Woods Hole Oceanographic Institution

WHOI-93-30
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Technical Report
May 1993

TOGA COARE Mooring Deployment, Mooring Check-out and Mooring Recovery Cruises

R/V *Wecoma* 7 October – 1 November 1992
R/V *Le Noroît* 2 December – 15 December 1992
R/V *Wecoma* 27 February – 11 March 1993

A.J. Plueddemann
R.P. Trask
W.M. Ostrom
R.A. Weller
B.S. Way
S. Anderson
N. Bogue
J. Shillingford
S. Hill

Upper Ocean Processes Group
UOP Technical Report 93-5

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Approved for Distribution:

James Luyten, Chair
Department of Physical Oceanography

Abstract

The Tropical Ocean - Global Atmosphere Coupled Ocean - Atmosphere Response Experiment (TOGA COARE) was conceived in order to improve understanding of the principal processes responsible for coupling of the ocean and atmosphere in the western Pacific warm pool region. Field work for TOGA COARE was concentrated in an Intensive Flux Array (IFA) and included a variety of atmospheric and oceanic platforms. The Upper Ocean Processes Group (UOPG) was involved in TOGA COARE through the preparation, deployment, and recovery of a heavily instrumented surface mooring for the observation of air-sea fluxes and oceanic temperature, salinity, and currents in the upper 300 m. The mooring was deployed at 1°, 45.27' S, 155°, 59.73 E on 21 October 1992 in 1744 m of water. An instrument check-out cruise was undertaken in December of 1992 in order to evaluate the meteorological systems on the buoy. The mooring was recovered on 4 March 1993. This report describes mooring deployment operations, the instrument check-out cruise, and the mooring recovery. UOPG personnel also assisted with the deployment and recovery of five other moorings as a part of the COARE IFA and these operations are discussed.

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Section 1-1: Introduction

During evaluation of the progress in the Tropical Ocean - Global Atmosphere (TOGA) program, it became clear that the complexity of the coupled ocean-atmosphere system in the western Pacific warm pool region warranted further study. The Coupled Ocean - Atmosphere Response Experiment (COARE) was designed to fill this need. The principal scientific objective of COARE was to improve understanding of the processes responsible for coupling of the ocean and atmosphere in the warm pool region (WCRP, 1990). Field work for TOGA COARE included a variety of atmospheric and oceanic measurement platforms in the COARE domain (figure 1-1). The methodology for the experiment was to concentrate the measurements in an Intensive Flux Array (IFA; figure 1-2) which was intended to produce a high quality heat, moisture, and momentum flux data set for the ocean-atmosphere system. A thorough discussion of scientific motivation and experimental design of COARE is given by Webster and Lucas (1992). Many more details on experimental logistics and implementation are given in the TOGA COARE Operations Plan (TCIPO, 1992)

The Upper Ocean Processes Group (UOPG) was involved in TOGA COARE through the preparation, deployment, and recovery of a heavily instrumented surface mooring in the IFA for the observation of surface meteorology and oceanic temperature, salinity, and currents. The goal of the project was to make high quality observations of the air-sea fluxes and detailed measurements of the temporal evolution of the vertical structure of the upper 300 m of the ocean. The measurements from the UOP surface mooring were complemented by sub-surface measurements from five other moorings within the IFA, and UOPG personnel assisted in the preparation and deployment of these moorings. The goals of the analysis effort will be to develop an improved understanding of the role of the air-sea fluxes and near-surface oceanic processes in determining the sea-surface temperature and vertical structure of the warm pool. Of particular interest is the oceanic response to atmospheric forcing events ranging in scale from small (5-50 km) convective elements to westerly wind bursts (1500 km zonal and 500 km meridional).

The purpose of the cruise aboard the R/V Wecoma was the deployment of six moorings in the COARE IFA. The deployment cruise was initiated from Honolulu, Hawaii on 7 October 1992, made a brief port call in Pohnpei to take on scientific personnel, and continued on to the IFA site for mooring operations. The Wecoma sailed for Guam upon completion of the mooring deployments on 27 October, arriving there on 1 November. The science party for the first leg of the cruise consisted of four people from the Woods Hole Oceanographic Institution (WHOI) with A. Plueddemann as Chief Scientist. The second leg of the cruise was conducted jointly with the University of Washington (UW). A party of five from UW joined the ship in Pohnpei,with C. Eriksen serving as Co-Chief Scientist. Also joining the ship in Pohnpei was a party of two from the Institute of Ocean Sciences (IOS), B.C., Canada, representing the interests of D. Farmer.

Figure 1-1. Moorings in COARE Domain

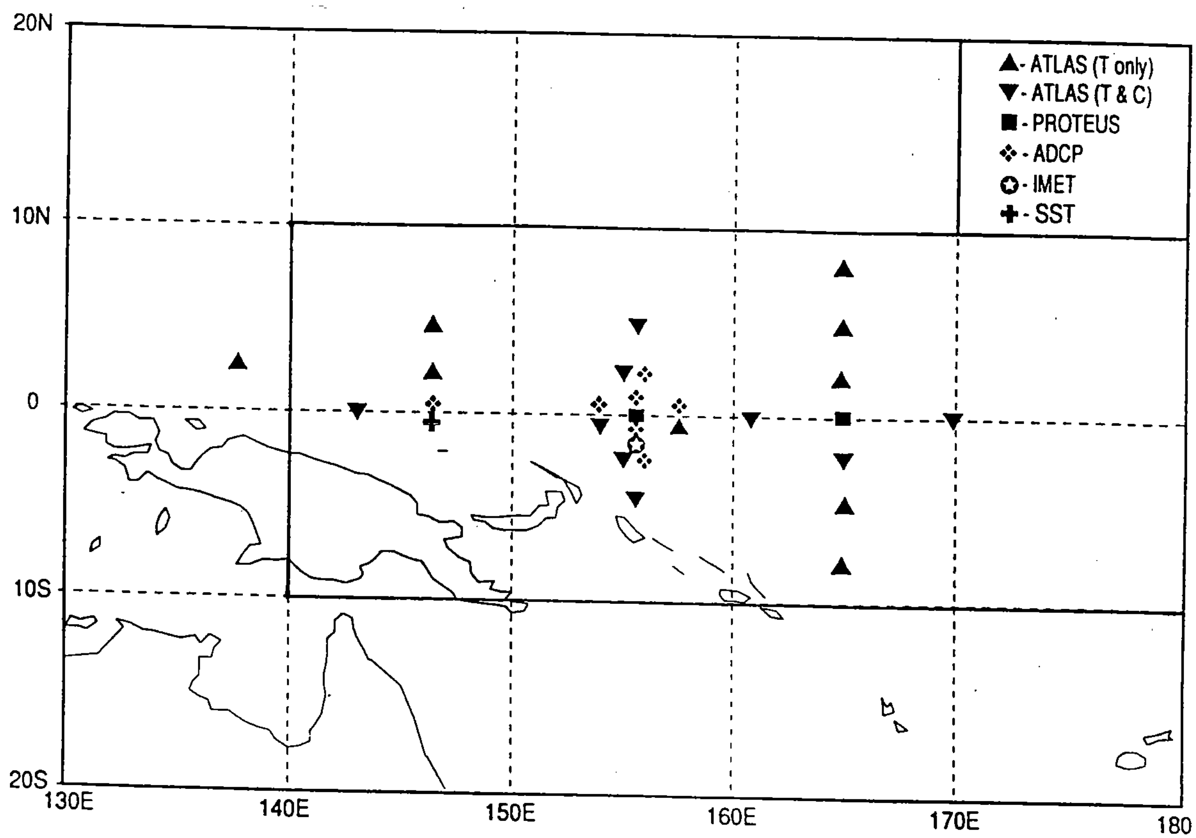
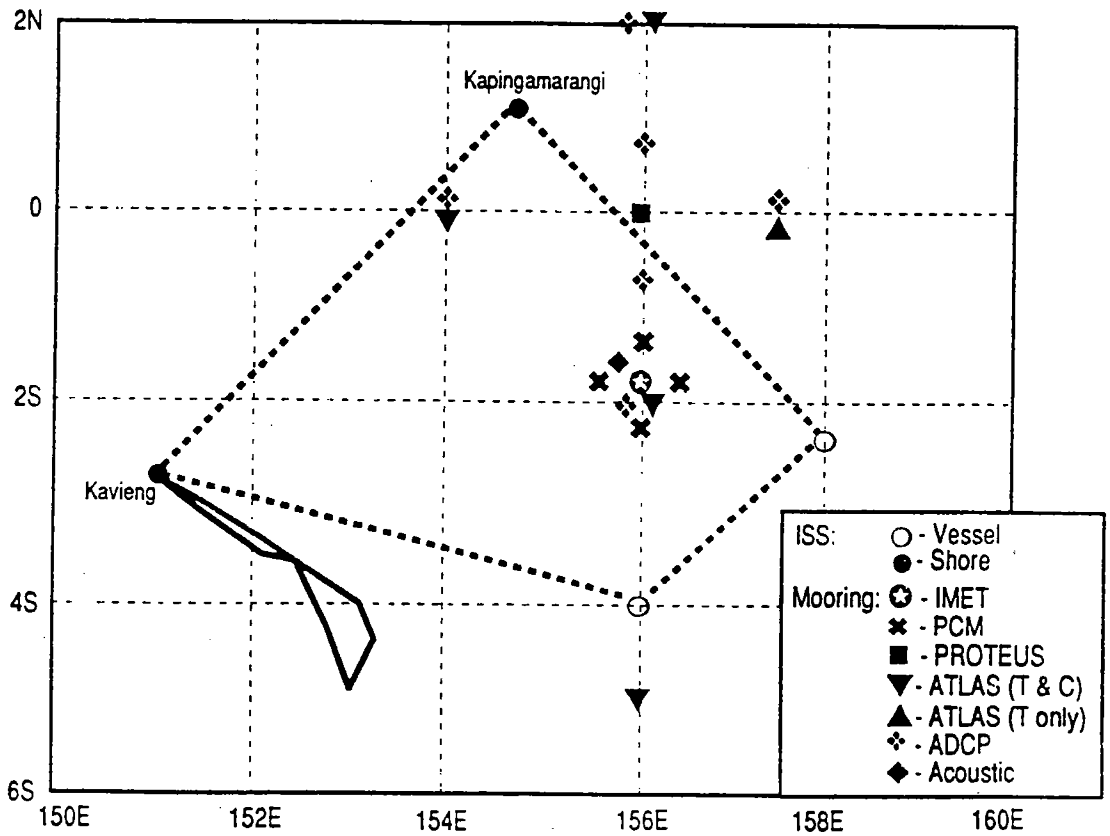


Figure 1-2. Mooring Array in COARE IFA



Section 1-2: Preparations

The tasks to be accomplished on this cruise were the deployment of six moorings: A meteorological and oceanographic surface mooring developed by the UOPG (denoted the WHOI-UOP mooring, figure 1-3a,b), a subsurface mooring containing an acoustics instrument known as ELSI developed by Farmer (figure 1-4), and four subsurface Profiling Current Meter (PCM) moorings developed by Eriksen. This report is principally concerned with the activities of the contingent from WHOI who were responsible for the deployment of the UOP mooring and ELSI.

The advance party from WHOI (Simoneau, Bouchard, Grant) arrived in Honolulu on 26 September followed two days later by the remainder of the group (Plueddemann, Allsup). A total of 11 days were spent in Honolulu engaged in cruise preparation. Accomplished during this time were:

- construction of the UOP buoy tower
- installation of VAWR and IMET sensors on the tower
- buoy spin
- preparation of 9 VMCMs including compass spins
- preparation of 13 WHOI Seacats
- acquisition of 5 Tomczak Seacats
- 3 releases checked
- near-surface Brancker string assembled
- tensiometer checked
- Edson sonic anemometer mounted on Wecoma
- Wecoma deck and lab loaded

A series of tests were performed comparing handheld meteorological observations to those of VAWR and IMET. Both Argos data and IMET optical disk data were processed and plotted for various test periods. At one point these comparisons showed that the IMET longwave (LW) radiation was consistently 50 W/m^2 higher than that of the VAWR. Some discussion with Woods Hole was initiated with regard to possible Argos contamination, but it was finally argued that the spare IMET LW should be tried. The original sensor was replaced with the spare on 6 October, and from that point on the IMET and VAWR LW values agreed to within 5-10 W/m^2. All other met comparisons indicated properly functioning sensors.

A series of minor difficulties were encountered during the mechanical preparation of the buoy tower. Much of the hardware supplied seemed inappropriate, necessitating many trips to the local hardware store. Some of the construction details had to be modified. The mounts for the solar panel above the buoy pick-up point were found broken upon arrival. Both mounts were re-constructed using a heavier gauge bracket.

One VMCM (S/N 051) had a problem writing a tape during an overnight test. The tape transport in this instrument was replaced with a spare, and no more problems were encountered. One WHOI Seacat (S/N 927) would not respond to RS232 interrogation by the computer. It was later found that one of the chips in the electronics board had worked loose. Another Seacat (S/N 995) did not have the battery pack modification. It was decided to deploy the instrument with the factory battery pack installation. The tensiometer did not register properly upon initial connection to the buoy. It was later found that the connector for the tensiometer cable in side the LOPACS was bad. This was repaired and the tensiometer performed as expected.

Figure 1-3a. UOP Mooring Schematic

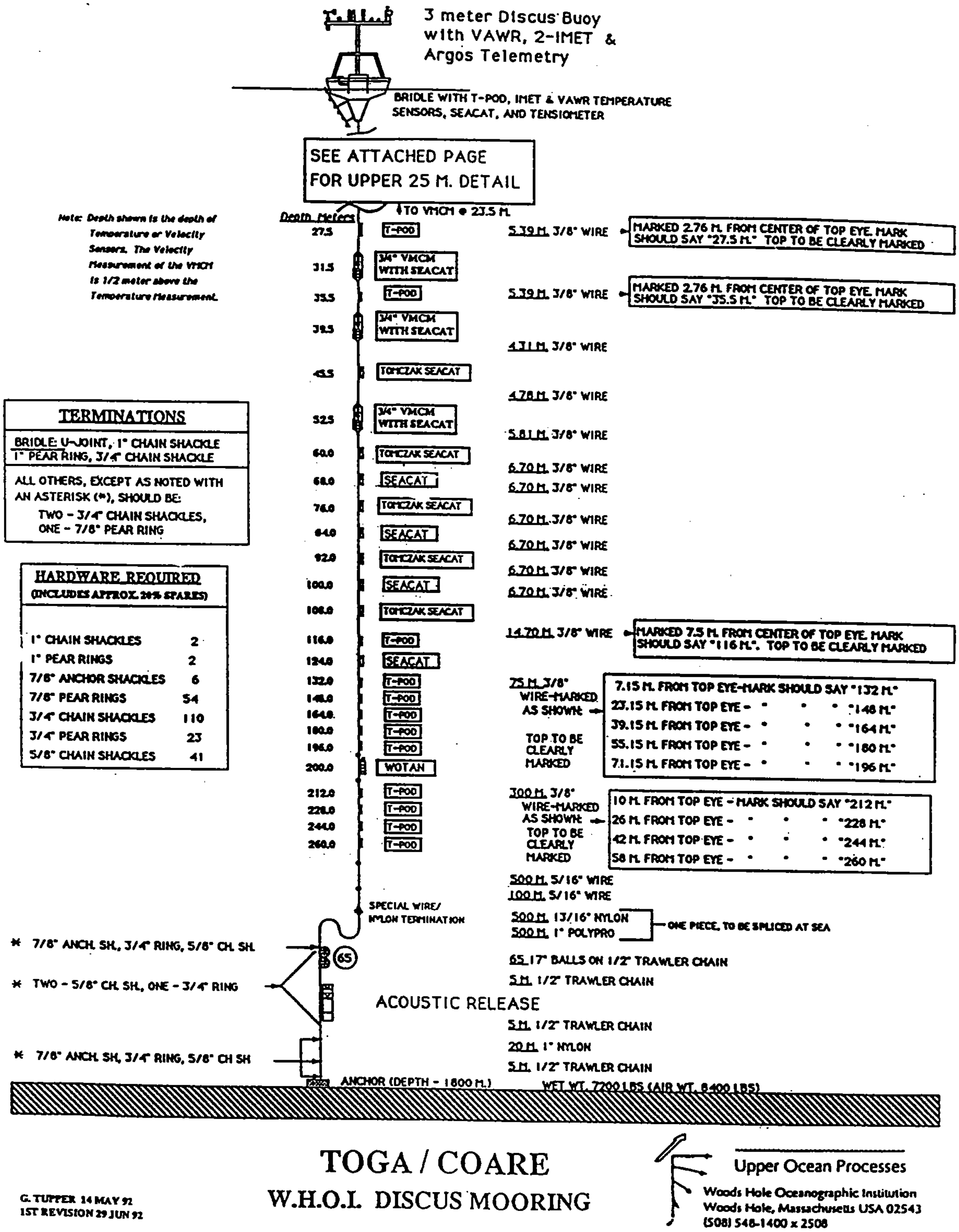
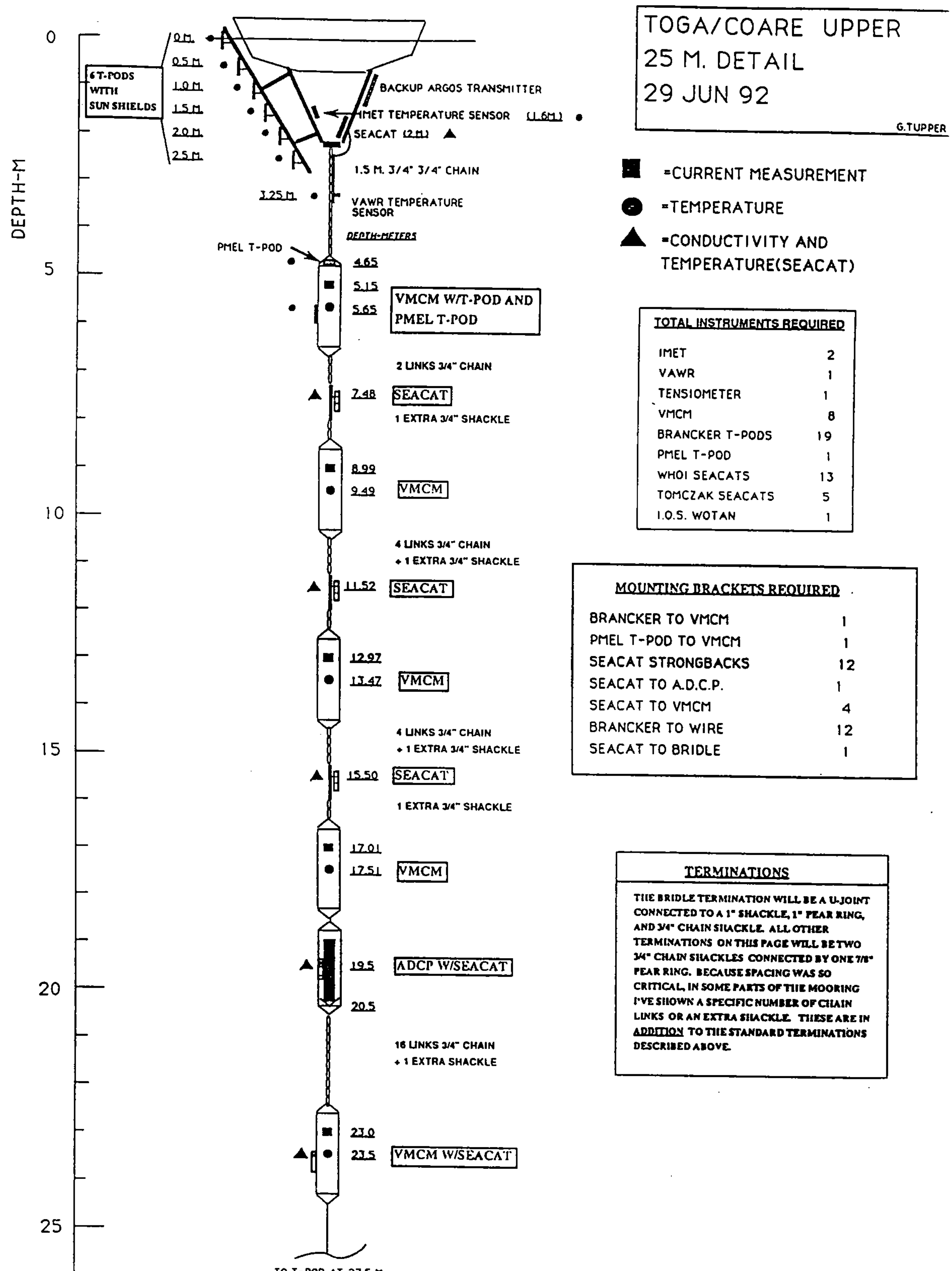


Figure 1-3b. UOP Mooring Upper 25 m Schematic



TOTAL INSTRUMENTS REQUIRED

IMET	2
VAWR	1
TENSIOMETER	1
VMCM	8
BRANCKER T-PODS	19
PMEL T-POD	1
WHOI SEACATS	13
TOMCZAK SEACATS	5
I.O.S. WOTAN	1

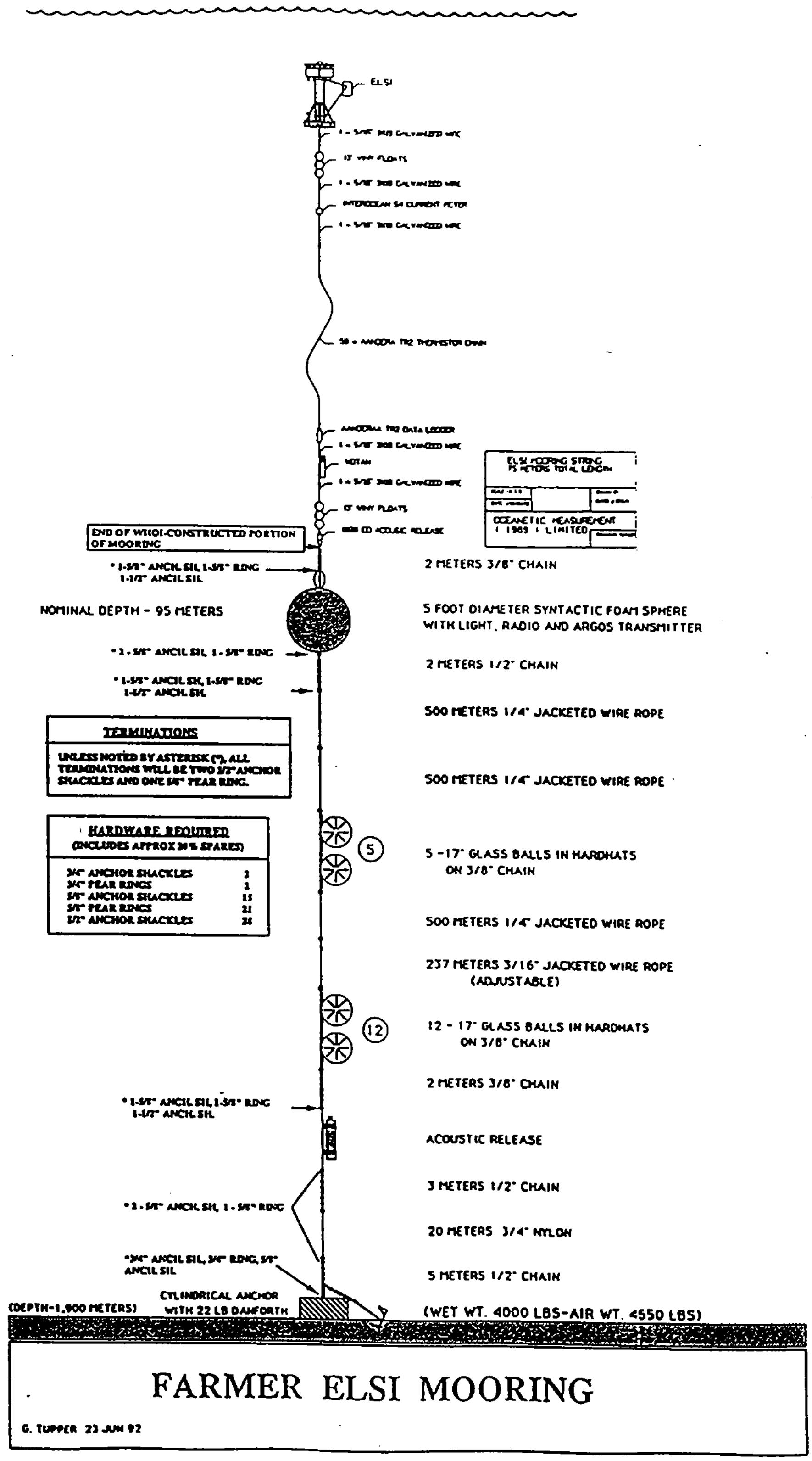
MOUNTING BRACKETS REQUIRED

BRANCKER TO VMCM	1
PMEL T-POD TO VMCM	1
SEACAT STRONGBACKS	12
SEACAT TO A.D.C.P.	1
SEACAT TO VMCM	4
BRANCKER TO WIRE	12
SEACAT TO BRIDLE	1

TERMINATIONS

THE BRIDLE TERMINATION WILL BE A U-JOINT CONNECTED TO A 1" SHACKLE, 1" PEAR RING, AND 3/4" CHAIN SHACKLE. ALL OTHER TERMINATIONS ON THIS PAGE WILL BE TWO 3/4" CHAIN SHACKLES CONNECTED BY ONE 7/8" PEAR RING. BECAUSE SPACING WAS SO CRITICAL, IN SOME PARTS OF THE MOORING I'VE SHOWN A SPECIFIC NUMBER OF CHAIN LINKS OR AN EXTRA SHACKLE. THESE ARE IN ADDITION TO THE STANDARD TERMINATIONS DESCRIBED ABOVE.

Figure 1-4. ELSI Mooring Schematic



Problems with two of the AMF acoustic releases necessitated an emergency shipment of spares from WHOI. The first release would transpond, but would not shut off when put into time-ping mode. The second would not respond at all in any mode. The spare units, BACS releases from Scott Worrilow's lab, arrived at approximately 5 AM on the morning of our scheduled departure after difficulty getting transferred from San Francisco onto a flight to Honolulu. Without the efforts of G. Tupper and K. Adams these would not have arrived in time and the departure would have been delayed.

Section 1-3: Transit Leg

The R/V Wecoma, operated by Oregon State University, arrived in Honolulu on schedule, the morning of 3 October. By 7 October, she was loaded and ready for departure. The deck load was near capacity, and difficulties were encountered attempting to fit the 3-meter discus buoy (the last item aboard) on deck. It became clear at this time that the deck load would have to be rearranged and that a new methodology would have to be worked out in order to lift the buoy safely. Wecoma sailed for Pohnpei on 7 October with Plueddemann, Simoneau, Grant, and Bouchard aboard. Allsup returned to Woods Hole from Honolulu.

During the transit leg, instrument preparation was completed, including the remaining 14 Branckers, the ADCP, and three BACS releases. The broken Seacat was fixed by refitting one of the chips to the electronics board. The sonic anemometer electronics was set up and logging started. It was noticed that the high frequency shuddering of the ship while underway was causing substantial "shaking" of the buoy tower. The R.M Young wind sensors were removed and the VAWR vane blocked in order to minimize possible wear on the moving parts. An interesting quirk was discovered in the IMET system by Butch. If the UTC "midnight reset" of LOPACS occurs during a period when the aspirators are on, they will come back on line in off position. Thus it will take at least 10 min (10 counts of SW > 150) before they will turn on again. Trickle charging was done duringmost of the transit to keep the IMET battery pack fully charged.

Instrument work was nearly complete by 13 October, and a 24 hr met watch was started in order to independently monitor the met sensors and to develop confidence (or lack of same) in ship's sensors. Wecoma was outfitted with only minimal meteorological instruments, since the "special" met package had not been requested for our cruise. We found the only useful information from the ship to be GPS position, wind speed and direction, and barometric pressure. Handheld instruments were used to provided the remaining observations (air temperature, sea surface temperature, and relative humidity). From this monitoring several problems were found: Failure of the secondary IMET system due to a cracked stuffing tube nut, erroneous values from the VAWR relative humidity sensor due to water in the endcap (Paul suggests that this resulted from the sensor being "upside down" from its typical installation), and failure of the secondary IMET wind sensor due to a shorted pin. The stuffing tube nut and shorted wind sensor pin were fixed while underway. The VAWR RH sensor was replaced with the spare.

Section 1-4: Mooring Deployments

Upon arrival in Pohnpei on 17 October, we met up with the remainder of the scientific party. Joining the ship were Charlie Eriksen, Neil Bogue, Bob Reid, Carmen Martorella, and Chaz Wichman from UW, and Steve Hill and Don Lapishov from IOS. The morning of the next day, still in Pohnpei, we re-arranged the deck load, attached the bridle leg to the IMET buoy and took the opportunity to test the stability of the buoy during pick-up with the crane. Lifting from the designated pick-up point resulted in the buoy nearly falling over onto the sensor tower. It was determined that a special sling would be needed to make the crane lift safe and manageable, and that this sling would stay on the buoy after deployment, to be recovered via a small boat operation later. We departed Pohnpei 18 October without incident.

Three days of steaming brought us to the COARE IFA region. The UOP buoy was the first to go in, but we were worried by strong winds and rough seas the day and night before the scheduled deployment on 21 October. These conditions were the result of a succession of tropical storms, some strong enough to be typhoons, passing to the north of our position. The morning of the deployment showed some moderation of conditions, and we decided to proceed. We were very concerned with the methodology of attaching the VAWR temperature sensor on the chain between the bridle and the first VMCM and rigged up a mount which would allow the sensor to remain on the bridle if attachment to the chain was not feasible. The buoy was lifted from the (very crowded) fantail and over the starboard rail without incident, at which time the VAWR temp sensor was attached to the chain while the 4000 lb buoy took several large swings over David and Paul, held only by the release hook and tag lines. After this tense moment, the remainder of the deployment went relatively smoothly, finishing by about 1500 local.

Four hours of intensive (15 minute interval) meteorological observations were done immediately following the deployment as well as a CTD cast to 300 m. The shipboard and handheld met observations agreed well with both IMET and VAWR sensors on the buoy (figure 1-5a-j). Conditions of heavy rain during the observation period made independent of air temp and relative humidity difficult, and may have resulted in strong near-surface temperature gradients. A possible processing problem with the IMET barometric pressure was brought to light (figure 1-5f), but not considered serious. It was decided that it would be necessary to re-survey the ELSI site since the deployment was very depth-sensitive. This, in addition to general exhaustion, left no window for the IMET anchor survey, which we postponed until later. A compilation of sensors on the mooring was made (table 1-1) and forwarded to WHOI for use in securing insurance.

After a follow-up survey of the ELSI mooring site during the night, we began deployment of the mooring on 22 October. Steve Hill provided a new drawing of the upper portion of the mooring (figure 1-6), and indicated that the target depth for ELSI should be 25 m, not 20 m. The expected water depth was 2078 m, and the mooring length was adjusted accordingly. Some difficulties were encountered in setting the upper portion of the mooring due to lengths which could not be wound on the winch and could not be stopped off. The remainder of the deployment went smoothly. Pressures to survey the PCM sites meant foregoing the anchor survey. No CTD cast was done at this time.

Following the ELSI deployment on 22 October, four PCM moorings were set on four successive days. The weather was better, and these deployments went mostly without incident. After each PCM deployment, the anchors were surveyed, and a CTD cast was done at the time of the first PCM profile. During the transit from the East to North PCM sites, we stopped at the IMET site and completed the anchor survey (figure 1-7). After the last (West) PCM was deployed, we moved to the ELSI site, completed the anchor survey there (figure 1-8), and made a CTD cast.

Figure 1-5a,b. VAWR, IMET, ship and GTS sensor comparison wind speed and direction

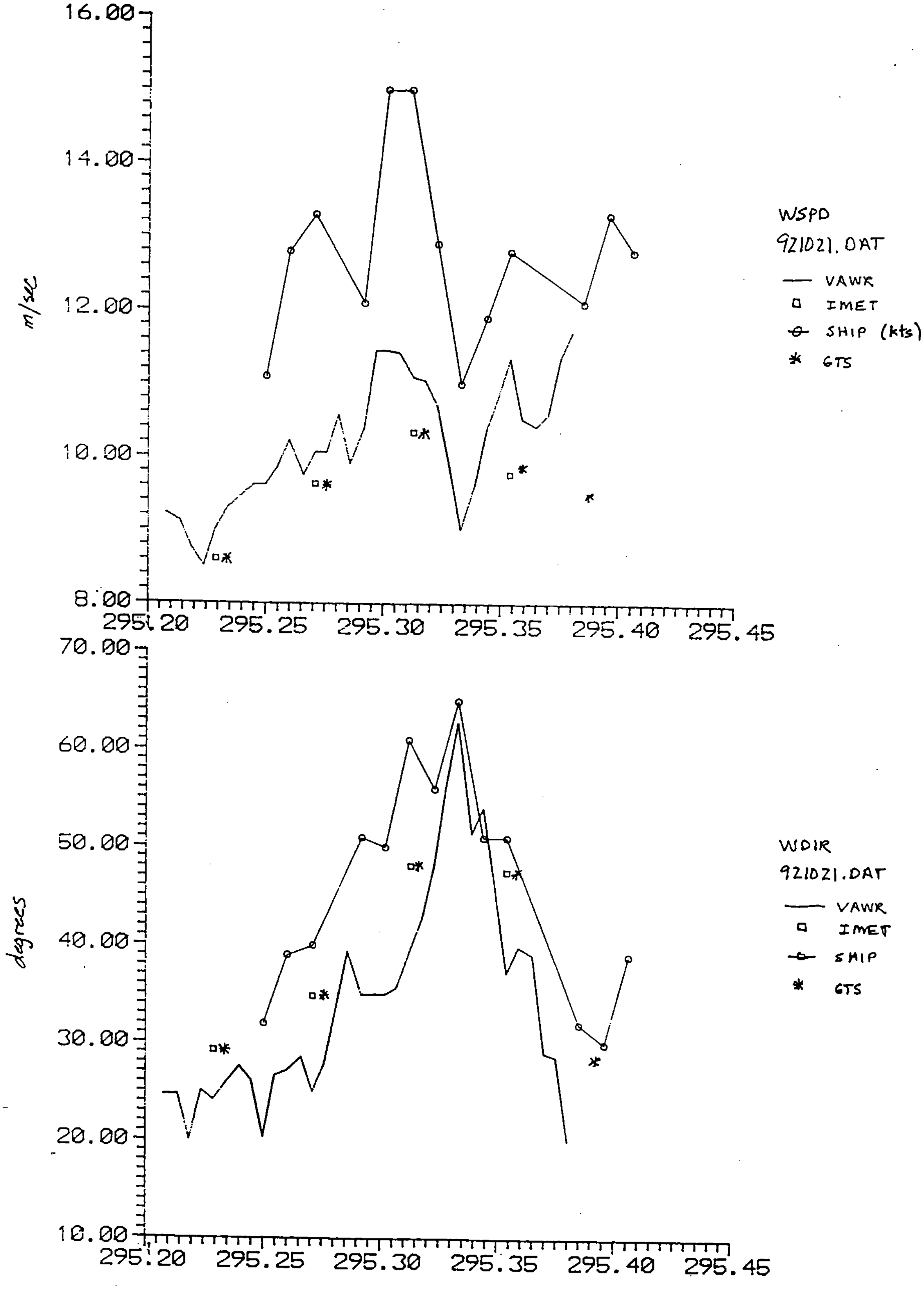


Figure 1-5c,d. VAWR, IMET, ship and GTS sensor comparison shortwave and longwave

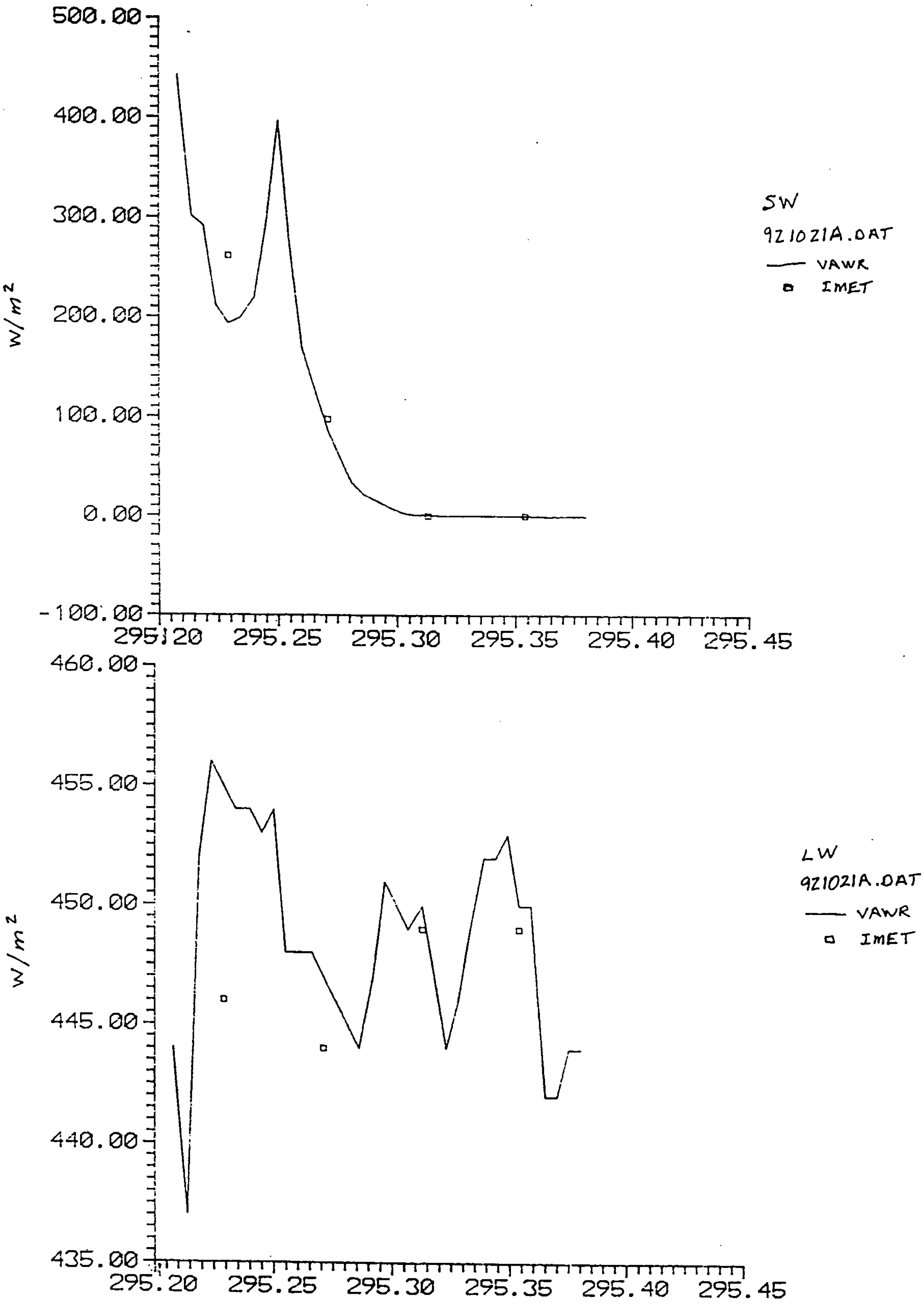


Figure 1-5e,f. VAWR, IMET, ship and GTS sensor comparison relative humidity and barometric pressure

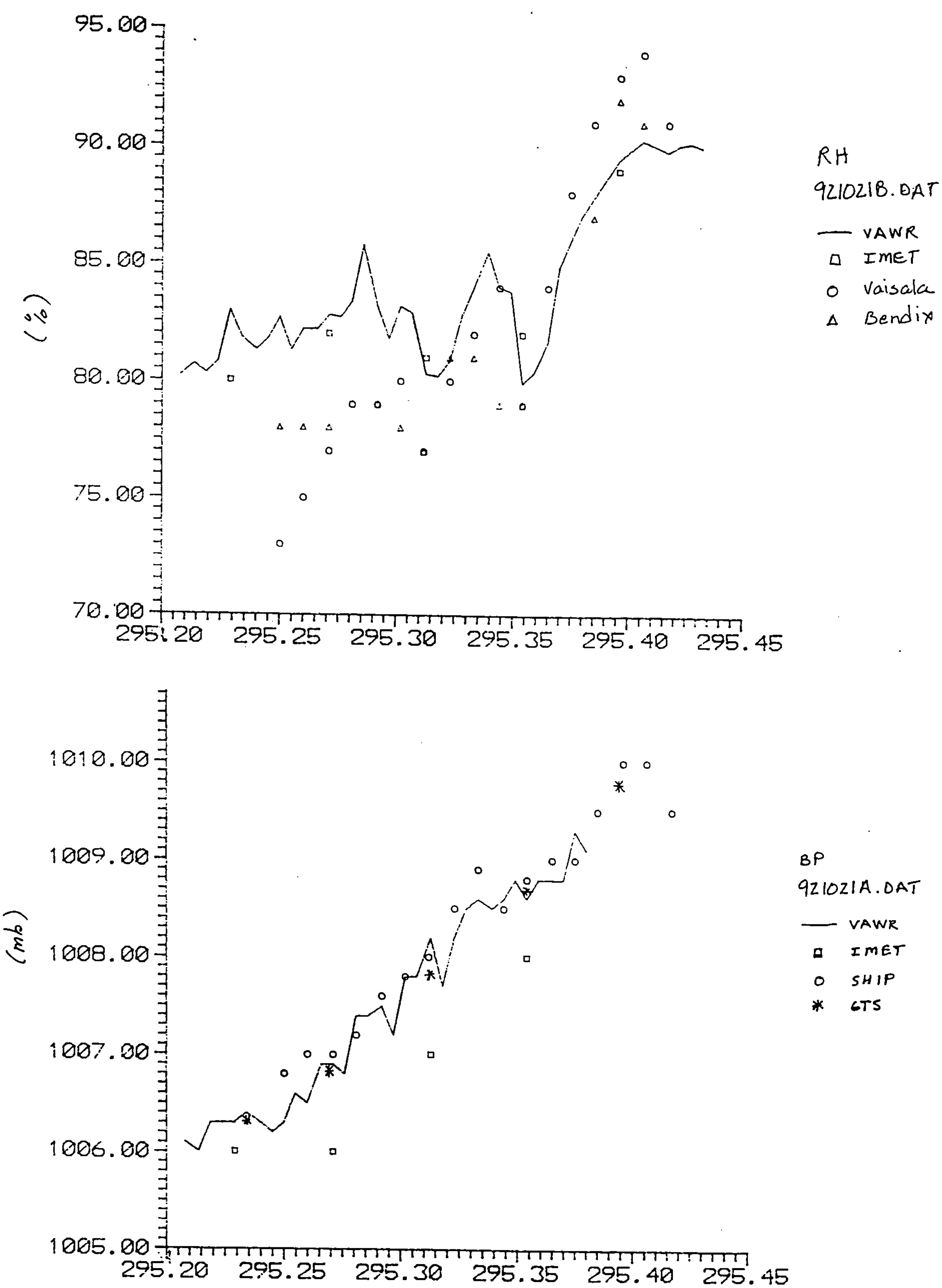


Figure 1-5g,h. VAWR, IMET, ship and GTS sensor comparison sea temperature and air temperature

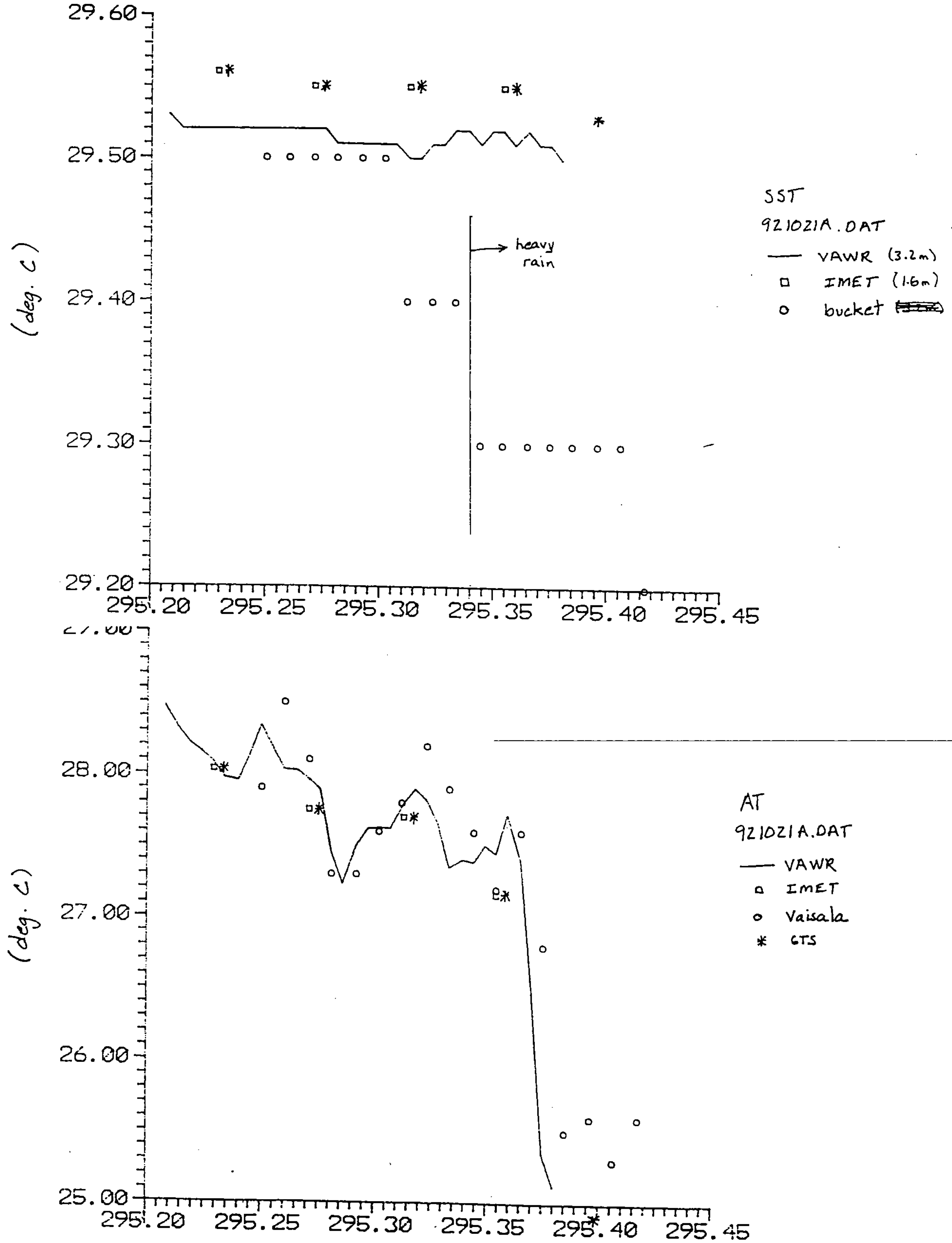
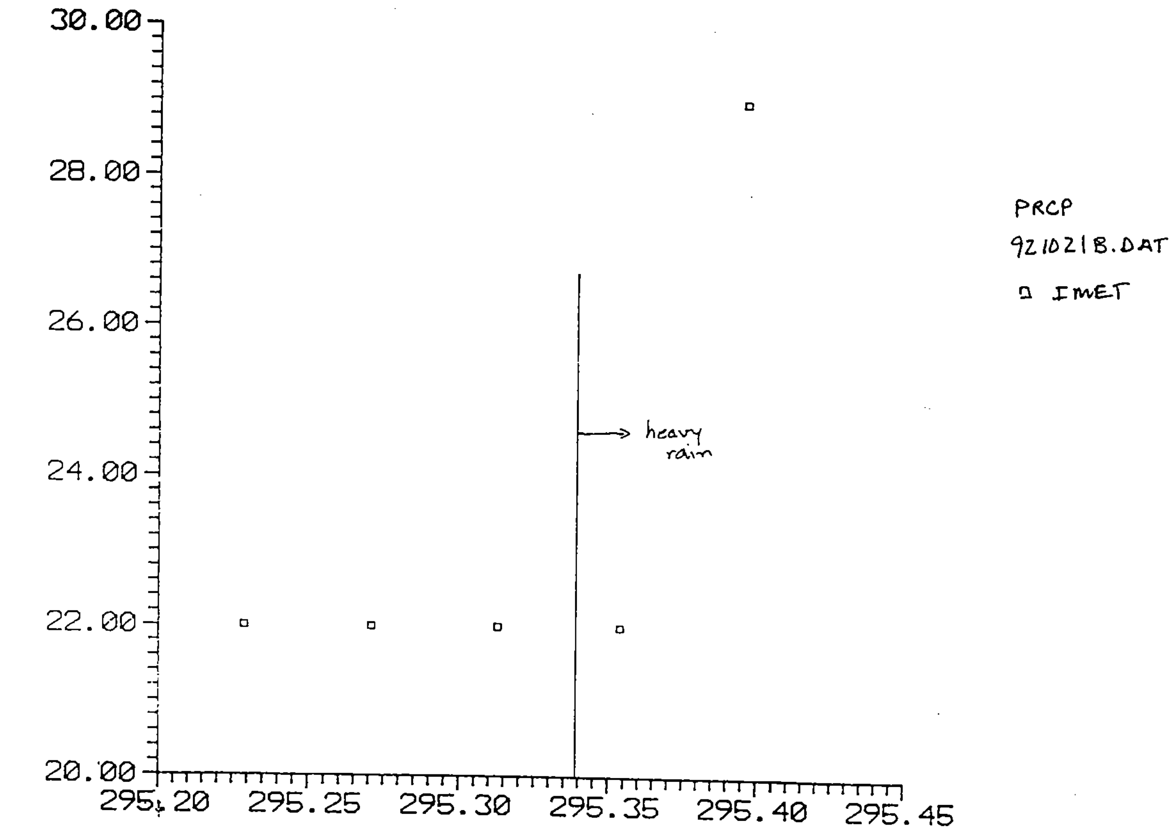


Figure 1-5i,j. VAWR, IMET, ship and GTS sensor comparison precipitation and tension



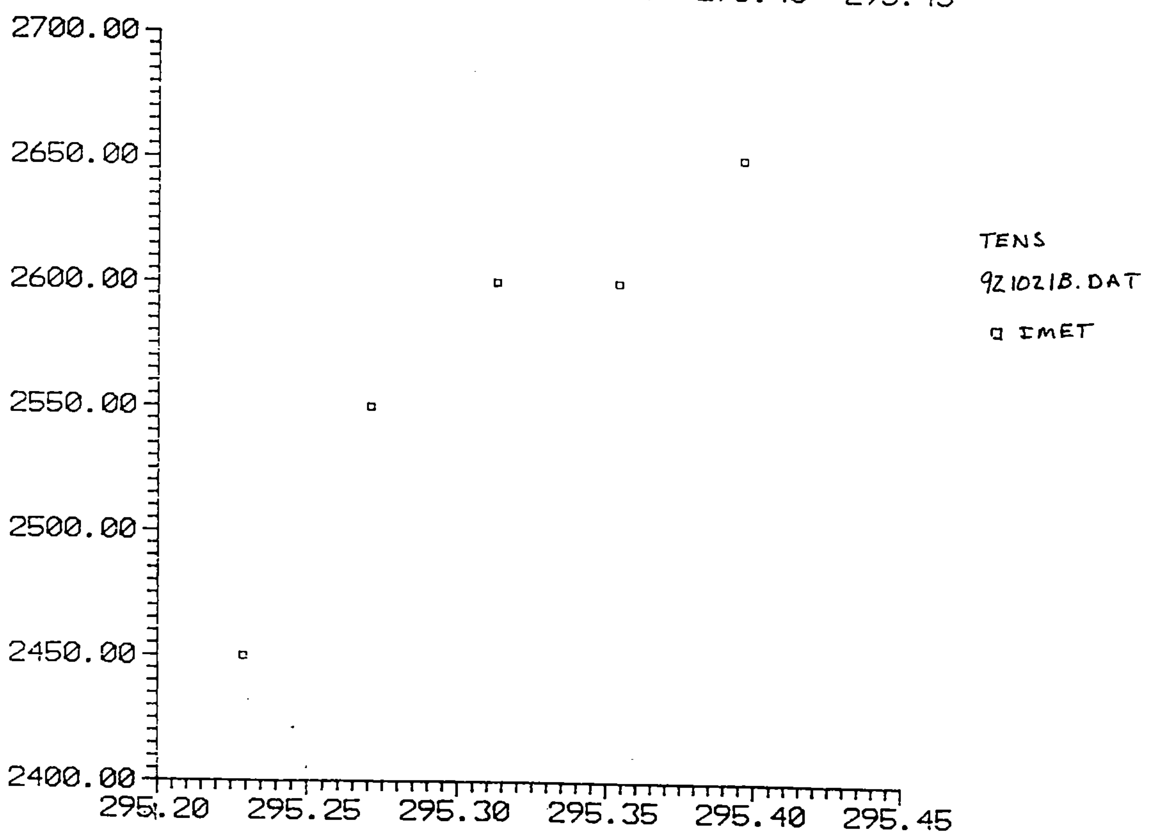


Table 1-1. UOP TOGA COARE Mooring Instrumentation

Time of deployment: 0430 UTC 10-21-92
Position: 1°, 45.27' S, 155°, 59.73' E
Water depth: 1744 m

Instrument	Serial No.	Depth
VAWR	723	-2.5
VAWR WIND	na	-2.5
VAWR SW	28315	-2.5
VAWR LW	27237	-2.5
VAWR RH	V-029	-2.5
VAWR BP	44149	-2.5
VAWR AT	T5850	-2.5
IMET WND01	111	-2.5
IMET WND02	112	-2.5
IMET SW	103	-2.5
IMET LW	003	-2.5
IMET AT01	110	-2.5
IMET AT02	106	-2.5
IMET RH01	110	-2.5
IMET RH02	102	-2.5
IMET BP	110	-2.5
IMET PRCP	109	-2.5
IMET PTM	001	-2.5
IMET PTT	107	-2.0
3-m discus buoy	na	0.0
Brancker T-pod	3667	0.4
Brancker T-pod	3705	0.5
Brancker T-pod	3838	1.0
Brancker T-pod	3832	1.5
Brancker T-pod	3699	2.0
Brancker T-pod	3839	2.5
IMET SST	109	1.6
Seacat	142	2.0
Tensiometer	43845	2.4
VAWR SST	T5502	3.2
PMEL T-pod	2011	4.65
VMCM	203203	5.15
Brancker	3308	5.65
Seacat	143	7.48
VMCM	401105	9.0
Seacat	928	11.5
VMCM	401004	13.0
Seacat	929	15.5

Instrument	Serial No.	Depth
VMCM	051	17.0
Seacat	991	19.5
ADCP	448	20.5
VMCM	203304	23.0
Seacat	992	23.5
Brancker	3761	27.5
VMCM	202803	31.5
Seacat	993	32.0
Brancker	3834	35.5
VMCM	202002	39.5
Seacat	994	40.0
Seacat (Tomczak)	1069	45.5
VMCM	203504	52.5
Seacat	995	53.0
Seacat (Tomczak)	1065	60
Seacat	141	68
Seacat (Tomczak)	1066	76
Seacat	144	84
Seacat (Tomczak)	1067	92
Seacat	927	100
Seacat (Tomczak)	1068	108
Brancker	3835	116
Seacat	146	124
Brancker	3301	132
Brancker	3762	148
Brancker	3701	164
Brancker	3763	180
Brancker	3836	196
WOTAN (Farmer)	8846	200
Brancker	3702	212
Brancker	3703	228
Brancker	3387	244
Brancker	3764	260
AMF Release	130	1714

Figure 1-6. ELSI Mooring Schematic modified 10/21/92

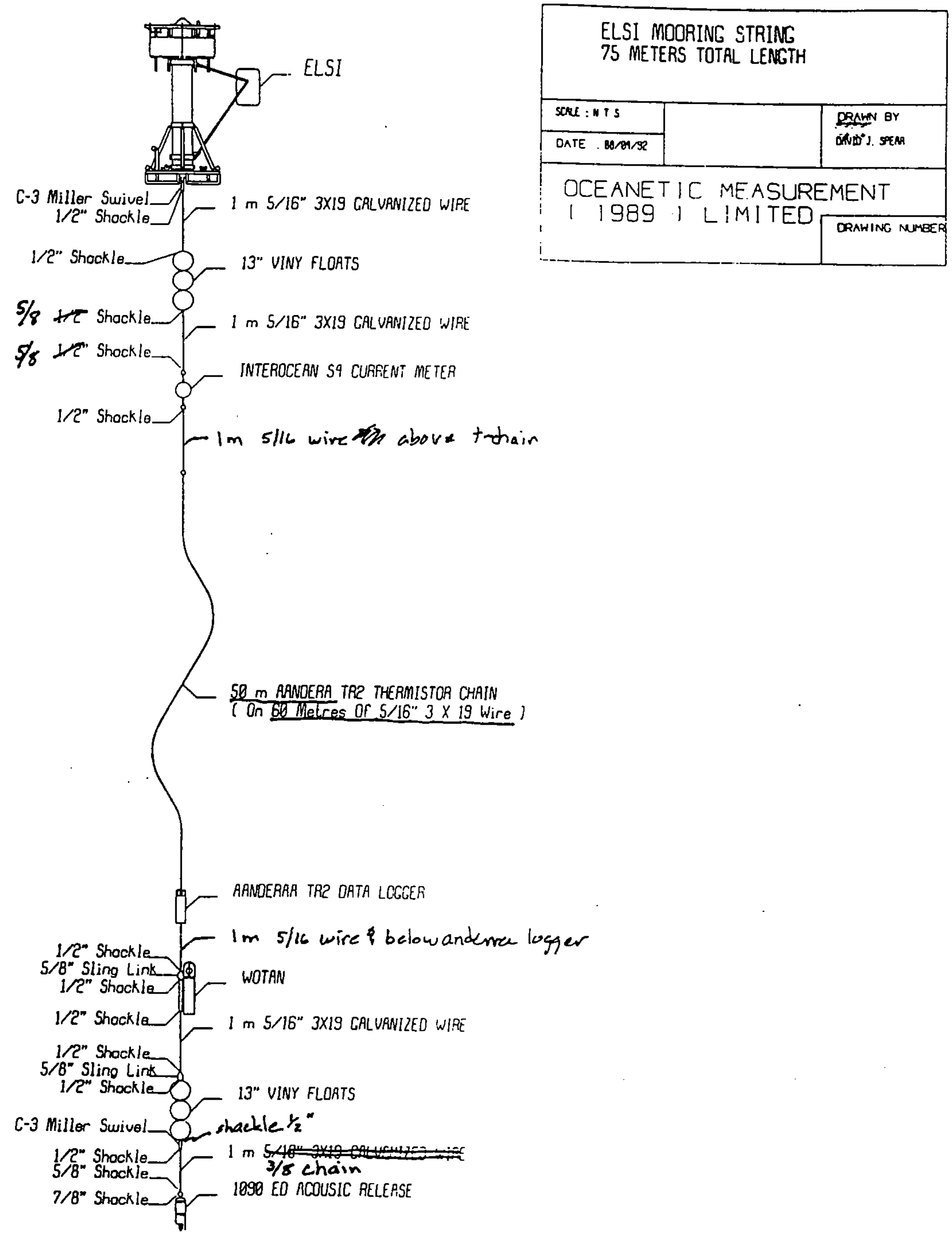


Figure 1-7. UOP Mooring Anchor Position

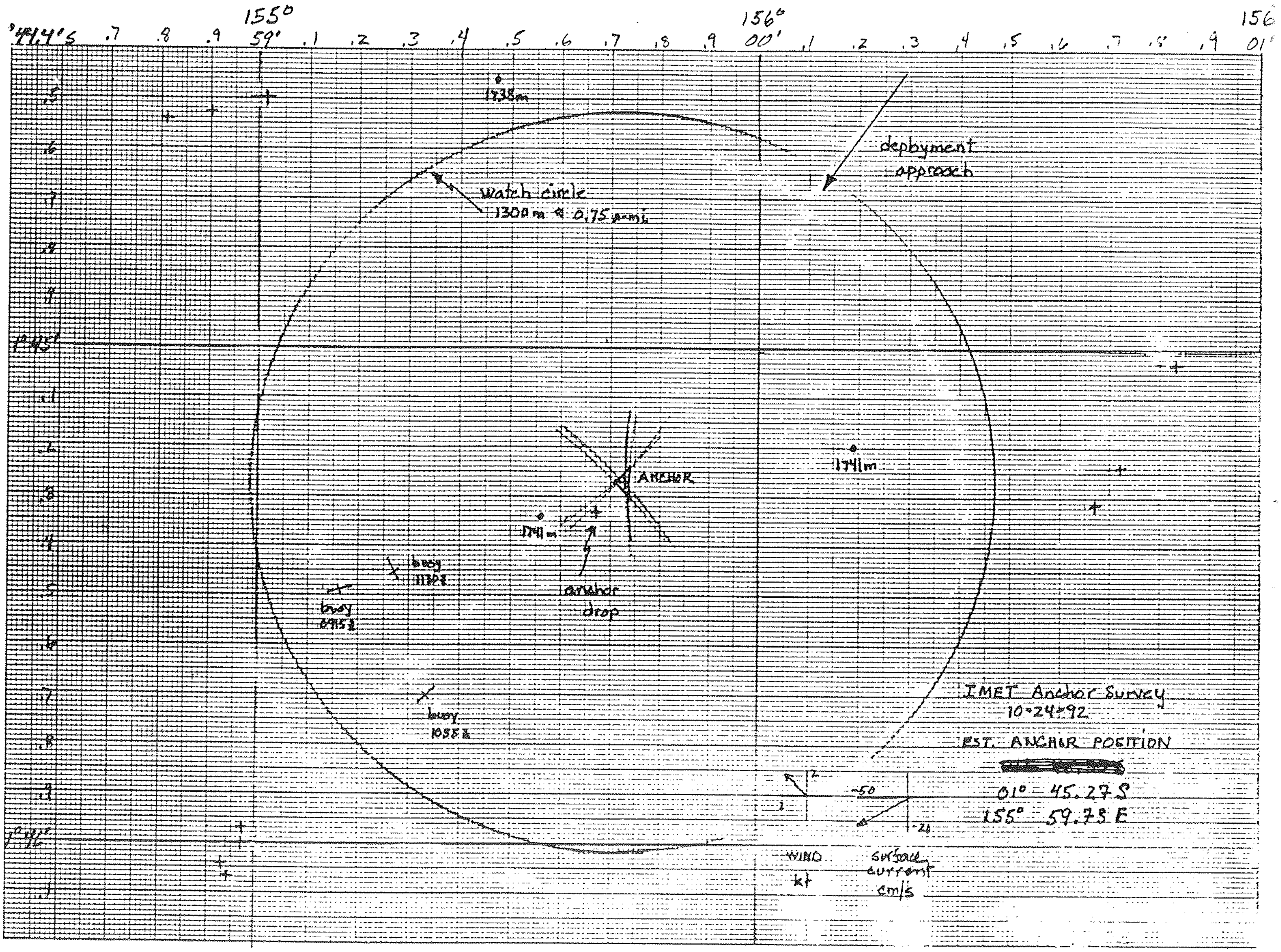
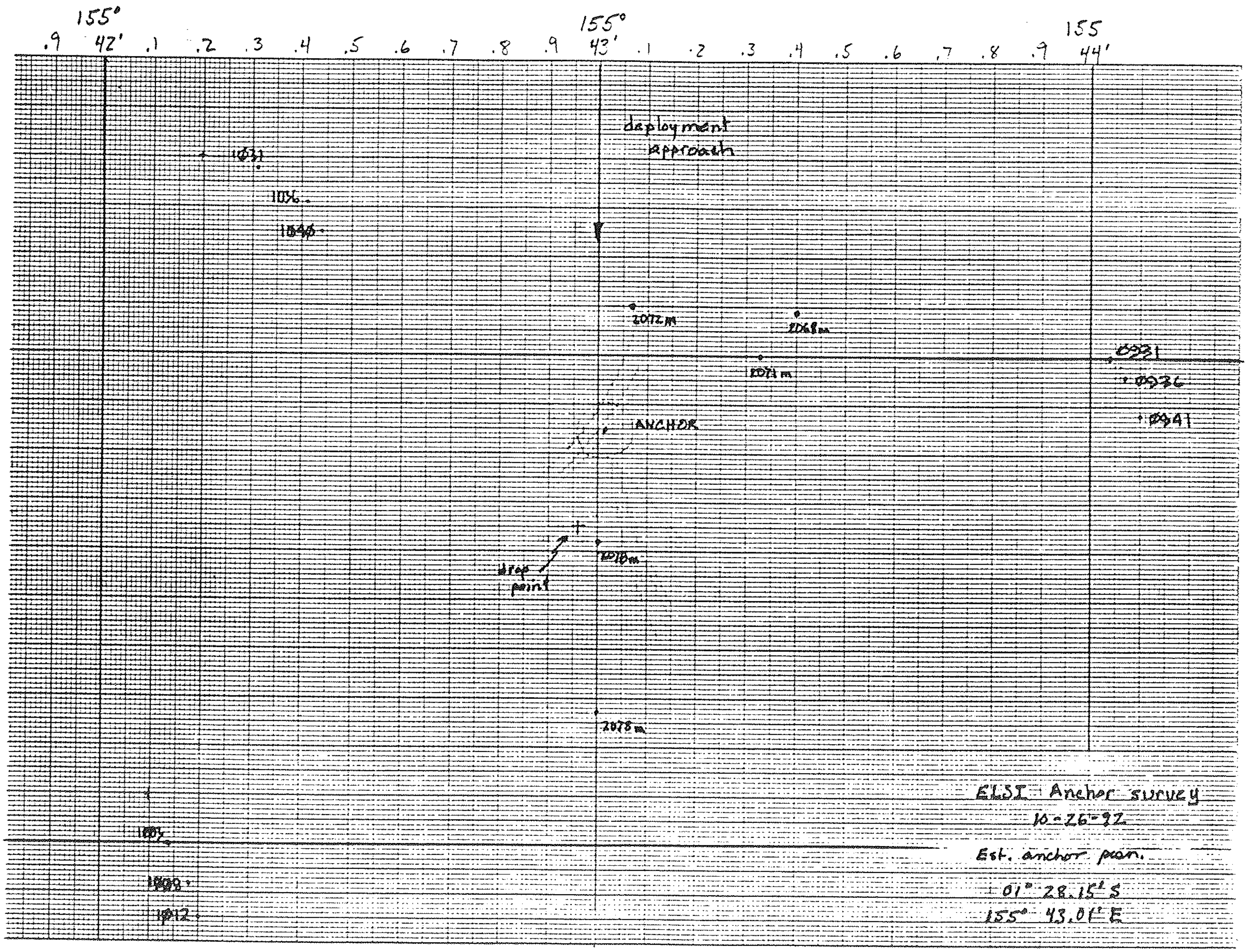


Figure 1-8. ELSI Mooring Anchor Position



With all of the moorings set, we began a transit of the IFA array on 27 October, intending to do CTD's at each mooring with Doppler surveys in between. The timing of visits to the PCM sites was dictated by the time of the PCM profiles, plus the desire to visit the UOP mooring site in daylight to retrieve the sling used in deployment. The survey was started by revisiting the North PCM site at 0000 local, then the South PCM at 0600. At this point we steamed back to the central site, arriving at about 1000 local. The ship's Zodiac was launched successfully in rainy weather with some swell, but little wind sea. Neil and Paul successfully recovered the sling, and reported that the solar panels on the buoy deck had been knocked vertical, presumably by wave wash. It was clear that the buoy was riding quite a bit lower in the water than immediately after launch, having only about 30 cm of freeboard. A second intensive met observation period was scheduled concurrently with the Zodiac operation, but again rain made quality measurements difficult, and the short duration of the stay on site (2.5 hr) resulted in little data for comparison.

During the visit to the UOP mooring site, trouble was encountered with the CTD and no cast was done there. We hoped to have the CTD fixed for the visit to the East PCM. However, it appeared that the problem was more serious, possibly taking until the next day to fix. At this point we decided to forego the redundant CTD casts at the remaining moorings and head home. This early departure from the IFA region got us into Guam on 1 November, one day earlier than scheduled.

References:

TOGA COARE International Project Office (TCIPO), 1992. TOGA COARE Operations Plan: Working version. University Corporation for Atmospheric Research, Boulder, Colorado.

Webster, P. J. and R. Lukas, 1992. TOGA COARE: The Coupled Ocean-Atmosphere Response Experiment. Bulletin American Meteorological Society, 73 (9), 1377-1416.

World Climate Research Program (WCRP), 1990. Scientific plan for the TOGA Coupled Ocean-Atmosphere Response Experiment. WCRP Publication Series, No. 3, Addendum, WMO/TD-64.

Acknowledgments:

The deployment operations were facilitated by the cooperation and assistance of the Captain and crew of the R/V Wecoma. Pre-deployment calibrations of UOPG instruments were done by R. Payne and W. Horn. The UOP and IOS moorings were designed by G. Tupper, fabricated at the WHOI rigging shop, and deployed at sea under the direction of D. Simoneau. B. Way and G. Allsup contributed to the pre-cruise preparation of hardware and instrumentation. C. Grant and P. Bouchard handled preparation of the mooring and its instrumentation at sea, and assisted in deployment operations. Personnel from the University of Washington and the Institute of Ocean Sciences, Canada also assisted in deployment operations. This work was funded by the National Science Foundation under Grants OCE-9110554 and OCE-9110559.

Appendix 1-1
R/V Wecoma Science Personnel, Cruise Number W9210A

Leg 1: Hawaii - Pohnpei

A. Plueddemann	WHOI	(Chf. Sci.)
D. Simoneau	WHOI	
C. Grant	WHOI	
P. Bouchard	WHOI	

Leg 2: Pohnpei - Guam

A. Plueddemann	WHOI	(Co-Chf. Sci.)
C. Eriksen	UW	(Co-Chf. Sci.)
D. Simoneau	WHOI	
C. Grant	WHOI	
P. Bouchard	WHOI	
N. Bogue	UW	
R. Reid	UW	
C. Martorella	UW	
C. Wichman	UW	
S. Hill	IOS	
D. Lapishov	IOS	

Part 2: TOGA COARE Mooring Check-out
R/V Le Noroit Cruise Report

Section 2-1: Introduction

On 3 November 1992, the satellite data telemetry from the IMET meteorological package on the WHOI UOP surface mooring that had been deployed as part of the TOGA COARE stopped transmitting to Service ARGOS. The last transmission from the IMET system was received at 2200 UTC. Four hours later, at 0200 UTC on 4 November, Service ARGOS received the last updated message from the VAWR mounted on the same buoy. In an attempt to understand the cause of the failures the R/V Monana Wave which was working in the area was asked to stop by the buoy and look for any obvious problems. With instructions from WHOI technicians, personnel aboard the Moana Wave conducted several tests to ascertain the condition of the IMET system. The information that was gained from those tests indicated that the problem was not trivial and any attempt at repair would require special hardware and personnel who were familiar with the buoy and it's electronics.

The R/V Le Noroit was asked if they could accommodate four WHOI technicians and if they would be willing to participate in the work required to repair the meteorological systems. Dr. Thierry Delcroix, chief scientiist aboard the ship agreed to help by offering space aboard the ship for the WHOI personnel and ship time to check out the buoy.

This report describes the buoy repair activities that were carried out aboard the Le Noroit.

Section 2-2: Mooring Check-out

The R/V Le Noroit departed Noumea, New Caledonia on Wednesday 2 December 1992. The primary purpose of the cruise was to conduct a CTD survey along 156° East between 5° South and 5 North latitude. The chief scientist was Dr. Thierry Delcroix of the ORSTOM Center in Noumea.

Four people from WHOI (Bryan Way, Geoff Allsup, Will Ostrom and Rick Trask) were on board to make a service call to the WHOI surface buoy deployed in October as part of the TOGA.experiment. The purpose of their visit was to repair the failed VAWR and IMET meteorological systems which had stopped telemetering data as of 4 Novemeber 1992 (year day 309). Previous visits to the buoy by the R/V Moana Wave had not been able to restart the IMET system or determine whether the VAWR was operational.

The ship arrived at the buoy on 9 December 92. Upon arrival a small boat was sent to the buoy with the WHOI contingent and two of the ship's crew. Visual inspection of the buoy sensors and cabling did not reveal any obvious problems. Attempts to communicate with both the VAWR and IMET were however unsuccessful. Since it was impossible to determine the operational status of both the VAWR and IMET externally a decision was made to recover the buoy and attempt a repair on board ship.

Prior to leaving the buoy the near-surface part of the mooring was inspected from the small boat using a diving mask. The VAWR SST housed in a stainless flexible tube was hanging down from the bridle and not connected to the chain directly below the bridle as it should have been. Eight instruments were visible from the surface. The propellers on the upper VMCMs all seemed operational.

With the mooring still anchored the ship backed down on the surface buoy. The small boat was utilized to attach the recovery lines to the buoy. The buoy was then pulled to the ship and lifted out of the water and placed on deck at approximately 0030 UTC 9 DEC 92. The mooring was stopped off on deck. This operation raised all the in-line instrumentation approximately 2 meters.. The mooring was disconnected from the buoy and transferred to a toroid buoy that had previously been placed in the water and tied off to the port side of the ship. A ten meter shot of 3/8" wire was put in-line below the toroid buoy so as to facilitate connecting the toroid to the mooring. The mooring was then lowered back into the water using a 36 meter long shot of polypropylene that had been shackled to the top of the UOP mooring (ie the bottom of the 10 m shot of wire below the toroid). The tension was then transferred to the toroid and the polypro was cast off with a polyform float tied off to the end. Beginning at about 0045 UTC 9 Dec 92 the mooring string dropped down 10 meters below its normal position. Le Noroit then got underway to the north to continue its CTD work.

With the bridle still attached the tower was lowered and the hatch opened. Moisture was detected in the well with a few drops of water on the IMET Lopacs and VAWR Argos transmitter. Approximately 1 or 2 cups of water were siphoned from the bottom of the well.

A problem was identified in the IMET primary sensor junction box. A failed component (FET) did not permit power to the modules. The failed component was bypassed and all modules could be addressed using a laptop computer. The lopacs however was not functioning properly. The original lopacs was replaced with a spare unit. The original lopacs was brought into the air conditioned lab and within several hours started working. The spare lopacs could not at first address all the sensor modules routinely. After disconnecting Wind 02 the lopacs was able to reliably address the remaining modules. The original Wind 02 (wind module number 112) was replaced with a spare wind module (wind module number 108). With this change the lopacs was then able to address both winds and all the other modules.

The RM Young speed and direction sensor of Wind 01 was replaced with the same components from the original Wind 02 (wind module number 112) which was no longer in use since it was causing problems when the spare lopacs tried to address the other modules The wind direction bearings in the original Wind 01 unit were rough and had a tendency to cog. The bearings from the original Wind 02 unit were in better condition and therefore the entire speed and direction assembly was used on Wind 01.

Another module problem identified on the IMET system was the sea surface temperature module. The original SST module (SST module number 109) was replaced with a spare (SST module 106). The original and the spare both have PVC pressure housings. After openning the original SST sensor a few drops of water were found inside the pressure case. The clamp used to hold the SST to the buoy bridle was a newer style compression clamp that held the module by compressing its end caps. This new clamp had been used because it was thought that the "clam shell" style clamps might be deforming the pressure case and causing a leak.

The VAWR Argos transmitter was openned and the Tattletale program within the controller was found to be unresponsive. Despite repeated attempts to talk to the Argos telemetry unit it remained unresponsive. The program had to be reloaded into the controller. Having done that the Argos telemetry unit started working properly. Since the cause of the log jamb in the tattletale program is unknown it was decided to replace the original ARGOS transmitter unit with a spare. The ARGOS IDs in the spare are however the same as the original unit.

The VAWR cassette data tape was removed from the instrument and read. The tape appears to have a full record despite numerous (8) clock resets. By piecing the various segments of data together it appears that the VAWR continued to record data up to the point where the tape was removed on board Le Noroit.

Since the cause of the repeated clock resets is unknown the original VAWR was replaced with VA184WR. The clock reset time for VA184WR is 0330 UTC 10 Dec 92. All sensors were replaced in their original mounts except SST which was mounted at the same depth as the IMET SST rather than on the chain below the bridle.

The compass and vane follower shipped with VA184WR had become corroded some time after being shipped for the original TOGA deployment. The shipping box had gotten wet which presumably caused the corrosion. Since they were suspect another spare compass and vane follower were used with VA184WR.

The discus buoy was redeployed at 0525 UTC 13 December 1992. A small shot of chain (approximately 1 meter in length) was inserted below the buoy inorder to reconnect the buoy to the mooring. The exact length of that additional shot of chain will have to be measured at the time of recovery. Following deployment the buoy was boarded in order to raise the Argos antennaes and to adjust the tower stays. Several photographs were taken of the near surface instrumentation using a camera and a homemade glass bottom bucket. The propellers on the 2 upper VMCMs were clearly visible and spinnning freely. After returning to the ship the ARGOS transmissions were checked and everything was working properly and the data appeared reasonable. The ship then got underway so as to finish the series of CTD stations before transitting to Rabual, East New Britain Island, Papua New Guinea.

Addendum

On 18 December 1992, the IMET meteorological system failed a second time and remained off the air for the remainder of the deployment. The VAWR continued to record and transmit data until the buoy was recovered on 4 March 1993.

Acknowledgments:

We are grateful for the skill of the captain and crew of the R/V Le Noroit. Their buoy handling techniques though different from the ones we are accustomed to turned out to be quite satisfactory. We especially wish to thank Theirry Delcrois for giving us the opportunity to visit the buoy and Joel Picaut for all the logistic support he offered while in New Caledonia. Without Joel's help we would never have received the equipment that turned out to be essential for the buoy repair prior to the ship's departure.

Part 3: TOGA COARE Mooring Recovery
R/V Wecoma Cruise Report WE93-02A

Section 3-1. Introduction

On 27 February,1993 at 1000 local RV Wecoma left Guam on cruise number WE93-02A. to recover the WHOI surface mooring, the four University of Washington / Draper PCM moorings, and the IOS subsurface mooring. On 1 March, clocks on board were moved ahead one hour to Pohnpei time. Figure 3-1 is a map showing the cruise track of R/V Wecoma on WE93-02A. The locations of the four surface moorings, central WHOI surface mooring, and acoustic (ELSI) mooring are shown in figure 3-2.

An attempt was made to reach the surface mooring by mid-day of 3 March and recover the mooring on that afternoon. Strong (1 to 1.5 knot) currents to the northwest slowed Wecoma and it was not possible to reach the UOP mooring with sufficient day light to complete the meteorological comparison and recovery. From approximately 1400 to 1600 local on 3 March, a preliminary comparison of hand held and ship meteorological sensors was carried out. At 1600 local Wecoma arrived at PCM N and carried out a 3 point survey of the anchor position. CTD #1 was taken at 2000 local near PCM N, and CTD #2 was taken at 2300 near PCM N.

At approximately 0000 local on 4 March, 1993 Wecoma steamed to the acoustic (ELSI) mooring. An acoustic survey of the anchor site was completed at 0330 local. CTD #3 was taken at 0400 local to coincide with the sampling of the Aanderaa thermistor chain. After the CTD, Wecoma steamed to the surface mooring. Visual inspection was made at approximately 0700 local, and two hours of ship-buoy meteorological inter-comparisons were made between 0730, see figure 3-6 for inter-comparison data. CTD #4 was made near the surface mooring beginning at 0950 local. The acoustic release was commanded to release at 1106 local. Surface mooring recovery was finished at 1415. At 1500, the ship got under way to the site of PCM W.

An anchor survey of PCM W was completed at 0500 - 0630 local on 5 March, 1993. CTD #5 was made near PCM W at 0800 local, and CTD #6 was made near PCM W at 1100 local. PCM W was recovered from 1230 local to 1530 local. Wecoma moved on to PCM S. An acoustic survey of PCM S was carried out between 2030 local to 2200 local. CTD #7 was made near PCM S at 2300 local.

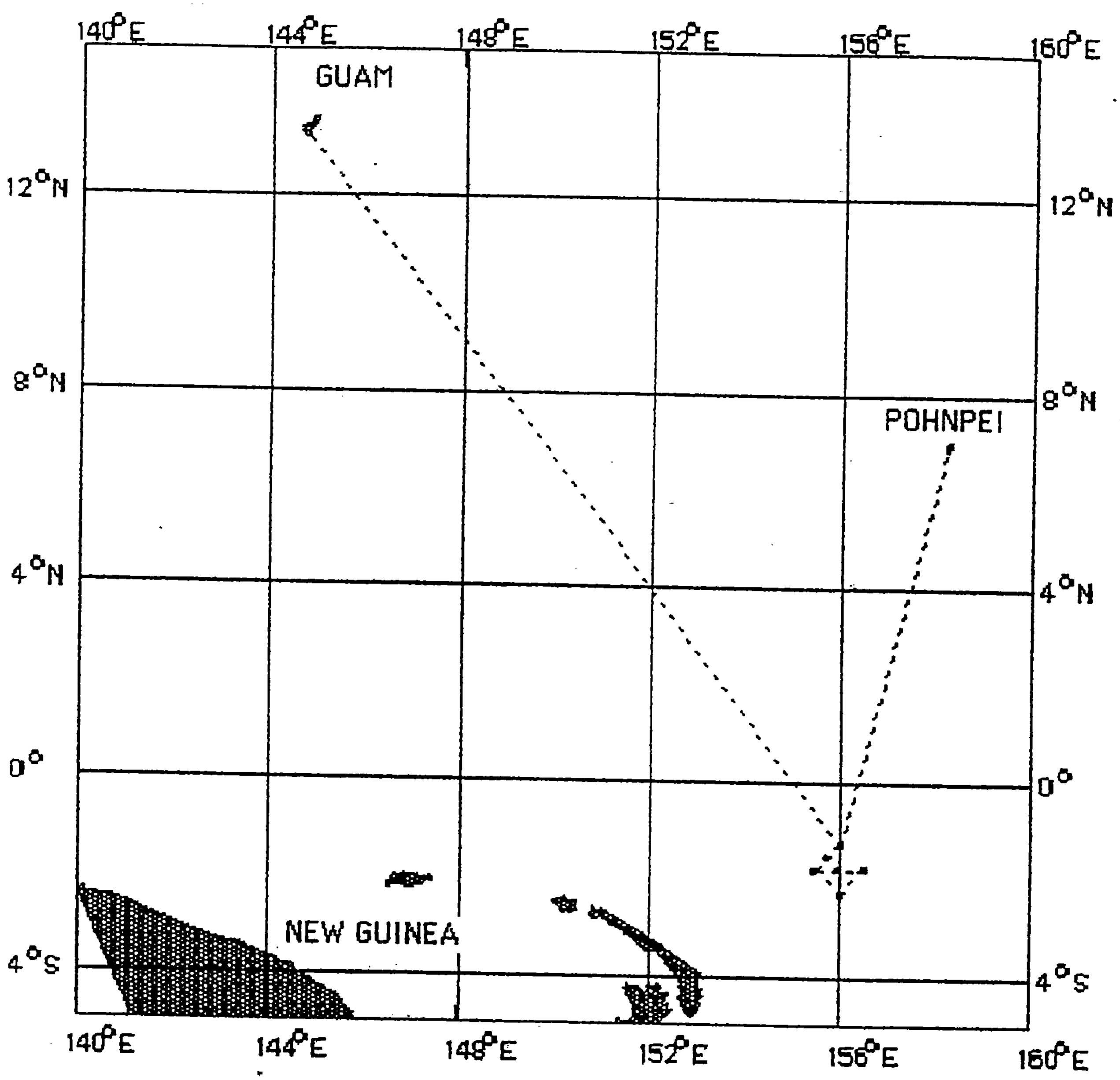
Wecoma steamed to PCM E, and an acoustic survey of the anchor was carried out beginning 0345 local 6 March, 1993. CTD #8 was made near PCM E at 0500 local 6 March, 1993. A failure of the controller of the hydro winch prolonged this CTD. Wecoma got underway toward the ELSI mooring at 0830 local. The ELSI mooring was recovered from 1300 to 1647 local on 6 March. After the recovery Wecoma steamed toward PCM S.

CTD #9 was made near PCM S at 0500 local, 7 March, 1993. PCM S was recovered from 0830 to 1130 local. PCM S was found to be flooded. Wecoma steamed north past the Atlas mooring at approximately 2° S, 156° E and on to PCM E.

CTD #10 was made at 0500 local on 8 March, 1993. PCM E was recovered from 0800 to 1100 local. Wecoma got underway to PCM N with a pause for engine maintenance.

On 9 March,. 0745 local PCM N was released and recovery operations completed at 1100. Wecoma then transited to Pohnpei arriving in port 11 March, 1993.

Figure 3-1. Map showing the cruise track of RV Wecoma on WE93-02A. The locations of the four surface moorings, central WHOI surface mooring, and acoustic (ELSI) mooring are shown.



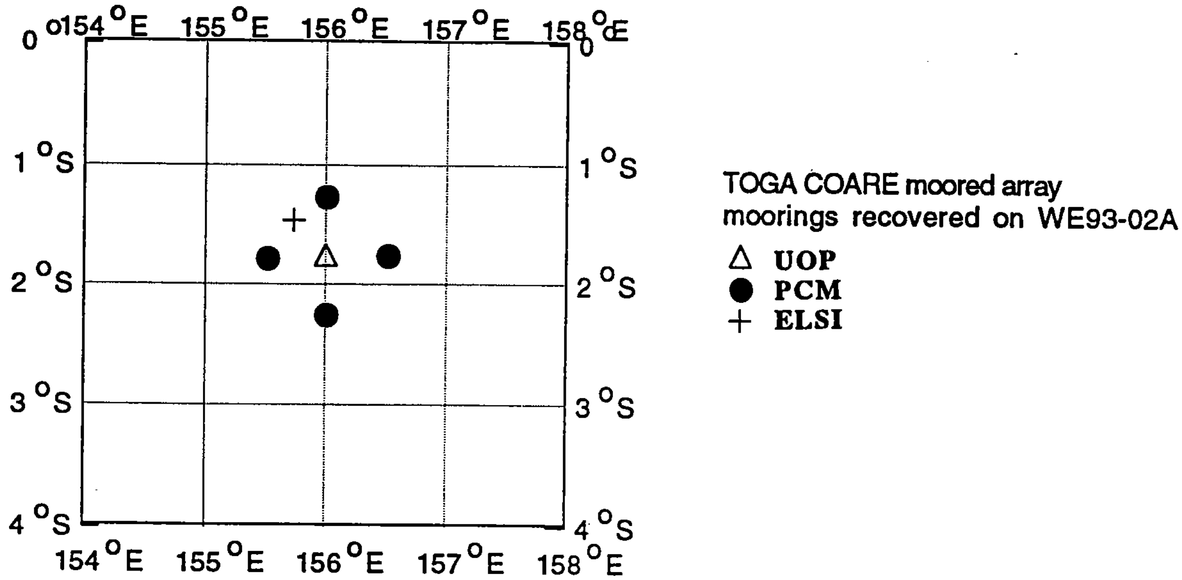


Figure 3-2. Mooring Positions for TOGA COARE IFA.

Table 3-1 TOGA COARE Mooring Positions

Mooring	Latitude	Longitude
UOP	1° 45.27' S	155° 59.73' E
ELSI	1° 28.15' S	155° 43.01' E
PCM N	1° 15.499' S	156° 01.001' E
PCM W	1° 46.500' S	155° 30.075' E
PCM S	2° 15.225' S	156° 00.425' E
PCM E	1° 44.315' S	156° 31.210' E

Section 3-2: The Mooring Program

A. UOP Surface Mooring Recovery

On 4 March, 0730 local the R/V Wecoma was positioned 1/4 mile down wind of the UOP discus mooring for visual inspection, and meteorological inter-comparison. Figure 3-3 details mooring schematic. The acoustic release was fired at 1106 and confirmation was made that the bottom of the mooring was coming up. The ship, then steamed slowly towards the discus buoy with the wind slightly on the starboard bow. The crane boom was at this time in position crowned up with the whip lowered to the ship's starboard rail, midships. The discus was hooked, using a standard Woods Hole pick up pennant into the main lifting bail and tension taken up from the ship's crane whip. The discus was raised to a height parallel to that of the main deck bulwark. The crane then slewing inboard, pinching the buoy into the ship's bulwark rail.

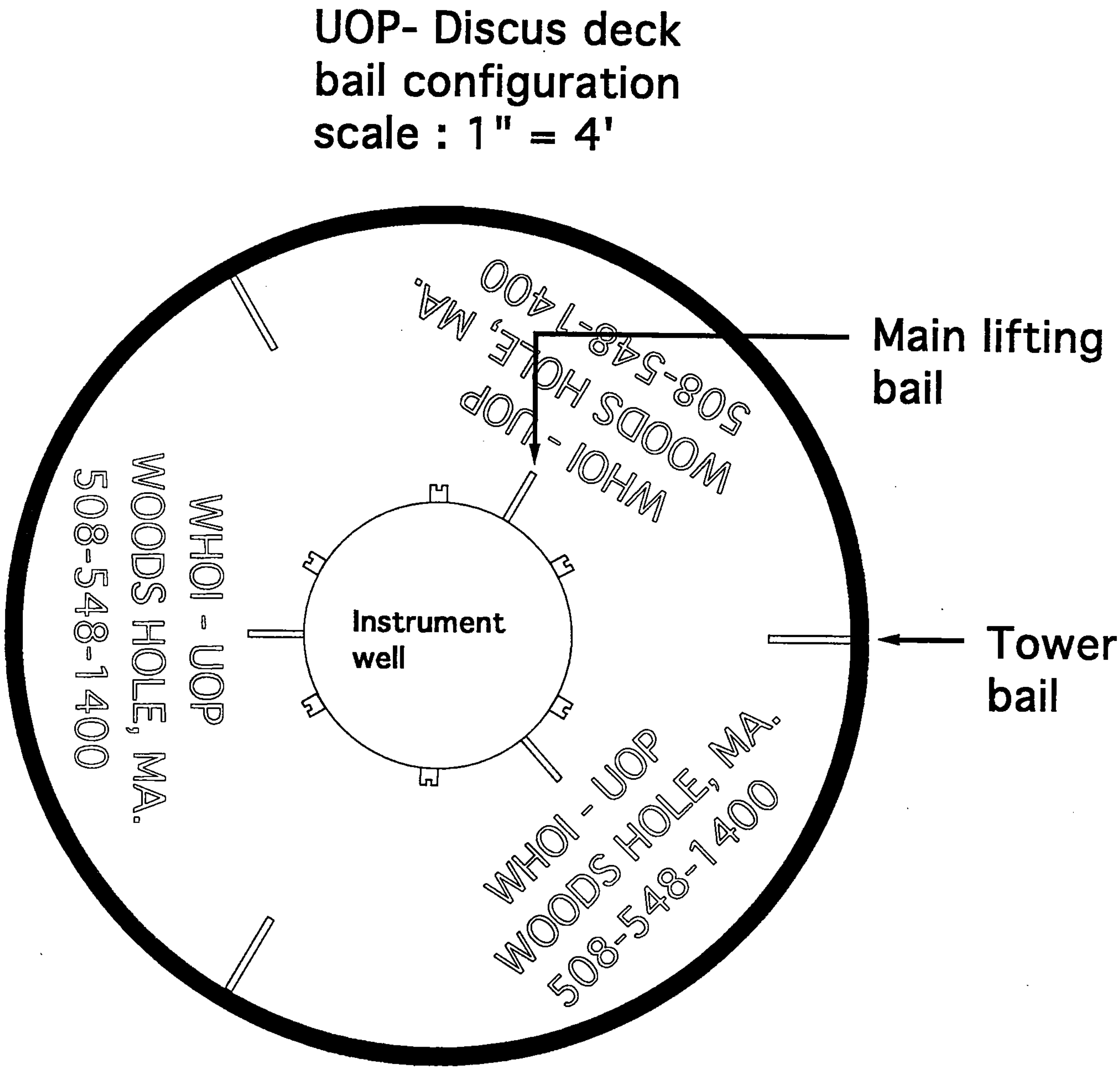
Two air tugger cables were hooked into two opposing tower bails, located on the deck of the discus (figure 3-3). These cables were fair leaded as such, one cable ran outboard to the ship's bulwark and the other tended inboard. These tugger wires were put in place to reduce port to starboard swing, once the buoy cleared up and over the ship's rail. While,the tuggers applied tension to the buoy, the hull was raised up approximately 4 ft. above the rail. This height was required to allow the 3/4"chain shackled to the apex of the bridle to be accessible for stopping off as the buoy transited inboard and down onto the deck.

A 3/4" chain grab shackled to a 1 1/2" nylon bull rope was then hooked into the 3/4" chain, apx. 2 ft. below the apex of the bridle. This line was then reeved around the ship's capstan. An additional checking line was tied to the bridle and tended forward to keep the buoy hull from swing aft. The crane was directed to swing slowly inboard, in conjunction with the three checking line controlling the discus swing. As the buoy transited over the side of the ship inboard, the capstan / bull rope was hauled up slowly taking the mooring tension away from the discus.

When the buoy had been swung completely inboard of the ship's rail the crane was instructed to lower the buoy to the deck. All checking line were hauled up and secured and wooden chocks wedged between the hull and deck. The bull rope was then hauled in enough to allow slack in the shackle connection between the bridle apex and the 3/4" chain. The bull rope was then secured to a deck cleat. The buoy at that time was chained to the deck. The shackle connection at the apex of the bridle was disconnected.

Due to the close proximity of instrumentation in the upper 25 meters in the mooring, see figure 1-3b, the crane was used to recover this segment, in the following fashion. The crane was positioned so that the crane whip hung vertical approximate 30 ft. over the mooring string, which was hanging over the starboard deck edge.The bitter end of the stopped off 3/4" chain that was disconnected from the apex of the discus bridle was hooked onto the crane whip hook. The crane whip was hauled up and the capstan line was eased off and removed.. The crane whip was raised up approximately 25 ft. to lift the first 2 VMCMs.up clear of the ships deck. The crane then slewed inboard and the capstan bull rope was re-hooked below the second instrument and secured to a deck cleat.. The crane whip then lowered the instrumentation down onto the deck.The VMCM's were unshackled from the stopped off mooring and removed. The crane whip was re-hooked into the stopped off shot at the rail and again was raised, lifting up the next section of the mooring string. This procedure was repeated 3 times until the 25 meter depth VMCM.was recovered.

Figure 3-3. Discus Deck Bail Configuration



The TSE mooring winch tag line was passed through the Gifford mooring block which hung in the center of the ship's A-frame and around the starboard aft quarter of Wecoma. The crane whip was then lowered and hooked into the first 5.39 m wire shot and tension taken up and the capstan / bull rope was removed. The crane then lowered its boom outboard and slewed aft out around the discus hull and tower, towards the TSE tag line bringing the mooring string to the tag line. This wire termination was lowered to the TSE tag line and shackled together. A short length of 3/4" nylon slip line was reveed though the pear ring at that termination and made fast to the ship's rail. The crane whip was then lowered to allow the mooring tension to shift to the slip line The crane whip was removed. With the A-frame extended out board, the slip line was paid out transferring the mooring tension to the TSE tag line. The time was 1238 local. The remainder of the mooring was recovered in the standard Woods Hole subsurface mooring procedure(Heinmiller, 1976).

The following personnel were required for this operation:

1 mooring operations leader
2 capstan operators
2 air tugger operators
1 crane operator
2 tag line handlers
1 mooring log recorder

B. PCM Array

The TOGA COARE Profiling Current Meter (PCM) array consisted of four sub-surface PCM moorings, PCM-N, PCM-S, PCM-E, and PCM-W, each set one-half degree (approximately 55.5 kilometers) due north, south, east, and west, respectively, of the UOP mooring.

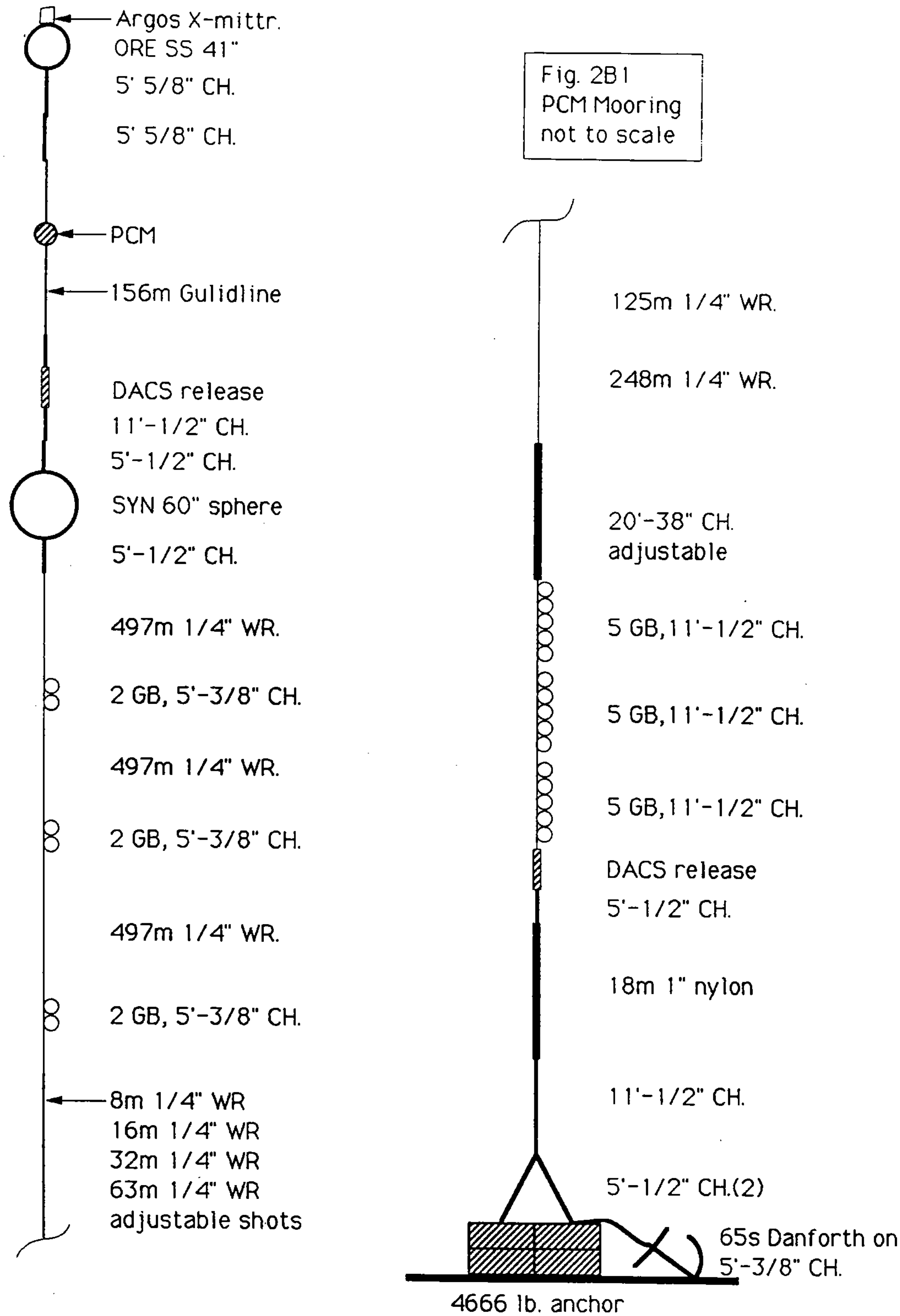
The PCMs and their moorings are designed and prepared by the Charles Stark Draper Laboratory, Cambridge, MA, under contract to Dr. Charles Eriksen of the University of Washington School of Oceanography . The moorings were set and recovered by personnel from CSDL, UW, and WHOI.

This section of the report will describe a typical PCM mooring and its recovery, followed by short comments on each individual mooring recovery and instrument performance.

The PCM mooring is designed to be released in two parts. The upper part consists of a 41"-diameter ORE sphere at about 20 meters depth, followed by a 180-meter plastic-jacketed stainless steel guide line on which the PCM profiles, and then an acoustic release (figure 3-4). The lower portion of the mooring starts just below the upper acoustic release with a 60" diameter syntactic foam float, followed by sufficient plastic-jacketed 1/4" wire rope for the depth of the mooring, then glass balls for backup floatation just above the bottom release.

Mooring recovery requires six people: a mooring operations coordinator, a winch operator, two people to operate air tuggers, stopper lines, handle the PCM, and assist on the fantail as needed, and one recorder/safety observer. In addition, the Wecoma's bosun usually operated the A-frame as required and the marine technician assisted on the fantail and served as a safety observer.

Figure 3-4. PCM Schematic



The typical PCM recovery began with the ship positioned about 0.5 nautical miles down-current from the mooring position, confirmed by acoustic survey. The upper release was fired and in less than one minute the ORE sphere was on the surface, floating with the ARGOS transmitter upright and vertical.

The ORE spheres floated with the lifting ring downward. A tag line was rigged with tape to the end of a pick-up pole, with the bitter end made fast to the rail. The ship approached the sphere and brought it close aboard along the starboard side. One person passed the loop of line around the sphere, brought it back to the ship and made it fast. Additional tension on this line capsized the float and exposed the lifting link or bail. A standard WHOI pick-up sling and pole was used to hook into the sphere. The end of the lifting sling was shackled into the 1-1/2" Samson braid line spooled on the TSE winch. The ORE sphere was then lifted through the A-frame, and with two people lifting on the ARGOS transmitter housing to keep it off the deck, the sphere was lowered to the deck.

Immediately below the ORE sphere is chain, a shock absorber, and the top stop of the PCM guide-line. We tied a tag line to the PCM guide line and let it fetch up against the top stop, then used that line to hold the mooring while we disconnected the ORE sphere.

Once the PCM guide-line was connected directly to the winch line, and the ORE sphere was rolled out of the way, we hauled in on the PCM guide line. The hauling was stopped with the PCM spherical housing at the water's edge. A safety line (tag line with a bowline in the end for making a slip knot) was looped around the PCM and brought taut around the neck of the PCM just above the main spherical hull, but below the conductivity probe arms. The PCM was then lifted through the A-frame and held just above the deck while it was placed in its cage. The top release was hauled in by hand to complete the recovery of the top section of the mooring.

The bottom release was fired from a distance of 0.75 nautical miles. The orange 60" syntactic foam sphere appeared on the surface (from 200 meters depth) in about three minutes. The 20 glass balls followed approximately 15 minutes later, arriving at the surface about 50 meters upwind of the orange sphere.

Recovery of the orange sphere was similar to the recovery of the ORE sphere. A loop of line was passed around the ball to hold it in place. Capsizing was not necessary and a lifting hook was placed in one of the sling links attached to the chain draped over the top of the ball. This lifting hook's attached sling was shackled to the Samson braid on the winch and the ball lifted to the counter. Air tugger lines were clipped into the bails on the equator of the sphere and used to guide and steady the sphere into a ring stand placed on deck. The ring stand was placed just forward of the starboard A-frame pedestal and the ball was lifted through the A-frame and pulled into position with the tuggers. The winch operator then lowered the orange sphere into the ring stand. From there on, it was a standard recovery of wire and glass balls. The twenty balls at the bottom of the mooring came up in one clump and were all lifted aboard through the A-frame in one lift, using the air tugger to pull the balls inboard and forward. Once again, the release was pulled in hand-over-hand at the counter.

The entire process from first release firing to last release on deck was about three hours for PCM moorings of around 2000 meters depth.

The following are brief summaries of each PCM mooring recovery, instrument condition, and data return.

PCM-W (S/N 07, Mission 1): Top release was fired at 0033Z, 6 March 1993. The entire mooring was aboard at 0437Z, the extra time due to multiple approaches to each sphere before being able to reach an hook them. The profiling line was fouled with goose-neck barnacles. On-board memory dump showed only 12 successful profiles before depth readings indicate 0.0 meters. The instrument may have functioned as a fixed instrument at the bottom stop for the duration of the deployment.

PCM-S (S/N 03, Mission 5) Top release was fired at 2129Z, 6 March 1993. The entire mooring was aboard at 2355Z. The profiling line was fouled with barnacles on the upper one-third, but clean on the lower two-thirds. As the PCM came into view it was clearly venting air from its equatorial joint as large clouds of bubbles trailed the instrument. The system was flooded. No data was recoverable at sea, although some tape had been written prior to the failure.

PCM-E (S/N 04, Mission 5) Top release was fired at 2054Z, 7 March 1993. The entire mooring was aboard at 2323Z. The profiling line was clean and the instrument was mechanically sound. The on-board data dump showed the instrument profiled every three hours for the duration of the deployment; it completed 1077 profiles The current probe was inoperative the entire mission. Temperature and conductivity profiles were nominal.

PCM-N (S/N 06, Mission 2) Top release was fired at 2046Z, 8 March 1993. The entire mooring was on deck at 2320Z. The profiling line was clean and the PCM was in good condition. The on-board data dump revealed the instrument profiled throughout the deployment, and completed 1076 profiles. All sensors operated normally and yielded nominal values. Battery levels on instruments 4 and 6 showed sufficient reserves for an additional 1.5 months of profiling.

C. ELSI mooring

ELSI (Extended Life Sonar Instrument) was deployed on a separate mooring (figure 1-4). The upper 75 m of this mooring was prepared by IOS, and had a separate release attached to the lower approximately 2000m of the mooring, which was prepared by Woods Hole Oceanographic Institute, under contract to IOS. The upper face of ELSI was estimated on deployment to be at 26m from the surface in a zero-current environment. In addition to ELSI, there were also an S4 current meter at 7.5m below the top of ELSI, a 50m thermistor chain (11 thermistors at 5m intervals) starting 65m below the top of ELSI, and a 6-channel WOTAN 70m below the top of ELSI.

ELSI is mainly an acoustic instrument, with 4 upward looking sonars operating at 55, 110, 200 and 300 kHz. These send both short uncoded and long coded pulses toward the surface. The short pulses are used to determine the fine-scale bubble size distribution with depth above the instrument, and the long coded pulses can be used to measure the vertical velocity as a function of range above the instrument. In addition there are 4 sidescan sonars directed to the side, at 45 SYMBOL 176 /f "Symbol" intervals in the horizontal plane. The fan-shaped beam is oriented so that it is narrow in the horizontal plane and wide in the vertical plane. Thus the beam intercepts the surface at a minimum horizontal range roughly equal to the depth of ELSI, and a maximum horizontal range of roughly 250m. The long coded pulses at 100 kHz can be used to infer bubble cloud distributions and radial velocities with range out to roughly 300m. As well as these active acoustic sensors, there was also a hydrohone measuring ambient noise in the 50 Hz to 20 kHz band. Other sensors on ELSI included: Seabird temperature and conductivity sensors and a Paroscientific pressure sensor, which were sampled at 2 Hz during acoustic sampling periods; and an experimental total dissolved gas sensor, which was mounted near the Seabird sensors.

The ELSI mooring was recovered on 6 March. The upper portion was released at 0215 UCT, and ELSI was sighted at the surface at 0217 UCT. Recovery proceeded without incident: the only damage was a broken antenna on an RDF beacon. There was heavy biofouling on ELSI and on the other instruments, although there were very few of the ubiquitous gooseneck barnacles: most of the fouling was algae. Recovery of the lower portion of the mooring began at 0350 UCT, and again proceeded smoothly, without incident.

Preliminary indications are that ELSI remained in operation throughout the entire period of the Intensive Operating Period, and has a full set of data tapes on board. The S4 current meter also has a full memory, and the thermistor chain has a full tape of data. Assessment of the quality of all these data sources will await the return of the instruments and tapes to IOS. Unfortunately, the 6-channel WOTAN arrived at the surface flooded, and appears to have been flooded from the beginning of the deployment, with no hope of any data available from that instrument.

Section 3-3: Instrumentation and Sensor Summary

Initial observation UOP mooring recovery

Prior to recovery of the UOP surface buoy, data was collected from the VAWR via a Telonics satellite up-link receiver. During a 2 hour period, intense meteorological measurements were collected from the Wecoma's met system and from hand held meteorological sensors. (see figures 3-5a-e). The acoustic release was then interrogated and fired at a range of 3195 meters.

IMET

The IMET system ARGOS transmitter did not appear to be functioning upon recovery. After the buoy was secured on deck, an attempt to communicate with the Lopacs inside the well was unsuccessful. The two R.M. Young propeller bearings spun smoothly. Both, the Longwave and Shortwave solar sensors had minimal dust and grim on their domes. There were no signs of damaged cables on the tower. The primary and secondary sensor junction boxes were dry. The two solar panel junction boxes were also dry. The battery voltage for the IMET system was up around 13 volts. The Lopacs was removed and placed in the main lab. Power was applied using a portable power supply. Initial power turn on showed no response from Lopacs, after brief inspection , found that a 3A fuse was blown. The fuse was replaced and the Lopacs was powered up, and the system booted up at this time. The Lopacs then began to run the TOGA logger program. A directory of the optical disk showed that the last file written, was on 18 Dec. 1992, the approximate time that IMET stopped transmitting ARGOS data.

VAWR

The VAWR was transmitting good data upon recovery. The R.M. Young cup bearing was spinning smoothly. The Shortwave and the Longwave solar sensors had minimal dust and grim on their domes. All sensors on the VAWR looked excellent. The VAWR SST was placed at a depth of 1.6 meters on the bridle leg. The Shortwave solar sensor was black bagged for 39 minutes to show a time mark on the tape. The VAWR was then removed from the tower top and placed in the main lab. The instrument was pulled from its case for tape removal and down cruise. The tape had pulled for the entire deployment. All battery voltages were good. The VAWR was recording data every 7.5 minutes..

Subsurface Instrumentation

There was a total of 51 subsurface sensors and instruments attached to the UOP mooring. Table 3-2 shows the depths and serial numbers of each instrument and sensor as deployed.

VMCM

A total of 8 VMCM's were deployed on the UOP mooring. All the VMCM's had very minimal growth on the propellers and the cages. The VMCM record rate was set at 3.75 minutes. Once the instruments were cleaned, they were placed in the lab for uncasing and down-cruise. All instruments pulled tape for the entire deployment. The battery voltages were all good, and the propeller spin down checks were all excellent. Some of the VMCM's had other types of instruments attached to their cages and these will be discussed later.

SEA-CATs

18 SEA-CATs were deployed with a variety of mounting techniques used. 12 SEA-CATs were mounted on in-line load bars, 4 on VMCM cages, 1 on the ADCP, and 1 on the bridle leg of the discus buoy. The following VMCM's had SEA-CAT's attached to their cages:

VMCM S/N	SEA-CAT S/N
203304	0992
202803	0993
202602	0994
203504	0995

Out of the 18 SEA-CAT's, 3 were an older version and had a sampling rate of 5 minutes, the remaining 15 were sampling at a rate of 225 seconds. All of the SEA-CAT's except one had a full data record in their memory. One SEA-CAT, S/N 1065 had taken water, and was unrepairable at sea, the memory chips looked good, so some data may be recoverable. The leakage path could not be determined at this time.

BRANCKER

There were a total of 19 BRANCKER temperature data loggers deployed in various ways on the UOP mooring. The UOP hinged style clamp was used for the in-line type. Thirteen were deployed in this fashion. One BRANCKER was placed on VMCM S/N 203203. The remaining 6 BRANCKERS were attached to the aft bridle leg of the buoy from a depth of 0.4 meters to a depth of 2.5 meters. These 6 had thaller type shield to compensate for solar heating near the surface. All the shields and the loggers were painted white as another precaution for solar heating. The BRANCKER's were set to record every 15 minutes. All 19 loggers had full data records in their memory. One logger S/N 3837 had taken water, and would communicate, its eprom was the removed and placed in another logger and communications were established and it had a full data record in its eprom.

PMEL

The PMEL MTR is a miniature temperature recorder. It was set to a record rate of 7.5 minutes. There was one on the UOP mooring, which was deployed on the cage of VMCM S/N 203203. The PMEL logger had a full data record in its memory.

Table 3-1. UOP Mooring Sensor IDs

TEMPERATURE SENSORS

Depth (METERS)		Serial Number
0.40	BRANCKER	3667
0.50	BRANCKER	3705
1.00	BRANCKER	3838
1.50	BRANCKER	3832
2.00	BRANCKER	3699
2.50	BRANCKER	3839
7.65	BRANCKER	3308
29.50	BRANCKER	3761
37.50	BRANCKER	3834
118.00	BRANCKER	3835
134.00	BRANCKER	3301
150.00	BRANCKER	3762
166.00	BRANCKER	3701
182.00	BRANCKER	3763
198.00	BRANCKER	3836
214.00	BRANCKER	3702
230.00	BRANCKER	3703
246.00	BRANCKER	3837
262.00	BRANCKER	3764

OTHER SENSORS

Depth (METERS)	Instrument	Serial Number
22.50	ADCP	448
1.60	IMET SST	109
6.65	PMEL-T-POD	2011
2.20	Tensiometer	43845
1.60	VAWR SST	T5075
202.00	WOTAN	8846

CTD

Depth (METERS)		Serial Number
2.00	SEA-CAT	142
9.48	SEA-CAT	143
13.52	SEA-CAT	928
17.52	SEA-CAT	929
21.50	SEA-CAT	991
25.50	SEA-CAT	992
33.50	SEA-CAT	993
41.50	SEA-CAT	994
47.50	SEA-CAT	1069
54.50	SEA-CAT	995
62.00	SEA-CAT	1065
70.00	SEA-CAT	141
78.00	SEA-CAT	1066
86.00	SEA-CAT	144
94.00	SEA-CAT	1067
102.00	SEA-CAT	927
110.00	SEA-CAT	1068
126.00	SEA-CAT	146

CURRENT METERS

Depth (METERS)		Serial Number
7.15	VMCM	203203
10.90	VMCM	401105
14.97	VMCM	401004
19.01	VMCM	51
25.00	VMCM	203304
33.50	VMCM	202803
41.50	VMCM	202602
54.50	VMCM	203504

ADCP

The RDI Acoustic Doppler Current Profiler (SN 0448) was deployed at a depth of 22.5. The transmit frequency was 150 kHz and it took a profile every 15 minutes. Sea-Cat SN 0991 was mounted to the ADCP cage.

The recovery of the ADCP went smoothly. There was only minor biofouling on the pressure case with none interfering with the transducer faces. The ADCP was cleaned and then remained on deck for approximately 36 hours until the data was down loaded. The ADCP was still transmitting during this time. This was determined by placing an AM radio tuned to 150 kHz next to the transducer heads.

The serial cable was connected to the external serial connector on the ADCP and the NEC computer prior to opening the pressure case. After sending a break through the external serial cable, the series of internal tests (SCTEST) were run with no reported failures. The ADCP internal clock was interrogated and compared with the GPS time base. The ADCP day was one day ahead of GMT. The ADCP time was approximately 17 seconds ahead of GMT. Internal tilt, heading and temperature sensors appeared to be operational.

Since the batteries appeared fine, we dumped all the data from the ADCP to the NEC portable prior to opening the pressure case. These are in data files *TOGA.001* to *TOGA.035* . Some data was unobtainable after two attempts at down loading. 20 ensembles are missing from files 012, 013 and 014. All data was then copied to floppy disk. We then opened the ADCP pressure case. The measured loaded and unloaded voltages were above acceptable values. We removed the batteries, closed up the case and packed the ADCP for shipping back to W.H.O.I.

WOTAN

A 12-channel WOTAN (Wind Observations Through Ambient Noise), S/N 16, was mounted at 200 m below the surface on the Weller UOP mooring. This instrument sampled ambient sound in 12 bands from 50 Hz to 18 kHz every 20s, and stored an average for each band at 5 minute intervals. These data will be used to infer local wind speed and precipitation.

The instrument came out of the water on 4 March at 0218 UCT. There was very little biofouling, and the housing and mounting bracket were very clean, although the sacrificial zinc anode was almost completely dissolved. Later in the day the data were dumped to computer: there were 38913 records collected, and a preliminary look at the data indicate that the quality is good.

Section 3-4: Wecoma - Manual meterological sensor intercomparsion

Prior to our arrival at the UOP mooring, we collected some met data by hand for intercomparison with the R/V Wecoma met instrumentation. We collected sea surface temperature, barometric pressure (Model AIR-HB-1A S/N 1B1621), relative wind speed (Turbometer), air temperature and relative humidity (Vailsala HM34 S/N 492782). These (as well as the simultaneous ship mounted measurements) were recorded every 10 minutes for 2 hours on the afternoon of 2 March 1993. The sky was mostly cloudy.

The bucket SST samples where taken from the starboard side of the ship. Other measurements were taken from the windward side of the bridge deck. The ship has two wind anemometers located on the port and starboard sides of the mast. The other met sensors are located on a short mast, on the port side, just fore of the fantail, next to the crane. The ship's SST measurement was made at from a engine intake port located at a approx. 5 m depth. SBE temperature and conductivity sensors were located in a barrel in the wet lab where sea water was continually pumped in from an input at the bottom of the ship's hull. The ship's met computer samples the sensors at approximately 2 Hz and makes 1 minute averages before displaying and recording to disk (in NetCDF format).

The results of the intercomparison revealed some problems. RH and BP measurements yeilded the closest match(figures 3-5a,3-5b). The BP appears to have a constant offset between the hand sensor and the ships sensor. The air temperature measurements disagreed by as much as 1.5°C. (figure 3-5c). The ship's SST was 0.6°C higher than bucket temperatures. (figure 3-5d) The location of the ship's met mast was not optimal for all wind directions, as can be seen in (figure 3-5e).

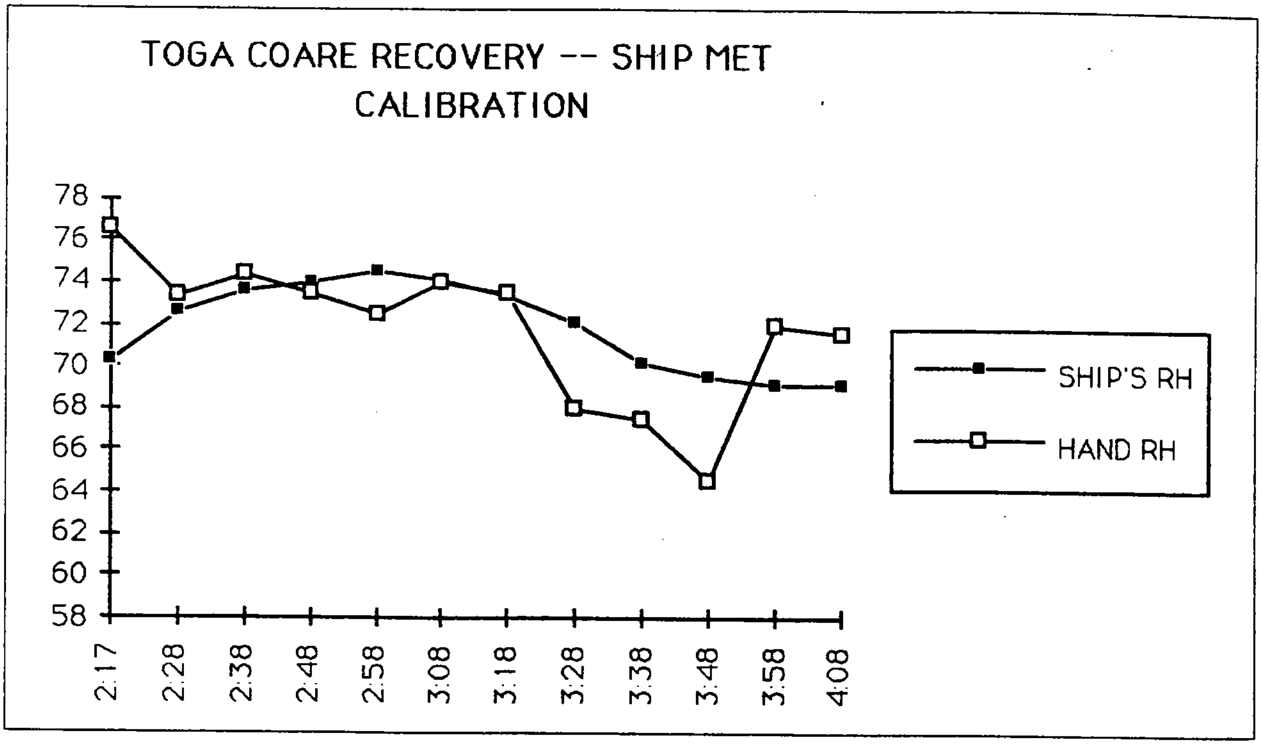
Because of the poor match between the data taken by hand, we decided not to totally rely on the ship's met system for intercomparison with the UOP buoy, but to use a combination of hand and ship met sensors for the intensive met. comparison at the UOP mooring site.

Section 3-5: VAWR - R/V Wecoma sensor intercomparison

Prior to the recovery of the UOP mooring, 2 hours of meteorological observations were taken from 0740 to 0940 local time. R/V Wecoma and hand held measurements were taken every 10 minutes. The VAWR data was collect through the telemetry unit which transmits measurements every 7.5 minutes. The telemetry data was converted to engineering units using the pre-cruise calibration coefficients.

During the observations, the R/V Wecoma was positioned a quarter mile down wind from the buoy and held the port side exposed to the wind. Hand measurements were conducted from the fantail using the "A"-frame for shade. We found the hand sensor measurements of air temperature and relative humidity were extremely sensitive to direct sun light.The Wecoma relative humidity was lower than the VAWR estimates by 10 percent. These measurements appeared less reliable as the sun rose higher.(figures 3-6a, 3-6b) The wind direction comparison revealed a 180° rotation between data reported by the Wecoma and the VAWR. (figure 3-6d) The Wecoma SST was consistently more than 0.4°C higher than the VAWR. Bucket temperatures had much better agreement with the VAWR(figure 3-6e). The Wecoma barometric pressure measurements were consistently higher than the VAWR and hand sensor measurements by 0.2 mbar. (figure 3-6f)

Figure 3-5a, 3-5b. Ship and Manual Sensor Comparisons Relative Humidity and Barometric Pressure



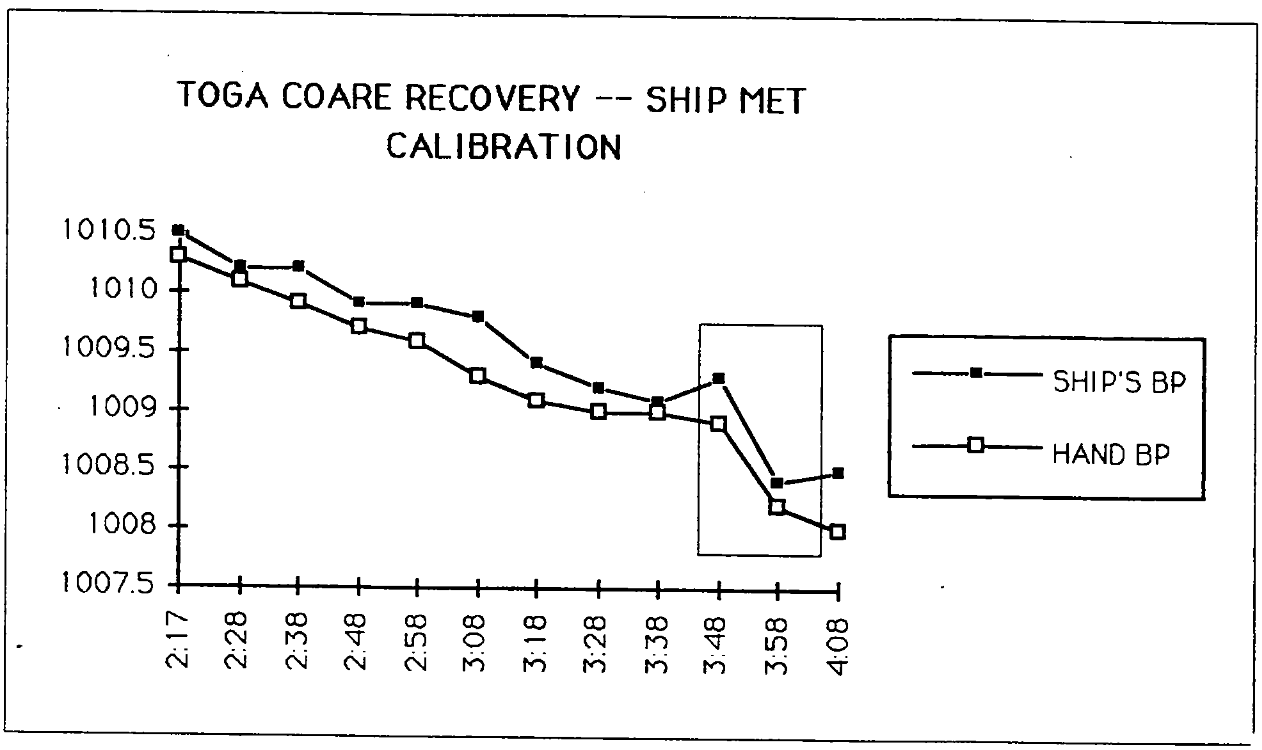
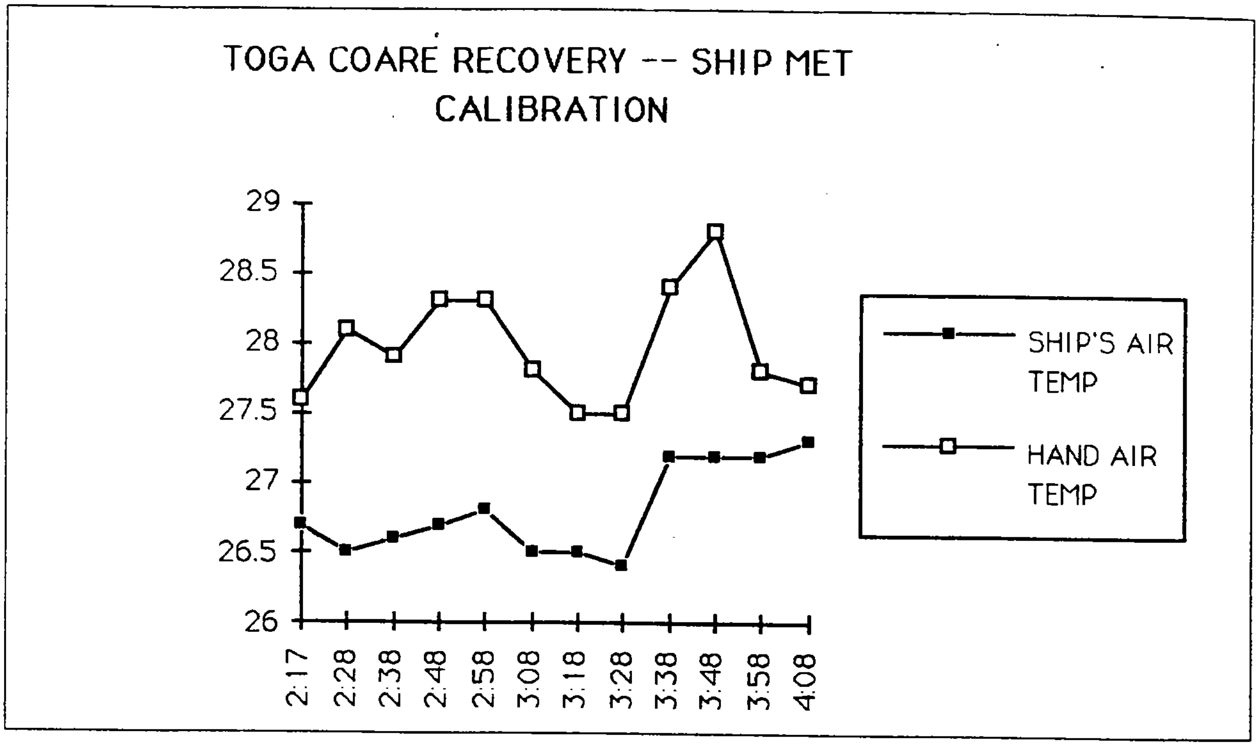


Figure 3-5c, 3-5d. Ship and Manual Sensor Comparisons
Air Temperature and Sea Temperature



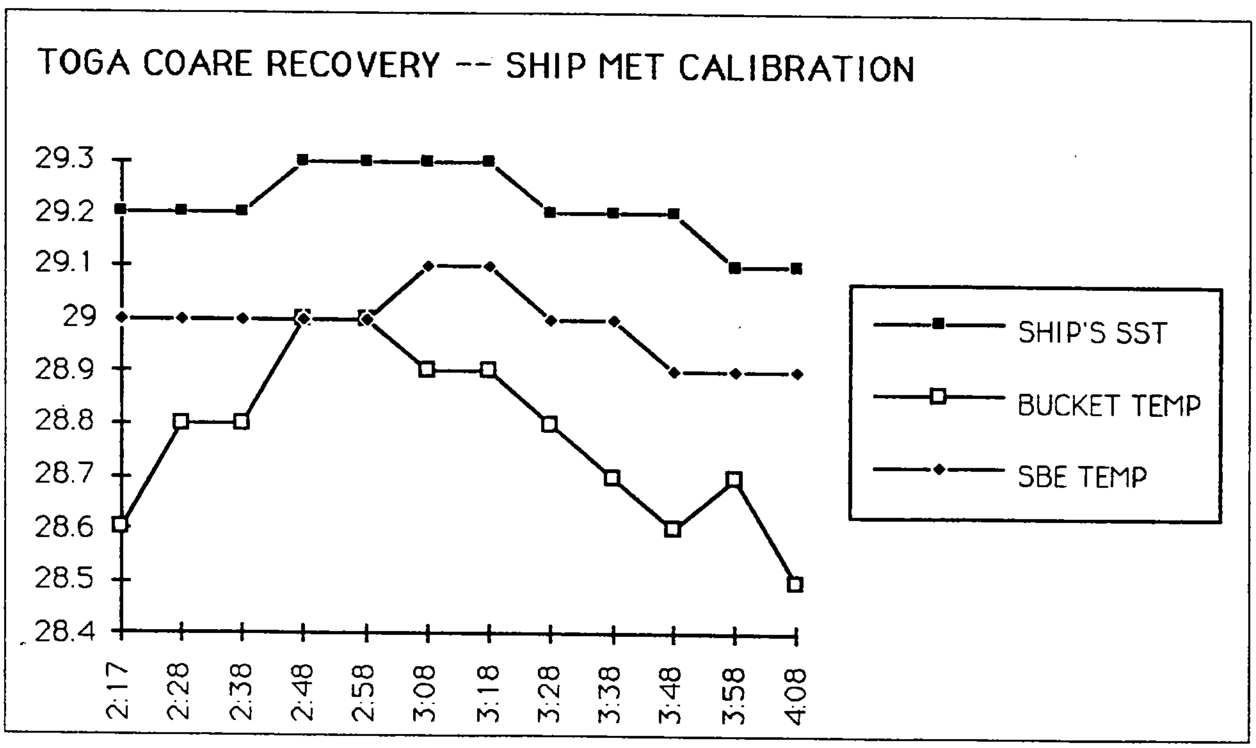


Figure 3-5e. Ship and Manual Sensor Comparison
Wind Speed

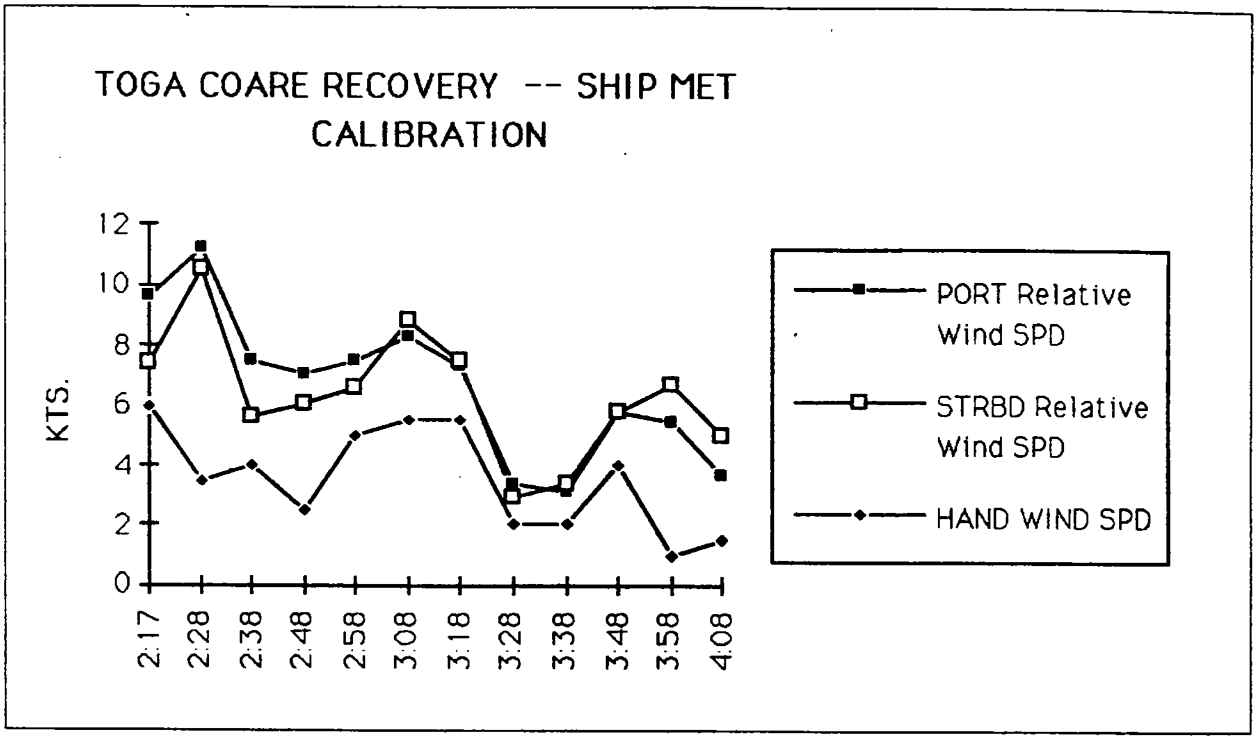
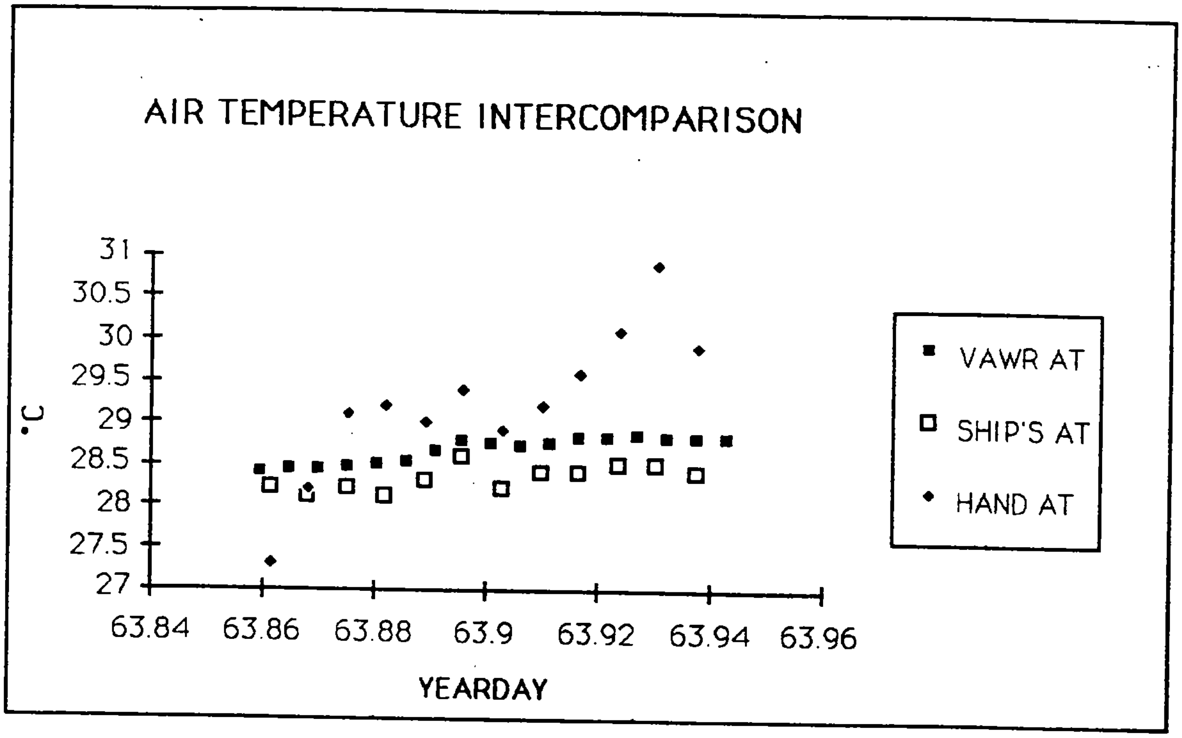


Figure 3-6a, 3-6b. VAWR, Ship and Manual Sensor Comparison Air Temperature and Relative Humidity



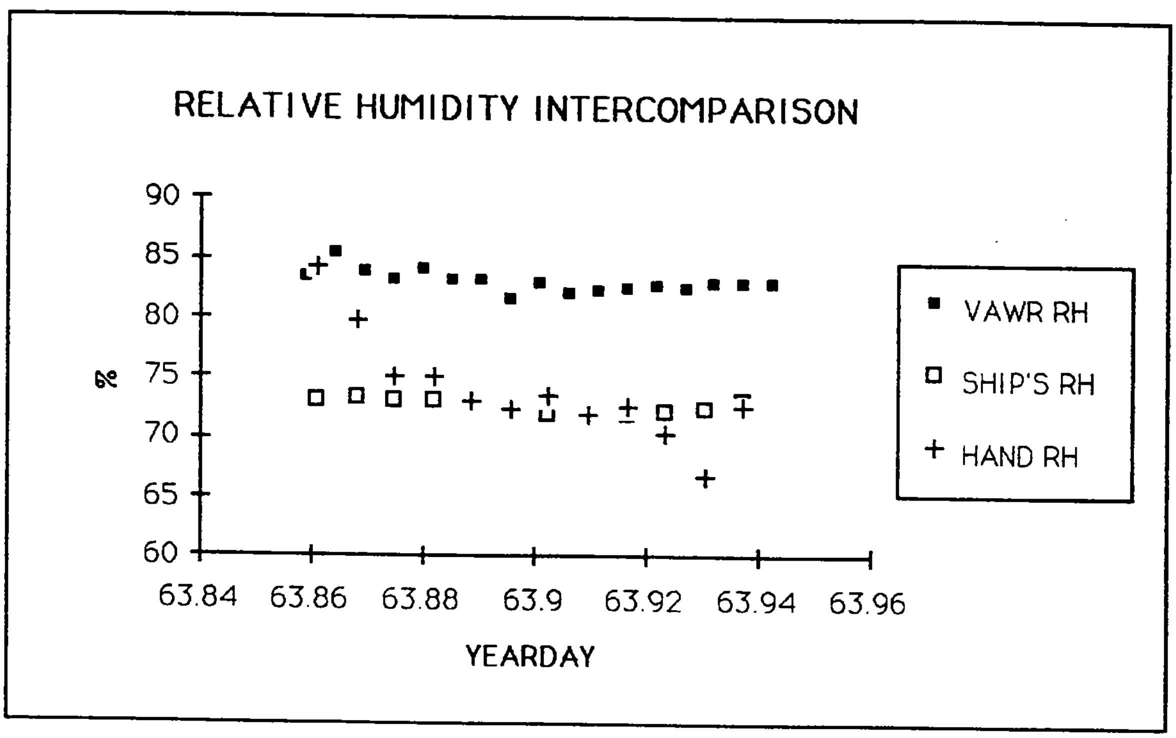
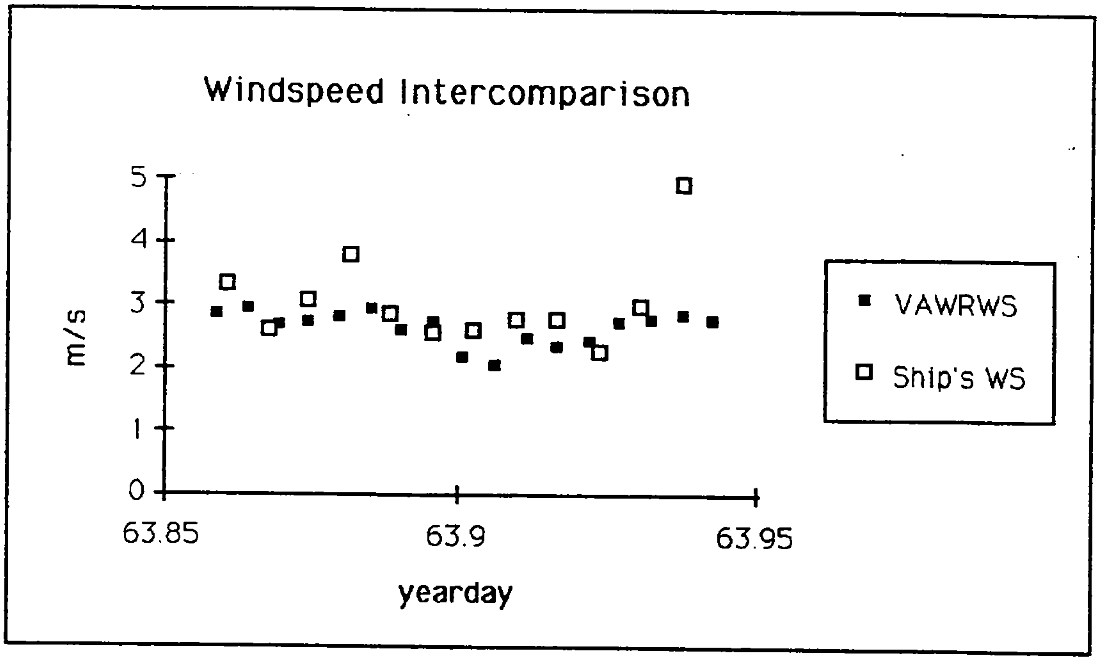


Figure 3-6c, 3-6d. VAWR and Ship Sensor Comparison Wind Speed and Wind Direction



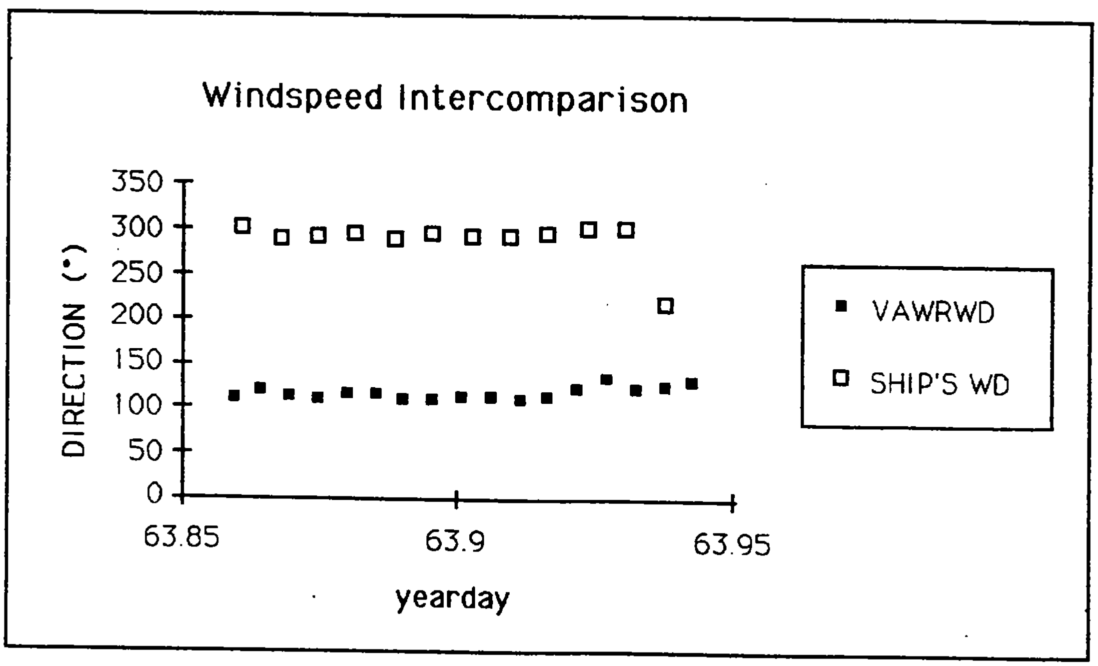
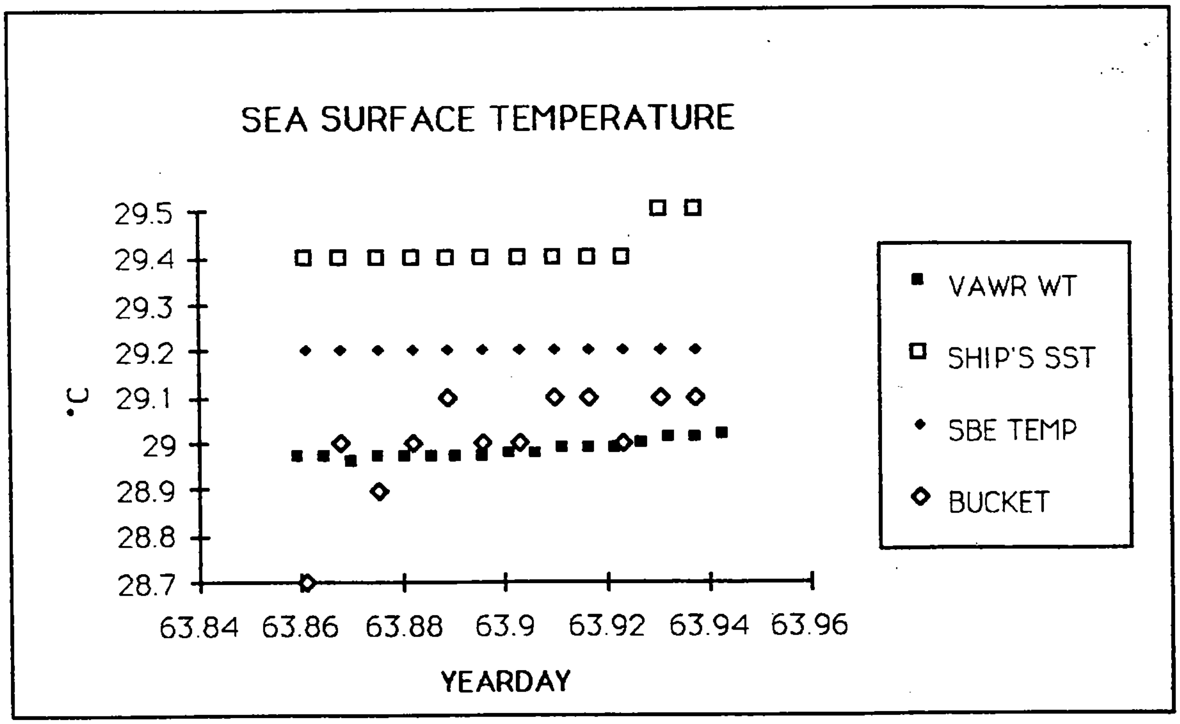
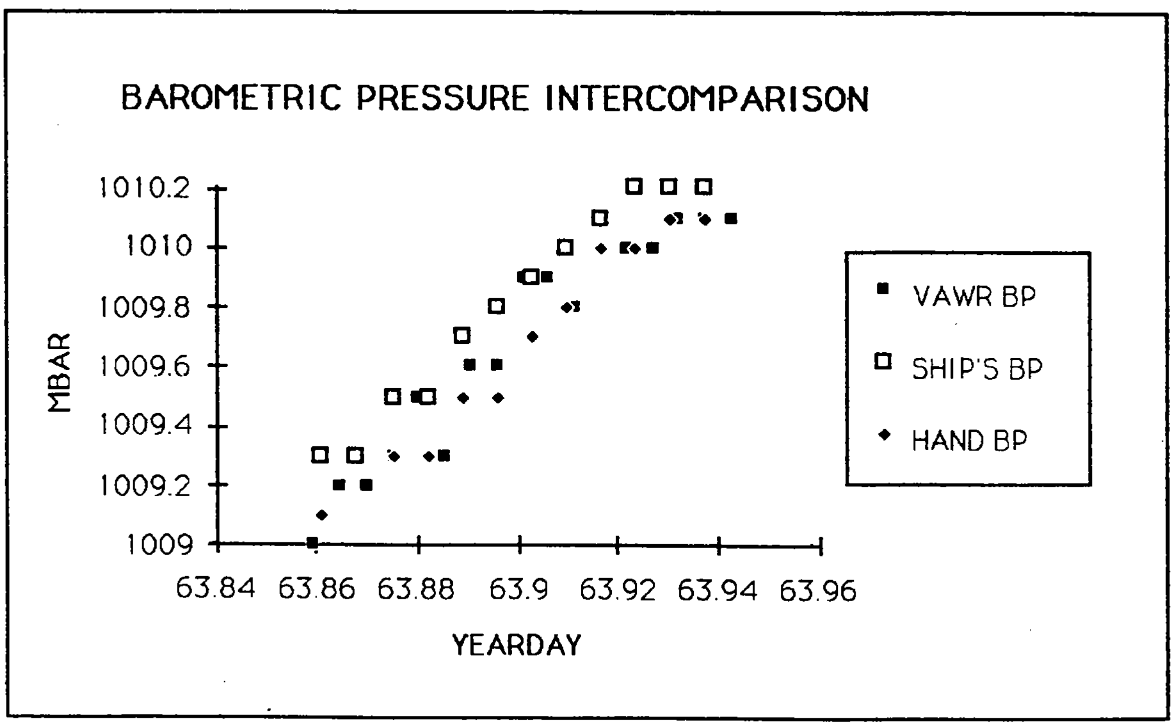


Figure 3-6e, 3-6f. VAWR, Ship and Manual Sensor Comparisons Sea Temperature and Barometric Pressure





Section 3-6: CTD survey

Two CTD casts to 1000 meters were done at each PCM mooring prior to recovery. These casts were timed to coincide with PCM profile times and were to provide data for closing comparisons with the PCM temperature and conductivity sensors. Bottle samples were taken at four depths in the top 300 meters in regions of relatively little change in salinity for further comparisons.

CTD	at	date	time
1	PCM N	3/03/83	0900Z
2	PCM N	3/03/93	1200Z
3	ELSI	3/03/93	1700Z
4	UOP	3/03/93	2255Z
5	PCM W	3/04/93	2100Z
6	PCM W	3/05/93	0000Z
7	PCM S	3/05/93	1200Z
8	PCM E	3/05/93	1800Z
9	PCM S	3/06/93	1800Z
10	PCM E	3/07/93	1800Z

References

Heinmiller, R. H., 1976 Woods Hole Buoy Project Moorings 1960 -1974. W.H.O.I. ref. 76-53 (Technical Report)

Acknowledgments:

The TOGA moored array recovered on the R/V Wecoma, cruise number WE93-02A was successful. due to the helpful assistance from the ship's captain and crew. University of Oregon, marine technician, Brian Wendler was instrumental in interfacing between the science party and shipboard personnel in getting our job done well and safely. The science party composed of four different science organizations; WHOI, UW, Draper Labs and IOS, all worked as a team in recovering all the moorings in a professional manner with success for the whole as our goal. Neal Bogue was invaluable during the deck operations and in assisting with the smooth running shore side shipping logistics. I sincerely thank Nancy Brink for her help preparing this report.

From Dr. Steven Hill, IOS

I would like to commend the mooring operations group at Woods Hole for their skilled and professional work in both the deployment and recovery of the ELSI mooring. Much of the credit for the successful conclusion of this deployment is due to their careful planning, preparation and execution.

Appendix 3:1
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Bryan Way, WHOI
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Neil Bogue, UW
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16. Abstract (Limit: 200 words)

The Tropical Ocean – Global Atmosphere Coupled Ocean – Atmosphere Response Experiment (TOGA COARE) was conceived in order to improve understanding of the principal processes responsible for coupling of the ocean and atmosphere in the western Pacific warm pool region. Field work for TOGA COARE was concentrated in an Intensive Flux Array (IFA) and included a variety of atmospheric and oceanic platforms. The Upper Ocean Processes Group (UOPG) was involved in TOGA COARE through the preparation, deployment, and recovery of a heavily instrumented surface mooring for the observation of air-sea fluxes and oceanic temperature, salinity, and currents in the upper 300 m. The mooring was deployed at 1°, 45.27'S, 155°, 59.73 E on 21 October 1992 in 1744 m of water. An instrument check-out cruise was undertaken in December of 1992 in order to evaluate the meteorological systems on the buoy. The mooring was recovered on 4 March 1993. This report describes mooring deployment operations, the instrument check-out cruise, and the mooring recovery. UOPG personnel also assisted with the deployment and recovery of five other moorings as a part of the COARE IFA and these operations are discussed.

17. Document Analysis a. Descriptors

1. air-sea interaction
2. moored data
3. western Pacific warm pool

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

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