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PUERTO RICO NUCLEAR CENTER

PUNTA VERRACO ENVIRONMENTAL STUDIES

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# PUNTA VERRACO ENVIRONMENTAL STUDI

by

E.D, Wood, M.J. Youngbluth, P. Yoshioks

and M. Canoy

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## 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, techniciuns and support staff of the Site Selec tion Survey Project.

The authors who contributed to the Punta Verraco Site

Selection Survey are:

E.D. Wood, Project Leader Physical, Chemical and

Geological Parameters

Marsh J. Youngbluth Zooplankton Studies

Paul Yoshioka Benthic Invertebrates and

Fish Studies

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Technical Editor Forne Galantai

Project Secretary Pauline Ortega de Cabassa

Data Processing: Rosa Asencio

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1.1 LWERODUCT LON

?The Puerto Rico Nuclear Center of the University of Puorto Rico has heen 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

br more of these sites.

Pucrto Rico Nuclear Center scientists have studied the physical, chemical and geologteal parameters of the Sites, and the ecological parameters of zooplankton, benthic invertebrate and fish communitics, Plant associations, except for the Cho Rojo Matform site, have been included.

The sites chosen for study were: Torguguero Bay,

Punta Sanati, Punta igucro, Cabo Rojo Platform, Punta

Verrace and Gabo Mala Pascua (see Figure T.1-FI}. The

seventh site, Barrio Islote, was studied and reported under

B separate contract.

Vhe reports in order of their dates of completion are:

?Tortuguero Bay Unvironmental Studies April 1, 1975

Punta Manati Environmental Studies April 15, 1975

Punta Wiguero [nvironmental Studies May 1, 1975

Cabo Rojo Mattorm Environmental Studies May 15, 1975

Previous studies of Punta iguero, also referred to as ?Rincon?

or "the BONUS site," have been reported in "Punta Higuero Power

Plant Fnvironmental Studies 1975-1974" (Wood et al., 1974).

This report covers the Punta Verraco study site. A Final report of this series, to be entitied "Cabo Mala Pascua Unvironmental Studies", will he completed on June 15, 1975.

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## 2.1 °HYSICAL AND CHEMICAL PARAMETERS AT PUNTA VERRACO

by

E.D. Wood

### 2.1.1 INTRODUCTION

Punta Verraco is an inward curving point which forms the western margin of the entrance to Bahia de Guayanilla on the south coast of Puerto Rico as shown in Figure 2.1-F1 (Beck, 1972), Tt connects to the mainland at its western end, is bounded on the north by a shallow arn of Bahia de wayanilla and its curving south and east facing coast presents ow (15-28) cliffs to the Caribbean Sea.

The Puerto Rico Nuclear Center carried out environmental studies of this region over a period of three years, 1972-1974. The coastal and nearshore currents have been measured on several occasions. The factors affecting nearshore currents such as winds, tides, bathymetry and density structure of the water column dre discussed in the following sections.

### 2.1.2 TIDES

The tidal waves that affect the south coast of Puerto Rico have their amphidromic point in the eastern Caribbean Sea. The waves move in a counterclockwise direction (Anikouchine and Sternberg, 1973), that is, from east to west past Punta Verraco. The'south coast tidés are diurnal. Two waves exist, but one is dominant for about ten days, followed by about

four days of neap tide conditions as one wave decreases in amplitude and the second wave builds. Then, the second wave is dominant for about ten days. Predicted tides for the south coast are shown in Figure 2.1-F2. These predictions were made from the National Oceanic Survey (1972)

?The tidal excursion is about 20 15 cm, The tidal plot in Figure 2.1-F2 is for the period May 9-11, 1972 covering a period of Current measurements using dye markers discussed below.

2.1.3 CURRENTS

Ocean currents in the Caribbean Sea flow generally to the west northwest with velocities at times in excess of | Knot (30,83 cn/sec). The current near the south coast of

Puerto Rico rarely exceeds 0.5 knots (25 cm/sec).

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Pip. 21-1 Punta Verraco eite with depth contour Lines and hydrographic sampling

vane ?three stations

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tides at Punta Vernaco covering one of the periods of

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The current pattern near Punta Verraco and Guayanilla Bay is affected by wind, tide and industrial discharges. The wind is usually from thé east (Wood, 1975a). The wind rises in the northeast in the morning, shifts to the southeast during the mid-day with velocities of about 7 m/sec (14 knots), then returns to northeast with reduced velocity by evening.

Guayanilla Ray is shellow, especiaily in that region north of Punta Verraco. With a?surface area of just over

3 km? south to Station PVE-6A, and a sidg of 20 cm, there would be a tidal exchange of 6.5 x 106 n> daily or? about S$ of the volume of the bay.

The combined effect, then, is for water along the coast to flow westward through fallaboa Say around Punta Guayanilla and then westward to the head of the bay north of Punta Verraco. The circulation continues as water flows out of the bay to the southwest along the southeast side of Punta Verraco.

A large flow of water enters the Corco Refinery complex fon Tallaboa Bay and flows out on the south side of Punta Guayanilla carrying thernal, chemical and sediment wastes.

?The inner bay circulation is such that upswelling occurs near the intake of the power complex cooling system. The condenser discharge enters a pond on the east side of Guayanilla Bay, then flows out into the mid-bay region spreading over a wide area. The plume characteristics are reported in Wood (197Sb).. ?There ure several sources of fresh water for the Tegion which are significant seasonally. The Yauco River enters near the head of the bay and nuncrous ditches drain agricultural, industrial and municipal wastes.

The currents in the vicinity of Pun

measured on three oceastons during thas study.

Sccasion was reported by Beck (1982) and 1s summarized briefly here. ?Four Savoniuis rotor type current meters were employed fo ncasure flows at the stations shown in figure. f.1-F3.. The daa collection period was about 24 hours at each site. The general trend of the flow is indicated by the vectors in

Figure 2.1-f3." The surface currents tended to the southwest

with sub/surface currents nore toward the southeast. The

Gate are simariced in Table 2.1-17-

Dye drops with aerial photography were used May 10, 1972

to measure currents along the seaward side of Punta Verraco

once in the morning and again in the afternoon.

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?Summation of current dava et Punta Verraco

Decener 19-20, 19718

STATION DEPTH(n)

(hy. Dray

?AND SPEED

Pe, ° Wat 0.2 - 0.3 knots

+ 9-24 2 Following high tide, W.S.W at

0.2 -'0.3 knotes remainder of

vine, 5.5. at less than 0.1 kt

? S.SM. at 2.10 = 0.2 nots.

7 E.S.8. at 0.3 knote.

° S.E. at 0.4 knots following low

ee) aoe side; S¥) at Dos - 0.2 Ftsey

Dees 20-2 Fron hiv to dow tide.

2 Following high tide, S.8.W, at

0.3 - 0.4 knots; remainder of

tine, SIW. at less than 0.1 kt.

7 5.5.8 ot 0.3 kote.

co Following hiph tide, 5. at 0.2

knots; remainder of the tine,

Siw. at Out knet.

Pv-3 ° Si. ot 9. CGnfcomat ion

Dee. 22-22 complete, soter malfunctioned

Gurine recording).

2 S.W. = S.o.W. at 0.1 = 0.2 kts.

S42 S.B. - E.S.8, at 0.2 knots.

Dec. 21-22

Aostained with four livdro Products Model 502 Recor

The morning drops shown in Figure 2.1-F4 occurred at

low tide (Figure 2.1-F2) when the wind wis from the east-

Southeast at 10 kt. The strongest current was at drop No. 7

near the head of the submarine canyon. The flow was to the

southwest at 15 cm/sec (0.3 kt). Drop Nos. 3, 4 and § started

to the southwest, then turned shoreward and finally northward into the bay at abont § cm/sec (0.1 kt). Drop Nos. 1 annd 2

moved around the tip of Punta Verraco into the inner bay re-

gion at about 10 cn/sec (0.2 kt). Drop No. was placed in

@ small channel between Unitas and Guavaniila Recfs. Tt flowed

to the northwest at about 10 m/sec (0.2 kt}, and then dis-

persed until it was no longer visible.

?

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Figure 2.1-F5 shows the afternoon drops which coincided

with a rising tide (Figure 2.1-F1). All of. the dye drops

moved to the north or northwest except No. 7 which went southeast. Drops No. § and 7 indicated that an eddy may have existed in the region of Punta Ventana at that time. The current was only 5-8 cm/sec in the lee of the reefs, but was about 15 cm/sec going around the tip of Punta Verraco with the combined effect Of the wind (from the southeast at 13 kt) and a flood current.

White making the dye study on Nay 10, 1972 it was noticed that considerable oil and solid waste had accumulated in the half-moon bay (Ballena Bay) between Punta Vaquero and Punta Criolla west of Punta Verraco. There was concern that heated water may also be entering the bay. Therefore, another dye study was performed on the afternoon of May 28, 1372.

Drops No. 1"4 Wore made slong the shore, as shown in Figure 2:i%B6, and followed for about one and 4 half hours before drops No. 5-8 were made, Drops No. 3,,7 and & flowed past

the bay with no indication of entering.? Tt seems that floating material would be carried into the bay especially during pe= Tiods of strong wind, but that very little surface water actually went into the bay during this period.

A study done by the Oceanographic Group, Department of Public Works (1971) showed similar current patterns in this region. Surface currents were to the northwest and deep Currents varied with a strong tendency toward the southeast in the vicinity of the reefs. Near Punta Ventana the surface currents were to the south-southwest with velocities of 8-12 cm/sec and were more variable with depth. The net deep flow was to the southwest. Velocities were 4 to 8 cm/sec.

The limited current studies in the region of Punta Verraco indicate that currents in the lee of the reefs are weak and flow into Guayanilla Bay a significant portion of the time. However, currents to the west of the reef area, that is, from the region of the sub-marine canyon and Punta Ventana, are predominantly to the west with velocities of 8-15 cm/sec. Surface flows into the bay are?balanced by deep water flow out. Much of the flow very near shore is from the inner bay as will be shown later in the chenistry section. Therefore, intake and discharge locations should be offshore at least?S00 m

with the discharge further to the west than the intake.

2.1.4 BATHYMETRY

The Puerto Rico Nuclear Center has undertaken no de-tailed bathymetry of the Punta Verraco site beyond that done during benthic and hydrographic sampling. The C&G Charts 902

and 928 (National Ocean Survey, 1972) are inadequate espe-

cially with regard to the definition of the shelf edge and

deep water soundings south of Punta Verraco. Also, there are



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some discrepancies in the shallow regions caused by coral growth and shifting sediments. The contour lines shown in Figure 2,1-F1 and the depth profiles in Figure 2.1-F7 were drawn using depths shown in the above mentioned charts and sonic depths obtained during hydrographic work.

The region north of Punta Verraco is shallow with a mud bottom, It receives the discharge of the Yauco River and several agricultural drainage ditches. The basin also re Ceives sediments carried in by wind driven currents.

?A large basin makes up the central part of Guayanilla Bay inmediately east of the tip of Punta Verraco providing anchorage for ocean-going ships that frequent the harbor. The basin leads to the sea through a channel between Punta Guayanilia to the east and the shallow recf area to the west. Jwo major reefs (Guayanilla and Unitas reefs) and a small island offer protection from the dominant wave and swell action to Punta Verraco. The channel between the reefs and Punta Verraco is shallow but does allow passage to small boats.

A submarine canyon marks the abandoned course of the Yauco River just est of the reefs. The canyon starts very hear shore (200-300 meters) and tends to the southeast dropping Off to the depths between Stations PVE-4B and PVE-SA. The Tegion west of the submarine canyon is generally free of out-Standing features. The rugged coastline tends to the south-west past Punta Ventana and Punta Vaquero to Ballena Bay. The 10 meter contour line is about 1 kilometer from shore in this region. The shelf edge drops off very rapidly to about 400 meters to 1 1/2 kilometers from shore along Punta Verraco as shown by the offset profiles in Figure 2.1-F7, Depths in excess Of 300 meters are available about § Kiloneters south

of Punta Verraco

## 2.1.5 TEMPERATURE, SALINITY AND DENSITY

?The physical parameters of temperature and salinity were measured at the Punta Verraco site on seven cruises covering four seasons (Table 2.1-T2).

TASLE 24-12 Sehedule of hydrographic cruises to Punta Verraco

winter spring Summer Faun

ao71 - - - PA-005

Dec. 19-29%

2973 PA-023 PA-028 - -

Feb 20 May 21-22

ss PA-029 Pa-0u2 PAR046 PA-052

Feb 12 Ape 22 fog 21 Nov 13

Results reported By Beck, TO7E.

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7 Botton pro?iles along the sampling trancects of the Punta Vernace 1 ite

Vertical lines indicate relative positions of the hydrorraphic sta: Lone,

GUAYAMILLA

GUAYANILLA BAY

VERTICAL

EXAGGERATION

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The hydrographic sampling stations are shown in

Figure 2.t-F 1, five transects were sampled on most cruises.

The transects are nearly noraal to the shoreline, each with

three stations. The "A" stations were most shoreward, the

"RY stations were in excess of 125 motors of water and the

most Seaward stations ("C") were in excess of 325 meters.

Fourteen depths wore sampled on each transect. Temperatures

were measured using deepsea reversing thermometers with

Teadings accurate iv 003°C, Salinities were determined

With an induction salinometer to an accuracy of * 0.005°/o0.

The values ave incluted 1a a report of hydrographic data for

the south coast of Pucrto Rico (Wood and Asencio 1975). These

data were converted to standard depths and averaged by season

and type of stations. The sampling, analytical and data pro-

cessing procedures ave described in"'A Manual for Hydrographic

Cruises? (wood 18756)

Temp:

Temperatures were determined using reversing thermometers in paits, or im triplicate when possible. Although only one tesperature is Shown on the computer print-out of the data (Wood and Asencio 1975) for cach depth, these values

fe often the average of two or three thermoneters. Most temperatures below sl meters were measured using both Nprotected? and ?unnrotected? reversing thernoacters. A thermometer depth, Iz was then calculated Cor the sampling depths and correlated quite well with the calculated depth, Cz, obtained from the nt of hydroxire paid out, WZ, and the cosine of the wire angle,#. A comparison of some of these depths ix shown in Figure 2.1-78,

The dats were averaged by a computer program which first interpolated between the depths sampled. to provide tempera turec) {and other hydrographic parameters) at "standard depths The averaged standard depth tonperatures and salinities. are plotted by season in Figure 21eF9. The diagonal Lines indicate Qonsity as Siumast,? hepth ix not shown on the plot, but gen= Grally increases 19 the lower right corner of the plot, ise Gensity increases with depth. Very Little change is seen Seasonally whore signi-t 1s greater than 25.5, however, a Ustinite Chanse canbe Seon tn the tower densities. (suFface waters). ?Ihe temperature increases between winter and summer, Unile salinity increases hetween fa!I and spring:

The averaging for the depth profiles was done first

for all stations by season (Figures 2.1-F10, 12, 14 and 16)

then by type of station by season (Figures 2.1-F11, 13, 15)

and 17), The tabulated data are in Appendix 2.14.



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PVE-C STATIONS

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Fig. 2.1-F10 Averayed bydronnaphic parameter (temperature y

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Ward depth in metere for she?winten season of 1973 and

Punta Verraro,

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rs averaged by type of

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2ut-122_ Averaged hydroyraphic parameter veptli profiles for the

season of 1973 and 197% at Punta Vers

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Fig. 24-716 Averaged hydrographic paraneter depth profiles for the fall

season of 1974.

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POY pg-at PI! X10. PVE-4

Tig. 2uicf27 Jepth profites of hydrographic paraneters averaged by type of station

for the fal] season of 197%,

24

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A comparison of the averaged "C" station standard

depth temperature data by soason is shown in Figure 2.1-P1@

A sequence of events can be seen from this comparison, Surface

temperatures were lowest in the winter (26.1°C).. The deepest

thermocline (100+m) occurred in the winter and is caused by

E90ling and deep mixing by winter storms. It persisted into

the spring season.

This mixing process tends to carry heat to the depths

$0 that the highest tenperatures between 100 and 200 meecrs

ogeur during the winter and springs "(onis condition fe part

of @ phenomenon ene mi cht call "seasonal tage") ?Little Feasonal

change was seen below 150 meters except that the fall tempers

atures were generally lower than the ocher seasons, There was

a steady tenperature decrease in the 100 to 120 meter depth

interval hotheen winter_and fall.? The theemoel ine curing

summer was 75 neters and in the fall vas shout 20 meters with

a slight temperature inversion existing in tne Fall as suréace

Sooling occurred.

Surface temperatures were at a maximum in the sunner (28,1°C). There was an average temperature range of about

1,7" between summer and winter in the nearshore surface water at Punta Verraco. Temperatures increase with distance from shore for al! seasons except fall (Figures 2.1-F11, 13, 18

and 17). This increase is due mostly from the large quantities of waste heat discharged from the Corco Refinery complex, the PRNRA power plants and to a lesser extent the industrics decated on the north side of Guayanilla Bay (Wood, 19756)

Some excess solar heating occurs in the shallow inner bay,

but this is minor compared to the industrial contributions.

Temperature depth profiles were obtained at all "c" Stations by lowering a bathythermography, ST, te 300 meters. The BT traces are in Appendix 2.1Be

The sea surface temperatures at Punta Verraco were mapped seasonally by acrial infrared scanning (Kood, 197Sb). Considerable heated water approaches the eastern side of

Punta Verraco from the PRWRA power plant discharges. Ilow-ever, the excess temperatures are usually reduced to less than isc by the time the water flows westward along the south side of Punta Verraco past Punta Ventana.

## Salinity

Salinity, $*/oo, is the total salt content of water expressed in parts per thousand. It is used along with teapera-ture to typify ocean water masses. Low salinity usually occurs at the surface and indicates dilution by precipitation, run= off, or fresh water intrusions. High salinities are found

in Sub-tropical regions and are the result of high rates of



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TEMPERATURE °C

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"om tation tenperatures at

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evaporation. The salinities at Punta Verraco were determined using an induction salinometer with the readings good to better than 2,0-005"/00. The average seasonal salinity data aro shown plotted against depth with the other hydrographic Parameters in Figures 2.1-F10 through F17,. in general, the salinities increased with depth to about i50 meters then de- vreused slightly. The layer of high salinity water with Baxinum of about 56.9°/oc was formed by evaporation in the sub-tropical North Atlantic Ocean.

\ comparison of the averaged "Cc" station data by season is shown in Figure 2.1-F19, The lowest surface salinities

ure found in the faii season coinciding with the end of the tropical rainy season. The highest surface salinities occur in the spring after the winter-spring dry season. The salinity depth profiles are very similar, below 75 meters for all seasons except fall. A sharp pyenocling exists at about 50 meters during the fail where the salinity increases from about 34.3 f0 36.7%/co Sezween the depths of 25 and 100 meters. The Salinity maximum is shallower for the fall season aiso. Little Seasonal chuage was noticed below 150 meters where the salinity decreased From 30.8 to about 30.3°/o0 at 300 neters.

Little difference was seen in surface salinities with distance from shore in the winter and summer. However, a@ Slight decrease in surface salinity was seen in the spring

due to evaporation in the shallow regions, and a prominent positive salinity pradient occurred in the fall as fresh water Tunoff diluted the nearshore waters.

Density

Water densities were calculated from temperature and salinity data and included with the other parameters as igma-t, ?t. Sigma-r is related to density at the temperature asured, ?t, by the following relationship

Hs (1) x 108 ny

(Changes in sigma-t with depth are an indication of the stability of the water column. A small sigma-t gradient indicates 4 well-mixed or unstable zone, whereas a high gradient is in= dicative of a very stable portion of the water column. The surface layer usually has a very small density gradient because of wind-induced wave mixing. This layer varies from less than $0 meters in the summer to an excess of 100 meters in the Winter. Sigma-t profiles are shown plotted with other Parameters in Figures 2,1-F10 through FI?

?A comparison of the averaged seasonal sigma-t profiles is shown in Figure 2.1-F20, Signa-t varies from 22.1 to

23.4 in the surface waters and is highest in the winter and

spring months duc principally to generally cooler surface

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SALINITY So

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pve

Spring 2

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Fol 4

9. Avevaged seasonal depth profiles of "C" station salinities at

Ponts Varraco for 1973 and 1974.

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DENSITY

20, 22 24 26 28

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Pir. fyeraned water density (eigna-t) profiles of "C" stacion data plotted

by sea:

for Punta Verraco, 1973 and 1374

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temperatures in winter and higher salinities in the spring.

The pyenovline occurs at about 125 meters in winter because

of the deep storm mixing. The most stable water column occurs

°h the fall when surface water density decreases because of

dilution and fairly warm surface temperatures. Sigma t at

the surface decreases from winter through fali. Little

Seasonal change in density ccurs below 150 meters,

here is a Slight increase in sigma-t with distance from shore for atl seasons as shown in Figures 2.1-FI1, 15, ibind to. the winter, spring and summer density gradients are due to high nearshore temperatures, and the fall season tow nearshore density 1s due to low salinity water coming out Of Gua anilia Bay. This type of density eradient contributes to a seaward ce flow, Both wind and the Coriolis effect then cause this flow to turn to the west.

## 2.2 CHEMISTRY

### 2.2.1 DISSOLVED OXYGEN

mounts of dissolved oxygen, D.0., in the water off a Yerrace uere derormined by the Winklef titration nethod giefct land ani Parsons, 1908) with the analyses usually per~ (Stned on shipboard mthin a. few hours of sanple collection.

qhettierition values are generally ood to better than ¢ 18.

Digsoived ovygen data are? included With the hydrographic data Peperted sv Nood and Asencio (1978) in wi/t, mg/ and % sat.

oxygen saturation is a function of both temperature and salinity, Since neither shift drastically in the tropics Teele Uhange in near surface D,0. is expected nor was it seen. Averaged DO. values in milliliters per liter are plotted with Other hydrographic parameters in Figures 2.1-F10 through F17 by season and type ef station. The highest values were in

the winter season, Surface values were near saturation, A Conparison of seasonal averaged values 1s shown in Figure 252+ Fie "the oxygen minimum occurred at about 200 meters for all Seasons except spring When it was at about 160 meters. The lowest DO. values were about 3.9 mi/t at 200 m during the winter season. Many "A" station D.O. values were only about Dos of saturation due to the high BOD and COD of the Guayanilla Bay waters.

2.2.2 NUTRIENTS

Nutrients are important from two aspects. First, nutrients are generally low in the tropical Atlantic Ocean and Caribbean Sea surface waters and Timit primary preductivity. 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.

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DISSOLVED OXYGEN mi

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Ma: 2.2°F1 Averaged dtssolved oxygen depth protites by ueason ct Punta Verrace

for 1373 and 1974

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Reactive phosphe

can be determined quickly and ac~

curately sith the Murne. and Riley molybdate blue complex hethod (Strickland and arses, 1948 and is a good indicator Of poliution, \ timitee auabér of nitrate analyses were perforaed un the waters off Punza Verraco. The tropical egion: wound Puerto Rico are generally deficient in surface water nutrients, especially nitrate. Reactive silica is hsuilly not regarded as a pollution? problem.

Reactive Phosphate,

The concentration of reactive phosphate was generally Low (ca 0.05 ux. Py in the surface waters off Punta Verraco is seen hy the averaged "C" station seasonal phosphate profiles shown én firure 2.2-F2. The phosphate values remained

Tow with deptk to nea neiers before increasing to about

oeSs iycats P/! excep: Sor the Winter season when the increase

Starte! at 100 meter: ard weat to about 0.38 ug-at. P/k at

Ihere was vary Jittie eifference in surface phosphate

concentrations with distance ?rom shore seen in the spring

Gnd sumer, However, the vinter and fall seasons saw high

Surface phosphate va earshore (ca 0.13 ug-at. P/t).

These. anomalies col @ with low salinity (runoff) in? the

fall but the phosphate scurce is not obvious for the winter

Vitrate was determined by the cadmivn-copner reduction

Mood ct ale, ?Tl; A-Linitsd number of samples were

for nitrate at Punta Yerraco for the summer and fall

seg ition lata were plotted by season

Rue J 2-FS. The concentration of nitrate was less than

Nya from the surface tc about 7§ meters in the sunmer

S than one re shout &3 meters Im the fall except for a

Surface value of nearly 2 \geat. M/k. Nitrate values were

higher in the Tal! than the summer between 30 and 123 meters.

Little seasonal divference existed below 125 meters. The

Concentration of narrate increased from about 2 rg-at. N/E

at 100 meters to over 18 at 30U meters.

the only wnomities of s

were values to 6 ug-at. X/2 al

9.20 at PYF 0A,

nificance in the nitrate data

PVi-aA and 2.88 at PVE-#8 and

High nitrate values were found in the nearshore stations

in the fall S6.0y 2rd and 9.2 ug-at. N/E at PVE-dA,

AB and OA, respectively: Tals coincided with high phosphate

and Tow salinity values for these stations for the Same season.

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REACTIVE PHOSPHATE g-at. P/i

© 01 02 03 04 05 06

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oD 4

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Mood

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pve :

' Winter 1

j Soring 2 :

| summer 3

4

Fig. 2.2-F2 Averaged reactive phosphate depth profiles by season, 1973 and 1974,

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NITRATE pg-at. N/i

0 2 4 6 B 10 12 14 16

3 I4vmo

200

wofiles for the sunmer and fall seacone of 197%

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Ba GEOLOGICAL PARAMETERS AT PUNTA VERRACO

by

E.D. Wood

PyPRODUC PION,

The geology of the Punta Verraco site was described in an carlicn report (Keck, 1972). Portions of that report will be repeated here along with a brief description of the marine sediments

The maior portion of Punta Verraco is composed of tisry Ponce Limestone which forms the coastal clifes (Grossman, 10%) rising abruptly 45-S0 meters above the sea around thé area where Punta Verraco joins the mainland (Figure 3,1-F1). The rugged coast is broken? at two arcas by Lowlands, of Quaternary deposits, the major one (Figure 7.1-B1) bein:

4 long ubandoned valley of the Rio Yauco (Grossman, 1963) which is now fronted by low sand duncs stabilized by coconut palms

ul various forms of ground coverine vegetation. This abandoned valley continues offshore as a submarine canyon having depths of 9 meters within 0.5 kilometers of the shore and 18 meters

CLS kilometers of the shore (Figure 3.1-F1).

however, protect this channel from even the

hose dunes stayed above water during the flooding of 1928, the highest food for which obtainable, when? the flood diverted northeastward into Guayanitta?Bay (Fields, 1971), The original diversion of the Rio Yauco from this channel (mow long abandoned) is postulated to he due to the presence

of an last-West trending Strike fault, the San Francisco Fault, Which must have occurred after the consolidation of the Ponce Limestone, which it offsets, but before the deposition of the undisturbed Quaternary alluvium which covers it (Grossman, 1963). This makes its axe between three and twelve million years (according to the geologic time-scale as compiled by llolnes, 1905)

Sedine?

There are three general regions along the Punta Verraco site with respect to sediments. First, the shallow regions Souward of the rects out to the shelf Gdge are high cnergy areas because of Frequent wave action. Sediments here are coarse and sparse. Numerous attempts retrieved no sediments from the PVE-2A, 3A or SA stations.

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The second region is associated with the reefs. The Sediments are coral sand and often in motion because of the wave action, Storms tend to build temporary islands of sand especially iandward of Unitas Reef, Sand sediments were seen from the air near the reefs and between the reefs and Punta Verraco. There may be considerable sand transport westward along the shore at tines,

The third type of sediment region is low energy. This type is protected from the effects of wave uction and strong currents, The sediment in these areas are very fine and high in organic matter, Two such areas wero sampled (PVE-SA and GA). Station PVE=4A is? in the middle of the Yauco submarine canyon and PVE-6A is in the main channel into Guayanilla Bay.

The sediments from these two stations were air dried and sieved for size distribution, The PVE-GA sediment was especially troublesome because of its tar-like texture. The results were plotted as cumulative weight percent and weight

Percent histograms in Figure 3,1-F2, The size analysis sta-

tistics are shown in Table 3,1-T1.

Taste 3

STATTONS

PvEuA as at 2

PvE-8a

The mean Mé for the two sediments is very similar.

However, as shown in Figure 3.1-F2, the standard deviations are quite different. The PVE-4A sediment contains about 17% of grains larger than 0.25 mm (2 6 ) while the PVE-6A sediment had only about 2.5% of its grains preater than 0.25 mm.

Most of the region inside Guayanilla is in the low energy sediment area. Wind-swept currents do resuspend some of the fine sediments and carry them eventually to the southwest along the Punta Verraco shoreline where some of them settle in the Yauco submarine canyon. Most of these fine sediments were carried on down the beach to the west.



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Wistograns and cumulative weieht percent plots of sedinents at

Stations PYEUA and fA.

are

Fig

38

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at ZOOPLANKTON STUDIES 1975-1974

by

Marsh J. Youngbluth

INTRODUCTION

The following report provides estimates of the abundunce and density of zooplankton in the surface waters along

@ western portion of the south coast of Puerto Rico. These data form one part of an environmental survey conducted by

the Puerto Rico Nuclear Center. All collections were gathered in an area adjacent to the region proposed for the siting of a future power plant. Samples were gathered on 7 days during 1978 and 1974--21 February, 22 Nay, 28 November, 1° February, 22 April, 21 August, and 13 November.

4.1.2 MATERIALS AND NETHODS

E

1d Proced

Zooplankton were collected with a 1/2 meter dianeter cylinder-cone shaped nylon net, This net was designed to ice clogging error (Smith ct al., 1968). Mesh size was 3 microns. The net was towed from a 17 foot 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 cach 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 44/sea water formalin buffercd to pil 7.6. ?ALL Sampics were gathered during the daylight hours. The volume of water filtered through 4 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 mS. The meters were calibrated every 2 months. Cali-bration 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 FT).

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Fig. 4.1-F1 Zooplankton stations at Punta V

---Page Break---

Laboratory Procedures

Within 24 hours after samples were collected the pil

was checked and adjusted, if necessary, to 7.6. If a sample

contained a noticeable conglomerate of phytoplankton or

detritus, the -ooplankton were scparated from such material by

gentle filtration through 20? micron mesh netting. Before

estimates of biomass or numbers wcre made all organisms larger

than 1 cmsisually hydrocoan medusne, were removed, Niomass was calculated as wet volume (AhIstrom and Thraikitl 1962), This estimate ix 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 the variable pro. portion of interstitial water aml detritus,

he total number of organisms was estimated by volumet ric subsampling with replacement (Brinton 1962). Three aliquots from cach sewple were counted. The abundance of Major taxonomic groups of holoplankton and mcroplankton were determined from dilutions of 300 to 500 organisms. Copepods , Usually the most numerous of the zooplankters, were identi. fied to species,

All biomass and enumeration data were standardized to a per cubic meter basis or multiple thereof. Nata were initially Teduced with hand calculators (Hewlett Packard Mode! 48) and more recently with a computer (PDP-IN}. See Appendix 414

for a listing of the progran

4.1.3 RESULTS

A total of 49 sampies were collected from 5 stations

(Figure 4.1-Fl}. The densities of several taxonomic groups ©f Zooplankton at each station have been determined (Tables 4-1-T1-T0-17). These data are arranged to facilitate com: parisons between sets of consecutive tows, nearshore tows, and offshore tows.

Densities of total zooplankton differed more hetween catches from different areas than between consecutive samples from one area. This observation is summarized in Table 4-1-T1.

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Geib seiethy ume of ities between the binhest and Towest density yn each period.

values Ptooubanston di

maneutive Tews 2m Ded 1S 2.2 28

Recarsmans Taw AB 26 1R4T ye

Sbonore owe - ee fone om ur L6

1) Toms aa out tar |e as 82S

the degree of variation hetween samples is expressed as a pitig formed by dividing the largest total number of z00-plankton by the smallest within each set. The ratios are Uinilar te those observed in other coastal regions around Ducrto Rico (Younghluth 1975). Another way of judging Ulfferences between samples is also presented (Table 4.1-T2). By calculating the varianee between consecutive samples, the hunber of tows needed to detect various levels of difference was determined.

TABLE W172. stormed) fram 1 outs of replicate

DE vopliests tes (n) neeind to detert

ne in density i) Indioate

bare

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10 Feb 22 Apt "71 ang 13 Now

Station 2 2 : 2 2 2

3.46762 9.9320 9.72079 2.63569 2.9942 3.6054 9.78U90

racRet

.80082 3.29954 9.80875 2.65298 3.06165 3.39965 3.34635,

270057

2.75386 4.96473 4. 72509 2.94968 3126126 2.96419

rit

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i 6 1 3 3 20

> i 1 1 4

> 1 i 1 1 2

Wyre (2) fe student's t for the 988 confidence Level (.f.=2),

22'S the conple vor ianse haced on replicate tows, and dis the

Ratiewitth of the cong idence interval desire

4 nidaiant /nidiay values.

a2

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These data indicate that a large number of replicate tows would he necessary to detect density differences at the St level. However, on the average, differences of 50% can be noted with only? tows. Differences of 70% of more my be revealed with a single tow. Density estimates larger than 208 or more were found within and between nearshore and off shore catches. the range of density values during a sampling period was usually two to four-fold.

Seusonal changes in the average abundance of total zoo-Plankton were small, i.e., about 3 t0 SX (Table 41-13). The highest concentrations occurred in November each year. These larger densities, however, probably represent the range of variation anong tropical Zooalankton communities in the coastal waters wround Puerto Rico rather than recurrent sea-sonal pulses since the 95% confidence limits from each station overlap.

TAR: 4.1273. Averujw denadty af all zooplankton collected

?otal ooplankton/a®

1974

28 Now Feb 22 Apr 27 Aug 19 fov

Range 863-190 woa-z6my wso-su7e [227-969 2a4-942 350-7185 890-309N

Wo vow | sey guetta

Mean 044 2528 suo 48027) te

poss 42597 8 gun? gan

The preceding fluctuations in density refer primarily fg Roleptanktonic organisms since they conposed, in most cases, (89,208 9? the total zooplankton. Meropiankton were most abundant on 22 May 1975 and 13 November 1974. In proportion te holoplankton they were very numerous during 21 hupase 1994 uhen they formed over 30% of the total zooplankton. in two gccasions at Station 3, on 22 May 1973 and 22 April 1974

30 to 59% of the *ooplankton caught were meroplanktonic forms. {a both instances barnacle nauplii and caridean larvae were abundant,

Fish exes were abundant in this area although they usually conposed less than S¥ of the total zooplankton (Table 4.1-T4).° The largest density, 352/m, was observed at



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tion 5 on 28 Yovenber 1973. Fish eggs were most numerous 1) February H71 when they averaned 87/n5 and formed 20% fT Git sooplankton, ?The largest densities were generally Touwnl at the offshore stations. Most of the eggs were round ml U8 to 2 mn in diameter. Oblong eggs were common, It is hot kaos stich groups of fish are represented by most of the sea luimioy of denaitiog of fish epgs from lL

fine: sans desl aL Punta VerRaeo.

AIL groups tended to be more numerous in the night samples. The overall density inerease was about $ tines the Gis lever, loloplankton were 3X numerous, peroplankton about The hulk of the holopiankton were copepods. Decapod

yae ani virripede nauplii dominated the meroplankton. A Similarly targe nocturagl increase in meroplankton was also hoted ina series of diurnal samples gathered at the Tslote dnd cabo Sata Pascua sites (Youngbluth 1974).

Copenods formed $0 to 908 of the zooplankton community.

A total of 3 specie: were identified. Time did not allow detailed study Of species abundances at all stations. Con-Xequentiy, one sample from Station 2 for each period was Yected jor analysis. The entire Sample was scanned to form species list and subsampled for quantitative analysis.

Using these data, the species most numerous, those commonly vbserved, and others occasionally found are?listed in Fable 4, 4-15.



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Species usually most numerous

Sindee

snus funeatn

is Sop. UP,

T grask Lie

ie Tor plunizera, 0. app.)

jebongtt

enor turbinates

?aculeatus, P. crassinostris, P. parwus)

Species commonly present

(ohserved gh 8 Oe more Samplini periods)

Conyciws spp. (2. giesbrechti, C. pacificus, ¢. spretosus)

Species occasionally present

Euchaete marina

(Ce paves

(Cs paves &. pavoninus

(©. Fureatus, C- cardbbeanen:

?pavoninus)

5)

Soudeefehete san

Tablincera sj TL. acotti, b. spp.)

Canale pechy dase



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4.1.4 pIScUSsION

whe variety of zooplankton observed at Punta Verraco

was similar throughout the year. However, the abundance

Telationships betwcen the more numerous groups fluctuated.

The highest. total ensities were found in August and November.

Ihe lamest proportion of meroplankton occurred during April

Mave Fish eues were most numerous during February 1974,

\ianktonic exes were also generally more abundant

of tshor

Limit Sor the Mat

The sampling program was designed to provide quanti-
tative estimates of; 1) the standing stock of zooplankton,
V'(KS Variety of major taxonomic groups, and 3) the diver-
Sity and abundance of the more oumerous Copepod species.

The wanner of field sampling determined the variety and homies of organisms encountered. The dats in this report te based on colicct inns made in the surface waters during

the daylight hours, the sampling gear wil methods were

kept uniform, ics, net type, Met mesh, towing speed, and depth range sampled. A smal} number of repiicate tows

Mere gathered at cach site to obtain some measure of the Variability between samples. To obtain a better under-Standing of the coaplankton community more sampling with replicatiwn should be done at frequent intervals, at a heater number o| stations, at different depths, ?during the Aay"dng night. and during different seasons tor? several years. Information gathered in these ways will be necessary {oointerpret. tluctuat ions. in standing stock and diversity

tn relation to environmental changes and hiotic interactions.

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## 4.2 BENTHIC INVERTEBRATES AND FISH STUDIES

by

Paul Yoshioka

### 4.2.1 INTRODUCTION

The results of benthic studies conducted at the Punta Verraco site from the winter of 1973 through the summer of 1974 are reported

Most of che investigative effort involved the mapping and description of the major benthic communities. Quantitative Samples were taken in an attempt to assess the biological structure of selected communities and to provide quantitative base line information.

The qualitative and quantitative descriptions of communities are important aspects of community studies. However, these aspects represent preliminary levels of conmunity investigations and are often insufficient to satisfy the demands of contemporary environmental concerns. It is often necessary to ascertain the direct effect of a pollutant on populations

of specific species and also its secondary and tertiary ecological effects upon the entire community.

The role of secondary or tertiary ecological effects should not be underestimated. Several studies have demonstrated that the structure and diversity of many natural conmunitics

are determined by ecological interactions (Dayton 1971; Paine 1960; Painc and Vadas 1909; Kitching and Ebling 1961; Huffaker 1959} Harper 1969). Tn such cases predictions based solely upon?the direct effects of physicochemical perturbations on Single species populations would be inadequate and misleading

if extrapolated to the community level

What is reuuired to predict the effect on an environmental pollutant is an insight into those factors responsible for the ecological organization of communities. Descriptive or structural aspects of communities provide only a static, steady state out-look upon a community. Spectes lists provide little insight

into the interactions of their component species populations Diversity indices, derived from the biological structure of ommunities, are Speculative in their origin. Their ecological

Lications remain a point of controversy (Hedgpeth 19735



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What is necded is an awareness of the dynamic process responsible for 1 community's control and regulation. This tntaids a knowiedge of the functional roles of various species Comprising the natural coumunity.

With these considerations in mind, a series of preliminary

field exnerinen's designed to ascertain? the functional roles

Si the spevics in selected communities was begun in the spring

af gta

The gorgonian comminities were selected as the major

objoct of investigation daring the latter phases of this study

because the gorgonians represent a dominant feature of the

ponthic communities of the Punta Verraco site and, as such,

Geserve major attention; the growth form of gorgonians adds

considerable snount of physical structure and heterogenes ty

tothe benthic environment and such physical structure greatly

Juclucnces the renainder of the biological community (Elton

toe tand worgonians may be usefUl indicators of such environ-

nial paraneters.as wave action, currents, and turbidity (Grigg

Tats, Qpres tn 1803; Goluherg 1973; Kinzie 1975)

Clearing experiments were conducted in an attempt to asvoss the tele oe settied gorgonian colonies on the recruit-tent of new colonies. Permanent observation quadrats were Set up as controls

## 4.2.2 MATERLALS AND METHODS

### Eield Procedures

Surveys of the major benthic communities were made by traversing widerwater transects and making station dives. A ?iver propulsion vehicle (DPV) was usually employed for tran-seteTwbrke Notes were taken on dominant or unusual organisms, bottom type und topography, depth, visibility, surge, and Other pertinent biological or physical data. ?Photographs (ere taken to aid in describing the benthic communities. In The latter stages of the investigation, increasing emphasis ius placed on station rather than transect diving in an effort fo generate information on the benthic communities at selected

locales which would be more appropriate for statistical analysis.

Quantitative samples were replicated whenever possible to assess the effect of sampling variability. Samples of the infaunal and smaller epibenthic organisms were taken within 41/4 m2 quadrat, These samples were placed in a plastic bag held as close to the sampling site as possible to minimize the loss of orgauisms. Substrate was removed with the aid of @ hanmer andechisel, Bescription of the sampling method can be found in Vicente (PRNC=174 1974).

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Gorgonians were collected in 3 m2 (1 x Sm) or 10 m2

(2 x Spi quadats fepending on the dens ty of gorgonians and

Timitactoas of bottom diving time,  Gorgonian samples were

taken in May. Augus?, aad Nevenber of 1974, Two replicate

samples wore usually? taken

nanent t a2 (1.x 7 @) gbservation quadrats were set

up in Febsuary 1974, ?the Larger sessile organisms in these

Quadrars wore identified te ths Lowest poss.ble taxonomic

Category snd were "onitored both visually and yhotographically.

seer Toca, the gorgonians ia a single Tm quadrat were

tages and measurce

?The quadrats which had been cleared of worgonians in

197d were observed thereafter to assess the effcct of

aionies ca recruitment of new colonies. theit

May

established

groweh, and

then

species

Gorgorian samples were dried for several weeks

weighed, measured, ang sdentified. The nore familia

Mere ideneitied ca tie hasis of oxternal characterist

Questionabic individuals were ideat?fied with the tid of

Spicuie presarations. sybstrste samples Were brought to the

SRboratory, sorted ito phylogenetic groups, and preserved

Soe erhy: alcono! o: ?Us butfered formatin for Vater ples were often frozen prior to sorting.

{to identify organisms wre listed tn

cations and other pertinent information of transects,

Vives and beach sites at Punta Verraco are shown in

Fighre 4.2-F1 and Appendix 4 The following description js"based on observasians conpitcd from these dives.

collected or identified at three shore locations

co site are listed in Appendix 4.25. The

oilections are listed in Appendix 4.2C.

he inshore areas between Punta Verraco and a sand spit

island near the entrance of Guayanilla Ray (Transect T1, Station

31. appear to be dominated by Thalassia, Syringodium, Caulerpa,

Syptcal thalisste-bed' species such as the

and Diplanshe

urcaln'Tripncustes ceculensiis and [ptechinus the starfish

Dpeaster Terieubiiuss and The yolluses Vasua muricatum and

Pinna were observed there. A small coral fringing reef was

enesiintered about 190 m offshor: of Punta Verrace. Organisms

observed here incinded the alga Udotea sp., the corals Siderastrea



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and Millepora sp., the gorgonians Pseudopterogorgia sp.

ureLla sp J Palythow, ?ond the sponge

Sphagelospongta ves) vdepth in this area ranged etween D and 3 aot

On the seaward sive of the sand spit island the substrate

apnears to be Jominated by algae and some sponges (Station $1).

Qccasional colonics of corals, principally Diploria strigosa,

Porites astrevides and Monrastres annutaris were obsewved:

Salrthoa, Tes Mieopotion and Mitlepora were much more. abundant

Bhan the? sctoruselnrar coratee Cbraonans nee Fela toen

Searce compared to other reefs and were Comprised mostly of two genera, unicea and Plexauretia

The dusky dauselfish Pomacentrus fuscus, the sargeant

Abedefdul sunat ilis, the rock Beatty Molocanthus tricofer.

the Bruchead wrasse Thslassona bifasclatum, the spanish hogfish

Bodianus cufu:. the hue tang Acanthurus coerulus, the doctor=

TiS Reanthan wig and grunts Maenilen sp. were observed.

Further westward along Punta Verraco (Transect 12) the

substrate is comprised mostly of dead corat heads with oceasi onal

Patches of sant. ?These coral heads provide uch topographic

relief, up to 2 meters in places. Only occasional cetonies

of Living corais were observed. argonians were conron, Algue

primarily Sprr.dia was abundant. Fish were fairly abundant,

due to the hivh topographic reliet available for cover, Anong

the species observed: were grunts Haenulon sp., the high hat

Tquetus acuminatus, the bluehead wrasse Thalassona bifaselatum,

the Hogfish Lachiolsinus naxinus and the quech trigeertish-

Halistes vesiilas Water depth 14 this aren ranged between $6

Reters. Tie ?ubstrate was covered with a layer of sediment which was probably derived from Guayaniiia fy

A submarine canyon was encountered offshore of the Rfo Yauco (Cerro fore}. A soft sand-mud mixture dominates the bottom substrate \iransect Ti, Station 83). It is characteristic of guch substrate that visually conspicuous organians.are usually rare, | However, small patches of algae Ulva lactuca, typnea musciformes, Gracilaria sp., the fight ing conch BUF pits and Several bivalves Arca i¢bra, lelling alternara were observed in this area,

fo the west of the Cerro Toro submarine canyon, off Punta Vaquero and Punta Ventana, the bottom substrate consists mostiy of low relief rock with occasional patehes of sani? (Teansects 74, 15, 6; "Stations 88) 85, S0y $7), Areas near shove (Traaseces Th Uo) anpear to 6 dodinated by algaes Various? spertes of algae Sargassum. Dictyotay and red algae were observed. The hard? coral Stiviaitrex Sierea; gorgontans: Pevoserpie? and Eunicea; and the sponges Sphacciospongia wesparise Anthosigmelia vartans, and Tethy were see asters

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In areas further offshore (Transect T4, Stations $4, $5,

57) hard corais, sponges and gorgonians become more abundant,

the latter being the most visually conspicuous. In general,

the faunal characteristics of Stations S4 and $$ are probably

representative of this area.

Relatively flat, low relief rock dominates the substrate

at Stations $4 and SS. Small sand patches cover less than 108

Of the bottom, 'he water column is relatively turbid, during

this study visibility never exceeded 7 meters. Macroalgae

Were conspicuously absent and the sea urchin Diadema was quite

Connon. the hard corals were visually estimated to cover

between 1-106 of the bottom substrate. Amonz the more common

Corals observed worr Montastrea annularis, M. caveronosa and

Dipforia sp., and at both stations the gorgonians were the

fobt visual iy conspicaous organisms. Among the genera observed

were Eunicea, Murivea, Muriceopsis, and Plexuura. Quantitative

Sane eegorgertine wate ERT ae bork Starians.

The fish and larger invertebrate species observed at

both stations a?l also Station SSA are listed in Appendix 4.2D.

Fish were observed on two different occasions at Station $4 in gn effort to estimate the frequency of occurrence of various Species. Of the total of six species identified, only the blue~ head wrasse Thalassoma bifasciatum appeared during both periods of observation (12 Feoruary T97E and 21 August 1974). However, Of the seven total species observed at Stations $4 and SS on August 1974, five occurred at both stations, This suggests

at the fish fauna at both stations are quite similar. Seven Of the 13 species of scleractinian corals and 19 of the 24 Qorgonian species co-occurred at both stations

* gorgonian colonies collected on #1 Decesber 1974

?sn area oreviously cleared of zoryonians on

5/4 ne Height(range)

Fry -

Eunfees laetep: 5

Sergonfa? ventalina 5

2

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?aarieata +

adap iexaura? st 2

Funte 2

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Species found in 1/4 m2 quadrat substrate sampies

taken at Stations S! and Spare listed in Anpendie tsb.

Noth sanples show sim:iar distributions of sndividus

among species, The 240. individuals were represented by

Ao Spectes (excluc-oy stane and colonial orcaniens) inthe

S1 sample, and 46 indtviduals among 2? species in the So

sample. ?Joti distributions were Aighiy cquitable, sore, than

SU oF the species were represented hy two cr fewer individuals.

Large discrepancies appear when the species lists are compared. Of the $8 species found in tho samples only nine wore found in hoth. It could not be determined if ?his discrepancy was caused by habitat differences between che two

Stations or by sampling variability, therefore, two replicate Samples were taken 9 few meters apart at Station $4 These results are atso shown in Appendix 4.21. The

nunber of individuats shows a highly equitable distribution;

17 individuals avone 14 species in one replicate; 7 individuals among 23 specie: in the other. Over 501 of the total number af species (37) were represented by single individuals. How-

ever, only four snucies eccurred in both replicates

The lack of similarity between the two replicates in terns of co-eccurrencys of species vould indicate an in- adequacy of the 1/4 x? quadrat in obtaining « representative sample of the infaunal community. This is probubly due to distribution patterns as well as the ?rarity? of individuals relative to the saupiing scale.

Gorgonign species and numbers of individuals collected fron two 10 a° quadrats at Station $4 are liste! in Appendix 4.2F. ?Overall cotony density of the subsamples was very sintiar, 9 colonies per m?, Correlation of the

relative nces Was statistically Significant (Kendall -

tau =+9.46, > 0.05) indicating that the quadrat size was sufficient'to representatively sample the gorgenian community. The four most abundant species in decreasing order ef abundance

Were Muriccopsis flavida, Gorgonia vontalina. Plexaura flexuosa, and Murivea muricata. ?These species accounted For bout

of the total number of individuals.

Gorgonians were found in much higher densitigs at Station §5, an averaxe of 25 and 30 colonies per me, This corresponded with the general visual impression that gorgonian densities decreased at shallower depths. Relative abundances of gorgonian species in the two subsaapics were significantly correlated (Kendali-Tau =+0.06, p .<c0.01). The five most abundant species in decreasing order of ubtndance were Eunicea tourneforti, junicoa laxispica, Muricea muricata, Plexaura exuasa, Dinicen clavigers,-and Mariccopsis Havidge These

Species accaiinted Tor about 781 of The toral WUbeFOF colonies.

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No correlation was found between the relative abundances goreentins at Stations Sf nd $5. The causative factor(s) fesponcibls for the dicserences tn relative abundances are hnlotermined at present, However, Kinzie (1973), Goldberg $953), avd Opreske (1973) discuss several environmental factors which @av isftuenee the abundance of gorgonian species.

Whey revisited on 21 August 1974, the area cleared of

yn 2} Apeg? 1874 ar Station?S4 had an average of

(354 Cut.) newly reeruited gorgonian colonics per

Wed aces quadrats. ALL recruits were

less than Sc pied previously, the density,

of sintlar sized colonies was only 0.45 colonies per 1/4 m2,

the presence of settied colonies inhibits

of other colonies. Established colonies

(iluently play a regulatery role in the recruitment o1 new

Latanies. "The mechanism by which this occurs is unknown,

Pn 1} december 1374 ergonian colonies were collected

From a dome ives previeusl: cleared of ali sorgonians the

brevious springs Ssectes coliected and their abundances are

Lcedvon fable"). The relative abundances correlsted posi-

tively but not significantly with the gorgonians collected th precious soring (Kendali-tau, p~.20), suggesting that

Perustaent of gorgenan species occurs in the same order of

folative abuscumce as the netural mature populations.

Vhe distribution of colonies in the cleared and controlled

arcas were also determined ty $2 (2x 2m) quadrats, The

AU Syibution natterne ef sho colonics for various wtadrat sizes

nt of orgonians

n natural areas,

over, seem £9 be nore randomly distributed.

OYisted on Table t.c-T2. Evidently, recruit

Sitar. on an ageregated pattern. Colonies

ho

Tiopersfon oF porgonian colonies oi

?calaa in cluared and natural areas

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Growth rates for tagged gorgonian colonies in she

observation quatrat hetween August and Deceaber 1974 ave

Jisted in table 1.2.13. An apparent trend for higher efowth

Fares for snalivr colonies was not significant at the 0.05

vel (Tukey Corner Test). Due to limitations of diving

bottom time, a!) the gorgonians were not tagced, therefore

natural rectuitnent and Mortality rates could nét be detcrmined, TAB 4.278, Growth oF tayged gorgontans dn the permanent qusdnit at

Station $4, Funta Verraco

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4.2.4 vIscussz0N

The intertidal biota of the Punta Verraco site appears fo be representative of this environment along the cousts oF Puerto Rico (Glynn 1964).

The infaunal populations possess a high species diversity and cquitability. This feature has been found to be conmon to all substrate samples taken at various sites arcund the island (Tortuguero, Manati, Cabo Mala Pascua). However, due to high sampling variability, the structure of this comminity cannot be deduced, The greatest abundance of fish life observed at the

Punta Verraco site was associated with areas of high topographic

pelief. This feature is common to several sites around Puerto

Rico (Manati, Tortuguero), and is probably related to the shelter

provided in such areas (Smith 1973). Repeated observations of

fish life at the permanent station indicated that only @ small

portion of the fish species at a given location are observed

at any single given tine.

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Fowever, if 1s nog,

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as PLANT ASSOCIATIONS

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Michael J, Canoy

4.3.1 INTRONUCT ION

res rocoiving.

Face, on the south-west coast, is in an arid

gas'than $7 inches rainfall per years The

cil is spaveard has Tztle or no organics. ?In te aren? in

ack of ?het points (Punta foro and funta Verrace) there

are a Typha svanp and sugar cane fields, The forest on the

Sho pouty is"topseal tertiary dry commiry tuccstssenet

The terres:rial fauna is not obviously different from the rest of Puerto Rico's coasts, (See Appendix #-5A) The major species are rats, cats, mongoose, cattle, dogs, and a fem ?pest? birds such as gracktes, ani, and pigeors. Pelicans, frigate bir. { Clanper ratis were observed, nore nesting. seeemaer atte Leazures are (a) possible inciusien in the breeding arca of = rare snecies, the Puerto Rican Fhippoorwill, Gue to the proximity of the Guanica forest, (h) 2 large number of bats which issue from soveral caves and'a large sinkhole in the point

The oviience of extensive caves in the point may make the area unssitabic for heavy construction.

The forest essociation is one of the less disturbed dry n Pusrto Rico. It easily ranks with the Cuanica forests, h area; the banks and clif?s rise rapidly

res

There is very Littie beac

to the forests

Among the nore seaward plants are Iponea, Canavali, and Sperobelus. Opuntia spectes begin near the sea and continue through the forest. These seaward associations are vagrant and often vet was'od away only to reappear later.

TALS AND METHODS

The Punta Verraco site represents an anonolous ecological assemblage. Tt consists of parts of a dry forest, a beach community, a Typha swamp, and a fringing mangrove forest. Therefore, it was necessary to establish one long transect roughly north east by southwest (Figure 4,3-F1) and three small perpendicular

83

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transects on Punta Ventana, the old river mouth, and Punta Verraco. | The lon, transect was roughly 1 ke. in Length while phe smaller transccts werm 10. One meter plots were examined for wrasses and iorh at the juncture of the transects and at, tho distal end o° cach 10 m transect. This gave six 1 meter? plots. ALL unknown satera:1 was removed to the laboratory.

for :dentiFiestion

3 Dzscy

SON

The tertiary successional forest of the hills is more complex than it fis: appears. The xerephytic nature of these tertiary Limestone bills is deceptive, fo the untrained eye many species appear as onc.

wus teature of the forest is the number of sent. The succulents Cephalocereus

A cons

suceutents and

Toyeni, Leptocereus ouadricostatus, and cact!; OpERTTS Species,

and the cYingpre creer ?Sema. The

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agave Agave

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is a Typha skamp whic

white mangroves. |

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t Ponta Verraco, but not on the site,

?ainy to a mangtove fringed say. Black

suncularia and Avicennia) stray short

---Page Break---

REFERENCES


Ahlstrom, D.H. and J.R. Thraikill, 1962. Plankton volume

Yoss with tine of preservation. CALCOFI Rept. 9:57-73,

Alny, C.C., Jr. and C, Carrion-Torres, 1963,  Shallow-water

Stony Corals of Puerto Rico, Carib, J, Sci. 3(263):133-162.

?Anikouchine, W.A. and R,W, Sternberg, 1973, The World Ocean:

?An Introduction to Oceanography, Prentice-Hall, Inc., Englewood Cliffs, N.J.

Bailey, R.M, (Chairman), 1970, A List of Common and Scientific Nakes of Fishes from the United States and Canada (Third Edition Amer. Fish, Soc. Publ.) No. 6:1-149.

Bayer, F.M., 1961, The Shallow-water Octocorallia of the West Thdian Region! Martinus Nijnoff, The Hague, Netherlands.

Beck, 3.F., 1972, Preliminary report on the proposed Punta Verracs power plant site. Suomitted to PRWRA Feb. 1, 1972. PRNC, Mayaguez

Bigelow, H.B. and N.C. Schrocder, 1953, Fishes of the Gulf, of Maine. Fish'and Wildl, Serv, Fish, Bull. ?4, Voly 53, U.S. Dept. of the Interior, GOP, Washington, D.C.

Bohike, J.E. and C.C.G, Chaplin, 1968. Fishes of the Bahar ?and Adjacent Tropical Waters, Acad. of Nat, Sci, of Phila., Livingston Publ. Co., Wynnewood, Pa.

Breder, C.M., Jr., 1948. Field Book of Marine Fishes of the
Atiantic?Coast, G.M: Putnam's Sons, New York.

ps, BPs and J.P. Akevs, 1962, Hydrogeotegic.cap of
uerto Rico and adjacent islands. Atlas NA-197, U.S.
Geological Society, Washington, D.C.

Briggs, R.P,, 1965. Geologic Map of the Barceloneta Quadrangle,
Bigrto alco: 17142, US. Geological Survey. ®

Brinton, E., 1962. Variable factors affecting the range and
?estimated concentration of euphausiids in the North
Pacific. Pac. Sci. 16:374-408.

Brock, Y-E., 1954. A preliminary report on @ method of
estinating recf fish populations. J. of Wildl. Mgmt.
28 (3) 297-308.

Brooks, J.L. and $.L. Dodson, 1963. Predation, body size,

?and competition of plankton. Science 150:28-35.



---Page Break---

Carpenter, f.J., 0.3. Anderson, and DLR, Peck, 1974. Copepod

and chioropfyt? concentrations tn'roceiving waters of &

Rucloar power station and problems associated with their

mescuronent. Lsvdt, ant Coast, Mare Seis 2s1-26¢

Casey, Jec., 13 ngler's goide to sharks ef the north-

inites states Maine to Chesapeake Bay. Bur, of

pies and Wildlife, Circular 179, Washington, D.C.

Los Corycaeidae del Caribe suroriental

). Men, Soc, Scionce Nat. La Salle,

Peces Marin:

Caracas

de Venezuela, Tonos I

undacion La Saile de

mps of the Snighsoni

a sunnary 6

stacea: Dect

Chaplin, C.¢.

1972. Fishwatcher's Cuide to

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Livingston Pubi. Co.,

Sgientifie sarsey of Porte Rico and the

A handheck ox the littoral echinoderms

cocker West Incian islands, N.Y.

of interspecific competition

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S2:790-723,

Darwin, D., {854 A nonogvapa on the su

Ray Sodicry, Londen. Repr. by Joh

48), Neve? Ye

class Cirripedia,

Reprint Corp

t

Dawson, £.Y., ?sin. Hew to know the Seaweeds, William C.

Brown Co, Dubucue, Iowa.

Day,

cH.. 1907, 4 monograph on the polychaeta of southern

Aftica, Pares | ano IT, British Museum (Natural History),

London:

Dayton, P.K., Competition, disturbance, and community

organizatien: the provision and subsequent utilization of

space in a ruchy intertidal community. Ecol, Non, 41:551-389,

» 1972. Toward an understanding of community

?FestTTence of the potential effects of enrichments to the

Benthos at ?icNundo Sound Antarctica. Prac, Coll, Conserv.

Prob. in Antarctica, Ee. B.C. Parker, Allen Press, p. 81-85,

eo

---Page Break---

Dukin, Wed. and A.N. Colefax, 1940, The plankton of the

Austraiian coastal waters of New South Wales. Univ,

Sydney Dept. Zool., Monogr. 1

Elton, C., 1966 Animal Ecology. Sedgwick and Johnson, London.

Fager, E.W., 1972. Diversity: A sampling study. An, Naty

186:2932s10.

Fields, F.K,, 1977

Puerta Rico: 1.8

Atlas BAGS

gods in the Guayanilla-Yauco Area,

Fields, F.t D.G. Jordan, 1972, Storm-wave swash along

thé north coast of Puerto Rico! HA-430. U.S. Geological

Fraser, Jui, and YK, Hansen (Eds.), Fiches d' Identification

4,?Zoopiankton. Conse.: Dernanent International Pour

?Exploration ce ca Nor, Andr, Fred. Host @ Fils, Copenhague.

1

eminger, 1968. A revision of the genus

(Copepoda: Calanoida) with remarks on

Si patterns in diagnostic characters, Bull.

Frost, 8. and A

Clausocats

Sseribatt

Scripps In)

Glynn, P.¥., 1964, Conmon Marine Invertebrate Animals of
the Shallow Waters of Puerto Rico, Inst. Mar. Sci.,
Univ, Puerto Rice, Mayagues

Goldberg, W.M., 1975. The ecology of the coral-octocoral
conminities off the southeast coast of Florida: geo-
morphology, species composition, and zonation. Bull.
Mare Sei. 23:805-488

Gonzatez, J.G. and T.£. Bowman, 1965, Planktonic copepods
fron?Bahia fosforescente, Puerto Pico, and adjacent waters.
Proc. U.S, Nat. Mus. 117C3513) 2241-304,

Grice, G.D., 1960. Copepods of the genus Qithona from the

GULF of Mexico, Bull. Mar, Sci. 10:485-490.?

1961, Calanoid copepods from equatorial waters

aT the Pacific Ocean. Fish. Bull, 61:1-246.

_____, 1965. a revision of the genus Candacia, Zool.

WedeTTigen. 38:171-194,

Grigg, R.W., 1972. Orientation and growth forms of sea fans.

Linnol. and Oceanogr. 17:185-192.

Grossman, 1.6., 1963. Geology of the Guanica-Guayanille Bay

REED: Goutiwestern Puctee Rico! U.S.G-S. Profs Paper 475-8,

pp. B1tasarie

---Page Break---

Cooper, end E.E. Werner, 1970. An experimental

he production dynamics and structure of fresh

communities, Limnol, and Oceanogr. 18:83:

Harper, J.t., 1969. The role of predation in vegetational

iversity. Nrockhaven Symp, Biol, Mo, 22:48°62.

18S. A collection of sponges from the west

© Yucatan Peninsula with descriptions of two

sull. Mar. Sei. Gulf Carib. 8(3):161-189

the sponges of La Parjuera, Puerto Rico.

o1., Univ. of Puerto Rico, Mayaguez, No, 1789:

The impact of impact studies. Helgol.

Mires. 24rh36-245,

ealoopec, 4.J., 1967. Floods at Barceloneta and Manati,

Paevts ile! ?i202. U.8,Ceologica! Survey.

Holmes, Arthur, 165. Principles of Physical Geolo;

Bdision: The Renard ?ress Co., New Yorks

1288 pp.

Ye.

Huffaker, ¢

vegetsti

math Kee)

Pé C.F, Nenneth, 1989. 4 ten year study of

anges associated with bsological control of

". Range Manag. 12:69-82

tee. A revision of the

enus Lucicutia. Bull

E.. 1961. The paradox of the plankton. An,

The invertebrates: Echinodermata, The

ria. Vel. 4,

Hierbivores and the nunber of tree species

Fore An. Nat. 104:50=328

Kaas, P-, 1972. Potynacophora of the Caribbean region. Studies

en the fauna of Curacao and other Caribbean istands,

SUT te,

Kendall, 1.2., P.v. Wood, and T. Smith, 1975. Hydrographic

data report, ?north coast of Puerto Rico, 1978-1984,

PRNC Report ?177,

Kinzie, R.A., T11, 1975. The zonation of West Indiaa gorgonians.

Bull. "Mat, Sei. 23:95-185,

Kitching, J.A

Tre kth

Eckindidea

and F.J. Ebling, 1861. The ecology of Lough

contro? of algae by Paracentrotus lividus

'. Animal Eeol. 30:37%-383,



---Page Break---

Laubenfeis, M. de, 1935. A discussion of the sponge fauna

of the Dry Tortugas in particular and the West Indies in

general, vith material for a revision of the families and

Erders of the Porifera, Publ, Carneg. Inst. 467 (Paps.

Tortuas Lab, 30):1-225.

1949, Sponges of the western Bahamas. Am, Mus.

Se TTT

Lietle, E.l., Full, Wadsworth, and J. Marrero, 1967, Arboles

Comuncs de Pucrto Rico y'Las Isias Virgenes, Editorial,

Univ, de Puerto Rico.

Manning, R.8., 138. Key to the genera and species of Western

?Atiantic Sronatopoda. \fter Schmitt, W.L., The stomatopods

Of she west coast cf America, based on the collections made

he Allan Hancock Lxpeditions, 1935-38. Allan Hancock

285,

Pac. Expeds, 5/4) 212

McLean, S.A., 125%. Selentific survey of Porto Rico and the

Virgin iilan's! Tae Pelecypoda of Porte Rico and the

Virgin issands. Ne, Acad. Sei. 171)

Menzies, RuJ., and P.M, Glynn, 1968. The common marine isopod

Crustacea of Tuctte Rico.? Studies on the Fauna of Curacao

and orier Caribbean Islands. 27(104):1-13

Monroe, W.ll., 187%. Geologic map of the Manati Quadrangle,

Duarte Reo-Map 107, U.S.G.S., Dept of the Interior,

National Ocean Survey, 1971. Tide Tables 1972, East Coast

OE North and South America, NOAA, U.S. Dept. of Commerce.

National Occan Survey, 1972a, Tide Tables 1973, East Coast

SF North and South America, NOAA, U.S, Dept: of Commerce.

_ , 1972b. North Coast of Puerto Rico,

ChaFT WoT CEOS WTS. NOAA; Dept. of Commerce, Nov. 4, 1972

.. , 1972c. South Coast of Puerto Rico,

?CHEFE NOVTRGS OZ, NOAA, U.S. Dept. of Commerce, Washington,

BC

_ , 1972d, Guayanilla Bay & Tallaboa Bay,

?TRAFE'NOT TIES WOAA, ULS! Dept. of Commerce, Washington, 'D.C.

National Weather Service, 1973, Raw weather data taken hourly

fat San Juan International Airport. NOAA, Dept. of Commerce,

San Juan.

Nutt, M.E., 1975. Islote Environmental report, 1975, Puerto

Rico Mictear Center.

---Page Break---

Oceanographic Prouram, 1971, Report on oeeunographic base

Aine date for nearshore arcas along the coasts of Puerto

Rico, Dent. of Public Works, Conmonwealth of Puerto Rico,

San Juan

Onder, J.C; RA. Brava, and N. Satesky, 1973. Grazing by

the echinoid Diadena antiliarun Philippi, Formation 9£

halos around Wes Indian patch reefs, Science 182:718- 717,

Opresko, D.M., 1975. Abundance and distribution of shallow-
water gorgonians in the area of Miani, Florida. Bull.
Mar, Sli. 20:885. 358,

Owre, J.B. ad. Fayo, 1967. Copepods of the Florida current.
Fauna Caribaca 1212137.

Paine, R.T., 1960. Food web complexity and species diversity.
Nai! goret-108)

Paine, 2.7. ané Rib. Vadas, 1969, 7
the ea urchin, S:rongylozertrot

© effect of grazing of
yon benthic algal

popula Linn. and Ocean, 14:410-791,

Park, T.S., Janeic copepods fron the Caribbean Sea
and Gulf of Mex?co, =, New snecies end new records from
plenkton samples. ?Suit, Mer, Sel, 20:472-546-

1969, The shaliow-water hermit crabs of
Mar. Sci. Gulf and Carib, 9(4):349-420,

Provenzano, A.J
Florida. Ri

~ 1 '388. Pagurid crabs (Decapoda, Aromura) from

SEL SoH, Virpin Isisnds, with descriptions of three new

species.? Crustaceana, 3(2):181=106.

Puerto Rico Nuciear Center, 1972. Preliminary report on the

Survey of Tortuguero Bay Site for the installation of

nuclear power plants. Report to Puerto Rico Water Resources

Authority, Aug. 23, 1972,

; 1974. PRNC-174, Punta Higuero power plant

envtronnentai studies 1973-1974, Report to P.R. Water

Resources Authority.

Puerto Rico Water Resources Authority, 1975. North Coast

Nuclear Plant No, 1 Environmental Report.

Rathbun, M.J., 19

Virgin? T.

Virgin Isl.

5. Scientific survey of Porto Rico and the

Is.? Rrachyuran crabs of Porto Rico and the

nds. N.Y. Acad. Sei. 1511).

Roos, P.J., 1971. The shallow-water stony corals of the

Netherlands Antilles. Studies on the fauna of Curacao

and other Caribbean islands. 37(150):1-108.

---Page Break---

Rose, M., 1933. Copepods pelagiques, Faune Fr. 26:1-374,

Schmitt, W.L., 1935. Scientific survey of Porto Rico and the Virgin Islands, Crustacea Macrura and Anomura of

Porto Rico and the Virgin Islands. .Y. Acad, 15(2):

28-277,

Schultz, G.A., 1969. How to know the Marine Isopod Crustaceans.

Willian ?! Brown Co., Dubuque, Towa.

Shoemaker, C-R., 1935. Scientific survey of Porto Rico and

the Virgin islands. The amphipods of Porto Rico and the

Virgin Islands, N.Y. Acad, Sci 15(2):229-262,

smith, F.G.W., 1971, Atlantic Reef Corals. Univ. Mi

Corai Gables, Florida.

ami Press,

smith, P.E., R.C, Counts, and R.I, Clutter, 1968, Changes in

tiiteride efficiency of plankton nets due to clogging under

tow. J. Cons. perm, int. Explor. Mer, 32:232-248, snith, S.V., 1973. Factor-analysis of presence-absence data

fn Atlas of Kanesha Bay: A Reef Ecosystem under Stress.

Strickland, J.D.H, and T.R. Parsons, 1968. A Practical Hand-

?Sook of Seawater Analysis, Bulletin 167, Fish. Res. Bd.

Canada, Ottawa.

Suarez-Caabro, J.A,, 1955. Quetongnatos de los mares Cubanos

Nom. de 1a Sociedad Cubana de Historia Natural. 22:125-180.

Taylor, W.M., 1960, Marine algae of the eastern tropical

Gnd subtfopical coasts of the Americas. Univ. Michigan

Studies Sel. Ser., 21

?Thomas, L.P. 1962, The shallow water amphiurid brittle stars

(Echinodermata, Ophiuroidea) of Florida. Bull. Mar, Sci.

Guif Carib, 12(4):625-694.

Treadwell, A.L., 1939, Scientific survey of Porto Rico and

?the Virgin islands. Polychaetous annelids of Porto Rico

and vicinity. N.Y. Acad, Sci. 16(2):151-319, Van Name, W.G., 1930. Scientific survey of Porto Rico and the Virgin Islands, The ascidians of Porto Rico and the Virgin Islands, N.Y. Acad. Sci. 10(4):405-535.

11945. The North and South American ascidians. ITT AWGF! Mus. "Nat. Hist., 84.

cente, V.P., A key to the sponges of the West Indies. Unpubl.

Warnke, G.L. and R.T, Abbott, 1962, Caribbean Seashells. Livingston Pubi. Co., Wynnewood, Pa.

n

---Page Break---

Wiebe. Pil, and #.%. Hoiland, 1968, Plankton patchiness: Mffects of reveated net tows. Linnol. and Oceanogr. VarFHS-32t, Villiups, A.B., 1965. Marine decapod crustaceans of the

fazolinas. "U.S. Fish Wildl, Serv, Fishery Bull. 65(1),

Wood, i1.D., ALS

mination of

reduction to aitrate. J. dar, Aioiy Assmey

strong and T.A. Richards, 1967. Deter-

trate in Sea water by cadmiun-copper,

Kee 7223-31,

Wood, #.0., 1274, Punta Higuere power plant environmental

Studies 1975 !19"@, FRNCST74,

Wood, 1.9., 18754, Winds for Puerto Rico with sumaries-

Voi il Porce, i371. 1974, Puerto nice Nuclear Center,

Mavaguess

Wood, 3.0. yer discharge

fee alternate power lant sites.

kee. co Muclear Center Teck, Report,

PRY

Wood * Maruat c Cruises.

Youd, 6.2 joe Data Report

West Pucrte Rico. in press as a RNC Techaical

Report

» Mod, Younsblith, MLE. Nutt, D. Yoshioka and

WY Nanoy, i975, Tortuguote Bay Environmental Studies,

Puerto Rico Wuctear Center, PRNC-181.

Yanayi, wustvations of thy Marine Plankton of

satan! Publishing Co., Ltd., Tokyo,

Youngbiuth, M.., 1973. Results of the plankton survey at

Bahai de Tortuviers, Punta Manati and Quebrade de Tero,

T. January ang March, 1973. (unpublished) -

Youngoiuth, MaJ,, 18744. Diel changes in the composition of

A tropical, Coussa? zeoplankton community. In proparation,

mst i978%- Died changes in the composition of

TFSHTER! ?Feptankton assemblages from coastal waters around

Pucrto Rico.? Unpublished

;,,1978 Survey of zooplankton populations in

Tenos in preparation as part of Jobos bay Environmental

Studies, Puerto Rico Nuclear Center,

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APPENDIX 2,14

Tabulated Averaged Hydrographic Data

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PUNTA VERRACO ~ ALL STATIONS~ SPRING

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PUNTA VERRACO ~ ALL STATIONS- SUMMER

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AVERAGE DATA FOR ?25294 THRUUGH 939675 PUNTA VERRACO = RINTER = "A" STATIONS

DEPTH TEMPERATURE SALINITY SIGMA T OXYGEN PHOS AI TROGEN

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we Bgleaa 23,301 4819

23 (sleat 23,381 4,87

SP 251618 35,785 2sy3ae ?5y387

AVERAGE OATA Fow E238B1 THROUGH 259674 PUNTA VERPACO ~ WINTER - "E STATIONS

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APPENDIX 2.18

Rathythermograph traces for the

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BATHYTHERMOGRAPH TRACES

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APPENDIX 4.14

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APPENDIX 4.28

?Transects, Station Dives and Beach Stations

?at Punta Verraco

pansect Tt Location: perpendicular to shore off Punta Vernaco

Depth O15 m

Date 24 May 1979

Investigator: V. P, Vicente

?Teansect 72 Locarion: parallel to shore off Punta Verraco

Depth! Se

Date: 22 April 1976

Investigator: P.M. Yoshioka

?Transect 73 Location: parallel to shore at Cerro Toro Canyon

Depth: Dee 17

Date 2 May 1973

Investigator: U.P, Vicente

sransect TH Location: perpendicular to shore off Punta Verraco

Depth 1-7 mn

pate: 22 April 1974

Inventigator: P.Mt. Yoshioka,

?Transect 75 tocation perpendicular to shore near Punta Vernaco

Depth: Bo

Da 21 May 1973

Investigator: V.P. Vicente

Transect T6 Location: perpendicular to shore off Punta Verraco

Depth: aoe

bate: 23 May 1973

Invest igetor

Yep. Vicente

Location: reef outside of sand spit off Punta Verraco

Depth: oe

Date: 5 March 1973

Investigator: A, Smmant-Froelich

Station 2 Location: between sand spit and Punta Verraco

Depth on

ate: Dt May 1973

Investigator: V.P, Vicente

Station 2 Location: canyon off Cerro Toro

Depth 26m

Date: 6 march 1973

Tnvestigat

V.Py Vicente

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APPENDIX &.28 (continued)

Station 4 Location;

Permanent station

Investigator:

Station 5 tocation:

Depth:

Date:

Investigator:

Station 58 Location:

Investigator:

Station 7

Investigator:

1 Location:

pete:

Investigator:

22 Location

Dete

Investigator:

33 Location:

Date:

Investigator:

off Punta Ventana

on

12 Feb, 197%, 22 May 1974,

24 August 1974, 18 November 1974

Pim, Yoshioka

off Punta Ventana - offshore of

Station 4

a

24 ugar: 1976

P.M, Yoohiona,

off Punta Ventana - offshore of

Stations # and 5

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13 Novender 1974

Pix, Yoshiok

off Punta Ventana

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21 March 1973

Pt, Yorhioka

off Punta Vaquero

to =

6 March 1973

V.P. Vicente

sand apit off Punta Verraco

March 1973

W.Fs Vicente

Cerro Tore beach

28 February 1873

ver. Vicente

Punta Vaquero

26 February 1973,

V.P. Vicente

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APPENDIX 4.2¢ (continued)

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APPENDIX 4.20 (continued)

Permanent Station

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APPENDIX 4,26

Species occurring in 1/4 m quadrat substrate

samples at Punta Verraco, Stations §1, $6, and Si

(Replicatas'& and 8),

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(Permanent station)

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Phylun Chlorephyta

Phylum Rhodophyta

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Spateteggia Piste ° ° °

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Phylun Coelenterata

Astrangia solitans ° ° 2

Phylum onertes

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APPENDIX 4.28 (continued)

Phylun Annelida

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Uni. sylidae

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Phylum Sipunculoidea

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Sipuncutia sp.

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Onder Pericarida

?Subordes Isopoda

(Permanent Station)

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Phytun Echinodermata

Clase Ophiuroidea

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Phylum Chordata

Class Ascidacea

Microcosmus helen!

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class Scaphotoda

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Clase Gastropoda

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