453	31.01	114.32	80	28
45	9/7	1214	30.93	114.46	22	29
46	9/8	1222	30.75	114.55	31	30
47	9/9	0436	31.01	114.52	31	31
48	9/9	1158	30.79	114.22	103	
49	9/9	1242	30.77	114.28	74	
50	9/9	1417	30.75	114.39	38	
51	9/9	1452	30.74	114.45	34	
52	9/9	1615	30.71	114.57	29	
53	9/9	1653	30.70	114.62	19	
54	9/10	0444	30.91	114.58	23	35
55	9/10	1218	31.00	114.62	22	36
56	9/11	0441	30.48	114.25	91	37
57	9/11	1204	30.94	114.08	105	38
58	9/11	1315	30.94	114.15	148	
59	9/11	1357	30.94	114.22	181	
60	9/11	1536	30.94	114.35	33	
61	9/11	1617	30.94	114.42	34	
62	9/11	1750	30.94	114.55	23	
63	9/11	1826	30.94	114.62	24	
64	9/11	1900	****	Bad Data	****	
65	9/12	0435	31.01	114.52	28	41
66	9/13	0436	31.07	114.41	28	42
67	9/13	1001	30.97	114.08	105	43
68	9/13	1115	31.02	114.08	102	
69	9/13	1152	31.07	114.08	90	
70	9/13	1317	31.17	114.08	80	
71	9/13	1352	31.22	114.08	66	
72	9/13	1521	31.32	114.08	45	
73	9/13	1558	31.37	114.08	21	
74	9/13	1603	31.37	114.08	20	
75	9/14	1208	30.81	114.62	32	
76	9/16	0446	31.01	114.42	25	47
77	9/16	1211	31.35	114.36	34	48
78	9/17	0434	30.84	114.52	28	49
79	9/18	0435	31.21	114.47	34	50
80	9/18	1212	31.19	114.56	31	51

Figure 1. Bathymetry (m) from NOAA/NESDIS/National Geophysical Data Center Marine Trackline Geophysics CD-ROM Data Set. Dashed lines are Vaquita survey boundaries. Sediment samples collected during leg 1 (•).

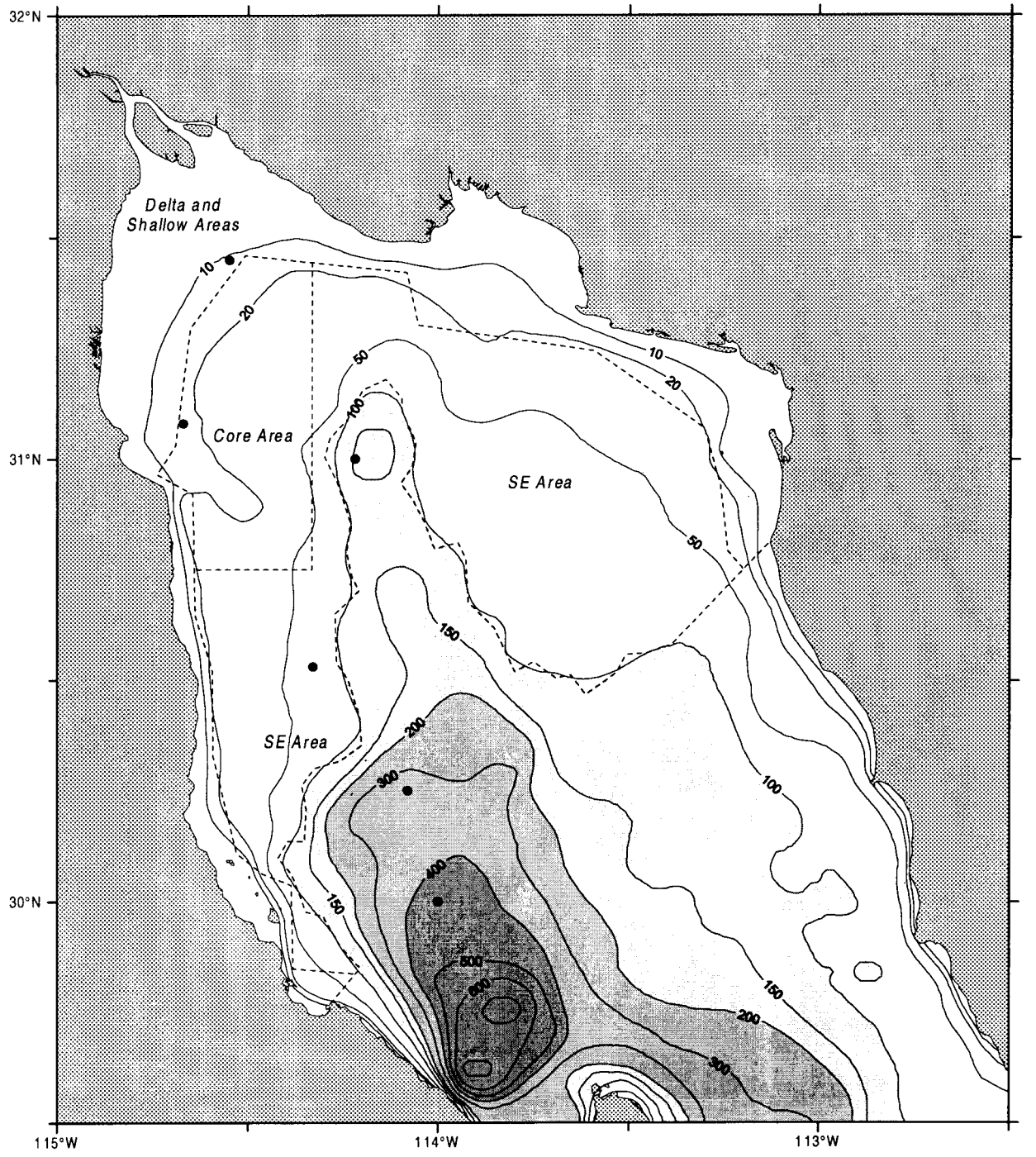


Figure 2. Cruise tracks, *Jordan*, 04 August – 19 September 1997. Oceanographic transects are shown in bold.

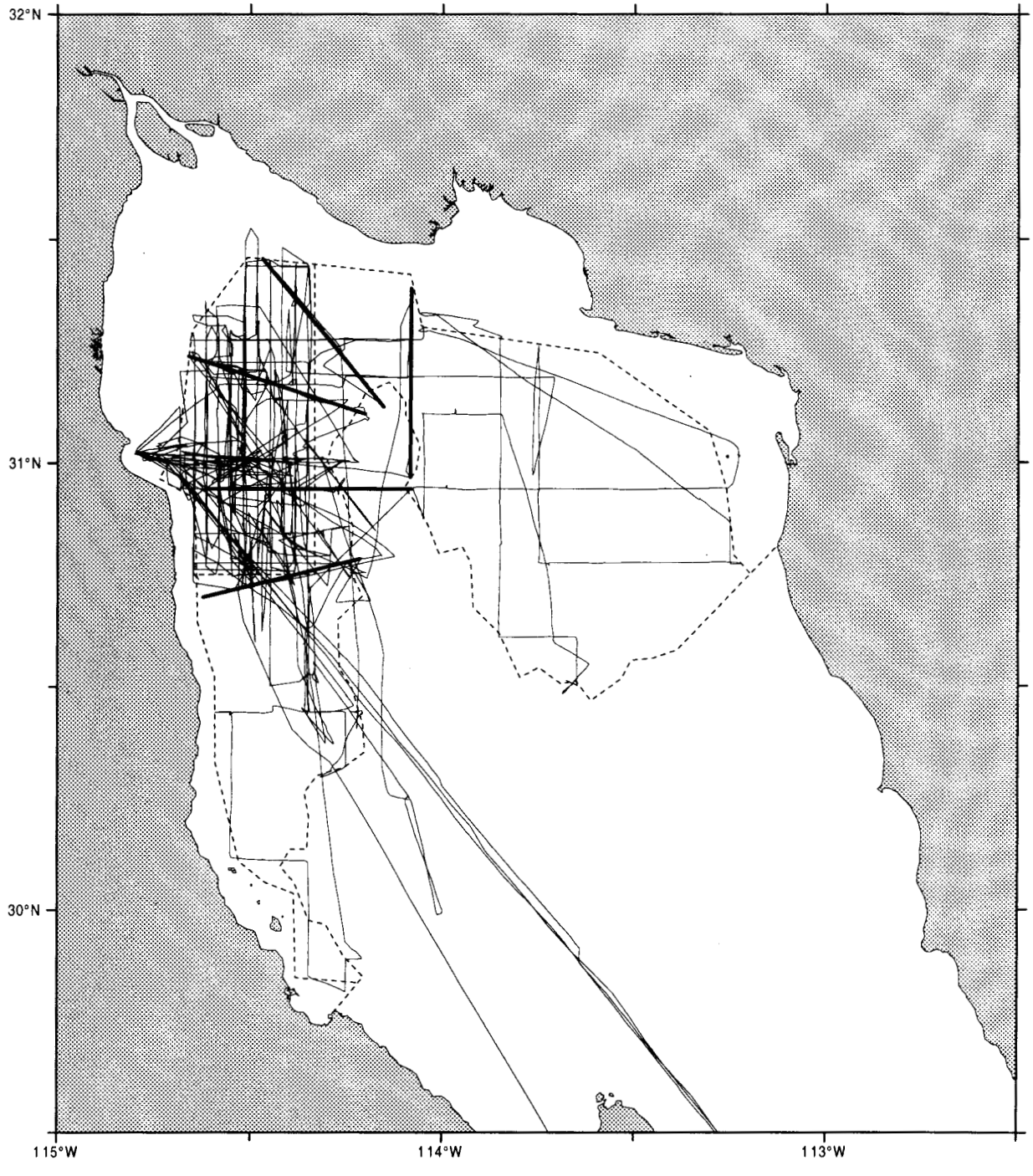


Figure 3. CTD stations, Sea-Bird (o) and Seapig (+), *Jordan*, 04 August - 19 September 1997.

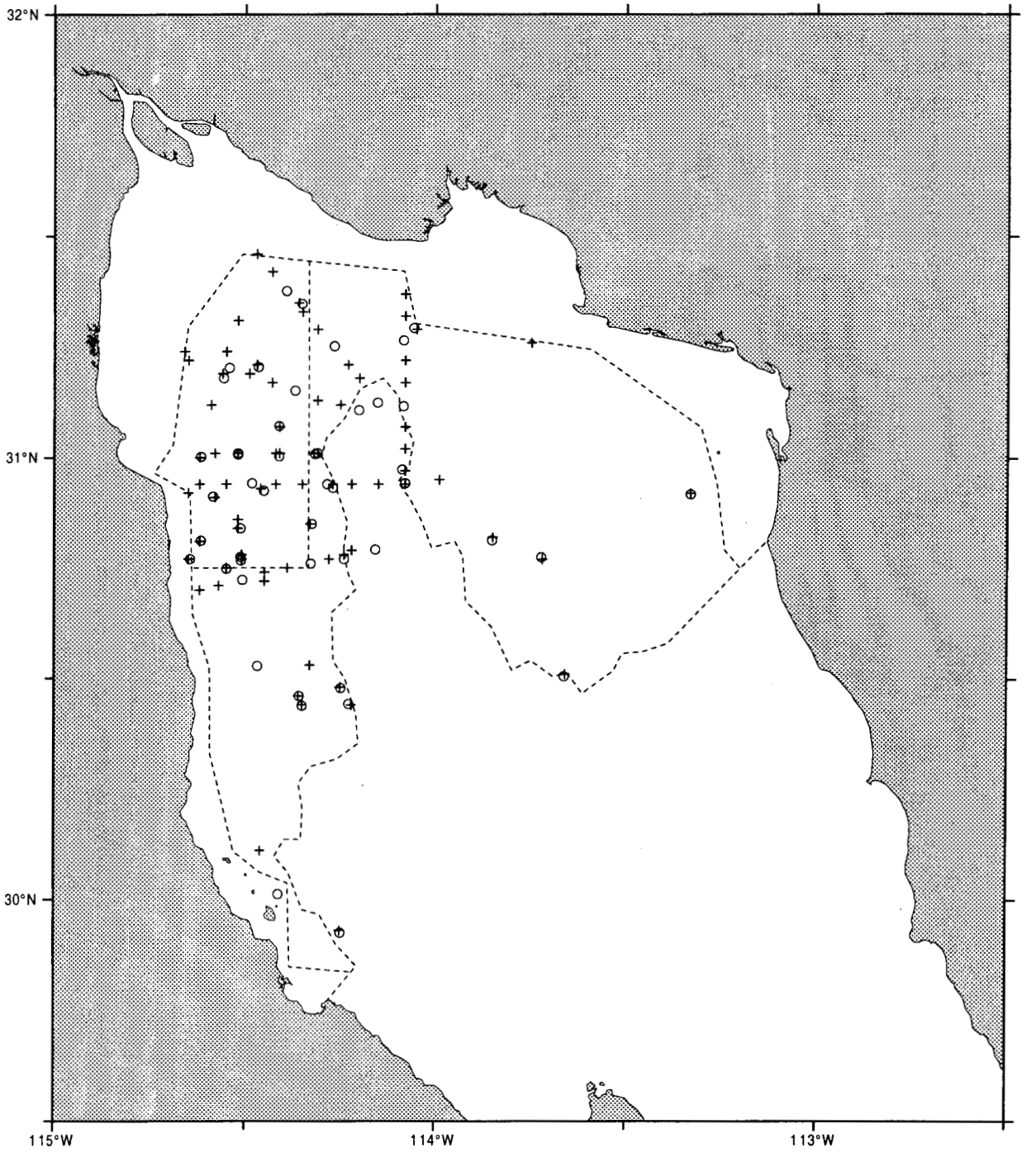


Figure 4. Sea surface temperature (°C) from along-track thermosalinograph data, *Jordan*, 04 August – 19 September 1997.

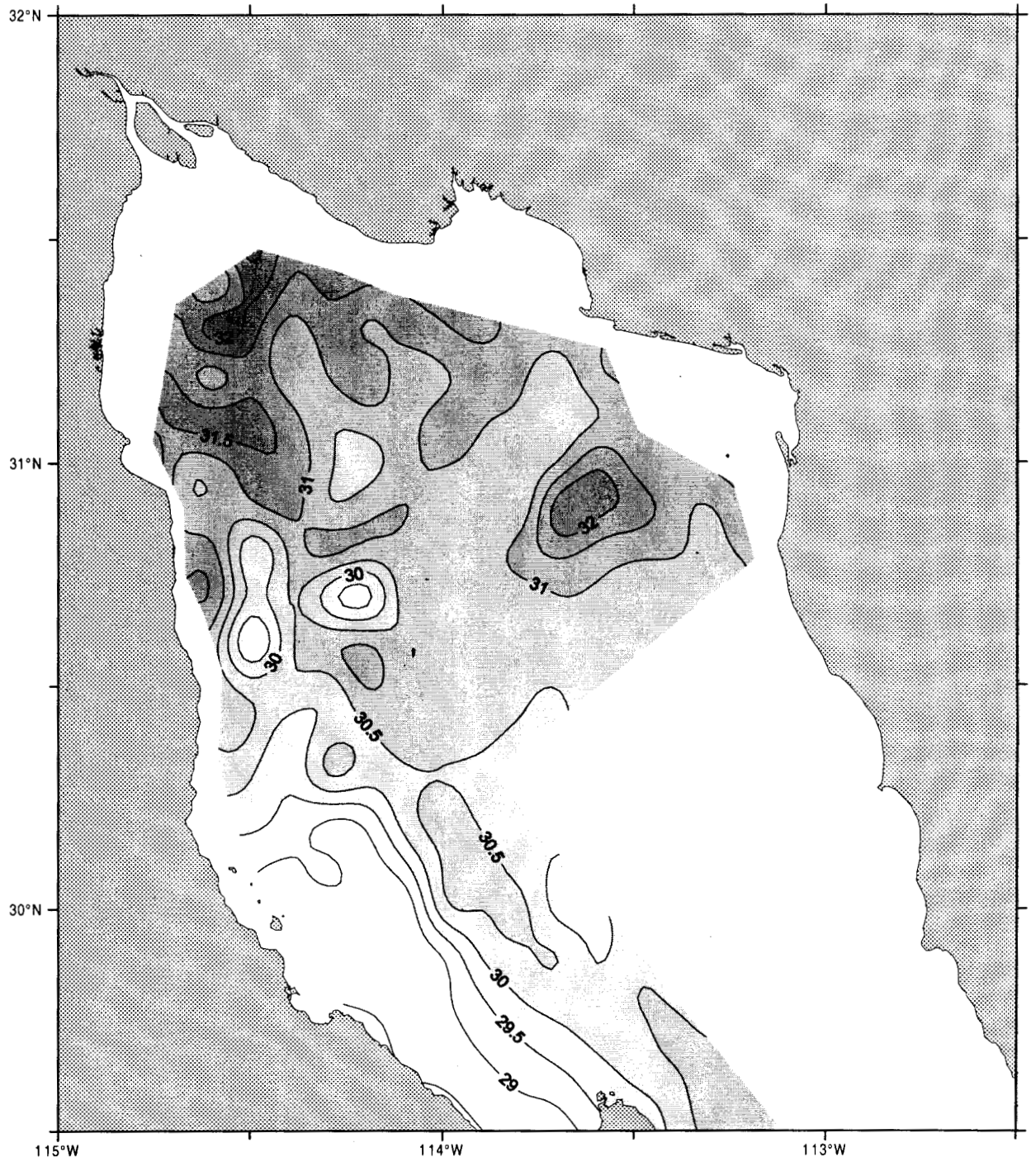


Figure 5. Sea surface salinity (psu) from along-track thermosalinograph data, *Jordan*, 04 August – 19 September 1997.

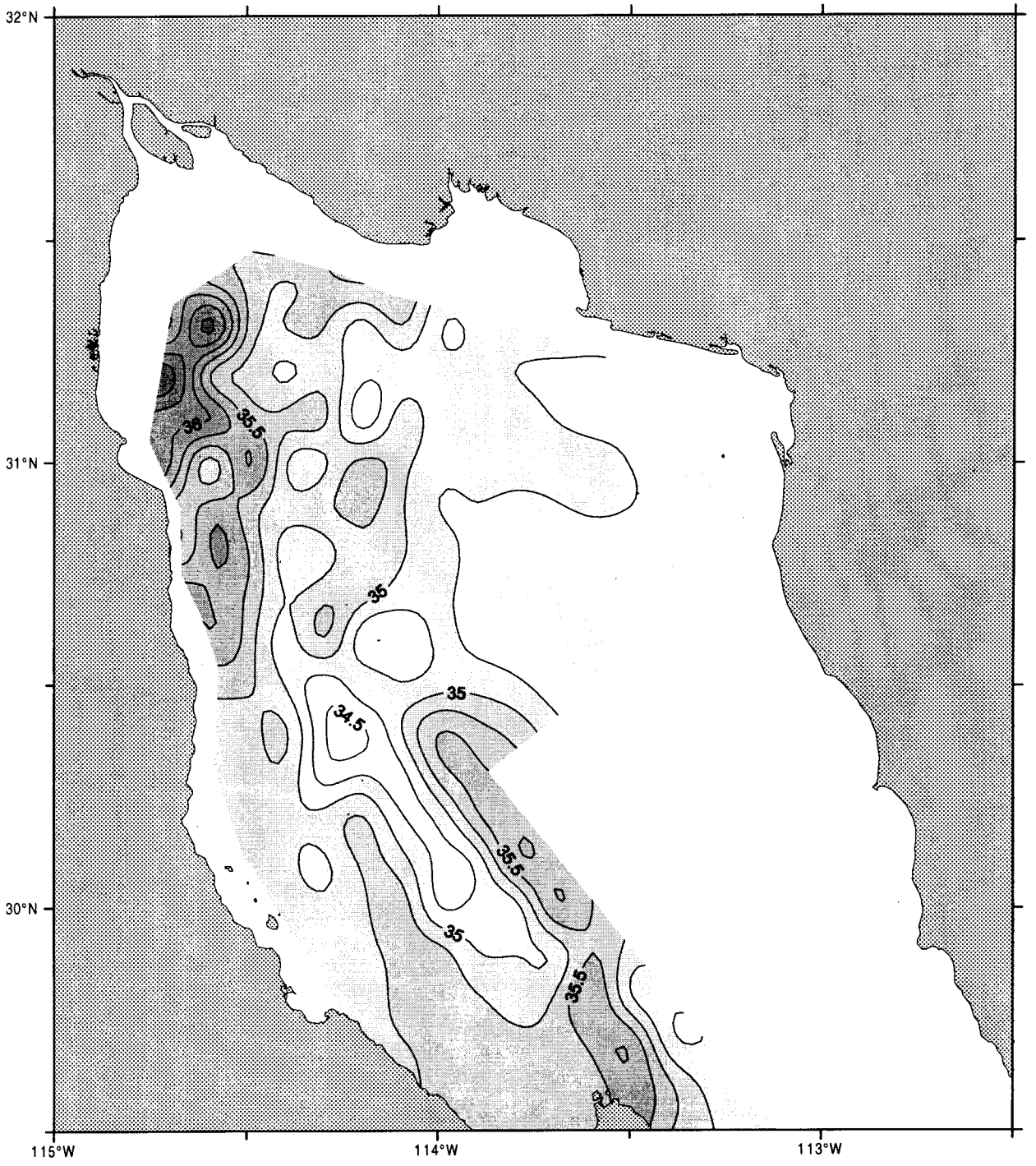


Figure 6. Thermocline depth (depth of maximum temperature gradient, m), from CTD data, *Jordan*, 04 August - 19 September, 1997.

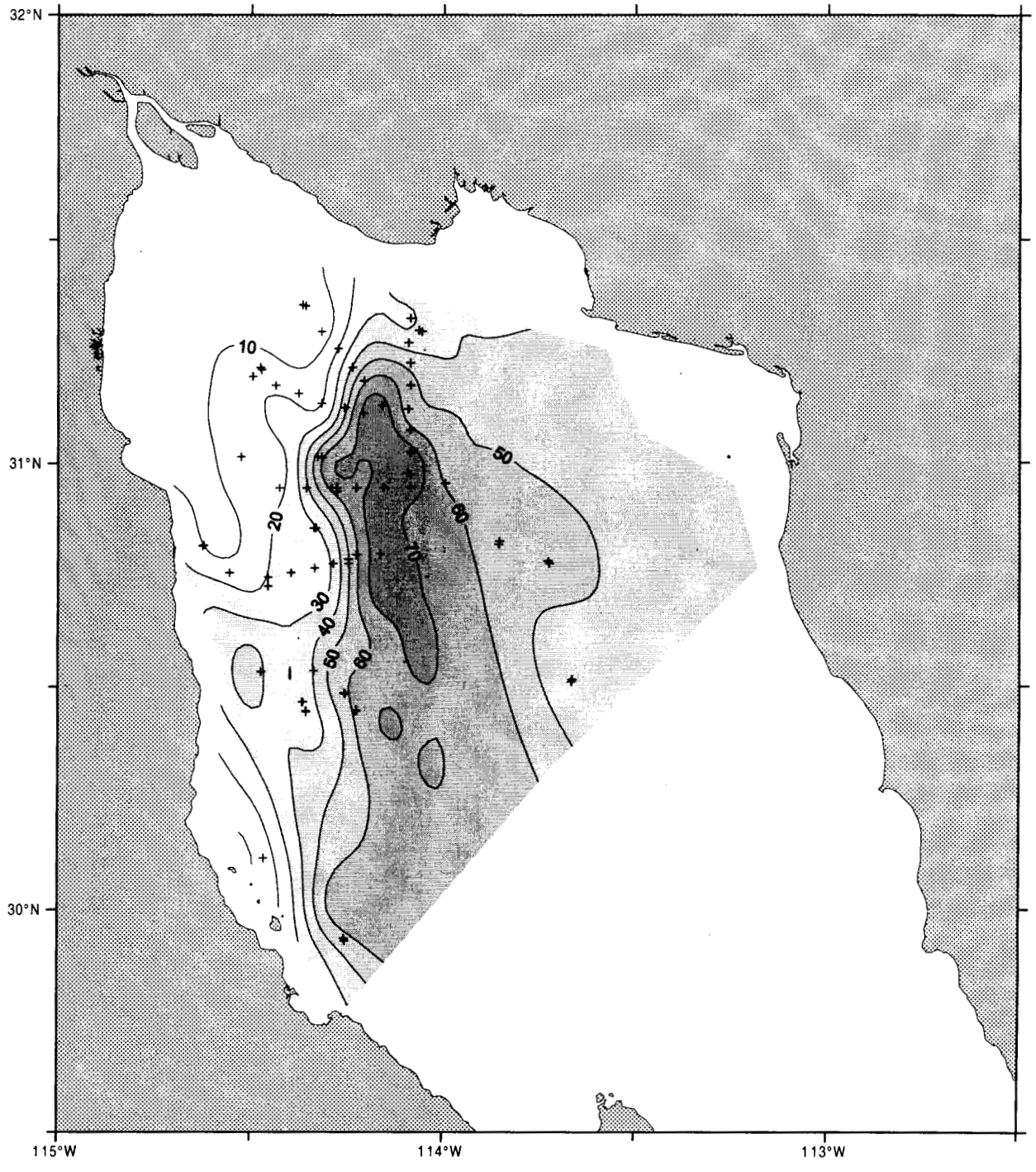
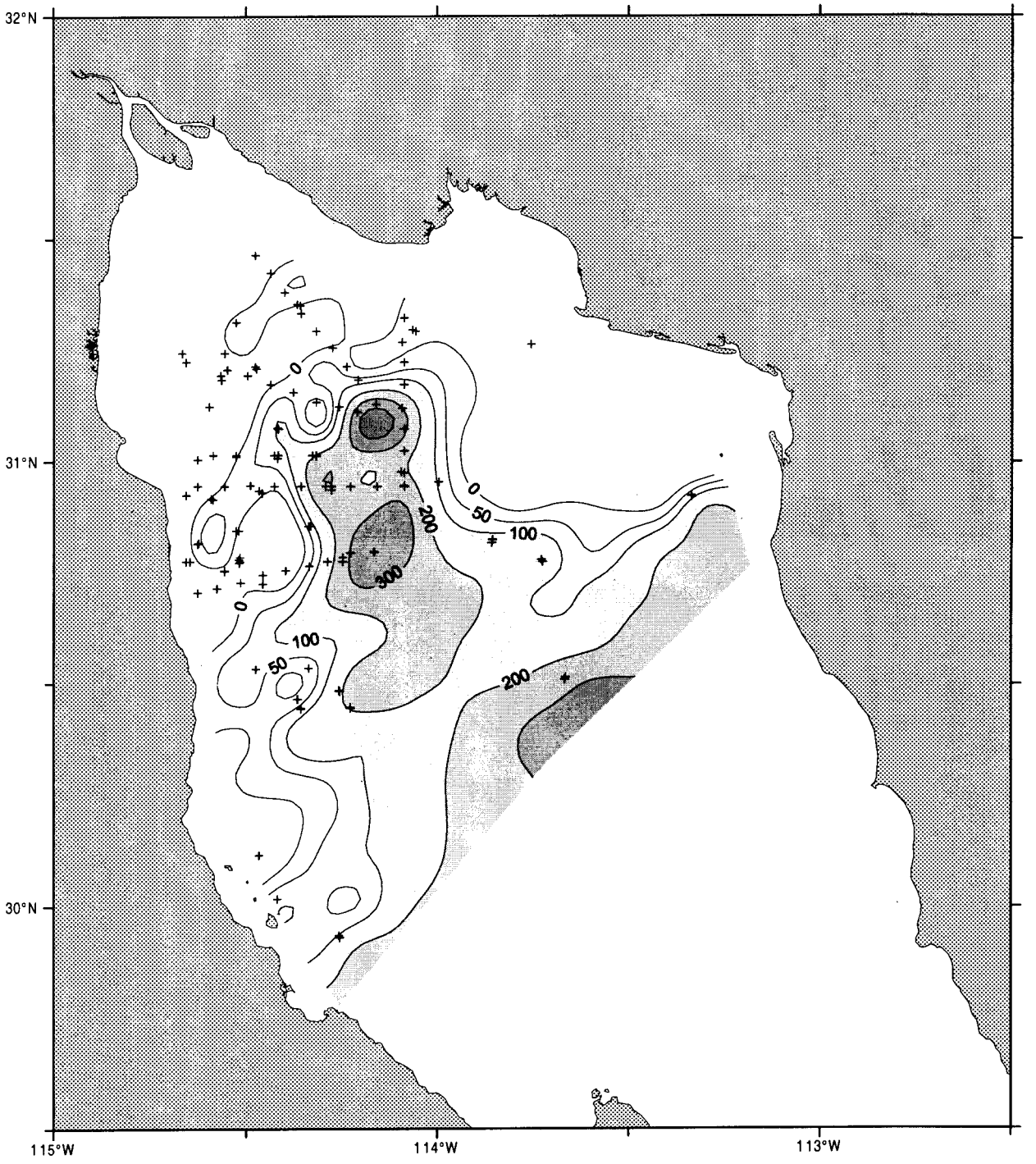


Figure 7. Stratification (potential energy anomaly, J m^{-2}), from CTD data (+), *Jordan*, 04 August – 19 September 1997.



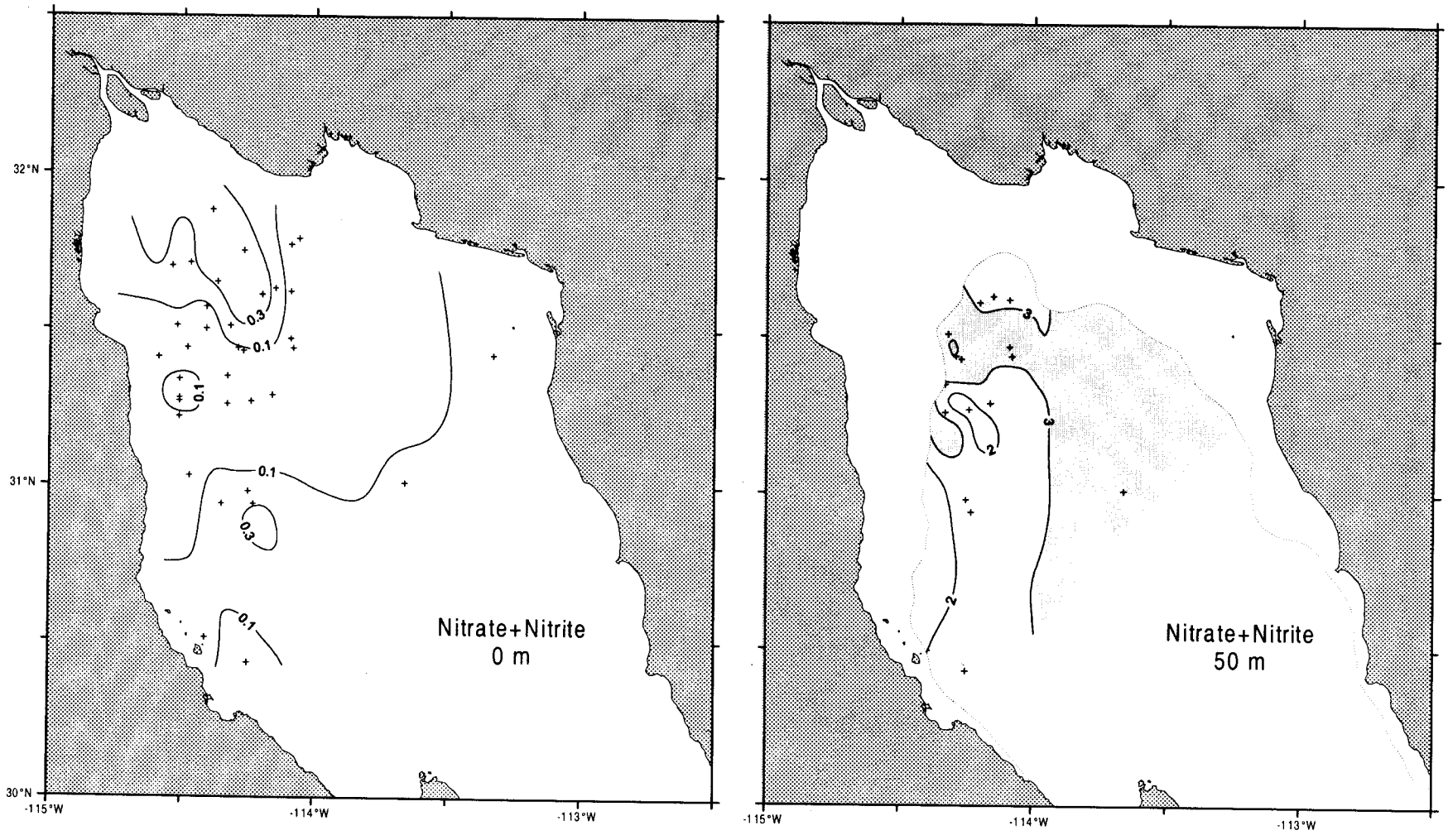


Figure 8. Nitrate+nitrite concentration (μM) at the surface (left) and at 50 meters depth (right), from CTD cast samples (+), *Jordan*, 04 August - 19 September 1997. Dotted line is the 50m isobath.

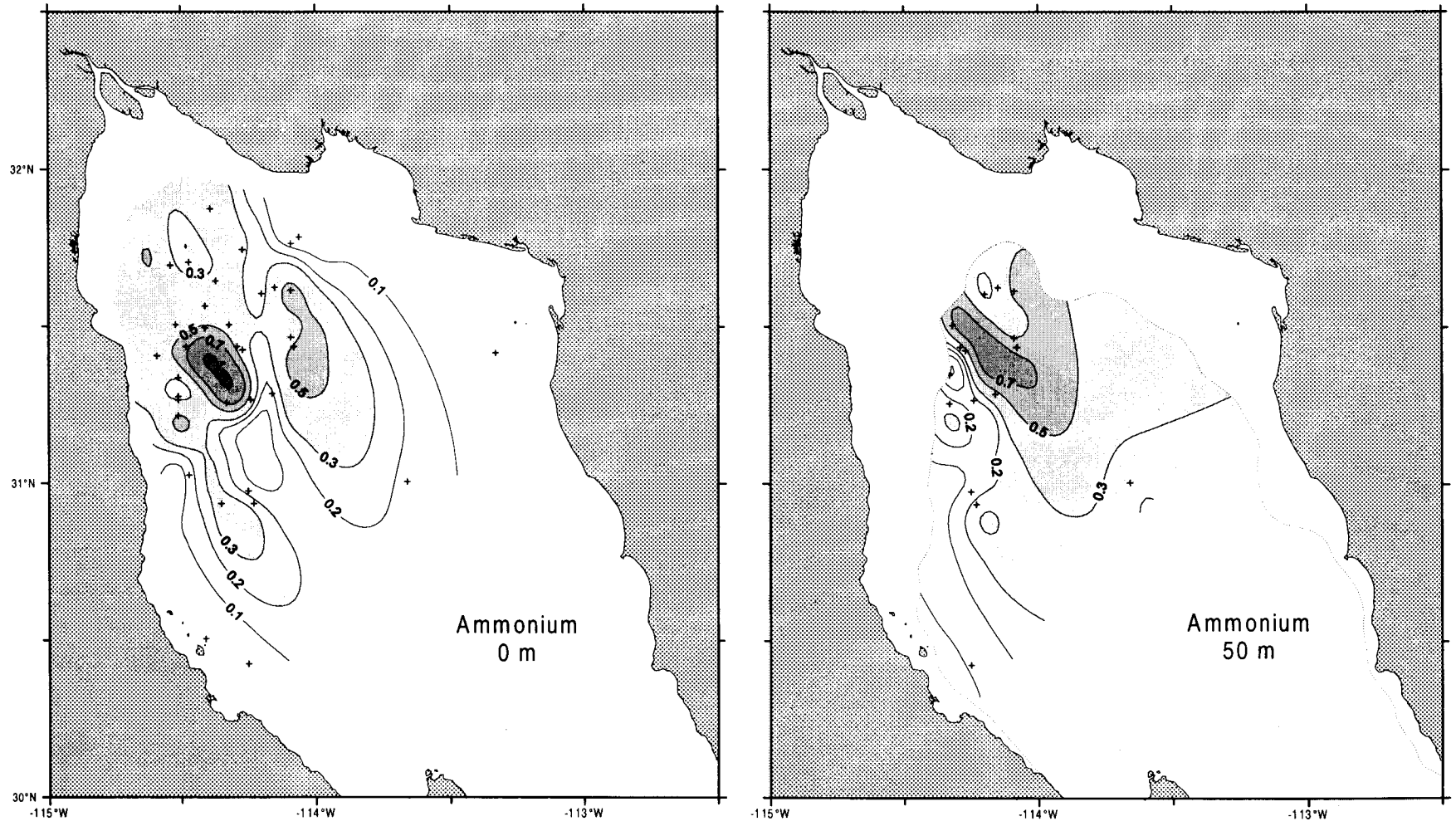


Figure 9. Ammonium concentration (μM) at the surface (left) and at 50 meters depth (right), from CTD cast samples (+), *Jordan*, 04 August - 19 September 1997. Dotted line is the 50m isobath.

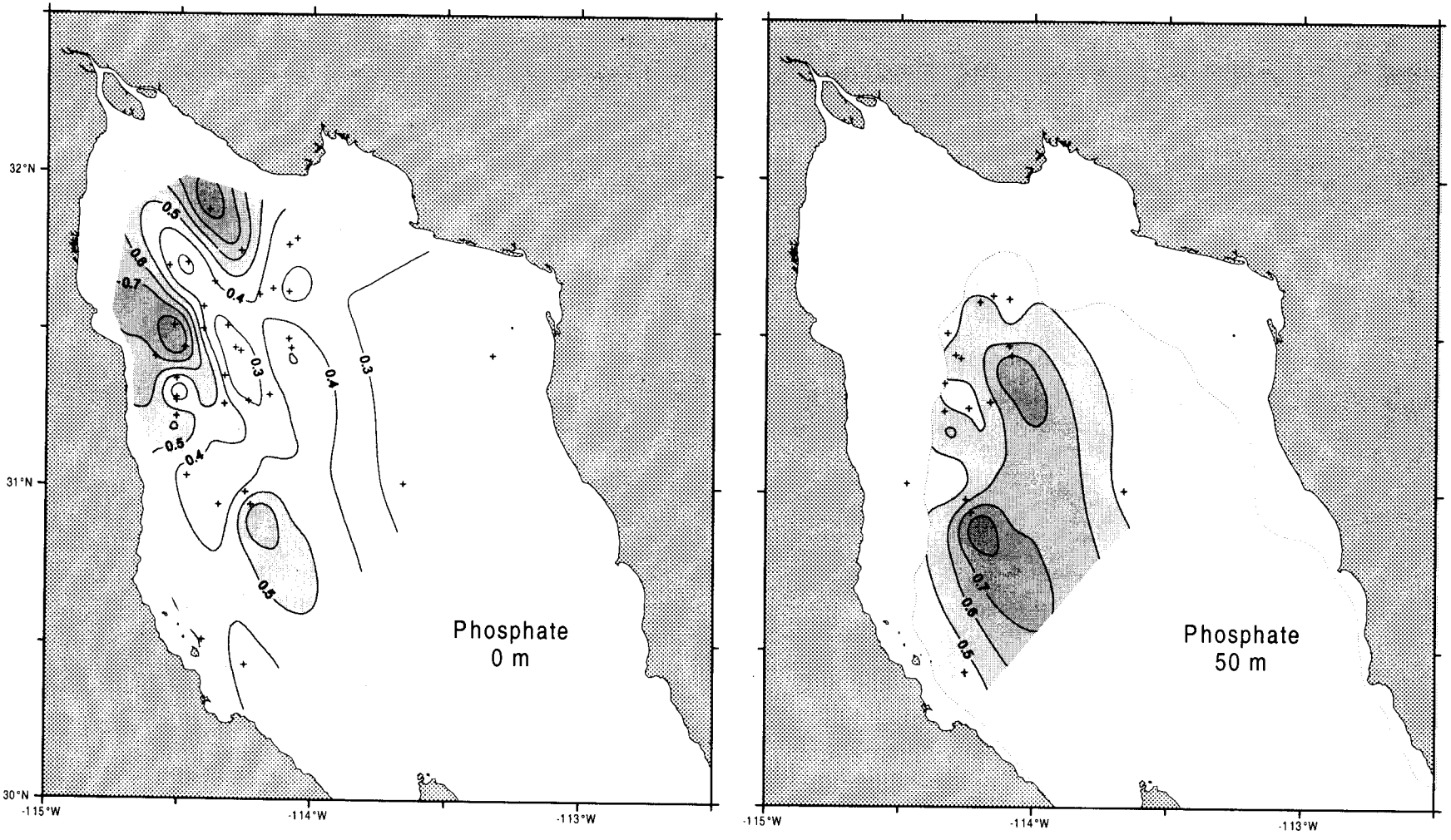


Figure 10. Phosphate concentration (μM) at the surface (left) and at 50 meters depth (right), from CTD cast samples (+), *Jordan*, 04 August - 19 September 1997. Dotted line is the 50m isobath.

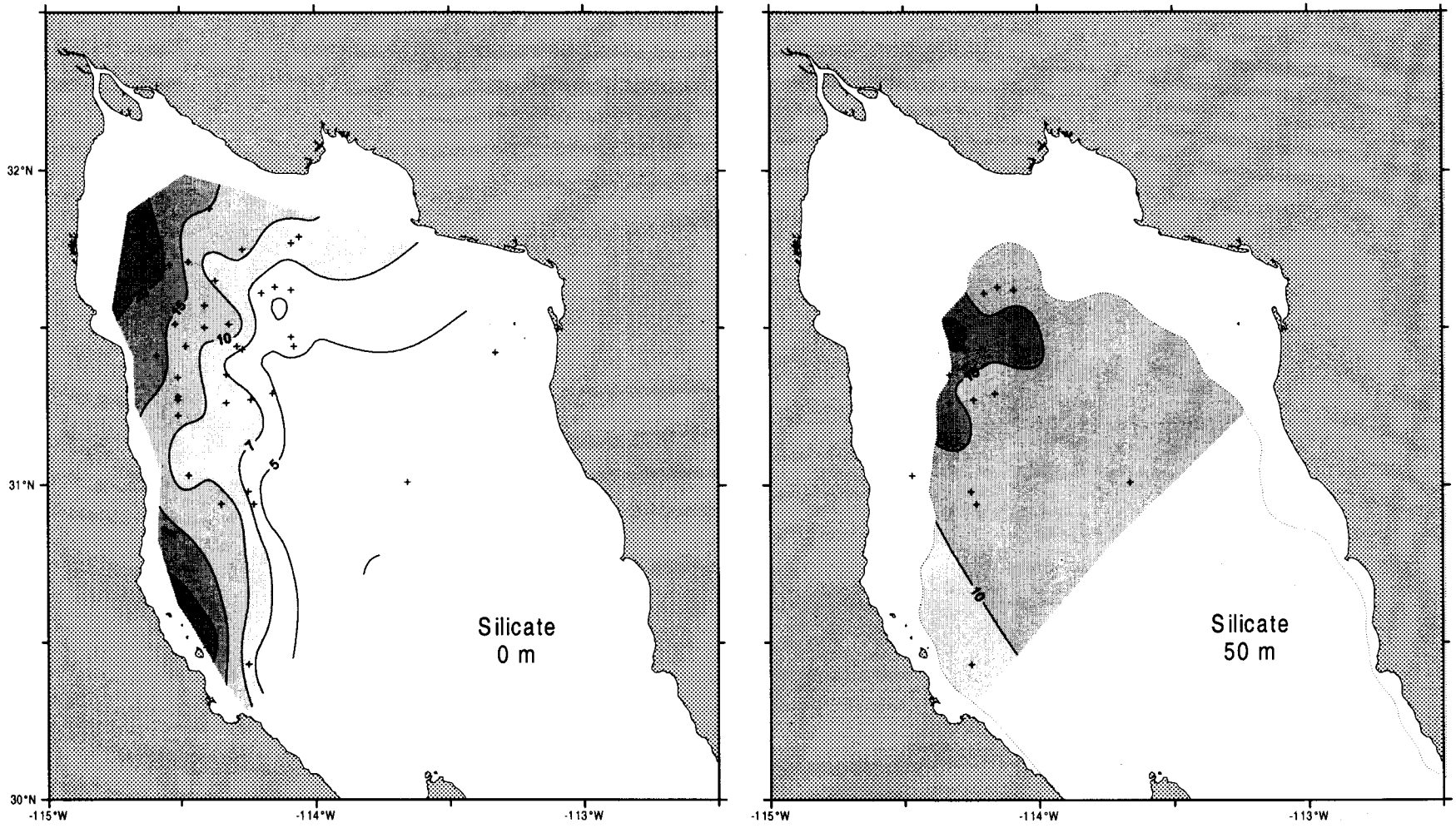


Figure 11. Silicate concentration (μM) at the surface (left) and at 50 meters depth (right), from CTD cast samples (+), *Jordan*, 04 August - 19 September 1997. Dotted line is the 50m isobath.

Figure 12. Surface chlorophyll concentration (mg m^{-3}), from CTD casts and underway samples (+), *Jordan*, 04 August - 19 September 1997.

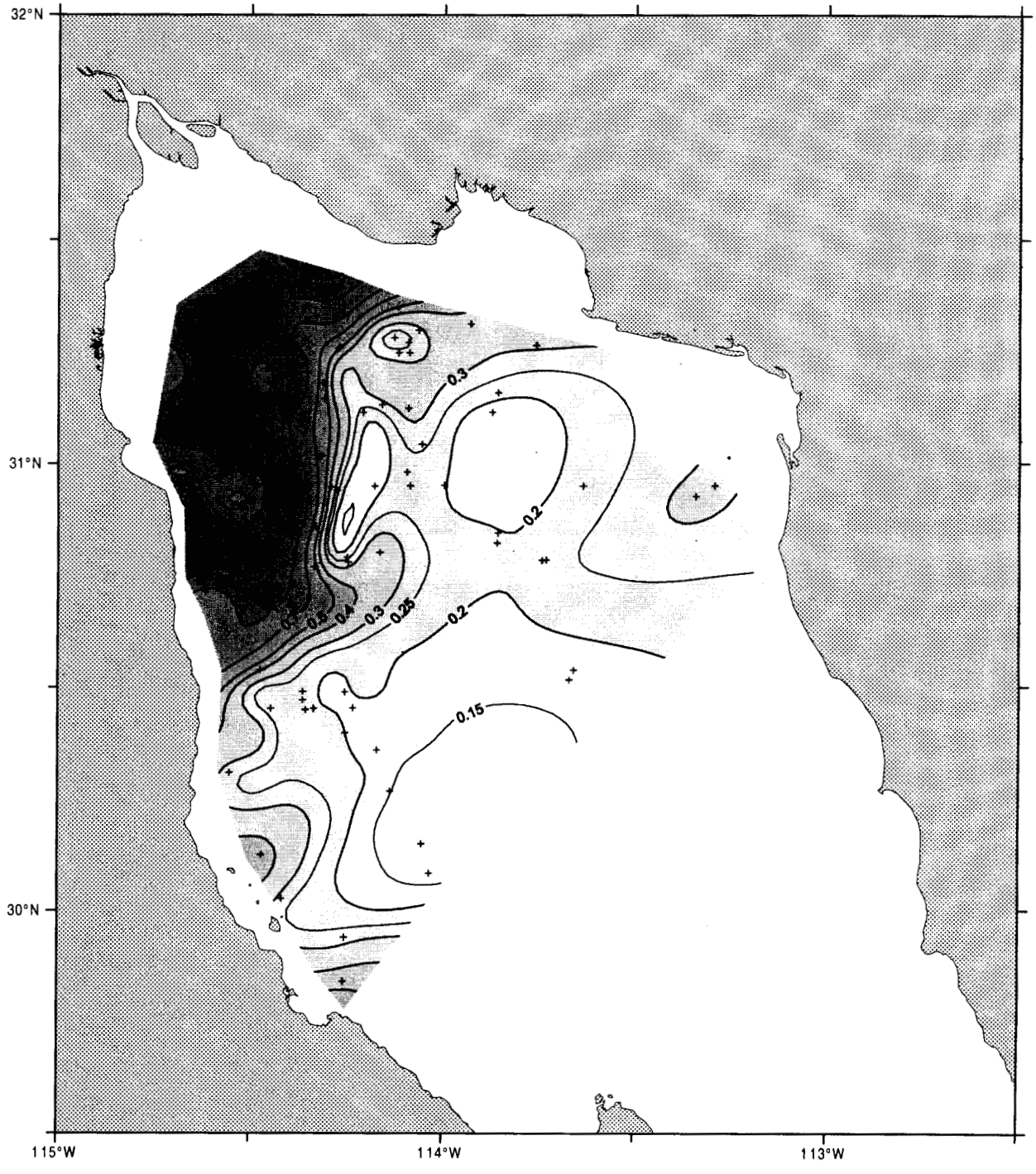
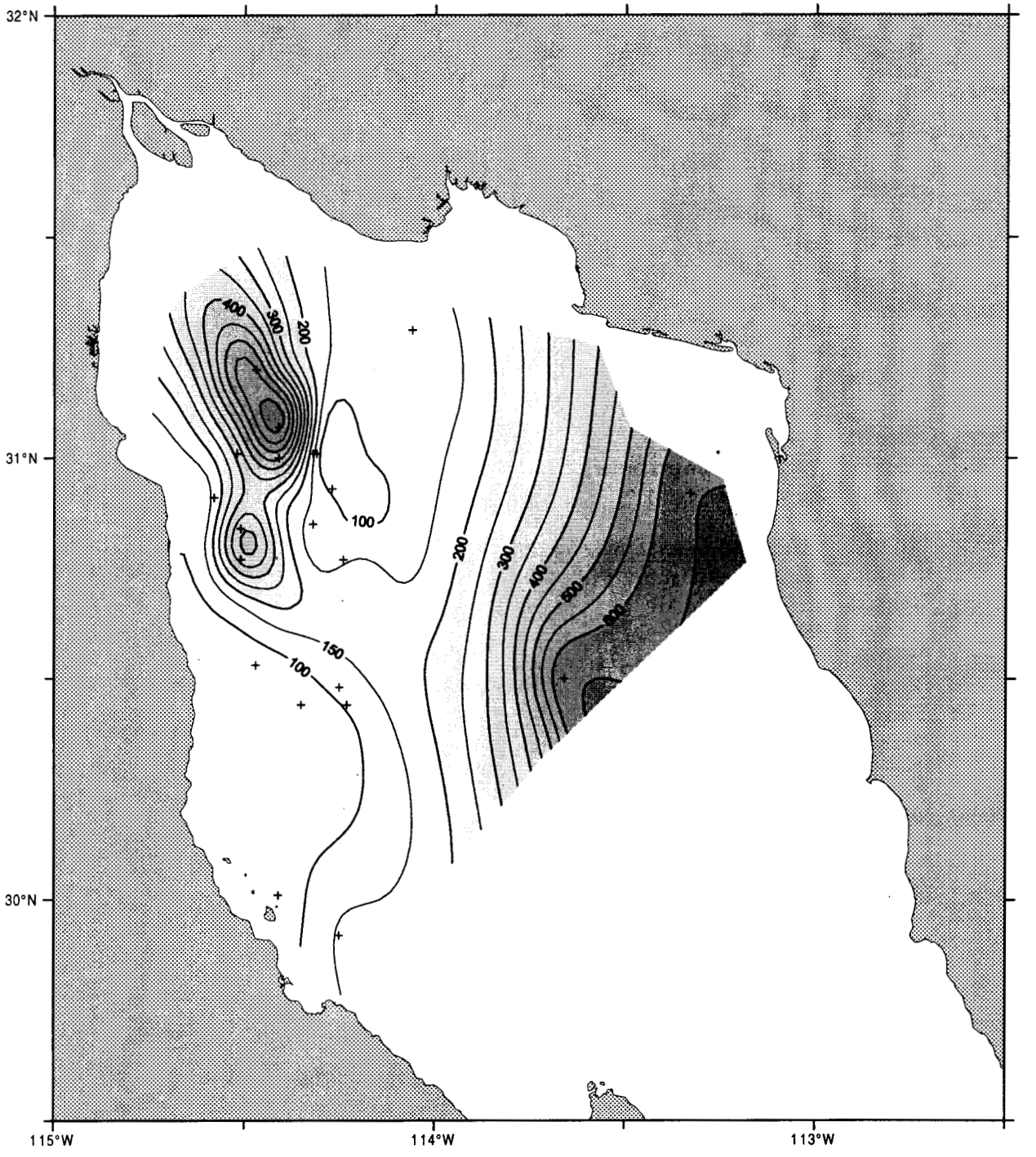


Figure 13. Primary productivity (mg C m^{-2} day^{-1}) in the euphotic zone, from morning Sea-Bird CTD casts (+), *Jordan*, 04 August - 19 September 1997.



APPENDIX A

SCIENTIFIC PERSONNEL

Cruise Leader	Ship (Leg #s)
Tim Gerrodette, SWFSC (Chief scientist)	D.S. Jordan (1-2)
U.S. Marine Mammal Observers	
Jay Barlow	D.S. Jordan (1)
James Carretta (tracker)	D.S. Jordan (1)
James Cotton (tracker)	D.S. Jordan (1-2)
Meghan Donahue (recorder)	D.S. Jordan (2)
Michael Force	D.S. Jordan (1-2)
Doug Kinzey	BIPXI (1-2)
Paula Olson	D.S. Jordan (1-2)
Jon Peterson	D.S. Jordan (1-2)
Robert Pitman	D.S. Jordan (1-2)
Todd Pusser	D.S. Jordan (1-2)
Richard Rowlett	D.S. Jordan (1-2)
Barbara Taylor (tracker)	D.S. Jordan (2)
Alexandra Von Saunder (recorder)	D.S. Jordan (1)
Janice Waite (tracker)	D.S. Jordan (2)
Mexican Marine Mammal Observers	
Lorenzo Rojas (Chief scientist, INP)	BIPXI (1-2)
Jorge Del Angel, CICIMAR	D.S. Jordan (1-2)
Sherman Hernandez, INP	D.S. Jordan (2), BIPXI (2)
Armando Jaramillo, INP	BIPXI (1-2)
Roberto Moncada, UABCS	D.S. Jordan (2), BIPXI (2)
Jorge Navarro, INP	BIPXI (2)
Jose Luis Patino, INP	D.S. Jordan (1), BIPXI (1-2)
Hector Perez-Cortes, INP	D.S. Jordan (1), BIPXI (1)
Jorge Torre, University of Arizona	D.S. Jordan (1)
Ernesto Vázquez, UABCS	D.S. Jordan (1-2), BIPXI (2)
Oceanographer	
Valerie Philbrick, SWFSC	D.S. Jordan (1-2)

SWFSC - Southwest Fisheries Science Center, La Jolla, California, USA
INP - Instituto Nacional de la Pesca, Mexico
CICIMAR - Centro Interdisciplinario de Ciencias Marinas, Mexico
UABCS - Universidad Autónoma de Baja California Sur, Mexico

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(May 2002)

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(May 2002)

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(May 2002)

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W. WATSON, R.L. CHARTER, H.G. MOSER
(May 2002)

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D.A. AMBROSE, R.L. CHARTER, H.G. MOSER
(May 2002)

334 Ichthyoplankton and station data for Manta (surface) tows taken on California Cooperative Oceanic Fisheries Investigations Survey Cruises in 1998.
D.A. AMBROSE, R.L. CHARTER, H.G. MOSER
(May 2002)

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(May 2002)

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(May 2002)

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(June 2002)

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W. WATSON, E.M. SANDKNOP, S.R. CHARTER, D.A. AMBROSE, R.L. CHARTER, and H.G. MOSER
(June 2002)