

NOAA Technical Memorandum NMFS



JULY 2001

**REPORT OF OCEANOGRAPHIC STUDIES CONDUCTED
DURING THE 1998 EASTERN TROPICAL PACIFIC OCEAN SURVEY
ON THE RESEARCH VESSELS
*DAVID STARR JORDAN, McARTHUR, AND ENDEAVOR***

Valerie A. Philbrick

Paul C. Fiedler

Joshua T. Fluty

Stephen B. Reilly

NOAA-TM-NMFS-SWFSC-307

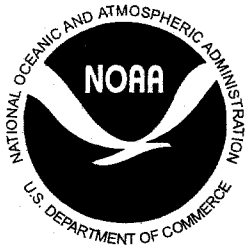
U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

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

NOAA-TM-NMFS-SWFSC-307

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

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INTRODUCTION

In 1998, the Southwest Fisheries Science Center (SWFSC) conducted the first 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.).

Three vessels were used for this survey: the NOAA ships *David Starr Jordan* (hereafter referred to as the *Jordan*) and *McArthur*, and the UNOLS ship *Endeavor*. The vessels operated concurrently in the ETP for four months, from July 30 to December 9, 1998. 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, and summarizes the data collected aboard the *Jordan*, *McArthur*, and *Endeavor* during the 1998 *Stenella* Population Abundance Monitoring (SPAM) survey. Separate reports summarize the marine mammal data (Kinzey *et al.* 1999) and the seabird, marine turtle and surface fauna data (Olson *et al.* 2000).

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* both departed San Diego, California on 31 July, and returned to San Diego on 9 December. The *Endeavor* departed Panama City, Panama on 30 July, and returned to Panama City on 9 December. The cruise was conducted in six legs on the *Jordan* and five legs on the *McArthur* and *Endeavor* (see itinerary below).

The itinerary for each ship was as follows:

	<u>Jordan</u>	<u>McArthur</u>	<u>Endeavor</u>
<u>Leg I</u>			
Departure	San Diego, California 31 July	San Diego, California 31 July	Panama City, Panama 30 July
Arrival	Mazatlan, Mexico 14 August	Puerto Quetzal, Guatemala 16 August	Hilo, Hawaii 27 August
<u>Leg II</u>			
Departure	Mazatlan, Mexico 18 August	Puerto Quetzal, Guatemala 21 August	Hilo, Hawaii 01 September
Arrival	Panama City, Panama 08 September	Panama City, Panama 08 September	Manzanillo, Mexico 25 September
<u>Leg III</u>			
Departure	Panama City, Panama 12 September	Panama City, Panama 13 September	Manzanillo, Mexico 30 September
Arrival	Manzanillo, Mexico 01 October	Manzanillo, Mexico 07 October	Puntarenas, Costa Rica 24 October
<u>Leg IV</u>			
Departure	Manzanillo, Mexico 05 October	Manzanillo, Mexico 12 October	Puntarenas, Costa Rica 28 October
Arrival	Puntarenas, Costa Rica 24 October	Manzanillo, Mexico 09 November	Callao, Peru 16 November
<u>Leg V</u>			
Departure	Puntarenas, Costa Rica 29 October	Manzanillo, Mexico 14 November	Callao, Peru 21 November
Arrival	Panama City, Panama 16 November	San Diego, CA 09 December	Panama City, Panama 09 December
<u>Leg VI</u>			
Departure	Panama City, Panama 22 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 Windows¹ 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 NOAA ships' Scientific Computing Systems (SCS) also collected these data, as well as information from other navigational and weather sensors. The *Endeavor* had a similar backup procedure. 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). The Shipboard Environmental (data) Acquisition System (SEAS), developed by NOAA, collected the data from Sippican Deep Blue probes. Low resolution, unprocessed XBT data were transmitted in real-time over the Global Telecommunications System after acquisition by the SEAS. 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 in the morning before sunrise and in the evening after sunset using a Sea-Bird Electronics 911*plus* CTD and General Oceanics rosette system. The CTD was lowered to 500 m (morning) or 1000 m (evening) and sensors connected to shipboard computers measured conductivity (salinity), temperature and pressure (depth). For the morning casts, a WET Labs WETStar miniature fluorometer was attached to measure in situ fluorescence. Water samples were collected on all CTD casts for salinity calibration, nutrient and phytoplankton pigment analysis. Samples for ¹⁴C-uptake incubations were taken only from morning casts.

CTD cast data were processed using Sea-Bird Electronics' software package, SEASOFT[®], version 4.233. 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* and *Endeavor*) 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 "ZLIGHT" 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 ≤ 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 IAPSO² 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, ZLIGHT, calculated an initial estimate of euphotic zone depth (1% light level) from pigment profiles observed on previous ETP cruises (1986-1990, 1992, 1993) 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 than predicted. A trial procedure to calculate light depths based on the preliminary fluorescence profile from the WETStar fluorometer downcast and a database of fluorescence per unit chlorophyll observed on previous casts proved to be unfeasible.

Samples were drawn into conditioned screw cap "Vitro" glass 150 ml bottles (Wheaton Corporation) rinsed twice with sample water. Radioactively labeled sodium carbonate ($\text{NaH}^{14}\text{CO}_3$) 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. A Bongo net was then 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.

The *McArthur* performed two additional zooplankton tows when time allowed. These were both oblique tows from 200 meters depth (for 15 minutes). The first was a 2-meter Isaacs-Kidd Midwater Trawl (IKMT) fitted with a 505- μ m mesh plankton net. The other was a 1/2 meter ring net, with 333- μ m mesh. 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 shows the actual cruise tracks for the *Jordan*, *McArthur*, and *Endeavor*. Tables 1 to 3 list the total number of oceanographic casts, net tows and samples collected on all three ships.

Figure 2 shows the locations of the 174 *Jordan*, 188 *McArthur*, and 185 *Endeavor* CTD casts. Tables 4 to 6 are CTD cast summaries for each ship, including the number of samples taken per station (chlorophyll, productivity, nutrient, and salinity) for which data exist. CTD stations where samples were not collected due to equipment malfunctions 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).

The WETStar fluorometers on both the *Jordan* and *McArthur* were defective at the start of the cruise and not replaced until leg 2. Both had cases that leaked under pressure. There were no bottle samples for two stations on the *Jordan*, which were aborted due to the WETStar unit problem and an entanglement in a long line. Three stations on the *McArthur* also did not have any bottle samples due to both WETStar and rosette malfunctions. Five *Jordan* stations at end of leg 5 did not have any salt samples taken due to lack of bottles (no analysis during the leg).

Figure 3 shows XBT deployment locations (895 total drops) for all three 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*, *McArthur*, and *Endeavor* are shown in Figure 7. The WETStar fluorescence information has not been calibrated to discrete samples and is not presented here.

Nutrient samples (6126 total) are in frozen storage and will be analyzed for nitrate, nitrite, silicate and phosphate at a later time.

Primary productivity samples were analyzed and the data were processed after the cruise at the SWFSC. 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 261 Manta tows was completed on this cruise: 82 on the *Jordan*, 95 on the *McArthur*, and 84 on the *Endeavor*. A total of 167 Bongo tows was completed: 11 on the *Jordan* (leg 4 only), 77 on the *McArthur*, and 79 on the *Endeavor*. All Manta and Bongo samples have been sorted and identified. Results will be presented in a separate technical memorandum (Ambrose, *et al.* in prep). The 55 *McArthur* ring net samples have been volumed, but not sorted or identified. The 34 *McArthur* IKMT samples are archived at the SWFSC. Zooplankton volumes (ml 1000m⁻³) from ring net (*McArthur* only) 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 thank the officers and crews of the research vessels *Jordan*, *McArthur* and *Endeavor* for their considerable time and skilled efforts in making this cruise a success. Special thanks go to oceanographers Kerry Kopitsky, Kerri Danil, Kathryn Noyes, and Lynne Butler; the *McArthur* Chief Survey Technician, Kaye Kinoshita; the *Endeavor* Marine Technicians Bill Fanning, David Nelson, and Tom Orvosh; electronics technicians and other scientists who collected these data at sea. We are grateful to LTJG Alexandra Von Saunder for her logistical assistance, and John Freitag of the Marine Technical Services Group (URI Graduate School of Oceanography) who coordinated technical support for the *Endeavor*. We also thank Robert Holland, who provided several data processing programs and plots for this report and Dr. Lisa Ballance, Dr. Tim Gerrodette, and Paula Olson for reviewing this manuscript.

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Table 1. Summary of data collected aboard the *Jordan*, 31 July – 9 December 1998.

	LEG 1	LEG 2	LEG 3	LEG 4	LEG 5	LEG 6	TOTALS
CTD casts	19	37	35	35	29	19	174
CTD chlorophyll samples	170	356	357	367	293	195	1738
Surface chlorophyll samples	45	84	68	67	60	57	381
Primary productivity samples	63	117	118	118	0	63	479
Nutrient samples	183	384	403	401	320	213	1904
Salinity samples	44	78	73	68	48	48	359
XBT drops	29	52	56	54	49	44	284
Manta tows	11	20	19	11	15	6	82
Bongo tows	0	0	0	11	0	0	11

Table 2. Summary of data collected aboard the *McArthur*, 31 July – 9 December 1998.

	LEG 1	LEG 2	LEG 3	LEG 4	LEG 5	TOTALS
CTD casts	27	31	43	52	35	188
CTD chlorophyll samples	283	312	440	538	364	1937
Surface chlorophyll samples	63	67	91	111	91	423
Primary productivity samples	97	102	154	175	77	605
Nutrient samples	312	343	485	596	400	2136
Salinity samples	70	91	124	144	50	479
XBT drops	44	44	60	81	67	296
Manta tows	14	17	21	25	18	95
Bongo tows	11	16	11	25	14	77
Nekton trawls (IKMT)	10	5	6	6	7	34
Ring net tows	9	15	21	4	6	55

Table 3. Summary of data collected aboard the *Endeavor*, 30 July – 9 December 1998.

	LEG 1	LEG 2	LEG 3	LEG 4	LEG 5	TOTALS
CTD casts	46	42	40	27	30	185
CTD chlorophyll samples	444	438	417	281	309	1889
Surface chlorophyll samples	107	93	94	56	61	411
Primary productivity samples	125	198	187	124	140	774
Nutrient samples	503	482	456	309	336	2086
Salinity samples	114	90	80	54	60	398
XBT drops	67	71	77	50	50	315
Manta tows	18	22	17	13	14	84
Bongo tows	17	20	16	13	13	79

Table 4. *Jordan* 1998 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	8/2	0353	29.41	-115.69	250				
2	8/3	0339	27.59	-115.12	1012	9		11	12
3	8/3	1214	26.86	-114.18	91	7	7	7	2
4	8/4	0311	26.04	-112.97	97	6		6	2
5	8/4	1209	24.92	-112.44	101	7	7	7	1
6	8/5	0314	24.01	-111.39	397	10		11	2
7	8/5	1209	23.54	-110.61	89	7	7	7	1
8	8/6	0326	22.79	-109.38	1008	10		11	4
9	8/6	1203	23.64	-108.57	510	11	7	12	2
10	8/7	0323	24.49	-108.93	1008	10		11	2
11	8/7	1200	24.61	-109.99	508	11	7	11	2
12	8/10	0330	27.64	-111.64	1025	10		11	2
13	8/10	1212	27.75	-110.85	137	11	7	11	2
14	8/11	0301	25.85	-110.86	455	10		11	2
15	8/11	1211	25.97	-109.72	101	9	7	9	
16	8/12	0325	24.48	-109.47	1010	10		11	2
17	8/12	1201	24.14	-108.83	502	11	7	12	2
18	8/13	0300	22.95	-108.71	1008	10		11	2
19	8/13	1203	23.87	-107.75	508	11	7	12	2
20	8/19	0218	22.17	-106.40	546	10		11	4
21	8/20	0240	20.66	-105.97	1002	10		11	2
22	8/20	1204	21.29	-106.54	504	11	7	12	2
23	8/21	0255	21.62	-108.51	1004	10		11	2
24	8/21	1205	21.11	-107.33	503	11	7	12	2
25	8/22	0244	19.99	-105.79	976	10		11	2
26	8/22	1204	19.03	-104.87	500	11	7	12	2
27	8/23	0243	18.15	-103.36	919	10		11	2
28	8/23	1151	18.01	-103.43	510	11	7	12	2
29	8/24	0212	17.32	-101.81	1008	10		11	2
30	8/24	0232	16.37	-99.10	1002	10		11	2
31	8/25	1132	16.08	-98.29	506	11	7	12	2
32	8/26	0214	15.46	-96.73	1002	10		11	2
33	8/26	1119	15.75	-95.44	471	11	7	12	2
34	8/27	0145	15.56	-94.28	215	10		11	2
35	8/27	1112	14.84	-93.46	199	12	7	12	2
36	8/28	0155	13.73	-92.21	1002	10		11	2
37	8/28	1100	12.63	-91.59	512	11	7	12	2
38	8/29	0135	11.03	-90.76	1002	10		11	2
39	8/29	1057	10.59	-90.11	502	11	7	12	2
40	8/30	0125	12.50	-90.47	1019	10		11	2

Table 4. (*Jordan* 1998 CTD cast summary) continued.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
41	8/30	1043	13.52	-90.66	508				
42	8/31	0115	13.18	-90.23	171	9		9	2
43	9/1	0123	12.26	-88.58	1002	10		11	2
44	9/1	1039	12.56	-88.16	80	7	7	7	2
45	9/2	0110	11.53	-87.15	111	6		6	2
46	9/2	1038	11.45	-86.66	99	9	7	9	2
47	9/3	0124	10.04	-86.32	1010	10		11	7
48	9/3	1046	9.69	-85.62	506	11	7	12	2
49	9/4	0053	9.16	-84.44	859	10		11	2
50	9/4	1039	9.15	-84.06	87	7	7	7	2
51	9/5	0107	8.10	-83.35	1006	10		11	2
52	9/5	1032	7.92	-82.88	504	11	7	12	2
53	9/6	0112	7.16	-82.03	1004	10		11	2
54	9/6	1041	7.59	-81.54	66	7	7	7	1
55	9/7	0052	7.28	-79.94	520	8		9	2
56	9/7	1022	7.45	-78.65	516	11	7	12	2
57	9/13	1017	7.17	-80.22	407	11	7	12	5
58	9/14	0057	6.95	-81.80	1002	10		11	2
59	9/14	1017	7.02	-82.95	500	11	7	12	2
60	9/15	0055	7.28	-84.82	1099	10		11	2
61	9/15	1030	7.36	-85.72	502	11	7	12	2
62	9/16	0108	7.69	-87.55	1004	10		11	2
63	9/16	1049	7.73	-88.58	500	11	7	12	2
64	9/17	0129	8.05	-90.04	1035	10		11	2
65	9/17	1105	8.18	-91.16	502	11	7	12	2
66	9/18	0139	8.68	-93.08	1002	10		11	2
67	9/18	1118	8.79	-94.37	502	11	7	12	2
68	9/19	0202	9.27	-96.25	1006	10		11	2
69	9/19	1130	9.57	-97.37	502	11	7	12	2
70	9/20	0204	9.69	-98.47	1006	10		11	2
71	9/20	1131	9.83	-99.73	506	11	7	12	2
72	9/21	0212	9.93	-101.72	1006	10		11	2
73	9/21	1148	9.98	-102.70	504	11	7	12	2
74	9/22	0223	10.18	-104.53	1006	10		11	2
75	9/22	1201	10.13	-105.61	508	11	7	12	2
76	9/23	0223	10.31	-107.29	1004	10		11	2
77	9/23	1219	10.27	-108.53	506	11	7	12	2
78	9/24	0235	10.27	-109.20	651	10		11	2
79	9/24	1218	10.43	-110.14	502	11	7	12	2
80	9/25	0242	10.43	-111.31	1006	10		11	2
81	9/25	1233	10.74	-112.57	504	11	7	12	2
82	9/26	0255	11.06	-114.41	1004	10		11	2
83	9/26	1232	11.33	-115.07	506	11	7	12	2
84	9/27	0258	11.76	-113.26	1019	10		11	2
85	9/27	1230	12.02	-112.04	502	11	7	12	2

Table 4. (Jordan 1998 CTD cast summary) continued.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
86	9/28	0242	12.38	-110.15	1006	10		11	2
87	9/28	1220	12.67	-109.20	504	11	7	12	2
88	9/29	0228	12.94	-107.51	1006	10		11	2
89	9/29	1221	13.73	-106.51	506	11	7	12	2
90	9/30	0222	15.59	-105.89	1002	10		11	2
91	9/30	1200	16.80	-105.47	500	11	7	12	2
92	10/6	0211	18.13	-104.38	1006	10		11	2
93	10/6	1202	16.70	-104.11	498	11	7	12	2
94	10/7	0210	14.96	-104.40	1006	10		11	2
95	10/7	1149	13.55	-104.57	504	11	7	12	2
96	10/8	0208	11.78	-104.79	1004	10		11	2
97	10/8	1146	10.41	-105.02	504	11	7	12	2
98	10/9	0207	8.50	-105.22	1004	10		11	2
99	10/9	1145	7.18	-105.48	506	11	7	12	2
100	10/10	0209	5.21	-105.75	1006	10		11	2
101	10/10	1147	3.95	-105.93	506	11	7	12	2
102	10/11	0351	1.80	-106.27	1006	10		11	2
103	10/11	1131	1.19	-106.31	506	11	7	12	2
104	10/12	0211	-0.23	-106.60	1014	10		11	2
105	10/12	1129	-1.37	-106.68	506	11	7	12	2
106	10/13	0227	-3.08	-106.90	1006	10		11	2
107	10/13	1130	-4.38	-107.09	500	11	7	12	2
108	10/14	0228	-6.56	-107.40	1002	10		11	2
109	10/14	1132	-7.71	-107.56	500	11	7	12	2
110	10/15	0233	-8.23	-107.15	1004	10		10	2
111	10/15	1132	-7.47	-106.36	506	11	7	12	2
112	10/16	0231	-6.07	-104.95	1008	10		11	2
113	10/16	1131	-5.24	-104.12	516	11	7	12	2
114	10/17	0208	-3.96	-102.89	1004	10		11	2
115	10/17	1131	-3.09	-101.95	506	11	7	12	2
116	10/18	0158	-1.88	-100.91	1016	10		11	2
117	10/18	1116	-1.16	-100.02	500	11	7	12	2
118	10/19	0135	0.26	-98.59	1002	10		11	2
119	10/19	1114	1.15	-97.70	506	10	7	12	2
120	10/20	0138	2.55	-96.32	1004	10		11	2
121	10/20	1114	3.45	-95.40	506	11	7	12	2
122	10/21	0119	4.87	-93.79	1006	10		11	2
123	10/21	1100	5.53	-92.56	506	11	7	12	2
124	10/21	1843	6.09	-91.52	203	11		11	
125	10/22	1051	7.23	-89.40	506	11	7	12	2
126	10/23	0056	8.15	-87.56	1006	10		11	2
127	10/30	0057	9.50	-85.36	954	10		11	2
128	10/30	1043	10.57	-86.16	103	7		7	
129	10/31	0117	11.46	-87.39	923	10		11	2
130	11/1	0129	10.27	-89.29	1002	10		11	2

Table 4. (*Jordan* 1998 CTD cast summary) continued.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
131	11/1	1108	9.12	-89.74	502	10		11	2
132	11/2	0126	7.40	-90.31	1002	10		11	2
133	11/2	1101	6.30	-90.78	502	10		11	2
134	11/3	0127	4.43	-91.49	1004	10		11	2
135	11/3	1106	3.22	-92.14	504	11		12	2
136	11/4	0128	1.44	-93.32	1002	10		11	2
137	11/4	1117	-0.13	-94.17	506	11		12	2
138	11/5	0155	-0.86	-94.85	1004	10		11	2
139	11/5	1119	-1.96	-95.54	502	11		12	2
140	11/6	0157	-1.82	-93.79	1004	10		11	2
141	11/6	1117	-1.38	-92.67	502	11		12	2
142	11/7	0155	-1.16	-91.65	bad file	10		11	2
143	11/8	1100	-1.19	-89.06	500	11		12	2
144	11/9	0126	-1.40	-87.88	1004	10		11	2
145	11/9	1048	-1.67	-86.81	504	11		12	2
146	11/10	0111	-2.05	-85.15	1002	10		11	2
147	11/10	1032	-2.34	-83.97	502	11		12	2
148	11/11	0059	-2.63	-82.16	1004	10		11	2
149	11/11	1018	-2.21	-81.25	504	11		12	2
150	11/12	1015	-0.03	-80.58	123	11		11	2
151	11/13	0049	1.43	-79.51	552	10		11	2
152	11/13	1015	2.20	-79.01	354	11		11	
153	11/14	0049	3.08	-78.18	123	7		7	
154	11/15	0025	4.73	-77.94	1004	10		11	
155	11/15	1019	6.07	-77.58	502	11		12	
156	11/23	0111	7.83	-79.68	101	6		6	
157	11/25	1020	8.66	-87.74	506	11	7	12	2
158	11/26	0109	9.20	-89.61	1008	10		11	12
159	11/26	1116	9.84	-91.21	506	11	7	12	2
160	11/27	0108	10.44	-92.99	1004	10		11	2
161	11/27	1123	11.06	-94.46	506	11	7	12	2
162	11/30	0141	16.54	-101.11	1006	10		11	2
163	11/30	1217	16.93	-102.71	502	11	7	12	2
164	12/1	0155	17.48	-104.16	1010	10		11	2
165	12/1	1216	17.84	-105.74	510	11	7	12	2
166	12/2	0227	18.34	-107.79	1004	10		11	2
167	12/2	1231	17.56	-109.10	506	11	7	12	2
168	12/3	0254	19.03	-110.47	1004	10		11	2
169	12/4	0225	20.01	-111.21	1006	10		11	2
170	12/4	1248	21.34	-111.75	504	11	7	12	2
171	12/5	0226	22.50	-112.22	1004	10		11	2
172	12/5	1304	23.85	-112.82	504	11	7	12	2
173	12/6	1320	25.85	-114.94	504	11	7	12	2
174	12/7	0216	27.53	-115.27	1006	10		11	4

Table 4. (*Jordan* 1998 CTD cast summary) continued.

Table 5. *McArthur* 1998 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 longitude values indicate western (W) positions.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
1	8/1	1216	29.69	-118.86	516	10		11	8
2	8/2	1216	26.55	-119.40	506	10	6	13	2
3	8/3	0404	24.46	-118.09	1007	10		11	2
4	8/3	1219	23.65	-117.59	512	11	7	12	2
5	8/4	0330	21.75	-116.43	572	10		11	2
6	8/4	1216	20.67	-115.81	504	11	7	12	1
7	8/5	0321	18.73	-114.63	1055	10		11	2
8	8/5	1212	17.90	-114.20	510	11	7	12	2
9	8/6	0316	15.94	-113.03	1018	10		11	2
10	8/6	1215	15.66	-112.77	504	11	6	12	2
11	8/7	0249	14.31	-111.26	1020	10		11	2
12	8/7	1219	14.32	-111.26	1012	10	7	12	2
13	8/8	1223	13.94	-109.40	1012	11	7	12	2
14	8/9	0239	13.63	-107.90	1008	10		11	2
15	8/9	1147	13.49	-106.96	510	11	6	12	2
16	8/10	0225	13.11	-105.07	1012	10		11	2
17	8/10	1146	12.86	-103.98	510	11	7	12	2
18	8/11	0232	12.42	-101.96	1012	10		11	2
19	8/11	1128	12.22	-100.96	510	11	7	12	2
20	8/12	0154	12.72	-99.37	1014	10		11	2
21	8/12	1127	13.62	-98.86	510	11	7	12	2
22	8/13	0214	14.93	-98.07	1012	10		11	12
23	8/13	1108	14.60	-97.14	510	11	7	12	2
24	8/14	0144	13.95	-95.34	1012	10		11	2
25	8/14	1108	13.74	-94.81	510	11	7	12	2
26	8/15	0131	13.20	-93.39	1012	10		11	2
27	8/15	1059	12.83	-92.25	514	11	7	12	2
28	8/22	0125	12.94	-90.55	1012	10		11	12
29	8/22	1047	11.78	-90.31	506	11		11	2
30	8/23	0113	11.67	-91.31	1012	10		11	2
31	8/23	1049	12.10	-92.54	506	11	7	12	2
32	8/24	0127	12.75	-94.31	1010	10		11	2
33	8/24	1109	13.07	-95.65	512	11	7	12	2
34	8/25	0145	11.59	-97.31	1014	10		11	2
35	8/25	1118	10.78	-98.25	510	11	7	12	2
36	8/26	0156	9.22	-100.03	1014	10		11	2
37	8/26	1121	8.40	-100.99	514	11	7	12	2
38	8/27	0204	6.92	-102.66	1010	10		11	2
39	8/27	1136	6.14	-103.58	509	11	7	12	2
40	8/28	0203	5.32	-103.55	1012	10		11	2
41	8/28	1135	5.33	-102.38	515	11	7	12	12

Table 5. (McArthur 1998 CTD cast summary) continued.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
42	8/29	0152	5.33	-100.44	1022	10		11	2
43	8/29	1130	5.33	-99.18	509	11	7	12	2
44	8/30	0139	5.34	-97.09	1012	10		11	2
45	8/30	1133	5.01	-96.21	520	11	7	12	2
46	8/31	0152	5.04	-94.79	1014	10		11	2
47	8/31	1114	5.30	-93.55	511	11	5	12	2
48	9/1	0111	5.33	-91.65	1012	10		11	2
49	9/1	1105	5.33	-90.47	507	11	7	12	2
50	9/2	0100	5.33	-88.25	1012	10		11	2
51	9/2	1100	5.56	-87.13	511	11	7	12	2
52	9/3	1045	5.31	-85.80	515	11	7	12	2
53	9/4	0041	5.31	-83.69	1012				
54	9/5	0126	5.32	-81.04	1010	10		11	2
55	9/5	1023	5.33	-80.19	506	11	7	12	2
56	9/6	0017	5.34	-78.90	1016	10		11	12
57	9/6	1009	5.53	-78.31	516	11	7	12	3
58	9/7	1030	7.39	-78.91	514	10	5	10	2
59	9/13	1006	7.52	-79.07	511	11	7	12	12
60	9/14	0017	6.23	-80.28	1010	10		11	2
61	9/14	1018	6.40	-81.57	509	11	7	12	2
62	9/15	0030	6.56	-83.68	1016	10		11	2
63	9/15	1032	6.71	-84.83	516	11	7	12	2
64	9/16	0043	6.75	-86.76	1016	10		11	2
65	9/16	1046	6.86	-88.08	511	10	6	12	2
66	9/17	0058	7.07	-89.95	1014	10		11	2
67	9/17	1102	7.09	-91.28	507	11	7	12	2
68	9/18	0106	7.31	-93.22	1006	10		11	2
69	9/18	1108	7.32	-94.59	511	12	7	12	2
70	9/19	0123	7.57	-96.71	1016	10		11	2
71	9/19	1131	7.56	-97.97	513	11	7	12	2
72	9/20	0131	7.76	-99.82	1010				
73	9/20	1129	7.78	-101.12	516	11	7	12	12
74	9/21	0153	7.93	-103.06	1018	10		11	2
75	9/21	1142	7.99	-104.21	513	11	7	12	2
76	9/22	0158	8.15	-106.40	1022	9		11	2
77	9/22	1202	8.03	-107.72	509	11	7	12	2
78	9/23	0205	6.62	-109.23	1016	10		11	2
79	9/23	1203	6.17	-108.68	511	11	7	12	2
80	9/24	0220	5.00	-109.99	1010				
81	9/24	1216	5.07	-111.27	515	11	6	12	2
82	9/25	0227	5.52	-112.87	1010	10		11	2
83	9/25	1224	5.26	-114.38	517	11	7	12	2
84	9/26	0247	6.53	-115.92	721	10		11	2
85	9/26	1238	5.68	-116.69	520	11	6	12	2
86	9/28	0253	7.44	-117.14	1018	10		11	2

Table 5. (McArthur 1998 CTD cast summary) continued.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
87	9/28	1232	7.78	-116.00	514	11	7	12	12
88	9/29	0236	7.87	-113.72	1012	12		12	2
89	9/29	1217	7.96	-112.28	511	11	7	12	2
90	9/30	0221	8.78	-110.58	1014	10		11	2
91	9/30	1209	9.32	-110.14	507	11	7	12	2
92	10/2	0218	10.40	-108.98	1014	10		11	2
93	10/2	1203	10.97	-107.86	514	11	7	12	2
94	10/3	0200	11.83	-106.07	1012	10		11	2
95	10/3	1202	12.52	-104.77	514	11	7	12	2
96	10/4	0148	13.52	-103.14	1010	10		11	2
97	10/4	1133	13.94	-101.90	510	11	7	12	2
98	10/5	0146	14.80	-100.18	1010	10		11	12
99	10/5	1143	15.54	-100.28	512	11	7	12	2
100	10/6	0200	16.45	-101.81	1010	10		11	2
101	10/6	1148	17.35	-103.14	516	11	7	12	2
102	10/13	0208	18.20	-105.31	1015	10		11	12
103	10/13	1138	17.32	-106.01	512	11		12	2
104	10/14	0212	15.65	-106.98	1017	10		11	2
105	10/14	1147	14.86	-107.79	518	11	7	12	2
106	10/16	0243	11.28	-110.73	1020	10		11	2
107	10/16	1204	10.46	-111.26	514	11	7	12	2
108	10/17	0243	8.93	-111.93	1041	10		11	2
109	10/17	1159	7.68	-112.12	515	10	7	12	2
110	10/18	0244	5.52	-112.46	1020	9		10	2
111	10/18	1159	4.55	-112.62	511	11	7	12	2
112	10/19	0253	3.07	-112.93	1010	10		11	2
113	10/19	1157	2.18	-113.13	513	11	7	12	2
114	10/20	0244	1.34	-113.86	1010	10		11	12
115	10/20	1213	1.33	-114.86	530	11	7	12	2
116	10/21	0300	1.33	-116.83	1010	10		11	2
117	10/21	1219	1.34	-117.80	513	11	7	12	2
118	10/22	0310	1.34	-119.88	1010	10		11	2
119	10/22	1230	1.35	-120.73	511	11	7	12	2
120	10/23	0326	1.34	-122.91	1022	10		11	2
121	10/23	1237	1.80	-123.34	513	11	7	12	2
122	10/24	0325	3.78	-123.34	1020	10		11	2
123	10/24	1241	4.57	-123.33	513	11	7	12	2
124	10/25	0323	6.56	-123.33	1014	10		11	2
125	10/25	1240	7.57	-123.33	511	11	7	12	2
126	10/26	0320	9.70	-123.33	1010	10		11	2
127	10/26	1243	10.60	-123.34	511	11	7	12	2
128	10/27	0319	12.48	-123.35	1018	10		11	12
129	10/27	1247	13.51	-123.33	512	11	7	12	2
130	10/28	0309	15.63	-123.33	1013	10		11	2
131	10/28	1251	16.78	-123.33	512	10	7	12	2

Table 5. (McArthur 1998 CTD cast summary) continued.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
132	10/29	0300	18.74	-122.46	1019	10		11	2
133	10/29	1247	19.88	-121.81	510	10	7	12	2
134	10/30	0250	21.78	-120.71	1009	10		11	2
135	10/30	1244	22.87	-120.07	514	10	7	12	2
136	10/31	0244	21.07	-119.27	1011	10		11	2
137	10/31	1236	19.86	-118.79	508	10	7	12	2
138	11/1	0259	17.85	-118.03	1013	10		11	2
139	11/1	1230	17.70	-117.61	512	10	7	12	2
140	11/2	0253	19.77	-117.43	1011	10		11	12
141	11/2	1230	20.17	-116.22	508	11	7	12	2
142	11/3	0226	22.26	-115.78	1013	10		11	2
143	11/3	1236	22.99	-115.28	510	11	7	12	2
144	11/4	0218	21.54	-114.00	1009	10		11	2
145	11/4	1218	20.54	-112.70	510	11	7	12	2
146	11/5	0211	21.26	-112.17	1013	10		11	2
147	11/5	1216	22.01	-111.01	512	11	7	12	2
148	11/6	0207	20.50	-110.99	1009	10		11	2
149	11/6	1207	20.20	-109.66	512	11	7	12	2
150	11/7	0157	22.16	-109.67	1013	9		10	2
151	11/7	1205	21.95	-109.67	510	11	7	12	2
152	11/8	0116	20.57	-108.37	1025	10		11	2
153	11/8	1158	20.31	-107.71	506	11	7	12	2
154	11/15	0141	18.66	-105.43	1011	10		11	1
155	11/15	1152	18.08	-106.15	512	11	7	12	1
156	11/16	0154	17.00	-107.66	1013	10		11	1
157	11/16	1157	16.30	-108.64	510	11	7	12	1
158	11/17	0213	15.15	-110.21	1018	10		11	2
159	11/17	1213	14.53	-111.09	510	11		12	1
160	11/18	0223	13.85	-112.99	1010	10		11	2
161	11/18	1223	13.37	-114.02	514	11		12	2
162	11/19	0236	12.72	-115.93	1010	10		11	2
163	11/19	1228	12.38	-117.12	512	11		12	2
164	11/20	0250	11.53	-119.00	1014	10		11	2
165	11/20	1234	10.47	-119.00	510	11		12	2
166	11/21	0254	8.73	-119.33	1014	10		11	2
167	11/21	1243	9.00	-120.29	511	10	7	11	2
168	11/22	0308	8.06	-121.76	1010	10		11	2
169	11/22	1243	7.62	-122.85	511	11	7	12	2
170	11/23	0326	6.63	-124.62	1012	10		11	2
171	11/23	1257	6.06	-125.76	513	11	7	12	2
172	11/24	0330	5.07	-127.62	1014	10		11	1
173	11/24	1300	4.53	-128.67	518	11	7	12	1
174	11/25	0346	6.50	-129.29	1026	10		11	1
175	11/25	1313	7.47	-129.60	512	11	7	12	1
176	11/26	0359	9.45	-130.22	1014	10		11	1

Table 5. (McArthur 1998 CTD cast summary) continued.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
177	11/26	1328	9.95	-130.37	513	11		12	1
178	11/27	0338	11.59	-130.85	1018	10		11	1
179	11/27	1327	12.77	-131.33	512	11	7	12	1
180	11/28	0342	14.85	-132.01	1012	10		11	1
181	11/28	1343	15.23	-132.27	510	11		12	1
182	11/1	0313	15.72	-125.97	1015	10		11	1
183	12/3	1313	21.90	-123.27	518	10	7	12	1
184	12/4	0308	23.51	-122.32	1013	9		10	1
185	12/5	0239	24.20	-120.26	1017	10		11	1
186	12/6	1327	26.24	-122.42	516	10	7	12	1
187	12/7	0237	27.53	-123.18	1011	10		11	1
188	12/7	1330	28.35	-122.10	510	11	7	12	1

Table 6. *Endeavor* 1998 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	7/31	0232	7.74	-79.81	78	11		11	11
2	7/31	0953	7.10	-80.17	512	9	5	10	9
3	8/1	0121	5.92	-81.41	1016	9		11	2
4	8/1	1017	5.32	-82.08	518	10	7	11	2
5	8/2	0246	4.16	-83.69	1014	9		11	2
6	8/2	1122	4.04	-84.38	511	10	7	11	2
7	8/3	0102	3.66	-86.24	1008	4		5	2
8	8/3	1054	3.45	-87.06	513	10	7	11	2
9	8/3	1913	3.28	-88.12	1006	9		11	2
10	8/6	0203	1.58	-97.66	1004	8		10	2
11	8/6	1200	1.31	-98.97	513	10	7	11	2
12	8/7	0226	0.89	-101.39	1008	9		11	2
13	8/7	1140	0.46	-102.69	509	9		10	2
14	8/8	0211	0.13	-104.82	1008	9		11	2
15	8/8	1150	-0.18	-106.09	507	9		10	2
16	8/9	0219	-0.59	-108.30	1004	9		11	2
17	8/9	1222	-0.85	-109.58	515	9		10	2
18	8/10	0238	-1.19	-111.13	1006	8		10	2
19	8/10	1230	-1.39	-112.38	503	11		12	2
20	8/11	0236	-1.72	-114.17	1008	9		11	2
21	8/11	1240	-2.29	-115.36	505	11		11	2
22	8/12	0254	-3.26	-117.44	1008	10		11	2
23	8/12	1250	-3.85	-118.65	515	4		11	2
24	8/13	0317	-4.90	-120.69	1006	10		11	2
25	8/13	1304	-4.44	-121.76	513	10		11	2
26	8/14	0338	-3.26	-123.29	1004	10		11	2
27	8/14	1320	-2.53	-124.30	513	9		11	2
28	8/15	0332	-1.34	-125.80	1010	10		11	2
29	8/15	1328	-0.72	-126.70	509	10	6	11	2
30	8/16	0354	0.45	-128.28	1008	10		11	3
31	8/16	1318	1.26	-129.29	507	11	6	12	2
32	8/17	0359	2.75	-131.28	1008	10		11	2
33	8/17	1331	3.51	-132.30	507	11	7	12	2
34	8/18	0418	4.74	-134.04	1006	9		11	2
35	8/18	1402	5.32	-134.75	505	11	7	12	2
36	8/19	0430	6.31	-136.01	1014	10		11	2
37	8/19	1413	6.73	-136.62	505	11	7	12	2
38	8/20	0428	7.69	-137.95	1006	10		11	2
39	8/20	1418	8.19	-138.63	509	11	7	12	2
40	8/21	0440	9.43	-140.38	1006	10		11	2

Table 6. (*Endeavor* 1998 CTD cast summary) continued.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
41	8/21	1423	10.08	-141.31	505	11	7	12	2
42	8/22	0513	11.29	-143.08	1006	10		11	2
43	8/22	1442	11.82	-143.75	506	11	7	12	2
44	8/23	0525	12.64	-144.93	1006	10		11	2
45	8/25	0502	16.10	-150.86	330	11		11	2
46	8/26	1512	18.91	-155.85	506	11	7	12	4
47	9/3	1516	13.98	-153.70	510	11	7	12	4
48	9/4	1510	10.19	-153.03	508	11	7	12	6
49	9/5	0515	8.75	-151.19	1006	10		11	2
50	9/5	1501	8.02	-150.14	505	10	7	12	2
51	9/6	0446	6.77	-148.39	1004	10		11	2
52	9/6	1448	6.09	-147.43	501	10	7	12	2
53	9/7	0454	6.16	-145.90	992	10		11	2
54	9/7	1437	7.16	-144.99	505	11	7	12	2
55	9/8	0433	8.68	-143.57	992	10		11	2
56	9/8	1425	9.55	-142.79	503	11	7	12	2
57	9/9	0424	10.54	-141.84	1067	10		11	2
58	9/9	1417	11.35	-141.10	504	11	7	12	2
59	9/10	0422	12.76	-139.72	994	9		10	2
60	9/10	1411	13.62	-138.93	502	11	7	12	2
61	9/11	0410	14.64	-137.92	998	10		11	2
62	9/11	1406	13.94	-137.20	502	11	7	12	2
63	9/12	0407	12.07	-136.02	992	10		11	2
64	9/12	1357	11.04	-135.38	530	11	7	12	2
65	9/13	0353	9.14	-134.15	994	10		11	2
66	9/13	1404	8.02	-133.52	503	11	7	12	2
67	9/14	0412	5.95	-132.28	994	10		11	2
68	9/14	1348	6.08	-131.67	507	11	7	12	2
69	9/15	0337	7.86	-130.55	994	9		10	2
70	9/15	1336	8.93	-129.86	503	11	7	12	2
71	9/16	0328	10.63	-128.78	994	10		11	2
72	9/16	1326	11.61	-128.19	502	11	7	12	2
73	9/17	0323	12.74	-126.69	992	10		11	2
74	9/17	1315	12.62	-125.52	502	11	7	12	2
75	9/18	0321	12.59	-124.05	994	10		11	2
76	9/18	1305	12.57	-122.75	502	11	7	12	2
77	9/19	0303	12.56	-121.32	994	10		11	2
78	9/19	1308	12.51	-120.11	510	11	7	12	2
79	9/20	0253	13.37	-118.20	996	10		11	2
80	9/20	1242	13.90	-117.03	504	11	7	12	2
81	9/21	0241	14.82	-115.02	1016	10		11	2
82	9/21	1216	15.26	-114.08	508	11	7	12	2
83	9/22	0240	16.10	-112.24	1013	10		11	2
84	9/22	1216	16.49	-111.26	518	11	7	12	2
85	9/23	0220	17.26	-109.38	1013	10		11	2

Table 6. (*Endeavor* 1998 CTD cast summary) continued.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
86	9/23	1216	17.71	-108.34	518	11	7	12	2
87	9/24	0206	18.25	-107.00	1013	10		11	2
88	9/24	1204	18.49	-106.42	518	11	7	12	2
89	10/1	0153	19.03	-105.89	1019	10		11	2
90	10/1	1212	18.93	-106.82	518	11	7	12	2
91	10/2	1215	19.70	-108.11	526	11	7	12	2
92	10/3	0210	19.15	-109.63	1013	10		11	2
93	10/3	1220	19.17	-111.15	518	11	7	12	2
94	10/4	0215	19.40	-112.52	1011	10		11	2
95	10/4	1226	19.01	-113.58	518	11	7	12	2
96	10/5	0225	17.91	-115.10	1012	10		11	2
97	10/5	1253	17.42	-116.21	516	11	7	12	2
98	10/6	0237	16.27	-118.04	1015	10		10	2
99	10/6	1253	15.66	-119.00	518	10	7	11	2
100	10/7	0244	14.24	-119.57	1012	10		11	2
101	10/7	1251	13.61	-118.93	518	11	7	12	2
102	10/8	0241	12.13	-117.66	1014	10		11	2
103	10/8	1248	11.09	-117.45	518	11	7	12	2
104	10/9	0243	9.25	-116.81	1014	10		11	2
105	10/9	1247	8.30	-116.33	532	11	7	12	2
106	10/10	0244	6.94	-117.59	1016	10		11	2
107	10/10	1249	6.02	-118.52	526	11	7	12	2
108	10/11	0245	4.83	-119.29	1012	10		11	2
109	10/11	1247	4.20	-118.39	520	11	7	12	2
110	10/12	0251	3.61	-117.62	1014	10		11	2
111	10/12	1244	3.32	-117.02	518	10	6	11	2
112	10/13	0247	3.58	-115.59	1018	10		11	2
113	10/13	1227	4.12	-114.60	518	11	7	12	2
114	10/14	0232	5.02	-113.13	1020	10		11	2
115	10/14	1216	5.69	-111.98	522	11	7	12	2
116	10/15	0223	6.94	-110.04	1014	10		11	2
117	10/15	1208	7.72	-108.71	518	11	7	12	2
118	10/17	0141	10.73	-103.54	1010	10		11	2
119	10/17	1150	11.22	-102.33	516	11	7	12	2
120	10/18	0130	10.99	-100.41	1014	10		11	2
121	10/18	1135	10.96	-99.26	532	11	7	12	2
122	10/19	0118	10.46	-97.50	1020	10		11	2
123	10/19	1131	10.71	-96.34	520	11	6	12	2
124	10/20	0110	10.57	-94.42	1012	9		10	2
125	10/20	1115	10.45	-93.46	518	11		12	2
126	10/21	0106	10.22	-92.01	1014	10		11	2
127	10/21	1104	10.18	-90.88	518	11	7	12	2
128	10/22	1046	10.09	-89.62	518	10		11	2
129	10/30	1039	7.56	-86.13	503	10	6	11	2
130	10/31	1052	4.73	-88.23	505	11	7	12	2

Table 6. (*Endeavor* 1998 CTD cast summary) continued.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
131	11/1	0112	3.09	-89.48	1010	10		11	2
132	11/1	1057	2.04	-90.28	507	11	7	12	2
133	11/2	0116	0.43	-91.48	505	10		12	2
134	11/4	1053	-2.79	-92.05	507	10	6	11	2
135	11/5	0128	-4.16	-93.25	1010	10		11	2
136	11/5	1104	-5.30	-94.26	507	11	7	12	2
137	11/6	0147	-6.87	-95.66	1008	10		11	2
138	11/6	1109	-7.93	-96.62	505	11	7	12	2
139	11/7	0154	-9.46	-98.01	1006	10		11	2
140	11/7	1102	-10.48	-98.95	510	11	7	12	2
141	11/8	0228	-12.26	-99.86	1006	10		11	2
142	11/8	1104	-12.27	-98.59	508	11	7	12	2
143	11/9	0159	-12.25	-96.49	1010	10		11	2
144	11/9	1105	-12.29	-95.12	510	11	7	12	2
145	11/10	0143	-12.42	-93.04	1014	10		11	2
146	11/10	1047	-13.28	-92.08	512	11	7	12	2
147	11/11	0137	-14.83	-90.35	1010	10		11	2
148	11/11	1030	-15.64	-89.42	510	11	7	12	2
149	11/12	0134	-17.12	-87.70	1010	10		11	2
150	11/12	1021	-18.04	-86.62	506	11	7	12	2
151	11/13	0119	-16.82	-84.60	1010	10		11	2
152	11/13	1007	-16.49	-84.10	508	11	7	12	2
153	11/14	0107	-15.34	-82.32	1006	9		10	2
154	11/14	1004	-15.09	-81.94	506	9	5	12	2
155	11/15	0100	-14.02	-80.36	1008	10		11	2
156	11/22	0057	-11.60	-78.18	659	9		10	2
157	11/22	0950	-10.60	-78.01	99	9	7	9	2
158	11/23	1015	-10.63	-79.79	503	11	7	12	2
159	11/24	0100	-11.25	-81.31	998	10		11	2
160	11/24	1015	-10.47	-82.29	506	11	7	12	2
161	11/25	0100	-9.75	-80.90	1004	10		11	2
162	11/25	1008	-9.46	-79.79	507	11		12	2
163	11/26	0032	-8.29	-79.64	85	10		10	2
164	11/26	1008	-8.17	-80.52	509	10		11	2
165	11/27	0035	-7.53	-80.31	147	12		12	2
166	11/27	1008	-7.25	-80.92	507	9		10	2
167	11/28	1018	-6.59	-81.17	511	11		11	2
168	11/29	0055	-4.73	-81.53	1004	10		10	2
169	11/29	1023	-3.49	-81.28	507	11		11	2
170	11/30	0055	-4.44	-82.44	1004	10		11	2
171	11/30	1027	-5.23	-83.33	221	11		11	2
172	12/1	0104	-6.68	-84.95	1004	10		11	2
173	12/1	1032	-7.46	-85.82	509	11		12	2
174	12/2	0132	-8.87	-87.39	1059	9		10	2
175	12/2	1043	-8.20	-88.11	511	10		11	2

Table 6. (*Endeavor* 1998 CTD cast summary) continued.

Station number	Date	Time	Latitude	Longitude	Depth	Chl.	Prod.	Nutrients	Salinity
176	12/3	0139	-6.66	-89.14	1004	10		11	2
177	12/3	1048	-5.54	-88.72	509	11		12	2
178	12/4	0123	-3.50	-87.99	1006	10		11	2
179	12/4	1052	-2.34	-87.58	507	11		12	2
180	12/5	0110	-0.76	-86.57	1004	10		11	2
181	12/5	1047	0.05	-85.69	509	10		11	2
182	12/6	0055	1.19	-84.50	1006	10		11	2
183	12/6	1042	2.01	-83.56	509	11		12	2
184	12/7	0046	3.36	-82.12	1004	10		11	2
185	12/7	1041	3.83	-81.11	509	11		12	2

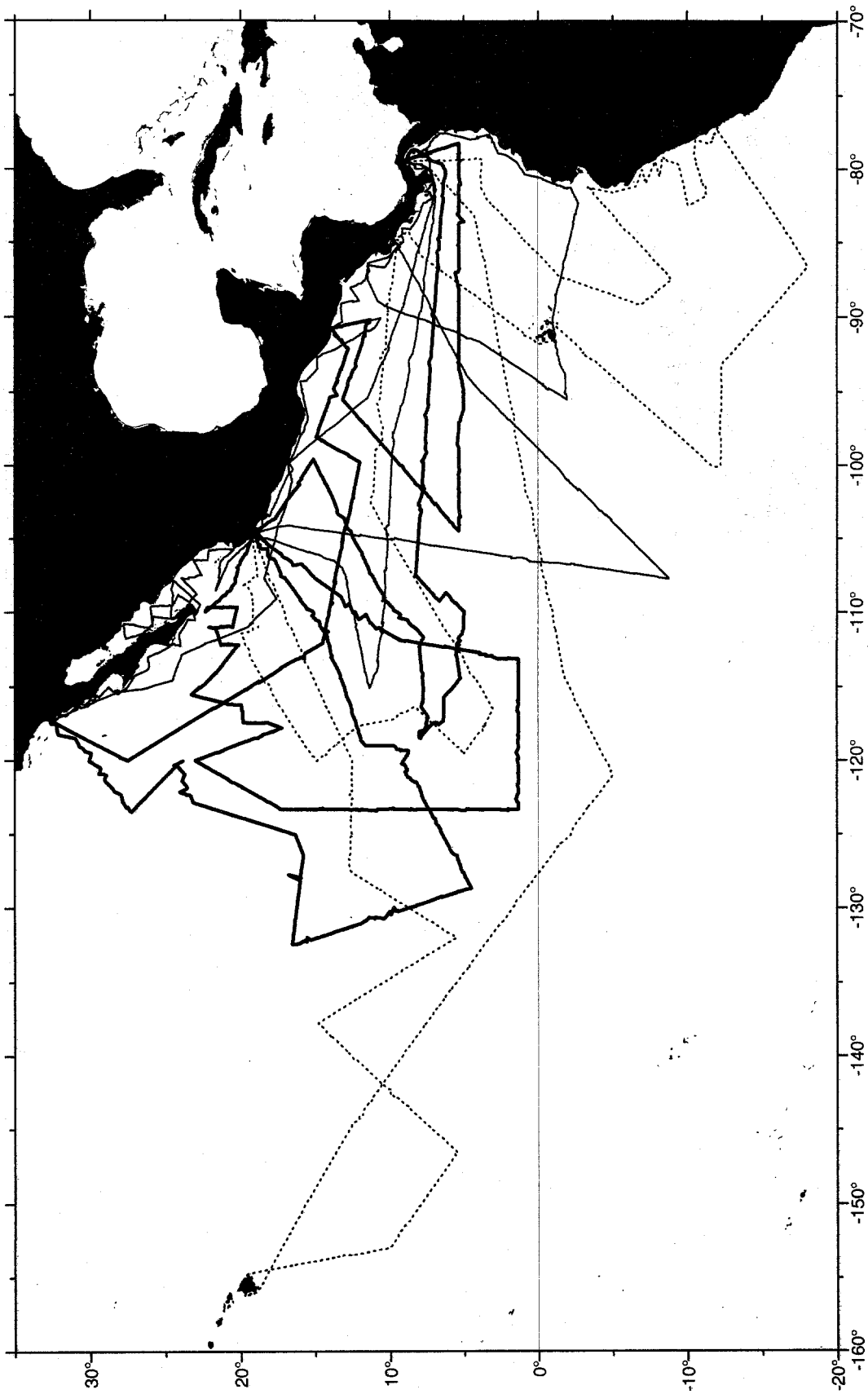


Figure 1. Cruise tracks, *Jordan* (—), *McArthur* (---), and *Endeavor* (···), 30 July - 9 December 1998.

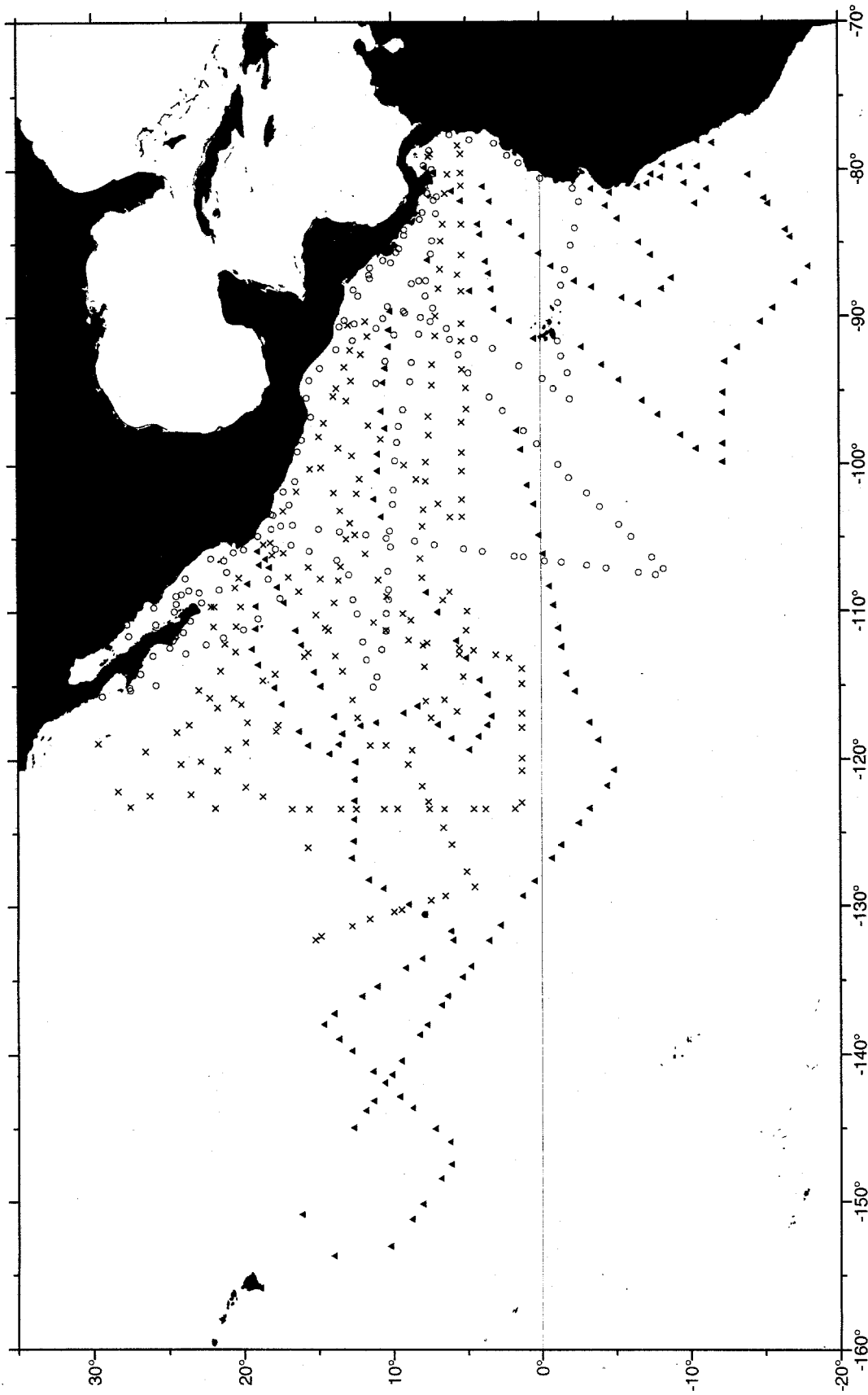


Figure 2. CTD stations, *Jordan* (○), *McArthur* (x), and *Endeavor* (△), 30 July - 9 December 1998.

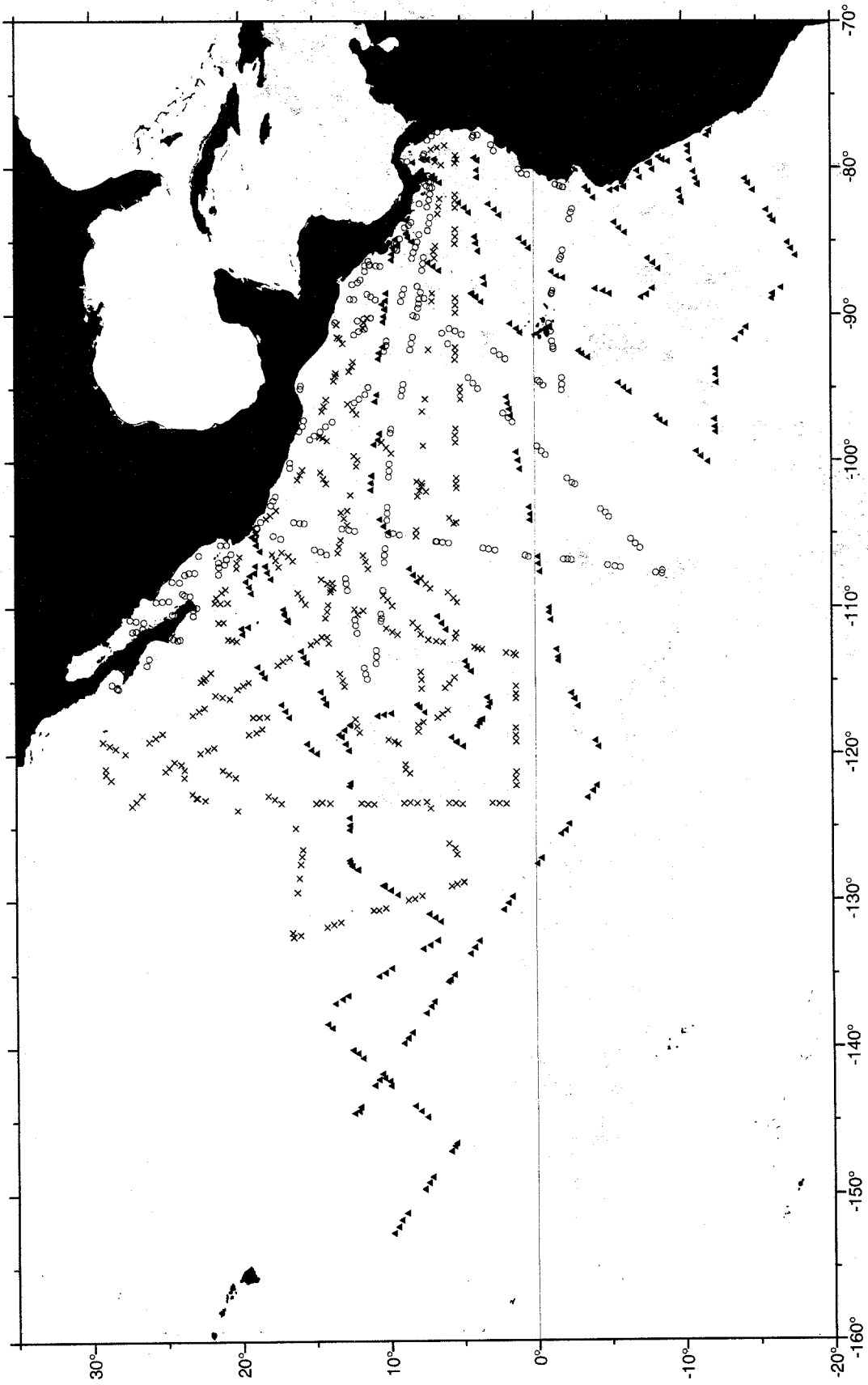


Figure 3. XBT deployments, *Jordan* (○), *McArthur* (x), and *Endeavor* (▲), 30 July - 9 December 1998.

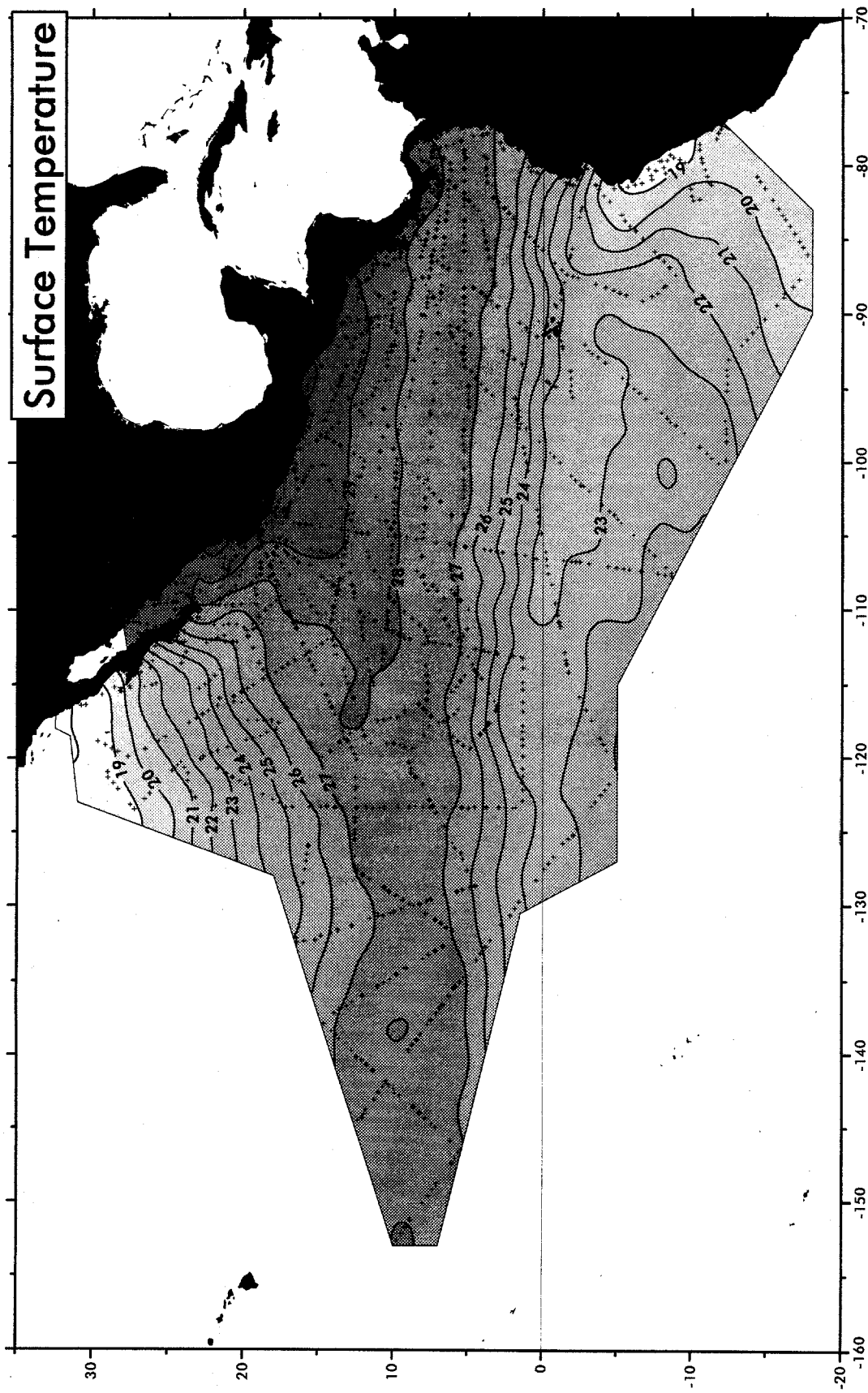


Figure 4. Sea surface temperature ($^{\circ}\text{C}$) from CTD and XBT profiles (+), 30 July - 9 December 1998.

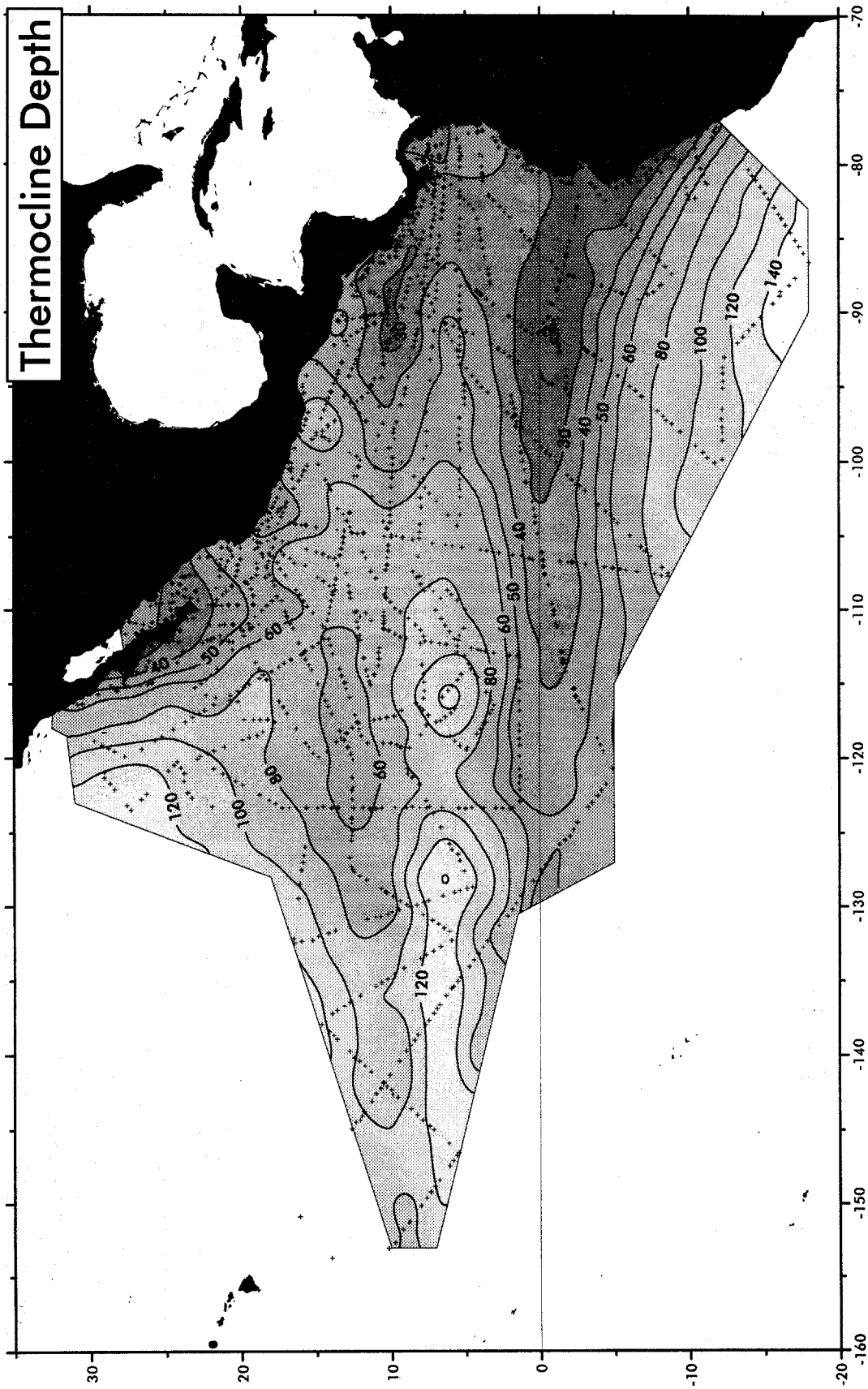
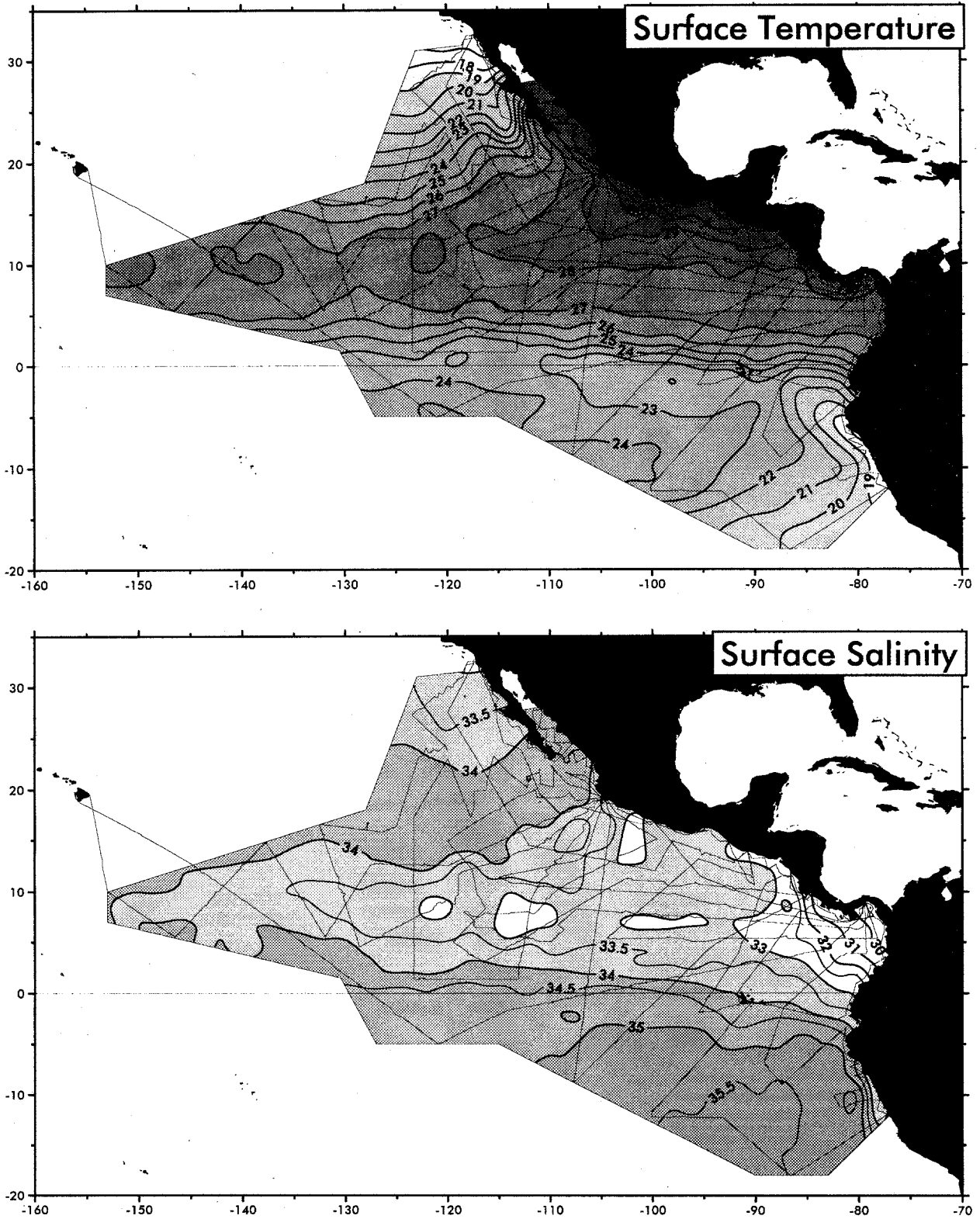


Figure 5. Thermocline depth (m, depth of maximum temperature gradient over an interval of 30 m) from CTD and XBT profiles (+), 30 July - 9 December 1998.

Figure 6. Sea surface temperature ($^{\circ}\text{C}$) and salinity (PSU) from thermosalinograph data, 30 July - 9 December 1998. Thin lines indicate cruise tracks for both ships.



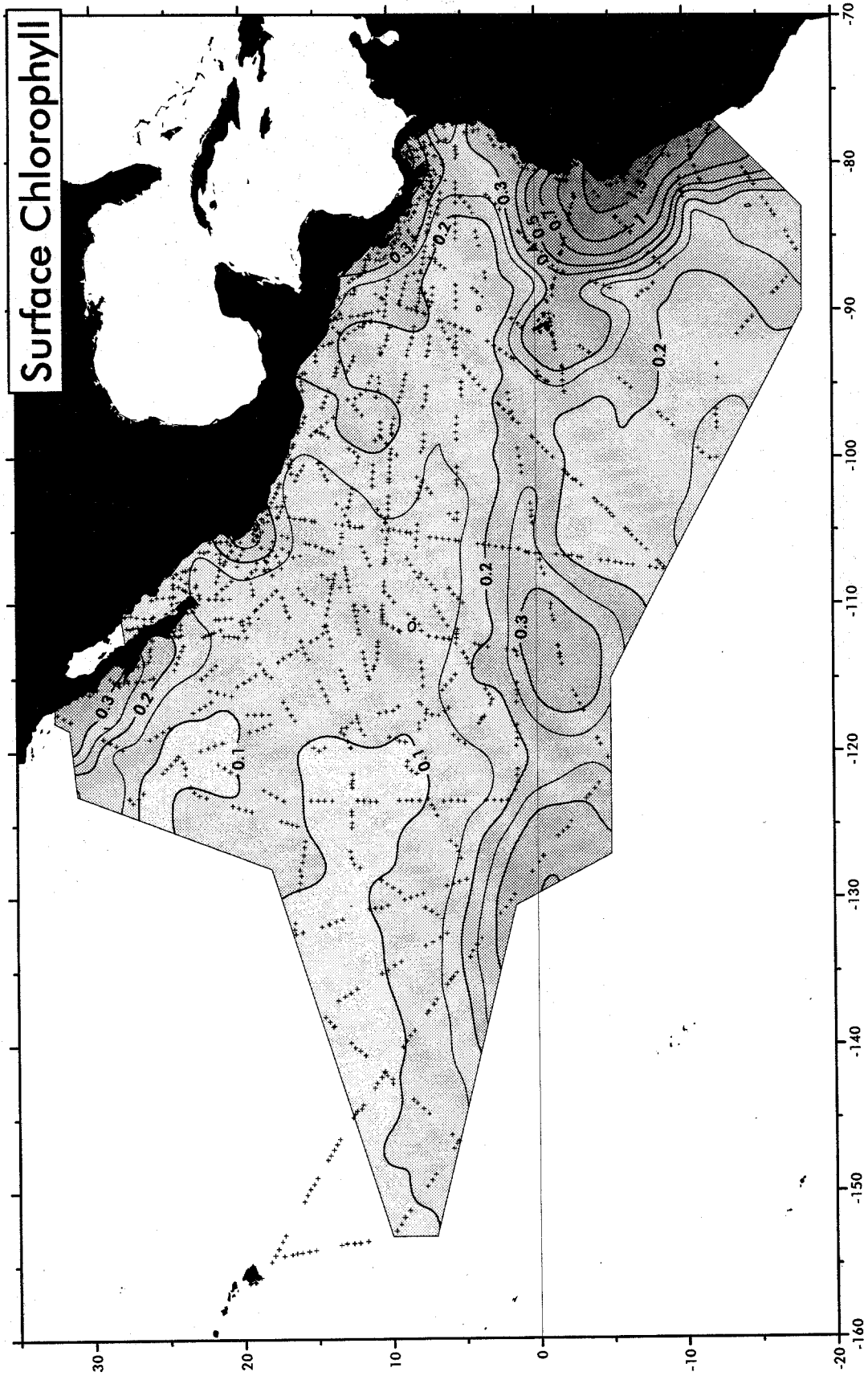


Figure 7. Surface chlorophyll concentration (mg m^{-3}), from CTD casts and underway samples (+), 30 July - 9 December 1998.

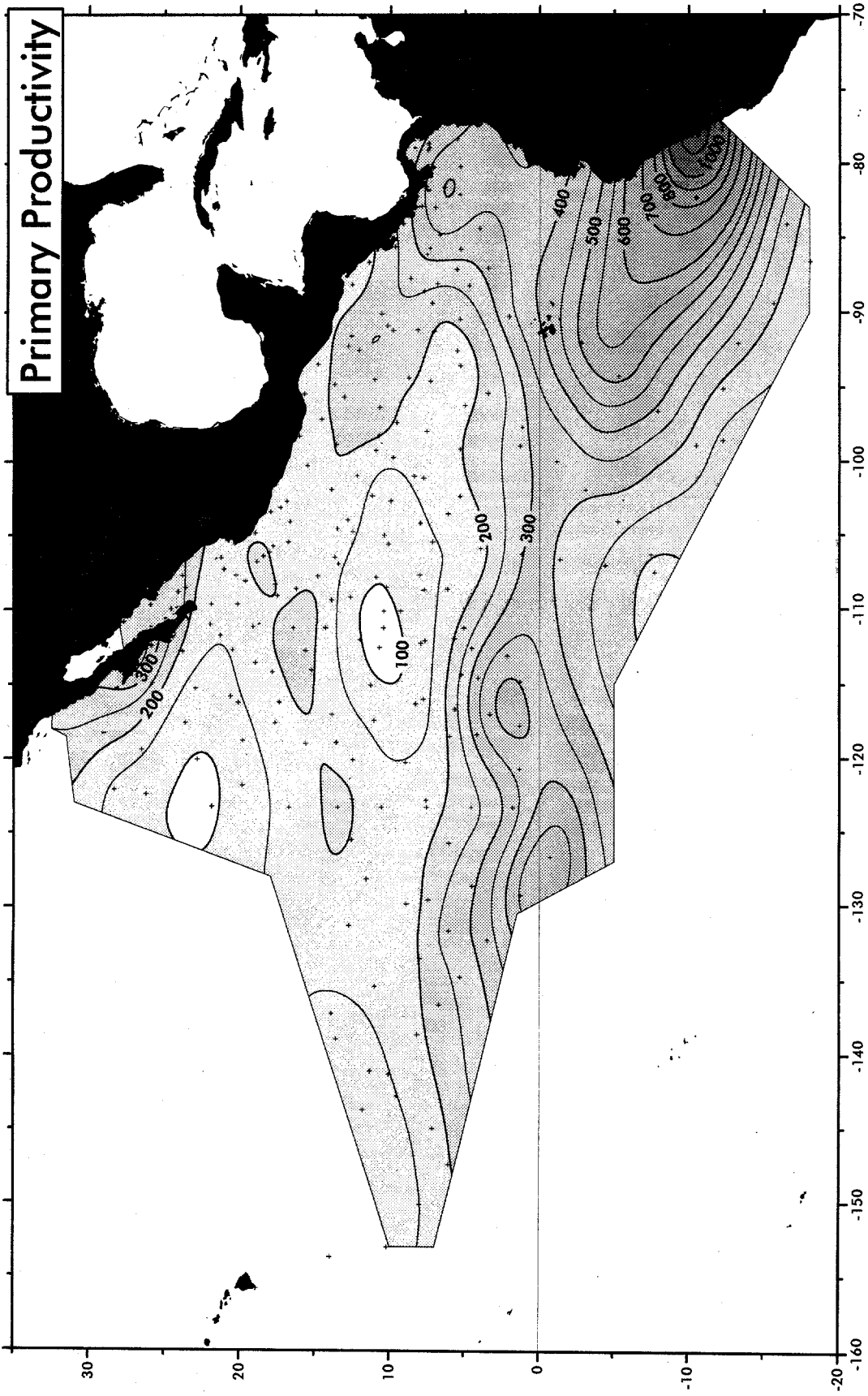


Figure 8. Primary productivity ($\text{mg C m}^{-2} \text{d}^{-1}$) in the euphotic zone, from morning CTD casts (+), 30 July - 9 December 1998.

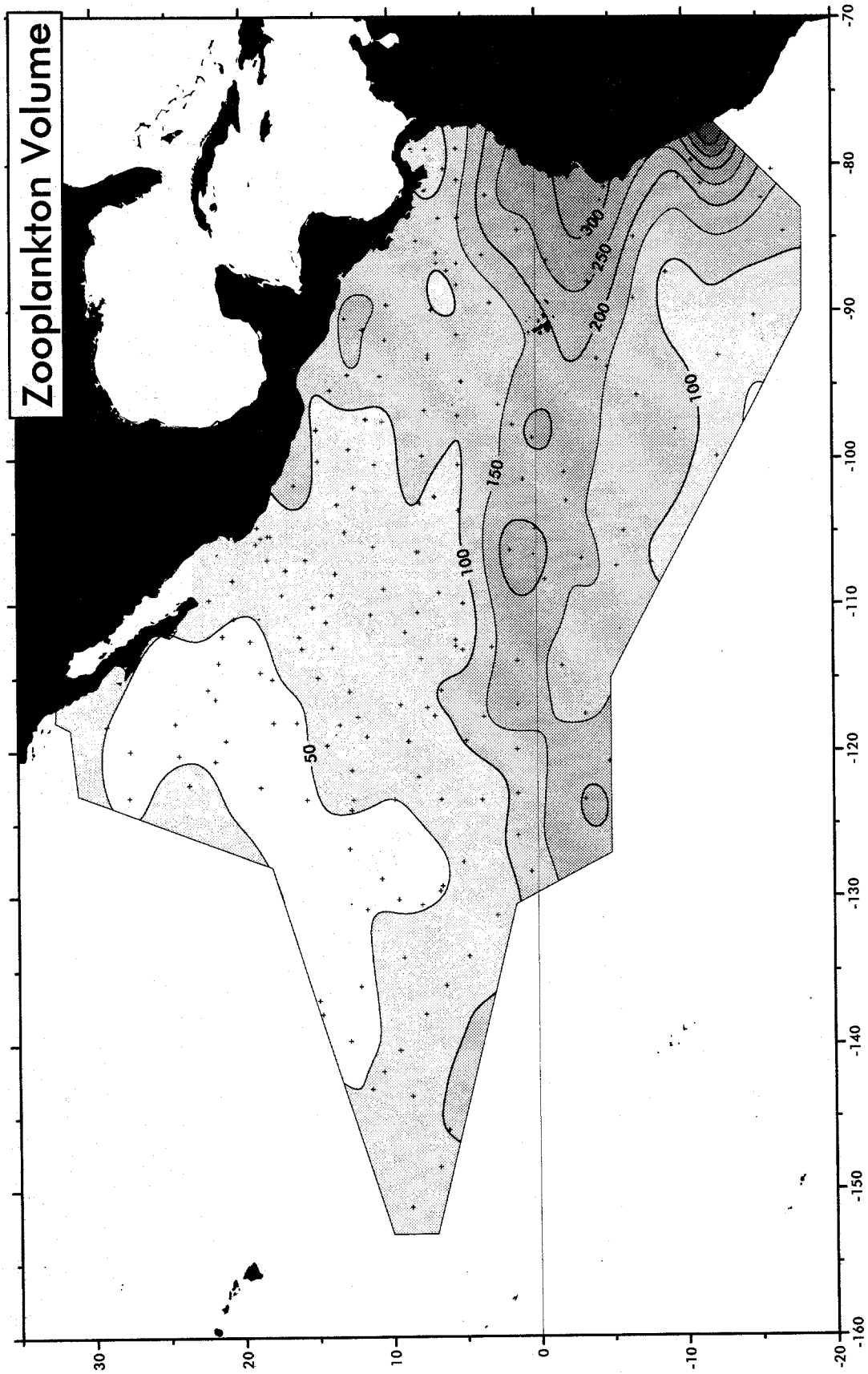
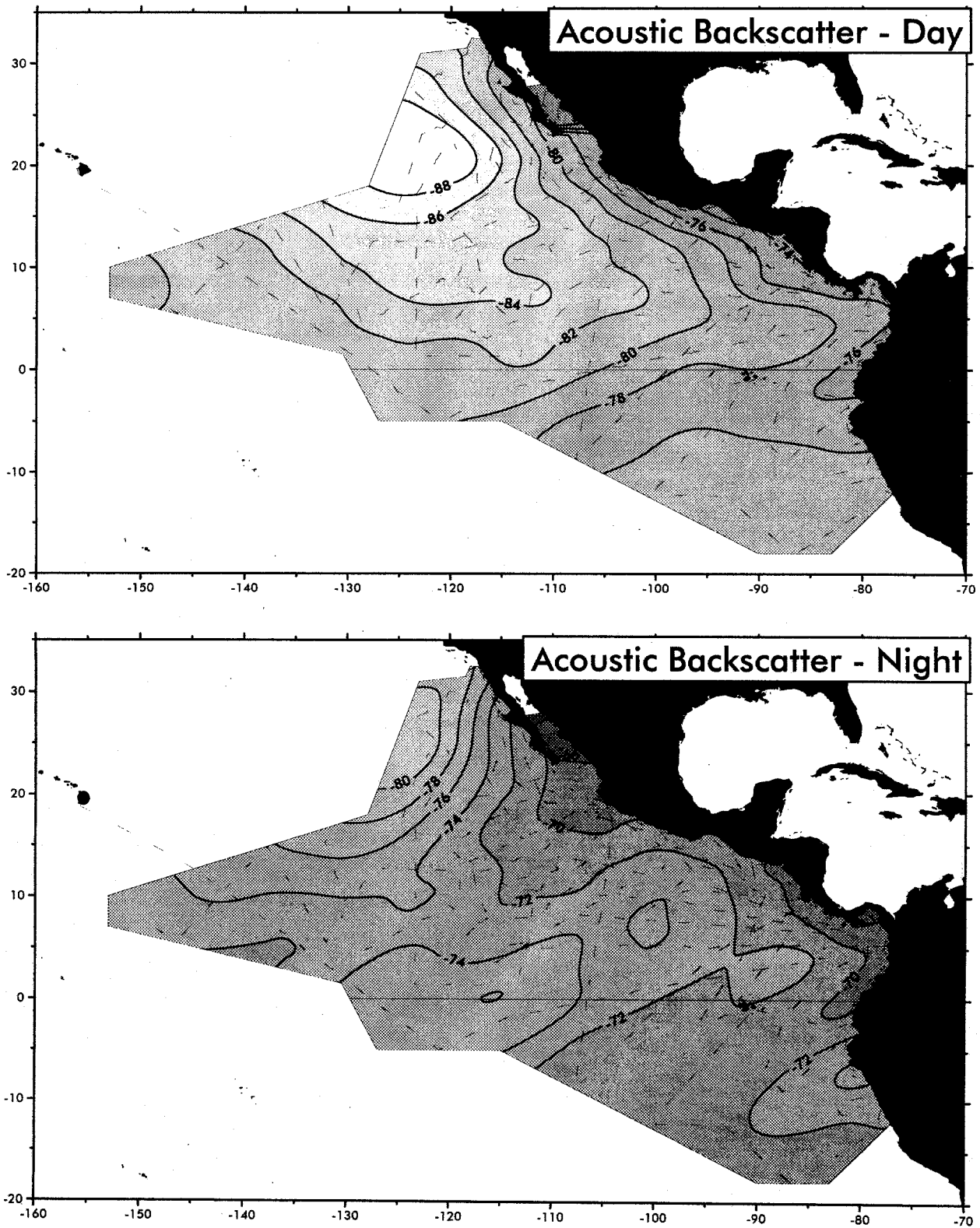


Figure 9. Zooplankton volume (ml 1000m⁻³) from 333- μ m ring net (*McArthur* only) and Bongo net tows (+), 30 July - 9 December 1998. Bongo net tow volumes adjusted by a factor of 0.43.

Figure 10. Acoustic backscatter (dB, 38 kHz), daily 0-100m means from 0800-1600 hours local ship time (top) and 2000-0400 h (bottom), 30 July - 9 December 1998. Thin lines indicate transect intervals during which displayed data were collected.



APPENDIX A

SCIENTIFIC PERSONNEL

Cruise Leaders

Tim Gerrodette, SWFSC (Chief Scientist)
Robert Pitman, SWFSC
Lisa Ballance, SWFSC
Paul Fiedler, SWFSC
James Carretta, SWFSC
Andy Dizon, SWFSC
Susan Chivers, SWFSC
Mark Lowry, SWFSC
Jay Barlow, SWFSC
Karin Forney, SWFSC
Barb Taylor, SWFSC
David Au, SWFSC
Meghan Donahue, SWFSC

Ship (Leg #s)

D.S. Jordan (1)
D.S. Jordan (2)
D.S. Jordan (3-6)
McArthur (1)
McArthur (2)
McArthur (3)
McArthur (4)
McArthur (5)
Endeavor (1)
Endeavor (2)
Endeavor (3)
Endeavor (4)
Endeavor (5)

Marine Mammal Identification Specialists

James Cotton, SWFSC
Brian Smith, SWFSC
Douglas Kinzey, SWFSC
Paula Olson, SWFSC
Richard Rowlett, SWFSC
Tom Jefferson, SWFSC
Gary Friedrichsen, SWFSC
Rick LeDuc, SWFSC

D.S. Jordan (1,2) McArthur (3-5)
D.S. Jordan (1,2) McArthur (3,4)
D.S. Jordan (3,4) McArthur (1,2) Endeavor (4,5)
D.S. Jordan (3,4) McArthur (1,2) Endeavor (4,5)
D.S. Jordan (5,6) Endeavor (1-3)
D.S. Jordan (5,6)
Endeavor (1,2)
Endeavor (3)

Marine Mammal Observers

Elizabeth Moses, SWFSC
Todd Pusser, SWFSC
Kristen Rasmussen, SWFSC
Ernesto Vázquez, SWFSC
Lisa Baraff, SWFSC
Jorge Del Angel, SWFSC
Greg Krutzikowsky, SWFSC
Laura Morse, SWFSC
John Mason, SWFSC
Stephanie Norman, SWFSC
Cheryl Ryder, SWFSC
Juan Carlos Salinas, SWFSC
Kathy Hough, SWFSC
Joe Raffetto, SWFSC
Shannon Rankin, SWFSC
Koen Van Waerebeek, SWFSC

D.S. Jordan (1,2) McArthur (3-5)
D.S. Jordan (1,2) McArthur (3-5)
D.S. Jordan (1,2) McArthur (3-5)
D.S. Jordan (1,2) McArthur (3-5)
D.S. Jordan (3,4) McArthur (1,2) Endeavor (4,5)
D.S. Jordan (3,4) McArthur (1,2) Endeavor (4,5)
D.S. Jordan (3,4) McArthur (1,2) Endeavor (4,5)
D.S. Jordan (3,4) McArthur (1,2) Endeavor (4,5)
D.S. Jordan (5,6) Endeavor (1-3)
D.S. Jordan (5,6) Endeavor (1-3)
D.S. Jordan (5,6) Endeavor (1-3)
D.S. Jordan (5,6) Endeavor (1-3)
D.S. Jordan (6)
McArthur (5)
Endeavor (1-5)
Endeavor (1-5)

Bird Observers

Brett Jarrett, SWFSC
Robert Pitman, SWFSC
Fritz Hertel, University of California, Los Angeles
Stuart Pimm, University of Tennessee
Michael Force, SWFSC

D.S. Jordan (1,2) McArthur (3-5)
D.S. Jordan (1,3-6)
D.S. Jordan (2,3)
D.S. Jordan (6)
McArthur (1-5)

Dawn Breese, SWFSC
Larry Spear, SWFSC
Cornelia Oedekoven, SWFSC

McArthur (1,2)
Endeavor (2-4)
Endeavor (1-5)

Scientific Observers

Luana Galver, SWFSC
Kathy Hough, SWFSC
Katie Cramer, SWFSC
Elyse Bixby, SWFSC
Nick Kellar, SWFSC

D.S. Jordan (3)
D.S. Jordan (5)
Endeavor (2)
Endeavor (3)
Endeavor (4)

Oceanographers

Valerie Philbrick, SWFSC
Kerry Kopitsky, SWFSC
Kerri Danil, SWFSC
Kathryn Noyes, SWFSC
Lynn Butler, SWFSC

D.S. Jordan (1-4,6)
D.S. Jordan (1-6)
McArthur (1-5)
McArthur (1-5)
Endeavor (1-5)

Acoustic Technicians

Tom Norris, SWFSC
Christine Vitulli, SWFSC
Julie Oswald, SWFSC
Mark MacDonald, SWFSC
Karen Fear, SWFSC
Aaron Thode, SWFSC

Endeavor (1-5)
Endeavor (1)
Endeavor (2)
Endeavor (3)
Endeavor (4)
Endeavor (5)

Marine Technicians

William Fanning, University of Rhode Island (URI)
David Nelson, URI
Tom Orvosh, URI

Endeavor (1,4)
Endeavor (2,3)
Endeavor (5)

Foreign Observers/Guest Scientists

Alonso Aquilar, Mexico
ENS Williams Casasola, Guatemala
Guillermo Jiménez, Mexico
Ruth Bello Calvo, Instituto del Mar del Perú, Peru
Jaume Forcada, University of Barcelona, Spain.

McArthur (1)
McArthur (2,4)
McArthur (5)
Endeavor (5)
Endeavor (5)

Photogrammetrists

Morgan Lynn, SWFSC
LT Alexandra VonSaunders, SWFSC
Daniel Palacios, Oregon State University
Jim Gilpatrick, SWFSC
LT Tom Martin, SWFSC
Wayne Perryman, SWFSC

D.S. Jordan (1,2,4,5)
D.S. Jordan (1)
D.S. Jordan (2,4,5)
D.S. Jordan (3,6)
D.S. Jordan (3)
D.S. Jordan (6)

Helicopter Support

LT Debra Barr, NOAA
Ron Helgeson, Aircraft Operations Center (AOC)
Pete Yates, AOC
LT Steve Pape, NOAA
Jimmy De La Cruz, AOC

D.S. Jordan (1,2,5,6)
D.S. Jordan (1,6)
D.S. Jordan (2,3,5)
D.S. Jordan (3,4)
D.S. Jordan (4)

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