

# The Gulf of Cadiz Expedition: R/V *Oceanus* Cruise 202

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Maureen A. Kennelly  
John H. Dunlap  
Thomas B. Sanford  
Eric L. Kunze  
Mark D. Prater  
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Technical Report  
**APL-UW TR 8914**  
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**Applied Physics Laboratory University of Washington**  
**Seattle, Washington 98105-6698**

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## ABSTRACT

Velocity, hydrographic, and dissipation measurements were made during the Gulf of Cadiz Expedition, 4-28 September 1988, to observe the vortices shed in the wake of Ampere Seamount, to survey eddies formed by the Mediterranean outflow near Cape St. Vincent, and to study the structure and dynamics of the outflow plume west of the Strait of Gibraltar. The expedition, the instrument systems, and their deployments are described, and preliminary results are presented.



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## 1. INTRODUCTION

This report describes the Gulf of Cadiz Expedition aboard R/V *Oceanus* and the instrument systems used, summarizes the instrument deployments made during the cruise, and presents some preliminary results. The objectives of the expedition were to observe the vortices shed in the wake of Ampere Seamount, to survey eddies (Meddies) formed by the Mediterranean outflow near Cape St. Vincent, and to study the structure and dynamics of the outflow plume west of the Strait of Gibraltar. The cruise consisted of two legs: leg 1, from 4–19 September 1988, corresponded to leg IV of *Oceanus* voyage 202 and leg 2, from 21–28 September 1988, corresponded to Leg V.

This scientific program was funded by the Office of Naval Research and was under the direction of four Principal Investigators: T. Sanford and E. Kunze of the University of Washington, J. Price of the Woods Hole Oceanographic Institution, and R. Lueck of Johns Hopkins University. The operational areas for the expedition included Ampere Seamount, the area around Cape St. Vincent, Portugal, and the Gulf of Cadiz west of the Strait of Gibraltar (Figure 1).

During the first leg, measurements were made on the flanks of Ampere Seamount ( $35^{\circ}03'N$ ,  $12^{\circ}52'W$ ) to examine the fine-scale potential vorticity field, which is postulated to exist on the same scales as internal waves. The likelihood of finding fine-scale vortices was thought to be greater in the wake of a seamount. Four drifters, drogued to track water between 100 and 300 m depth, were deployed to determine the structure of the mean flow. They revealed an east-southeast flow of approximately  $6 \text{ cm s}^{-1}$  on the north flank of the seamount and a stagnation point to the southeast. Two surveys were conducted with expendable current profilers (XCPs) in search of eddies shed in the wake of the seamount. Each survey was a cross pattern. The first was  $4 \times 7 \text{ km}$ , and the second was  $9 \times 7 \text{ km}$ . By combining horizontal temperature and velocity gradients, it will be possible to estimate potential vorticity. Anomalies in potential vorticity are an irrefutable signature of shed vortices since internal waves have no potential vorticity signal.

Another purpose of the first leg was an extensive survey of the slope and the deep water regions southwest of Portugal to observe forming and newly formed Meddies. Eddies containing cores of Mediterranean water often have been observed in the

Sargasso Sea (McDowell and Rossby, 1978) and Canary Basin (Armi and Zenk, 1984; Armi et al., 1988) and may be an important mode for the movement of Mediterranean water into the Atlantic. One Meddy was surveyed extensively. The core of this Meddy was in near-solid-body rotation out to 8 km radius.

The second leg of the expedition was devoted to measuring the structure and modifications of the Mediterranean water as it exits the Strait of Gibraltar and flows down the steep channels leading into the Gulf of Cadiz. These observations will be used to determine characteristics of the outflow plume as a function of distance from the strait, and to evaluate a model developed by Jim Price for such flows.

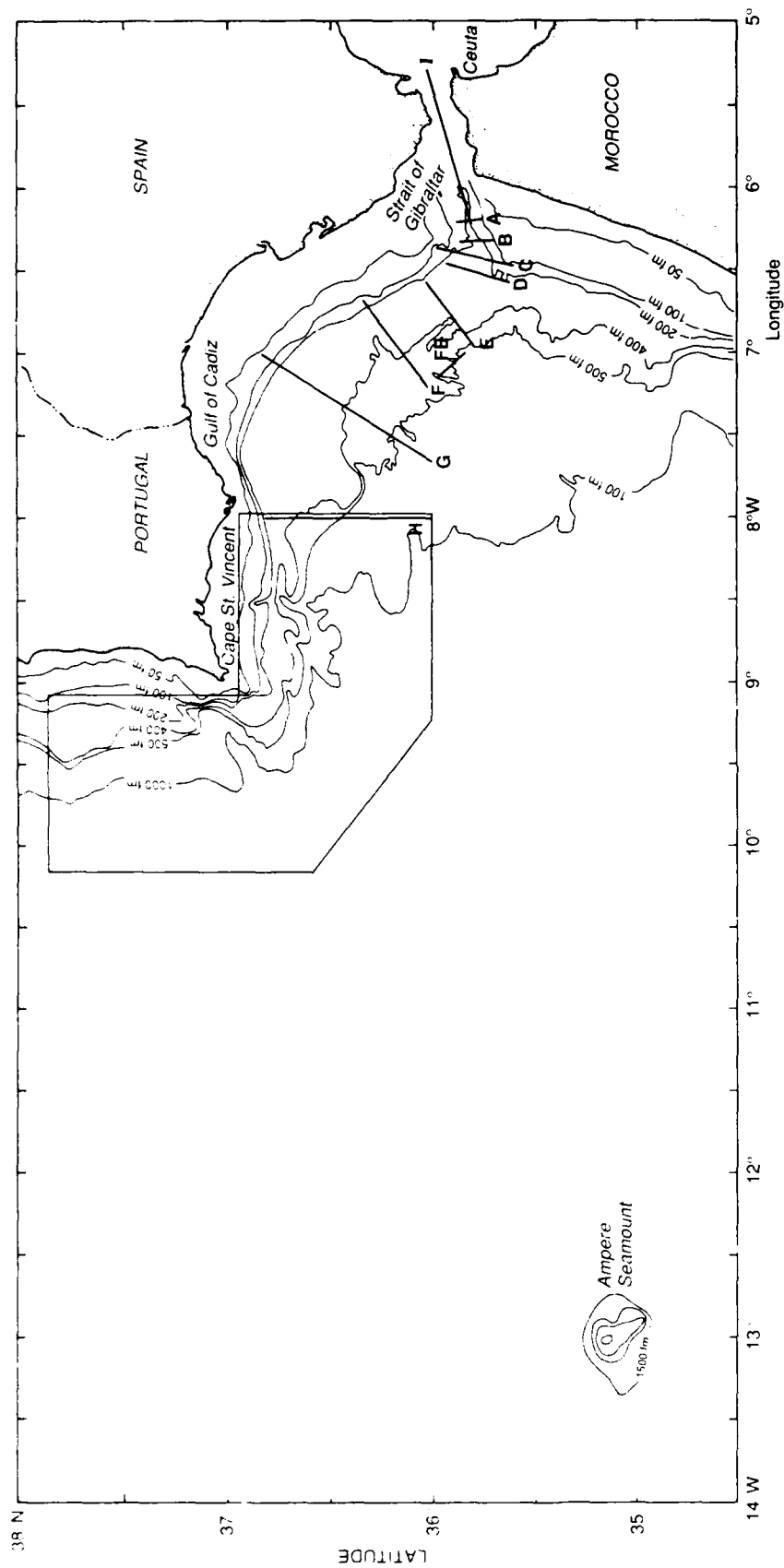


Figure 1. Operational areas for the Gulf of Cadiz Expedition. The areas included Ampere Seamount, the Cape St. Vincent region (boxed), and the continental slope west of the Strait of Gibraltar (sections A-I).

## 2. INSTRUMENT SYSTEMS

Various instrument systems were used throughout the cruise. Much of the field work during leg 1 was conducted with expendable profiling devices while the vessel was under way. These included expendable bathythermographs (XBTs), expendable current profilers (XCPs), and expendable sound velocity profilers (XSVs). Additional instrument systems included a moored radar transponder, drifters, a conductivity-temperature-depth (CTD) profiler, an acoustic Doppler current profiler (ADCP), a bottom depth recorder, a serial ASCII instrumentation loop (SAIL), and navigation equipment. These instrument systems were supplemented with expendable dissipation profilers (XDPs) on leg 2.

### 2.1 Mooring

A radar transponder was moored atop Ampere Seamount (which is at a depth of approximately 50 m) to aid navigation during the seamount component of the experiment. The mooring was designed by Marv Stalcup of the Woods Hole Oceanographic Institution and consisted of a tethered float and an anchored float (Figure 2). These two floats were connected by 20 ft of polypropylene line. Attached to the free float were a radar transponder, light, battery pack, retrieval line with a small float, and ballast weights. A 350-lb anchor made of steamer chain was attached to the second float by 100 m of plastic-covered steel cable and pear links.

The tethered float was top heavy when initially deployed, so 90 lb of lead were added to the bottom. The anchored float was also top heavy, but no additional weight was available so it floated on its side rather than upright. The batteries in the radar transponder were replaced after 72 hours of deployment. Unfortunately, the second battery pack flooded shortly thereafter.

### 2.2 Drifters

Four drifting buoys (drifters) were deployed in the vicinity of Ampere Seamount and tracked to determine the mean flow around the seamount. The drifters were designed by Robert Drever of APL-UW. Their design was simple in concept, as shown in Figure 3. They were composed of an OAR Inc. xenon flasher, a radar reflector, a Polyform float, a small float with a tag line for recovery, lead ballast weights, nylon and Dacron

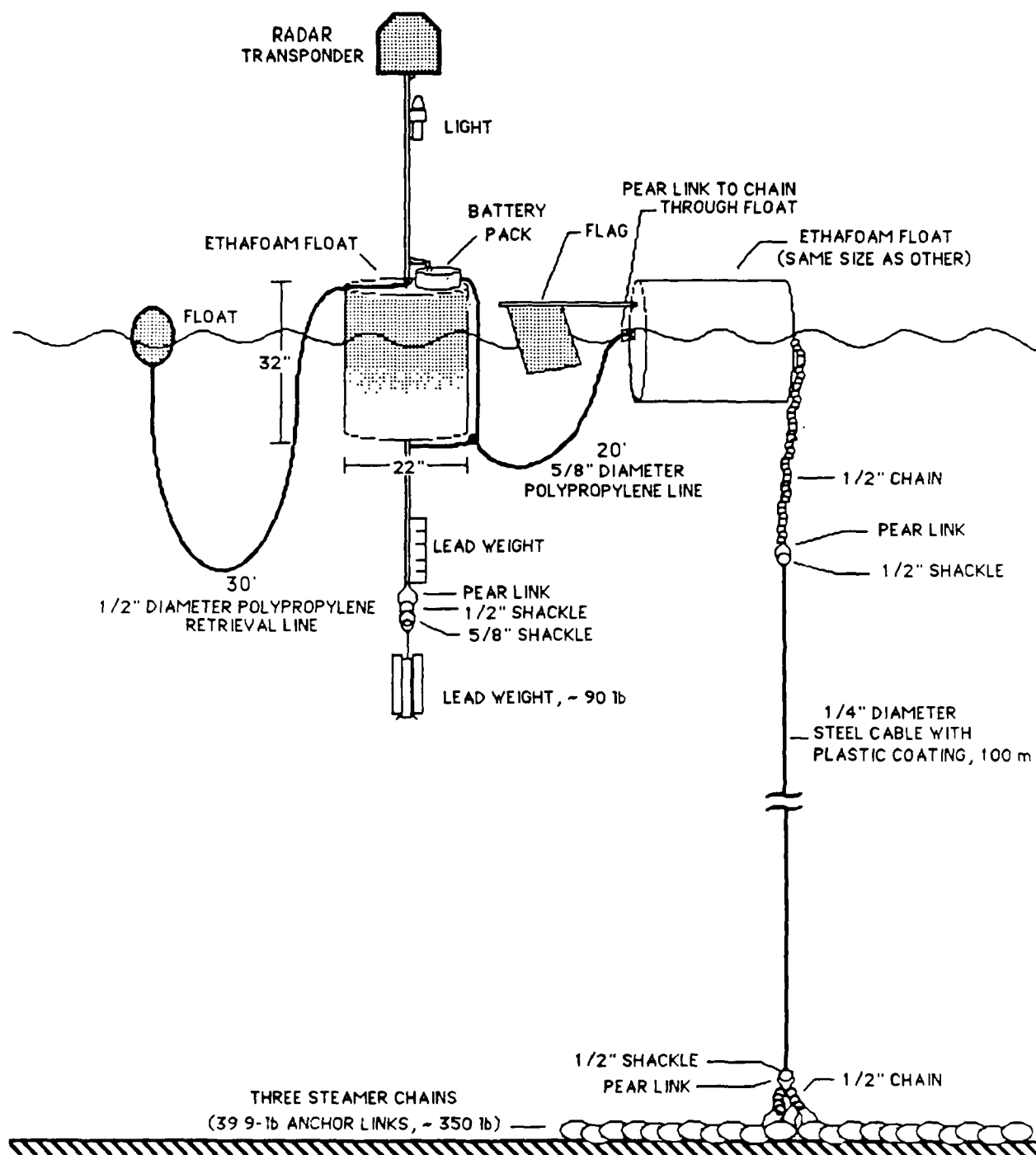


Figure 2. Radar transponder mooring on summit of Ampere Seamount.

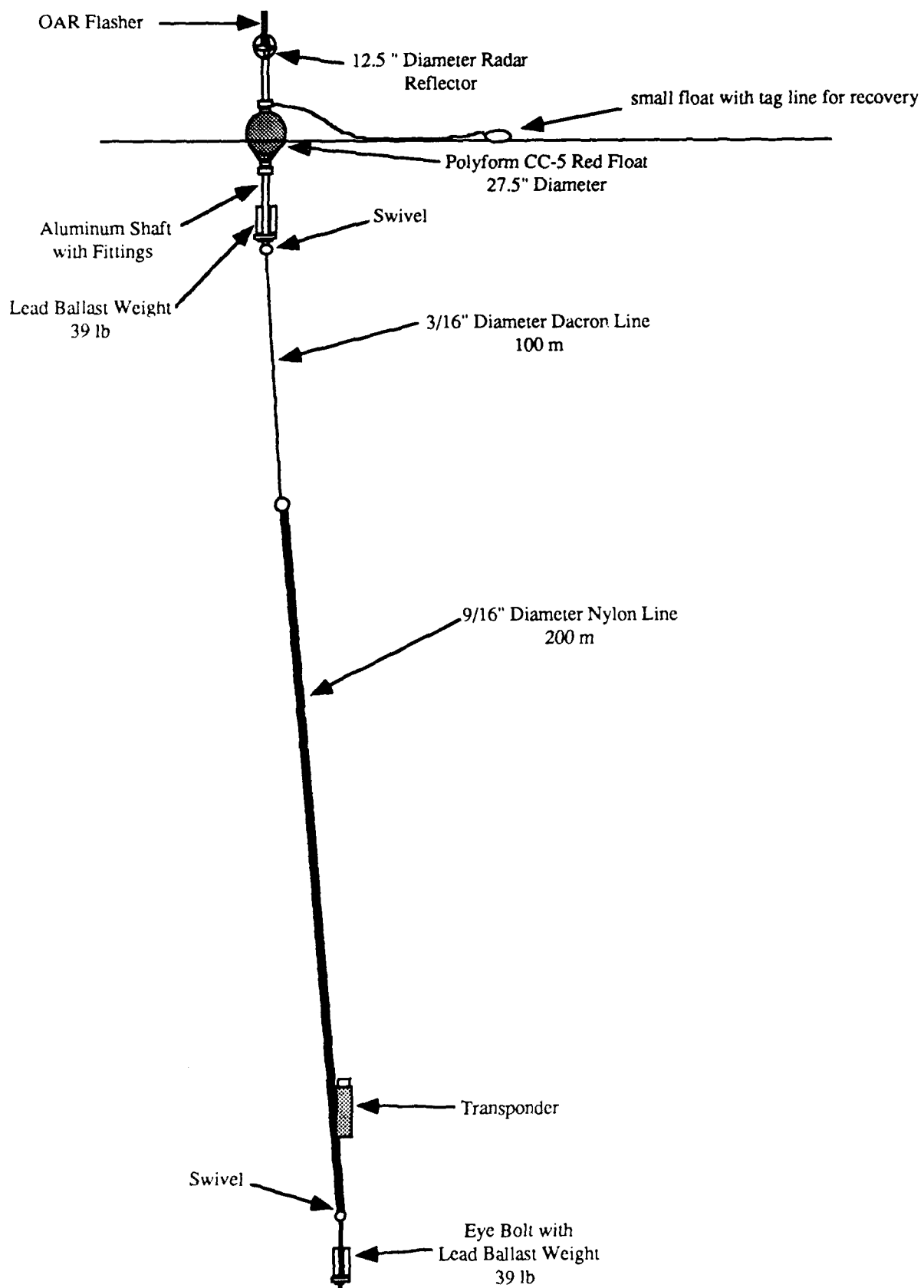


Figure 3. Drifter design.

line, and either an Oceanographic Instrument Systems Inc. transponder or an acoustic command receiver/transponder/timer. The acoustic command receivers were used only in the transpond mode.

The drifters were designed to have low drag in the first 100 m and high drag between 100 and 300 m to track the flow below the seamount summit. XCP profile data from *Meteor Cruise 57* in 1981 for the area in which the drifters were going to be used showed that most of the high current structure was in the upper 50 m. Below 50 m the current was less than  $15 \text{ cm s}^{-1}$ . The largest drag force would be on the 200 m of 9/16-in. nylon, causing the drifters to track the water in the 100 to 300 m depth range. The transponders were used to track the drifters acoustically from the ship, using the standard 12-kHz depth sounder. The drifters each had a separate acoustic signature. The depth recorder was run at a 4-s repetition rate; the two transponders would reply once every 4 s, and the command receivers/transponders would reply once every 8 s because of a built-in circuit that set their fastest reply rate to 8 s. The pulse duration was set to about 12.5 ms for one transponder and one command receiver and to about 25 ms for the other two units. The range was limited to a few kilometers because of the strong decrease in sound speed in the upper thermocline. The radar reflectors on the drifters were painted in different color combinations to aid in visual identification. Table 1 summarizes the drifter characteristics.

Table 1. Drifter characteristics.

| Drifter No. | Serial No. | Model No. | Type             | Transmit Pulse (ms) | Markings     |
|-------------|------------|-----------|------------------|---------------------|--------------|
| 1           | 2419       | 2000      | Transponder      | 25                  | Orange       |
| 2           | 2392       | 3000      | Command Receiver | 12.5                | Orange/black |
| 3           | 2393       | 3000      | Command Receiver | 25                  | Orange/green |
| 4           | 2418       | 2000      | Transponder      | 12.5                | Orange/white |

The drifters served our purposes well, but the limited radar range due to sea-surface backscatter and the short acoustic range (<2 km) constrained their use to relatively small-scale experiments where their positions could be monitored regularly by ship. It might have helped to have something like an AMF Inc. acoustic command system that would have been more omnidirectional than the ship's narrowbeam depth recorder. A

transponder that could have been lowered over the side would have also helped. There is a need for better gear to recover the drifters because of the small diameter of the line and the large drag as the ship pulls the drifters through the water.

### 2.3 XCP/XBT/XSV Acquisition System

XCP/XBT/XSV data were acquired in real time with a Hewlett Packard 9020 computer using an integrated acquisition program written in HP-Basic, which also provided real-time processing and display of the data. Data from up to three probes could be acquired and displayed simultaneously (with three co-running "partition" programs controlled by a fourth "master" program). Raw XBT and XSV data and processed XCP data were archived on floppy disk. In addition, as the data were acquired the complete raw data stream was saved on an HP9144 magnetic cartridge tape drive connected to the HP9020. Raw data from the XCPs, XBTs, and XSVs were stored along with a time stamp, an indication of the probe type, and the partition that acquired the data.

A schematic of the acquisition system is shown in Figure 4. There were four Sippican-manufactured MK-10 XCP signal processors, one for each of the four channels (10, 12, 14, and 16) of XCPs deployed.\* At any time, only three MK-10s could be connected via GPIB cables to the three available I/O ports on the computer. Therefore the channel-10 MK-10 and channel-12 MK-10 were alternately attached to partition 1. The channel-14 MK-10 was always attached to partition 2, and the channel-16 MK-10 to partition 3. MK-9 XBT/XSV receivers were also connected to partitions 2 and 3 on the computer via GPIB cable.

In case of computer failure, the data were also stored on VHS audio/video magnetic tape. One backup system was dedicated to the XCP data and a second, independent system to the XBT/XSV data. Each backup system consisted of a VCR, a Sony Model PCM-F1 digital audio processor (PCM stands for pulse code modulation), and a power adapter. The frequency-modulated data from XCP channels 14 and 16 were stored

---

\*MK-10 XCP signal processors used during Cruise 202:

| Channel | Serial # | Local ID |
|---------|----------|----------|
| 10      | 844003   | AMP      |
| 12      | 852601   | EM2      |
| 14      | 844001   | EM1      |
| 16      | 845103   | Niiler   |

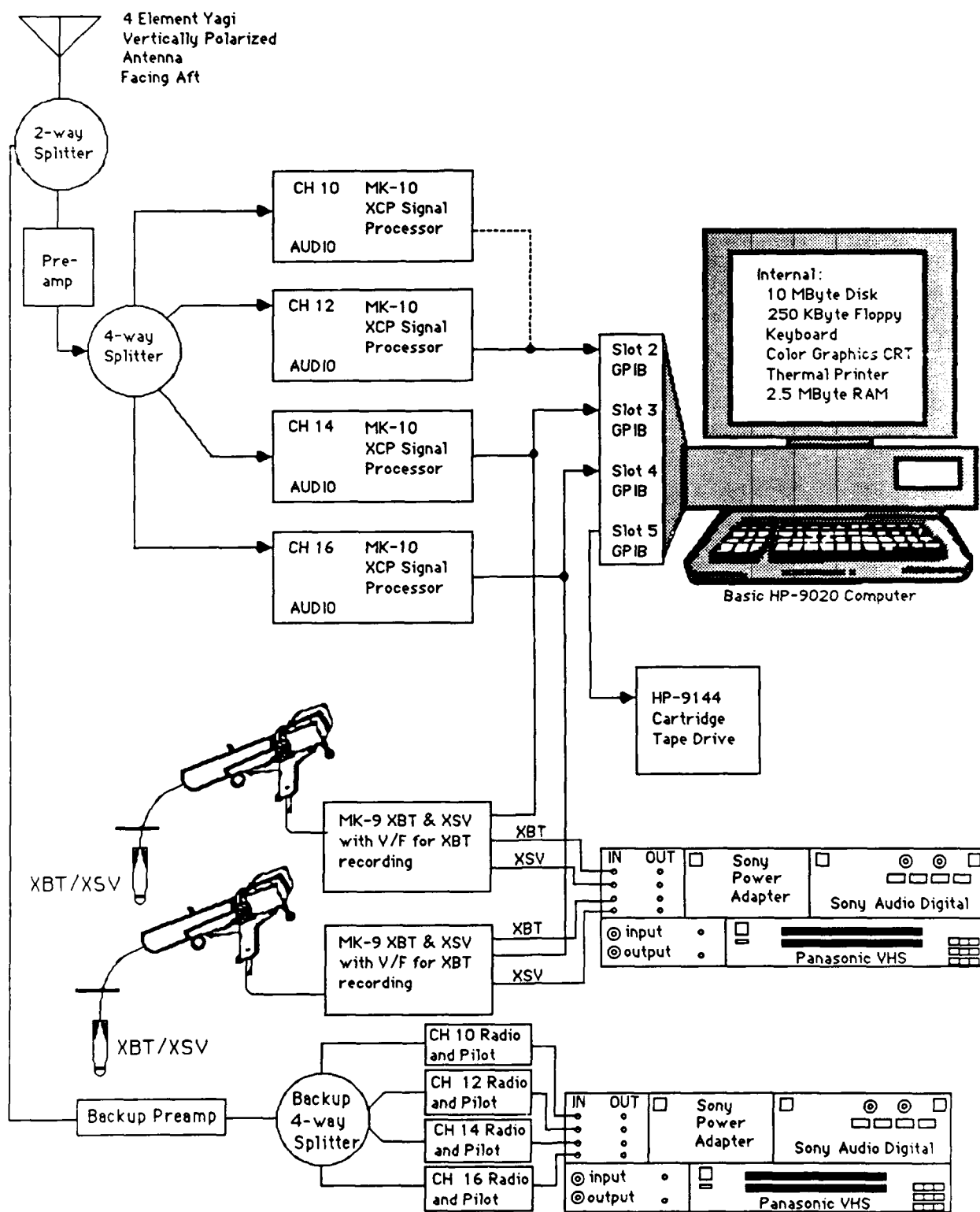


Figure 4. XCP/XBT/XSV acquisition system configuration.

directly on the audio tracks of the VHS tape. XCP data from channels 10 and 12 passed through the digital audio processor for storage on the video tracks.

The XBT and XSV data were recorded on VHS tape as four frequency-modulated (FM) signals. The XSV signals are FM signals to begin with. They need only to be amplified and filtered to be recorded. The XSV data were passed through a digital audio processor and stored on the video tracks of a VHS tape. The XBT output was an analog voltage that was converted to an FM signal. The frequency range of the XBT FM signal was selected to use the frequency range of the Air Deployed XBT (AXBT), so that with a little work the AXBT card in the MK-9 receiver could be used to play through the backup data if they were needed. (The standard AXBT output is an FM signal.) The converted, FM XBT data were stored on the two VHS audio tracks. Both MK-9s were modified to emit a frequency-modulated voltage for recording the XBTs on VHS tape.

### 2.3.1 XCP Drops

In all, 184 Sippican Inc. Mod 7 XCPs were launched. Four channels (10, 12, 14, and 16) were used during the cruise. The channel-10 XCPs were specially manufactured for this expedition. Appendix A gives the drop particulars.

Three aluminum Cushcraft four-element Yagi antennas were mounted on the *Oceanus* for XCP reception. The antennas were located facing aft on the main mast, facing starboard on the main mast, and facing forward on the catwalk between the stacks. All antennas were mounted with the elements vertical for vertical polarization. All the elements were located on one side of the aluminum mounting pipe in the direction of the antenna's directivity. RG-8 cable connected the antennas to the MK-10s.

Before deployment, each probe was tested for radio operation, probe operation (shown by the presence of the three audio frequencies), and compass-channel response to a moving magnet. The squib wires coming out the base of the electronics housing were also examined. Only one XCP failed the prelaunch check for radio operation and was not deployed.

Of the 184 XCPs deployed, 46 were on channel 10, 46 on channel 12, 45 on channel 14, and 47 on channel 16. The channel-16 probes had the poorest record with 11 failures, followed by channel 12 with 7 failures, channel 10 with 4 failures, and channel 14 with 2 failures. Two failure modes were channel specific: the wire broke early

only on channel-10 probes, and the compass coil area was half its expected value only on channel-14 probes. The other problems, excluding drops for which there were no good data at all, were electrode reversals, bad temperature data, and noisy data. The overall success rate for the XCPs was 87%, or 160 good drops.

### 2.3.2 XBT Drops

Three types of Sippican Inc. XBTs (T-5, T-6, and T-7), going to depths of 1830 m, 460 m, and 760 m, respectively, were used during the cruise. Launchers were located on both the starboard and port aft quarters of the ship. Each launcher was connected to a MK-9. In all, 229 XBTs were deployed. Appendix B gives the drop particulars.

Seven type T-6 probes were deployed during the cruise, and all provided good data. Forty T-7s were deployed, with a 90% success rate: two did not provide any good data and two did not provide data to full depth. The T-5 success rate was somewhat disappointing—82%, or 150 good drops out of 182. The failure modes for the T-5s were as follows: 13 yielded no good data, 13 did not provide data to full depth, 3 had obvious temperature offsets, 2 were noisy, and 1 contained temperature jumps.

### 2.3.3 XSV Drops

Two types of Sippican Inc. XSVs (XSV-02s and XSV-03s), going to depths of 2000 m and 850 m, respectively, were used during the cruise. The same launchers were used for the XSVs as for the XBTs. In all, 55 XSVs were deployed. Appendix C gives the drop particulars.

During the first few deployments, the XSVs would not process or display. It was observed that as an XSV-02 (slowfall type) was launched it neither started the MK-9 nor provided ac signals more than 10 mV. More solid grounds were placed on the MK-9; however, they did not seem to solve the problem. Next, the XSV boards were swapped between MK-9 units. The next XSV-02 (XSV 5) worked well, giving voltages of more than a volt.

However, the XSV failure problem recurred. Seldom were the proper prelaunch voltages measured from the MK-9 or usable signals received from the falling probes. The condition of the launcher and cables was repeatedly checked. For a while it was thought one or both of the XSV boards were damaged.

Closer examination of the XSVs revealed that the cannister was often improperly aligned with the shipboard spool. Evidently, the probes were assembled without regard to the notch on the cannister and the arrowhead on the spool. There are three connecting tabs on the cannister, allowing three different orientations between the cannister and spool. Because only one orientation permits the correct connections to be made at the launcher, the data return was poor. Seven probes failed before our discovery of the manufacturing error. The remaining probes were checked and realigned if necessary. The probes that were realigned are noted in Appendix C.

Of the 55 XSVs launched, 52 were type 02 and the remaining three were type 03. All the type 03s provided good data. The overall success rate for the type 02s was 79%. Before the manufacturing error was detected, seven of the first nine XSV-02s failed. After that, one failed to provide good data; another was noisy, and two did not provide data to full depth.

## 2.4 CTD Casts

A Sea-Bird Electronics (SBE) Model 9 underwater CTD unit, serial number 1, was used for this cruise. A 12-kHz pinger was attached to the frame of the unit and used for casts going to the bottom. Ninety-nine pounds of ballast were also attached to the frame.

The underwater unit was modified by SBE before the cruise to change the order of the data variables to match SBE's software.

The underwater unit contained the following sensors: a Paroscientific Digiquartz pressure sensor (model 76KB-036, serial number 18377) with a pressure range of 0 to 6000 psi, dual temperature sensors (model SBE-3-01F, serial numbers 574, primary, and 575, secondary), dual conductivity sensors (model SBE-4-01, serial numbers 166, primary, and 179, secondary), and a submersible pump (model SBE-5-01, serial number 1). The pump increased the flushing speed of water through both conductivity sensors to improve their dynamic response.

The CTD data-acquisition computer was a COMPAQ Deskpro 286 Personal Computer (Model 40, serial number 4809AM3B1351). A NEC Multisync II monitor was used with the computer. Boards installed in the computer included a VEGA brand enhanced graphics adapter (EGA) board, a National Instruments GPIB-PC-IIA board,

and an Intel 80287 math coprocessor (8 MHz). An Epson FX86e dot matrix printer was used with the system for screen dumps.

The SBE Model 11 deck unit, serial number 6, was connected to the COMPAQ computer via a GPIB (IEEE-488) interface. A Sony TC-K555 stereo cassette recorder was used to store the raw CTD data on analog tape. The schematic in Figure 5 shows the system's configuration.

Approximately 9000 m of Rochester Corporation three-conductor cable (code #I30030022MB00) was spooled onto the Markey Desh5 dc electric winch onboard the R/V *Oceanus* for use as CTD cable. Only two of the three #20 AWG 7/0.0126-in. copper conductors were usable. One conductor was shorted to the armor about 6000 m into the spool. Only one of the two "good" conductors was used during the first 31 CTD casts. The cable was reterminated, and both conductors were operated in parallel for casts 32-148.

Standard stainless steel termination cups from UW Ocean Technical Services were used during the cruise. The mechanical link used to attach the cable to the CTD unit was

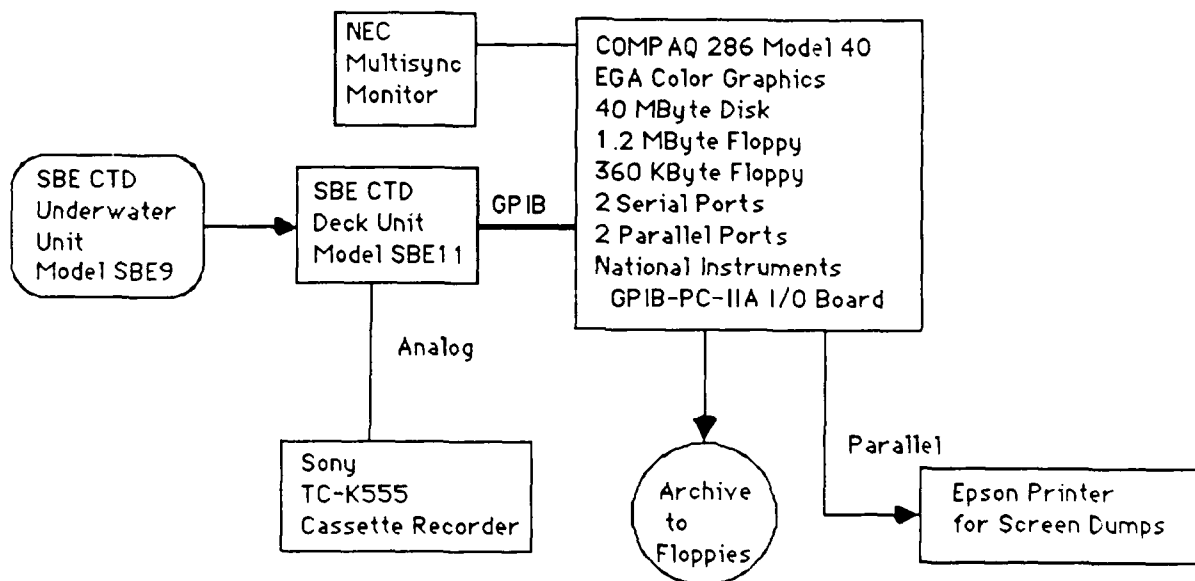


Figure 5. CTD acquisition system configuration.

a Cerrabend alloy. Individual electrical conductors were soldered, insulated from seawater, and attached to a two-pin SeaCon connector to mate with the Sea-Bird CTD bulk-head connector. Normally, the University of Washington conducts static load tests on the terminations; however, these tests were not done for this cruise.

A 1.5-liter Niskin bottle was used to collect water samples. The Niskin bottle was attached to the electromechanical wire supporting the Sea-Bird CTD unit. The bottle was attached 2 m above the sensors on the CTD. The bottle was tripped by means of a brass "messenger." Water samples were taken either at or close to the terminal depth of the CTD cast. In areas with large vertical gradients in temperature and/or conductivity at terminal depth, the sampling depth was adjusted during the messenger's fall time ( $200 \text{ m min}^{-1}$ ) to remain constant within several meters. Later in the cruise, the CTD was raised to a depth with a smaller gradient for better calibrations between bottle-sample salinity and sensor salinity.

In all, 148 CTD casts were made. Appendix D summarizes the station information. The first cast went down to 2500 m. All others were to either the bottom or approximately 2000 m.

## 2.5 XDP Drops

XDPs made by Rolf Lueck of JHU/CBI were used during leg 2 of the cruise. A special launcher was installed on the fantail for deployment. In all, 61 XDPs were deployed. Appendix E gives the drop particulars.

## 2.6 ADCP Data

An RD Instruments 150-kHz ADCP is installed on R/V *Oceanus* as part of the ship's scientific equipment. The ADCP system consists of a hull-mounted transducer connected by cable to a deck unit in the main laboratory. A computer is connected to the deck unit via a GBIP cable for data acquisition and storage. Prior to our cruise there were reports that the ADCP did not work. The head of the Shipboard Scientific Group at WHOI indicated there was a "beam 4 failure," and the chief scientist of the cruise preceding ours had examined the connector and noticed that some of the pins were corroded.

Two members of the APL group examined the ADCP when the ship arrived in port. They noted that there was no O-ring in the connector as there should have been. The connector leaks if no O-ring is present. The corrosion was probably caused by electric current flowing through seawater between the pins in the connector while the ADCP unit was in operation.

Two technicians were dispatched from WHOI to replace the cable and the bulkhead connector. Replacing the bulkhead connector requires removing the transducer from its mounting on the hull. In case the transducer had other damage besides just corroded pins, members of our group went into the well to put a cover plate on the hole so the transducer could be brought up to the laboratory for examination. (There was concern that the pins might have corroded all the way through the connector block, allowing seawater to enter the preamplifier electronics housing.)

As it happened, there was no easy way to cap off the hole (the cap we had was a bit too big, and we would have had to remove the recessing ring from the hull), so we gave up and put the transducer back in place. This took 3 or 4 hours at the bottom of the well, which was pressurized to about 7 psi so the water would not come in the hole in the hull.

The two technicians from WHOI arrived on 3 September and replaced the bulkhead connector. This involved unsoldering the old ribbon cable and resoldering the new one to the internal electronics. They had to take the transducer out again under 7 psi pressure.

The WHOI technicians also replaced the entire run of cable from the transducer to the deck unit in the laboratory. The cable, ordered specially from RDI Inc., contains some interesting connections at the connector to reduce noise, and it was considered impractical to try to solder another connector on the end of the existing cable and check it out in the time available.

The system worked satisfactorily at the dock when tested later on 3 September. However, it was only run for 5 or 10 minutes. It would have been better to have run it longer, because we had equipment failures soon after getting under way. If these failures had become apparent before sailing, we could have had the WHOI technicians troubleshoot the system.

After the ship got under way, the ADCP was run continuously to obtain profiles of velocity. While steaming to the first station, we noticed that the ADCP was failing. It would work for a few minutes after being turned on and then stop working. If the unit

was turned off and then on again, the computer would display a message that the RDI unit would not "wake up."

There seemed to be two problems with the ADCP. First, the so-called 5-Vdc source was closer to 4.5 Vdc, significantly less than expected. It was thought that this might be related to the wake-up problem. Replacing the power regulator board cured the low voltage state and the failure to wake up. After this fix, however, the computer would still hang up after running the ADCP for several minutes, and it was necessary to reset the system and reboot. It was not clear which part of the ADCP system was causing the problem, the computer or the deck unit. We contemplated inserting all the spare ADCP cards in the deck unit in the hope that this would cure the problem. The computer finally posted an error message indicating a problem with the directory on disk A. Disk A was not being used, so the computer itself, a NEC APCIV Power-Mate 1, was suspect.

We decided to try another computer and/or different software. A long IEEE 488 bus cable was strung from the ADCP to the COMPAQ Deskpro 286 used with the CTD system, which was running the same version of the RDI software (2.34). In this configuration, the system worked.

The backup CTD computer (an APC-3000 AT clone belonging to the University of Washington) was brought into the laboratory and used to operate the ADCP. After a few hours the screen went dark, so the ADCP was reattached to the CTD system COMPAQ Deskpro 286. Later, it was discovered that the problem was in the UW monitor and that the WHOI monitor could be used instead. This hybrid system was assembled and continued to work throughout the rest of the cruise.

It was thought that the transducer was rotated  $135^\circ$ , since the reference layer showed equal magnitudes for the east and north components when steaming due north. In addition,  $135^\circ$  was used in the software to make ADCP indicate a velocity opposite to the ship's. This orientation was confirmed on subsequent cruises.

The RDI system needs test equipment. It is virtually impossible to test it fully at the dock.

## 2.7 Depth Recorder

Bathymetric data were acquired continuously throughout the cruise, using a Raytheon LSR-1811 depth recorder. During leg 1 of the cruise, 15 days of bathymetry

data were acquired; 7 days of data were acquired during leg 2. Of the leg 1 data, 5 days were acquired in the vicinity of Ampere Seamount.

## 2.8 SAIL

The following data were acquired from the shipboard SAIL (Serial ASCII Instrumentation Loop): gyrocompass heading, ship's speed, Satellite/Omega Navigator position, wind speed (knots), relative wind direction, Northstar Loran position, sea surface temperature, and sea surface conductivity. The controller for the SAIL system was an IBM PC/XT clone. The control program for the SAIL system was Procomm, a terminal emulator program. Figure 6 shows a schematic of the SAIL system. Initially, data were acquired via the output port shown in Figure 6. However, this port broke after about half a day. Data were then acquired via the Y connection. The data acquired using these two methods have slightly different formats.

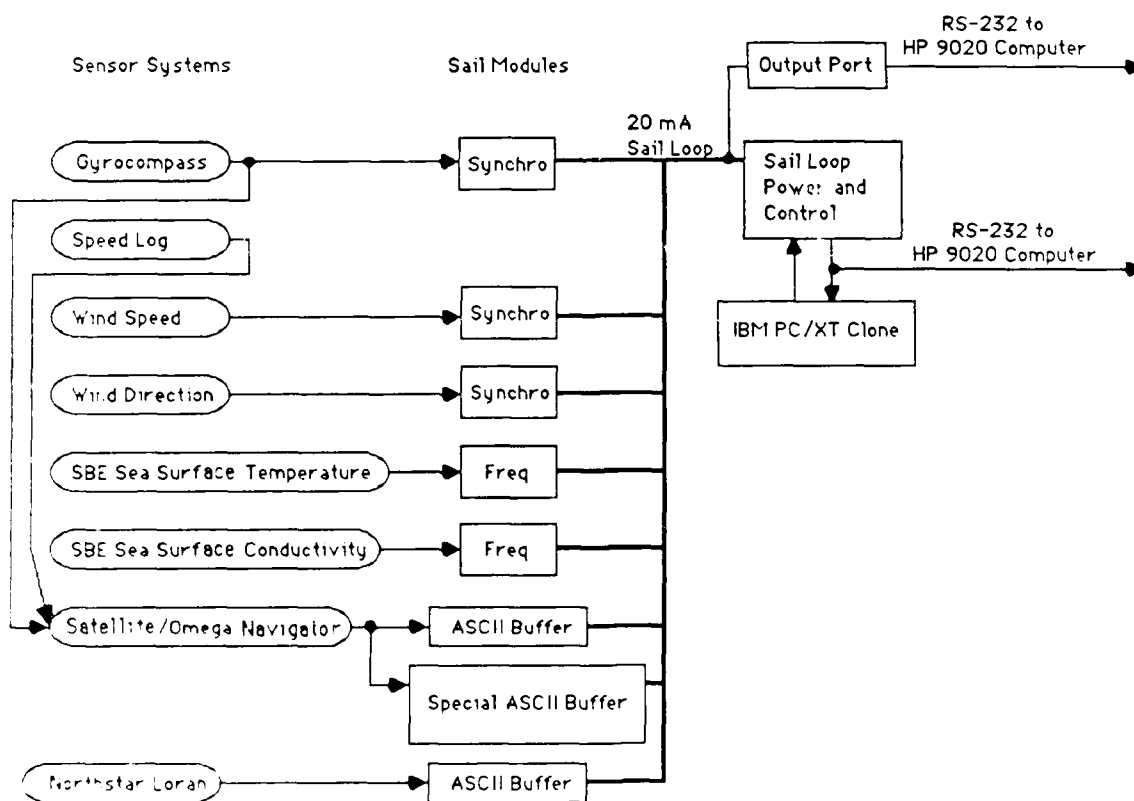


Figure 6. SAIL system configuration.

The standard ASCII buffer module captures only the first 255 bytes of the Satellite/Omega Navigator output. We wanted to get the entire 396-byte data stream. Therefore a SAIL ASCII buffer module was modified by Rod Mesecar's group at Oregon State University to discard the first 200 bytes of input data and retain the next 255 bytes. By using two modules, one standard and one modified, we were able to capture the entire 396 bytes of Satellite/Omega Navigator output.

## 2.9 Navigation

Accurate determination of station positions as well as the positions of the four drifters and the radar transponder was essential during this cruise. Much of the Ampere Seamount work was done with station spacings of 400 m. Other work depended on navigating accurately to repeat stations near small topographic features (seamounts) and oceanographic features (eddies). Therefore, a variety of navigation systems were used throughout the cruise and were integrated to produce the best positioning possible.

### 2.9.1 LORAN-C

A two-chain, range-range Loran-C system brought by the APL-UW researchers was used during the cruise. It consisted of two Megapulse Accufix-500 survey-quality receivers, each with an Efratom rubidium oscillator.

The maximum range of various European Loran-C stations was obtained from the U.S. Coast Guard, using their signal propagation model. These maximum ranges are a function of bearing and were taken to be where the signal-to-noise ratio in the model dropped to  $-10$  dB. At Ampere Seamount only the station at Soustons, France, was within range. The stations at Estartit, Spain, and Lessay, France, were just out of range. The French stations are in a separate chain from the Mediterranean stations, so both Loran-C receivers would be required to combine data from both chains. One problem is that the timing of the two chains is not tightly controlled with respect to each other. The Mediterranean chain is within  $2.5 \mu\text{s}$  of Universal Coordinated Time (750 m); the French chain's accuracy is not known by us. It was hoped that these offsets would change slowly so that they could be removed by periodic calibration with satellite fixes.

One Loran-C antenna was mounted on the catwalk between the stacks. The other was mounted on the aft port corner of the 01 deck with the coupler several feet above a

van. They were not mounted at the highest point on the ship to protect the active couplers from lightning, and they were set as far as possible from tall metal structures. The Loran-C grounding is very important. About 10 ft of No. 8 copper wire was connected between each coupler and the ship's hull. All connecting points were scraped bare, and serrated washers were used to ensure good electrical connections during the cruise. The antenna on the catwalk was installed in July before the ship left Woods Hole.

The Megapulse Accufix-500 receivers and Efratom rubidium oscillators were installed in the laboratory at the beginning of the cruise. Initially, both Loran-C receivers were set to receive the two stations of the French chain. This was to verify that the receivers and antennas were functioning correctly. Both gave the same time differences and the same signal-to-noise ratios for each station.

Later, set number two was switched to the two strongest stations of the Mediterranean chain. These stations were not as strong as the French stations, and the lock on them was lost several times until we had passed Ampere Seamount.

The Loran-C signal timing is specified at the third zero crossing. The sets are supposed to determine that crossing automatically. They usually do for good signals. The determination of the third zero crossing is hard when the signal is weak or distorted. With weak signals, the set may not be able to hear the first couple of cycles and may chose a later crossing thinking it is the third. To keep the sets from losing their lock on the signals when they were weak, the sets were forced to track a later zero crossing than they chose automatically.

The first zero crossing is not used because the signal starts with a low amplitude and builds to a maximum over 10 or 20 cycles. This slow buildup is to keep the bandwidth of the signal within  $\pm 10$  kHz so the Loran-C does not use up too much of the spectrum.

Using a later crossing potentially made the sets more susceptible to sky-wave interference, which is normally delayed several cycles from the ground wave. If the sets had in fact tracked the sky wave, this would be apparent in comparisons with Omega and satellite fixes. In addition, the ship's velocity over the ground would be very erratic as the ionospheric index of refraction changed the sky wave travel times. No such trouble was noted, except that data were noisier and the signal-to-noise ratio became much poorer at night, when the sky wave is much stronger.

The French stations gave the cleanest position data while the ship was south of and near Ampere Seamount. Farther to the east, where the crossing angles from the French chain became poorer and the stations in the Mediterranean chain became stronger, the Mediterranean stations were included to advantage.

There was one several-hour-long transmission outage at a Loran-C station, and there were several times when the Mediterranean chain was too weak to receive.

### 2.9.2 *Satellite/Omega Navigator*

A Magnavox Inc. MX-1103 Satellite/Omega Navigator was part of the ship's navigation system. The MX-1103 console contains a single-channel TRANSIT satellite receiver, a three-channel Omega receiver, two microcomputers, a video display unit, and a keyboard. TRANSIT is the Navy's navigation satellite system and provides accurate position fixes (here called Transit or satellite fixes) every few hours. The MX-1103 obtains these fixes and dead reckons the ship's position from them using information on the ship's heading (from the gyrocompass) and speed (from the speed log); this information is entered electronically.

The MX-1103 attempts to compute a set and drift based on the difference between two fixes and the integrated vector computed from the forward speed and heading. This method works well when the speed and direction of the wind, current, and ship all vary slowly, but otherwise degrades.

Besides the Transit fixes and the Transit/dead-reckoned positions, the MX-1103 can give integrated Transit/Omega position fixes.

The MX-1103 on the R/V *Oceanus* bridge was operated by the officer on watch and provided Transit fixes, as well as Transit/dead-reckoned and Transit/Omega positions, once every minute to the ship's SAIL system.

### 2.9.3 *Differential Omega*

A Sercel Inc. Model M-620 differential Omega receiver was purchased specifically for this expedition. It combined standard Omega signals with differential information transmitted by certain medium-frequency (200 to 400 kHz) radio navigation beacons. The specifications indicated that position accuracy in the differential mode would depend

on the range from the differential station—0.3 n.mi. at 50 n.mi., 0.5 n.mi. at 200 n.mi., and 1.0 n.mi. at 500 n.mi.

The differential Omega antenna was mounted on the catwalk between the stacks. The mounting post, cable, and ground wire were installed in July at Woods Hole, and the antenna was quickly mounted and connected in September in Madeira. The Sercel M-620 receiver was installed in the ship's laboratory.

The differential station in Porto Santos, Madeira, was used initially and then the station in Lagos, Portugal, when it became the closer station. The operation at Ampere Seamount was nearly equidistant from these two stations, and position accuracy might have been improved if an average of the two could have been used. Unfortunately, the M-620 did not allow that. The Porto Santos station was used near Ampere Seamount.

The Sercel M-620 worked as advertised for the most part. There were several instances of losing the differential signal within 100 n.mi. of Lagos, probably because of radio propagation effects. The differential Omega position was not good near local dawn as well as near 10:00 a.m. local time. These problems have not been explored further.

Unfortunately, the ROM in the M-620 did not perform as expected and did not provide station quality indices on the RS-232 port.

During leg 1 of the cruise, data from the differential Omega receiver were averaged in near real time and passed to a Macintosh computer running NAVplus. This program graphically presented the ship's track on the Macintosh screen and was helpful in monitoring the ship's progress during the various experiments. Unfortunately, the Macintosh's power supply blew up early on leg 2, and the program could not be used.

#### 2.9.4 *Global Positioning System (GPS)*

A Magnavox Inc. T-set GPS navigator was to have been part of the R/V *Oceanus* navigation system, but the GPS system was inoperable for the duration of the Gulf of Cadiz Expedition.

### 3. THE EXPERIMENT

#### 3.1 Leg 1

The R/V *Oceanus* departed Funchal, Madeira, at 1200 local time on 4 September. All the instrument systems were tested and checked out adequately. The existing hand-held XBT launcher on the port quarter failed the isolation test and was replaced with a new WHOI unit. The XCP system was tested and worked well except that there was more noise on channel 16 than on the other channels. This did not appear to affect the profile quality.

A test CTD station (CTD 1) was made around 1600 GMT. The CTD was lowered at a rate of  $30 \text{ m min}^{-1}$  to 300 m and then at  $60 \text{ m min}^{-1}$  thereafter to 2500 m. The CTD station showed the classic Mediterranean water core and a  $\sigma_t$  that decreased monotonically with depth. Before leaving the site, two XBTs (XBT 1 and XBT 2) were deployed. Both the port and starboard XBT launchers and the MK-9s operated successfully. Figure 7 shows the location of the test drops.

##### 3.1.1 Ampere Seamount

The R/V *Oceanus* then headed for the first operational area, Ampere Seamount. Upon arriving at the seamount on 5 September, we moored a radar transponder on the summit in water about 50 m deep at  $35^\circ 03.62'N$ ,  $12^\circ 52.72'W$  at 1529 GMT. The mooring line was 100 m of plastic-jacketed steel cable. The float carrying the radar transponder was top heavy and had to be recovered to attach more weight. A weight pack prepared for the drogued drifters was at hand and was attached. The float then balanced nicely. The ship remained at the mooring site until a satellite fix was obtained.

A CTD station (CTD 2) to 1600 m was taken due east of the mooring in water deeper than 2000 m. From there the ship headed to a point 23 n.mi. northeast of the mooring. Starting at this point, XBT sections were taken around the seamount in a box pattern 60 km on a side (Figure 8). Probes were deployed every half hour (every 10 km) around the circuit.

The XBT survey was finished by 0630 GMT on 6 September. There were no apparent trends to the isotherms and thus no evidence of strong, large-scale geostrophic flows.

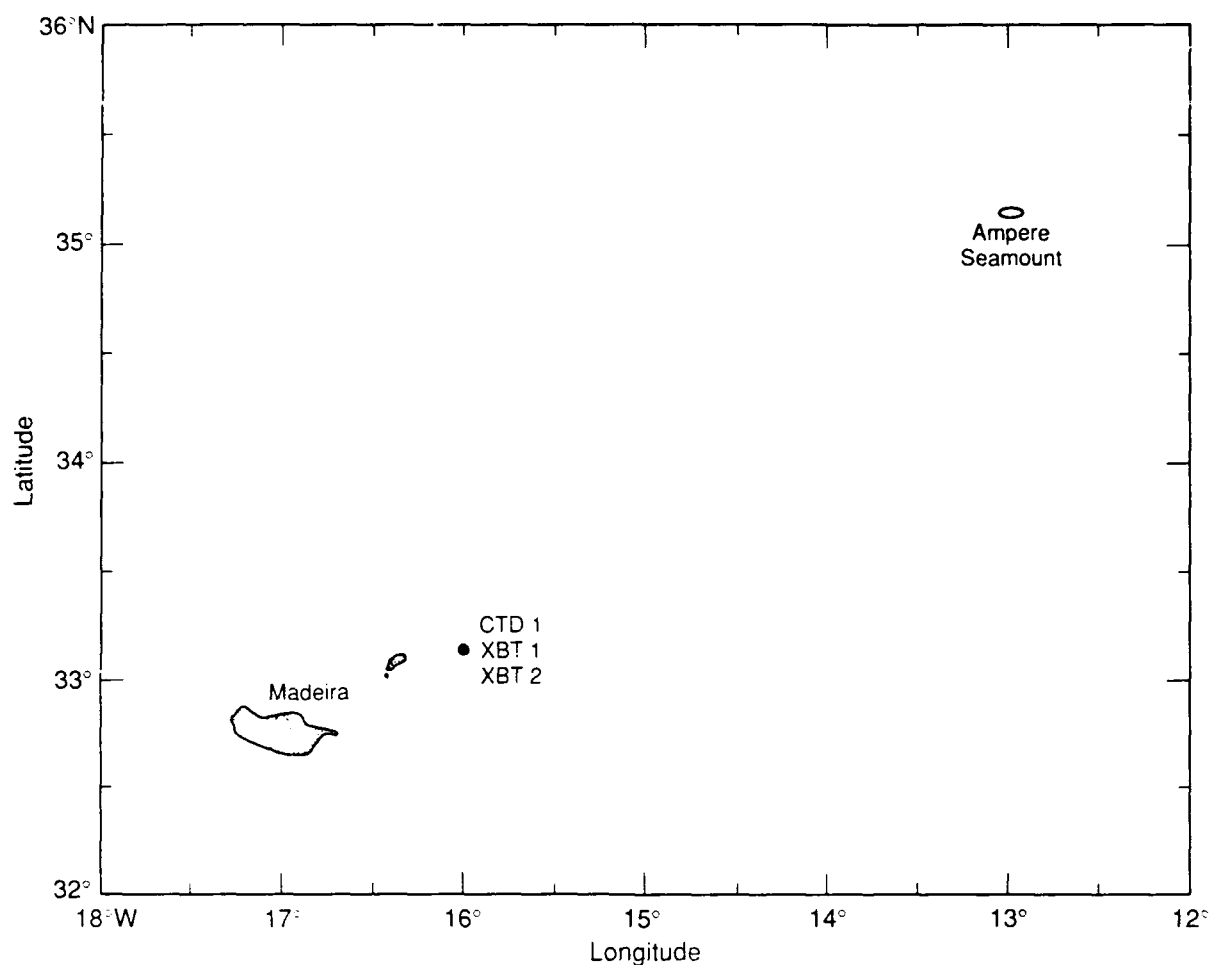


Figure 7. Test station locations.

The four initial drifter deployments were nested about 5 n.mi. around the radar transponder at sites northeast, northwest, southwest, and southeast of the mooring (Figure 8). The NE drifter, denoted #1, was deployed at 1035 GMT on 6 September. The NW drifter (#2) was delayed going in because the acoustic command receiver did not seem to respond. The unit was pinged at a 1-s rate and no response was obtained. When a 4-s rate was used and the depth recorder was momentarily on standby, the release responded every second ping (every 8 s) as expected since it has a 7.5-s blanking interval. The SW and SE drifters (3 and 4) went in easily within an hour of the previous launch. Table 2 summarizes the drifter deployments.

After drifter 4 was released and a position taken, the ship returned to the radar transponder to await a satellite fix. This fix indicated a drift of 0.4' to the east over 24 hours.

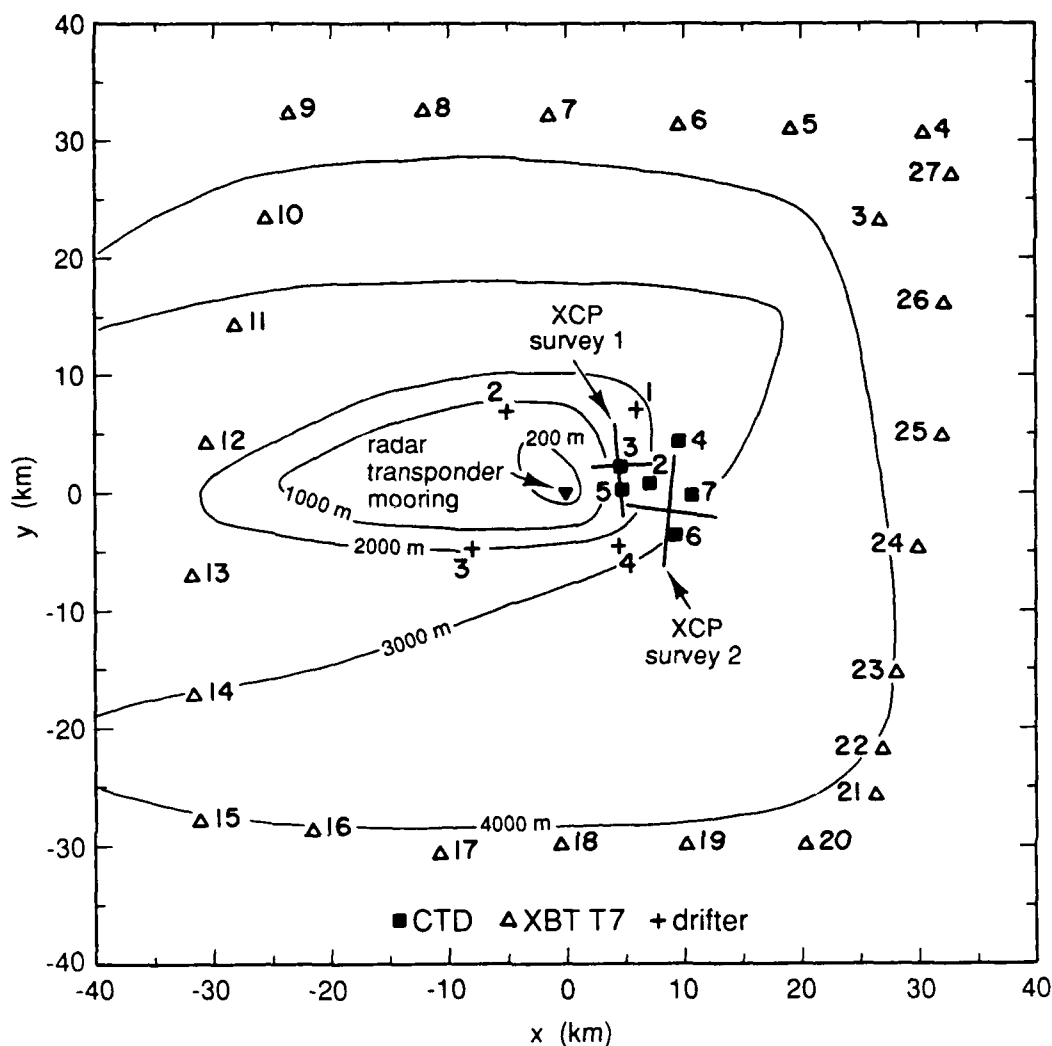


Figure 8. Locations of XBT drops, CTD stations, XCP survey patterns, and initial drifter deployments, Ampere Seamount component. Crude topography is also shown.

The average drift was about 0.3 n.mi. per day, or  $0.6 \text{ cm s}^{-1}$ . The water depth was still about 50 m. The various parts of the mooring were strung out along  $110^\circ\text{T}$ , about opposite the wind but in the direction of the mooring's drift.

Drifter tracking was then started. The ship would go to a drifter's last position or anticipated position and use acoustic pinging, bridge radar, and visual sightings to bring the ship alongside the drifter for a position fix. The first circuit of the drifter box was completed at 1833 GMT on 6 September. Drifter tracking continued for the next 10 hours until suspended briefly to obtain a satellite fix at the radar transponder mooring. This fix agreed well with that taken about 13 hours earlier. From the mooring, the drifter circuit was resumed at drifter 3 which by then was almost out of radar transponder range.

Table 2. Drifter deployment summary.

| Drifter        | Time       | Deployment |           | Speed ( $\text{cm s}^{-1}$ ) |                     | Recovery (or last sighting) |           |                        |
|----------------|------------|------------|-----------|------------------------------|---------------------|-----------------------------|-----------|------------------------|
|                |            | N. Lat.    | W. Long.  | $\langle u \rangle$          | $\langle v \rangle$ | Time                        | N. Lat.   | W. Long.               |
| 1              | 6 Sep 1035 | 35°06.54'  | 12°49.13' | 5.3                          | -3.3                | 7 Sep 1238                  | 35°04.40' | 12°44.48'              |
| 2              | 6 Sep 1238 | 35°06.21'  | 12°55.90' | 6.9                          | -1.9                | 8 Sep 2035                  | 35°03.68' | 12°43.75'              |
| 3 <sup>a</sup> | 6 Sep 1330 | 35°00.41'  | 12°57.34' | -0.9                         | -13.3               | 7 Sep 0919                  | 34°52.87' | 12°56.76'              |
| 4              | 6 Sep 1443 | 35°00.25'  | 12°49.14' | 0.3                          | -1.6                | 9 Sep 1149                  | 34°57.35' | 12°47.98'              |
| 5              | 7 Sep 1125 | 35°02.03'  | 12°49.24' | -2.0                         | -3.4                | 8 Sep 1145                  | 34°55.91' | 12°50.37' <sup>b</sup> |
| 6              | 7 Sep 1502 | 35°03.46'  | 12°49.91' | -0.9                         | -5.4                | 8 Sep 0908                  | 34°57.55' | 12°50.12'              |
| 7              | 8 Sep 2142 | 35°04.64'  | 12°49.35' | 1.8                          | -9.1                | 9 Sep 1844                  | 34°59.63' | 12°47.35'              |

<sup>a</sup>Lost acoustic transponder and drag line<sup>b</sup>Last known position. Drifter lost and never recovered.Drifter 5 is a redeployment of drifter 3; drifter 6 is a redeployment of 1; 7 is a redeployment of 2.  
All times are GMT.

Around 0930 GMT on 7 September, drifter 3 was recovered for redeployment closer to the seamount. Unfortunately, the drifter's line had parted 2 ft below the swivel, explaining the lack of an acoustic record after deployment. Had the significance of this observation been recognized at the time, the drifter would have been examined more closely and, possibly, recovered.

Drifter 3 was redeployed (without acoustics) at 1125 GMT on 7 September 3.2 n.mi. and on a bearing of 105° from the radar transponder. Two 100-m lengths of 1/4-in. wire were used, followed by 225 ft of 3/4-in. nylon line and 85 ft of 3/8-in. chain. A new position was then determined for drifter 2.

Next, drifter 1 was retrieved for redeployment. During this operation, the thin Dacron line jumped the sheave a couple of times and could have been damaged. Finally, the blocks were adjusted properly, so the whole drifter could be winched in. The Dacron line could not be reused, but the rest of the setup could be. Drifter 1 was repositioned closer to the seamount in 1250 m of water at a range of 2.30 n.mi. and a bearing of 260° from the radar transponder. A satellite fix was again obtained at the radar mooring at 1531 GMT on 7 September. The fix indicated possible drift to the west.

The drifter tracks indicated a flow of 5–6  $\text{cm s}^{-1}$  toward the east over the north flank of the seamount and weak flow directly to the east. The drifters were tracked during the night of 7–8 September, and a satellite fix was taken at the radar transponder at 0421 GMT on 8 September.

While drifter tracking continued during the morning of 8 September, the group prepared to conduct the first XCP survey. We decided to place an XCP cross pattern in the shear region between the eastward flow to the north and the stagnation point to the southeast; the site was 3.0 n.mi. from and at  $255^\circ$  with respect to the mooring, in the near wake of the seamount. Its location relative to the other stations is shown in Figure 8; individual XCP deployments are shown in Figure 9.

The west-to-east leg (XCPs 2401–2411) went well, but the radar transponder's response was lost at the end, and there was no response during the south-to-north leg (2412–2428). The transect was completed on the basis of the differential Omega data displayed on the Macintosh computer. It appeared that the ship was being set to the

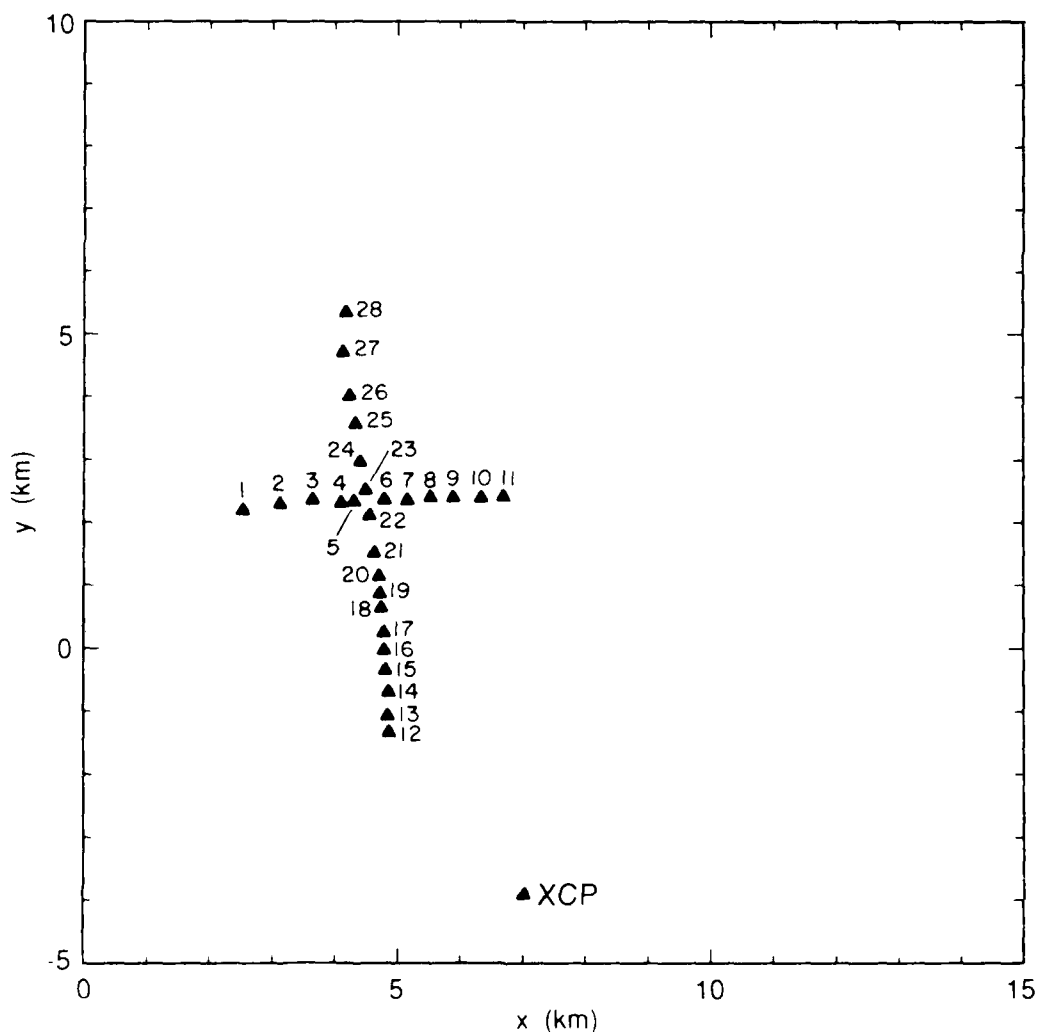


Figure 9. XCP survey 1, drop locations. Drop numbers have been shortened for plotting. Actual drop numbers are 2401 to 2428.

south by head winds and, possibly, current. More probes were launched to cover the intended section.

It was clear that we needed to get the radar transponder back in operation. The ship returned to the radar mooring at 1713 GMT on 8 September, the buoy was hauled up to the rail, and the batteries were replaced. In a fine display of seamanship, Captain Howland kept the vessel close to the anchor buoy for the few minutes needed to change the batteries.

With the radar transponder working again, the ship headed for the center of the XCP survey, and a CTD station (CTD 3) was taken to 1500 m. Drifter tracking resumed with a search for drifter 2, which was last seen moving rapidly east and out of transponder range. It was found 7.3 n.mi. from the radar transponder and recovered at 2003 GMT on 8 September. Some difficulty was encountered during recovery when the small float on the tag line started down the port side of the bow while the main float was going down the starboard side. Ultimately, things were sorted out, and the gear was brought aboard. New batteries were put in the xenon flasher, and it was redeployed at 2142 GMT nearer the seamount. Both the flasher and the acoustic transponder were working when deployed.

Drifter 4 was located at 2236 GMT. From there, we went to the last position of drifter 3 but could not find it. We spotted a light, only to discover it was the radar transponder. We proceeded to it and obtained a satellite fix at 0031 on 9 September. We then went back to drifter 4. From drifter 4, we attempted to go to drifter 1, but ended up at drifter 2 again. (Visibility was poor at the time.) From drifter 2, we did a leg to the east in search of either drifter 1 or drifter 3. Continuing our search pattern, we eventually ended up at drifter 4 but could no longer pick up the signal from the radar transponder. Without a range and bearing back to the radar mooring, we had to wait at drifter 4 for a satellite fix to get an accurate position. We continued on with tracking, passing by the radar transponder on the way to drifter 2. It was intact but not transponding. Without the radar range, we again had to wait for a satellite fix.

Drifter 1 was found at daylight while on a run from drifter 2 to drifter 4 and was recovered at 0835 GMT on 9 September. The mast was missing along with the light, but otherwise all elements were present. It was far from its expected position and may have been dragged. Drifter 4 was located later on 9 September and recovered at 1058 GMT. Then the radar transponder, its float, and the anchor float on the seamount were

recovered. Without the electronics package, drifter 3 was not considered worth searching for further.

The second XCP survey was centered 8 n.mi. east of the seamount (Figures 8 and 10). This time the section lines were twice as long. The central 2.2 n.mi. of the sections were conducted at 3 kn with drops every 5 min (the same as the first survey), but four extra drops were added to each section to provide information on larger scales; the extra drops were located 0.5 and 1.0 n.mi., respectively, from each end. This time two probes, both channel 16, failed to fall. Another channel-16 probe suppressed the AF modulation for more than 1 min into the drop, but stopped transmitting on time. One channel-14

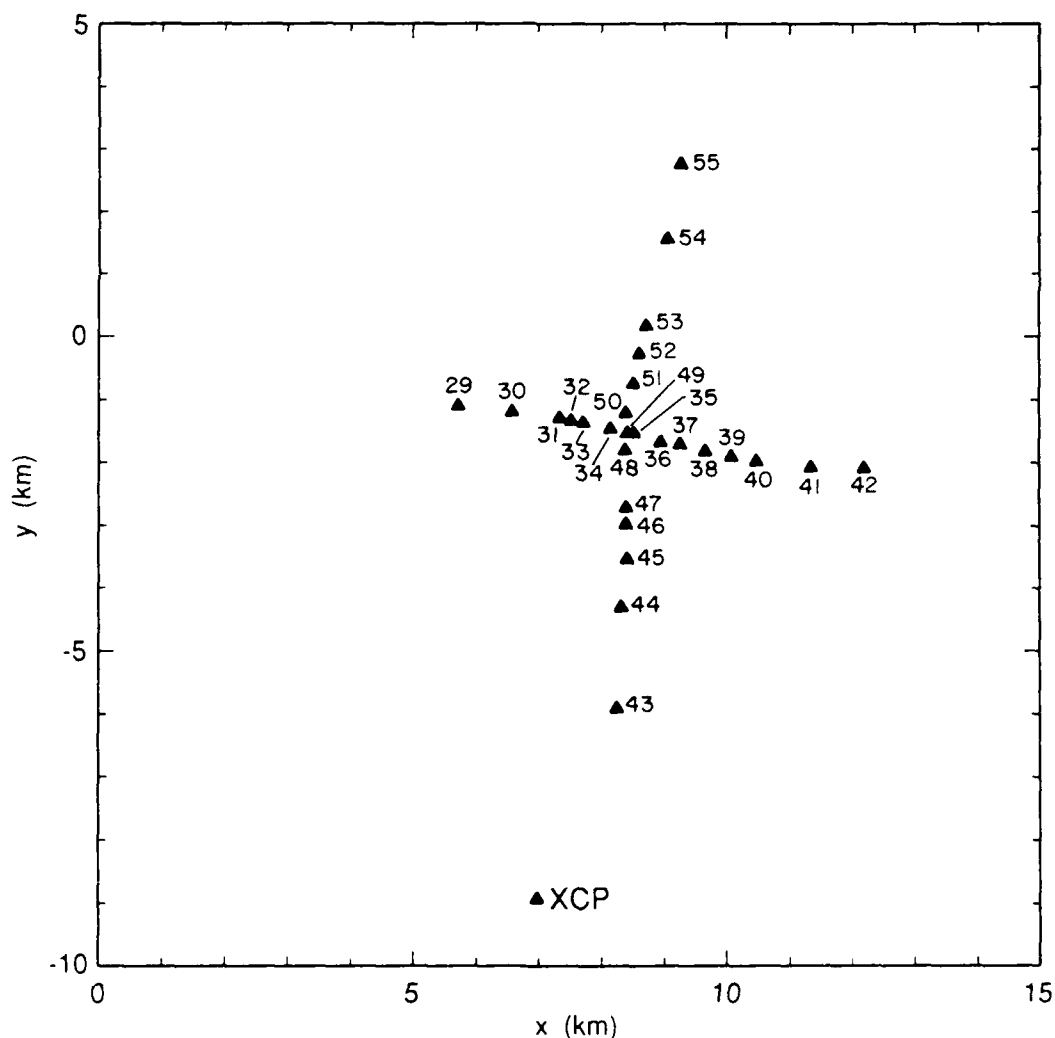


Figure 10. XCP survey 2, drop locations. Drop numbers have been shortened for plotting. Actual drop numbers are 2429 to 2455.

probe failed to shut off, but the channel could still be used for a subsequent drop. The second XCP survey was completed at 1700 GMT on 9 September. CTD station 4 was then taken at the north corner of the survey. Drifter 2 was recovered at 1840 GMT. Three more CTDs (5, 6, and 7) were taken west, south, and east of XCP survey 2. The *Oceanus* then proceeded to the next operational area off Cape St. Vincent, Portugal.

### 3.1.2 Meddy Component

The *Oceanus* arrived at 36°N, 8°W at 0230 GMT on 11 September to begin the Meddy phase of the expedition. Figure 11 shows the survey pattern for this experiment. Figures 12 through 15 show the locations of the individual drops and stations.

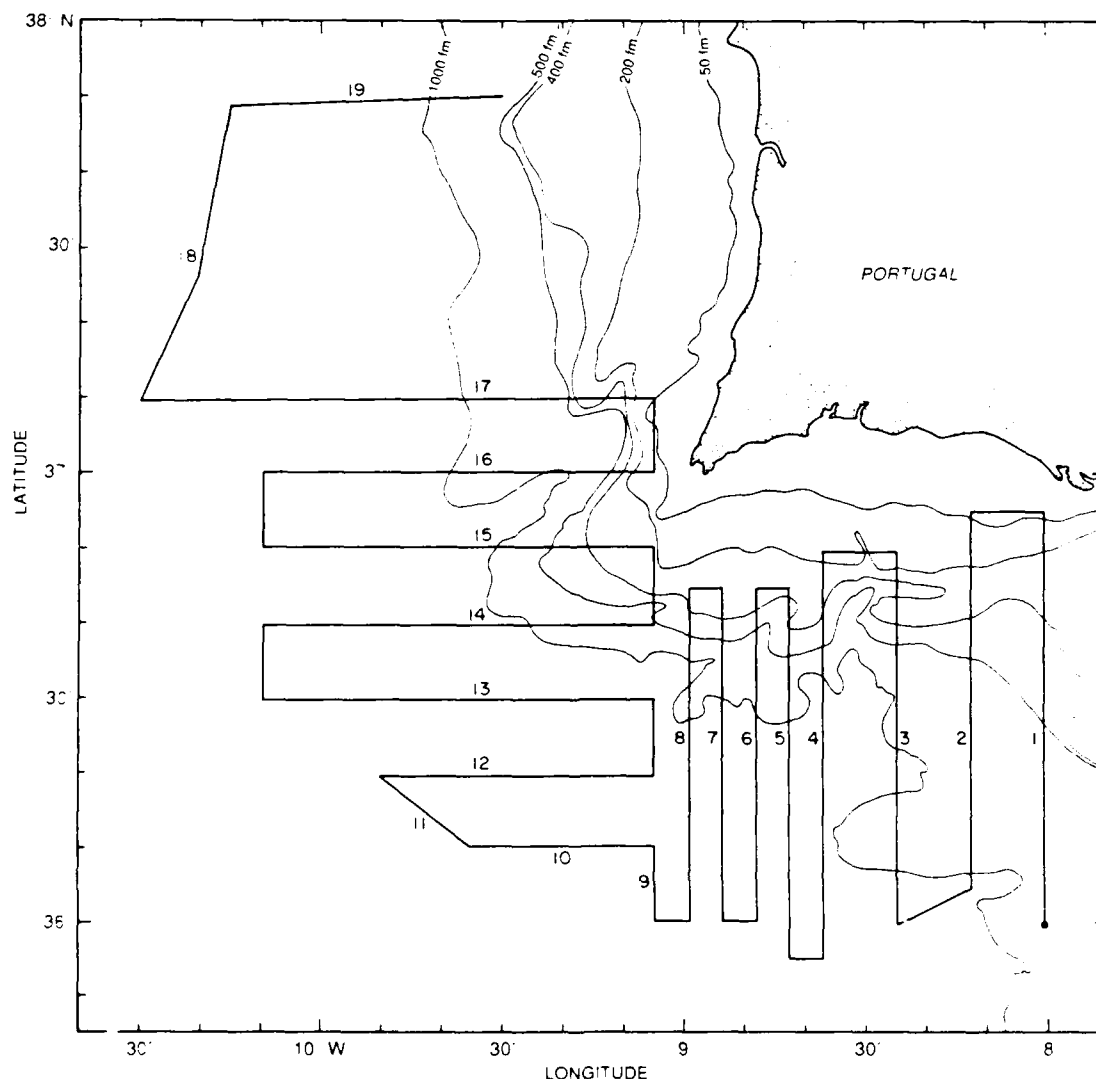


Figure 11. Survey pattern for Meddy component.

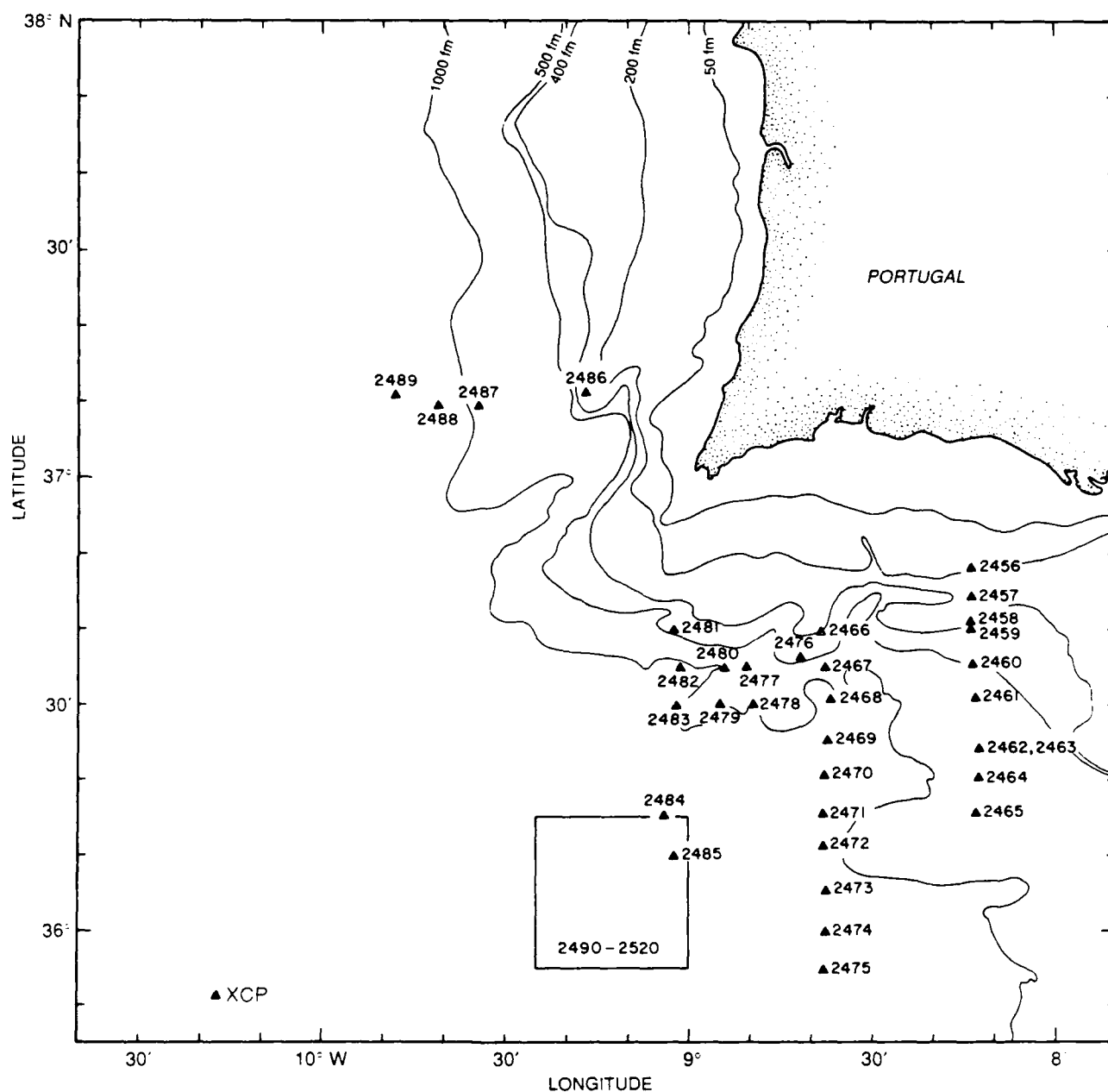


Figure 12. Locations of XCP drops during Meddy component. Drops during survey of Meddy (2490-2520, boxed area) are shown in detail in Figure 20.

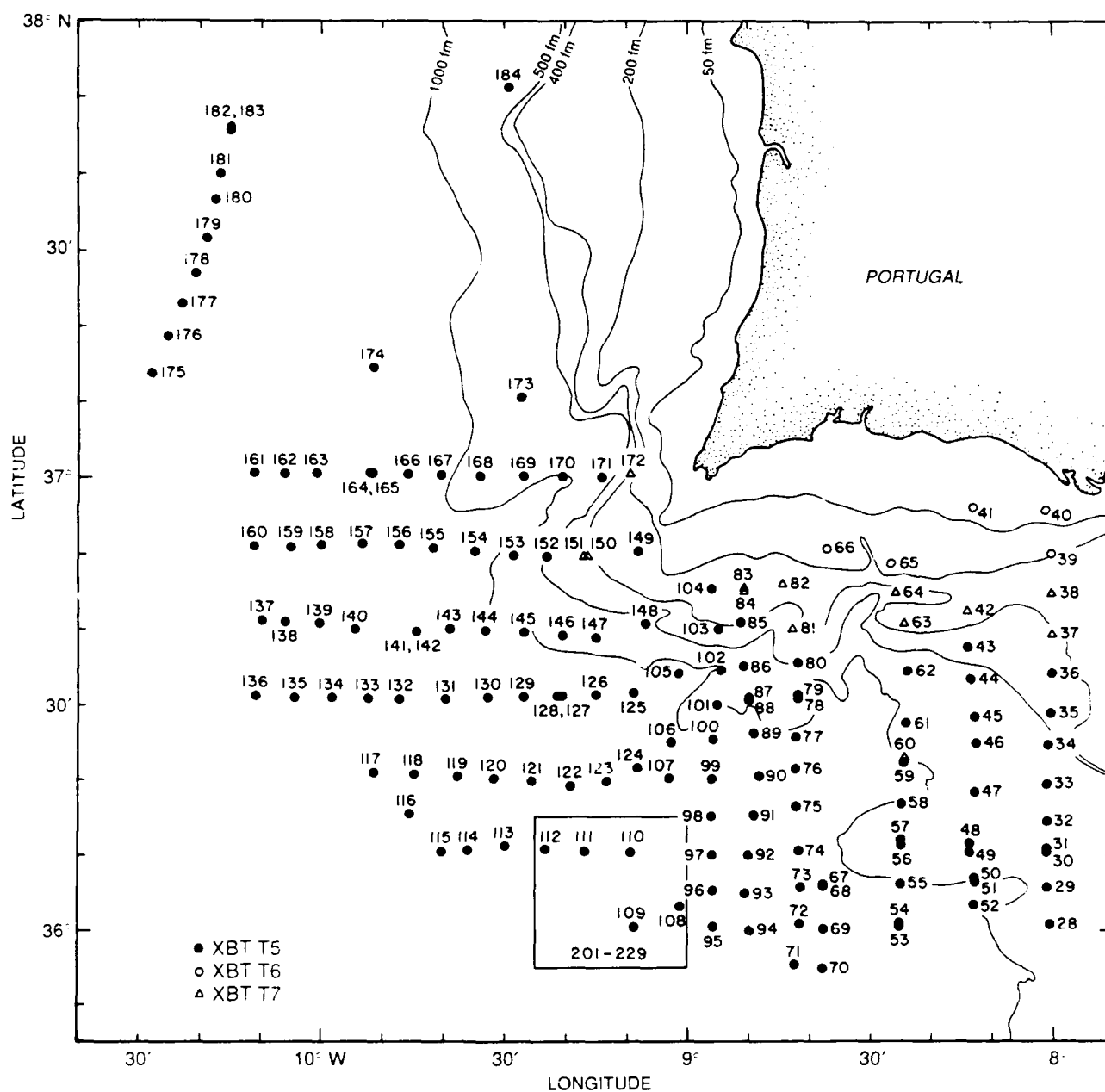


Figure 13. Locations of XBT drops during Meddy component. Drops during survey of Meddy (201-229, boxed area) are shown in detail in Figure 21.

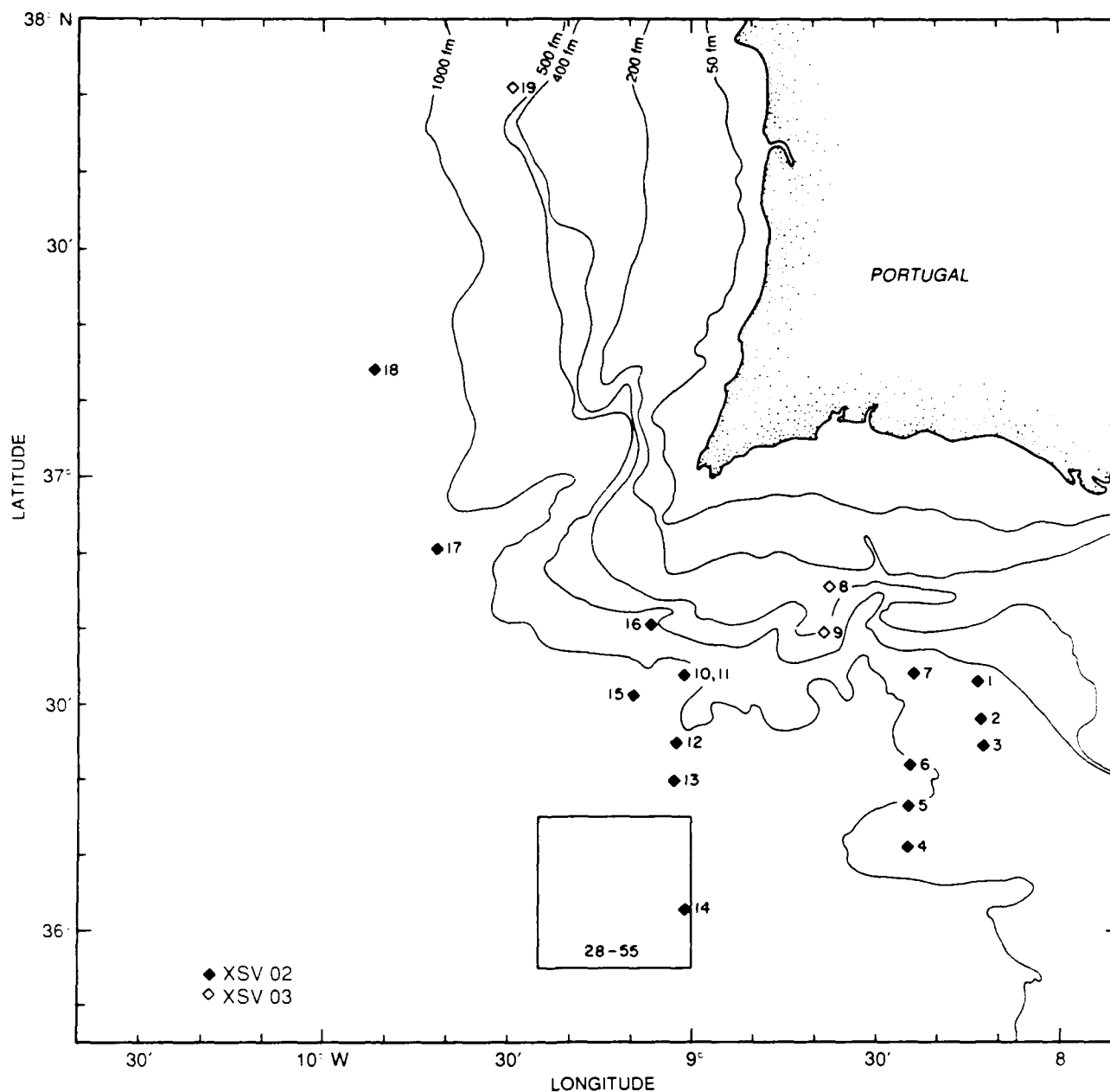


Figure 14. Locations of XSV drops during Meddy component. Drops during survey of Meddy (28-55, boxed area) are shown in detail in Figure 22.

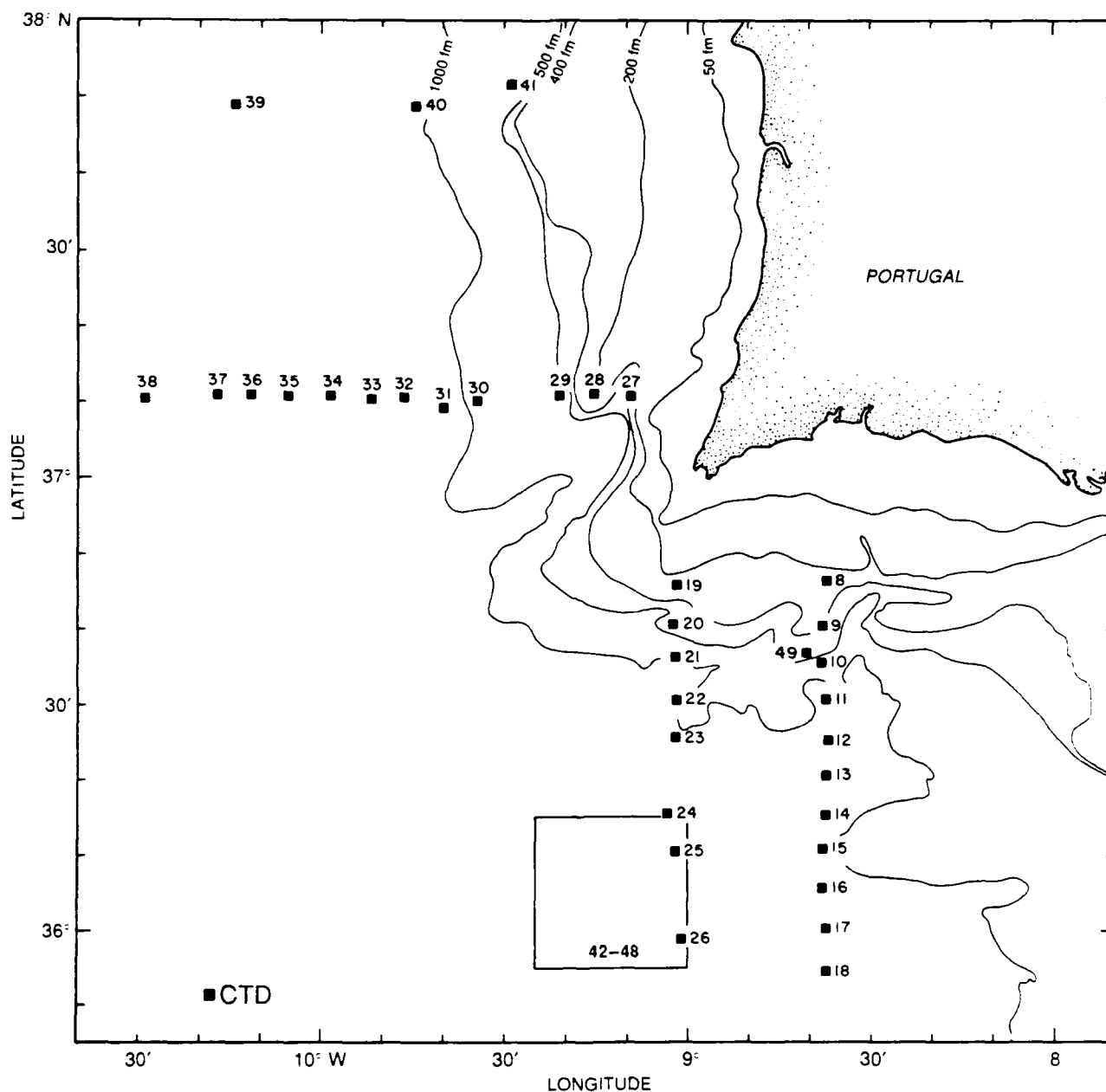


Figure 15. Locations of CTD stations during Meddy component. Stations during survey of Meddy (42-48, boxed area) are shown in detail in Figure 19.

The first line consisted of XBT drops (XBTs 28–40) and took the ship close to the Portuguese coast (Figure 13). Line 2 consisted of XCP (2456–2465), XBT (41–52), and XSV (1–3) drops. As already mentioned, there were problems with the XSVs. They would not process or display because of misalignment during manufacture. By XSV 12 however, the misalignment problem had been discovered and corrected.

On line 3 (XBTs 53–65), the type T-5 XBTs experienced high data losses. At one stage, four probes in a row failed to return good data. The equipment was examined, and a more solid ground was placed on the MK-9.

Line 4 consisted of CTD (8–18) and XCP (2466–2475) stations and took most of 12 September. The CTD data taken on line 4 revealed a strong lower core with a salinity of 36.5 psu (practical salinity units) and a weak upper core. (An upper and a lower core of Mediterranean water have been observed in this location by previous investigators, e.g., Ambar and Howe, 1979a,b.) The XCPs accompanying the section did not show any dramatic shears. Lines 5–7 proceeded without problems, but no interesting features were noted.

Most of 13 September was devoted to the CTD section along line 8 (CTDs 19–26) off Cape St. Vincent. Various blobs of water were found, but little velocity signal accompanied them. Some XCPs showed a small shear through features, but the overall impression was that the features were density-compensated and had no circulation. Whether this is a general feature of such eddies or there was little outflow at the time is not known. The CTD section was finished at 2244 GMT, and the second part of our survey was begun.

XBTs were launched through the night (lines 9–12). No particularly notable features were observed. A large swell was running from the northwest. The differential Omega system experienced some large shifts ( $\approx 5$  n.mi.) around sunrise, even though the Lagos station was within 60 n.mi. Lines 13 and 14 consisted of XBTs with two XSVs at the eastern ends of the lines. Again, there was little of interest.

Lines 15 and 16 were completed, and line 17 (CTDs 27–38) was started with no unusual features found. As this CTD line progressed, a thick feature with salinity  $>36.5$  psu was observed. There was some velocity shear across the zone and an indication of horizontal density gradients. Unfortunately, the CTD developed frequent errors.

When the computer did not get data from the GPIB for >30 s, it halted the program and erased the screen. This happened several times during a cast. The acceptable delay was increased to 100 s, which helped. The cable was reterminated using both "good" conductors, this time in parallel. (The connection to the slip rings allowed both conductors to be used.) The performance after these changes was little better. Next, the voltage threshold in the deck unit was checked. It was 2.79 Vdc; the manual indicated it should be 2 Vdc. The voltage threshold was set to 2.0 Vdc, and the pulse duration was shortened by 10–20  $\mu$ s from its previous value of about 100  $\mu$ s. The combination seemed to cure the problem, and the CTD could then be run at any speed without error. Unfortunately, when the test clips on the BNC cable to TP1 and GND were removed, the error light on the deck unit lit repeatedly. We decided to leave the clips attached, coil the cable into a loop, and secure it inside the unit. The CTD performed well after the fix, which occurred during CTD 33.

An additional station (CTD 37) was taken west of 10° 17'W, and more water with a salinity of 36.5 psu was found. We decided to occupy one more station at 10°29'W before transiting to the line of mooring sites off the west coast of Portugal. That station (CTD 38) showed a continuation of the rather thick ( $\approx$ 200 m) 36.5 psu water seen in other stations on this line. It was decided that this was not an isolated blob but a slowing spreading plume. No further stations were taken on this line.

On line 19, a CTD station was taken at each of three sites where current meters had been moored as part of the Portuguese CIRMAR (CIRculation on the Portuguese continental MARgin) experiment. The locations are summarized in Table 3. For convenience, we have denoted these moorings W, M, and E, for west, middle, and east.

*Table 3. Portuguese current meter mooring locations.*

| Mooring | Latitude<br>(N) | Longitude<br>(W) | Depth<br>(m) |
|---------|-----------------|------------------|--------------|
| W       | 37°46.4'        | 10°14.0'         | 3226         |
| M       | 37°48.1'        | 9°43.6'          | 2000         |
| E       | 37°49.9'        | 9°30.6'          | 1115         |

The survey data were reviewed, and we decided to study a feature seen near CTD 25 (line 8) around 1900 GMT on 13 September which had a 12°C core with a salinity of 36.5 psu (Figure 16). During the early morning of 17 September, *Oceanus* steamed to a point 5 n.mi. west of CTD 25 coming along a line from the northwest. Hourly XBTs were taken starting with the crossing of line 14, with half hourly drops after crossing line 12 (Figure 17, XBTs 185–190). Little evidence of the 12°C core was found on the way, so a box pattern (XBTs 191–200) was commenced. XSVs were also dropped during the box survey (Figure 18, XSVs 20–27). Finally, the Meddy was found about 10 n.mi. SW of CTD 25.

The first CTD station (CTD 42) was taken west of the Meddy. Stations 43 and 44 were taken at the center and eastern edge, respectively. Station 45 was taken 9 n.mi. south of the Meddy's center (Figure 19). On the run north, XCPs, XBTs, and XSVs were taken at 2-n.mi. intervals while steaming at 6 kn. About 4 n.mi. south of the Meddy's center, a most unusual profile was observed, with shear of  $25 \text{ cm s}^{-1}$  over 300 m (XCP 2494).

We continued to have difficulty getting the MK-9 to produce the correct prelaunch voltages. The XSVs need a voltage of about  $-4.5 \text{ Vdc}$  before launching, and often it was necessary to turn the MK-9 off and on numerous times to get it into the correct state.

Leg 1 (XCPs 2490–2500) of a star pattern confirmed that there was a reasonable circulation ( $>20 \text{ cm s}^{-1}$ ) around the Meddy. Figures 20–22 show the location of the XCP, XBT, and XSV drops during the Meddy survey. Legs 2 and 3 provided additional evidence of the velocity and density structure. The run on leg 2 was somewhat marred by the need to stop and maneuver to avoid a vessel. Just about that time the differential Omega station was lost.

Two CTD stations (CTD 47 and CTD 48) were taken after completing leg 3 of the star to sample the Meddy's core further.

From there, the ship steamed to another Portuguese current-meter mooring just west of line 4. We tried for more than an hour to get an acoustic signal from the mooring on the ship's echo sounder. Neither echoes from the subsurface buoy nor the current-meter signals at 14 kHz every half hour were observed. Around 2100 GMT, a CTD station (CTD 49) was taken to the bottom, and the ship departed for Cadiz.

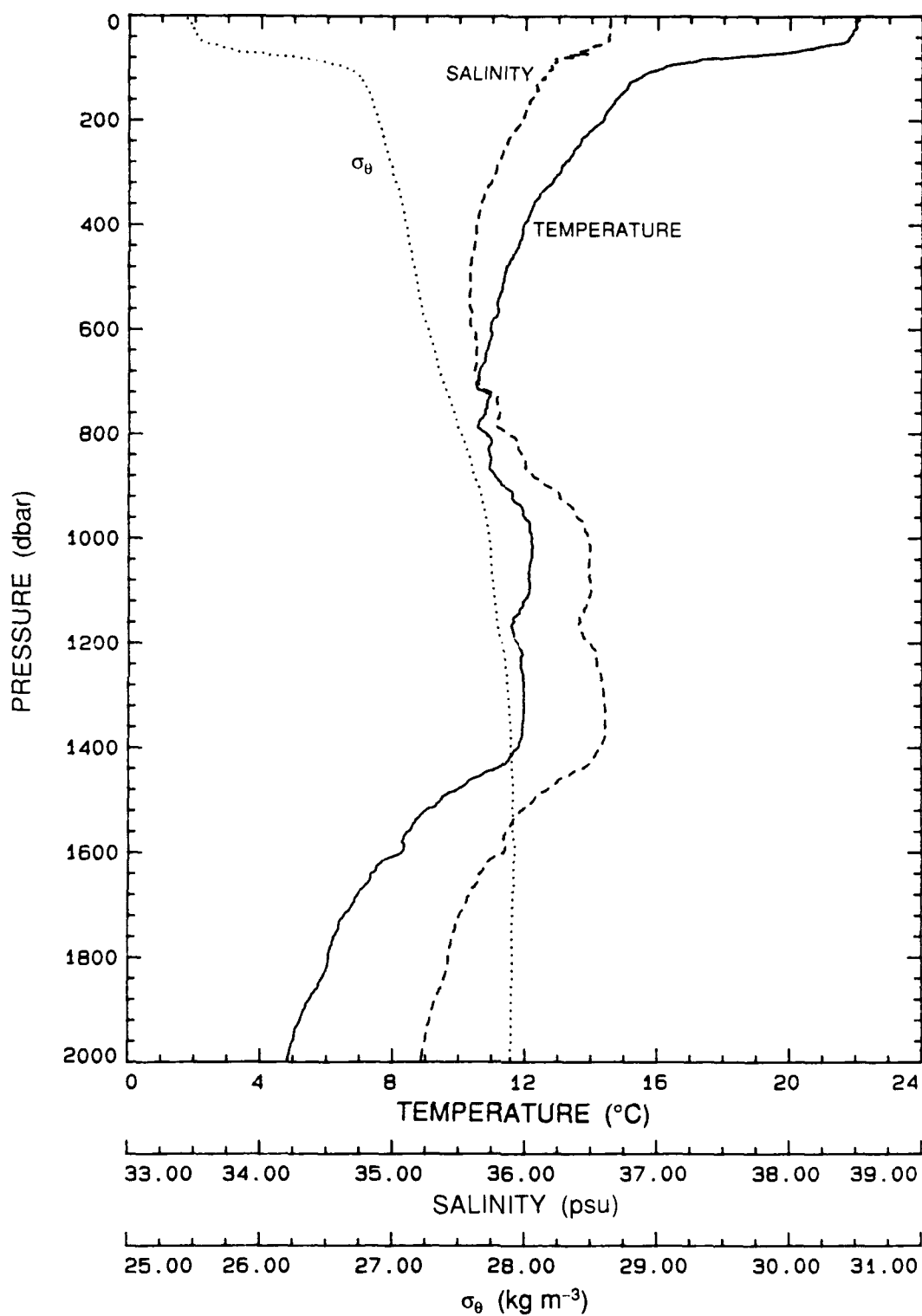


Figure 16. Temperature, salinity, and  $\sigma_\theta$  data from CTD 25.

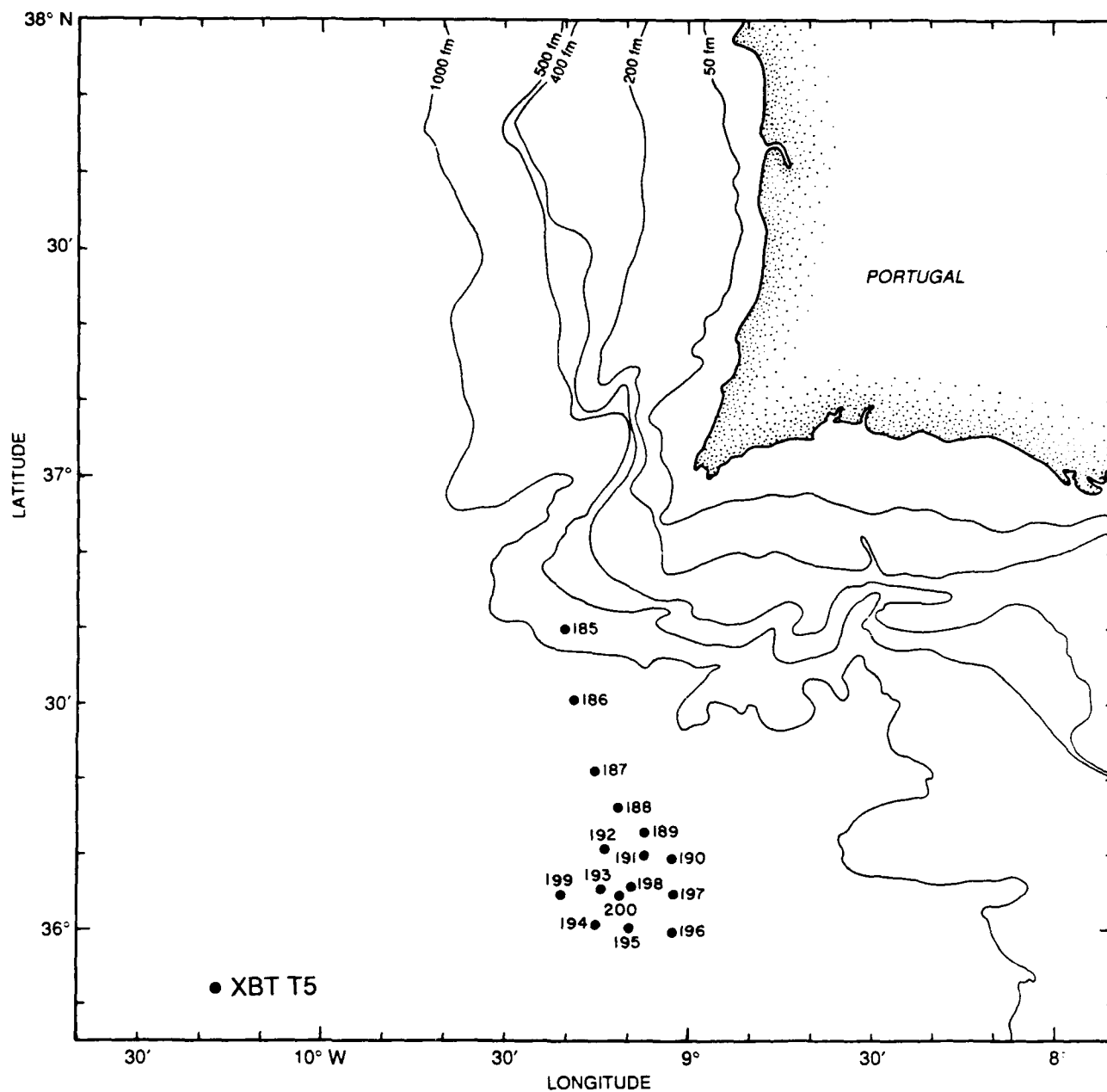


Figure 17. Locations of XBT drops enroute to Meddy and box pattern.

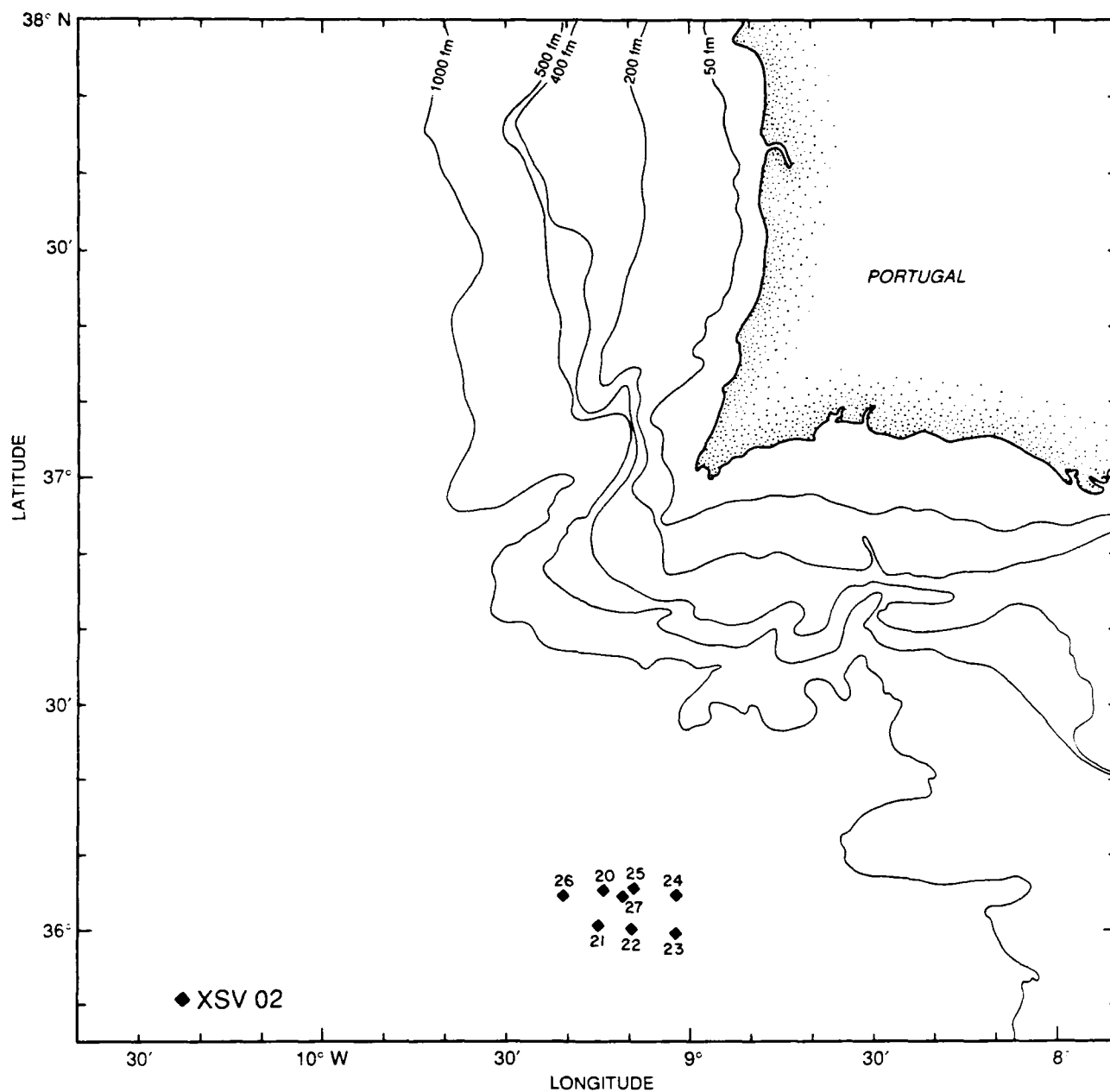


Figure 18. Locations of XSV drops during box pattern.

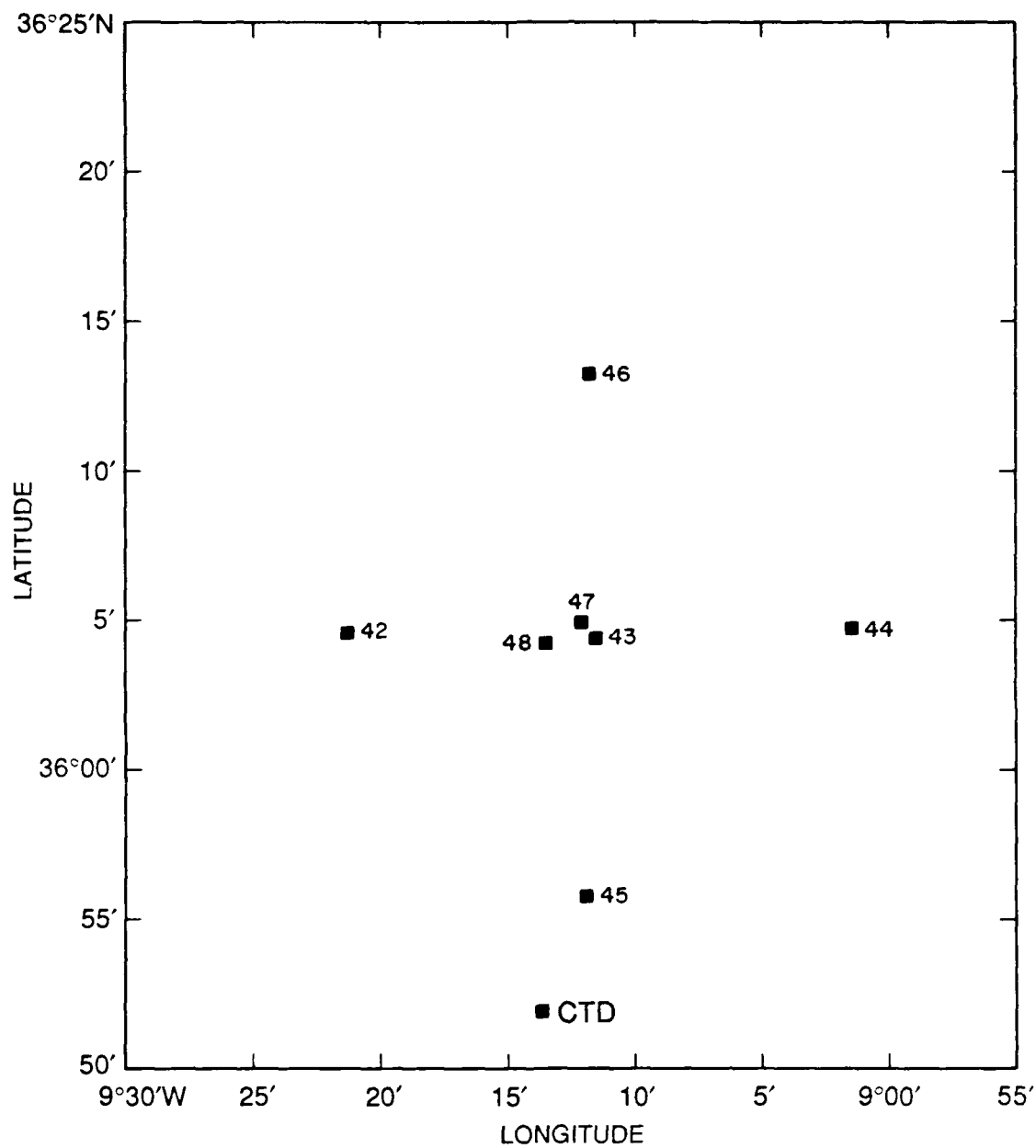


Figure 19. Locations of CTD stations around Meddy.

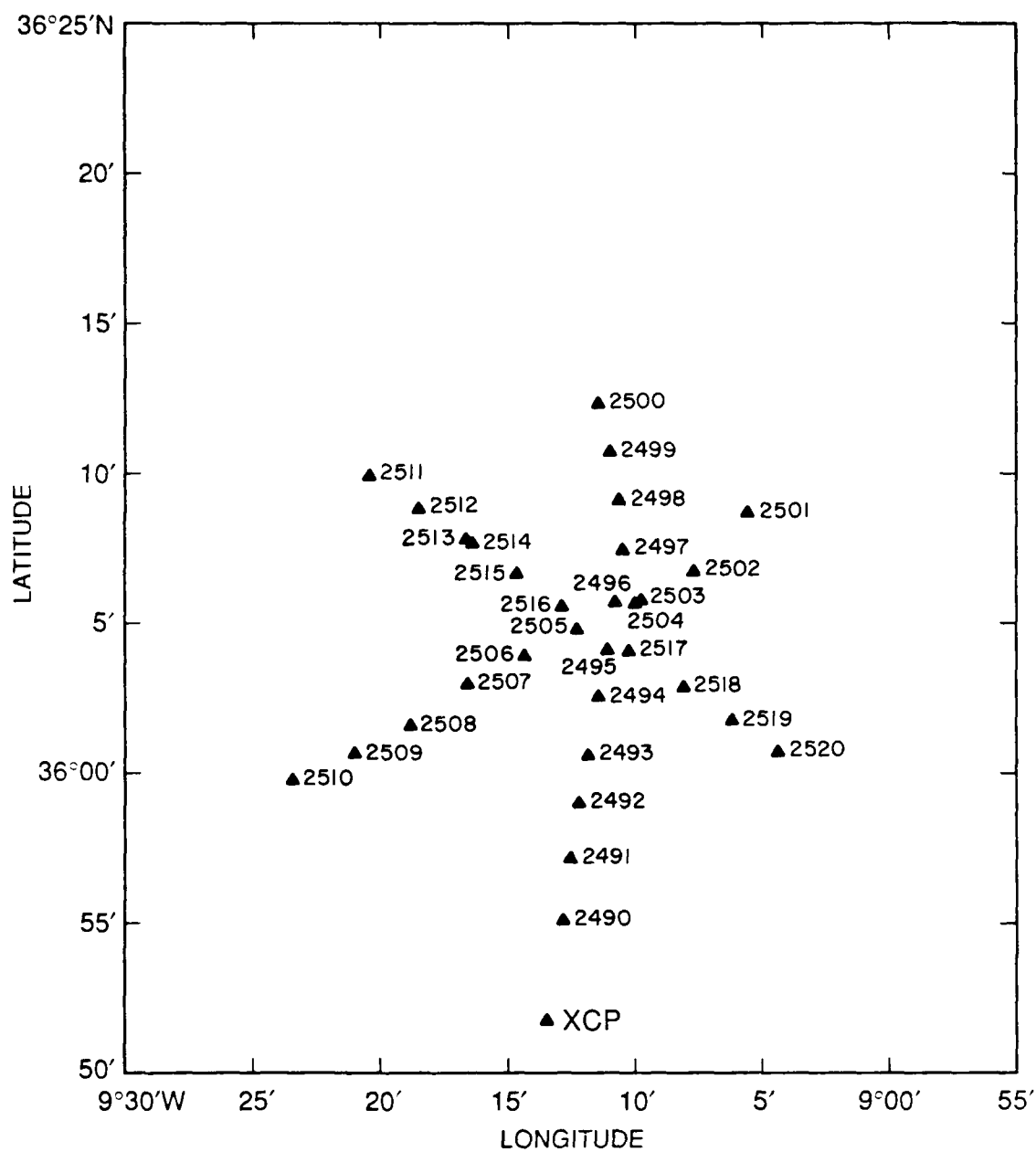


Figure 20. XCP drop locations in Meddy.

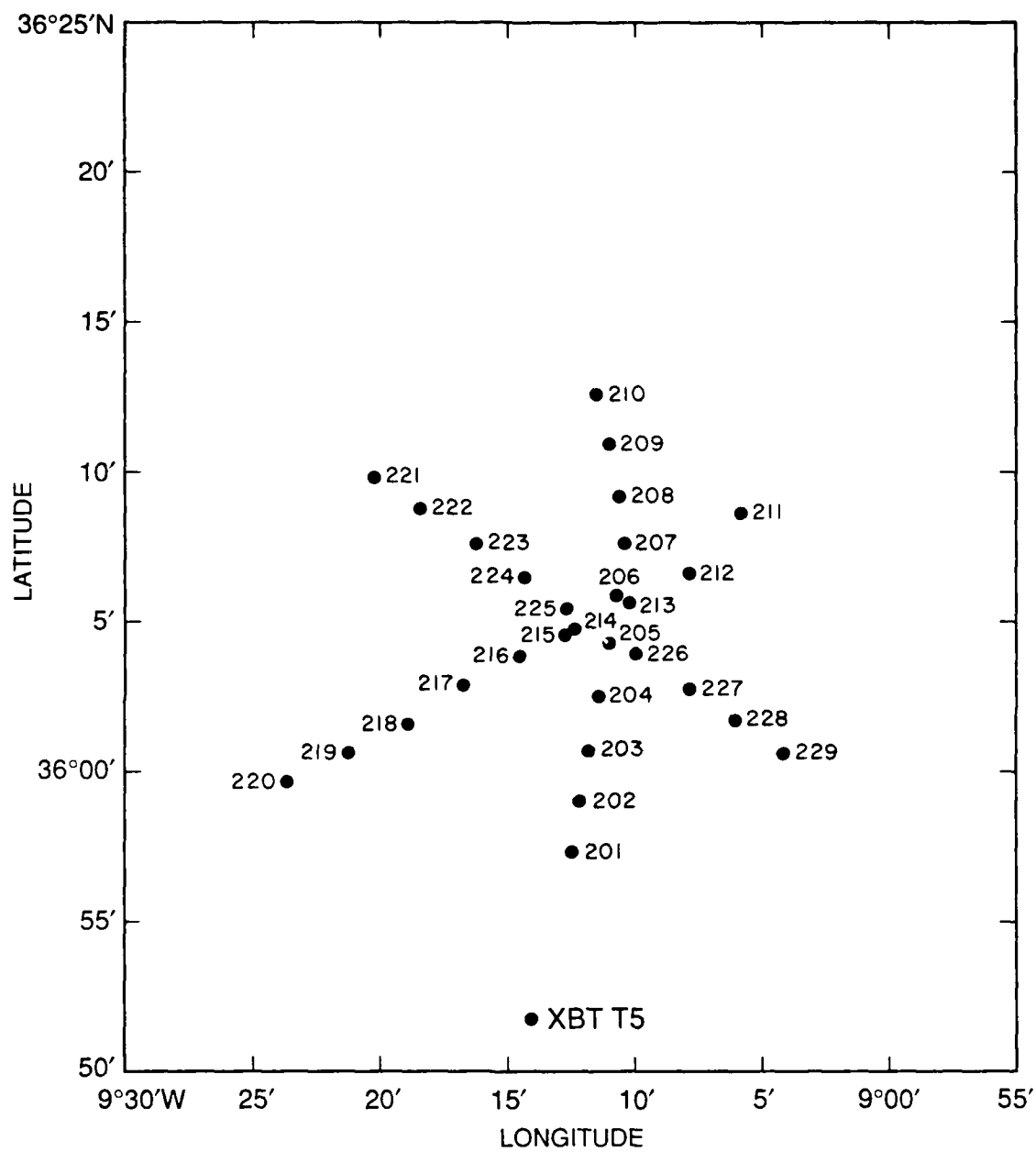


Figure 21. XBT drop locations in Meddy.

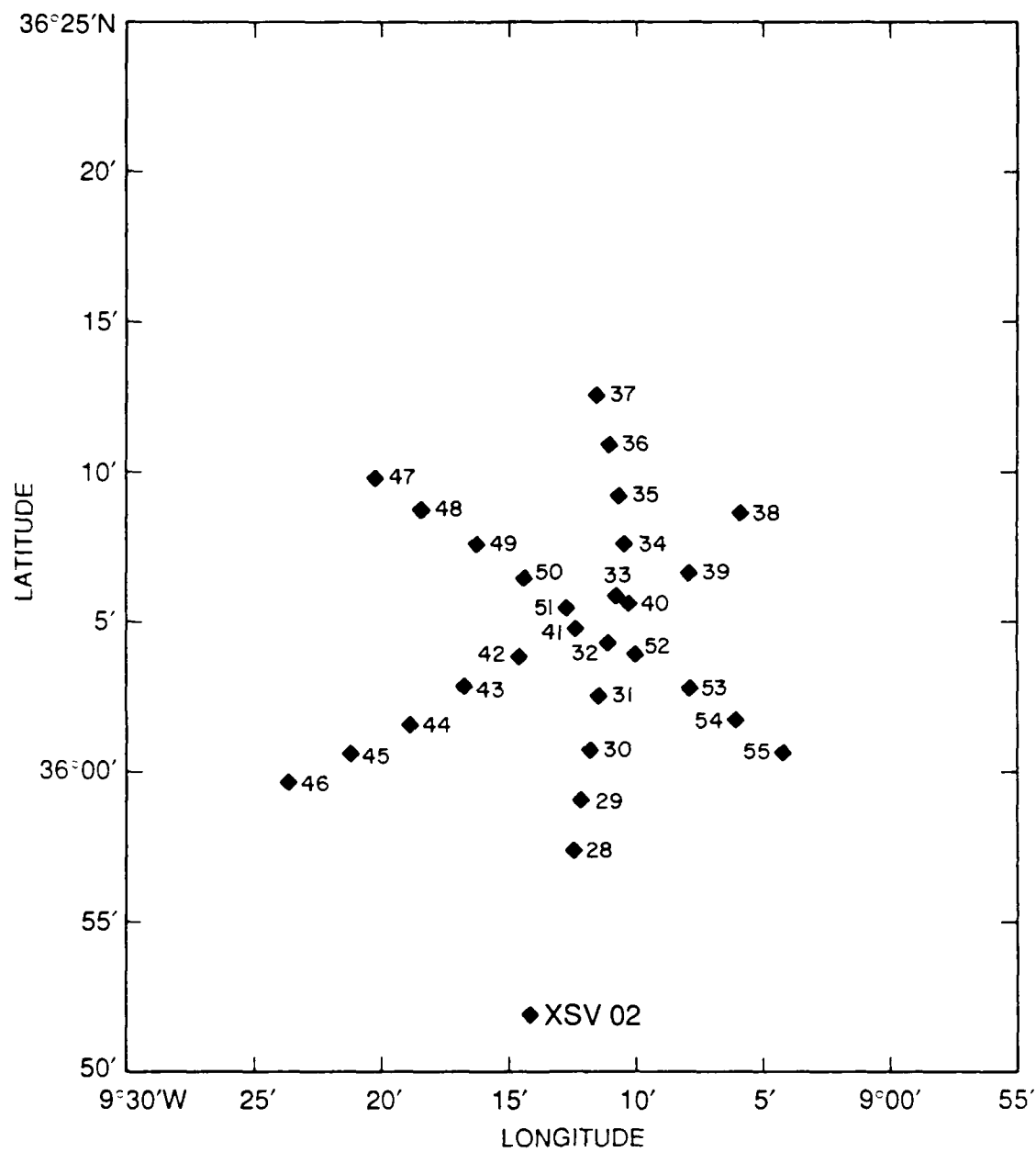


Figure 22. XSV drop locations in Meddy.

### 3.2 Leg 2: The Mediterranean Outflow

After a brief stop to change personnel and load the XDP equipment, the *Oceanus* departed Cadiz, Spain, at 0900 GMT on 21 September. Before commencing the sections that had been planned across the axis of the outflow plume, we selected individual sites at which to make measurements (see Table 4 and Figures 23–25). After a brief transit to site 1, we took a CTD station (CTD 50) at 1310 GMT (Figure 23). We then took a CTD station (51), an XCP drop (2523), and an XDP drop (801) at site 2 to the east-northeast. At site 3, a bit farther northeast, we took another CTD (52), XCP (2525), and XDP (1030) station. The water mass (Figure 26) and velocity structure at each of these sites appeared very similar. The source for the outflow appeared to be adequately described by site 1 and maybe sites farther to the west. Therefore, we decided to leave site 3 and concentrate on those sites. The *Oceanus* returned to site 1 for CTD station 53, XCP drop 2527, and XDP drop 1040.

Table 4. Location of sites on leg 2, outflow component.

| Site<br>No. | N.<br>Latitude | W.<br>Longitude |
|-------------|----------------|-----------------|
| 1           | 35°49'         | 6°13'           |
| 2           | 35°51'         | 6°01'           |
| 3           | 35°53'         | 5°53'           |
| 4           | 35°46'         | 6°20'           |
| 5           | 35°45'         | 6°28'           |
| 6           | 35°49'         | 6°37'           |
| 7           | 35°54'         | 6°31'           |
| 8           | 35°56'         | 6°26'           |
| 9           | 35°44'         | 6°37'           |

We then steamed to site 4 at 35°46'N, 6°20'W to look for evidence of appreciable mixing. We wanted to occupy a site about 500 m deep, some 100 m deeper than at site 1. However, the depth was about the same as at site 1, so we decided to steam north awhile to look for deeper water. After steaming north and then south, we learned that our original choice was about the deepest along this meridian. An XCP drop (2528) showed a large and unidirectional shear ( $0.02 \text{ s}^{-1}$ ) right into the bottom. A CTD cast (CTD 54) showed a lowering of the maximum salinity.

Because a good deal of time was lost conducting the bathymetry survey at site 4, we decided to head south and then north looking for the deepest part of the channel. The

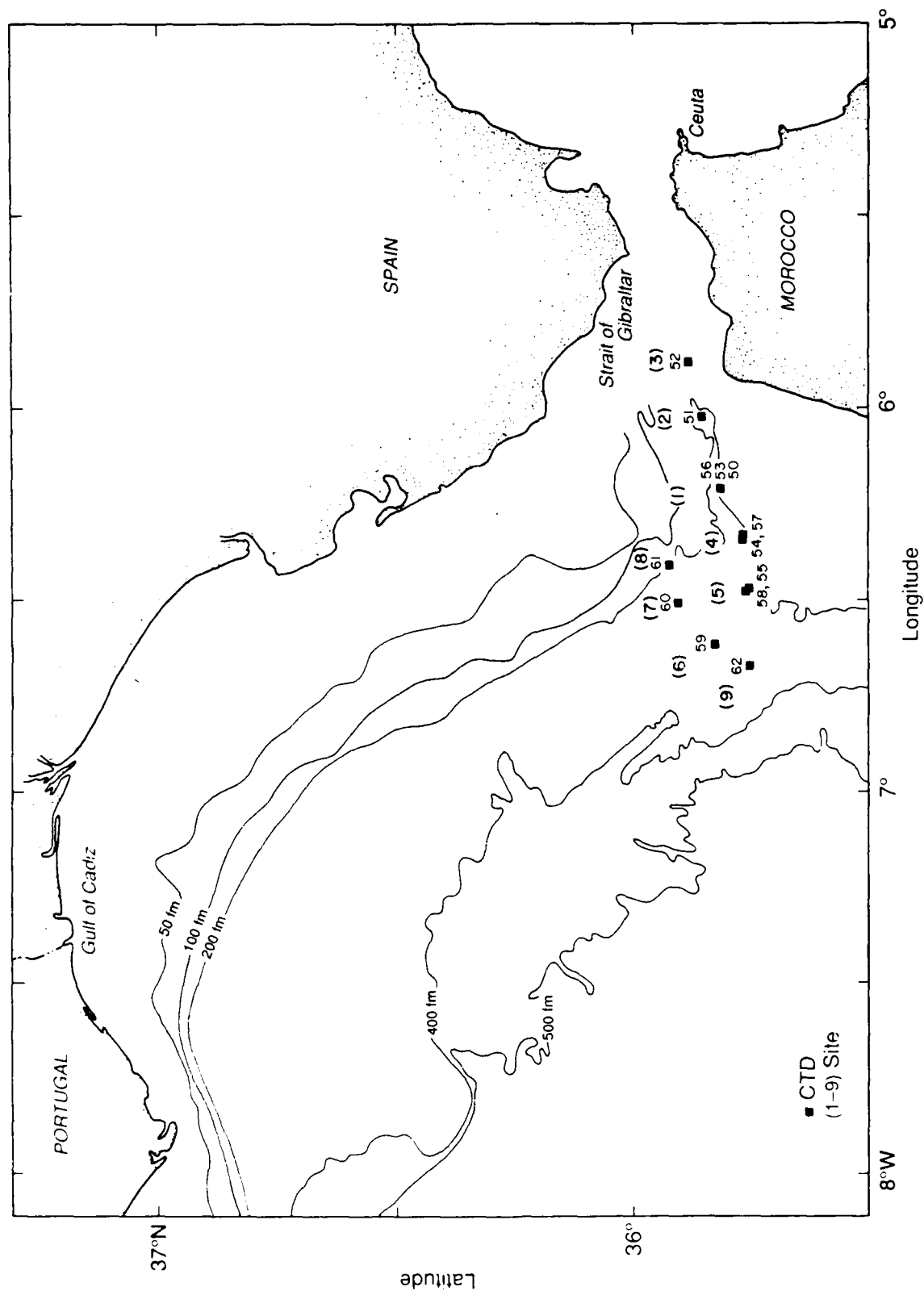


Figure 23. Locations of CTD stations. Site numbers are in parentheses.

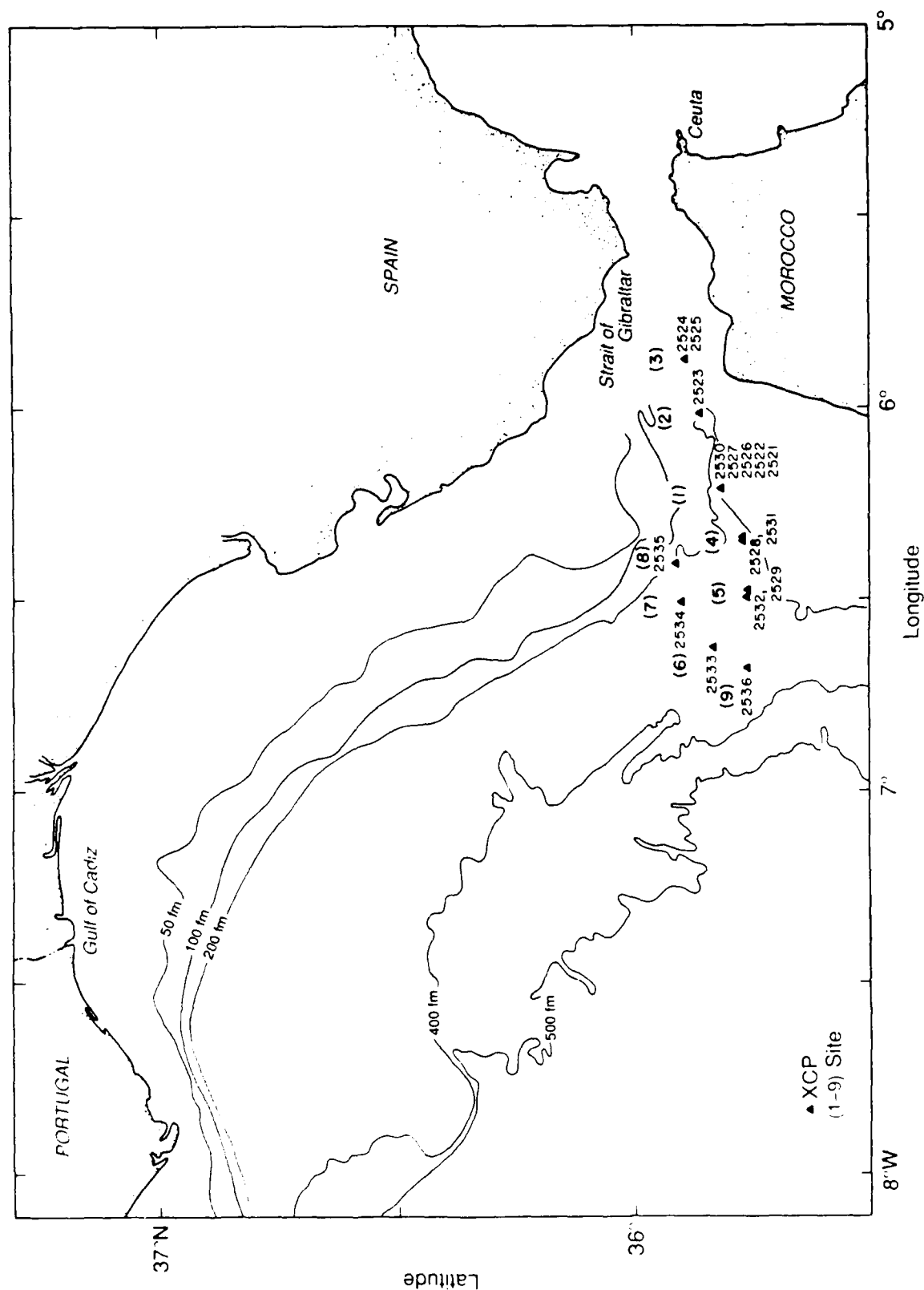


Figure 24. Locations of XCP drops. Site numbers are in parentheses.

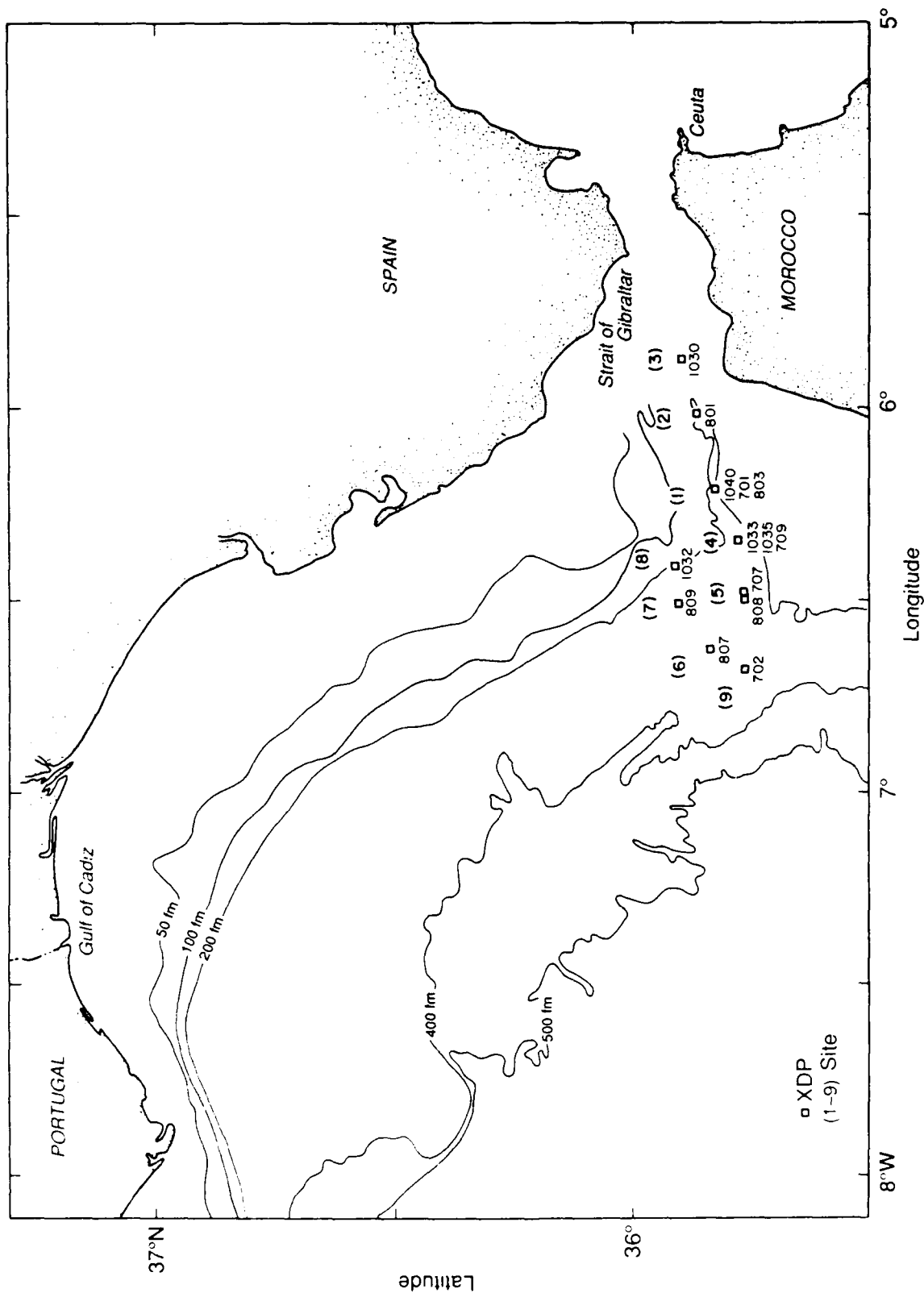


Figure 25. Locations of XDP drops. Site numbers are in parentheses.

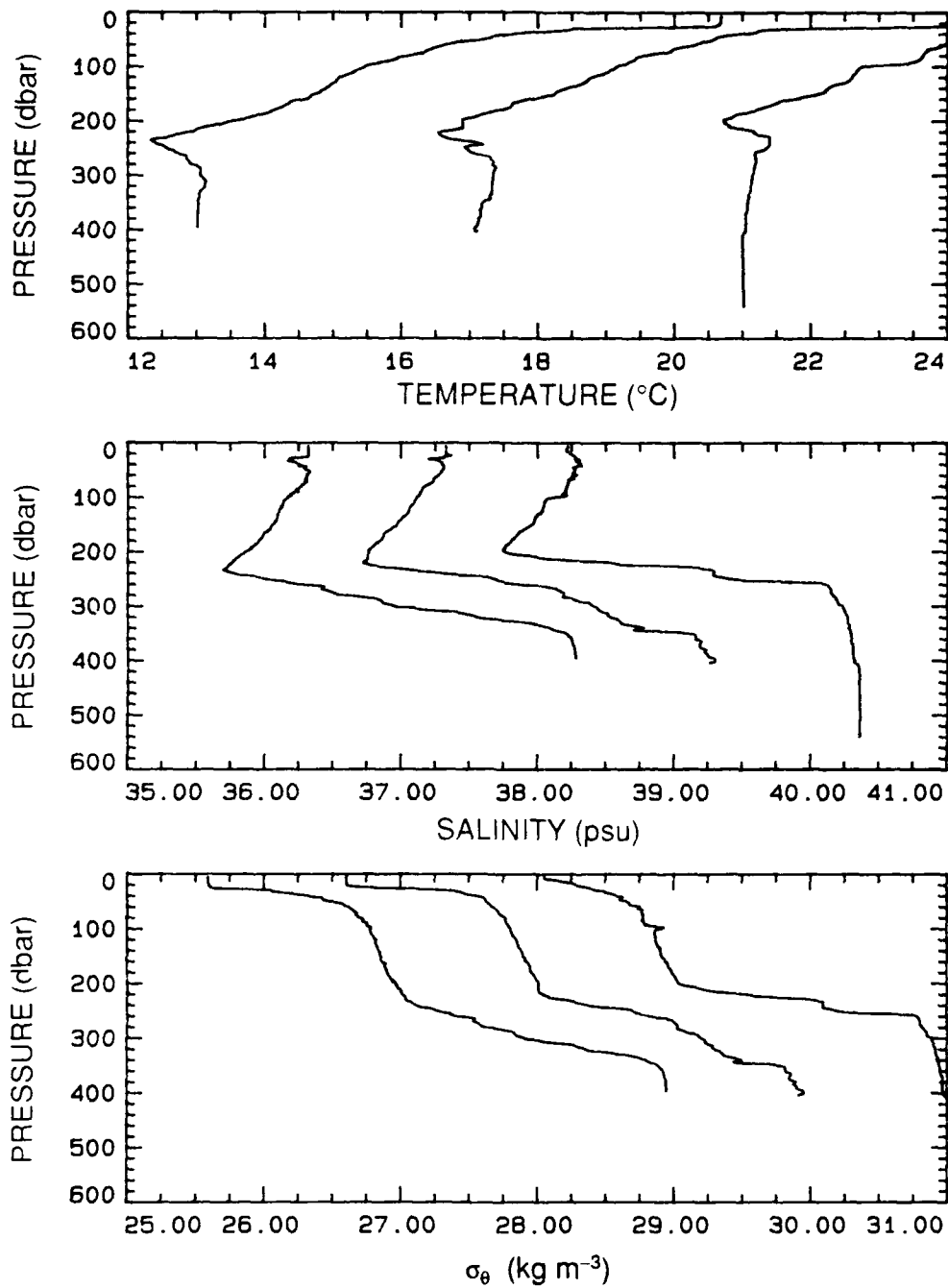


Figure 26. Temperature (top panel), salinity (middle), and  $\sigma_\theta$  (bottom) for CTD stations 50-52. The leftmost profile is plotted to scale. The other profiles are shifted successively 2.0° for temperature, 1 psu for salinity, and 1 kg m<sup>-3</sup> for  $\sigma_\theta$ .

channel along 6°29'W was rather flat, but there was a deep groove west-southwest of site 4 where we located site 5. The data showed a strong southwest bottom jet (XCP 2529), but the flow reversed about 40 m above the bottom, as if bottom drag were beginning to decelerate the flow.

Site 7 was at 35°54.24'N, 6°31.29'W, along a line about 060° from site 6. Here there was only a weak jet ( $v < 50 \text{ cm s}^{-1}$ , XCP 2534), but the salinity was about 37.0 psu (CTD 60). The results at sites 6 and 7 conform to those of Serrano (1962). The low velocities were puzzling, but the salinity and density anomalies disappeared as expected. A station to the northeast seemed appropriate to complete this preliminary study. This station (site 8) showed no Mediterranean water and little velocity (CTD 61 and XCP 2535).

Because stations 6–8 did not indicate large flow, we decided to make a cast at a location more down slope from site 5. This location (site 9) contained considerable Mediterranean water (CTD 62 and XCP 2536).

On the basis of the information on hand, we decided to begin with section A through site 1. Section B went through site 5, and section C farther west through site 9. Figure 27 shows the locations of the sections, and Figures 28–30 show the CTD stations and XCP and XDP drops.

Section C was completed the morning of 23 September and section D by late evening. After station D12, the ship returned to station C4 to obtain a dissipation profile (XDPs 1049 and 804) along with CTD (CTD 91) and velocity (XCP 2556) profiles. Rolf Lueck had had poor success during section C and wanted to obtain a profile at station C4.

Most of section E was completed on one watch. Before continuing the sections, we decided to conduct a preliminary bathymetric survey to make sure we were not being fooled by any topographic features. We steamed along the new section, denoted section F, until the 300 m contour, then turned around and hit all the deep channels. In hindsight, it was not clear that the extra steaming was worthwhile. The work went on until mid-morning of 25 September.

The next section, G, was along a line at 033°T and had 12 stations. It was argued that we should complete the CTD lines and then go back to the Strait of Gibraltar for a run along the principal channel. One reason was that the moon would be full in a day or so, and it was thought that the spring tides might produce different flows and mixing. However, the moon appeared almost full during the early morning of 25 September.

Section G was completed around 2100 GMT, and the ship steamed to section H, a line down the 8th meridian. The station spacing on sections G and H was 5 n.mi. Section H was extended to the middle of the Gulf of Cadiz, where an additional station, H11, was taken at  $35^{\circ}53'N$ ,  $8^{\circ}00'W$  in mid-afternoon of 26 September.

Station H11 seemed to be far enough to provide a mid-gulf profile, and no more stations were taken on this line. Instead, a short line of stations, denoted as section FE, was conducted between the ends of sections F and E.

During the early morning of 27 September, the ship steamed to station I1 south of Gibraltar. During the afternoon, the stations on line I were occupied, ending with station I10 at 1974 GMT. Thereafter, just XCPs and XDPs were launched until the supply was exhausted around 0200 on 28 September. The ship then headed into port at Cadiz.

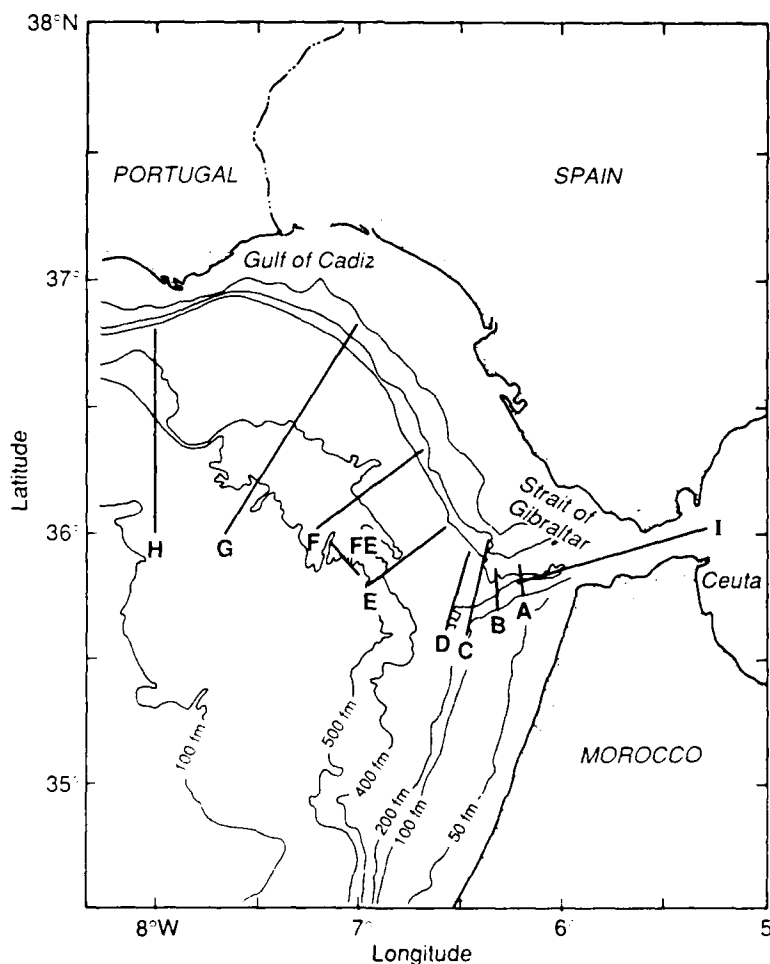


Figure 27. Section plan.

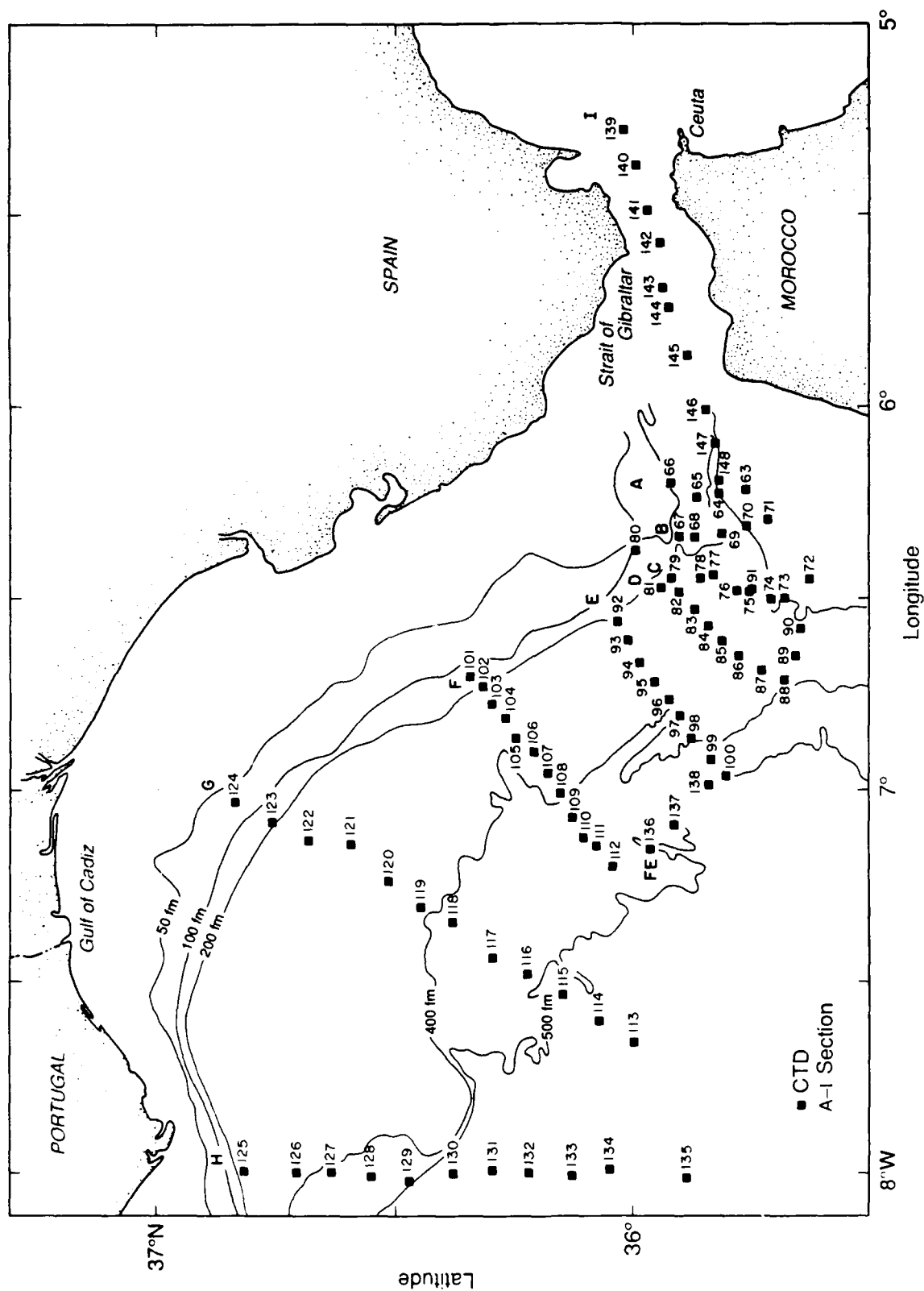


Figure 28. CTD stations, sections A-I.

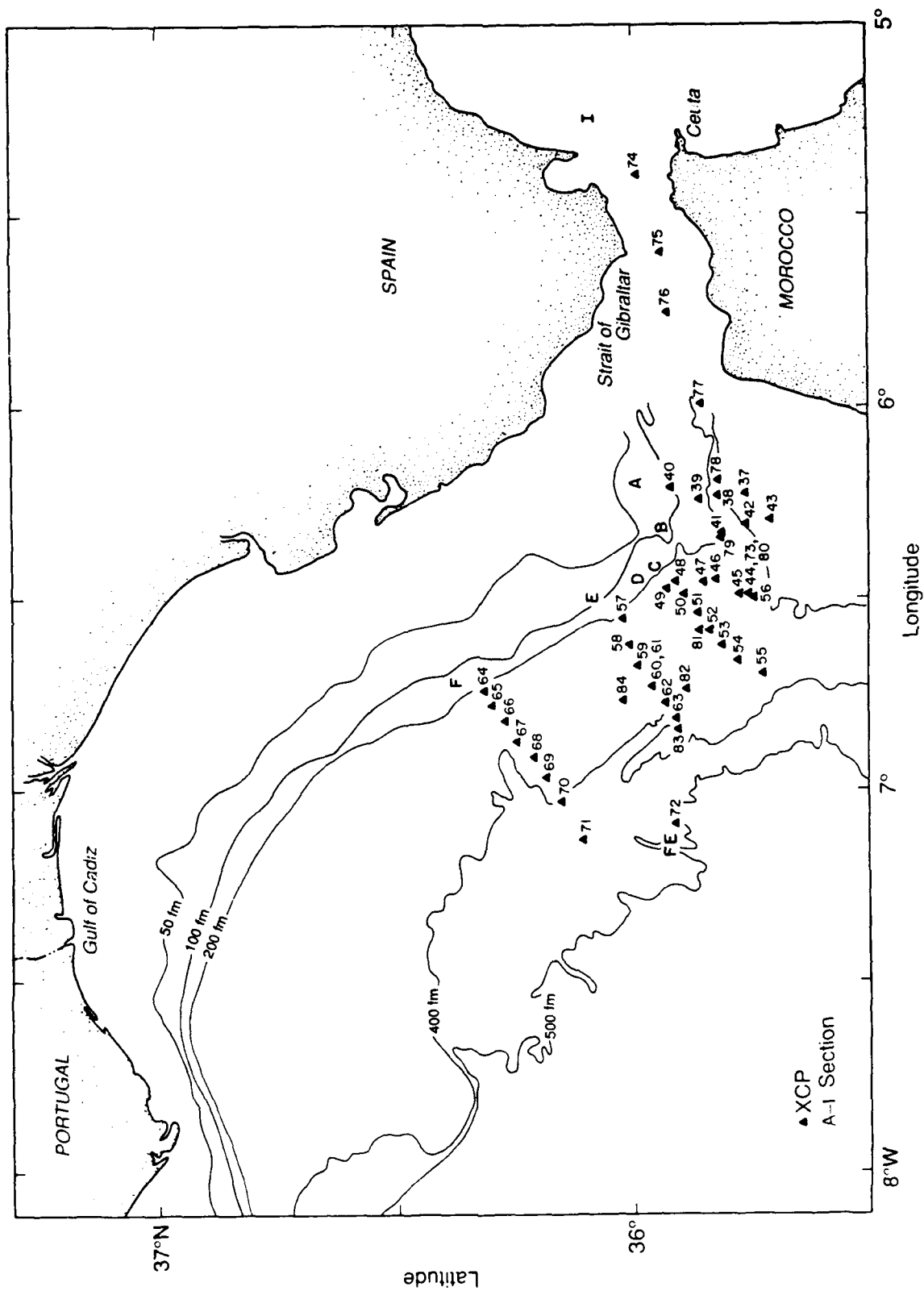


Figure 29. XCP drops, sections A-I.

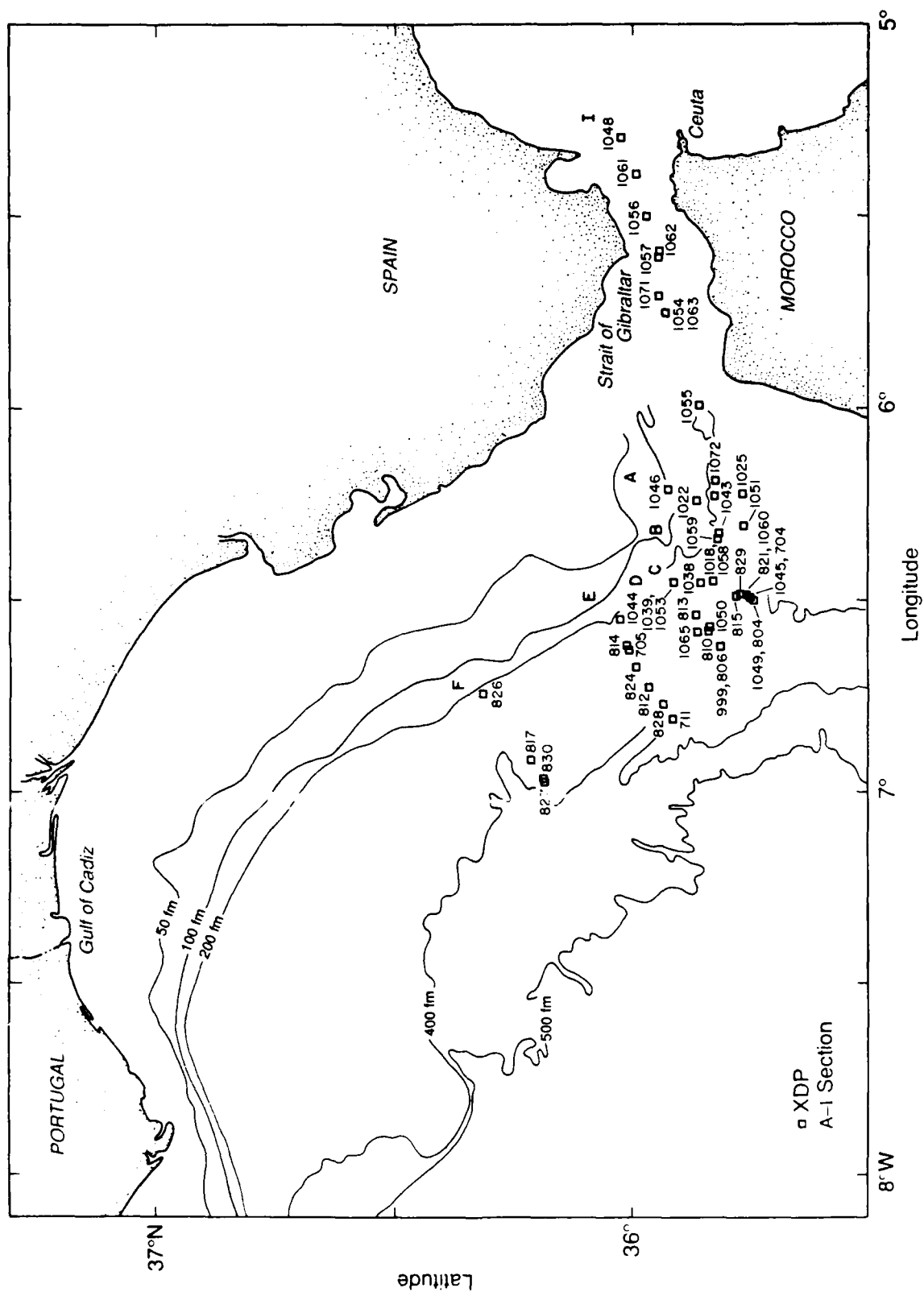


Figure 30. XDP drops, sections A-I.

## 4. DATA PROCESSING

### 4.1 Drifters

The drifter tracks (Figures 31–36) were derived from the ship's position when the ship was alongside each drifter. There were seven deployments (Table 2). The first four were on the NW, NE, SW, and SE corners of the summit of Ampere Seamount approximately 7 km from the navigational radar mooring (Figure 6). Drifter 3 lost its command receiver and drag line, so its rapid movement to the south may have been due to windage on the surface float. Drifters 1 and 2, deployed above the north flank of the seamount, moved off to the east at approximately  $6 \text{ cm s}^{-1}$ . Drifter 4 (deployed east-southeast of the summit) moved little before 8 September, suggesting that it may have been near a stagnation point. During 8 September, drifter 4 began moving south at approximately  $9 \text{ cm s}^{-1}$  as did drifters 6 and 7 on the eastern flank of the seamount. Individual tracks are not shown for drifters 1 and 3 since their movement can easily be seen in Figure 31.

### 4.2 XCP, XBT, and XSV Drops

To combine data from expendable probes (such as XBTs, XSVs, and XCPs) with CTD data for contouring and computing heat and salt transports, the depth needs to be calibrated against a standard. For the expendable probes used in this experiment, the depth (and thus the fall rate) of the probe is estimated as a quadratic function of time. The coefficients of the quadratic polynomial are empirically determined by Sippican Inc., the manufacturer of the probes. During the Gulf of Cadiz experiment, we had an opportunity to verify the depth estimates of the probes by comparing the high-wavenumber structure of their temperature or sound velocity signal with that obtained by the Sea-Bird CTD unit. This process also gave us information about the random errors and systematic offsets in these variables. This section summarizes the computational procedure and presents the results. An additional comparison was made between the XSVs and the XBTs, since the data from these probes can be combined to estimate salinity.

Because the CTD's vertical reference is pressure and the expendable probe's reference is depth, a conversion is needed before the expendable probe's depth can be calibrated. Saunders and Fofonoff (1976) present a conversion method that consists of integrating the hydrostatic equation downward from the sea surface, while accounting for

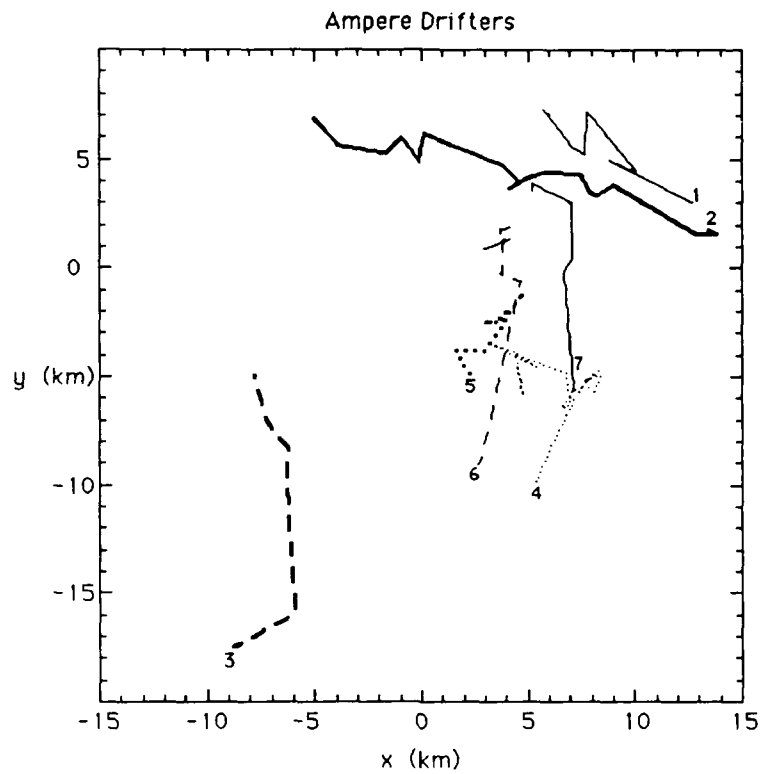


Figure 31. Tracks for drifter deployments 1-7.

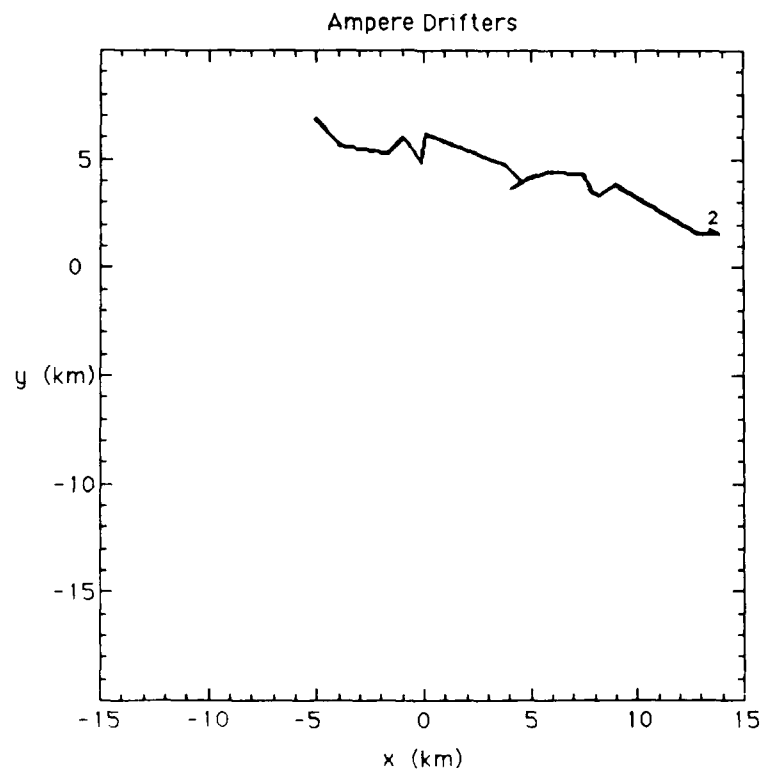
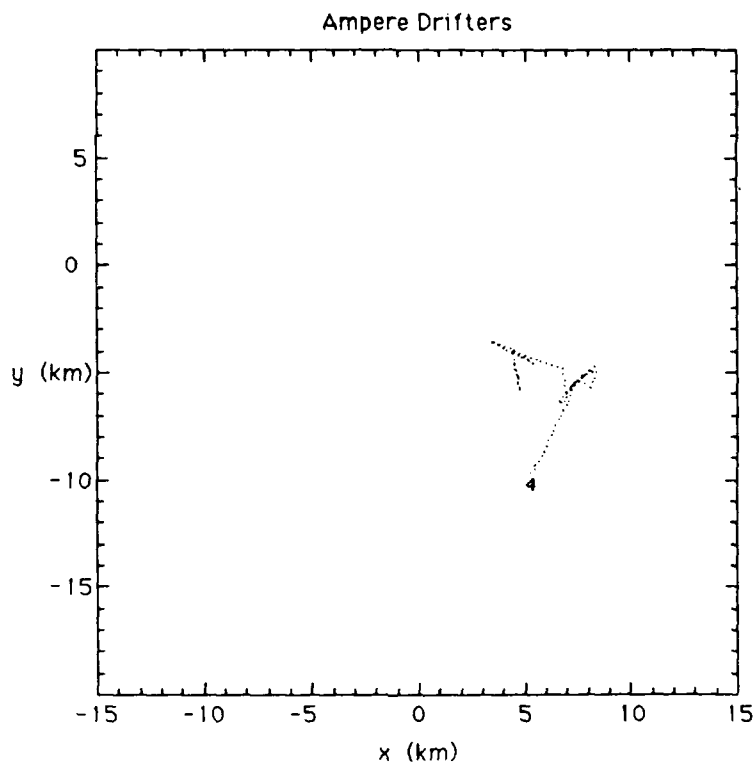
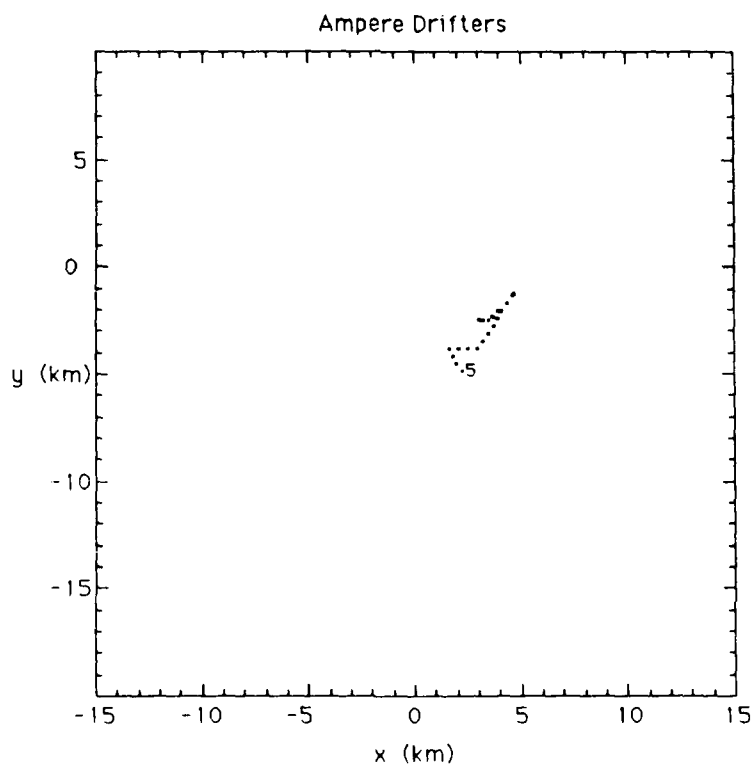


Figure 32. Track for drifter deployment 2.



*Figure 33. Track for drifter deployment 4.*



*Figure 34. Track for drifter deployment 5.*

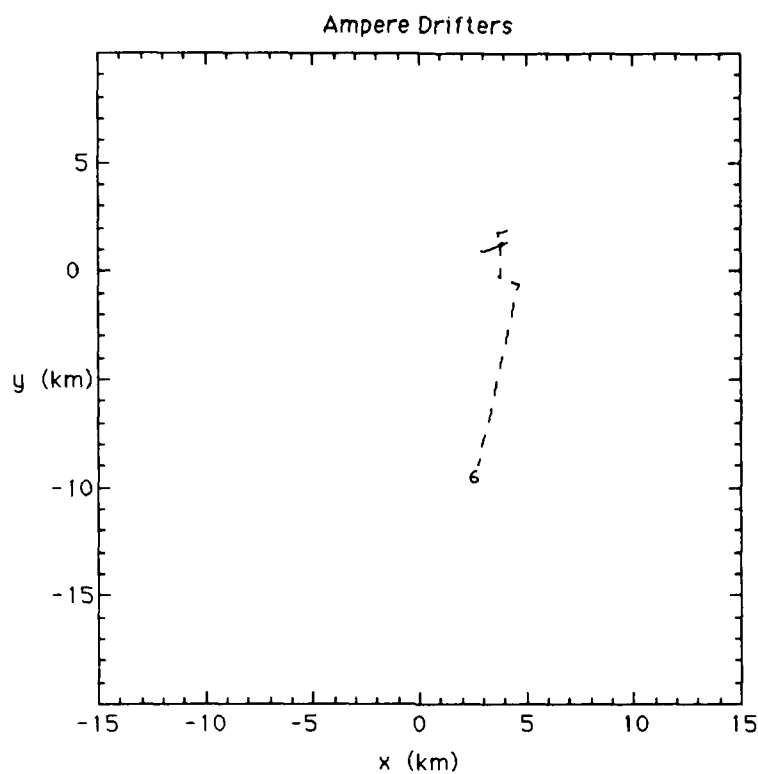


Figure 35. Track for drifter deployment 6.

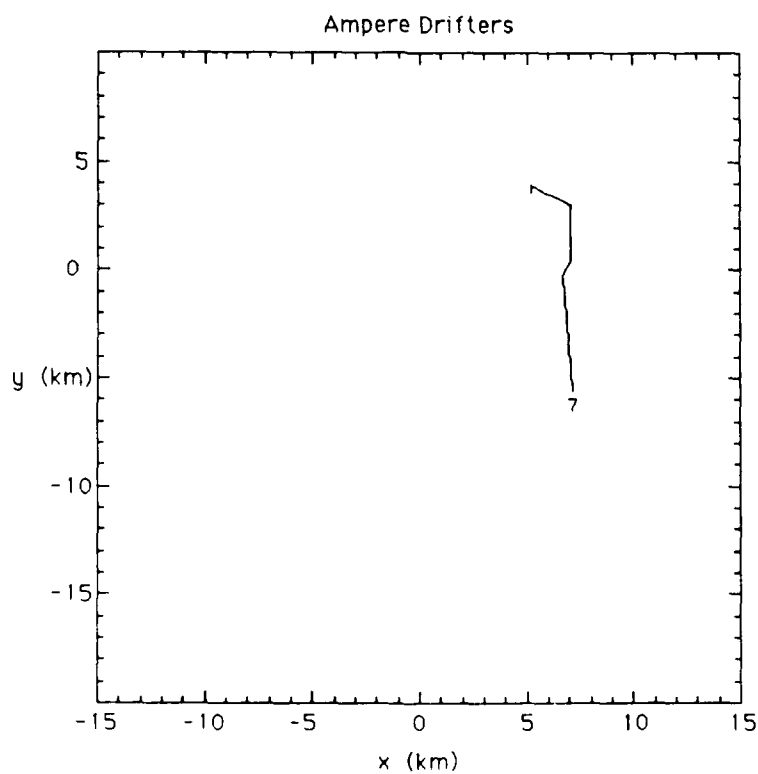


Figure 36. Track for drifter deployment 7.

the horizontal and vertical variations in the earth's gravitational field. For this analysis, the CTD data collected on the cruise were averaged into 10-dbar bins, and the vertical integration was performed for each cast. At each bin level, a ratio was formed between the computed depth (in meters) and the measured pressure (in decibars). The resulting ratio-pressure curves from all the casts were combined at each bin level to give a curve for the average ratio. An approximation to the average ratio curve is given by

$$\text{ratio ( pressure )} = 0.9927 - 2.55 \times 10^{-6} \text{ pressure} + 0.0073 \exp ( -\text{pressure}/50 ) .$$

Figure 37 shows the average ratio curve (steppy) and the approximate curve (smooth). The depth is found by multiplying the measured pressure by the ratio appropriate for that pressure. Thus when the pressure is 1000 dbar, the corresponding depth is  $1000 \times 0.9901$ , or 990.1 m. The maximum error in depth caused by using the approximate curve instead of the one for any particular CTD cast is about 0.5 m. Pressure and depth will be used interchangeably in this section, but with the understanding that the appropriate conversions have been made.

Software was then developed to determine the relative depth offset as a function of depth between two drops or casts, assuming the instruments passed through similar ocean features on their descent. The vertical scales of the features used to compare the depths were between 10 and 100 m. To accent these features, the signal from the probe (either temperature or sound velocity) was bandpass filtered to remove very-high-wavenumber noise and low-wavenumber features. The program then shifted one profile with respect to the other and found the depth offset that maximized the correlation of the two over a limited depth range. This process was repeated for each depth value in the drop. Rather than compute the correlation for every offset possible, a "golden section search" (Press *et al.*, 1986) was performed to find the maximum correlation. The correlation was assumed to be a smoothly varying function of offset, with a global maximum at the optimal offset. The optimized search procedure gave results comparable to the point-by-point search and ran 5 to 10 times faster. The maximum correlation achieved and the corresponding depth offset were recorded, as well as the temperature or sound velocity differences in the nonfiltered signals at the optimum offset. Figure 38 shows an example of the program output for an XSV/XBT drop pair.

After a depth offset record was obtained for all the expendable probes, a second program computed the mean and rms of the depth offset and the signal difference. During many drops, the maximum correlation at a depth bin was below 0.5, lowering the confidence that a good estimate of the depth offset and signal difference was obtained. To keep these values from being included in the average and contributing to the rms value, if the maximum correlation obtained for each depth bin during a drop was below a user-defined minimum (usually 0.9), the depth offset and signal difference were not included in the subsequent calculation.

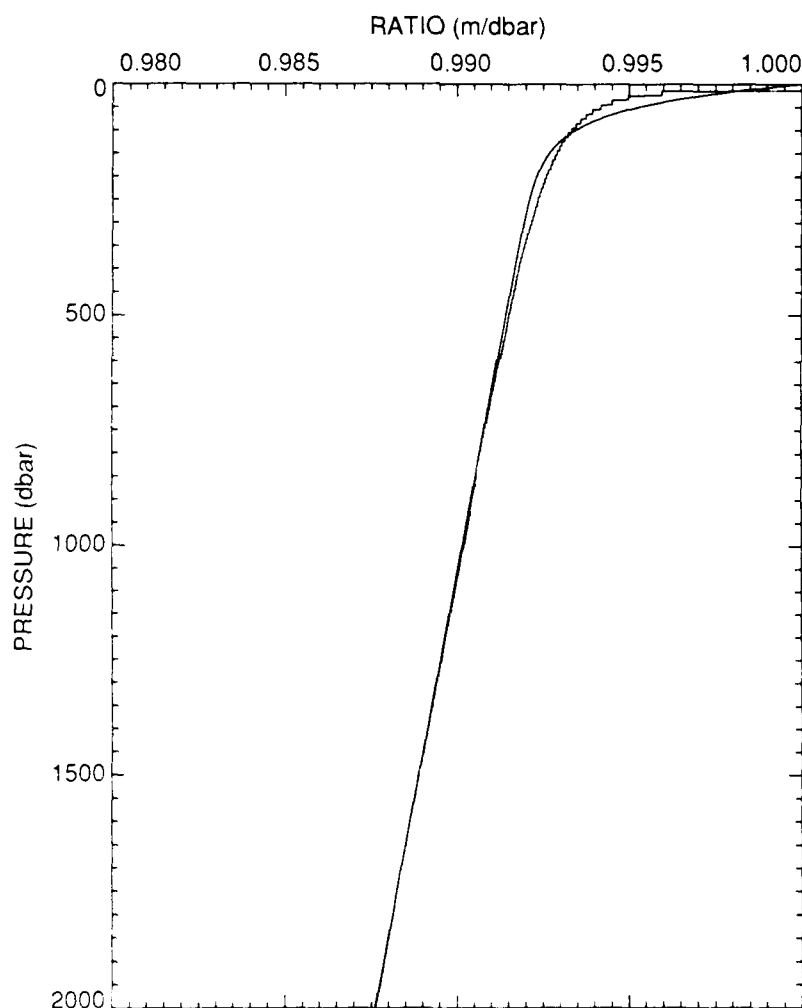


Figure 37. Relation between pressure and depth derived from the vertical integration of CTD data. The steppy curve is the integrated value, and the smooth curve is a fit to the data.

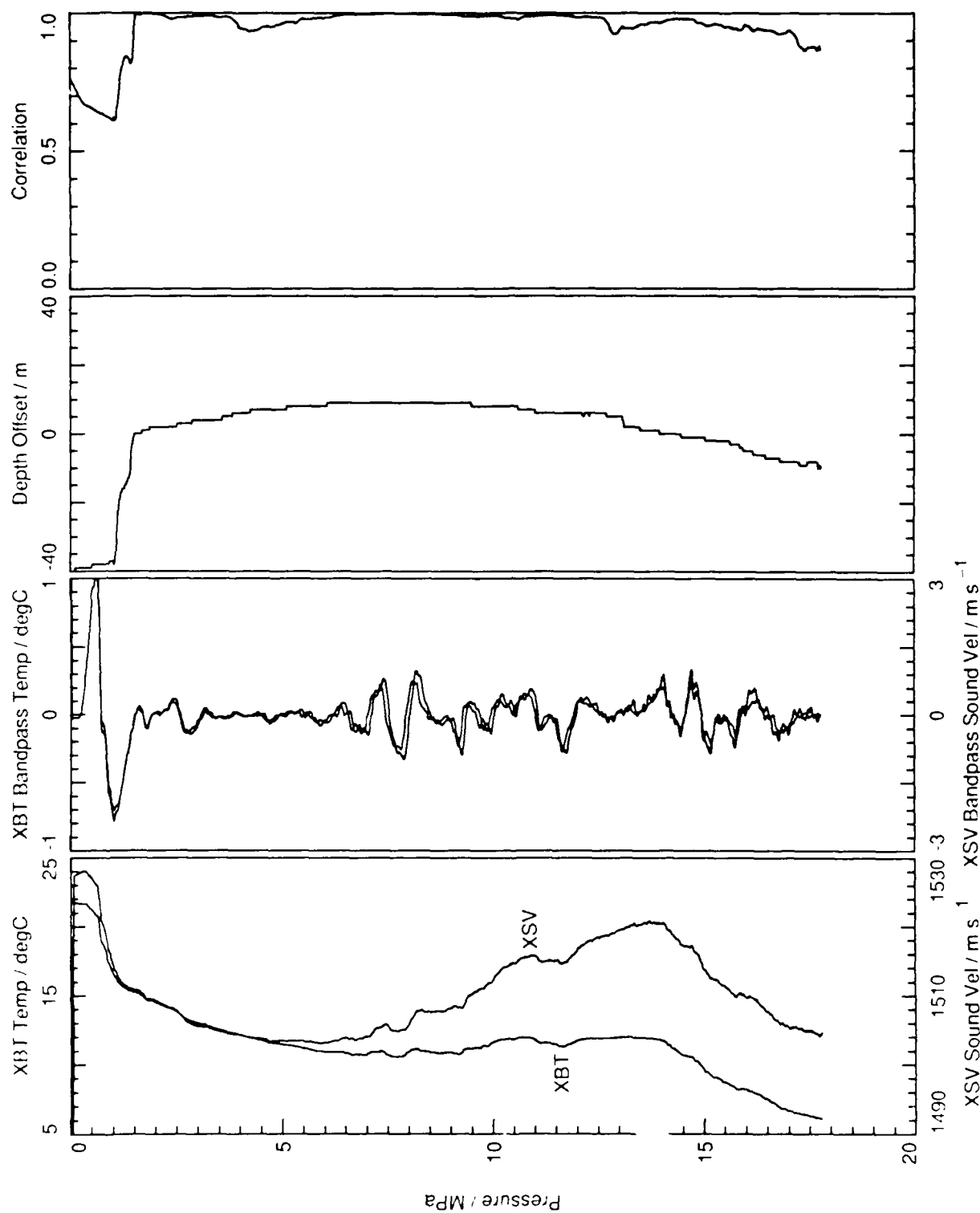


Figure 38. Output of program comparing an XSV/XBT drop pair.

A probe/CTD pair was considered acceptable for analysis if the processed data from the probe passed a visual inspection (no noticeable offsets, spikes, wire breaks, etc.) and the probe was dropped within 1 hour and within 1 n.mi. (2 km) of the CTD cast. These temporal and spatial constraints may appear harsh, especially compared with a previous error analysis by Heinmiller *et al.* (1983) which used XBT/CTD pairs 15 to 50 km apart; however, because of the complex structure and interleaving of the Mediterranean outflow in the Gulf of Cadiz, small differences in time or position severely degraded the signal correlations.

There are 65 XCP/CTD pairs; the majority (47) occurred during the second leg of the cruise while the ship was in relatively shallow water (less than 500 m). The analysis was separated into deep drops and shallow drops, which were then recombined to give the final results. The XCPs were typically dropped immediately after leaving a CTD station. This process led to spatial separations of up to 1 n.mi. and temporal separations of up to 1 hour. When a high correlation was imposed on the mean and rms computations, the number of accepted values was much smaller than the number of drop pairs. By chance, the processing software used at sea for the Cadiz cruise did not use the depth coefficients for the Mod 7 XCPs, but rather the coefficients for earlier models. The Mod 7s supposedly fall about  $0.3 \text{ m s}^{-1}$  slower than earlier models. Because the depth of the probe is computed from the elapsed time after launch, the depth coefficients would reflect this difference in fall rate. However, the offset between the depths calculated for the XCP drops when using the earlier depth coefficients and those obtained from the CTD data was usually less than 5 m, even at 1600 m. Where the earlier coefficients placed the probe at 1600 m, the Mod-7 coefficients gave a depth 90 m shallower. Table 5 lists the depth coefficients used for the Mod 7 and the earlier models. It is not known yet what effect the unique temperature and salinity structures in the Mediterranean outflow may have on the XCP fall rates.

Table 5. XCP fall rate coefficients.

| Coefficient | Mod 7    | Earlier Models |
|-------------|----------|----------------|
| pcal0       | 4.875    | 3.1            |
| pcal1       | 4.276    | 4.544          |
| pcal2       | -0.00063 | -0.0006749     |

A nearly linear trend was observed in the temperature difference between the XCPs and the CTDs, with the XCPs being  $0.05^{\circ}\text{C}$  warmer at the surface and  $0.25^{\circ}\text{C}$  warmer at 1600 m. It is unknown whether the trend was due to a pressure effect on the thermistor and circuitry or to a temperature effect on the circuitry alone. The rms temperature variation between the XCPs was  $0.1^{\circ}\text{C}$ . Further work is needed to determine the source of the temperature offset, perhaps by analyzing XCP/CTD pairs from other cruises where the temperature and salinity structure is substantially different than in the Gulf of Cadiz.

Four T-5 XBT/CTD pairs, one T-6 XBT/CTD pair, and one T-7 XBT/CTD pair were used in this analysis, but did not provide enough comparisons to estimate the depth offsets accurately. However, a systematic mean temperature offset of  $0.075^{\circ}\text{C}$  was observed throughout the drops, with a rms temperature variation of less than  $0.1^{\circ}\text{C}$ . The accuracy of the probe is given by Sippican Inc. as  $\pm 0.15^{\circ}\text{C}$ .

Three XSV-02/CTD and two XSV-03/CTD pairs were used in this analysis. During the cruise, it was noticed that features in the XSV data were roughly 8% shallower than similar features in the XBT or CTD data. No more accurate estimate could be made at the time because of the small number of pairs. A better estimate of the depth offset is made later in this section. The analysis showed a  $0.20\text{ m s}^{-1}$  offset in all the sound velocities. The sound sensor is probably the same for all the XSV probes, so the same offset is expected for both types of XSVs. The accuracy of the probe is given by Sippican Inc. as  $\pm 0.25\text{ m s}^{-1}$ .

The XSV-02/XBT(T-5) drops give the highest quality comparisons, primarily because the two probes were dropped simultaneously, with a spatial separation of 10 m (the width of the fantail). XSV depths were multiplied by 1.08 before processing to partially correct the depth offset noticed on the cruise and to reduce the search for the maximum correlation. The results show the rms offset varies linearly with depth, from 1 m rms at the surface to 6 m at 1500 m depth. Table 6 gives the fall rate coefficients computed from this analysis.

For processing the Cadiz cruise XCP data, we recommend using the XCP Mod 6 depth coefficients, subtracting  $0.05^{\circ}\text{C}$  from the surface temperatures and  $0.25^{\circ}\text{C}$  from the 1600-m temperatures, and applying a linear correction between these depths. This

Table 6. XSV fall rate coefficients.

| Coefficient | Sippican | $1.08 \times \text{Sippican}$ | Cadiz Cruise |
|-------------|----------|-------------------------------|--------------|
| pcal0       | 0.0      | 0.0                           | 3.38         |
| pcal1       | 5.5895   | 6.0367                        | 5.8561       |
| pcal2       | -0.00147 | -0.00159                      | -0.000883    |

analysis assumes that the XBTs have the correct fall rate which, given the limited data, is the only assumption possible at this time. Subtracting  $0.075^{\circ}\text{C}$  from the type T-5 XBT temperatures is recommended. The Cadiz cruise depth coefficients are recommended for any XSV-02 processing, along with adding  $0.2 \text{ m s}^{-1}$  to the sound velocities. Because of the limited data for XSV-03s, their depths have been assumed to be correct.

### 4.3 CTD Data

Seasoft version 3.0, dated 23 May 1988, written by John Backes at Sea-Bird Electronics, was used for CTD data acquisition. Data were acquired on the down cast only.

In the Seasoft 3.0 SEASOFT.CFG file, the number of scans to average in the deck unit was set to 24 (i.e., 1 s). This was done by running the SEACON program. Further averaging was done with respect to pressure, in 10-dbar bins, using the Seasoft 3.0 BINA VG file for all CTD casts during the cruise.

Water samples were taken by attaching a single 1.5-liter Niskin bottle to the electromechanical wire supporting the Sea-Bird CTD underwater unit.

Marker files, Seasoft version 3.0 CTD###.MKR files, were created on the COMPAQ computer at the beginning and end of the Niskin bottle soak time for later comparison with salinity values determined by the Guildline Autosol salinometer. The marker files include time, date, pressure, temperature, salinity, density, sound velocity, and scan number.

The individual water samples were collected from the Niskin bottle using glass citrate of magnesia bottles supplied by the Physical and Chemical Oceanographic Data Facility at Scripps. The bottle and seal were flushed twice before drawing the final sample. Replicate samples were taken for CTD stations 50 through 148. The samples were

stored for at least 24 hours in the laboratory next to the Autosol to stabilize their temperature. The Autosol was calibrated using standard Wormley seawater during the first few days of the cruise after the bath had initially stabilized. Six separate batches were run on the Autosol. The two conductivity ratios for each sample were averaged for use in computing salinity.

Wormley water batch number P108 was used for all Autosol standardizations. The  $K_{15}$  value was 0.99980 and the chlorinity 19.371. The raw salinity of this water was calculated to be 34.994 psu, using the IEEE algorithm (Lewis, 1980). Averaged conductivity ratios for each water sample, determined with the Guildline Autosol, were used to correct the raw salinity values.

An offset between the Autosol salinity values and known standard seawater values was found for runs 4, 5, and 6. The formula (standard water salinity initial value, in psu) – (34.994 psu) was used to determine the offset for each run. The drift throughout the individual runs was calculated also. The drift per sample was found using the formula [(standard water salinity final value, in psu) – (standard water salinity initial value, in psu)] / (number of samples + standards – 1). These values are summarized in Table 7. Because replicate samples were taken only for stations 50–148, only those samples were used in comparing the SBE CTD salinity values and the Guildline Autosol salinity values.

The replicate salinity samples from the Niskin bottle for stations 50–148 were logged and stored in the main laboratory aboard R/V *Oceanus* for transport to the Woods Hole Oceanographic Institution. Marv Stalcup at WHOI analyzed the replicates using another Guildline Autosol.

Table 7. Salinometer run information.

| Run Number | CTD Stations | No. of Samples | Std Water Initial Salinity (psu) | Std Water Final Salinity (psu) | Offset Per Run | Drift Per Sample |
|------------|--------------|----------------|----------------------------------|--------------------------------|----------------|------------------|
| 4          | 50–92        | 24             | 35.0216                          | 35.0276                        | 0.02760        | 0.000240         |
| 5          | 93–116       | 19             | 35.0198                          | 35.0277                        | 0.02580        | 0.000395         |
| 6          | 122–148      | 13             | 35.0161                          | 35.0229                        | 0.02210        | 0.000486         |

Comparison of the salinity values calculated with the *Oceanus* Autosol and the replicate values calculated with the WHOI Autosol showed a mean difference of  $-0.0003$  psu with a standard deviation of  $0.0084$ . Five of the 55 samples collected on casts 50–148 were not used in the calculation because of large differences between the Sea-Bird and Autosol measurements. These differences result from sampling in an area of high vertical gradients.

An average difference of  $-0.0089$  psu with a standard deviation of  $0.0096$  was calculated for the same set of samples when comparing Autosol seawater salinity measurements performed on the R/V *Oceanus* with the Sea-Bird Seasoft version 3.0 marker file salinities. Also, an average difference of  $-0.0092$  psu with a standard deviation of  $0.012$  was calculated for the same set of samples when comparing Autosol seawater salinity measurements performed at WHOI with the Sea-Bird Seasoft version 3.0 marker file salinities. These results are summarized in Table 8.

Table 8. *Sea-Bird CTD salinities (version 3.0 software) versus corrected Autosol salinities.*

|                    | $\Delta S_1$<br>(SB–SC)<br>(psu) | $\Delta S_2$<br>(SB–WA)<br>(psu) | $\Delta S_3$<br>( $\Delta S_2 - \Delta S_1$ )<br>(psu) |
|--------------------|----------------------------------|----------------------------------|--------------------------------------------------------|
| Average            | $-0.0089$                        | $-0.0092$                        | $-0.0003$                                              |
| Standard Deviation | $0.0096$                         | $0.012$                          | $0.0084$                                               |

SB = Sea-Bird salinity (version 3.0)

SC = Ship's Autosol, corrected salinity

WA = WHOI Autosol, corrected salinity

During and after the cruise, there was concern about the offset between the Autosol and Sea-Bird salinities. John Backes of SBE looked into the residual difference after initial Autosol correction factors were applied, and found that the compressibility of the conductivity cell needed to be compensated for in the software. SBE Application Note No. 10, dated October 1988, was written to document the updated version of Seasoft, now version 3.2, which automatically implements a compression compensation equation.

To test this new software, Backes and Tom Lehman ran the bin-averaging routines in both Seasoft 3.0 and Seasoft 3.2 using the same data set for CTD 12. They found that

the new software with its pressure-dependent term changed the computed salinity at the bottle sampling depth, 2010 dbar, from 35.189 psu to 35.197 psu, a change of 0.008. The increase in salinity when using Seasoft version 3.2 was in the right direction to offset the difference. The next step was to compute salinities with version 3.2 and compare them with the corrected Autosol values. This was done for a subset of the data, 24 stations. Both precruise and postcruise calibrations were tried at this stage. The results are summarized in Table 9. The salinities computed using the postcruise calibrations agreed well (within the stated accuracy of  $\pm 0.002$  psu for the Guildline Autosol model 8400A) with the corrected Autosol salinities and were used in all subsequent reprocessing.

All the data from *Oceanus* Cruise 202 were reprocessed using the postcruise calibrations and version 3.2 of Seasoft, producing pressure, temperature, and conductivity values in 2-dbar bins. Derived quantities (e.g., salinity, density, etc.) were calculated using seawater routines written by Ngoc Dang at APL.

Table 9. *Sea-Bird CTD salinities (version 3.2) versus corrected Autosol values.*

|                    | $(SB_{pre} - SC)$<br>(psu) | $(SB_{post} - SC)$<br>(psu) |
|--------------------|----------------------------|-----------------------------|
| Average            | -0.0083                    | -0.0019                     |
| Standard Deviation | 0.0088                     | 0.0089                      |

SB = Sea-Bird salinity (using version 3.2)  
SC = Ship's Autosol, corrected salinity

#### 4.4 Navigation

The Loran-C, differential Omega, and Transit/dead-reckoned data were processed separately by similar averaging programs which provide positions on a uniform time grid. The time grid usually has a 60-s interval. Position data are averaged over 60 s and velocity data over 300 s. Grid times when no data are available or when the programs sense abnormal data have a "bad value" flag.

The differential Omega and Transit/dead-reckoned positions are decoded and averaged using least-squares techniques to get the average position and rate of change, i.e., the velocity over the ground.

The average and rate of change of the Loran-C travel times are also computed, using the same least-squares techniques. These values are then converted to position and velocity over the ground, using standard Loran-C conversion equations.

The Transit satellite fixes are used to keep the range-range Loran-C position error from increasing without bound as the shipboard rubidium clock drifts. This also removes the differences in emission times between the two chains.

The difference between the travel time measured by Loran-C to each station and the expected travel time based on the position determined by the satellite fix provides a clock error at each fix time. This error was plotted and graphically fit by eye to a straight line to provide clock drift and offset over periods of several days to a week.

The corrections were made to a resolution of  $1\text{ }\mu\text{s}$ , since the rms travel time noise was about 1 or  $2\text{ }\mu\text{s}$ . Thus ranges to the stations are no better than 300 m. If more accuracy is desired, more effort could profitably be put into these clock drift and offset calculations.

We used only satellite fixes that had elevation angles between  $15^\circ$  and  $70^\circ$  and that were not rejected by the MX-1103. This screens out many bad fixes but not all.

Early in the cruise, the Loran-C sets would periodically lose the weak signals and automatically reacquire them sometime later, so the clock offset would need to be recalculated. The offset could not be computed as accurately when the set stayed locked for only a few satellite fixes because of the large variability. The drift was assumed to remain the same during those periods.

The satellite fixes are also used to correct lane jumps in the Loran-C sets and the propagation delays (additional secondary phase factors) not corrected by the simple over-water propagation model used in the program.

There is a strong diurnal character to the quality of the Loran-C data. It is much better during the day than at night. The rms variability over a 1-min average of the Loran-C travel times ranges from 100 to 200 ns at night to as little as 30 ns during the day.

A problem uncorrected to date is that the HP-UX computer time was in error by almost 2 min by the end of the cruise. It had been set at the beginning and allowed to drift. When the Transit fixes are compared with the Loran-C data to obtain the clock bias

and drift, this time error introduces a position error of as much as 600 m when the ship is moving at 10 kn. This may account for part of the rms variability between the Transit fixes and the Loran-C positions. Sufficient data were recorded to correct for this problem.

The decision of which stations to include in the position determination was fairly straightforward later in the cruise. All four of those mentioned were used. Earlier in the cruise, including the Mediterranean chain in the calculations seemed to give poorer results. This was determined by examining the ship's tracks obtained when using various stations. During the XCP surveys over Ampere Seamount, the smoothest ship track was obtained when only the two French stations were used.

Unfortunately, there were times when one of those stations was not available, so the Mediterranean stations had to be used to obtain any Loran-C positions at all.

## 5. OBSERVATIONS AND RESULTS

### 5.1 Ampere Seamount

#### 5.1.1 Mooring

The mean position of the radar mooring determined using Loran-C data was  $12^{\circ}52.3'W$  ( $\pm 1$  km),  $35^{\circ}03.3'N$  ( $\pm 0.5$  km). The greater errors in the east-west position are due to Loran-C noise. The Omega data appear to contain the same noise. There was a standard deviation of 0.25 km in the satellite fix positions.

#### 5.1.2 XCP Survey 1

Figure 39 is a plot of current speed versus depth as determined from XCP drops 2429–2442 (except 2431 and 2440) for leg 1 of the second Ampere Seamount survey. The nominal spacing between consecutive drops was 500 m. A mid-depth (1100–1400 m) mean was removed from each drop before the speed was computed. The first drop is plotted to scale, and each successive drop is offset  $10 \text{ cm s}^{-1}$ . The drop spacing used during this survey produces good correlation between adjacent profiles yet resolves features (for example, the feature centered around 650 m) well enough to show changes from the beginning to the end of the survey.

### 5.2 Meddy Component

The inset in Figure 40 shows the velocity vectors at mid-depth ( $\approx 1050$  m) of the Meddy surveyed during this cruise. The core of the Meddy out to 8 km is in near-solid-body rotation, with  $\zeta / f \approx -0.9$ , where  $\zeta$  is the relative vorticity and  $f$  the planetary vorticity. This Meddy appears to have a low-order axial asymmetry.

### 5.3 Outflow Experiment

Figure 41 is a plot of  $u$  velocity ( $\text{cm s}^{-1}$ ) versus depth as determined from XCP drops in and west of the Strait of Gibraltar (inset). Shading indicates regions where  $u < 0$ . The leftmost drop is plotted to scale; each successive drop is offset  $100 \text{ cm s}^{-1}$ . Each probe operated until it hit the seafloor. Note evidence of a bottom boundary layer (BBL) which tends to bring the velocity to zero at the seafloor. Processing with higher vertical resolution will exhibit the BBL more clearly and permit the estimation of  $u^*$ , the friction velocity.

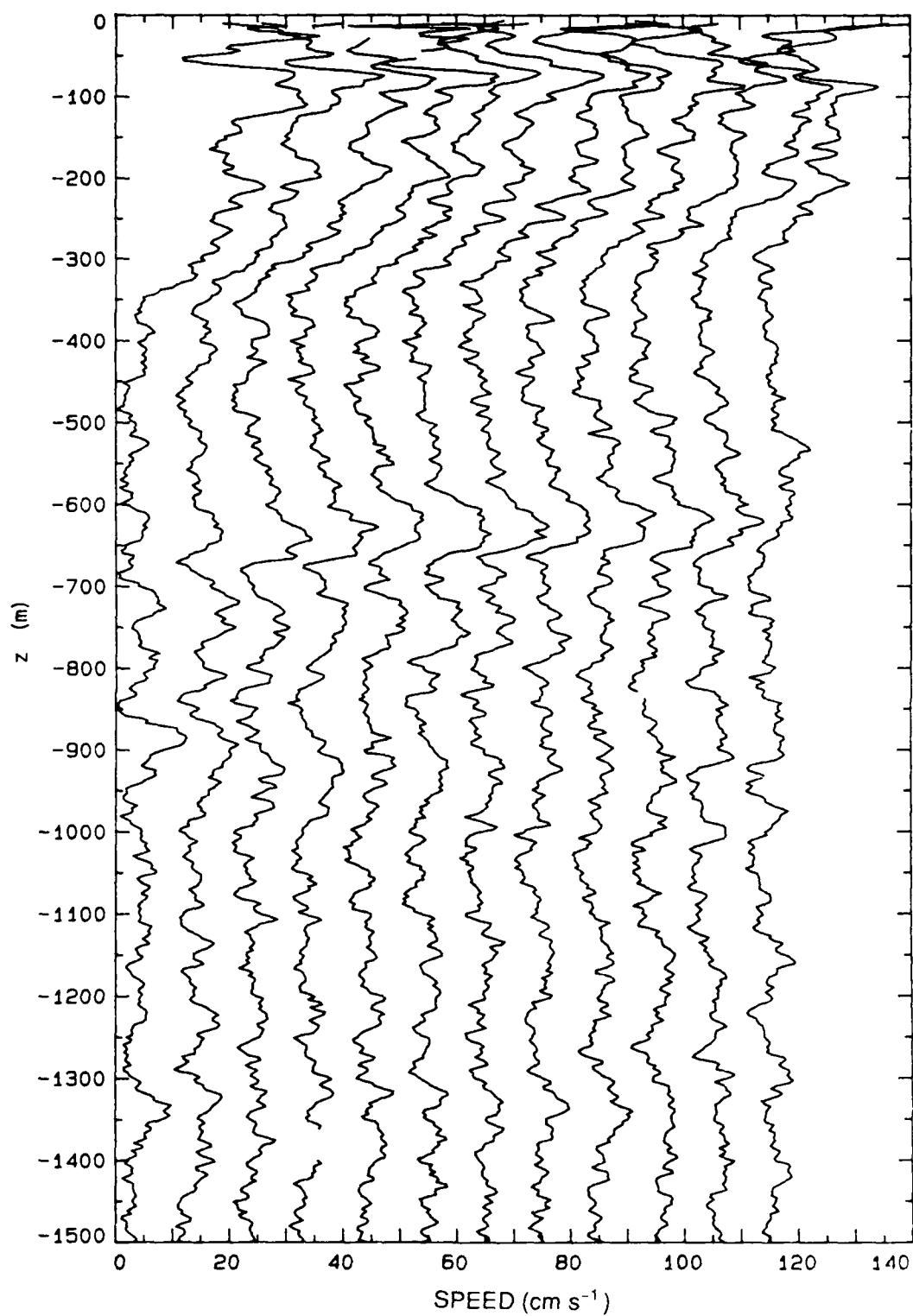


Figure 39. Plot of current speed versus depth as determined from XCP drops 2429-2442 (except 2431 and 2440) during leg 1 of the second Ampere Seamount survey. These profiles are based on at-sea processing.

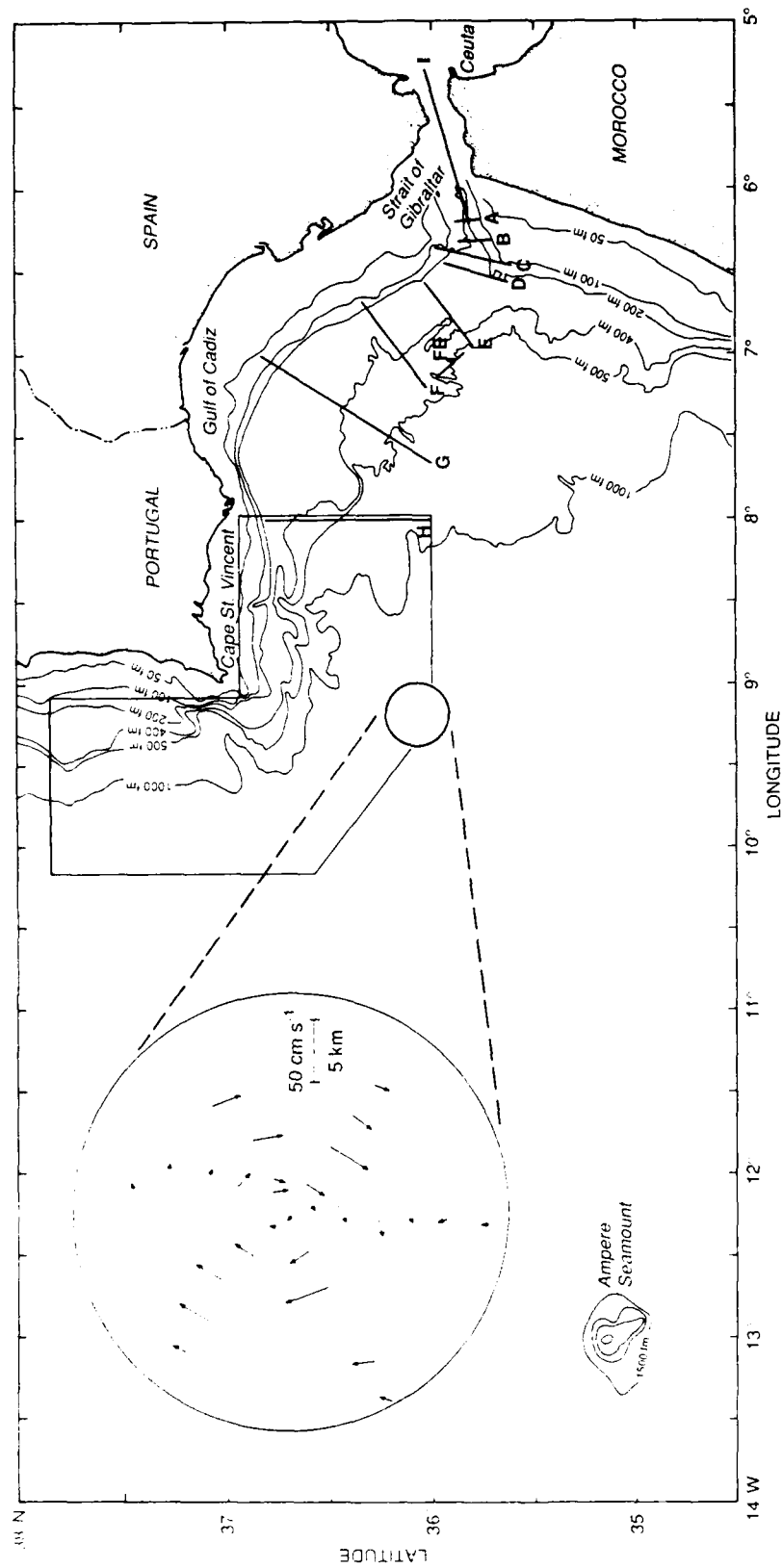


Figure 40. Velocity vectors at mid-depth ( $\approx 1050 \text{ m}$ ) of a Meddy (inset). The scale above the plot shows length of  $50 \text{ cm s}^{-1}$  vector.

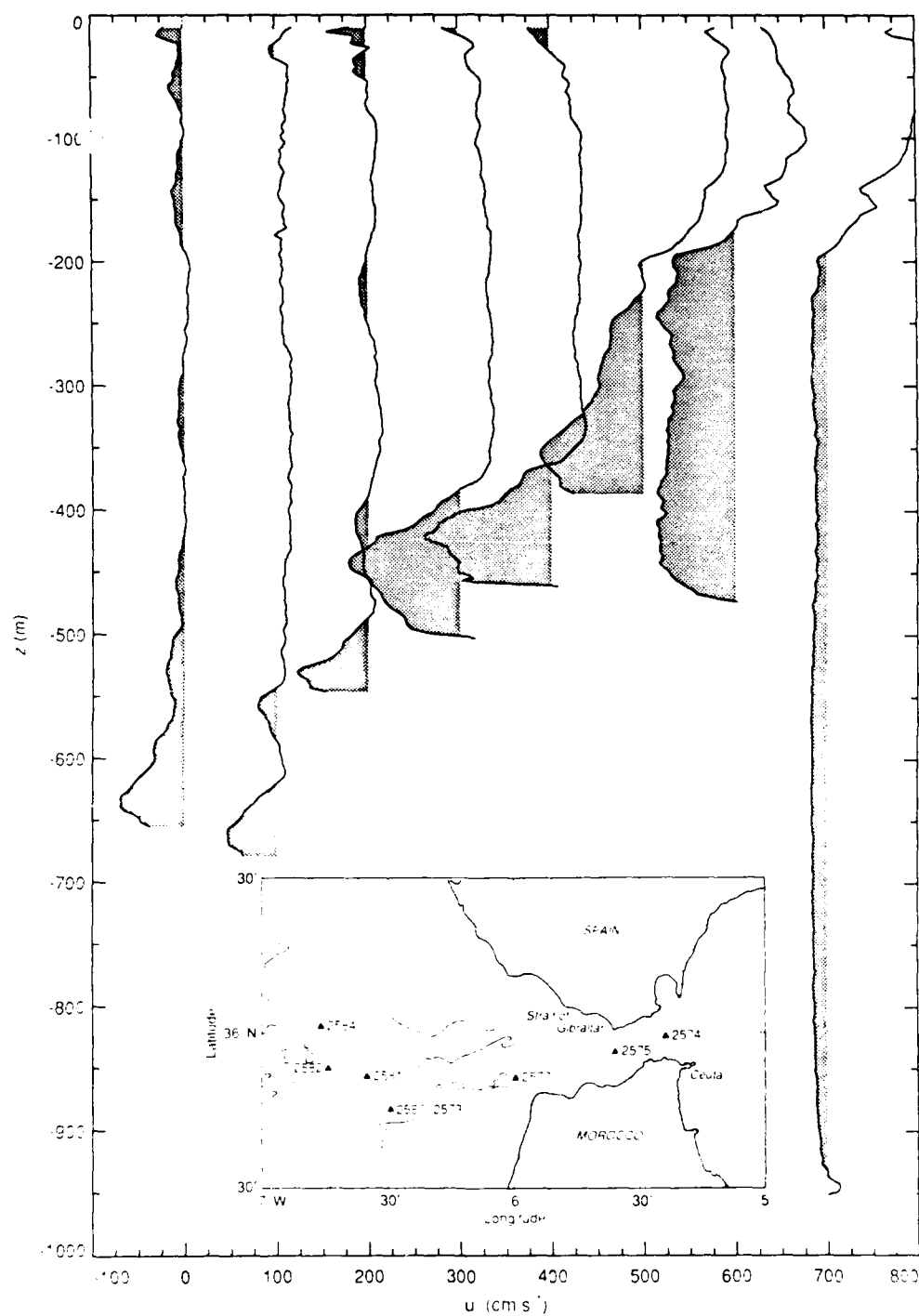


Figure 41. Plot of  $u$  velocity ( $\text{cm s}^{-1}$ ) versus depth from XCP drops in and west of the Strait of Gibraltar. Shading indicates regions where  $u < 0$ . The leftmost drop is plotted to scale; each successive drop is offset  $100 \text{ cm s}^{-1}$ .

#### 5.4 Navigation: Which System Provides the Most Accurate Positions?

Ship tracks obtained from Loran-C, differential Omega, and Transit/dead reckoning were plotted for the XCP surveys near Ampere Seamount as well as for the Meddy survey. The peak-to-peak variability over several miles of track is about 200 m or less for the Loran-C data and about 600 m for the differential Omega data. There are times when the Omega track deviates by several miles from both the Loran-C and Transit/dead-reckoned tracks. The Transit/dead-reckoned tracks occasionally jump several miles when new satellite fixes arrive.

The Loran-C seems to provide the best position data for use in computing short-term differences in position. There can be some errors in long-term differences because the various combinations of stations have not been adjusted for minimum offset. There is also a jump in position when switching to a new combination of stations. This could be adjusted with more effort, but this adjustment has not been attempted for this data set. These position jumps could have some effect on the velocities computed for the floats. An attempt was made to keep the station suite constant during each XCP survey.

In an attempt to decide which positions were best, the rms error in the positions calculated by the three methods was computed for each day of the cruise. These data are shown in Table 10. The offset between the differential Omega and Transit/dead-reckoned positions is generally 1500–2000 m, rising to 2800 m on several days. For 4–5 September, the difference between the Loran-C positions and those calculated by the other two methods exceeded 2000 m; after that, the Loran-C and differential Omega positions differed by 1000–2000 m. The difference between the Transit fixes and the Loran-C data is about 1000 m rms (Figure 42). It seems that the Loran-C data are the best for 7 September and later. The GPS data would have been very valuable in deciding which of the systems gave the most accurate positions.

The Loran-C data have been used as the primary position data for the whole cruise except for isolated times when there were no Loran-C data; in that case, the differential Omega data were used or, if they were not available, the Transit/dead-reckoned data.

Table 10. Standard deviations of position differences between Loran-C, differential Omega, and Transit/dead reckoning for 4-28 September 1988. Values are in meters.

$x$  = East component;  $y$  = North component;  $sm$  = standard deviation about the mean;  $st$  = total rms error including the mean error, i.e.,  $\sqrt{\text{mean} \times \text{mean} + sm \times sm}$ .

$lc$  = Loran-C;  $om$  = Differential Omega;  $dr$  = Transit/dead reckoning

| date | x sm  | x sm  | x sm  | y sm  | y sm  | y sm  | xy sm | xy sm | xy sm | xy sm | xy st | xy st | xy st |
|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1988 | lc-om | lc-dr | om-dr | lc-om | lc-dr | om-dr | lc-om | lc-dr | om-dr | lc-om | lc-dr | om-dr | om-dr |
| 0904 | 1664  | 2153  | 1258  | 1436  | 1653  | 866   | 2198  | 2715  | 1527  | 2687  | 2803  | 1789  |       |
| 0905 | 2306  | 2404  | 1417  | 1648  | 1590  | 758   | 2834  | 2882  | 1607  | 2853  | 2899  | 1713  |       |
| 0906 | 1503  | 1359  | 1017  | 1318  | 1501  | 946   | 1999  | 2025  | 1389  | 2020  | 2032  | 1465  |       |
| 0907 | 933   | 1008  | 1461  | 760   | 775   | 742   | 1207  | 1272  | 1638  | 1424  | 1280  | 1870  |       |
| 0908 | 1639  | 1088  | 1614  | 617   | 667   | 752   | 1751  | 1276  | 1780  | 1941  | 1418  | 1796  |       |
| 0909 | 2394  | 657   | 2522  | 544   | 963   | 1029  | 2455  | 1165  | 2724  | 2489  | 1202  | 2808  |       |
| 0910 | 1434  | 801   | 1713  | 576   | 836   | 1004  | 1545  | 1158  | 1986  | 1836  | 1241  | 2195  |       |
| 0911 | 630   | 728   | 732   | 332   | 637   | 637   | 712   | 967   | 971   | 949   | 1115  | 1013  |       |
| 0912 | 762   | 899   | 1107  | 322   | 677   | 624   | 828   | 1125  | 1271  | 1029  | 1187  | 1339  |       |
| 0913 | 406   | 1150  | 1187  | 277   | 1010  | 978   | 492   | 1532  | 1538  | 704   | 1674  | 1620  |       |
| 0914 | 8775  | 1237  | 8816  | 668   | 1120  | 1296  | 8800  | 1711  | 8614  | 9403  | 1751  | 9278  |       |
| 0915 | 327   | 1087  | 1211  | 320   | 929   | 1038  | 980   | 1415  | 1595  | 1142  | 1480  | 1604  |       |
| 0916 | 644   | 1258  | 1265  | 260   | 800   | 812   | 695   | 1490  | 1503  | 901   | 1573  | 1514  |       |
| 0917 | 922   | 720   | 1050  | 352   | 748   | 827   | 987   | 1038  | 1337  | 1063  | 1154  | 1435  |       |
| 0918 | 1053  | 1067  | 2444  | 758   | 677   | 961   | 2377  | 1263  | 2626  | 2622  | 1290  | 2854  |       |
| 0919 | 843   | 1092  | 1343  | 321   | 1407  | 1475  | 902   | 1781  | 1995  | 1879  | 1831  | 2841  |       |
| 0920 |       |       |       |       |       |       |       |       |       |       |       |       |       |
| 0921 | 749   | 954   | 1227  | 303   | 540   | 614   | 808   | 1038  | 1372  | 1593  | 1121  | 2047  |       |
| 0922 | 1049  | 1608  | 1563  | 480   | 765   | 792   | 1146  | 1779  | 1752  | 1587  | 1737  | 1843  |       |
| 0923 | 848   | 879   | 1032  | 407   | 756   | 961   | 940   | 1159  | 1425  | 1125  | 1193  | 1400  |       |
| 0924 | 740   | 746   | 898   | 360   | 689   | 759   | 823   | 1016  | 1174  | 1075  | 1038  | 1334  |       |
| 0925 | 872   | 1053  | 1439  | 252   | 811   | 896   | 718   | 1448  | 1557  | 883   | 1476  | 1744  |       |
| 0926 | 498   | 1104  | 1075  | 285   | 717   | 830   | 560   | 1396  | 1354  | 831   | 1447  | 1747  |       |
| 0927 | 1814  | 2189  | 2294  | 373   | 929   | 979   | 1645  | 2374  | 2404  | 2189  | 2489  | 2607  |       |
| 0928 | 1064  | 881   | 1401  | 320   | 378   | 394   | 1111  | 1451  | 1455  | 1875  | 1944  | 2344  |       |

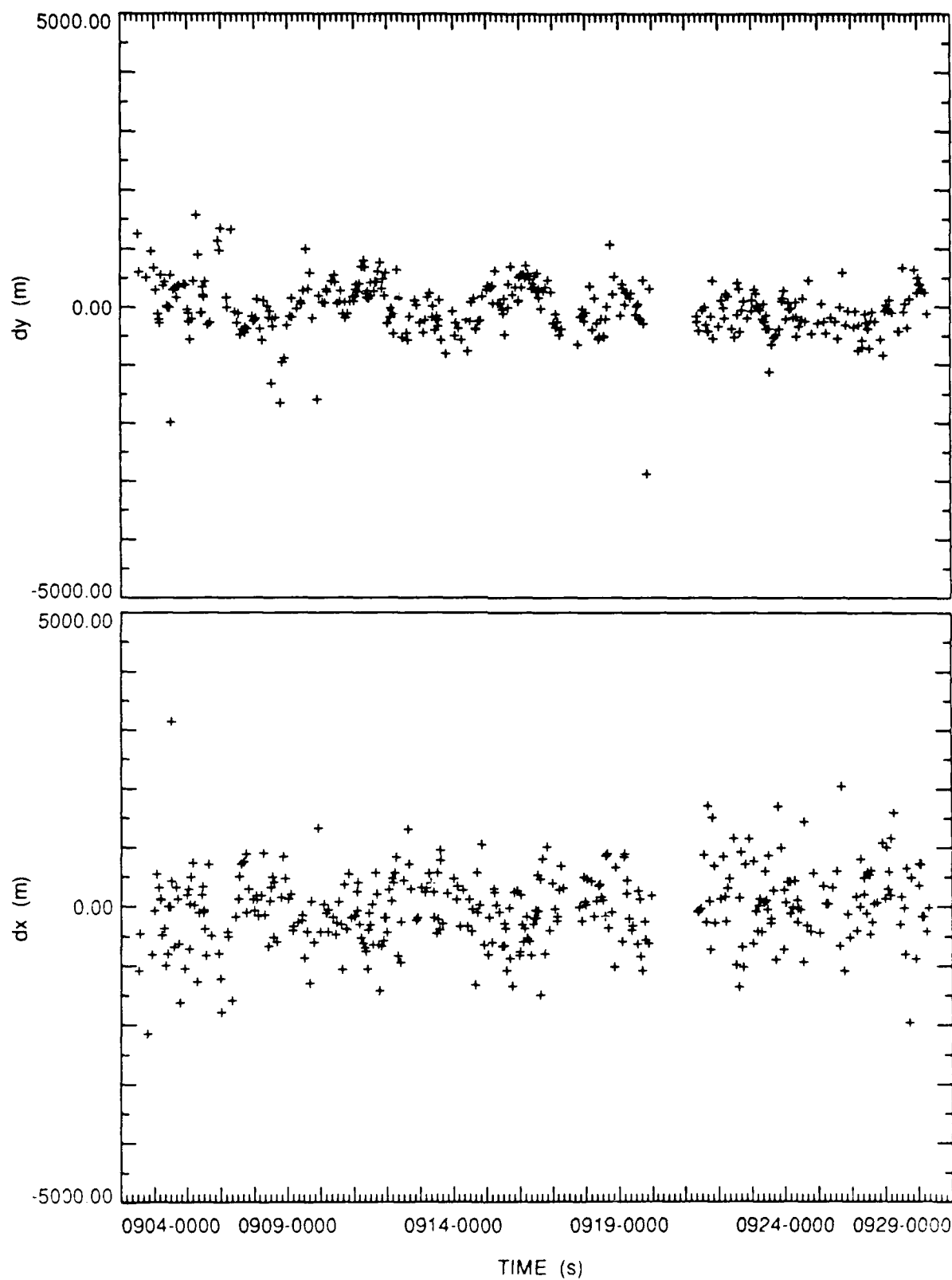


Figure 42. Position difference between transit fixes and Loran-C data.

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## APPENDICES

Note: In these appendices, "Method" refers to the navigation method used to obtain the positions listed. LC denotes Loran-C and OM denotes differential Omega. All times are GMT. All latitudes are in degrees, decimal minutes North, and all longitudes are in degrees, decimal minutes West.

**APPENDIX A**

*Oceanus* Cruise 202

XCP Log

| Drop # | Serial # | Channel # | Date | Time | Latitude | Longitude | Method | Comment |
|--------|----------|-----------|------|------|----------|-----------|--------|---------|
|--------|----------|-----------|------|------|----------|-----------|--------|---------|

Ampere Seamount Survey 1

|      |         |    |          |       |          |          |     |        |
|------|---------|----|----------|-------|----------|----------|-----|--------|
| 2401 | 88031   | 12 | 09/08/88 | 13:59 | 35 03.89 | 12 51.00 | LC* | good   |
| 2402 | 88142   | 14 | 09/08/88 | 14:06 | 35 03.94 | 12 50.61 | LC  | good   |
| 2403 | 871084  | 16 | 09/08/88 | 14:12 | 35 03.98 | 12 50.28 | LC  | good   |
| 2404 | 88215   | 12 | 09/08/88 | 14:17 | 35 03.96 | 12 49.97 | LC  | good   |
| 2405 | 88159   | 14 | 09/08/88 | 14:19 | 35 03.97 | 12 49.84 | LC  | good   |
| 2406 | 8708290 | 16 | 09/08/88 | 14:25 | 35 03.98 | 12 49.52 | LC  | good   |
| 2407 | 88179   | 12 | 09/08/88 | 14:29 | 35 03.98 | 12 49.28 | LC  | good   |
| 2408 | 88153   | 14 | 09/08/88 | 14:34 | 35 04.00 | 12 49.03 | LC  | good   |
| 2409 | 88206   | 16 | 09/08/88 | 14:38 | 35 04.00 | 12 48.79 | LC  | good   |
| 2410 | 88038   | 12 | 09/08/88 | 14:43 | 35 04.00 | 12 48.50 | LC  | Note 1 |
| 2411 | 88141   | 14 | 09/08/88 | 14:47 | 35 04.00 | 12 48.26 | LC  | good   |
| 2412 | 871079  | 16 | 09/08/88 | 15:20 | 35 01.98 | 12 49.15 | LC  | good   |
| 2413 | 8708209 | 12 | 09/08/88 | 15:24 | 35 02.12 | 12 49.18 | LC  | good   |
| 2414 | 871027  | 14 | 09/08/88 | 15:29 | 35 02.33 | 12 49.21 | LC  | good   |
| 2415 | 8708289 | 16 | 09/08/88 | 15:33 | 35 02.52 | 12 49.27 | LC  | good   |
| 2416 | 88196   | 12 | 09/08/88 | 15:37 | 35 02.68 | 12 49.31 | LC  | good   |
| 2417 | 871047  | 14 | 09/08/88 | 15:41 | 35 02.84 | 12 49.34 | LC  | good   |
| 2418 | 87087   | 16 | 09/08/88 | 15:46 | 35 03.05 | 12 49.40 | LC  | good   |
| 2419 | 871044  | 12 | 09/08/88 | 15:49 | 35 03.17 | 12 49.43 | LC  | T bad  |
| 2420 | 871065  | 14 | 09/08/88 | 15:53 | 35 03.32 | 12 49.47 | LC  | good   |
| 2421 | 88187   | 16 | 09/08/88 | 15:58 | 35 03.52 | 12 49.55 | LC  | good   |
| 2422 | 88184   | 10 | 09/08/88 | 16:05 | 35 03.85 | 12 49.65 | LC  | good   |
| 2423 | 8710126 | 14 | 09/08/88 | 16:10 | 35 04.07 | 12 49.72 | LC  | good   |
| 2424 | 871068  | 16 | 09/08/88 | 16:15 | 35 04.31 | 12 49.82 | LC  | good   |
| 2425 | 88171   | 10 | 09/08/88 | 16:22 | 35 04.63 | 12 49.92 | LC  | good   |
| 2426 | 8710135 | 14 | 09/08/88 | 16:27 | 35 04.87 | 12 50.02 | LC  | good   |
| 2427 | 871093  | 16 | 09/08/88 | 16:35 | 35 05.25 | 12 50.15 | LC  | good   |
| 2428 | 88101   | 10 | 09/08/88 | 16:41 | 35 05.60 | 12 50.17 | LC  | good   |

\*Dead-reckoned position based on LC-derived positions for drops 2 and 3.

| Drop # | Serial # | Channel # | Date | Time | Latitude | Longitude | Method | Comment |
|--------|----------|-----------|------|------|----------|-----------|--------|---------|
|--------|----------|-----------|------|------|----------|-----------|--------|---------|

### Ampere Seamount Survey 2

|      |         |    |          |       |          |          |    |              |
|------|---------|----|----------|-------|----------|----------|----|--------------|
| 2429 | 88174   | 10 | 09/09/88 | 14:00 | 35 02.10 | 12 48.60 | LC | good         |
| 2430 | 88150   | 14 | 09/09/88 | 14:05 | 35 02.05 | 12 48.03 | LC | good         |
| 2431 | 8710100 | 16 | 09/09/88 | 14:10 | 35 02.00 | 12 47.52 | LC | bad          |
| 2432 | 88153   | 10 | 09/09/88 | 14:12 | 35 01.98 | 12 47.40 | LC | good         |
| 2433 | 88178   | 14 | 09/09/88 | 14:15 | 35 01.96 | 12 47.27 | LC | good         |
| 2434 | 8708292 | 16 | 09/09/88 | 14:21 | 35 01.91 | 12 46.98 | LC | good         |
| 2435 | 88169   | 10 | 09/09/88 | 14:26 | 35 01.87 | 12 46.72 | LC | good         |
| 2436 | 88207   | 14 | 09/09/88 | 14:31 | 35 01.80 | 12 46.42 | LC | good         |
| 2437 | 871059  | 16 | 09/09/88 | 14:35 | 35 01.78 | 12 46.22 | LC | good         |
| 2438 | 88162   | 10 | 09/09/88 | 14:40 | 35 01.72 | 12 45.94 | LC | good         |
| 2439 | 88194   | 14 | 09/09/88 | 14:45 | 35 01.67 | 12 45.66 | LC | good         |
| 2440 | 871057  | 16 | 09/09/88 | 14:50 | 35 01.63 | 12 45.39 | LC | started late |
| 2441 | 88160   | 10 | 09/09/88 | 14:58 | 35 01.58 | 12 44.81 | LC | good         |
| 2442 | 88211   | 14 | 09/09/88 | 15:03 | 35 01.57 | 12 44.25 | LC | good         |
| 2443 | 8710149 | 16 | 09/09/88 | 15:56 | 34 59.50 | 12 46.53 | LC | T bad        |
| 2444 | 88188   | 12 | 09/09/88 | 16:04 | 35 00.38 | 12 46.62 | LC | good         |
| 2445 | 88209   | 14 | 09/09/88 | 16:08 | 35 00.79 | 12 46.62 | LC | good         |
| 2446 | 8710134 | 16 | 09/09/88 | 16:14 | 35 01.09 | 12 46.68 | LC | bad          |
| 2447 | 88161   | 10 | 09/09/88 | 16:16 | 35 01.23 | 12 46.70 | LC | good         |
| 2448 | 871089  | 14 | 09/09/88 | 16:24 | 35 01.72 | 12 46.79 | LC | good         |
| 2449 | 870825  | 16 | 09/09/88 | 16:27 | 35 01.88 | 12 46.79 | LC | T bad        |
| 2450 | 88177   | 10 | 09/09/88 | 16:30 | 35 02.05 | 12 46.83 | LC | good         |
| 2451 | 8708286 | 14 | 09/09/88 | 16:35 | 35 02.30 | 12 46.79 | LC | good         |
| 2452 | 8708281 | 16 | 09/09/88 | 16:40 | 35 02.56 | 12 46.77 | LC | good         |
| 2453 | 88168   | 10 | 09/09/88 | 16:45 | 35 02.80 | 12 46.73 | LC | good         |
| 2454 | 88208   | 16 | 09/09/88 | 16:54 | 35 03.55 | 12 46.63 | LC | good         |
| 2455 | 88189   | 14 | 09/09/88 | 17:00 | 35 04.20 | 12 46.59 | LC | good         |

| Drop # | Serial # | Channel # | Date | Time | Latitude | Longitude | Method | Comment |
|--------|----------|-----------|------|------|----------|-----------|--------|---------|
|--------|----------|-----------|------|------|----------|-----------|--------|---------|

Cape St. Vincent Region

(line 2)

|      |         |    |          |       |          |         |    |        |
|------|---------|----|----------|-------|----------|---------|----|--------|
| 2456 | 87085   | 12 | 09/11/88 | 09:24 | 36 47.82 | 8 13.71 | LC | good   |
| 2457 | 88205   | 12 | 09/11/88 | 09:43 | 36 44.07 | 8 13.75 | LC | Note 1 |
| 2458 | 870842  | 12 | 09/11/88 | 10:00 | 36 40.70 | 8 13.86 | LC | noisy  |
| 2459 | 88155   | 10 | 09/11/88 | 10:05 | 36 39.70 | 8 13.86 | LC | good   |
| 2460 | 8708170 | 12 | 09/11/88 | 10:30 | 36 35.10 | 8 13.54 | LC | good   |
| 2461 | 8708197 | 12 | 09/11/88 | 10:58 | 36 30.57 | 8 13.01 | LC | Note 2 |
| 2462 | 88039   | 12 | 09/11/88 | 11:32 | 36 23.88 | 8 12.43 | LC | bad    |
| 2463 | 88169A  | 10 | 09/11/88 | 11:32 | 36 23.88 | 8 12.43 | LC | good   |
| 2464 | 871064  | 12 | 09/11/88 | 11:51 | 36 20.08 | 8 12.48 | LC | good   |
| 2465 | 871061  | 12 | 09/11/88 | 12:20 | 36 15.36 | 8 12.88 | LC | good   |

(line 4)

|      |        |    |          |       |          |         |    |        |
|------|--------|----|----------|-------|----------|---------|----|--------|
| 2466 | 871058 | 12 | 09/11/88 | 22:40 | 36 39.40 | 8 38.37 | LC | good   |
| 2467 | 88142  | 10 | 09/12/88 | 00:21 | 36 34.63 | 8 37.70 | LC | good   |
| 2468 | 88165  | 10 | 09/12/88 | 02:05 | 36 30.31 | 8 36.85 | LC | good   |
| 2469 | 88175  | 10 | 09/12/88 | 03:50 | 36 24.95 | 8 37.34 | LC | Note 3 |
| 2470 | 88170A | 10 | 09/12/88 | 05:38 | 36 20.27 | 8 37.80 | LC | good   |
| 2471 | 88161A | 10 | 09/12/88 | 07:48 | 36 15.30 | 8 38.02 | LC | good   |
| 2472 | 88150  | 10 | 09/12/88 | 09:32 | 36 10.96 | 8 38.03 | LC | good   |
| 2473 | 88157  | 10 | 09/12/88 | 11:41 | 36 05.12 | 8 37.54 | LC | good   |
| 2474 | 88163  | 10 | 09/12/88 | 13:33 | 35 59.61 | 8 37.64 | LC | good   |
| 2475 | 88158  | 10 | 09/12/88 | 15:37 | 35 54.60 | 8 37.96 | LC | good   |

(line 5)

|      |       |    |          |       |          |         |    |        |
|------|-------|----|----------|-------|----------|---------|----|--------|
| 2476 | 88176 | 10 | 09/12/88 | 20:07 | 36 36.07 | 8 41.75 | LC | Note 3 |
|------|-------|----|----------|-------|----------|---------|----|--------|

(line 6)

|      |         |    |          |       |          |         |    |      |
|------|---------|----|----------|-------|----------|---------|----|------|
| 2477 | 8708118 | 12 | 09/12/88 | 23:25 | 36 34.63 | 8 50.64 | LC | good |
| 2478 | 871026  | 12 | 09/13/88 | 00:01 | 36 29.70 | 8 49.52 | LC | good |

(line 7)

|      |        |    |          |       |          |         |    |      |
|------|--------|----|----------|-------|----------|---------|----|------|
| 2479 | 870824 | 12 | 09/13/88 | 06:49 | 36 29.77 | 8 55.01 | LC | good |
| 2480 | 88035  | 16 | 09/13/88 | 07:22 | 36 34.51 | 8 54.27 | LC | bad  |

| Drop # | Serial # | Channel # | Date | Time | Latitude | Longitude | Method | Comment |
|--------|----------|-----------|------|------|----------|-----------|--------|---------|
|--------|----------|-----------|------|------|----------|-----------|--------|---------|

(line 8)

|      |         |    |          |       |          |         |    |      |
|------|---------|----|----------|-------|----------|---------|----|------|
| 2481 | 871048  | 16 | 09/13/88 | 11:04 | 36 39.60 | 9 02.56 | LC | good |
| 2482 | 871086  | 14 | 09/13/88 | 12:46 | 36 34.59 | 9 01.51 | LC | good |
| 2483 | 8710173 | 16 | 09/13/88 | 14:37 | 36 29.50 | 9 02.09 | LC | good |
| 2484 | 871088  | 16 | 09/13/88 | 18:36 | 36 15.05 | 9 04.17 | LC | good |
| 2485 | 88036   | 16 | 09/13/88 | 20:27 | 36 09.66 | 9 02.50 | LC | good |

(line 17)

|      |         |    |          |       |          |         |    |      |
|------|---------|----|----------|-------|----------|---------|----|------|
| 2486 | 8710133 | 16 | 09/15/88 | 12:20 | 37 11.01 | 9 16.99 | LC | good |
| 2487 | 8708282 | 16 | 09/15/88 | 15:44 | 37 09.14 | 9 34.49 | LC | good |
| 2488 | 870819  | 16 | 09/15/88 | 17:34 | 37 09.25 | 9 41.09 | LC | good |
| 2489 | 88034   | 16 | 09/15/88 | 20:05 | 37 10.65 | 9 48.16 | LC | good |

Meddy Survey (leg 1)

|      |         |    |          |       |          |         |    |        |
|------|---------|----|----------|-------|----------|---------|----|--------|
| 2490 | 8710122 | 16 | 09/17/88 | 21:07 | 35 55.05 | 9 12.79 | LC | T bad  |
| 2491 | 871050  | 14 | 09/17/88 | 21:31 | 35 57.14 | 9 12.48 | LC | Note 4 |
| 2492 | 871073  | 14 | 09/17/88 | 21:52 | 35 59.00 | 9 12.16 | LC | good   |
| 2493 | 871094  | 14 | 09/17/88 | 22:10 | 36 00.58 | 9 11.82 | LC | good   |
| 2494 | 88125   | 14 | 09/17/88 | 22:32 | 36 02.52 | 9 11.44 | LC | good   |
| 2495 | 88166   | 14 | 09/17/88 | 22:50 | 36 04.11 | 9 11.09 | LC | good   |
| 2496 | 88151A  | 14 | 09/17/88 | 23:08 | 36 05.69 | 9 10.77 | LC | good   |
| 2497 | 88210   | 14 | 09/17/88 | 23:29 | 36 07.45 | 9 10.46 | LC | good   |
| 2498 | 88154   | 14 | 09/17/88 | 23:48 | 36 09.09 | 9 10.60 | LC | good   |
| 2499 | 871049  | 14 | 09/18/88 | 00:08 | 36 10.75 | 9 10.97 | LC | Note 4 |
| 2500 | 88173   | 14 | 09/18/88 | 00:27 | 36 12.34 | 9 11.43 | LC | good   |

Meddy Survey (leg 2)

|      |       |    |          |       |          |         |    |      |
|------|-------|----|----------|-------|----------|---------|----|------|
| 2501 | 88181 | 10 | 09/18/88 | 02:49 | 36 08.71 | 9 05.54 | LC | good |
| 2502 | 88168 | 10 | 09/18/88 | 03:20 | 36 06.71 | 9 07.66 | LC | good |
| 2503 | 88170 | 10 | 09/18/88 | 03:40 | 36 05.75 | 9 09.74 | LC | bad  |
| 2504 | 88145 | 10 | 09/18/88 | 03:42 | 36 05.66 | 9 09.99 | LC | good |
| 2505 | 88130 | 10 | 09/18/88 | 04:03 | 36 04.79 | 9 12.27 | LC | good |
| 2506 | 88183 | 10 | 09/18/88 | 04:23 | 36 03.88 | 9 14.35 | LC | good |
| 2507 | 88163 | 10 | 09/18/88 | 04:44 | 36 02.93 | 9 16.56 | LC | good |
| 2508 | 88108 | 10 | 09/18/88 | 05:34 | 36 01.56 | 9 18.80 | LC | good |
| 2509 | 88165 | 10 | 09/18/88 | 05:54 | 36 00.65 | 9 21.03 | LC | good |
| 2510 | 88157 | 10 | 09/18/88 | 06:16 | 35 59.73 | 9 23.46 | LC | good |

| Drop # | Serial # | Channel # | Date | Time | Latitude | Longitude | Method | Comment |
|--------|----------|-----------|------|------|----------|-----------|--------|---------|
|--------|----------|-----------|------|------|----------|-----------|--------|---------|

Meddy Survey (leg 3)

|      |        |    |          |       |          |         |    |       |
|------|--------|----|----------|-------|----------|---------|----|-------|
| 2511 | 870874 | 12 | 09/18/88 | 07:48 | 36 09.92 | 9 20.43 | LC | good  |
| 2512 | 870884 | 12 | 09/18/88 | 08:08 | 36 08.82 | 9 18.53 | LC | good  |
| 2513 | 870318 | 12 | 09/18/88 | 08:28 | 36 07.78 | 9 16.63 | LC | bad   |
| 2514 | 870322 | 12 | 09/18/88 | 08:30 | 36 07.67 | 9 16.44 | LC | T bad |
| 2515 | 88180  | 12 | 09/18/88 | 08:50 | 36 06.61 | 9 14.63 | LC | good  |
| 2516 | 870320 | 12 | 09/18/88 | 09:10 | 36 05.53 | 9 12.88 | LC | good  |
| 2517 | 870841 | 12 | 09/18/88 | 09:40 | 36 04.04 | 9 10.25 | LC | good  |
| 2518 | 88212  | 12 | 09/18/88 | 10:06 | 36 02.85 | 9 08.05 | LC | good  |
| 2519 | 88169  | 12 | 09/18/88 | 10:30 | 36 01.73 | 9 06.14 | LC | good  |
| 2520 | 870845 | 12 | 09/18/88 | 10:55 | 36 00.67 | 9 04.31 | LC | good  |

| Drop # | Serial # | Channel # | Date | Time | Latitude | Longitude | Method | Comment |
|--------|----------|-----------|------|------|----------|-----------|--------|---------|
|--------|----------|-----------|------|------|----------|-----------|--------|---------|

### Outflow Component

(site 1)

|      |         |    |          |       |          |         |    |      |
|------|---------|----|----------|-------|----------|---------|----|------|
| 2521 | 8710128 | 16 | 09/21/88 | 13:33 | 35 48.46 | 6 12.18 | LC | bad  |
| 2522 | 88202   | 14 | 09/21/88 | 13:58 | 35 49.14 | 6 12.64 | LC | good |

(site 2)

|      |        |    |          |       |          |         |    |      |
|------|--------|----|----------|-------|----------|---------|----|------|
| 2523 | 871096 | 16 | 09/21/88 | 15:45 | 35 51.40 | 6 00.96 | LC | good |
|------|--------|----|----------|-------|----------|---------|----|------|

(site 3)

|      |        |    |          |       |          |         |    |      |
|------|--------|----|----------|-------|----------|---------|----|------|
| 2524 | 871062 | 16 | 09/21/88 | 17:06 | 35 53.18 | 5 52.54 | LC | bad  |
| 2525 | 88143  | 10 | 09/21/88 | 17:10 | 35 53.26 | 5 52.44 | LC | good |

(site 1)

|      |        |    |          |       |          |         |    |      |
|------|--------|----|----------|-------|----------|---------|----|------|
| 2526 | 871082 | 16 | 09/21/88 | 19:30 | 35 48.99 | 6 13.10 | LC | bad  |
| 2527 | 870839 | 12 | 09/21/88 | 19:36 | 35 49.02 | 6 12.94 | LC | good |

(site 4)

|      |         |    |          |       |          |         |    |      |
|------|---------|----|----------|-------|----------|---------|----|------|
| 2528 | 8710132 | 16 | 09/21/88 | 22:22 | 35 46.10 | 6 20.82 | LC | good |
|------|---------|----|----------|-------|----------|---------|----|------|

(site 5)

|      |         |    |          |       |          |         |    |      |
|------|---------|----|----------|-------|----------|---------|----|------|
| 2529 | 8710101 | 16 | 09/22/88 | 02:10 | 35 45.39 | 6 28.57 | LC | good |
|------|---------|----|----------|-------|----------|---------|----|------|

(site 1)

|      |        |    |          |       |          |         |    |      |
|------|--------|----|----------|-------|----------|---------|----|------|
| 2530 | 870403 | 16 | 09/22/88 | 04:41 | 35 48.71 | 6 12.34 | LC | good |
|------|--------|----|----------|-------|----------|---------|----|------|

(site 4)

|      |        |    |          |       |          |         |    |      |
|------|--------|----|----------|-------|----------|---------|----|------|
| 2531 | 871091 | 16 | 09/22/88 | 05:56 | 35 46.04 | 6 20.39 | LC | good |
|------|--------|----|----------|-------|----------|---------|----|------|

(site 5)

|      |         |    |          |       |          |         |    |      |
|------|---------|----|----------|-------|----------|---------|----|------|
| 2532 | 8708127 | 16 | 09/22/88 | 07:40 | 35 45.49 | 6 29.68 | LC | good |
|------|---------|----|----------|-------|----------|---------|----|------|

(site 6)

|      |        |    |          |       |          |         |    |      |
|------|--------|----|----------|-------|----------|---------|----|------|
| 2533 | 870316 | 12 | 09/22/88 | 09:08 | 35 49.74 | 6 37.46 | LC | good |
|------|--------|----|----------|-------|----------|---------|----|------|

| Drop # | Serial # | Channel # | Date | Time | Latitude | Longitude | Method | Comment |
|--------|----------|-----------|------|------|----------|-----------|--------|---------|
|--------|----------|-----------|------|------|----------|-----------|--------|---------|

(site 7)

|      |         |    |          |          |       |         |    |      |
|------|---------|----|----------|----------|-------|---------|----|------|
| 2534 | 8710148 | 14 | 09/22/88 | 10:36 35 | 53.82 | 6 30.43 | LC | good |
|------|---------|----|----------|----------|-------|---------|----|------|

(site 8)

|      |         |    |          |          |       |         |    |      |
|------|---------|----|----------|----------|-------|---------|----|------|
| 2535 | 8708166 | 12 | 09/22/88 | 12:04 35 | 54.44 | 6 24.44 | LC | good |
|------|---------|----|----------|----------|-------|---------|----|------|

(site 9)

|      |         |    |          |          |       |         |    |      |
|------|---------|----|----------|----------|-------|---------|----|------|
| 2536 | 8708126 | 12 | 09/22/88 | 14:18 35 | 45.34 | 6 40.74 | LC | good |
|------|---------|----|----------|----------|-------|---------|----|------|

Section A

|      |        |    |          |          |       |         |    |      |
|------|--------|----|----------|----------|-------|---------|----|------|
| 2537 | 870846 | 12 | 09/22/88 | 17:34 35 | 45.68 | 6 13.47 | LC | good |
| 2538 | 88115  | 12 | 09/22/88 | 18:25 35 | 49.21 | 6 13.77 | LC | good |
| 2539 | 88158  | 14 | 09/22/88 | 19:20 35 | 51.57 | 6 14.42 | LC | good |
| 2540 | 871028 | 12 | 09/22/88 | 20:16 35 | 55.14 | 6 12.53 | LC | good |

Section B

|      |        |    |          |          |       |         |    |      |
|------|--------|----|----------|----------|-------|---------|----|------|
| 2541 | 88170  | 12 | 09/22/88 | 22:58 35 | 48.76 | 6 19.80 | LC | good |
| 2542 | 871085 | 14 | 09/23/88 | 00:05 35 | 45.58 | 6 18.34 | LC | good |
| 2543 | 88195  | 14 | 09/23/88 | 00:56 35 | 42.62 | 6 17.59 | LC | good |

Section C

|      |         |    |          |          |       |         |    |      |
|------|---------|----|----------|----------|-------|---------|----|------|
| 2544 | 870823  | 12 | 09/23/88 | 04:45 35 | 45.04 | 6 29.51 | LC | good |
| 2545 | 870331  | 12 | 09/23/88 | 05:55 35 | 46.49 | 6 29.28 | LC | good |
| 2546 | 8708125 | 12 | 09/23/88 | 06:55 35 | 49.51 | 6 27.00 | LC | good |
| 2547 | 8710129 | 14 | 09/23/88 | 08:12 35 | 51.04 | 6 27.35 | LC | good |
| 2548 | 88156   | 10 | 09/23/88 | 09:18 35 | 54.59 | 6 27.22 | LC | good |

Section D

|      |        |    |          |          |       |         |    |      |
|------|--------|----|----------|----------|-------|---------|----|------|
| 2549 | 88148  | 10 | 09/23/88 | 11:50 35 | 55.65 | 6 28.43 | LC | good |
| 2550 | 88152  | 14 | 09/23/88 | 12:45 35 | 53.47 | 6 29.27 | LC | good |
| 2551 | 88122  | 10 | 09/23/88 | 13:39 35 | 51.72 | 6 32.25 | LC | good |
| 2552 | 88175  | 14 | 09/23/88 | 14:31 35 | 50.22 | 6 34.89 | LC | good |
| 2553 | 871045 | 14 | 09/23/88 | 15:56 35 | 48.67 | 6 37.25 | LC | good |
| 2554 | 88191  | 12 | 09/23/88 | 17:07 35 | 46.65 | 6 39.67 | LC | good |
| 2555 | 88144  | 10 | 09/23/88 | 18:11 35 | 43.45 | 6 41.76 | LC | good |

| Drop # | Serial # | Channel # | Date | Time | Latitude | Longitude | Method | Comment |
|--------|----------|-----------|------|------|----------|-----------|--------|---------|
|--------|----------|-----------|------|------|----------|-----------|--------|---------|

(Station C4)

|      |       |    |          |       |          |         |    |      |
|------|-------|----|----------|-------|----------|---------|----|------|
| 2556 | 88146 | 10 | 09/23/88 | 22:29 | 35 44.64 | 6 29.83 | LC | good |
|------|-------|----|----------|-------|----------|---------|----|------|

Section E

|      |         |    |          |       |          |         |    |              |
|------|---------|----|----------|-------|----------|---------|----|--------------|
| 2557 | 8708280 | 14 | 09/24/88 | 01:43 | 36 01.24 | 6 33.09 | LC | good         |
| 2558 | 88160   | 14 | 09/24/88 | 02:57 | 36 00.41 | 6 37.19 | LC | good         |
| 2559 | 8708293 | 14 | 09/24/88 | 04:06 | 35 59.33 | 6 40.43 | LC | good         |
| 2560 | 88159   | 10 | 09/24/88 | 05:14 | 35 57.60 | 6 43.59 | LC | questionable |
| 2561 | 88216   | 16 | 09/24/88 | 05:21 | 35 57.53 | 6 43.86 | LC | fair         |
| 2562 | 88032   | 16 | 09/24/88 | 06:32 | 35 55.77 | 6 46.26 | LC | good         |
| 2563 | 88193   | 16 | 09/24/88 | 07:47 | 35 54.53 | 6 48.71 | LC | good         |

Section F

|      |        |    |          |       |          |         |    |        |
|------|--------|----|----------|-------|----------|---------|----|--------|
| 2564 | 871081 | 14 | 09/24/88 | 18:01 | 36 18.66 | 6 44.25 | LC | good   |
| 2565 | 88173  | 10 | 09/24/88 | 18:56 | 36 17.78 | 6 46.68 | LC | good   |
| 2566 | 88167  | 10 | 09/24/88 | 20:03 | 36 16.15 | 6 49.13 | LC | good   |
| 2567 | 88141  | 10 | 09/24/88 | 21:03 | 36 14.66 | 6 52.38 | LC | good   |
| 2568 | 88143A | 10 | 09/24/88 | 21:55 | 36 12.46 | 6 54.77 | LC | Note 2 |
| 2569 | 88167  | 10 | 09/24/88 | 23:23 | 36 10.88 | 6 57.91 | LC | good   |
| 2570 | 88118  | 12 | 09/25/88 | 01:08 | 36 09.11 | 7 01.68 | LC | good   |
| 2571 | 870872 | 12 | 09/25/88 | 03:25 | 36 06.42 | 7 07.74 | LC | good   |

Section FE

|      |        |    |          |       |          |         |    |      |
|------|--------|----|----------|-------|----------|---------|----|------|
| 2572 | 871041 | 16 | 09/26/88 | 21:45 | 35 54.63 | 7 05.19 | LC | good |
|------|--------|----|----------|-------|----------|---------|----|------|

(Station C4)

|      |        |    |          |       |          |         |    |      |
|------|--------|----|----------|-------|----------|---------|----|------|
| 2573 | 871095 | 16 | 09/27/88 | 02:09 | 35 45.85 | 6 29.08 | LC | good |
|------|--------|----|----------|-------|----------|---------|----|------|

Section I

|      |        |    |          |       |          |         |    |        |
|------|--------|----|----------|-------|----------|---------|----|--------|
| 2574 | 871037 | 12 | 09/27/88 | 10:24 | 35 59.17 | 5 23.50 | LC | good   |
| 2575 | 871074 | 14 | 09/27/88 | 12:46 | 35 56.25 | 5 35.68 | LC | good   |
| 2576 | 871099 | 14 | 09/27/88 | 14:29 | 35 55.38 | 5 45.16 | LC | fair   |
| 2577 | 88204  | 16 | 09/27/88 | 17:24 | 35 51.21 | 5 59.46 | LC | good   |
| 2578 | 871060 | 16 | 09/27/88 | 19:56 | 35 49.11 | 6 11.34 | LC | Note 1 |

(Station B8)

|      |        |    |          |       |          |         |    |      |
|------|--------|----|----------|-------|----------|---------|----|------|
| 2579 | 871080 | 16 | 09/27/88 | 20:59 | 35 48.82 | 6 20.37 | LC | good |
|------|--------|----|----------|-------|----------|---------|----|------|

| Drop # | Serial # | Channel # | Date | Time | Latitude | Longitude | Method | Comment |
|--------|----------|-----------|------|------|----------|-----------|--------|---------|
|--------|----------|-----------|------|------|----------|-----------|--------|---------|

(Station C4)

|      |        |    |          |       |          |         |    |      |
|------|--------|----|----------|-------|----------|---------|----|------|
| 2580 | 871067 | 16 | 09/27/88 | 21:50 | 35 45.28 | 6 29.19 | LC | good |
|------|--------|----|----------|-------|----------|---------|----|------|

(Station D6)

|      |         |    |          |       |          |         |    |      |
|------|---------|----|----------|-------|----------|---------|----|------|
| 2581 | 8710136 | 16 | 09/27/88 | 22:38 | 35 51.50 | 6 34.95 | LC | good |
|------|---------|----|----------|-------|----------|---------|----|------|

(Extra station)

|      |        |    |          |       |          |         |    |      |
|------|--------|----|----------|-------|----------|---------|----|------|
| 2582 | 870317 | 12 | 09/27/88 | 23:22 | 35 53.18 | 6 44.10 | LC | good |
|------|--------|----|----------|-------|----------|---------|----|------|

(Station E6)

|      |       |    |          |       |          |         |    |      |
|------|-------|----|----------|-------|----------|---------|----|------|
| 2583 | 88197 | 14 | 09/27/88 | 23:56 | 35 54.35 | 6 50.43 | LC | good |
|------|-------|----|----------|-------|----------|---------|----|------|

(Extra station)

|      |       |    |          |       |          |         |    |      |
|------|-------|----|----------|-------|----------|---------|----|------|
| 2584 | 88149 | 10 | 09/28/88 | 00:47 | 36 01.12 | 6 45.91 | LC | good |
|------|-------|----|----------|-------|----------|---------|----|------|

Note 1. Electrodes reversed.

Note 2. Needs to be played back.

Note 3. Wire broke early.

Note 4. 1/2 compass coil area.

**APPENDIX B**

*Oceanus* Cruise 202

XBT Log

| Drop # | Serial # | Type | Date | Time | Latitude | Longitude | Method | Comment |
|--------|----------|------|------|------|----------|-----------|--------|---------|
|--------|----------|------|------|------|----------|-----------|--------|---------|

Test drops

|   |     |          |       |          |          |    |      |
|---|-----|----------|-------|----------|----------|----|------|
| 1 | T-6 | 09/04/88 | 17:52 | 33 07.92 | 16 01.20 | LC | good |
| 2 | T-6 | 09/04/88 | 17:58 | 33 07.96 | 16 01.37 | LC | good |

Ampere Seamount Survey

|    |     |          |       |          |          |    |                |
|----|-----|----------|-------|----------|----------|----|----------------|
| 3  | T-7 | 09/05/88 | 19:00 | 35 15.18 | 12 36.79 | LC | good           |
| 4  | T-7 | 09/05/88 | 19:30 | 35 19.28 | 12 34.94 | LC | good           |
| 5  | T-7 | 09/05/88 | 20:00 | 35 19.44 | 12 42.45 | LC | good           |
| 6  | T-7 | 09/05/88 | 20:27 | 35 19.62 | 12 48.79 | LC | good           |
| 7  | T-7 | 09/05/88 | 20:58 | 35 20.06 | 12 56.17 | LC | good           |
| 8  | T-7 | 09/05/88 | 21:28 | 35 20.29 | 13 03.28 | LC | good           |
| 9  | T-7 | 09/05/88 | 22:02 | 35 20.17 | 13 10.86 | LC | good           |
| 10 | T-7 | 09/05/88 | 22:30 | 35 15.33 | 13 11.41 | LC | good           |
| 11 | T-7 | 09/05/88 | 22:59 | 35 10.42 | 13 12.32 | LC | good           |
| 12 | T-7 | 09/05/88 | 23:29 | 35 04.98 | 13 13.05 | LC | good           |
| 13 | T-7 | 09/06/88 | 00:00 | 34 58.87 | 13 12.91 | LC | good           |
| 14 | T-7 | 09/06/88 | 00:29 | 34 53.40 | 13 11.90 | LC | good           |
| 15 | T-7 | 09/06/88 | 01:04 | 34 47.66 | 13 10.66 | OM | good           |
| 16 | T-7 | 09/06/88 | 01:31 | 34 47.17 | 13 04.28 | LC | good           |
| 17 | T-7 | 09/06/88 | 01:59 | 34 46.15 | 12 56.96 | LC | good           |
| 18 | T-7 | 09/06/88 | 02:29 | 34 46.55 | 12 50.25 | LC | good           |
| 19 | T-7 | 09/06/88 | 03:00 | 34 46.53 | 12 43.22 | LC | good           |
| 20 | T-7 | 09/06/88 | 03:30 | 34 46.57 | 12 36.54 | LC | good           |
| 21 | T-7 | 09/06/88 | 03:59 | 34 48.85 | 12 32.98 | LC | bad below 350m |
| 22 | T-7 | 09/06/88 | 04:10 | 34 50.91 | 12 32.94 | LC | good           |
| 23 | T-7 | 09/06/88 | 04:29 | 34 54.42 | 12 32.68 | LC | good           |
| 24 | T-7 | 09/06/88 | 05:00 | 35 00.18 | 12 32.32 | LC | good           |
| 25 | T-7 | 09/06/88 | 05:30 | 35 05.32 | 12 31.76 | LC | good           |
| 26 | T-7 | 09/06/88 | 06:00 | 35 11.40 | 12 32.60 | LC | good           |
| 27 | T-7 | 09/06/88 | 06:30 | 35 17.30 | 12 33.10 | LC | good           |

Cape St. Vincent Region

(line 1)

|    |     |          |       |          |         |    |                  |
|----|-----|----------|-------|----------|---------|----|------------------|
| 28 | T-5 | 09/11/88 | 02:30 | 36 00.46 | 8 00.22 | LC | hit bottom 1460m |
| 29 | T-5 | 09/11/88 | 03:00 | 36 05.33 | 8 00.74 | LC | good             |
| 30 | T-5 | 09/11/88 | 03:30 | 36 09.99 | 8 00.69 | LC | bad below 175m   |
| 31 | T-5 | 09/11/88 | 03:36 | 36 10.55 | 8 00.74 | LC | hit bottom 1440m |

| Drop #   | Serial # | Type | Date     | Time  | Latitude | Longitude | Method | Comment             |
|----------|----------|------|----------|-------|----------|-----------|--------|---------------------|
| 32       |          | T-5  | 09/11/88 | 03:59 | 36 14.14 | 8 00.75   | LC     | hit bottom 1350m    |
| 33       |          | T-5  | 09/11/88 | 04:29 | 36 19.06 | 8 00.80   | LC     | hit bottom 1250m    |
| 34       |          | T-5  | 09/11/88 | 05:02 | 36 24.26 | 8 00.54   | LC     | hit bottom 1150m    |
| 35       |          | T-5  | 09/11/88 | 05:29 | 36 28.49 | 8 00.17   | LC     | hit bottom 795m     |
| 36       |          | T-5  | 09/11/88 | 05:59 | 36 33.72 | 7 59.94   | LC     | hit bottom 775m     |
| 37       |          | T-7  | 09/11/88 | 06:29 | 36 39.02 | 7 59.86   | LC     | good                |
| 38       |          | T-7  | 09/11/88 | 06:59 | 36 44.33 | 7 59.98   | LC     | hit bottom 700m     |
| 39       |          | T-6  | 09/11/88 | 07:29 | 36 49.58 | 8 00.10   | LC     | hit bottom 400m     |
| 40       |          | T-6  | 09/11/88 | 07:59 | 36 55.39 | 8 00.96   | LC     | hit bottom 80m      |
| (line 2) |          |      |          |       |          |           |        |                     |
| 41       |          | T-6  | 09/11/88 | 08:46 | 36 55.80 | 8 13.01   | LC     | hit bottom at 50m   |
| 42       |          | T-7  | 09/11/88 | 09:53 | 36 42.08 | 8 13.85   | LC     | hit bottom at 690m  |
| 43       |          | T-5  | 09/11/88 | 10:17 | 36 37.25 | 8 13.79   | LC     | hit bottom at 840m  |
| 44       |          | T-5  | 09/11/88 | 10:42 | 36 33.00 | 8 13.26   | LC     | hit bottom at 1110m |
| 45       |          | T-5  | 09/11/88 | 11:11 | 36 28.00 | 8 12.68   | LC     | needs playback      |
| 46       |          | T-5  | 09/11/88 | 11:29 | 36 24.47 | 8 12.38   | LC     | hit bottom 1150m    |
| 47       |          | T-5  | 09/11/88 | 12:03 | 36 17.97 | 8 12.62   | LC     | good                |
| 48       |          | T-5  | 09/11/88 | 12:41 | 36 11.19 | 8 13.44   | LC     | wire broke 1125m    |
| 49       |          | T-5  | 09/11/88 | 12:47 | 36 10.02 | 8 13.47   | LC     | wire broke 1125m    |
| 50       |          | T-5  | 09/11/88 | 13:05 | 36 06.63 | 8 12.69   | LC     | noisy               |
| 51       |          | T-5  | 09/11/88 | 13:11 | 36 06.11 | 8 12.58   | LC     | good                |
| 52       |          | T-5  | 09/11/88 | 13:30 | 36 03.02 | 8 12.74   | LC     | ? below 1100m       |
| (line 3) |          |      |          |       |          |           |        |                     |
| 53       |          | T-5  | 09/11/88 | 14:29 | 36 00.20 | 8 25.09   | LC     | no file created     |
| 54       |          | T-5  | 09/11/88 | 14:33 | 36 00.61 | 8 25.08   | LC     | bad                 |
| 55       |          | T-5  | 09/11/88 | 15:04 | 36 05.87 | 8 24.89   | LC     | needs playback      |
| 56       |          | T-5  | 09/11/88 | 15:35 | 36 11.05 | 8 24.73   | LC     | bad                 |
| 57       |          | T-5  | 09/11/88 | 15:42 | 36 11.72 | 8 24.74   | LC     | bad                 |
| 58       |          | T-5  | 09/11/88 | 16:17 | 36 16.47 | 8 24.62   | LC     | hit bottom 1590m    |
| 59       |          | T-5  | 09/11/88 | 16:52 | 36 21.94 | 8 24.35   | LC     | bad                 |
| 60       |          | T-7  | 09/11/88 | 16:59 | 36 22.68 | 8 24.28   | LC     | good                |
| 61       |          | T-5  | 09/11/88 | 17:24 | 36 27.20 | 8 24.02   | LC     | hit bottom 1440m    |
| 62       |          | T-5  | 09/11/88 | 18:00 | 36 34.06 | 8 23.71   | LC     | hit bottom 1300m    |
| 63       |          | T-7  | 09/11/88 | 18:34 | 36 40.42 | 8 24.19   | LC     | hit bottom at 730m  |
| 64       |          | T-7  | 09/11/88 | 18:58 | 36 44.53 | 8 25.66   | LC     | good                |
| 65       |          | T-6  | 09/11/88 | 19:20 | 36 48.36 | 8 26.41   | LC     | hit bottom at 310m  |

| Drop # | Serial # | Type | Date | Time | Latitude | Longitude | Method | Comment |
|--------|----------|------|------|------|----------|-----------|--------|---------|
|--------|----------|------|------|------|----------|-----------|--------|---------|

(line 4)

|    |  |     |          |          |       |         |    |                    |
|----|--|-----|----------|----------|-------|---------|----|--------------------|
| 66 |  | T-6 | 09/11/88 | 20:13 36 | 50.32 | 8 36.96 | LC | hit bottom at 250m |
| 67 |  | T-5 | 09/12/88 | 11:32 36 | 05.78 | 8 37.61 | LC | bad                |
| 68 |  | T-5 | 09/12/88 | 11:35 36 | 05.57 | 8 37.62 | LC | bad below 300m     |
| 69 |  | T-5 | 09/12/88 | 13:30 35 | 59.86 | 8 37.57 | LC | good               |
| 70 |  | T-5 | 09/12/88 | 15:35 35 | 54.57 | 8 37.69 | LC | good               |

(line 5)

|    |  |     |          |          |       |         |    |                  |
|----|--|-----|----------|----------|-------|---------|----|------------------|
| 71 |  | T-5 | 09/12/88 | 16:02 35 | 55.07 | 8 42.29 | LC | good             |
| 72 |  | T-5 | 09/12/88 | 16:36 36 | 00.51 | 8 41.49 | LC | good             |
| 73 |  | T-5 | 09/12/88 | 17:04 36 | 05.35 | 8 41.25 | LC | good             |
| 74 |  | T-5 | 09/12/88 | 17:31 36 | 10.13 | 8 41.51 | LC | good             |
| 75 |  | T-5 | 09/12/88 | 18:03 36 | 16.10 | 8 41.96 | LC | good             |
| 76 |  | T-5 | 09/12/88 | 18:31 36 | 21.07 | 8 42.05 | LC | good             |
| 77 |  | T-5 | 09/12/88 | 18:56 36 | 25.33 | 8 42.01 | LC | T jump at 250m   |
| 78 |  | T-5 | 09/12/88 | 19:27 36 | 30.46 | 8 41.72 | LC | hit bottom 1290m |
| 79 |  | T-5 | 09/12/88 | 19:32 36 | 30.93 | 8 41.67 | LC | hit bottom 1260m |
| 80 |  | T-5 | 09/12/88 | 20:00 36 | 35.20 | 8 41.72 | LC | hit bottom 1020m |
| 81 |  | T-7 | 09/12/88 | 20:26 36 | 39.73 | 8 42.51 | LC | bad below 470m   |
| 82 |  | T-7 | 09/12/88 | 21:06 36 | 45.58 | 8 44.22 | LC | hit bottom 650m  |

(line 6)

|    |  |     |          |          |       |         |    |                  |
|----|--|-----|----------|----------|-------|---------|----|------------------|
| 83 |  | T-7 | 09/12/88 | 22:17 36 | 45.04 | 8 50.58 | LC | bad              |
| 84 |  | T-7 | 09/12/88 | 22:19 36 | 44.82 | 8 50.66 | LC | hit bottom 650m  |
| 85 |  | T-5 | 09/12/88 | 22:49 36 | 40.50 | 8 51.08 | LC | hit bottom 740m  |
| 86 |  | T-5 | 09/12/88 | 23:25 36 | 34.63 | 8 50.64 | LC | hit bottom 1200m |
| 87 |  | T-5 | 09/12/88 | 23:52 36 | 30.55 | 8 49.79 | LC | bad              |
| 88 |  | T-5 | 09/12/88 | 23:56 36 | 30.20 | 8 49.70 | LC | good             |
| 89 |  | T-5 | 09/13/88 | 00:24 36 | 25.79 | 8 48.86 | LC | good             |
| 90 |  | T-5 | 09/13/88 | 01:02 36 | 20.07 | 8 48.04 | LC | good             |
| 91 |  | T-5 | 09/13/88 | 01:33 36 | 14.90 | 8 48.95 | LC | good             |
| 92 |  | T-5 | 09/13/88 | 02:06 36 | 09.60 | 8 49.85 | LC | good             |
| 93 |  | T-5 | 09/13/88 | 02:38 36 | 04.44 | 8 50.42 | LC | good             |
| 94 |  | T-5 | 09/13/88 | 03:08 35 | 59.56 | 8 49.74 | LC | good             |

| Drop # | Serial # | Type | Date | Time | Latitude | Longitude | Method | Comment |
|--------|----------|------|------|------|----------|-----------|--------|---------|
|--------|----------|------|------|------|----------|-----------|--------|---------|

(line 7)

|     |  |     |          |       |          |         |    |                    |
|-----|--|-----|----------|-------|----------|---------|----|--------------------|
| 95  |  | T-5 | 09/13/88 | 03:43 | 36 00.11 | 8 55.78 | LC | good               |
| 96  |  | T-5 | 09/13/88 | 04:13 | 36 04.89 | 8 55.76 | LC | good               |
| 97  |  | T-5 | 09/13/88 | 04:43 | 36 09.65 | 8 55.84 | LC | good               |
| 98  |  | T-5 | 09/13/88 | 05:15 | 36 14.86 | 8 55.96 | LC | good               |
| 99  |  | T-5 | 09/13/88 | 05:45 | 36 19.77 | 8 55.89 | LC | good               |
| 100 |  | T-5 | 09/13/88 | 06:17 | 36 25.02 | 8 55.62 | LC | good               |
| 101 |  | T-5 | 09/13/88 | 06:47 | 36 29.61 | 8 55.07 | LC | good               |
| 102 |  | T-5 | 09/13/88 | 07:18 | 36 34.21 | 8 54.37 | LC | needs playback     |
| 103 |  | T-5 | 09/13/88 | 08:12 | 36 39.64 | 8 54.79 | LC | hit bottom at 750m |
| 104 |  | T-7 | 09/13/88 | 08:42 | 36 45.03 | 8 55.97 | LC | hit bottom at 675m |

(line 8)

|     |        |     |          |       |          |         |    |                 |
|-----|--------|-----|----------|-------|----------|---------|----|-----------------|
| 105 |        | T-5 | 09/13/88 | 12:54 | 36 33.78 | 9 01.30 | LC | bad below 1500m |
| 106 | 178742 | T-5 | 09/13/88 | 16:17 | 36 24.64 | 9 02.51 | LC | good            |
| 107 | 200982 | T-5 | 09/13/88 | 16:53 | 36 19.81 | 9 02.93 | LC | good            |
| 108 | 200981 | T-5 | 09/13/88 | 21:03 | 36 02.81 | 9 01.14 | LC | good            |

(lines 9 thru 12)

|     |        |     |          |       |          |         |    |      |
|-----|--------|-----|----------|-------|----------|---------|----|------|
| 109 | 200980 | T-5 | 09/13/88 | 23:25 | 35 59.96 | 9 08.69 | LC | good |
| 110 | 200985 | T-5 | 09/14/88 | 00:24 | 36 09.87 | 9 09.23 | LC | good |
| 111 | 200984 | T-5 | 09/14/88 | 00:59 | 36 09.91 | 9 16.73 | LC | good |
| 112 | 200983 | T-5 | 09/14/88 | 01:29 | 36 10.28 | 9 23.24 | LC | good |
| 113 | 200986 | T-5 | 09/14/88 | 02:00 | 36 10.66 | 9 29.88 | LC | good |
| 114 | 200988 | T-5 | 09/14/88 | 02:29 | 36 10.13 | 9 36.05 | LC | good |
| 115 | 200987 | T-5 | 09/14/88 | 02:53 | 36 09.92 | 9 40.31 | LC | good |
| 116 | 200846 | T-5 | 09/14/88 | 03:38 | 36 14.97 | 9 45.59 | LC | good |
| 117 | 200847 | T-5 | 09/14/88 | 04:24 | 36 20.51 | 9 51.53 | LC | good |
| 118 | 200845 | T-5 | 09/14/88 | 04:56 | 36 20.22 | 9 44.81 | LC | good |
| 119 | 200848 | T-5 | 09/14/88 | 05:30 | 36 19.91 | 9 37.69 | LC | good |
| 120 | 200843 | T-5 | 09/14/88 | 05:59 | 36 19.61 | 9 31.71 | LC | good |
| 121 | 200850 | T-5 | 09/14/88 | 06:29 | 36 19.29 | 9 25.42 | LC | good |
| 122 | 200859 | T-5 | 09/14/88 | 06:59 | 36 18.69 | 9 19.08 | LC | good |
| 123 | 200842 | T-5 | 09/14/88 | 07:29 | 36 19.28 | 9 13.07 | LC | good |
| 124 | 200851 | T-5 | 09/14/88 | 08:00 | 36 21.06 | 9 08.07 | LC | good |

| Drop #    | Serial # | Type | Date     | Time  | Latitude | Longitude | Method | Comment         |
|-----------|----------|------|----------|-------|----------|-----------|--------|-----------------|
| (line 13) |          |      |          |       |          |           |        |                 |
| 125       | 200854   | T-5  | 09/14/88 | 09:06 | 36 31.05 | 9 08.63   | LC     | good            |
| 126       | 200855   | T-5  | 09/14/88 | 09:45 | 36 30.83 | 9 14.82   | LC     | bad below 1600m |
| 127       | 200856   | T-5  | 09/14/88 | 10:15 | 36 30.65 | 9 20.34   | LC     | good            |
| 128       | 200889   | T-5  | 09/14/88 | 10:23 | 36 30.58 | 9 21.23   | LC     | T offset        |
| 129       | 200890   | T-5  | 09/14/88 | 10:51 | 36 30.46 | 9 26.68   | LC     | good            |
| 130       | 200891   | T-5  | 09/14/88 | 11:21 | 36 30.38 | 9 32.69   | LC     | good            |
| 131       | 200892   | T-5  | 09/14/88 | 11:56 | 36 30.26 | 9 39.61   | LC     | good            |
| 132       | 200881   | T-5  | 09/14/88 | 12:33 | 36 30.22 | 9 47.16   | LC     | good            |
| 133       | 200882   | T-5  | 09/14/88 | 13:00 | 36 30.35 | 9 52.31   | LC     | good            |
| 134       | 200883   | T-5  | 09/14/88 | 13:31 | 36 30.47 | 9 58.33   | LC     | good            |
| 135       | 200884   | T-5  | 09/14/88 | 14:02 | 36 30.48 | 10 04.45  | LC     | good            |
| 136       | 200885   | T-5  | 09/14/88 | 14:38 | 36 30.71 | 10 10.84  | LC     | good            |

|           |        |     |          |       |          |          |    |                  |
|-----------|--------|-----|----------|-------|----------|----------|----|------------------|
| (line 14) |        |     |          |       |          |          |    |                  |
| 137       | 200886 | T-5 | 09/14/88 | 15:43 | 36 40.78 | 10 09.73 | LC | good             |
| 138       | 200887 | T-5 | 09/14/88 | 16:02 | 36 40.55 | 10 05.98 | LC | good             |
| 139       | 200888 | T-5 | 09/14/88 | 16:30 | 36 40.37 | 10 00.31 | LC | good             |
| 140       | 200913 | T-5 | 09/14/88 | 16:58 | 36 39.46 | 9 54.49  | LC | good             |
| 141       |        | T-5 | 09/14/88 | 17:44 | 36 39.16 | 9 44.49  | LC | bad              |
| 142       | 200914 | T-5 | 09/14/88 | 17:45 | 36 39.16 | 9 44.38  | LC | T offset         |
| 143       | 200915 | T-5 | 09/14/88 | 18:21 | 36 39.51 | 9 38.90  | LC | good             |
| 144       | 200916 | T-5 | 09/14/88 | 18:47 | 36 39.26 | 9 33.09  | LC | good             |
| 145       | 200905 | T-5 | 09/14/88 | 19:18 | 36 39.03 | 9 26.71  | LC | good             |
| 146       | 200912 | T-5 | 09/14/88 | 19:47 | 36 38.66 | 9 20.40  | LC | hit botoom 1500m |
| 147       | 200911 | T-5 | 09/14/88 | 20:19 | 36 38.27 | 9 14.89  | LC | hit botoom 1600m |
| 148       | 200910 | T-5 | 09/14/88 | 21:01 | 36 40.31 | 9 06.74  | LC | hit bottom 1000m |

|           |        |     |          |       |          |         |    |                  |
|-----------|--------|-----|----------|-------|----------|---------|----|------------------|
| (line 15) |        |     |          |       |          |         |    |                  |
| 149       | 200906 | T-5 | 09/14/88 | 22:01 | 36 49.92 | 9 07.97 | LC | hit bottom 600m  |
| 150       | 640596 | T-7 | 09/14/88 | 22:42 | 36 49.29 | 9 16.43 | LC | bad              |
| 151       | 640591 | T-7 | 09/14/88 | 22:46 | 36 49.25 | 9 16.91 | LC | good             |
| 152       | 200907 | T-5 | 09/14/88 | 23:16 | 36 49.16 | 9 22.99 | LC | hit bottom 850m  |
| 153       | 200908 | T-5 | 09/14/88 | 23:43 | 36 49.31 | 9 28.51 | LC | hit bottom 1275m |
| 154       | 200909 | T-5 | 09/15/88 | 00:15 | 36 49.80 | 9 34.87 | LC | good             |
| 155       | 200413 | T-5 | 09/15/88 | 00:50 | 36 50.33 | 9 41.65 | LC | good             |
| 156       | 200414 | T-5 | 09/15/88 | 01:19 | 36 50.77 | 9 47.27 | LC | good             |
| 157       | 200415 | T-5 | 09/15/88 | 01:49 | 36 50.91 | 9 53.37 | LC | good             |

| Drop # | Serial # | Type | Date | Time | Latitude | Longitude | Method | Comment |
|--------|----------|------|------|------|----------|-----------|--------|---------|
|--------|----------|------|------|------|----------|-----------|--------|---------|

(line 15), cont.

|     |        |     |          |       |          |          |    |      |
|-----|--------|-----|----------|-------|----------|----------|----|------|
| 158 | 200416 | T-5 | 09/15/88 | 02:23 | 36 50.73 | 10 00.08 | LC | good |
| 159 | 200417 | T-5 | 09/15/88 | 02:49 | 36 50.50 | 10 05.15 | LC | good |
| 160 | 200418 | T-5 | 09/15/88 | 03:22 | 36 50.61 | 10 11.18 | LC | good |

(line 16)

|     |        |     |          |       |          |          |    |                  |
|-----|--------|-----|----------|-------|----------|----------|----|------------------|
| 161 | 200419 | T-5 | 09/15/88 | 04:23 | 37 00.42 | 10 11.22 | LC | good             |
| 162 | 200420 | T-5 | 09/15/88 | 04:50 | 37 00.30 | 10 06.13 | LC | good             |
| 163 | 200421 | T-5 | 09/15/88 | 05:17 | 37 00.34 | 10 00.91 | LC | good             |
| 164 | 200422 | T-5 | 09/15/88 | 06:00 | 37 00.38 | 9 52.16  | LC | bad below 150m   |
| 165 | 200423 | T-5 | 09/15/88 | 06:04 | 37 00.37 | 9 51.65  | LC | good             |
| 166 | 200424 | T-5 | 09/15/88 | 06:32 | 37 00.21 | 9 45.89  | LC | T offset         |
| 167 | 200857 | T-5 | 09/15/88 | 06:59 | 37 00.02 | 9 40.36  | LC | good             |
| 168 | 200858 | T-5 | 09/15/88 | 07:29 | 36 59.85 | 9 33.92  | LC | hit bottom 1525m |
| 169 | 200859 | T-5 | 09/15/88 | 08:01 | 36 59.83 | 9 26.78  | LC | hit bottom 1525m |
| 170 | 200860 | T-5 | 09/15/88 | 08:29 | 36 59.77 | 9 20.41  | LC | good             |
| 171 | 200861 | T-5 | 09/15/88 | 09:03 | 36 59.63 | 9 13.96  | LC | hit bottom 1000m |
| 172 | 640590 | T-7 | 09/15/88 | 09:27 | 37 00.17 | 9 09.19  | LC | hit bottom 600m  |

(line 17)

|     |        |     |          |       |          |         |    |                  |
|-----|--------|-----|----------|-------|----------|---------|----|------------------|
| 173 | 200863 | T-5 | 09/15/88 | 13:53 | 37 10.37 | 9 27.17 | LC | hit bottom 1270m |
| 174 | 200862 | T-5 | 09/15/88 | 21:22 | 37 14.42 | 9 51.45 | LC | hit bottom 1550m |

(line 18)

|     |        |     |          |       |          |          |    |                 |
|-----|--------|-----|----------|-------|----------|----------|----|-----------------|
| 175 | 200864 | T-5 | 09/16/88 | 10:17 | 37 13.68 | 10 27.94 | LC | good            |
| 176 | 200866 | T-5 | 09/16/88 | 10:50 | 37 18.56 | 10 25.32 | LC | good            |
| 177 | 200868 | T-5 | 09/16/88 | 11:22 | 37 22.97 | 10 22.92 | LC | good            |
| 178 | 200867 | T-5 | 09/16/88 | 11:51 | 37 26.99 | 10 20.75 | LC | good            |
| 179 | 200865 | T-5 | 09/16/88 | 12:23 | 37 31.71 | 10 18.87 | LC | bad below 1250m |
| 180 | 200869 | T-5 | 09/16/88 | 12:55 | 37 36.85 | 10 17.43 | LC | bad below 1350m |
| 181 | 200871 | T-5 | 09/16/88 | 13:16 | 37 40.29 | 10 16.69 | LC | good            |
| 182 | 200872 | T-5 | 09/16/88 | 13:53 | 37 46.15 | 10 14.99 | LC | bad             |
| 183 | 200873 | T-5 | 09/16/88 | 13:57 | 37 46.51 | 10 14.91 | LC | bad             |

| Drop # | Serial # | Type | Date | Time | Latitude | Longitude | Method | Comment |
|--------|----------|------|------|------|----------|-----------|--------|---------|
|--------|----------|------|------|------|----------|-----------|--------|---------|

(line 19)

|     |        |     |          |       |          |         |    |      |
|-----|--------|-----|----------|-------|----------|---------|----|------|
| 184 | 640592 | T-7 | 09/16/88 | 21:19 | 37 51.68 | 9 29.11 | LC | good |
|-----|--------|-----|----------|-------|----------|---------|----|------|

To Meddy and initial search

|     |        |     |          |       |          |         |    |                 |
|-----|--------|-----|----------|-------|----------|---------|----|-----------------|
| 185 | 200876 | T-5 | 09/17/88 | 04:13 | 36 39.84 | 9 19.84 | LC | bad below 1300m |
| 186 | 178744 | T-5 | 09/17/88 | 05:08 | 36 30.37 | 9 18.31 | LC | good            |
| 187 | 200875 | T-5 | 09/17/88 | 06:03 | 36 20.93 | 9 14.81 | LC | good            |
| 188 | 200877 | T-5 | 09/17/88 | 06:39 | 36 16.04 | 9 11.03 | LC | good            |
| 189 | 200878 | T-5 | 09/17/88 | 07:09 | 36 12.77 | 9 06.71 | LC | good            |
| 190 | 200879 | T-5 | 09/17/88 | 07:41 | 36 09.29 | 9 02.14 | LC | good            |
| 191 | 200880 | T-5 | 09/17/88 | 08:09 | 36 09.70 | 9 06.71 | LC | good            |
| 192 | 200893 | T-5 | 09/17/88 | 08:42 | 36 10.62 | 9 13.20 | LC | good            |
| 193 | 200894 | T-5 | 09/17/88 | 09:25 | 36 05.29 | 9 13.82 | LC | good            |
| 194 | 200895 | T-5 | 09/17/88 | 09:57 | 36 00.54 | 9 14.72 | LC | good            |
| 195 | 200896 | T-5 | 09/17/88 | 10:34 | 36 00.09 | 9 09.21 | LC | good            |
| 196 | 200897 | T-5 | 09/17/88 | 11:15 | 35 59.51 | 9 02.02 | LC | good            |
| 197 | 200901 | T-5 | 09/17/88 | 11:56 | 36 04.59 | 9 01.86 | LC | good            |
| 198 | 200902 | T-5 | 09/17/88 | 12:37 | 36 05.58 | 9 08.82 | LC | good            |
| 199 | 200903 | T-5 | 09/17/88 | 13:35 | 36 04.53 | 9 20.42 | LC | good            |
| 200 | 200898 | T-5 | 09/17/88 | 16:59 | 36 04.37 | 9 10.70 | LC | good            |

Meddy Survey (leg 1)

|     |        |     |          |       |          |         |    |      |
|-----|--------|-----|----------|-------|----------|---------|----|------|
| 201 | 200904 | T-5 | 09/17/88 | 21:33 | 35 57.30 | 9 12.46 | LC | good |
| 202 | 200900 | T-5 | 09/17/88 | 21:52 | 35 59.00 | 9 12.16 | LC | good |
| 203 | 200899 | T-5 | 09/17/88 | 22:11 | 36 00.68 | 9 11.79 | LC | good |
| 204 | 201003 | T-5 | 09/17/88 | 22:32 | 36 02.52 | 9 11.44 | LC | good |
| 205 | 201002 | T-5 | 09/17/88 | 22:52 | 36 04.26 | 9 11.04 | LC | bad  |
| 206 | 201009 | T-5 | 09/17/88 | 23:10 | 36 05.85 | 9 10.75 | LC | good |
| 207 | 201006 | T-5 | 09/17/88 | 23:31 | 36 07.60 | 9 10.42 | LC | bad  |
| 208 | 201005 | T-5 | 09/17/88 | 23:49 | 36 09.18 | 9 10.63 | LC | good |
| 209 | 201001 | T-5 | 09/18/88 | 00:10 | 36 10.93 | 9 11.01 | LC | bad  |
| 210 | 201004 | T-5 | 09/18/88 | 00:30 | 36 12.58 | 9 11.52 | LC | good |

| Drop # | Serial # | Type | Date | Time | Latitude | Longitude | Method | Comment |
|--------|----------|------|------|------|----------|-----------|--------|---------|
|--------|----------|------|------|------|----------|-----------|--------|---------|

Meddy Survey (leg 2)

|     |        |     |          |       |          |         |    |       |
|-----|--------|-----|----------|-------|----------|---------|----|-------|
| 211 | 201007 | T-5 | 09/18/88 | 02:52 | 36 08.61 | 9 05.86 | LC | good  |
| 212 | 201008 | T-5 | 09/18/88 | 03:22 | 36 06.61 | 9 07.86 | LC | good  |
| 213 | 201010 | T-5 | 09/18/88 | 03:44 | 36 05.59 | 9 10.23 | LC | good  |
| 214 | 201011 | T-5 | 09/18/88 | 04:04 | 36 04.71 | 9 12.34 | LC | bad   |
| 215 | 201012 | T-5 | 09/18/88 | 04:08 | 36 04.53 | 9 12.75 | LC | bad   |
| 216 | 200821 | T-5 | 09/18/88 | 04:25 | 36 03.81 | 9 14.57 | LC | good  |
| 217 | 178745 | T-5 | 09/18/88 | 04:46 | 36 02.83 | 9 16.76 | LC | good  |
| 218 | 200823 | T-5 | 09/18/88 | 05:35 | 36 01.54 | 9 18.91 | LC | good  |
| 219 | 200824 | T-5 | 09/18/88 | 05:56 | 36 00.58 | 9 21.24 | LC | good  |
| 220 | 200825 | T-5 | 09/18/88 | 06:18 | 35 59.63 | 9 23.68 | LC | noisy |

Meddy Survey (leg 3)

|     |        |     |          |       |          |         |    |                |
|-----|--------|-----|----------|-------|----------|---------|----|----------------|
| 221 | 200826 | T-5 | 09/18/88 | 07:50 | 36 09.80 | 9 20.24 | LC | good           |
| 222 | 200827 | T-5 | 09/18/88 | 08:09 | 36 08.77 | 9 18.45 | LC | good           |
| 223 | 200828 | T-5 | 09/18/88 | 08:32 | 36 07.57 | 9 16.25 | LC | good           |
| 224 | 200829 | T-5 | 09/18/88 | 08:53 | 36 06.44 | 9 14.35 | LC | good           |
| 225 | 200830 | T-5 | 09/18/88 | 09:12 | 36 05.42 | 9 12.71 | LC | good           |
| 226 | 200831 | T-5 | 09/18/88 | 09:43 | 36 03.90 | 9 09.97 | LC | bad below 300m |
| 227 | 200832 | T-5 | 09/18/88 | 10:08 | 36 02.74 | 9 07.88 | LC | bad below 400m |
| 228 | 201013 | T-5 | 09/18/88 | 10:31 | 36 01.69 | 9 06.06 | LC | good           |
| 229 | 201014 | T-5 | 09/18/88 | 10:57 | 36 00.58 | 9 04.16 | LC | good           |

**APPENDIX C**

*Oceanus* Cruise 202

XSV Log

| Drop # | Serial # | Type | Date | Time | Latitude | Longitude | Method | Comment |
|--------|----------|------|------|------|----------|-----------|--------|---------|
|--------|----------|------|------|------|----------|-----------|--------|---------|

Cape St. Vincent Region

(line 2)

|   |  |        |          |       |          |         |    |        |
|---|--|--------|----------|-------|----------|---------|----|--------|
| 1 |  | XSV-02 | 09/11/88 | 10:42 | 36 33.00 | 8 13.26 | LC | failed |
| 2 |  | XSV-02 | 09/11/88 | 11:11 | 36 28.00 | 8 12.68 | LC | failed |
| 3 |  | XSV-02 | 09/11/88 | 11:29 | 36 24.47 | 8 12.38 | LC | failed |

(line 3)

|   |  |        |          |       |          |         |    |        |
|---|--|--------|----------|-------|----------|---------|----|--------|
| 4 |  | XSV-02 | 09/11/88 | 15:35 | 36 11.05 | 8 24.73 | LC | failed |
| 5 |  | XSV-02 | 09/11/88 | 16:17 | 36 16.47 | 8 24.62 | LC | good   |
| 6 |  | XSV-02 | 09/11/88 | 16:52 | 36 21.94 | 8 24.35 | LC | failed |
| 7 |  | XSV-02 | 09/11/88 | 18:00 | 36 34.06 | 8 23.71 | LC | failed |

(line 4)

|   |  |        |          |       |          |         |    |      |
|---|--|--------|----------|-------|----------|---------|----|------|
| 8 |  | XSV-03 | 09/11/88 | 21:14 | 36 45.45 | 8 37.47 | LC | good |
| 9 |  | XSV-03 | 09/11/88 | 22:40 | 36 39.40 | 8 38.37 | LC | good |

(line 8)

|    |        |        |          |       |          |         |    |              |
|----|--------|--------|----------|-------|----------|---------|----|--------------|
| 10 |        | XSV-02 | 09/13/88 | 12:54 | 36 33.78 | 9 01.30 | LC | failed       |
| 11 |        | XSV-02 | 09/13/88 | 12:55 | 36 33.68 | 9 01.29 | LC | good         |
| 12 |        | XSV-02 | 09/13/88 | 16:16 | 36 24.76 | 9 02.53 | LC | Note 1, good |
| 13 |        | XSV-02 | 09/13/88 | 16:53 | 36 19.81 | 9 02.93 | LC | good         |
| 14 | 013619 | XSV-02 | 09/13/88 | 21:03 | 36 02.81 | 9 01.14 | LC | good         |

(line 13)

|    |        |        |          |       |          |         |    |      |
|----|--------|--------|----------|-------|----------|---------|----|------|
| 15 | 013629 | XSV-02 | 09/14/88 | 09:16 | 36 30.98 | 9 09.70 | LC | good |
|----|--------|--------|----------|-------|----------|---------|----|------|

(line 14)

|    |        |        |          |       |          |         |    |      |
|----|--------|--------|----------|-------|----------|---------|----|------|
| 16 | 013626 | XSV-02 | 09/14/88 | 21:01 | 36 40.31 | 9 06.74 | LC | good |
|----|--------|--------|----------|-------|----------|---------|----|------|

(line 15)

|    |        |        |          |       |          |         |    |      |
|----|--------|--------|----------|-------|----------|---------|----|------|
| 17 | 013666 | XSV-02 | 09/15/88 | 00:50 | 36 50.33 | 9 41.65 | LC | good |
|----|--------|--------|----------|-------|----------|---------|----|------|

| Drop # | Serial # | Type | Date | Time | Latitude | Longitude | Method | Comment |
|--------|----------|------|------|------|----------|-----------|--------|---------|
|--------|----------|------|------|------|----------|-----------|--------|---------|

(line 17)

|    |       |        |          |       |          |         |    |      |
|----|-------|--------|----------|-------|----------|---------|----|------|
| 18 | 01362 | XSV-02 | 09/15/88 | 21:22 | 37 14.42 | 9 51.45 | LC | good |
|----|-------|--------|----------|-------|----------|---------|----|------|

(line 19)

|    |        |        |          |       |          |         |    |      |
|----|--------|--------|----------|-------|----------|---------|----|------|
| 19 | 011177 | XSV-03 | 09/16/88 | 21:19 | 37 51.68 | 9 29.11 | LC | good |
|----|--------|--------|----------|-------|----------|---------|----|------|

To Meddy and initial survey

|    |        |        |          |       |          |         |    |              |
|----|--------|--------|----------|-------|----------|---------|----|--------------|
| 20 | 013630 | XSV-02 | 09/17/88 | 09:25 | 36 05.29 | 9 13.82 | LC | Note 1, good |
| 21 | 013628 | XSV-02 | 09/17/88 | 09:57 | 36 00.54 | 9 14.72 | LC | Note 1, good |
| 22 | 013622 | XSV-02 | 09/17/88 | 10:34 | 36 00.09 | 9 09.21 | LC | Note 1, good |
| 23 | 013627 | XSV-02 | 09/17/88 | 11:15 | 35 59.51 | 9 02.02 | LC | good         |
| 24 | 013665 | XSV-02 | 09/17/88 | 11:56 | 36 04.59 | 9 01.86 | LC | good         |
| 25 | 013623 | XSV-02 | 09/17/88 | 12:37 | 36 05.58 | 9 08.82 | LC | good         |
| 26 | 013624 | XSV-02 | 09/17/88 | 13:35 | 36 04.53 | 9 20.42 | LC | good         |
| 27 | 013664 | XSV-02 | 09/17/88 | 16:59 | 36 04.37 | 9 10.70 | LC | Notes 1 & 3  |

Meddy Survey (leg 1)

|    |        |        |          |       |          |         |    |              |
|----|--------|--------|----------|-------|----------|---------|----|--------------|
| 28 | 013654 | XSV-02 | 09/17/88 | 21:33 | 35 57.30 | 9 12.46 | LC | good         |
| 29 | 013643 | XSV-02 | 09/17/88 | 21:52 | 35 59.00 | 9 12.16 | LC | good         |
| 30 | 013644 | XSV-02 | 09/17/88 | 22:11 | 36 00.68 | 9 11.79 | LC | good         |
| 31 | 013651 | XSV-02 | 09/17/88 | 22:32 | 36 02.52 | 9 11.44 | LC | good         |
| 32 | 013653 | XSV-02 | 09/17/88 | 22:52 | 36 04.26 | 9 11.04 | LC | failed       |
| 33 | 013652 | XSV-02 | 09/17/88 | 23:10 | 36 05.85 | 9 10.75 | LC | good         |
| 34 | 013646 | XSV-02 | 09/17/88 | 23:31 | 36 07.60 | 9 10.42 | LC | good         |
| 35 | 013647 | XSV-02 | 09/17/88 | 23:49 | 36 09.18 | 9 10.63 | LC | Note 2, good |
| 36 | 013645 | XSV-02 | 09/18/88 | 00:10 | 36 10.93 | 9 11.01 | LC | good         |
| 37 | 013648 | XSV-02 | 09/18/88 | 00:30 | 36 12.58 | 9 11.52 | LC | Note 1, good |

Meddy Survey (leg 2)

|    |        |        |          |       |          |         |    |              |
|----|--------|--------|----------|-------|----------|---------|----|--------------|
| 38 | 013649 | XSV-02 | 09/18/88 | 02:52 | 36 08.61 | 9 05.86 | LC | Note 1, good |
| 39 | 013650 | XSV-02 | 09/18/88 | 03:22 | 36 06.61 | 9 07.86 | LC | noisy        |
| 40 | 013640 | XSV-02 | 09/18/88 | 03:44 | 36 05.59 | 9 10.23 | LC | Note 1, good |
| 41 | 013641 | XSV-02 | 09/18/88 | 04:04 | 36 04.71 | 9 12.34 | LC | good         |
| 42 | 013642 | XSV-02 | 09/18/88 | 04:25 | 36 03.81 | 9 14.57 | LC | good         |
| 43 | 013637 | XSV-02 | 09/18/88 | 04:46 | 36 02.83 | 9 16.76 | LC | Notes 1 & 4  |
| 44 | 013638 | XSV-02 | 09/18/88 | 05:35 | 36 01.54 | 9 18.91 | LC | good         |
| 45 | 013639 | XSV-02 | 09/18/88 | 05:56 | 36 00.58 | 9 21.24 | LC | Note 1, good |
| 46 | 013636 | XSV-02 | 09/18/88 | 06:18 | 35 59.63 | 9 23.68 | LC | good         |

| Drop # | Serial # | Type | Date | Time | Latitude | Longitude | Method | Comment |
|--------|----------|------|------|------|----------|-----------|--------|---------|
|--------|----------|------|------|------|----------|-----------|--------|---------|

Meddy Survey (leg 3)

|    |        |        |          |       |          |         |    |              |
|----|--------|--------|----------|-------|----------|---------|----|--------------|
| 47 | 013635 | XSV-02 | 09/18/88 | 07:50 | 36 09.80 | 9 20.24 | LC | Note 1, good |
| 48 | 013634 | XSV-02 | 09/18/88 | 08:09 | 36 08.77 | 9 18.45 | LC | Note 1, good |
| 49 | 013633 | XSV-02 | 09/18/88 | 08:32 | 36 07.57 | 9 16.25 | LC | Note 1, good |
| 50 | 013632 | XSV-02 | 09/18/88 | 08:53 | 36 06.44 | 9 14.35 | LC | Note 1, good |
| 51 | 013631 | XSV-02 | 09/18/88 | 09:12 | 36 05.42 | 9 12.71 | LC | good         |
| 52 | 013678 | XSV-02 | 09/18/88 | 09:43 | 36 03.90 | 9 09.97 | LC | good         |
| 53 | 013677 | XSV-02 | 09/18/88 | 10:08 | 36 02.74 | 9 07.88 | LC | good         |
| 54 | 013676 | XSV-02 | 09/18/88 | 10:31 | 36 01.69 | 9 06.06 | LC | good         |
| 55 | 013673 | XSV-02 | 09/18/88 | 10:57 | 36 00.58 | 9 04.16 | LC | good         |

Note 1. Probe end misaligned/rotated to proper alignment.

Note 2. Wire wrapped around tab.

Note 3. Bad below 175 m and 750 m.

Note 4. Bad below 125 m and 175 m.

**APPENDIX D**

*Oceanus* Cruise 202  
CTD Log

| Drop # | Date | Time | Latitude | Longitude | Method | Cast Depth (m) |
|--------|------|------|----------|-----------|--------|----------------|
|--------|------|------|----------|-----------|--------|----------------|

Test Cast

|   |          |       |          |          |    |      |
|---|----------|-------|----------|----------|----|------|
| 1 | 09/04/88 | 16:18 | 33 08.27 | 15 59.87 | LC | 2466 |
|---|----------|-------|----------|----------|----|------|

Ampere Seamount

|   |          |       |          |          |    |      |
|---|----------|-------|----------|----------|----|------|
| 2 | 09/05/88 | 16:29 | 35 03.10 | 12 47.80 | LC | 1604 |
| 3 | 09/08/88 | 18:21 | 35 03.88 | 12 49.58 | LC | 1494 |
| 4 | 09/09/88 | 17:11 | 35 05.03 | 12 46.46 | LC | 1602 |
| 5 | 09/09/88 | 20:15 | 35 02.82 | 12 49.28 | LC | 1624 |
| 6 | 09/09/88 | 21:54 | 35 00.72 | 12 45.99 | LC | 1596 |
| 7 | 09/09/88 | 23:12 | 35 02.54 | 12 45.34 | LC | 1606 |

Cape St. Vincent Region

(line 4)

|    |          |       |          |         |    |      |
|----|----------|-------|----------|---------|----|------|
| 8  | 09/11/88 | 20:40 | 36 45.92 | 8 37.15 | LC | 682  |
| 9  | 09/11/88 | 21:49 | 36 39.99 | 8 37.82 | LC | 758  |
| 10 | 09/11/88 | 23:15 | 36 35.09 | 8 38.17 | LC | 1308 |
| 11 | 09/12/88 | 00:49 | 36 30.23 | 8 37.39 | LC | 1992 |
| 12 | 09/12/88 | 02:37 | 36 24.86 | 8 36.97 | LC | 2022 |
| 13 | 09/12/88 | 04:25 | 36 20.19 | 8 37.44 | LC | 2006 |
| 14 | 09/12/88 | 06:14 | 36 14.99 | 8 37.46 | LC | 2000 |
| 15 | 09/12/88 | 08:22 | 36 10.51 | 8 37.93 | LC | 2002 |
| 16 | 09/12/88 | 10:12 | 36 05.29 | 8 38.15 | LC | 1988 |
| 17 | 09/12/88 | 12:24 | 35 59.97 | 8 37.48 | LC | 2020 |
| 18 | 09/12/88 | 14:14 | 35 54.37 | 8 37.53 | LC | 2018 |

(line 8)

|    |          |       |          |         |    |      |
|----|----------|-------|----------|---------|----|------|
| 19 | 09/13/88 | 09:14 | 36 45.44 | 9 01.79 | LC | 584  |
| 20 | 09/13/88 | 10:19 | 36 40.19 | 9 02.43 | LC | 780  |
| 21 | 09/13/88 | 11:22 | 36 35.83 | 9 02.07 | LC | 2002 |
| 22 | 09/13/88 | 13:21 | 36 30.13 | 9 01.96 | LC | 1988 |
| 23 | 09/13/88 | 15:02 | 36 25.22 | 9 02.05 | LC | 1992 |
| 24 | 09/13/88 | 17:29 | 36 15.13 | 9 03.52 | LC | 1992 |
| 25 | 09/13/88 | 19:06 | 36 10.15 | 9 02.10 | LC | 1996 |
| 26 | 09/13/88 | 21:31 | 35 58.61 | 9 01.23 | LC | 1970 |

| Drop # | Date | Time | Latitude | Longitude | Method | Cast Depth (m) |
|--------|------|------|----------|-----------|--------|----------------|
|--------|------|------|----------|-----------|--------|----------------|

(line 17)

|    |          |       |          |          |    |      |
|----|----------|-------|----------|----------|----|------|
| 27 | 09/15/88 | 10:33 | 37 10.39 | 9 09.37  | LC | 586  |
| 28 | 09/15/88 | 11:40 | 37 10.72 | 9 15.42  | LC | 646  |
| 29 | 09/15/88 | 12:44 | 37 10.53 | 9 21.09  | LC | 884  |
| 30 | 09/15/88 | 14:36 | 37 09.83 | 9 34.59  | LC | 1750 |
| 31 | 09/15/88 | 16:17 | 37 08.90 | 9 40.19  | LC | 2014 |
| 32 | 09/15/88 | 18:06 | 37 10.36 | 9 46.58  | LC | 2012 |
| 33 | 09/15/88 | 22:35 | 37 10.14 | 9 51.95  | LC | 2004 |
| 34 | 09/16/88 | 01:17 | 37 10.59 | 9 58.67  | LC | 2014 |
| 35 | 09/16/88 | 03:01 | 37 10.57 | 10 05.61 | LC | 2006 |
| 36 | 09/16/88 | 04:45 | 37 10.79 | 10 11.69 | LC | 2016 |
| 37 | 09/16/88 | 06:22 | 37 10.76 | 10 17.19 | LC | 2024 |
| 38 | 09/16/88 | 08:32 | 37 10.38 | 10 29.00 | LC | 2002 |

(line 19)

|    |          |       |          |          |    |      |
|----|----------|-------|----------|----------|----|------|
| 39 | 09/16/88 | 14:21 | 37 49.39 | 10 14.18 | LC | 2014 |
| 40 | 09/16/88 | 17:56 | 37 49.00 | 9 44.63  | LC | 2012 |
| 41 | 09/16/88 | 20:32 | 37 51.86 | 9 28.92  | LC | 1052 |

Meddy Survey

|    |          |       |          |         |    |      |
|----|----------|-------|----------|---------|----|------|
| 42 | 09/17/88 | 13:49 | 36 04.55 | 9 21.35 | LC | 1614 |
| 43 | 09/17/88 | 16:02 | 36 04.36 | 9 11.56 | LC | 1804 |
| 44 | 09/17/88 | 17:49 | 36 04.68 | 9 01.44 | LC | 1622 |
| 45 | 09/17/88 | 19:53 | 35 55.71 | 9 11.92 | LC | 1758 |
| 46 | 09/18/88 | 00:45 | 36 13.26 | 9 11.81 | LC | 1810 |
| 47 | 09/18/88 | 12:05 | 36 04.89 | 9 12.12 | LC | 1810 |
| 48 | 09/18/88 | 13:35 | 36 04.20 | 9 13.51 | LC | 1798 |

Portuguese Mooring Location

|    |          |       |          |         |    |     |
|----|----------|-------|----------|---------|----|-----|
| 49 | 09/18/88 | 20:15 | 36 36.43 | 8 40.40 | LC | 920 |
|----|----------|-------|----------|---------|----|-----|

| Drop # | Date | Time | Latitude | Longitude | Method | Cast Depth |
|--------|------|------|----------|-----------|--------|------------|
|--------|------|------|----------|-----------|--------|------------|

Outflow Component

(site 1)

|    |          |       |          |         |    |     |
|----|----------|-------|----------|---------|----|-----|
| 50 | 09/21/88 | 12:52 | 35 48.48 | 6 12.72 | LC | 396 |
|----|----------|-------|----------|---------|----|-----|

(site 2)

|    |          |       |          |         |    |     |
|----|----------|-------|----------|---------|----|-----|
| 51 | 09/21/88 | 15:14 | 35 51.07 | 6 01.42 | LC | 404 |
|----|----------|-------|----------|---------|----|-----|

(site 3)

|    |          |       |          |         |    |     |
|----|----------|-------|----------|---------|----|-----|
| 52 | 09/21/88 | 16:32 | 35 52.80 | 5 52.96 | LC | 540 |
|----|----------|-------|----------|---------|----|-----|

(site 1)

|    |          |       |          |         |    |     |
|----|----------|-------|----------|---------|----|-----|
| 53 | 09/21/88 | 18:53 | 35 48.89 | 6 12.89 | LC | 416 |
|----|----------|-------|----------|---------|----|-----|

(site 4)

|    |          |       |          |         |    |     |
|----|----------|-------|----------|---------|----|-----|
| 54 | 09/21/88 | 21:46 | 35 45.94 | 6 20.54 | LC | 430 |
|----|----------|-------|----------|---------|----|-----|

(site 5)

|    |          |       |          |         |    |     |
|----|----------|-------|----------|---------|----|-----|
| 55 | 09/22/88 | 01:32 | 35 45.12 | 6 28.37 | LC | 492 |
|----|----------|-------|----------|---------|----|-----|

(site 1)

|    |          |       |          |         |    |     |
|----|----------|-------|----------|---------|----|-----|
| 56 | 09/22/88 | 03:35 | 35 48.94 | 6 12.66 | LC | 406 |
|----|----------|-------|----------|---------|----|-----|

(site 4)

|    |          |       |          |         |    |     |
|----|----------|-------|----------|---------|----|-----|
| 57 | 09/22/88 | 05:28 | 35 45.89 | 6 19.90 | LC | 396 |
|----|----------|-------|----------|---------|----|-----|

(site 5)

|    |          |       |          |         |    |     |
|----|----------|-------|----------|---------|----|-----|
| 58 | 09/22/88 | 06:50 | 35 45.47 | 6 28.69 | LC | 476 |
|----|----------|-------|----------|---------|----|-----|

(site 6)

|    |          |       |          |         |    |     |
|----|----------|-------|----------|---------|----|-----|
| 59 | 09/22/88 | 08:33 | 35 49.47 | 6 37.07 | LC | 534 |
|----|----------|-------|----------|---------|----|-----|

| Drop #    | Date     | Time  | Latitude | Longitude | Method | Cast Depth (m) |
|-----------|----------|-------|----------|-----------|--------|----------------|
| (site 7)  |          |       |          |           |        |                |
| 60        | 09/22/88 | 10:01 | 35 54.09 | 6 30.49   | LC     | 450            |
| (site 8)  |          |       |          |           |        |                |
| 61        | 09/22/88 | 11:24 | 35 55.20 | 6 24.68   | LC     | 330            |
| (site 9)  |          |       |          |           |        |                |
| 62        | 09/22/88 | 13:42 | 35 45.05 | 6 40.30   | LC     | 710            |
| Section A |          |       |          |           |        |                |
| 63        | 09/22/88 | 17:15 | 35 45.74 | 6 13.13   | LC     | 264            |
| 64        | 09/22/88 | 18:00 | 35 49.10 | 6 13.70   | LC     | 408            |
| 65        | 09/22/88 | 18:55 | 35 51.93 | 6 14.26   | LC     | 330            |
| 66        | 09/22/88 | 19:55 | 35 55.22 | 6 12.05   | LC     | 220            |
| Section B |          |       |          |           |        |                |
| 67        | 09/22/88 | 21:24 | 35 54.13 | 6 20.43   | LC     | 286            |
| 68        | 09/22/88 | 22:09 | 35 52.10 | 6 20.49   | LC     | 240            |
| 69        | 09/22/88 | 22:33 | 35 48.75 | 6 20.02   | LC     | 360            |
| 70        | 09/22/88 | 23:31 | 35 45.68 | 6 18.78   | LC     | 388            |
| 71        | 09/23/88 | 00:29 | 35 42.96 | 6 17.78   | LC     | 276            |
| Section C |          |       |          |           |        |                |
| 72        | 09/23/88 | 01:57 | 35 37.69 | 6 27.12   | LC     | 256            |
| 73        | 09/23/88 | 03:02 | 35 40.88 | 6 30.09   | LC     | 352            |
| 74        | 09/23/88 | 03:36 | 35 42.58 | 6 30.22   | LC     | 350            |
| 75        | 09/23/88 | 04:21 | 35 45.27 | 6 29.03   | LC     | 486            |
| 76        | 09/23/88 | 05:27 | 35 46.82 | 6 28.86   | LC     | 444            |
| 77        | 09/23/88 | 06:32 | 35 49.87 | 6 26.43   | LC     | 390            |
| 78        | 09/23/88 | 07:45 | 35 51.51 | 6 26.98   | LC     | 494            |
| 79        | 09/23/88 | 08:55 | 35 55.19 | 6 27.01   | LC     | 406            |
| 80        | 09/23/88 | 10:11 | 35 59.63 | 6 22.59   | LC     | 216            |
| Section D |          |       |          |           |        |                |
| 81        | 09/23/88 | 11:08 | 35 56.37 | 6 28.52   | LC     | 408            |
| 82        | 09/23/88 | 12:12 | 35 54.16 | 6 29.13   | LC     | 426            |
| 83        | 09/23/88 | 13:05 | 35 52.26 | 6 31.87   | LC     | 526            |
| 84        | 09/23/88 | 14:00 | 35 50.57 | 6 34.48   | LC     | 532            |

| Drop # | Date | Time | Latitude | Longitude | Method | Cast Depth (m) |
|--------|------|------|----------|-----------|--------|----------------|
|--------|------|------|----------|-----------|--------|----------------|

Section D (continued)

|    |          |       |          |         |    |     |
|----|----------|-------|----------|---------|----|-----|
| 85 | 09/23/88 | 15:23 | 35 48.75 | 6 36.77 | LC | 544 |
| 86 | 09/23/88 | 16:32 | 35 46.66 | 6 39.10 | LC | 634 |
| 87 | 09/23/88 | 17:32 | 35 43.80 | 6 41.34 | LC | 610 |
| 88 | 09/23/88 | 18:31 | 35 40.92 | 6 42.89 | LC | 734 |
| 89 | 09/23/88 | 19:31 | 35 39.52 | 6 39.12 | LC | 600 |
| 90 | 09/23/88 | 20:28 | 35 38.85 | 6 34.82 | LC | 474 |

(Station C4)

|    |          |       |          |         |    |     |
|----|----------|-------|----------|---------|----|-----|
| 91 | 09/23/88 | 21:53 | 35 45.03 | 6 28.73 | LC | 492 |
|----|----------|-------|----------|---------|----|-----|

Section E

|     |          |       |          |         |    |     |
|-----|----------|-------|----------|---------|----|-----|
| 92  | 09/24/88 | 00:49 | 36 01.92 | 6 33.77 | LC | 376 |
| 93  | 09/24/88 | 02:08 | 36 00.59 | 6 36.71 | LC | 514 |
| 94  | 09/24/88 | 03:30 | 35 59.14 | 6 40.19 | LC | 514 |
| 95  | 09/24/88 | 04:35 | 35 57.25 | 6 43.21 | LC | 600 |
| 96  | 09/24/88 | 05:51 | 35 55.50 | 6 46.00 | LC | 698 |
| 97  | 09/24/88 | 07:05 | 35 54.06 | 6 48.48 | LC | 764 |
| 98  | 09/24/88 | 08:21 | 35 52.67 | 6 52.08 | LC | 734 |
| 99  | 09/24/88 | 09:22 | 35 50.18 | 6 55.38 | LC | 820 |
| 100 | 09/24/88 | 10:20 | 35 48.25 | 6 57.95 | LC | 946 |

Section F

|     |          |       |          |         |    |     |
|-----|----------|-------|----------|---------|----|-----|
| 101 | 09/24/88 | 16:57 | 36 20.50 | 6 42.35 | LC | 302 |
| 102 | 09/24/88 | 17:36 | 36 18.93 | 6 43.87 | LC | 380 |
| 103 | 09/24/88 | 18:21 | 36 17.82 | 6 46.60 | LC | 580 |
| 104 | 09/24/88 | 19:26 | 36 16.05 | 6 48.95 | LC | 678 |
| 105 | 09/24/88 | 20:25 | 36 14.75 | 6 52.04 | LC | 728 |
| 106 | 09/24/88 | 21:20 | 36 12.51 | 6 54.25 | LC | 688 |
| 107 | 09/24/88 | 22:37 | 36 10.76 | 6 57.54 | LC | 740 |
| 108 | 09/25/88 | 00:19 | 36 09.15 | 7 00.67 | LC | 738 |
| 109 | 09/25/88 | 01:27 | 36 07.68 | 7 04.50 | LC | 746 |
| 110 | 09/25/88 | 02:40 | 36 06.23 | 7 07.64 | LC | 758 |
| 111 | 09/25/88 | 03:41 | 36 04.64 | 7 08.98 | LC | 778 |
| 112 | 09/25/88 | 04:46 | 36 02.63 | 7 12.12 | LC | 822 |

Section G

|     |          |       |          |         |    |      |
|-----|----------|-------|----------|---------|----|------|
| 113 | 09/25/88 | 07:41 | 35 59.91 | 7 39.62 | LC | 1252 |
| 114 | 09/25/88 | 09:11 | 36 04.22 | 7 36.32 | LC | 1028 |
| 115 | 09/25/88 | 10:38 | 36 08.97 | 7 32.25 | LC | 1016 |

| Drop # | Date | Time | Latitude | Longitude | Method | Cast Depth (m) |
|--------|------|------|----------|-----------|--------|----------------|
|--------|------|------|----------|-----------|--------|----------------|

Section G (continued)

|     |          |       |          |         |    |     |
|-----|----------|-------|----------|---------|----|-----|
| 116 | 09/25/88 | 11:57 | 36 13.38 | 7 29.10 | LC | 846 |
| 117 | 09/25/88 | 13:15 | 36 17.74 | 7 26.45 | LC | 710 |
| 118 | 09/25/88 | 14:27 | 36 22.77 | 7 20.83 | LC | 806 |
| 119 | 09/25/88 | 15:32 | 36 26.82 | 7 18.49 | LC | 666 |
| 120 | 09/25/88 | 16:32 | 36 30.79 | 7 14.43 | LC | 564 |
| 121 | 09/25/88 | 17:36 | 36 35.56 | 7 08.65 | LC | 508 |
| 122 | 09/25/88 | 18:35 | 36 40.86 | 7 08.08 | LC | 486 |
| 123 | 09/25/88 | 19:36 | 36 45.41 | 7 05.15 | LC | 352 |
| 124 | 09/25/88 | 20:27 | 36 50.20 | 7 02.06 | LC | 108 |

Section H

|     |          |       |          |         |    |      |
|-----|----------|-------|----------|---------|----|------|
| 125 | 09/26/88 | 00:42 | 36 49.04 | 7 59.81 | LC | 470  |
| 126 | 09/26/88 | 01:56 | 36 42.36 | 8 00.02 | LC | 730  |
| 127 | 09/26/88 | 02:57 | 36 37.99 | 7 59.99 | LC | 758  |
| 128 | 09/26/88 | 04:05 | 36 33.02 | 8 00.61 | LC | 776  |
| 129 | 09/26/88 | 05:06 | 36 28.13 | 8 01.31 | LC | 880  |
| 130 | 09/26/88 | 06:27 | 36 22.72 | 8 00.10 | LC | 1240 |
| 131 | 09/26/88 | 07:43 | 36 17.71 | 7 59.63 | LC | 1186 |
| 132 | 09/26/88 | 09:08 | 36 13.12 | 8 00.05 | LC | 1468 |
| 133 | 09/26/88 | 10:54 | 36 07.77 | 8 00.55 | LC | 1656 |
| 134 | 09/26/88 | 12:04 | 36 02.99 | 7 59.50 | LC | 1490 |
| 135 | 09/26/88 | 14:09 | 35 53.32 | 8 00.83 | LC | 1782 |

Section FE

|     |          |       |          |         |    |      |
|-----|----------|-------|----------|---------|----|------|
| 136 | 09/26/88 | 18:52 | 35 57.88 | 7 09.42 | LC | 984  |
| 137 | 09/26/88 | 21:02 | 35 54.78 | 7 05.65 | LC | 956  |
| 138 | 09/26/88 | 22:24 | 35 50.03 | 6 59.87 | LC | 1006 |

Section I

|     |          |       |          |         |    |     |
|-----|----------|-------|----------|---------|----|-----|
| 139 | 09/27/88 | 07:40 | 36 00.94 | 5 16.99 | LC | 852 |
| 140 | 09/27/88 | 09:29 | 35 59.37 | 5 22.50 | LC | 924 |
| 141 | 09/27/88 | 11:24 | 35 57.97 | 5 29.55 | LC | 872 |
| 142 | 09/27/88 | 12:13 | 35 56.44 | 5 34.67 | LC | 514 |
| 143 | 09/27/88 | 13:24 | 35 56.14 | 5 41.64 | LC | 458 |
| 144 | 09/27/88 | 14:10 | 35 55.36 | 5 44.75 | LC | 256 |
| 145 | 09/27/88 | 15:33 | 35 52.96 | 5 52.16 | LC | 432 |
| 146 | 09/27/88 | 16:54 | 35 50.70 | 6 00.64 | LC | 316 |
| 147 | 09/27/88 | 18:11 | 35 49.51 | 6 05.97 | LC | 398 |
| 148 | 09/27/88 | 19:23 | 35 49.11 | 6 11.72 | LC | 404 |

**APPENDIX E**

*Oceanus* Cruise 202

XDP Log

| Drop # | Date     | Time  | Latitude | Longitude | Method | Comment          |
|--------|----------|-------|----------|-----------|--------|------------------|
|        |          |       |          | (site 2)  |        |                  |
| 801    | 09/21/88 | 15:48 | 35 51.41 | 6 00.84   | LC     |                  |
|        |          |       |          | (site 3)  |        |                  |
| 1030   | 09/21/88 | 17:14 | 35 53.36 | 5 52.35   | LC     |                  |
|        |          |       |          | (site 1)  |        |                  |
| 1040   | 09/21/88 | 19:38 | 35 49.05 | 6 12.88   | LC     |                  |
|        |          |       |          | (site 4)  |        |                  |
| 1033   | 09/21/88 | 22:25 | 35 46.17 | 6 20.76   | LC     | bad              |
| 1035   | 09/21/88 | 22:31 | 35 46.33 | 6 20.65   | LC     |                  |
|        |          |       |          | (site 5)  |        |                  |
| 808    | 09/22/88 | 02:13 | 35 45.54 | 6 28.63   | LC     |                  |
|        |          |       |          | (site 1)  |        |                  |
| 701    | 09/22/88 | 04:04 | 35 49.13 | 6 12.79   | LC     | receiver failure |
| 803    | 09/22/88 | 04:29 | 35 49.11 | 6 12.51   | LC     |                  |
|        |          |       |          | (site 4)  |        |                  |
| 709    | 09/22/88 | 05:58 | 35 46.11 | 6 20.43   | LC     |                  |
|        |          |       |          | (site 5)  |        |                  |
| 707    | 09/22/88 | 07:42 | 35 45.49 | 6 29.79   | LC     |                  |
|        |          |       |          | (site 6)  |        |                  |
| 807    | 09/22/88 | 09:11 | 35 49.87 | 6 37.52   | LC     |                  |
|        |          |       |          | (site 7)  |        |                  |
| 809    | 09/22/88 | 10:37 | 35 53.85 | 6 30.41   | LC     |                  |

| Drop #    | Date     | Time  | Latitude | Longitude | Method | Comment    |
|-----------|----------|-------|----------|-----------|--------|------------|
| (site 8)  |          |       |          |           |        |            |
| 1032      | 09/22/88 | 12:09 | 35 54.24 | 6 24.56   | LC     |            |
| (site 9)  |          |       |          |           |        |            |
| 702       | 09/22/88 | 14:21 | 35 45.46 | 6 40.73   | LC     |            |
| Section A |          |       |          |           |        |            |
| 1025      | 09/22/88 | 17:36 | 35 45.73 | 6 13.47   | LC     |            |
| 1034      | 09/22/88 | 18:27 | 35 49.31 | 6 13.77   | LC     |            |
| 1022      | 09/22/88 | 19:21 | 35 51.56 | 6 14.51   | LC     |            |
| 1046      | 09/22/88 | 20:17 | 35 55.13 | 6 12.67   | LC     |            |
| Section B |          |       |          |           |        |            |
| 1043      | 09/22/88 | 23:01 | 35 48.82 | 6 19.60   | LC     |            |
| 1051      | 09/23/88 | 00:05 | 35 45.58 | 6 18.34   | LC     |            |
| Section C |          |       |          |           |        |            |
| 1045      | 09/23/88 | 04:47 | 35 44.98 | 6 29.57   | LC     | wire broke |
| 704       | 09/23/88 | 05:00 | 35 44.58 | 6 30.05   | LC     |            |
| 815       | 09/23/88 | 05:56 | 35 46.47 | 6 29.33   | LC     |            |
| 1058      | 09/23/88 | 06:56 | 35 49.49 | 6 27.05   | LC     | wire broke |
| 1018      | 09/23/88 | 06:58 | 35 49.41 | 6 27.15   | LC     |            |
| 1038      | 09/23/88 | 08:13 | 35 50.98 | 6 27.39   | LC     |            |
| 1053      | 09/23/88 | 09:19 | 35 54.52 | 6 27.27   | LC     |            |
| 1039      | 09/23/88 | 09:22 | 35 54.30 | 6 27.41   | LC     |            |
| Section D |          |       |          |           |        |            |
| 813       | 09/23/88 | 13:40 | 35 51.67 | 6 32.35   | LC     |            |
| 810       | 09/23/88 | 14:32 | 35 50.17 | 6 34.93   | LC     |            |
| 1050      | 09/23/88 | 15:00 | 35 50.09 | 6 34.23   | LC     |            |
| 999       | 09/23/88 | 15:57 | 35 48.65 | 6 37.31   | LC     |            |
| 806       | 09/23/88 | 16:10 | 35 48.51 | 6 37.65   | LC     |            |

| Drop #       | Date     | Time  | Latitude | Longitude | Method | Comment                 |
|--------------|----------|-------|----------|-----------|--------|-------------------------|
| (Station C4) |          |       |          |           |        |                         |
| 1049         | 09/23/88 | 22:31 | 35 44.57 | 6 29.94   | LC     |                         |
| 804          | 09/23/88 | 22:48 | 35 44.50 | 6 30.21   | LC     |                         |
| Section E    |          |       |          |           |        |                         |
| 1044         | 09/24/88 | 01:43 | 36 01.24 | 6 33.09   | LC     |                         |
| 814          | 09/24/88 | 02:57 | 36 00.41 | 6 37.19   | LC     | wire broke              |
| 705          | 09/24/88 | 03:08 | 36 00.10 | 6 37.92   | LC     |                         |
| 824          | 09/24/88 | 04:08 | 35 59.22 | 6 40.53   | LC     | broken wire near bottom |
| 812          | 09/24/88 | 05:16 | 35 57.58 | 6 43.68   | LC     |                         |
| 828          | 09/24/88 | 06:34 | 35 55.77 | 6 46.34   | LC     |                         |
| 711          | 09/24/88 | 07:49 | 35 54.53 | 6 48.69   | LC     |                         |
| Section F    |          |       |          |           |        |                         |
| 826          | 09/24/88 | 18:05 | 36 18.50 | 6 44.69   | LC     |                         |
| 817          | 09/24/88 | 22:02 | 36 12.43 | 6 55.13   | LC     |                         |
| 827          | 09/24/88 | 23:25 | 36 10.83 | 6 58.09   | LC     |                         |
| 830          | 09/24/88 | 23:30 | 36 10.76 | 6 58.50   | LC     |                         |
| Section FE   |          |       |          |           |        |                         |
| 829          | 09/27/88 | 02:12 | 35 45.91 | 6 28.98   | LC     |                         |
| Section I    |          |       |          |           |        |                         |
| 1048         | 09/27/88 | 08:26 | 36 01.02 | 5 17.74   | LC     |                         |
| 1061         | 09/27/88 | 10:25 | 35 59.16 | 5 23.45   | LC     |                         |
| 1056         | 09/27/88 | 11:40 | 35 57.87 | 5 29.98   | LC     |                         |
| 1062         | 09/27/88 | 12:44 | 35 56.24 | 5 35.52   | LC     |                         |
| 1057         | 09/27/88 | 12:54 | 35 56.25 | 5 36.40   | LC     |                         |
| 1071         | 09/27/88 | 13:50 | 35 56.29 | 5 42.51   | LC     |                         |
| 1054         | 09/27/88 | 14:29 | 35 55.38 | 5 45.16   | LC     |                         |
| 1063         | 09/27/88 | 14:35 | 35 55.48 | 5 45.14   | LC     |                         |
| 1055         | 09/27/88 | 17:23 | 35 51.19 | 5 59.52   | LC     |                         |
| 1072         | 09/27/88 | 19:58 | 35 49.15 | 6 11.27   | LC     |                         |

| Drop # | Date | Time | Latitude | Longitude | Method | Comment |
|--------|------|------|----------|-----------|--------|---------|
|--------|------|------|----------|-----------|--------|---------|

(Station B8)

|      |          |       |          |         |    |  |
|------|----------|-------|----------|---------|----|--|
| 1059 | 09/27/88 | 20:59 | 35 48.82 | 6 20.37 | LC |  |
|------|----------|-------|----------|---------|----|--|

(Station C4)

|      |          |       |          |         |    |  |
|------|----------|-------|----------|---------|----|--|
| 821  | 09/27/88 | 21:51 | 35 45.29 | 6 29.16 | LC |  |
| 1060 | 09/27/88 | 21:54 | 35 45.35 | 6 29.15 | LC |  |

(Station D6)

|      |          |       |          |         |    |  |
|------|----------|-------|----------|---------|----|--|
| 1065 | 09/27/88 | 22:40 | 35 51.53 | 6 34.91 | LC |  |
|------|----------|-------|----------|---------|----|--|

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| 12 PERSONAL AUTHOR(S) Maureen A. Kennelly, John H. Dunlap, Thomas B. Sanford, Eric L. Kunze,<br>Mark D. Prater, and Robert G. Drever                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |       |                                       |                                                                                               |                                                    |                                 |
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| 08                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 03    |                                       | Meddy Gulf of Cadiz                                                                           |                                                    |                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |       |                                       | Ampere Seamount Mediterranean outflow                                                         |                                                    |                                 |
| 19 ABSTRACT (Continue on reverse if necessary and identify by block number)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       |                                       |                                                                                               |                                                    |                                 |
| <p>Velocity, hydrographic, and dissipation measurements were made in the Gulf of Cadiz from 4-28 September 1988 to observe the vortices shed in the wake of Ampere Seamount, to survey eddies formed by the Mediterranean outflow near Cape St. Vincent, and to study the structure and dynamics of the outflow plume west of the Strait of Gibraltar. The expedition, the instrument systems, and their deployments are described, and preliminary results are presented. Keywords: Mediterranean outflow eddies (Meddies); Iberian Peninsula gulfs; Sea water flow; Seamount wake vortices; Satellite altimetry data; Fluid mechanics; Eddies (eddies).</p> |       |                                       |                                                                                               |                                                    |                                 |
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