NOAA Technical Memorandum NMFS

JULY 2001

REPORT OF OCEANOGRAPHIC STUDIES CONDUCTED DURING THE 1999 EASTERN TROPICAL PACIFIC OCEAN SURVEY ON THE RESEARCH VESSELS *DAVID STARR JORDAN, and McARTHUR*

Valerie A. Philbrick
Paul C. Fiedler
Joshua T. Fluty
Stephen B. Reilly

NOAA-TM-NMFS-SWFSC-308

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

The National Oceanic and Atmospheric Administration (NOAA), organized in 1970, has evolved into an agency which establishes national policies and manages and conserves our oceanic, coastal, and atmospheric resources. An organizational element within NOAA, the Office of Fisheries is responsible for fisheries policy and the direction of the National Marine Fisheries Service (NMFS).

In addition to its formal publications, the NMFS uses the NOAA Technical Memorandum series to issue informal scientific and technical publications when complete formal review and editorial processing are not appropriate or feasible. Documents within this series, however, reflect sound professional work and may be referenced in the formal scientific and technical literature.

NOAA Technical Memorandum NMFS
This TM series is used for documentation and timely communication of preliminary results, interim reports, or special purpose information. The TMs have not received complete formal review, editorial control, or detailed editing.

JULY 2001

REPORT OF OCEANOGRAPHIC STUDIES CONDUCTED DURING THE 1999 EASTERN TROPICAL PACIFIC OCEAN SURVEY ON THE RESEARCH VESSELS *DAVID STARR JORDAN*, AND *McARTHUR*

Valerie A. Philbrick, Paul C. Fiedler, Joshua T. Fluty, and Stephen B. Reilly

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center
P.O. Box 271
La Jolla, California, USA 92038-0271

NOAA-TM-NMFS-SWFSC-308

U.S. DEPARTMENT OF COMMERCE
Donald L. Evans, Secretary
National Oceanic and Atmospheric Administration
Scott B. Gudes, Acting Under Secretary for Oceans and Atmosphere
National Marine Fisheries Service
William T. Hogarth, Acting Assistant Administrator for Fisheries

CONTENTS

LIST OF TABLES

LIST OF FIGURES

REPORT OF OCEANOGRAPHIC STUDIES CONDUCTED DURING THE 1999 EASTERN TROPICAL PACIFIC OCEAN SURVEY ON THE RESEARCH VESSELS *DAVID STARR JORDAN* AND *McARTHUR*

Valerie A. Philbrick, Paul C. Fiedler, Joshua T. Fluty and Stephen B. Reilly

INTRODUCTION

In 1999, the Southwest Fisheries Science Center (SWFSC) conducted the second year of a three-year research project designed to estimate the absolute abundance of dolphin populations in the eastern tropical Pacific Ocean (ETP). The International Dolphin Conservation Program Act (IDCPA), a 1997 amendment to the Marine Mammal Protection Act, required this research to aid in determining if the intentional chase and encirclement of dolphins in the purse-seine fishery for tuna is having a significant adverse impact on depleted dolphin stocks (primarily *Stenella* spp.).

Two research vessels were used for this survey: the NOAA ships *David Starr Jordan* (hereafter referred to as the *Jordan*) and *McArthur*. The vessels operated concurrently in the ETP for four months, from July 28 to December 9, 1999. Approximately the same area and time period were surveyed during each year of the study.

This report describes the types of oceanographic data collected and sampling techniques used, as well as summarizes the data collected aboard the *Jordan*, and *McArthur* during the 1999 *Stenella* Abundance Research Project (STAR) survey. Oceanographic data collected during the first survey in 1998 are reported in Philbrick *et al.* (2001). Separate reports summarize the marine mammal data (Kinzey *et al.* 2000) and the seabird, marine turtle and surface fauna data (Olson *et al.* 2001).

OBJECTIVES

The primary objective of this survey was to estimate absolute abundance of several dolphin stocks. The secondary objective was to collect physical and biological oceanographic data in the area inhabited by these stocks. The oceanographic data are collected and analyzed to provide information about the effects of large-scale environmental variation on changes in estimated dolphin abundance. Oceanographic and other environmental variables, including chlorophyll *a*, nutrients, temperature, salinity, zooplankton biomass and the occurrence of seabirds and other animals, are sampled concurrently with the dolphin sighting survey. These parameters fluctuate both seasonally and as a result of large-scale ocean-atmosphere interactions, notably the El Niño-Southern Oscillation (ENSO). In addition to year-to-year environmental effects on estimated abundance, studying oceanographic patterns and variability concurrently with the fauna may reveal regional or local associations related to ecosystem processes. This ecosystem approach provides information necessary for understanding the biological basis of dolphin distribution and abundance

STUDY AREA AND ITINERARY

The ships covered the eastern tropical Pacific Ocean from 33°N to 18°S, west to 153°W and east to the coasts of North, Central and South America. These tracklines (Figure 1) were selected to encompass the known ranges of the target dolphin species (Gerrodette *et al.* 1998). The area was systematically surveyed using line-transect methods to estimate dolphin abundance.

The *Jordan* and *McArthur* departed San Diego, California on 28 July, and returned to San Diego on 9 December. The cruise was conducted in six legs on the *Jordan* and five legs on the *McArthur* (see itinerary below). The *Jordan* had an unscheduled port stop during leg IV in Puerto Ayora, Ecuador (Galapagos Islands) due to a medical emergency and equipment repairs.

The itinerary for each ship was as follows:

	Jordan	**McArthur**
Leg I		
Departure	San Diego, California 28 July	San Diego, California 28 July
Arrival	Manzanillo, Mexico 16 August	Honolulu, Hawaii 26 August
Leg II		
Departure	Manzanillo, Mexico 20 August	Honolulu, Hawaii 01 September
Arrival	Acapulco, Mexico 09 September	Puntarenas, Costa Rica 29 September
Leg III		
Departure	Acapulco, Mexico 13 September	Puntarenas, Costa Rica 05 October
Arrival	Puntarenas, Costa Rica 01 October	Acapulco, Mexico 23 October
Leg IV (A)		
Departure	Puntarenas, Costa Rica 08 October	Acapulco, Mexico 27 October
Arrival	Puerto Ayora, Ecuador 13 October	Manzanillo, Mexico 17 November
Leg IV (B)		
Departure	Puerto Ayora, Ecuador 18 October	
Arrival	Callao, Peru 28 October	
Leg V		
Departure	Callao, Peru 01 November	Manzanillo, Mexico 21 November
Arrival	Panama City, Panama 15 November	San Diego, California 09 December
Leg VI		
Departure	Panama City, Panama 19 November	
Arrival	San Diego, California 09 December	

MATERIALS AND METHODS

Oceanography

Temperature and salinity of surface water were measured continuously and recorded in digital form. Seawater was sampled from an intake 3 meters below the surface by a Sea-Bird Electronics (SBE) thermosalinograph (Model SBE-21). A Windows[1] data acquisition program (WinDACS; Holland 1993) recorded the data on a laptop computer with a serial connection to a Sea-Bird junction box. GPS position information was appended to the data stream through the box's NMEA 0183 input port. The ships' Scientific Computing System (SCS) also collected these data, as well as information from other navigational and weather sensors. Discrete bucket temperatures and salinity samples were collected at regular intervals to verify thermosalinograph readings.

Expendable bathythermograph (XBT) drops, to 760 meters depth, were made daily at 0900, 1200 and 1500 hours (local ship time). On the *McArthur*, the Shipboard Environmental (data) Acquisition System (SEAS), developed by NOAA, collected data from the Sippican Deep Blue probes. On the *McArthur*, low resolution, unprocessed XBT data were transmitted in real-time over the Global Telecommunications System after acquisition by the SEAS. The *Jordan* used Sippican software to acquire data, and conversion to the SEAS format was not possible at sea. The XBT data presented here (full resolution) were processed after the cruise according to guidelines presented in Bailey *et al.* (1994).

Conductivity, temperature and depth (CTD) casts were made each morning before sunrise and each evening after sunset using a Sea-Bird Electronics 911*plus* CTD and General Oceanics rosette system. The CTD was lowered to 1000 meters and sensors connected to shipboard computers measured conductivity (salinity), temperature and pressure (depth). Water samples were collected on all CTD casts for salinity calibration, nutrient and phytoplankton pigment analysis. Samples for ^{14}C-uptake incubations were taken only from morning casts.

CTD cast data were processed using Sea-Bird Electronics' software package, SEASOFT©, version 4.236. Standard processing following the manufacturers instructions were used with the pre-cruise calibration coefficients and post-cruise calibration adjustments.

Hydrochloric acid (2%) and Micro®-washed General Oceanics Niskin bottles (1.7-liter on the *Jordan* and 5-liter on the *McArthur*) were retrofitted with silicon rubber o-rings in the valves and endcaps. Silicon rubber tubing was used as the closing mechanism. On morning casts, Niskin bottles 1 (surface) to 9 were tripped at 7 variable light depths and 2 additional depths less than 200 m as determined by the "ZECALC" program (see below). Two additional bottles were tripped at 500 m and 1000 m (or bottom) for salinity calibration samples. On evening casts, bottle samples were collected from 12 standard depths (0, 20, 40, 60, 80, 100, 120, 140, 170, 200, 500, 1000 m).

Nine samples from $\leq$ 200 m were collected for chlorophyll *a* (275 ml each) and nutrient (15 ml each) analysis at each station. Chlorophyll *a* and phaeophytin were determined by the

1 Windows is a registered trademark of the Microsoft Corporation.

fluorometric technique (Holm-Hansen *et al.* 1965) using a Turner Designs Model 10-AU fluorometer calibrated with chlorophyll *a* standards (Turner Designs). 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 (or twelve on the first cast of each leg) were also collected and analyzed on a Guildline Instruments AutoSal® salinometer (Model 8400) calibrated during each run with IAPSO[2] standard seawater.

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, ZECALC, calculated an initial estimate of euphotic zone depth (1% light level) from pigment profiles observed on previous ETP cruises (1986-1990, 1992, 1993, 1998) according to the spectral model of attenuation by Morel (1988). This estimate was adjusted by a few meters when euphotic zone depths estimated from observed pigment concentrations at preceding stations were much deeper or shallower than predicted.

Samples were drawn into conditioned screw cap "Vitro" glass 150 ml bottles (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 in 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-phenyl-ethylamine 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 processed after the cruise at the SWFSC.

Net Tows

On each ship, in complete darkness after the evening CTD cast, a Manta net was towed at the surface for 15 minutes. Following the manta tow on the *McArthur*, a Bongo net was towed obliquely from 200 meters depth for 15 minutes. This is a paired zooplankton net frame with two 333-micrometer (μm) mesh nets, fitted with a flowmeter in the outboard side. A sample was collected only from the outboard net, preserved in 5% buffered formalin, then labeled and stored for post-cruise analysis.

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

When time allowed, both ships also used a ½ meter ring net, with 333-μm mesh, towed obliquely from 200 meters depth for 15 minutes. Samples were preserved in buffered formalin, then labeled and stored for later analysis.

Bongo net plankton volumes were converted to ring net equivalent plankton volumes using a factor of 0.43. Bongo nets are more efficient samplers of zooplankton due to lower avoidance. In 86 sets of paired net tows (one immediately following the other) during 1998 and 1999, the mean ratio of ring net plankton volume to Bongo net plankton volume was 0.43 ±0.02 (SE).

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 surface and a depth of 500 meters (actually 5 m below the transducer, or about 9 m, and 504 m). Nominal ping interval was 5 seconds; thirty pings were averaged every three to seven minutes to reduce data volume, depending on the central processing unit (CPU) speed of the ADA PC. Data collection and processing were similar to the methods described in Fiedler, *et al.* (1998). Acoustic backscatter profiles were corrected for variation in time-varied gain and sound absorption using observed sound speed profiles derived from CTD data.

RESULTS

Oceanography

Figure 1 illustrates cruise tracks for the *Jordan* and *McArthur*. The total number of oceanographic casts, net tows and samples collected on the *Jordan* and *McArthur* are presented in Tables 1 and 2, respectively.

Figure 2 shows the locations of the 194 *Jordan* and 199 *McArthur* CTD casts. Tables 3 and 4 are CTD cast summaries for each ship, including the number of samples taken per station (chlorophyll, productivity, nutrient, and salinity) for which data exist. There were no bottle samples for station number 117 on the *Jordan,* as it was a calibration cast for a TOGA/TAO buoy (8°N, 95°W). CTD stations where samples were not collected due to equipment malfunction or lack of processing time are blank. In general, the CTD water sample salinities on all three ships agreed with the CTD sensor values to within ±0.006 PSU (practical salinity units).

Figure 3 shows XBT deployment locations (655 total drops) for both ships.

Sea surface temperature (Figure 4) and thermocline depth (Figure 5) are plotted from both CTD and XBT data. Surface temperature and salinity data from the thermosalinograph are presented in Figure 6.

Surface chlorophyll concentrations from the *Jordan* and *McArthur* are shown in Figure 7.

Nutrient samples (4274 total) are in frozen storage, to be analyzed for nitrate, nitrite, silicate and phosphate at a later time.

Primary productivity data integrated within the euphotic zone are shown in Figure 8.

All CTD, XBT and sample data will be submitted to NOAA/National Oceanographic Data Center following this publication.

Net Tows

A total of 196 Manta tows was completed on this cruise: 98 on the *Jordan*, and 98 on the *McArthur*. A total of 69 Bongo tows was completed on the *McArthur*. All Manta and Bongo samples have been sorted and identified. Results will be presented in a separate technical memorandum (Watson, *et al.* in prep). The 12 *Jordan* (legs 4 and 5 only) and 66 *McArthur* ring net samples have been volumed, but not sorted or identified. Zooplankton volumes (ml $1000m^{-3}$) from ring and Bongo net tows are shown in Figure 9.

Acoustic Backscatter

In general, attenuation of the 200 kHz pulse was too high for the backscatter data to be useful at depths below about 50 m. Echograms (time-depth plots) derived from the archived 38 kHz backscatter data show detailed and informative views of the distribution of scatterers in the water column, but are too extensive to include in this report. Results are summarized by contour plots of daily mean backscatter in the surface layer (5-100 m) during the day (0800-1600 L) and night (2000-0400 L) in Figure 10. The day-night difference reflects the importance of a deep scattering layer that moved up into and down out of the surface layer during hours of the day near sunset and sunrise, respectively.

ACKNOWLEDGEMENTS

The authors wish to commend all the officers and crews of the research vessels *Jordan* and *McArthur* for their considerable time and skilled efforts in making this cruise a success. Special thanks go to oceanographers Kerry Kopitsky and Kathy Noyes; the *McArthur* Chief Survey Technician Russell Haner; electronics technicians and other scientists who collected these data at sea. We are grateful to LT Anne Nimershiem for her invaluable logistical assistance and to Robert Holland, who provided several data processing programs and plots for this report. We also thank Dr. Lisa Ballance, Dr. Tim Gerrodette, and Paula Olson for reviewing this manuscript.

LITERATURE CITED

Bailey, R., A. Gronell, H. Phillips, E. Tanner, and G. Meyers. 1994. Quality control cookbook for XBT data (expendable bathythermograph data): Version 1.1. Report. Marine Laboratories. CSIRO Australia, (221): 84p.

Chavez, F. P. and R. T. Barber. 1987. An estimate of new production in the equatorial Pacific. Deep-Sea Res. 34: 1229-1243.

Fiedler, P. C., J. Barlow, and T. Gerrodette. 1998. Dolphin prey abundance determined from acoustic backscatter data in eastern Pacific surveys. Fish. Bull., U.S. 96:237-247.

Gerrodette, T., P. Olson, D. Kinzey, A. Anganuzzi, P. Fiedler, and R. Holland. 1998. Report of the survey design meeting for estimating abundance of eastern tropical Pacific dolphins, 1998-2000. SWFSC Admin. Rep., La Jolla, LJ-98-03, 25 p.

Holland, R. C. 1992. A program for the Microsoft® Windows™ environment to collect analog-to-digital and serial communication data on a personal computer based system. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-170, 11 p.

Holm-Hansen, O., C. J. Lorenzen, R. W. Holmes, and J. D. Strickland. 1965. Fluorometric determination of chlorophyll. J. Cons. Perm. Int. Explor. Mer, 30: 3-15.

Kinzey, D., T. Gerrodette, J. Barlow, A. Dizon, W. Perryman, P. Olson. 2000. Marine mammal data collected during a survey in the eastern tropical Pacific Ocean aboard the NOAA ships *McArthur* and *David Starr Jordan*, July 28 - December 9, 1999. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-293, 89 p.

Morel, A. 1988. Optical modeling of the upper ocean in relation to its biogenous matter content (Case I waters). J. Geophys. Res. 93: 10,749-10,768.

Olson, P., R. Pitman, L. T. Ballance, K. R. Hough, P. Dutton, and S. B. Reilly. 2001. Summary of seabird, marine turtle, and surface fauna data collected during a survey in the eastern tropical Pacific Ocean July 28 - December 9, 1999. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-301, 55 p.

Philbrick, V. A., P. C. Fiedler, J. T. Fluty, and S. B. Reilly. 2001. Report of oceanographic studies conducted during the 1998 eastern tropical Pacific Ocean survey on the research vessels *David Starr Jordan*, *McArthur* and *Endeavor*. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-307, 35 p.

Watson, W, E. M. Sandknop, S. R. Charter, D. A. Ambrose, R. L. Charter, and H. G. Moser. In prep. Ichthyoplankton and station data for Manta (surface) and Bongo (oblique) tows taken during a survey in the eastern tropical Pacific, July 28–December 9, 1999. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC.

Table 1. Summary of data collected aboard the *Jordan*, 28 July – 9 December 1999.

	LEG 1	LEG 2	LEG 3	LEG 4	LEG 5	LEG 6	TOTALS
CTD casts	34	36	33	29	26	36	194
CTD chlorophyll samples	340	360	327	270	260	350	1907
Surface chlorophyll samples	72	75	67	55	54	65	388
Primary productivity samples	112	126	112	91	77	119	637
Nutrient samples	368	396	359	308	286	396	2113
Salinity samples	71	77	70	62	52	88	420
XBT drops	50	64	56	48	42	64	324
Manta tows	17	18	17	15	13	19	99
Bongo tows	0	0	0	0	0	0	0
Ring net tows	0	0	0	6	6	0	12

Table 2. Summary of data collected aboard the *McArthur*, 28 July – 9 December 1999.

	LEG 1	LEG 2	LEG 3	LEG 4	LEG 5	TOTALS
CTD casts	50	45	34	40	30	199
CTD chlorophyll samples	478	445	329	400	300	1952
Surface chlorophyll samples	110	105	66	77	63	421
Primary productivity samples	166	161	111	133	98	669
Nutrient samples	528	491	372	440	330	2161
Salinity samples	118	130	98	110	90	546
XBT drops	82	82	52	61	54	331
Manta tows	26	17	18	21	16	98
Bongo tows	22	5	7	20	15	69
Ring net tows	4	9	17	20	16	66

Table 3. *Jordan* 1999 CTD cast summary: station number, date, time, location, depth of cast (m), and numbers of samples for phytoplankton pigments (chl), primary production (prod), nutrients and salinity. Station dates and times are in Greenwich Mean Time. Negative latitude values indicate southern (S) positions and negative longitude values indicate western (W) positions.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
1	7/29	1212	30.75	-116.54	901	10	7	11	2
2	7/30	1158	28.77	-116.01	800	10	7	11	12
3	7/31	0356	27.46	-115.43	1012	10		11	2
4	7/31	1156	27.00	-115.42	1010	10	7	11	2
5	8/1	0348	26.39	-113.76	153	8		8	1
6	8/2	0339	24.24	-112.40	701	10		11	2
7	8/2	1154	24.14	-113.26	1008	10	7	11	2
8	8/3	0353	23.09	-114.10	1002	10		11	2
9	8/3	1153	22.75	-113.60	1006	10	7	11	2
10	8/4	0339	23.46	-111.66	566	10		11	2
11	8/4	1210	23.67	-111.88	179	11	7	11	11
12	8/5	0325	22.76	-110.62	1008	10		11	2
13	8/5	1153	22.20	-111.66	1004	10	7	11	2
14	8/6	0339	20.87	-113.07	1006	10		11	2
15	8/6	1152	20.49	-112.34	1010	10	7	11	2
16	8/7	0323	21.62	-110.51	1004	10		11	2
17	8/7	1153	21.86	-109.64	1010	10	7	11	2
18	8/8	0323	20.32	-109.68	1002	10		11	2
19	8/8	1156	19.34	-109.60	1004	10	7	11	2
20	8/9	0311	20.09	-108.37	1012	10		11	2
21	8/9	1139	20.86	-108.00	1012	10	7	11	2
22	8/10	0308	22.40	-107.77	1004	10		11	2
23	8/10	1145	23.03	-108.24	1006	10	7	11	2
24	8/11	0325	24.47	-109.41	1002	10		11	2
25	8/11	1121	25.27	-110.15	1006	10	7	11	2
26	8/12	0337	25.30	-109.29	689	10		11	2
27	8/12	1154	24.86	-108.45	107	8	7	8	1
28	8/13	0328	23.05	-107.37	598	10		11	2
29	8/13	1142	22.56	-106.87	1006	10	7	11	2
30	8/14	0259	21.25	-105.84	423	10		11	2
31	8/14	1134	20.92	-106.10	600	10	7	11	2
32	8/15	0311	19.69	-107.17	1004	10		11	2
33	8/15	1208	19.29	-106.81	1010	10		11	2
34	8/16	0312	19.21	-105.30	1004	10		11	2
35	8/21	0258	18.38	-105.31	1010	10		11	2
36	8/21	1144	17.50	-105.98	1006	10	7	11	2
37	8/23	0255	14.04	-108.71	1010	10		11	2
38	8/23	1200	13.22	-109.39	1004	10	7	11	3
39	8/24	0259	12.12	-110.70	1008	10		11	2
40	8/24	1213	11.43	-111.43	1014	10	7	11	2
41	8/25	0311	10.06	-112.54	1012	10		11	2

Table 3. (*Jordan* 1999 CTD cast summary) continued.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
42	8/25	1227	9.48	-113.20	1004	10	7	11	2
43	8/26	0326	10.80	-114.58	1010	10		11	2
44	8/26	1227	11.56	-115.34	1008	10	7	11	2
45	8/27	0326	11.89	-116.99	1008	10		11	12
46	8/27	1240	11.57	-118.03	1012	10	7	11	2
47	8/28	0336	10.95	-119.90	1002	10		11	2
48	8/28	1241	10.35	-119.08	1008	10	7	11	2
49	8/29	0327	9.12	-117.53	1010	10		11	2
50	8/29	1242	8.39	-117.90	1012	10	7	11	2
51	8/30	0324	7.07	-119.28	1006	10		11	2
52	8/30	1254	6.28	-119.71	1006	10	7	11	2
53	8/31	0325	5.32	-118.44	1008	10		11	2
54	8/31	1241	5.44	-117.65	1010	10	7	11	2
55	9/1	0322	6.55	-115.87	1010	10		11	2
56	9/1	1225	7.07	-114.83	1012	10	7	11	2
57	9/2	0303	8.14	-112.82	1010	10		11	2
58	9/2	1211	7.73	-111.67	1004	10	7	11	2
59	9/3	0252	6.48	-109.98	1008	10		11	2
60	9/3	1210	5.80	-108.95	1004	10	7	11	2
61	9/4	0237	5.62	-107.65	1004	10		11	2
62	9/4	1153	6.70	-107.22	1004	10	7	11	2
63	9/5	0243	8.67	-106.39	1008	10		11	2
64	9/5	1153	9.72	-106.00	1010	10	7	11	2
65	9/6	0235	11.75	-105.14	1004	10		11	2
66	9/6	1137	12.65	-104.81	1006	10	7	11	2
67	9/7	0236	14.64	-104.04	1010	10		11	2
68	9/7	1136	15.48	-103.64	1008	10	7	11	2
69	9/8	0221	17.12	-103.06	1006	10		11	2
70	9/8	1150	17.65	-102.74	1008	10		11	6
71	9/14	0211	15.45	-100.09	1008	10		11	2
72	9/14	1122	14.33	-100.20	1010	10	7	11	2
73	9/15	0207	12.37	-100.46	1006	10		11	2
74	9/15	1121	11.32	-100.51	1006	10	7	11	2
75	9/16	1122	8.52	-100.79	1010	10	7	11	2
76	9/17	0208	6.77	-100.93	1010	10		11	2
77	9/17	1121	5.66	-101.08	1010	10	7	11	2
78	9/18	0207	6.93	-100.36	1012	10		11	2
79	9/18	1123	7.98	-99.84	1004	10	7	11	2
80	9/19	0205	9.45	-99.07	1008	10		11	6
81	9/19	1122	10.52	-98.59	1010	10	7	11	2
82	9/20	0151	12.30	-97.69	1012	10		11	2
83	9/20	1107	13.27	-97.21	1012	10	7	11	2
84	9/21	0152	14.75	-96.53	1004	10		11	2
85	9/21	1105	15.59	-96.04	986	10	7	11	2
86	9/22	0152	13.98	-95.70	1010	10		11	2
87	9/22	1107	12.66	-95.36	1008	10	7	11	2
88	9/23	0135	10.64	-94.87	1010	10		11	2
89	9/23	1104	9.38	-94.68	1008	10	7	11	2
90	9/24	0135	7.42	-94.23	1006	10		11	2
91	9/24	1052	6.28	-94.04	1008	10	7	11	2
92	9/25	0137	5.89	-93.38	1010	10		11	2
93	9/25	1051	6.97	-92.87	1008	10	7	11	2

Table 3. (*Jordan* 1999 CTD cast summary) continued.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
94	9/26	0147	8.70	-91.99	1008	10		11	2
95	9/26	1051	9.74	-91.56	1010	10	7	11	2
96	9/27	0122	11.52	-90.70	1006	10		11	2
97	9/27	1037	12.54	-90.22	1004	10	7	11	2
98	9/28	0112	12.85	-89.73	451	10		11	2
99	9/28	1038	11.92	-89.60	1002	10	7	11	2
100	9/29	0122	11.46	-89.22	1008	10		11	2
101	9/29	1036	10.38	-88.14	1006	10	7	11	2
102	9/30	0104	10.74	-86.63	873	10		11	2
103	9/30	1105	10.33	-86.11	121	7		7	2
104	10/9	0057	8.12	-83.64	1010	10		11	6
105	10/9	1041	7.38	-84.38	1006	10	7	11	2
106	10/10	0055	6.23	-85.53	1006	10		11	2
107	10/10	1021	5.43	-86.05	1010	10	7	11	2
108	10/11	0108	4.08	-87.01	1004	10		11	2
109	10/11	1022	3.14	-87.60	1010	10	7	11	2
110	10/12	0108	1.47	-88.68	1010	10		11	2
111	10/12	1039	0.54	-89.32	1010	10	7	11	2
112	10/13	0127	-0.31	-90.91	899	10		11	2
113	10/19	0121	-4.11	-92.48	1012	10		11	2
114	10/19	1054	-5.04	-93.12	1006	10	7	11	2
115	10/20	0141	-6.87	-94.26	1008	10		11	2
116	10/20	1056	-7.91	-94.96	1014	10	7	11	2
117	10/20	1422	-8.02	-95.06	508			11	2
118	10/21	0139	-9.20	-95.61	1004	10		11	2
119	10/21	1055	-9.70	-94.65	1002	10	7	11	2
120	10/22	0209	-10.38	-93.18	1010	10		11	2
121	10/22	1038	-10.93	-92.27	1006	10	7	11	2
122	10/23	0123	-11.73	-90.76	1010	10		11	2
123	10/23	1024	-12.26	-89.73	1010	10	7	11	2
124	10/24	0120	-13.23	-88.08	1006	10		11	2
125	10/24	1009	-13.64	-87.03	1008	10	7	11	6
126	10/25	0108	-14.04	-85.42	1004	10		11	2
127	10/25	0955	-14.09	-84.29	1012	10	7	11	2
128	10/26	0052	-14.05	-82.50	1010	10		11	2
129	10/26	0939	-14.08	-81.37	1006	10	7	11	2
130	10/27	0052	-14.29	-79.90	1004	10		11	2
131	10/27	1008	-14.10	-78.68	1004	10		11	2
132	10/28	0039	-13.20	-77.14	1010			11	2
133	11/2	0044	-11.80	-78.20	1006	10		11	2
134	11/2	1009	-11.61	-79.28	1010	10	7	11	2
135	11/3	0054	-11.02	-81.33	1010	10		11	2
136	11/3	0954	-11.02	-82.48	1010	10	7	11	2
137	11/4	0108	-10.44	-84.41	1012	10		11	2
138	11/4	0953	-9.33	-84.38	1004	10	7	11	2
139	11/5	0107	-7.33	-84.45	1006	10		11	2
140	11/5	1006	-6.54	-85.42	1006	10	7	11	2
141	11/6	0109	-5.62	-85.86	1008	10		11	2
142	11/6	1005	-5.49	-84.83	1008	10	7	11	2
143	11/7	0053	-5.35	-83.64	1014	10		11	2
144	11/7	0954	-5.18	-82.53	1014	10		11	2
145	11/8	0053	-4.74	-81.59	1014	10		11	2

Table 3. (*Jordan* 1999 CTD cast summary) continued.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
146	11/8	0953	-3.98	-82.52	1010	10	7	11	2
147	11/9	0052	-3.00	-83.77	1004	10		11	
148	11/9	1007	-2.12	-84.66	1006	10	7	11	
149	11/10	0111	-0.67	-86.35	1016	10		11	2
150	11/10	1021	0.18	-87.30	1006	10	7	11	2
151	11/11	0115	1.45	-87.03	1012	10		11	2
152	11/11	1023	2.38	-86.53	1012	10	7	11	2
153	11/12	0053	3.87	-85.49	1014	10		11	2
154	11/12	1023	4.86	-84.90	1012	10	7	11	
155	11/13	0052	5.89	-83.17	1010	10		11	6
156	11/13	1007	5.86	-81.87	1010	10	7	11	2
157	11/14	1019	6.66	-78.94	1010	10		11	2
158	11/14	0024	5.83	-79.92	1010	10		11	2
159	11/20	0036	6.55	-80.80	1008	10		11	6
160	11/20	1008	6.66	-81.96	1008	9	7	11	2
161	11/21	0040	6.92	-83.85	1008	10		11	2
162	11/21	1023	7.09	-85.11	1006	10	7	11	2
163	11/22	0052	7.42	-86.81	1010	10		11	2
164	11/22	1037	7.48	-88.07	1004	10	7	11	2
165	11/23	0110	7.64	-89.49	1010	9		11	2
166	11/23	1054	7.84	-90.76	1004	10	7	11	2
167	11/24	0108	8.01	-92.27	1012	10		11	2
168	11/24	1108	8.21	-93.58	1012	10	7	11	2
169	11/25	0124	8.48	-94.87	1004	10		11	2
170	11/25	1121	8.51	-96.19	1006	9	7	11	2
171	11/26	0142	8.86	-97.89	1008	10		11	2
172	11/26	1125	8.99	-99.36	1002	10	7	11	2
173	11/27	0153	9.27	-101.34	1008	10		11	2
174	11/27	1136	9.45	-102.80	1010	10	7	11	2
175	11/28	0208	9.65	-104.90	1012	10		11	2
176	11/28	1151	9.91	-106.32	1004	10	7	11	2
177	11/29	0205	10.32	-108.28	1004	10		11	2
178	11/30	0224	10.56	-109.30	1010	10		11	2
179	11/30	1207	11.84	-109.90	1004	10	7	11	2
180	12/1	0224	13.61	-110.20	1010	10		11	2
181	12/1	1237	15.01	-111.32	1004	10	7	11	2
182	12/2	0223	16.70	-112.14	1008	10		11	2
183	12/2	1238	17.61	-112.52	1006	10	7	11	2
184	12/3	0226	18.79	-111.33	1004	10		11	2
185	12/3	1239	19.30	-110.76	825	10	7	11	2
186	12/4	0208	19.43	-111.29	1010	10		11	2
187	12/4	1239	19.30	-110.76	1004	10	7	11	2
188	12/5	0224	19.81	-112.73	1008	10		11	6
189	12/5	1304	22.21	-114.86	1008	10	7	11	2
190	12/6	0223	24.11	-115.68	1012	10		11	2
191	12/6	1320	24.92	-115.73	1006	10	7	11	2
192	12/7	0225	25.91	-116.51	1006	10		11	2
193	12/7	1319	27.45	-116.78	1010	10	7	11	2
194	12/8	0224	29.19	-117.07	1019			11	6

Table 4. *McArthur* 1999 CTD cast summary: station number, date, time, location, depth of cast (m), and numbers of samples for phytoplankton pigments (chl), primary production (prod), nutrients and salinity. Station dates and times are in Greenwich Mean Time. Negative latitude values indicate southern (S) positions and negative longitude values indicate western (W) positions.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
1	7/29	0418	31.31	-116.97	1008	10		11	12
2	7/29	1151	30.94	-118.01	1009	10	7	11	2
3	7/30	0435	29.91	-120.61	1009	10		11	2
4	7/30	1203	29.71	-121.71	1011	10	7	11	2
5	7/31	0425	27.41	-122.09	1009	10		11	2
6	7/31	1223	26.39	-122.09	1009	10	7	11	2
7	8/1	0420	23.74	-122.08	1007	9		10	2
8	8/1	1201	22.77	-122.08	1007	10	7	11	2
9	8/2	0413	20.31	-122.08	1005	10		11	2
10	8/2	1242	19.30	-122.09	1011	10	7	11	2
11	8/3	0404	17.06	-122.08	1006	9		11	2
12	8/3	1240	16.10	-122.09	1010	10	7	11	2
13	8/4	0403	13.78	-122.07	1006	10		11	2
14	8/4	1241	12.68	-122.09	1018	10	7	11	12
15	8/5	0418	10.55	-122.10	1012	10		11	2
16	8/5	1240	9.55	-122.07	1006	10	7	11	2
17	8/6	0404	7.15	-122.03	1002				
18	8/6	1304	7.15	-122.04	1008	4		5	2
19	8/7	0348	4.95	-122.09	1014	8		9	2
20	8/7	1255	3.87	-122.09	1010	10	7	11	2
21	8/8	1258	3.57	-123.02	1002	9	6	10	2
22	8/9	0353	5.16	-124.22	1010	9		10	2
23	8/9	1309	5.62	-124.58	1008	10	7	11	2
24	8/10	0443	7.04	-125.73	1016	10		11	2
25	8/10	1311	7.85	-126.36	1008	10	7	11	2
26	8/10	0406	9.27	-127.71	1016	10		11	2
27	8/10	1307	8.65	-128.75	1010	10	7	11	2
28	8/12	0427	7.64	-130.50	1004	10		11	2
29	8/12	1324	7.11	-131.43	1008	10	7	11	2
30	8/13	0440	6.11	-133.16	1006	10		11	2
31	8/13	1338	5.54	-134.16	1004	10	7	11	2
32	8/14	0441	4.49	-135.98	1016	10		11	2
33	8/14	1354	3.80	-137.19	1008	10	7	11	2
34	8/15	0437	5.05	-138.47	1010	10		11	2
35	8/15	1412	6.10	-138.88	1006	10	7	11	2
36	8/16	0513	8.01	-139.63	701	10		11	2
37	8/16	1415	8.59	-140.24	1024	10		11	2
38	8/17	0512	7.18	-141.76	1006	10		11	1
39	8/17	1408	6.47	-142.54	1010	10	7	11	1
40	8/18	0511	5.08	-144.02	1006	10		11	1
41	8/18	1421	5.79	-144.51	1010	10	7	11	1

Table 4. (*McArthur* 1999 CTD cast summary) continued.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
42	8/19	0512	7.82	-145.41	1008	10		11	1
43	8/19	1423	8.77	-145.91	1012	10	6	11	1
44	8/20	0543	10.20	-146.68	1020	10		11	1
45	8/20	1426	11.41	-147.12	1010	10	7	11	1
46	8/21	0552	9.94	-148.73	1022	10		11	1
47	8/21	1440	9.00	-149.48	1010	10	7	11	1
48	8/22	0545	7.81	-150.75	901	10		11	2
49	8/22	1455	8.12	-151.34	1022	10	7	11	2
50	8/23	0553	8.90	-152.83	1014	10		11	12
51	9/5	1408	13.35	-141.89	1008	10	7	11	2
52	9/6	0706	13.82	-139.73	1010	10		11	12
53	9/6	1355	13.95	-138.78	1008	10	7	11	2
54	9/7	0446	14.38	-137.02	1008	10		11	2
55	9/7	1339	14.51	-135.92	1010	10	7	11	2
56	9/8	0430	15.01	-133.66	1010	10		11	2
57	9/8	1322	15.20	-132.36	1012	8	6	10	2
58	9/9	0428	15.58	-130.37	1008	10		11	2
59	9/9	1327	15.45	-129.49	1010	10	7	11	2
60	9/10	0408	13.59	-129.01	1012	10		11	2
61	9/10	1319	12.32	-128.89	1012	10	7	11	2
62	9/11	0408	10.29	-128.52	1012	10		11	2
63	9/11	1322	8.96	-128.34	1008	10	7	11	2
64	9/12	0439	6.73	-127.96	1008	10		11	2
65	9/12	1306	5.63	-127.80	1008	10	7	11	2
66	9/13	0409	3.96	-126.79	1018	10		11	12
67	9/13	1313	3.21	-125.95	1014	10	7	11	2
68	9/14	0351	1.94	-124.65	1014	9		10	2
69	9/14	1429	1.19	-123.89	1008	10	7	11	2
70	9/15	0355	0.13	-122.65	1006	9		10	2
71	9/15	1310	-0.70	-121.95	1010	10	7	11	2
72	9/16	0335	-2.24	-120.53	1012	10		11	2
73	9/16	1238	-2.92	-119.71	1010	10	7	11	2
74	9/17	0420	-3.09	-117.64	1018	10		11	2
75	9/17	1223	-2.66	-116.53	1010	10	7	11	2
76	9/18	0306	-2.20	-114.91	1008	10		11	2
77	9/18	1222	-1.85	-113.65	1008	10	7	11	2
78	9/19	0251	-1.24	-111.51	1010	10		11	2
79	9/19	1206	-0.91	-110.28	1008	10	7	11	2
80	9/20	0236	-0.51	-108.66	1008	10		11	12
81	9/20	1153	-0.11	-107.43	1010	10	6	11	2
82	9/21	0217	0.38	-105.48	1008	10		11	2
83	9/21	1144	0.74	-104.40	1016	9	6	10	2
84	9/22	0207	1.26	-102.90	1006	10		11	2
85	9/22	1123	1.44	-101.89	1020	10	7	11	2
86	9/23	0205	1.96	-100.10	1010	10		11	2
87	9/23	1122	2.30	-98.81	1010	10	7	11	2

Table 4. (*McArthur* 1999 CTD cast summary) continued.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
88	9/24	0150	2.92	-96.58	1008	10		11	2
89	9/24	1109	3.30	-95.24	1010	10	7	11	2
90	9/25	0136	3.91	-93.09	1008	10		11	2
91	9/25	1054	4.25	-91.79	1008	10	7	11	2
92	9/26	1039	5.34	-87.86	1010	10	7	11	2
93	9/27	0138	5.70	-86.98	1008	10		11	12
94	9/27	1037	6.34	-86.64	1012	10	6	11	2
95	9/28	0103	7.81	-85.70	1010	10		11	2
96	10/6	0055	8.60	-84.68	1008	9		11	12
97	10/6	1024	7.86	-85.06	1010	10	7	11	2
98	10/7	0107	8.20	-87.03	1010	10		11	2
99	10/7	1039	9.00	-87.14	1008	10	7	11	2
100	10/8	0109	10.53	-87.38	1012	10		11	2
101	10/8	1038	11.73	-87.48	358	11	7	12	2
102	10/9	0109	11.87	-87.92	1010	10		11	2
103	10/9	1038	10.96	-88.39	1012	10	7	11	2
104	10/10	0108	9.19	-89.13	1010	10		11	2
105	10/10	1035	8.06	-89.68	1049	10	7	11	2
106	10/11	0118	6.50	-90.35	1010	10		11	2
107	10/11	1035	5.42	-90.85	1016	10	7	11	2
108	10/12	0119	6.61	-91.37	1014	10		11	2
109	10/12	1053	7.63	-91.60	1006	10	7	11	2
110	10/13	0119	9.29	-91.97	1010	10		11	2
111	10/13	1052	10.53	-92.25	1008	10	7	11	2
112	10/14	0122	12.24	-92.64	1012	10		11	12
113	10/14	1053	13.53	-92.91	1008	9	6	10	2
114	10/15	1051	14.00	-94.10	1008	10	7	11	2
115	10/16	0118	12.02	-94.99	1010	9		10	2
116	10/16	1105	10.91	-95.56	1010	10	7	11	2
117	10/17	0132	9.83	-96.06	1012	10		11	2
118	10/17	1105	8.59	-96.65	1010	10	7	11	2
119	10/18	0134	6.58	-97.55	1008	10		11	2
120	10/18	1104	5.50	-98.08	1008	10	7	11	2
121	10/19	0139	6.85	-98.34	1024	10		11	2
122	10/19	1106	7.99	-98.37	1008	10	7	11	2
123	10/20	0135	10.10	-98.42	1010	10		11	2
124	10/20	1122	9.33	-99.09	1012	10	7	11	2
125	10/21	0148	11.04	-98.46	1006	10		11	12
126	10/21	1127	11.83	-98.46	1012	10	7	11	2
127	10/22	0139	13.49	-98.29	1010	10		11	2
128	10/22	1121	14.49	-98.53	1008	10		11	2
129	10/23	0138	15.57	-98.39	1010			11	2
130	10/28	0153	16.14	-101.21	1010	10		11	12
131	10/28	1136	15.07	-101.78	1012	10	7	11	2
132	10/29	0152	13.02	-102.40	1008	10		11	2
133	10/29	1140	11.87	-102.74	1008	10	7	11	2

Table 4. (*McArthur* 1999 CTD cast summary) continued.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
134	10/30	0151	9.73	-103.37	1010	10		11	2
135	10/30	1134	8.61	-103.71	1012	10	7	11	2
136	10/31	0207	6.54	-104.31	1008	10		11	2
137	10/31	1135	5.39	-104.65	1006	10	7	11	2
138	11/1	0211	6.37	-106.03	1010	10		11	2
139	11/1	1155	7.03	-106.66	1010	10	7	11	2
140	11/2	0208	8.70	-108.25	1022	10		11	2
141	11/2	1150	9.76	-108.86	1008	10	7	11	2
142	11/3	0251	10.24	-109.22	1008	10		11	2
143	11/3	1207	9.69	-109.82	1010	10	7	11	2
144	11/4	0221	7.97	-110.81	1008	10		11	12
145	11/4	1206	7.43	-111.83	1010	10	7	11	2
146	11/5	0236	5.80	-113.12	1010	10		11	2
147	11/5	1213	5.36	-113.73	1008	10	7	11	2
148	11/6	0251	7.24	-115.01	1008	10		11	2
149	11/6	1222	8.18	-115.66	1012	10	7	11	2
150	11/7	0250	9.96	-116.90	1010	10		11	2
151	11/7	1235	10.93	-117.57	1012	10	7	11	2
152	11/8	0254	12.73	-118.83	1010	10		11	2
153	11/8	1237	13.42	-118.16	1022	10	7	11	2
154	11/9	0235	14.37	-116.34	1012	10		11	2
155	11/9	1221	13.77	-115.33	1012	10	7	11	2
156	11/10	0236	12.56	-113.68	1012	10		11	2
157	11/10	1218	13.40	-113.39	1014	10	7	11	2
158	11/11	0235	15.48	-113.13	1010	10		11	12
159	11/11	1220	15.93	-111.91	1010	10	7	11	2
160	11/12	0221	15.57	-110.10	1012	10		11	2
161	11/12	1206	14.65	-109.32	1008	10	7	11	2
162	11/13	0220	13.15	-108.04	1010	10		11	2
163	11/13	1205	14.48	-108.27	1010	10	7	11	2
164	11/14	0220	13.13	-109.30	1010	10		11	2
165	11/14	1203	12.95	-107.97	1008	10	7	11	2
166	11/15	0220	12.34	-106.85	1010	10		11	2
167	11/15	1154	13.40	-106.37	1008	10	7	11	2
168	11/16	0148	14.93	-105.49	1012	10		11	12
169	11/16	1150	16.13	-104.93	1010	10		11	2
170	11/22	0152	18.85	-105.63	1009	10		11	12
171	11/22	1219	18.61	-107.08	1007	10	7	11	2
172	11/23	0219	17.12	-108.40	1015	10		11	2
173	11/23	1221	16.76	-109.18	1015	10	7	11	2
174	11/24	0219	17.61	-111.23	1019	10		11	2
175	11/24	1233	17.16	-112.23	1011	10	7	11	2
176	11/25	0235	16.34	-114.20	1011	10		11	2
177	11/25	1237	15.96	-115.42	1012	10	7	11	2
178	11/26	0235	15.58	-117.06	1010	10		11	2
179	11/26	1249	14.95	-117.99	1010	10	7	11	2

Table 4. (*McArthur* 1999 CTD cast summary) continued.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
180	11/27	0250	14.42	-119.95	1008	10		11	2
181	11/27	1249	15.65	-119.75	1010	10	7	11	2
182	11/28	0253	16.86	-117.96	1009	10		11	2
183	11/28	1248	17.60	-116.87	1007	10	7	11	2
184	11/29	0237	18.98	-115.86	1009	10		11	12
185	11/29	1251	19.65	-117.04	1009	10	7	11	2
186	11/30	0237	19.16	-119.25	1011	10		11	2
187	11/30	1249	20.40	-119.85	1009	10	7	11	2
188	12/1	0235	21.37	-117.89	1015	10		11	2
189	12/1	1252	21.61	-117.25	1009	10	7	11	2
190	12/2	0222	22.33	-115.37	1009	10		11	2
191	12/2	1250	22.69	-116.06	1013	10	7	11	2
192	12/3	1308	22.70	-118.84	1011	10	7	11	2
193	12/4	0321	23.91	-119.87	1007	10		11	2
194	12/4	1320	23.94	-119.09	1013	10	7	11	2
195	12/5	0319	24.94	-117.56	1011	10		11	2
196	12/5	1320	25.00	-117.62	1009	10	7	11	2
197	12/6	0321	26.77	-117.65	1011	10		11	12
198	12/6	1319	27.42	-117.76	1007	10		11	2
199	12/7	0306	29.12	-117.85	1013	10		11	2

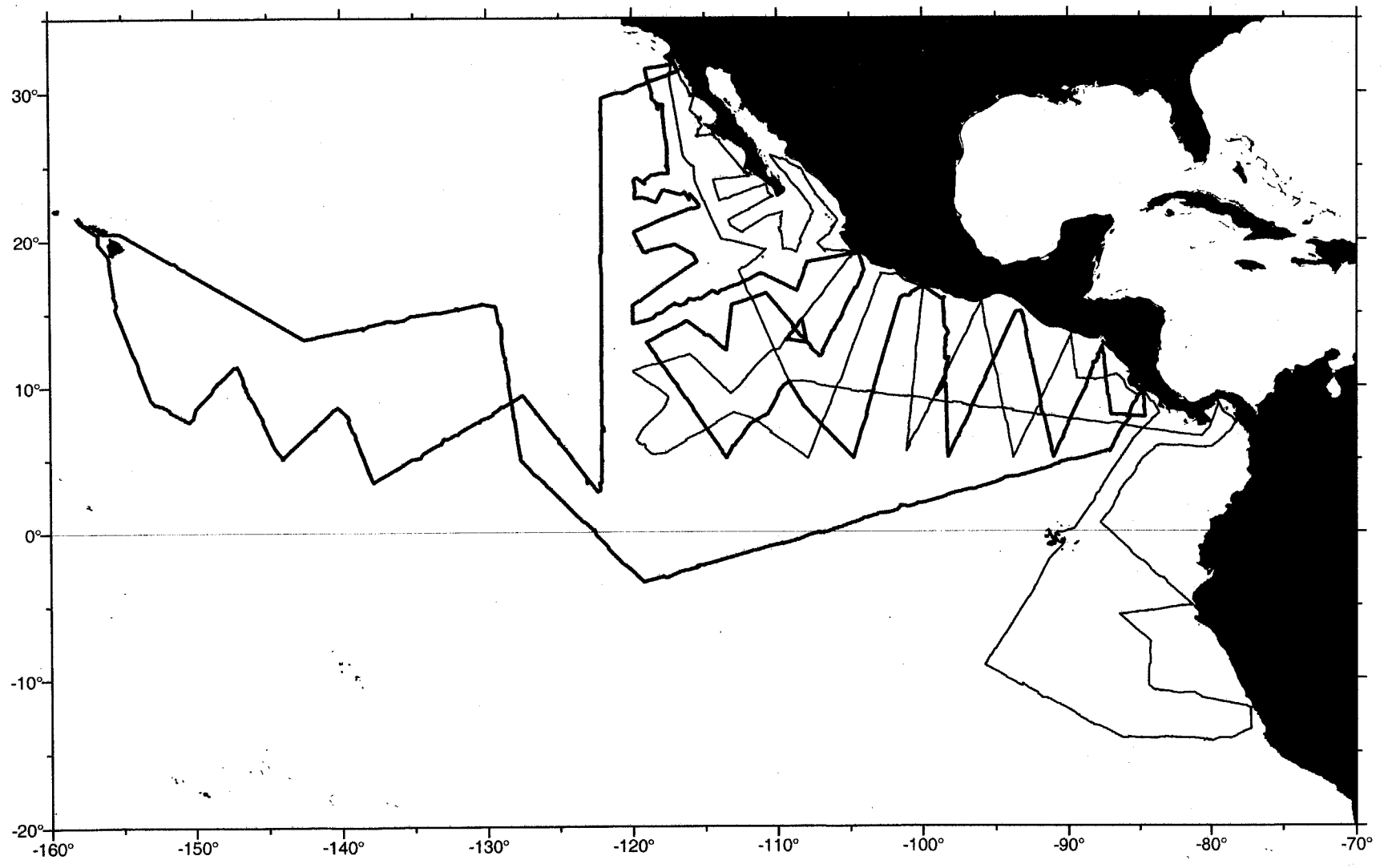


Figure 1. Cruise tracks, *Jordan* (—) and *McArthur* (—), 28 July - 9 December 1999.

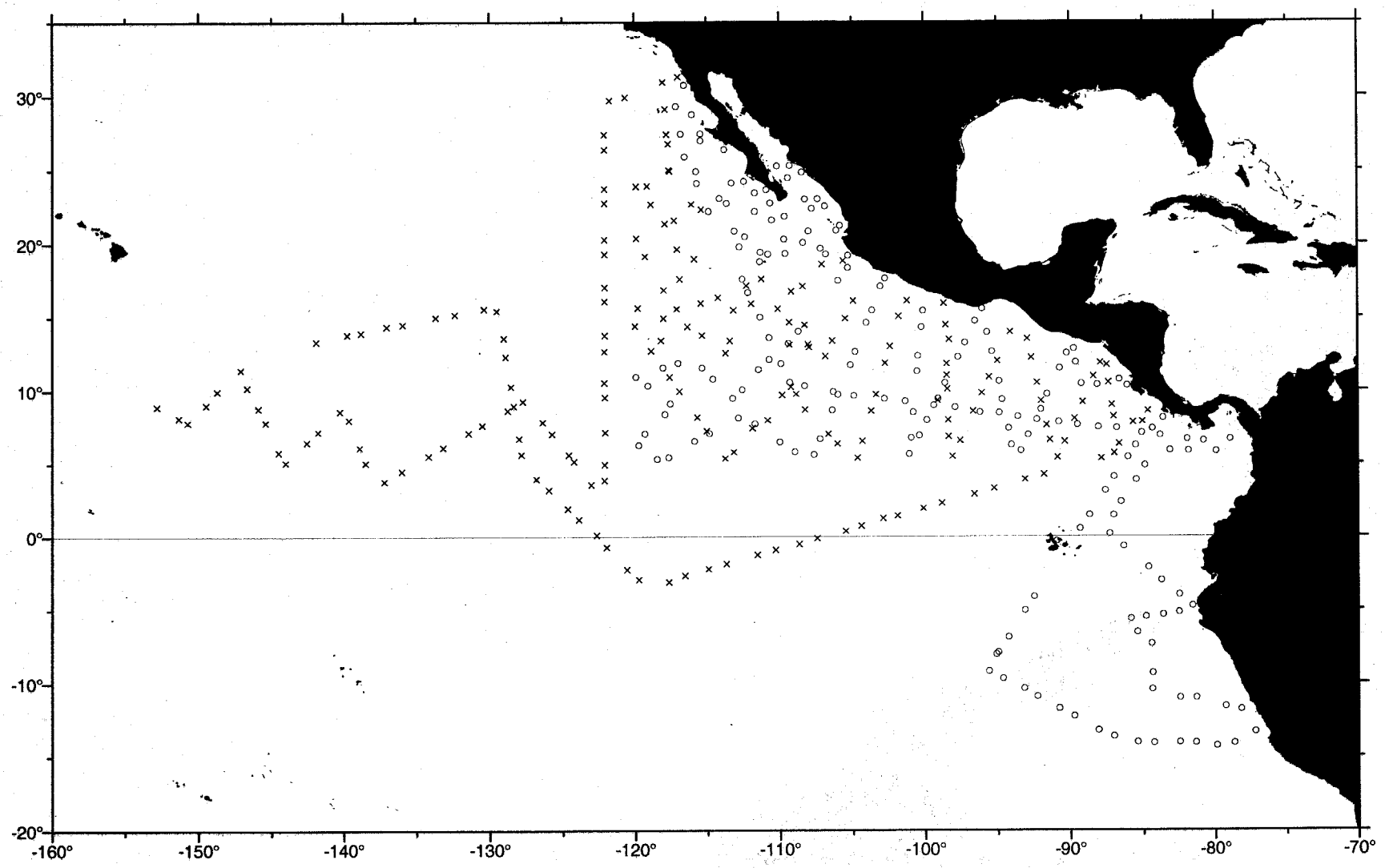


Figure 2. CTD stations, *Jordan* (○) and *McArthur* (x) 28 July - 9 December 1999.

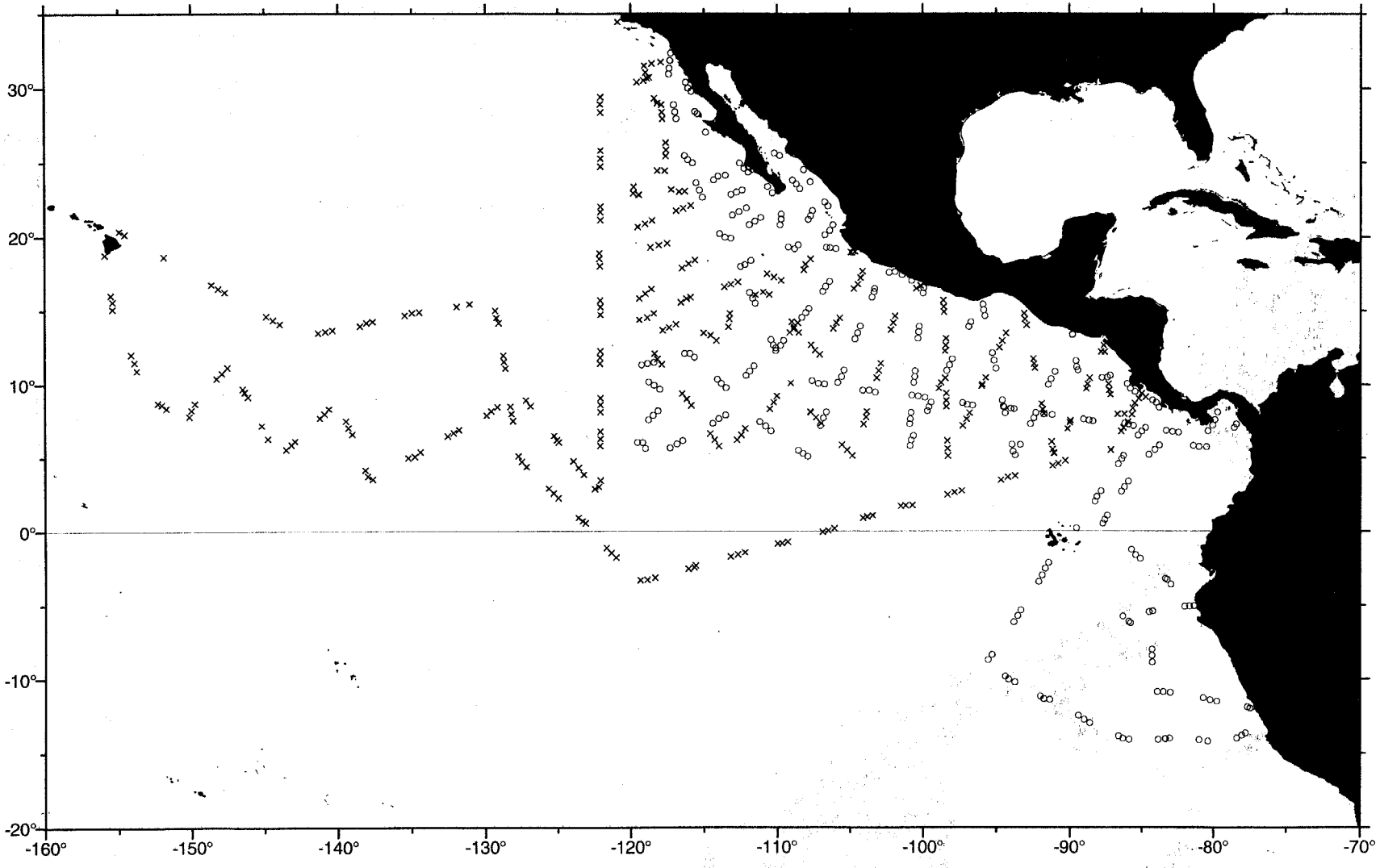


Figure 3. XBT deployments, *Jordan* (○) and *McArthur* (x) 28 July - 9 December 1999.

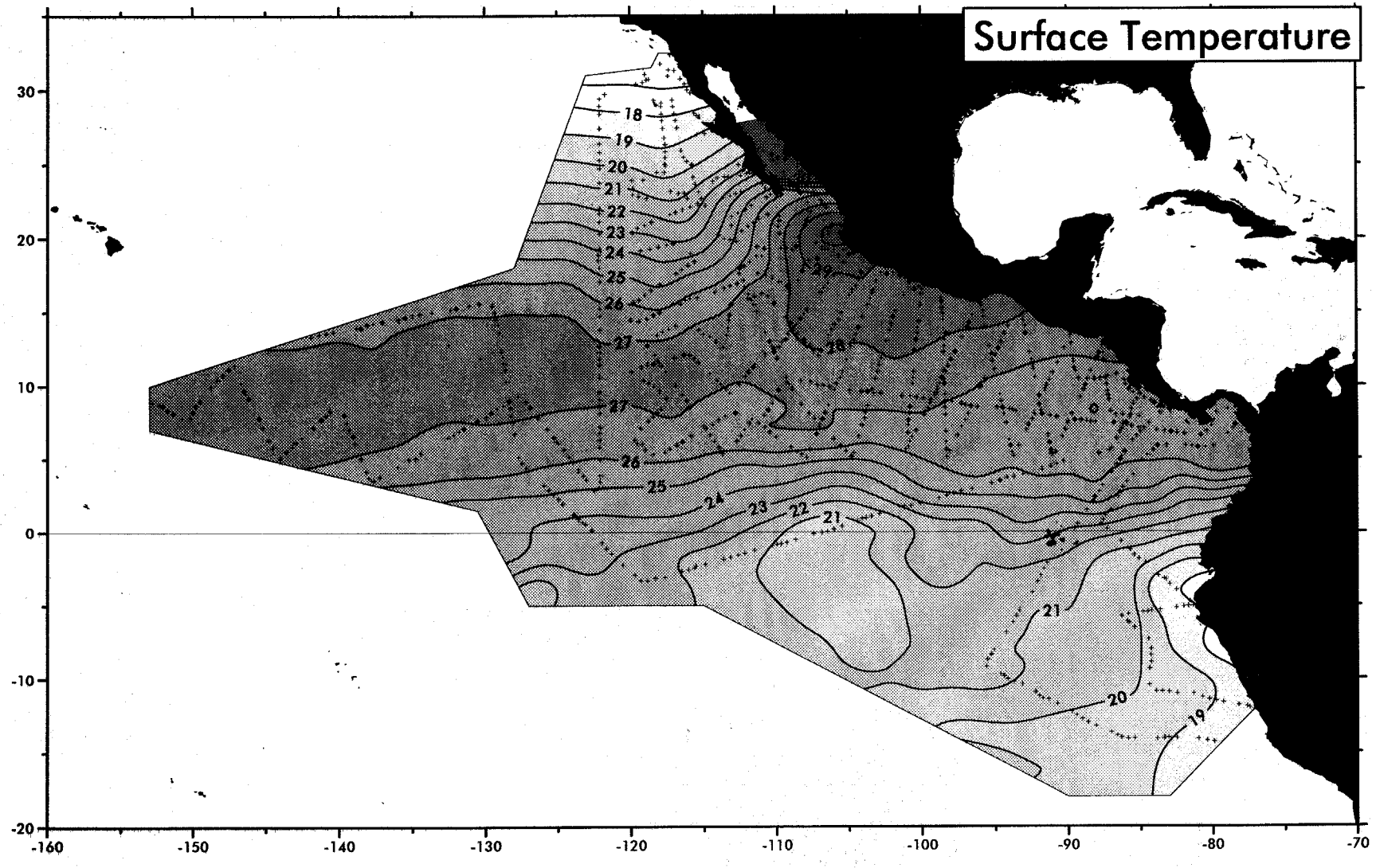


Figure 4. Sea surface temperature (°C) from CTD and XBT profiles (+), 28 July - 9 December 1999.

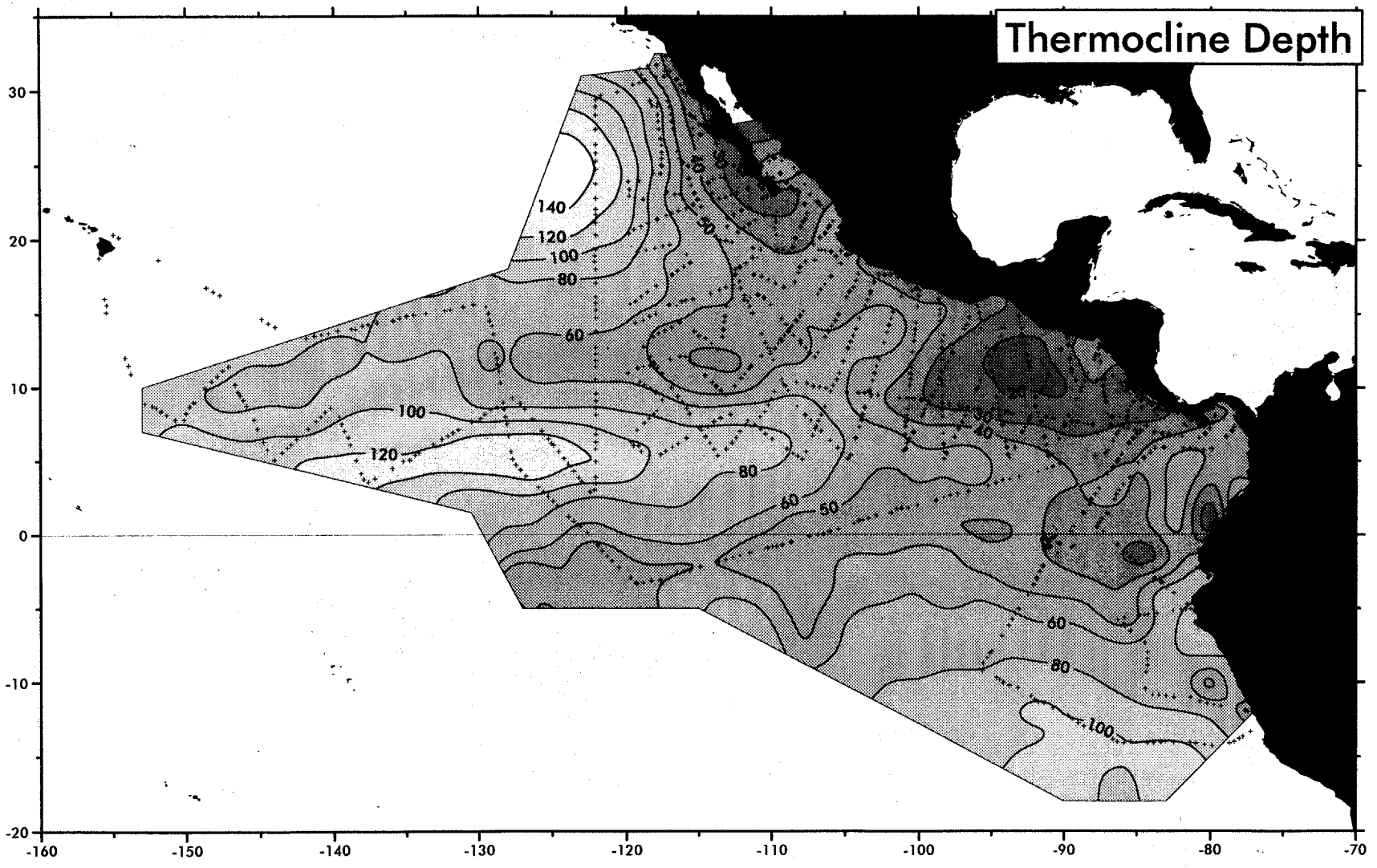
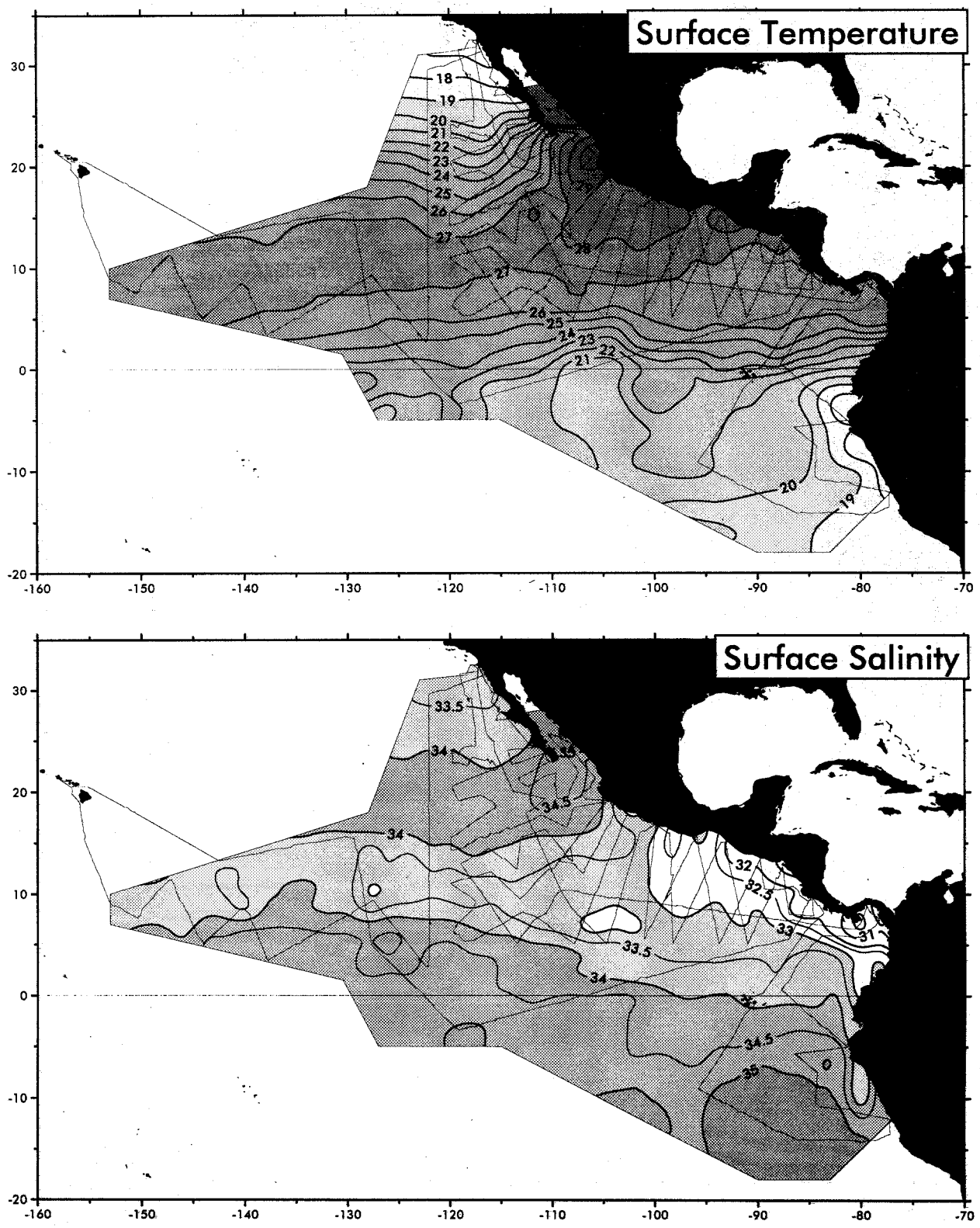


Figure 5. Thermocline depth (m, depth of maximum temperature gradient over an interval of 30 m) from CTD and XBT profiles (+), 28 July - 9 December 1999.

Figure 6. Sea surface temperature (°C) and salinity (PSU) from thermosalinograph data, 28 July - 9 December 1999. Thin lines indicate cruise tracks for both ships.



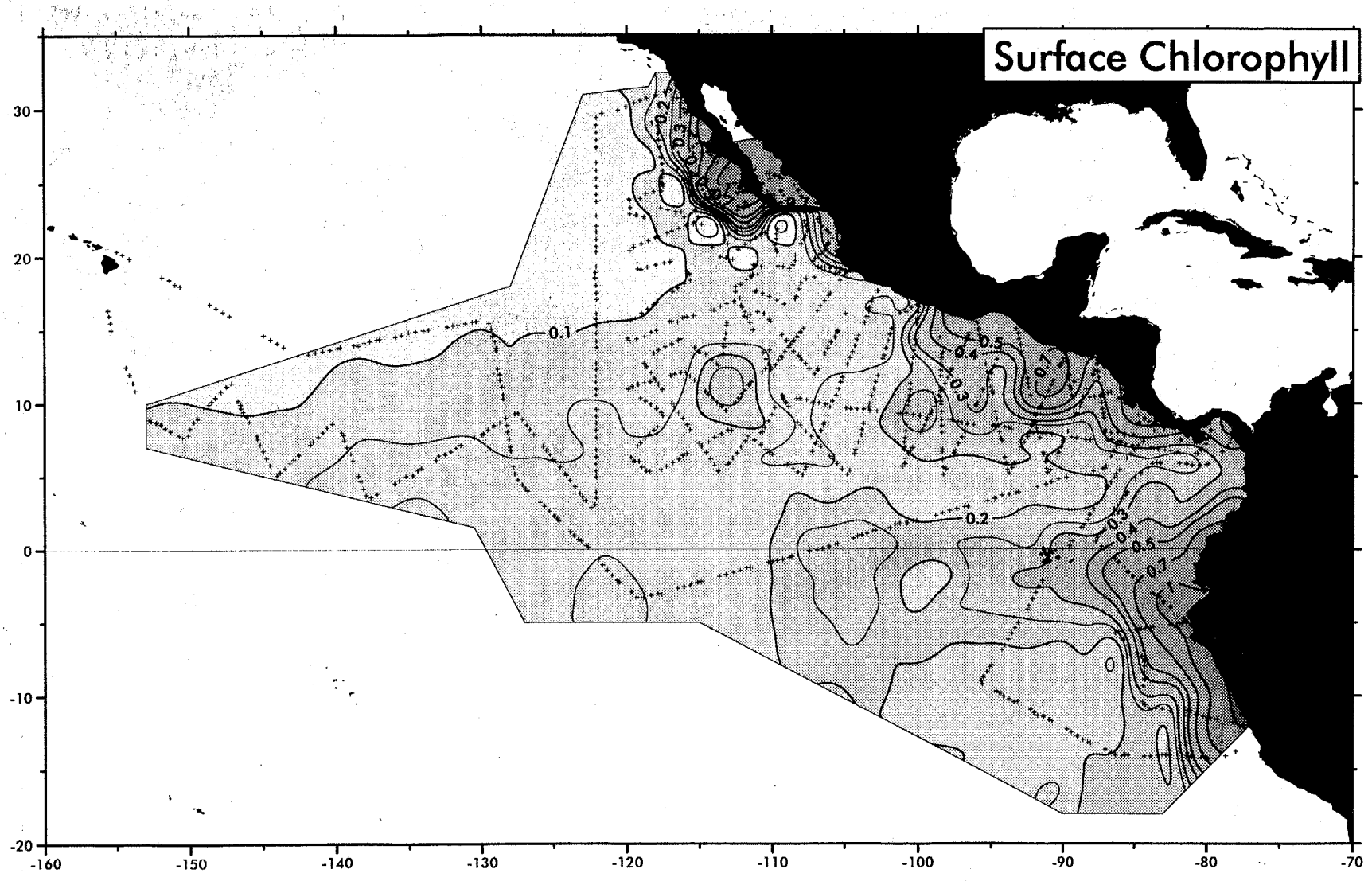


Figure 7. Surface chlorophyll concentration (mg m^{-3}), from CTD casts and underway samples (+), 28 July - 9 December 1999.

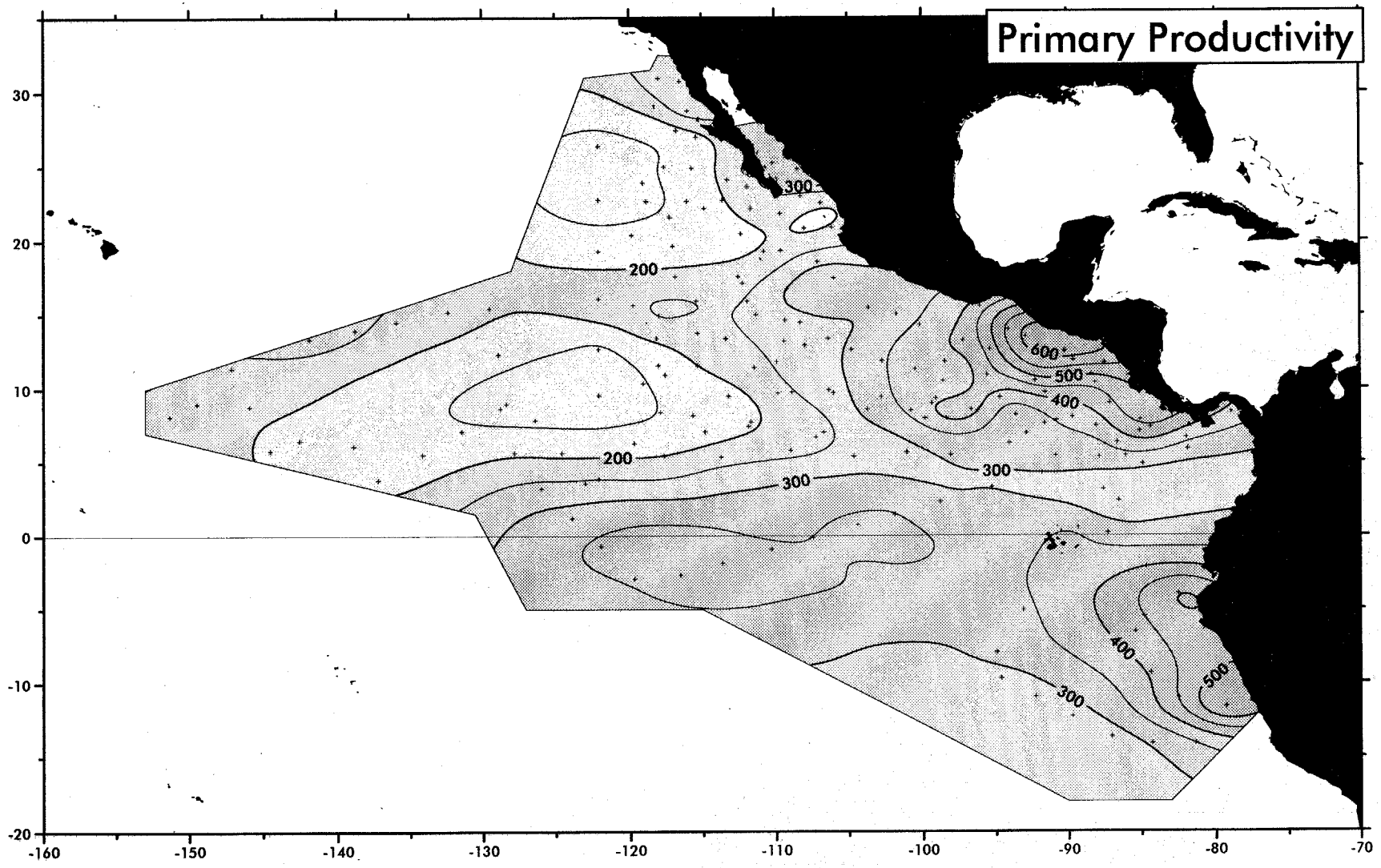


Figure 8. Primary productivity (mg C m^{-2} d^{-1}) in the euphotic zone, from morning CTD casts (+), 28 July - 9 December 1999.

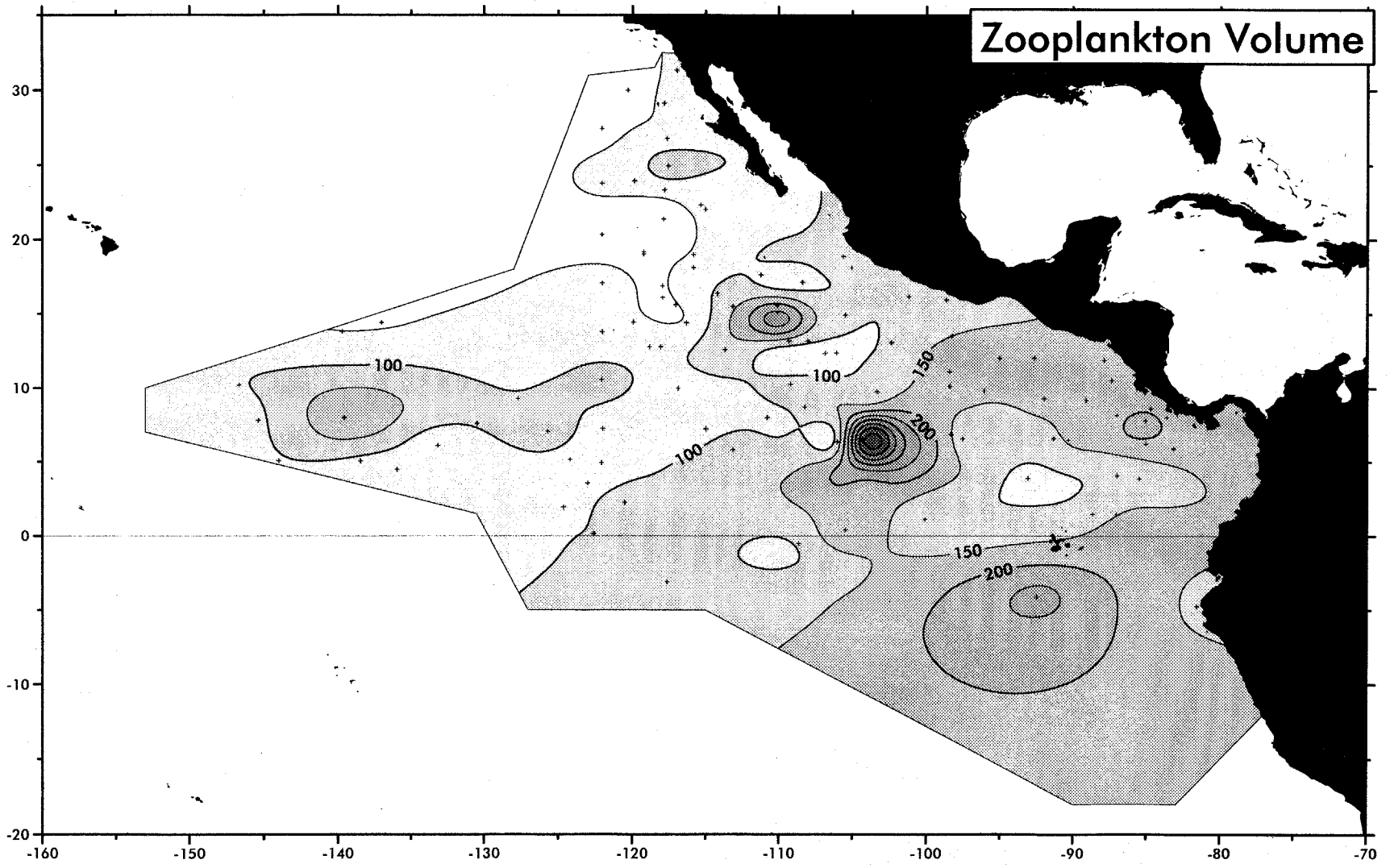
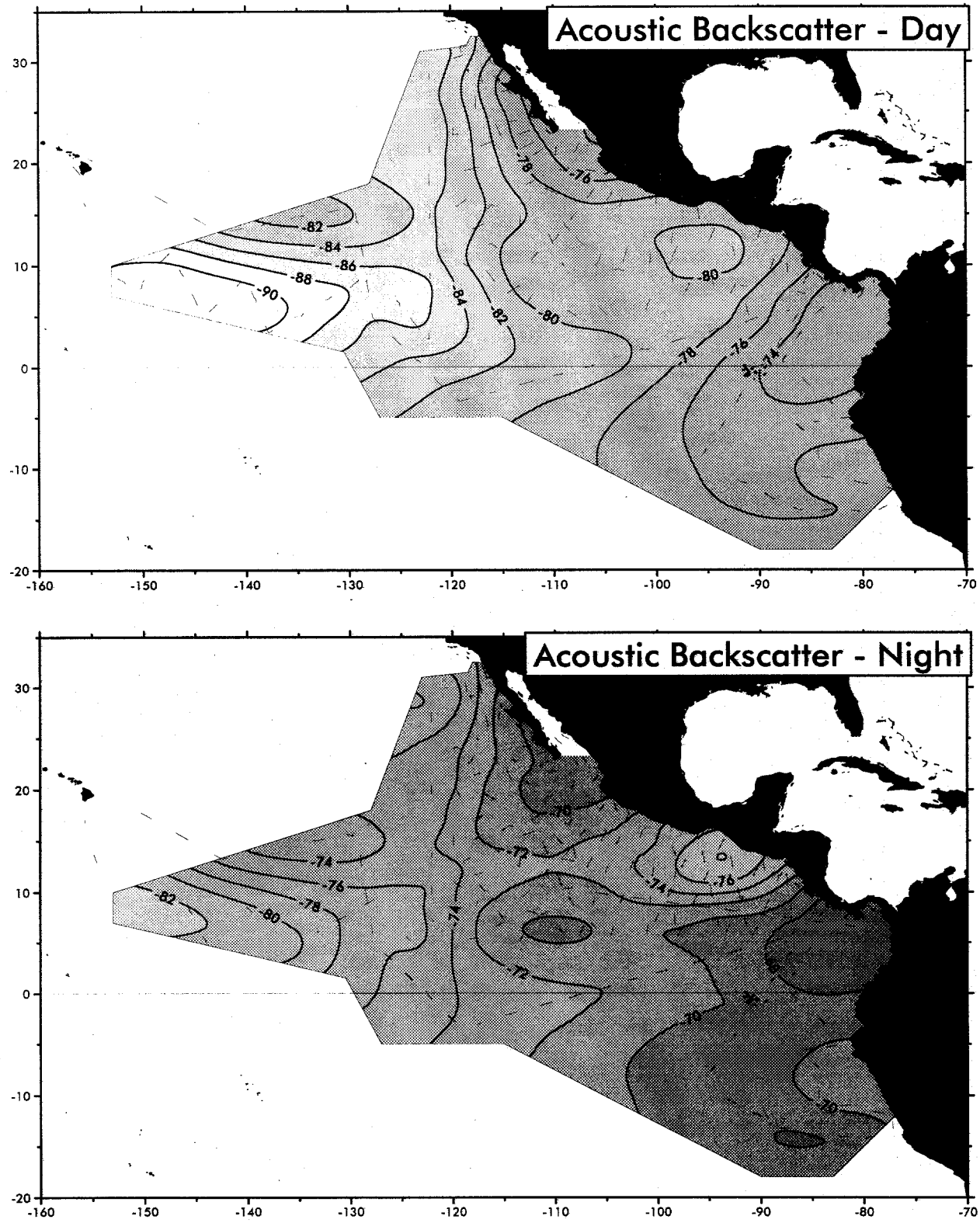


Figure 9. Zooplankton volume (ml $1000m^{-3}$) from 333-µm ring net and Bongo net tows (+), 28 July - 9 December 1999. Bongo net tow volumes adjusted by a factor of 0.43.

Figure 10. Acoustic backscatter (dB, 38 kHz), daily 0-100m means from 0800-1600 hours local ship time (top) and 2000-0400 h (bottom), 28 July - 9 December 1999. Thin lines indicate transect intervals during which displayed data were collected.



APPENDIX A

SCIENTIFIC PERSONNEL

Cruise Leaders	Ship (Leg #s)
Lisa Ballance, SWFSC (Chief Scientist)	D.S. Jordan (3-5), McArthur (1)
Robert Pitman, SWFSC	D.S. Jordan (1,2,6)
Barbara Taylor, SWFSC	McArthur (2)
Jay Barlow, SWFSC	McArthur (3)
Susan Chivers, SWFSC	McArthur (4)
Mark Lowry, SWFSC	McArthur (5)

Marine Mammal Identification Specialists	
Doug Kinzey, SWFSC	D.S. Jordan (1-3) McArthur (3-5)
Paula Olson, SWFSC	D.S. Jordan (1-3) McArthur (3-5)
James Cotton, SWFSC	D.S. Jordan (4-6) McArthur (1,2)
Richard Rowlett, SWFSC	D.S. Jordan (4-6) McArthur (1,2)

Marine Mammal Observers	
Jorge Del Angel, SWFSC	D.S. Jordan (1-3) McArthur (3-5)
Shannon Rankin, SWFSC	D.S. Jordan (1-3) McArthur (3-5)
Juan Carlos Salinas, SWFSC	D.S. Jordan (1-3) McArthur (3-5)
Suzanne Yin, SWFSC	D.S. Jordan (1-3) McArthur (3-5)
Isabel Beasley, SWFSC	D.S. Jordan (4-6) McArthur (1,2)
Laura Morse, SWFSC	D.S. Jordan (4-6) McArthur (1,2)
Ernesto Vázquez, SWFSC	D.S. Jordan (4-6) McArthur (1,2)
Elizabeth Zúñiga, SWFSC	D.S. Jordan (4-6) McArthur (1,2)

Bird Observers	
Chris Hoefer, SWFSC	D.S. Jordan (1-3) McArthur (3-5)
Brett Jarrett, SWFSC	D.S. Jordan (1-3) McArthur (3-5)
Cornelia Oedekoven, SWFSC	D.S. Jordan (1-3)
Mike Force, SWFSC	D.S. Jordan (4-6) McArthur (1,2)
Robert Pitman, SWFSC	D.S. Jordan (4-5)
Dawn Breese, SWFSC	D.S. Jordan (6)

Oceanographers	
Kerry Kopitsky, SWFSC	D.S. Jordan (1-6)
Valerie Philbrick, SWFSC	D.S. Jordan (1-6)
Kathy Noyes, SWFSC	McArthur (1-5)

Foreign Observers/Guest Scientists	
Robert Pitman, SWFSC	D.S. Jordan (3)
Carl Safina, National Audubon Society	D.S. Jordan (4)
Luis Vilchis, UCSD	D.S. Jordan (4)
Jan Hodder, University of Oregon	D.S. Jordan (5)
Erica Goetze, University of California, San Diego (UCSD)	McArthur (1)
Julie Oswald, San Diego State University	McArthur (1)
Paola Amador, Ecuador	McArthur (2)
Gill Braulik, Great Britain	McArthur (2)
Jaume Forcada, SWFSC	McArthur (2)
Peter Dutton, SWFSC	McArthur (3)
Edith Zárate, Instituto National de la Pesca, Mexico (INP)	McArthur (3)

Lanna Cheng, UCSD	McArthur (4)
Kathy Hough, SWFSC	McArthur (4)
Raul Zamora, Armada de Guatemala	McArthur (4)
Pedro Castaneda, Armada de Ecuador	McArthur (5)
Areli Cortés, INP	McArthur (5)
Milena A. Schreiber, Instituto del Mar del Perú	McArthur (5)

Photogrammetrists

Morgan Lynn, SWFSC	D.S. Jordan (1,2,6)
Katie Cramer, SWFSC	D.S. Jordan (1)
John Brandon, SWFSC	D.S. Jordan (2,3)
Jim Gilpatrick, SWFSC	D.S. Jordan (3,4,5)
Robert Pitman, SWFSC	D.S. Jordan (4,5)
Charles Stinchcomb, SWFSC	D.S. Jordan (6)

Helicopter Support

David Gardner, Aircraft Operations Center (AOC)	D.S. Jordan (1,4)
Roy Dehart, AOC	D.S. Jordan (1,3,5)
LT Debora Barr, AOC	D.S. Jordan (2,5)
Ron Helgeson, AOC	D.S. Jordan (2,4,6)
LT Julie Helmers, AOC	D.S. Jordan (3,4,6)

RECENT TECHNICAL MEMORANDUMS

Copies of this and other NOAA Technical Memorandums are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22167. Paper copies vary in price. Microfiche copies cost $9.00. Recent issues of NOAA Technical Memorandums from the NMFS Southwest Fisheries Science Center are listed below:

NOAA-TM-NMFS-SWFSC-298 Summary of seabird, marine turtle, and surface fauna data collected during a survey in the eastern tropical Pacific ocean, July 30 - December 9, 1998.
P.A. OLSON, R.L. PITMAN, L.T. BALLANCE, and S.B. REILLY
(August 2000)

299 The physical oceanography off the Central California coast during March-April and May-June, 1990: A summary of CTD data from pelagic juvenile rockfish surveys.
K.M. SAKUMA, F.B. SCHWING, M.H. PICKETT, and S. RALSTON
(September 2000)

300 U.S. Pacific marine mammal stock assessments: 2000.
K.A. FORNEY, J. BARLOW, M.M. MUTO, M. LOWRY, J. BAKER, G. CAMERON, J. MOBLEY, C. STINCHCOMB, and J.V. CARRETTA
(December 2000)

301 Summary of seabird, marine turtle, and surface fauna data collected during a survey in the eastern tropical Pacific ocean, July 28 - December 9, 1999.
P.A. OLSON, R.L. PITMAN, L.T. BALLANCE, K.R. HOUGH, P. DUTTON, and S.B. REILLY
(March 2001)

302 AMLR 1999/2000 field season report, objectives, accomplishments and conclusions.
J.D. LIPSKY (editor)
(March 2001)

303 Marine mammal data collected during a survey in the eastern tropical Pacific Ocean aboard the NOAA ships *McArthur* and *David Starr Jordan*, July 28 - December 9, 2000.
D. KINZEY, T. GERRODETTE, A. DIZON, W. PERRYMAN, P. OLSON, and S. RANKIN
(May 2001)

304 Summary of seabird, marine turtle, and surface fauna data collected during a survey in the eastern tropical Pacific Ocean, July 28 - December 9, 2000.
P.A. OLSON, R.L. PITMAN, L.T. BALLANCE, K.R. HOUGH, P.H. DUTTON, and S.B. REILLY
(May 2001)

305 Cetacean survey line-transect data verification and management.
A.R. JACKSON
(May 2001)

306 Age validation of the first, second, and third annulus from the dorsal fin rays of lingcod *(Ophiodon elongatus)*.
T.E. LAIDIG, K.R. SILBERBERG, and P.B. ADAMS
(June 2001)

307 Report of oceanographic studies conducted during the 1998 eastern tropical Pacific Ocean survey on the research vessels *David Starr Jordan*, *McArthur*, and *Endeavor*.
V.A. PHILBRICK, P.C. FIEDLER, J.T. FLUTY, and S.B. REILLY
(July 2001)