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Woods Hole Oceanographic Institution

WHOI-97-13

Technical Report

August 1997

Coastal Mixing and Optics Experiment

Mooring Deployment Cruise Report
R/V *Oceanus* Cruise Number 284
31 July- 11 August 1996

by

Nancy Galbraith • William Ostrom

Bryan Way • Steve Lentz

Steve Anderson • Mark Baumgartner

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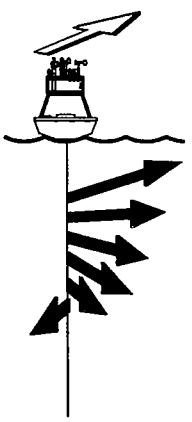

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UOP Technical Report 97-02

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Approved for Distribution:

Philip L. Richardson, Chair

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Abstract

An array of moorings at four sites at a mid-shelf location in the mid-Atlantic Bight was deployed for a period of 10 months beginning in August 1996 as part of the Coastal Mixing and Optics Experiment (CMO), funded by the Office of Naval Research (ONR).

The purpose of this array is to gather information to help identify and understand the vertical mixing processes influencing the evolution of the stratification over the shelf. The observations from this moored array will be used to investigate changes in the stratification in response to atmospheric forcing, surface gravity wave variability, surface and bottom boundary layer mixing, current shear, internal waves, and advection.

This report describes the primary mooring deployments carried out by the Upper Ocean Processes (UOP) Group on the R.V. *Oceanus*, sailing out of Woods Hole during July, August, and September of 1996.

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I: Introduction

The objective of the Office of Naval Research (ONR) Coastal Mixing and Optics (CMO) program is to quantify and understand the role of vertical mixing processes in determining the mid-shelf vertical structure of hydrographic and optical properties and particulate matter. As part of CMO, the Upper Ocean Processes (UOP) Group deployed a series of moorings at a mid-shelf location in the Mid-Atlantic Bight in August 1996, which will be recovered in June 1997. The purpose of the array is to gather information to help identify and understand the vertical mixing processes influencing the evolution of the stratification over the shelf. The observations from this moored array will be used to investigate changes in the stratification in response to atmospheric forcing, surface gravity wave variability, surface and bottom boundary layer mixing, current shear, internal waves, and advection.

The array consists of a central mooring site, at approximately 40.5°N 70.5°W on the 70-m isobath, and three surrounding mooring sites. Relative to the central mooring site, the three surrounding mooring sites are ~10 km onshore at about the 60-m isobath, ~10 km offshore at about the 80-m isobath and ~25 km along isobath to the east. To monitor the ocean variability, each mooring site includes a surface/subsurface mooring pair with Vector-Measuring Current Meters (VMCMs) and temperature and conductivity instruments (SeaCATs) spaced every 5 m in the vertical, spanning the water column. In addition, an Acoustic Doppler Current Profiler (ADCP) is located on both the inshore and offshore subsurface moorings. Most sensors are sampling at intervals of 5–15 minutes, but a subset of the sensors are logging at short (45 sec. -3 min.) intervals to monitor internal wave variability. In order to completely characterize surfaee forcing and the near surface processes relevant to mixing, the Central Site also includes a pitch-roll buoy to obtain surface wave spectra and a surface-scanning Doppler sonar to image the near surface velocity field to identify Langmuir circulation.

Figure I.1 is a map of the CMO area showing depth contours and mooring locations, and Figure I.2 is a schematic diagram of the 10 instrumented moorings.

The oceanic response on the continental shelf is closely tied to temporal and spatial variability in the atmospheric forcing. To characterize the local atmospheric forcing, a surface buoy at the Central mooring site contains redundant meteorological instruments, Vector Averaging Wind Recorders (VAWRs). Each VAWR measures wind speed and direction, incoming short-wave and long-wave radiation, relative humidity, air temperature, sea-surface temperature, and barometric pressure. In addition, two stand-alone internally logging precipitation gauges and a sonic anemometer, which measures the wind stress using the inertial-

dissipation method, are on the buoy. The buoy observations will provide the various parameters necessary for estimating the local surface momentum, heat and buoyancy fluxes. The surface buoys at the three surrounding mooring sites are more sparsely instrumented with the surface buoy at each site supporting a Weatherpak meteorological package which records wind speed and direction, air temperature, relative humidity and barometric pressure.

This report describes the primary mooring deployments carried out by the UOP Group on the R.V. *Oceanus*, sailing out of Woods Hole during July, August, and September of 1996.

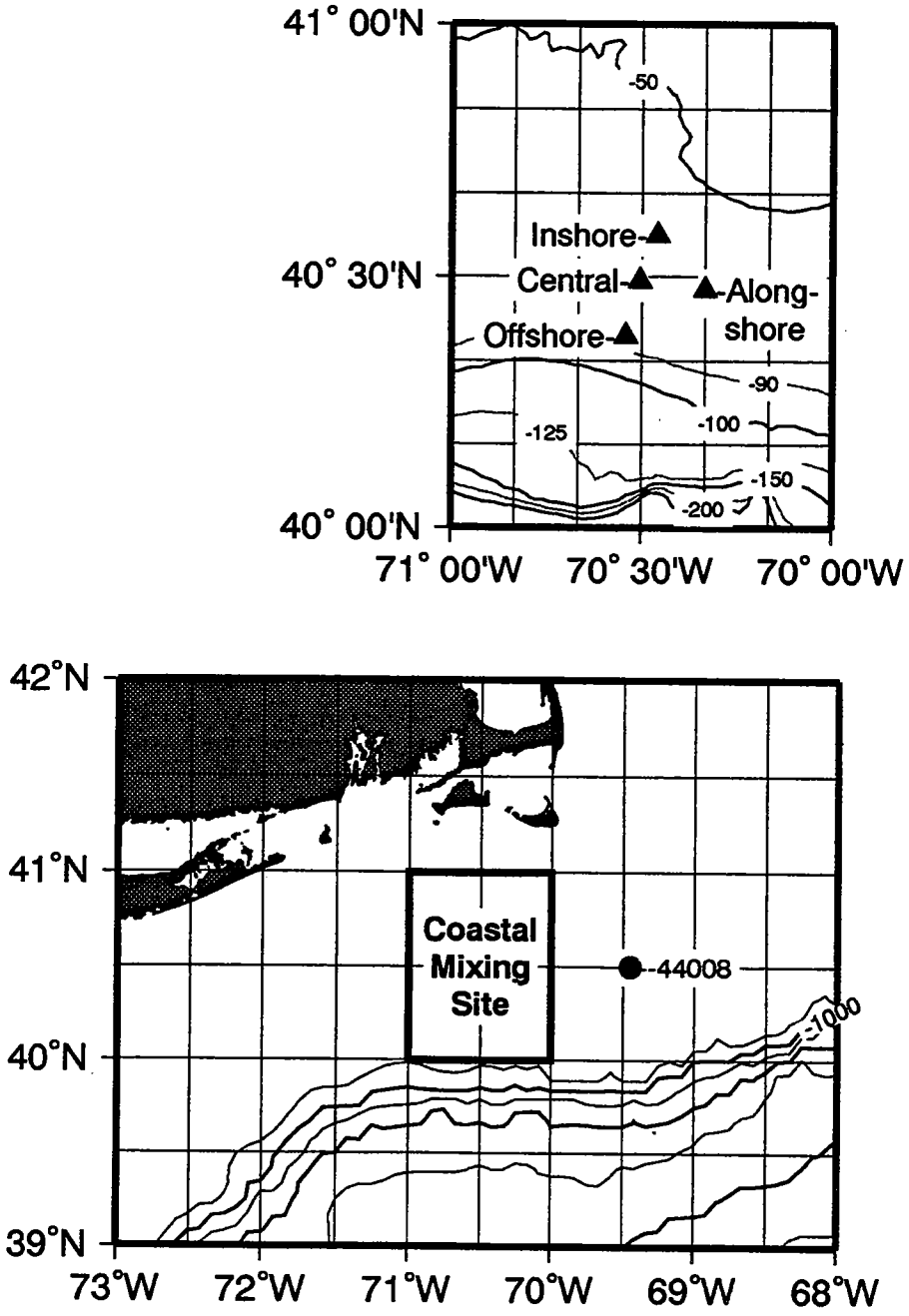


Figure I.1. CMO Site

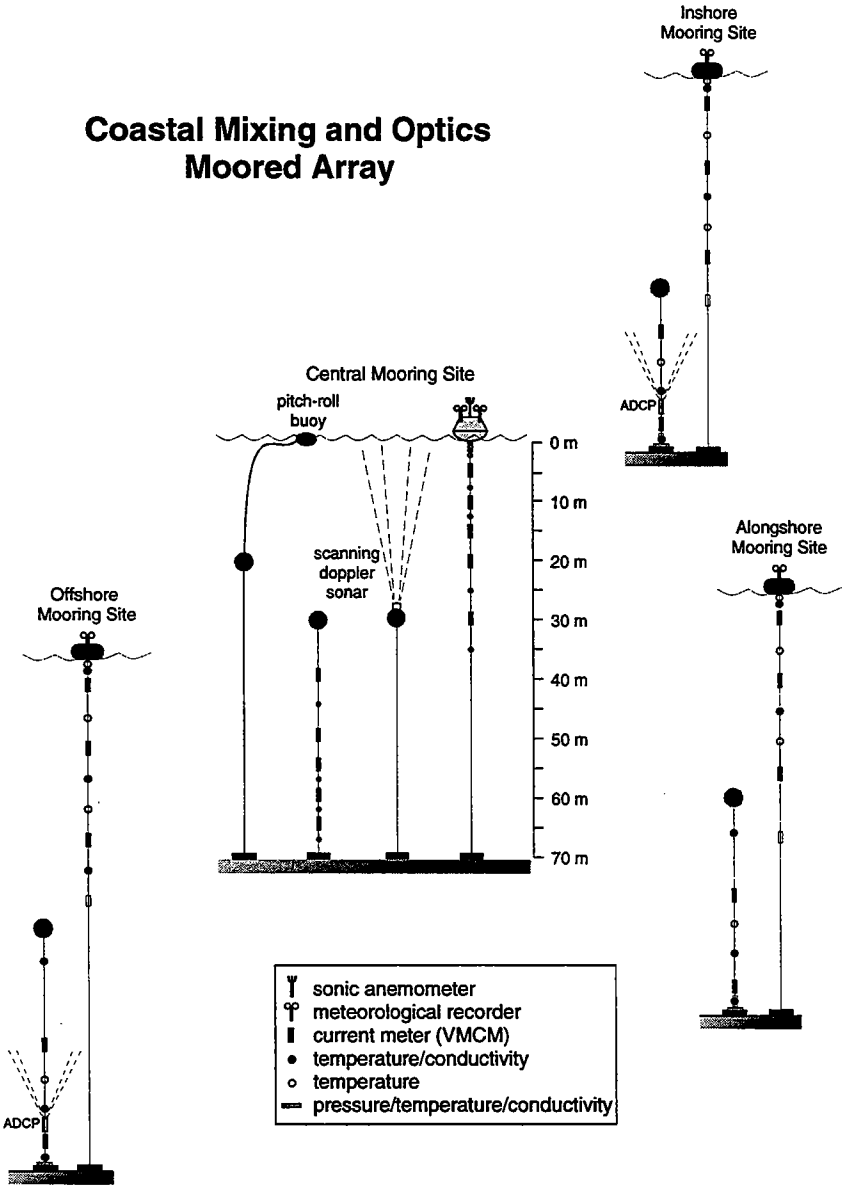


Figure I.2 Mooring Schematic

II: The Deployment Cruise

A. Cruise Chronology

R.V. Oceanus Cruise #284

July 30 The R/V *Oceanus* departed Woods Hole at 0830 (all times are local time unless noted otherwise) on July 29, 1996. We arrived at the Central Site at first light on July 30; weather was excellent, foggy but calm. The two Oregon State University (OSU) moorings and our two guard moorings deployed on Murray Levine's cruise were on station with the lights and the anemometer on the OSU meteorological buoy working fine. We checked the position of the OSU main mooring which is 40°29.52'N 70°30.46'W.

We began setting the deck to deploy the Central Site surface mooring at 0530 hours. Several shackles were added to the mooring to align all the current meters in the same orientation to minimize relative compass errors. We began the Central Site surface Mooring deployment at 0950 hours. The deployment went smoothly and was completed by 1115 (all mooring positions and times are listed in tables in section III.C). Bushings were not put into two swivels on this mooring. Began setting the deck for the Central Site subsurface mooring after lunch, again aligning the chain and instruments to have all the current meters in the same orientation. Began subsurface mooring deployment at about 1330 and finished at 1432 hours.

Visually the mooring looked about halfway between the two guards and slightly toward our surface discus buoy. However, plotting up the positions indicates the mooring was placed too far south and east. Bryan Way was unable to disable the release on this mooring after deployment, despite numerous attempts. We began setting the deck for the Seatex mooring immediately after completing the subsurface deployment. The Seatex mooring deployment started at 1620 and was completed at 1728 after a fairly long steam to get into position. Set the deck for the temporary toroid mooring at the Central Site before dinner. We added Steve Anderson's CHLAM instrument (see Appendix 6) to the mooring at 4 m below the base of the bridle. (Note: we simply added this 4 m shot of chain to the mooring.) The CHLAM was configured to take a point sample every 5 minutes. Began deployment at 1930 and the deployment was completed by 2015. All the deployments went smoothly.

Al Plueddemann and Steve Lentz setup the SeaBird SBE-25 CTD and took four CTD casts (#1–#4, section IV.B) at the Central Site between 2143 and 2231 hours. The CTD profiles looked reasonable, with a strong thermocline in the upper water column and a thick bottom

mixed layer. During the CTD station, the sea surface temperature and salinity from the ship's data acquisition system were not functioning. It turned out the water wasn't being pumped through the sensors. This was corrected and the subsequent data looked reasonable.

July 31 We steamed to the Offshore Site during the night and began setting the deck around 0530 for the surface mooring deployment. We steamed over the proposed offshore mooring site and found the water depth was 87 m rather than 84 m. This was a little puzzling as both the chart and a bathymetry survey by Murray Levine indicated it should be 84 m. We steamed north to see how far we would have to go to reach the 84 or 85 m isobath. The 84 m isobath was on the edge of the shipping lane, so we decided to stick with the original mooring site location rather than move closer to the shipping lanes.

The mooring deployment began at about 0830 and finished at 0950 hours. We then set the deck and deployed the southern and northern guard buoys. Each deployment took about half an hour. The light of the northern guard buoy was flashing after we deployed it; the skies were overcast. Deployment of the subsurface mooring at the offshore site began at 1350 and was completed at 1440 hours. There was a slight hold up as one of the lines got stuck just before the subsurface float was to go over the side. Otherwise all the mooring deployments went fairly smoothly. Bryan Way did not get a chance to disable the release as we were anxious to get back to Woods Hole and load the remainder of the moorings.

We began steaming for Woods Hole at about 1450 hours. We made a brief stop at the Central mooring site to take surface water samples for Heidi Sosik and to take a bucket temperature. The samples were taken at 40°29.2' 70°30.1' at 1530 (1930 UT). The bucket temperature was 16.5°C. We arrived in Woods Hole around 2030 hours.

August 1 Loaded the ship in the morning and departed for the Inshore Site at 2130 hours.

August 2 Arrived at the Inshore Site early in the morning. The weather remained calm and foggy. Began preparing the deck at 0530 for deployment of the surface mooring at the Inshore Site. The mooring deployment began at 0830 and was completed at 1000 hours. We then deployed the southern (label P) and northern (label T) guard moorings for the Inshore Site. The deployments both went smoothly, took about 20 minutes each and were completed just after lunch. We set the deck for subsurface mooring and began deployment at 1330 hours. For some unexplained reason the acoustic release fired on deck just as we were beginning the

deployment. We brought out a spare release and proceeded with the deployment which went smoothly after that and was completed by 1425 hours.

We took four CTD casts at the Inshore Site (#5–8, Section 4.b), the first at 1535 and the next three from 1710 to 1730 hours.

After completing the CTD casts we proceeded to the Central Site. All the buoys were in place at the Central Site and all the lights were working. We took three CTD casts (#9–11) at this site between 1936 and 1955 hours. Bryan Way was finally able to disable the release on the Central Site subsurface mooring by having the ship move about a mile from the site.

August 3 Weather continues to be ideal. We began setting up to recover the temporary toroid mooring at the Central Site at about 0630 hours. While setting up for the recovery we took three CTD casts (#12–14) at about 0700 hours. The release was fired at 0820 hours. The recovery went smoothly and was completed before 0900 hours. Steve Anderson's CHLAM seemed to work fine. Steve hooked the CHLAM up to the salt water intake to monitor surface chlorophyll during the remainder of the cruise (see Appendix 6).

We then steamed to the alongshore site. Initial bathymetric survey of the planned alongshelf site (40°27.0' 70°20.0') revealed the water was too deep. So we steamed north until we reached the 70-m isobath which was at 40°28.5'. This had the added advantage of putting us closer to the center between the outbound and inbound shipping lanes. The surface mooring deployment began at 1100 hours and was completed just before noon without incident. After lunch we deployed both guards in less than an hour, finishing just before 1400 hours. Deployment of the subsurface mooring began at 1520 and was completed by 1540 hours. This completed the mooring deployment operation which went very smoothly.

We took three CTD casts (#15–17) at the alongshore site between 1638 and 1701 and then proceeded to the offshore site where we also took three CTD casts (#18–20) from about 1830 to 1848 hours. Bryan also communicated with the release from the subsurface mooring at the offshore site because we hadn't done that after deployment as we were anxious to get back to WHOI and reload the deck.

We then steamed offshore to the shelfbreak and at 9:08 pm began a cross-isobath CTD transect of 21 stations (casts 21–41) extending from the 170-m isobath to about the 40-m

isobath. Station separation is about 5 km. We divided into three watches: Lentz, Ostrom and Way 4–8; Anderson, Baumgartner, Ray 8–12; and Fischer, Marquette, Ware 12–4.

August 4 The cross-shelf transect was completed by 0845 hours. The temperature and salinity sections look classical for this shelf. There is very warm water (20–17°C) above a sharp thermocline located 10 to 20 m below the surface, with cold pool water (7–8°C) below. The shelfbreak front is clearly visible in salinity (>34 psu offshore of front and < 33 psu inshore), the foot of the front intersects the bottom at the 110 m isobath.

We began an along-isobath survey at 1137 hours. The survey consists of 11 casts per isobath, with casts separated by about 5 km and the transect centered on the mooring line. The survey transects run along the 60, 70, 80, 90, 100 and 125-m isobaths. Near the end of the 60-m isobath transect the CTD stopped recording due to a battery failure. This was a little peculiar because the voltage output according to the instrument status report was 10.7 volts and the manual indicated 10.2 volts as a cutoff. After checking things out we replaced the batteries and the system worked fine.

August 5 Continues to be flat calm and foggy. We haven't seen the sun in several days. The alongshore survey proceeded all day.

August 6 Completed the alongshore survey, including repeating the 70-m transect, at about 1230 hours. There were a total of 80 CTD stations in the alongshelf survey (casts 42–121). We stopped by the alongshore mooring site at 0845 hours. The buoys looked fine. The waterline on the guards was about 6 inches below the bottom of the yellow paint (i.e., about 6 inches of brown was showing). The waterline on the toroid was at the bottom of the W. After completing the alongshore survey, we steamed to the Inshore Site and inspected the buoys. Again everything looked fine, the waterline on the toroid was a few inches below the bottom of the X. We took a CTD station at the Inshore Site (cast 122).

Arrived at the Central Site around 1630 and did a complete tour around the moorings. It was really quite impressive, especially the Wavescan with its green tail. All the buoys were in place and looked fine including both of Levine's. The waterline on the Discus was right at the painted waterline. The sun finally came out as we left the Central Site.

We began the second cross-shelf CTD transect at about 2030 hours. We extended this transect about 10 km further offshore adding two more stations to include more of the slope structure (casts 123–145). We took pictures of the radar images of the lobster pot high-flyers for Jack Barth at some of the CTD stations so they have some idea of the density and location of the lobster pots.

August 7 Finished the second cross-shelf CTD transect at 0830 hours. Water samples were again taken at the Central Site for Heidi Sosik at 0325 hours. The transect looks very similar to the previous cross-shelf transect we took. Arrived in Woods Hole around 1330 and unloaded the ship.

August 8 In port.

August 9 Departed from Woods Hole for Leg 3 at 0915 and steamed to the Central Site to deploy Yogi Agrawal's bottom tripod. Arrived at the Central Site around 1500 hours. Paul Hill checked out his release. We lowered the tripod into the water and Paul disabled it while it was hanging over the side. We then steamed slowly into position and released the tripod at 1524 hours (1924 UT).

We steamed to the offshore end of the cross-shelf CTD transect to repeat that line (casts 146–168). Watches were: Lentz and Barlow 4–8; Hill and Chang 8–12; and Carr and Tran 12–4. Began the CTD transect at 1820 on August 8 and completed the transect at 0600 on August 9.

A very successful cruise. We deployed all the moorings and the tripod and had time to do a rather extensive CTD survey of the region. The success of this cruise is largely due to the skill and cooperation of the crew and scientific party and the calm weather.

B. Shipboard Data Systems

The *Oceanus* was equipped with an Improved Meteorological System (IMET) meteorological package. Data was displayed throughout the ship, and recorded on a Sun SparcStation. Variables available were air temperature, sea surface temperature, barometric pressure, relative humidity, precipitation, short wave radiation, ship-relative winds, and ship's speed over ground, course over ground, and gyro heading. SST measurements were incorrect until July 30, because the pump supplying seawater to the sensor was not powered up. The data has been archived and may be used if needed at a later date.

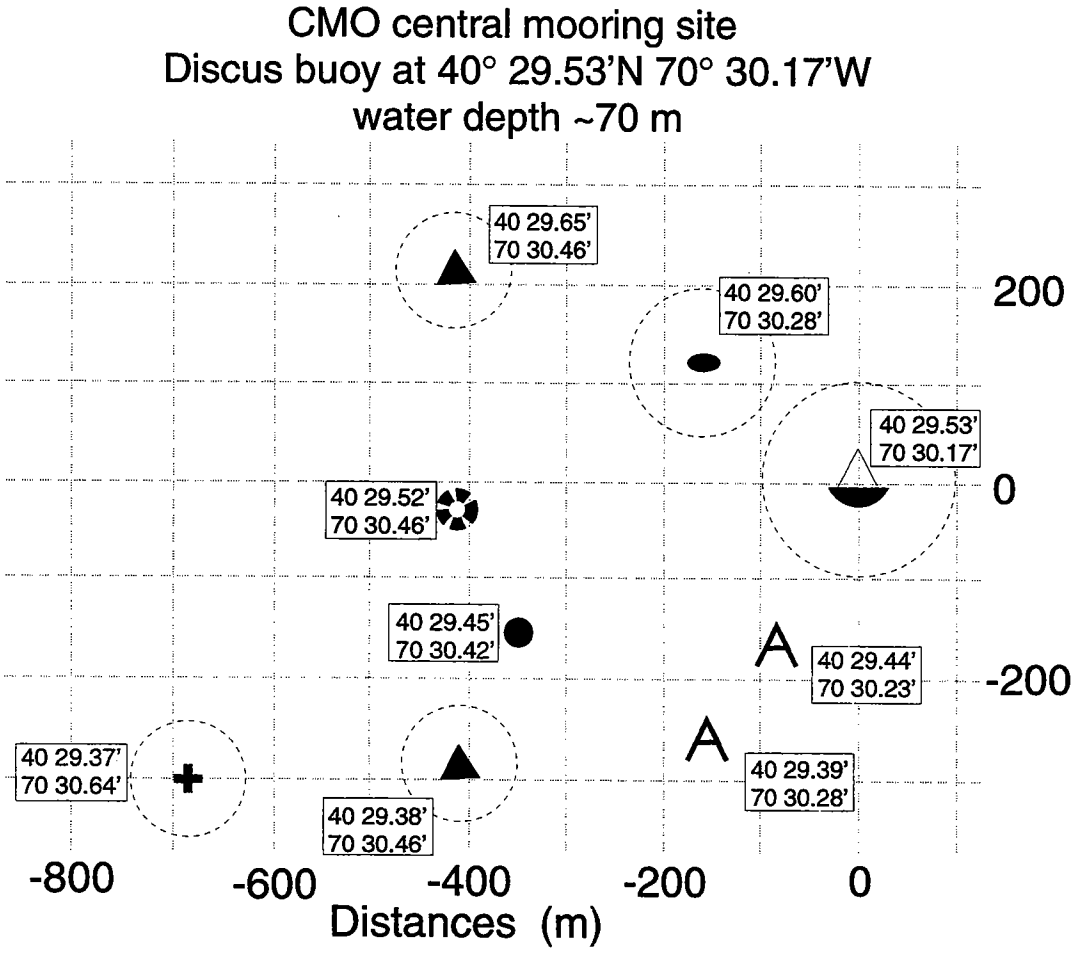
Two hull-mounted Acoustic Doppler Current Profiler (ADCP) systems were recording during the deployment cruises. Data from these systems was collected, but not analyzed during the cruise.

III: The Moored Array

A. Summary Description

The Central Site includes seven moorings and two bottom tripods in a region roughly 0.5 km square (Figure III.A.1). The basic strategy was to surround the subsurface moorings and tripods with surface moorings and guards in a fairly tight configuration to protect the site from the heavy fishing and shipping activity in the region. The two guards and the OSU surface and subsurface moorings were deployed on a previous cruise. One of the bottom tripods was deployed on a subsequent cruise. The other three moorings were deployed July 30 (Table III.C.4) and one bottom tripod was deployed August 9 on this deployment cruise. Additionally, one of the toroid buoys was deployed approximately 300 m south of the Central discus buoy from July 31 to August 3 to compare wind measurements (Appendix 5).

The three surrounding sites each consisted of four moorings, a toroid, two guards and a subsurface mooring (Figures III.A.2–4). The toroid and two guards form a triangle that is approximately 400 m on a side, with the subsurface mooring in the middle. Deployment times, water depths and positions for the moorings at each of the sites are listed in Table III.C.4. Mooring designs for the toroid and subsurface moorings are shown in Figures III.B.5–6 for the alongshore site, Figures III.B.7–8 for the inshore site, and Figures III.B.9–10 for the offshore site.



- surface discus buoy
- OSU met
- OSU subsurface w/surface spar
- guard buoy
- subsurface mooring
- waverider
- tripods

Figure III.A.1. Central Site Plan

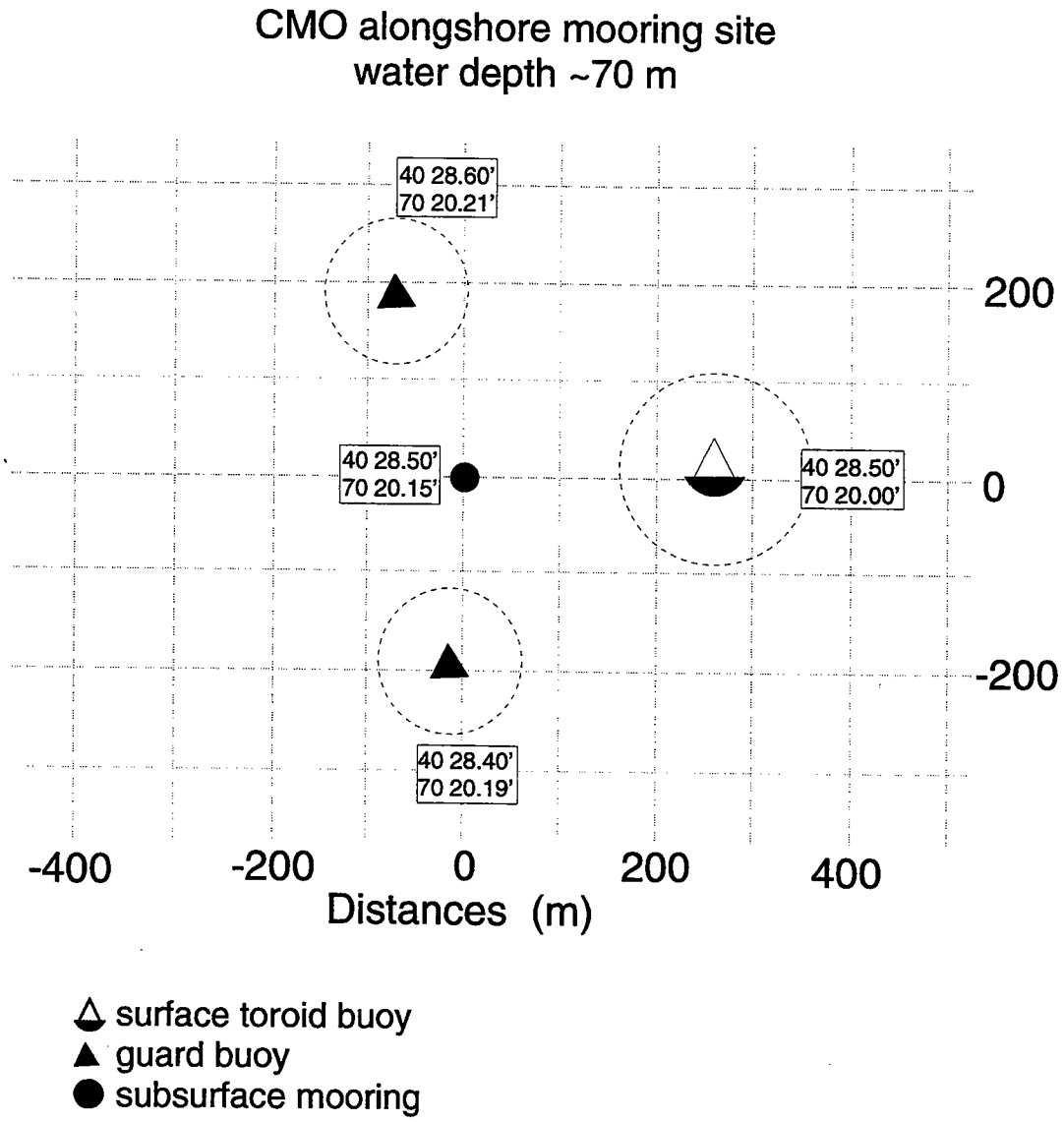


Figure III.A.2. Alongshore Site Plan

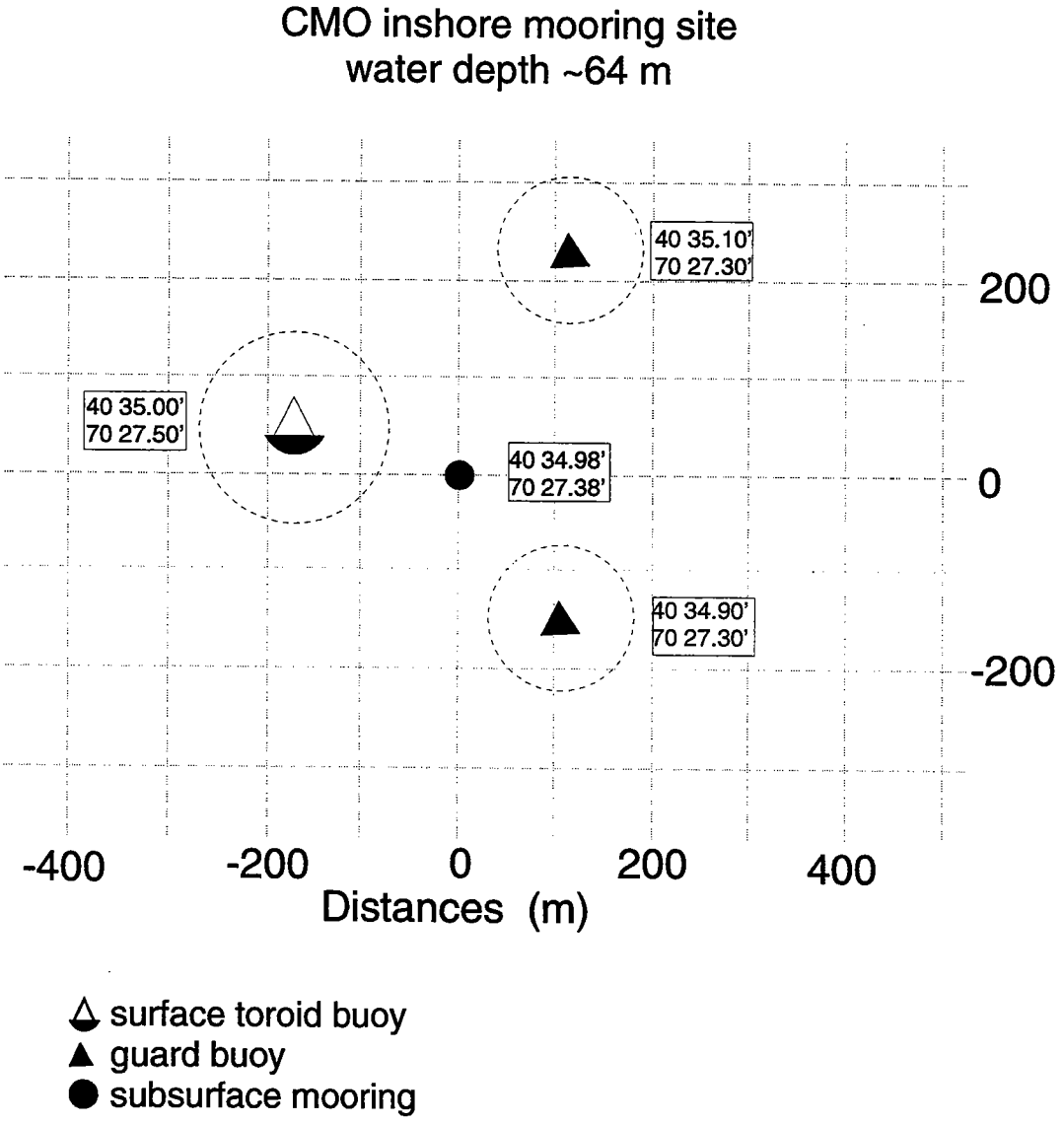


Figure III.A.3. Inshore Site Plan

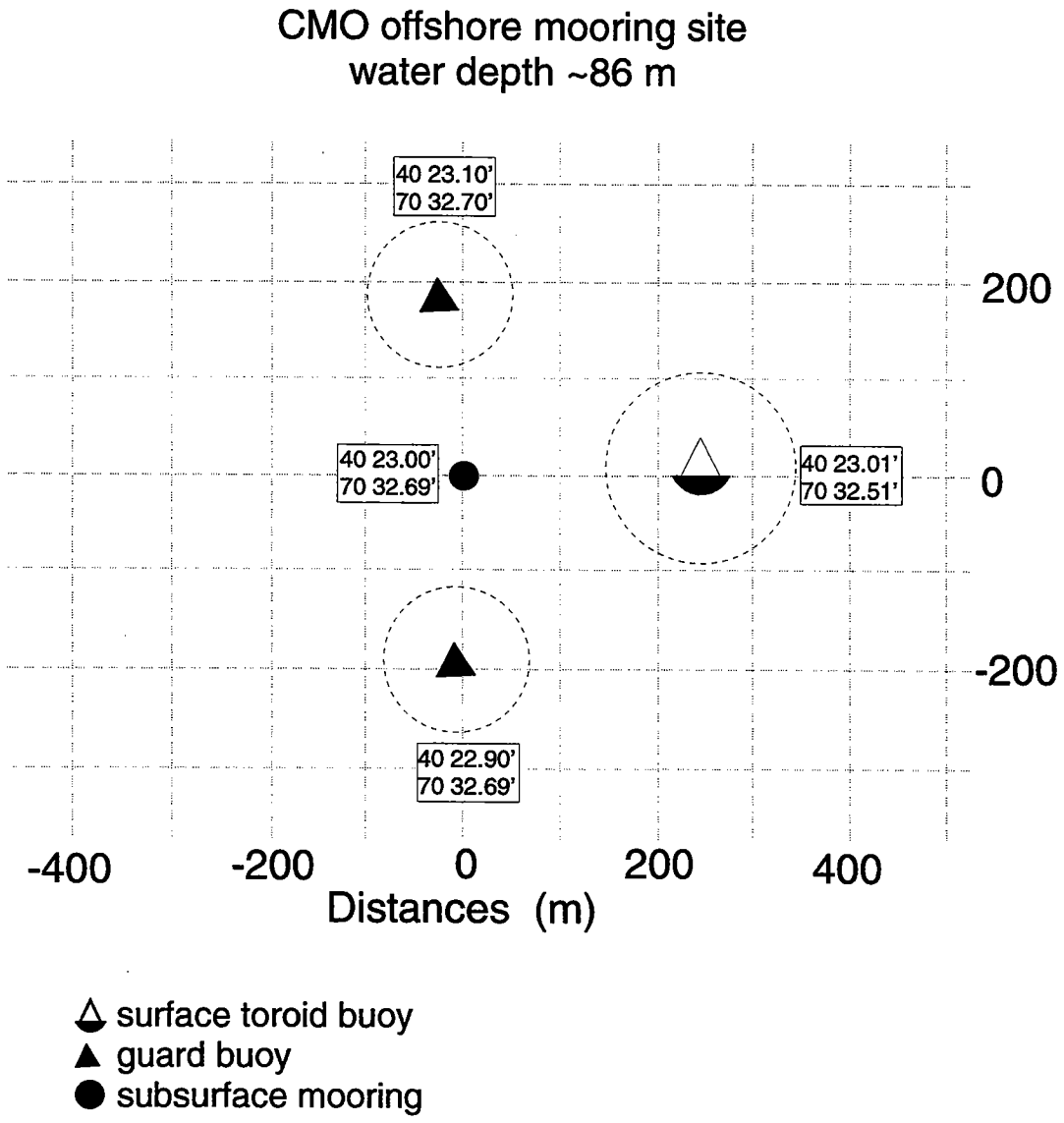


Figure III.A.4. Offshore Site Plan

B. The Moorings

The designs for the discus, toroid, Wavescan, subsurface, and guard moorings are shown in section III.B. Mooring numbers and deployment information are listed in Table III.B.1. Mooring diagrams are illustrated in Figures III.B.1 through III.B.11.

Number	Buoy	Set date	Time	Depth	Lat	Long
1000	Discus	96-07-30	15:14	70.0	40 29.532	70 30.167
1001	Subsurface	96-07-30	18:32	69.9	40 29.453	70 30.416
1002	Seatex	96-07-30	21:28	70.9	40 29.599	70 30.285
1003	Toroid	96-07-31	00:16	70.0	40 29.348	70 30.205
	recovered	96-08-03	12:18			

Number	Buoy	Set date	Time	Depth	Lat	Long
1004	Toroid	96-07-31	13:50	87.0	40 23.009	70 32.509
NA	Guard	96-07-31	15:23	87.0	40 22.898	70 32.691
NA	Guard	96-07-31	16:49	86.0	40 23.102	70 32.704
1005	Subsurface	96-07-31	18:38	86.0	40 23.003	70 32.687

Number	Buoy	Set date	Time	Depth	Lat	Long
1006	Toroid	96-08-02	14:04	64.0	40 35.002	70 27.500
NA	Guard	96-08-02	15:02	64.0	40 34.901	70 27.301
NA	Guard	96-08-02	16:36	64.0	40 35.104	70 27.301
1007	Subsurface	96-08-02	18:25	63.0	40 34.978	70 27.380

Number	Buoy	Set date	Time	Depth	Lat	Long
1008	Toroid	96-08-03	15:51	70.0	40 28.500	70 20.002
NA	Guard	96-08-03	17:18	70.0	40 28.401	70 20.193
NA	Guard	96-08-03	17:57	69.5	40 28.601	70 20.205
1009	Subsurface	96-08-03	19:39	69.5	40 28.504	70 20.147

Table III.B.1. Mooring Deployment Information

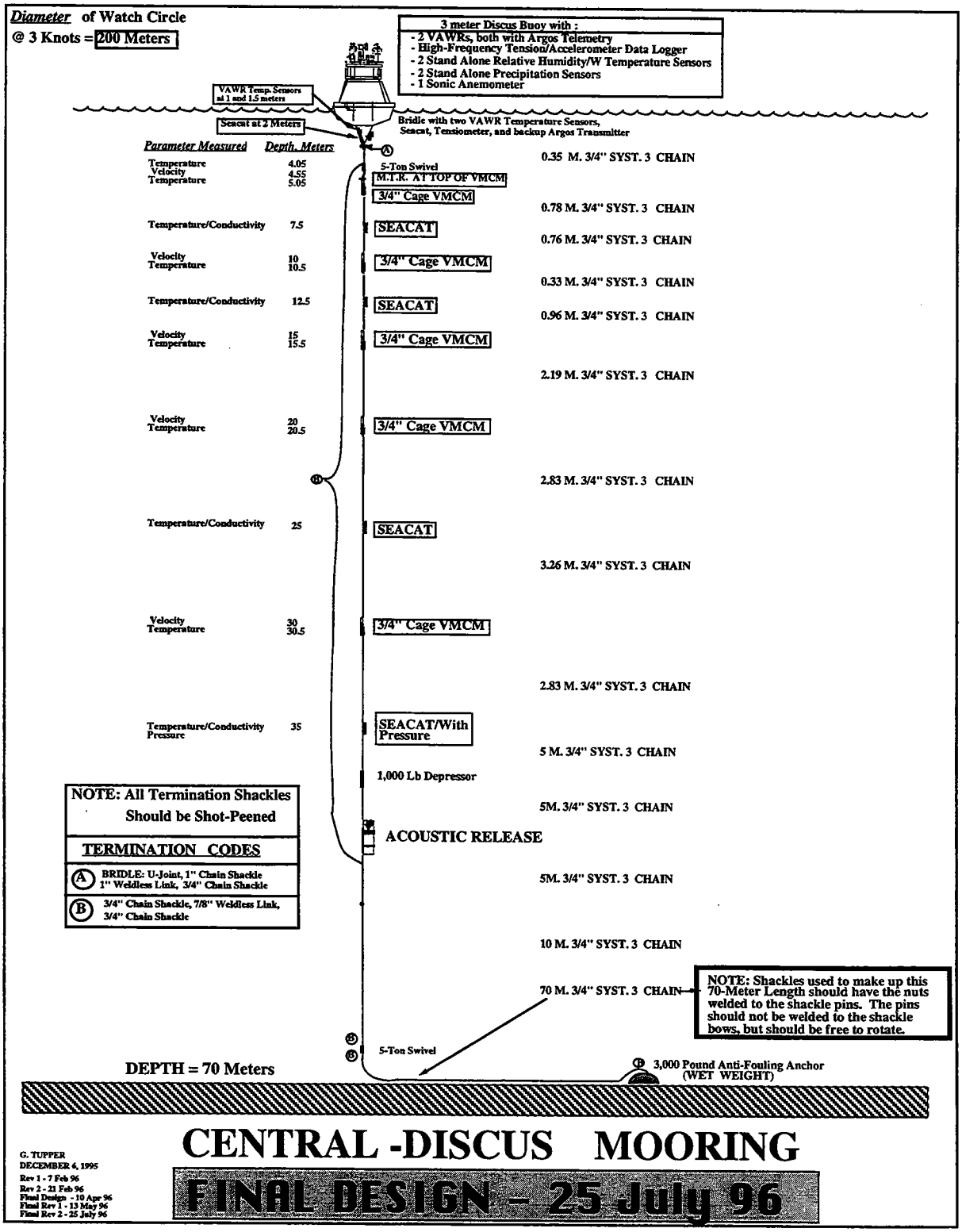


Figure III.B.1: Central Discus Diagram.

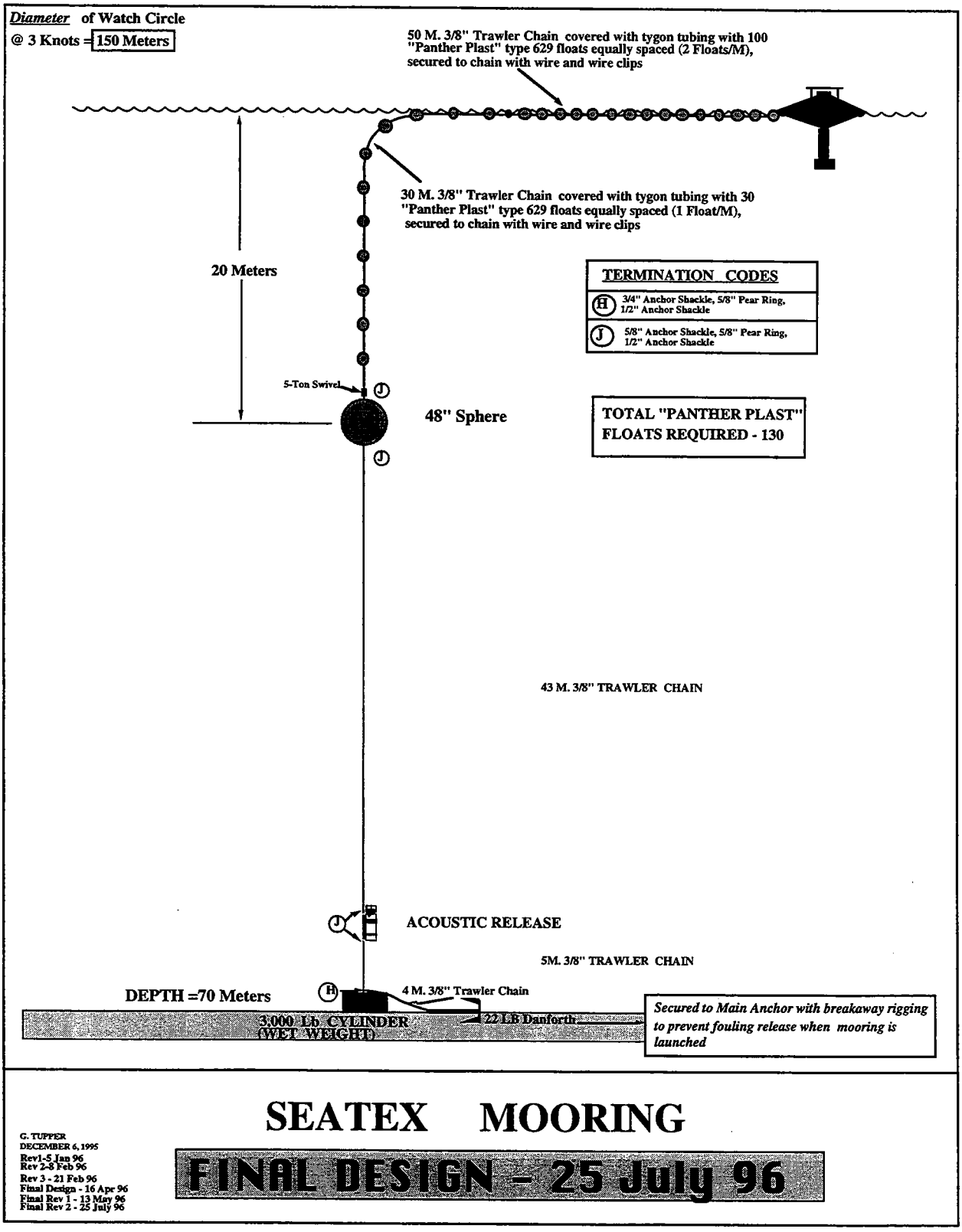


Figure III.B.2: Seatex Wavescan Diagram.

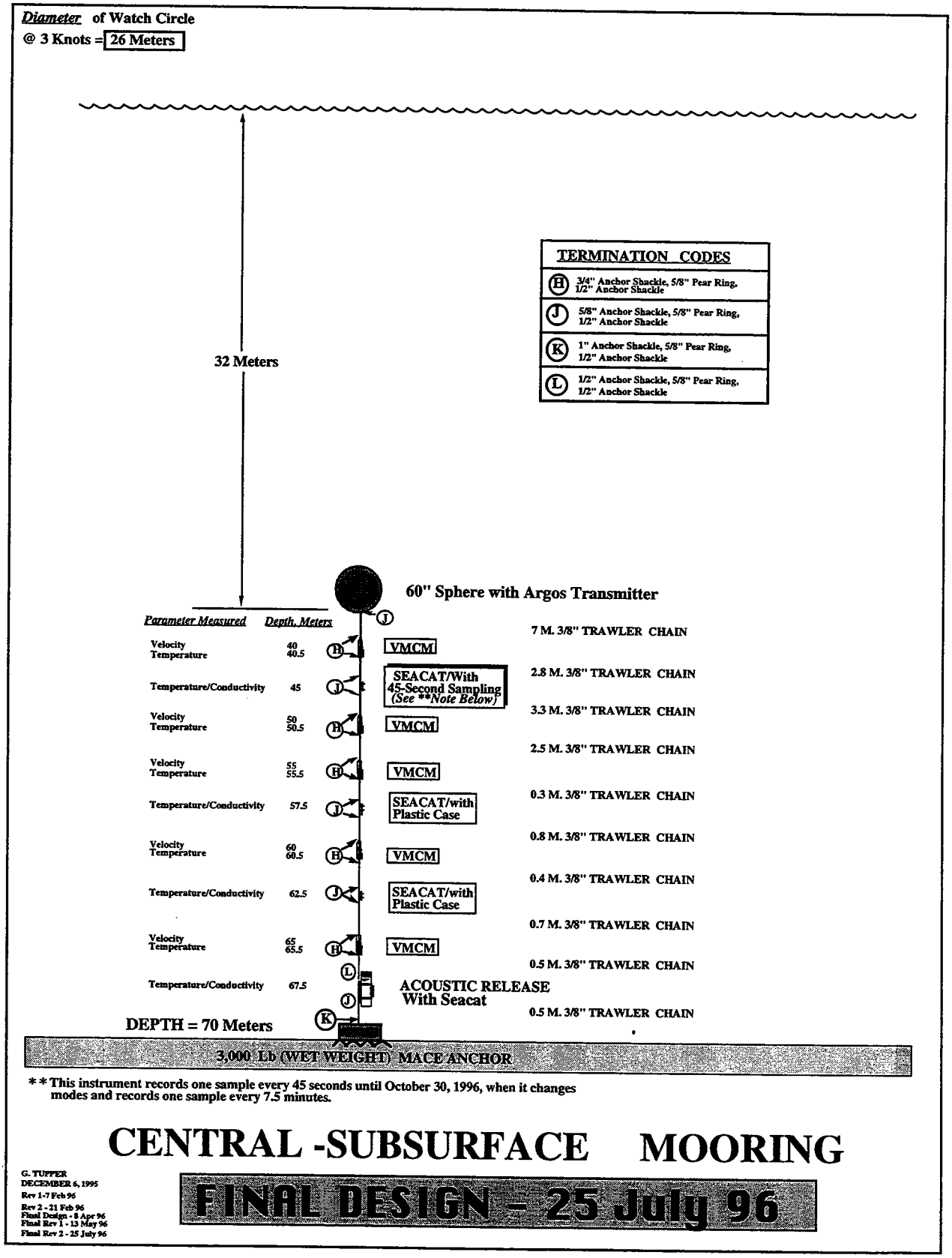


Figure III.B.3: Central Subsurface Diagram.

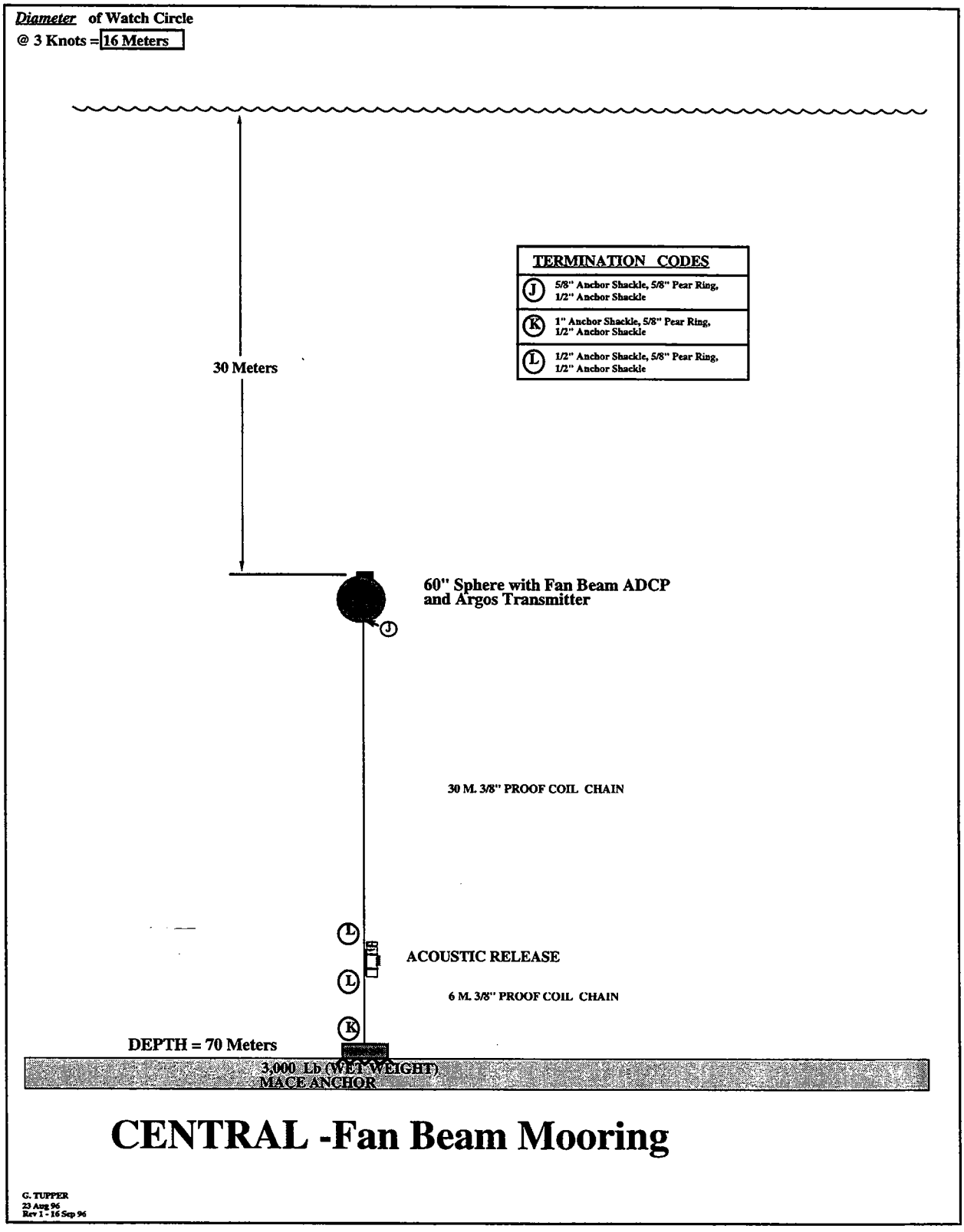


Figure III.B.4: Central Fan Beam Mooring Diagram.

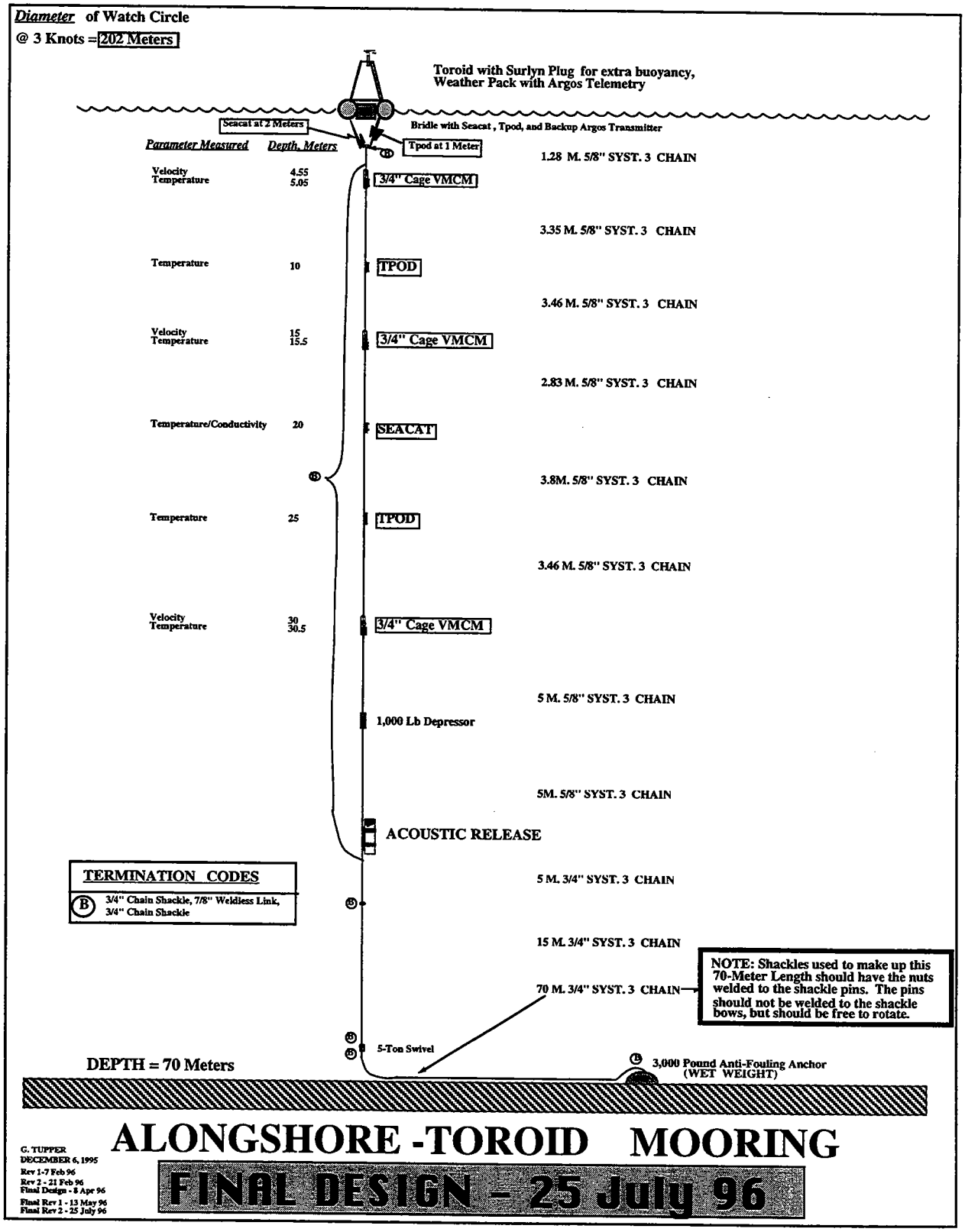


Figure III.B.5: Alongshore Toroid Mooring Diagram.