PRNC060

PROGRESS RETORT

MARINE T1010GY PROGRAM

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. TABLE OF CONTE

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?PROGRESS REPORT

MARINE BIOLOGY PROGRAM

FY-1965,

I. Title of Project: Marine Biology Program

2. Inseieution: Puerto Rico Nuclear Center

Project abstract:

The research progran outlined herein is a continuation of studies

started at the Puerto Rico Nuclear Center in January, 1962 aad coo tae

Jeect Prevent tie. Although the prograa is composed of five cajor pase

srenteat ts fuset fons are integrated. The five original areas of seseten,

although altered in sone details to fit the aims of the prograc, seen at

pegetees at the present tine. It is proposed that they be continued aad

that an additional ares, Marine Ecology, be recognized,

The Progras vas designed to provide measureaents of the distribu:

Hop and movenent of selected trace elenents in a restricted but conplece

sqological and biogeochenical syaten. It includes limited lavestises ince

Sf the Lehosphere as vell as detailed studies of the marine Dlowshere nad

hydroaphere,

In order to obtain information on interact!

Biosphere and hydrosphere, weasurenents are being made of diologieel prodecs

[AZM aounta of trace élesents in the organiens and the environnca, bios

logical half-lives of trace eleuents, characteristics of food saben and oho {efluence of physical and chemical oceanographic factors upon the diserions elenents in the marine waters, organiea, and sediments off, ghore from the west coast of Puerto Rico. ?he latter studies include sheer Yatton on the effects of varying rates of deposition of mineralcricn sit ?pon the aiseribution patterns of marine organiens. ?The resesren rrojecte are as follows:

(1) Measurements of Biologicel Productivity,

The clé aethod for seasuring biological productivity ts being The uptake of cl4 4s correlated with plankton volumes. acount of Ghlororhylt, phosphate and aterate content of the water, depth of water, Giskance from shore, amounts of suspended aaterial in water, salinity, FAtgE tenperature, and uptake of selected radioisotopes by shytoplanccon, Jo a eeivity ceasuronents have been made in water sanplee frou the mttace,

50M and 300 distant froa the outflows of

Analyses have been started to determine

specific activity of cl in, phe total carbonate of sea water and in ahyees

pagniton, eine ssounts of Cl? in the sanples are measured by fi -coustlag

and the total carbon content determined by a gas chromatographic technigee,

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(2) Analysis for Selec Blegent

?Trace element analyses have been continued in samples of aarine

grganisns, sea water, marine sediments, river water, river sedinente, sod

Selected rocks, minerals, and soils of the aflasco River valley. The? wechods

sed to determine the soounts and forms of trace eleneats in the variecy of

samples include destructive and non-destructive neutron-activation analgsie, atoate absorption spectrophotonetry, flaze spectrophotometry, colorineceic analysis, fluoronetric analysis, X-ray emission spectrograpiy, and Xesey diffraction analysis. In addition to the measurements Of trace elescace, nilyses are being made for carbon, hydrogen, nitrogen, Lithium, potsseiog, calcium, strontiuo, and magnesium ia eany of? th ntti recently.

khe azounte of elenents were determined on the basis of ash, dry and'eee weight of organism. The anounts of trace elenente are now celaced ales to the carbon, nitrogen, and hydrogen content of the saaples,

(3) Meagurenents of Concentration Factors of Selected Orgenisas for Given Badioisotopes, ees Organon for Given

sed ap hPR, MEDS ee ered odo coninad a

cr5t) F659) 2065) ayes, Ki? and Ce! Ag Sargaseum lendigerum and other selected algae; and mn**, orl, re°9, 2n®, and Tal8? with. ?Acanthopleura nt WS wth deetosle

(4) Measurenents of Radioactivity and Radioisotopes now Present in the

Marine Orgenisas, Waters and Botton Sediseaee aff Rete

Measurements of world-wide fallout in several large samples of parine sediment, algae, gorgonians, sponges, crustaceans, and flebes hace been completed.? The disintegration rates of the radloiegtopes hare been calculated on the basis of wet, dry, and ash weight. Co3!, ts Ose) Fyttog, have been seasured in the senpies and have been compared with the Cob? /ost0 ratio in sauples from the Pacific Ocean. Determinations of specific accwvie tice for all of the samples are in progcese (dieintegeat ion rate of Tedion tsotope per gran of the corresponding stable elezent in the savple).

(©) Rackaround Observations in Physical and Chentcal Oceanography off the Hest Coast of Puerto Rico.

Measurenents of botton contours, salinities, tenperatures, turbidi-ties, dissolved oxygen contents, and current directions and velocities ave. sa Progress and will be continued. The work has been concentrated ealely in the area Off the Anasco River and vest of the Bonus site at Punta Higusre,

(6) Marine Ecology

?The earine ecology project has been carried out on @ Limited parts of projects two and three for the past two years. The ecological ?studies are concerned prisarily with Investigations of food web Telationahipe

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Assoctations now under observations include algse-nolluses, algae-echino= demas, echinoderns-gorgontons, sponges-arthropods, omnivorous fishes. aed smollusc~sipunculid-annel id-echinoders-crustacean relationships te aedinect ?coupositions and sizes.

SCIENTIFIC BACKGROUND

Investigations of trace elenent distributions in the sea is of scientific interest in the field of oceanographic chemistry and in allied areas including those concerned with biological prodvctivicy, the tafles ences of organic detritus upon the chemical and physical fetus of cf ments in sea water, and the geochemical histories of eleaente inteodeced into the sea by natural processes.

Im addition to the scientific value of the investigations, a

of the biogeochenistry of trace elesenta is of critical sapertance fo san insofar as radioactive isotopes of the sane elewents cay bern Sorperated into food webs from which food for human consumption te aeeived, the relative influences of the physical, chenteal and Biolog

which control the trangport and distributions of these elenents. Thee,

[iecle ie known even of the relationships betveen rates of photosynthesis

by sarine phytoplankton and the rates of incorporation of trace evesenee

into marine food webs.

tribution patterns, in the sane environnent, of selected trace elenents

which represent the different chesical groups. The analyses for the teace

gleaeats should be sade on a Linited nuaber of ainerals, rocks, serie, iver

waters and river sediments from the landnass vhich contributes? trace

2 0 the neighboring marine waters and on a representative aber of

les of estuarine and offshore deep-sea aarine waters, pelagic and 1itto-

ral orgentsns and sedinente.

Several elecents naturally present in trace anounts in the marine hydrosphere are concentrated by factors of at least 10° by sone marine ron dens. ?Radioisotopes of the sane clenents are present in radioactive aactee ind contaminants produced in nuclear technology. An understanding of the seochenical routes of these stable eleneats may be utilized to predict geo-chemical routes of radioactive contaminants vhich way be introdeced inte the sarine environsent from a variety of sources,

The use of the oceans for disposal of low-activity radioactive contaainants is and will continue to be attractive for several ressone

Man resides prinartiy on land, vhich constitutes only 29:22 of the coval surface of the earth. The renaining 70.8% is covered by the sea uhich 1a

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?sore or less remote from human pabitat fon, contains a large voluse of die

jutant (approxinately 1.4 x 10° Kn), and has a mean depth Of about 3800

$100 weters with deep trenches or depressions far reagved from wan or his

food organ: idition, the division of the earth's crust between

Anental blocks is abrupt, with the continental

sore than 6% of the tote} area of the earth.

The oceans contain large amounts of salt (4.8 x 10'S tons) which aay cone

Eribute to the process of {sotope dilution (1). Because of the Lasge

fuantity of contained salts, even those clenents which occur tn sen eater

galy in trace aoounts constitute a large reservoir of material foc the

@flution of radioelenents introduced at a controlled race, be used to define the factors

duced into given areas of the sea under specified conditions, other ante

are not available. The latter include (1) the distrivution jatteres ay

Gary trace elenente in the sarine environaent both near and offshore,(2)

fo which specific aarine organises concentrate different le

ments and the individual variability which may exist within species free

the sane locality, and (3) the effects of biological activities aed eestor

sical relationships upon the distributions of the trace elenents in s given

Beographical area.

?The answers cannot be derived entirely from laboratory expert-

ents but cust be obtained from field observations, analyses, and eepeel

ents in a natural and functioning ecological and biogeochemical? ayeree

Certain laboratory experiments aay be used to denonstrate and aeaseee che

vaderlying physical and biological sechanisst which control the patteree

Of distribution observed in the field work. Such laboratory investieat long

Anclude: (1) the determination of the physical and cheatcal forus oft

elesents in river water before and after mis at which the changes in form occur, (2) the weasurenents of the sat

which precipitates, produced by the action of sea vater on the aajor fi

yee ths coblosdar elenents in river vater, settle as a result of gravity,

(3) the measurement of the adsorptive capacities of known typer of eeeine

organic detritus, inorganic colloids and precipitates and specific saving

sediments and (4) the deteraination of the rates of uptake snd. lose at

Fadiotsctopes of trace elenents by dosinant marine species of placte and

ania?

SCIENTIFIC ScOPE OF THE nnsn> >

The research is designed to seasure the distribution and, indi

rectly, the sovenents of selected trace elenents froma land macs inte ehe

sea and the sarine sedinente and to relate measure,

BEST OF biological productivity and novenents of organic coaponents thsough

food vebs and chains with the incorporation and transfer of trace elesrate

Chrough the trophic levels.

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The studies aay be divided into tvo gajor divisions: (1) The

measurement of the distribution patterns of trace elenents in the water

shed of the Anasco River, in the biosphere and hydrosphere of Atasce. Bay

and in the offshore areas in Mona Pase (fig. 1). This work includes

studies on the interactions of the biosphere and hyérosphere upon the

istribution patterns of the elenents

(2) The developsent of techniques with oufficient accuracy,

reproducibility, sensitivity, and simplicity to achieve the measurements in a large number of samples. ?This includes not only the developaent of ssethods for trace elenent analysis in the microgram range, or less, but the adaption of ecological field procedures to quantitative geasurenents in vhich correlations of observations with large nucbers of biological

and environgental variables sey be made by sorting the data with eachine nethods.

?The initial plans for the geographical range of the marine biology program included the uarine ares west fron La Parguera on the

South coast of Puerto Rico, along the entire west covet, and east along

the north coast to the tovn of Arecibo. However, the surveys which

were needed £0 establish background conditions offshore from Punta

Higuero, the site of the Bonus power reactor were given firet priority in the program, This was done to establish the radioisotope levels in

the offshore areas before startrup of the reactor so that subsequent alterations in the marine environment, produced by the operation of the Feactor, might be utilized in the trace elesent studies, Ae a result of the observations in that work it becane apparent that the geographical

area of the investigations could be reduced without lose of scientific scope oF coordination in program. Rather, a more closely integrated series of Kescarches could be realized by studying a restricted but complete ecolopical and biogeochemical systen-studies which included weasurenente of the govenents of selected trace elenents from the land mass, through the rivers, into the neighboring earine waters, through the carine biogphe: and into the marine sedisents

?The geographical area in which the sarine phases of investigations have been concentrated for the last two years extends north. froe Mayaguez past Atasco Bay and Pea. Higuero to the south of the Culebrinas River and west into Mona Pass to Desecheo Island and Sponge Bank. The farea includes the island shelf and waters to depths greater than 1000 neters (eg. 1D.

A spall sampling program vas aleo initiated to provide sample from other marine environnente for comparison with those collected in the experimental field area. Sampling, on a Llinited basis, has been completed

in three areas: The open Atlantic Ocean to the north, the Caribbean Sea to the south and an up-current area east of Puerto Rico. In addition, samples of sea water taken at depths to 4000 M in the open atiantic Ocean have be

Provided by Dr. Vaughn T. Bowen of the Woods Hole Oceanographic Institue

?and dried saaples of plankton and fish collected off Ilo, Callao, and

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Srisbote, Peru have been eine to the Marine Biology Prograa, PRNC, by Hes

Blanco Rojas of the Peruvian Marine Research Inctacuce,

?The terrestrial studies have been restricted to the afasco water-

thed which is located primarily in a gountainous ares. Of the 129,000 saves

Comprising the watershed only 6400 acres are flat bottom land sicested ag

ihe Auaese Plata near the sea. all of the uplands of the watershed ve rugged

and wost of the tributary atreans have steep gradients and high raves of ceee

sion.

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?The ainerals and rocks exposed in the watershed are eainly extru-

five Gancous, andesite and basaltic rocks) or sediuentary rocks eoneein, St volcanic or igneous debris and linited amounts of Limestonee, ?The soils of the uplands are sainly of the cub-lateric, red acid type an! conecin IN claves The soils of the flat land have high contests of silty clay, Fe neutral to slightly acid and are subject to frequent flostioe

Rainstoras in the vatershed cause the introduction of varying but tevally large amounts of silt~laden water into ARasco Bay. The lateeutee tion of the silt into the bay is the basis for locating the field seedias of the marine biology program in the Afasco Area,

Upon entering Atlasco Bay the river water, with its dissolved and sponded saterial, usually forms a surface layer of a few centineters hick: REEE ovat, the heavier saline waters of the bay except during periods of high wave and breaker activity vhen rapid mixing occurs near the meh ot ope river: During pertode of relative calm, hovever, the Lighter water of low Stlinity say eaintain its identity as a district surface layer of nigh tore SEUY fo as far ae five miles out from the south of the river. Upoe mixing of the river water with the ocean water, rapid precipitation accusam sents uhich are enriched with trace elegente including mangane scandius are deposited in the bay.

?The deeper and predominant current pattern in Anasco Bay results in transport of the river water to the north slong the coast cone fen Higuero-? Usually during the afternoon, however, wind driven surface, currents {isplace the surface vaters in a southerly direction although the deeper

saintain theis northerly movement. During the night the surface and SfgPer currents again move to the north. In the vicinity of Pea. Higuers, the westerneaost end of the island, the northerly current vith the scree Sq fnasco River water is usually net by a southerly current conteining atsed Tiver vater from the Culebrinas watershed. The currents marge at the poice and ove westward into Mona Pass. Occasionally a clockwise syre foran ann uediately north of the point.

The Punta iguero marine area is of interest biogeochentcally

thease, of the convergence of the north and south shore currents contalaiag

the entrained waters from the two rivers. The Atasco River draine e acte

shed prinerily of volcanic origin. In contrast, the Gilebrinas River deeies

4 watershed predominantly comprised of Lisestong:

Because the carine waters containing the outflows of the Anasco

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4 Culebrinas rivers converge at Pta. Higuero, individuals of the sane

Species of organisas located to the north and to the south of the peine

live in waters containing different compositions of trace elexents, The

differences in environnent are reflected in the trace elenent cosposttttons

of the organisss which have been analyzed thus far. Analyses for additional

flesents and species of organiens will be continued on samples fron che tos

Geanajibo river which enters the sea seven alles to the eouth of the Areeco and draine 2 different type of watershed containing large areas of serrest ine outcroppings.

In the proposed research, the trace element analyses are of Lisited Welus unless they are related to ecological investigations, especially to studies of food webs. The ecological studies are being conducted by direct Sbservations using scuba gear, by analyses of caldbrated plankton and dredge hauls, and by analysis of stomach contents. Quantitative estimates of iat faunal abundance in sedinents collected off the Anasco River hace h ?and will be continued. Species composition and feeding type have lated to distance offshore from the mouth of the river and analyses for teace Glesents in selected species of the benthic organtons have teow stared Se eeteraine if cl with distance offshore cay be related to trace elemmat content. |The distribution of cone of the elewents in the sediments doen change with distance from land. The anounts of scandiun, manganese sod? tron decrease but the agounts of calcium and strontiun increase with iasrerces distance offshore from the mouth of the Afasco River, been reported to be inde

4 value of 8.9 x 1073

(Schretber, 1962)- abgut equal to that reported for the crustal average of the earth (9 x 10°3) (Taylor 1964). These values differ, frow tho found in the present vork for Anasco River water (5.5 x 10°) and, codi- feats of Anasco Bay (2.7 x 10-3 at 2 alles offshore and 5.5 x 10°) s0°5 Biles offshore). Samples of benthic organiens have been collected fros the ?timent core stations and will be analyzed for $r/Ca ratios to detereine Af the ratio of strontium to calciua in the sediment influences the ratios Of the two elements in the organisns. A change in Sr/Ca ratio has bees tot ported by Odum (1951) in studies in which the environsental Sr/Cs ratio cee exPerinentally varied. However, the effect of the elewental conporition of fhe te¢iments wpon the elesentai content of the contained benthic orgastecs

4s not dependent only upon the total amounts of a given eleseat in cee sens sent but is also influenced by the chemical and physical fores of thee: nents ix the sedisents. The availability of the elenents to the berchic Grganisas is being studied by leaching experinente and by the deteretnecton of crystalline conponents.X-ray diffraction and entssion disgtans of acain mente with Xray diffraction measurements, frou Alasco Bay and the otfenete ges have been made and wore than 65 conpounds have been Identified, Ine ition, X-ray diffraction diagrane of the gut contents of deposit: feeders hhave been wade and compared with those of the sedinents. Differences seve

---Page Break---

seraoat ihe attraction éinceans of the gut content of the heart urchin

ae ee rae abe and the sedinent in which it lives. These investigeeiens

depowie sear neanuee several species of benthic orgentens, inclonieg

deposit ard suspension feedere.*

In addition to the use of x

peecrane, ttudies, the technique {s being used for the identificscion of

The interpretation of trace element analyses in serine orgentons

4s coaplicated by tho effects of individeal variability.

studies, nuabere of individuals of a given pelagic of Litt,

thas snag one place ae the sane tine show greater individuel variapiiiey

fhan that found in benthic species. In addition, greater eer lebticey

STERTE AMEN elenence which are not biologically signiticane (ie, $0)? chan

Te tense gattach £F¢ thought to be biologically important (im, zn), although

SE wateinsneectoIgEscAlly important clement, iron, exhibits a high? demeec

Sheteisbilicy. | Investigations on tndividiat variability have tern are

TEL Sune species of marine organisas including algae, achinederse, ore len-

?wolluscs and fishes, Further work is needed to determine the

Rioegbtcal factors, including feeding habite and size of organiecsy co vel

44 the environmental factors which influence variabilicy.

Avggetel "tag" for measuring incorporation of trace eleaents by

"ezine otganisas ts provided by radiotsotopes in world-uide fallout, Goes

serge tansri7see have been mide on large senples of algae, pleakton, eoneen, gorgontan; sen vrching, solluscs, and fishes. ?The analyses whites

GMREAnued vith samples of the sane species collected in areas aece the wee

sage sof the thee rivers in che fel study area ag well aa. tn auapten cele

pected ?wprcurrent? from Puerto Rico. The data will be used for (1) eose

redisoces signe tmounts of radioisotopes measured in the marine ofgenions,

@ Near the outflow of the Bonus power reactor after the

Epaster,t brought to power, (2) analysis of the effects of river sffluccs

Tien the radioisotope content of the warine organieas growing in the sore

(ara Patterns of che three water sheds, (3) specific activies snalyaee

See oe Tadtolnotone per grea of corresponding stable elesest) ons vartety

Of marine organieae.

* aactsTay gitfraction unit is located in the Solid State Physics Division of

Calle of age reaycemtttion spectrograph is owed by the Deye. of Agriceltere,

ites OF Aettculture and Engineering, U.P.R. Through a cooperative ageece

cae une ute Of the Xray equipsent is" furnished without cost tn exchacee for

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Wartations in spec-fic activity between organtans collected at

She tame tise and place provide indices of variations in rater empilibelun

schteved by the organisas with the elenents in the water. Variations ie

collected at the same time but in dif-

ferent localities or at different tines in the sane locality ales provide

specific activities in the different

{avironnents. This would be true whether the variations in specific eee

tivities were due to variability in the rates of addition of the saute

Stotope or in the rates of addition of the stable element to the wacees

of a given area,

Avong the sarine organisas analyzed for vorlé-wide fallout in

the Present work are phyto- and zooplankton. These two types of orgacteas

RUE Darkedly different patterns of radiotsotopes contere but both geoepa

Propel Fe a? equilibrium with the radioteotopes and the corresponding

stable element in the surrounding sea water.

?The anounts of the radioelements present in the phytoplankton are

Pre enld Cigebse £0, the ohotonyathacie activity of the organtens,, Bachess

{74 Odua (1960) reported that the uptake of Zn¥5 by tarine benthic elene was

Lnearly related to oxygen production. They suggested that sine oan

up An direct proportion to the rate of photosynthes

a function of net biological production. In the pre

of mtctosyathetic rates are being correlated with uptake of radioactive ciect

cobalt, manganese, ruthenium, cerium and iron,

Although methods are available for sessuring the effects of photosynthesis by the prisary producers upon the uptake of trace eleaente, the sabe SgGuent transfer of organic satter and che easociated trace eleaents? through ascending trophic levels cannot be eastly measured. Hedgepeth (1957) eters that "the gost difficult problem in godera ecology 1s thet of detiniog nan Renauring efficiency" - in the transfer of energy and matter throvgh food Weve or chine. Although the eeasuresents of such transfers through « given jeries of arine trophic levels vill not necessarily provide applincble dete for other marine food webs it will provide the basis for planning seacuree ents and analyses of tranefer in other ecological systems.

Ie peasurenents of organic and inorganic eater in food webs, one of the probleas to be solved is that of determining which unite of reference should be used for defining the anounts of trace elements in the sauslees

In the present work the weights of trace elements have been reported on the deseo of wet, dry and ash weights of orgonian - they are now also reporteg fon the basis of organic nitrogen and carbon content. For correlations af Sovenente of trace clesents with transfer of potential enersy (te, srsagie Batter) through the food webs the amounts of the eleaents shovld be served also to the calorific content of the organises. Plans have deen asde ta cake

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In addition, the different bases of comparison we

work for the following applications,

needed in the pre

(1D Hee wetghe = Comparison of trace elecent content per gr

Uixing mirine organier vith the anount of the sane element per geen or nes

(2) Dey weight - comparison of "trace element to food value"

sipegebetween Frophic levels: ?comparison of food values and ecolaniee!

?significance of the dominant species

(4) Sarbon and nitrogen content _ couparison of protein content

and food (energy) values of the species involved: conpariaos ot trace en

?ment to protein? ratios between trophic levels

(5) Calorie content - coe;

ison of trace elenent contents with

?amounts of potential energy in succes

five trophic levels,

The correlation of trace elenents with wet, dry and ash veights and

TUE fhe carbon, nitrogen and caloric contents of the succeasive teostes

Hevels, ust also be related to other characteristics of the syslog nod

Populations involved. These measurenents have deen started ane city

Htnued,

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Nenoir 67, Geol, aser. Wash. D.C, 1296 pp

---Page Break---

SCIENTIFIC PERSONNEL of time devoted to

project

Principal Investigator:

Frank G. Lowoan, Ph.D Chief Scientist I, 100

PRNC. Professor of Biology, University of

Puerto Rico

Senior Investigator

Robert A. Stevenson, Ph.D, Associate Sclentist 100

1. PRC.

Senior Investigator:

Donald K. Phelps, Ph.D, Associate Scientist I. 100

ane

Investigator:

Borique Avila Laguna, M.S, Research Associate, 100

aN

wech Asoctate: Ross Julia Santiago, ¥.S. 100

uch Associate: Ragl MeClin, M.S. 100

Laboratory Technician: Edgar Ramos Seda 100

" ? Vilna R. de Vega 100

. Traida 0. de Padovant 100

" ? Lydia Quinones Rivera 100

? . Sara Lugo Ufret 100

? " Rafael J. Garcta 100

" " Russell W. Davis 100

" Donald S. Erdman 25

OTHER PERSONNEL

Technical Assistant: Maria Socorro Cruz 100

Boat Captain: Santos Lope: Acosta 100

Boat Engineer: Edwin Zapata Stlvestry 100

---Page Break---

crewman:

Secretary:

Watchaan:

Edwin Jusino Laboy

Noem{ Del Toro

José almenia

1% of tine devoted

to project

100

100

100

---Page Break---

Marine Biology Program

Puerto Rico Nuclear Center

College station, tiayaguez, Puerto Rico

PROGRA ACCONPLISHNE:YTS AND WORK 18 PROGRESS DURING FY-1965

Introduction:

phe esearch program in marine biology vas started at the fuerte Rico sluclear center in January, 1962. Tt was, ang is, sponsored by the Environmental sciences Branch, Division ot Biology and Medicine, u. 5. atomic Energy Commision

the (work in progress in the Marine Biology Program is ese y gone vith a otatf of 1h scientific workers inclading ear genior investigators. the boat crew and secretarial stage include a total of six people.

rthough the program is comprised of five major projects seas eeporting wxeas of research, it functions as an integeaced nent OF One sean with no well-defined divisions of staff, equip- Delng ra rerations budget. Research in all of the projecte te Pesng carried out although greater emphasis has been pieced upon some phases than on others.

done on neatly Part of the program, trace clement analyses Tear sees nt Variety of samples collected in selected geogrten:

Setiments in which they live. other studies on the accunalatinn Of specific trace elements by closely related species are in progress ao well as studies on the influences of secgrapnice) pyration on the uptake and retention of selected stable clonents by given species.

poeal zecently the amounts of trace elenents in the organisne have been related to ash, dry and wet weights, in che ?ecological syusies, and especially in the food web investigations, the fagnants should also be related to carbon and nitrogen? content

Tovere parison of "trace element to protein ratios? in trophic Revels and to caloric content for comparison of "trace elenece

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content to potential energy" between trophic levels. carbon, hydrogen and nitrogen analyses have been in progress during the past year and the trace element contents are being related to the levels of these primary element:

Investigations on the accumulation of radioisotopes of World-wide fallout by marine organisms are being related to the observations on stable trace elements. The same species collected in different areas exhibit geographical effects in contained radioisotopes while species differences are found in samples taken in a given geographical area. The fallout contents of local marine organisms have been compared with those of samples from Peru and the open Atlantic Ocean.

Investigations on marine sediments collected off the Aflasco River have been continued. A preliminary report was presented last year concerning the trace element analyses of the firet series of sediment cores. This phase of the work has been completed and a summary of the distribution of the elements in the cores is given in the present report. In addition to the elemental analyses, the sediment samples are being subjected te analysis of grain size by the dry sieving technique and the pipette method. Investigations on the biogenous and terrigencus components of the sediments are in progress and the physical studies on the sediments have been expanded to include x-ray diffraction analyses. The diffraction diagrams are analyzed

by @ nachine-sorting program. A limited program of x-ray fluorescence analysis on sediment samples has been initiated. ?The fluorescence peaks are analyzed by a computer technique

A method for the determination of stable scandium in rocks, minerals, soils, clays, sands, sediments, plankton, algae, invertebrates, vertebrates, and river and sea water was reported last year. The method has been in use for more than a year and a total of 260 samples have been analyzed. ?The method is reliable and reproducible and the analyses are being continued,

Due to lack of adequate control over air contamination

in the present laboratories, analyses for elements in sea water, other than scandium, cannot be done. The problem will be alleviated this sunmer with the completion of the new laboratory for sea water analysis. Rapid methods have been developed during the past year, however, by the use of radioactive spikes, for the determination of lithium, zine and bismuth in sea water, In addition, a method, utilizing neutron activation

---Page Break---

has been developed for biological samples in which sodium, phosphorus, calcium, rubidium, antimony, cadmium, cesium, iron, manganese, copper, zinc, strontium and gold may be determined in two aliquots of an ashed sample. A total of 0.4 g of ash is required and dried material may be used if desired,

?The elements which are now being determined by the atomic absorption and flame spectrophotonetric method include caleium, strontium, magnesium, thallium, cesium, potassium, rubidium, Lithium, manganese, iron, cobalt, zinc, nickel, chromium, antimony, vanadium, cadmium, lead, bismuth, rhodium, molybdenum, tungsten, platinum and gold. ?The results from the atomic absorption method are being checked against those from neutron activa, tion analysis.

?The productivity measurements have been continued and will be reported at a later time when sufficient analyses have been completed to demonstrate geographical and seasonal patterns of product ion.

Uptake experiments with radioactive tracers were continued @uring the past year. Measurements of the accumulation and

loss of zine (labeled with zn®5) were made with young and old specimens of the algae Penicillus capitatus and Udotea flabellum, In addition, experiments were done to determine the turnover rates of several species of algae for Ta'®?, secause of the lack of adequate laboratory space the uptake experiments were done in the laboratory used for processing samples for stable element analysis. The sea water reservoirs containing the radio-isotopes, were aerated with compressed air, The air stream carried trace amounts of the radioisotopes into the room. The experiments were stopped when the contamination problem was discovered. This summer (1965) the marine laboratory of PRNC will be completed at the Bonus site. The laboratory is equipped with a salt water system and the uptake experiments will be started anew this year,

The amounts of data which may be collected by using the Several methods of instrumental analysis have increased to a degree that manual methods of tabulation and analysis are no longer feasible. During the past year an IBM method of data storage and retrieval has been adapted to the marine biology

program. This method, as well as the individual research

projects are described in the following sections of this report.

---Page Break---

BENTHIC STUDIES = ANASCO BAY

Benthic Infaur

ptifial results from a survey of benthic infauna, being car-

rite gut in Aflasco Bay, indicate that numbers of organisms decrease

?GIR distance fron the?river's mouth and with increasing depth

ith distance from the river's mouth and with increasing de

gapsenships between sediment and faunal distributions have boon weil

fubstantiated (Petersen 1913, Davis 1928, Thorsen 1997, Sansere

1956, 58, 60, 62).

Numerical abundance of benthic fauna/n, as a measure of stan-

Ging crops places Aflasco Bay (X'= 2,346), on a par with the Engiian

Chane) (X= 2,365), a little under? puseard's Bee Massachusetts

Gr rg ' 4430) + but weil under Loch Craigiand, Scotland (k's 14,275)

(Mare 1942, Sanders 1958, Raymont, 1949)

Forty Six species of polychaetes, 42 species of pelecypods, 27 species of amphipoda, isopoda, decapodd combined, five diffcrons' ee Ghinoderns, 3 holothuria, 2 nemerta and 2 ostracoda have been eels yehacter? Sate. Special ?taxononic interest is being paid to the pol yehaetes, since they represent the major group, and since most of" them have not been described previously from Puerto Rings

rrgedualitative distribution of organisms follows relationships

between feeding requirenents of fauna and the nature of sediment nice position as initially described by Davis (1995). Deposit. feeders Gominate populations in fine sediments located close to the rivers BONEN: gfidter feeders become more important in population structure

the finer portions of the sediment decrease with depth and aise Range from river inflow. Polychactes dominate fine sediments while mollusks and crustacea become increasingly more significant as the Coarse sedimentary fraction increases. (fig. 3).

An intensive sampling program was initiated during October and

posenber , 964. Samples collected during this period are still being

Processed. | From these data, more precise information regarding @

Uitative and quantitative distributions with depth and distance faa

fhe rivers mouth will be forthcoming. Another Sampling of these ?tone

tions is currently being conducted to monitor effects of seasonal

Shanges.. Future sampling is planned to follow stability of popslation

Structure over tine.

Stable E:

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?As samples are processed, fauna having comparatively large bio-

mass are analyzed for trace element content immediately. Fauns having

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FIG.3.' Tilustration of the effect of the Aflasco River on the conposi-

{ion of populations. P = polychaetes, composed mostly of deposit fecders.

mol1eeLtusGs, Composed mostly of suspension feeders (some deposit feeding

molluscs are found in the fine shallow water sedinents). C= crustacea,

composed primarily of suspension feeders.

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g lesser biomass are save until enough material has been accumu-

lated for the various analyses. Certain echinoderms, polychaetes,

mollusks ?and crustacea have been analyzed for k, Fe, Coo nv Mins

and Ni by atomic absorption analysis, and for S¢ by? activation we:

thods. (Figs. through 7).

Sediments are now being prepared for analyses. The nature of

Shgrtic physical properties is being determined by standard sieving

and pipetting analyses. Trace element content is being determined

by atomic absorption as well as activation analysis and elemental

Gomposition is being studied with X-ray diffraction methods. To gate, the stable element composition of the detrital fraction of some sediments has been accomplished for K, Fe, Co, Zn, Mn, Ni by atomic absorption and Sc by activation analysis (Figs._4 through?).

A qualitative sample of benthic feeding fish was made in Decenber, 1964. Qualitative analysis of stomach contents demonstrated that Symphurus plaguisa and Larinus breviceps, dominant forms, concentrated detritus and shrimp in. their sespeeri ve na ee hal tracts. As with the invertebrates, abundance Of fish deck markedly with depth. Similar hauls will be made in the future, to monitor and attempt to quantify this next higher trophic level,

The fish are being analyzed for K, Fe, Co, Zn, Nn and Ni by atomic absorption methods. Results obtained to date are listed in Table 1, and presented graphically in Figures 4 through}.

Symphurus plaguisa, was analyzed with and without its gastro-

ancostinal track. ?The sconach contents ofthis Hak costae pri-

marily of detritus. While the content of Fe was much higher in fish

with their gastrointestinal tracts intact, the level of the other

trace elements were not apparently affected. The level of Fe tn de=

tritus is very high (Fig./4) and in this instance presence of setei-

tus in the stomach apparently influences the elemental analyses aie

rectly (Table -1-).

Levels of K and 2n are generally higher in Syaphurus plagi

aguisa

which feeds directly in the bottom sediments as compared to Lerieas

breviceps which feeds primarily on shrimp. Nickel seems to be nore

evenly distributed between specion in general (Fig. 6). Differences

in levels of K and 2n may reflect differences in feeding habits bet.

Ween these two species of fish.

Discussion

Data listed in Fig. 6 suggests that while levels of Ni and Co

in comparatively constant from the detritus on through the vasi=

ous animal groups, there are distinctly different levels of Ky Fey

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MICROGRAMS /6RAM ASH

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TABLE 1

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Larimus breviceps 40,000 200 90 s70

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Zerit and Sc maintained within cach group. While the distribution seul omer, ETOUP OF elements throughout an ecological syeten Sovicurty function of tote! bionass, the latter elements xocia be Ceydougly affected by variations in faunal abundance and cosessicson (Fig. 8 J. "the reservoir of certstn sangha msanee: aa any one point in time would then be © function of the benthic. comny ices fessting in a given area as they interact with the next lever ioe Ceeeet, TePhic levels (Figs. 1 through a) It'is within the sntpe Qf this study to establish representative amounts of stable elects Ge they exist throughout the ecological system under consiserurnee, Tate persegooints im time. Future studies will be developed to co- late passage of trace elements to energy flow through this sysvent

hiopod, anpnomic interest is the discovery of a single living bra Teeekgt;, Ths organism apparently of the genus Lingula, wes tone iGSbededt 2 depth of 125'From a muddy-sand substFates Bek ini seee identification is being carried out.

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67, 1; 461-534,

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FALLOUT RADIOISOTOPE INVESTIGATIONS

wera uiies on the amounts and distribution of radioisotopes

Aro Morlé-wide fallout were continued during the past yore pee

Soaples ents ,nave been hindered by difficulties in obtaining large

?igples of organisms free of detritus and other organisms asdf

the relatively high radiation backgrounds which occuriin these teld

he ganna spectroneter detector asa result of the presesce? sf

OF the came reactor and a gamma irradiation pool in the vicinicy

wrathe ounting facility. The latter problem will be solved te

TAC {96S when the counting facility is'moved to the new busidigg

which is shielded from the two radiation sources,

In comparison with the amounts of plankton normally found in

Toeerg mperate marine areas, the tropical seas are usually relay

period Speraes Bepeated tows of 10 or more plankton nets over

period of 10 to 20 hours are often required to collect s sertieds

Uedume of one Liter of plankton. Some types of zooplankton may be

SagETY codlected however, by the use of lights. ?In the present may tbe tals, been observed that separations of species of plankton ay de Bade by attracting the plankton at night with lights oF aore ferent intensity. In an area populated with some specice of asc pods and euphausid shrimps the former organisms were attracted co 41000 watt water-cooled lamp placed three to six feet below the SETEACe Of the water on one side of the boat while the shrimps were, Bove ene ytime, aEtracted to a 300 watt lamp placed immedistely above the surface of the water on the other side of the beat. Gye diter settled-volumes of these organisms were collected within s gnevhour period with cross-contanination of species in the two col- lections amounting to less than 18 (based on counts),

1188e, gorgonians, corals and large fishes are easily collected in volumes sufficient for fallout analyses. Sponges are sbusdace But must be carefully dissected to remove the symbiotic orpensene oem the pores and canals. Small fishes are collected in filesran lots by means of monofilament nylon gill nets and total body cere eee ftbiout radioisotopes may be determined, However® attenpts

fe dissect organs from individuals in numbers sufficient for gases

Spectrum analyses have been only partially successful,

ane wet-weight of material required for gamma spectrum analysis fgpends upon the type of organism and varies from oneshalf to ey Kilograns. | The samples were carefully cleaned (dissected if necus~ fary) and were weighed in the wet condition. They were dried for 24 hours at 95°C) weighed, and ashed at 450°C. The ash was placed ice to beakers which had been calibrated for volume, tanped tb « ainieum yogume and counted with a 3" x 3" NaI(Tl) detector for periods nr 200 to 400 minutes. Background counts were made daily Bnd the back= Gueund spectra were subtracted from the sample spectre by a date sec duction system. Corrections were made for geometry, detector cetie ciency, decay schemes of the isotopes, and physica? radioactive dae cay after collection.

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For stat 1eeena SPectra were made, aliquots of the samples were are bescy Sale clewent analyses. The analyses for nanse emitters abserved an uaree f° Stable element content in the sake nanenee ors sosgree amounts of radioclements are being related en foe webs, GPferencce! CfFects Gnfluences of river outflows) and'eesveeigs differences,

2 athe TeSet#, Of tMo plankton samples of one liter settled
Nona age sare shown in Figure 9.? Both samples were Later (Sektle: fone pass within a one week period in June Wea.? Worked differences are "shown ahe content between the phytoplankton and ssopittene

Coleen eetag 125,Phytoplankton contained relatively large orenkte of coset (G24 OF the total fallgut actieetty Pee he iggtope was and 2n68c°ee i the zooplankton. The amounts of tinSt cos} Pe 6S' and 2nd, on a wet-weight basis, were three co fou pépes, nbgher in ibe, 7opptankton than in the phygoplankton but: the fyldBesy contents Basis the ene Sane in both trophic levels, Thus, cn a wet-weight the fos wecePtankton, which represent the second tropnin tooeient and 2ige Tebz_GoRCeMtFated the transition elements mereivere? dot ae aBaigee gat Relation to their food souree but stronein discriminated against the uptake of cerium.

OF ieepde? athe 20ePlankton were taken separate collections were Rade of isopods and euphausid shrinps by use oF the lighting method and the dypiescTived. Because these isopods are select ree ee uetho Aaeiee STAMPS. filter feeders, it was thought ther eke feeding Failoae oud be Feflected in different patterns of nctteusses toe shows fnregigisotones. ?The ganma spectra of the tus eee ao gee Beewcen There, 10; No difference in radivisotepe cocrsar ans aT SLEoeN, these two types of organisms of the same ereokie Teett® ?Ad~ Secupy iytoTk 38 in progress with other plankton oreeieas etc, Pine Tn? aegiaes {ZOpRLC evel and which bre collected atthe sate

time in a given locality,

ne ane: gRroUR Of Ofganisms which are being studied for fallout

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in the? two apeasng amounts of runoff fron the land. the organreee

in the two areas are subjected to markedly gifferent terse patterns,

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FIG.10 Gamma spectra of two somples of plankton, each of one titer settled volume, collected at Mona Island on June 18, 1964.

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isately thes ahe® Mf,cRe algae collected at the two sites were

approximately the same, However, ihe amount of Mno in Padina col-

oFF the teat hepaayth coast wes about two thirds Of anae sellecrss

Off the west coast. The decrease in amounts of 279: NDYS, Ru

RHI06, and Celds Pridd from Guanica was even greater,

An another investigation two similar species of

er eag ero were compared and the ganma spectra aa}

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fang 2p59iggogont@ined approximately equal amounts of sul OS 7ot 66,

and 2195 Nb9:

ofrendiOf fhe organisms collected, only the algae accumulated

metry, TeomtuR in amounts that could be measured by aamag omatete?

roe Eamma spectra of samples of Sargassum collected at Punta

Figusee SMES> Coast) and at Cuanica (south coast) areretony fe

eure 12. As was shown for another species (rice ny A), the

Tere ccapes eacTonthe west coast contained larger amounts of nee

SEodSREPES Sha did those fron tho south goase, Onin ease amounts

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Bane species ouanica but relatively large amounts were presse S2 the

Same species collected at Punta Miguers, 2 15Ca) SFOUP Of organisms under investigation are the sponges.

LETS 13) [shows the ginma spectra of two sanpice of eke sPe Spe.

o Saatpiggiespengia vesparia collected gt Punta igucro® Except for

& small dittetence in tee eects ee Nn°4 the two specimens do not

Show differences in radioisotope content. ?Tight | (8) demonstrates

sage {icant differences in the ganna spectra Sf tus (ackenem of the

the sauthye® spusected at Punta Higuero and Negro Reef Cis ei ioe fh

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The g9ppa_spgetra shoyy in Figure 14 A indicate much lower amounts

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Puerto Rico in comparison with those from the west cease? Sesto

Gifferences for specimens of the sane species are shown in saabige

collected 13 mites apart on the west coast (Figei4 Bye? thus he

degree of change in uptake pattern for fallout radiorsotores arrears

tolbe related to the degree of environmental change ane fo hese oy

lated to distance:

Marine fishes exhibit remarkably different patterns of fallout content than do the other organisms under investigation. The species of fish reported here (Makaira nigricans are of especial interest in their radioisotope content since they fern a third trophic level of the series: prinary producers (phytoplankton), grazers (zooplankton) and carnivores (fish)

Figure 15(A) shows the gamma spectra of the gastro-intestinal tract and spleen of a large fonale blue marlin collected at Virgin Gorda Island east of Puerto Rico. Almost 1001 gf the fallout re-dioactivity in the spleen was contributed by Zn®®. In contrast to the gagma spectrun fron the spleen, the GL tract shows, in addition £0,795, a large photopeak of Nn°4?and a detectable amount of Cst3? Bal3/m.? The presence of significant amounts of cesium in the organs and tissues of this species is different from the pattern of distrie bution found in most other marine organisms. During a tqapling pe-riod of 13 years at the Pacific Proving Ground Cs!S/ Bals/A was hot gbserved in any marine organism in amounts that could be detected in a total gamma spectrum aithough several thousands of samples were taken, in the lagoons and the surrounding seas-

Figure 15(3) shows the gamma spectra of gonads and liver from the fish described above. In the gonad the rain Tadioisotope is Zn6S although small amounts of Nind4 are evident, In distinction to the other three urgans, the Jiver contains Cos? and CoO in addition to the larger anounts?of zn®> and Mn°4.? The pattern shown in the four gamma spectra is similar to those taken from tissues and organs of Most of the pelagic fishes collected in the offshore areas ef Puerto Rico.

The ratio, coS7/co6 in the marine samples collected near Puerto Rico in the sufmer of 1964 had a value of approximately fives The Same ratio in samples collected at the same tine at the Pacific Pro Ving Ground were: Eniwetok, 0.059; Bikini, 0-060.. Thus the ratio Co>7/Go60 in the Caribbean? area i3 approximately 100 tines that in the Pacific. CoS? has a physical half-life of 267 days and Co60, $.27 years. The radiocobalt in the Pacific area is primarily derived from older weapons'debris from the U.S. tests at Bikini and Eniwetok. On the basis of measurenents of fallout tn. fainfall made by the Marine Biology Progran and the observed CoS//Coo0 ratio reported a-bove, the principal source of radiocobalt in the Caribbean? was. supe plied by the last Russian test series.

---Page Break---

?SpunOE G6» PaUbleR Ys UL ?DR oZ9ng Jo 4808 pud|s} BpL09

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Bue marlin

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Arecibo

July 17, 1964

north coast of Puerte Rico

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The gamma spectra of gastro-intestinal tracts and gonads of

Alco dn snaysinytaken near Arecibo on the north coash ?of Pacsee

theo eaueys 1964 are shown in Figure 16." the goust See uettO,

Sept thar che (£22,168) are similar to those in Figure te nay?

fish have relatively higher amounts of

Fhe gonads came, dowet amounts of nS. ?In ¢heragher spectra of

pnSstNsgs Of the blue sarlin samples (Fig. 168) ?the amet etoe

2n6S, MnS4 and C5137 Bal3tm are similar but the amounts of K40 are

Monts Oyine {8a tabulation of the fallout contents in the

three trophic levels described abov.

Isotope Phytoplankton Zooplankton

Mn54 ang 0.85 0.08 0.9 0.16

co87 d/m/g 0.85 05 ne

C08? d/a/g 0.13 - On ae

2n65 d/m/g 0.8 4334

C8137 ayn/g

neentearige Fidieisotopes, only 2n65 exhibited marked increases per gram oF ac gnith, increase ?in trophic level- Radionicc eres Phytoplankton toreegyigh, increased fron a value of 0-12 a/a/ernt eke Epyenplankton to 0:47 d/a/g in the zoeplanktons ?In ine G48, 0o cooplanta een eRe amount Of Zn65 was approtinacely dere1e that of the Righer $03 (9c5,4/n/e)- The values in'the liver angeueal see RIERRT: 423 0/B/e and 3.4 a/a/g respectively. thus feng first Shaun © ATefs; $0, the third an increase of 7 30 "for shee fhe, first B2eUT ap eRiMAlaE pattern was noted between trophic Lene }s investi- Saiy za8s trey acific Proving Ground (Lowman, 1965)° Sy°deqs study,

ony #n®S and radioiron were concentrated with seoveadng trophic levels.

REFERENCE

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a)

Reinhold Publ. Corp and am. Inst. Biol. Sei. chapman Hall, Lea,

London pp, 145-149,

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Radioisotopes and Stable Elements in Plankton, Fish Meal and Guano fron Perd

The Peruvian coastal waters constitute one of the most productive areas of the entire world ocean. Three lines of evidence support this statenent: Plankton is abundant in the said area throughout the whole year, ?jsh meal is being manufactured af the annual rate of over 1.5 x'100 metric tons and about 1.8 x 10° metric tons of guano are produced by large colonics of narine fish-eating birds whose numbers average approximately 12 x 10? actively fishing individuals.

These facts form the basis for undertaking the determination of the level of radioactivity and the concentration of some stable elements in the plankton, fish meal and guano from PerG*. Of particular interest to the Marine Biology Program of the PRNC is the compa rison of the conditions obtained in the marine waters of Puerto Rico, whose fertilization mechanism is prinarily dependent on land run-off, With those of the Perd Current, whose fertilization depends mainly on upwelling.

Fallout was investigated by means of a $12 channel gamma spectroneter, and the stable elements were determined either by the atomic absorption method or by a gas chromatographic method for carbon, hydrogen and nitrogen analysis.

Results are summarized in Tables 11, 11, IV and V and Fig. 17.

Table II presents the results of atomic absorption and gas chroma-?Tographic analyses run on anchoveta fish meal samples from three different localities of the Peruvian coast, namely Chimbote, Callao and Ilo. The elements analyzed were Fe, Co, Ni, Cr, Pb, Nn, Zn, C, H and nN.

Table 111 summarizes the results of similar analyses carried out on two aSsorted Peruvian plankton samples, one from Chimbote and the other from Callao.

Table IV is again a tabular presentation of the analyses conducted ?on a guano sample collected in Chincha Norte Island, PerG from the

nesting ground of a large colony of Peruvian cormorants (Phalacroco-

Fax boupainvillii L-), by far the most abundant species of the guano

ornithofauna, (Avila, 1955).

* The plankton samples were supplied by Dr. 8. R. de Mendiola,

IREMAR, La Punta, Pera.

The fi5h meal samples were provided by Dr. T. Sparre, Inst. Invest.

Recursos Marinos, La Punta, Perd.

The guano sample was sent by Mr. J. M. Cabrera, Corp. NI.

Fertilizantes, Lima, Perd.

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FIG 17 GAMMA SPECTRA FOR PERUVIAN ANCHOVY (Engreutis rinens J.)

FISH MEAL FROM cuimBote, PERU

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TABLE 111

: Chimbote "

Material "Wet OY aR we

Assorted : : "

mixture : ? ?

of Peru : ' *

sr : : *

plankton : : "

Amount : :

ou : :

sample, : :

srens boar 8 ase 1 65.2 45.0

ve Fe/e {4288957 "7ossts68 131968352 + 4653%515

ug Co/g ! 1 23.9%2.3 139,344 130,383.51 43.725

oe Ni/e 1 38.2t6.7 ts7.7ti 130.88.1 § 44.7206

ve Cr/a (3.440.6 ' 38.6%6 165.3810 ta.ato.s t39.stie 1 57.7420

ve Pb/g 113.121.3 § 147.4219 +242¢31,7 "7,120.6 1116.127.2" 168t10

vg Mn/g * 1 20.782.8 134.4%4.6 t.2t.a ri9.ttis + 27eztead

ve Zn/g '24.8%10.8" 278.8¢121 1457198 r10at4.7 © 180,.72214

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TABLE IV

pee

Chincha Norte Isiand

Material ey ep

teria) ee ay a

Guano of Peruvian

Cormorant (Phalla~

crocorax bougain-

SEES FEE,

ve Co/g | 0,640.0 + 4,940.0 + 15.5%0.0

ug Ni/g 1 a.7tor 1 s.atoee } 1782.6

ve Cr/g ' 0.78 2 18.5% : 17.38 2

ug Pb/g Vet) 7s 1 46.3t8.5

ug Mn/g [2sto.2 6 20.388 1 64.t5.6

vetn/e | 14.90.86 + t19.686.6 | 576,7820.8

? K : - aa -

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? © : : ~

- ft 20.5

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-2- 48

Tabled 15,4 Summary of the radioactivity foupd in.ghe fish meal

Samples. Part A gives the radioactivity of K40, zn and MnS@ a3

disintegrations per minute per gran of Sample. "Part 8 presents

the specific activitzis* of zn6> and Mn°4 compared to the corres-

Peptang paxinur persissible specific activities, as given in

fable I-8 of Disposal of Low-Level Radioactive Waste into the Pa~

fific Coastal Waters (ISAACS et al., NI. Acad. Sc., NI. Res. Counc.

Pub. 985, Washington, D.C., 1962).

Table III indicates that both Fe and Zn are the most abundant

trace elements among those analyzed. This result is in keeping

with the knowledge on the metabolic characteristics of diatoms (the most important aliquot in the plankton sample which was analyzed), since these organisms actively take up these elements from the en. Vitonment. Marine plant organisms are capable of utilizing ferric hydroxide as colloidal micelles or even larger aggregates which are first adsorbed onto the surface of the organisms and later incorpo: rated, to varying degrees, in the protoplasm of the unicellular al- Bae (GOLDBERG, 1963; HARVEY, 1955). Zinc is a well known constitu- ent of several enzymatic systems and has been shown to catalyze the vtilization of sone sugars intracellularly (SEYMOUR, 1963; RICE, 1963; DAY, 1963; CALDECOTT, 1960).

Cobalt was present in low amounts in the plankton although its biological significance may be out of proportion to the minute amounts in which it is present in the organisms. It is known, for instance, that glycyglycinase is activated by cobalt, and it 1s con- tained in the vitamin By) (DAY, 1963)

It was surprising to find a relatively high concentration of Ni, about 0 ug per gram of wet plankton, since this element is not known to be of any biological importance.

The amounts of lead were unexpectedly high. It is not known to have any biological role and its relationship to the plankton organisms should be investigated.

Tables II and IV may be generally interpreted in terns of what has been said for Table IIT. ?both fish moaland guano are ogee

two rungs higher, respectively, in the sane trophedynonie Laddes' of

sie nade aneCTHS Laon at shot dahamena 12 aemerzctred ron an

gngraulid locally known as "anchoveta" (Engraulig ringens -J')> whose

GEEE"TS made up, co's great extents ce AenBee SP FRADE, J:) whose

ceag and Dinophiceae. ?Guano 1s the waste product of three martes

bird species that feed almost exclusively bn the anchovers.

Table V demonstrates that the Peruvian fish meal is essentially

free of radioactive nuclides, except for the very low concentration

* Specific activity defined as disintegrations per minute per gram

of the element concerned.

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TABLE V

Aadiosctivity in the Peruvian anchovy (Engraulis ringens J.)

A. Disintegrations/minute/gram

(ny

Sample '_d/n/g, x49" aym/g, 265 d/m/g,_MnS4

from Ash Bry Wee SO By RG py re

Chimbote '51.6' 7.44 '1.38 "0.52 '0.07 '0.01 "0,69 '0.10 .0.02

Callao 162.8, 9.8 11.63 "0.86 10.13 10.02 "0.52 10.08 *0.01

To 163-7) 10.5 11.87 "0.84 10.14 "0.02 "0.15 '0.03 *0.005

B. Specific radioactivity in fresh Peruvian anchovy

) Specific Activity? Waxman ?Safety factor

: | 9f radionuclide ' permissible ?for fresh

: 1 Gue/g of activity 'Peruvian

Sample | Radio- ' stable element) ' (uc/g of

fron __' nuclide! + stable element) '

Chimbote: zn5 + 5 x1gn4 5 268 52000

Cattao * nS g.5 x19-4 1 26 31000

To! 2nS + 6.8 xr0n4 + 26 39000

Chimbote? MnS41 8.3 x10-3 * toe 1200

Callao + MnS4 + 6.09x1073 1 10 1600

Mo + win84 + 2, 03x10-3 "40 4900

* According to Table I-B of Disposal of Low-Level

Radioactive Waste into Pacific Coastal Waters,

National Acadeny of Sciences, National Research

Council Publication 985, Washington, D.c., 1962.

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of K40, 2n65 and Mn54. This result was to be expected for two main) Te is well established that present world-wide fallout ly Festricted to the northern hemisphere and, therefore, fonsidering the circulation pattern of the Pacific Ocean, it is nae {ural that ?the contamination of the Peruvian waters is only of a Binor character, and b) The upwelling, so prevalent a phenomenon seenge he Peruvian coast, brings to the surface waters from deeper levels that are essentially uncontaminated by world-wide fallovs:

he results of this investigation were compared briefly, in the Preceding section, with the findings for fallout radioactivity in the organisms fron Puerto Rico.

RI

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ANALYSES OF RIVER WATER

Analyses of river waters were begun in 1964 in an effort to determine the contribution of elements by rivers in western Puerto Rico to the surrounding sea water. Three main rivers

in western Puerto Rico drain watersheds that have a somewhat different mineral composition. The Aflasco River drains a watershed that is predominately igneous in origin, whereas

the Culebrinas River drains a watershed that contains a large amount of limestone as well as igneous materials. In addition to areas that contain igneous materials, the Guanajibo River Grains deposits that are rich in serpentine. All of these rivers enter the sea aloman 18 mile length of coastline. Consequently there exists an opportunity to compare the distribution, abundance, elemental make-up, and amounts of fallout materials in marine organisms that live close to these river outflows as well as those that might be affected by materials from more than one river.

Since the major part of the program is concerned with the influence of the Aflasco River, investigations began with an analysis of water from that river. In august, 1963 one litre of surface water was collected approximately 300 feet inland from the mouth of the river. The sample was filtered through 2 0.54 Millipore filter and the filtrate was evaporated to

a few ml and then diluted to 10 ml with 0.2N HCL. A white precipitate was filtered out and was washed with 15 ml of 0.2N HCl. This filtrate was added to the original filtrate to give a final volume of 25 ml.

?The filtrate was analyzed by atomic absorption spectro-

photometry for content of Ni, Cr, Mn, and Fe. An aliquot of

the filtrate was mixed with an equal amount of 0.2N HC] which

contained 4000 ppm of lanthanum as the chloride and was analyzed above for Mg, Sr and ca.

The results of stable element analyses on the soluble frac-

tion of the water were as follows:

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52

Element ?ug/Lit,

Mg 9,500

sr 330

ca 25,000

Ni 18

cr 4.3,

Mn 3.5 Total dissolved

Fe 20. solids/liter

se 0.63 0.32 gms.

Of the elenents analyzed, ca and Mg were present in the

highest amounts. Iron, cr, Ni, Mn and Sc were present in

amounts of 20 ug/liter or less.

A comparison of the amounts of the elements in the afiasco

River water with those found in some major U. §. rivers (Clarke 1924) showed that the amounts of most elements were approximately the same. However, there was about one order of magnitude less Fe and Mn in the Afiasco River than in other U. 8 rivers.

In February, 1965, samples of water were collected from the Aflasco, Culebrinas and Guanajibo Rivers. collections were made by lowering a Van Dorne bottle into the rivers and taking the water immediately beneath the surface. the two aliquots from each river were analyzed as above except that 6N acia was used in the washing process.

?The water was not processed until the day after collection and it was noted that floccular material, probably of bacterial origin, had formed in the samples from the Anasco and Guanajibo Rivers. water from the 2 rivers was collected a short distance downstréam from sugar mills which dump waste Products into them. Water from these 2 rivers had a strong odor of bagasse which probably provided a substrate for a high rate of bacterial activity. although is not known to what extent such activity may have altered the amounts of

@issolved elements studies have been started to evaluate the effects of organic material on the physical states of the trace elements in the river water

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?The following table shows the analyses that have been performed to date:

Element	?Aflasco	Guanajibo	
mi	0.009	0.017	0.016
Mn	0,018	0.007	0-109
co	0.002	0.003	0.008

?The quantities observed here are mich smaller than those previously observed for the Afasco River. The recent samples Were collected during the dry period of iow river flow ana the near drought conditions that prevailed during the winter may have Eeaulted in the greatly reduced anount of dissolved lenents. Another factor that would help te account for the low values is the fact that the samples vere taken several niles upstream from the previous Afmaco samples where the Amount of dissolved mterial ie greatiy redeced (Lowman, in Press).

Additional samples are being taken to determine seasonal fluctuation in the amounts of elements in the three river:

The data to date suggest qualitative differences in the trace element composition of the three rivers. An expanded and intensified sampling program will be carried out over time to define seasonal variatione within and between these rivers. automatic stations to monitor height, flow rate ?oxygen content and pH levels of the three rivers should be installed in order to provide a quantitative basis for inter-Preting the observed trace element contents in relation to total contribution into the marine environment.

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TEMPERATURE AND CURRENT STUDIES AT PUNTA HIGUERO

Studies of marine organisms and their environment at the Bonus sage TETE,begun im 1963 and are continuing. "These studies are Sevag sade te Provide background information for the evalustion of got sible changes induced by the future operation of the Raves tuoi oar pover plant. Because of the release of large amounts of therseity hot water from the plant, the environmental parancters ten ereeey and currents are considered to be of primary importance oni cate quently are receiving particular attention. Abundsnes any dior bution of the nore common flora and fauna are being nade eo ieccee ine temporal and spatial fluctuations. Levels of stavie electors in organisns are being deternined in order to provide the facie tor determining specific activities in the event that sidionctane carer rials enter the environment.

Temperature

Fgnperatures were measured by holding the thermometer about one £90E beneath the surface of the water and by observing it tarovchen F256 Bask. Observations were made at a distance of about S movers from shore. With two exceptions, readings were made at least eee Sach month, hen more than one reading was taken within any month, each value is reported separately.

Taeer® jeeghows, the fluctuations in temperature observed during 3a see og _DUTIN this period of tine the average temperature waz 38,30C land the range extended fron 26.5 to 29.6." Total sesconat fluctuations are similar and are of the slight magnitude charneter= istic of tropical areas.

The Cominant feature shown in the figure is the relatively wide Yrdetion wathin periods of one month. These variations are most vakely due to @ combination of diurnal changes in air tenperaroce, Wapke Gekges BRd geographic and hydrographic features. During day-

When the aang duhere flushing is relatively poor. During the might when the sand cools, the waters becone correspondingly cocker ?ae TARE periods of slight wave activity, warm water extends farther uff anes im ghe,"pocket" formed by the curve of the beach, but stronces Wes, tend to flush the area and to bring sea water temperatures closer to shore.

Currents

ang Bath of coolant water which leaves the plant has been traced

sersed eocepeTiment reported Last year. At that time, water was abe

Ageved to, flow southward along the beach and to turn westward at Sonta

Miguero and then to forn a gyre which rotated ina clockwise diteronca

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back toward the beach. Since then, another dye experiment and stud-

Ags of temperature structure have further clarified the path of

water after it leaves the outlet from the plant.

On November 19, 1963, 3/4 pound of rhodamine-8 dye dissolved in

agetpne as poured into the outlet while the water was being expelind

gr_the normal capacity of 30,000 gallons/minute. The path of che

ereents observed and notes were later integrated with photographs

faken throughout the 48 minute period during which the dye ses? nisi-

?As in the previous experiment, the dye flowed south along the

beach and then turned westward where it eventusliy Seren toeneeths

gyre as it turned to the north.? A small amount of dye floved tales

TRY Ground Punta Higuero, but then turned northward again to. join ihe seaward sweep of the ?remaining dye. One snail body of ayo rowed se neee tistance northward soon after passing the point. This patch oid aergnamained above @ sandbar discovered in aerial photographs and probably explains the origin of the sandbar.

When the dye was first introduced into the water the currents ePayca taimeoyihe shape of a fan. ?After about two minutes, the Body Stvebn?o¥Gve FSYTSEES ERS LESS, SepaE ward towafd Pata AigustS. The other flowed southward about 80 meters from shore and traced the main course of water flow fron the outlet. The two streans of water 7, mained distinct, but followed the same course after they left the point. The forward edge of the dye moved southward along the beach at a measured speed of one knot.

On October 13, 1964 a series of temperature measurements were made while the plant was operating at a total power output of 20 mega~ watts (Fig.19). Four temperature readings were taken at distances of approximately 3, 8, 20, and 40 meters from the beach at four loca- tions of 25 meter intervals southward along the beach. Two additional temperatures were taken farther south along the beach and one was taken in the coolant water and another farther off the beach in the unheated sea water.

Dilution effects can be seen when the observed temperatures are compared with the temperature of the coolant water (35.8°C) and with the unheated sea water (29.3°C) (Fig.19). The temperature of the water dropped rather uniformly as seen in the Ist 3 transects southward along the beach, although it dropped more slowly farther offshore in the second transect (33.1°C).. In the fourth transect the temperature declined until it approached that of sea water (29.8°C). Although strong wave action prevented further observations offshore, the strength and direction of the current at the most seaward stations indicate that a warm current containing the flow from the outlet, passed offshore to the south. The reading of 29.5°C cited above

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Tepresents the area between the two streams of warm water. Therefore, the situation was much the sane as seen in the dye experiment gne year earlier and suggests that this type of current pattern may frequently prevail. Observations are being wade to determine whether zonation of marine organisms is occurring that confor to the current patterns.

ABUNDANCE AND DISTRIBUTION OF MARINE ORGANISMS AT PUNTA HIGUERO

ABUNDANCE AND DISTRIBUTION OF MARINE ORGANISMS AT PUNTA HIGUERO

Because of the difficulties encountered in working in an area of rapid currents and strong wave action only a few of the more bundant species were selected for study. Their abundance and distribution are determined periodically insofar as is possible, in five different locations. One location is upcurrent from the outlet and was intended to be a control area. The other four locations extend downcurrent to Punta Higuero. Collections were made at distances S to 15 meters from shore. During a survey of the locations, a grid of 1/16 square meter area was randomly thrown on the bottom and ail of the algae in the quadrate were collected and placed in a plastic bag. This procedure was followed eight tines at each location. In the laboratory, the species, Dictyota dentata, D. cervicornis, Cla dophora sp., Padina sp., and Sargassum sp, were separated for each quadrate.(gtid)-and an average sat weight/square meter was calculated. A similar procedure was followed with the sea urchin Ech: jometra lucunter which was the most abundant of the large invert

Brute aninalsin the area, ?The urchins were Ceusteg aneeya Myers and were not renoved.

Figures 20, 21, 22, show the, distribution and abundance of the algal species over a one year period. The two species of Dictyota Were small and less abundant than the other species and therefore Were grouped together, They were most abundent in areas close the outlet, but a limited number were present throughout the ar. (Fig.20). "species of Padina were the most abundant and widespread of the alga studied (Fig.21). They were the most abundant species upcarrent, from the outlet and large numbers extended about half-way to Punta Higuero. Cladophosa sp. had the narrowest range of any. alga- | It was abundant only at the location indicated in Figure 21, Species of Sargassum tended to be less abundant in the area closer to the outlet, and were most abundant at Punta Higuero where they covered rocks?in a dense mat (Fig.22).

During the winter of 1964-65 sand completely covered the bottom, 3 well as the algae, in the survey area above the outiet. Much of the algae within about 30 meters of the outlet was also covered but less complete inundation was observed with increasing distance southward along the beach. The sand was so deep that water leaving the

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outlet at low tide was contained in a channel that had been cut in ?the sand. The data do not show cyclic fluctuations in abundance of algae over the one year period reported. This may be due to sampling problems or it may reflect the changes that have occurred in the environment due to the construction of a jetty.

Another inundation by sand that occurred early in 1964 influenced the numbers of sea urchins in the vicinity. At that time the study area upstream from the outlet received most of the sand. A decrease in numbers of Echinonetra lucunter at that location in April is probably due to the effects of the sand (Fig.23).

Because urchins move around when the holes and crevices in which they live become filled with sand, large numbers were swept onto the beach by waves. Advantage was taken of the situation to gain some infornation as to the size distribution of the population. The lengths of 189 urchin tests were measured and Figure 24 shows their size frequency distribution when the measurements were grouped into 2mm, intervals. A large, distinct mode appeared between 20 and 30 mm, and two smaller modes at 34 and 38 mm, The modes represent the bulk Of the population and when correlated with weights of urchins they afford 4 basis for the calculation of biomass and hence the mounts of stable elements/sq are meter.

Levels of Stable Elements in Epibenthic Organisms

Analyses of the stable element content of epibenthic marine or-ganisms are continuing in accordance with procedures outlined in the Section on Stable Element Analyses. One of the considerations that determine the number of analyses performed on a particular species is the variability of levels of elements within that species. Fi-gure'25/Shows ?the. elight amount of variability of Fe, Mi and vn, in four intact individuals of the gorgonian Eunicea mamnosa collected at Punta Higuero, Puerto Rico. Iron varied the most, but in com Tison with other species reported here, all three elements showe little variability. Greater variability was encountered in the tissues of six individuals of the sponge, Ircinia strobilina, collected at Negro Reef in western Puerto Rico (Fig-26). Except, for one value, the level of Niwas only slightly more variable than that in Eunicea However, there was more than a 3-fold difference between the Towest and highest values for Mn. Oata are not yet available for Fe.

hs more organisms were analyzed, it became apparent that levels of elements within a particular species might vary with location.

The mean values and standard deviations in Figure 27 show that levels of Fe in the skeletons of 15 Tripneustes esculentus collected at Punta Riguero, Puerto Rico (west coast), were significantly higher than a mount of Fe in as many individuals of the same species collected at La Parguera, Puerto Rico (south coast). Differences of the same magnitude were noted when the work was repeated one year later. In ge-

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Fig 25. verabilty of Fe, Ni ond Mn im four indivievel Gunises

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A comparison was made between the food of Tripneustes Punta

tisuero (Padina gymnospora) and the food of the sane species at

La Parguera (Thalassia testudinum). Figure 28 shows that thecg

Than tnsnehigher levels of Fe in the urchin's food at Punta iiguero

fhan there were at La Parguera. A relationship, therefore exttvea

Phere noni® Pigher levels of Fe in the urchin's? skeletons and in

parison between the stable element content of species of Facus fron

Scotland (Black and ilitche!1 1952) and Padina showed that tee clatoer

Contained one order of magnitude less Fe and Ni, but one order ay

Eigure 29 shows a comparison between elements in a single batch

Siythe same species of plants collected at La Pargueras Punta Hosiero

Rosen Bre Rect (west coast). Iron was high in Thalassia from Notre

Reet, Dut was low in the same species from the other t¥e locations:

Beet GaMas tittle difference in levels of Ni between the locations

but Mn was slightly higher on the south coast. The figure size shows

saonbatison between single batches of Padina gymnospora collected on the south and west coasts. In this case,-a greater amount of cach

gilement was found in the plants from the south coast. The hatch face fhe Sguth coast was growing on an iron bridge piling and further cock is underway to clarify the possibility that the proximity to the toh resulted in the higher levels observed in the plants,

are tevel of Sr, the only elonent analyzed to date (data not re= Ported) in the starfish Oreaster reticulatus, was almost twice oo

Tan ano tgeectnen from the west coast that was compared inva specinen fron the south coast. In the organisms reported, it is evident shin ag 20RSt Some. trace elements can be expected to be found in higher ie~ vels in individuals of the same species from different locategens

Differences within the same species of organism have also been found in two locations along the west coast.? Figure 40 Shouse seers Tities and differences between the sane species of organieee than gee sg bette, locations, each of which is influenced by a river drainag a,ifferent watershed. | The figure shows a comparison between aecriee Values in the tissues of four individuals of an unidentified key fogotd sponge, the skeletons of three gastropods (Strombus gursiia) and the skeletons of two individuals in each of tor geeries eee (leandrina noandrites): Levels! of Sr'vete:alnost identical in Mean- Spina and Eusmilia at the two different locations. Although teeeie of,St were loner in Strombus, individuals fron beth locations eee fained similar amounts. "No Sr was detected in She sponge either

site. The Mg content of Stronbus was noticeably higherein the ieee

1ipydattuenced by the ?Culebrings iver, whereas gone tendency tovard

4 hagher Mg content occurred in both Meandrina and Eusmite sy he

locality influenced by the Anasco River. Levels of Stand Me it the

gastropod Strombus were of the same order of magnitude sects othe

in three different species of gastropods from the west coast of ake

U.S.A. (Krinsley 1860).

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Fig. 20 Meon valves and stondord eviction ct Fe, Ni, ond Mn in

two species of marine plants

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The evels of Fe, Ni, and Mn in two species of gorgonians varied with distance from the mouth of the hiasco River,? Results of analyses of intact single individuals of both species appear in Figure 31. The individuals of both species from Punta Cadena, approximately three and one-half miles fron the river mouth fad higher levels of all three elements than corresponding individuals from Punta Higuero, eight miles from the river mousht

The foregoing observations point out the variability that may Occur within individuals of a single species that are separated by short distances. Observations of local variability will aid efforts to determine palececological conditions (Pilkey and Good- ell, 1963), studies in biogeochemistry (Chave 1962, Lowenstam 1954, Odum? 1957), and studies involving indicator ?Organisms (Osterberg et al; 1964).

?The stable element content of organisms from five locations along the West coast and one location on the south coast are now being studied. Work is continuing to more adequately quantify the differences that have begun to Spear and new species that are found in different locations are being analyzed. The food items of selected organisms are also being analyzed to determine whether relationships exist between levels of stable elements in an organism and in its food, and to determine the positions the organisms occupy in trophic? levels. An increasing number of both micro and macro elements are also being analyzed.

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CARBON, HYDROGEN, NITROGEN ANALYSES

Introduction:

In order to relate energy flow through an ecological system to the distribution of trace elements through that system, it is Recessary to know the stable element content, the "food value" and the caloric content of the individuals and groups of organisms that compose the system. A survey of the stable element content of various marine organisns. is well underway. The study of "food value" has recently been initiated in the Marine Biology Program.

Food values" are being determined on the basis of the car-bon, hydrogen, nitrogen content of representative forms ffon vari-ous "trophic levels. ?The per cent composition of Cy Hy and N af analyzed directly fron a single sample using the F. @'N, Scientific Corporation's Carbon Hydrogen Nitrogen Analyzer Model 180° "A" sual dried sample (fron 0.2 to .3 mg) is introduced into a conbustion chanber. Combustion products are cooled and collected im an expan sion chamber. "then combustion is complete, the products are intros duced into a gas chromatograph. Levels of Clas COs), hitas tz) and N as Nz are sensed by appropriate detectors and perwanené ly? re corded on a strip chart recorder. The height of the peak for gach glenent is directly proportional to its occurrence inthe sample;
The entire analysis takes less than ten minutes?

Using Acetanilide as a standard, ten replicates were run to determine the reproducibility of the method. The Tesults are con

tained in Table 8. The values for the 951 confidence level varied

by 0.6%, 0.1% and'0.09% for H, C, and N respectively. Conventional

(Pregi or Dumas) methods showed 0.34%, 0.6, 0.4% variation in Hy Cy

and N respectively. The least favorable comparison between the two

methods is between H values. There is 0.261 greater variation using

the Model 180. However, the greater precision with C and N values

and the ease of operation and time saving aspects of the Model 180

make it the more desirable of the two choices.

In order to relate stable element content and relative quanti-

ties of C, H, and N directly to the energy contained in animals com=

prising different levels in the food chain, calorimetry of represen=

tative forms will be carried out. These direct energy measurements

by calorimetry will be started after July 1.

Result:

fegults of CON analyses are listed in Tables ¢ and 7. In

general it will be noted that aside from mollusk shells, ee detri~

tal fraction of the sediments has the lowest values of N. This most

likely results fron di-nitrification through bacterial activity. Es

chinoderns have the lowest values of Cy Hand Ns The soft parts of

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Table 6, Percent of dry weight of organisns and tissues contributed by

hydrogen, nitrogen and carbon.

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Table 7. Percent of dry weight contributed by hydrogen, nitrogen and carbon

in samples from Peru and the Marshall Islands,

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Standard: Acetantiide

HYDROGEN ANALYSES:

ample # Weight of sample in age. Hydrogen in sample

L 0.8212 6.79

2 0.7098 6.77

3 0.6104 6.78

4 0.5082 6.78

5 0.4348 6.78

6 013986 6.80

? 013432 6.78

a 0.2718 6:80

9 on19s2 6.8L

10 0/1010 6.73

Average ~ % Hydrogen = ?6-872

(95 % confidence level) + 0.0440

CARBON ANALYSES:

Sample # Weight of sample in age carbon in sampte

1 70.99

2 70:91

3 7100

4 70.99

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Average - % Carbon =

(95% Confidence level) +

Semple ¢ Wetght of cample in og ?ENitrogen in sample

1 o.s2iz 10.36,

2 0.7098 10.34

3 0.6104 10.35

4 015082 10.35

5 0.4348 10.34

6 0.3986 10.36

7 0.3432 10.37

8 0.2718 10.37

9 on19s2 10.34

10 0.1010 10:39

Average ~ % Nitrogen = ?10.357

(95% confidence level) + ? ;09818,

Table

Test for accuracy of the gas chromatographic method for determin=

tng carbon, hydrogen, and nitrogen on sazples of biological origin.

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mollusks from Afiasco Bay, Puerto Rico, as well as from the Marshall Islands, while having levels of C that compare favorably with other organists, have relatively low levels of N (3.7% to 8.1%). Poly-chaetes, Sipunculids, Crustacea, and fish have slightiy larger a-mounts of N, in that order of occurrence, generally ranging from 8.34 to 14.44. The highest levels of N (14.3% to 18.9%) were found in Peruvian guano, Low levels of H, N and ¢ were found in phyto-plankton samples from Peru. The greatest bulk of these samples ap-peared to be diatoz frustuios. This could account for the low per Centages which were determined on the basis of total weight.

Discussion:

A point of interest becones apparent in Fig._3z- While there is little correlation between weight, H and C content of organisms, there is a direct relationship between increase in weight, and the

Necontent.

The comparative ease with which the H, N and C analyses may be carried out allows an intensive study of variation within individuals of the same species, and between individuais of different taxa. The importance of such information is emphasized by the relationship between size (weight) of individual animals and their N content demonstrated in these preliminary results. Through such intensive studies of groups composed of many individuais, will cone representative "food value" estimates upon which sound evaluations of the role that energy flow through an ecological system plays in the distribution of stable elements throughout that system.

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SEDIMENT INVESTIGATIONS

A preliminary report was made last year on trace element distributions in marine waters and sediments collected in Afasco Bay. Since then the elemental analyses have been completed and the distribution patterne of the elements in the sediments are given in the present report .

?The sediment samples were collected in two ways: by an orange peel grab and a piston coring tube. The grab had a capacity of one hundred cubic inches and was used only for collection of sedinents in water with depths 1 than 300 meters. The piston coring tube of the Ewing design was used to collect the sediment cores in a tubular plastic sleeve with ineide divensions of 3.9 om by 91.5 cm. ?The cores were removed from the sleeves at the laboratory and divided into three inch (7.62 om) increments and each section was placed in a polypropylene bottle. ?The sections were weighed and dried to constant weight at 958¢ (subsequent samples have been divided into two fractions - one is frozen and the other dried at room tenperature). Aliquots for analysis were taken from the centers of the samples to reduce the possibility of contamination from the sampling device.

A chart of the sampling area and a diagram of a cros

section through the area are shown in figure 33. Sediment

mples one through six were taken in water less than 100 meters in depth on the sloping island shelf. samples 7-14 were collected in watets 190 to 370 meters deep on the slope beyond the edge of the shelf. In this area the slope was approximately twice that of the shelf.

During the past vear additional sediment samples have been taken in the deeper waters. Purther sampling will be continued from the site of sample 1K to Desecheo Island and to Sponge Bank (fig. 1). In addition, a limited coring program is being started off the culebrinas and Guanajibo Rivers.

Figure 34 shows the distribution patterns of manganese, zinc, chromium and nickel in the sediment cores. The abundance of elements are shown with core depth in the diagrams to depths of 36 inches. Of the four elements, the

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amounts of chromium, nickel and zinc were not related to distance offshore and they did not exhibit (stratification) with depth within the cores except in core 11. In this core the amounts of the three elements were greater in the top 15 inches than in the lower part of the core. Manganese exhibited a similar pattern of distribution

in the same core. However, unlike the other three elements, amounts of manganese decreased with increased distance from shore. The average amount of manganese

in the two inshore stations was about 500 micrograms per gram of sediment. At the station farthest from shore the average amount of the same element was about 30 °/o of that of the inshore stations.

?The distribution patterns of manganese, zinc, chromium and nickel in core number 11 as well as the patterns for iron and magnesium suggest that the top 15 inches of core 11 were deposited from a sediment slide from the nearby island shelf. If this is correct, the sediment scavenged manganese, nickel, chromium, zinc, magnesium and iron

from sea water as it moved from the shelf to the site

of core 11. Additional sediment samples will be taken

in the area in an attempt to explain the anomalous

pattern in the core.

Figure 35 shows the distributions of iron and scandium in the same sediment cores. The patterns of distribution of iron and scandium were similar to that of manganese in that they decrease with increased distance offshore. The amounts of iron dropped from an average of 40 mg per gram of sediment at a distance of one mile offshore to a value of about 12 ng per gram at five miles offshore. The scandium levels dropped form an average value of 20 mg Per gran at one mile to approximately 8 ng per gram at five miles. Thus the reduction in the amount of scandium in the sediments with increased distance offshore was not as great as that of iron or manganese. In addition, the distribution pattern of scandium was distinguished from that of iron and manganese in that scandium showed no marked decrease with depth in core nunber 11. If the altered distribution patterns were due to the effects of @ submarine slide the amounts of scandium in sediment

umber 11 would not be expected to be influenced by the S116" since the amounts oF scandium in the ses water

of the area are low. Most of the scandium from the Aflasco River is precipitated within the first hour after it mixes with sea water and would probably be deposited hear shore on the island shelf.

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?The distribution pattern of magnesium is shown in figure 36. Except for core number 11, the distribution pattern of magnesium was the same for?all cores and was not influenced by depth in the core or distance offshore.

Pigure 37 shows the distribution patterns for calcium and strontium in the sediments. ?The average amounts of calcium and strontium, in contrast to the patterns of

iron, manganese and scandium, increased with increased distance offshore. The umounts of strontium and calcium in the cores were covariant. The covariance was especially marked in cozes 8, 11, 12, 13 and 14, Neither the rates at which the sediments aze deposited are known, nor have the sources of the calcium and strontium been determined. As a result, the mechanisms responsible for the varia- bility in the amounts of the two clements with depth in the cores cannot be defined. However, the variability

is much greater than that exhibited by the other elements and may be a direct resu=t of biological activity. work is now in progress to subdivide duplicate sediment samples, taken in connection with the benthic ecological studies, into biogenous and terrigenous components. The two com ponents will be analyzed separately for strontium and calcium distribution as well as for the trace elements.

In addition, work is being done on the sediment samples with X-ray diffraction to determine into which compounds the strontium and calciom are incorporated.

Figure 36 shows the inter relationships of the elements in the sediments. tron and manganese (Fig. 38 A) were linearly covariant. The atom ratio, manganese to iron, is 1.0% x 10" in the sediments whereas in the water of the Aflasco River the ratic was 17.5 x 10", ?Thus, the sediments were enriched with iron in respect to manganese. In figure 38 B the relationships of nickel and zine to chromium are shown. Both nickel and zinc are related linearly to chromium. These data are supported by the observation that the ginc chromite diffraction peaks occurred in the X-ray diffraction diagrams.

Scandium was not linearly related to any of the other

elements analyzed in the samples. However, the amounts

Of scandium were directly related to the logarithns of

?the amounts of iron and manganese in the sediments (fig.

36c, D).

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FIG. 38 Relationships of elements in marine sediments off the Affosco River. Jon and manganese(A) exhibit a linecr relationship in levels of abundonce ond ?are known 0 coprecipitate in sea water, The amounts of nickel ond zinctS) or linearly related to the amounts ot chromium, The levels of acondium exhibit linear relationships with the logarithms of the amounts of iron{C) ond mangonese (0) in the sediments

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As mentioned before, strontium and calcium exhibited similar patterns of distribution with core depth (Pig. 37). Thus variations in the arounts of calcium in the cores were directly related to variations in the amounts of strontium in the same parts of the samples and the atom ratios strontiun/ealcium exhibited a direct and positive relationship to distance of sample from the outflow of the aflasco River (Fig. 41 A). ?The ratio varied from an average value of about 2.7 x 10"? at one and a half miles offshore to a value of approximately 5.5 x 10 at five miles. ?Thus, the amount of strontium with respect to calcium increased with increased distance from the shore. ?The atom ratio strontiun/ealcium also exhibited a direct and positive relationship to the amounts of calcium in

the samples (41 8).

Figure 40 presents a sunmary of relationships of element abundance in the sediments with distance offshore. Although the elements show well defined patterns of distribution, the analyses herein reported are not suffi- cient to explain the mechanisms responsible for the elemental distributions, or to demonstrate that the aflasco River is the major source of these sediments. Observations made during the past year suggest that a large eddy starting at Punta Higuero often rotates in a counterclock wise direction between the island of Desecheo and sponge bank and re-enters the coastal circulation pattern near Punta cadena thence to Punta Higuero. The outflow from the culebrinas River empties to the north of Punta Higuero and usually follows southward along the shore and joins

the area of Punta Higuero. It may be that the contribu-

tions of calcium and strontium are mainly from this river

since it drains an area which is predominantly lime stone.

?Thus it vould explain the increased amounts of strontium

and calcium offshore from the Aflasco River.

Investigations on the currents of this area have been

started and will be continued.

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FIG. 39 Relationship of strontium ond colcium in marine sediments off the outflow

of the Afosco River

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FIG. 40 Amounts of ine elements per gram of sediment related to distonce

offshore trom the outflow of the aAkasco River

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METHODS OF ANALYSIS

Scandiva:

The scandium aethod, developed by sesbers of the murine biology pro- gran in late 1963, has been used to analyze acounts of the element in 260 Specinens of a wide variety of sample types. The oethod has been succes: folly used vith river water, rocks, minerals, soils, sends, arine sedinent: terrestrial plants, plankton, narine invertebrates and sarine vertebrate The acthod was described in detail last year and, in sumary, consists of!

G) jrradiating the sample for four hours in a neutron flux of 2.5 x 10 nfeat/sec, (2) dissolving the sample in weak acid (after alkali fusion, if necessary), (3) passing through q,Dowex-50 column on which the scandiyg is retained wile neutron-indvced P passes through, (A) eluting the Se? and other cations with 26 HNO; (5) coprecipitating the Se?® with zirconiua

Phytate, (6) rinsing the other cations from the precipitate with 0.2N HCI and 4X HNO and (7) measuring the SeOS by ganna spectrometry.

The large nusber of samples which have been successfully analyzed by

the method have confirmed the hopes that the method would be practical and applicable to the work in the marine biology. The reproducibility of the tuethod hag been tested with duplicate rune on several types of samplé

ally with differences of lees than 52.

The precipitation step does coprecipitate neutron-activated Fe? and 0125 ££ the two radioisotopes are present. However, the antinony is renoved in the ion exchange atep and the interference from the Fe2? activity aay be sasily corrected in the counting procedure. Thin fe {Illustrated in fig. 42 4m which the ganma spectrum of the sanp]s wae essentially identical with that of the comparator standard after the Fe°® component was gubtracted, Scandiue in Sea Kater:

The scandium method has been adapted to the analysis of the elenent

in sea water. In this analysis the scandium {s coprecipitated with scandium free sodiue carbonate. Five precipitations vith milligram anounts of carbonate quantitatively renove the scandiua from one liter of sea water, The precipitate is then analyzed by the regular scandius analysis. Figure 43 shows the gamma spectra fron a neutron activation analysis of, scandium in sea water. Tyg 6 Paration vas contaminated with a trace of Br? and a large anount of Fe?, how fever, the Se was easily determined by analysis of the 2.01 sum peak of the scandium isotope. The values for scandiun in sea water samples analyzed thus far range from 0,020 in the open Atlantic Ocean to 0.083 off the west coast of Puerto Rico.

Non-destructive activation analysis:

During Novenber, 1964 a rabbit system was installed in one of the chemistry laboratories of the marine biology program. Preliminary work has

been started on a non-destructive neutron activation analysis program. Whether

oF not an element may be analyzed by the method depende upon its abundance in

the samples, the % of the total isotopic abundance of the stable precursor,

the neutron cross-section of the precursor, the half-life (1e specific activity)

---Page Break---

95

08

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%,

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A

veal

cm

?? SEPARATION ON 0.1 GRAM

(OF ORGANIC DETRITUS

= FE°cOMPONENT SUBTRACTED

* SCANDIUM STANDARD

Os 16, 1s 20

F1G.42 Gamma spectrum of a phytate precipitate of scandium~ 46 precipitated

from O4 gram of orgonic detritus. The detritus wos separated from sediment

collected. in Afasco Bay, The sample was irradiated four hours in o neutron flux

Of 2% 10% n/emé/second, A smali amount of activated Fe?® wos coprecipitated

with the scandium phytate. Also shown is the spectrum of the precipitate after

the iron component wos subtracted as well as tnat of o 8.4y9 standord,

---Page Break---

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% - se sum peak

= RY ten ois nce.

Ea SSS rept

L ° a ?scandium

BOS Bg sum peak

Za ?wo

z

§

10 spectrum tm & 7q

"scandium ?

eparation on 8

-

UII

Us

Mi

TE boekgrouna:

Os 10 wey 1S 20

FIG.43 Gommo spectrum from 9 neutron activation anohsis for stable

Scandium in $00 mi of seo woter previously filtered through filter of

5 micron pore size before the scandium wos seporoted. Also thown

?is the gamma spectrum trom a comparator stondard (015S micrograms.

?f ?octvoted scandium). The woter contained 00203 + 00016 micrograms,

of seondiom per liter.

---Page Break---

of the activation product and the type of radiation enitted by the activation

Product. Of the eleaents selected for study, manganese, rubidium, rhodiun,

silver, indius, europiun and dysprosiun eait ganna rays in cascade. Coinci-

dence gauca spectronetry nay therefor be used to count the radiation froe

these activated products, thus reducing the interference from other ganas

eaitters, Other elenents vhich produce activation preducte which aay be ana.

lyzed by ganna spectrometry include caleiua, cobalt and iodine.

Figure 44 shows the gamma spectra from 4 non-destructive activation

analysis of sandstone froa Atasco Valley. The sandstone sauple (0.1 g) was

Put into a polyethylene vial and placed with another vial, containing « com

Parator standard of 5 ug of Mn, into a polyethylene rabbit. The sample and

Standard vere irradiated with neutrons for 30 seconds, allowed to cool 30,

?sinutes, transfered to new vials and counted at 30, 60 and 85 minutes after

irradiation. In this sample the amount of manganese was easily deterained from the spectrum. Calcium could have been deterained simultaneously had

4 calcium comparator standard been included with the wangenese standard,

Bisouth:

A method for rapid analysis of bisauth is many types of samples has been developed as a resvit of work done this year in an area of research not directly concerned with the marine biology program. During August 1964 two bmeabers of the marine biology program of PRNC, Radi MeClin and Frank G. Lowman participated in a resurvey of the Pacific Proving Ground at Enivetok and Bikini Atolls in the Marshall Islands. The survey was under direction of the Laboratory of Radiation Biology, University of Washington, Seattle, Washington. Among the samples collected were sediments from the large craters formed in the Feefs by the firing of thersonuclear weapons during the wegqons- test. pro- gram. Gonua spectrom analyses of the crater samples showed Cot® to be the deetnant radiocontaninant and Bi!0? to be second ip disintegration rate (Pig. 454). The only reference to the occurrence of Bi-07 known to the writer is hat of Lowsan and Palumbo (1962).

?Two 20 gram samples of crater sedisent vere dissolved in aqua regia and dried. One sample was dissolved in 0,26 HCl and the bisauth separated fon a Dowex-50 coluan (Lovuan and Palumbo, 1962), "A gamma spectrum from the leading fraction of the elution peak is shown in figure 45 (A). The other sample wes subjected to the following treataent:

(2) The sample was counted in the gaana spectrometer then redissolved in 100 al of triple distilled water.

(2) The solution vas poured into a separatory funnel and 100 al of 0. M Tri-n-octylphosphine oxide (TOPO) in cyclohexane were added to the funnel.

©) The

Paratory funnel was shaken for 15 minutes on @ eechanical shaker.

(4) The phases vere separated and two more extractiot

with 100 al of 0.1 TOPO,

(S) The fractions were counted and # 99.3 % yield vas achieved

---Page Break---

98

108

1} neutron-activated

11 mangane

1 (heitite 26 ne)

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i 2 30 3

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rei eB ae

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9 minutes, The haiflife

calculated from the

?above curves wos 9.0

minutes.

0304 0808 1012 14 1618 20 3.0

ev

FIG. 44 Gamma spectro from 0.19 of red sandstone mode 30,

60 ond 85 minutes after irradiation for 30 seconds ino

neutron flux of 2.5210! n/cm®/second. Also shown is the spectrum

of a comparator standard of 5.09 of manganese which wos.

activated with the sample.

---Page Break---

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%

TUL poz¥d O??

toe! 220

Nolwavd 3s

3ONUHOXS

NOIWOHS jo2!8

%

?NINOb/9

<0!

yo!

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(6) The bismuth was back extracted into 7H HCI for a final overall

yield of 99%.

(7) The bismuth is measured by atonte absorption methods.

?The wethod has been adapted to analyses for bismuth in biological, segigent, and aineral sanples. The yield is determined vith carrier-free Bi207 and the Linit of detection (+ 10% at the 95% confidence level) is, 1 ug Bi/g of sample, using cne gras seaples.

Lichium:

An adaptation of a published sethod for the analysis of Lithium in sea water has been tested and is in use.

?The procedure 1s a8 follows:

@) An fon exchange column (1.55 x 40 em) was prepared from 50-100 mesh Dowex-50 x 8. The coluen was treated with 100 wl of 6X HCL followed by 200 al of triple distilled water.

(2) Twonty al of sea water were added to the column.

(G) The column was eluted at 2 flow rate of 0.Sab/sinute with 25

of distilled water and 500 ml of 0.2N Cl. The eluates were Siscarded.

(4) Fiverhundred al. of 0.5N HCL was added to the column and the first 135 al of solution collected (ehis fraction contained the Lithiun) (Fig. 46).

(5) The solution containing the Lithiva vas dried in a quartz or platinun cructbio and the Lithiun redissolved in one ml of 0.28 Rel.

(6) The Lithium content vas neasured by atomic absorption and flane spectrophotonetry.

The Lithium in 20 nl of cea water may be meagured with an accuracy of + 51 (95 T confidence level). Complete separation of Lithium from sodium {8 hieved.

zine:

A wethod for weacuring zinc in sea water has been developed for analyzing large nunbers of samples collected off the outflow of the Afasco River. ?The eethod is aconablo to sivsleancous analyses on several samples, by one technician . In brief, the uethod consists of precipitating the zine from the sea water with a ferric hydroxide scavenge, rinsing the sodium chloride

out of the precipitate, separating the sine from the tron on a Dowex-1 ton

?exchange coluan and measuring the zinc by atomic absorption spectrophotonetry.

?The principal coure:

of error in the technique are caused by reagent.

---Page Break---

101

on 9 Dowex-50x8 ion

?exchange column (50-100 mesh; bed dimensions 155 «

40 em).

---Page Break---

102

contamination with zinc. Triple distilled water is used and the last stage

of distillation is done with a polyethylene condenser, The iron chloride

Keagent is freed from zine by an lon-exchange-chloride complexing method

(Kraus ang Moore, 1953). HCI and asmonia vapor are used rather than the

Liquid reagents except in the ion-exchange procedure.

?The procedure 19 ax follow

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2n65 tracer (containing less than 0.001 ug of stable zinc) was counted in the gauna spectroneter, then added to 500 al of sea water in a polyethylene beaker.

?The water vas acidified to a pl of 2 with HCL vapor and iron chloride (5 mg Fe) vas added,

One-half of the water was added to another polyethylene beaker fon a oagnetic mixer and the solution stirred while ammonia was

bubbled into the Liquid until a pl of 9 was achieved and the iron was precipitated.

?The ferric hydroxide precipitate was centrifuged and the super=

nate decanted.

?The precipitate was redissolved by the addition of HCL vapor and

steps 3 and 4 repeated on the renaining one-half of the sea water.

?The supernates from steps 4 and 5 were again acidified to a pi

of 2 with HCl vapor.

\dded to one of the acidified

and stepe 3, 4 and 5 were repeated.

Iron hydroxide (5 mg Fe) ws

superna

The precipitates were combined and dissolved in 2 al of redie-

tilled 6N HCl (a quarte condenser was used).

?The iron solution was placed on a Dovex-1 (100-200 mesh) ion

exchange colusn (8 2a x 260 sn) which had been previously treated

With sine-free water and 6N HCl.

The coluen was rinsed with 10 wl of 6N HCL, 20 wi of 0.6% Hel.

The coluan vas eluted with 20 wl of zinc-free vater which was collected in one ml aliquors,

Each al of water was counted for 2n® and the stable zinc was determipgd by atomic absorption spectrophotoaet-y. The counts from Zn°° were plotted against micrograns of stable tine in

each a1 (Fig. 47). Any point which fell co the right of the

Line shown ia the figure was considered to have been contaninated by environsental stable sinc,

?The total counts of 2n® added to the sea water was equated to the corresponding anounts of stable sine detected by the atomic absorp-tion wethed. (Fig. 47).

---Page Break---

ol

00.1 0.2030405 10 1s 20

yg zn

Figure 47. A comparison of the octivity of a Zrf° tracer and the

stable zine separated from one liter of sea water collected oft

the west coast of Puerto Rico. The high specitic-activity-2n®

(0.001 ug of stable Zn in the tracer) was added to the

sea woter and the stoble zinc plus tracer seperated by a

combination precipitation ion exchenge method. The values shown

are tose of one mi fractions which wer

Dowex-1 ion exchange column,

collected from tne

---Page Break---

References

Lowoan, F.C, and R. F. Palumbo. 1962. Occurrence of Bismuth - 207 at Enivetok Atoll.? Nature 193:796-797,

Kraus, K. A. and G, B. Moore. 1953. inion exchange studies. VI. the divalent transition elenonts manganese to zine in hydcochloric acid. anal. Chem, 75:1460-1462

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DATA STORAGE AND RETRIEVAL

4 fystenm for storage and rapid retrieval of data has been in=

collected poreee Kgqhandle the volume of information watch £S"heiny

Tau ected bY the Marine Biology Program. Information is punched es

TBM cards in two forns:

+ Geded descriptors indicating items such as sex, location,

date of collection, sample type, species, etc,

Ray data such as temperature, salinity, weight of sample,

aRoMNE OF Stable element present in ash, wet weight. ond

dry weight, etc.

dePTasase, tection is reserved on each card for a specific

piece of information (Fig. 44). Each card has the basic hesutigtive

srecumation pertinent ?to a-sample plus either ecological oe erabie

grgment data for a given series of elements aneiyzed from thar tae

ple.

By making use of the IBM Sorter and Accounting Machine, this

stem Provides an opportunity to make quick comparisons in addr tion

koa rapid print-out of al! data. Gross correlations between

dents of tase sepcteneats contained in organisms in relation to gra

dhents of temperature, sedinents, or salinity aay be quickignascest

grapnig 1acng With differences in stable element content between geo-
graphic locations, or between organs within the same animals oe dees
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Hang ling and analyses of information collected for the Nerina giee
logy Program.

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X-RAY DIFFRACTION STUDIES

Marine and terrestrial sediment samples are analyzed for their G}astic properties and stable element compositions as described previously. X-ray diffraction diagrams are used to determine in which compounds the elements occurs

The sediment and marine samples are transformed into a fine Powder and a diffraction pattern run for each one. The tubes usually employed as targets for the X-rays are Mo and Cu. The voltage used for the first one is 45 KV and the current 17 MA; for the see Gond one 45 KV and 35 MA is used. The diffraction pattern is run fron 2 cquals 2° until 2@ equals 80; running it at'a chart speed of 1*/minute.

The 26 angles and intensities are then read from the pattern for each peak that appears. ?With the 26 readings, the interplanar spacings or "D" values are determined from tables prepared previous~ ly according to the Bragg equation n = 2d Sin @ where n is consid= ered to be 1, 4 is the Ka, radiation characteristic of the target used, and ¢ is ons-half of the total angle of deviation of the incident X-ray bean.

The ?D" values are punched into IBM cards. A computer program is then employed which searches out and defines all of the possible compounds (on the basis of ASTM listings for powdered compounds) which ate characterized by the observed "D" values. If two peaks of the ?compound appear and the given intensities correspond to the observed ones in the graph, a tentative identification 1s made, since the third peak may be hidden by the background, especially if it is of low intensity, If the three peaks occur and the intensities correspond to the observed ones, a positive identification is (Fig. 49). The present progtam utilizes only the observed " Ues. The intensities for each peak must be checked manually. The Program is being re-written so that both the observed "b" values and intensities will be checked by the computer. Then, computer print= out will include only those peaks and intensities occurring in the Prescribed ratios for known compounds .

The spectra of elenents are obtained by using X-ray fluorescence instead of X-ray diffraction, and elements are identified in the tables for flucrescence using ?the 28 angles readings and intensities only. Several elements have been identified and others corroborated using this method.

The more than $0 compounds identified to date, both positively and tentatively, appear in Table IX. The utilization of these tech niques should provide basic information as to the compounds through

which stable elements are either locked into the physical environsent

or made available for the diverse biological pathways.

---Page Break---

proyon Sample jProanmed"O" values \ Jfroganmed \ASTMie

cord ne we f \ seta \ faterence na.

cate, 1.97 3.2L 2479 1CO CHO 040 9-b4 CuS-Cu,S copper

oars LBP ASSL ELS AGS cho bao acbe J J satis Gig

ose Wet iE 3cH9 tea ee Ono &-C861 | eeu,8. ae caper

Osta? 1197 1lee 2.79 LCO C90 ORO 40861 F guide , Digerite

ota Hor les 313 te co ono Scouet

ptt Nhe 328 TL tee Yeo too 2656

orien TBS AIR) IG te dhe ose Sono

a 38) SME TN Yeo eke 80 aoe

ony Bh RSE ATG BEG Yoo oko 3cFats

cies RSENS NG LEE G50. ban T0235 parasanes

eee MES th BES SS EE Eso Ono tons) [eee

cuPeAsoopH

0321-2 2.87 216 2ze7 243 CO C9090 ~e~o9tT FEED

0327-32163 ele 2287 2243 LCO C90 0906-0317

0326-2 2-83

0330-1 2-55,

0330-2 5.85

0332-13212

0333-t 3211

0333-2 2.32

0334-3 1.84

0335-1 2225

Gser1 lie Fae ata _2te3 tco C90 090 est}

S85 160 620 000 Te apo

BE 188 Sooo os te vetennpyemosrepy

7 too Gao 960 Lo-asa fase * Oneronte

1ee ee os5--tosear

0336-13213

0337-3 3.26

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omer 3013 [eo eso eso 7-404

3113 reo cao 070 10-474 4

3113 1Co C90 070 10-474, ICugS Big SyEmpiectie?

RAY te 190 979.2051

lea 16s 39 208 #aeze~ 7

{Tes (x=070, siver

lea tee Coe 208 49820 SeRRae,

21ET WO C90 OHO 10-436 ?Piha empeete

1172 ico C70 60 2-coe),

2i49 100 cur ust 1-216 Ywgsiog Eee

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cuss

Weer Dade

rune 2055.

Cywam3 2087

349-3 1672

350-2 2287

caso-3 2045

c35i-2 2.4C

353-3 2168

354-1 2246

356-2 $121

O3yr-1 2037

casr-2 172

cast-3 1245.

24g ico ca? O51 7-716

1le4 160 C70 065 9-436

2ieg 160 C26 024 B-467

3217 ico ceo 0802-1066

2259 1co C75 075 10-440

Tlag Leo C80 ONO 6-035 70398 [TEA TRENTON FA,

1143 Ico C30 ORO 6-035 TC 30H fF Eschwegeite

1149 Ico C80 GAD 6-0357C 398

FIG 49 A. sample poge of print-out trom a computer program written to serch out ond

?dantity compounds in s-Foy diffraction analyses on rocks, minerals, soils ond marine sediments

---Page Break---

10

9

CcoMPOUNDS TH ARASCO SEDIMENTS

1) (&,Wa)AL3(0HDE(S04)2 Alunite

2) T4305 Theantum Oxide

3) ou Fe 32 Copper tron Sulfide

8) Gu 5 copper Sut fide

5) 2 Pb 5. 4983 Dufrenoyeite

6) NazCa(G03)2.5H0 Sodium Galeton

carbonate Hydrate

7) Co Sep Cobait Selenide; Hastite

8) (Ca, Co,¥a,K)2(N,Fe)206(0 08,7)

Kopoite (fyrochtore)

9) Mn Fep(P04)2 (Oit)g. 2820 Baste Yh,

Fe (III) Phosphate llydrate

0) 103.810) Kyantte

1) Me Sp Molybdenum DL Sulfide

2) 0,851.5 Ca0.5t02.Nex 120

Plosbierite (Gel)

3) POO. 2Fe203 Pluaboferrite

(ead Icon Oxide)

4) S102 Silicon (1¥) oxtse

(atoha Ouarte)

5) Saponite

6) Sassolite; 13803 (Forte Actd)

2) ¢ Diamond

8) tng TO, Manganese Titanat

Hausnanaice

9) cag(P0,)9F Calctom Fluoride

Phosphate

0) Au = Gold

1) Sodium Calcium Aluntnun Stiteate

Hydrate

2) tie § Mercury (11) Sulfide

(hexagonal)

3) 7 imyzn,Ca) 0.3 510.8

Toucophoeniette

4) Cayna,Ped2Taz. (0,08, F)7

Microtite

5) Fe38y Saythite

6) 1g20 Cl Terlinguatte

7) 0,

8) Samarskite

9) Sauconite 3(zn,Ms,Pe,41)0.4

(54,4190) .2820

10) Fe 8 tron (11) Sulfide

NY nyt, Fe).(Fe.t)20,

Franklinive

12) MgO, Manganese Oxide

12) Pb5(PO4)5 OH Lead Hydroxide

Phosphate

4) HO Mercury (11) oxide

Table 9.

35)

36)

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0,83 MaAlSI0g, 0.16 CaAlySt90q ~

sodiun Ca, Al, Silteate

(8e.00),6 48 'S1

Maco Magnesive Carbonate

caceg At) (alg 884] .220,9(OH)y

Xanthoph {2 1it.

BeO Beryllivm Oxide; Bromel lite

(Wag6ay9) (A109) 996510,)6(0p) 9

(s0)12 » 1610 Viseite

(ve Fe) (Ce,A1),0, Magnestochronite

2 Fe" Feq"" (80,)q (OH)s Baste Tron

Phosphate

Gu 5.4 Cups Copper Sulfide; Digentte

Pd Palladium

Au Ag Teg Sylvanite

BigTeS, Bisouth Telluride Sulfide;

Geuenl ingize

(inFe),0, Iron Manganese Oxide

5 MgO.A1905.3 S40) .4H,0 Penninite

(above 600°C)

Mey rALSFeSt, 049 40H,0 Vermiculite

Ni,5 Mickel Sulfide; Va

e003 Iron (11) Carbonate

NeSb.0g, Bystromite

CupagSt Berzeltantte

cal002)2 (P0,,)p-8-128,0 Catetum Ur

Phosphate Hydrate

Me(OH), Magnesiom Hydroxtde

K,Cu(50,)p .6H0 Potasatum Copper (II)

Sulfate Hexa Hydrace

?Ag Fe,5q Silver Iron Sulfide; Argentopy-

rite

Cig Te Copper Telluride (x = 0.6)

Coat, Cobalt Arsenide; Skutterudite

(Pe, (Ta,%),0, Tapiolite

FeO. (Cr,A1)203 Chronite

(co,Fe) As § Cobalt Arsente Sulfide

cohaitite

&e Copper

8 6x0, Copper (TI) Chromite

came (5103) Catciua Magnesiue eta

sitteace

Me Fe,0, Nonganes

site (oynthette)

ste

a

Iron Oxide; Jacob-

Compounds tentatively or positively identified in Anasco Bay Sediments

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New Facilities

During April, 1965 two buildings for use in the Marine Biology Progran will be completed. A nev building, located on the grounds of the Puerto Rico Nuclear Cénter, Mayaguez, is a two-floor structure and Will house an instrument laboratory (including 4 low-background facility) fon the first floor and two chemistry laboratories on the second floor to be used for trace elenent analysis of sea water, The other building is Iocated on the BONUS site at Pea. Higuero and is being converted into @ natine biological laboratory.

?The building at the BONUS site wae purchased from the U.S. Navy by the U. S. Atomic Energy Comission. The AEC also allowed $4000

for conversion of the building for use in the marine biology progras. The building, as purchased, was 40 by 20 feet in length and width, and 13 feet high with a pitched root, It was constructed on a concrete slab with steel framing covered by 1/2 inch thick asbestos-cenent panels, It was completely insulated with fiberglass batts, wae wired for laboratory use with 110 and 220 volt outlets and contained shower and toilet facilities, One end of

the building was provided with sliding garage-type doors,

?The conversion vork on the building is almost completed and in-

cludes the following project

(1) Purring strips vere bolted to the inside of the steel frane and the interior of the building was paneled with sheet rock.

(2) A stairway vas butlt to the space over the shower and toilet for access to storage area.

(3) The garage-type doors were resoved, steel framing installed in the opening and the opening was paneled on the outside with estos-cenent board and on the inside with sheet rock, A Fegular exterior door was installed in this wall.

(4) sn instrunent Laboratory 12' x 12! wee constructed in one corner of the building and an air conditioner wis installed. ?The walls between the instrument laboratory and the sain laboratory were provided vith windows,

(5) Sleeping and cooking accomodations for four researchers were constructed. Because the building will be used for uptake fexperinents and other marine biological vork which often require 24 hours attention, these facilities are necessary.

(6) A salt water system vas installed with puaps, a settling tank, a salt water table and running ealt water.

(7) A total of 60 feet of laboratory benches were constructed tn
the two laboratory rooms

(8) 4 protective cover was built for the air conditioner.

(9) The building vas painted.

---Page Break---

dil

Barly in 1965 construction was started at the Puerto Rico Nuclear Genter, Yayagues on a new building for use as a chemistry and instrument laboratory in the marine biology program, The structure ts buile of reine forced concrete, 1s thirty two by twenty feet in Length and width and te two stories high. The new building ie located 300 feet northeast of the pain PRNC building.

?The new building is constructed in the side of a hill. the second floor of the building coincides with the outside ground level on the sic facing the sain PRNC building - on the opposite side of the new building the lover floor is at ground level. Thus the rediation counting eqipaeat, which

WALL be placed on the first floor, vill be shielded fron the research reactor and; CoS? gasna source in the main PRNC building by more than 300 feet of foil. Entry to the instrument room is gained through an office with dicen sions of approximately nine by twelve feet.

?The second floor of the building contains a central office and Storage room with dimensions of approxinately thirteen by twenty fect. A lavatory and toilet is built into one corner of this room. On opposive

sides of the office are two chesistry laboratories to be used for trace element analyses of sea water. Each laboratory has dimensions of nine by twenty feet. The entrances from the office to the chemistry laboratories are fitted with sliding doors. Entry to the laboratories is gained by pase- ing through the length of the office from the outside office door, The laboratories are this isolated from direct entry from outside the building.

The two chemistry laboratories and the central office are se:

viced by separate air conditioners and the outside alr which Ls supplied

to the laboratories 1s subjected to special filtration. Each laboratory

4s supplied with @ stainless steel hood and the ordinary cheaistry laboratory

furniture.

---Page Break---

STABLE ELENENT ANALYSES

The following tables list the samples for which trace element

analyses have been made and corrected for wet, dry and ash weights.

Analyses which have been made on other samples are not includes bes

cause the calculations are not yet completed.

qre,values presented were intended to present only two significant figures. In some instances, the final calculations in these tables were not rounded to two significant figures. this docs nee signify confidence in the third figure and these values should be rounded to two places,

The analyses were made in two ways - scandium and rubidium by activation anglysis and the remainder by atomic absorption or flege gpectrophotonetric measurements. The activation analysis methods, ate descrived elsewhere in this report.

Sapples ere prepared for emission and absorption spectrephotonetry An the following manner: (If necessary, specinens are Frosentretsy Processed). The specimens are wet weigheds dried and then sehen tt

4 temperature of 450°C. ?An aliquot of'0.25 gram of ash is dissolecd

in agua regia and warmed on a hot plate. Iti filtered by vaccum through two thickness of glass filter paper and washed three Cisne with 0-2N HCL. The filtrate is brought to a final dilution of 1/100 (weight/volune) by adding distilled water. ?The filtered sampie 44 analyzed for content of stable elements, The atomic absorption analyses for the elements reported in these tables (Ni, Zn, Cr, Mn, Co, Cd) have been tested for possible intergeronce errors in the types of samples used in the present work. Interference effects have not been found. However, this method ie also used for the determination of magnesium, calcium and strontion and, for these elements, interferences do exist if large amounts oF phosphate, silicate, or?sluninum are present in the sample. These effects may be eliminated by the addition of excess lanthanum to the samples

---Page Break---

on ae 6 dort . ot 16 aay .

wm s rort . ost ot stat, *

ork » dort 4 » ost ott oat .

oz ot gE ott oot ?oar .

one 6 fort " ones earn 7

ort 09 e2eewy 350 vor oz oat aan

adep "atee commuy 330 VEL .

m 0% horL . ote KotL .

2a Te ? or ze TL

- ar ? . oft 8 MATL ?

wo . . on . ?

oon ? ost om o

x 86 . . one . .

oon ? . ooz ot : :

zoo . * om oo : . "

es oe . " on 96 . « 7

or oos . oor as " "

ur . ot 68 . " o

1 6s . ot ge cot .

ot "5 eoseuy 330 8 Oct ce oosewy 330° v ott ?poe

tadop ?te 9409 uoasya Tepaseaz01 adap "wpye S20 uoaeya Tesazeeazer

?hag Sog¢ aap saa ayaa Sef saa as

TT TRPT EE wopao01109 ? oygsauay9g go. 9d ?? aA oystavaras yo 9dr

1

---Page Break---

? 62 "4 conry

m9 9°98 ITE

yz 9T wang orb ya0g

wadep "zw

WT CT §¢*__opewpy winoe

wadop "ag 7°28 GE "

? t% =a ?x ooeeny

wader ?ast 9I-d " ot .

a a 2 . ato " wor ?

os me " een " a 88

giz sts . e- ?por

~ 1202209 %R . a se eS

=

=a eon we ETRE . os ow DOL a

se CIE 4 ? ss ee « ?OTL

oct oe 6 DIE ? vB tS eoewBy 330

wadep "Ryd -VBT-T

ae ra " ost oor .

sot nw OVIRT 4 " ost oot

ore u POL w . ot 66

one 6 TORE . onto.

oct ozt 6 HOE : ost 96. 6 Rae .

Oct ?8_ooeeUY 330 9 OZ-1 ?Pas T¥EI2N0Az0r ort 08 aeare 9 1-1

wadep ?eIs¢ 9409 wore cooevuy 330 9309 UoaeTa Teyaaseaze5

yx cot x

sara Tae 30 war wo ?s yaa

sysvauayos 30 add, ???"Wes¥7@HH ?woyasaytop ? avs raue2g 50 dA

---Page Break---

?type of Sciontitic Collection

an site

Terrestrial bottom 20m. a

ied. 7-7 Enriquez Pass

" ?ome 20 fe. depth

Inside cat Is.

" ?mas 230 depth

Atasco River

" "mea 358 a. depth

off Afanco R.

a "pee "

" ? mee ®

? ?pap «

* "nae .

« ? nee "

~ m6 ?

. "med "

Water

Water ?anaseo

a

150

140

nu

10

200

200

120

130

130

250

230

180

190

320

350

210

230

250

35 us/al

37

---Page Break---

i1s

Type of Scientific Collection vg Cd /

agp le naw ite wee bey ae

Terrestrial Piston core 64 a. depth

2 TB off Anasco R. 3.4 5.0

" ? 18 27

. Sea botton 65 ». off

sed. T-12 Anasco R. 5.8 87 9

: ?ons 20 fe. depen

Inside cat Is. 3.9 5.4 5.5

? "nas 230 a. depth

anasco R. Lae 27 3.8

7 ?rae 190 m. depth

Anaseo Re 26 49 5.2

" "ons 20 =, depth

Enciquez's

Pass 36 56 5.8

" ?mr " 207 4

7 " n10 50.3, 22m. depth

mouth Anasco R. 1.7 3,6 4

" ?ro St.2, 8m. depth

south anaseo'R. 9.7 17 18

" "26 20a. depth

Enrique: Pass 5.1 7.8

? ?ora St. 60m, depth

wouth Aflasee R. 1.93.4 3.6

? ?nara Off AnascoR. 4.36.8

" ?omy 33 52

? ni7¢ 26 42

" ?me ? 20 35

? "nave " 2.9 48

" ?rik ? 25 39

. "mins " 2235

" nt ? alo

" "nara ? 28 4.6

---Page Break---

ir

Scientific Collection

pane site

Cetengraslis South of

edentuius La Boquilla

FS 0.26 0.7% 3,8

. ?ope ? 0.22 0.82 2.9

"ee ? O21 0.91 28

" ny ? 0.50 2.2 6.8

" "ne 0.28 2.0 36

"Be " 0.29 0.96 3.8

. ? " 0.38 0.8527

" " " 0% 12 43

? "pa ? 029 4d oa

. "pase " 0.23 0.8932

" "ea ? 0.21 0.80 3.5

? "pag " 0.25 0.88 3

" "pa ? 038 15 as

" a a 0.29 14 34

" =) 056 1865.

ne) " 0.55 2.2 6a

" "po 025 103.0

? a 0.52 2.0 6

" "ete 025° 10 3.0

" "pe " 0.52 16 ws

? "pe ? 0.29 a 3a

" no) " 0.25 0.9 36

. "rae 039 ee

? "mn " 0.36 16 52

" "pas 023 Ls 42

---Page Break---

?Type of

Fach

cotengrau'

edentulue

Scientific

ais

P33

By

¥39

Po

28

Fug

P22

P46

P26

118

Collection

South of

Ta Boquilla

0.24

0.28

0.27

0.43

0.36

0.29

0.40

0.62

0.69

0.75

0.43

on

1.0

13

0.90

0.59

La

0.7%

0.91

1a

La

0.95

1

0.98

Le

13

Le

16

he

16

La

3.3

5.3

a7

4a

---Page Break---

119

?Type of Sctentific Collection ug ca

imple nase ce me ae

Fish Gmtorescosbrus South of

crysurie F-0008 La Bomilla 0.170.833.

" v2 " 019 103.5

? "pan . os 0.8327

° 25 ? 016 0.7% 3.0

" "pe ? 012 0.6817

? a 0.16 0.66 27

" "oR . 0.16 0.92 28

? "26 " O12 0.96 18

" ?pas " 0.23 0.95 4

" ?pw . 002 0.87 3.4

" "pas . 0.22 100 a

? rm ons 0.68 28

. one ? 0.10 0.08 Le

. "ons " on 009 ne

. "pao ? O16 0.58 2.9

. ? " 0.20 0.92 3.4

" "peg " 0.08 086 22

" "pe 021 058 at

" "pa . 019 0.8734

? "pen . o1s 07525

? ?per ? 0.20 0.92 4t

" "pe " 0.16 on 29

* "opm " 0.21 0.97 2.7

Fish Cetengraulis

edentulus

F-0005 * 0.50 2.0 0 6.5

" oy " 0.20 0.88 3.8

---Page Break---

120

ype of Scientific collection va ca

sample__nane tte BEE pry

Fish Barengula South of

37 Ta Boqiilla 0.23 0,783.2

» "pas ? 028 100037

? "50 " 0.1 0.98 2.9

. "pa " Ome 17

. ? p26 " 033 136

? ear " 025 0.90 2.6

" optethonena

oglinue

Pt " 0.17 On 3.0

. "Re " 01s 0.6225

? pao " Ou 07% 2.8

? Pe? " 0.10 0.39

* ps ? O16 05518

. "Bs . 0.16 0.66 3.2

"pe 0.19 0.76 2.9

? "6 ? 0.15 0.60 2.8

ne ? 0.16 0.6029

Ps . om 052 28

Caranx (food)

Tata

8 " on 32

* ?ors " 0.09 0.06 1.9

* ?en " om 055 at

* ?Rs ? om os 18

. ? P6 ? 017 09933

* peu as 0.62 3.2

» ?ons " 029 13288

Pz " 0.17 0.67 2.8

---Page Break---

Scientific Collection ug df

name site ie aa

Caranx (food) South of

latue F-2 Ta Boqilla 0,291.2 62

7 "oR? ? 019 0.874

. "pas " 015 0.62 28

* "pe 0.3343 4a

word ? om 057 Le

" ?pas " O16 0.72 3b

Algae Laurencia

obtusa Cayo Enriquez

a5. ot 245 47

? HsLineda

?opontia

a4 " 163.6 3.9

" A-0026 a1 Cayo Turremste 0,22 2.7 12

Codiun

Tayloréi

a7 Guanica 0.26 3.0 6.2

: Sypme

muteiformts

15 ? 0.27 0.68 6.4

? Bnteromorpha Cayo Enriquez 0,10 2.4 5.7

" Grecilaria

amet lacie ouanica 02725 37

" Thalassia Belvedere O10 0.91 3.4

? ?Acantophora

spicifera Cayo Enriquez 0,08 1.8 47

" vatonia

ventricosa

a3 ? 0.22 at 5.9

? Laurencia

papillos

aol? oventea O72 5.7

. Lyagbia

ayuscula

a2 Cayo Turrencte 0.15 2.1 43

---Page Break---

Terrestrial

Scientific

Gracilaria

?caudataA-10

Mixture of

?Acantophora

sptcifera &

Spyridia fila

swentosa

ot Known

Mango Leaves

Pueraria

hireuta

Mangrove

leaves

Sugar cane

Tasarindo

leaves

Chucho

Pajuil rojo

Coconut hard

shell & meat

Mangrove

sube. roots

Sugar cane

eaves

Alnonds

Brazil rubber

Mangrove

aereal roots

Piston core

eed. 7-20 E

nist

422

Collection

cayo Enriquez

Parguera

Coconut area

Rincon

RNC

Coconut area

Rincon

PRNE

Coconut area

Rincon

1a Parguera

Coconut area

Rincon

La Parguera

351 a. depth

off Atasco R.

31. deep

off nacco Ry

0.10

0,082

or

0.08

0.42

22

0.63

0.23

0.13

0.49

o.61

0.39

0.30

0.069

0.82

0.075

3.0

a8

a3

35

3.5

35

---Page Break---

123

?Type of Scientific Collection ug Cd /

sample Dey

pase a aE

Terrestrial Piston core Off Anasco

sed. 17 B River Mts

" ?mare Ma 2a

" "np . L628

Platon core 343 a. deep

TAG off Afasco R. 1.8 2.8

. ? 16 F . 23 42

. "ren . 21 36

. "nies " 22 35

. "m6 K ? 2200 435

? "met " 26 38

" "m6 a " 2.8 5.0

. " m66 " 238

" "rier " 2a 35

" "rie B ? 29 52

" " 166 ? 29 7.0

. "nip ? 37 6.6

. " niee " 2.0 3.8

? "20 351 @ depen

Off Anasco R. 2.22.9

. Sea botton 20 fe. depth

sed. Tod feside cat Is. 2.9 3.9

Plankton Mixture P21 South of

Vieques 0m 5.8 %

" "1B 3. south

of Desecheo 0.96 8.4 2

" "20 Sponge bank 0.26 4.07.0

" "mts amasco Ry

south 14 10 %

---Page Break---

Type of

1e

Plankton

Scientific

124

collection

Fern Point

south of

Vieques

21/2 alle

off Point

Brea Parguera

ug cd

ie

3.3 20 38

1.826 56

0.083 3.3 23

---Page Break---

125

Type of Scientific Collection vg of Co/g

senple nave ce ie a

Fish Makaira Virgin Gorda

nigricans Keland 8, B.

(gonads) end 0.36 12 © 20

" " (liver) " 002 12 82

. (er exact) ? 053 3.3 82

" " (spleen) " Le 5.238

? " (gonads) Arecibo 037 LS

. " (Gr tract) " 056 3.9 50

Invertebrate

(eponge) Doniriella 22 13 24

---Page Break---

Type of Scientific Collection ug Co. ug Ma /

sample nas site iet_?ory ? Sch?Wet Bey aah,

Detritus Atasco Bay = 17 HLS

87 15883085

1 48163 460.700

MoLluse Anadara sp. ? eM

? Pitar sp. ? 565858788

: " ? 2 55 5997s a6

Echinodermata Luidéa

senegalensis 1327 3648100130

2 35 46 mH

---Page Break---

Type of

Plarkton

Invertebrate

(sponge)

Invertebrate

(Corgoniun)

Invertebrate

(sponge)

Invertebrate

(gorgoniun)

Sctentiftc

Mixture

Lot of

paycoplankton

Mixture

Treinia

fasciculata

Purple sponge

Hal selona,

Soall grey

?sponge

Bunices

Peerogorgia

Dyctiopteris

justit

Coraline

Padina

Collection va ce

Mona Isl, O82 42

5 win, vest

Of Mayaguez 2.3 26

78 ai. depth

Alasco R. south 0.70 5,2

3m. south of

Desecheo Isl. 0.32 2,8

Sponge bank = 1.218

South of

Vieques 49 38

. 60 760

Porn point

south of

Vieques 33200

2 1/2 ml. off

Point Brea,

Parguera 0.43 a7

Pea, Higuero

Negro Reef 6.915

? 64 28

Mona Tel.

Pra. Higuero

? 4935

?7

93

1,800

120

750

a

7

37

50

3?

7

7

0

---Page Break---

128

Scientific Collection raed

tees ae

Algae Sargassum 39

Fish Thunnus albscore

(skin 6 scales) Ghana, Africa 7.5 27 75

Algae Gracilaria . wo 18

" Bryothamaion

triquetrun ? O80 500 9

" Coddon

taylorit ? Nor DETECTED

? Galaxaura

cylindrica " ?oon

? Laurentia

Papillosa " «

Invertebrates Panulirus

argos 1-18 Joyuda beach 0.66 2.7,

(sponge) Species 774 12 at. off

Pte. Higuero 0.48 2.3 9

Invertebrate : 3 ai. from Pea.

jellytien Arenas Mayaguez 0.22 7,2 9

Invertebrate 12 atte off

?sponge Species 744 Pea. Wiguero 1458.8 a8

? Species 767 1/2 atte off

Pta. Higuero Wor DETECTED

Invertebrate

sponge Species 727 ? Ls? oas

" Cayo Turresote NOT DETECTED

Invertebrate unite

urchin Cayo Turrenote ML 11 13

sponge Species 732 1/2 atte off

Pla. Wiguero 7.612 16

Invertebrate Brittle star Cayo Turrenote 6,212 %

Acanthopleura

granulate Hard Bonus Nuclear

tissue 6H Plant now 6

---Page Break---

129

Sctentifie Collection gor) gs

8 te ee

Invertebrate chiton Bonus Nuclear

Squancsue Plane woe 20

wa

" Panulizue

argu 245 Joyuda beach Nor DETECTED

Fish Harengula South of

Peis La Bomilla 0.96 3,4

Terrestrial Piston core 3588. off

sed, 1-226 von

" "mre " woo

" ?raza " yoo

? ?nae " z 2

" ?mae ? w oR

" "mez " 236

" ?nae " a6

" "pee ? won

" "nae ? a7

"mes . woo

Invertebrate 1/2 mite of

(sponge) Pea, Higuero 0,492.29

"om . Nor DETECTED

" "767 " wor DETECTED

" "736 . 84 13 16

Invertebrate Acanthopleura

(wolluse) granulate Bonus Nuclear

(hard Ciseve) Plant 91 2 4

" . " CTS 16

Invertebrate Brown sea

urchin Cayo Turresste 6.313 8

" Panulirus

argu Joyuda beach 0.66 2.78

---Page Break---

439

Type of Scientific collection vg ce ug Fe

sample name aice etry a Wet ey aah

Echinodera Tripneustes

esculentus Bonus Site 1638? 43 as.

. ? we 53 50

? ? ? 2 46 52 2% 596

23 5966

. ? . ez 7% 87 259 66

? " . 2% 63 on

. ? . 47 10130 2% 60 69

" 4% 10 20 2355 62

? : . 8787 3994 110

" 7 . 47 10120 27 8s

" " . @ 95 0 23 6368

? ? 2 32 60 wo 653

? " ? wo 60 29 868

2 73, 0

7 " " 7 682 369910

" " " 97 110 2% 7388

. . " 2% me 97 0

7 » ? 38 0130 30898

? . " «2 0 130 30 7 90

" " Parguera 41100120 7 wm 82

" " " 35s ww % 82

. " ? 3% 86 100 ws 82

. ? ? me 6% on 2 65H

? " " 2% 7995 2 5876

" " " 44 0130 2% 676

---Page Break---

13t

?Type of Scientific Collection vp Fe) ug Ce,

nase ite ie Tak ee aa

Echinodera _Tripneustes

esculentus Rincon 120 150 170° 250 310350

. " . 80 92 100 190 220 250

. a ? 330 480 540 210 310350

. " ? 6 100 110 200 300340

* " " wo 140 150 260 300340

. " " 160 160 180 300 300340

" " " 140 140 160250 270300

. . ? Mo 150 160 210 290320

" ? 78 88 100 260 290 330

. " " 100 100 110 300 300340

. " 150 190 210 180 230250

" . ? 150 220 240 210 10340

? ? ? 280 280 320 240 240 270

. " 660 680 760 230 240 260

" " . 150 180 200 200 230 260

" 53 100 0

" " " 2% 47 500

? ? " 82 150 160

? . ? n 133 wo

. " " 81 170 190

" " ? 60 100 110

? ? " 33963

? " ? 55 100 110,

52 100 10 160 310 340

---Page Break---

40

38

2

se

6

a1

sh

30

80

uo

%

45

?

100

x20

?

37

1

8

34

85

160

8

10

a

170

130

6

n

37

6

260

n

%

6

10

130

90

6s

6

100

100

95

180

ct

0

?

190

40

n

63

120

160

Mo

130

140

150

160

nto

120

150

130

150

120

3

2

m

2»

3

2%

n

19

a

a

2

28

230

260

320

200

260

270

270

200

240

260

250

350

210

49

4

a?

49

ey

a

250

290

310.

290

B's 8

260

290

270

240

3s

8

50

?

a

2

a

---Page Break---

4133

Type of Scientific Collection ug Fe/p ug Cr/g

te nae te et dey Aah tee

Echinodere _Echinometra

lucunter Parguera 95 140 wo | 28s

? ? ? om 8 2 so

. " " ?mom w nox

. . ? 170 180 200 28 2933

? " ? 81 uo 20 28 eae

. ? " 20 190 210 29a.

7 . . uo no wo ww

" ? " 100 100 110 40 a6

" 357 63st

7 . ? 6 6 ono 506

? " " 430 470 5208391100

. " ? 9% no 20 30 a5 8

? . ? 5758 65

" " 190 200 220 4 tae

? ? " 21036 sas

. ? " 6% 68 7 mas

? . 180 180 200 282933,

7 ? ? a ee ee)

---Page Break---

Type of Scientific collect ton

sample pane site

Echinodern Tripneust

esculentus ?Farguera 3090 7 654

? ? " 7 7 95 we 506

? - " 45 m0 20 2% 61 70

" Echinonetra

lweunter Pea, Wiguers 36 4046,

: Bucidaris

eribulotdes % 3% ow u0 130 140

---Page Break---

135

6 ot oot

exensava eenp eH

ot mae aera o-k

eayony eaetnuead ex 9geaq

souog -noqdoyquesy -aazequT

ore ez oso yueg oposne s33q

9 ,201dd039 nny xueae9 .

ose ort 92 ? art ? oe ee et yee queyg tesaaeeaz0n

09 92 ovo aoa ore . we oa se sees 9 Oras

seuragetng sorry oaeqTe

souuatay swung, usa

?2Bucds

mM ort sto . . ? SL 020m on8oN uot orTeR 23034,

-oazaauy

M960 920 oapoaay speuct

suv9} 385

carer " 0S ty ez oxanByueagetteanexota *

1 $90 ato " apruos ,, . somo eaezouay

er8 909 93034

sxofooag?-23 39007

9 OT azo 6 RRL 1D, . 98 ee 9 g90u onto oBuods

fo38 11905 .

Buds

Te 290 . uoetds ? mm cee oxonisH eavtnotoee3 eae1q

read eruysay ?-ea9au7

% 680 te?0 porter soar wre 08 as gz exerts, wosqung aaezeauay

epx09 sueayayu vena 909 93029

WA aT sena9auy

Yaa aor sae Ear ar aed sya

WRT HT uoyavatt09 ayzyauay9g woravettog 73 TauaTlg 30. BdKE

---Page Break---

Type of Scientific Collection ce n

sample ane site ee bey Wet pry ? ah

Alga Pagina Pea. Miguero 8.52743

. Padin,

aymnospora " 3.8 2159

" Penicillus ? 61 304

. Dictyosphaeria

Eevuloe ? S135 a

? Cymopolia| " no ase

" Dictyopteris

Justit " 85 338k

? Dictyophaeria =" 39

? Aaphiroa 22 ee

" Codius ? 440 700 1100 20s

. Penicillus ? wo 27 33a

" cynopolia ? Ro aw

? cavlerpa ? wm mews

" Diceyota

dentaca " 7 530 98 38 20220

: Bryothasnion " mo Bo 230 sk

" aaphiroe " 335 wa

Miscelaneous

sediment 6 alga " a a a

alga Penicitiue " 9 35 46 as

Marine

angiospera Thalassia ? wo 6s 8 tw

Alga Sargassun . 5 25

" Dictyota

dentata ? 4 mw

? Aaphizoa ? wow

" Dictyopterie

juseit 3 Bo

---Page Break---

?Type of

sanple

Marine

angiospers

alga

Marine

angiospers,

Scientific

Thalassia

testidunee

Sargassum

Tendigenus

Sargasoun sp.

Bryothannion

triquetrun

Penicttius

Dictyopteris

Auphiroa fra

silissins

Padina

Dictyota

Padina

collection

i

Pea, Higuero

Bonus Site

3.4

40

47

12

Le

a

33

49

2

a1

16

9.0

6.9

35

35

4.0

307

48

9.0

3.9

2

97

5.1

5.6

2.0

5.7

42

28

12

4s

42

6.0

Ni

a a

a 86

we 49

2

B55

3 66

28

9 as

mw 8

7 66

38

37

7 on

37

Be

aoe

38 100

2 96

37

33 100

39100

---Page Break---

?oo on mu .

St 8 19 ooqsoved 0s000-1 .

© st 0% coponed 1800-1

wo 8073088 .

1S 1h goo oxen waptygorae

super .

mo ve evade 03

suads Goap -eiqeaz0nny

«om et oxondyx

oo vag ewes .

br} & st oy oxonsyH syaenr

wad eyz03doy390q ?

wo ve sno super .

96 TE T'S g0my osfom wrterzyeem saesqeazenm gy oy Tsang.

vag .

sr ?0 P9009 oe oo we «

92 eso 10 0071 ee ee s0a0g srorsola *

woe oo » 398E I ? om se soru009 worpea .

Oy zt tar epzos ??waotds . 6 aes sorueng 7500-¥

rea ssoanea03

Oz aT 670 onzaay apn, 9909 ez nakande ?1E-¥-9500-¥

wrasundo

epont en

ve bt 90 ongoeay spewod wera 099s tno pos

weap 3870 trad woayuia

caret uy Te309 shy

aaa au aan ayaa a or wae sa

?EERIE worssetig oursesas pe 00d TTT ? woyaoeytey ?arsawey9g 30 ad

coe @ © © @© @ © © © © © © © a 8

---Page Break---

Type of ?Sclentific collect ton we NY or

sample nave te wet bey Wat Dry heh

Bchinodera Tripneustes

esculentus| Fea. Higuero 1636 wow

? " 8.6 6 38 os

. " . v6 ow wm 303s

. " 2 os 2 458

. ? % 2 on 3» Bow

" " . 2 mw wot

. " wow on a 50

. . " 2 49 54 me 50

" " 2% wo 2 35

" " mw ow 2 4h 50

" " . yoo» yom 73

: . : woo ww

? ? . B85 2 8

" " " yo 2% 47 50

" " " 20 we yon 3s

" " " we 2730 233850

" 2 6 40 130235

. . . 3 2 3s 1943

? " ? 20 7 ow

. " 23 38

* . * moe ow

. ? . a3 2% 6

" « ? ao

. " " ao

" ? won 3s 23 a8

---Page Break---

?Type of

1e

Bchinoderm

Scientific

Echinonetra

Yucunter,

collection

Salt Key

26

26

2%

7

28

26

29

28

2s

29

26

4s

a

39

?5

aL

46

43

st

65

50

45

?9

so

8

16

w

6

16

15

w

1B

3

18

6

v

v

wv

wv

a

1s

8

18

20

v

2

2

29

4

2

32

2

26

26

2

7

Ey

26

a

2

a

Fy

3

2

a

2

6

Fa

?

2

3

8

2

2

3

---Page Break---

?Type of Scientific Collection ug Ni ys

sample ane site Wee bey eh Wee Dey

Coclenterate Eunicea

laciniata Pea. Wiguero 2000-466

- " ? 3 73S

" Paeudptero-

sorgia aneri-

cana " 6s 8B

" . " 92 2 38

" Eutlicea ?

calyeulata 2 Sw

7 Bontces

sasnosa . 27 60k

" ? " Boo

? * . 5s ow #

® ? " Bb oo os

a ? . Bow

" Plexaurella sp." wo 2 mM

woricea

atlantica " Ww 2% 3 2 6

" Bs 3

" Buntcea

? 2% 57?

Buntces

tournefortt " ew

« " " 33 ew

optriuroia Pea Higuero 24656 G56

" " 50 1100630

? " Ww 2 4 6 © 6

* won Mw 2 6

" ? 3 27 wD

? ? ww

---Page Break---

i42

Type of Sctentific Collection ug ML ue G

sample page site Set bey ashe bey hah

ophturose

Pea, Higuero 122733

" 7 ? yp 2 M

" ? Ww 0 7 Is 33

ophiuroie ? 83

" " wow

? ? 2 0 6

" woos

. " Bo woe

" ? uo 38s

---Page Break---

2 of

Bane

Terrestrial

P

Invertebrate

(eponge)

Scientific

Jabone tite

Pucrarta

hirsute

Res

mixture

Denirielle

Species 727

?me

"om

"765

?we

"one

"8

"766

?om

"om

"768

?oo

750

?ae

"736

?ms

"769

"a

o

celtectton

Pave m 150 1,200

36 01,600

8. of \teqes 67 86021, 000

Sponge bank 721,100 1,900

3 mt. south of

Dececheo Isl, 8 7%, 180

Negro Reef 2 701,300

12 atte of

Fea. Wiguero 130 790 ??«1,500

330 1,900 3,900

? 372701, 300

" 8 on 200

" 70 2,900 4,400

? 1707580 3,100

" 270 1,200 3,300

" Nor perscreD

. 53920 240

. 48 180 500

? 6 6 170

" a 230 70

" 490 1,700 3,400

" 22 100 290

. zt 60

" 150-790 2,300

? n 260 890

? 0180 240

---Page Break---

?Type of

Invertebrate

(sponge)

Invertebrate

Invertebrate

(wolluse)

Invertebrate

144

Scientific Collection

2 ice

1/2 alle of

Species 738 Pea, Higuero

om .

"756 ?

?om "

"M0

Parguera

Cayo Turrenote

Black sponge Desecheo

Orange sponge

Nudibranch Cayo Turrenote

Chiton squamosus Bonus Nuclear

(hard tissue) Plant

?Acanthopleura

granulate

(hard eieave) ?

Acanthopleura

granulate ?

Panulirus Joyuda

argus (gills) beach

Panulirus

argue

Panulirus

argus (adéoninal

uscle) "

Panulirue

argus

Brittle star Cayo Turremote

8360

3.6 07

wo 570

390

88 Mo

100580

27350

130820

2 48

3 8B

273s

3 Ow

cc?

34s

28

3s

L743

2750

130540

4 6

3.4 5

23

250

2%

00

208

200

1,500

1,600

220

460

39

2

2

sn

13

4,200

130

n

33

---Page Break---

Type of

te

Invertebrate

Scientific

Brown sea

urchin

Waite sea

urchin

crab

Medusa

Codtun

eaylorit

Gractlaria

Hypnea

useiformis

Spatoglovsus

schroeders

Peniestius

capitatus

iva lactuca

Not Koows

Bryothaanion

triquetrun

Galaxaura

cylindrica

Laurene ia

Papillosa

Laurencta

obtusa,

valonia

ventricosa

Halineds

opontia

Laurentia

papillosa

Hypnea

musciformis

a

Collection

site

Joyuda

beach

3 atles fron

Pra. drenas

Ga nica

cayo Enriques

Guentca

Cayo Bariques

cuantea

35

39

aL

12

7.3

17

26

84

190

4

280

37

1

2

LB

99

96

4

80

75

a

230

27

4

80

300

no

750

210

1,500

360

250

v0

150

1,900

220

200

200

86

n

410

34

140

140

10

1,500

1,000

3,200

640

a10

1,200

1,900

---Page Break---

14s

Scientific collection ug of Fe,

nage ite eee

codsun, cayo

taylorit Henriques 6 2 200

? Gractlaria

samtllaris ? 36 Ko 760

Plankton 20-8 21/2 nile

off Point Brea 9.6 390 2,700

" 6-8 Fern point

8. of Viewes 1,300 8,100 15,000

Terrestrial mangrove

plants subt. roots Parguera 23m 330

Fish Makatra Virgin Gorda

nigricans Isl, 8. B.end 16 52 880

(gonads)

" wCliver) " 20 56 2, 500

" "Gu, trace) ? 871,400

. ? (spleen) . 350 1,200 8,500,

" " Ceonace Arecibo 25° 100 1,500,

" " (6E exact) 13 701,600

Marengula 5. of La

F-36 Boqilla 100 400 1,200

? ray . 370 1,300 4,200,

" "R38 . 93 301,300

" ? pas 700 2,500 6,600

? Opisthonena

oglinum F3 « 420 1,500 5,000

" Marengula

F-36 ? 190 680 2,400

" P39 " 330 1,300 3,500,

? "pa " 240° 9402, 600

" ?pe ? 260 1,000 3,000

---Page Break---

Type of

sample

Plenkton

Fish

Scientific

Caranx latus

Fas

Bs

rT

Fe

Fos

Pu

147

Collection

270

120

100

uo

140

310

150

33

En

300

140

no

670

0

370

160

310

180

430

66

95

37

300

1,100

130

600

470

470

640

41,800

680

240

230

160

1,200

130

1,500

220

360

220

1,200

4,200

580

2,200

2,100

2,400

2,900

6,000

2,200

1,000

3,000

6,600

3,000

1,500

8,200

4,800

4,000

2,200

3,400

2,300

4,400

930

1,600

1,000

3,900

---Page Break---

type of Setentitic Collection _ugre/g

sesple___pane atte ee bey a

Fish caranx 8. of Ls

27 Bogle 200 002,600

" Ghlorosconbrus 5. of La

chrysurvs Boquitla 20670 2,300

" " " 280 1,400 4,700

" ? . 6 01,200

pas " 25160

" pe " 3530 1,300

" " p20 " 110505 2,100

? " pe " 7% 201,500

? ras . 88-430 1,700

" "pas " 1 730 2,700

" Re " Mo 640 2,400

" 7 " 9% 560 1,700

" "ps " 170700 ?3,100

? "ne " 90500 1,300

" * p10 " 6 270 1,400

" "En ? 230 488 1,900

" ?ps " 401,300

"en . 82 470 1,500

? "par " R150 660

" " B26 " 70 560 1,100

" "nas 100460 1,900

" "p24 " uo 607 2,500

" Coranx 1atus

F-16, " 20480 1,500

" Macengula

ea) " 230 920 2,800

? ?p29 ? 150 520 1,900

---Page Break---

Scientific Collection va Fe

Bane ice ie

Harengula S. of ta

F-30 Boqilla 250 $20 3,000

. ¥52 ? 240 540 1,700

. "peas " 180 630 2,200

" "R10 ? 190 700 2,300

" "p20 " 170660 2,000

. "R40 " 100 280 900

" Fez ? 430 1,700 4,100

? "p28 " 30190 590

" "Rg . 3007302400

. "ras " 8 20 1,200

" "Ray " 480 1,200 4,900

" ? 26 ? 210730 2,400

? "par " 230 1,100 3,400

" "Ras 190 670 230

. "ns ? 9% 380 1,200

? "eae " 140590 1,700

? "ons ? 390 990 3,400

" * rst " 250 590 2,100

. Pe ? 160 430 1,300

. "me " 220 © 820 2,100

" "Rs . zo 530 1,800

. "pas . m4 1,300

" "pas " 9% 340 1,200

? pas ? 50 180 eo

? "6 " 370 1,300 5,000

" ? pe ? 300 1,900 5,400

---Page Break---

Scientific

150

Collection

?Terrestrial

Plants

Marengula

cotengraulis

Poe

F-50

edentulus

Fl

6

rT

Fe

Fa

Fb

8

Bs

opisthonens

oglinus

Chloroscanbrus

Fel

2

F6

9

P10

chrysucue

F-2

el

Sugar Cane

South of

La Bogitlla

Coconut ares

Rincon

up Fe fe

suo 1,400 3,700

0 380 1,100

150 650

260 880 3,600

300 1,800 6,500

700 3,100 9,900

320 2,300 7,000

360 2,500 4,400

470 1,800 6,000

590 1,800 7,500

270 1,100 4,700

io 630 2,900

180700 3,300

28 120 560

400 2,100 8,200

260 1,000 4,000

260° 1,100 4,400

no 470 2,100

410 1,600 6,200

130 670?2,700

39270 760

4 0 400

---Page Break---

Terrestrial

Plante

Scientific

Mangrove

eaves

Mango leaves

Tamarindo

leaves

Coconut hard

shell & meat

Mangrove

aereal roots

Pajuil Rojo

Chucho

Brazil rubber

?Alaonds

Sugar cane

Teaver

Enteronorpha

Acanthophora

sptciters

Mixture of

Acantho

spisifers &

Spyridia £1la-

Gractlaria

eaudata

codiun

taylorit

Thalassia

Spyridia

Filasentos

Nor identified

Collection

La Parguera

RNC

Coconut area

Rincon

Parguera

RNC

Coconut area

Rincon

RNC

Coconut area

Rincon

caye

Enrique:

Guaniea

Hacienda

Belvedere

cayo

Enriquez

2

63

20

86

%

35

3?

50

200

u

29

n

180

29

120

70

48

120

150

%

8s

220

1,100

1,900

76

130

260

760

960

360

1,000

250

840

510

3,000

3,900

160

270

---Page Break---

152

Type of Scteneific collection us Fo/g

sample we site Dey

Bchincders Hchinonetra

Aucunter Salt Key 38h

. . . 2 55 60

. > " 8 6s

" ? . 61 00

? " " a on 6

. . ?7m

? . " 36

. . " 7 20130

" " " 78130 140

" " " 8 140150

: " ? 2 130150

" " " % 20 130

73 120 130

" " ? 83 140150

Desecheo 6 10120

? ? ? 90 140 160

. - . 7 130 140

? . . 91 150 160

? " ? 68 120130

" " ? 8613040

" " 87140160

" ? " nm 0 130

. 7 " a 150 160

" ? " 86 13040

" ? ? a 140160

" " : 83130140

---Page Break---

153

type of Scientific collection Fe / a

pl sane etry ah

Behinoders, Bchinouetra

lucunter Desecheo 7 10130

8B 140160

? * " 2 10 40

" " . 80 130 140,

---Page Break---

154

6 eh Sh TE Of gete Te 6t 99 19 29 . « ?

6h Bh Sr 6 ge leSe Ge fz 9 SE EE ? . "

on 6E 9? Of 62 Jzgr it of LE Of EC . ? .

49 G9 09 09 gS 4S 22 Te 02 mL ee lg . . "

Ttz Otz 06t oft oft eet " « .

LE 9 of TE Of g2 . ? (rreus)

46 2h 2T 0ST G9 02 006 002 19 . ? "

TS ET LSSH Et HS out eb te . " .

Oot zh zt oz 26 2 OOT Ex ET 029 092 gL o 6 ?

49 12 6S ott LE oF ors Olt Lt . . "

Of OT OE T9 Tz 29 OOF COT OE or LE TT " * ?

6? ?2 TE by 62 IT eS HE eT Of opr Tr snuog ? smyeozanu ?APOq 9709

a Raa oY ra son ae Fo Te gon a SS

w/z 67

weyIN ot wb /ay BT

wbjeq BH vor300TToo

DtsTaueTOS 50 adAL,

---Page Break---

155

1 ot ont

oz eS 019 exontavg

et on6e ? .

sy ee 0096 . " «

oz at ose . ® ?

em ost . . *

or ex ooze . ? «

oz ze oon ? »

ET ose sruog woes way

1 at oote « ert

694 wopmeds .

BT 8S 065 oon

seg 30 set «08 we one exonayy ?_eaetnot

9178 YT Tee sotoods veag-oy eyuronT .

Or 6 og) esansaeg 1000-1 ox zt onze oan,

80d ? Sead oBuode 29 .

a et ow " sex oo £9 oct zt

594 so}oeds . o0y2200q ofuode a8%e50 ?

me oot * cer 0% ez 0st ? or

ze setoeds . oBuode Set .

8 tT o0zz ont sBu0ds 0st 6° 00st porter Voc-1 s800de

tea 30 ter 29 oototed seuods?oaeaq

oTe 7/1 aye soysads -eaz007 suri -eazenoy

ox cor OLX cor

yh ar ar ?veer sqaure "ey ?hag sR ae sare 97a

SS SRATHY A woyas?ite9 ? apsraaey3¢ go eda wae woras91T99 ?ongsaueT2g 30: ody

of 8 © 8 4 1 sek.

---Page Break---

156

ge gto 7 enavase> 2 ?0°6 once f0q 3308

snqaosas reas, .

TS 6 ootz ¥898509 ??enavas0> Apog 2508 92° 92082 vusa

nquoa3s a ys91309 ? .

wow oo ce ae one . "

fe ae" ote t803509 crete ? .

eurra

09" 65" ous? seuTag srrvand (row) estou suraq srryind fp0q 2308

ser 330 shqwozag?YemrToR sng 330 enguoaag yen ton

gOLx go1x OLX cot x

fey faa a san ?oyaas Sey Sg aap a sary

TO TERAT FA sovarotie9 ?orgya09725 30 9dKt HIRES} uopanetiey ?aygsauerae genes

8 © © 48 ' © © @ @o4 ' . hth

---Page Break---

?z ooze oat sean a8u0ds soqnoyde/n

eommuy 330 dno erqerra ?afuods._ gt zy gore . . .

© o0sz os 6 muTTgors ? wBueds zt gy go6t aeant

eruyoar ooeeuy 330 . .

ST 00ST 0193904 o2foy . . 7 et o06e : . oBu0ds

®T 068 ozs exon Baeg . . OL 9S oct ?u seurag ?afuods dno

-9179 330 oraas3g .

st ov sa ena

oqrfeueny ? -eqnoyaes

350 392800 azopouyyoN sz gggt?eaontaeg ?

6° ose ose ?a ooeeuy % So on 590M orBoN ?wUsTZGoaag satnozds/m

330 wyurasy Buoy

97 ose ose ? 1 og soary ove sneoyz08

739919 350 eoasaandeg weowaenID

Pe Ove Ovex surg

-2199 330 " . «09 008 . ?

oy ose one . . oes oe . ?

fe ze ose hu Boappunae

wurapueon ? oc 1 o00z . "

6° ose one supapuean ovez

901A IZ «GL (OOST . .

1 o0Le o0xz . . ? 1 yk oozt .

0068 0062 . " 1 18 oz * .

6 822309 © enaopazoe wz 89 oe exondavg erode opfue

PITFA ?soasunBeq_ve2easaza Uae

1 x

ey ar ar ara yaa Te oar ava oda

TORTI S worss0r 109 orsyaueyeg 30.9842 ? TERT IPG © woyavarey oygyaueres goa

hth

---Page Break---

08 eZ oot uor9q orn a

epnéor Ze-1 202097909

sofize 9ae3q tt 9" ade . cor

ensytnoeg 2330007 ELL s0t205 ?

8 96 0002 oon ? oz 8°6 o0zz oxontyH, euods

veag 30 Bt tag 30 sor oarsq

2TTE e/T Le 8970s 91@ Z/1 99g eoyseds ? -eaaz0auy

om ot ony or eaex

ruasy eenpam -e2uT909

a or cogs: . ovr o3eq

see serseds . sea znoT

ez 6 oot oxondyy eBuods 006 Sonne e8uode

a 24 70 So-1 oq purist oY 6-1 aaeaq

OTF@ 2/1 99 soRoeds -oaz0nuy onysesed 9Buods yoetg ? -2a 30807

oar

on St ooee worq g7z eT2EMM -eausq207 gL" Obs aura, 9-H pent ros

wpnsor andze aaa xeoTo0 vaetnuest ex o2e3q enaytnuea 9330807 snuog ?-noqdoyauesy ? -23.z0auy

(19°80 ony siuods gg 62092 ezon83va_vy-E 7100-1) -a8ntTo#

teag 30 oer 23034 saomeaany, p3e1q

ere 7/1 ast soyoeds 920007 69 -23300u

BE ye 09 worq ?2000-T 61-1

?epnkor (prucd)enfize ost 9°9 oosz ?

enaprnueg 7 ?

Te oxapaateg $00

9s ey 0082. r Ut

9 -930n0T zee sero0ds .

oT 6k 096 aantzeg efucde og 1's OTT ozontya, eBuods

zo000-1_a383q 83 GET eaeag

waeypzog -2az0au1 SUE Z/t 6rd sayseds ? -*z00UT

1X cor OLX cor x.

wy ?ag a9 ae sara ?syaaes "yey ?tag a, sae sara ea

STERIPT BAYH vovssa ten ?ayzyausvss 30. akg ? HEH FA) F?uovg0ay tog ?aygraumnag «30 ad

' © © © © © @© © @ © © 6 t+ 8b @ e@ ¢

---Page Break---

159

(oote ?were; aq 8117804 p0q aos

91m 320 anquozag_? Dent To

St et goer ? .

et 9t oor wooury

vroer et ?

vr er at .

or ot wosgne .

vr oF . .

Ort 06" 09" vxondaeg seaunont

wxuomousyon azepouyysg

TT or 6 a 6s" onus . unserdaes

ero se . ost 98" 0066 ?swog sr Tex09331

PrapUOD vay

St et ge Te oe" 06. ?

Vr or 19 ? mee ont

vr et 6 ? Te ez" oct ?wou

sxporye,

TT ot os" waen3zeq ?_zaunany 9t 890092 ?24 oarfeuEn9

weayomouyyog BzapouTyoR veowasnag

zk 0005 00st 8u0de 0S 12 009 © eantaeg

ano 913373

?2 00% ?ooct soar ofucds 89 96 16 0o6T ?_aaaty eeu stuode

ooseuy 330 dno o1getTa -F3qoTM 330 én9 eTaPyTa Bods

OU ore - Or x ore

fey aq sar ar uy ? kero sae $y

TETWPA corpora ? orsste TIE ousraworss 0 odKy

' © © @ @ o8 ' © © © © © © © 4

---Page Break---

9° oz oz exandavg eazy 20 EER OOEE wooUTE

sionesan atuois "oaesa vere (8) staat

he) E-1 yl000-T #229807 anuoseg aur -TeBNg .

suo" $9" sy aurta{-H 9000-1 >emttos ETS oor exontang are

aaramt esenanai es ages suaret

ncog aetdouaueoy ? -920007 enon .

965 ones 11x 61000-1

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ve Zz Oore oxondtH aSuods:

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ay Sega ae seat ayaa ay Sha a a aaa

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---Page Break---

oT se oat u 96" Set gz ?E289 opreur

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162

eT sort ? or ce oS .

ve 6 HORT . ee ot 96rE ?

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ot 6 FORT . vy ee Gert .

0°z ooeeuy 330

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ey VE . 59 Se oxae

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oz 6 ROE w . SE Lz oopeuy 330

dep "B99 BLL ?

zt soak g 1-4 ?pos er rt S0aRE x CTH ?poe

ooeeuy 330 9200 VoIsFa Teys380239r coseuy 330 9409 uox¥yq Teya389z302

7m ae an STaaT er sya

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EL St 6s saKenSeH ?1E-¥-9¢000

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PpeRt TH WE YORE .

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re ve 6 Porky . er 6 AL ?

6z Uz soseuy 330d ORE . oz 21 ?8 osseuy

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06 zs" zean : . oe OF aan

ooseuy 330 oommuy 350 TATE w .

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dep "BTSE COTE w ?

se ve MIL . 2 eT osseuy 350

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o's oz coseny 330 Ve Bt "wosewy 1 zed ?pee

oop ?a 00 9409 Uoabyg TeFaRS0z201 330 "w gge 209 Uorsyg Teyaysoaz0y

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T o1gTaweT9g

SRR wosas0rte9 © aasTaeFIg 30 ad,

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rs oy ose oa sentto#

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Seg PHUDAT ? avozony endog ?neydouuesy ? -925080T

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st 26 one neat stuods ort 2383

Sea aréana . sec Serseds 2330007

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os ez 009 santa or ouods

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aye g/t (96 ser20d§ -223080T ate a/t ove sorseds ?933000,

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S aeopomd wveoaess es 93a yo despa §I-L ?P98

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az 2 OopT onan

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ed ort zz 92 00eT?tonteken (eat)

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ose OTT eeorsenss ?TT 0079 Fone (s-an)

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ea) -933280 Joqgna Tyeeag 1552892201

sor gore soL* got

a a7 sana yams ae a sane aya

SERPS S wovaverteo ? atsraueras 30 ett eS et a

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exonBieg 9308

wm el Ot sauog w20KoKd seit woaany, oke9 ovtty,

wy asa ae saa Saaee Ta sae SaaS

FT wopavotten ? ongtauorag 30 ad, «TASB wopavvt90 oygsauoros 50 dK.

. eo, : . ft ht eo © © @ #? 8 ne

---Page Break---

166

of 1s 1s zendexex ? y-a 90000-a

evuoay ?wag ?908 3007 9z-g sped

3 voouta . oe 0" 9T ?TAT wamK ?-08T ArasoH

o eo Ue oe 084

2 EL UT anedmy 30 sca vosmoerd 4OF g3r08

Sa ove =o2kug 30 201 *y osseuy era

woaqueté: PoxTK sndop ?© ez szt vorwerd .

ze mo" exondizeg

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Jo's (uoayieta ?uoawueTa ove eft z $0 OOMTLL "

eo ve « 2200" ore eta rer

vaeot soa oe s0orA zea

e030 yo wanes § zt voawuera .

oy TL 86° exepentoR t100-¥ st of 99" meg oduods oz-a

erecoteuL set uorteerg ? vonwueta

Wee a aa ser aS ay sas sas

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---Page Break---

Setentific Contection a Kn

ai wee

Fish (2077) Symphurue

Plaguiss

anasco By = 2.743

(2085) " 22 94 53

(2086) " 20 85 ae

" (2081) ? 2200 on 43

(2030) Larimus

Brevicepe " 21 86 on

"Qos " 80 ca. ? 7 6.827

"(2082)" 110 ew, " 17

"(053)" 221 ew, 18 9 a7

(2054) 126 ca, ? 16 6.826

" ose) 146 em, " 19 8.0 33

"(2063)" 149 em, ? 27 1040

"(2082)" 166 ce, " 2300 84

" (@050) ? 2200 95 8

---Page Break---

?Type of

1

Detritus

017)

" (2016)

YoLluse

(@ouy

(2002)

" (2013)

" (2007)

Echinodermata

(aor)

* (ory

" (2061)

* (2063)

(2060)

" (2064)

Polychaeta

anpharete ep

" (2068)

* (2065)

* (2068)

(2090)

"enn

? (2069)

Fish (2073)

" 07)

* (2076)

(2075)

(2080)

Scientific

Lutata

senegalensis

CUithrata

Crustacea

Shriap

Crustace,

Syephurus

Plaguisa

"111 ea,

"125 ew.

168

Collection __ag K/g oe Fe / p

site ee aah wee

anasco Bay 2.2 45 5.6 183.5 4.2

? 80.29 5.4 9.6 35 64

? 22.28.30 hh

? 02 kaa

" 1362130

" s24 26 124.082.083.085

" SPL Ls 3.0 64 85

? LL ee

" 902.5 3.7 242 47

" L233 4.8 23.6494

" L232 46 2m aa

? LS 4.0 6.0 299

" 32 13 60

. 21 8.6 37

" 2.0 8.3 37

. 21 8. 8s

" 29 83

" 2.3 9.6 4

. 2.7 9.7 57

" 2.8 54

. 2.3 91 55

" 2.0 8.0 40

" B16

. 2.3 9.6 52

---Page Break---

isa

Type of Scientific Collection

te nase ee

Terrestrial Piston core 343 a. depth off

ned, T-16 A Agasco River. 65 120

? "nibs . 220 20

. " mise . 83 150

" "nas D " a 160

? "mee 120 210

? miee ? 120 190

. ?mies " 100 160

"mae K . 100 160

? "nae L . 220 190

Tem " no 170

---Page Break---

170

?Type of Sclentisiec collection

nave ite ier

x 107 x 10"

Terrestrial Piston core 343 a. depth off

sed, T-16-A Anaseo River 1% 25

" "6B . % 26

" " ree . 19 4

" "m6 D " 9.3 6

? 116 8 ? B 2

? ?mie r ? 8.5 1

. "m6 6 9.0 3

7 " n16 H " 10 v

" ?mer ? 10 ?

" m6 a . 10 6

"Tek " n 7

. "one L 89 %

? ns M ? 9.0 1%

" ?nara Off Anasco R. 10 7

. + nize ' 5.8 10

. " nire " 9.0 5

? "nar . 9.3 16

? nave ? 9.6 6

Te " 8.2 w

---Page Break---

a6

6 purrer

aes oprser gna ?poe

adap ?25 02 wo3a0q tag " a ow 6 kore .

st 6 ?tet « oe ow 6 were .

08 ate 4 ? a 6 dort "

or 2 s TeE . m6 6 9 6rE .

ot ee 6D zen ? a 89 6 Gorn "

mn 08 ?9, " a 99

vor .

fom 6 Ween st oot 6 9 ert .

ot 96 6 Out w . st oot w dere .

a1 66 6 emt 66 cert .

1 08 ooveay 330

aden ?mage vy zz-1 aon 6 Dern .

et oz wate » tae eer "

no «art . 9t O01" eoseay 330

wep ?B99 vet .

nw oD Tee st 96 oT

or 68 ett "6 6 Me

tou oo vIeE . aw 66 * ?

98 Fort 08 =

16 "w o2seuy 330 1 7-1 ?pos a 2 sesry Ut-u ?pes

vadep ?Stge o409 woasta Teyazee2301 coseuy 330 8200 Goastg 1wra3802302,

or x zor x sg x_orx

?ag ? San a7 sar aa ag ? om au aI aya

TRH woraseti09 ?ovgsauszeg 30 adh, ?????"HHT HN worav0qt0y ?ovgrausy9g 0 od

' ft © a o4 1 .

---Page Break---

7 a oct ? A0rt 4 ?

seats at 6 ? lo a ?

30 yu/8n

6

30304 oT 86 ? Gort «

TT TL 65 seg zonbyaug

widen "mz gy ? eT 6e ? DOr .

uss sy ooeouy,

wndop "3302 yor « 1m 8 « Gort 4 .

tet aa kk ooseuy 330

ne wdop ?miSz Vv Oz-E ?

SST eosvay 330

wadep "806z ST-r, « oo 49, . KEL ?

oo to

at . moe . T6t-L 4 »

16 esea zorb aug

wadep m9z gr ? or 8 ? AOE w .

tT Stee ?4 coseuy

wanow yadep

Boon as Hw « ac ? LoL «

or 66 96 *y osseuy

anos wadap

Bers bry ? ou ? 16rd «

Tg 880g zonbyaug

4adeP "?9Z dy . te . HOI

4 9t ort casey 530 ing ?pow ST 98 eoReuY 3309 GH ?pow

adap ?mgg0a30q vas Teraze0zz07 wdep ?ate 9x09 uorsyg Traye030z

OL OLX 201 * ot x

wy ae save ayaa aq ao ae sare saa

SST osasetiy orssauseg 30 ad ae wora9erteg oesFaUesog 30 ody

tt Fb Ff

---Page Break---

?type of Sctentific Collection

1e

?Terrestrial Piaton core 351 a. depth

eed, 1-206 off Afiaaco 96 6

" " n208 . 150 20

---Page Break---

iv

Type of Scientific collection Me / g

sample nape te et beg ae

Alga Dictyota

dentata Pea, Miguero 5.60 17

. Bryothaen {on " a7 Rm ow

" ?uphiroa " 7 mo

Miscelancous

sediment & algae ? soa? 2.0

alge Penicitlus " wow 15

Marine

angiospern . 55 Le

Alga " 3 32

" Dictyoea

dontaca ? mw 23

---Page Break---

i%5

Scientific Collection vg Sr

nase site ie bey Wet br

Dictyosphaeria Pea. Higuero 5.3 2023

Marine Thalassia

angiosperm testudinus Parguera 6.0 2 iL a a0

? . . 20 2 3 3825060

La 1 230680

? ? " 20 Mm 2 48 260 720

" " " 3 280760

" " 2.3 13 33 68) 360960

" " " 20 1 56 330 920

" " 1.0 7.0 40 © 36 3401300

? . ? 118.0 32 48 3601400

Alea Padina Bonus Stee 18 13489 1200

. . 2.9 20 36 130 1600

" " . 2.9 19 36 130 8201600

" " " 2.0 12 30 1106501600

3.2 15 26 1707901400

" . ? 2:3 20 66 96 5701400

? ? " 2.9 21 36 07801300

? " . 3.3 22 42 230 1500 2800

Diceyora " 16 9.1 2H 955501500

? Saga " 2.3 1 4 130 8002400

" Chondria

Littoralis " 12 0 Not verEcteD

" cosine Pea. Higuero 3.75.8 9.4

" Penieiilus 90 2 26

? oyeopolta . 36 ow

cavlerpa " wo om

---Page Break---

ivG

Type of Scientific collection _eava/p me Seg

sample ane site ieee ey a

Echinoderes? Echinosetra

Tweunter Rincon wm ms kos

. " " wo mw as

" " " nom wes

? ? " wo me a

" " ? wo as se

? " " wos

* ? " 2 ss

; " ? Rm ew as

. " B20 ewes

* " " Bon ws

? " ? sh es

" ? . mom mw os sas

" " ? aoa

* ? " woo we oe as Le

. woo saa ase

? " Peers 132k gs

? " Be was

" " Bom es

* " " RB mo 2 mia 1s

® ? ? wos te ss

? " " B23

? " Bs Ls

" ? " wom wee sw

" * ? a

* ? " 3% we se

? " " wR me

---Page Break---

iv?

Scientific Collection ee Me / we St /

name site ee bry ash Wet Dry ash

Echinowetra

lucunter. Parguera Bg

" " ? we me es

? " Rincon no wm RM ae os

" " " mw 2 om B14 LS

" Trtpneustes

eeculentos Rincon 90 19 2K

. " ne 21.98 1.8 Le

? . « » oo» 2%

" Echinonetra

lucunter Pea, Miguero 1922

" Eucidaris|

tribuloides ? now ow

---Page Break---

ivs

Type of Scientific Collection ug Me/g_ mg Sg

sample as site wet Dey ash Wet Dry aah

Bchinoders ?Tripneus

@scuientus Rincon wR

" " " wa

? " " B23 2 eb

? " ? 3 2%

" " . ww 2 ss

" ? wo aL

? ? . wo Mw

" " " wow 3 Le

? ? " am

. . Bw 1 aes

? " " ws

" ? ? wom es

* . ? we ass

" " " wo 2s LS

" " wm ss

? ? Parguera wo 2 31S Le

" . . no os hoe os

? " ? now oe 80 1S Le

? " " w 20 BL Le

? " ? nom om 8 LS

? ? " nom mM 9 3 LS

? ? " wok oS 6

" " . um Boos

" " . wR 2 mw 7 12 13

" " no 2 my 7 Sh

" ? ? nooo BS 16

---Page Break---

Type of

Sctentific

Collection s_ Sx)

seple nae site Wet pry Ash _Wee bey ah

Echinodern ? Teipneustes

esculentus ?Parguera 99 20 oe 6 Le

" " " u woo Tse

. ? " 10 2 66 Sh

" " 89 7s 83016 7

? oreaster

reticulatus ?Parguera 1S 2 5S 6

" " Negro Reof = 7.719 2h ol 12 6

" " OFF Guanajibo

Pe. 17 206 9 3 oT

Coclenterate Meandring off anasco

anérites River Ma 5s 5k

" " . 786 8B 5

. Meandrina ep." 86 86 B60 66.0

" Yeandrina Off Culebrinas

mesndrites River M73 805.253

? Busnilie off an:

fastigiata River, W243 505

? ? OFF Culedrinas

River 100 2.00 20 5252

Mollusk Stronbus

pugtlis, Ville cofrest 22023

. " ? We 25] aaa

. " . 32am

" : 80" depen,

Off Culebrinas R27 27282

" ? " 000 00 Oat

" ? " 9 2.020096 990

? Strombue

costatus " M7? oe.

Crustacea ?_Paguristes

sericeus Villa Coftesi Boe ae

---Page Break---

?Type of Sctentific Collection 8 e/a eg Sr/e

sample nase aite ee ey wet_?bey ash

Crustacea ?_Paguristes vita

rieeus cofrest 250 78 26 ese

. . 443 wer aw

Yollusk Paguristes Off Culebrinas

sericeus River - 10 2 ele

" Petrochirus

dtogenes . 3285-2 aos

Porifera liable cup

sponge u/

spicules dis- OFF atasco

solved River 25°11 3,4 Nor pereoren

: " ? 26 0a .

. " OFF Cole-

brings R. Mose "

" Brittle cup

age ¥/

spicules dts-

solved " 3 16 eH "

" ? Anasco R. 2 it 16 .

? . " 221 30 "

" Spheciospongia

vesparia w/

spicule dis

solved Negro Reef 063.607 .

" Yreinia strobi-

Ming w/epicules

dissolves Parguera 67 3.9 9.2 038 225

" Spheciospongia Off anasco

vesparia River 1082.37 1.1 or petecrsD

" Pliable cup Off Culebrinas

sponge River 15 70000 28 Hm

? Brittle cup

sponge " 125.300 9.6 Hw

? ? Off amascoR. 19 7.6 Law

L633

---Page Break---

Type of Scientific collection 5 Me/e 2g St/e

sample. name site ee bry ae Wet Dey ash

Porifera ?Ircinia

strobilina Parguera Ll 63 SS

" Spheciospongia

vesparia Negro Reef 8747 62.0603

" Ireinia

strobilina Perguera M1 6.30 SS

---Page Break---

it2

Scientific Collection

wane si

Fishes Chioroscoabrue South of

crysurus F-20 La Boqilla 1477.9 3

" "pa " 230 2 2

" "py " 21 10 38

" "pa . 169.3 30

? Py " Aa sat 20

"Rag " 0.72 3.0 3

" " RDy " 20 8.9 3?

. "p26 ? 3 a

. "pa " Bt 68 25

? ne) " La 53 20

" "pag ? 33°15 35

" "ope . Ls ag 27

. "re " LS 83 a

" "po ? L350 25

? "pas, ? 13 6.2 25

? "pean " 3.9 20 65

" "pe laa 2

P27 " 0.86 3.8 v

? ary " 0.46 4.3 v

" "pas 1.10 10 a

"oes " 28 2 33

" "pL ? 12 54 1s

? "pe ? 1986 33

" Opisthonems

oglinus F =7 572 87

. "pe " 33013 a

---Page Break---

Scientific Collection up Me / a.

2 me ak

Fishes optsthonens South of

oglin F-3 La Boguilla Lat 136

. ?ops " 2913 39

. "to " 9.4 50 190

" Cetengraviis

edentulus

7 . Re 150

? " R6 ? R99 160

. "Re . noo 140

" "pa ? Lae 65 28

: "pe Bost 170

a) . ~ aL 250

. no) " was 180

" ?ope " 2 70 220

. 29 2 a?

? " L782 29

. "Rg " 2s on 50

. no) 2.0 9.7 a

? "pas " 1a 48 2

" "pe " 4419 n

? "Bb " 478 92

" Fie " 20 8.3 a

. "pte " 166.3 26

" ?a " 10 4 8

" "oR? . 1 a7 40

. "ope " 34 ow n

---Page Break---

Scientific

caranx

hitus F-13,

Bs

Fat

P22

F-30

ag

is4

g

Collection

site

South of

La Boqilla

ize

1.0

3.0

5.6

97

5.7

43

7.2

1

n

7.0

v

a

46 20

n 38

a 93

36 10

a Ea

82

20 66

3 2

cay 6

2s 7%

2 a

a 52

23 80

?w ?4

2 6

9.5 40

20 66

2s 93

2 86

R 38

29 8

26 83

39 no

26 80

64 180

---Page Break---

a1

Scientific Collection ug Ye /

at ite eee

Harengula, South of

P65 LaMoqilla 3.8 14 52

? "ran ? 6 6% 160

? "po " 99 2m 80

"B50 . 1S mH 7

? "Ras " 47 oo 30

? "Be " 49 1B 39

" ? F39 » n 46 120

? "p28 " 34 40

ras " 45 38

? " po " 45 8 38

" "pa? ? 29 9.7 40

" ? pie " 63007 32

: "pay " 458 38

"Ban ? 838 90

? cae} " 5.323 8

. " F36 " 370 n

" ?pa " 7.8 30 86

? "Ras " v 6 160

" "paw " 3000 3

? "p29 " 37s oe

: ?pe " 5.6 20 60

" "R23 " 20 96 35

" "RSL " 70 as 60

" "Pe " 593 42

? "rae " 32003 36

---Page Break---

?Type of Scientific Collection vg meg

ple ice ie bey a

Fishes Marenguia South of

Fd Ta Boqilla = 2.718 ?9

? pe . 48 20 38

" ?Re " 67 27 80

Invertebrates

sponge 1 Cayo Turresote 14514 2

" Species 747

T-26 " 7 no 160

" Species 749 nile of

1-28 Higuero 15, 2 ~~ 100

? Spectes 769

1-43 " 3200 oe 40

. Species 736

1-39 ? 5.8 92 on

Invertebrate Brown sea cayo

urchin 1-13 ?Turrenote 550 3

. Brittle star

rl ? 93 1B 2

Invertebrate

sponges Parguera 98 850 1,500

Invertebrate chiton Bonus Nuclear

Seuaeosis Plant, 2 1s v

we

* Species 728 1/2 atte of

?sponges 123 Pla. Miguero 5.424 9

" Spectes 768

1-34 ? 1.0 4529

Acanthopleura onus Nuelear

Granvlata 6H Plant 6.6 92

? Panulirus:

argua I-17 Joyuda beach 2.3 93 7?

" Species 732 1/2 wile of

sponge Fast Pea, Miguero 6.6L res

Invertebrate Wuddbeanch

rs Cayo Turrenste 0.51 4.916

---Page Break---

?Type of

le

Invertebrate

sponge

Invertebrate

Invertebrate

sponge

Invertebrate

Invertebrate

Jellyfish

Invertebrate

sponge

Invertebrate

sponge

Invertebrate

Scteneific

Species 745

124

Species 746

1-29

Species 792

1-37

Species 773

1-47

Acenthopleura,

granulata dit

Species 767

1-46

Species 774

1-42

Species 754

1-27

Species 727

2

Species 791

1-36

Species 748

31

E10

Acanthopleura

granvlata 7H

Species 772

£33

Species 766

45,

Species 738

1-40

bite sea

wrehin T-LL

5

NI

Collection

ite ee

12 aile off

Rta, Higuero 6.5

. 2

. 16

0.73

Bonus Nuclear

Plant 87

1/2 mile off

Pea, Higuero 0.97

? 2.5

" u

? Pr

" Ls

" 9.0

3 min. from

Pea irenas 0.14

Bonus Nuclear

Plant, n

1/2 wile from

Pta, Higuero 1.9

? 2.0

5.5

Cayo Turrenote 9.8

34

cy

43

2

2

67

1s

8.7

2

32

10

7.0

36

u

10

vg Me /

ah

100

140

10

10

3

B

?6

36

27

uz

2

20

2s

v

2

---Page Break---

?Type of

Invertebrate

Invertebrate

?sponge

Scientific

Panulirus:

argue 1-18

Chiton equasosue

inne

Panulirus

argos 26H

Acanthopleura

fgranula #3

Panulirus

argos 26.8

Species 750

1-30

Spectes 731

38

Species 765

1-35

Black sponge

T49a

Orange sponge

1-30

Not Known

al

Lavrenct a

obtusa AsS

oractlaria

caudata 4-10

Gracilaria

mawnilaris A-14

Acantophora

spicifera

a-0014

Halineds

opuntia AG

Yiatore, of

Katte,

Specttera

ais fslamentoes

iss

Collection

rf ie

Joyuda beach 0.30

Bonus Nuclear

Plant 87

Joyuda beach 33

Bonus Nuclear

Plant 6.5

Joyiida beach 0,35

1/2 mile of

Pa. Higuero 63

. 0.70

Cayo Tarrenote 2.9

cayo Eariqes 1.4

Guanica Ls

. 2

cayo

Enriquez LM?

" v

? 87

Le

n

6a

87

16

230

35

16

B

250

38

39

3

aa

3

2

v

10

430

B

16

49

»

95

28

560

99

180

---Page Break---

2

i839

Scientific Collection ug Me /

nae site ee

Algae Lyngbia

payuscula A-2 Cayo Turrenote 4.8 69 wo

" Valonia

ventricosa 4-3 Cayo Enriquez 441 79 no

" Bypnes

useiformis

?a-15 Guantca MT 42 40

: Spyrisio

Eilanentos Cayo Boriqes 4.1 44 95

" Acantophora

specifera . 19 an no

? Mixture of

Acanchophora

specifers &

spyridia fils:

nentoda " 10 100 210

jelvedere 7 0 260

" Cayo Borie: 0.25 6.0 1g

? ? 087 45 10

Plankton Mixture P-18 3. mi, south of

Desecheo Isl. 0.83 7.218

" "poe South of

Vieques 27 om a

" "p23 " 1% a4 160

" "pa 78 m. depth

anasco R.

south Le 91 tt

" pa 2 17 alle off

Pra. Brea 0.06 26 8

" "p20 Sponge bank 2.132 56

" "pan South of

Vieg 4535 85

Terrestrial Sugar cane Coconut area

stems Rincon 2 v 70

---Page Break---

i990

ype of Scientific collection ve Mo / g

te tee aah

Terrestrial Brazil rubber PRNC n 951,300

" chucho Coconut ares

Rincon ooo 6

" Pajusl rojo Pane 62 89 850

" Mangrove

eaves Parguera n 26 200

" Coconut hard Coconut area

shell & meat Rinwon oe 2 30

? Mangrove

aereal roots Parguera Ls 6.2 290

? ?Tasarindo RNC 10 36 480

" Mangrove

sub. roots Parguera 40 at 36

? Algonés Coconut area

Rincon 0.57 0,906.

" Pocraria

hirsuta RNC 35 100 1,500

? Sugar cane Coconut area

leaves. Rincon 27 a 410

? Jabone {110 RNC be 701,500

" Piston core 358 a off

sod. 7-224 Agaseo R. 120 200

. ?mae " 120 200

* " pee ? 100 180

. "2p " 9% 160

" ?pee " 98 170

" "nae anasco R88 160

. r226 ? 2 170

" "mee ? % v0

" ?med ? 140 240

" rs " us 230

---Page Break---

Type of

Invertebrate

?aponge

mollusc

Plankton,

Invertebrate

Setentitic

Spectes 740

146

Spectes 765

1-35

Porpure Parula

238

7.28 Buphaueie

?shrimps Leopode

P26 Isopod:

P27 Buphaueid

?shrimps

Danirielle

a

o

collection vg te / pe.

12 aile of

Pea, Riguero 9,7 8

. 0.97 37

ayo Turrenots 110 x0

Yona Island

2 29

" 2 23

" 2 26

Negro Reef 5.2 2

220

240

120

280

320

37

---Page Break---

Type of ??Sctentifte

Echinoderm Tripneustes

esculentus Pa. Higuero 7 1517 43 92 no

« . . 82 13 uw 89 179 200

" - 87 6B 372s 150

? " " 44 9.2 10 63130 140

3868 as

" " ? 52 now 386

" " 4309 0 a)

. ? 13 eos 2% 90

" " " 94 16 18 a6

" " " 2 ww 6 us 130

. " " Boa 2s 4% 92 100

. ? " 16s a 63 68

" " " 97 223 3998

" " " 9.6 17 23 wo 5

. now 2 4s 8899

» ? ? noo an 2 90

7 * " 2 20m 5899 0

" ? 9.9 172s 373 a6

. ? " w 2 2 3796 110

. " " now oa 8 90

» " " 1» 6 oD 971500

" . . no 20 3389

? " now % 2 9

" " " now oa 3998 10

---Page Break---

Type of Scientific Collection Yo Fe

sanple nae site Wet bey ae Wet Dey ae

Coclenterate Bunicea

laciniate Pea. Miguem 4.37.1 WH 83270

? " . we 2838 B00

" Peeudoptero-

gorgia anericana ? mFS 130250

" " " 35 96 1637 10050

? Bunices

ealyculata - 9:6 18 21 52,1000

. Buntees

samnosa " no 5H O60

? " " 66 1 19 58 20170

. ? . 5.0 1 15 58 0170

" . 55 Ml 1S 58 O80

? . . 49 9.5 13 52 100140

Plexaurella

sp. ? S20 Rk

. Murtcea

atlantica " B20

" ? ? 42 82 M53 100 140

? 68 2 1s 75 190 A0

asperula ? 9 15 19 20 200250

? Bunicea

tournefort{ ? 7 2 wm 4 5 2

" " " 89 15 78 100

Pea, Higuero 16 37h 56 35040

? . vy 39a 870

? . a 506202800

" " 1 37h 160 370k

---Page Break---

Type of Scientific Coltection Yo ug Fe

me mane site ee Dey ah Wek Dry ash

ophivrotds Pea. Higuero 21 44 54ND 250 300

" " wo BO 250300

" " % 07240530650

. 1233518020490

" " 1 8 16035040

? 1 23H 100280330

" " 1836100 190230

" " 2833708010

" ? 96 22 © 26 0240300

. " 1% 29 HBO 350420

? ? no 378220270

7 . 1% 29360830990

Pagina Bonus wm 83 210

" " " 120-220

Marine ?Thalassia

angiospers testudinus Parguera 5.5 43 130-62 «4901500

? ? ? 8.3 54 © 1401006701700

. " " 1.7 5617052 3801100

. " ? 1583230230360

" " " 33 26 98

. ? " we 75200

" ? ? 8.8 53150

---Page Break---

Type of Scientific collection ug Mo/en Fo)

mp ave ite Set ?bey eh Wee Dry aa

Alga Sargassun

lendigerun Pea, Higuero 9.3 48 130

" Sargassun oj ? 6.6 28 88 77 1.0

" Gracilaria

dosingensis Rincon 2% 9% 70 10 bao

" Bryothamnion

cetquetrun " 20092 17h Ha

" Padina ? 37% 1s 37.9

" Penicitlus : 2 56 8 2

" padina Rincon wom wo 139 26 5.2

? Dictyopteris = 2.926 49 85 5 ay

" Penieitius " 158340

" Galaxaura 7 8 ao

" Auphiroa

fragilissiaa 2 73° 91.80 2.02

? Bryothaenion

erlgietrun " 55 M0 1605 LL?

" Padina ? 7.876 290 18 1.767

? Dietyora ? 5.8 80 410 18 25.3

Marine Thalase)

angiospera ?testudiaum " 2B 599 wow 3.270

Alga Padina Bons 7 0 21078 5.09.7

" 9.0 65 120 8k SS

" " * 2 160 280

? " " 2198170

? " ? 21 130300

---Page Break---

i396

Type of Scientific collection we Mo/ee 1g Fo/se

ple name aie et bey Ssh Wee Dry aah

Alga Anphizoa Pta. Wiguero 85 150 1706.0 10

? Padina 35° 110 180.8 6.09.0

° Padina

symnospora ? 35 20 5% 41370 2.0

" Penicillus " 97 40 105.04

? Dictyosphaeria

faveloss . 7 20 0 7s 5,272.0

" Cynopolia " 99 150 200622 2.9

? Dictyopteris

Justi ? 27 100 707.8

" mph iroa 5357690

" Dictyosphaeria 60 230 260 16 6.2 6.8

? Cynopolia " Bl 2 49 66 26h

? ?smphiroa . Mo 130 1506.2 7.3 Be

" Penieittus " 88 190 240

" Cymopolia W596 90 2a

? cavlerpa " 7% 120 180

? Dictyota

dentate " 25 80 150

? Bryothesnion 130 200 260

Miscelaneoue

?sediments & algae " 120 160 180

Alga codiun " 49 70 230

" Penicilive " 73 130 170

Marine Thalassia

angioepers testudinum " 66 85k

Alga Dictyopterts

justi " wo wo 8 49 89

Marine Thalassia

angiospera ?_testuiaua . uo 53 00 1.0

" . 1358 130s Ls

---Page Break---

Type of

Terrestrial

Scientific

Piston core

sed.

T-16 B

Tec

116 D

Tee

T6H

65

116K

Tie L

Ts M

Piston core

eed.

Te? A

hue

nine

Tae

Piston core

sed.

TB a

Tee

Piston core

eed.

1-19 B

ric

Te

196

119 #

rit

ns

re

1-208

ist

Collection og Na / p

mm

343 acters

deep-off

snatco R 93007

" 10 8

? 9900

" 10 18

" 10 wv

" u v

" u 18

. 10 16

. n v

off Anasco

River 86

" 10 v

" 89s

" 2 19

64 9. deep

off anasco R. 9.515

. n wv

31m deep

off anasco R. 9.618

. 9918

? 82s

" 90 6

" 970

" 98 1B

" 10 16

823

351 seters

deep of Afasco It 18

---Page Break---

ids

Type of Scientific Collection ag Na /

ple name te ee ay

Terrestrial Piston core 351 @. deep

|. T-20 off Afasco R943 8

" "208 ? n 8

" +" mor 13 v

. " 206 « 10 6

. Piston core 200 a. deep-

ged, T-21 A off Afasco R. 9.2 »

" "ree " 2 a

rap " 99 6

---Page Break---

isa

Scientific Collection Wig

ple na ite ise bey

Algee Not Known cayo

4-0019 Enriquez 5.5 29 ow

" Viva lactuea

a2 Guanica 196 2

. Rypnea

musciforais

4-26 L922 cr

" Peniettius

?capieatu

25 ? 5.6 22 30

" Gractiaria

?4-27 ? Loon 9

? codivm

Taylorit " Ls 19 29

Seatoglossum

a2 " L815 3

Bryothamaton

eriqetrus 4-200" 3.723 a

Laurenesa

papiilosa a-28 Le 13 2

calaxaura

cylindrica

24 ? 5.523 28

" Mixture of

Aeantophora

spteifers &

Spyridia fila Cayo

eentoi Enriquez 47 os 95

. Halineda

Opureta a4 " 2333 37

" Lyngbia

sayuscula cayo

2 Turresote 23 33 6

: oracilaria

suamnilarie

ale cusntes 5.853 120

---Page Break---

?Type of

Algae

Scientific

Bypnea

suse fore

15

Gracilaria

eaudata A-10

Valonia

ventricosa

a3

?Acantophora

spictfera

Enterosorpha

Chiorosconbrus

erysurue

Marengula

Chioroscombrus

erysvtus

F-15

P-7

F-25

200

Collection

ite

Cayo

Enriquee

South of

La Boquilla

eM /g

wae rt

Bsa 200

21 a9 a

3.5 66 95

5.6 65 123

0.96 21 56

030007300 7

R59 2%

a 0 a

O56 25

10 46 ag

0.43 26 6

Lt 4120

L254 oe

0.89 4.316

35323

2.76 3

22 9.8 8

Ls a1

21 66 or

079 3.7 aM

22 10 a

40 2 7%

---Page Break---

Scientific

chiorosconbrus

erysurus Fo14,

" "pay

? "Re

. ?pes

. a)

" "pam

Fs

" "pw

* ?pu

ny

? ~ pag

" Pon

" pee

South of

La Boquilia

0.43

1s

La

0.82

0.45

Le

Ba

5.1

2.3

22

22

3.2

36

wy

22

4.0

9.0

3.5

aa

13

6.6

8.3

a

as

29

6

25

26

4

3

2

26

31

36

2s

a

---Page Break---

292

Type of Scientific Collection ug Ni fg

empl name ite i Dry ash

Fil Harengula South of

Fe31 La Boqilla = 2.6 10 3

" spa . 26 86 6

" "Rh " 2.6 10 2

" ?P30 " 28 9.5L

? "pho . 32 86 8

" 9 Bey ? 3.6 15 40

? pal ? 7.2 25 80

" "Re . 20 7.

? St ? L350

" "P38 ? LS 5.7 20

") ? 27 85

? "pen " 28 a7

" "B39 ? Le 647

? "pe . 44000 48

. "Ra . Le 65

" "pe. ? Le 6.39

? "p20 " 230 890

? eas, " 2.8 10 8

7 "oss " 197.9 2s

? "p26 " 23 Bl 6

? ?rt " 3.00 38

? "pas " 18 602

? "ope " 260 6300 tL

. "pg . 51 18 32

? ?pag " Le 6.523

" 6 p35, " 20 007.300 25

---Page Break---

293

Setentific Collection we

nave site ie

Harengula South of

Ply La Boqitla 3.212 36

" ?par ? 25 9.0 26

" ?op . L662

" "6g " 26 88

" "m0 . 3.6 13 4s

ophisthonena

oglinun F-6 . 12

" "pe " L767 25

"ope " 13508

" "Re ? Le 56

" sora " 1978

" ?pao " L683

" a) " Le 7s

? "Be " 26 ry

? "ops. " 0.65 3.707

"os " 1S 56

Fish Cetengraulis

edentulus

7 . a1 40

"re " 2.3 16 29

. a) . 28 8636

? "pa " Lo 4520

. "pe " Mr72

" "ons . 3.6 16 4s

"ne 23078

. "ne " soso

Fish Caranx

lacus F-16 ? 4.0 16 50

---Page Break---

Type of Scientific Collection Mi /

1 nase ite ier br ah

Fish Coranx South of

Lstue F-5, La"lomilla 0.77 3.8K

? "pas Lo 4520

? pas ? 10 4320

" Harengula

F-16 " 27 neo

" ?par ? A247

? ?pas " 20 8.06

. "ps " 40 16 50

? caranx latus

P16 " LS 49 a5

? Fe? " 13 5.40 oa7

. ?op " 21 9.845

? * pL ? ee?

? ?op " 6 7.200 23

? ?me 15 5.925

ra ? 0.38 18 8

? "9 " 22 10 45

. "FB " 26 «0

Fish Ghioroscombrus

crysuras Fel " Le 66

. "pe 4.0 8 %

Plankton pe2i South of

Vieques 86 67 160

? P-20 Splinge bank 4.874, 130

" Pais Three wiles

8. of Desecheo

Island 36 2 9

" Pe2g 212 a. from

point Brea

Parguera 0.4518 120

---Page Break---

205

Scientific Collection va ME

nae ie

Plankton P13 78 a. depth

Anasco R. south 5.0 37 86

Sugar cane Coconut area

stens ?TP-00008 Rincon O72 18m

Roots (mangle)

subterraneas?TP-000013, LaParguere 5.85.9 a.

Fajuil rojo 1P-00009 RKC 3.0 4h a

Raices area

de Mangles ?7P-000014 la Parguera 0.35569

Mango Leaves TP-000020 RNC 122.6 oor

Tamar indo

leaves P-000016 RIC L243 oT

cascara y Coconut area

cachipa de Rincon

e0co ?7P-000018 Ll 2.8 66

Mangrove

leaves ?rP-000017 La Parguera 1.63.8 29

Goma de

Brazil 1TP-00005 PRNC 5.8 7.7 107

Chucho ?7P-000012, Coconut area

Rincon Ost 5.6 32

Sugar cane Coconut area

leaves Te-00002 Rincon ae 72 on

Jabonet 110 P-00007, RNC 330 6788

Almonds ?TP-00004 coconut area

Rincon 0.39 0.60 az

Algae Mixture of

?Acantophora

spisiters &

Spyridia fila Cayo Enriquez

wentosa A-0018 La Parguera 4.746, 95

Invertebrate Nudtbranche

16 Cayo Turrenote 23° 220 n

Brown sea

urchin I-13 ? no 2 25

---Page Break---

206

Scientific cottection ve N/a

nae site ie aah

Invertebrate Panvlirus

argos I-12 Joyuda beach 9.339 a

. chiton Bonus Nuclear

Squazosus Plant we 23 25

1B

Pac Lirue

argos 1-22 2.8 22 2

* 3s. from

Jelly tia 310 Bea. arenas 8.8 200 25

Invertebrate Species 745 1/2 alle from

sponge 124 Pea. Wiguero 1262 180

Squanosus Bonus Nuclear

Linne 16 Plane 2 oar 20

. Panu lirue

argos I-17 Joyuda beach 1.6 60s

" 13s 1/2 aile fron

sponge Species 765 Pea. Higuero 3.112 %

Invertebrate Acanthopleura Bonus Nuclear

granulate 7H Plant Boo 20

sponge 1-7 Cayo Turremote 2.2 20 38

Invertebrate white sea

urchin ? wo 23

. Black sponge

T49 a 2 150 310

. Orange sponge

1502 " 6.5 25 uo

Terrestrial Pueraria

hirsuta axe 2195 Mo

" 5.6 7.5 100

Not Know Cayo Entice 6.6 35 7%

? Spyridia

Filanentosa " M7? 38

Terrestrial Piston core 3580. off

sed. 7-22 A ?Anasco R. 3% 8

---Page Break---

Type of Sctentitic collection ug ML

ple te wee ory

Terrestrial Piston Core 3580. off

sed, 7-22 B Anasco R, 37 60

" " mee ? 3

" " r22 ? ??

. " nae ? 4068

. "nF . 6 8

126 4073

" "naw " me

. "reed 60

. rg ? 6S

Invertebrate Species 732 1/2 ai. off

sponge ran Pea. Higuero 4979 100

> Species 792

Li ? ?wo 8

? Species 774

42 w 66 260

" Species 731

138 " 2349 99

" Species 738

48 " 37 93

" Species 769

143 " wer 230

. Spectes 766

Tas " 6 2 200

" Species 747

126 " w 56 8%

" Acanthopleura Bonus Nuclear

granvla it Plane 6 °

Invertebrate Acanthopleura

granulate 3H " 93 107

1/2 atte off

Pea, Higuero 1269 160

sponge

---Page Break---

20

DB

Type of Scientific Collection ra

te ite iat a

Invertebrate 1/2 afte off

sponge Species 767 Pea, Higuero 6.329 86

Invertebrate Panulirus

argos 24 Joyuda beach 27 50 99

" ?as ? 5.0 2 no

Sponge Species 745

126 6 88 260

" Species 728

123 . ? 3.0 260

Invertebrate Brittle star

Td Cayo Turrenote 35 6 80

sponge La Parguera 6.337 96

" Species 727 1/2 aile from

132 Pta, Higuero 9.2 57 uo

" Species 748

Tt . cy n 190

" Species 772

133 " n 9 no

" Species 750

130 " 20 70 140

. Species 768

134 " 5223 140

" sey % 160

. B 83 7

Species 736

1-39 ? 46 3 88

---Page Break---

209

Scientific Collection ug NL

Site et ey aa

2 9

" s 2

" 3B 388

Yolluse Anadara sp. 345s

. Pear sp. " 38

" . " vom

? " " 6 ar

Echinogeraata Lidia

senegalensis " 86

" . " 2 ow

Crustacea Sheiap " 35 1 6s

Fish Syaphurus

Plageiea ? 2.6 19 50

" "111 ca. " Ls 6 ow

" "125 oe, . 29 258

? 126 ca. ? 21 ot

. "126 en. " 187.6 at

? "130 ca. " 37 59

« #110 cm. ? Ly 7a 40

" "131 ca. ? 18

" "132 om. " 187.6 3s

" Lartous

brevice

149" c=. 6 23 90

" "166 ca. ? 2.30 848

---Page Break---

Type of ?=Sclentific ? Collection ug NL vg

sap a site tee by aa ey

Echinogera Echinosetra

Tweunter incon 636

" " " 6 28 6 0 6 28

" . 9 5057 tok

" " ? m 8 9 19 2 om

" a7 a

. . . 7 55D

" . " 4 6

. " 9 5057 Om

. " " 7 6 Fs mw

" " " 2 33 eo

. . ? 4 6 Sk?

. ? " 2% 7 9616 1B

. " wae

? . " yw

" " so kyo as

. " Parguere Rs 5 ww

. " ? xo

. " " v4 wz

. " " 3 sw

? . B53 88D

. ? " % 4

. " " 2% wl

. « a ee ae)

. " " 2%

" " " 55a

---Page Break---

Scientific Collect ion ve ML / ig x Mn / g

page site. et bey ? ish Wet bry ar

Bchinodere ?Echinometra

lucunter Parguera ask 55 keg

? ? . 24 aw

" " . ma ow 93°17 8

? ? 3 36 6

" " " 3 St 56 sag

? ? " 355 aww

" ? 3s 8 8 wp ww

? " : 3 4 50 waa

? 7 az Ms sas

? . " 2% 3 aww

" " " 6 mo ls

" . . vo 2 2m ww 6

" ? " ez 68 4 on ow os

" . 2% 2 mas

" ? ? %® nos 98 13

" ? ? 2% we on wp wy

" . 3043 ag 86 1 ow

" ? " woo on a1 13 wy

? ? 2 ww nu 3

7 . mee a1 1 16

" ? ? wesw 65 13 ow

" : " ao wt 2 ow

" " . ws 74 Ww 16

" ? " poy 74 6

7 ? . wo on Mw 68 1 a5

---Page Break---

Type of Scientific Collection vg Mi Mo

sample name site et be wet dey hah

Behinodera ?Echinosetra

lueuater Parguera ye 8 sw

. " . 2 7 6 16

? . 2 as 78 6

. ? yon oe 7 ow 6

? . . 289 wow ow

. ? " 2 mw

: ? 7 Bb 2 62 2 ow

91 18 20 65 13

---Page Break---

Type of ?Sctentitic collection

sample pane site

Echinodera Tripnevstes

esculentus Bonus Site

" . . % 3 40 2%

? . . wo 4 12326

" " ? vw 45 nooo

. " " 2 4853 wo 32

? " " 45 50 wom

? ? ? yom 9.7 2 27

. " . won 6 7s

? ? . us 8.5 2 25

" " " wom st 8.7 25 29

. ? Bo 83

? . " ws 86 2% 27

? " " wo ow 9.3230 a7

? " . 348 7.2020 23

. . " 1B 5058 89 25 29

" . " wa 8.0 mm

. . Parguera 2359 6g 92 23 27

" " ? 27 69s 10% oa

" . . me 59 68 1 2% 0

? . . vo 5 1 28 30

" ? ? 2 67 8.3 22 28

---Page Break---

Type of Scientific

ms mo

12 ane Te aa

Echinoderms Tripn

esculentus ?Parguera 2 6069 88 25 28

. ? . 2% 7 7.0 20 24

" ? . 2% 66 5 9.0 2 24

" Echinoaetra

lucunter Higuero 29 3237 i122 ast

? Bucidarie

tribuloides % 90 2 now ow

---Page Break---

Type of

1e

Invertebrate

sponge

mollusk

Invertebrate

Invertebrate

Invertebrate

Scientific

Species 765

135

Species 738

40

Species 769

143

Species 749

1-28

Species 736

1-39

Spectes 745

1-26

Acanthopleura

granulate 7H

Penulizue

arges 24°

Specie

1-26

747

Chiton

squanosus

Species 744

1-29)

1

Species 792

1-37

Species 731

1-38

Brittle star

EL

Acanthopleura

granulata 6H

Pen lizue

argue 24

Species 727

132

Collection

1/2 wile off

Pta, Higuero

4/2 nile fron

Pea. Higuero

Bonus Nuclear

Plane,

Joyuda beach

1/2 alle off

Pea. Higvero

Bonus Nuclear

Plant

1/2 mile off

Pea. Wiguero

Cayo Tarrenote

12 aile off

Pea. Higvero

1/2 mile off

Pea, Higuero

Cayo Turrenote

Bonus tuclear

Plant

Joyuda beach

12 atte off

Pea. Higuero

16

38

23

33

1.0

63

43

3.8

3.0

43

9.0

26

2

8

La

30

1%

a

31

2

os

5.0

26

23

28

2

7

4s

7.0

ah

16

4

?8

29

60

32

4

38

59

46

sa

26

4

58

0

13

---Page Break---

Type of

le

Invertebrate

Capone)

Invertebrate

Lobster

Invertebrate

sponge

Invertel

olluse

Sellytish

Invertebrate

sponge

Invertebrate

olluse

Invertebrate

?sponge

Invertebrate

Setentitic

Species 766

145

Species 748

T-31

Species 791

1-36

Panulirus

argus 1-18

Orange sponge

sp. #2 1-503

Species 768

34

Species 728

1-23

chiton

squanosue

10

1-46

?Acanthopleura

granulate Hs

Mudibranchs

Ts

Species 772

1-33

crab

White sea

urchin

Collection 2 Pe /g

rt ee be aah

1/2 wile Pra,

Biguero oO 46 3

" 3.3 15 a

* 27 16 ?8

Joyuda beach 0,612.6 27

Desecheo L764 9

1/2 aile off

Pea. Higuero 0.75 3,321

? LS 66 27

Bonus Nuclear

Plane ww 49

3 et. fron

Pea. Are

Mayaguer, Ls 36 a

Rta, Higuero 5,723 2

1/2 aile off

Riguero 28 4a, 6

. O37 7 5

Bonus Nuclear

Plane. moe 36

Cayo Turrenote 0.41 4.0 13

1/2 atte off

Pea. Higuero 4.717 49

Cay Turrenote 14 41 n

Cayo Turrenote 37 38 45

---Page Break---

217

Type of Scientific Collection vg b/g

name re ie ro

ate Panulirus

argue 1-22 Soyuda beach 0.56 4.3

* Species 767 12 wile off

sponge 146 Pea, Higuero 0.753.510

7 ¥-00001 Parguera 1.8 10 27

" Species 750 1/2 mile off

1-30 Pta, Higuero 7.025 ?8

. Acanthopleura Bonus Nuclear

granulate H-3 Plant ne 48

" Species 732 1/2 alle off

TAL Pea. Higuera 2743 36

Invertebrate Panulirus

argue 1-17 Joyuda beach = 1.7 7-15,

Brown sea

vuechin I-13 cayo Turrenste 2349 35

" Species 774 12 aile off

sponge 1-42 Pea. Higuero 2.110 »

Algae Galaxaura

cylindrica Ouanica no 46 56

. Bryothamnion

triqetrun Guantea 46 28 50

. Gracilaria " L718 31

" codiua

taylorts " La 8 28

" Penicillus

eapitacus ? nM 38

" viva tactuca " 21 8 ey

" ypnes

smusciforais " 2.30027 6

. Spatogiossun

schroedert " 3.1 26 36

" Laureneta

papillose . 3.0 2 6

Hypnea

musciforais ? 20 5.0 4h

---Page Break---

218

Type of Scientific Collection ig Pb /

waple name site Set bry

Algae

cayo Turrenote 2.1 25 6s

Lavrencia

obtusa a5 Cayo Enriquez 1.3 15 29

? Lyngbia

mayuscula A-2 Cayo Turremote 2.333, oo

Valonia

ventricosa

a3) Cayo Enriquez 2.5 48 cy

" Gracilaria

caudata A-10 Guanica 0.79 7.00 1s

. Moxture

Acantophora

spicifera &

Spyridia fLlamen-

© cayo Enriquez 1.8 18 36

? Enteronorpha Nor DETECTED

codsvm

Taylors Gusniea 62 73 150

" Malineds cayo

opuntia Enrique wo 45

- Lavrencta

papilloss: ouantes 139.0 ae

. oractlaria

aunt aris ? 2.6 24 56

" ?Thalaseia Belvedere oe 5.6 th

" Spyridia cayo

Filamentosa Enriquez lao 26

? Acantophora

spleifere ? om 7 au

Terrestrial Mangrove

subt. roots Parguera 220022 0 9

" Pueraria

hireuta RNC Le 5.479

" Mangrove

aereal roots Parguera 0.071 0.29 14

---Page Break---

t

Type of Scientific Collection ug Pb

253 name eee a

Terrestrial Alaonds Coconut a1

Rincon 0.32 0.50 35

. Brazil rubber PRNC 43 6.0 80

? Mangrove

leaves Parguera 0.93 220-7

? Jaboneilto RNC 27 5.6 6

Sogar Cane coconut area

stens Rincon MoT DETECTED

" ?Tamarindo

leaves RNC 26 91 120

chucho coconst area

Rincon O61 6.6 8

? Coconut hard

shell & meat " Ol 1.0 2H

. Pajuil rojo RNC 32 46 4h

. Mango leaves " La 22 25

" Sugar cane coconut area

leaves Rincon 3.00 4S Mb

Chloroscombrus South of

crysurvs F-4 la Bolla «1.9 9.034

" sora . 17 80

. Harengula

Fol ? 2 68

" opisthonems

oglinim . 12 4720

? Cetengraulis

edentulus F-8 " 15 6.020

Plankton Mixture P-24 2-1/2 aile off

Point Brea

Parguera La 45 300

? "p13 78 sever depeh

Amasco R, mouth 4.7 35 a1

" "pig 3. wiles souen

of Desecheo Isl. 9.2 80 200

---Page Break---

?Type of Scientific

Plankton Mixture

P20 Sponge bank 1.218 35

Invertebrate Black sponge

149 a Desecheo 35a a

---Page Break---

221

Scientific Collection _ugSr/g

name ie

eacles Cayo Turrenote 0.032 0.26 9,2

21s

? Teipnevstes

esculentue ? 0.53 055 6.5

" Species 744 1/2 mile of

129 Pea. Higuero 0.051 0.30 6.2

. Species 748

r3. . 0,025 0.12 3a

? Black sponge

1494 Desecheo 0.011 0,065 1.3,

Invertebrate Acanthoplevra Bonus u-

granlata clear Plant 1.10158

?sponge 18 2B 6s 960

Invertebrate Panulirus

argus 1-22 4 0.13 0.98 100

" Acanthopleura

granclata 6-H 59 831,000

Species 746 12 mite of

(sponge) 1-25 Pea, iguero 2.6 6.580

Invertebrate Purpura patula Cayo Turre-

2H ote wo 150 1,500

(sponge) rT ? 24 23400

" Species 740 1/2 mite of

Tha Rta, Higuero 51 © 801,200

Invertebrate Acanthoploura Bonus Nuclear

granulate He Plan 310 420 4,800

Panulirus Joyuda

argus 1-17 beach 0.38 1.6 120

Species 773 1/2 atte of

Ceponge) 1-47 Pea, Higuero 9.4 56 1,300

Invertebrate Panulirus Joyuda

argus 1-18 beach 0.23 0.95 100

Alga Enteronorpha Cayo Eari-

wes 2006 0.11 3,3

---Page Break---

Type of

Marine

angiosperm

ala

Plankton

Fishes

Terrestrial

Scteneitic

Thalassia

Dictyots

divaricata

Acanthophora

spicifera

Codium isth-

rocladun

cavlerpa

Penicttius

capitatus

caulerpa

Mixture of

shrtaps &

isopods

Mostly

shriaps

Mostly

isopods

Plankton 6

river sed.

Cypstiurus

cyanopterue

PV. (akin &

scales)

Ablenne:

iene gills

4G, muscle

Piston core

eed. 7-20 E

?miss

222

Collection

Cayo Bari

vee,

Belvedere

cayo

Bnriquer

Belvedere

Pargue

Yona

Toland

3 at. out

side Pea.

Aven:

South of

Vieques,

Culedrinae

Bay

351 a. depen

oft aia

31m. dopeh

off dnasco R.

2 Re

2 Sela

wee aa

012 0,077 5.2

0.015 0,11 10

O07 3.2

O82 13 250

13 10 B00

7.2 62 2,100

4% 230 3,400

15 26 00

6.9 690

20 4.3 520

6.9 13 1,600

32 5020

sk 280

2130440

100

951,600

6.3 100

---Page Break---

Type of

Je

Terrestrial

Scientific

Piston core

Sed. T-16 A

"one L

"nie m

?mara

?nize

"nize

"nip

?nie

Collection

343 a, depth

off Atasco R.

351 a, depth

off Afasco R

370

630

760

600

820

690

1,300

770

1,400

70

850

890

2,000

1,300

1,500

1,600

1,700

1,200

1,000

1,100

1,100

1,200

1,200

1,500

680

1,000

1,300

1,400

2,000

4,400

1,100

2,200

1,300

2,200

1,200

1,400

1,300

1,400

1,200

---Page Break---

24

Type of Scientific Collection x Srl

as nape ive me bry

Terrestrial Piston core 31a. depth

sed. T-19 A Off Anasco R. 2.5 4g

? " nioK " 6.6 100

" " mise . 5.9 100

. ?nist " 6.1 100

? nive " 26 ae

. "nse ? 45 8h

? "new " 2 180

. " mive ? 25 ae

? ?nis Bl 56

. " niss " 8.8 M0

? ?mise " 5.6 100

" "nage ? woo

" "nish " os 70

. ?ipa

. 38 60

. ?mise " Ea 30

? " mipe " 6 90

? "nie " 6 90

? "nee ? 37 8

. Tse ? 13 190

" "m6 . 8 20

? "mea 200 M. depth

off Afasco R.200 420

"rae ? Mo 260

? "mae " 560 960

" "m2 ? 20 400

" "mae " 160 230

---Page Break---

225

?Type of Scientific Collection ug Se

sample nase sit wet bey ae

Terrestrial Piston core 351 mmm depth

sed. 7-20 B off Afsco R. 1,100 1,800

? " neo¢ " 1,300 2,200

" " n20D " 1,100 1,700

" " 120F " 1,100 1,500

" ? m206 ? 1,100 1,700

? "120 # " 1,300 2,100

" " m202 1,000 1,600

" 1205 " 1,100 1,800

" oma 358 a. depth

Off Anasco R. 1,600 2,600

7 " mee " 1,400 2,300

? ?m2 ? 1,300. 2,200

? "mee " 1,700 2,800

" "mee " 1,700 3,000

" "mee ? 1,300 2,400

?mee " 1,300 2,400

" ?mee " 1,200 2,100

" "mars ? 1,200 2,300

Sea bottom 230 m. depth

se. 1-15 anaseo R. 40 280 400

" ne 190 =. depen

anacco R, 70 310330

? "oma 20 ft. open

inside Cat Te. 3,900 5,500 5,600

" ?one 20 a. depth

Enriqes P. 3,100 4,600

" "ne " 2,700 4,200

---Page Break---

Scientific collection ug Se.

nage ste eee aa

Terrestrial Sea bottom 20 fc. depth

sed. TH ?anasco R, 4,500 6,000

" ?ono St. 2, 8m,

depth south

aiasco R Be

? "me 65 a. depth

eff AnascoR. = 72100100

?mu St. 4, 60m

deep mouth

?Anasco Re 39 100 100

? ?ras 28 a. depth

?anasco R. 150 290310,

---Page Break---

227

?Type of Scientific Collection _ug Se/g ug Za/g

ample pane ee ee ? Dey i Wet Dey ash

Detritus ?Anasco Bay 65 1316 230 460 550

? ? 45 19 om 86 300570

" " 47 war 340 990 1500

Mollusc anadara sp. ? 0.03 0.04 0.04 150 200 220

" Piear Sp. . No ScaNpnUM 150160160

0.07 0.18 0.20 38 © 93100

? ? No ScaNDrUM 150150160

Echinoderasta Lidia

jenegalensis =" 21 45 6.0 7150200

0.08 0.23 0.31 81230300

96 270 390

86 240350

* " . 100270390

" Claeheaes 0460470

" Polychaeta " 4.827 66

Crustacea shrimp 27 10500

" 60 ca. ? 21 84370

? 70-80 ex. " 26 10500

" 80 co. 21 a 350

36 140670

" . 27 0820

? " " 2799580

Fish Synphurus

plaguisa " 30 20580

" "an es. " 2 79 0

? "125 em. " 23 91460

" "126 en. " 2% 10 560

" "126 em. ? 28 0 620

---Page Break---

Scientific

Symphurus

plaguica

130"ce,

* 118 cm,

"131 ew.

"132 ce.

Lariaus

brevicepe

"80 ca.

"110

vg Za /g

me rr

3130 540

2% 10570

15 65330

25 100470

2 Bono

23930

739 320

a 020

6260

2 93380

150 570

% 120580

2% 87350

---Page Break---