Appendix E

Preliminary Cruise Report

Research Vessel MOANA WAVE

Cruise 2

April - May

1974

by

A. F. Amos

MOANA WAVE CRUISE 2 PRELIMINARY REPORT

MOANA WAVE Cruise 2 was designed to investigate the base-line conditions on the ocean floor and in the entire water column overlying a manganese nodule province centered in the North Pacific Ocean. The cruise started on 16 April, 1974 and ended on 15 May, 1974. We occupied a network of stations centered on 8°27'N; 150°47'W in the form of a N-S/E-W cross whose arms extended 1 degree in both directions from the center. Sixteen scientists from Lamont and City College of New York participated in the cruise under the major sponsorship of NOAA.

The following areas of research were undertaken:

A. OCEAN FLOOR

(i) Topography and Sedimentology

- underway 12KH$_Z$ and 3.5KH$_Z$ precision depth records.

(ii) Sedimentology

- box coring (photographic documentation, shear strength, bulk properties, classification, x-radiography of biologic and lithologic structures, physical properties of substrate).
- ocean floor photographs.
- nephelometry.

(iii) Manganese Nodules

- box coring (surface and subsurface distribution).
- bottom dredging and ocean floor photographs

(number, size, morphology, degree of cover, etc.)

(iv) Benthic Ecology

- box coring (washed sample, sub-core sample left intact).
- small biological trawl (nodules, rocks examined for benthos).
- ocean floor photographs (identification of epibenthic fauna).

(v) Bottom Currents

- direct measurements (current meters)
- indirect measurements (ocean floor photographs).

(vi) Bottom Microorganisms

- cultured from box core sediments.

(vii) Trace Metals

- box core sediments.

B. <u>WATER COLUMN</u>

(i) Physical Oceanography

- continuous profiles of salinity and temperature (STD) surface to bottom.
- hydrographic stations (samples for salinity analysis and reversing thermometers).
- bottom and near-bottom currents (level of no motion for geostrophic determinations).
- underway temperature profiles to 750 m (XBT's).

(ii) Chemical Oceanography

- determination of pH, alkalinity and dissolved O_2 concentration at all depths.
- determination of nutrients (NH_3, NO_3, NO_2, PO_4, SiO_4) at all depths.
- determination of nutrient utilization during enrichmcnt study.
- trace metal (Hg, Cd, As, Pb, Cu, Zn, Cr, Ni, Se, V, Be) analysis from near surface and near-bottom samples.

(iii) Biological Oceanography

- nannoplankton - net plankton productivity
- chlorophyll <u>a</u> determinations.
- photosynthetic capacity and photosynthesis-light intensity relationship.
- enrichment study (phytoplankton growth experiment in bottom water/surface water mixtures.
- phytoplankton taxonomy.
- Secchi disc measurements.

(iv) Suspended Particulate Material

- nephelometry (continuous profiles of light scattering: surface to bottom).
- particulate dry-weight analysis.
- organic carbon, nitrogen determinations.

C. MISCELLANEOUS EQUIPMENT AND EXPERIMENTS

- Satellite Navigation System (SATNAV)
- Acoustic Transponding Navigation System (ATNAV)

- continuous pyroheliometer measurement.
- H-P 9830 computer (system of programs devised to process hydrographic data at sea).

This cruise afforded a particularly good opportunity to do multiple near-bottom STD profiles in the North Pacific Ocean to continue work started in this area (Gordon and Gerard, 1970) and to compare time-series nephelometry and near-bottom temperature and salinity variations with conditions found in similar experiments in the Atlantic Ocean (Eittreim and Amos, 1974).

A summary of the measurements made is given in Table 1. The station locations are shown in Figures 1-4. A more detailed description of the STD/Hydrographic and ATNAV/Current Meter programs follows. Cruise Track shown in Figure 1A.

PHYSICAL OCEANOGRAPHY

I. STD/Hydro Stations

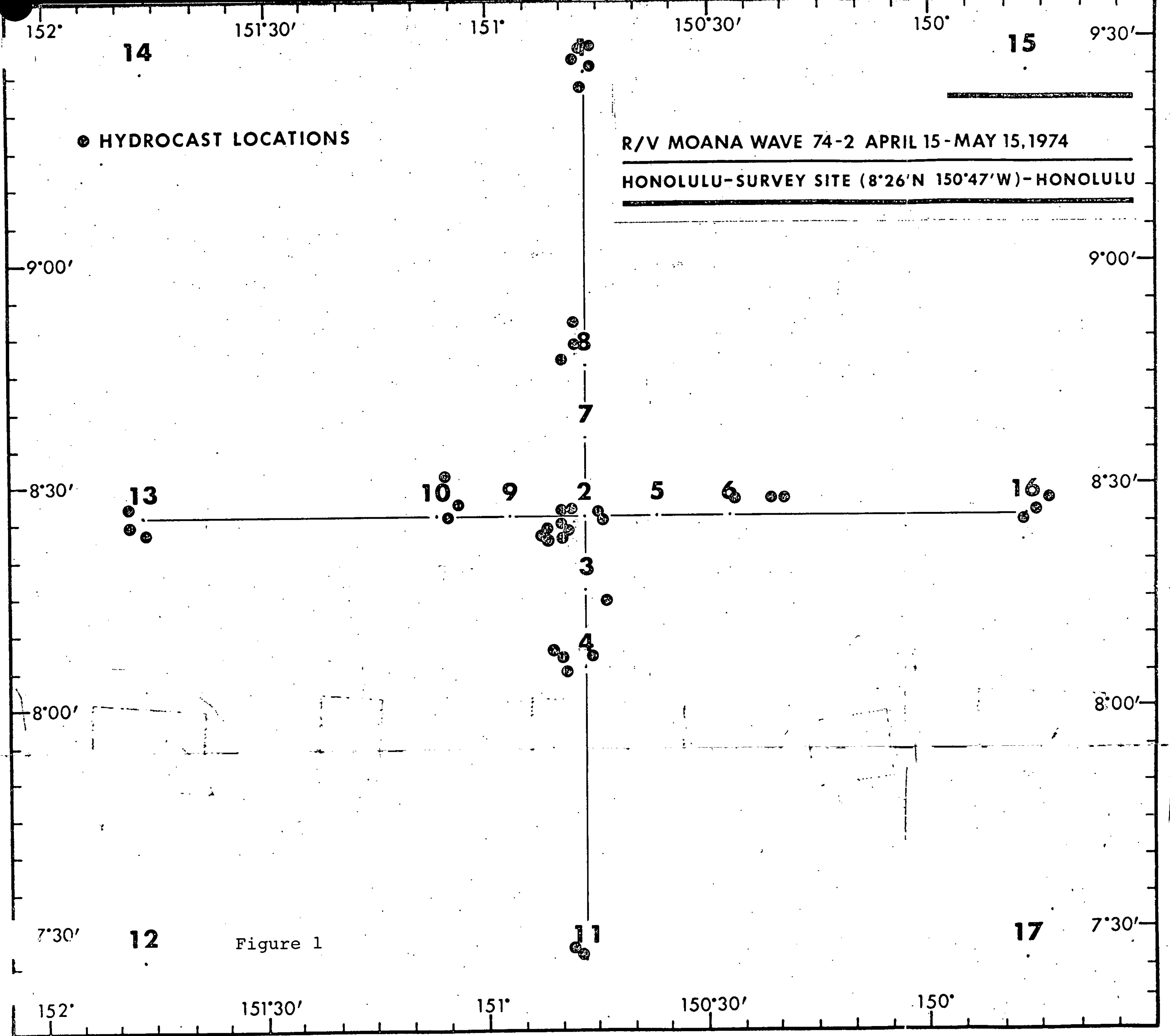
STD/Hydro stations combine the use of the continuously recording salinity/temperature/depth (STD) sensor with standard hydrographic observations using sampling bottles equipped with deep-sea reversing thermometers. During the cruise a rosette sampler (Niskin, 1968) was used to trigger the sampling bottles for the first 24 stations (until the sea cable used to trigger the sampling bottles broke down rendering the continued use of the rosette and the STD impossible). The rosette sampler held 12 x 12 liter Niskin bottles (six with thermometer frames). These bottles were tripped on a command

TABLE 1

DATE	TIME Z START	END	ACTIVITY	CAMERA STN #	STD + HYDRO STN	TRACE METAL HYDRO	BOX CORE	NEPH. METER	SHALLOW CAST	SUB-BOTTOM TRAWL	DEEP HYDRO	MINI LUB	CURRENT METER	OTHER
Apr. 16 21	0802	0255	Steam Honolulu to Stn. #1	-	-	-	-	-	-	-	-	-	-	-
21	0255	1400	Occupy Stn.#1	-	1	-	-	-	-	-	TV	-	-	TV
21 22	1400	1830	Steam between Stn.#1 & 2	-	-	-	-	-	-	-	-	-	-	-
22 26	1830	2022	Occupy Stn.#2	1	2,3,4, 5,6,7, 8,9	1	1,2	1	1,2	1	1	1	Deploy 1,2,3	-
26	2022	2358	Steam between Stn.#2 & 3	-	-	-	-	-	-	-	-	-	-	-
26 27	2358	1817	Occupy Stn.#3	-	10	-	3,4	-	-	-	2	-	-	-
27	1817	2325	Steam between Stn.#3 & 2	-	-	-	-	-	-	-	-	-	-	-
27 28	2325	0415	Occupy Stn.#2	-	11	-	-	-	-	-	-	-	Deploy 4	-
28	0415	0712	Steam between Stn.#2 & 4	-	-	-	-	-	-	-	-	-	-	-
28 29	0712	1622	Occupy Stn.#4	1	12,13 14,15	2	5,6	2	3	-	3	-	-	SES 2
29	1622	2132	Steam between Stn.#4 & 11	-	-	-	-	-	-	-	-	-	-	-
29 May 1	2132	0600	Occupy Stn.#11	2	16,17 18	3	7	3	4	2	4	-	-	-

DATE	TIME START	Z END	ACTIVITY	CAMERA STN #	STD + HYDRO STN	TRACE METAL HYDRO	BOX CORE	NEPH. METER	SHALLOW CAST	SUB-BOTTOM TRAWL	DEEP HYDRO	MINI LUB	CURRENT METER	OTHER
May 1	0600	1950	Steam between Stn.#11 & 13	-	-	-	-	-	-	-	-	-	-	-
1 2	1950	2100	Occupy Stn.#13	3	19,20 21	4	-	4	5	-	5	-	-	-
2 3	2100	0356	Steam between Stn.#13 & 10	-	-	-	-	-	-	-	-	-	-	-
3 4	0356	0830	Occupy Stn.#10	-	22,23 24	5	9,10	5	6	-	6	-	-	-
3 4	0830	1601	Steam between Stn.#10 & 2	-	-	-	-	-	-	-	-	-	-	-
4 5	1601	0400	Occupy Stn.#2	4	-	-	-	-	-	4	4	-	-	Atnav 1 & 2
5	0400	0732	Steam between Stn.#2 & 6	-	-	-	-	-	-	-	-	-	-	-
5 6	0732	1318	Occupy Stn.#6	5	-	6	11	6	7	5	7	-	-	-
6	1318	1835	Steam between Stn.#6 & 16	-	-	-	-	-	-	-	-	-	-	-
6 7	1835	1600	Occupy Stn.#16	6	-	7	12	7	8	-	-	-	-	-
7	1600	2314	Steam between Stn.#16 & 8	-	-	-	-	-	-	-	-	-	-	-
7 9	2314	0433	Occupy Stn.#8	7	-	8	14	8	9	-	9	-	-	-

DATE	TIME Z START	END	ACTIVITY	CAMERA STN #	STD + HYDRO STN	TRACE METAL HYDRO	BOX CORE	NEPH. METER	SHALLOW CAST	SUB-BOTTOM TRAWL	DEEP HYDRO	MINI LUB	CURRENT METER	OTHER
May 9	0433	0837	Steam between Stn.#8 & 2	-	-	-	-	-	-	-	-	-	-	-
9 10	0837	2203	Occupy Stn.#2	8	-	9	15	-	-	-	10	-	Recover 2,3,1	Atnav 3,4,5
10 11	2203	1146	Steam between Stn.#2 & 1	-	-	-	-	-	-	-	-	-	-	-
11 12	1146	0300	Occupy Stn.#1	9	-	10,11	17	-	10	-	11	-	-	-
12 15	0300	1648	Steam between Stn.#1 & Honolulu	-	-	-	-	-	-	-	-	-	-	-



152°
151°30′
151°
150°30′
150°
9°30′
9°00′
8°30′
8°00′
7°30′
14
15
HYDROCAST LOCATIONS
R/V MOANA WAVE 74-2 APRIL 15-MAY 15, 1974
HONOLULU-SURVEY SITE (8°26′N 150°47′W)-HONOLULU
8
7
13
10
9
2
5
6
16
3
4
12
11
17

Figure 1

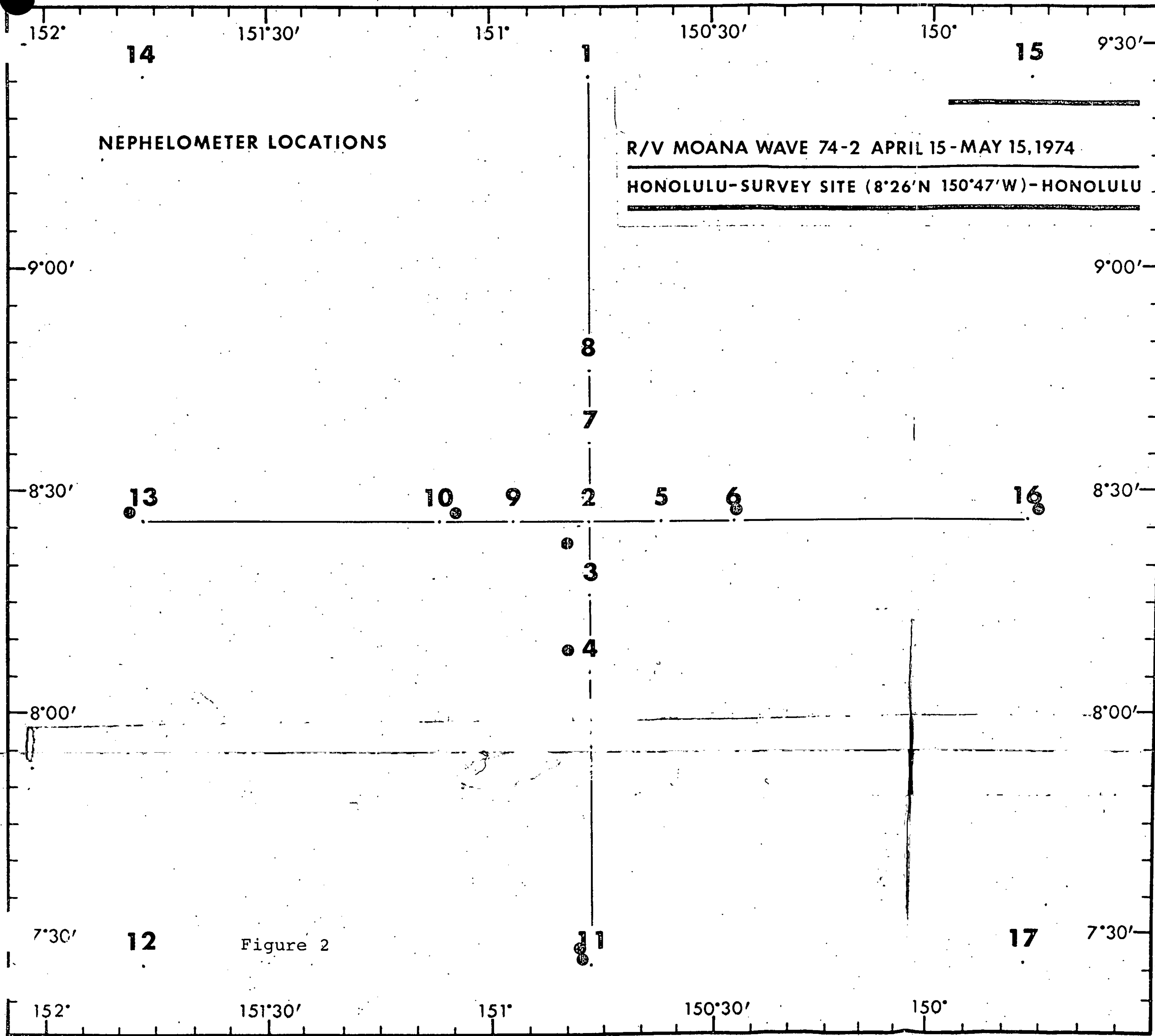

NEPHELOMETER LOCATIONS
R/V MOANA WAVE 74-2 APRIL 15-MAY 15, 1974
HONOLULU-SURVEY SITE (8°26'N 150°47'W)-HONOLULU
152°
151°30'
151°
150°30'
150°
9°30'
9°00'
8°30'
8°00'
7°30'
1
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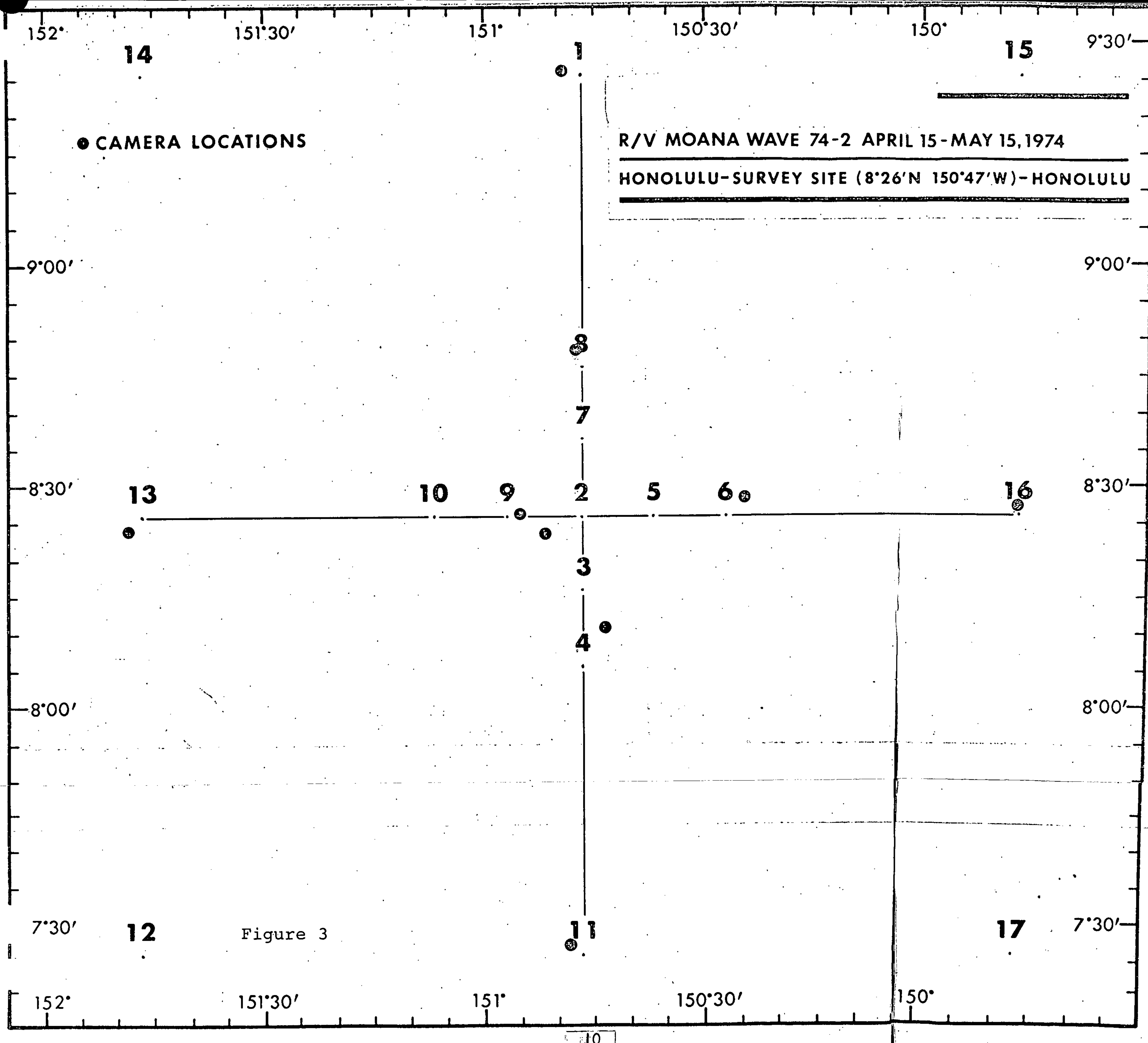
Figure 2



152°
151°30′
151°
150°30′
150°
9°30′
9°00′
8°30′
8°00′
7°30′
CAMERA LOCATIONS
R/V MOANA WAVE 74-2 APRIL 15-MAY 15, 1974
HONOLULU-SURVEY SITE (8°26′N 150°47′W)-HONOLULU
1
2
3
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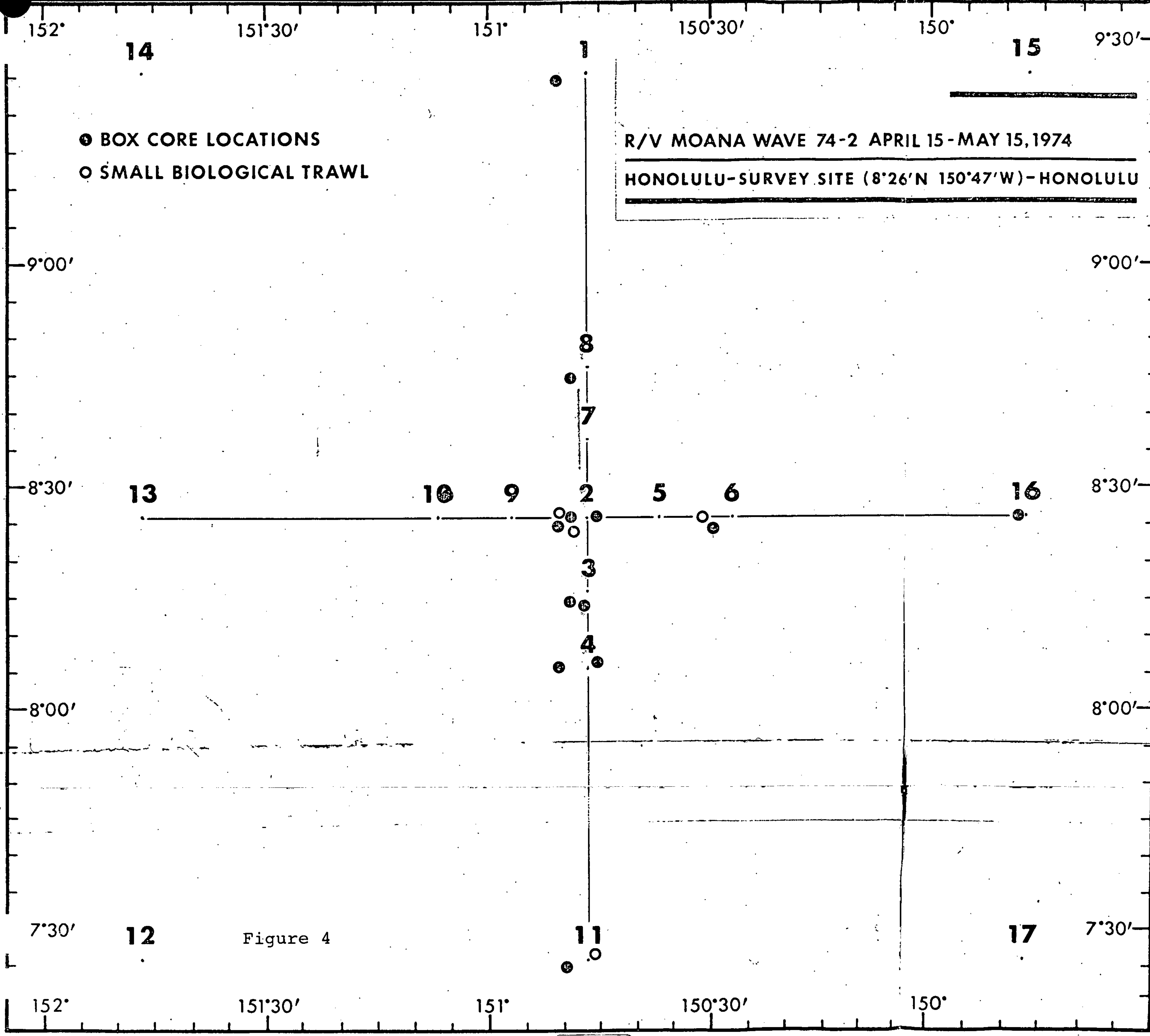
10
11
12
13
14
15
16
17

Figure 3



R/V MOANA WAVE 74-2 APRIL 15-MAY 15, 1974
HONOLULU-SURVEY SITE (8°26'N 150°47'W)-HONOLULU
BOX CORE LOCATIONS
SMALL BIOLOGICAL TRAWL
152°
151°30'
151°
150°30'
150°
9°30'
9°00'
8°30'
8°00'
7°30'
1
2
3
4
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7
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15
16
17

Figure 4

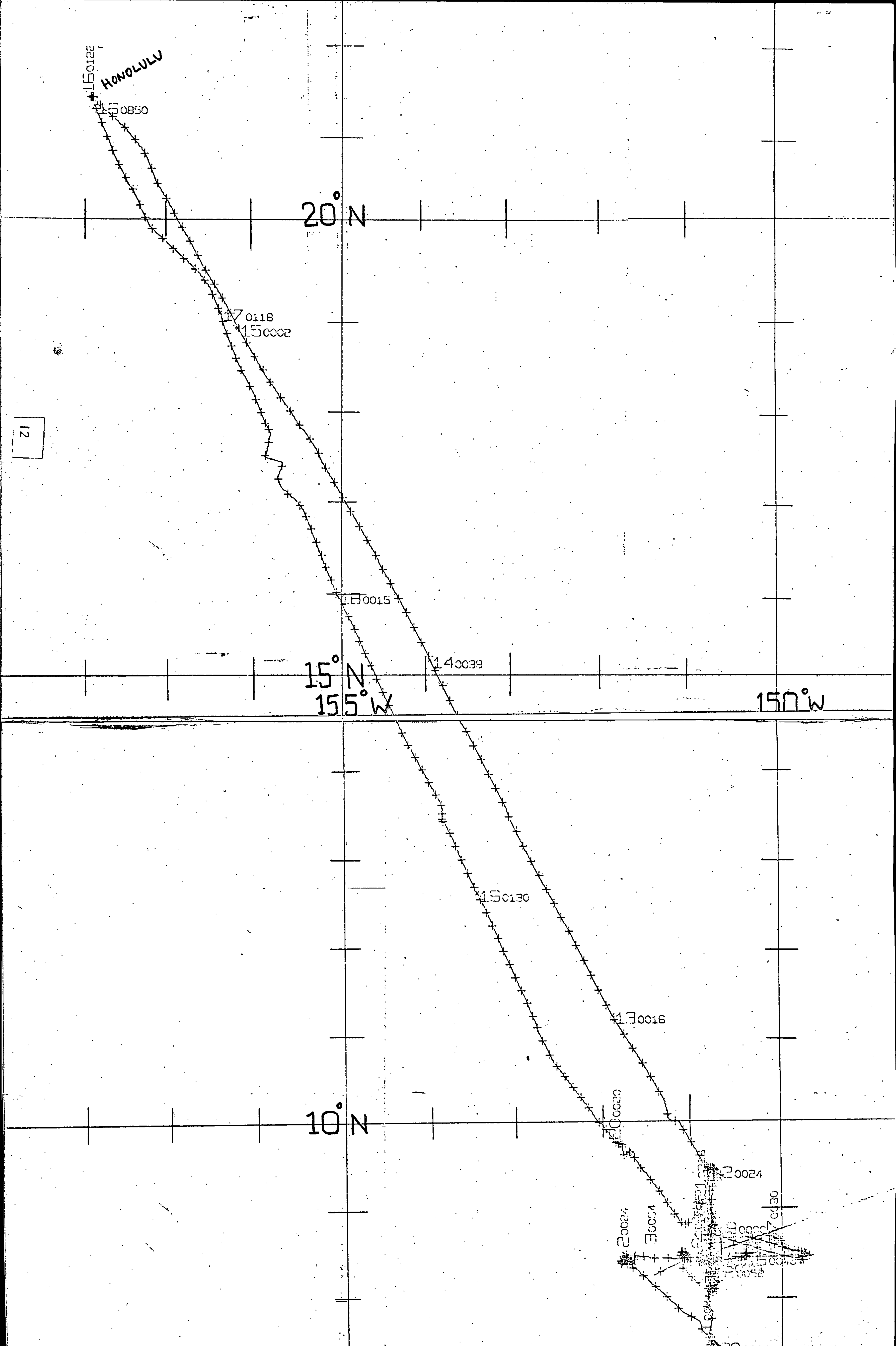


Figure 1A. MOANA WAVE 2 TRACK

signal from the deck control unit, obviating the need for attaching the bottles individually to the cable and waiting for a messenger to descend and trip them. As each bottle was tripped, the exact output from all three STD parameters was noted giving us a more accurate measurement of the depth at which each one was tripped than is normally possible with a standard hydrographic cast. Both the STD and a bottom-finding pinger were attached directly to the large frame of the rosette sampler which allowed for (a) close proximity of STD-rosette for good calibration; (b) accurate determination of how far above the ocean floor our samples were collected and some measure of protection from mechanical shock during launching and recovery procedures. Despite the large size of this STD-rosette-pinger package, and the lack of a 'hero' platform, safe launchings and recoveries were made by using the hydraulic 'A' frame, the large opening in the rail and snubbing lines on the underwater package. A detailed description of the techniques we used in taking the STD stations is given in Amos (1973). The salinity and thermometer data from the rosette samples were used to (a) describe the physical oceanography of the water column and augment the STD data (b) provide *in situ* calibration data for the STD sensors. Sample spacing in the water column was determined largely by the needs of other programs (trace metals, particulates, primary productivity, etc.) whose samples came from the same Niskin bottles. An attempt was made, however, to cover the entire water column with samples to adequately describe its dissolved oxygen and nutrient content.

When the sea cable conductor shorted out, it was decided not to replace it with the spare as its length of 5400 meters was marginally adequate to reach the ocean bottom. The STD-rosette was abandoned and the 12-liter bottles were put directly onto the sea cable after this. Fifteen additional hydro stations were occupied in this way.

II. Data Reduction, Storage and Display System

A series of programs were written during MOANA WAVE 2 to reduce, store and display the hydrographic data.

A Hewlett-Packard Model 9830 with high speed page printer was available on board and was found to be a most versatile computer to perform these tasks.

Programs written to date:

- THERM 1 - computes temperature, thermometric depth, for hydro stations
- THERM 2 - computes temperature, thermometric depth for rosette stations and compares these data with STD temperatures and depths
- SALIN 1 - computes corrected salinity from conductivity ratio of samples run on an inductive salinometer
- SALIN 2 - computes salinity as above for rosette samples and compares with STD derived salinities
- TSTORE - stores thermometer calibration data on cassette
- ILIST - lists thermometer calibration data stored on cassette

DSTORE - stores hydrographic data on cassette

HLIST - lists hydrographic data on cassette

SIGMA - computes sigma-T from temperature and salinity

SDVEL - computes sound velocity from temperature, salinity and depth.

III. ATNAV/Current Meter Program

(a) ATNAV System

At Station 2, in the center of our survey grid, an Acoustically Transponding Navigation (ATNAV) system was deployed. This system made by AMF Inc., consists of 3 bottom-mounted acoustic transponders, deployed in a triangle whose sides are approximately 5 km in length. Precise navigation of both the surface vessel and a fourth, submerged transponder (attached to the dredge or camera wire, for example) with respect to the fixed beacon locations on the ocean floor is obtained using the ATNAV system. The purpose of the ATNAV system was threefold in this study:

1. To provide an accurate location system for our main central station so that we could reoccupy it at any time throughout the survey.
2. Precisely locate the position of a camera (for example) so that the effects of dredging on the ocean floor may be photographed after the dredging has occurred.
3. Provide recoverable anchorages for 3 of the 4 strings of current meters that were deployed at Station 2.

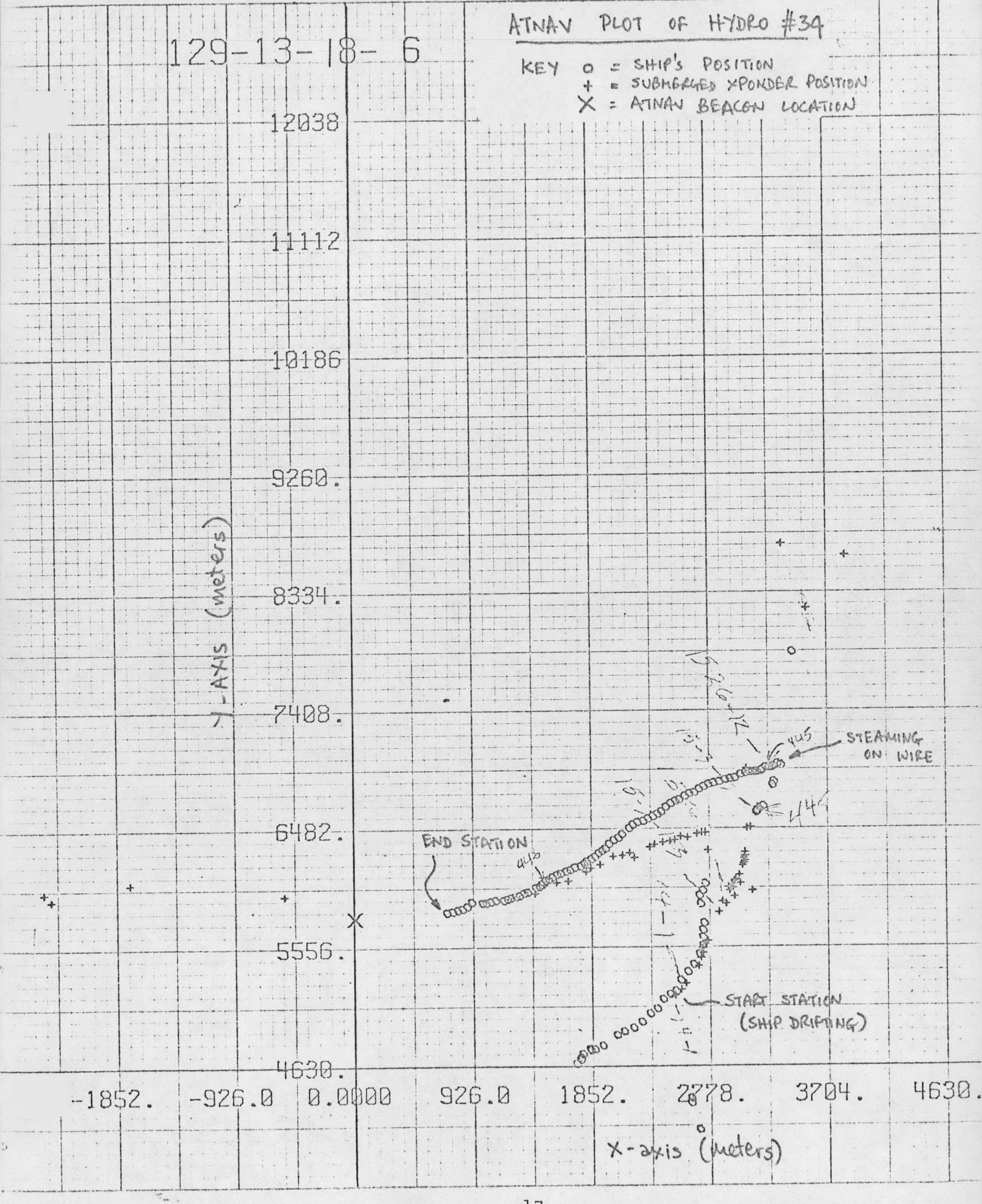
The shipboard end of the ATNAV system consists of a transducer, deck command unit, PDP-11 computer, teletypewriter and a flat-bed plotter. A towable transducer was provided with the system, but as MOANA WAVE did not have a suitable winch to handle the towing body and faired cable, a non-towed transducer was used, necessitating stopping the ship before the transducer could be lowered.

The ATNAV program can also be regarded as an evaluation of the whole system, used here for the first time in the deep ocean, as a tool to aid in research on manganese nodule areas (Figure 5 shows an example of an ATNAV plot).

(b) Current Meters

Nine Geodyne film-recording current meters (three Model 101, six Model 102) were deployed on four separate arrays: three on the ATNAV beacons at the apices of the ATNAV triangle (designated sites A, B and C) and one in the center of the triangle (designated site D). The distances between these arrays was considered to be insignificant (as far as horizontal variability of currents in this deep ocean basin is concerned) although there were some small seamounts within our study area.

The heights of the current meters above bottom were 10, 20, 30, 50, 100, 210, 410, 1010, 2010 meters. They were deployed in three strings of 2 meters each and one string of 3 meters (Table 2).



ATNAV PLOT OF HYDRO #34
129-13-18- 6
KEY o = SHIP'S POSITION
+ = SUBMERGED XPONDER POSITION
X = ATNAV BEACON LOCATION
12038
11112
10186
9260.
8334.
7408.
6482.
5556.
4630.
Y-AXIS (meters)
-1852.
-926.0
0.0000
926.0
1852.
2778.
3704.
4630.
X-axis (meters)
STEAMING ON WIRE
445
END STATION
START STATION (SHIP DRIFTING)

Figure 5

TABLE 2

CM #	SITE	# OF CM's IN ARRAY	HEIGHT ABOVE BOTTOM (m)	REMARKS
2	A	3	30, 50, 100	Acoustic release failed to respond to release command*
3	B	2	210, 410	Recovered intact
1	C	2	1010, 2010	Recovered intact
4	D	2	10, 20	Left for recovery in Oct. 1974

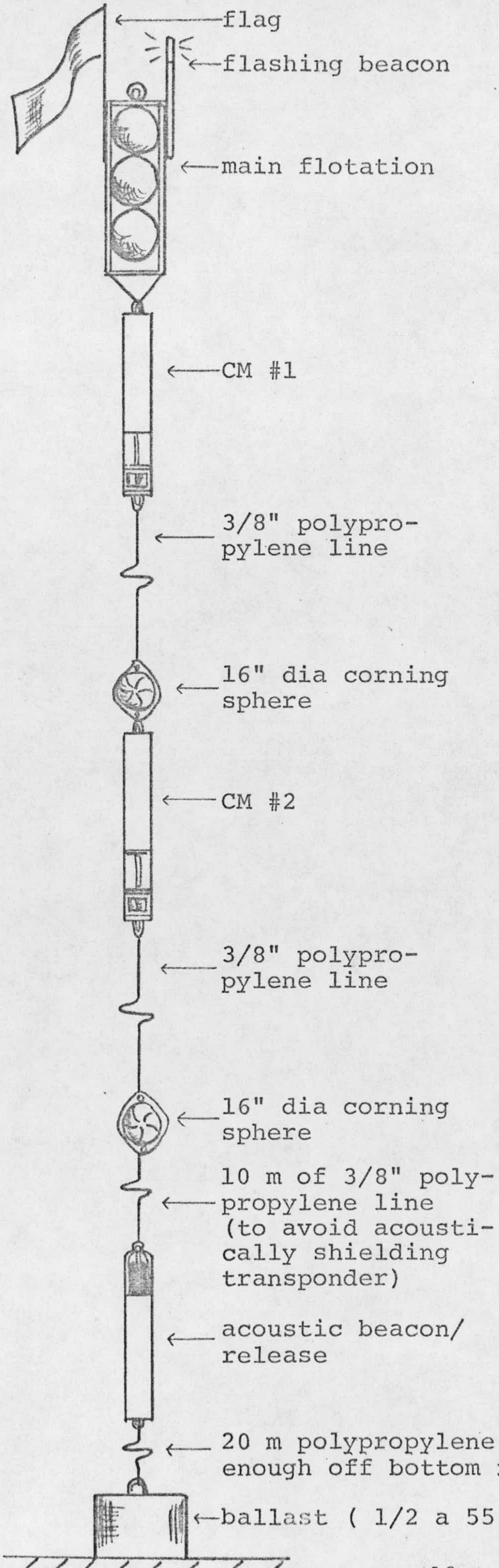
*A further attempt to recover these will be made in October 1974.

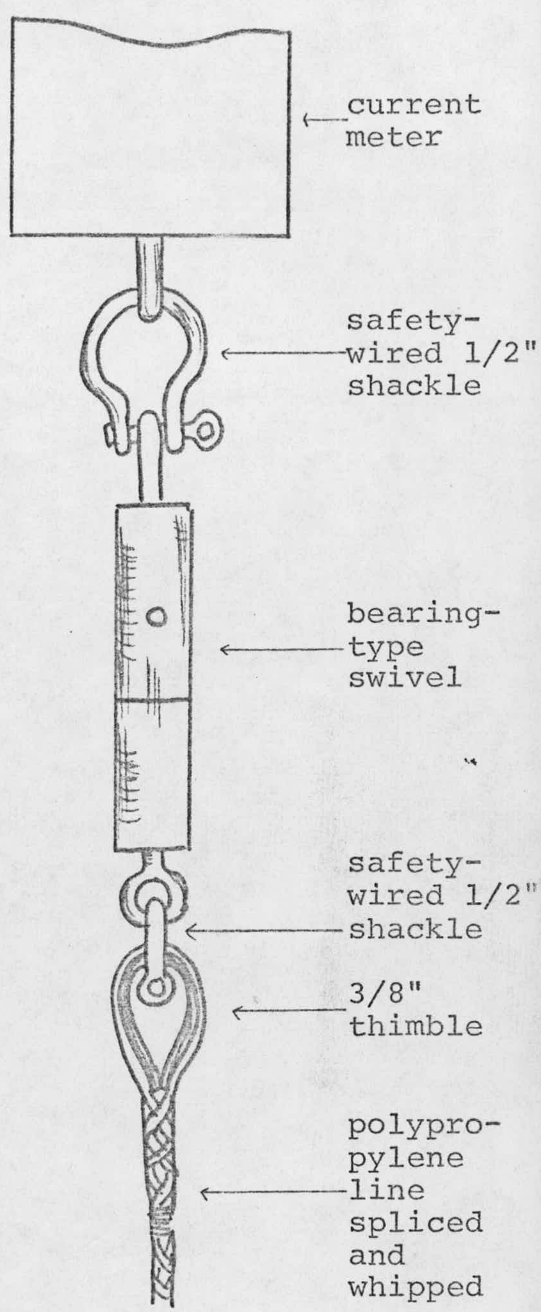
A typical array is shown in Figure 6.

Deployment

Each array was deployed by first lifting the main flotation and the current meter immediately below that clear of the deck and into the water using the coring winch and 'A' frame on the ship's stern. When these were in the water they were released and allowed to float away from the ship by putting a few turns on the engines (if necessary), while paying out the polypropylene wire from storage reels. Each subsequent meter and the acoustic beacon were made slightly positively bouyant by adding a single 16" diameter glass sphere immediately above them. When all the line of each section was payed out, it was stoppered-off around a cleat while the next current meter or beacon was attached to the

Figure 6.





Details of (top and bottom) connections to current meters.

end (with its section of line already attached to it). This was then lifted over the stern manually and cast off and the process repeated until only the anchor weight remained on deck. This was then manually pushed over the stern to complete the deployment (it had already been placed close to the edge of the ship, but tied off to prevent a premature launch).

The descent rate was approximately 70 m/min except for CM #4 which used a main flotation package of two 16" spheres. This descended at approximately 120 m/min.

Recovery

This was accomplished at night because we have found that the flashing surface beacon is the best way to visually locate the flotation package once it has surfaced. Unfortunately one of the flashers failed due to a faulty pressure switch, but we were able to spot the yellow polypropylene line even though the visibility was extremely poor due to heavy squalls. The long lengths of line were hauled aboard using a capstain on the hydrographic winch. The meters and beacons were hauled aboard manually. The ascent rate was approximately 100 m/min.

General Notes

(i) The AMF flotation package (3 x 17" diameter Benthos spheres in a vertical frame did not ride well on the sea surface when ballasted only by a single current meter (or acoustic beacon). A triangular package with the flag in the center would be preferable for better visibility.

(ii) Although the acoustic beacon provides continuous slant-range data (displayed on Nixie tube readout) while the package is ascending and when it is on the surface, a submersible radio direction finder beacon would be a useful addition to aid in recovery.

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