Woods Hole Oceanographic Institution

WHOI-98-07

Technical Report

April 1998

Pan American Climate Study (PACS)

Mooring Deployment Cruise Report
R/V *Roger Revelle* Cruise Number Genesis 4
9 April - 5 May 1997

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Upper Ocean Processes Group
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543
UOP Technical Report 98-01

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Approved for Distribution:

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Abstract

Three surface moorings were deployed in the eastern equatorial Pacific from the R/V *Roger Revelle* as part of the Pan American Climate Study (PACS). PACS is a NOAA-funded study with the goal of investigating links between sea surface temperature variability in the tropical oceans near the Americas and climate over the American continents. The three moorings were deployed near 125°W, spanning the strong meridional sea surface temperature gradient associated with the cold tongue south of the equator and the warmer ocean north of the equator, near the northernmost, summer location of the Intertropical Convergence Zone. The mooring deployment was done to improve understanding of the air-sea fluxes and of the processes that control the evolution of the sea surface temperature field in the region.

Two surface moorings of the Upper Ocean Processes Group at the Woods Hole Oceanographic Institution (WHOI) were deployed—one at 3°S, 125°W and the other at 10°N, 125°W. One mooring from the Ocean Circulation Group (R. Weisberg) at the University of South Florida (USF) was deployed on the equator at 128°W.

The buoys of the two WHOI moorings were each equipped with meteorological instrumentation, including a Vector Averaging Wind Recorder, and an Improved METeorological (IMET) system. The WHOI moorings also carried Vector Measuring Current Meters, single-point temperature recorders, and conductivity and temperature recorders located in the upper 200 meters of the mooring line. In addition to the instrumentation noted above, a variety of other instruments, including an acoustic current meter, acoustic doppler current meters, bio-optical instrument packages and an acoustic rain gauge, were deployed during the PACS field program. The USF mooring had an IMET system on the surface buoy and for oceanographic instrumentation, two RD Instruments acoustic doppler current profilers, single-point temperature recorders, and conductivity and temperature recorders. Conductivity-temperature-depth (CTD) profiles were made at each mooring site and during the transit between mooring locations.

This report describes, in a general manner, the work that took place during the Genesis 4 cruise aboard the R/V *Roger Revelle*. The three surface moorings deployed during this cruise will be recovered and re-deployed after approximately nine months, with a final recovery planned for 17 months after the first setting. Details of the mooring designs and preliminary data from the CTD profiles are included.

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Section 1: Introduction

The fourth leg of the R/V *Roger Revelle's* first science expedition, Genesis 4, departed Callao, Peru, on April 9, 1997, at 1930 hours local time (0030 UTC, April 10, 1997.) The purpose of the cruise was to deploy three surface moorings in the eastern, equatorial Pacific. In addition to setting the three moorings, CTD profiles were taken at each mooring location and along 125°W. A turnaround cruise is planned for January 1998 and a final recovery cruise for August 1998. The mooring deployment schedule is shown in Figure 1.

The cruise involved personnel from the Upper Ocean Processes (UOP) Group at the Woods Hole Oceanographic Institution (WHOI), and the Ocean Circulation Group at the University of South Florida (USF). The science party also included two volunteers from the University of Colorado, one volunteer from the National Center for Atmospheric Sciences; and two volunteers who were freelance journalists. Appendix 1 lists the cruise participants. Figure 2 shows the cruise track and mooring locations. Table 1 lists the positions of the moorings deployed during this cruise.

The locations of the CTD profiles are shown in Figure 3 and listed in Table 2. Appendix 2 shows the temperature, salinity, and density profiles for each station.

In addition to this introduction, this report has three sections. The second section primarily describes the WHOI and USF moorings and their instrumentation and the third section presents a chronology of the cruise.

Section 2: The Moored Array

Three moorings were deployed during cruise Genesis 4 of the R/V *Roger Revelle*. The north and south moorings in the array were WHOI/ UOP group surface moorings with meteorological and oceanographic instrumentation.

Each of the buoys of the two WHOI moorings were equipped with meteorological instrumentation, including a vector averaging wind recorder, an Improved METeorological (IMET) recorder, and a stand-alone humidity and temperature recorder. The WHOI moorings also carried vector measuring current meters; temperature recorders; and conductivity and temperature recorders located in the upper 200 meters of the mooring line. The oceanographic instrumentation on the southern WHOI mooring included a chlorophyll absorption meter, a Falmouth Scientific Instruments, Inc., acoustic current meter, and a prototype acoustic doppler current meter developed by Russ Davis and Jeff Sherman at Scripps Institution of Oceanography. The northern WHOI mooring also carried an acoustic rain gauge at a depth of 29 meters on the mooring line. The USF mooring had an IMET system on the surface buoy; and for oceanographic instrumentation, two RD Instruments acoustic doppler current profilers, temperature recorders, and conductivity and temperature recorders. CTD profiles were made at each mooring and at selected locations along 125°W. Figure 4 schematically shows all three moorings and the location of the sub-surface instrumentation.

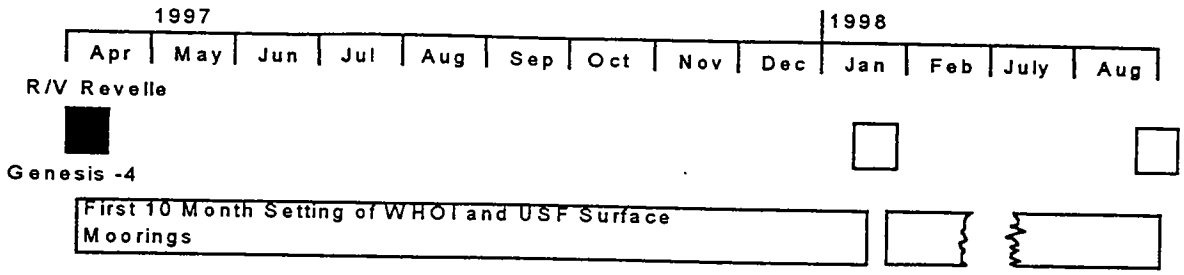

Figure 1: PACS 1 mooring cruise schedule.

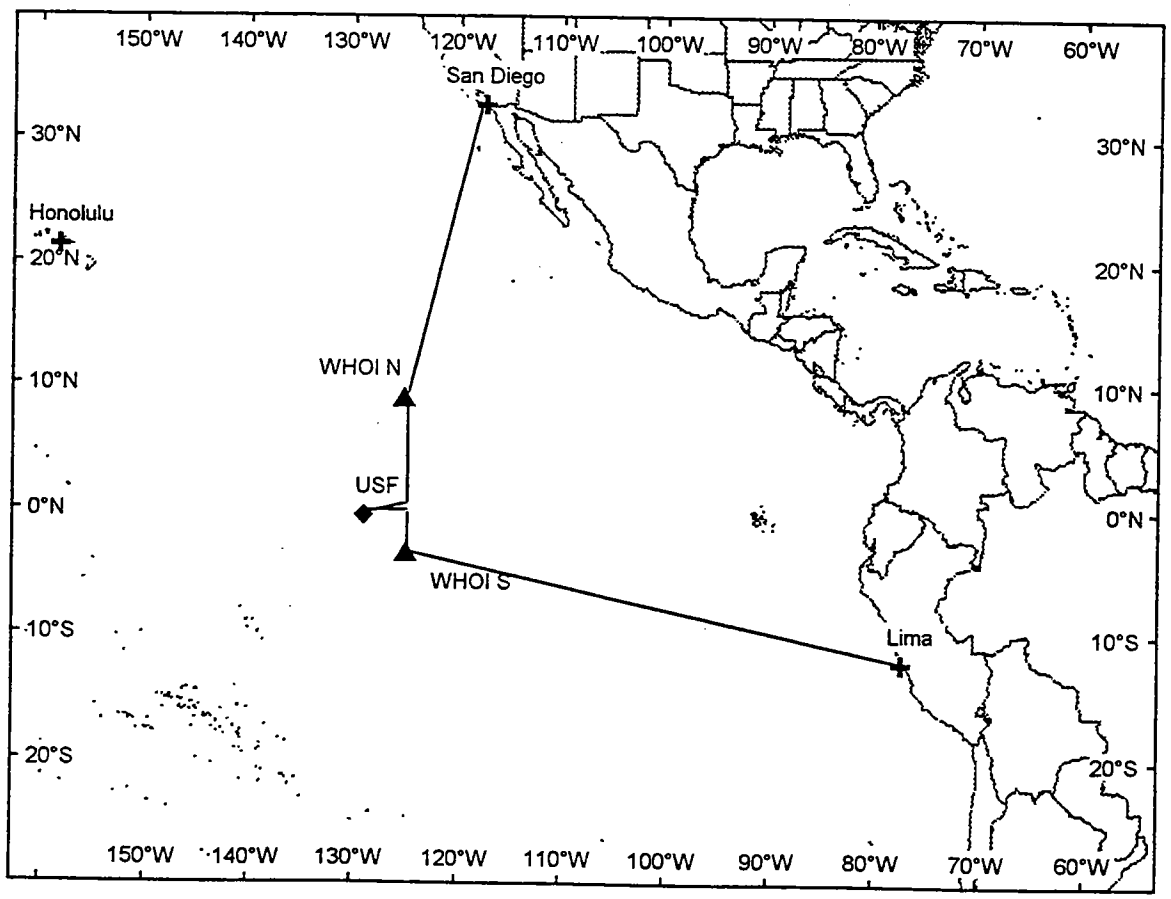

Figure 2: Cruise track and mooring locations.

Table 1: PACS mooring deployment information

Mooring	Deployment Date and Time	Anchor Position
WHOI PACS - South Discus Buoy (WHOI Moor. Reference No. 1014)	21 April 1997 @0002 UTC	2°46.78'S 124°39.38'W
USF Toroid Buoy	24 April 1997 @2154 UTC	00°00.39'N 127°58.34'W
WHOI PACS - North Discus Buoy (WHOI Moor. Reference No. 1015)	29 April 1997 @2135 UTC	9°58.99'N 125°23.39'W

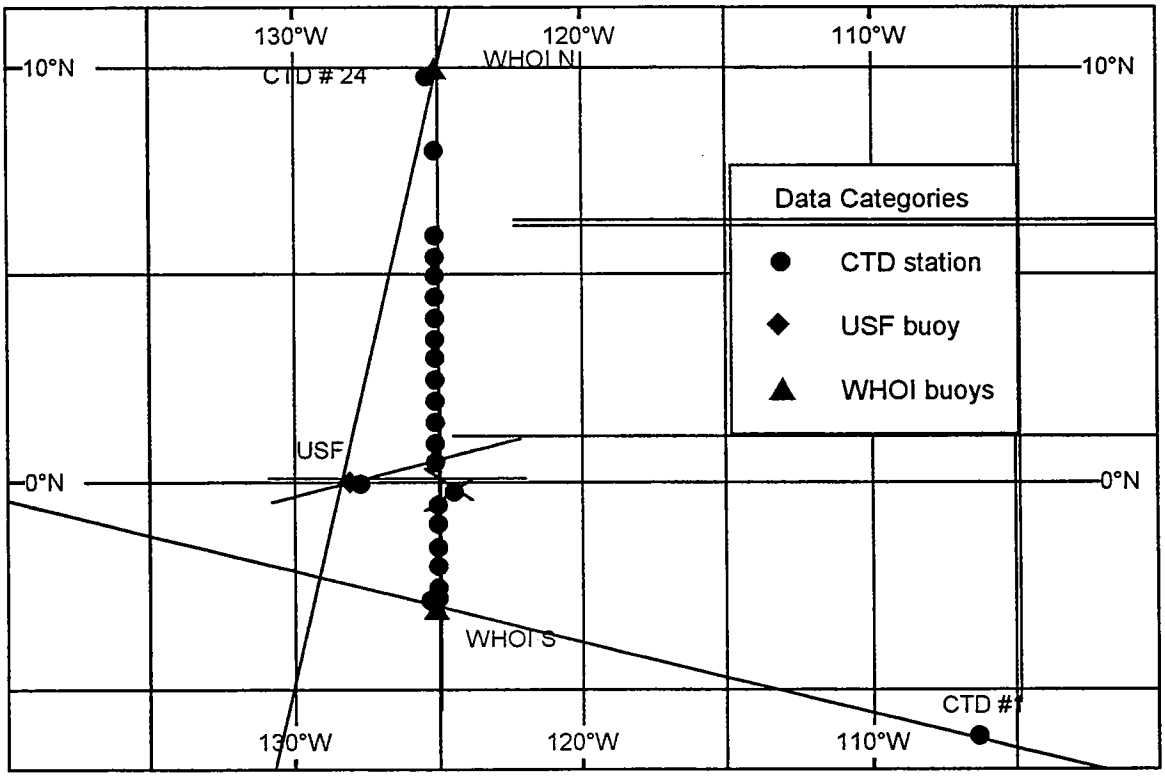

Figure 3: CTD profile locations.

Table 2: CTD stations occupied during Genesis 4.

Note: The time and location are those associated with the start of the CTD profile.

CTD#	Date	Time (UTC)	Latitude	Longitude	Wire Out	File ID
1	4/15/97	1617	5° 57.7 S	106° 11.9' W	1000	PACS060
2	4/19/97	1508	2° 45.0'S	124° 51.6'W	4000	PACS070
3	4/19/97	2016	2° 29.8'S	124° 59.8'W	4000	PACS080
4	4/20/97	0221	2° 46.1'S	124° 39.5' W	4000	PACS090
5	4/22/97	1018	2° 00.0'S	125° 00.0'W	1000	PACS100
6	4/22/97	1404	1° 29.9'S	124° 59.5'W	1000	PACS110
7	4/22/97	1756	1° 00.0'S	125° 00.0'W	1200	PACS120
8	4/22/97	2200	0° 30.0'S	125° 00.0'W	1500	PACS130
9	4/23/97	0400	0° 12.6'S	124° 20.1'W	1000	PACS140
10	4/25/97	1526	0° 00.7'N	127° 35.3'W	4000	PACS150
11	4/26/97	1256	0° 30.1'N	124° 59.7'W	1000	PACS160
12	4/26/97	1630	1° 00.1'N	124° 59.9'W	1000	PACS170
13	4/26/97	1947	1° 30.1'N	124° 59.9'W	1000	PACS180
14	4/26/97	2307	2° 00.0'N	125° 00.0'W	1000	PACS190
15	4/27/97	0235	2° 29.9'N	125° 00.0'W	1000	PACS200
16	4/27/97	0600	2° 59.9'N	124° 59.9'W	1000	PACS210
17	4/27/97	0934	3° 30.0'N	125° 00.0'W	1000	PACS220
18	4/27/97	1302	4° 00.0'N	124° 59.8'W	1000	PACS230
19	4/27/97	1625	4° 30.1'N	124° 59.9'W	1000	PACS240
20	4/27/97	1937	5° 00.0'N	125° 00.0'W	1000	PACS250
21	4/28/97	0015	5° 30.0'N	125° 00.0'W	1000	PACS260
22	4/28/97	0341	6° 0.00'N	125° 00.0'W	1000	PACS270
23	4/28/97	1746	8° 04.7'N	124° 58.2'W	1000	PACS280
24	4/30/97	1531	9° 57.3'N	125° 25.7'W	4000	PACS290

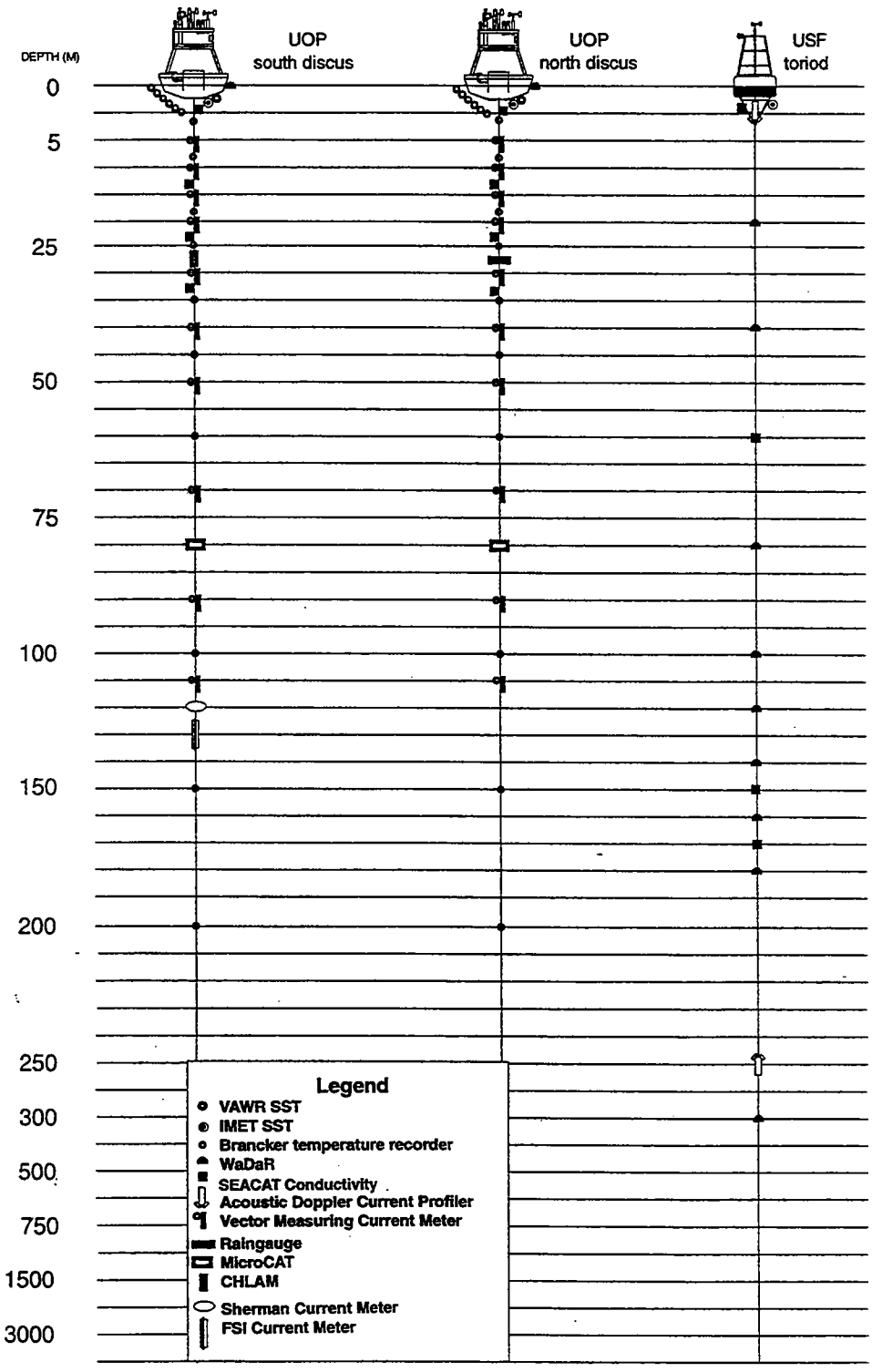

Figure 4: PACS moored array instrument locations.

A. WHOI Surface Moorings

A total of 38 recording instruments with 74 sensors were deployed on the PACS South surface mooring. There were two meteorological systems, one stand-alone relative humidity/air temperature recorder (SAHTR), ten current meters, seventeen temperature data loggers, five conductivity/temperature-recording instruments, one accelerometer recorder, one chlorophyll absorption meter (CHLAM), and two acoustic current meters.

The PACS North surface mooring had a total of 36 recording instruments with 72 sensors. There were two meteorological systems, one SAHTR, ten current meters, seventeen temperature data loggers, five conductivity/temperature-recording instruments, one tension/acceleration recorder, and one acoustic rain gauge. Each instrument used on the WHOI moorings was given a pre-cruise electronics checkout while at the dock in Callao.

All of the instrumentation used on the WHOI moorings had some type of pre-deployment time mark applied. The Vector Averaging Wind Recorder (VAWR) and Improved METeorological (IMET) recorder had their short-wave radiation sensors black bagged for two record cycles. The VMCMs had their rotors spun. All of the temperature recorders were put in an ice bath for their time intervals. The time marks can be used to verify the accuracy of the instrument's clock in data processing. Appendix 3 has a complete listing of all WHOI instrumentation deployed during Genesis 4. For each instrument type, the listing shows the instrument serial number, the mooring on which it was deployed and the corresponding depth.

The PACS South mooring is shown schematically in Figure 5 and the PACS North mooring is shown in Figure 6. Both WHOI moorings are an inverse catenary design utilizing wire rope, chain, nylon and polypropylene line; and each mooring has a scope of 1.18 (Scope = slack length/water depth). The surface buoy is a three-meter diameter discus buoy with a two-part aluminum tower and rigid bridle.

The two PACS surface moorings are almost identical in design and instrumentation. Fifteen meteorological sensors are mounted on the top half of each buoy tower and are described in the following section. Ten near-surface oceanographic sensors are attached to the bridle and buoy hull. In addition to the buoy-mounted instruments, the South mooring supports an additional 27 recording packages, some of which have multiple sensors; the North mooring supports an additional 25 recording packages.

The design of these surface moorings took into consideration the predicted currents, winds, and sea-state conditions expected during the deployment duration. Further, they were constructed using hardware and designs that had been proven in the recent Arabian Sea deployment.

Shackles used on the WHOI moorings were shot peened to improve their fatigue endurance. Weldless endlinks replaced previously used weldless sling links based on their superior performance in the fatigue tests. Vector measuring current meter (VMCM) cages were gussetted and welds redone to meet new specifications established during Arabian

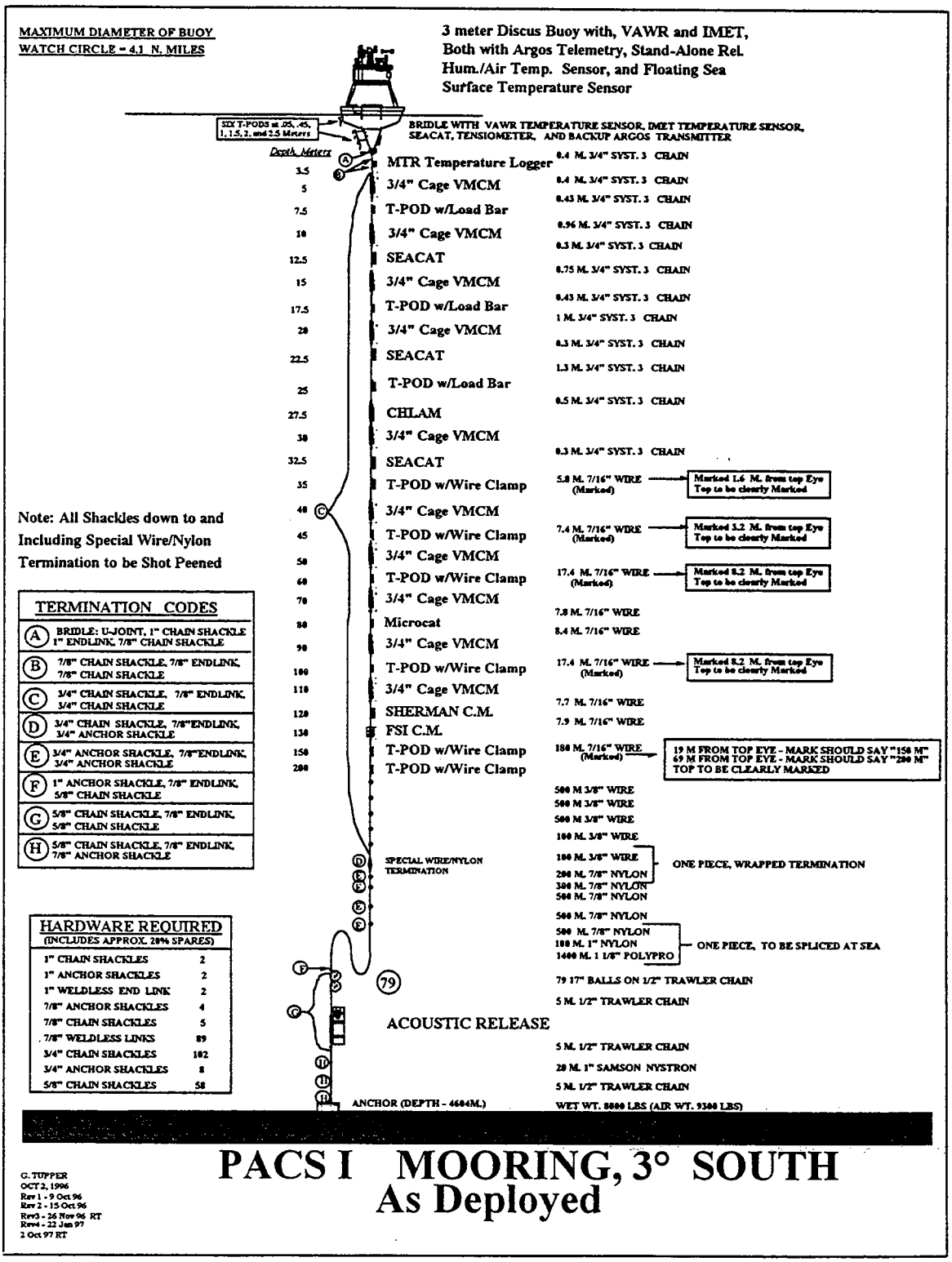

Figure 5: WHOI PACS South mooring schematic.

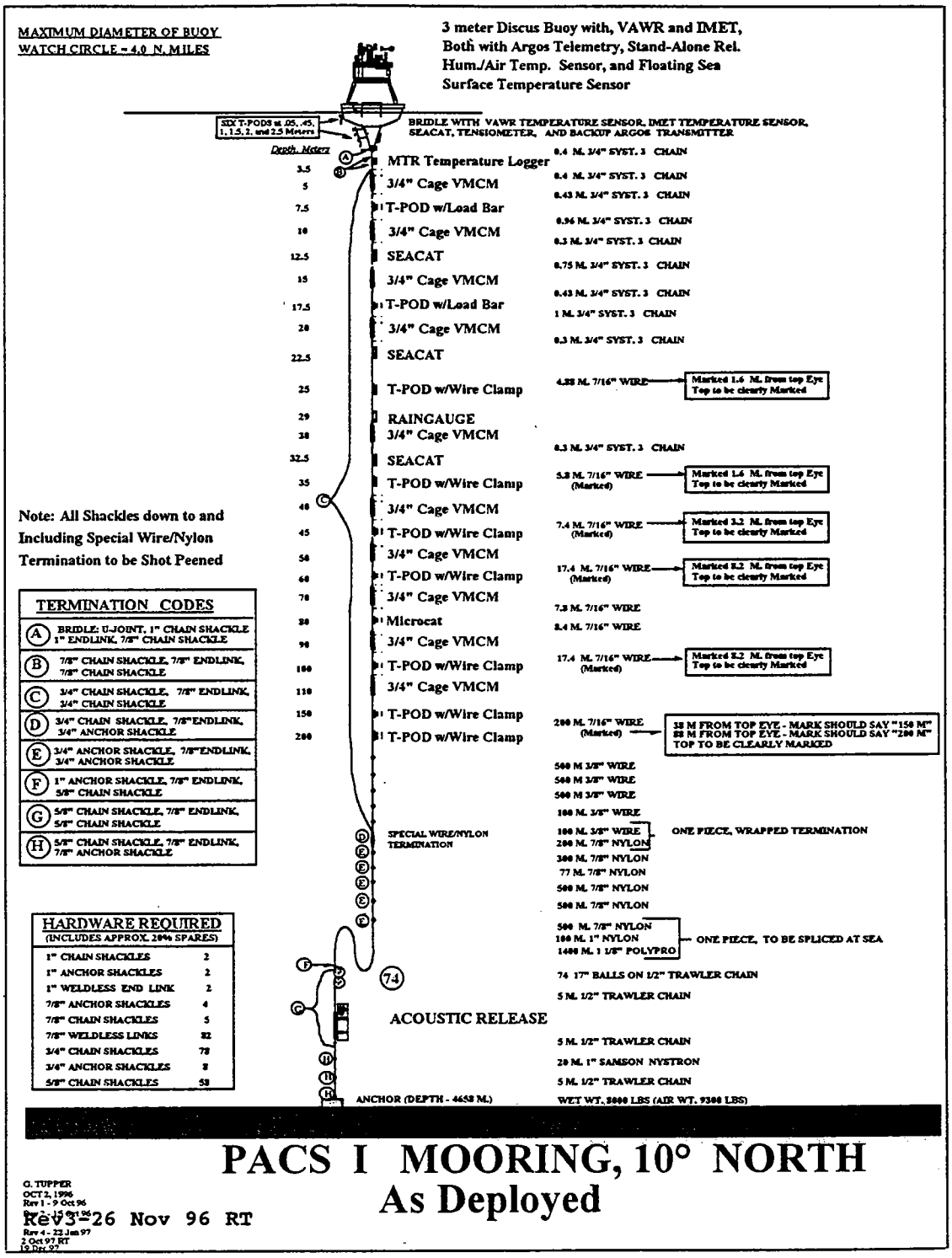

Figure 6: WHOI PACS North mooring schematic.

Sea cyclic fatigue testing. More information about the design effort and cyclic fatigue tests can be found in Trask *et al.*, 1995; and Trask and Weller, 1995.

1. WHOI Meteorological Instrumentation

The discus buoys were outfitted with two separate meteorological packages. One system was a VAWR, which logged and telemetered data from eight meteorological sensors. The second meteorological data recording system, IMET, logged data from nine meteorological sensors; this data was also telemetered via Argos. A third instrument made an independent measurement of relative humidity and air temperature and recorded the data internally. Figure 7 shows an aerial view of the meteorological instrumentation mounted on the WHOI discus buoys; Table 3 gives the serial numbers of the sensors and modules of the meteorological instruments. A buoy spin of the South and North buoys was performed at the dock in Callao to confirm that the compasses of each VAWR and IMET were in proper working order. The data from the buoy spins are as follows: Tables 4 and 5, IMET and VAWR compass/vane listings; Figures 8 and 9, buoy spin orientation; Figures 10 and 11, plots of buoy spin data. All three meteorological systems are described in detail below.

a. Vector Averaging Wind Recorder

One of the two meteorological units mounted on the three-meter discus buoy was a VAWR, which was configured to measure wind speed, wind direction, short-wave radiation, long-wave radiation, relative humidity, barometric pressure, air temperature, and sea surface temperature. Recording on a digital cassette, the VAWR was writing data to tape every 15 minutes. Table 6 shows the type of sensors used for the meteorological measurements and the sampling scheme. Data from the VAWR were telemetered via satellite back to WHOI through Service Argos. The VAWR Argos transmitter had three PTT ID numbers for data transmission, one of which was used for obtaining position information. The standard temperature range typically used in the VAWR is 0° to 30°C. This range was modified to be 0 to 35°C for the PACS experiment due to the expected high temperatures. The VAWR sea-surface temperature (SST) sensor was mounted on the bridle at a depth of approximately one meter. A continuous length of cable was run from the VAWR to the buoy deck and then down to the bridle-mounted SST sensor via an external aluminum pipe mounted on the side of the buoy in order to protect the cable. This method eliminated the need for multiple bulkhead connectors that can affect the temperature reading. Details of the VAWR configuration can be found in Trask *et al.*, 1995.

b. Improved METeorological System

The IMET system for the PACS discus buoys consisted of nine IMET sensor modules and one Argos transmitter module to telemeter data via satellite back to WHOI through Service Argos. Table 7 details IMET sensor specifications. The modules measure the following parameters:

1. relative humidity with temperature
2. barometric pressure
3. air temperature (R. M. Young passive shield)

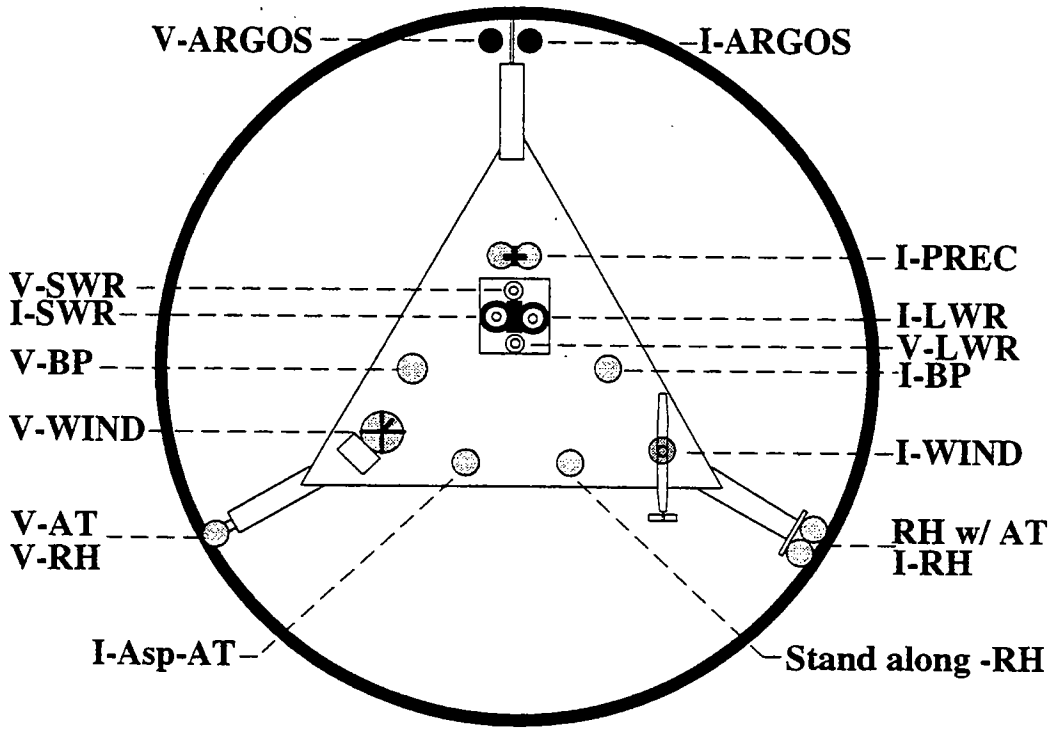

Figure 7: Aerial view of meteorological instrumentation.

Table 3: Meteorological sensor serial numbers PACS WHOI discus buoys.

NORTH

IMET

WND	111
SWR	111
LWR	006
HRH	107
BPR	107
SST	109
TMP 01 AT	105
TMP 02 ASP	101
PRC	102
LOGGER	295
PTT	106
ARGOS I.D. #1	27950
ARGOS I.D. #2	27951
ARGOS I.D. #3	27952

VAWR

V722WR	
SWR	26257
LWR	28459
RH	V-028-001
BP	44141
SST	5005
AT	5815
PTT	23978
ARGOS I.D. #1	27919
ARGOS I.D. #2	27920
ARGOS I.D. #3	27921
RESET TIME	1530:00
	5 APR 97

STAND-ALONE

BRH008	

SOUTH

IMET

WND	105
SWR	109
LWR	104
HRH	110
BPR	110
SST	005
TMP 01 AT	104
TMP 02 ASP	106
PRC	109
LOGGER	143
PTT	101
ARGOS I.D. #1	27953
ARGOS I.D. #2	27954
ARGOS I.D. #3	27955

VAWR

V707WR	
SWR	28298
LWR	27957
RH	V-028-001
BP	53235
SST	5510
AT	5814
PTT	23974
ARGOS I.D. #1	27916
ARGOS I.D. #2	27917
ARGOS I.D. #3	27918
RESET TIME	1715:00
	2 APR 97

STAND-ALONE

BRH006	

Table 4: South IMET and VAWR compass/vane listings.

BUOY SPIN - PACS SOUTH - PERU - 4 APRIL 97

	VAWR	IMET
1.	CO=5B VANE=62 158 062 DIR=220	CO=158.8 VANE=57.7 DIR=216.5
2.	VAWR CO=49 VANE=41 101 121 DIR=222	IMET CO=101.0 VANE=116.7 DIR=217.7
3.	VAWR CO=74 VANE=1E 037 183 DIR=220	IMET CO=36.9 VANE=179.3 DIR=216.2
4.	VAWR CO=3A VANE=01 340 236 DIR=216	IMET CO=339.2 VANE=236.2 DIR=215.5
5.	VAWR CO=2D VANE=25 278 304 DIR=222	IMET CO=277.0 VANE=298.1 DIR=215.1
6.	VAWR CO=14 VANE=7E 217 003 DIR=220	IMET CO=216.2 VANE=0.7 DIR=216.9

Table 5: North IMET and VAWR compass/vane listings.

BUOY SPIN - PACS NORTH - PERU - 5 APRIL 97

	VAWR	IMET
1.	CO=52 VANE=63 152 065 DIR=217	CO=162.3 VANE=56.3 DIR=218.6
2.	VAWR CO=15 VANE=7C 214 006 DIR=220	IMET CO=222.2 VANE=355.8 DIR=218.0
3.	VAWR CO=2F VANE=24 270 307 DIR=217	IMET CO=279.6 VANE=297.4 DIR=217.0
4.	VAWR CO=33 VANE=03 335 245 DIR=220	IMET CO=342.2 VANE=234.8 DIR=217.0
5.	VAWR CO=71 VANE=1D 031 188 DIR=219	IMET CO=39.2 VANE=178.6 DIR=217.8
6.	VAWR CO=4E VANE=44 093 127 DIR=220	IMET CO=100.0 VANE=116.7 DIR=216.7

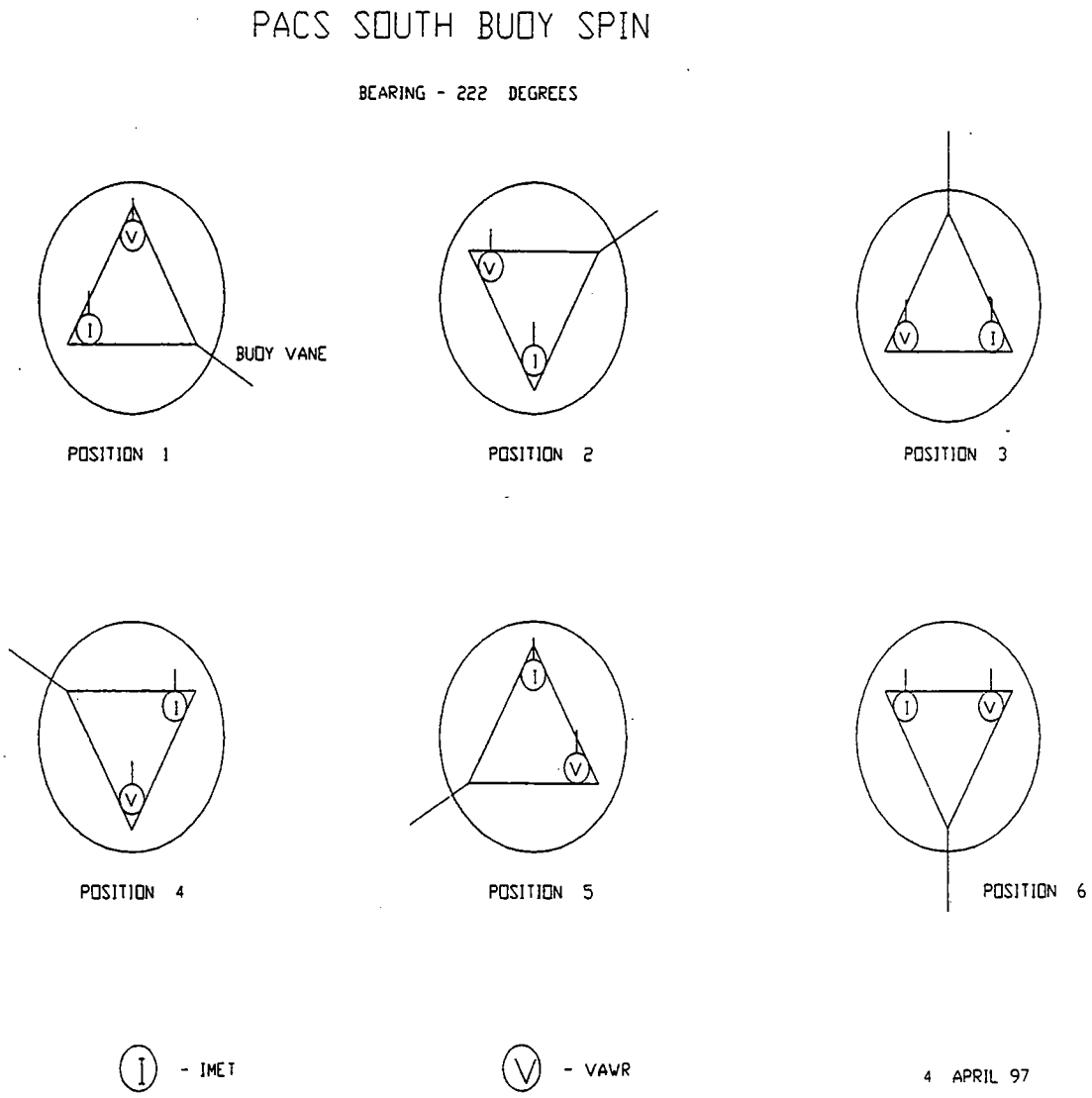

Figure 8: South buoy spin orientation.

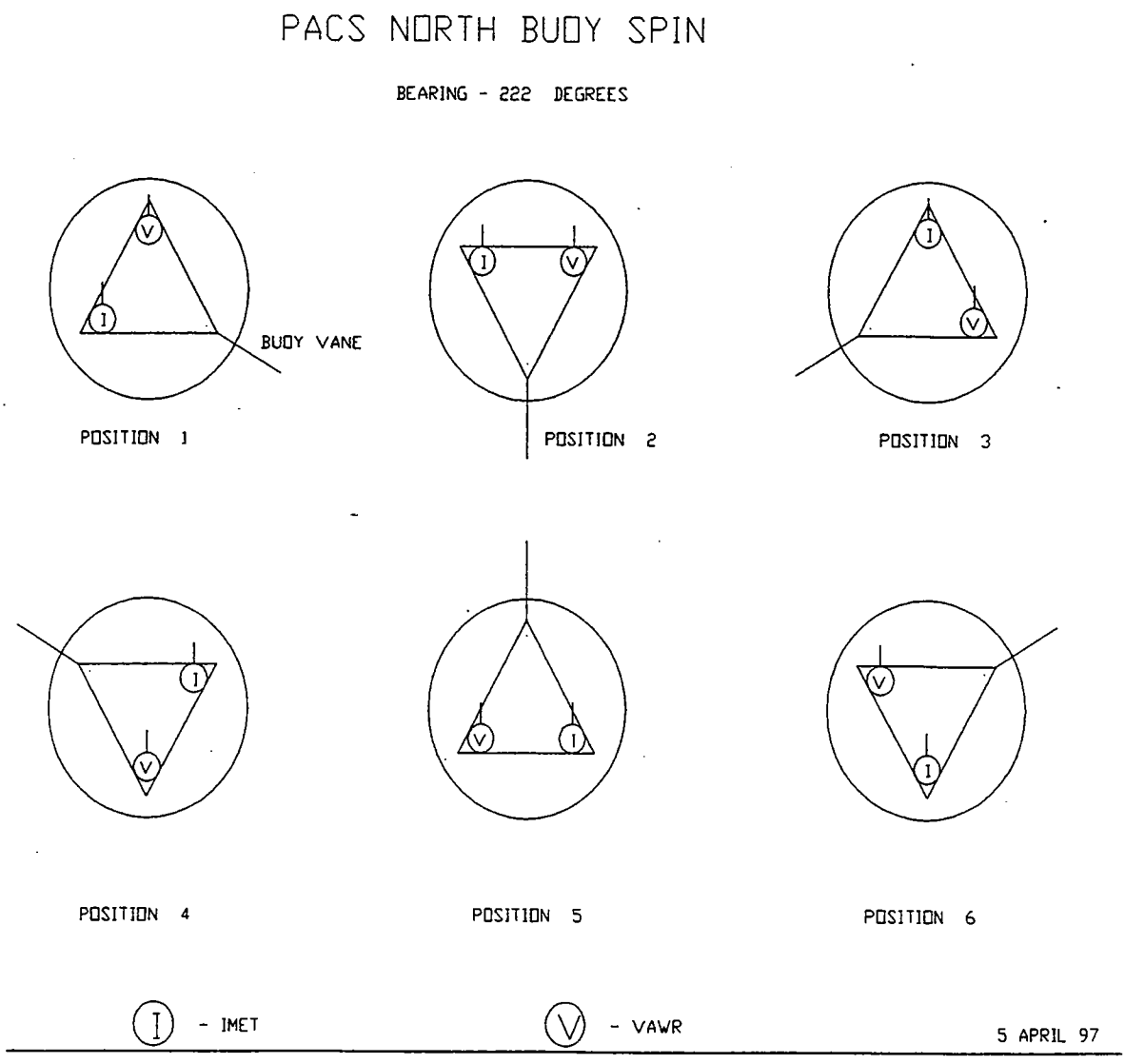

Figure 9: North buoy spin orientation.

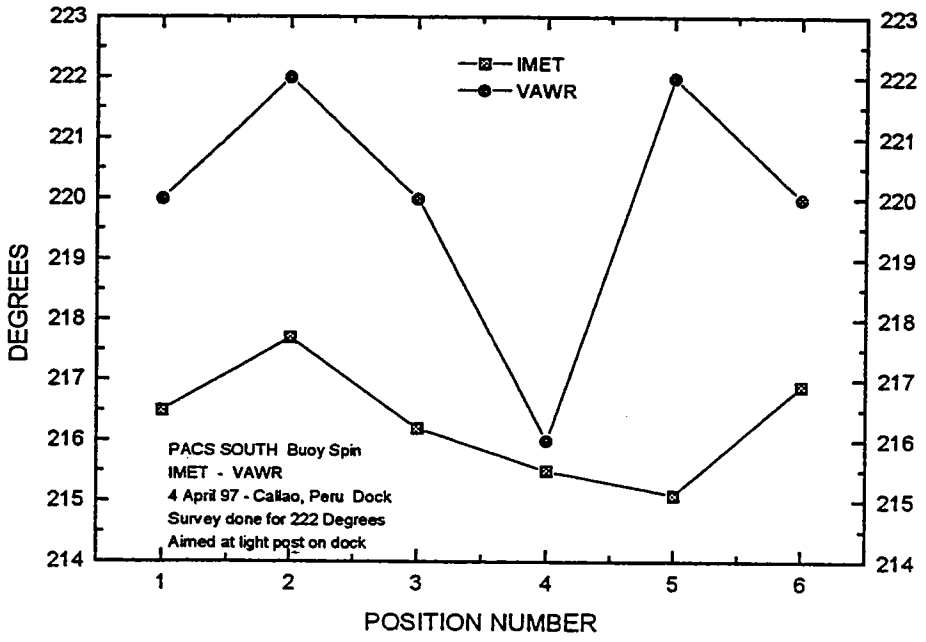

Figure 10: South buoy spin data plot.

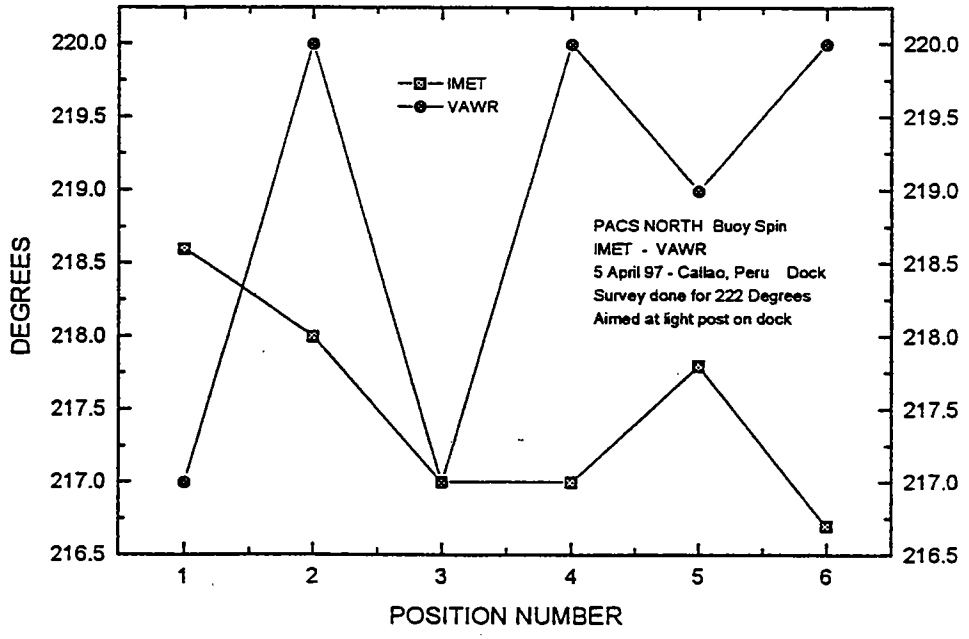

Figure 11: North buoy spin data plot.

Table 6: VAWR sensor specifications

Parameter	Sensor Type	Nominal Accuracy	Comments
Wind speed	R.M. Young 3-cup Anemometer	+5% +/-2%	Vector - averaged Note 1
Wind direction	Integral vane w/vane follower WHOI/EG&G	+/- 1 bit 5.6°	Vector- averaged
Insolation	Pyranometer Eppley 8-48	+/-3%	Averaged° of reading
Long-wave radiation Thermopile body Temp. dome Temp.	Pyrgeometer Eppley PIR PIR 10K @ 25° C 10K @ 25°C	+/- 10%	 Averaged Note 2 Note 3
Relative humidity	Variable dielectric conductor Vaisala Humicap 0062HM	+/- 2% RH	3.515 sec. Sample Note 4
Barometric pressure	Quartz crystal digiquartz Paroscientific Model 215, 216	+/- 0.2 mbars wind < 20 m/s Note 4	2.636 sec. Sample
Sea temperature	Thermistor Thermometrics 4K @ 25° C	+/-.005 °C	Note 5
Air temperature	Thermistor Yellow Springs #44034 5K @ 25° C	+/- 0.2°C wind > 5 m/s	Note 6

Notes:

1. Over estimation of wind speed is characteristic of cup anemometers
2. LWR body temperature is measured during the third quarter of the recording interval, for one quarter of the record time. Error associated with solar heating is not included in accuracy.
3. LWR dome temperature is measured during the fourth quarter of the recording interval, for one quarter of the record time
4. Relative humidity and barometric pressure are burst samples taken in the middle of the recording interval.
5. Sea temperature is measured during the first quarter of the recording interval, for one quarter of the record time.
6. Air temperature is measured during the second quarter of the recording internal, for one quarter of the record time. Error associated with solar heating is not included in accuracy.

Table 7: IMET sensor specifications

Parameter	Sensor	Nominal Accuracy
Air temperature	Platinum Resistance Thermometer	+/-.25°C
Sea temperature	Platinum Resistance Thermometer	+/-.005°C
Relative humidity	Rotronic MP-100F	+/- 3%
Barometric pressure	Quartz crystal AIR DB-1A	+/- .5 mbar
Wind speed and wind direction	R.M. Young model 5103 Wind Monitor	-3% (speed) +/- 1.5° (dir)
Short-wave radiation	Temperature Compensated Thermopile Eppley PSP	+/- 3%
Long-wave radiation	Pyrometer Eppley PIR	+/- 10%
Precipitation	R.M. Young Model 50201 Self-siphoning rain gauge	+/- 10%
Aspirated air temperature	Platinum Resistance Thermometer	+/-.25°C

The logger polls all IMET modules at one-minute intervals (takes several seconds) and then goes to low-power sleep mode for the rest of the minute. Data are written to disk once per hour. The logger also monitors main battery and aspirated temperature battery voltage.

The air temperature, sea surface temperature, barometric pressure, relative humidity, long-wave radiation and precipitation modules take a sample once per minute and then go to low-power sleep mode for the rest of the minute.

The short-wave radiation module takes a sample every 10 seconds and produces a running, one-minute average of the six most recent samples. It goes to low-power sleep mode between ten-second samples.

The vane on the wind module is sampled at one-second intervals and averaged over 15 seconds. The compass is sampled every 15 seconds and the wind speed is averaged every 15 seconds. East and north current components are computed every 15 seconds

Once a minute, the logger stores east and north components that are an average of the most recent four 15-second averages. In addition average speed from four 15 second averages is stored, along with the maximum and minimum speed during the previous minute, average vane computed from four 15-second averages, and the most recent compass reading.

In addition, an IMET Argos PTT module is set for three IDs and transmits via satellite the most recent six hours of one-hour averages from the IMET modules. At the start of each hour, the previous hour's data are averaged and sent to the PTT, bumping the oldest hour's data out of the data buffer.

4. air temperature (aspirated shield)
5. sea surface temperature
6. precipitation
7. wind speed and direction
8. short-wave radiation
9. long-wave radiation

All IMET modules for the PACS experiment were modified for lower power consumption so that a non-rechargeable alkaline battery pack could be used.

The data logger for the system was based on an Onset Computer Corp. model 7 Tattletale computer with hard drive, also configured and programmed with power conservation in mind. An associated interface board ties the model 7 via individual power and RS-485 communications lines to each of the nine IMET modules, including the PTT module.

c. Stand-alone Relative Humidity/Temperature Instrument

A self-contained relative humidity and air temperature instrument was mounted on the tower of the WHOI discus buoys. This instrument, developed and built by members of the UOP Group, takes a single point measurement of both relative humidity and temperature at a desired record interval. The sensor used was a Rotronics MP-100. The relative humidity and temperature measurements are made inside a protective Gortex shield. The logger is an Onset Computer, Corp., model 4A Tattletale, with expanded memory to 512K. The unit is powered by its own internal battery pack. The instrument interval was set to 3.75 minutes for the PACS Experiment.

The height (and depth) of the buoy and bridle mounted instrumentation can be found in Table 8 for the PACS South buoy and in Table 9 for the PACS North buoy.

2. Sub-surface Instrumentation

The measured water line for the PACS South and North buoys was .33 meters below the buoy deck. Figure 12 illustrates the location of the sub-surface sensors attached to the discus bridle of the PACS South discus and Figure 13 illustrates the PACS North discus.

a. Buoy Tension Recorder

Buoy tension was not measured on the South buoy, instead inside the well was a three-axis accelerometer manufactured by Summit Instruments, model #34103A, which measures X, Y, and Z components. The data were recorded using an Onset Computer, Corp., model 6 Tattletale, with a 40-Mega Byte hard drive attached. Acceleration was sampled every 12 hours beginning at 0000 hours UTC and 1200 hours UTC at a 4 HZ rate for a period of 23 minutes. The data for a two-day period was stored in a temporary buffer where it was then written to the disk drive. The North buoy incorporated the same accelerometer; and included in the measurement was a tension cell placed at the bottom of the three-part bridle. The tension cell, model TH-LB1B-SPL, manufactured by Omega-

Table 8: PACS South buoy sensor elevations.

Parameter	Sensor ID	Elevation relative to (meters)		Measurement Location
VAWR		buoy deck	water line	
Air temp.	22338	1.77		end of the temp. probe
Relative humidity	V-021-001	2.17		tip of the sensor
Barometric pressure	. 53235	2.39		center of the vane
Wind speed	707	2.97		axis of cups
Short-wave radiation	28298	3.05		dome shoulder
Long-wave radiation	27957	3.05		dome shoulder
Sea temperature	5510		-1.03	tip of sensor
IMET				
Air temperature	104	1.72		end of temp. probe.
Relative humidity	110	2.31		tip sensor
Barometric pressure	110	2.37		center of the vane
Wind speed	105	2.89		axis of cup
Short-wave radiation	109	3.05		dome shoulder
Long-wave radiation	104	3.05		dome shoulder
Precipitation	109	2.74		edge of the pre-cip. cup
Sea temperature	5		-1.03	tip of sensor
Aspirated Air temp.	106	1.86		end of temp. probe
Stand-alone RH w/ temp.	6	2.41		RH probe
Radar reflector				reflector base to deck
Argos antenna				antenna base to deck
SEACAT	143		-1.38	temperature probe
Temperature recorder	3835		-0.3	thermistor
Temperature recorder	3699		-0.54	thermistor
Temperature recorder	3701		-1.01	thermistor
Temperature recorder	4492		-1.51	thermistor
Temperature recorder	4489		-2.01	thermistor
Temperature recorder	3764		-2.52	thermistor
Tension cell	dummy			bridle spider
WaDaR	274		waterline	

Distance between buoy deck and water line was .33 meters

Table 9 : PACS North buoy sensor elevations.

Parameter	Sensor ID	Elevation relative to (meters)		Measurement Location
		buoy deck	water line	
VAWR	V722WR			
Air temperature	5815	2.06		end of the temp. probe
Relative humidity	V-028-001	2.17		tip of the sensor
Barometric pressure	44141	2.38		center of the vane
Wind speed	V722WR	2.97		axis of cups
Short-wave radiation	26257	3.05		dome shoulder
Long-wave radiation	28459	3.05		dome shoulder
Sea temperature	5005		-1.03	tip of sensor
IMET				
Air temperature	105	1.63		end of temp. probe.
Relative humidity	107	2.37		tip sensor
Barometric pressure	107	2.36		center of the vane
Wind speed	111	2.9		axis of cup
Short-wave radiation	111	3.05		dome shoulder
Long-wave radiation	6	3.05		dome shoulder
Precipitation	102	2.73		edge of the pre-cip. cup
Sea temperature	109		-1.03	tip of sensor
Aspirated air temp.	101	1.85		end of temp. probe
Stand-alone RH w/ temp.	BRH008	2.38		RH probe
Radar reflector		1.83		reflector base to deck
Argos antenna		0.51		antenna base to deck
SEACAT			-1.53	temperature probe
Temperature recorder	3263		-0.28	
Temperature recorder	4491		-0.51	thermistor
Temperature recorder	4483		-0.99	thermistor
Temperature recorder	3258		-1.49	thermistor
Temperature recorder	3838		-1.99	thermistor
Temperature recorder	3704		-2.49	thermistor
Tension cell			-2.1	bridle spider
WaDaR	275	waterline		

Distance between buoy deck and water line is .33 meters.

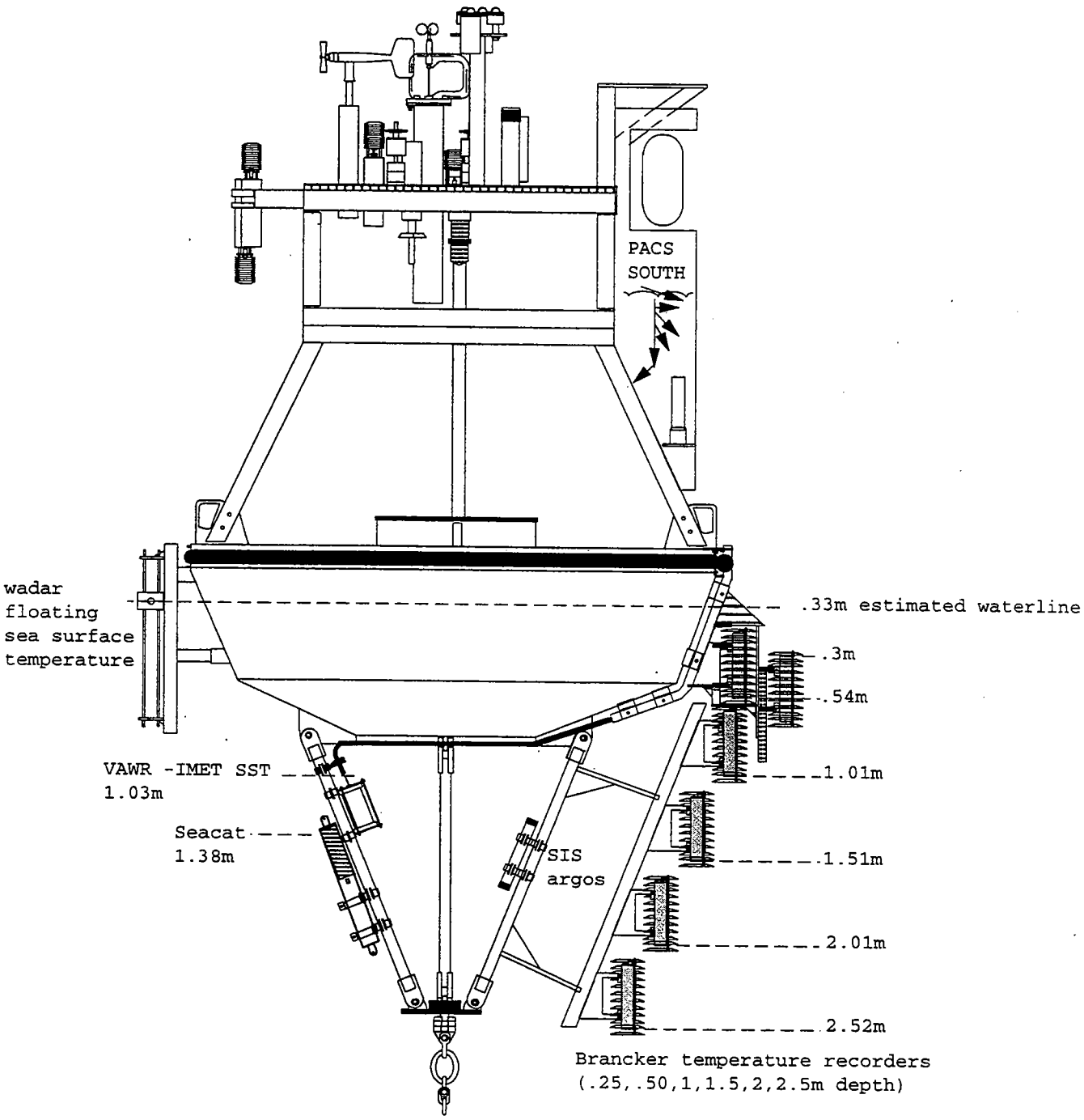

Figure 12: South discus sub-surface profile