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CABO ROJO PLATFORM ENVIRONMENTAL STUDIES

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CABO ROJO PLATFORM ENVIRONMENTAL STUDIES

by

E.D. Wood, M.J. Youngbluth, and P. Yoshioka

PREFACE

This report stems from investigations carried on by the Puerto Rico Nuclear Center. The studies were designed to provide data upon which to judge the suitability of a site for the construction of power generating facilities and to allow the determination of the impact of such construction and operation upon the environment.

The report represents the combined effort of the scientists, technicians and support staff of the Site Selection Survey Project.

The authors who contributed to the Cabo Rojo Platform Site Selection Survey are:

E.D. Wood, Project Leader	Physical, Chemical and Geological Parameters
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1.1 INTRODUCTION

The Puerto Rico Nuclear Center of the University of Puerto Rico has been under contract to the Puerto Rico Water Resources Authority since 1972 to conduct site selection surveys and environmental research studies of seven coastal sites. Experience gained from these investigations will add to the knowledge about these areas, and provide useful data which will aid in the assessment of the desirability and practicability of locating power generating plants on one or more of these sites.

Puerto Rico Nuclear Center scientists have studied the physical, chemical and geological parameters of the sites, and the ecological parameters of zooplankton, benthic invertebrate and fish communities. Plant associations, except for the Cabo Rojo Platform site, have been included.

The sites chosen for study were: Tortuguero Bay, Punta Manati, Punta Higuero, Cabo Rojo Platform, Punta Verraco, and Cabo Mala Pascua (see Figure 1.1-F1). The seventh site, Barrio Islote, was studied and reported under a separate contract.

The first of these reports is entitled, "Tortuguero Bay Environmental Studies" and is dated April 1, 1975. The second report, dated April 15, 1975, is entitled, "Punta Manati Environmental Studies." The third report, entitled "Punta Higuero Environmental Studies" is dated May 1, 1975. Previous studies of Punta Higuero, also referred to as "Rincon" or "the BONUS site," have been reported in "Punta Higuero Power Plant Environmental Studies 1973-1974" (Wood et al., 1974).

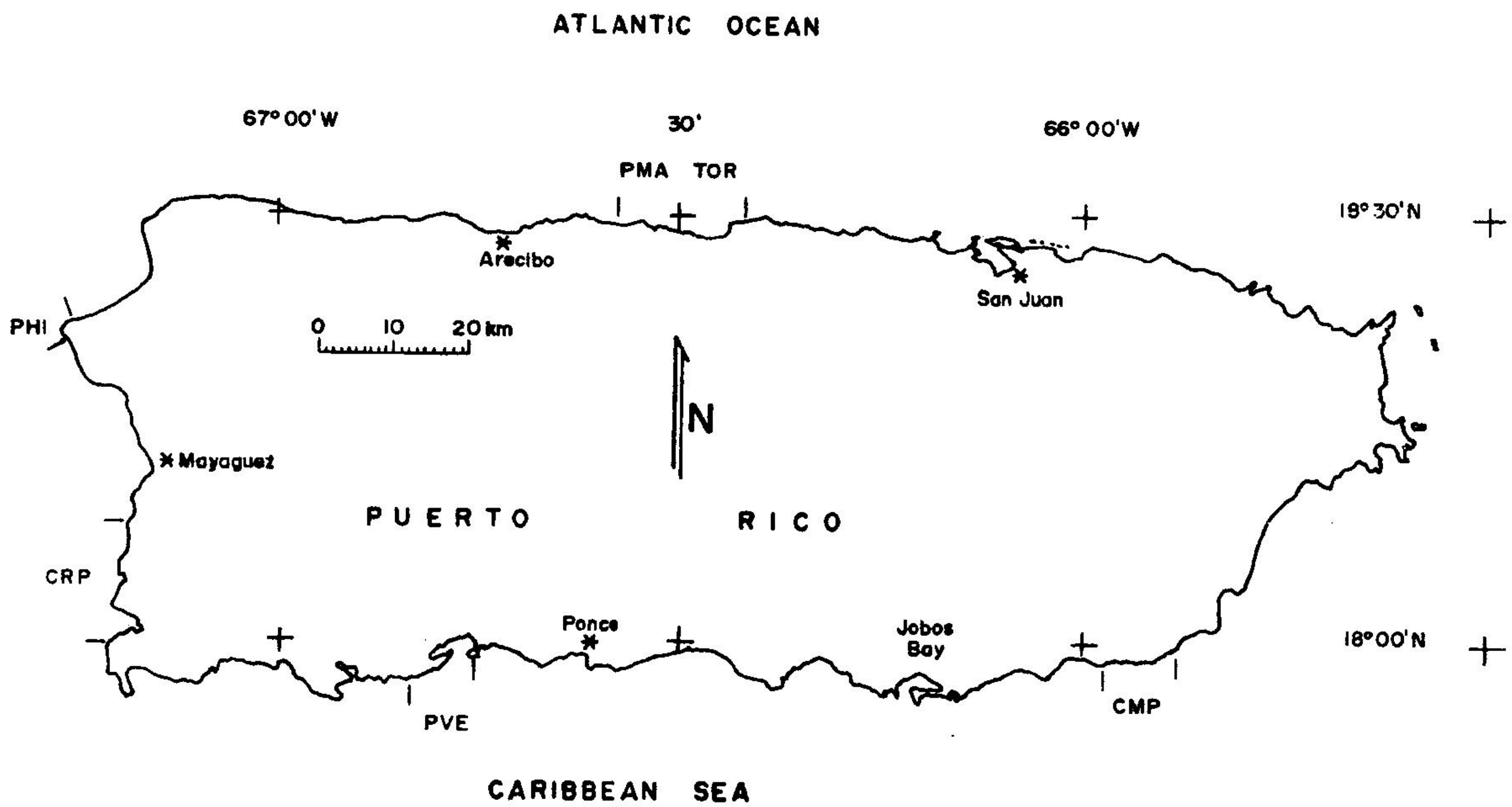


Fig. 1.1-F1. Site Selection Survey Sites. Tortuguero Bay (TOR); Punta Manati (PMA); Punta Higuero (PHI); Cabo Rojo Platform (CRP); Punta Verraco (PVE); and Cabo Mala Pascua (CMP). Barrio Islote site not shown.

2.1 PHYSICAL AND CHEMICAL PARAMETERS AT CABO ROJO PLATFORM

by

E.D. Wood

2.1.1 INTRODUCTION

Most of the physical, chemical and geological measurements at the Cabo Rojo Platform site were made at or near the stations shown in Figure 2.1-F1. The transects were spaced at one nautical mile with the "A" stations located as near to shore as it was safe to sample with the RMV R.F. Palumbo. The "B" stations were located on a north-south line which passed through the center of the two basins on the Platform. One "C" station was located in a channel on the seaward side of the south basin. The sample depths for the stations were: "A" - 0, 5m; "B" - 0, 10m; "C" - 0, (5), 10, (15) and 20m.

2.1.2 TIDES

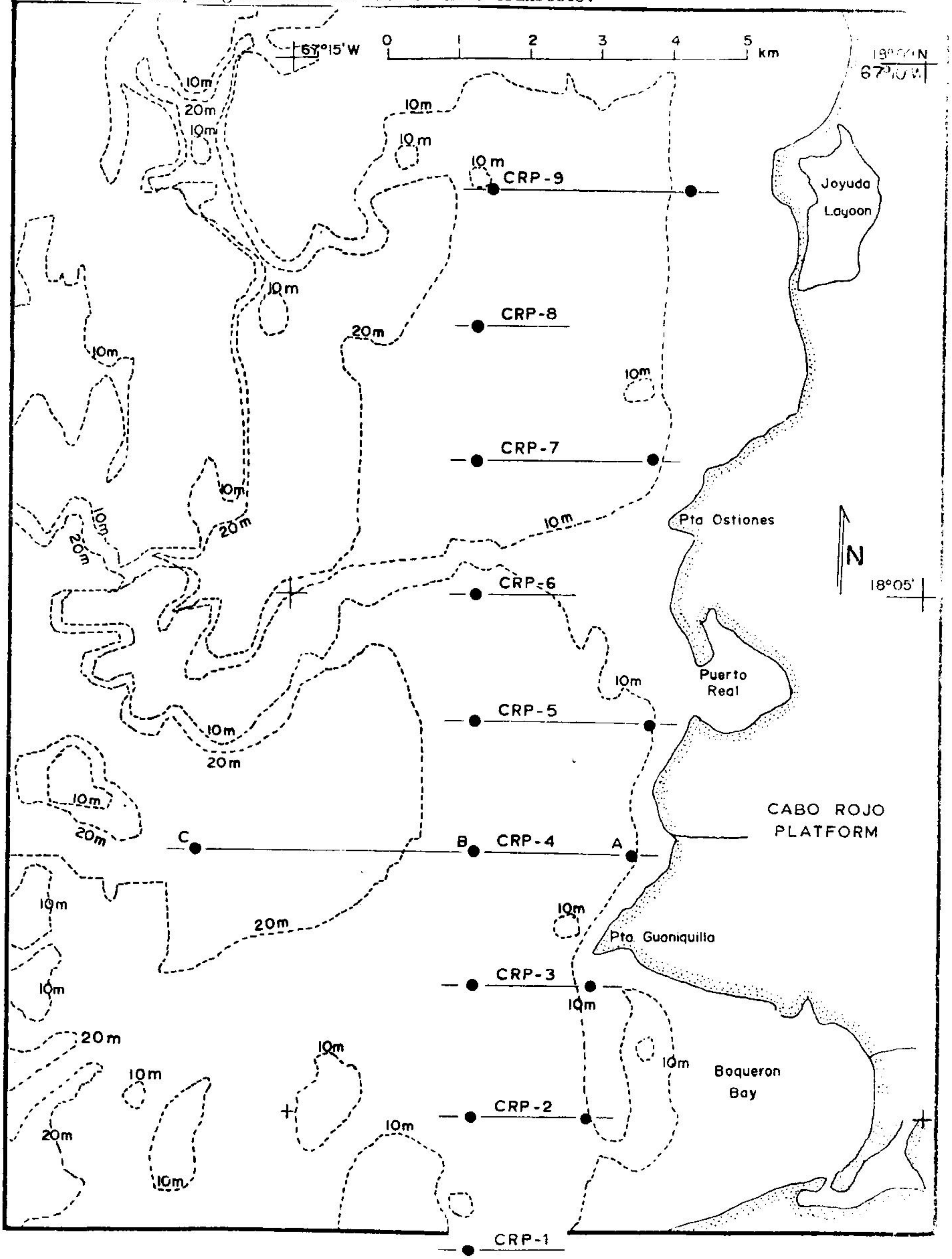
Tides that affect the Cabo Rojo Platform originate in the North Atlantic Ocean. The tides for Puerto Real, located on the east-central border of the Platform, (Figure 2.1-F1) are predicted by the National Ocean Survey (1972). The tides are semi-diurnal with an average diurnal excursion of 30 cm and a mean tide level of 12 cm. The tides for the period of current measurements on the Cabo Rojo Platform are plotted in Figure 2.1-F2. An example of the tides plotted over a lunar cycle is shown in Punta Higuero Environmental Studies (Wood et al., 1975).

2.1.3 CURRENTS

The Cabo Rojo Platform site is part of a broad shallow shelf off the southern half of the west end of Puerto Rico. The shelf edge extends some 25 kilometers seaward due west of the north basin of the site. The shelf edge is about 10 kilometers from the southern basin at its closest point. The shelf edge extends along a northwest-southwest line off the southwest corner of the island.

The open sea currents of the Caribbean flow generally to the west along the south coast then turn to the northwest around Cabo Rojo following the shelf contour lines. This flow is affected by wind and tide.

Fig. 2.1-F1 Cabo Rojo Platform site with depth contour lines and one to three hydrographic sampling stations on each of nine transects.



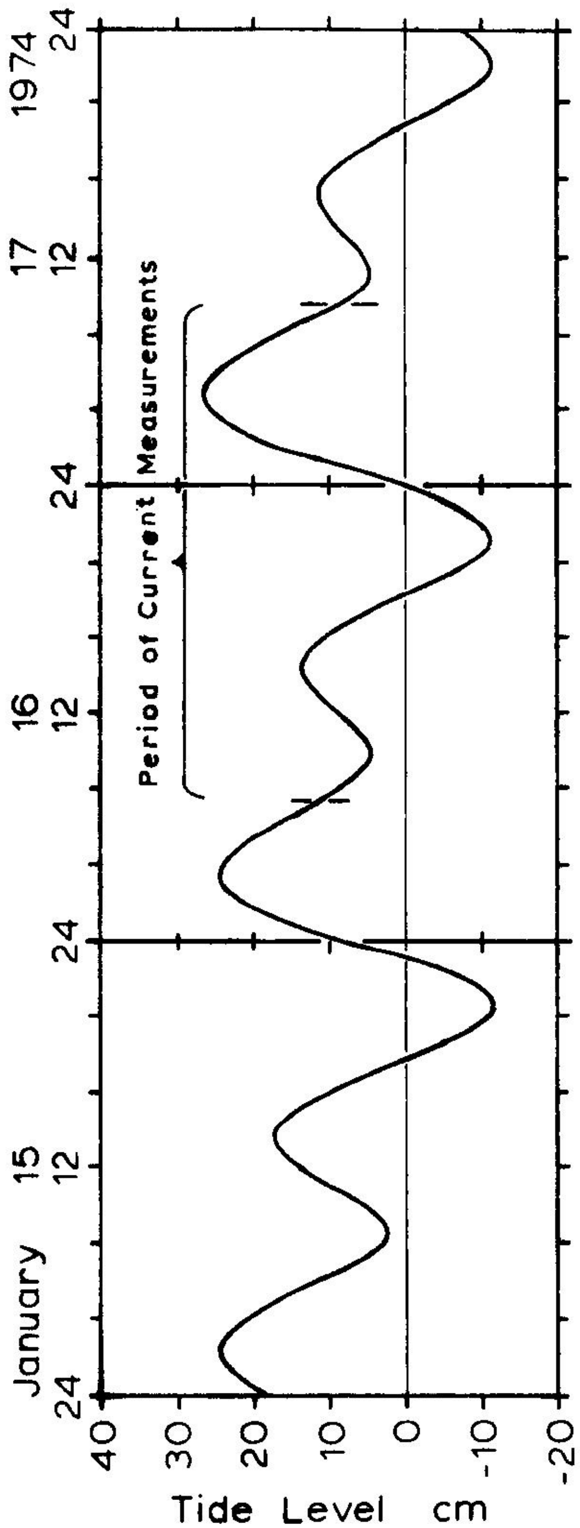


Fig. 2.1-F2 Tides on the platform predicted for Puerto Real, January 15-17, 1974.

There appears to be a large gyre or back eddy over the Platform which is strongly modified by wind and tide. This back eddy brings water shoreward to the vicinity of Mayaguez, where it divides, flowing north and south. The southern flow forces the plume of the Guanajibo River south around Punta Guanajibo through Bramadero Bay, past Punta Arenas and finally seaward between Puerto Real and Boqueron Bay. Currents over the reefs are quite strong at times, in excess of 50 cm/sec (ca one knot). This current pattern contributes much fine terrestrially-derived sediment to the eastern portion of the basins, especially the northern basin.

This general description is based on the work done by the author in the Puerto Rico Nuclear Center's Marine Biology Program and numerous observations in the course of PRWRA work.

The currents at the site were measured during the period 0745 January 16, 1974 to 1000 January 17, 1974 at four depths near Station CRP-4C. The weather was exceptionally calm during this period with the highest wind velocity only 3 m/sec (ca 6 knots) from the southeast in the early morning (Jan. 16) shifting to northeast for the rest of the morning, then from the northwest near noon and from the south in the afternoon. The sea surface was glassy calm the morning of January 17, 1974.

The currents were measured using General Oceanic film recording inclination meters. The data were computerized, averaged and plotted for each depth. The plots are in three forms: 1) direction and velocity versus time (Appendix 2.1A) 2) a progressive vector (Figure 2.1-F3) and 3) a "current rose" (Figure 2.1-F4).

The top current meter in the string of four was just beneath the surface (ca 1 m). It indicated the highest currents of about 20 cm/sec to the northeast during the last of the falling tide, low tide and the beginning of the rising tide. This was against the prevailing wind. The surface currents were generally to the southwest during the evening with velocities of about 10 cm/sec. Currents were light and variable during the night flowing to the southwest in the morning hours of January 17, 1974 at about 15 cm/sec.

The currents at the deeper meters generally followed the surface current during the day of January 16. The 7 meter depth showed more variation in the direction after 1400 January 16, but generally the flow was to the southwest.

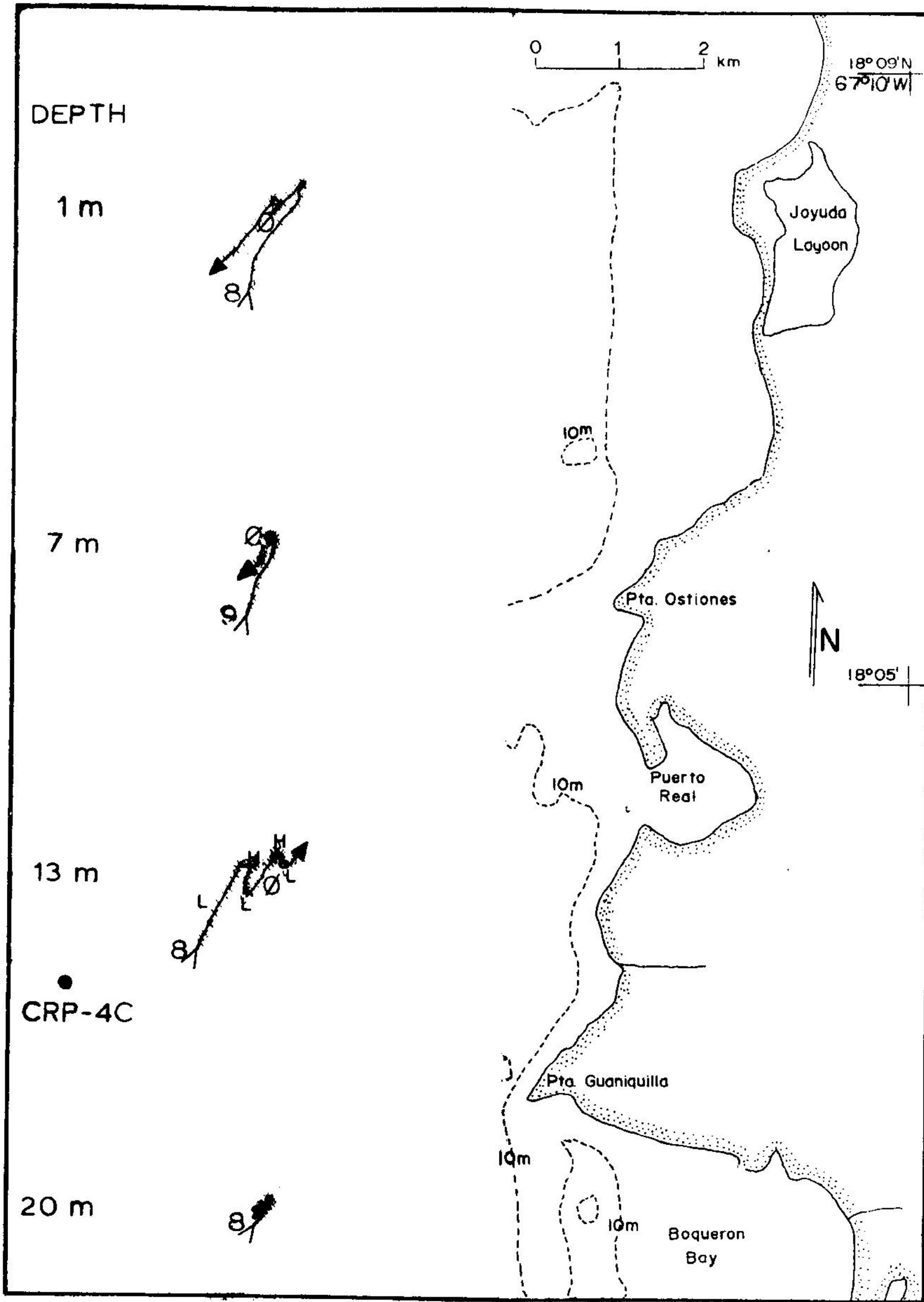
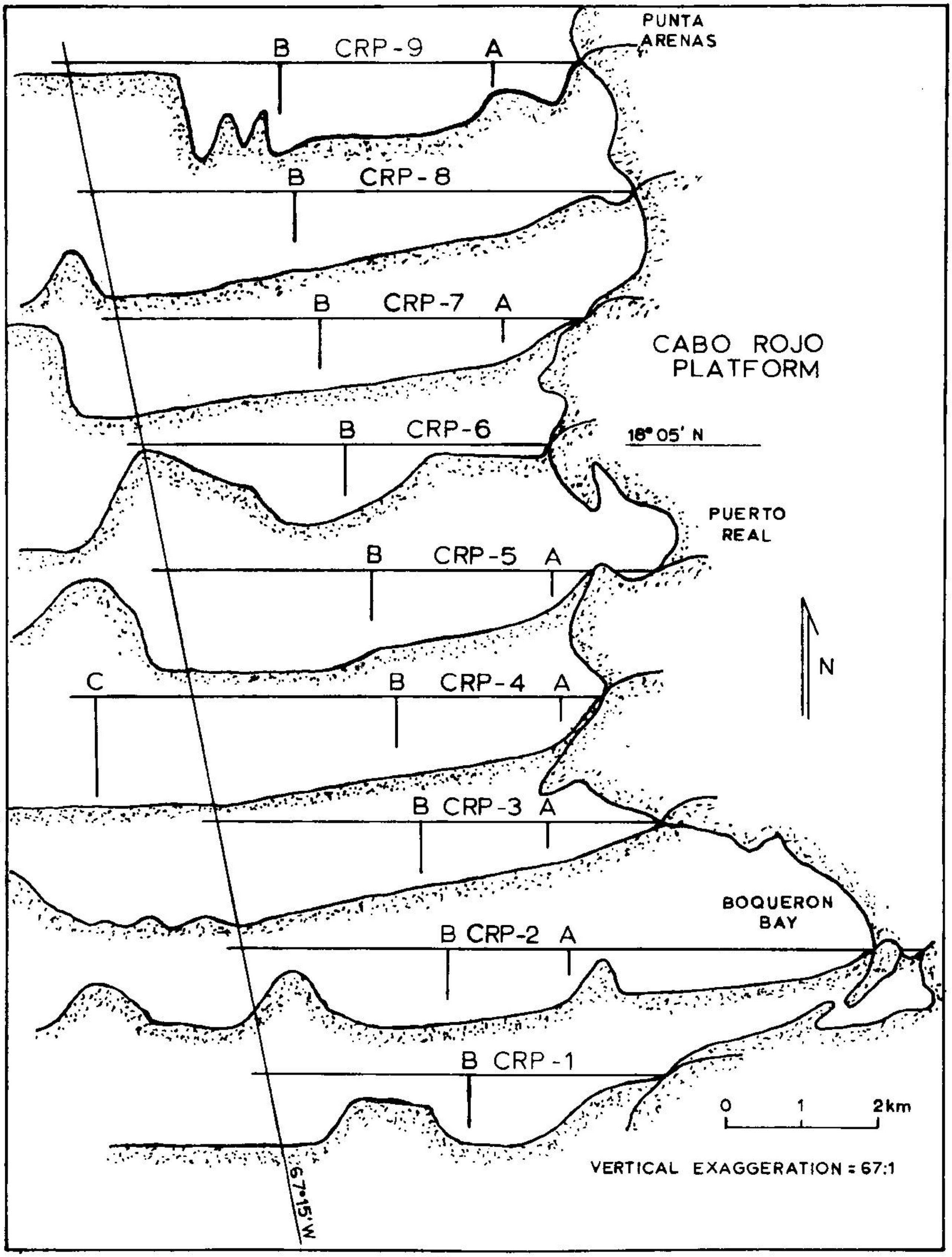


Fig. 2.1-F3 Progressive vectors for currents at Stations CRP-4C, Jan. 16-17, 1974

Fig. 2.1-F5 Offset bottom profiles along the sampling transects on the Cabo Rojo Platform. Vertical lines indicate relative positions of hydrographic stations.



2.1.5 TEMPERATURE, SALINITY AND DENSITY

The physical parameters of temperature and salinity were measured at the Cabo Rojo Platform on five cruises covering four seasons (Table 2.1-T1).

TABLE 2.1-T1 Schedule of hydrographic cruises to Cabo Rojo Platform.

	WINTER	SPRING	SUMMER	FALL
1973	-	-	PA-035 9/12/73	-
1974	PA-036 1/16/74	PA-040 4/2/74	PA-047 8/27/74	PA-052 11/15/74

The hydrographic sampling stations are shown in Figure 2.1-F1. The coordinates of the stations and hydrographic data are in the "Hydrographic Data Report West Coast of Puerto Rico" (Wood and Asencio, 1975). Nine transects were sampled on each cruise. The deepest sample was taken from 20 meters at Station CRP-4C. The "A" stations were sampled at 0 and 5 meters and the "B" stations at 0 and 10 meters. The sampling, analytical and data processing procedures are described in "A Manual for Hydrographic Cruises" (Wood 1975).

Temperature

Temperatures were measured using deep sea reversing thermometers, accurate to better than $\pm$ 0.03°C. The thermometers were used in pairs or three at a time. Although usually only one temperature is shown in the data for each depth, these values are often the average of two or three thermometer readings.

Averaged temperature depth profiles are shown plotted by type of station and by season along with other hydrographic parameters in Figures 2.1-F6 and F7. The temperature profiles are flanked by dashed lines in most cases to indicate the range of temperatures found.

Temperatures were highest in the summer with the September 1973 sampling registering temperatures of over 29°C. These were the highest temperatures measured at any of the sites and they are due to the water being shallow and protected. The lowest temperatures were measured in

Fig. 2.1-F6 Averaged hydrographic parameters (temperature, T°C; salinity, S°/oo; density, σ_t; dissolved oxygen, O_2; and reactive phosphate, $PO_4^{\equiv}$) vs. standard depth in meters for the winter and spring seasons of 1974 on the Cabo Rojo Platform.

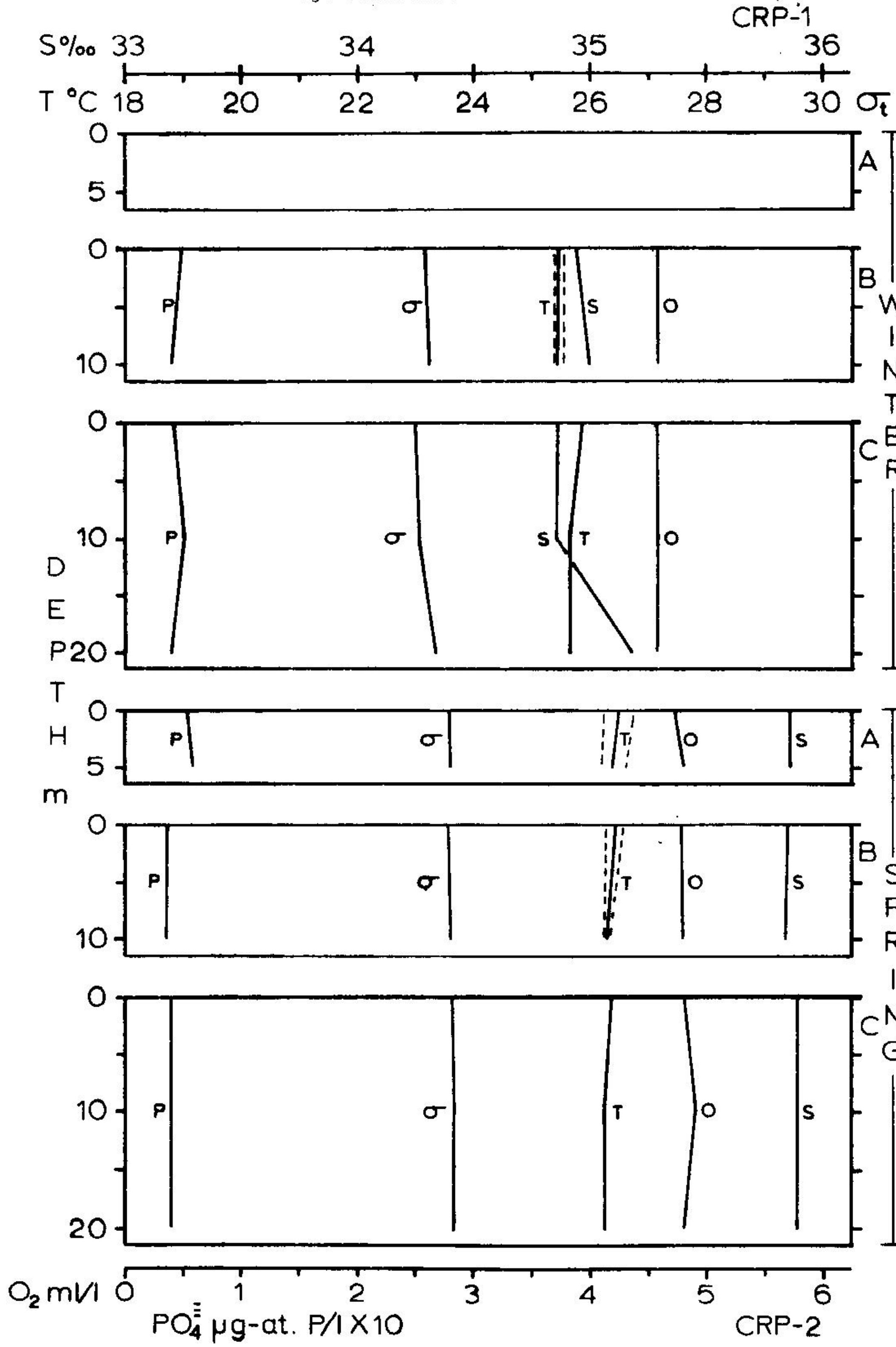
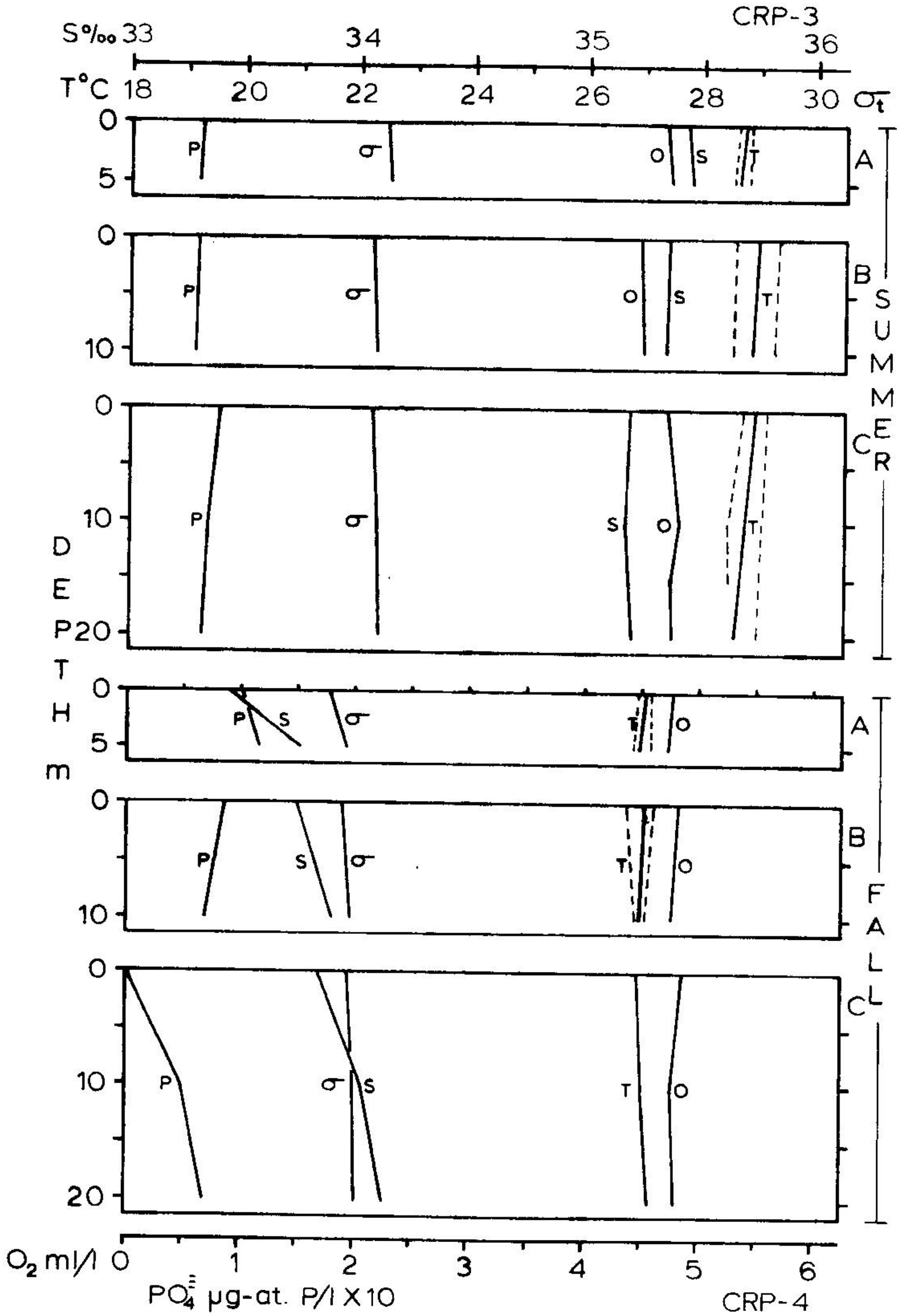


Fig. 2.1-F7 Averaged hydrographic parameters vs. standard depth in meters for the summer (1973 and 1974) and fall (1974) seasons on the Cabo Rojo Platform. Dashed lines show the range of the temperatures.



January 1974 (~25.5°C). Figure 2.1-F8 shows the distribution of temperatures along the line of the "B" stations. The dashed lines indicate the average for the quarter sampled. The winter and spring samplings show very little spread or trend in the temperatures with distance along the "B" line. However, the plots for other seasons show generally lower temperatures at the southern edge of the south basin and higher temperatures in the north basin. Low temperatures were found opposite Boqueron Bay in the fall season of 1974 which probably reflects run-off from the lowlands of southeastern Puerto Rico through Boqueron Bay. Temperature profiles (Figures 2.1-F6 and F7) show that the water is fairly well mixed with very weak gradients usually cooling with depth except that during the fall at the "C" station the water column warmed with depth. Temperatures increased with distance from shore in the winter and summer but showed little or no trend during the spring and fall seasons.

Salinity

Salinities for the Cabo Rojo Platform "B" stations are shown plotted by season in Figure 2.1-F9. The averages are indicated by dashed lines. Averages are also plotted with other hydrographic parameters by season in Figures 2.1-F6 and F7. The highest salinities (~35.85°/oo) were found in the spring and the lowest in the fall season (~33.75°/oo).

Salinities for the spring and summer seasons show little variation from their respective averages. Some trends are seen with distance. Salinities generally decreased from south to north in the spring of 1974 with the opposite trend seen in the late summer of 1973. Low salinity anomalies such as those found at Station 3B, fall of 1974, and Station 5B, summer of 1974, were accompanied by low temperature anomalies for the corresponding measurements (Figure 2.1-F8). A sharp difference in salinity was seen between the south and north basins in the winter of 1974.

Lower salinities were noticed in September 1973 than in August 1974 probably reflecting the effects of the summer-fall rainy season. Salinity profiles in Figures 2.1-F6 and F7 showed little or no gradient for the spring and summer seasons. The highest gradient occurred during the fall season in all types of stations and at the "C" station in the winter season. Salinity gradients with distance from shore reflected the seasons, that is, they were positive during the fall (rainy) and negative during the summer (end of dry season).

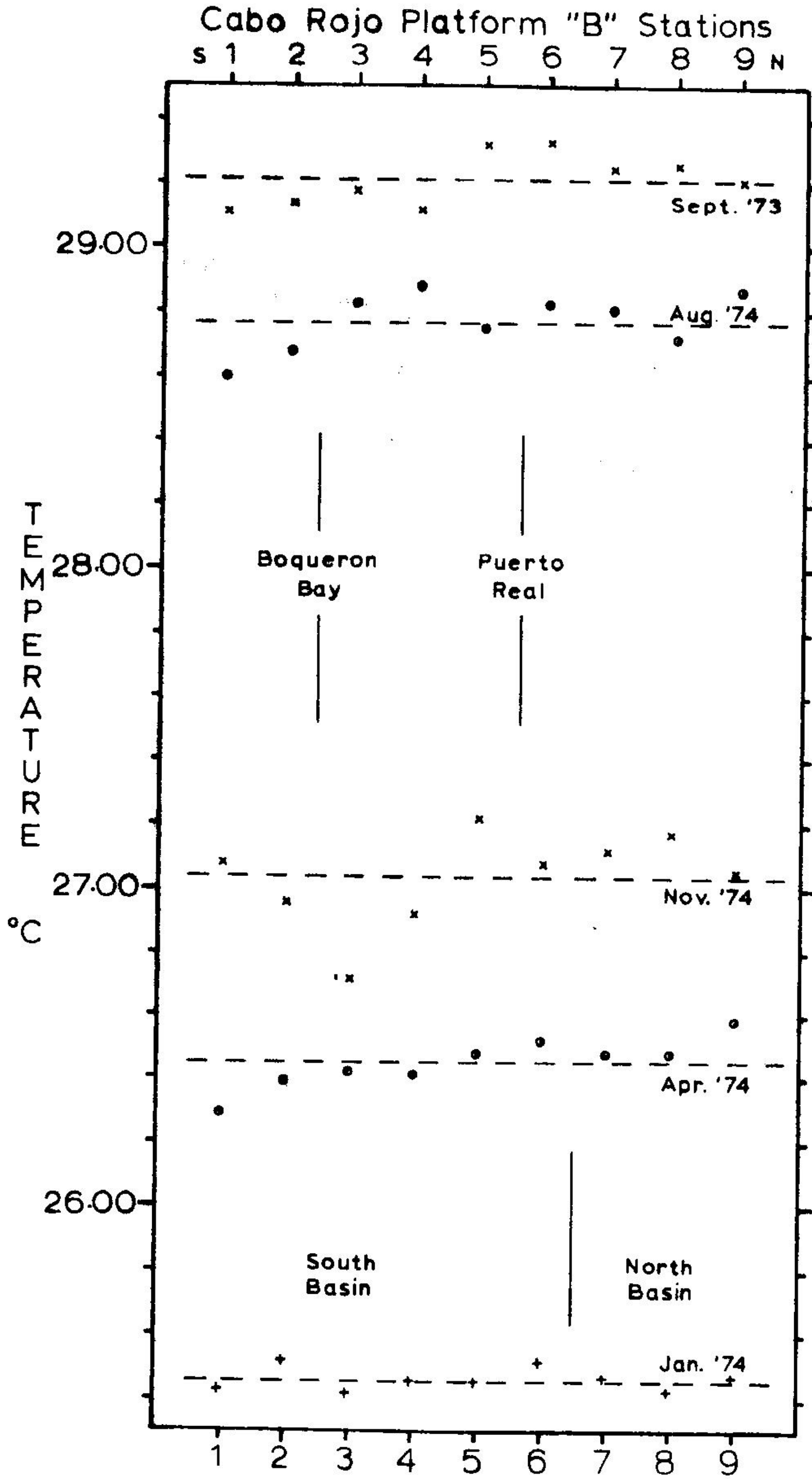


Fig. 2.1-F8 Surface temperatures plotted by "B" stations for each of the five sampling trips. Dashed lines indicate the average temperature.

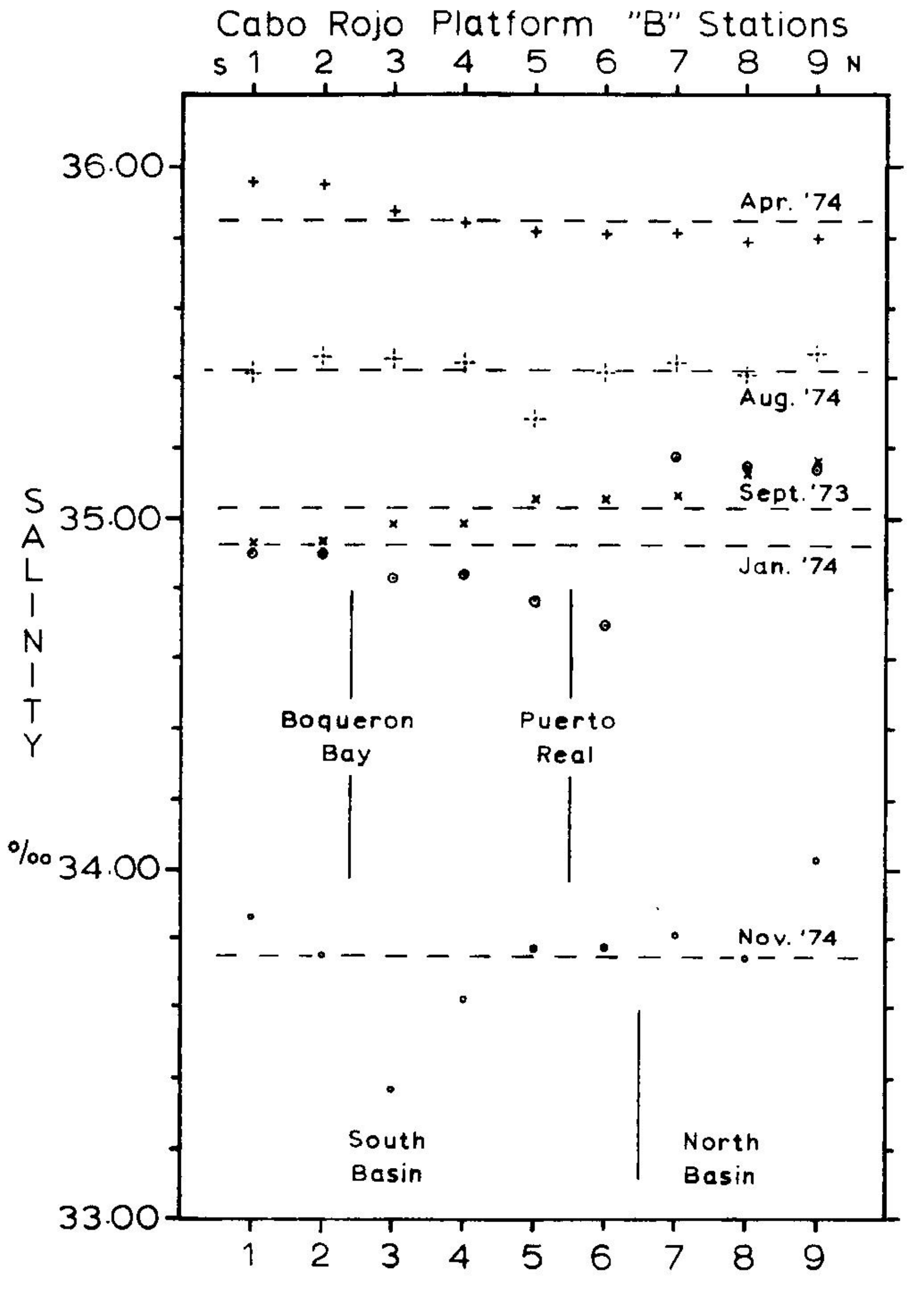


Fig. 2.1-F9 Surface salinity values vs. "B" stations for the five cruises. Dashed lines indicate average salinities.

Density

The stability of the water column is a function of the density gradient. Density, ρ, is a function of temperature and salinity (pressure is significant only at great depths) and always increases with depth in a stable water column. Density is usually converted for convenience to an expression, sigma-t, σt

$$\sigma t = (\rho t - 1) \times 10^3 . \qquad (2.1)$$

Small changes in sigma-t with depth indicate a well mixed or unstable zone, whereas a high gradient is indicative of a very stable region of the water column.

The average density is plotted by station for the four seasons in Figures 2.1-F6 and F7 with other hydrographic parameters. The density increased from fall through winter to spring as the salinity increased, then decreased through summer to fall as the salinity decreased and temperature increased (through summer). The density, as indicated by sigma-t, was nearly uniform with depth having only a slight positive gradient, except for the fall season nearshore ("A" stations). Most density anomalies coincided with major changes in salinity as the temperature changed little with depth.

There were two seasons where density gradients with respect to distance from shore existed. A negative gradient was detected in the summer with more saline water nearshore and a positive gradient in the winter from the low salinity run-off from the land.

2.2 CHEMISTRY

2.2.1 DISSOLVED OXYGEN

The amount of dissolved oxygen in the waters of the Cabo Rojo Platform was determined by the Winkler titration method described by Strickland and Parsons (1968). The samples were titrated within a few hours after being sampled. The values are usually good to better than ± 1% although an occasional value seems to deviate somewhat from the norm. The data are reported by Wood and Asencio (1975). The averaged data are plotted in Figures 2.1-F6 and F7.

All of the oxygen values are near saturation for all seasons with little or no gradient with depth or distance from shore. The discharges from the Guanajibo River to the north and Boqueron Bay to the south are the only significant sources of biological oxygen demand. They do not appear to be sufficiently large enough to make an impression upon the oxygen levels of the Cabo Rojo Platform because of the constant mixing and flushing.

2.2.2 NUTRIENTS

Nutrients are important from two aspects. First, nutrients are generally low in the tropical Atlantic Ocean and Caribbean Sea, limiting primary productivity. Second, the discharge of wastes from agricultural, municipal or industrial sources may contain such high nutrient levels that they cause eutrophication and local ecological degradation.

Reactive phosphate can be determined quickly and accurately with the Murphy and Riley molybdate complex method (Strickland and Parsons, 1968) and is a good indicator of pollution. Only limited nitrate analysis has been performed on the waters of the Cabo Rojo Platform because there exists a good relationship between phosphate, $PO_4^{\equiv}$, and nitrate, NO_3^-, in the open ocean (1:14) (except that nitrate is somewhat deficient in the tropical and sub-tropical Atlantic Ocean surface waters). Reactive silica is usually not regarded as a problem from a pollutant aspect.

Reactive Phosphate

Samples for reactive phosphate were frozen soon after sampling and returned to the laboratory for analyses. The phosphate values are given in the Hydrographic Data Report West Coast of Puerto Rico (Wood and Asencio, 1975) and the averages plotted in Figures 2.1-F6 and F7.

Phosphate levels are low over most of the Platform for all seasons ($\sim$0.05 µg-at. P/l) with the highest values being at "A" stations in the fall (rainy) season. The only distance gradient noticed was during the fall when an inverse relationship of phosphate and salinity occurred with distance from shore. That is, it appeared that the phosphate coincided with terrestrial run-off.

Nitrate

A limited number of nitrate samples were analyzed for the Cabo Rojo Platform during the fall 1974 season only. The data are too spotty to establish trends. The values were all less than 2 µg-at. N/l with the higher values nearshore.

3.1 GEOLOGICAL PARAMETERS ON THE CABO ROJO PLATFORM

by

E.D. Wood

The Cabo Rojo Platform is composed mainly of calcium carbonate in the form of sand shelf and coral fragments or coral formations. The nearshore sediments are principally non-carbonate, terrestrially derived.

A series of grab samples were taken at the "B" stations and at Station 4C (Figure 2.1-F1) and analyzed by sieving for size. The histograms and cumulative weight percent plots are shown in Figures 3.1-F1 through F4. The larger sediment sizes (phi equal -1 to +1) were mainly shell fragments. The fine material (90-95%) is finer than phi equal one (<0.5 mm) with the mean phi equal to about 3 ø (0.125 mm). The histogram plots for the stations at the north and south basin boundries were poorly sorted ($\sigma\phi \cong 2.0\ \phi$) with significant sediment fractions larger than 1.0 mm.

The largest mean in the center of the north basin was $M\phi = 3.3 \pm 0.9$ at Station 8A. The south basin had its finest sediments just seaward of Boqueron Bay ($M\phi = 3.7 \pm 0.7$). Fine, well-sorted sediment was also sampled at CRP-4C ($M\phi = 3.7 \pm 0.6$). The currents measured there January 16-17, 1974 were very weak near the bottom which allows for the deposition of fine sediments. Twenty to fifty percent of the basin sediments were finer than 0.063 mm (>4 ø). This shows that weak currents occur often enough to allow appreciable amounts of fine material to settle out. This does not preclude the occurrence of strong currents as fine, plate-shaped sediments require much higher currents to resuspend them than to keep them in suspension. The sieving statistics are given in Table 3.1-T1.

TABLE 3.1-T1. Sieving statistics for Cabo Rojo Platform grab samples.

STATION	Mean Mø	Median Mdø	Standard Dev. sø
CRP-1B	2.2	2.8	2.0
2B	3.7	4.0	0.7
3B	3.5	3.7	0.8
4B	2.9	3.2	0.9
5B	3.2	3.4	1.0
6B	3.3	3.1	0.9
7B	2.7	3.1	1.4
8B	3.3	3.4	0.9
9B	1.2	0.9	1.8
CRP- 4C	3.7	4.0	0.6

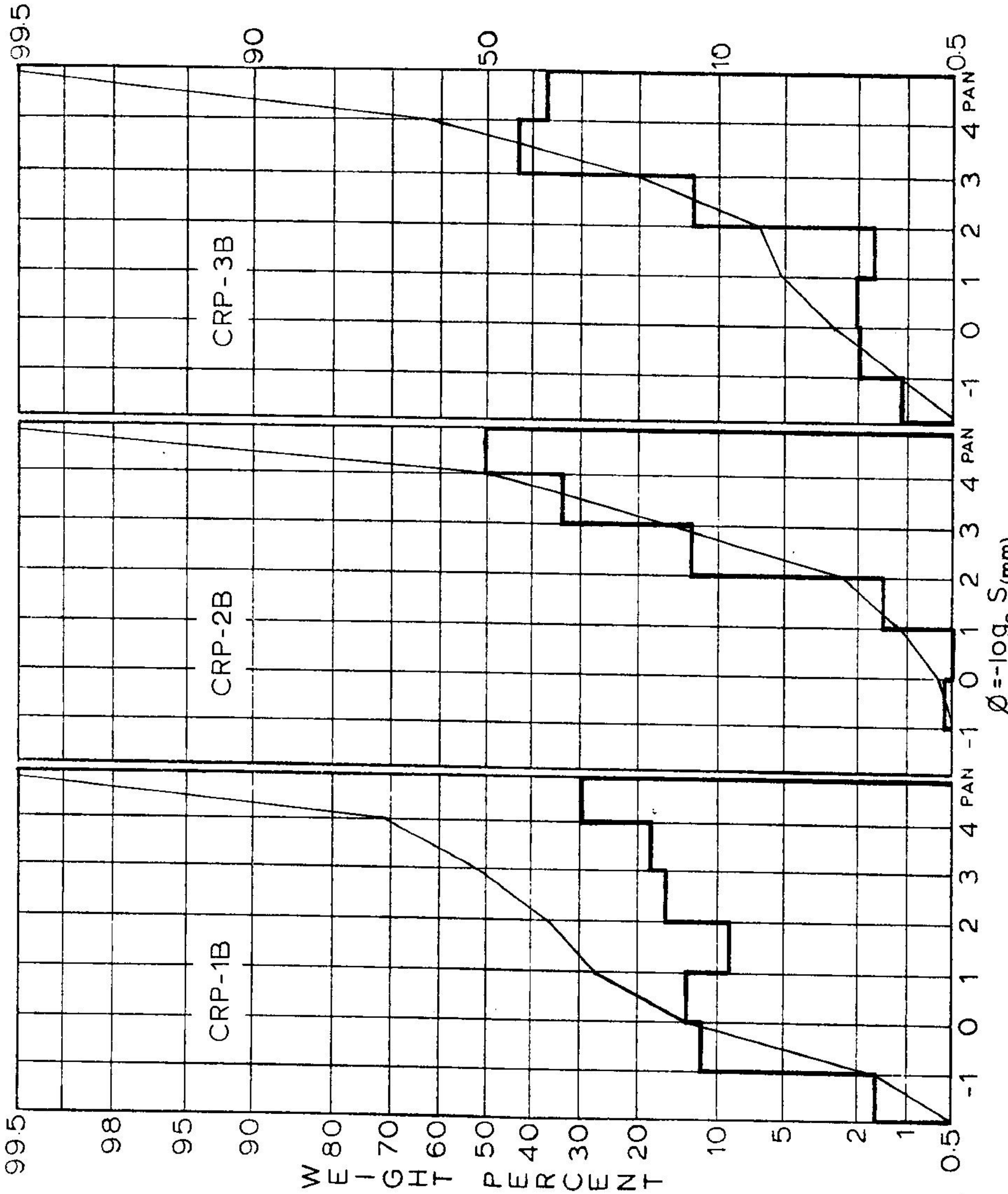


Fig. 3.1-F1 Sediment size analyses plots for CRP-1, 2 and 3 "B" stations showing cumulative weight percent and histograms.

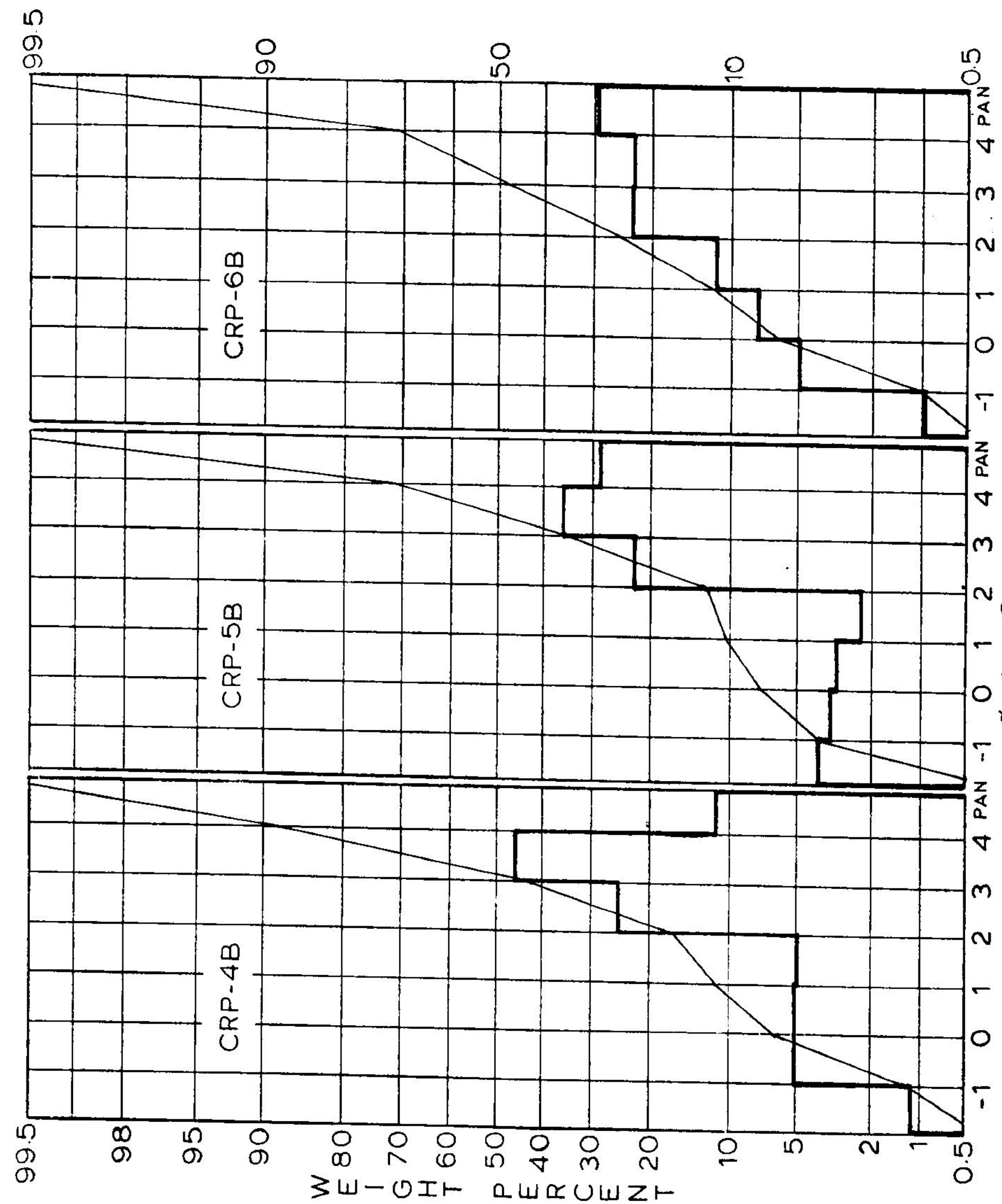


Fig. 3.1-F2 Sediment size analyses plots for CRP-4, 5 and 6 "B" stations showing cumulative weight percent and histograms.

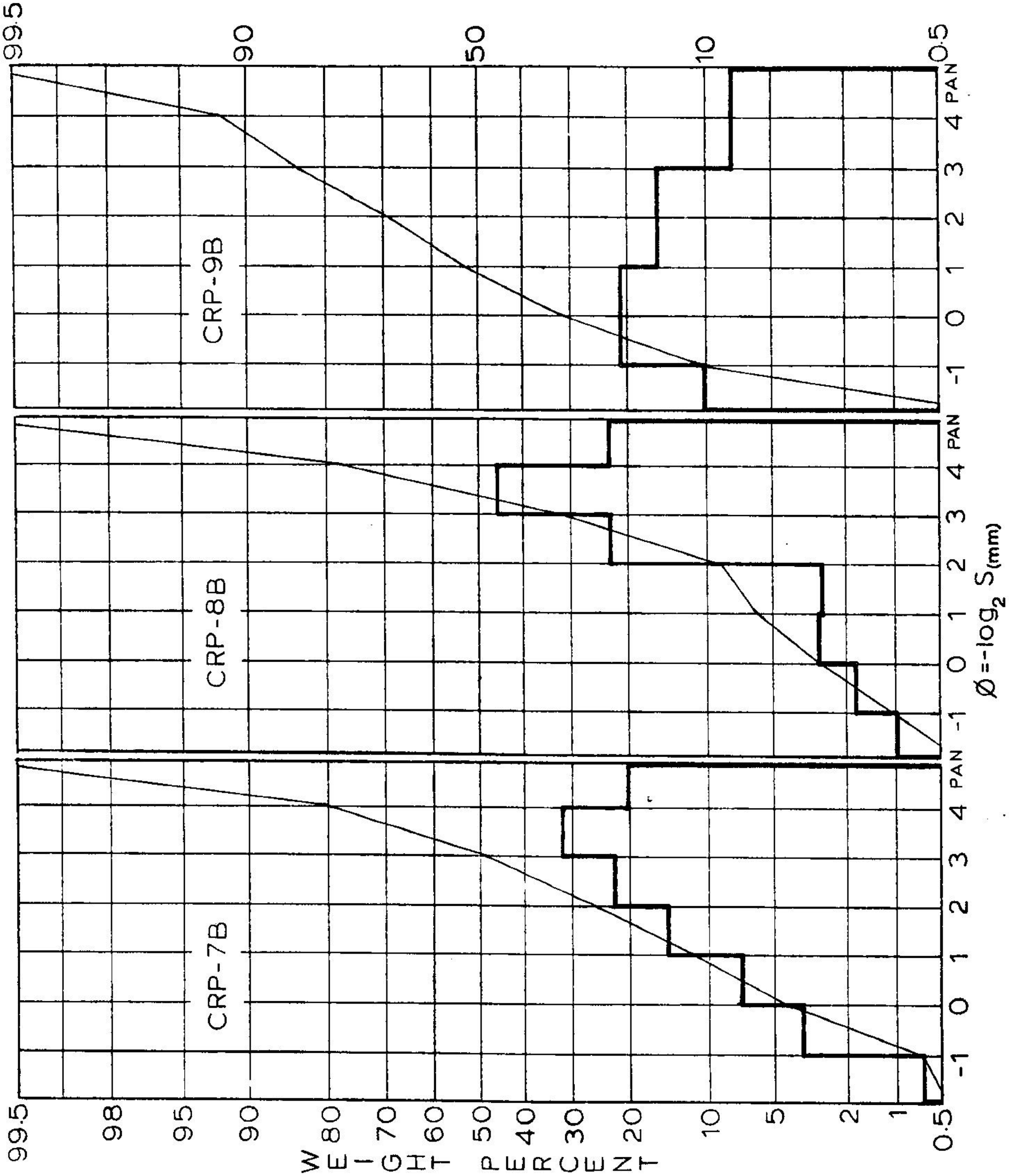


Fig. 3.1-F3 Sediment size analyses plots for CRP-7, 8 and 9 "B" stations showing cumulative weight percent and histograms.

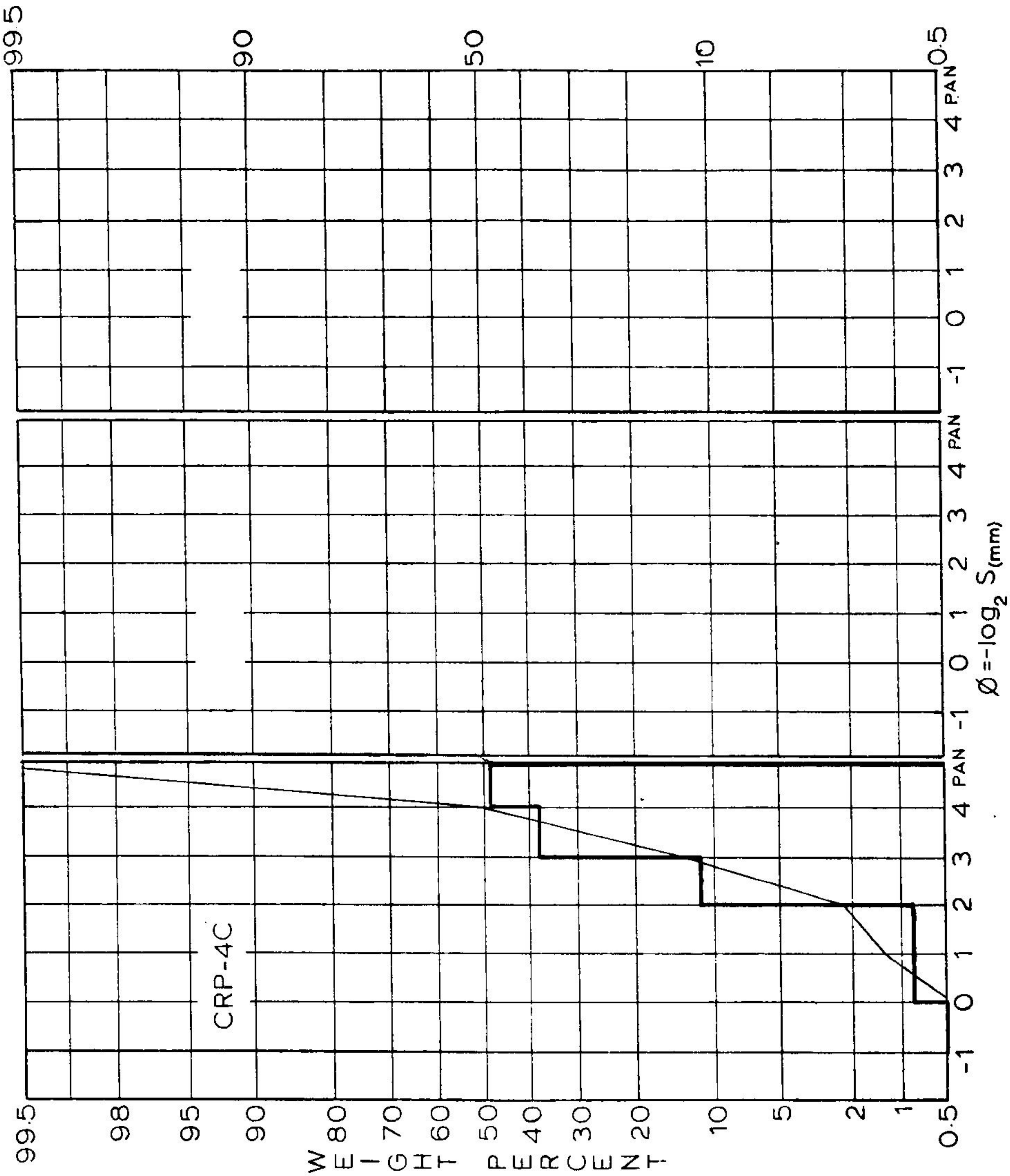


Fig. 3.1-F4 Sediment size analysis plot for CRP-4C showing cumulative weight percent and histogram.

Most of the terrestrial sediments are carried onto the Cabo Rojo Platform by the Guanajibo River plume. This plume flows south around Punta Guanajibo, south along the shore and then seaward over the Platform. The river flow is greatest in the late summer and fall (rainy season) and least in the spring (dry season).

4.1 ZOOPLANKTON STUDIES 1974

by

Marsh J. Youngbluth

4.1.1 INTRODUCTION

The following report provides estimates of the abundance and diversity of zooplankton in the surface waters near the southwestern coast of Puerto Rico. These data represent one part of an environmental survey conducted by the Puerto Rico Nuclear Center in an area proposed for offshore siting of power stations. Samples were gathered on 4 days during 1974 16 January, 2 April, 29 August, and 15 November.

4.1.2 MATERIALS AND METHODS

Field Procedures

Zooplankton were collected with a 1/2 meter diameter cylinder-cone shaped nylon net. This net was designed to reduce clogging error (Smith et al., 1968). Mesh size was 233 microns. The net was towed from a 17 ft. skiff in a circular path through the upper 2 meters. The speed of the vessel ranged from 2 and 3 knots (determined with a Sims yacht speedometer). The duration of a tow was 10 minutes. After each tow, before the cod end was removed, the net was washed with sea water with the aid of a battery driven pump (12 volt, Jabsco water-puppy). The catch was preserved in 4% sea water formalin buffered to pH 7.6. All samples were gathered during the daylight hours. The volume of water filtered through a net was estimated with a flowmeter (TSK or General Oceanics Model 2030) suspended off-center in the mouth of the net. The volumes usually ranged from 100 to 150 m^3. The meters were calibrated every 2 months. Calibration factors fell within 8% of the mean.

At each site three tows were made in the area adjacent to the region where a power station may be located. Single tows were taken at the other stations. The regions sampled were chosen in such a way as to collect within and around the area where thermal alteration is likely to occur (Figure 4.1-F1).

Laboratory Procedures

Within 24 hours after samples were collected the pH was checked and adjusted, if necessary, to 7.6. If a sample contained a noticeable conglomerate of phytoplankton or detritus, the zooplankton were separated from such material by gentle filtration through 202 micron mesh netting. Before estimates of biomass or numbers were made all organisms larger than 1 cm, usually hydrozoan medusae, were removed.

Biomass was calculated as wet volume (Ahlstrom and Thraikill, 1962). This estimate is subject to considerable error and should be viewed only as a rough measure of standing stock. The measurements were reproducible but are undoubtedly biased toward higher than actual values by variable proportions of interstitial water and detritus.

The total number of organisms was estimated by volumetric subsampling with replacement (Brinton, 1962). Three aliquots from each sample were counted. The abundance of major taxonomic groups of holoplankton and meroplankton were determined from dilutions of 300 to 500 organisms. Copepods, usually the most numerous of the zooplankters, were identified to species.

All biomass and enumeration data were standardized to a per cubic meter basis or multiple thereof. Data were initially reduced with hand calculators (Hewlett Packard Model 45) and more recently with a computer (PDP-10). See Appendix 4.1A for a listing of the program.

4.1.3 RESULTS

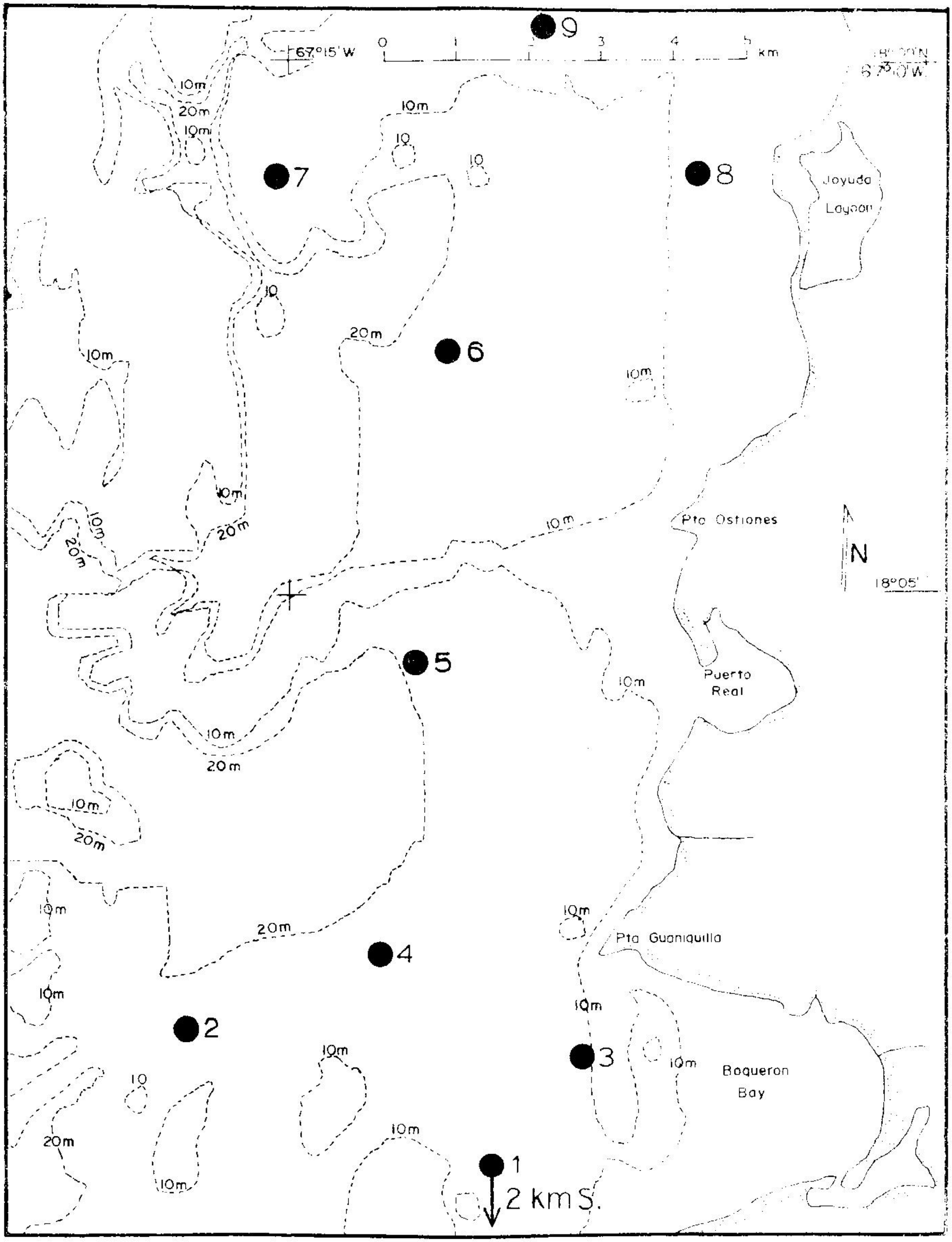
A total of 49 samples were collected from 9 stations (Figure 4.1-F1). The concentrations of several taxonomic groups of zooplankton at each station have been calculated (Table 4.1-T6 through 17). These data are arranged to facilitate comparisons between sets of consecutive tows, nearshore tows, and offshore tows.

Densities usually differed more between samples gathered from different areas than between consecutive tows from one area. This observation is summarized in Table 4.1-T1.

TABLE 4.1-T1 Summary of ratios between the highest and lowest density values of total zooplankton during each sampling period.

DATE	January	April	August	November
Consecutive Tows	1.4	5.6	1.2	1.7
Nearshore Tows	3.2	2.9	4.8	4.9
Offshore Tows	1.3	1.0	1.6	1.7
All Tows	3.7	2.9	4.8	4.9

Fig. 4.1-[illegible] Zooplankton stations: Cabo Rojo platform site.



The degree of variation between samples is expressed as a ratio formed by dividing the largest total number of zooplankton by the smallest within each set. The ratios are similar to those observed in other coastal regions around Puerto Rico (Youngbluth 1973, 1974). Another way of judging differences between samples is also present (Table 4.1-T2). By calculating the variance between consecutive samples, the number of tows needed to detect various levels of difference was determined.

TABLE 4.1-T2. Total zooplankton ($\log_{10}$ transformed from 4 sets of replicate tows. The number of replicate tows (n) needed) to detect ±5 - 50% difference in density is indicated.*

DATE	16 Jan. 74	2 Apr. 74	29 Aug. 74	15 Nov. 74
STATION	4	6	6	6
	2.95279	2.58546	2.78247	2.95279
	2.93551	2.92634	2.77379	2.93551
	2.80482	3.33062	2.54900	2.80482
n5%	1031	15	130	49
n30%	27	1	4	1
n50%	10	1	1	1

*$n = \frac{t^2 \times s^2}{d^2}$ Where (t) is the Student's t for the 95% confidence level (d.f. = 2), s^2 is the sample variance based on replicate tows, and d is the half-width of the confidence interval desired.

These data indicate that a large number of replicate tows would be necessary to detect density differences at the 5% level. However, in most cases, with only three tows, differences of 30% could be noted and significant differences of 50% or more can be detected with a single tow. These data agree with estimates of field sampling error found in other studies of zooplankton (Wiebe and Holland 1968, Carpenter et al., 1974). Differences larger than 50% were found between samples from different stations but these higher densities were rarely more than an order of magnitude greater.

Seasonal differences in the average abundance of total zooplankton were small, i.e., less than 3X (Table 4.1-T3).

TABLE 4.1-T3. Average density of all zooplankton collected
Total Zooplankton/m^3

	January	April	August	November
Range	423-1581	41-1128	261-1267	362-1776
Median	800	511	471	810
Mean	944	549	590	967
95% C.L.	600-1288	227-871	298-882	589-1345

The highest concentrations appeared in January and November. These larger densities, however, probably represent the range of variation among tropical zooplankton communities in the coastal waters around Puerto Rico rather than recurrent seasonal pulses since the 95% confidence intervals from each period overlap.

The foregoing remarks refer primarily to holoplanktonic forms as they composed 65 to 97% of the total zooplankton. Meroplankton tended to be slightly more numerous in January and August. However, the wide range of abundances recorded during any sampling period obscure any noticeable seasonal fluctuations in their densities.

Fish eggs were not abundant in this area (Table 4.1-T4). The largest density observed, 34/m , occurred at Station 9 during January. The mean number of eggs during this period was 10/m and twice the densities found at other times of the year. Fish eggs were usually round and 0.5 to 2 mm in diameter, but oblong eggs were common. It is not known which groups of fish are represented by most of the eggs.

Copepods dominated the samples, forming 57-92% of the zooplankton community. A total of 36 species was observed. Time did not allow a detailed study of species abundances at all stations. Consequently, one station out of nine was randomly selected from each period for quantitative analysis. In addition to these counts, all samples collected in January were scanned to form as complete a species list as possible. On the basis of these data the species most numerous, those commonly observed, and others occasionally found, are listed in Table 4.1-T5.

TABLE 4.1-T4. Summary of densities of fish eggs from all stations sampled at Cabo Rojo.

	STATIONS								
	1	3	4	5	6	8	9	2	7	ALL
Range	+-15	2-3	+-7	+-8	+-6	+-11	+-34	3-17	1-13	+-34
Median	9	3	2	3	3	3	13	6	6	5
Mean	9	3	3	4	3	4	15	8	7	6

4.1.4 DISCUSSION

The diversity of zooplankton and the levels of their abundances at Cabo Rojo within each sampling period were similar. Somewhat higher average abundances were noted in January and November. The range of density encountered among the stations was not associated with nearness to shore, depth, or current flow. This lack of pattern suggests that the density fluctuations probably present the patchy dispersion commonly observed among planktonic organisms.

Limitations of the Data

The sampling program was designed to provide quantitative estimates of: 1) the standing stock of zooplankton, 2) the variety of major taxonomic groups, and 3) the diversity and abundance of the more numerous copepod species. The manner of field sampling determined the variety and biomass of organisms encountered. The data in this report are based on collections made in the surface waters during the daylight hours. The sampling gear and methods were kept uniform, i.e., net type, net mesh, towing speed, and depth range sampled. A small number of replicate tows were gathered at each site to obtain some measure of the variability between samples. To obtain a better understanding of the zooplankton community more sampling with replication should be done at frequent intervals, at a greater number of stations, at different depths, during the day and night, and during different seasons for several years. Information gathered in these ways will be necessary to interpret fluctuations in standing stock and diversity in relation to environmental changes and biotic interactions.

TABLE 4.1-T5. Copepod populations at Cabo Rojo Platform.

Species usually most numerous (> 5 individuals/m^3)

Clausocalanus furcatus
Paracalanus spp. (*P. aculeatus*, *P. crassirostris*, *P. parvus*)
Farranula gracilis
Acartia spinata
Temora turbinata

Species commonly present (observed among 6 or 9 stations and 3 or more sampling periods)

Acartia lilljeborgii
Corycaeus giesbrechti
C. pacificus
C. subulatus
C. speciosus
C. spp.
Oncaea spp. (*O. venusta*, *O. mediterranea*, *O.* spp.)
Acrocalanus longicornis
Temora stylifera
Eutherpina acutifrons
Macrostella gracilis
Eucalanus spp. (E. crassus)
Calanopia americana
Labidocera scotti
Centropages furcatus
Undinula vulgaris

Species occasionally present

Euchaeta marina
Corycaeus latus
Nannocalanus minor
Calocalanus pavo
Scolecithrix danae
Miracia efferata
Sapphirina spp.
Labidocera spp.
Candacia pachydactyla
Mecynocera clausi

TABLE 4.1-T6 Total biomass of zooplankton (ml/m^3) Cabo Rojo Platform.

	Nearshore Replicate Tows Stations			Nearshore Tows Stations							Offshore Tows Stations	
Date	6a	6b	6c	1	3	4	5	6	8	9	2	7
160174	.077	-	.059	.089	.092	.096	.084	.068	.029	.064	.047	.058
20474	.034	.045	.096	.043	.062	.058	.034	.051	.034	.081	.055	.062
290874	.028	.031	.035	.055	.032	.027	.081	.032	.027	.095	.086	.087
151174	.052	.049	.023	.193	-	.050	.207	.041	.063	.082	.136	.152

TABLE 4.1-T7 Total number of zooplankton (number/m^3)

	Nearshore Replicate Tows Stations			Nearshore Tows Stations							Offshore Tows Stations	
Date	6a	6b	6c	1	3	4	5	6	8	9	2	7
160174	1381	-	765	1401	1438	799	1581	1073	448	800	423	535
20474	385	844	2141	512	788	449	476	1128	394	684	511	490
290874	424	468	520	261	319	41	1291	471	459	1267	354	555
151174	606	594	354	1776	362	645	1473	518	597	1163	810	1358

TABLE 4.1-T8 Total number of holoplankton (number/m^3) Cabo Rojo Platform Site.

	Nearshore Replicate Tows Stations			Nearshore Tows Stations							Offshore Tows Stations	
Date	6a	6b	6c	1	3	4	5	6	8	9	2	7
160174	1214	-	639	1192	1256	685	1525	927	415	695	353	460
20474	357	796	1925	424	618	339	448	1026	373	608	432	445
290874	379	449	477	206	293	32	1140	435	384	1027	320	366
151174	573	547	301	1698	338	595	1405	474	552	1096	735	1171

TABLE 4.1-T9 Total number of meroplankton (number/m^3)

	Nearshore Replicate Tows Stations			Nearshore Tows Stations							Offshore Tows Stations	
Date	6a	6b	6c	1	3	4	5	6	8	9	2	7
160174	167	-	119	174	163	105	45	143	30	69	47	67
20474	24	35	185	81	150	103	14	81	10	65	72	40
290874	43	19	40	43	23	8	74	34	63	240	23	187
151174	29	45	46	56	18	42	49	40	40	68	70	176

TABLE 4.1-T10 Total number of copepods (number/m^3) Cabo Rojo Platform Site.

	Nearshore Replicate Tows Stations			Nearshore Tows Stations						Offshore Tows Stations	
Date	6a	6b	6c	1	3	4	5	6	8	9	2	7
160174	1134	-	581	1065	1179	607	1452	860	334	599	297	388
20474	335	765	1861	372	587	258	412	987	362	589	374	400
290874	364	432	457	166	244	25	1081	418	349	967	275	318
151174	531	488	211	1523	307	518	1070	410	485	997	664	1049

TABLE 4.1-T11 Total number of chaetognaths (number/$10m^3$)

	Nearshore Replicate Tows Stations			Nearshore Tows Stations							Offshore Tows Stations	
Date	6a	6b	6c	1	3	4	5	6	8	9	2	7
160174	155	-	225	429	241	141	421	190	+	101	35	231
20474	68	100	159	378	170	693	246	109	7	81	461	82
290874	84	88	127	295	165	12	54	100	47	182	141	108
151174	363	407	698	1077	112	503	2431	489	536	312	229	765

TABLE 4.1-T12 Total number of larvaceans (number/$10m^3$) Cabo Rojo Platform Site.

Date	Nearshore Replicate Tows Stations			Nearshore Tows Stations							Offshore Tows Stations	
	6a	6b	6c	1	3	4	5	6	8	9	2	7
160174	644	-	338	805	428	629	280	491	803	861	522	461
20474	142	212	34	136	65	80	108	267	101	113	86	342
290874	63	75	45	95	329	54	522	67	281	376	266	184
151174	15	98	94	297	39	+	146	69	30	234	343	226

TABLE 4.1-T13 Total number of veliger larvae (number/10 m^3)

Date	Nearshore Replicate Tows Stations			Nearshore Tows Stations							Offshore Tows Stations	
	6a	6b	6c	1	3	4	5	6	8	9	2	7
160174	412	-	175	268	454	374	168	544	30	219	9	182
20474	173	245	1497	185	275	577	69	639	74	387	282	164
290874	35	19	35	73	112	22	252	30	180	1024	94	303
151174	30	70	73	186	67	27	632	58	89	441	64	226

TABLE 4.1-T14 Total number of caridean larvae (number/10m^3) Cabo Rojo Platform Site.

	Nearshore Replicate Tows Stations			Nearshore Tows Stations							Offshore Tows Stations	
Date	6a	6b	6c	1	3	4	5	6	8	9	2	7
160174	902	-	789	913	802	299	112	896	164	338	257	364
20474	37	67	319	506	890	351	23	141	20	129	363	123
290874	281	88	+	310	77	50	323	123	147	973	55	1179
151174	193	336	375	297	72	352	292	302	253	545	318	1566

TABLE 4.1-T15 Total number of brachyuran larvae (number/10m^3)

	Nearshore Replicate Tows Stations			Nearshore Tows Stations							Offshore Tows Stations	
Date	6a	6b	6c	1	3	4	5	6	8	9	2	7
160174	180	-	138	268	+	185	168	159	22	17	142	85
20474	12	+	+	36	+	22	8	4	+	81	25	14
290874	14	44	71	36	28	1	90	43	33	311	4	270
151174	59	+	63	74	39	34	146	41	89	52	275	70

TABLE 4.1-T16 Total number of cirripede nauplii (number/10m^3) Cabo Rojo Platform Site.

Date	Nearshore Replicate Tows Stations			Nearshore Tows Stations							Offshore Tows Stations	
	6a	6b	6c	1	3	4	5	6	8	9	2	7
160174	77	-	63	54	80	31	+	70	30	17	35	24
20474	+	+	+	14	39	+	+	+	+	+	12	+
290874	63	13	28	4	+	1	54	35	33	+	70	+
151174	22	14	10	+	6	17	+	16	15	+	21	70

TABLE 4.1-T17 Total number of fish eggs (number 10/m)

Date	Nearshore Replicate Tows Stations			Nearshore Tows Stations							Offshore Tows Stations	
	6a	6b	6c	1	3	4	5	6	8	9	2	7
160174	+	-	-	81	27	16	84	+	22	338	168	133
20474	31	45	96	+	27	15	15	57	114	81	31	27
290874	14	19	21	106	32	6	+	18	33	195	82	11
151174	22	14	73	149	33	67	49	36	+	+	42	87

4.2 BENTHIC INVERTEBRATES AND FISH STUDIES

by

Paul Yoshioka

4.2.1 INTRODUCTION

This report covers benthic studies at the Cabo Rojo Platform site from January to December 1974. The bulk of the effort was spent on descriptive surveys at the major benthic communities. Areas visited ranged from the mangroves to the offshore reef communities. Quantitative samples, when taken, were replicated to assess the magnitude of sampling variability. No permanent stations were established nor was any single area visited in all seasons, consequently no data on seasonal or other temporal changes in the benthic communities are available.

4.2.2 MATERIALS AND METHODS

Field Procedures

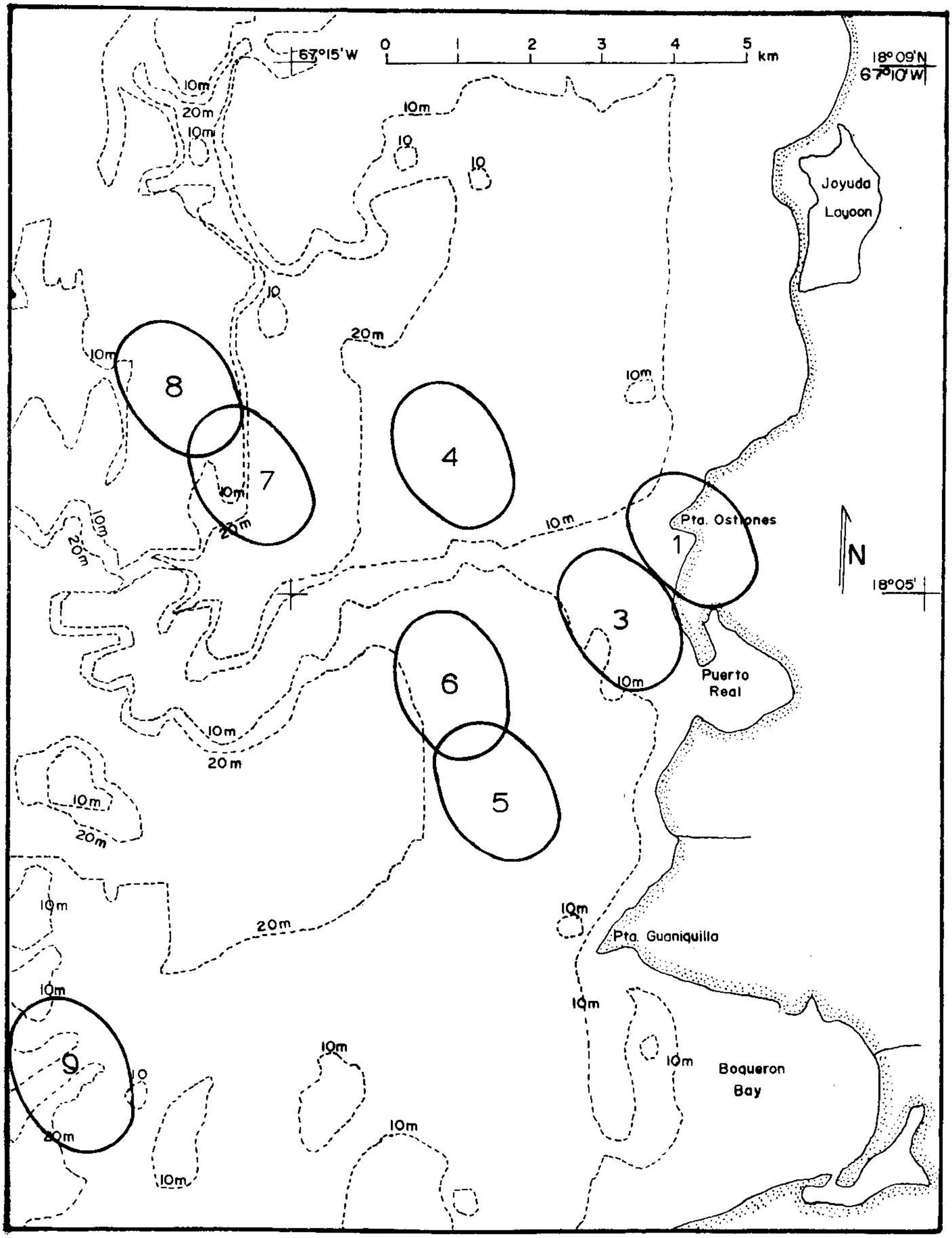
Field stations at the Cabo Rojo Platform site are shown in Figure 4.2-F1. Field procedures are divided into three categories: shore surveys, transect dives, and station dives.

Shore surveys. Shore surveys were descriptive in nature. The larger, more familiar organisms were identified in the field. Specimens of smaller or unfamiliar organisms were collected and identified in the lab. The shore biota investigated at the Cabo Rojo site were the mangrove root communities and shoreline fishes.

Transect dives. Transects were traversed on a predetermined compass direction by two divers either swimming or propelled by a diver propulsion vehicle (DPV). Notes were taken on depth, bottom type, topography, and dominant or unusual organisms.

Station dives. Dives were made at various stations to collect qualitative and quantitative samples. Quantitative samples were replicated whenever possible. Gorgonians were collected at Stations 3 and 9 in 5 m^2 (1 x 5 m) or 10 m^2 (2 x 5 m) subsamples. Gorgonians were collected from a total area of 10 or 20 m at each station. A qualitative sample only was taken at Station 8.

Fig. 4.2-F1 Benthic studies field stations at the Cabo Rojo Platform site.



All large macroinvertebrates were collected in 10 m^2 (2 x 5 m) quadrats at Stations 4 and 5. All macroinvertebrates were surveyed in a Thalassia bed (Station 1) in three 50 m^2 (2 x 25 m) quadrats.

Photographs were taken to aid in gaining a general description of the area. The presence and absence of the larger invertebrates and fish were also noted whenever possible.

Laboratory Procedures

Gorgonian samples were dried for several weeks, then weighed, measured, and identified. The more familiar species were identified on the basis of external characteristics. Questionable individuals were identified with the aid of spicule preparations.

Other samples were sorted into phylogenetic groups, and preserved in 70% ethyl alcohol or 10% formalin for later identification. Samples were often frozen prior to sorting.

Taxonomic references used to identify organisms are listed in the bibliography.

4.2.3 RESULTS AND DISCUSSION

The Cabo Rojo Platform site encompasses a large variety of benthic habitats, mangroves, Thalassia beds, soft bottomed basins, and coral reef communities.

Organisms observed on mangrove roots in a small bay bordering Punta Ostiones (Station 1) are listed in Table 4.2-T1. Organisms observed are commonly found on mangrove root communities in embayments (PRNC, 1972). Except for filamentous algae, few organisms were found on mangrove roots at Punta Ostiones, a few hundred meters away. This large difference in mangrove root communities agrees with observations by McNae and Kalk (1962) who found that no unique community is associated with mangrove roots, but rather that the composition of mangrove root communities is dependent upon other environmental parameters. Similarly, mangrove root communities differ greatly in species composition in Jobos Bay depending upon location. Shoreline fishes collected with rotenone at Punta Guanaguilla are listed in Appendix 4.2A.

Gorgonians sampled at Station B, an inshore reef, are listed in Appendix 4. B. Over 80% of the colonies were represented by two species Pseudopterogorgia acerosa and

Pseudopterogorgia americana. Gorgonians collected at a deeper offshore reef, Station 9, are also listed in Appendix 4.2B. The more abundant gorgonians at Station 9 were Pseudopterogorgia acerosa, Eunicea tourneforti, Eunicea laxispica, and Eunicea calyculata. However, the relative abundances of gorgonian species were not significantly correlated at the 0.05 level between replicate samples.

A sand-mud mixture dominates the substrate in the two basins of the Cabo Rojo site (Stations 4 and 5).

TABLE 4.2-T1 Mangrove root organisms observed at the Cabo Rojo Platform site Station 1.

PLANT KINGDOM

Phylum Chlorophyta

Caulerpa sertularoides
Caulerpa verticillata
Halimeda sp.

Phylum Rhodophyta

Acanthophora spicifera
Laurencia sp.

ANIMAL KINGDOM

Phylum Porifera

Desmacella jania
Sigmadoeca caerula
Tedania ignis
Haliclona sp.

Phylum Mollusca

Crassotrea rhizophorae
Littornia angulifera
Isognomon alatus

Phylum Arthropoda

Balanus sp.
Aratus pisonii
Pachygrapsus transversii

Phylum Chordata

Botryllus planus

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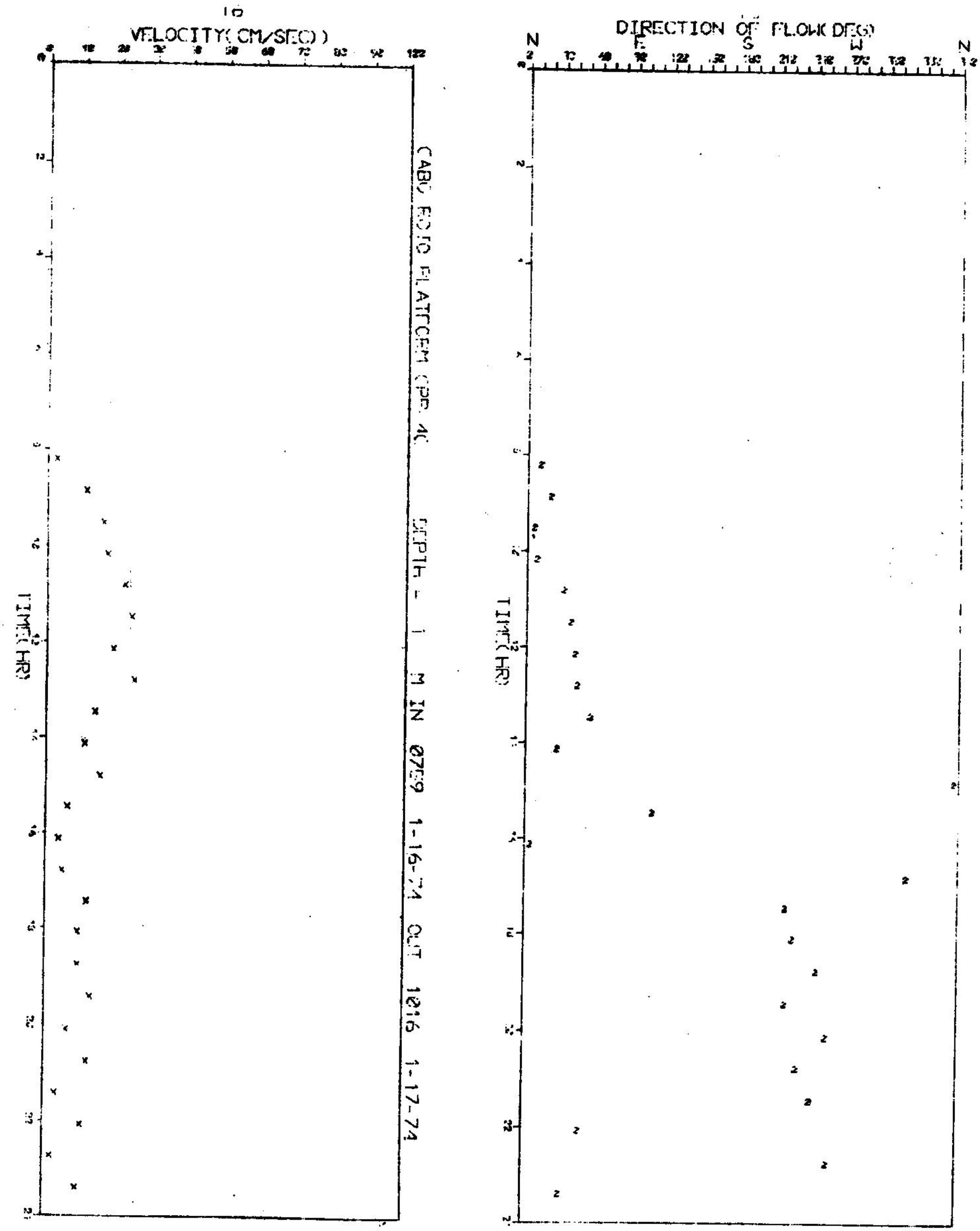
APPENDIX 2.1A

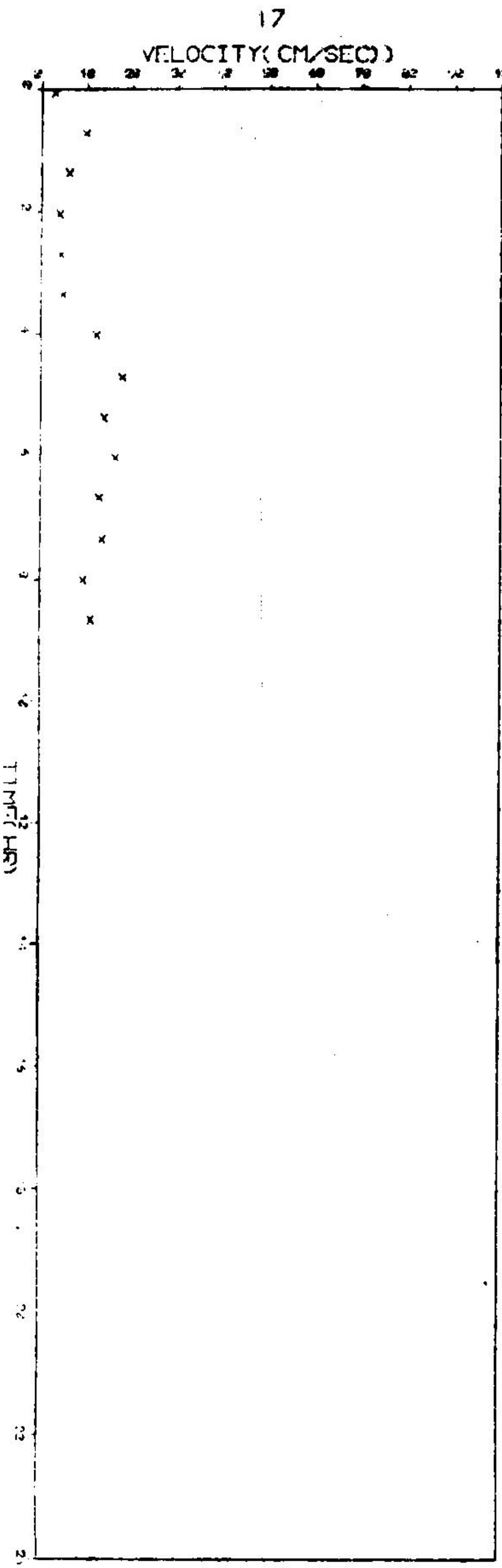
i. Current plots - velocity and direction vs. time.

ii. Averaged data for (:).

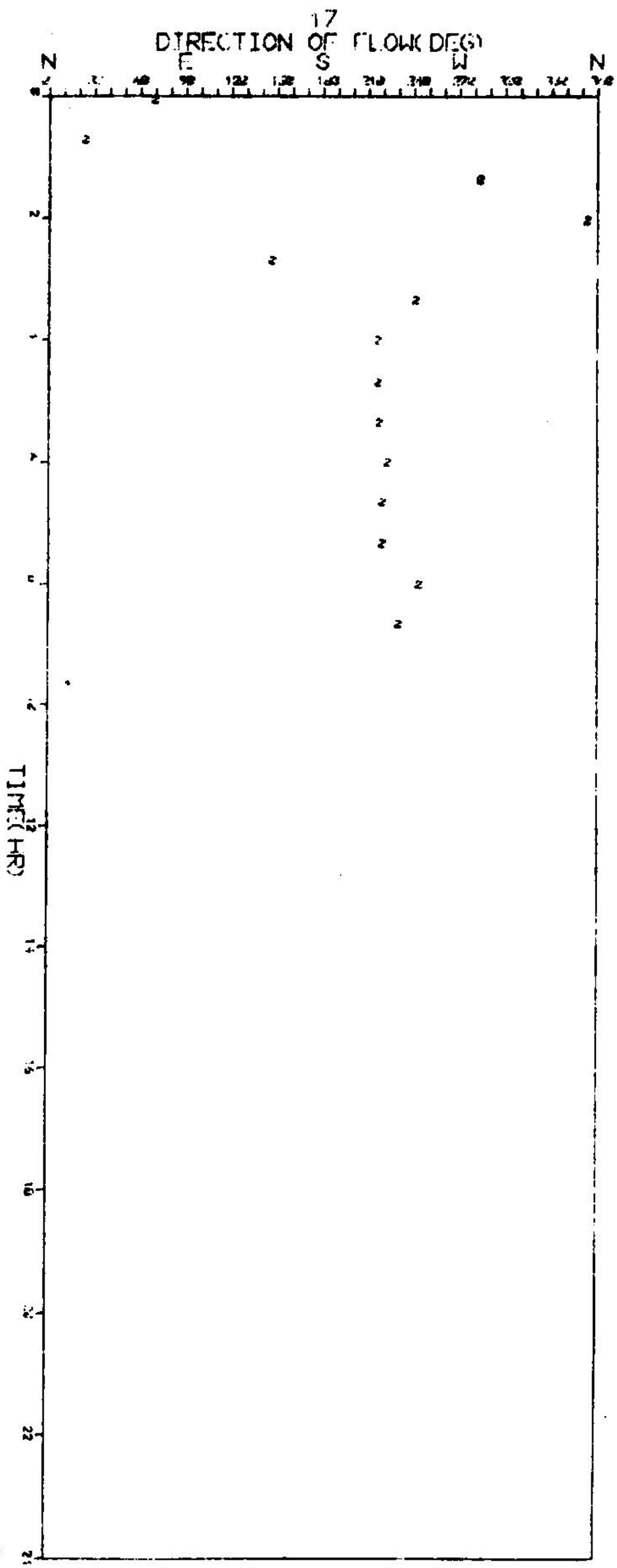
iii. Progressive Vector data for Figure 2.1-F3.

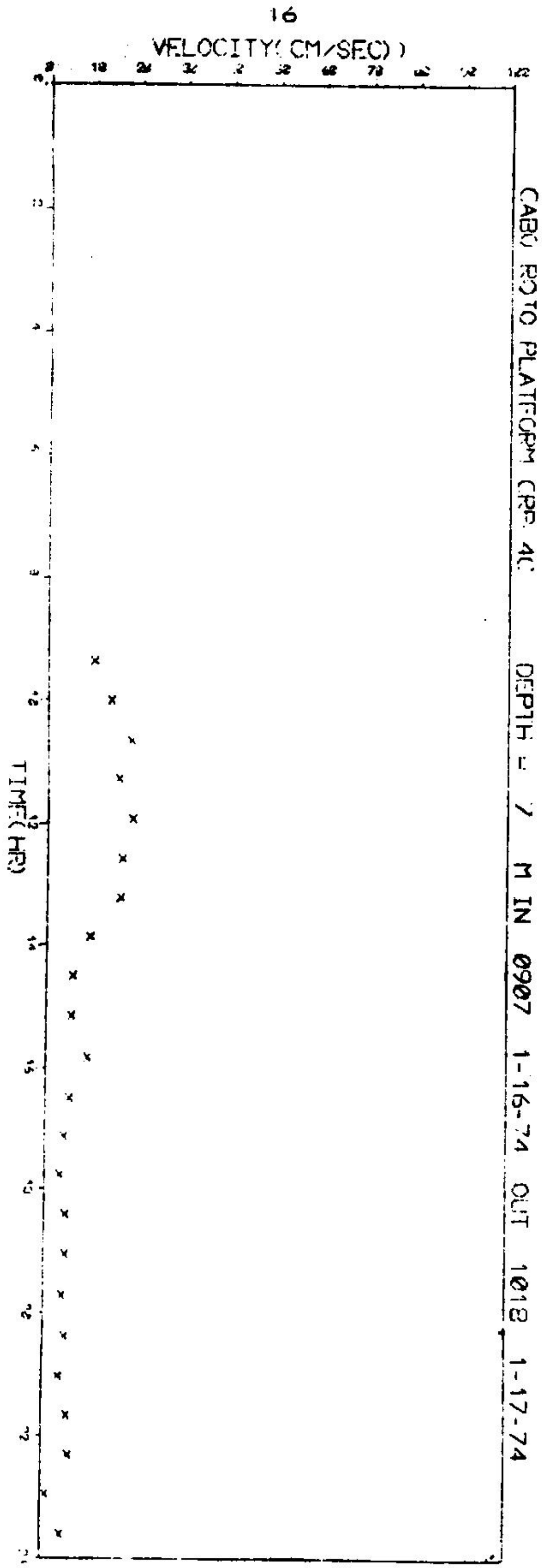
iv. Current Rose data for Figure 2.1-F4.


VELOCITY(CM/SEC)
DIRECTION OF FLOW(DEG)
N
E
S
W
N
TIME(HR)
TIME(HR)
CABO ROJO PLATFORM OPE. 4C DEPTH = 1 M IN 0759 1-16-74 OUT 1016 1-17-74

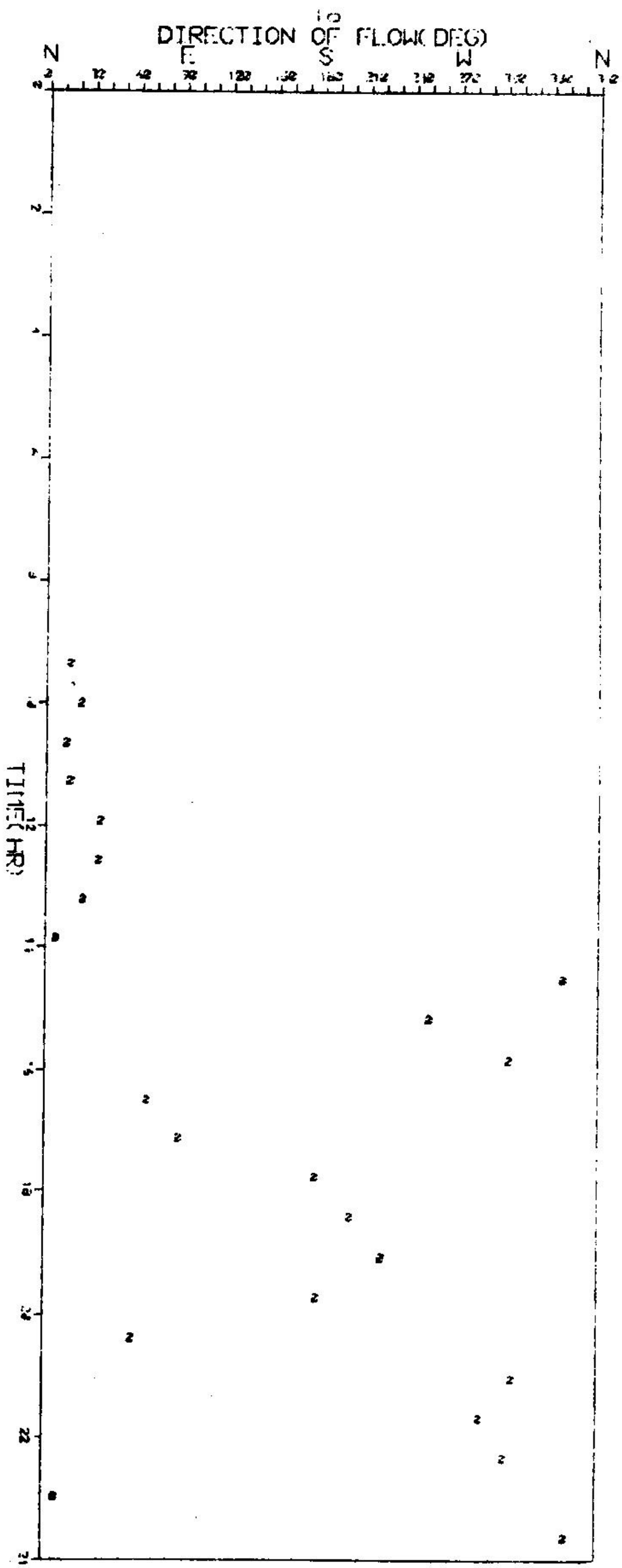


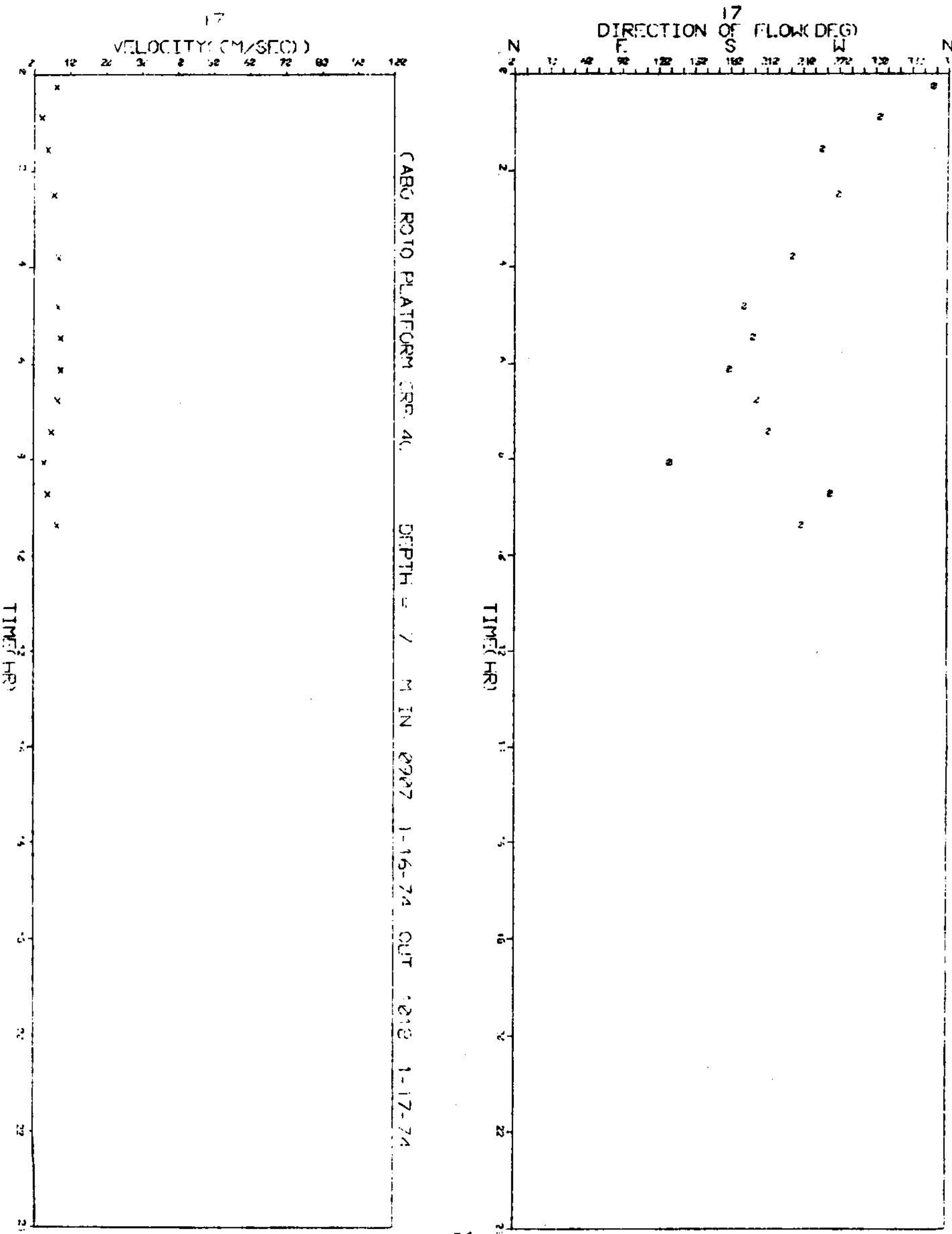
CABO ROJO PLATFORM CRE 40 DEPTH = 1 M IN 0759 1-16-74 OUT 1016 1-17-74

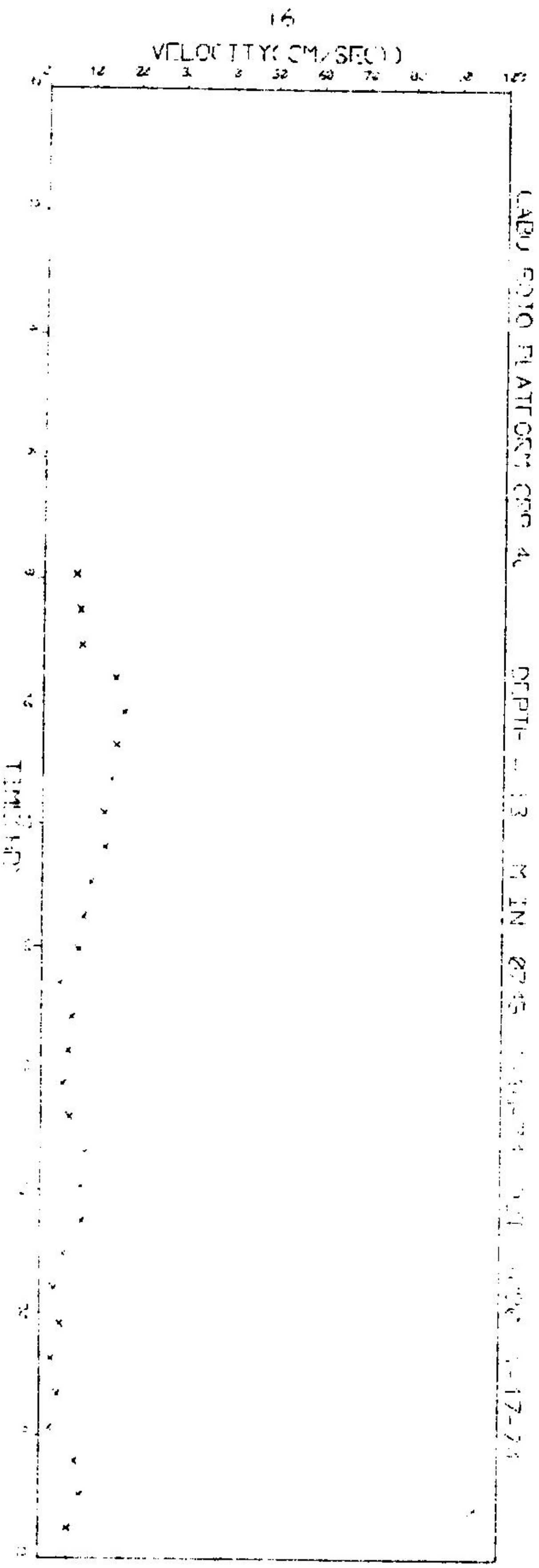




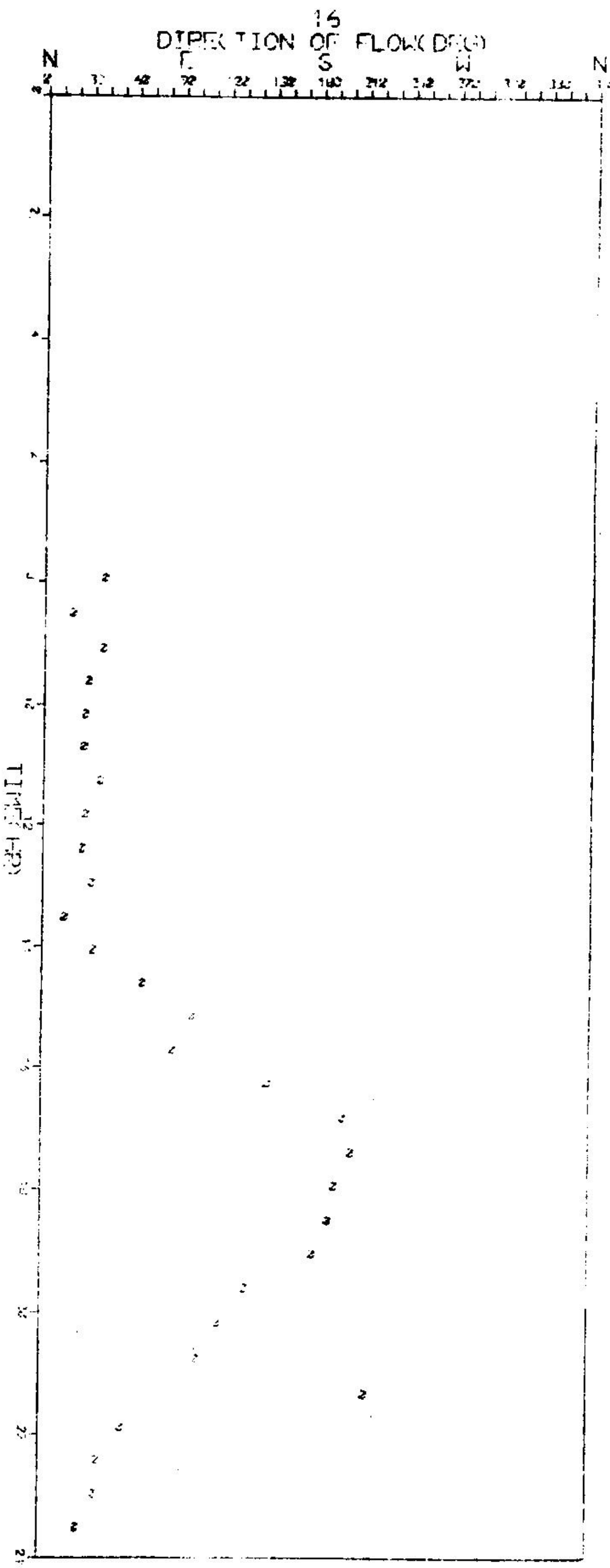
CABO ROJO PLATFORM CRP 4C DEPTH = 7 M IN 0907 1-16-74 OUT 1018 1-17-74



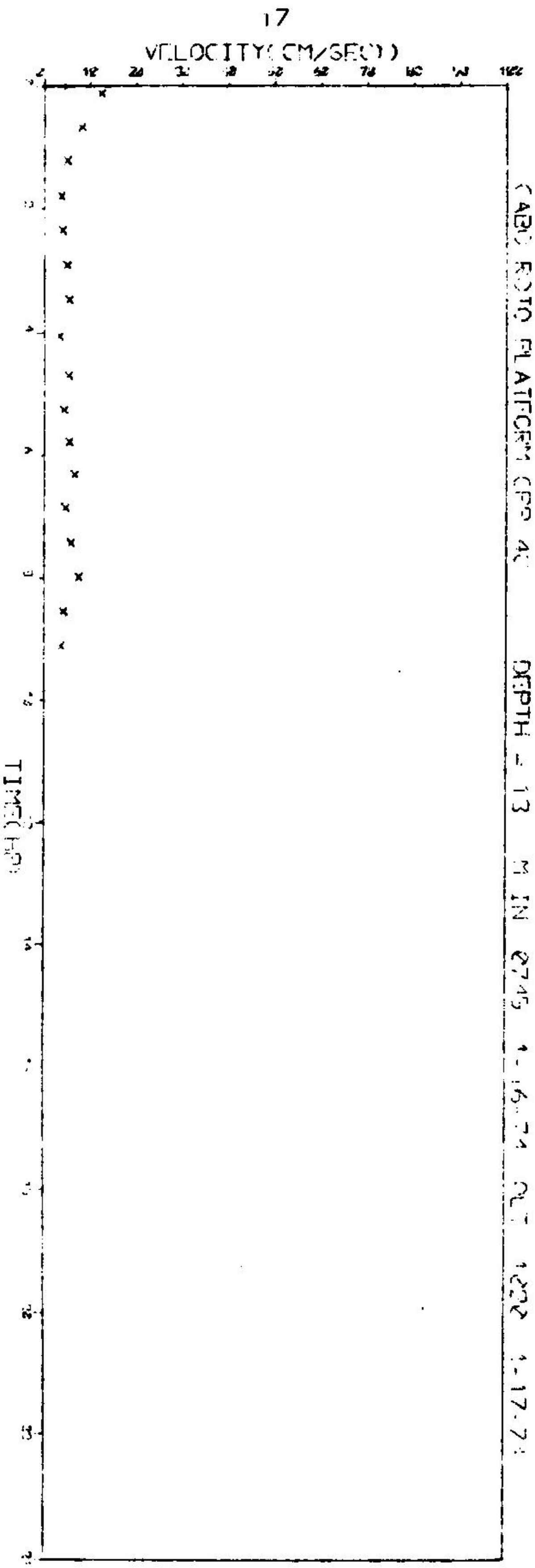

17
VELOCITY(CM/SEC)
TIME(HR)
CABO ROJO PLATFORM SRF. 40 DEPTH = 7 M IN 0907 1-16-74 OUT 1818 1-17-74
17
DIRECTION OF FLOW(DEG)
N
E
S
W
N
TIME(HR)

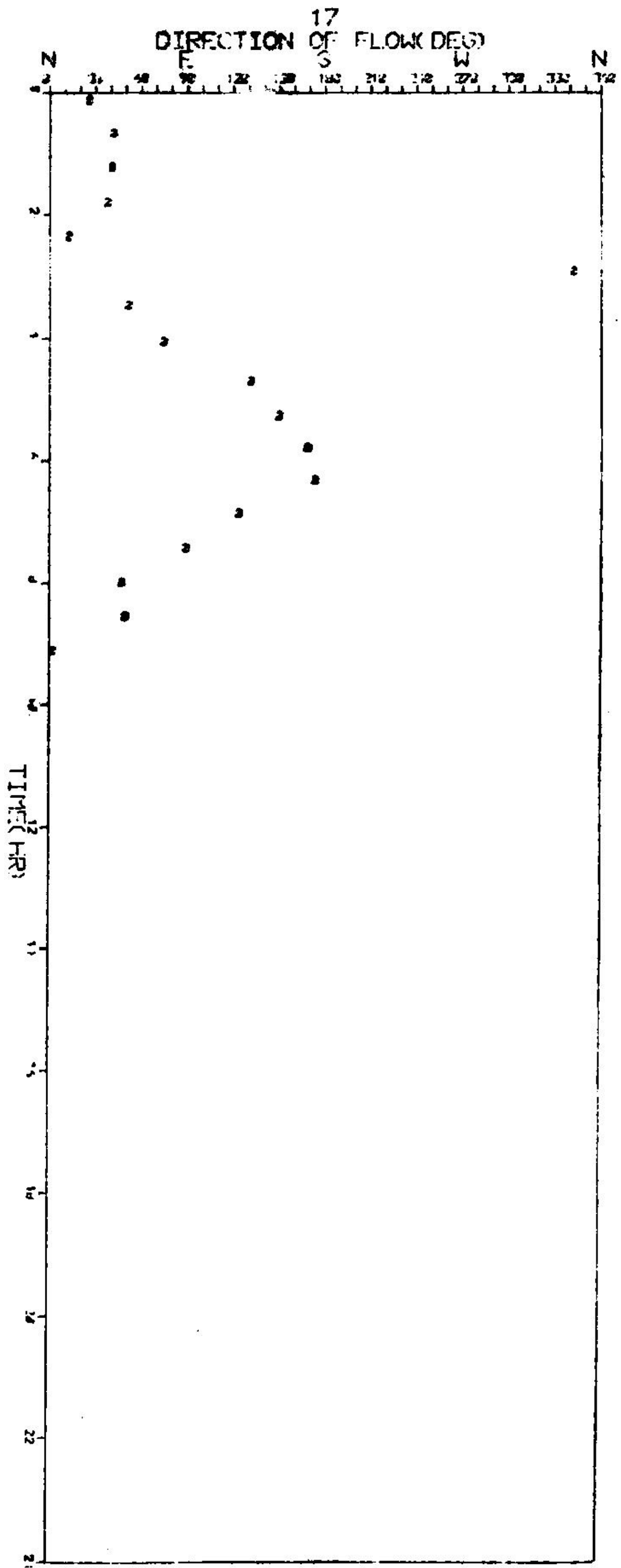


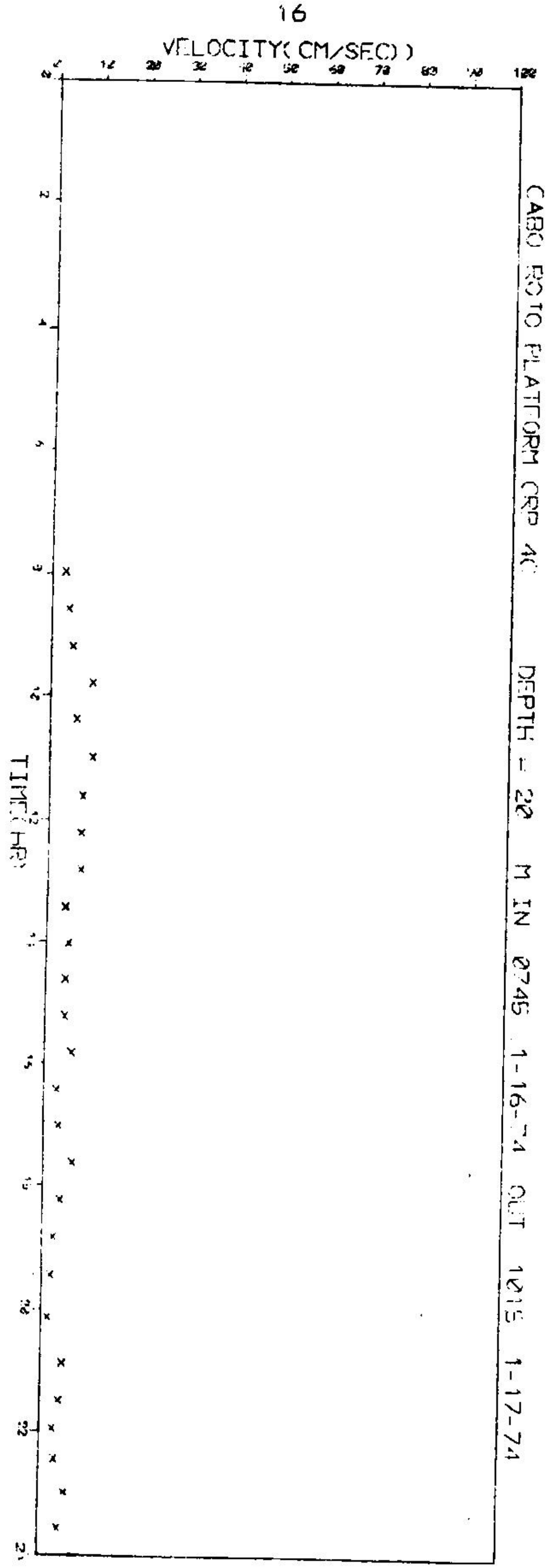
16
VELOCITY(CM/SEC)
TIME(HR)
CABO ROJO PLATFORM CPR 4C DEPTH = 13 M IN 07/15

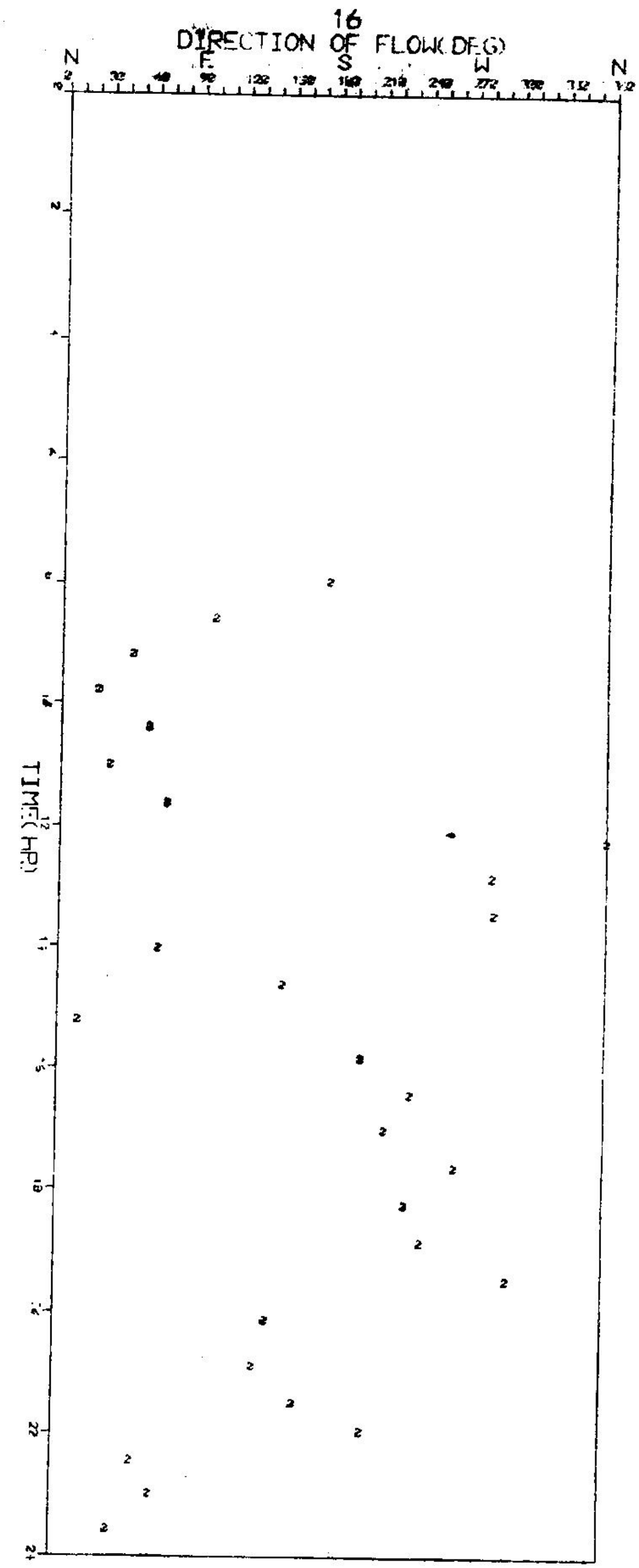


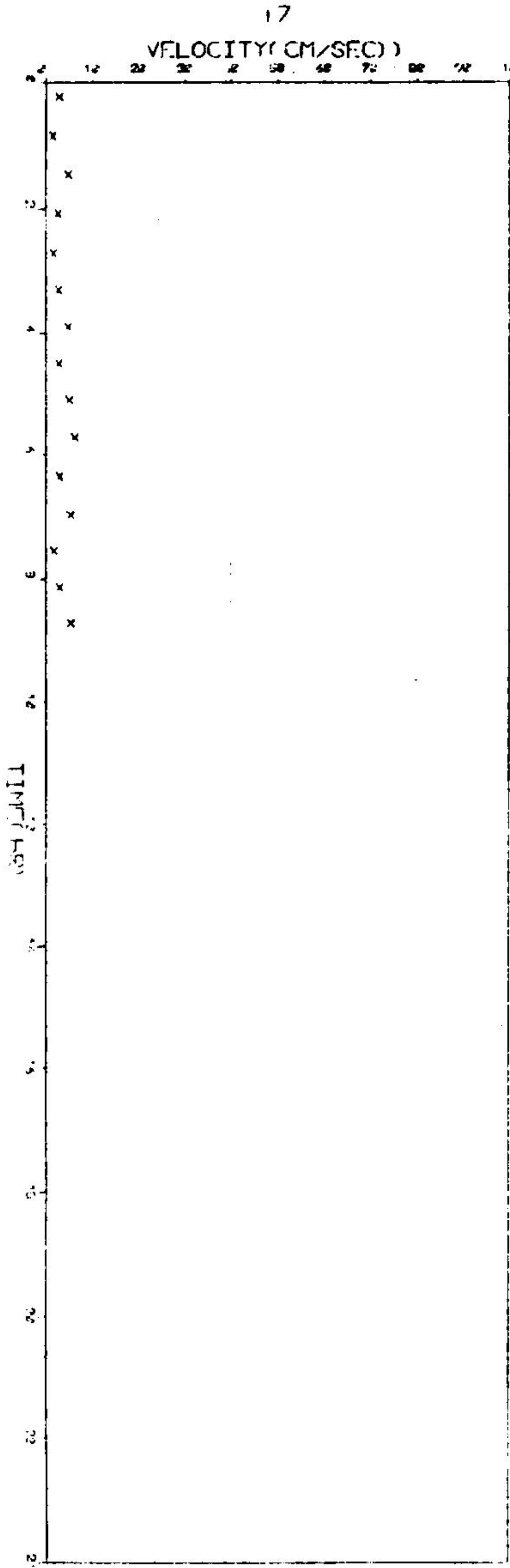
16
DIRECTION OF FLOW(DEG)
N
E
S
W
N
TIME(HR)


17
VELOCITY(CM/SEC)
TIME(HR)
DEPTH = 13 M IN 0745 1-16-74 OUT 1230 1-17-74

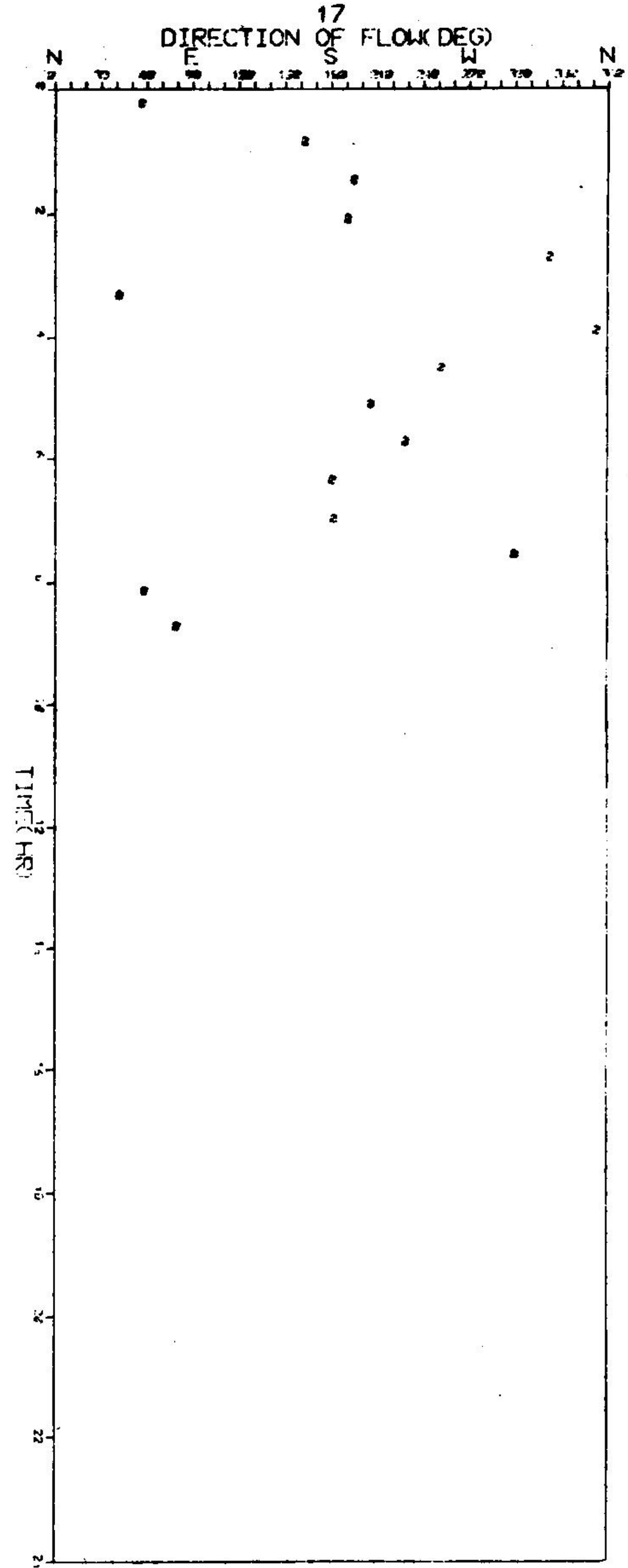

17
DIRECTION OF FLOW(DEG)
N
E
S
W
N
TIME(HR)


16
VELOCITY(CM/SEC))
TIME(HR)
CABO ROTO PLATFORM CRP 4C DEPTH = 20 M IN 0745 1-16-74 OUT 1015 1-17-74


16
DIRECTION OF FLOW(DEG)
N
E
S
W
N
TIME(HR)



CABO ROTO PLATFORM CRP 4C DEPTH = 20 M IN 0745 1-16-74 OUT 1018 1-17-74



CABO [illegible] PLATFORM CRP-4C

IN 2759 1-16-74 OUT 1016 1-17-74

DEPTH = 1 M

TIME	VELOCITY	DIRECTION
8:16.3	1.8	9.
8:55.1	12.1	17.
9:34.6	15.0	4.
10:14.1	6.0	6.
10:53.6	20.0	28.
11:33.1	22.9	34.
12:12.5	17.8	38.
12:52.8	23.8	40.
13:32.5	13.0	51.
14:12.1	12.1	24.
14:51.6	14.4	354.
15:31.6	5.4	103.
16:11.6	3.1	2.
16:51.1	4.2	315.
17:30.3	10.9	214.
18:10.3	8.5	220.
18:49.0	8.5	241.
19:29.5	12.0	215.
20: 9.6	5.5	242.
20:49.1	11.3	225.
21:28.6	2.6	236.
22: 8.1	9.7	49.
22:47.8	1.3	251.
23:27.8	8.5	29.
0: 7.6	2.2	67.
0:47.1	9.7	21.
1:26.6	5.4	281.
2: 6.1	3.4	351.
2:45.6	3.7	144.
3:25.1	4.2	338.
4: 5.0	11.6	214.
4:45.5	17.2	214.
5:25.5	13.3	215.
6: 4.3	15.7	220.
6:44.0	12.2	217.
7:24.5	12.0	217.
8: 4.6	5.7	241.
8:44.1	10.5	227.

DEPTH = 2 M

TIME	VELOCITY	DIRECTION
9:24.6	9.4	13.6
10: 4.1	13.1	22.9
10:42.7	17.4	11.1
11:20.2	14.8	13.6
11:58.3	17.7	33.7
12:37.3	13.4	12.3
13:16.1	15.2	22.5
13:54.6	5.7	4.2
14:33.6	5.1	335.5
15:13.1	4.8	248.1
15:52.6	0.3	302.5
16:32.1	4.5	64.9
17:11.1	3.4	65.9
17:49.6	2.6	274.4
18:28.3	3.9	197.5
19: 7.3	4.0	217.0
19:46.3	3.3	175.9
20:25.3	4.0	25.7
21: 4.3	2.8	293.8
21:43.3	4.8	282.3
22:22.3	5.2	292.5
23: 1.3	2.3	6.5
23:40.3	3.6	338.2
0:19.3	5.5	345.1
0:58.3	3.4	301.7
1:37.3	3.1	224.1
2:33.9	4.9	257.9
3:52.4	6.2	298.
4:53.3	5.1	189.3
5:32.3	6.7	196.7
6:11.3	6.8	174.9
6:52.3	6.0	192.7
7:29.3	4.2	269.4
8: 8.3	2.1	126.7
8:47.3	3.[illegible]	261.[illegible]
9:26.3	5.6	226.5

CABO ROJO PLATFORM CRP-[illegible]

IN 2245 1-16-74 OUT 1020 1-17-74

DEPTH = 13 M

TIME	VELOCITY	DIRECTION
8: 7.1	6.4	37.[illegible]
8:34.1	7.3	16.[illegible]
9: 7.7	7.7	36.[illegible]
9:40.7	15.0	27.[illegible]
10:13.7	15.9	29.[illegible]
10:46.7	15.2	29.[illegible]
11:19.9	14.3	65.[illegible]
11:53.4	12.7	25.6
12:26.9	12.9	23.[illegible]
13: 0.4	9.9	32.2
13:33.7	8.5	12.7
14: 6.7	7.4	31.[illegible]
14:39.9	3.2	54.[illegible]
15:13.4	6.2	57.5
15:46.9	5.2	34.5
16:22.9	4.0	147.5
16:53.7	5.5	197.4
17:26.7	[illegible].9	202.7
17:59.9	6.2	192.1
18:3[illegible]	8.4	188.1
19: 6.9	4.4	172.7
19:40.4	2.4	153.4
20:14.8	3.7	115.4
20:49.6	1.7	101.8
21:23.7	3.2	212.6
21:56.7	1.5	52.4
22:29.9	7.1	36.6
23: 3.4	8.2	34.7
23:36.9	5.5	23.5
0:10.4	11.7	23.8
0:43.9	7.5	40.0
1:17.4	4.4	38.0
1:50.9	3.1	36.1
2:24.4	3.4	10.9
2:57.9	4.4	340.4
3:31.4	4.9	40.7
4: 5.7	2.8	72.7
4:44.2	4.7	122.3
5:19.0	3.7	147.8
5:50.5	4.8	166.7
6:22.7	6.1	171.5
6:55.7	4.1	121.5
7:28.9	5.2	87.0
8: 2.4	7.0	45.3
8:35.9	3.5	47.7
9: 9.4	3.2	[illegible].5

DEPTH = 20 M

TIME	VELOCITY	DIRECTION
8: 1.2	2.2	173.7
8:37.7	3.2	20.[illegible]
9:14.2	4.[illegible]	44.[illegible]
9:50.7	4.6	22.2
10:27.2	5.3	56.[illegible]
11: 3.7	[illegible]	58.4
11:40.2	6.[illegible]	62.4
12:16.7	6.6	197.[illegible]
12:53.[illegible]	6.6	82.6
13:29.[illegible]	7.4	204.2
14: 5.[illegible]	4.3	64.[illegible]
14:41.[illegible]	3.7	45.5
15:17.[illegible]	3.0	11.6
15:53.[illegible]	5.3	37.8
16:29.[illegible]	2.1	31.2
17: 5.[illegible]	2.6	13.4
17:41.2	5.8	39.5
18:17.7	3.1	27.[illegible]
18:54.2	1.8	[illegible]
19:30.7	1.2	254.9
20:11.0	0.7	137.2
20:56.0	4.3	120.2
21:33.2	3.4	125.8
22: [illegible].7	2.1	[illegible].6
22:[illegible].9	2.7	[illegible]
23: 4.4	4.9	63.3
23:40.1	3.6	35.[illegible]
0:15.6	2.2	154.5
0:56.0	0.8	160.7
1:32.0	4.2	192.0
2: 8.4	2.0	158.3
2:45.4	1.0	322.3
3:22.0	2.1	39.6
3:58.2	4.1	250.6
4:34.2	2.1	249.8
5:11.7	4.4	202.9
5:47.4	5.5	265.4
6:24.4	2.3	178.1
7: 0.8	1.7	179.1
7:36.3	1.1	297.2
8:12.0	2.3	56.2
8:48.0	4.7	76.6

PROGRESSIVE VECTOR DATA

CABO ROJO PLATFORM GRP-4C DEPTH = 1 M 1[illegible] 275 1-16-74 OUT 1416

1-17-74

TIME	X	Y		
8:16.3	1.73	0.27	10.[illegible]	10.42
8:55.3	9.67	3.05	10.03	10.11
9:34.6	14.95	1.04	10.04	10.26
10:14.1	15.95	1.73	10.06	10.42
10:53.6	18.31	9.99	10.16	10.61
11:33.1	18.83	13.06	10.29	10.76
12:12.8	13.93	11.12	10.42	10.97
12:52.6	18.30	15.51	10.56	11.11
13:32.6	8.06	10.16	10.66	11.17
14:12.1	9.22	4.17	10.73	11.29
14:51.8	14.35	-1.51	10.69	11.43
15:31.2	-1.25	5.24	10.74	11.42
16:11.6	3.25	0.13	10.74	11.45
16:51.1	-2.94	-2.94	10.71	11.48
17:30.3	-8.91	-6.23	10.65	11.39
18: 9.3	-6.40	-5.52	10.59	11.32
18:49.0	-4.13	-7.44	10.52	11.28
19:29.5	-9.60	-6.95	10.45	11.19
20: 9.6	-1.96	-5.10	10.40	11.17
20:49.1	-7.86	-7.08	10.32	11.40
21:28.6	-1.41	-2.14	10.30	11.27
22: 8.1	6.90	6.80	10.37	11.14
22:47.8	-3.43	-1.28	10.35	11.14
23:27.8	7.41	4.17	10.39	11.21
0: 7.6	0.85	2.03	10.62	10.21
0:47.1	8.39	3.38	10.25	10.09
1:26.6	1.06	-5.27	10.00	10.10
2: 6.1	3.36	-4.51	10.03	10.14
2:45.6	-3.02	2.14	10.02	10.11
3:25.1	-2.19	-3.60	9.98	10.08
4: 5.0	-9.57	-6.48	9.92	9.99
4:45.5	-14.22	-9.75	9.82	9.85
5:25.3	-10.89	-7.66	9.74	9.74
6: 4.3	-11.94	-10.24	9.64	9.62
6:44.0	-9.75	-7.35	9.57	9.52
7:24.5	-10.27	-7.76	9.49	9.42
8: 4.6	-4.21	-7.66	9.41	9.36
8:44.1	-7.04	-7.74	9.33	9.31

PROGRESSIVE VECTOR DATA

CABO ROJO PLATFORM CRR-4C [illegible] 1-16-74 [illegible] 1-18

1-17-74

TIME	X	Y		
9:24.6	9.12	2.21	[illegible]	[illegible]
10: 4.1	12.26	4.68	[illegible]	10.21
10:42.7	17.05	3.34	[illegible]	[illegible]
11:20.2	14.34	3.46	[illegible]	[illegible]
11:58.3	14.71	9.01	[illegible]	[illegible]
12:37.3	13.16	[illegible]	[illegible]	[illegible]
13:16.1	14.06	5.81	[illegible]	[illegible]
13:54.6	8.66	6.74	[illegible]	[illegible]
14:33.6	4.62	-2.11	[illegible]	[illegible]
15:13.1	-1.77	-4.41	[illegible]	[illegible]
15:52.6	4.20	-7.16	[illegible]	[illegible]
16:32.1	1.91	[illegible]	[illegible]	[illegible]
17:11.1	3.24	3.41	[illegible]	[illegible]
17:49.5	-2.57	[illegible]	[illegible]	[illegible]
18:28.3	-3.68	-1.16	[illegible]	[illegible]
19: 7.3	-3.13	-2.43	[illegible]	[illegible]
19:46.3	-3.27	[illegible]	[illegible]	[illegible]
20:25.3	2.25	[illegible]	[illegible]	[illegible]
21: 4.3	1.54	-2.36	[illegible]	[illegible]
21:43.3	1.02	-4.69	[illegible]	[illegible]
22:22.3	2.46	-4.59	[illegible]	[illegible]
23: 1.3	2.26	0.23	[illegible]	[illegible]
23:42.3	3.34	-1.34	[illegible]	[illegible]
0:19.3	5.28	-1.42	[illegible]	[illegible]
0:58.3	[illegible]	-1.17	9.97	[illegible]
1:37.3	-0.85	-2.97	9.94	[illegible]
2:33.9	-0.16	-4.98	[illegible]	[illegible]
3:52.4	-3.96	-4.72	9.85	10.21
4:53.3	-6.05	-0.99	9.84	[illegible]
5:32.3	-6.42	-1.92	9.62	[illegible]
6:11.3	-6.77	0.37	[illegible]	[illegible]
6:50.3	-5.54	-2.02	9.82	9.76
7:29.3	-3.65	[illegible]	9.78	9.73
8: 8.3	-1.26	1.69	9.62	9.71
8:47.3	-2.57	-3.15	9.77	9.71
9:26.3	-3.18	-4.61	9.72	[illegible]

PROGRESSIVE VECTOR DATA

CABO ROJO PLATFORM CRP-4C DEPTH = 13 M IN 0745 1-16-74 OUT 1[illegible]20

1-17-74

TIME	X	Y		
8: 0.1	5.08	3.83	10.04	10.05
8:34.1	7.05	2.32	10.06	10.12
9: 7.7	6.24	4.59	10.17	10.18
9:40.7	13.34	6.60	10.17	10.32
10:13.7	15.32	7.10	10.21	10.47
10:46.7	13.63	6.23	10.31	10.61
11:19.9	11.60	6.33	10.36	10.73
11:53.4	11.44	5.49	10.44	10.84
12:26.9	11.78	5.23	10.51	10.96
13: 0.4	8.59	5.70	10.55	11.04
13:33.7	8.25	1.86	10.56	11.13
14: 6.7	6.25	3.88	10.62	11.19
14:39.9	1.36	2.88	10.63	11.20
15:13.4	-3.78	5.95	10.69	11.19
15:46.9	3.47	5.21	10.74	11.20
16:20.4	-3.41	2.17	10.77	11.16
16:53.7	-5.25	-1.65	10.75	11.11
17:26.7	-8.22	-3.43	10.73	11.03
17:59.9	-8.03	-1.72	10.74	10.95
18:33.4	-8.35	-1.19	10.69	10.87
19: 6.9	-4.44	0.13	10.69	10.82
19:40.4	-1.62	1.71	10.72	10.81
20:14.6	-1.59	3.35	10.74	10.79
20:49.6	-0.35	1.65	10.75	10.73
21:23.7	-2.67	-1.71	10.74	10.76
21:56.7	0.91	1.18	10.75	10.77
22:29.9	5.70	4.23	10.79	10.83
23: 3.4	6.76	4.68	10.84	10.89
23:36.9	5.07	2.20	10.86	10.94
0:10.4	10.69	4.72	10.05	10.11
0:43.9	5.70	4.65	10.10	10.16
1:17.4	3.41	2.74	10.12	10.24
1:50.9	2.54	1.64	10.14	10.22
2:24.4	3.33	0.64	10.15	10.26
2:57.9	4.13	-1.47	10.13	10.30
3:31.4	3.17	3.75	10.17	10.33
4: 6.7	0.63	2.68	10.20	10.34
4:44.2	-3.00	3.66	10.23	10.31
5:19.0	-3.16	1.99	10.25	10.28
5:50.5	-4.72	1.11	10.27	10.23
6:22.7	-5.98	0.90	10.27	10.17
6:55.7	-2.13	3.46	10.31	10.15
7:28.9	0.27	5.18	10.36	10.15
8: 2.4	4.92	4.97	10.41	10.20
8:35.9	2.38	2.62	10.44	10.22
9: 9.4	3.16	0.22	10.44	10.26

PROGRESSIVE VECTOR DATA

CABO ROJO PLATFORM CRP-4C   DEPTH = 20   M 14 0745 1-16-74 [illegible]
1-17-74

TIME	X	Y		
8: 1.2	-2.20	0.26	10.00	9.98
8:37.7	-0.44	2.98	10.03	9.97
9:14.2	2.96	2.89	10.06	10.07
9:50.7	7.97	3.26	10.09	10.05
10:27.2	2.95	4.38	10.14	10.11
11: 3.7	7.59	4.45	10.13	10.18
11:40.2	2.50	0.33	10.25	10.21
12:16.7	6.57	-0.24	10.24	10.28
12:53.0	1.44	-6.46	10.18	10.29
13:29.4	0.83	-3.28	10.15	10.34
14: 5.[illegible]	1.68	3.85	10.16	10.32
14:41.[illegible]	-3.04	2.[illegible]9	10.24	10.24
15:17.[illegible]	3.71	0.75	10.21	10.33
15:53.[illegible]	-5.08	-1.63	10.2[illegible]	10.28
16:29.0	-1.34	-1.61	10.19	10.26
17: 5.[illegible]	-2.16	-1.43	10.17	10.24
17:41.2	-1.05	-5.07	10.11	10.27
18:17.7	-2.11	-2.29	[illegible]	[illegible]
18:54.2	-0.95	-1.52	10.07	10.2[illegible]
19:30.7	0.51	-1.10	10.06	10.21
20:11.[illegible]	-0.48	0.44	10.06	10.2[illegible]
20:56.0	-2.55	3.13	10.13	10.14
21:33.2	-3.06	1.57	10.11	10.10
22: 0.7	-1.99	-[illegible].75	10.12	10.12
22:30.9	1.69	2.05	10.12	10.1[illegible]
23: 4.4	2.19	4.35	10.17	10.16
23:40.1	2.91	2.10	10.19	10.10
0:18.6	1.29	1.00	10.02	10.01
0:56.0	-0.72	0.25	10.02	10.01
1:32.0	-4.14	-0.95	10.01	9.96
2: 8.4	-1.93	-0.28	10.01	9.94
2:45.4	0.74	-2.61	10.00	9.95
3:22.0	1.62	1.34	10.02	9.97
3:58.0	4.06	-2.07	10.01	10.01
4:34.2	-0.77	-1.77	9.99	10.00
5:10.7	-4.01	-1.59	9.97	9.96
5:47.4	-3.88	-3.72	9.93	9.92
6:24.4	-2.27	2.48	9.93	9.93
7: 0.5	-4.74	0.04	9.93	9.85
7:36.3	0.48	-0.94	9.93	9.84
8:12.[illegible]	1.30	1.92	9.94	9.87
8:48.2	1.08	4.56	9.99	9.53

CURRENT ROSE DATA

CABO ROJO PLATFORM CRP-4C DEPTH = 1 M 1[illegible] 0/59 1-16-74 [illegible] 1.16
1-17-74

L	X	Y
1	10.0	11.5
2	10.0	10.2
3	10.3	10.8
4	10.9	11.6
5	10.7	10.9
6	10.6	10.5
7	10.2	10.1
8	10.1	10.1
9	10.0	10.0
10	10.6	10.0
11	10.1	10.0
12	10.0	10.0
13	10.2	9.9
14	10.2	9.8
15	10.0	10.0
16	10.1	9.9
17	10.0	9.9
18	10.0	9.9
19	10.0	9.3
20	10.0	9.9
21	9.9	9.8
22	9.8	9.7
23	10.0	10.0
24	9.7	9.7
25	9.6	9.8
26	9.7	9.9
27	9.8	10.0
28	9.5	10.0
29	9.9	10.0
30	10.0	10.0
31	10.0	10.0
32	10.0	10.0
33	9.8	10.3
34	9.8	10.3
35	9.9	10.3
36	9.9	10.3

17.
17.

L	X	Y
1	10.0	10.6
2	10.0	10.1
3	10.0	10.1
4	10.0	10.1
5	10.0	10.0
6	10.0	10.0
7	10.0	10.0
8	10.1	10.2
9	10.0	10.[illegible]
10	10.1	10.[illegible]
11	10.0	10.0
12	10.0	10.[illegible]
13	10.0	10.0
14	10.0	10.[illegible]
15	10.0	10.0
16	10.0	10.[illegible]
17	10.0	[illegible]
18	10.0	[illegible]
19	10.0	9.[illegible]
20	10.0	9.9
21	9.8	9.[illegible]
22	9.8	9.6
23	9.6	9.5
24	9.2	9.3
25	9.6	9.8
26	9.8	9.9
27	9.9	10.0
28	9.6	10.2
29	10.0	10.0
30	10.0	10.[illegible]
31	10.0	10.0
32	10.0	10.2
33	10.0	10.0
34	10.0	10.2
35	10.0	10.0
36	10.0	10.1

16.
16.

CURRENT ROSE DATA

CABO ROJO PLATFORM CRP=4C   DEPTH = 7 M IN 0907 1-16-74 OUT 1-16 [illegible]
1-17-74

L	X	Y	L	X	Y
1	10.0	11.2	1	10.0	10.0
2	10.2	11.0	2	10.0	10.1
3	10.3	10.8	3	10.0	10.0
4	10.3	10.6	4	10.0	10.0
5	10.5	10.6	5	10.0	10.0
6	10.2	10.2	6	10.0	10.0
7	10.0	10.0	7	10.0	10.0
8	10.1	10.0	8	10.0	10.2
9	10.1	10.0	9	10.0	10.2
10	10.3	10.0	10	10.0	10.0
11	10.1	10.0	11	10.0	10.2
12	10.1	10.2	12	10.0	10.2
13	10.0	10.0	13	10.0	10.0
14	10.0	10.0	14	10.0	10.0
15	10.0	10.0	15	10.0	9.9
16	10.0	10.0	16	10.1	9.9
17	10.0	9.9	17	10.1	9.[illegible]
18	10.0	10.0	18	10.0	9.9
19	10.0	9.8	19	10.0	9.5
20	10.0	9.6	20	10.0	9.5
21	10.0	9.9	21	9.9	9.7
22	10.0	9.9	22	9.9	9.7
23	10.0	9.9	23	9.9	9.9
24	9.9	9.9	24	9.9	9.9
25	9.9	10.0	25	9.9	9.9
26	9.9	10.0	26	9.9	10.0
27	10.0	10.0	27	9.8	10.0
28	9.4	10.8	28	9.9	10.0
29	9.9	10.0	29	9.9	10.0
30	9.9	10.0	30	9.9	10.0
31	9.9	10.1	31	9.9	10.1
32	10.0	10.0	32	10.0	10.0
33	9.8	10.2	33	10.0	10.1
34	9.9	10.1	34	10.0	10.0
35	10.0	10.0	35	10.0	10.1
36	10.0	10.1	36	10.0	10.0
17.			16.		
17.			16.		

CURRENT ROSE DATA

CABO ROJO PLATFORM CRP=4C

L	X	Y
1	10.0	10.7
2	10.0	10.1
3	10.6	11.7
4	11.0	11.7
5	10.3	10.4
6	10.6	10.5
7	10.0	10.0
8	10.4	10.1
9	10.1	10.0
10	10.5	10.0
11	10.0	10.0
12	10.1	10.0
13	10.0	10.0
14	10.0	10.0
15	10.1	9.9
16	10.0	10.0
17	10.1	9.7
18	10.0	9.9
19	10.0	9.2
20	10.0	9.9
21	9.9	9.6
22	10.0	10.0
23	10.0	10.0
24	9.9	9.9
25	10.0	10.0
26	9.9	10.0
27	10.0	10.0
28	9.8	10.0
29	10.0	10.0
30	10.0	10.0
31	10.0	10.0
32	10.0	10.0
33	9.9	10.1
34	10.0	10.0
35	10.0	10.1
36	10.0	10.1
17.		
17.		

DEPTH = 13 M IN 0745 1-16-74 OUT 1-17-74 1222

L	X	Y
1	10.0	10.4
2	10.0	10.0
3	10.2	10.6
4	10.0	10.2
5	10.0	[illegible]
6	10.5	10.4
7	10.0	[illegible]
8	10.2	10.1
9	10.0	[illegible]
10	10.4	10.0
11	10.0	[illegible]
12	10.2	9.9
13	10.0	10.0
14	10.0	10.3
15	10.1	9.8
16	10.0	[illegible]
17	10.0	9.9
18	10.0	10.2
19	10.0	9.5
20	10.0	10.2
21	10.0	9.9
22	10.0	10.0
23	10.0	10.4
24	10.0	10.0
25	10.0	10.0
26	10.0	10.0
27	10.0	10.0
28	10.0	10.0
29	10.0	10.3
30	10.0	10.0
31	10.0	10.0
32	10.0	10.0
33	9.9	10.1
34	10.0	10.0
35	10.0	10.1
36	10.0	10.0
16.		
16.		

CURRENT ROSE DATA

CABO ROJO PLATFORM CRP-4C   DEPTH = 20   M [illegible] 0747   1-16-74   [illegible]

1-17-74

L	X	Y	L	X	Y
1	10.0	10.4	1	10.0	10.1
2	10.1	10.4	2	10.0	10.1
3	10.2	10.5	3	10.1	10.2
4	10.2	10.4	4	10.0	10.1
5	10.3	10.3	5	10.1	10.1
6	10.3	10.3	6	10.1	10.1
7	10.3	10.1	7	10.0	10.0
8	10.3	10.1	8	10.0	10.0
9	10.1	10.0	9	10.0	10.0
10	10.3	10.0	10	10.1	10.0
11	10.1	10.0	11	10.1	10.0
12	10.1	10.0	12	10.1	10.0
13	10.2	9.9	13	10.1	9.9
14	10.0	10.0	14	10.0	10.0
15	10.0	9.9	15	10.1	9.9
16	10.1	9.8	16	10.0	9.9
17	10.0	10.0	17	10.0	9.9
18	10.0	9.9	18	10.0	9.9
19	10.0	9.8	19	10.0	9.9
20	9.9	9.6	20	10.0	9.9
21	9.9	9.8	21	10.0	9.9
22	9.9	9.8	22	9.9	9.8
23	9.7	9.7	23	9.9	9.7
24	9.7	9.8	24	9.9	9.7
25	9.6	9.8	25	9.8	9.7
26	9.8	9.9	26	9.9	10.0
27	9.8	10.0	27	9.9	10.0
28	9.9	10.0	28	9.8	10.0
29	10.0	10.0	29	10.0	10.0
30	9.9	10.0	30	10.0	10.0
31	10.0	10.0	31	9.9	10.0
32	10.0	10.0	32	10.0	10.0
33	10.0	10.0	33	10.0	10.0
34	10.0	10.0	34	9.9	10.1
35	10.0	10.1	35	10.0	10.2
36	10.0	10.2	36	10.0	10.0

17.
17.

APPENDIX 4.2A

Shoreline fishes of the Cabo Rojo Platform site.

	7 April 74
OPHIDRIDAE	
Ogilbia sp.	3
EXOCOETIDAE	
Hemishamphus biasiliensis	1
ATHERINIDAE	
Atherinomorus stipes	3
HOLOCENTRIDAE	
Adioryx vexillarius	8
Holocentrus ascensionis	2
Holocentrus rufus	2
APOGONIDAE	
Apogon conkline	17
Apogon maculatus	1
POMADASYIDAE	
Haemulon chrysargy	4
CHAETODONTIDAE	
Chaetodon striatus	1
POMACENTRIDAE	
Abudefduf saxatilis	4
Pomacentrus fuscus	9
Pomacentrus leucostictus	1
LABRIDAE	
Thalassoma bifasciatum	1
SCARIDAE	
Sparisoma chrysopterum	7
Sparisoma rubripinne	2
CLINIDAE	
Labrisomus bucciferus	1
Malacoctenus mac	4

APPENDIX 4.2B

Gorgonians collected at
Cabo Rojo Platform site-Station 9

	Station 9 15 m colonies/quadrat	Station 3 1-2 m colonies/quadrat left/right
FAMILY PLEXAURIDAE		
Plexaura homomalla	0,1	0,1
Plexaura flexuosa	6,2	1,4
Pseudoplexaura flagellosa	1,0	0,0
Pseudoplexaura wagenaari	2,2	0,0
Pseudoplexaura sp.	0,0	0,1
Eunicea fusca	2.3	0,0
Eunicea laxispica	8,4	0,1
Eunicea tourneforti	16,2	1,10
Eunicea calyculata	7,4	0,3
Eunicea clavigera	0,2	0,0
Eunicea succinea	9,1	0,0
Eunicea mammosa	0,0	0,1
Eunicea sp.	1,1	1,3
Muriceopsis flavida	0,1	0,0
Plexaurella dichotoma	1,1	0,0
Plexaurella sp.	0,0	0,4
Muricea muricata	0,0	0,2
Muricea atlantica	1,0	0,0
FAMILY GORGONIIDAE		
Pseudopterogorgia citrina	3,0	0,0
Pseudopterogorgia acerosa	6,17	43,102
Pseudopterogorgia americana	5,4	18,39
Pseudopterogorgia rigida	0,0	0,3
Pseudopterogorgia sp.	0,0	2,0

APPENDIX 4.2C

Macroinvertebrates collected in 10 m^2 (5 x 2 m) quadrats or observed in the Cabo Rojo basins (Stations 4 and 5).

	STATION 4 10 May 1974 g. wet weight	STATION 5 10 May 1974 g. wet weight
ANIMAL KINGDOM		
Phylum Porifera		
Axinella polycapella	54	4.1
Chondrilla nucula	36	49.0
Desmapsamma anchorata	2.0	
Haliclona rubens	422	298.0
Haliclona virdis		10.0
Haliclona molitba		3.5
Unid. Haliclonidae		2.5
Hymeniacidon sp.		4.0
Mycale angulosa	1.0	1.0
Microciona sp.		1.5
Trachygellius sp.	10.0	
Verongia sp.	37.0	28.5
Order Poecilosalerina	867	
Unid. sponge	51.5	25.0
Sponge fragments		26.0
Phylum Cnidaria		
Diodogorgia nodulifera	12	31.6
Phylum Echinodermata		
Oreaster reticulatus	138	
Eucidoris tribuloides	13	
Phylum Chordata		
Microcosmus helleri		6.6
PLANT KINGDOM		
Halophila baillonis	5	

APPENDIX 4.2D

Smaller invertebrates collected at the Cabo Rojo Basin.

	STATION 6	STATION 5
ANIMAL KINGDOM		
Phylum Porifera		
Sigmadocea caerulea	X	
Phylum Cnidaria		
Diodogorgia nodulifera	X	X
Lophogorgia sp.	X	
Phylum Sipunculoidea		
Sipunculid sp. 7		X
Sipunculid sp.	X	
Phylum Echiuroidea		
Unid. Echiuroid		X
Phylum Annelida		
Eunice sp.	X	X
Lumbrinereis sp.		X
Unid. Nereid	X	X
Pomatostegus stellatus		X
Unid. Sabellid	X	X
Unid. Serpulid	X	X
Unid. Syllid	X	
Unid. Terebellid	X	
Phylum Mollusca		
Class Gastropoda		
Alabina cerithidioides	X	
Calliostoma jujubinum	X	
Calyptrea centralis	X	
Crepidula aculeata		
Cylichna krebsi	X	
Lucapinella limatula	X	
Mangelia biconica	X	
Mangelia morra	X	
Murex brevifrons	X	
Murex recurvirostris rubidus	X	
Nerita sp.	X	
Olivella perplexa	X	
Rissoina cancellata	X	
Terebra protexta	X	
Turitella variegata	X	
Vermicularia knorri		
Zebina browniana	X	

APPENDIX 4. D (continued)

	STATION 6	STATION 5
Phylum Mollusca (continued)		
Class Pelecypoda		
<u>Aequipecten</u> <u>musosus</u>		X
<u>Anadara</u> <u>notabilis</u>	X	X
<u>Anadara</u> <u>transversa</u>	X	
<u>Anodontia</u> <u>alba</u>	X	
<u>Arca</u> <u>imbricata</u>	X	
<u>Arca</u> <u>zebra</u>	X	X
<u>Barbatia</u> <u>domingensis</u>	X	
<u>Barbatia</u> <u>tenera</u>	X	X
Fam. Cardidae	X	
<u>Chama</u> <u>macerophylla</u>	X	
Fam. Chamidae	X	
<u>Chione</u> <u>latilirata</u>	X	
<u>Chlamys</u> sp.	X	
<u>Codakia</u> <u>pectinella</u>	X	
<u>Codakia</u> sp.	X	
<u>Corbula</u> <u>caribaea</u>	X	
<u>Corbula</u> <u>contracta</u>		X
<u>Corbula</u> sp.	X	
<u>Crassinella</u> <u>guadalupensis</u>	X	
<u>Crassostrea</u> <u>rhizophorae</u>	X	
<u>Cyclinella</u> <u>tenuis</u>	X	
<u>Gemma</u> <u>purpurea</u>	X	
<u>Glycymeris</u> <u>pectinata</u>	X	
<u>Gouldia</u> <u>cerina</u>	X	
<u>Laevicardum</u> sp.	X	
<u>Leoptopecten</u> <u>barayi</u>	X	
<u>Lucina</u> <u>pensylvanica</u>	X	
<u>Lyropecten</u> <u>antillarum</u>		X
<u>Lysonia</u> <u>beana</u>		X
<u>Macoma</u> <u>tenta</u>		
<u>Nuculana</u> <u>acuta</u>	X	
<u>Ostrea</u> <u>equestris</u>	X	
<u>Ostrea</u> <u>frons</u>	X	
<u>Papyridea</u> <u>soleniformis</u>	X	
Fam. Pinnidae	X	
<u>Plicutula</u> <u>gibbosa</u>	X	X
<u>Pseudochoma</u> <u>radians</u>	X	
<u>Semele</u> <u>purpurascens</u>	X	
<u>Tellina</u> <u>alternata</u>	X	
<u>Tellina</u> <u>martinicensis</u>	X	
<u>Tellina</u> <u>mera</u>	X	
<u>Tellina</u> sp.	X	
<u>Transennella</u> <u>stimpsoni</u>	X	
<u>Trigoniocardia</u> <u>antillarum</u>	X	X

APPENDIX 4.2D (continued)

	STATION 6	STATION 5
Phylum Mollusca (continued)		
Class Scaphopoda		
Dentalium gouldi portoricense	X	
Phylum Arthropoda		
Class Crustacea		
Latreutes parvulus	X	X
Synalpheus apioceros	X	
Synalpheus minus		X
Phylum Echinodermata		
Amphiura sp.		X
Ophiothrix angulata	X	X
Ophiothrix brachyactis		X
Phylum Chordata		
Unid. Ascidian		X
Microcosmus helleri	X	