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PUERTO RICO NUCLEAR CENTER

PUNTA HIGUERO POWER PLANT

ENVIRONMENTAL STUDIES 1973-1974

Prepared fo the Puerto Rico Water Resources Asthorty

By the Staff of Puerto Rio Nuclear Center ofthe

Usieiy of Porto Rico

?OPERATED BY UNIVERSITY OF PUERTO RICO UNDER CONTRACT

NO. AT (40-1)=1833 FOR U S ATOMIC ENERGY COMMISSION

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PREFACE

?This report stems from investigations being carried on

by the Puerto Rico Nuclear Center. ?The studi

were designed

to provide data upon which to judge the eultabiiity of @ atte

for the constuction of pover generating facilities and to

allow the determination of the impact of such construction

land operation upon the envirorment. ?thie report 12 the

combined effort of the setentiets,

yehnfedans and support

staff of the Site selection survey Project:

B.D. Wood, Project Veader Paysical and Chemical

Taractere

March J. Youngblath Zooplankton

vance P, Vicente Benthic Invertebrates

FD. Martin Fish

Made Cancy Terrestrial surveys

?ALna Samant Froelich Benthic Invertebrates

Report assembled by B.D. Wood

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Current studie:

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of the Punta Higuero site.

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uy

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MEASIRMGENTS AND MONTTORING PROGRAMS

[FREOPERATIONAL ENVIRONMENTAL, PROGRAM

aurface Water

?Physical and Chemtcal Parameters

Physical Parazeters

Pa, Higuero comonly referred to as ?Rincon? or the "BONUS site?
is the most vesterly point on the Island of Puerto Rico (Fig. 1). seme
environmental work has been done in the Pta. Higuero region related to
?the construction and operation of the BONUS-Reactor pover plant. Data

?from independent studi

in the Mona Passage are also available. the
Puerto Rico Miclear Center has been collecting and analyzing data fron
?the immediate region of Pta. Higuera for about one year on a regular basis.
The nearshore currents have been measured on several occasions.
?Te factors effecting nearshore currents such as winds, tides, bathymetry,
and density structure of the vater column have been studied and are being
presented here,

a. aes

?The tidal excursion at Pta. Higuero is on the onder
of 30 om and ite period ic somi-diumal. ?the tides here
vere not measured, but can be calculated fran the san Juan
tidal data, Calculated tidal date (Fig. 2) are presented
for the perio 6/7/73 to 6/8/73 relating to currents
covered i the folloving subsection. In addition, a plot,
of the tides for the month of June, 2973 is shown in Fig. 3
?to cover @ lunar cycles

>, Currents

In general, the currents are tovard the west, both

north and south of Puerto Rico. The current; north of the

---Page Break---

"ims 2 = Rint Stmero (Rincon), vest coast of Fuerte Rico.

61°20"

i

DISTANCE (nent)

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TIOWBTH ?wid 9 ELET ?B-L ome wooN 04 wooN poRLOM 943 LOS STAAOT OPFT

PeUBTHOTEO = 2 +H

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Pig. 3 - Calculated tides for Pte. Higuero for the period May 28 to

June 24 to show the variation over a lunar cycle

te - ot

in-t

ore

£-

requ

sump U0)

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island, eidies around Pta. Boringuen in Aguadi2ia Bay and

westward north of Pia, liiguero, the current along the south

coast tume northward through Mona Passage and is generally

?to the north along the west coast of Puerto Rico with mmerous

eddies and reversals in the nearshore waters because of &

?complex bottom topography, tides, vind fluctuations and surface

runoff.

?ese two currents tent to meet at Pta. Higuero and tum

westward, although the convergence has been observed to oscillate

fra south to north depending upon wind and tide conditions. the

currents off Plas Higuero have been measured on five different

occasions.

2), 2) In the fal2 of 1972, the currents vere measured

using dye drops and aerial photography. Bight

Grope were made on the afternoon of Oct. 7, 1972 fand Photographed periodically for about two hours.

?he results are tabulated in the Appendix and shown

in Pig. 4. there was a 4,5-5 m/sec. wind from the

south and the beginning of a flooi tide which

caused the surface waters to move north at 15-30 en/sec.

?The folloving morning, a similar drop pattern was

repeated and folloved photographically for about

?two hours Fig. 5. The sane current trend vas ceon.

?The wind had been near calm, then picked up to

5-545 m/sec.

?the drop began. he tide was high

Slack, The currents north of Pta, Higuero were

sluggish, moving north and west converging with

the north floving west coast current. the offshore

---Page Break---

DISTANCE (nent)

---Page Break---

Fig.

67°20"

i

5 + Dye Study at Pt.

Hignero Morning of 8-X-72.

---Page Break---

3)

currents were nearly tvice as strong as in the nearshore region,

current Meters October 30 ~ Novenber 2, 1972.

?wo current meters vere anchored very near

station FiT-NA (Pig. 1) at depths of 3 and 6 m.

The tides (plotted fram tide book - appendex)

wore semi-diumal with highs at 0400-0700 and

1500-1800; lows fran 0900-1200 and 2200-2400.

?the average range of the tide for this period

aout 33 em, and the average vater level

?was about 21 cm, Maximum flood was about 0300

?and 1300 with maxim ebb near 0800 and 1900,

Tt Ae the convention to describe water currents

by the direction they are traveling and wind by

?the direction they are fram, Hovever, in order

to correlate wind and currents, both will be

Aeserived by the direction they are traveling.

?the station 1og date in the Appendix retains

?the "fren" convention for winds.

the nearest source of wind data was Raney AFB.

the airface winds are plotted in the Appendix.

?he direction was to the west northwest at about

3.5 m/sec, The winds were generally strongest

| and about 1.

fram 1000-1600 at about 5.1 m/s

m/sec. during the early morning hours,

A canbination of winde and tide should give the

strongest currents about noon. However, the nearly

---Page Break---

4)

?three days of continuous recordings (Appendix)

shoved that the strongest currents (M6 cn/eee.)

wore about 0400 to the north at 3m. the highest velocity at 6 m depth vas 25 en/sec, In general,

?the strongest currents were to the northeast.

?The 3 m currents osefliated betwoon NE and 5,

while the 6 m currents were betwepn E and iy

?the average 3 m current was about 23 en/sec. and

the average of 6 m current was 1 en/aec. the

3 m cttrront was about 80% of the outer aurface

current measured October 7-8, there was @

weak trend for the highest veloetties (3 m) to

the north to coincide vith Meh slack tide,

Lovest velocities (3 m) were to the south at low

snack tide, te trend was lese pronounced at ©

currents at 3 m and 6m vere atzectiy opposed on

several occasions, One of these tines vas of

rim current vhen the surface vind at Rasey

was ein, thls trend vas coon at soveral thees, It my be that the winds to the west over

Agandilla Bay retard the north bound currents

west of Pia, Hguoro so that vhon the vind caine

it allows high flow to the north,

current Meters

January 17-19, 1973.

Current meters were sispenied from an anchored buoy

at station FI-NA during the period of cruise FA-021.

?The tides were more extrone during this period than

---Page Break---

Guring the Oct.-Nov., 1972 sampling periods.

The maximm range was 76 om with the average

range 13 cn. ?The average water level was

15.5 om. ?The period of maximum flood was 0500

?and maxim ebb about 1200, the winds were generally to the west and northwest at velocities fran 0 to 7.6 m/sec, Winds recorded on the ship, ?together with the Ramey AFB surface winds, are plotted along with current data in the Appendix fant show only general correlation, there were several brief occasions when the wind was to the east during the sampling period. Average velocity

ant directions were 2.7 m/sec, to the west.

Surface currents were variable fram NIE through south around to IW, the average velocity and @irection var 27 cm/sec. to the S8, the strongest currents were W6 cm/sec. to the HME, the veakect surface currents were 15 cm/sec. to the south.

No direction was available for the 3 m depth, but ?the velocity tented to follow the surface currents in pattern at about 15 cm/sec, or about 56 of the surface current value.

Great differences are seen in both the current velocity and direction between the surface and

6 m depths, the average velocity was 18 cn/sec.

about 67% of the curfuce average. The direction

was varied between NE and & with the highest,

wo

---Page Break---

)

a

velocities to the AB. Flove in opposing directions

wore frequent between surface and 6 m, Also, when

surface currents vere strong, botten currents vere

weak and vice versa. There were periods vhen the

surface currents appeared to be onshore coinciding

with offshore currents at depth.

the currents at Pta, Higuero were measured for a

24 hour period, noon on June 7, to noon on

June 8, 1973, at four depths with General Oceanies inclination meters. The data were reconied on

film at 2 minute intervale, In canputer reducing ?the data, every nine points vere averaged to sooth ?the data and reduce computer and plotter tine. the data are presented in three fome,

4) Currently velocity and direction are plotted separately against time. An independent plot ts given for each depth and each day (Appendix).

11) A progressive vector for each depth, combining velocity and direction, 1s shown in Fig. 6. The tines are indicated. Tis approach treate the Water Passing the current meter as a point in motion which tay not be exactly correct, but dees give the reader @ feel for the oxtent of vater novenent. The four depths are plotted on one page with a land

reference drayn to seale,

---Page Break---

ae

Fig. 6 = Progressive vectors for currents

N cing acters et four depthe

(2,4,7 and 13 =) at station PHI-

4a June 7-8, 1973, 24 bre.

5

*

R

rs

S ae,

wer ere

FUNsA HuGUEKO

e%

4

DEPTH

DEPTH = 4

DEPTH=7

DEPTH =13

---Page Break---

Ai) the current vectors were sumed in 10°

Ancrenents and plotted on a "compass rose".

?A separate plot for each day and each depth are

given An the Appendix,

?he currents during the perio! measured vere

strongest to the north. the changes in velocity

?and direction vere periodic and appeared to be

related to tide, the aftemoon period of north

ward flow vas faster and more erratic than the

moming period, probably due to the influence

of wind.

Surface velocities reached a high of 60 on/aec.

An the afternom, but were acre cameonly 40-50 cn/eae.

during the northward flov, During the slack perio?s

Detveen northward flove the currents were weak at

?about 10 cm/sec. generally scutiward, but the

Atrection vee sporatic.

In the progressive vector plet, a noticeable trent

tovard rightchand twist to the current with depth

existay Tuls appears to be a coriolis effect.

The WAV R.F. Palunbo vas anchored about 250 = west

of the current meters during the period of data

collection releasing dye contimously and ccllecting

surface weather data. The direction of flov as

Anticated by the dye release coincided well with

?the data fren the surface current meter. The dye

ae not tracouble for any great distance as it was

Aispersed ani diffusod within about 0.5 Im of tho

---Page Break---

w

point of rele

?the release was photographed

?fran an aireraft perfodically during daylight

hours.

SQumary of Current:

?he currents at Pia, Higuere have been measured on five occasions during three seasons with varying wind and bidal conditions. the currents are generally strongest ?to the north during flood tide. Weakest currents are during ebb tide to the south. Generally good mixing can be expocted im the waters o&f Pla. Higuero with an wltinate offshore movenent of survace water. The highest currents observed ?were 60 cn/see. (2.2 kt) to the north. The northvant flove were sbous: 25-30 cm/sec. while soutiward currents were 10-20 en/ee. At 28 cx/sec. @ boty of water would flow about 4 im in a hour period typical of flood tide currents at Pta, Higuero, The data also shove that there may be periods of nearly four hours when very Little water mowment cceurss

With this in mind, a heated vater discharge should be far encugh offshore so that the build-up of heated water during clack periods would not seriously effect biologically sensitive regions. In addition, the dis-charge velocity should be sufficient to cause rapid initial mixing (150-300 cx/secs). An alternative would be a attfuser éocharee.

Current Meamurerents

current measurenents will continue at Pta. Higuero

generally ona uarterly basis. the periot of sampling

---Page Break---

Will increase up to about one week at @ tine and the points of current meter locations expantod to better define the currents in the region of convergence off Pta. Higuero, Dye releases and aerial photography coincidental with current meter measurements will be ?used to determine flow pact a point, path of a point in motion and mixing characteristics of the body of waters

ce Bathymetry

The Puerto Rico Muclear Center has undertaken no detailed bathymetry of the Pta, Higuero region to date Deyond thet done during benthic samplings ?the C&a.S.

chart 901 (Pig. 1) has been found to be adequate tor host work, The narrovest shelf (400 m) on the island of Puerto Rice is just south of Pia, Higuero in the region of Corcega. ?he narrov shelf gradually widens ?to about 5000 m off the point, then tums east and narrows to sbout 3000 m north of Pta. Higueros Wow ?that @ reconing depth sounder is available on the AMV Ailtana, detailed batiymetry is planed for the regions the botton traces will be correlated with photographs taken by svinners,

4, Domperature and salinity

Hydrographic cruises have been made to Pta, Higuero Guarterly since Jamary, 1973 except for the fail quarter of 1973. Temperature and salinity vere measured at 70

depths on each cruise, Three stations on each of the

---Page Break---

transects 2-6 (Pig. 1) were sampled each time

cotlecting data fron the surface to 10, 100 and 300 m

for AyBy and C stations respectively. Fifteen surface

samples vere measured for temperature ant salinity.

?Temperatures are neasired using oceanographic reversing

thermometers with readings good to 4 .03 °C, Salinity

samples are returned to the laboratory ant determined

with an induction salinmeter to an accuracy of # 4005 * /ooe

?the data for the fair emutses (PA-021, PA-OPT, PA-033,

and PA-036) are found in the Ampendix along with the plots

of tenperature, salinity and sigua-t vermis depth, Signa-t,

St, 16 measure of the water density, Pt

ot-(A-1x? a)

Signa-t indicates the stability of the water column.

A qual signa-t gradient with depth indicates a well mixed

or unstable cone} whereas, a high gradient is indicative

of a very stable yortion of the water column, ?The near

eurface mixing zone varies fron 50 m in the sumer to about

130 m dn the winter as shomn in Fig. 7 ty seasonal bathy-

?themograph, BY, plots. the BY recorded tenperature with

depth az st was lovered and retrieved at the 300 m station:

?me BY data for all cruises are in the Appendix.

2) Tesperature

Zt can be seen from Fig. 7 that there is very

Little seaconal change in temperature below about

200 m, the mixing zone is the deepest and the

surface temperature io the lovest in the winter

season with surface warming in the spring. ?the

---Page Break---

Fig. 7 - Corrected bathythemograph trac

frou FAI-3C for the sampling quarters:

Bl, T3-2, 73-3 and Thal,

wo 2 hb ww

uv

---Page Break---

shallovect mixing rone and the highest surface

?temperatures occur in the sumer followed by a

retum to winter conditions through the fall.

The vinter-sumer surface tonperature difference

Ls about 2.5 °C, 25-285 °C, Same of the BT

?traces show a sharp break in the temperature

gradient at about 225 m which indicates a shear

zone between two layers of water, ?he shear

zone 4s 30 to 50 m thick.

aurface tenperatures vary by Jess than 0.5 °C
4in any one quarter sampling and relate as well to

time of day as to their lateral distribution (Fig. 8)

except for the spring emule PA-O27 when @ tongue

of vam water appeared north and east of Pta, lguero

to inetule stations 4B, 5B, 50 and 6c (Fig. 9). At

least part of this difference can be explained by

?the fact that transects PHT-2 and 3 were sampled

a day after PHI-l, 5 and 6 when the air temperature

was about 3 °C lover than the first day, 27 versus 30.
Ible 1 gives an ?average? tenperature for the

depths meacured plus the range over the year. the

wide range near the surface te due to seasonal changes.

Avwide range 4s seen at the 150 m depth also and is

?due to high gradient, themocline, at this depth

and the fact that the depth of the thermocline (Pir.1)

changes fran station to station, The range narrows

velor 260 m and one finds greater differences between

stations in any one sampling period than between seasons.

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shop 30 omy youuu

PonzoTd oath ?wg 03 sovTnio mmoz maj somyUedaR, gous -

Tia

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61°20" ast

Oo]

+ pigs 9 murface temperature distribution, %, for Pia. Higuero

May 1-2, 197k, PHT-T3-2.

DISTANCE (nomi)

---Page Break---

?TABLE 1

?Temperatures at Pta. itiguero, averaged with dapth and

ranges for the yearl973-7

?Temperature, ?C

Depth Average Range

« s Ar

° 27.2(5) 2.8 = BT 29

25 21.2(0) 2.9 = 85 2.6

50 27.2(0) 5.9 = 285 26

100 25.9(0) 25.0 = 6.8 18

150 22.0(5) 2.7 = 23h a7

200 29.8(5) 19.3 = 20h aa

250 17.9(0) w6 - Be 6

300 26.95) WT - Te 5

---Page Break---

Fig. 10 ~ Teaperature, Avernge, and Range for the year 1973-74

® plotted against depth for Faas ?Higuero

618 20 22 ah 5 BB 30 rc

oH

Fig. 11 - @inity, Average, and Range for the year 1973-7h

plotted against depth for Pta. Kiguero

35.00 36,00 37,00 .8*/oo

---Page Break---

3

2) satinity

The salinity of the surface waters of Pea, Higuero varied from 35.00 °/oo in sumer and vinter to 35.90 "/oo in the spring, reflecting ?the heavy runoff fram June te November and the relatively dry season, Deconber through May. ?The averages and ranges of sulinitics with depth are sted in Table 2 and plotted in Figs HL. the average salinity Ls constant at 35.5 */oq in the ?ixing zone (50 m) then increases rapidly to about 3645 */oo at 130 m. A further increase to 36.7 */oo 4s oven at 200 m with lover salinities to 300 (38.2 */oo), sultnities st 200 m have been measured fs high as 37.00 */ooe This 40 usually at the deep stations north of Pta, lguero. the high salinity water between 100 and 250 m originates in the ?tropical Atlantic and flove westward north and south of Puerto Rico, Mixing in the Mona Passage probably accounts for the gonerally lever salinities at 200 2

south of Pia, Higuero.

3+ Denotty,

?Aa mentioned above, the stability of the water

column ie determined by density differences. Density

expressed ac signa-t (Equation 2) is a function of

?tomperature, salinity, and to a lesser extent, pressure.

A plot of temperature versus salinity is shown in Fig. 12.

---Page Break---

BSSRER see

TABLE @

falinities for Pta, Higuero, averaged with depth

and ranges for year 1973-Th

Range

¥ 2 2

35.0 = 359 9

B52 = 35.8 a

356 35.3 - 37 4

36.8 35.7 = 36.6 3

36.6 Bib - 368 ?

7 6.3 - 37.0 7

3.4 36.2 - 36.5 3

36.2 3.0 - 363 3

---Page Break---

Fig. 12 - 1S diagram shoving visually averaged tenperatures

and salinities for four sampling quarters? at

Pt. Higuero. Diagonal Lines show the density

factor. signa-t.

mlinity

?Temperature °C

---Page Break---

Bach Line is the average of the data ccllected

at the "C" stations for each cruise.

?The greatest seasonal density difference is

in the surface waters denoted by "A" on Fig. 12.

Amch lover sigma-t is seen in the aumer data,

(73-3) where 6% = 22,4, Bven though the tempera~

tures and salinities do di!

fer for the winter and

spring data, aigna-t does not change appreciably,

25.1 = 23.3. his dry soason-wet soason difference

in slgna-t probably accounts for most of the

aigference seen in the monthly mean tide levels.

?The monthly mean tide levels are generally 10¥

in the winter-spring (dry season) and high in the

mumer-fa21 (vet soason), The difference in

sigin-t decreases with depth trea "s? to "c" and

4s nearly unifora throughout the year below "co".

Teuperatuse and salinity nenmirenents wilt continue on a quarterly basis at Pta, liguero to

determine soasonad variation, and will be expanied

to better explain mixing processes which occur in

?the convergence of the vest coast current and the

north const current. More detailed nearshore

?temperatures will alzo be taken, the region has

boon scanned on three occasions with an aeria)

infrared canera (9/73, 11/73, 3/74). The surface

temperature distribution patterns fron the scans

fare being worked up.

---Page Break---

8, Marine Geology and sediment Transport

No FRNC inputs

£. Chemical Paraneters

Dissolved oxygen Op, and reactive phosthate, FO, were

determined at the sane tine and depths that teaperature and

salinity were on all cruises to Pta, Higuero as part of the

regular hydrographic work, ALL of the data are Listed ant

Plotted in the Appendix. Dissolved oxygen fe given in

s/L, me/t (coamenly called pee even though it is incorrect),

land percent saturation. Reactive phosphate is given in

+ FOU

2) Dissolved Oxygen

?the ancunt of dissolved oxygen in sea water was determined by the standard Winkler titration method. In addition, cxygens on the Pi-Th1 cruise were measured with a YSI probe on the same samples that were titrated. A comparison of the two methods ie plotted in Fig. 13. the agreenent is fairly goat, hovever, the titrated values are consistently higher than the probe values. Since the titrated values are st or near saturation in the surface waters, they appear to be sore reliable, the

oxygen concentrations were near saturation in the surface waters (6.7-7.0 mg 02/L). Same super

saturation war noted at 25 to 50m due to photo~

synthesis (1031). A typical plot of oxygen versus Gepth is show An Fig. lk, Below about 100 m, the concentration of Op decreased to a minimun of 9475

ng Op/ly 70% saturation, at 300m, the lowest

---Page Break---

surface Op vas no loser than 95% satura

en and

ay have been due to the BOD of surface munoft.

Reactive Phosghate

Reactive phosphate vas detemined by the

Murphy and Riley molybdate complex method using

44 Becinan DU spectrophotoneter. Phosphate can

bbe determined rapidly with good accuracy, there

?existe good relationship between phosphate and

nitrate in sea water (1:24) so that phosphate

can be used as a mitrient indicator.

Phosphate is very lov in most surface waters

cof the Caribbean except near very highly populated

regions. surface values charncteristically mun

0,058.05 ug-at. PO{/1 tron surface to 100m. A

sight increase in POf occurs at 150m, fotloved

by a steady increase to about .90 ug-ate 2Oi/1

ft 300m. A typical plot is seen in igs 2h,

Phosphate 1s vithdram fren the surface waters

during photosynthesis, incoryorated in biota witch

sinks and decomposes using up oxygen and releasing

sutriente into the vater column, the tumn-over rate

of the near surface mitrients 1s fatsly rapid

to allow what 1ittie productivity there 1s to eceur,

probably a matter of hours or a fou days at most.

?Me dtetribution of phosphate in the surface waters

soons to be spotty as Sn plankton. Probably lov

hoephate conditions existe where proiuctivity 16

active.

---Page Break---

?The chemical paraneters of dissolved oxygen and reactive

Phosphate will continue to be sampled ae yart of the quarterly hydro~

graphic work with attention given to diurnal changes and possible sources of nutrients or BOD fron terrestrial sources.

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---Page Break---

Hg 10 - btoeret oxygen apd reactive

?rofliee typical the

PerMitetto teeion, Wis), ve

2 Puy

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PLANKTON GURVEY AT THE PUNDA HIGUERO SITE, I, Standing, stock estimates of the major taxononic groups.

By Marsh J. Youngbluth

?DeTRODUCTION

?the folloving report provides quantitative estimates of the ?biomass and mmber of zooplankton collected in the surface waters near the coast. he data represent one part of an environmental, survey conducted by the Puerto Rico Muclear Center in the vicinity of the proposed site for fossil pover plants at Punta Kiguero, sumples vere gathered on 5 days during 1973 - 17 Jamary, 2 May, 1b August, 3 Docenber, and 11 Decenber.

MATERIALS AND METHODS

Plankton were collected with 1/2-meter dianeter, cyLinder-cone shaped nylon nets of two mesh sizes (64 and 202 microns). These nets were designed to reduce clogging error (Suith, Counts and Clutter 1968). me larger mesh netting retains most of the macrozooplankton. The smaller mesh captures the larger microzooplankton and phytoplankton. Nets of finer porosity are impractical to use in coastal areas since ?the mesh clogs very quickly.

221 samples vere gathered in a standard manner, ?he nete were toved froo a 17 ft. skiff ns cirewlar path through the upper 2 meters. The speed of the vessel was about 3 knots (determined vith @ Sine yacht

specdoneter). ?The maller mech net vas hauled for 5 minutes, the larger

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for 10 mimites. After each tov, before the cod end was renoved, the nets were thoroughly washed by sea vater with the aid of a battery powered pump (12 volt, Jabsco water-puppy). Samples were preserved in Wf con vater-formalin buffered to pli 7.6, ALL cwxples were gathered during the daylight hours, the volume of water filtered ?through a net vas estimated vith a flowmeter (General Oceantes, Mode 2030) suspended off-center in the mouth of the net.

One tow was mate with each net at every station except in the area adjacent to the proposed site for the pover plant (station 2) where triplicate tovs were made with the coarser net. these replicate samples were used to detemtne the range of variability between sic=

ive tovs and to provide more reliable estinates of the organtae present, he stations vere situated in such a way as to sample within land around the area vhere thermal alteration ie Likely to occur

(see Fig. 1). Station 1 to the north ie upcurrent from the proposed site and should depict a plankton comunity unaffected by a pollution source, Flankton populations in areas downcurrent, station 3, and

offshore, stations 4 and 5, may show pollution related stresses.

Iaboratory Procedure

Within 2h nours after squples ware collected the pil vas checked

and atjusted, Af necessary, to 7.6. If a sample contained a noticeable conglonerate of phytoplankton or detritus, the zooplankton were separated by gently fittering such material through 202 micron mesh netting.

Before eatinates of bionass and mmbers were made, all organtns larger ?than 2 centineter, usually hylrezoan nedusse, ctenophores, or scyphoccans, vere renoved.

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PUNTA CADERA

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NAUTICAL,

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the locations at Pinta Higuero where zooplankton vere

coljected.

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Biomass wae calculated as wet volume (Ahlstrom and Thratiei22

1962). This wet: was employed to measure biomass because it ts

\guick and does not damage the organims, Conversion factors for

wet volume to wet weight or dry velght have been determined fron other studies of zooplankton along the south coast of Puerto Rico (see Youngbluth 1974). These factors are cited in a footnote on Table 1.

?The umber of organiins in the coarse net catches was esti-

pated by Volunetric subsampling with replacenent (Brinton 1962). Tiree aliquots fron each sample were counted unless otherwise noted. ?he choice of which organtas are counted and identified to spectes needs sone clarification, Plankton tove collect masy different Kinds of organians, It to extremely difficult and tine conaming to identity ait organias to the species level. Fortunately, this Ae not necessary to detect changes in the abundance of the plankton community, Usually the gore abundant of the most merous organism 40 elven prinary attention. In the plankton copepods are usally numerically dominant. In thie report the majority of these animals have been Aentified to apecies. Quantitative estimates of their Felative abundances vill be the subject of a later report, me ?other fauna have been grouped into two categories, being identified by ite history and taxonomic position. Dilutions vere made so that bout 200-100 organtans vere categorized into major taxoncate groups. 411 biomass and emmeration data were standantized to a per cubic meter basis or multiple thereof. Data vere initially reduced

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with hand calculators (Jlewiett Packard Model 35) and, nore recently,

with a larger computer (P10). see Appendix A for a Meting of ?the program.

meante

A totat of M6 samples vere collected fram five sites around untae Higuero, Variations in the bloaass and mumber of zooplankton from 27 coarse net tovs are presented in thia paper. An earlier re port (Youngbtuth 19738) @iscussed the zooplankton caught in coarse land fine net tovs during Jamry 1973. For the sake of completeness 421 data fron coarse mesh tove taken at Punta Riguero in 1973 ere included in this report. Because of tine and manpover Linitations no further attention will be given to microzooplankton from the fine pesh tove for come tine,

?he range of variation for those subsamples that were counted three tines was alvays within the range expected for subsamples drawn from a Potseon Aistribution, Thus, counts were made on organise arava from randomly dispersed populations, Previous testing and continual checks on the aubsumpling technique inifeste that thore is no significant variation between replicate counts or counters, Thus three counts per sample are nov mie leas frequently.

The magnitule of variation ancng the replicate, inshore, and offshore tors and between inshore and offshore tove during each coltection period vas umarized by dividing the highest total number of organians by the lovest within each oot. Among the replicate nearshore tovs the

factors were 2.5, 1, 1.9, and 1.2 for Jamary, May, August and Decesber.

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hess variations are similar to those observed at Quebrada de Toro, Punta Manati, and Tortuguero (see Youngbluth 19736). Among the nea

shore tovs the @ifferences were 3., 3.1 and 6.0 for May, August and Vecenber. The retio among offshore samples during May ves 2.3. Thus St appears that there 4¢ umually more variation between tovs from ditterent stations than fran replicate tove at the sane station.

Variation in tems of total numbers between tovs at different stations must therefore be greater than 2.5 to be significant.

Zooplankton bioaass vas usualty greater near the coast. The largest concentrations were found just off the tp of Punta Higuero ?at station 2, Volunes in this area vere 4 to 5 times higher in

January aod Decesber (Tble 1). In terme of munbere per =? 6 to 10

times more zooplankton were present in December (Table 2). Holoplanktonte fauna dominated the catches composing 58 to 97% of the total numbers nearshore and 61 to SWf offshore. Munbers per m are listed in Tuble 3. During January and December copepoda accounted for about 60% of the zooplankton in either area (Table 4), In May and ?August copepods composed around 60% of the zooplankton, Chaetognaths were abundant in January and May (Table 5). Larvaceans, Otkopleure spp. and Fritilarta spp, were proportionately most mumerous in May and

Decenber (Table 6). Cladocerans, spp.) were not conspleuous at

fany tine of the year, Pteropats, mostly Cressle spp. and coiled forms, were an omer of magnitude more dense in December than in other months (mie 7).

The abundance of meroplanktonte organtes was lov and concentrations

averaging 30 individuals per m3 were common in May, August and December

(able 8). About balf this snount was recorded in January. Brachyuren

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?crab larvae were abundant in May (3/10%= 30, Table 9). Barnacle larvae vere preponderant in August: (5/103= 123, Tabie 10), Caridean shrimp darvue vere most mumerous in May and August, particularly near the coast (#/10*= 62, Table 11).

other heloplankton and meroplankton observed includ

2 tretomphalus

stage of « foraniniferan (probably Trotomphalus bulloldes), syedocopia

?ostracods, hyperid amphipods, ctenophores, siphonophores, hydranedusae,

snips, and the larvae of polychaetes, echinotems, laneliibranchs, end

Lsopoda, these groups occurred in densities of less than 5 individuals perm,

Fish eggs often ranked ac the second most abundant planktonic fom. Fish larmue vere such less rumerous, he largest densities of fish esse ?and larvae occurred in Decenber (f/n3= 64, tables 12 and 13). some of the fish eggs are football~shaped, resembling the anchovetta egg. Tt is not known at this tine which fish groups are represented by most of ?the exes.

?the 36 copepod and 8 chaetognath species identified are Listed An Tabre dh.

DISCUSSION

the zooplankton conmnity in the Pinta iliguero area is dominated

numerically by copepods, ?here are at least 36 specie

1. The majority

are mali (1-3 ma), herbivorous populations camon to tropical and coastal oceanic regions (Bjoruberg 1972). The chastognath species Jdentified are conspicuous in the mixed layer of the Atlantic and

caritbean (Suarez-Caabro 1955, Pierce and Wase 1962, Alvarifio 1969).

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TABS Lh, A Lt of the copepod and chaetognath species identified

fran the Punta Higuero collections.

CORPO 20!

Acartia spinsta

Reartia Tujeborgit

Taracalamie crassirostris

Paracalamus parvus

Farscalare acweatus

Ofthena oeutate

Sithons plusifera

?Oithona sp. A

Glausocalarus furcatus

Tenor Eurbinats

Tesora stylifers

reacts abla

Toueacis gloeehtt

copeaeus pasifieus

Coryeneus azilte

Goryeneus spectorue

oryoasus anglicus

Toryeucus

Fartamia gracilis

Farranula =p. A

Uidinula wigarts

?amocalame minor

Gentropages furcatus

?Getosetmnss pero

Tneleutia flavicomnts

Catanopia americana

Wacrosetella gracilis

Mlcroseteria norvegica

?Herovalanas longicomis

Saat mages

Bichaeta marina

icalande of, sttematus

Tabidocera spp+

Miracia efferata

?Baterping acutifrons

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Previous stuites of zooplankton in the coastal areas of Puerto Rico faze restricted to the bays and shelf regions along the southwestern Portion of the island (Duran 1957, Coker and Gonzales 1950, Bowman and Gonzalez 1961, Gonzalez and Bowman 1955). ?the species found at

Punta liiguero included many of those mentioned in the papers Just cited 485 welll as those encountered in several recent surveys around Puerto agtia,b).

?he range of variability between replicate tovs is similar to

Rico (Youngbluth 19738,

Previous ostinates observed in other plankton investigations (e.g. 20e ?the review by Wiebe and Holland 1968).

The seasonal increase in the abundance of most zooplankton Populations during December and January and the tendency for most groupe to be more mmerous nearshore probably reflect greater mixing of the water column and « higher level of primary production.

LIMTIATIONS OF THE DADA

?the sampling progran was designed to provide quantitative estimates

of: 2) the standing stock of zooplankton, 2) the variety of major taxo-

onie groups, and 3) the diversity and abundance of the more mmerous

copepod species. The manner of field sampling determined the variety

fand biomass of organiaus encountered, ?The data in this report are based

fon collections made in the surface waters during the daylight hours.

?The sampling gear and methods were kept uniform,

e+, net type, net

resh, toring speed, and depth range sample?. A ell mmber of replicate

tove were gathered at each cite to obtain sere measure of the variability

Yetween samples. To obtain a better understanding of the zooplankton

community more sampling with replication should be done at frequent

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ietervals, at a greater mnber of stations, at aifferent depths, ducing the day aod night, and during different seasons for several years, The am of the inforantion gathered in these ways 1 necessary to interpret fluctations in standing stock and diversity in retation to enviromental changes ant biotic interactions.

ACKIONTEDGRENTS

several people helped collect and analyze the samples, including amon E. Cintron, Lin Craft, Juan Miguel Mufior, Gary P. Oven, end oscar Mendez Ortiz. the majority of the chaetognaths were identified by Dre Jose As Suarez-Ceabro. Mr. Peter Willmann wrote the program appearing in Appendix A Root Ms Asensio cheerfully punched data on couyuter cards, ?This work vas supported Ly Puerto Rico Water Resources

Authority Contract No, At(IO-1)K079.

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3

© Benthic OCCURRENCE AND DISTRIBUTION OF THE MAJOR TYPES

| OF EPIIGNTLTC COMRNITIES AT FINTA HTCVERO

! fy: Vance P. Vicente

BeTmoverrox

?An doerease of electrical pover has beccne mandatory in Puerto

ico, due to population grovth and techntesl advances. A proposed

site for a fossil fuel plant is located at Punta Higuero on the vest

sonst OF Puerto Rico, See vater fran the samediate area ill be used

$5 4 coolant and then discharged at temperatures above axbient, In

?the mast there Is been much misuse of coastal waters by pover plants,

and thetr detrimental effect upon marine 1ife has been well docusented

(Zienan 19705 Roessler and Ztesan 1969), To prevent continuing aimee

sed eibeeguent bars, it has also Decene mandatory to evaluate the ecclogical

fet economic character of existing aarine comunities before exposing

?hen to industrial processes.

The purpose of this study was to make a preliminary aurvey of the benthic comunities at the Pinta Higuero site. tn onder to stuly benthic fe adequately three important aspects should be taken into consideration.

2) Determination of the types of comunities, Populations, and epectes of a particular area at a particular tine,

2) Matural changes (i.e. seasonal) occurring within © particular comunity and within its camponente,

3) Their tolerance to the fortheaaing environmental

impacts.

The present field study deals vith the first of th

For additional information consult « previous study of this

site (Semant 1972),

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MATERIALS AND METHODS

sampling was done during tvo periods ~ 25-28 June 1973 and AM-26 January 197h, ?Three stations were designated as sampling

Station A, located north of the dame at Pinta Hguero; Station B, located perpenticular to the done and slightly northwest of the Points and Station C, located south of the Point (Fig. 1). Although vacically the sane dethode were used during both sampling periods, Station B vas omitted fran the secon period due to unfavorable weather conditions.

?the field vork involved a total effort of three divers and 69 san houre (48 man hours during the firet campling and-2i during the second), The survey was done uelng SCUBA apparatus, undervater caneras (Nikonos)*, and collecting bags. Data on the types of benthos, dominant species, types of substrate and other geographical characters of the ares was recorded on an underwater plexiglass slate.

?tree transects were made, Each trancect spanned e distance of apprexizately 1 nautical mile. ?the divers svam along the transects, taking pictures, sampling and recording data. Benthic communities ia depths from 3-27 m vere surveyed in this manner, During the second sampling periol four samples were collected with 1/4 a grid by re- moving all epibenthic forms by hand. A species list, bicmass, and the

relative abundance of each species Were obtained from each of the samples.

In sumary, the results of this study are based on thr

aspect:

1) Field observations and notes.

2) the samples collected.

3) Detailed studios from the photographs taken of the area,

Vales etheryice cited, all photographs included were taken by Vance P. Vicente.

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Ponta itguore

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soANTON A = 26-08 June 1973

rove, ccemcarrons

oisctrate

the botton at auch depths in tiation A contisted of « sant

nbstrate except vhere sponge communities occurred. The stnd

consieted of large particles (approximately 1/2 2 m) and could be

caasatfied as course sant, according to the Wentvorth senie (Bird 1969).

om the bare epote wide ripple marke (aave Length of .3 - 6 m and vave weight of « fev continetere) vere cbaerved, arranged in e westiard

darectten.

A chin tayer of precipitated organte sedizents covered the stat.

om sown sections, thts layer had a green tinge probably dve to small

filamentous algel forms.

Donteant Organ

2. sponges

?As mentioned before, eponges (Forifera) vere the

dominant group, particularly the basket sponge

Xestorpongia mite, ovever, other foms were

quite abundant, including Sbecctomponcia veeparia,

Neofibularis massa (stinzing sponge), Incinia sp.

and Verongia sp. (Fig. 2).

2 pane

other groups of organise were present despite thesr

Limited distribution at auch depths, the red algae

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6+ 2, The sponges, X. muta (basket shaped) and Verongla sp.

(tubular shape in the lover left comer) at

2

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62

Laureacia intricate covered coe parte of the

votton and snetines covered sone of the sponges,

aod to # lesser extent the brova algae Dietyote

sentate and others.

3. Coraag (Octocoratiia)

one gorgonian was observed at this depth. Tie

was Peeutopter sp.

ED ALGAL COVER; SPONGES

substrate

?the botton at these depths vas practically all covered ty alese

land sponges. The substrate ie covered by sand but the inner substrate

consisted of hard rock.

Det atone

Aigae

Most of the botten substrate was covered by an

agerecation of algae. A sample of this alge}

cover revealed that 1t was composed mostly of

the red algae Auphiroa rigide entangled with

other red, brovn, end green algae, but the pre

Gominant form being Rholophytes (red elene).

2. gonges

gponges vere quite abundant throughout the wot. At these depthe the basket sponge

1%. muta, Desmopeamma anchorata, Yerongia 6p.

avd others, toa lese © ent, were quite commons

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Very few coral formations were observed. Only

scattered eal] patches of Neandrina ep. vere

obeerved.

CORALS coRcoNTANS

Dominant Organt ene

?At 18 ma transitional zone (ecotone) occurred between the algal

tnd coral gorgonian ccnmnities, ?Tis culminated at 16 m where corals

and gorgentans formed most of the eptdenthos (Figs. 3 antl). Many fishes

Live anong the coral formations,

2. Gorats

Varlous types of coral formations were present.

Corgontane such as Flexaurella sp., Peerogorgia

anceps, Pooudepterogorgia anceps and others occurred.

Hard corals included Meandrina_sp., Montastrea

cavernosa, Diploria sp., and Dendrogyre eylindrteue

(Fig. 4).

2 Algne

fone algae were attached to the hard substrate free

of coral formations; hovever, the specific daninant

alga! species were not recorded.

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FISES

Many fishes, mostly mall ones, aggregated in and around

?the gorgonian coral formations. These included: A school of over

50 specinens of blue chromi¢, Ghromis cyaneus (Pomacentridae);

4 adult forms and a school of 30 juvenile foras of the blue head

?Thalasscon bifascietun (Iabridae); 1 rock beauty, Holocenthus

tricotor (Chaetodontidae); a small school of the brom Chronis,

Chromis multi2inestus, 1 black durgon, Melichthys niger, (Balistidae)s

and 2 schools of surgeon fish, Acanthurus ep., (Acantiuridae).

Four queen trigger fish, Balistes vetula (Balistidae) and

a fev bicolor dameolfish, Eupamacentrus bipartitus (Pomcentridae) were

obcerved in the deeper wate:

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omar;

?the coral fomations were restricted to a depth of 16-18 m,

+ SPONGES; ALGAE

Av 15-5 m coral fomations were non-existent except for a few specimens of Prerogorgia anceps, Dichocosnia stokesii, and

Meandrins ep. At 12 n, patches of the sponge Anthosignella varians were observed.

From 9-12 m the botton was covered by two main types of growth;

1) sterh mats consisting mostly of the red algee saphira rigige and

Sstangied with other less camen coes. 2) targe patches of the sponge

As varians (Pig. 5).

The sediment in this cation consisted mostly of skeletons of

the deminant algal fom (coralline) Amphtroe sp.

3:25»

ca

At 7.5 my the bottom meisted of algal mat fomations, a fev

matter Tatches of A. variuus and « few gorgentans, such as Yuricen sp,

At 6 my the botton ws

Practically covered by an alge mat of a

Gt#terent composition than those found at greater depths. the algal over at thts depth consisted primrity of the red algae Corsltina ap.

and Jania sp., entangled with other algae.

A sandy tottoa, and heavily {ited water was encountered at

4-5 tm Prem 31.5 m the benthos consisted of miscollancous foms,

However, patches of algae, primarily Coralling sp., seemed to be

Aoninant.

---Page Break---

68

Fig. 5. The sponge A, vartans (pale patches on Lover

Tints lover 1eft and upper right corners)

Gnd red alga in apparent coupetition for

fubstrate at 912 mat Station A.

---Page Break---

6

Many other forms of Life made up the benthos of this shallow

region including Thallasia testuiinum, snail patches of the coral,

Siders

rea sideres, and the sponge Verongia sp. the cbservations

fat this tine were Linited due to poor visibility.

---Page Break---

70

STON A = 14-26 Janu

?the relative distribution of the dominant forms are discussed

?below in relation to their occurrence during the fret sampling period.

SPONGE AGGREGATION

Dibetrate

?me substrate vas generally unchanged fron the first sampling

perid.

Sponges,

The macro-epibenthic fauna consisted primarily

of sponge aggregations (Porifers:Denospongice)

Specimens of the basket sponge Xestospongia muita

?and Ixcinia sp. occurred quite comonly. This is

sinflar to the observations mede during June 1973.

2. Agee

Brown algre (Phaeophyta) such as Dictyota =p.

and Dictyopteris ep. were cbserved groving over portions of many sponges. This cbeervation was

not made during the previous trip. At that tine,

?the red alga (Biotophyte) Iaurencia intricate vas

observer groving on similar habitats,

3+ Gores

?The corr fata observed were considerably sparse.

?there were ac eeleractinian corals, and the coral

---Page Break---

n

fauna was represented only by scattered

gorgonians dvelling among and cn the sponges.

628,

ENTHOS

Sibstrate

Most of the bottoa consisted of a hand substrate, occasionally

Antermupted by sandy channels and sand holes.

Dominant Communit

2s Algae

A dominant algal commnity attached to the hard

substrate was observed. The dominant alga was

?the red alga (Rhodophyta), existing in a complex

arrangement with other brova (Fhaeophyta) and

green (Chlorophyta) algae.

?The most ccumon Rhodophytes included the articu-

lated coralline red algae Corallina cubenese

Amphirca fragilesina, and Jan

However, at 16.5 m, (Table 1) the ealeareaus

red algae Lithothamnion ocesdenta?

and

Goedarthrun albertisit constituted a large part

of the total bicmsa; while at 7.5m, the coralline

@lgns were the principal component (Table 2).

[At both depths mentioned above most of the algae

?aod articulated coraltines were entangled with the

Drow alga Dictyota Linearie and to @ lesser extent

---Page Break---

rR

ext TABLE 1

UW-16 Jamuary 21974

?the relative abundance of the algse obtained at 16.7 =

in sample at station A, The numbers represent the dry weight obtained for each species within the 1/4 m sample.

Dry

Wesent (6)

18.9

Lithothannion cceidentalic a6

Coelarthrum albertisit he

Fae

7

?Bictrote linearis.

Dictvepterte plagiogrens t

ctor

Cqulerpe vickerstac :

Gaulerps wicrophyss -

Miscelancous

?otal

---Page Break---

B

Tor TABLE 2

1-16 Jamuary 1974

?he relative abundance of the algae obtained at 7.6 m

at Station A. the mmbers represent the dry weight obtained for

each species within the 1/4 n° sample.

Bry

weteht (e)

88

Martensia _pavonia -

Dictyurue occidentalis)

Hesugia matics '} a

?Geliaium pasiline

Cuyptorente =.

Phacontyta

Dictyopterts ep. 5

Dickyots Linearie ?

Bictvots sp. 7

cer

Sladephors ep. a

Miscellaneous algse 25

total TE

---Page Break---

?

by Dictyeptorte sp. and Dictyots divartenta.

[A possibility 4s that @ brown alga} bloom may

have been occurring at this site, since this

was observed in many loostions along the transect.

2 Sponges

he sponges Iroinia fasciculata, Cynochire sp.,

Vorongia <p. occurred rather sparsely. Hovever,

?the heavily enerusting sponge Anthosignelia

vartane comonly femed patches anong the algal

mats (Pig. 6).

Several observations vere made concerning A. varians:

1) they were less abundant than during the sumer

of 1973; 2) coralline red algae (Rhodophyta) and brown

algae (Phaeophyta) were observed growing within the

patches which is unusual; 3) some of the patches were

surrounded by layer of mcuous. ?This could indicate

blological interaction within the algne-sponge inter-

face, as many corals and sponges secrete @ mcuous

slime when they are cut, Snjured, or under stres

3. Gorals

coral formations prevailed princtpally in ai of hard oubstrate that were unoccupied ty alge

land sponges, They occurred infrequently, except

ats

?me scleractinian corals Diploria Iabyrinthiforms,

yrnosa, Colpephyliie anaranthue and

---Page Break---

The encrusting sponge (Porifera: Denospongiae)

Anthosignelia varlans as in January 197. The

ence of aigal fatches within then ic

?unusual.

---Page Break---

Dichocconia stokesif formed encrustations and

coral heade on the hard bottoa.

?The gorgontane Bunt

Poeudopterogorgte

Iaxispics, Bunios

sricana and Peoudopterogongia

sp. were observed on the hard substrate.

---Page Break---

SOATION 8 - 25-28 June 1973

The weather conditions were favorable and there was little wave

faction, Water visibility w

approxinately 16.5 - 18 m.

BENTHOS

8o predominant formations characterized the area, except for

Possibly the sponges There vere primarily two bottom types: a sandy

dottom and a bard bottom.

Sindy bottom:

?the sane as that found

near the deep communities in station A, except for the absence of

ripple marks.

Dominant Organi ome

1. Alane

Portions of this candy region were covered by

lene, Ampbiroa rigide and A. feeg!itcetna vere

two conson ones. There vere patches of the

Movering plant Halophiia baitionte groving over

?the sand

2 Sponges

?The only sponge groving here was toe backet sponge

Hestospongia muta, vnich was quite common at these

depts,

---Page Break---

lard bottom:

?This area consisted mostly of coral-sponge aggregations. Many sponges occurred including Xestospongia muta, Sehaeciospongia vesperia, Vevongia longi seine, Y. fistularie, and Callyspongia vaginalis. Many of thege were covered by hydrozoans.

?the predominant coral forms vere the gorgonia:

Bm

RED ALGAL MAT

?me sandy botton was nearly entirely covered by algae. However, there was an underlying hard substrate to which algae and other organtsns wore attached.

Dominant Org:

?the algal mat forming most of the epibenthos

consisted primarily of an entanglenent of the

red algae (Rhodophyta) Corallina cubensis and

Janda adhserens; Coelarthrum albertesti was also

2, Sponges

?sponges were common here, Portions of the botton

substrate were covered with large patches of A. varians,

sone of the other sponges observed were X. muta

(very atundant on the deep benthos bordering the site),

?Sphacciospongia vesparia, Higginsia strigilate and

Desnapsema anchorata,

---Page Break---

°

Corals were not abundant in this region, but «

few patches of Diploria ep., Mon

and Sideractron stderea could be observed encrusting

the bottom. A few gorgonians were observed such

as Pleroyorgia anceps and Plexsurells ep.

BOUIDERS

Boulders were conspicuous, These were spaced between either «

sandy botton or a hard rocky bottom. There are three bottan types

fat this depth: the boulder themselves, ?he sandy bottea, and hard

botten between or among the boulders.

suDy porta

abstrate

A thin layer of organte sediments covered the sand. the ripple

marks were pel and arranged in a capillary fashion, Although there erally unfavorable for

fare exceptions this type of aubstrate 1s

HARD BOTTOM

Most Voulder surfaces were covered by algal aggregetions. A large amount of organic sedinent, polychaete tubes, bryozoans and hydvozoans war observed. the sponges present vere predeninantiy %, muta and a fav other such ae Halictona rubens and Callyspengia

vaginalis,

---Page Break---

inant Ongant ne

Le Algae

This hard flat rotten aneng the boulders

offered good substrate for algn} attachment.

[A red algal mat couposed of entangled Janie

sdhuerene and Anphiroa rigida covered most of

this substrate, Coslarthrun albertesti wes

commen but less so at 18 m.

varians fomed wide encrustations among

the algal mits, A few basket sponges were a1s0

present.

RED ~ BROWN ATGAL MAT

Most of the hard substrate was covered by an

?algal aggregation composed prinartly of two

?types: the red algse (Rhodophyte) Bryothannton

?riquetum, and the brom algae (Fhaeophyta)

Dictyopterts delicatula, less comon algse

cccurring in this

wwea were: Cora2iina sp.,

Janina sp., Valonia ventricosa, Halineda sp.

and a fev thalaeeia leaves.

Sponges

Patches of A. varians on the algal mat were

observes. Verongia sp. and the stinging sponge

Noofitwlaria massa vere also counon at this depth.

---Page Break---

15-3

a

?wo spects

of gorgonians, Muricea elongata

and Bunfees tournefort, occurred in reduced sizes.

Occasional patches of the scleractinian coral

Siderastre

eres vere seen, ?This coral seems

to be quite resistant to sedimentation, ac tt

repeatedly occurred in shalloy turbid water

It has also been cbserved in tide pools of
Anereased tenperatures, vith no apparent adverse
effects.

Tistore commmrrres

Tt 4s knom that the inshore benthos are affected throughout the

year by wave action snd cefiments in suspension; however, detatied

bservations on this shallow region vere not made due to poor visibility.

he mibstrate was sandy, and the portions covered with algal mate

vere underlined by hard structures,

?There were two types of algal cover in this range.
At 3 m there vas @ light algal cover of red fila-
nents over portions of the sand. this algae may

belong to the phylum cyanophyta, which has red accessory pignents (Prycoerythrin) used in photo

emnthesis, At 1.5 ma different algal aggregation

eccurred, consieting prinartiy of two kinds of red

---Page Break---

signe (Rhodephyta): Corsiina cub

sdbaerens,

Seue green algne (Chiorophyta) were conmon st

?these stalloy depths, ?These included Fonictiiue

capitatus, Halineds aiccoidea, Wotes flabelium

and Cladophora fuliginost

2. Corals

coral grovth are Linited in environments heavily

affected by siltations thus only a fev greatly

reduced encrustations of the coral Siderastre

sideres occurred.

3. Sponges

only one sponge, a species of Verongia, vas near

shore. Much of its surface was covered by bul-

ike structures which are probably used tn pro-

pegation.

No patches of A. variang vere observed.

---Page Break---

3

STATION C. Sune 1973

?The weather conditions vere favorable and permitted good water

visibility (18.2 m). there were no bottom disturbances and no wave

action.

?The biotic aggregations inhabiting this area vere characterized

by coral growths, unlike the epibenthic communities found at stations

A and B, These observations are in agreement with amant (1973).

?there vas a transitional zone at 3 - 12 m, which culminated in a

coral comunity. The biotic aggregations on the deeper portions of the

transect 21-27 m revealed that there vas biotic continuity at thie depth.

Similar to Stations A and B, the deep benthos consisted of sponge and

algal formations.

ae

AUGAL zone: (greFOROOTN ZomaTz)

?The abote description of the benthos present is descriptive rather

than real. It does not mean that this alga covered nost of the mbstrate,

?but rather characterized the area by its abundance (Fig. 7).

substrate

the botton at this depth consisted of a flat hard structure vith

few, sandy pockets

Pushes of the bron alga (Phaeophyta) stypopodius

Zonale characterized the area. Other algae covered

---Page Break---

Fig. 7. The brown bushes axe specimens of Stypopodiun

imey were abundant at 3a at Station C.

zonale.

---Page Break---

Portions of the hard substrat

These included

Coral2ina cubensis, Dictyota dentats, Vaoten

fabetns.

2 Gores

. Coraie were cmen despite the reduced size of

the epectos at this depth. The hard corals

(Scleractinian) occurred as small patches or

ncrustations on the hard substrate. sintiesly,

the gorgontans were consistently reduced in ctze.

thie war prebebly due to heavy efitation or wave

action,

?he hard corals which formed reduced petches

or sual heads inciuded Porites astorotdes, Siderastren sidores, Montastrea annularts and

cavernosa, The gorgonians included Martees <p.

Eunicea =

and Ploxauretia sp. they were less

common than the hard corals at thts depth.

3+ sponges

Many specinens of Yerongia sp., decribed tn

?the inshore comunities in station 3, occurred,

An occasional patch of A. varians was observed

[TRANSITIONAL Zone

Mo particular nane was assigned to this zone since the eptbenthos

had a miscellaneous composition. An algal mat ceneteting of tufts of

Janta

wrens entangled with other algae (e.g, Cladophora fultginoss)

---Page Break---

covered portions of the substrate. there vere hard corals and patches

of A, varians. Gorgonians occurred in larger numbers and sizes than

?those at 3m (Fig. 8).

Substrate

?me substrate was hard, rocky and generally flat, except a few

coral outgrowths.

Algal tufts composed of Jenin adbuerens entangled

with other algae covered portions of the ar

Other algae, including Anphtroa fragittesina

and Coraltina cubensis, were prevent.

2. Corate

?the hard corale fommed wider patches and bigger

fomations at this depth than at 3m. Those

corals present included: Siderastrea sideren,

Mesnarina sp., Diploria sp., Montastres cavernost

Mi1lepora ep. (hydrocorallina) and Porities asteroids

3. Sponges

?A. yariane vas the most common sponge, covering mich

of the aubstrate.

CORAL comancrrY

?the previously @iscussed transitional zone culminated at 12 m in

a coral reef comunity. the corals attained full size and fomed a

---Page Break---

Fig. 8. tie pale patches (center) are A. varians, sone

Gorgonians are also present.

---Page Break---

lex aggregation of organiens (Fig. 9). Also, many gorgontans and

occurred, covering most of the algal aggregations.

spones

aibetrate

Most of the substrate had @ calcarous composition, probably formed

by the many corals present, and in cone cases foming boulders (Pig. 9).

Dominant Organt.ens

Awide variety of corals, gorgonians, sponges, and other organias

cceurreds corals were the nost abundant, Algae alco occurred on certain

areas around the coral fomations.

1. Corals (Seleractinia)

?there seemed to be no predominant form of coral,

yet several types occurred. The corals observed

included Montastres cavernosa, Meandrina sp.»

Diploria ep., Isophylite simuose, Ieopyiiiea

ep.) and Mitiopore ep.

corns (Cotocoraiita)

Many gorgonians occurred, and they attained

greater size than at previous shallover depths,

They included Peerogergin sp., Muricen elongata,

flavida, N. sulprurea, Gorgonis ventalina,

?and Bunicea toumefortt.

A great variety of sponges oceurred on the coral formations, sone of then typical of coral reef

conmnities. There were the following: Gelliodes

---Page Break---

1. 9. A coral commmnity which occurred at

---Page Break---

areolata, Callyepongia vaginalis, Sphncctospensta vesperia, mall specinens of Xestospongia muta,

and Hizeinis ep. Other less conspicuous forme such as Microcions sp. formed thin encrustations

con the undereide of corals and over the surface

of dead corals, and Clions caribboes and Clicna sp.

barbored the inner calcareous structures.

28-27

DEEP RENTHOS

Sponge aggregations appeared to be the dominant group in this

region; hovever, these deeper regions vere difficult to characterize

Gue to the Limited bottom diving time.

Despite the Limited campling, three different bottom types were

observed: 1) candy flat bottoms 2) boulder-like structures with many

gorgonians

1nd a few coral patches; 3) doulder-like structures with

few gorgonian or coral formations.

Deep sandy bottom

thie type of bottom was observed at depths of 27 8, 2h m, 2m, an 18 a. In contrast to the sandy formation at station A, there were

no ripple marks observed and the formation was flnt in structure.

Similar to Station A at these depths, there wae @ thin layer of organic

sediments covering most of the sand. ?These areas were nearly devoid

of sarine Life, except for « thin layer of filamentous green algne

covering sone of the substrate. There vere no starfirh, sand dollars,

or any of the connonly found sandy bottom organisms.

---Page Break---

Boulder-like structures vith gorgonians, (18 m)

There vac a great variety of organims attached to the:

etmctures.

Most comon of\these were the gorgontans

slong with & few coral en-

crustations and sponges (Fig. 10). Ae found at Station A, the red algse

Jaurencia intricata covered many of the sponges and portions of the

Doulders. Alco, an unidentified species of hytrozoa and a few bryozoans

were on these deep boulders.

?The gorgonians observed included Bunice: laxtepica, Diodogorgia

notulifers, Plerogorgia ancepe and P. eftrina.

Frobably the most common sponge at this depth was the basket

sponge Xeetoepongia mite.

Boulder-1ike structuree-no gongontans (27 a)

The boulders at 27 m lacked the gorgonian formations found at 18s.

Instead, mich of their surface vas covered ty algse such ac Iaurencta

Anteis

ta, Coslarthrun albertecit, and Jania adhaerens (Fig. 21).

Onty one type of hard coral, Montastres anmlaris, was observed

groving on portions of these boulder

Many specimens of the sponge Xectoepongia muta were also found.

rises

Fish were coanonly found in and around the coral formations.

?The cbserved species included: 3 epecinens of Halachoeres bivatta:

(tabridse); 12 epecinens of Dupemacentrue partitus (Ponacentridae); 5 adult

blue head wrasces and 2 juveniles of Thelassoma bifasctatun (Iabridae);

2 queen triggerfich, Belister vetuda (Baltetidae); 3 groupers (Serranidae)s

5 surgeon fish, Acanthurts bahtanue (Acanthuridae); and 3 squirrel Sish

(Holocentridae).

---Page Break---

Like platforms with eeveral gorgontan

---Page Break---

fe platfome nearly devoid of gorgonians

---Page Break---

---Page Break---

95

Tor BLE 3

W-16 January 1974

?The relative abundance of the algae obtained at 6 m at

Station C. The munbers represent the dry weight obtained for each

spectee within the 1/4 n° sample.

Bectes

Rhodophyta

Auphiros ep.)

ania ep. d a

Hldenbrandia prototypus)

Gelidiue pusttiun :

Martensia?pavonia -

Dry

Weight (g)

Pracoptyta

Dictyote sp. a

lacettaneoue ae

ror 2.8

---Page Break---

3xP TABLE 4

e16 January 197%

?te relative abundance of the algae obtained at 18 =

lat stator C, The numbers represent the dry vetgnt obtained for

each species within the 1/4 n? sample.

Socies Dry

Weight (6)

moteptyta

corailina cubensis)

depres y aot

Dictyurus occidentalis 3

Coelarthrun alberteci 2

Gelidhum pteLLios te

Mirtensia pavonie :

Phacot

Dictyots sp.

iyota linearte

Digtvota Linearte

Bctvopteris hoyELt

Padina =p.

chiorephyta

?otal 2.3

---Page Break---

v0

conposed of articulated coralline red algne auch as Coralling cubensts,

Ampbiros ep., and

the brovn algae, Dictyota sp. and Dictyopteris sp. were observed living

© macroepiphytes and entangled within the dominant coralline red algae.

ibe:

Similar to the findings at station A,

Generally sparse coral fauna was observed. Gorgonians and en=

crusting corals vere rarely observed on thote boulders with available

hard cubstrate,

---Page Break---

prscusstos

?Ton different epitenthic associations were observed throughout,

?the study (Pigs 12):

2)

4)

?)

8

?

8)

9)

10)

sponge coemunities inhabiting the deep benthoe at all three stations.

Corals and gorgonians aid not ccur widely, probably due to the

Limited Light penetration at such depths, Light ts essential

for the grovth of corals since it 4s required by the symbiotic algae thet

sist then in caleification and other phystologicel

processes

fed algae communities usually among the patches of A. varians.

?hts situation was common at all three stations;

Cora communities, encountered at station A at depths of 13.5,

and throughout Station ¢, particularly at 12 m

Boulders at Station Bat 12

Red and broun algal communitics at 6 - 7.5 mat Station Bs

[A Stypopodium zonsle zone inshore at Station Cj

poulder-Like structures with gorgontane at 18 a at Station Cy

Roulder-like structures with no gorgoniane at station C at

ah = 27 as

Sandy bottoms with thin layers of organic sedimentss

sandy-ailty bottoms inshore at stations A and B, harboring

miscellaneous Biotic aggregations.

---Page Break---

1 NAUTICAL MILE

(ABH FD,BROWN BLGALMAT AA SPONGES

& s zoNALE vse SAND

CULE LIKE: Wr ?A VARIANS

SS ee HS

?2% RED ALGALMAT

©@ Haro coral

Fig. 12, Map iNustratiog the dteteibuting F corcoman

of the vmjor epitenthic agrregntions

at Binea Ripueroe

AA, souLceR LiKE WITH

?SPONGES

= SANDY SLTY

---Page Break---

00

?There 1s a tendency tovards dominant algal populations north of the

Point, while on the south of the Point there 1s a tendency tovarde

coral formations. However, there are coral reef formations slightly

north of the Point, (Station b, 16.5 m) although not as extensive

those occurring south of the Point. These observations, made during

?the sumer study, agree in sone ways vith those made by Semant (1973).

Most of the hand substrata occurring in the deep sublittoral zone north of Punta Higuero harbor benthic fauna eamposed principally of algae and sponges. A major change seemed to occur in the benthos Guring the winter expedition. The sponge Anthosignela vartans formed large patches, eonetines covering several square meters of hard sub-

strate, Hovever, almost all the patches of A. varians observed during

?the winter eampLing were smaller than thove observed during the sumer sampling. Algal aggregations were observed within the sponge mate

which {2 unusual. A mcuous sline within the spong

gal interface

on some patches vae cbserved, possibly indicating biological interaction.

?A transition in which algal communities deminate the sponge for-

mations ceened to be occurring. It is not known 4f thie ie a

jon

phenomenon, since no previous data are available.

one cause of successions within the benthic fauna at Punta Higuero

may be the influence of the nearby Affasco River (Fig. 13). the silt

clay and other terrigenous matter transported to the site would have

some affect on the benthic organiens. Hovever, no statement can be made

concerning the degree of the river's influence without further research.

---Page Break---

Fig. 13, Aerial photograph of Punta Higuero taken

during the winter of 197 tiiuetrating

?the sediment transported to the south

?round Punta Higuero,

ee

---Page Break---

aoe

ACKIONLEDEBENTS

?mis study was accompliched through a cooperative group effort

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04

B.D. Martin & Jie Patus

The fishes of the Panta Higuero site have Been sampled

by a mmber of methods. ?hey have deen taken using dip nets

sand rotenone and have been identified by svinming through an

?area and from photographs taken by the benthic team, Table 2

sts the species identified frou this area and the nethod used

to sample then. ?Tble 2 Iists only those species taken by rotenone ant the mabers taken at each station. For locations

of these stations sce Pig. 1. o samples taken thus far

have turned up epectes which are unusual for this end of the

sland snd all epectes thus far can be characterized as reef,

rocky shoreline, pelagic or candy bottom dvelling species.

?the habitats which these f1ch prefer are more or lees contin~

uous fran Cabo RoJo to Aguatt2ia and all have pelagic 1arvae

except for the blennies. Wide spread danage to these species

?then scene unlikely, Saupling 4¢ proceeding on a quarter

oar basis and will be contimations of the sampling pro-

cedures above.

---Page Break---

"Sampling ? **Normal,

Species Method habitat

Echidna catenata - Chain Moray R RE

Gymnothorax sp. - Moray (juv.)

Harengula clupeola ~ Palse pilchard

Jenkinsia lamproteeria - Dwarf Herring

Arcos rubrigenosus - Red Clingfich Rk

Atherinomorus stipee ~ Hardhead Silverside P

R RE

R

8

R

R

Adioryx vexillariue - Dusky Squirrelfish R RE, Rie

s

8

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Holocentrus ep. - Squirrelfich RE, Re

Serranus sp. - Grouper RE, Rk

Malacanthus plumieri - Sané Tilefish SB

Garanx fuscus ~ Bluerunner >

Garanx ruber ~ Bar Jack Pp

Lutjanue apodus ~ schoolmaster 8,8 RE, Rk

Haemulon parrai - Sailorschoice R RE

Pseudupencus maculatus ~ Spotted Goatfish S$ SB

Pempherie schomburgki - Copper Sweeper ?§ RE

Fomacanthus arcuatus - Gray Angelfish P RE

Abudefduf saxatilis - Sergeantmajor R,DS RE, Rk

Abudefduf taurus - Night Sergeant R Rk

Eupomacentrus leucostictus - Beaugregory $ RE

Euponacentrus variabilis - Cocoa Damsel § RE

Euponacentrus op. ~ Danselfich P RE

Mugil liza - Lize > P

Mugil sp. ~ lullet (juvenile) R P

Thalassoma bifasciatum - Bluehead DS RE, Rk

Unidentified small wrassee R,P RE

Scarus sp. ~ Parrotfich s Rt

Sparisoma sp. ~ Parrotfich s RE

Dactyloscopus tridigitatum - Sand

Stargazer R SB

Blennius cristatus - Molly Miller D Rk

Entomacrodus nigricans - Pearl Blenny R Rie

---Page Break---

?sampling **Normal

Species Method habitat

Qphioblennive gtlantious - Redlip blenny S RE

arigentified juvenile blenny R

Acanthemblemaria spinosa - Spinyhead

?_? blenny D Re

coralliozetue gordonae - twinhorn Blenny PD Rk °

Taorigomus guppyi - Mimic Blenny R Re

Tabrigomus puchipinnis - Weiry Blenny R RE, Rk

Nialacocterus yereicolor - Barfin Mlenny RyP Rk

Paraclinus faseiatue - vended Blenny K Rk

Unidentified juvenile clirid R

Bathgobiua soporator - ¥rillfin Goby R Rk, RE

Acunthurus balianus - Ocean Surgeon 8,P RE

Acanthurus coeruleus - Blue Tang 8yP RE

foanthurue ep. larval R

Balistes vetula - Queen Triggerfish P RE

Melichthye niger - Black Durgeon P RE

Rotenone stations, 15 & 16 January 1973,

Re

£2 Stinning mostly around "Steps", July 1972.

$I Photopraghs, benthic team samples, January 1973

fz pipnecting 18 February and 6 May 1972.

wert = Coral Reef fishes

fk = Rocky shoreline or Rock Reef area fish

'P = Pelagic

sb 2 Saray bottom, or sand patch species.

---Page Break---

17

COLLECTING SITES

Beach near Tofito's Place.

Phonic Rock - a large rock formation on Punta Gorda.

Splash Pools N. of Dome.

Rock Groin and protected water at the old Honus outfall.

Rocky shore between Dome and Lighthouse.

Rocky shore just S. of Lighthouse.

Surfer's Beach

?Small channel in the beach rock N. of Steps.

Funnel behind a beach rock outcropping N. of Steps.

Steps

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EXCNE SAMPLES

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Surfer's Beach

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© at least some specimens were juvenile

?Splash Fools W oF Ta

Teck GFoin wt Pome

Focky Shore beiweer

Teel] Channel TF Bem

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APPENDIX A

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would cut the beach at the dock area so there would be a "north beach"

accessible from Agusda and "south beach" accessible fron near the gate

to the PRVRA eite

With ready accees, adequate of1 ep{21 guards, and planting to screen

?the area from the public there should be no lose to recreational or

aesthetic values.

---Page Break---

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wr

Fauna observed in Pinta Kiguero was restricted. This was partially

Que to a natural paupsey in local taunt

Alto transect observations ao

ot get many of the more shy or rare bints or animals. These require

trapping and covert cbsermation. Macrofauna consisted mainly of pelicans,

Pete, mongoose, cats, and dogs. All, except pelicans, are introduced

pest species.

FAUNA Ls?

Reptiles and Amphibians

Leptodactylia frog

?Anolis crystatelue

?Anolis sp.

aves

Crotophage ant

?Tyrannus demtinTcensts

Mims pelygiottos

Guiscalse niger

MAMALS (native)

Hoctttonta bat

---Page Break---

[PROBABLE UNAVOIDABLE ADVERSE EFFECTS

?me most probable adverse effecte are those physical effects relating to removal of the vegetation for develoypent and disruption of run-off patterns. Nothing can be done about the former. A partial compensation ccan be made by planting fringe areas (Possible Remedial Actions). This action, plus care in grading, should help in advoiding the bad effects of Aisrupting run-off patterns.

POSSIBLE REMEDIAL ACTIONS

Designed Successional Forests:

Many attractive and useful plant species are normal menbere of the

secondary successional forest. ?These include coconuts, almendras, mangor, royal palne, tanarindo, cocoloba, casuarine, spodille (sanitkara),

Flasboyan, gumbo Lisbo, ete, ?These hardy spect

can be planted along

roads and the perinetere of developed areas. This would serve to (a) promote

natural succession, (b) provide « acreon agsinst noise, dust, anbient heat,

ete, (c) cover the plant from public view

Jn Front, Parke:

?the beach areas of Puerto Rico are considered public domain. Therefore,

any unsightly, hatardous, or prohfbitive developuents are undesirable. By

?and large, the beach front areas (etippled in Fig.3) are not planned for

extensive develoment. Much of the scenic beauty and community value could

be preserved by leaving existing natural sreas, planting trees along road (oy the fences) and between the beach and the plant and vater front (dock)

area, Bxclusion fences for the PRWRA facilities would be eosential, thio

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TABLE 3. Species iist for the secondary successional forest

on the Limestone Hille at Punta Higuero.

?TREES IN THE SECONDARY FOREST

TEER IN TE SECONDARY FOREST

Artocarpue altilue

Bucks buseres

Suusere simarat

Cacearte gulanenete

Govos nucifera

Hieus stahiit

Guares trichtiiotaes

Mangantfere indice

Piper aduncus

stones borinquetia

SEES Sate

?Temainatia catappe

Zanthoxylun- martinicense

soups

Daggene hireuta

Tantans Tavolucrata

?canara

?Sovanug tGrvum

Urenw ep.

vies

Abrue abrus

sa ep.

iis ?Euadalupensis

Faseiflore sp-

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Hees

Adiantum ertetutun

Folypodium ep.

Camphyloneurun =p,

Tectaria heracteifolia

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?TABLE 3. (cont.)

HERBS

Anthurium

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Digitaria sanguinalis

Fleas ope

?Sporsbolus sp.

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Figure | = Collecting Stes

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no

Additions to the Fish Species Lists

for the

Punta Higuero Site

by F. D. Martin

(12 March 1974 two shoreline rotenone stations were done. One was at the station designated as Picnic Rock in the 1973 first quarter report and the other was at a beach rock outcropping between stations 7 and 8 of that report.

Species taken are as follows:

Previously Picnic Station

Species Reported _Rock 5

Echidna catenata-Chain Moray x

Grmothorax sp.-Noray (Suv.) x

Grmothorax vicinss-Purplenouth Moray x x

Harengula clupeola-False Pilchard x

Harengula hueratis-Redear Sardine x

Jonkinsia lamprotaenia-Dearf Herring x x

jachoa lanprotaenia-Bigeye Anchovy

?Arcos rubrigenosus-Red Clingfish x

Opsbia sp.

Parophidion schnides-Dusky Gusk-eel

Atherinonoms stipes-Hardhead Silverside x

Adionyx vex

Scorpaena plumieri-Spotted Scorpionfish x x

Epinephalus adscensionis-Rock Hind x x

Dusky Squirrelfish x x

Serranus sp.-Grouper x

---Page Break---

Pseudograma gregoryi-Reef Bass

Rypticus subbifrenatus-Spotted Soapfish

?Avogon maculatus-Flanefish

Nalacanthus plunieri-Sand Tilefish

Garanx fuscus-Bluerumer

Garanx ruber-Bar Jack

Trachynotus goodei-Paloneta

Lutjamus,apodus-Schoolmaster

Haemlon carbonarium-Caesar Grunt

Haemilon parrai-Sailors Choice

Pseudupencus maculatus-Spotted Goatfish

Rempheris schonburgki-Copper Sweeper

Guetodon striatus-Banded Butterflyfish

Pomacanthus arcuatus-Gray Angelfish

Abude fduf saxatilis-Sergeant Major

?Abudefduf taurus-Night Sergeant

Ewponacentrus fuscus-Disky Dansel fish

Expenacentrus Leucostictus-Beaugregory

Euponacentrus rariabilis-Cocoa

Dansel fish

Mugit Liza-Liza

Mugil sp. (juventtes)

Doratonotus megalepis-Dearf Wrasse

Halichoores biviteatus-Slippery Dick

Halichoores maculipina-Clown Wrasse

UaLichoores posyi-Blackear Wrasse

Thalassom bi fasciatun-Bluchead

Scams sp, -Parrot fish

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Sporisona chnysoptenm-Redtail Parrotfish

<rnrisoma radians-Bucktooth Parrotfish

<parisona rubripinne-Redfin Parrotfish

Tuctyloscopus crossotus-Bigeye Stargazer

ductyloscopus tridigitatus-Sand Stargazer

Gittelus rubrocinetus-Sadéle Stargazer

Blemius cristatus-Yolly Miller

Entonacrodus nigricans-Pearl Blenny

Ophiobtennius atlanticus-Redlip Blenny

Acantherblesaria spinosa-Spineyhand

Coralliozetus cardonae-Twinhom Blenny

Labrisomss buccifenus-Puffcheek Blenny

Labrisoms guppyi-Minic Blenay

Labrisomis nuchipinnis-Hairy Blenny

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6,144.3 Ecological Parameters

TERRESTRIAL SIRVEY

By

Md. Canoy

Burnopuerron

?The terrestrial ecology of the Punta Higuero proposed pover site is divided into three broad coumunity regions: (A) coastal beach and Limestone communities, (B) eueceseional plains, and (C) ary Limestone. These are sub-provinces of the dry coastal (Little & Wadsworth, 1946) province, The Punta Higuero cite and bordering area was surveyed in February, 1973 ant 1974, For this purpose three transects were walked (Pig. 1) from east to west and three north to south, From these samples, species Lists and locale of plant communities vere established. From color aerial photos of the site, and referring to the eurface transect data, a wap of plant communities vas dravn. Three spot checks were made An anomalous areas (narked, Fig. 1) to verify local conditions.

Faunal Liste and region of occurrence were compiled by observation. ?Avifauna includes the sea birds ae well as terrestrial species.

?The structure and appearance of any ecological association depends primarily on the species present and the relative mmbers of each. Ina

normal tropical

enblage, the nunber of species might be very high. Rnerto Rico, hovever, is & densely populated and severely disturbed area. ?Also, At Le an teolated place in terms of zoogeography. Practically all rennants of the original forests are gone. In most cases, the ?nature?

forests are secondary or tertiary forests.

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Mach of the island is kept in a permanent state of succession due

te constant interference by man, The Pinta Higuero site ts no exception

to thie.

Jo determine the present and possible future trends of succession,

we followed well-established ecoldgical techniques, ?the accuracy and

completeness of the work is more or less dependent on the activities of

fan, both locally and "up wind".

wigan

te generat area is a nore or less xerophytic couatel regise on eand

ft Linestone with a narrev coastal plain of heawy clay. me 200 years

ago it vas forested with dry country hard woods. Wien these vere cut for umber and fuel a secondary forest began. This vas cleared off the plain rea for cugar cane and off the hil2e for fuel.

Signr cane culture continued until shortly before RRA acquired the and for the Bonus Reactor Project (approximately 1958). The area between incon and Punta Higuero is st{I2 in agricultural use for cane and for pasturage.

en MRRA butt the Bonus Reactor al the atte not used in cone struction returned to a tropleal old field mueceeston. A few large bread fruit (Artocerpue

Fins (Soystonea boringuefa) remtined but the major vegetation wae acact

}) Australian pine (pifiero, Casuarina) and Royal

?wines, and herbs, This grew to cover most of the plain and the lover hilletd

Hovever, most of it was bulldozed avay in January and February, 197h.(Rig. 2).

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AND comsnerriE

?he Beach Association (Map, Pig. 3) at the eite te quite typical (Fig.l).

?the dominant trees are the alnond (ainendra, Serainalia cateppa), sea-grape

(ova del wan, Coccolobe uviters), and coconuts (cecoa, Cocos nucifera).

Numerous sal shrubs, herbs, and vines form @ ground cover under the trees,

Germon among these are mother-tn-lay toungues (Anthariun), tantana {nvolucrata,

Awana wp.» and Solunun syp, Other species included are Seacvola plumtert

Crotalaria retuse, Bidens pilose, Erithetarie sp., and Bugenta sp.

The beach conmunity serves to hold the sand against vind and water, to

ako mums, and provide a basis for successional forests to follow. Also

on a densely populated, touret-oriented Leland, such as Puerto Rico, tt serves to hide less esthetic aspects of farms, barrios, and industry from Public view at the Beaches. For these reasons it should be preserved.

On a emai rocky point south of the Bonus plant there are a fev

Aguave and Plunierta

fand beach rock conglonerate.

Mais outcrop i sand and clay over a limestone

A Ut of the major species observed in the beach community is seen in Tabie 1.

Clay plains at the foot of the hille represent the most disturbed

sector of the site. This ares was cut over for timber many years ag0,

then cultivated, and finally left undicturbed when FRNA put in the Bonus Plant experiment. It was covered with old sugar can and cancilla (Leucaena

@lauca) (Fig. 5). Well over 90% of the biena:

was in these two specie

During the winter of 1973-7 thie area vas bumed and bulldozed by PEVRA 4n

preparation fer construction (Fig. 2).

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Pigs 3+ Coxmunity map of Punta Higuero site

Showing apprexizate boundrie

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TABLE 1. Beach community species list.

TREES end saws

. Gocos mucifera

. Goceoisbie wvitera

Shryscbalanus Teaco

?Tantena Iavolverata

?Flusierie alba

?Temminglia cata;

Eeiuialte tmuctistee

Sitharexytiun Fructicosun

?Scuevote plumieri

?Tantana ?camera

?Solem forme

HERBS and VINES:

Heitaofere suffriticos

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Hymenocallie littoralie

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?the fev large trees left on the plain are casuarina (Casuarina

equestrifolia), panapen (Artocarus altilis), elmendra (Terminslia catalappa)

?and pana real (Roystonea boringuefa). The species list for plants ts found

An Table 2.

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TABIE 2. Gyectes List for the plant community on the

coastal plaine at Pinta Higueros

TREES and SEES,

Aantana involuerata

?Tautaena glauca

Artocarpus alttite

Sasuaring: equiestritolie

?Terminalis eatappe

Handia aculeate

?Bleue torn

HERBS and vines:

Tpewes exp,

Hmmeltia fetreptyiia

Crotalaria fetus

Tndigeters suffriticoss

Bizschytarphets jamaicense

Hywenocallis 1ittoralis

oRASES:

loworatus

Sentels indicus

8. porratit

Digitaria songuinatis

Setaria geniculate

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SECONDARY SICCESSTONAL FOREST

?The Limestone Hills plant association ranges fron the dry con-

munities on the western elopes of the hills to moist forest stands in

oy areas of the eastern clopes. thie

soeiation has not been seriously

Sisturbes for 15-30 ye

Tt may serve as a propagation source for

re-population of the undeveloped portions of the plain area.

ear the base of the hills

re Jeucuone glauca, Bursera cinarba

and Zanthoxylus martentcinoe, ?These are over en under-story of Piper spp.»

Dieffenbachia, Pothomorphe, Randia, Urena, and Jsarantius. Young mangos

(yangifera indica) and Royal Pulme (Roystonea boringuefia) are appearing cn the slopes fron a fev mature individuals up the hills. The grass and

sugar cane from the flat area grad

nto shrubs and scrubby trees, No true denarcation can be made, A return to the mature forest would take a long period of tine, A species List appears in Tuble 3.

?the drier areas of forest do not have'a large ground flora but they fare difficult to walk through due to the munerous tree trunke, interlocking

branches, and thorn:

Prominent trees are the gumbo Limbo (Bursera simaruba), guebracho

?Thounia striata), and guaranguso (Guarea trichilicides). On the east

of the properties there are two moist valleys. Here are found mangos (vangifera indica), panapen (Artocarpus altilus), sone of the climbing

grasses, Lasincis and Abrus, also occur here. -

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APPEIDIX D

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PRELIMINARY OBSERVATIONS ON THE BENTHIC COMUNITTES OF THE PUNTA HIGURRO SITE

By

Alina Semant Froelich, stephen Martin,
Beverly Buchanan, Robert Castro

Bermowwerr08

?he Punta Higuero area ie under consideration as a possible site for the construction of a fosail fuel power plant. sua vater is to be

utilized ae a coolant and 1s later to be discharged into the immediate

environment at ax elevated tenperature, This action may have detrimental effects on the shallow water comunities of the insular shelf surrounding ?tho Punta Higuero site. Unlike flahes and scae of the plankton, the benthte organims, in wos: cases, cannot relocate thenselves pereanently or even tenporarily if they are being adversely affected by the increased temperature. Tt Le therefore important to determine whet benthic assexbleges are present, their areal extent, their sensitivity to increased temperatures, and their econemie importance to the nearby human communities. The insular shelf surrounding Panta Higuero is very narrov, ranging in vidth from approxinately fone to four kiloweters. Tt 4s an open unprotected area, influenced ty the targe North Atlantic vel north of the Point and by the Caribbean sea and Mona Passage currents south of the Point, resulting £: a complex current

pattern most of the year. The majority of the coastline in his area constets

of rocky outerops and unprotected beaches and there are few protected arens.

?AZeo, although no large rivers discharge inte the area,

say be influences

sonsily by the Afasco River south of the Point and the Culebrinas River of

@ Polat

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sitlal observations in the area (Puerto Rico Nuclear Center, 1972)

rocgested that the benthic ccumunities north of the Point might be aifferent

= those sou

of the Point, Therefore, our group first svam transects

ruAfeular to shore in areas north and due west of the Point, and also

uerved areas south of the Point, to detemine the couminity types present

and specifically the areas that woul? be sampled in detail, Observations

fron these and subsequent dives seen to confim that there 1s a transition

from a predeminately benthic algal community north of the Point to a pre-

dominately coral-sponge cemmnt'y south of the Point. As will be further

Asecussed later, this may be an ?nportent consideration in the design ant aocation of the plant.

semicos

entnte ccamunities in the near and offehore vicinity of Pinta Higuero wore observed and sampled fron January 16-19, 1973. PreLintnary observations Jaan with vieutl and photographie observations approximately one nautical

tle northeast of Punta Higuero, utilizing SCVEA apparatus and svimming « uransect perpendicular to the shoreline fro 60 to 15 foot depths, covering

?fn dottom area of approximately 4,000 square meters (m). Similar bottom ?servations were obtained adjacen: to Punta Higuere (20 to 40 foot depths) ?veerving an area of approximately 2,000 u®, and also approximately one nautical mile eouth of Punta Higuero (35 to 45 foot depths) observing an ?approximate 500 m2 area (Figure 1). Divers recorded basic tnformation relative to benthic community types, dominant organtens, botton composition, and

physical observations, including current strength and dire

jon, and vi

bility on plexigiass elacec, Alco, the area vas photographed ané repre-

ve crgarieny soMected lent Laboratory study.

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1 mile)

Figure 1.

Location of shore and offshore sampling stations

at Punta Higuero, Shore stations are listed ac PS-1,

RS-2, and RS-3, while offehore stations are munbered

Roz through R-5, Observation éives are shown as 0.

to0,. Dashed zines represe:t 30 ané 60 foot contdur

lane:

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?Ay Station selection

Based on these observations and on other previous pre-

Linary observations conducted by Puerto Rico Muclear

Conter biologists (PRI, 1972) Five offehore stations

tablished for more detailed study: Stations Rel,

(25 feet depth) and R2 (ls feet depth) approximately one

nautical mile northeast of Punta Higuero; Stations R-3

(35 feet depth) and Rel (65 feet depth) dizectay adjacent

to Pinta Higuero; and station RS (25 feet depth) approxt-

od)

mately one nautical mile southeast of Pants Hquero(

Also, three shore stations were ectabliched, one at Punta

Higuero, RG-1, and two others, located one nautical mile

northeast and southeast of thie point, RE&2 and RS3,

respectively (Pig. 1).

Seation sampling:

?The sampling techniques at Stations Rl, Re2, Rel, and RS

were contueted ae followe: three divers

corded to the

le area and asceabled the tvo meter-equare quadret samp)

apparatus, consisting of four metal role, each tvo meters

An length, and six nylon Lines connected to the rode at

one-half meter intervals, establishing 16 quarte--neter

square areas. Wille one diver photographed each smal?

(2/4 m2) quadrat in sequence ant then the {mediate

surrounding area, the others recorded observations of bottos

organisms on plexiglass teblete and collected representative

organisms from the iemodiate area. then all divers re-

Astenblod and removed the benchie assemblage free. 4 re-

precercative Y/t Pauadre:, efter ueing @ hammer 1

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to remove sections containing encrusting and/or boring Organise that vere impossible to renove otherwise, the samples vere imediately placed in large plastic bags, held next to the collecting site by one diver, in order to comure that mall free-living forms such as erube and Drittle stare could not escape, As the botten area at Station R-3 was composed alnost entirely of sand, vith Little biomass, quadrat samples vere not obtained but rather three 400 cn® samples vere taken with « standard Bekman dredge. these saaples vere sieved through a series of screens, mesh sizes 1/8 inch to 1/2 inch, and the re- ?ined organtans placed in sali plastic vials. As for the shore stations, benthic organisms were cbserved and/or collected from a variety of habitats, including tide pools, attached to rocky mibstrata, and burroved in send. Also, organisms washed up on the beach vere collected, usually ?frou the upper sendy beach zone.

©. laboratory ansiysee:

ALL samples were returned to the laboratory, eorted into Phylogenetic groupe, weighed, and preserved in 7Of ethanct

for later identification. Corals vere weighed, subject te clorox digestion, dried, and weighed agsin to estinate

the amount of Living aninal and plant material present,

Also, large pieces of rock vere split apart and various

creantars renoved for identifieation. Pinally, pieces

of mbble that remine? after most encrusting and bering

organise Sad been removed vere weighed and the velghts

muteiotia

by A factor obtained from previons work (Seman?,

5:72) 20 eatinata the

organior eft in the ibe

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ALL eaJor groupe of benthic organtams, including sponges,

corals, gorgonians, molluscs, annelids, crustaceans, and
?echinoderms were classified to genus and species vhen possible. However, due mainly to tine Limitation, the classification of stpuneulide and other minor phyla wae not attempted, Therefore, informtion was obtained on species composition and total biomass for each 2/4 n?

quadrat sample collected.

D. Photographic analyse:

?To augnent the laboratory studies, photographs obtained

from the transect observations and from station aress

surrounding cach quadrat were studied and those with representative commnities were selected for ineluston 4 the report. Ih addition, photographs fron the station quadrats were projected onto specially prepered graph paper, and cores, sponges, and algne cover outlined.

men the percentage bottom areas cccunted by these groupe were calculated and reported as percent 2 =~ guadrat cover.

means

A total of 27 mn-diving hours were epent cbserving and collecting the

senie communities, vo transects, one spot check and five quant!

spies were obtained, In addition, six man houre vere spent cbserving and

collecting organtas frou the beaches snd rocky shore areas. The results

with be atvided into descriptions of the communtties observed and an evalue

atlon of the quantitative data btatzed.

description of Benthic Cominstics

1. sandy Botton:

?ery few organiers roe" +2 ?ve in or on ?hie betic

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type, Wo sand dollars, sea pansies, sea pens, or other usual sandy bottoa organims were cbeerved.

This bottom type was found near shore, out to 15-20 feot in depth, and interspersed vith higher and harder dotten types farther offshore (20 to ho foot depths) in other ares

Tn the future, aerial photcgraphe will be used in determining the areal extent of the sandy areas.

2, Shaliow algal (soft botton):

Taie bottom type was observed in the shaliow (15-25 feet)

oar shore area north of the Point, Figure 2 4s « Photograph of @ 1/!\ n® aection from this area, Tutte of benthic algae on a sendy bottom characterizes thte community types Oly an occastonal. sponge or gorgontan Antermupt the fairly Lowogeneous substratun.

3+ Shadow aiged (hard bottee):

This botion type extents outvard fron the previous one,

fron approximately 20 to 35 feet in depth. Lese sand

4s present which permite gorgontans acd sponges to

?became mich more abundant, Tn addstton, locee cobbles

provide sary invertebrates (brittle stars, crabs, ete.)

with shelter. Only occasional encrusting coral colontes

were present. Tals type of bottom was observed both

north anf due west of the Point in the above mentioned

depth range, Most arens where thts comnity type vas

found had fairly ?regular botton topographies.

4 peep atgat (tar? potter):

Sponges become incressingly more importen: with deptibs

Many of the algae tn thie gone are axa!

?4 encrus

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Gorgonians also increase in iapertance. Occasional beads of Montastres cavernoe ard Sideractres sideree exerge frm a gently sloping botten and mary fish wore observed oviaming in the area, utilizing the corals for foal and protection, ?The trancition between the three algal zones 4s, of course, gradual and the relative extent of each zone depents on the bathymetry ?and on the wave pattern affecting each particular area.

5» Deop gorgontan-sponge-coral:

?Mts botton type was fount only west of Punta Higuero, fat a depth of approxiaately 65 fect, and vas characterized Dy & sparse overall botton cover. the ares vas different from other coral comminities observed because of a much

lover density of cover organises. Most of the encrusting

corals, such a& M. cavernoss, Diploria app., Agaricta sgaricttes, Pavia fragun, Isophyliia epp., Musse anguloss Porites astrecides aod Yycetophylia Iasavciana were ange gorgoniane (mary Bunfceas and

Gorgonias) and several large basket sponges. The botton

prevent, as well

was very drsegular with up to 10-feot variations in dept.

che deeper areas were covered with soft silty seinen

only @ few gorgontans ant pores. < igure 3 te a Mi

section of the bottom in th:

6, Sariow corel- sponge:

this bottom type was encountered couth of the Point free

approxinately 20 fect to 35 ie not,

?ovn bow far covante shore ay no how

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g Racrcalgne interspersed with occasions]

rubble and hard sandy

Photograph by A.S. Froelich.

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PIGIRE 1, otograph of

large sponges,

(Kestosper

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?T. Deep

arge beses of the encrusting corel M. cavernosa,

Piploria cLivoss, the octocoral Brtaroun asbestinun, the hytrocoral Mi1iepore aleicornts and the som

urchin Diadess antiilarue are sane of the nore abundant organise present. uall encrusting algae and epouges covered zo of che botton between the larger corale snd eponges. In addition, many encrusting orcnniens, such a3 bryozoans, sponges, tubifercus polychactec, and eastrepods Live under large, seni-loose boulders. feet ?Tah were much more common here than around the algal arene and several large lobsters vere also etghted,

?coral:

?Tis type of corel community probably extete tres found 35 to No feet to the edge of the shelt. the

area we exazined was 45055 feet deep, with « fev deeper holea, Figures 5, 6 and 7 show typical scenes from this

area. he bottom is heavily encrusted with M. cavernosa

Diplorie <irigoss, Porites astercides and gorgonians,

?and encrusting algne vere observed groving among the colonies. coral coverage here was approximately 50

Percent of the bottom area and is similar to coral cone

munities found on the outer shelf south of Puerto ateo,

Fishes vere very abundant, expectally large parrot fishy

snappers, surgecn fish and grunts (table II). notton

depressions or holes contained many large schools of the

A map of the posstb:

grunts ard snappe: {tetrfoution

of the above bovtom sypee e presented in Flgure 8, ths ne te ae Poca ?mere are

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FIGURE 5. Photograph of coral formatio

ed wainly of Montastr

Photograph by A.S. Froelich,

observed at S:a:ton Rb,

cavernosa and gorgoniana.

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mixture of rocky shores and sandy beaches. The observed

rocky shore communities were similar to those of other

rocky shores around the north and eastern coasts of

Puerto Rico, A good description of rocky shore biota,

which applies as well to the rocky outerope at Punta

iguero, te that of Glynn (1964). No large tide pools

were found on the rocks, but tide pool type organi an:

were found in the pool bebind the breakwater of the old

meters fron shore along much of the beach near the

Roms plant, Tt vas not possible to adequately sample

this shelf due to bigh wave action. It was noticed, hovever, that mich of the algal cover on the shelf con-

teted of Padina ep. Some invertebrates from this area

were collected by Dr. F-D. Martin (FRUC) while rotenone

potecning for fish, They are included in Table 2 under

?the heading, "Tide Poot".

Finally, & fev samples of beach sand from the swash cone

were sieved for beach organiams, however, only a few

Individuals of Hippa eubenele were found. We vere not,

ble to examine the sandy area Just offshore due to rough

weather conditions, Table II is a compendium of organtsas

?that were sfghted at various tines during the dives or

chore work, although they vere not collected ant

seta tted

tn che lstoratory. They are included here tor conp:evene

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able 1

Qrganiens collected at varioun sunping stations,

for station locations). i-1, Re2y A-dand Has

Stations; 3 is from } gokmin drédge haule on

"Wiscollancous* are specimens collec!

3 sites; "Tide Pool? includ

by Hotenone

"65 ft. Bransect?

Made 65)

Hot M2 3 Red RS Misc, Pool Pransect

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Chioropny ta

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Phaeophyta *

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a8

le 1 (cont.) tide

65+

Rel 2 R3 Rt RS Mec. Poot transect

Rhodophyta

Ceranium op. x

Coraline 5 xt x x x

roralling Sibensis

Galeraure x

xox x x

x

x

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x x

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x x

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Thalassia testudiua x

Foraminifera

ate x

Seine es, fone eras compressa x x

Porifera

Geliyepongi= sp. x

Grote Rei x x

?Gitona sp x

Granta x.

x

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x

Covtenterata

Hyérozoa

?Ghidoseyphus aarginatue x x

?Hiphsete wigs tere x

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Table 1 (cont.)

mde 65"

R45 Mise, Pool Transect

x

Anthozoa,

Actinieria

x

x

x

x

x

x

x

x

Farices *

Sea atlantice x

Birieeopeie Tame x *

fexaura TTexu6 x x

x

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eae ep, |X x x

?Wicidion Kinvergis,

?Gaaphis sb x

Yentogente x

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exe 2 (cont)

Tide 65"

Rel Re2 Be} Red BS Mie. Pool transect

cigar

cae

Tefeberie ap;

x

one

Moet oe

Sipunculada.

Mollusca,

Amphineura

Acanthonleure granulate

?Chiten squamosus

Gastropoda

?Reston enttLiarus

moe

MOM HHO Mo Mane ned ne eee

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Table 1 (cont.)

mee 65!

Rel Re2 Be} Red RS Misc. Pool Transect

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MoM MMM

fe ee :

Sores fereetite

Nodoltttorina tuberculata

?Sdostouta Teevigate

Sacetoats sectnada

Mo MO

Pinta

ae ee on

Pignasis nucleus

Folinices Tacteus

MMH AO MRDOOO

BGS Sewanee

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Table 1 (cont.)

Ra

Gastropoda

eCRyCeFETGS muricatus

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iguecute goers

Eye Bea

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?THivis qisdFipunctate

tome ateivog

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peaacypoca

S18 sennm fhorisana

x

Fapyrides seateuteata X

Eater

Arthropoda

Crustacea

Teopoda

eoratians leorn

?Cirolana perve

Re2 Re} Red RS Mise.

x

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Bde 65"

Pool Transect

x

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Table 1 (cont)

Rl R2 Ry

Teopoda

: Paracereie 9

eerste oRidate

x

?Stonapos

Gonodactylus ceretedss

Decapoda,

Reptantia

?Alpheus erietulafrons

Periclimenseus schai tti

Anomura

?Albunes gibbeois

Tosnobt te clypentue

Brachyura

?Actas

Eplattus ongiroserse x

achyarapsis gracilia ~

fodoche! 2 EroEsI pee =

Echinodermata

Asteroides

terias forbesii =X

Behinoide

?Behinouetra lucunter

Echinosetrs viridis?

aris tributeiges x

ophiuroides

Agghiure fimutata

Red RS Moe.

moe me

323

Bide 65"

Pool transect

x

x

x

x

x

x

x

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goie 1 (conte)

Bel Red Re} Red BS

wet wag t

?Chntecoma x

i

iy

Holothuroiéea

Holotnuria sp. x

Bryoroa

unidentifies x x ox

?Sehizoporelle

Chordata

Avcidiaces

Mierscosmus

Total fap. 268 collected 49 49 2 48 62

3a

mide 65"

Misc. Pool Transect

ws 7

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325

eighted at the Punta Higuero eite.

Coelenterata

?Arthozoa: Hexacorallia

Paiythoa cari baorun

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egaricites

Hetreteaecaetio?

?unices laxiepica

Flere Fogotete gundeiupensie

?Fecitopteronorsta op.

Arthropoda, Crustacen

Panuitiue ay

?Sapeur grapeus

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wenicnthye niger

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?Thalassous bifasciatun

anus

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Table 11 (cont)

Fish

Besa Re

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Guansseative

Ar yet the quantitative dats collected Sx not euftictent to make

?conclusions from them about the communities present and the differences

between then, At most, only one sample uas collected fren each botton

?wpe and in some cases none vere collected. the botton types for the

?five photographed and collectad guadrete were ae follows:

station Botton ype

ma ' quattow atgat (soft botten)

Re Poop alga (hard totton)

RS fanly dotrem (dresee samples)

Rh Deep gorgentan ~ sponge = coral

Re Bulioy cera: - sponge

Total Blouses for the stations were (in gre, net weight 2/4 a):

attr Blamaee

Ra 320.8

ne 616

BS 36

Rb 3736

RS 2386.55

stinates tndteate that the sendy and shalloy soft

Dottos algal camunities were much lover in biomass thin the coral ant

deeper algal comunition. tevever, ?he muber of species prosent was

syproxinntely the case for all camplee excopt R-3 (Table 1). Taauffietent

Geta is avaliable at the present tine to Look at distribution of bicoass

?asong the various plylogenetic groups or to compile trophic level atagrans.

Bamination of the remite of the photographed quadrats able Ir) shows

the predominance of algae at Stations Rel and Be

+ The category "eoattored

?aigse? {nctufes all areas where encrusting or foltacecus algae vere groving

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Le 111 - Percentages of bottom cover for the Rincon 2x2 m quandrats

om Station Nusber

Rl PORES

#4 _ st

arene ?9 07 w

Seattered alguet* 50 3365 ?

Sponge 03 1 9 7

cavernoca 2 2 16

sxnularie 3 a

treoidee a

Siderastres sidere ?4

biploria strigosa 5

Diploria elivoss 2 2

vavie feague 2

Dichocoenia stokesit, a

Leophylie strea rigias 3

YsophylLia gultiflors 2

Tsophyllie sinuosa 1

Willepora alcicornie a

Briareun asbestinum 2 2

Gorgontens 42 2

lo coverage _? Le eS

Total 99.3 993 998 1000

as This includes areas where the algal tufts were too little or too

aiffuoe to distinguish and outline thes.

Amount of algae/area varies in this category, but it would be very

oul to quantify.

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in very mall patches so that it vas not possible to dfatinguich the

actus) areas covered by algae and the areas vhere nothing was growing.

Most of this area bad around a 30-50f algal coverage on it. Therefore,

around two-thinis to one-half of the category "scattered algae? could be added to "no coverage?. Although Station R-2 had a fev corals, Rel ant

R65 had much more variety in the corals present there.

piscussto

Alshough the existing data are insufficient for an in-depth analysis of the situation, 4t {e apparent that the benthic communities north of the Point are mostly algse; vhtle in those south of the Point corals predamtnate.

?Aigne are urually coneidered fairly resistant to theraal alter: ations, watle corals have been chown not to be Also, siltation can usually be overcane nore easily by algae than by corals. since the major possible detrimental effects to the environment by the plants would ?be 1) sediment disturbance during construction of the plant, 2) sediment Gteturbance and suspension at the discharge channel of the plant, and 3) discharge of heated sea water into the environment, care should be ?taken that the heat and sedinent laden waters do not affect the coral lareas which are of more econcnte isportance to the nearby inbabitente ?as fishing grounds. Therefore, it 4s recomented thet the discharge channel be well to the north of the Point where 4 will have tise to

2) cool off thru mixing, and 2) drop its eedinent load before crossing

the highly profuctive coral - sponge cormuni ties.

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