PROGRESS RETORT MARINE T1010GY PROGRAM MMe 1565 ---Page Break--- . TABLE OF CONTENT ---Page Break--- 'PROGRESS REPORT MARINE BIOLOGY PROGRAM FY-1965, I. Title of Project: Marine Biology Program 2. Inscription: Puerto Rico Nuclear Center Project abstract: The research program outlined herein is a continuation of studies started at the Puerto Rico Nuclear Center in January, 1962 and continues the project present time. Although the program is composed of five major areas, the functions are integrated. The five original areas of research, although altered in some details to fit the aims of the program, remain at present time. It is proposed that they be continued and that an additional area, Marine Ecology, be recognized. The Program was designed to provide measurements of the distribution and movement of selected trace elements in a restricted but complex ecological and biogeochemical system. It includes limited investigations into the Lithosphere as well as detailed studies of the marine biosphere and hydrosphere. In order to obtain information on interactions between the biosphere and hydrosphere, measurements are being made of biological products [AZM amounts of trace elements in the organisms and the environment, bios

logical half-lives of trace elements, characteristics of food webs, and the influence of physical and chemical oceanographic factors upon the distributions of elements in the marine waters, organisms, and sediments offshore from the west coast of Puerto Rico. The latter studies include sheer speculation on the effects of varying rates of deposition of mineral-rich silt upon the distribution patterns of marine organisms. The research projects are as follows: (1) Measurements of Biological Productivity. The clear method for measuring biological productivity is being developed. The uptake of C14 is correlated with plankton volumes, the account of chlorophyll, phosphate and nitrate content of the water, depth of water, distance from shore, amounts of suspended material in water, salinity, temperature, and uptake of selected radioisotopes by phytoplankton. Activity measurements have been made in water samples from the surface, 50m and 300m distant from the outflows of rivers. Analyses have been started to determine specific activity of C14 in the total carbonate of seawater and in various plankton. The amounts of C14 in the samples are measured by liquid scintillation and the total carbon content determined by gas chromatographic techniques. ---Page Break--- (2) Analysis for Selected Elements. Trace element analyses have been continued in samples of marine organisms, seawater, marine sediments, river water, river sediments, and selected rocks, minerals, and soils of the Añasco River valley. The methods used to determine the amounts and forms of trace elements in the variety of samples include destructive and non-destructive neutron-activation analysis, atomic absorption spectrophotometry, flame spectrophotometry, fluorescence analysis, fluorometric analysis, X-ray emission spectrography, and X-ray diffraction analysis. In addition to the measurements of trace elements, analyses are being made for carbon, hydrogen, nitrogen, lithium, potassium, calcium, strontium, and magnesium in many of the samples recently. The amounts of elements were determined on the

basis of ash, dry and wet weight of organism. The amounts of trace elements are now calculated relative to the carbon, nitrogen, and hydrogen content of the samples, (3) Measurements of Concentration Factors of Selected Organisms for Given Radionuclides, and Organon for Given Red and hPR, MEDS are recorded and contained a crust) F659) 2065) rays, K? and Ce! Ag Sargassum lendigerum and other selected algae; and Mn**, orl, re°9, 2n®, and Tal8? with. ‘Acanthopleura nt WS with detritus (4) Measurements of Radioactivity and Radioisotopes now Present in the Marine Organisms, Waters and Bottom Sediments and Rete Measurements of world-wide fallout in several large samples of marine sediment, algae, gorgonians, sponges, crustaceans, and fishes have been completed.” The disintegration rates of the radionuclides have been calculated on the basis of wet, dry, and ash weight. Co3!, ts Ose) Phytoplankton, have been measured in the samples and have been compared with the Cob? /ost0 ratio in samples from the Pacific Ocean. Determinations of specific activity for all of the samples are in progress (disintegration rate of radionuclide per gram of the corresponding stable element in the sample). (©) Background Observations in Physical and Chemical Oceanography off the West Coast of Puerto Rico. Measurements of bottom contours, salinities, temperatures, turbidities, dissolved oxygen contents, and current directions and velocities are in progress and will be continued. The work has been concentrated mainly in the area off the Anasco River and west of the Bonus site at Punta Higuero, (6) Marine Ecology ‘The marine ecology project has been carried out on Limited parts of projects two and three for the past two years. The ecological studies are concerned primarily with investigations of food web relationships ---Page Break--- Associations now under observations include algae-mollusks, algae-echinoderms, echinoderms-gorgonians, sponges-arthropods, omnivorous fishes, and mollusks-sipunculids-annelids-echinoderms-crustacean relationships.

aedinect ‘coupositions and sizes. SCIENTIFIC BACKGROUND Investigations of trace element distributions in the sea are of scientific interest in the field of oceanographic chemistry and in allied areas including those concerned with biological productivity, the influences of organic detritus upon the chemical and physical features of sediments in seawater, and the geochemical histories of elements introduced into the sea by natural processes. In addition to the scientific value of the investigations, an understanding of the biogeochemistry of trace elements is of critical importance for humanity insofar as radioactive isotopes of the same elements can be incorporated into food webs from which food for human consumption is derived, the relative influences of the physical, chemical, and biological factors which control the transport and distribution of these elements. There is evidence of the relationships between rates of photosynthesis by marine phytoplankton and the rates of incorporation of trace elements into marine food webs. Distribution patterns, in the same environment, of selected trace elements which represent the different chemical groups. The analyses for the trace elements should be made on a limited number of minerals, rocks, sediments, river waters, and river sediments from the landmass which contributes trace elements to the neighboring marine waters and on a representative number of samples of estuarine and offshore deep-sea marine waters, pelagic and littoral organisms and sediments. Several elements naturally present in trace amounts in the marine hydrosphere are concentrated by factors of at least 10 by some marine organisms. Radioisotopes of the same elements are present in radioactive waste and contaminants produced in nuclear technology. An understanding of the geochemical routes of these stable elements may be utilized to predict geochemical routes of radioactive contaminants which may be introduced into the marine environment from a variety of sources. The use of the oceans for disposal of low-activity radioactive contaminants is

and will continue to be attractive for several reasons. Man resides primarily on land, which constitutes only 29.22% of the overall surface of the earth. The remaining 70.8% is covered by the sea which is more or less remote from human habitat, contains a large volume of dissolved (approximately 1.4 x 10^9 km³), and has a mean depth of about 3800 meters with deep trenches or depressions far removed from land or its food organisms. In addition, the division of the earth's crust between continental blocks is abrupt, with the continental shore comprising more than 6% of the total area of the earth. The oceans contain large amounts of salt (4.8 x 10^15 tons) which may contribute to the process of isotope dilution. Because of the large quantity of contained salts, even those elements which occur in sea water only in trace amounts constitute a large reservoir of material for the dilution of radionuclides introduced at a controlled rate. They can be used to define the factors introduced into given areas of the sea under specified conditions; other data are not available. The latter include (1) the distribution patterns of trace elements in the marine environment both near and offshore, (2) for which specific marine organisms concentrate different elements and the individual variability which may exist within species from the same locality, and (3) the effects of biological activities and ecological relationships upon the distributions of the trace elements in a given geographical area. The answers cannot be derived entirely from laboratory experiments but must be obtained from field observations, analyses, and experiments in a natural and functioning ecological and biogeochemical system. Certain laboratory experiments may be used to demonstrate and assess the underlying physical and biological mechanisms which control the patterns of distribution observed in the field work. Such laboratory investigations include: (1) the determination of the physical and chemical forms of elements in river water before and after mixing at which

the changes in form occur, (2) the measurements of the salt which precipitates, produced by the action of seawater on the major five thousand coloidal elements in river water, settle as a result of gravity, (3) the measurement of the adsorptive capacities of known types of marine organic detritus, inorganic colloids and precipitates and specific saving sediments and (4) the determination of the rates of uptake and loss at radiostopes of trace elements by dominant marine species of plankton and animals. SCIENTIFIC SCOPE OF THE RESEARCH The research is designed to measure the distribution and, indirectly, the movements of selected trace elements from a land mass into the sea and the marine sediments and to relate measures of biological productivity and movements of organic components through food webs and chains with the incorporation and transfer of trace elements through the trophic levels. ---Page Break--- The studies may be divided into two major divisions: (1) The measurement of the distribution patterns of trace elements in the watershed of the Anasco River, in the biosphere and hydrosphere of Atascocita Bay and in the offshore areas in Mona Passage (fig. 1). This work includes studies on the interactions of the biosphere and hydrosphere upon the distribution patterns of the elements (2) The development of techniques with sufficient accuracy, reproducibility, sensitivity, and simplicity to achieve the measurements in a large number of samples. This includes not only the development of methods for trace element analysis in the microgram range, or less, but the adaptation of ecological field procedures to quantitative measurements in which correlations of observations with large numbers of biological and environmental variables may be made by sorting the data with machine methods. The initial plans for the geographical range of the marine biology program included the marine areas west from La Parguera on the south coast of Puerto Rico, along the entire west coast, and east along the north coast to the town of

Arecibo. However, the surveys which were needed to establish background conditions offshore from Punta Higuero, the site of the Bonus power reactor, were given first priority in the program. This was done to establish the radioisotope levels in the offshore areas before startup of the reactor so that subsequent alterations in the marine environment, produced by the operation of the reactor, might be utilized in the trace element studies. As a result of the observations in that work, it became apparent that the geographical area of the investigations could be reduced without loss of scientific scope or coordination in the program. Rather, a more closely integrated series of research could be realized by studying a restricted but complete ecological and biogeochemical system—studies which included measurements of the movements of selected trace elements from the land mass, through the rivers, into the neighboring marine waters, through the marine biota, and into the marine sediments. The geographical area in which the marine phases of investigations have been concentrated for the last two years extends north from Mayaguez past Atasco Bay and Punta Higuero to the south of the Culebrinas River and west into Mona Pass to Desecheo Island and Sponge Bank. The area includes the island shelf and waters to depths greater than 1000 meters (e.g., 1D). A small sampling program was also initiated to provide samples from other marine environments for comparison with those collected in the experimental field area. Sampling, on a limited 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 seawater taken at depths to 4000 m in the open Atlantic Ocean have been provided by Dr. Vaughn T. Bowen of the Woods Hole Oceanographic Institute and dried samples of plankton and fish collected off Ilo, Callao, and ---Page Break--- eres ssv4 Yon y souyeainy 1) onsen 021 oxwang 0.01 nva20 ouNVULY - FT wr rr Se eS ow

lel lee lel lle lel rll lle ---Page Break--- Srisbote, Peru have been invited to the Marine Biology Program, PRNC, by Hes Blanco Rojas of the Peruvian Marine Research Institute. The terrestrial studies have been restricted to the Afasco watershed, which is located primarily in a mountainous area. Of the 129,000 acres comprising the watershed, only 6,400 acres are flat bottom land situated at the Auaese Plata near the sea. All of the uplands of the watershed are rugged and most of the tributary streams have steep gradients and high rates of erosion. The minerals and rocks exposed in the watershed are mainly extrusive (volcanic, andesite, and basaltic rocks) or sedimentary rocks containing volcanic or igneous debris and limited amounts of limestone. The soils of the uplands are mainly of the sub-lateritic, red acid type and consist in clay. The soils of the flat land have high contents of silty clay, are neutral to slightly acid, and are subject to frequent flooding. Rainstorms in the watershed cause the introduction of varying but generally large amounts of silt-laden water into Afasco Bay. The sedimentation of the silt into the bay is the basis for locating the field studies of the marine biology program in the Afasco Area. Upon entering Afasco Bay, the river water, with its dissolved and suspended material, usually forms a surface layer of a few centimeters thick, floating over the heavier saline waters of the bay except during periods of high wave and breaker activity when rapid mixing occurs near the mouth of the river. During periods of relative calm, however, the lighter water of low salinity may maintain its identity as a distinct surface layer of high turbidity as far as five miles out from the mouth of the river. Upon mixing of the river water with the ocean water, rapid precipitation accumulates, and sediments which are enriched with trace elements including manganese and scandium are deposited in the bay. The deeper and predominant current pattern in Afasco Bay results in the transport of the river water to the north along the coast.

cone fen Higuero-” Usually during the afternoon, however, wind driven surface currents displace the surface waters in a southerly direction although the deeper currents maintain their northerly movement. During the night the surface and deeper currents again move to the north. In the vicinity of Pea. Higuero, the westernmost end of the island, the northerly current with the nearby Anasco River water is usually met by a southerly current containing added River water from the Culebrinas watershed. The currents merge at the point and move westward into Mona Pass. Occasionally a clockwise surge forms immediately north of the point. The Punta Higuero marine area is of interest biogeochemically due to the convergence of the north and south shore currents containing the entrained waters from the two rivers. The Anasco River drains a watershed primarily of volcanic origin. In contrast, the Culebrinas River drains a watershed predominantly comprised of limestone. Because the marine waters containing the outflows of the Anasco and Culebrinas rivers converge at Pta. Higuero, individuals of the same species of organisms located to the north and to the south of the point live in waters containing different compositions of trace elements. The differences in environment are reflected in the trace element compositions of the organisms which have been analyzed thus far. Analyses for additional elements and species of organisms will be continued on samples from the Guayanilla River which enters the sea seven miles to the south of the Arecibo and drains a different type of watershed containing large areas of serpentine outcroppings. In the proposed research, the trace element analyses are of limited value unless they are related to ecological investigations, especially to studies of food webs. The ecological studies are being conducted by direct observations using scuba gear, by analyses of calibrated plankton and dredge hauls, and by analysis of stomach contents. Quantitative estimates of infaunal abundance in

sediments collected off the Anasco River have been analyzed and will be continued. Species composition and feeding type have been related to distance offshore from the mouth of the river and analyses for trace elements in selected species of the benthic organisms have been started to determine if concentration with distance offshore can be related to trace element content. The distribution of concentrations of the elements in the sediments does change with distance from land. The amounts of scandium, manganese, and iron decrease, but the amounts of calcium and strontium increase with increasing distance offshore from the mouth of the Anasco River, which has been reported to be in the value of 8.9 x 10^-3 (Schretber, 1962), about equal to that reported for the crustal average of the earth (9 x 10^-3) (Taylor, 1964). These values differ from those found in the present work for Anasco River water (5.5 x 10^-3) and, in sediments of Anasco Bay (2.7 x 10^-3 at 2 miles offshore and 5.5 x 10^-3 at 5 miles offshore). Samples of benthic organisms have been collected from the sediment core stations and will be analyzed for Sr/Ca ratios to determine if the ratio of strontium to calcium in the sediment influences the ratios of the two elements in the organisms. A change in Sr/Ca ratio has been reported by Odum (1951) in studies in which the environmental Sr/Ca ratio was experimentally varied. However, the effect of the elemental composition of the sediments upon the elemental content of the contained benthic organisms is not dependent only upon the total amounts of a given element in the sediment but is also influenced by the chemical and physical forces of the elements in the sediments. The availability of the elements to the benthic organisms is being studied by leaching experiments and by the determination of crystalline components. X-ray diffraction and emission diagrams of sediments with X-ray diffraction measurements from Anasco Bay and the offshore sites have been made and more than 65 compounds have been identified. In addition, X-ray diffraction diagrams of the gut contents of

deposit: feeders have been made and compared with those of the sediments. Differences serve ---Page Break--- separate the attraction sequences of the gut content of the heart urchin and the sediment in which it lives. These investigations depowie several species of benthic organisms, including deposit and suspension feeders. In addition to the use of x-ray techniques, studies are being used for the identification of the interpretation of trace element analyses in marine organisms. Studies show that the effects of individual variability complicate these analyses. In studies, numbers of individuals of a given pelagic species at one place at the same time show greater individual variability than that found in benthic species. In addition, greater relative variability exists for elements which are not biologically significant (i.e., <0) than the ones thought to be biologically important (i.e., >1), although the water-insoluble, biologically important element, iron, exhibits a high degree of variability. Investigations on individual variability have been made on several species of marine organisms including algae, echinoderms, bivalves, and fishes. Further work is needed to determine the biological factors, including feeding habits and size of organisms, that correlate with the environmental factors which influence variability. A potential "tag" for measuring incorporation of trace elements by marine organisms is provided by radionuclides in worldwide fallout. Goes serge transfers have been made on large samples of algae, plankton, corals, gorgonians, molluscs, and fishes. The analyses will be continued with samples of the same species collected in areas across the watersheds of the three rivers in the field study area as well as in adjacent locations expected to receive "upcurrent" flow from Puerto Rico. The data will be used for (1) assessing radioactive signatures amounts of radioisotopes measured in the marine organisms, (2) analysis of the effects of

river influences the radioisotope content of the marine organisms growing in the shore (area Patterns of the three watersheds, (3) specific activities analyzed See one Tadtolnotone per gram of corresponding stable elements) on a variety of marine organisms. The fractionation unit is located in the Solid State Physics Division of the College of Agriculture. The radiochemistry spectrograph is owned by the Department of Agriculture, Institute of Agriculture and Engineering, U.P.R. Through a cooperative agreement, a unit of the X-ray equipment is furnished without cost in exchange for ---Page Break --- 10 variations in specific activity between organisms collected at the same time and place provide indices of variations in water equilibrium achieved by the organisms with the elements in the water. Variations collected at the same time but in different localities or at different times in the same locality also provide specific activities in the different environments. This would be true whether the variations in specific activities were due to variability in the rates of addition of the same isotope or in the rates of addition of the stable element to the waters of a given area. Among the marine organisms analyzed for worldwide fallout in the present work are phyto- and zooplankton. These two types of organisms exhibit markedly different patterns of radioisotopes content but both geochemically propel toward equilibrium with the radioisotopes and the corresponding stable element in the surrounding seawater. The amounts of the radioelements present in the phytoplankton are presented alongside the photoluminescence activity of the organisms. Bachess (74 Odua (1960) reported that the uptake of Zn-65 by marine benthic organisms was linearly related to oxygen production. They suggested that zinc can be taken up in direct proportion to the rate of photosynthesis, a function of net biological production. In the present study, photosynthetic rates are being correlated with the uptake of radioactive isotopes cobalt, manganese, ruthenium, cerium, and iron. Although methods are available for

assessing the effects of photosynthesis by the primary producers upon the uptake of trace elements, the subsequent transfer of organic matter and the associated trace elements through ascending trophic levels cannot be easily measured. Hedgepeth (1957) notes that "the most difficult problem in modern ecology is that of determining an accounting efficiency" - in the transfer of energy and matter through food webs or chains. Although the measurements of such transfers through a given series of marine trophic levels will not necessarily provide applicable data for other marine food webs, it will provide the basis for planning securements and analyses of transfer in other ecological systems. In measurements of organic and inorganic matter in food webs, one of the problems to be solved is that of determining which units of reference should be used for defining the amounts of trace elements in the samples. In the present work, the weights of trace elements have been reported on the basis of wet, dry, and ash weights of organic matter - they are now also reported on the basis of organic nitrogen and carbon content. For correlations of the amounts of trace elements with the transfer of potential energy (i.e., storage matter) through the food webs, the amounts of the elements should be related also to the calorific content of the organisms. Plans have been made to take ---Page Break--- In addition, the different bases of comparison we work for the following applications, needed in the pre (1) Wet weight = Comparison of trace element content per gram of living marine organism with the amount of the same element per gram of tissue (2) Dry weight - comparison of "trace element to food value" significance between trophic levels: “comparison of food values and ecological significance of the dominant species (4) Carbon and nitrogen content - comparison of protein content and food (energy) values of the species involved: comparisons of trace element to protein ratios between trophic levels (5) Calorie content - comparison of trace element contents with

‘amounts of potential energy in success five trophic levels. The correlation of trace elements with wet, dry and ash weights and TUE the carbon, nitrogen and caloric contents of the successive trophic levels must also be related to other characteristics of the system and populations involved. These measurements have been started and continue, ---Page Break--- 12 REFERENCES 1. Defane, A. 1961. Physical Oceanography, Vol. I, Pergamon Press, New York, 729 p. 2. Bachman, R. W. and P. Odum, 1960. Uptake of 2a and primary productivity in marine benthic algae. Limnology and Oceanography. 549. 355. 3. Hedgpeth, J. W. 1957. Concepts of marine ecology in Treatise on Marine Ecology and Paleoecology, Vol. I (J. W. Hedgpeth ed.) Memoir 67, Geol. Survey, Wash. D.C, 1296 pp. ---Page Break--- 13 SCIENTIFIC PERSONNEL of time devoted to project Principal Investigator: Frank G. Lowman, Ph.D Chief Scientist I, 100 PRNC. Professor of Biology, University of Puerto Rico Senior Investigator Robert A. Stevenson, Ph.D, Associate Scientist I, 100 PRC. Senior Investigator: Donald K. Phelps, Ph.D, Associate Scientist I. 100 and Investigator: Borique Avila Laguna, M.S, Research Associate, 100 and Technical Associate: Ross Julia Santiago, M.S. 100 such Associate: Ragl McClain, M.S. 100 Laboratory Technician: Edgar Ramos Seda 100 " “ Vilna R. de Vega 100 . Traida 0. de Padovan 100 " ” Lydia Quinones Rivera 100 “ . Sara Lugo Ufret 100 ” " Rafael J. Garcia 100 " " Russell W. Davis 100 " Donald S. Erdman 25 OTHER PERSONNEL Technical Assistant: Maria Socorro Cruz 100 Boat Captain: Santos Lopez Acosta 100 Boat Engineer: Edwin Zapata Silvestry 100 ---Page Break--- Crewman: Secretary: Watchman: Edwin Jusino Laboy Noemi Del Toro José Almenia 14 1% of time devoted to project 100 100 100 ---Page Break--- Marine Biology Program Puerto Rico Nuclear Center College Station, Mayaguez, Puerto Rico PROGRAM ACCOMPLISHMENTS AND WORK IN PROGRESS DURING FY-1965 Introduction: The research program in marine biology was started at the Puerto Rico Nuclear Center in January,

1962. It was, and is, sponsored by the Environmental Sciences Branch, Division of Biology and Medicine, U.S. Atomic Energy Commission. The work in progress in the Marine Biology Program is being conducted with a total of 11 scientific workers including several senior investigators. The boat crew and secretarial staff include a total of six people. Although the program is comprised of five major projects focusing on areas of research, it functions as an integrated unit with no well-defined divisions of staff, equipment, or budget. Research in all of the projects is being carried out, although greater emphasis has been placed upon some phases than on others. Work is done on nearly all parts of the program, including trace element analyses from a variety of samples collected in selected geographic regions and sediments in which they live. Other studies on the accumulation of specific trace elements by closely related species are in progress, as well as studies on the influences of geographic variation on the uptake and retention of selected stable elements by given species. Recently, the amounts of trace elements in the organisms have been related to ash, dry and wet weights. In the ecological studies, and especially in the food web investigations, the elements should also be related to carbon and nitrogen content. This would allow for a comparison of "trace element to protein ratios" in trophic levels and to caloric content for comparison of "trace elements 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 elements. Investigations on the accumulation of radioisotopes from worldwide 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 first 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 to analysis of grain size by the dry sieving technique and the pipette method. Investigations on the biogenous and terrigenous 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 a machine-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 summer 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, zinc, and bismuth in sea water. In addition, a method utilizing neutron activation 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 spectrophotometric method include calcium, 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 activation 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 production. Uptake experiments with radioactive tracers were continued during the past year. Measurements of the accumulation and loss of zinc (labeled with Zn^{65}) 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^{137}. Because of the lack of adequate laboratory space, the uptake experiments were done in the laboratory used for processing samples for stable element analysis. The seawater reservoirs containing the radioisotopes 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 saltwater 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--- 18 BENTHIC STUDIES = ANASCO BAY Benthic infaunal results from a survey of benthic infauna, being carried out in Anasco Bay, indicate that numbers of organisms decrease with distance from the river's mouth and with increasing depth. Relationships between sediment and faunal distributions have been well substantiated (Petersen 1913, Davis 1928, Thorsen 1997, Sanders 1956, 58, 60, 62). Numerical abundance of benthic fauna, as a measure of standing crops, places Anasco Bay (X'= 2,346) on par with the English Channel (X= 2,365), a little under Buzzard's Bay, Massachusetts (X= 4,430), but well under Loch Craggisland, Scotland (X= 14,275) (Mare 1942, Sanders 1958, Raymont 1949). Forty-six species of polychaetes, 42 species of pelecypods, 27 species of amphipoda, isopoda, decapoda combined, five different echinoderms, three holothuria, two nemertea, and two ostracoda have been collected. Special taxonomic interest is being paid to the polychaetes, since they represent the major group, and since most of them have not been described previously from Puerto Rico. The qualitative distribution of organisms follows relationships between feeding requirements of fauna and the nature of sediment, as initially described by Davis (1995). Deposit feeders dominate populations in fine sediments located close to the rivers, while filter feeders become more important in population structure as the finer portions of the sediment decrease with depth and distance from river inflow. Polychaetes dominate fine sediments while mollusks and crustaceans become increasingly more significant as the coarse sedimentary fraction increases (fig. 3). An intensive sampling program was initiated during October and November 1964. Samples collected during this period are still being processed. From these

data, more precise information regarding qualitative and quantitative distributions with depth and distance from the river's mouth will be forthcoming. Another sampling of these stations is currently being conducted to monitor effects of seasonal changes. Future sampling is planned to follow the stability of population structure over time. Stable elements as samples are processed, fauna having comparatively large biomass are analyzed for trace element content immediately. Fauna having ---Page Break--- 19 ‘guifeweyiobso 1010} Jo eavopunge uo JeARy o2souy jo soueNYH ous Jo voNBAAERINL 2 "D1 s08 ome ove oa , \w08 sa qo ovo2 ous e2s1 se sve t 0s ieee iss2 rece son 52 oun 1 aun zn 1 uw 27 sunt 10 nes — wiwoN Monat BAI ---Page Break--- RIVER ce NORTON 8. gout becth mite aye ne Va mite — 1 mie [PETG PIETY PICO FET oT a 251 |m 39.7 7d 17) 413.9 4 26.7 °7¢ 3.5 eo © 7.6 %9 PB 7A P 70.8 7A sot | m 22/8 M 28.5 °7o| c &_o-t %e BOS Fo] / peek 75° M5.3 °7e ¢ to %el/ rest a 150! ase FIG.3.' Illustration of the effect of the Aflasco River on the composition of populations. P = polychaetes, composed mostly of deposit feeders. mollusks, composed mostly of suspension feeders (some deposit feeding mollusks are found in the fine shallow water sediments). C = crustaceans, composed primarily of suspension feeders. ---Page Break--- - 21 g lesser biomass are saved until enough material has been accumulated for the various analyses. Certain echinoderms, polychaetes, mollusks and crustaceans have been analyzed for K, Fe, Co, Mn and Ni by atomic absorption analysis, and for Sc by activation methods. (Figs. through 7). Sediments are now being prepared for analyses. The nature of the aquatic 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 composition is being studied with X-ray diffraction methods. To date, 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 December, 1964. Qualitative analysis of stomach contents demonstrated that Symphurus plagiusa and Larinus breviceps, dominant forms, concentrated detritus and shrimp in their respective na ae hal tracts. As with the invertebrates, abundance of fish decreased 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, Mn, and Ni by atomic absorption methods. Results obtained to date are listed in Table 1 and presented graphically in Figures 4 through ?. Symphurus plagiusa was analyzed with and without its gastro-intestinal tract. The stomach contents of this fish consisted primarily of detritus. While the content of Fe was much higher in fish with their gastrointestinal tracts intact, the levels of the other trace elements were not apparently affected. The level of Fe in detritus is very high (Fig. 4) and in this instance, the presence of detritus in the stomach apparently influences the elemental analyses directly (Table 1). Levels of K and Zn are generally higher in Symphurus plagiusa, which feeds directly on the bottom sediments, as compared to Larinus breviceps, which feeds primarily on shrimp. Nickel seems to be more evenly distributed between species in general (Fig. 6). Differences in levels of K and Zn may reflect differences in feeding habits between these two species of fish. Discussion Data listed in Fig. 6 suggests that while levels of Ni and Co are comparatively constant from the detritus on through the various animal groups, there are distinctly different levels of K and Fe. ---Page Break --- MICROGRAMS /GRAM ASH 10® 22 bits Potassium detritus crustacea SHRIMP Honora, Osteichthyes Echinodermata Asteroidea (Starfish) Mollusca Pelecypoda (Bivalve, etc.) Arthropoda Crustacea (Shrimp) Echinodermata Asteroidea

(STARFISH CHORGATA Mo cusca ° Pececyropa (HELO. ---Page Break--- 10% 3, 23 wottisca (Sor PARTS) ‘Crustacea (sui TECHINCDERMATA vefRitus " asreRowes ‘STARION cHoRGara ostewres ris motlisca PeLecypooa, (SHELL ARTHROPOOA Crustacea, (SHRIMPS EcHINopE RMA TA aeremoroes ‘Staneisn (sheLD eHoRDATA, ostercntires| ise ---Page Break--- MicROGRAMS / GRAM ASH & 24 mene cooatr cnonosra ‘rio zx z wou.usca oerarive sotitsca eececveson xan (sorr pants See ran ocFRirus x= Ecunooennara “Gmusracen ASTEROIDE A (SHRINE), = SranFIoW wouCusca aniWorooa retecyPota ecyotcorainata cnusvaces wn KETARFISH) | MOLLUSCA suri) Pectevrooa ‘we Figures. wean esse) and tool ranget) of steble slamens trom representative bene groups (omea) collected in ahase ---Page Break--- 25 3% Scanowuw ~ ~~ anion POLYcHaeTa ~ | oeTRITUS 6 _ MICROGRAMS/ GRAM ASH LL L . od i | | ECHINGDERMATA L ASTEROIOEA STARFISN) Motuusea revecroba on ee sens from representative ---Page Break--- 26 TABLE 1 ve/ge. Ash Fe an 6. 1. tract Symphurus plaguisa $3,000 305 Fenoved 4 570 . $2,000 122, 41 628 " 43,000 340 59835 ” 43,500 1600 4330 ” 43,000 © 210 38 ars 54,000 2,200 Intact so $80 . 55,000 sis 28 47s " 40,000 98s 58460 . 62,000 720 st s60 Larimus breviceps 40,000 200 90 s70 ” 39,000 210 39 sas . 38,000 160 53380 . 31,000 470 310 ” 27,000 650 380 . 31,000 680 320 " 27,000 $70 320 " 26,000 720 260 " 33,000 1,100 380 ---Page Break--- 27 ‘unipuoag. jo. ew0160120H yueuduy on 2-0 909 sect sy, zo se ont oun 27 t oun art uw w1a30 Wino MOTANI wigow wnt ! ---Page Break--- 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 consideration, Tate perspectives in time. Future studies will be developed to correlate the passage of trace elements to energy flow through this system. An economic interest is the discovery of a single living brachiopod, this organism apparently of the genus Lingula, was found at a depth of 125' from a muddy-sand substrate. Further identification is being carried out.

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Detritus and other organisms affect the relatively high radiation backgrounds which occur in these fields due to the gamma spectrometer detector as a result of the presence of the came reactor and a gamma irradiation pool in the vicinity of the counting facility. The latter problem will be solved by TAC {96S when the counting facility is moved to the new building which is shielded from the two radiation sources. In comparison with the amounts of plankton normally found in temperate marine areas, the tropical seas are usually relatively poor. Repeated tows of 10 or more plankton nets over a period of 10 to 20 hours are often required to collect a certified volume of one liter of plankton. Some types of zooplankton may be safely collected, however, by the use of lights. In the present study, it has been observed that separations of species of plankton can be made by attracting the plankton at night with lights of different intensity. In an area populated with some species of copepods and euphausid shrimps, the former organisms were attracted to a 4000-watt water-cooled lamp placed three to six feet below the surface of the water on one side of the boat, while the shrimps were, at every time, attracted to a 300-watt lamp placed immediately above the surface of the water on the other side of the boat. Greater settled volumes of these organisms were collected within a given hour period with cross-contamination of species in the two collections amounting to less than 18 (based on counts). Gorgonians, corals, and large fishes are easily collected in volumes sufficient for fallout analyses. Sponges are a substance but must be carefully dissected to remove the symbiotic organisms from the pores and canals. Small fishes are collected in sizable lots by means of monofilament nylon gill nets and total body counts without radioisotopes may be determined. However, attempts to dissect organs from individuals in numbers sufficient for gas spectrum analyses have been only partially successful, and wet weight of material.

required for gamma spectrum analysis depends upon the type of organism and varies from one-half to eight kilograms. The samples were carefully cleaned (dissected if necessary) 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 in two beakers which had been calibrated for volume, tamped to attain uniform volume and counted with a 3" x 3" NaI(Tl) detector for periods of 200 to 400 minutes. Background counts were made daily and the background spectra were subtracted from the sample spectra by a data reduction system. Corrections were made for geometry, detector efficiency, decay schemes of the isotopes, and physical radioactive decay after collection. ---Page Break--- For statistical spectra were made, aliquots of the samples were analyzed for specific radionuclide analyses. The analyses for gamma emitters observed an increase of stable element content in the same nanoseconds of degree amounts of radiocomponents are being related to the web, references! Effects influenced by river outflows and receiving differences, at the test. Of the two plankton samples of one liter settled non-age are shown in Figure 9. Both samples were later settled for one pass within a one-week period in June. Worked differences are shown in the content between the phytoplankton and zooplankton. Phytoplankton contained relatively large amounts of cesium (Cs-134) of the total fallout activity, whereas the zooplankton contained 2.68% of the isotopes. The amounts of cesium (Cs-137) and Cs-134, on a wet-weight basis, were three to four times higher in the zooplankton than in the phytoplankton, but the findings indicated that the contents were the same in both trophic levels. Thus, on a wet-weight basis, the zooplankton, which represent the second trophic level and higher concentrations of the transition elements, were discriminated against the uptake of cerium. The zooplankton were taken from separate collections.

Rate of isopods and euphausiid shrimps 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 gamma 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 Targe number of T1826", These plants are capable of concesratite’s Sroend ta ere cee trace, Clements and were found at the Pectin Proving Ses iapoced ts fePOrt. In addition to the environaceeal deeeer in the? two apeasng amounts of runoff fron the land. the organreee in the two areas are subjected to markedly gifferent terse patterns, ---Page Break--- 32 ‘spodos; 40 jeuyue is0W)9 pesoayo> som duos woyyuo|deoz ayy “sieiUojdo02 3; 0 pauoiv0> ‘NI 02/9 Wornuordoskud 944 “$80g OUOW UI pelD%IOD YDDe 4aH!] 9U9 40 seRdUOS UOLAUD|E OM) 40 O1}2eds OUMIDD 61a naw aw si so : st so avo B10 6009909 seo 820 4,99 seo. 180 gu vowed vownuoyd ° “ear -o4hud 4m 43M 9710/0 Q 5 (sdodosi)] 2 NOLANY1d00Z NOLNWIdOLAHE og? £1 ov 0902 211 — geez ert 098? £e1— 09 21 ost 802 arr 2 ---Page Break--- oo a go o¢ 3 8 a 8 ae? 7 38 q Se j I 8 i 3 | eh d q = 8 1 3 [——1sopoos eee SHRIMP | ok 4 r Mev! FIG.10 Gamma spectra of two somples of plankton, each of one titer settled volume, collected at Mona Island on June 18, 1964. ---Page Break--- 34 O10r64 Dig 1D palrajjor 908|0 40 sezeas pi Omi 40 0119848 wwe (6) {18002 wins) o>1UONg 4 pu (48009 19m) ovanBH “Did 4D pai2aI/02 06/0 Jo eIDede Ave 40 O4i2ads oMWOD ols Aan naw B19! 1 zi o1 80 90 0 20 0 om le FE 01 Pp ousnb1H “01g 210Ki2.0 ---Page Break--- 35 OEE OFF the south coast are exposed to single-pass currents where~ sntnaeysToRA Ene

Breas of study off the west coast encompass areas containing numerous current gyres and oscillating currents. The algae collected at the two sites were approximately the same. However, the amount of Mno in Padina collected off the west coast was about two-thirds of that collected off the east coast. The decrease in amounts of 279: NDYS, Ru RHI06, and Cells Pridd from Guanica was even greater. In another investigation, two similar species of algae were compared, and the gamma spectra showed that Semele and Ed collected approximately equal amounts of sul OS 7ot 66, and 2195 Nb9. Of the organisms collected, only the algae accumulated material in amounts that could be measured by gamma spectrometry. The gamma spectra of samples of Sargassum collected at Punta Higuero (north coast) and at Guanica (south coast) are shown in Figure 12. As was shown for another species, the gamma spectra from the west coast contained larger amounts of certain isotopes than did those from the south coast. In the case of amounts, certain isotopes were detected in the Sargassum species from Guanica, but relatively large amounts were present in the same species collected at Punta Higuero. A group of organisms under investigation are the sponges. Figure 13 shows the gamma spectra of two samples of the sponge species collected at Punta Higuero. Except for a small difference in the isotopes, the two specimens do not show differences in radioisotope content. Figure 8 demonstrates significant differences in the gamma spectra of the sponges collected at Punta Higuero and Negro Reef. Thus, a change in the collection site of specimens resulted in significant differences in the amounts of isotopes detected. ---Page Break--- “spe. wipes) o9%0nD 49 PUD (40> If0m) O1eNbY “Did 10 (Oany ouang 40 18009 Isam) cvanbiH aw ot vl 2) ol 8 paisa) 2 0b} 40 SeiDeds eu yo pureds ues (6) 2 e0b|o

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and carnivores (fish). Figure 15(A) shows the gamma spectra of the gastrointestinal tract and spleen of a large female blue marlin collected at Virgin Gorda Island east of Puerto Rico. Almost 100% of the fallout radioactivity in the spleen was contributed by Zn^{65}. In contrast to the gamma spectrum from the spleen, the GI tract shows, in addition to 0.795, a large photopeak of Cs^{137} and a detectable amount of Co^{60}. The presence of significant amounts of cesium in the organs and tissues of this species is different from the pattern of distribution found in most other marine organisms. During a sampling period of 13 years at the Pacific Proving Ground, Cs^{137}/Ba^{137}

was not observed in any marine organism in amounts that could be detected in a total gamma spectrum although several thousands of samples were taken in the lagoons and the surrounding seas. Figure 15(B) shows the gamma spectra of gonads and liver from the fish described above. In the gonad, the main radioisotope is Zn^65 although small amounts of Mn^54 are evident. In distinction to the other three organs, the liver contains Cs^137 and Co^60 in addition to the larger amounts of Zn^65 and Mn^54. 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 of Puerto Rico. The ratio Cs^137/Cs^136 in the marine samples collected near Puerto Rico in the summer of 1964 had a value of approximately five. The same ratio in samples collected at the same time at the Pacific Proving Ground were: Eniwetok, 0.059; Bikini, 0.060. Thus the ratio Cs^137/Cs^136 in the Caribbean area is approximately 100 times that in the Pacific. Cs^137 has a physical half-life of 267 days and Co^60, 5.27 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 measurements of fallout in rainfall made by the Marine Biology Program and the observed Cs^137/Co^60 ratio reported above, the principal source of

radiocobalt in the Caribbean was supplied by the last Russian test series. ---Page Break--- ‘SpunOE G6» PaUbleR Ys UL “DR oZ9ng Jo 4808 pud|s} BpL09 8 4 SuDb10 sno} 40 ones OMS gt ‘O14 WBA 49 peisqoo HBSUEG aT—y I For t FO uaa 05 dor | fod _ : ons 3 28 i 6 8% s gey gS 8 Se 8% | ---Page Break--- 41 [oR Re prre rr Bue marlin gonads of final Hacte ord gonads of the blue marlin (Makaira nigricans) taken near gastrointestinal tracts of blue marlin Arecibo July 17, 1964 north coast of Puerto Rico the ---Page Break--- 42 The gamma spectra of gastrointestinal tracts and gonads of Alco dn snaysinytaken near Arecibo on the north coast of Ponce the aquatics 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 the gonads came, lower amounts of nS. “In the spectra of pnSstNsgs of the blue marlin 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 above. 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 from a value of 0-12 a/a/ernt eke Epyenplankton to 0:47 d/a/g in the zooplanktons “In ine G48, 0o cooplanta een eRe amount Of Zn65 was approximately dere1e that of the higher $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 le- vels. REFERENCE Kowman, F- G-, 1963 in Radicecology (eds. V. Schulte and A. W.

Klement, a) Reinhold Publ. Corp and Am. Inst. Biol. Sci. Chapman Hall, Lea, London pp, 145-149, ---Page Break--- Radioisotopes and Stable Elements in Plankton, Fish Meal and Guano from Peru The Peruvian coastal waters constitute one of the most productive areas of the entire world ocean. Three lines of evidence support this statement: Plankton is abundant in the said area throughout the whole year, fish meal is being manufactured at an annual rate of over 1.5 x 10^6 metric tons and about 1.8 x 10^6 metric tons of guano are produced by large colonies of marine fish-eating birds whose numbers average approximately 12 x 10^6 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 Peru. Of particular interest to the

Marine Biology Program of the PRNC is the comparison of the conditions obtained in the marine waters of Puerto Rico, whose fertilization mechanism is primarily dependent on land run-off, with those of the Peru Current, whose fertilization depends mainly on upwelling. Fallout was investigated by means of a NaI(Tl) channel gamma spectrometer, 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 II, III, IV and V and Fig. 17. Table II presents the results of atomic absorption and gas chromatographic 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, Mn, Zn, C, H and N. Table III 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, Peru from the nesting ground of a large

colony of Peruvian cormorants (Phalacrocorax bougainvillii), by far the most abundant species of the guano ornithofauna (Avila, 1955). The plankton samples were supplied by Dr. S. R. de Mendiola, IREMAR, La Punta, Peru. The fish meal samples were provided by Dr. T. Sparre, Inst. Invest. Recursos Marinos, La Punta, Peru. The guano sample was sent by Mr. J. M. Cabrera, Corp. NI. Fertilizantes, Lima, Peru. ---Page Break--- 44 1000 1000 72000 min 308078 8040 180189170 Teo -Bho 850 F0 FIG 17 GAMMA SPECTRA FOR PERUVIAN ANCHOVY (Engraulis ringens) FISH MEAL FROM Chimbote, PERU ---Page Break--- cw - fe “fat “ozz9°8E5 , S874" 88 sr2ge8z) gy sagz"ks) Shyy'e agree! sce" 2 : Sosrepsan, otgerz £750" orgest! corgsz eye ozgive | 'szssi 13291 we eer9ts zt ! oo 008 008 ozey suas ‘ :) ‘ordaes: : ‘ 1 50 : ‘ ‘ qurowy ‘ : {Ces : : (nena) : \knoypue : : lueranzeg wy tang a a ay TT ou ovttea saoqurys Wr aia ---Page Break--- a 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 sone BAZ bn ae Boome as Lt a Bre ---Page Break--- a7 TABLE IV pee Chincha Norte Island Material ey ep teria) ee ay a Guano of Peruvian Cormorant (Phalacrocorax bougainvillii) 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 - ‘ N : foe - ‘ © : : ~ - ft 20.5 ---Page Break--- -2- 48 Tabled 15,4 Summary of the radioactivity found in the fish meal Samples. Part A gives the

radioactivity of K40, Zn, and MnS at 3 disintegrations per minute per gram of Sample. "Part 8 presents the specific activities of Zn and Mn compared to the corresponding permissible specific activities, as given in Table I-8 of Disposal of Low-Level Radioactive Waste into the Pacific Coastal Waters (ISAACS et al., N.I. Acad. Sc., N.I. 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 environment. 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 incorporated, to varying degrees, in the protoplasm of the unicellular algae (GOLDBERG, 1963; HARVEY, 1955). Zinc is a well-known constituent of several enzymatic systems and has been shown to catalyze the utilization of some 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 is contained in the vitamin B12 (DAY, 1963). It was surprising to find a relatively high concentration of Ni, about 0 µg 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 terms of what has been said for Table III. “Both fish meal and guano are one or two rungs higher, respectively, in the same trophodynamic.

Ladders of sea made an CTHS loan at shot Dahamena 12, aamerzctred ron an gngraulid locally known as "anchoveta" (Engraulis ringens), whose GEEE"TS made up, to great extents ce AenBee SP FRADE, whose ceag and Dinophiceae. “Guano is the waste product of three marine bird species that feed almost exclusively on the anchovies. 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. ---Page Break--- 49 TABLE V Radioactivity in the Peruvian anchovy (Engraulis ringens) 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 x10^4 5 268 52000 Callao * nS 9.5 x10^-4 1 26 31000 To! 2nS + 6.8 x10^-4 + 26 39000 Chimbote’ MnS41 8.3 x10^-3 * toe 1200 Callao + MnS4 + 6.09 x10^-3 1 10 1600 Mo + win84 + 2.03 x10^-3 "40 4900 * According to Table I-B of Disposal of Low-Level Radioactive Waste into Pacific Coastal Waters, National Academy of Sciences, National Research Council Publication 985, Washington, D.C., 1962. ---Page Break--- of K40, Zn65 and Mn54. This result was to be expected for two main reasons: a) It is well established that present world-wide fallout is largely restricted to the northern hemisphere and, therefore, considering the circulation pattern of the Pacific Ocean, it is natural that the contamination of the Peruvian waters is only of a minor character, and b) The upwelling, so prevalent a phenomenon seen along the Peruvian coast, brings to the surface waters.

from deeper levels that are essentially uncontaminated by worldwide fallouts: the results of this investigation were compared briefly, in the preceding section, with the findings for fallout radioactivity in the organisms from Puerto Rico. RINCES AVILA, E. Second Report to the Marine Biology Program of the PRNC entitled On the Biological Aspects of the Peru Currents MS, Lima, Peru, 1963, CALDECOTT, R.S. and L.A. Snyder, Editors, A Symposium on Radioisotopes in the Biosphere. Univ. of Minnesota, Minn., 1960. DAY, F.H. The Chemical Elements in Nature. Reinhold Publishing Corporation, New York, 1963. EISENBUD, M. Environmental Radioactivity, McGraw Hill Book Company, Inc., New York, 1963. GOLDBERG, E. Mineralogy and Chemistry of Marine Sedimentation, in Submarine Geology, 2nd ed. by F.P. Shepard. Harper and Row, New York, 1963, HARVEY, H.W. The Chemistry and Fertility of Sea Waters, Cambridge at the University Press, London, 1955. RICE, T.R. Review of Zinc in Ecology. In Radioecology, ed. V. Schultz and A.W. Klement, Jr., Reinhold Publishing Corp. and The American Institute of Biological Sciences, 1963. SEYMOUR, A.H. Radioactivity of Marine Organisms from Guam, Palau and the Gulf of Siam, 1958-1959. In Radioecology, ed. V. Schultz and A.W. Klement, Jr., Reinhold Publishing Corp. and

The American Institute of Biological Sciences, 1963 ---Page Break--- 51 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 seawater. 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 drains deposits that are rich in serpentine. All of these rivers enter the sea along 18 miles.

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 liter of surface water was collected approximately 300 feet inland from the mouth of the river. The sample was filtered through a 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 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 spectrophotometry for the content of Ni, Cr, Mn, and Fe. An aliquot of the filtrate was mixed with an equal amount of 0.2N HCl 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 fraction of the water were as follows: ---Page Break--- 52 Element —µg/Liter, 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 elements analyzed, Ca and Mg were present in the highest amounts. Iron, Cr, Ni, Mn, and Sc were present in amounts of 20 µg/liter or less. A comparison of the amounts of the elements in the Aflasco River water with those found in some major U.S. 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 Aflasco River than in other U.S. rivers. In February 1965, samples of water were collected from the Aflasco, Culebrinas, and Guanajibo Rivers. Collections were made by lowering a Van Dorn 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 acetic acid 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 two rivers was collected a short distance downstream from sugar mills that dump waste products into them. Water from these two rivers had a strong odor of bagasse, which probably provided a substrate for a high rate of bacterial activity. Although it is not known to what extent such activity may have altered the amounts of dissolved 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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53 The following table shows the analyses that have been performed to date:
Element — Anasco Guanajibo
Mi 0.009 0.017
Mn 0.018 0.007
Co 0.002 0.003

The quantities observed here are much smaller than those previously observed for the Anasco River. The recent samples were collected during the dry period of low river flow, and the near drought conditions that prevailed during the winter may have resulted in the greatly reduced amount of dissolved elements. Another factor that would help to account for the low values is the fact that the samples were taken several miles upstream from the previous Anasco samples where the amount of dissolved material is greatly reduced (Lowman, in Press). Additional samples are being taken to determine seasonal fluctuations in the amounts of elements in the three rivers. 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 variations 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 interpreting the observed trace element contents in relation to total contribution into the marine environment. ---Page Break--- TEMPERATURE AND CURRENT STUDIES AT PUNTA HIGUERO Studies of marine organisms and their environment at the Bonus sage TETE, begun in 1963 and are continuing. "These studies are intended to provide background information for the evaluation of possible changes induced by the future operation of the Raves tuoar power plant. Because of the release of large amounts of high temperature hot water from the plant, the environmental parameters temperature and currents are considered to be of primary importance and consequently are receiving particular attention. Abundance and distribution of the more common flora and fauna are being made to assess temporal and spatial fluctuations. Levels of stable elements in organisms are being determined in order to provide the factor determining specific activities in the event that significant contaminants enter the environment. Temperature temperatures were measured by holding the thermometer about one foot beneath the surface of the water and by observing it thoroughly. Observations were made at a distance of about 50 meters from shore. With two exceptions, readings were made at least once each month; when more than one reading was taken within any month, each value is reported separately. Temperature graphs show the fluctuations in temperature observed during this period of time; the average temperature was 28.3°C and the range extended from 26.5 to 29.6. Total seasonal fluctuations are similar and are of the slight magnitude characteristic of tropical areas. The dominant feature shown in the figure is the relatively wide variation within periods of one month. These variations are most likely due to a combination of diurnal changes in air temperature, local geography, and geographic and hydrographic features. During the day, when the flushing is relatively poor. During the night when the sand cools, the waters become...

correspondingly, during periods of slight wave activity, warm water extends farther off into the "pocket" formed by the curve of the beach, but stronger waves tend to flush the area and bring sea water temperatures closer to shore. Currents and the bath of coolant water which leaves the plant have been traced, as reported last year. At that time, water was observed to flow southward along the beach and to turn westward at Punta Higuero, and then to form a gyre which rotated in a clockwise direction.

Since then, another dye experiment and studies 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 acetone was poured into the outlet while the water was being expelled at the normal capacity of 30,000 gallons/minute. The path of the currents observed and notes were later integrated with photographs taken throughout the 48-minute period during which the dye was visible. As in the previous experiment, the dye flowed south along the beach and then turned westward where it eventually entered the gyre as it turned to the north. A small amount of dye flowed towards Punta Higuero, but then turned northward again to join the seaward sweep of the remaining dye. One small body of dye moved a considerable distance northward soon after passing the point. This patch of dye remained above a sandbar discovered in aerial photographs and probably explains the origin of the sandbar. When the dye was first introduced into the water, the currents appeared to take on the shape of a fan. After about two minutes, the body started to move southward toward Punta Augustin. The other flowed southward about 80 meters from shore and traced the main course of water flow from the outlet. The two streams of water remained distinct but followed the same course after they left the outlet.

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 megawatts (Fig. 19). Four temperature readings were taken at distances of approximately 3, 8, 20, and 40 meters from the beach at four locations of 25 meter intervals southward along the beach. Two additional temperatures were taken farther south along the beach, 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 first 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 ---Page Break--- ---Page Break--- 58 represents the area between the two streams of warm water. Therefore, the situation was much the same as seen in the dye experiment one year earlier and suggests that this type of current pattern may frequently prevail. Observations are being made to determine whether zonation of marine organisms is occurring that conforms 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 abundant species were selected for study. Their abundance and dis-

tribution 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 5 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 all of the algae in the quadrate were collected and placed in a plastic bag. This procedure was followed eight times at each location. In the laboratory, the species, Dictyota dentata, D. cervicornis, Cladophora sp., Padina sp., and Sargassum sp., were separated for each quadrate, and an average wet weight/square meter was calculated. A similar procedure was followed with the sea urchin Echinometra lucunter, which was the most abundant of the large invertebrates in the area. The urchins were collected and were not removed. 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 abundant in areas close to the outlet, but a limited number were present throughout the area (Fig. 20). Species of Padina were the most abundant and widespread of the algae studied (Fig. 21). They were the most abundant species upcurrent from the outlet, and large numbers extended about halfway to Punta Higuero. Cladophora 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, as well as the algae, in the survey area above the outlet. 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 outlet at low tide was contained in a channel that had been cut in the sand. The data do not show cyclic fluctuations in the 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 information 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 2 mm 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 the weights of urchins, they afford a basis for the calculation of biomass and hence the amounts of stable elements/sq meter. Levels of Stable Elements in Epibenthic Organisms Analyses of the stable element content of epibenthic marine organisms 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. Figure 25 shows the slight amount of variability of Fe, Mn, and Zn in four intact individuals of the gorgonian Eunicea mamillosa collected at Punta Higuero, Puerto Rico.

Iron varied the most, but in comparison with other species reported here, all three elements showed 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 Ni was only slightly more variable than that in Eunicea. However, there was more than a 3-fold difference between the lowest and highest values for Mn. Data are not yet available for Fe. As 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 Higuero, Puerto Rico (west coast), were significantly higher than the amount 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 general, various species of echinoderm skeletons show variability.

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64 «0 « « vs 2 20 . . : 7 0 4 3 22 26 30084 380 420:«46 50 Site in April, 1964

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o a 150 140 _ Be fe : 20 = 10 * 00 ° 90 § £60 R 70 z 60 & z 50 € 40 30 “ 20 I wn © ° 1 cunces mommose Fig 25. variability of Fe, Ni, and Mn in four individuals of Gunises mammese from Punta Higuero, Puerto Rico.

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WEIGHT asa ORY too Ni 66 oo | 80 Fig from 26. Variability of Ni and Mn in Ircinia strobilina at La Parguera, Puerto Rico.

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68 A comparison was made between the food of Tripneustes esculentus at Punta Higuero (Padina gymnospora) and the food of the same species at La Parguera (Thalassia testudinum). Figure 28 shows that there were higher levels of Fe in the urchin's food at Punta Higuero than there were at La Parguera. A relationship, therefore, exists between higher levels of Fe in the urchin's skeletons and in comparison between the stable element.

content of species of Facus from Scotland (Black and Ilitche!1 1952) and Padina showed that the clatoer contained one order of magnitude less Fe and Ni, but one order ay. Figure 29 shows a comparison between elements in a single batch of the same species of plants collected at La Pargueras Punta Hosiero Rosen Bre Rect (west coast). Iron was high in Thalassia from Notre Reet, but was low in the same species from the other t¥e locations: Beet GaMas little difference in levels of Ni between the locations but Mn was slightly higher on the south coast. The figure size shows a comparison between single batches of Padina gymnospora collected on the south and west coasts. In this case, a greater amount of each element was found in the plants from the south coast. The batch from the south coast was growing on an iron bridge piling and further work is underway to clarify the possibility that the proximity to the iron resulted in the higher levels observed in the plants. The level of Sr, the only element analyzed to date (data not reported) in the starfish Oreaster reticulatus, was almost twice as high compared to the specimen from the west coast that was compared to a specimen from the south coast. In the organisms reported, it is evident that some trace elements can be expected to be found in higher levels in individuals of the same species from different locations. Differences within the same species of organism have also been found in two locations along the west coast. Figure 40 shows both similarities and differences between the same species of organisms from different locations, each of which is influenced by a river drainage from a different watershed. The figure shows a comparison between the tissue values in the tissues of four individuals of an unidentified key foxtail sponge, the skeletons of three gastropods (Strombus gursinia), and the skeletons of two individuals in each of two genera (Leandrina noandrites): Levels of Sr were almost 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). ---Page Break--- 69 S000 Pi" Bodo qymnosser, Ante iowro | 4000 + TPs Tholtsic tatusinae, Le Perguere 3000 F 4 2000 F 4 tooo fF = b 4 z r é a PHT PH TP Phot Fig. 20 Meon valves and stondord eviction ct Fe, Ni, ond Mn in two species of marine plants ---Page Break--- 70 Poding gymnospora testudinum assia tt ttre = (Focus persis on < — evant ung ¢ omy ee vans iung tiny on £ ter yur es ovo menos 81 pe csantey tun nna | awtey on zs J cven61 owung jem eden a oe ® 8 2* $8 $8 ¢ sg g ge too plonts species of marine Ni, ond Mn in the some Voriiity of Fe, trom different localities Figure 29 ---Page Break--- 7 (oot x AMDIaR dua 40 MIMD W3d_Sm¥MOOHOM wan onsen 48 caaKammsnt WAM swmiueyWD AB azDNan raw 09 FoF of 02 ot O02 Ok oe oso aaa aS s s ane aaa otvsds— pomnsen arew23139 Jo} arevi9a3C LON as ---Page Break--- ---Page Break--- 73 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

paleoclimatic conditions (Pilkey and Goodell, 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 appear, 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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Yale Univ.: 647 pp. ---Page Break--- 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 necessary 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 organisms 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 carbon, hydrogen, nitrogen content of representative forms from various "trophic levels." The percent composition of C, H, and N is analyzed directly from a single sample using the F. & N, Scientific Corporation's Carbon Hydrogen Nitrogen Analyzer Model 180. A usual dried sample (from 0.2 to 0.3 mg) is introduced into a combustion chamber. Combustion products are cooled and collected in an expansion chamber. When combustion is complete, the products are introduced into a gas chromatograph. Levels of CO_2, H_2O, and N_2 are sensed by appropriate detectors and permanently recorded on a strip chart recorder. The height of the peak for each element is directly proportional to its occurrence in the 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 results are contained in Table 8. The values for the 95% 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 H, C, 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 quantities of C, H, and N directly to the energy contained in animals comprising different levels in the food chain. Calorimetry of representative forms will be carried out. These direct energy measurements by calorimetry will be started after July 1. Result: Results of C, N analyses are listed in Tables 6 and 7. In general, it will be noted that aside from mollusk shells, the detrital fraction of the sediments has the lowest values of N. This most likely results from di-nitrification through bacterial activity. Echinoderms have the lowest values of C, H, and N. The soft parts of ---Page Break --- Type of Collection site um 8 ue ne Deeritue anasco Bay 2.89 1.390 24.3 . " 287 100 a Sipunculid " 6.32 ai? 42.3 ™ " 6323 429 " 679 Le 427 Sipunculid " 5.81 10.5 36.3 Polychaete (epthys " an o's a7 ° ” 6279142 46.9 ” ” 5.92 9.27 45.8 ” " 6.70 10.8 45.2 " " 580 8.6028 51569172, a 5.25 9.24165, 63010156 46.23 656 82 a3 58 6.404313 4695403913 ” 0.00 0.00 11.3 hein) " 0.00 0.00, 9.60 " 0.00 0.00 10.3 Shrimp " 5.28 and 40.0 5.67 io 423 * 5.79 als 46.7 ” 5i57 an 427 copepod 4x7 922276 ri 35281274516 " 5.06 azi00 83 " : 3153 zis " 6.43 * 38.0 " 52397 uae ” " 5.88 9100 36.9 " 5.52 10d 35.2 Fish a2 uly 35.2 a2 1074 348 . 495 lo 360 " * 700123 513 * “ 5.15 13.0 375. Echinoderms (ira only) 017% = 0.001006 “ " 110 0.00100 « . 0.70 0:00, 9.40 Echinoderm (Body leg arse) " 2.30 2.30 20.7 " " 70 1180 16.4 " ” 270 lao 8.7 Table 6. Percent of dry weight of organisms and tissues contributed by hydrogen, nitrogen, and carbon. ---Page Break --- Type of Sample Collection site ki tm ze Phytoplankton Peru Lb 35 m " 223 77 * i as. ” 2a 8.2 2195 ian ” 2185 22 ” 3.41 15.5 " 3127 25 Fish Meal (Chinbotey 6.27 44.3 " 6.37 45.3 " (attae) " 6.36 43:3 " " 6.92 43.0 “ ” 6.97 43.2 (tte) " 6:83 46.4 * 6.75 43.0 guano “ a 20.2 431 20:3 312 aia ” 3.77 2613 3.88 23.4 * 3199 28.3 ” 3156 26.6 ” 3.51 23.7 3:33 22:5 Giant Clam Kidney (Heavy Fraction) 4.26 39.6 ” . " 436 40:3 Giant Clam Kidney (Light Fraction) ” " 4.55 37.3 " ” ” sin

38.9 Giant clan Visceral Mass 6.29 42.3 “ 53 ans " 5185 45.5 Giant Clam Kidney (Heavy Fraction) " “ 6.200 6.60 an Giant Clam Kidney (Light Fraction) ” ” 3.3L 470 37.3 Giant clan Visceral Mass 6.90 5.60 4a Teva Crater = 068 0:70 10.7 " 20.80 10.7 ” * . O82 20 a0. Table 7. Percent of dry weight contributed by hydrogen, nitrogen and carbon in samples from Peru and the Marshall Islands, ---Page Break--- 78 Standard: Acetantiide HYDROGEN ANALYSES: Sample # 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 0.13986 6.80 ? 0.13432 6.78 8 0.2718 6.80 9 0.01952 6.81 10 0.1010 6.73 Average ~ % Hydrogen = "6.872 (95 % confidence level) + 0.0440 CARBON ANALYSES: Sample # Weight of sample in age carbon in sample 1 70.99 2 70.91 3 71.00 4 70.99 5 70.99 6 7 8 9 10 0.1010 Average - % Carbon = (95% Confidence level) + Sample ¢ Weight of sample in age 'Nitrogen in sample 1 0.8212 10.36 2 0.7098 10.34 3 0.6104 10.35 4 0.5082 10.35 5 0.4348 10.34 6 0.3986 10.36 7 0.3432 10.37 8 0.2718 10.37 9 0.01952 10.34 10 0.1010 10.39 Average ~ % Nitrogen = "10.357 (95% confidence level) + 0.09818, Table Test for accuracy of the gas chromatographic method for determining carbon, hydrogen, and nitrogen on samples of biological origin. ---Page Break--- at © mollusks from Afiasco Bay, Puerto Rico, as well as from the Marshall Islands, while having levels of C that compare favorably with other organisms, have relatively low levels of N (3.7% to 8.1%). Polychaetes, Sipunculids, Crustacea, and fish have slightly larger amounts 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 C were found in phytoplankton samples from Peru. The greatest bulk of these samples appeared to be diatom frustules. This could account for the low percentages which were determined on the basis of total weight. Discussion: A point of interest becomes apparent in Fig. 3; while there is little

correlation between weight, H and C content of organisms, there is a direct relationship between increase in weight, and the N content. 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 individuals 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 individuals, will come 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. ---Page Break--- Siubiom Aup 104 aus 0 ---Page Break--- 81 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 patterns 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 sediments in water with depths less than 300 meters. The piston coring tube of the Ewing design was used to collect the sediment cores in a tubular plastic sleeve with inside dimensions of 3.9 cm by 91.5 cm. The cores were removed from the sleeves at the laboratory and divided into three inch (7.62 cm) increments and each section was placed in a polypropylene bottle. The sections were weighed and dried to constant weight at 95°C (subsequent samples have been divided into two fractions - one is frozen and the other dried at room temperature). 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 cross-section through the area are shown in Figure 33. Sediment samples one through six were taken in water less than 100 meters in depth on the sloping island shelf. Samples 7-14 were collected in waters 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 year, additional sediment samples have been taken in the deeper waters. Further 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 is shown with core depth in the diagrams to depths of 36 inches. Of the four elements, the 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% 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 seawater 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 from an average value of 20 mg per gram 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 number 11. If the altered distribution patterns were due to the effects of a submarine slide, the amounts of scandium in sediment number 11 would not be expected to be influenced by the S116 since the amounts of scandium in the seawater of the area are low. Most of the scandium from the Aflasco River is precipitated within the first hour after it mixes with seawater and would probably be deposited near shore on the island shelf. ---Page Break--- 85 00-19 s 2 sl e10ys wo1y e0u04sI of pe oor oven 40° 48009 js0m ey) 440 UeYD) fiotsenus e10m —wnypu0ss pus vox) Jo synowe eu wwmpuoos pu vo4i yo a st of ot Sot 02.8 oO 8201 0, 09 op oF oF OF 9. te we ee of a i oda3 a Pe f 0 02.0 a \o2-9! Ge oe ite P| labs vz 4 8 23] 3 0 ---Page Break--- 86 ‘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. Figure 37 shows the distribution patterns for calcium and strontium in the sediments. The average amounts of calcium and strontium, in

In contrast to the patterns of iron, manganese, and scandium, these increased with increased distance offshore. The amounts of strontium and calcium in the cores were covariant. The covariance was especially marked in cores 8, 11, 12, 13, and 14. Neither the rates at which the sediments are deposited are known, nor have the sources of the calcium and strontium been determined. As a result, the mechanisms responsible for the variability in the amounts of the two elements 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 result 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 components 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 calcium are incorporated. Figure 36 shows the interrelationships of the elements in the sediments. Iron 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 ratio 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 zinc to chromium are shown. Both nickel and zinc are related linearly to chromium. These data are supported by the observation that the zinc 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 logarithms of the amounts of iron and manganese in the sediments (fig. 36c, D). ---Page Break--- 87 0214 148g Jo $002 188 ous 0 vero} $2109 juowpes uy wie;i0d uoUnauisiE eyL gf “O14 00081 J stat ---Page Break---

Stuswele om) 4s jo sunoWo eborerD aq “save: soyoul ul yydep 8209 o st.81 ---Page Break--- 89 ox w l 7] 9 150} \ 9 Ma w So wo ve 6 wh a oo @ mo Fe 50] °° (8) 50 00 yocr b 16) 9g " 9g 8 8 ‘ : : ‘ ofa iil aereeven 1, gy eat, FIG. 38 Relationships of elements in marine sediments off the Affosco River. Iron and manganese (A) exhibit a linear relationship in levels of abundance and are known to coprecipitate in seawater. The amounts of nickel and zinc (S) are linearly related to the amounts of chromium. The levels of scandium exhibit linear relationships with the logarithms of the amounts of iron (C) and manganese (D) in the sediments ---Page Break--- 90 As mentioned before, strontium and calcium exhibited similar patterns of distribution with core depth (Fig. 37). Thus variations in the amounts 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 strontium/calcium exhibited a direct and positive relationship to the distance of the sample from the outflow of the Affosco River (Fig. 41 A). The ratio varied from an average value of about 2.7 x 10^-3 at one and a half miles offshore to a value of approximately 5.5 x 10^-3 at five miles. Thus, the amount of strontium with respect to calcium increased with increased distance from the shore. The atom ratio strontium/calcium also exhibited a direct and positive relationship to the amounts of calcium in the samples (Fig. 41 B). Figure 40 presents a summary 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 sufficient to explain the mechanisms responsible for the elemental distributions, or to demonstrate that the Affosco 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 counterclockwise 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 contributions of calcium and strontium are mainly from this river since it drains an area which is predominantly limestone. Thus it would 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. ---Page Break--- 91 oe L of? 9 ' i. from ms stn on ° ° oot su pt i ' % c= "000 milligrams of calcium FIG. 39 Relationship of strontium and calcium in marine sediments off the outflow of the Aflasco River ---Page Break--- 92 & crcage_ set gob. sone 3 rape for om te © tvaroge tor Yop 1S 5 ove a @ Average tor bottom 24", core #11 2s is 8 10) t she. e@ Bol i pal SES a6 300 zen) »9 foof © % tats 3 150, @ st cr Oe \ sop t j ben | oot

345 6 re rc Distance tom' ae Datos fom "she FIG. 40 Amounts of trace elements per gram of sediment related to distance offshore from the outflow of the Aflasco River ---Page Break--- ---Page Break--- 94 METHODS OF ANALYSIS Scandium: The scandium method, developed by members of the marine biology program in late 1963, has been used to analyze accounts of the element in 260 specimens of a wide variety of sample types. The method has been successfully used with river water, rocks, minerals, soils, sands, marine sediments, terrestrial plants, plankton, marine invertebrates, and marine vertebrates. The method was described in detail last year and, in summary, consists of: (1) irradiating 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 a Dowex-50 column on which the scandium is retained while neutron-induced isotopes pass through, (4) eluting the scandium and other cations with 26 HNO3; (5) coprecipitating the scandium with zirconium phytate, (6) rinsing the

other cations from the precipitate with 0.2N HCl and 4X HNO3 and (7) measuring the SeOS by gamma spectrometry. The large number 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 marine biology. The reproducibility of the method has been tested with duplicate runs on several types of samples, with differences of less than 5%. The precipitation step does coprecipitate neutron-activated Fe and 0125 ££ the two radioisotopes are present. However, the antimony is removed in the ion exchange step and the interference from the Fe2+ activity may be easily corrected in the counting procedure. This is illustrated in fig. 42 where the gamma spectrum of the sample was essentially identical with that of the comparator standard after the Fe60 component was subtracted. Scandium in Sea Water: The scandium method has been adapted to the analysis of the element in sea water. In this analysis the scandium is coprecipitated with scandium-free sodium carbonate. Five precipitations with milligram amounts of carbonate quantitatively remove the scandium from one liter of sea water. The precipitate is then analyzed by the regular scandium analysis. Figure 43 shows the gamma spectra from a neutron activation analysis of scandium in sea water. The separation was contaminated with a trace of Br and a large amount of Fe, however, the Se was easily determined by analysis of the 2.01 sum peak of the scandium isotope. The values for scandium 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 November, 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 or not an element may be analyzed by the method depends 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 asc %, g 1 A veal cm —— SEPARATION ON 0.1 GRAM (OF ORGANIC DETRITUS = FE°cOMPONENT SUBTRACTED * SCANDIUM STANDARD Os 16, 1s 20 FIG.42 Gamma spectrum of a phytate precipitate of scandium~ 46 precipitated from 0.4 gram of organic detritus. The detritus was separated from sediment collected in Atasco Bay. The sample was irradiated four hours in a neutron flux of 2% 10% n/emé/second. A small amount of activated Fe?® was coprecipitated with the scandium phytate. Also shown is the spectrum of the precipitate after the iron component was subtracted as well as that of a 8.4y9 standard, ---Page Break --- 96 z % - 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 ' separation on 8 - UII Us Mi TE boekgrouna: Os 10 wey 1S 20 FIG.43 Gamma spectrum from 9 neutron activation analysis for stable Scandium in 500 ml of sea water previously filtered through a filter of 5 micron pore size before the scandium was separated. Also shown is the gamma spectrum from a comparator standard (0.15 micrograms of activated scandium). The water contained 0.0203 + 0.0016 micrograms of scandium per liter. ---Page Break --- 97 of the activation product and the type of radiation emitted by the activation product. Of the elements selected for study, manganese, rubidium, rhodium, silver, indium, europium and dysprosium emit gamma rays in cascade. Coincidence gamma spectrometry may therefore be used to count the radiation from these activated products, thus reducing the interference from other gamma emitters. Other elements which produce activation products which may be analyzed by gamma spectrometry include calcium, cobalt and iodine. Figure 44 shows the gamma spectra from 4 non-destructive activation analysis of sandstone from Atasco Valley. The sandstone sample (0.1 g) was put into a polyethylene vial and placed with another vial, containing

« com Parator standard of 5 µg of Mn, into a polyethylene rabbit. The sample and standard were irradiated with neutrons for 30 seconds, allowed to cool 30 minutes, transferred to new vials and counted at 30, 60 and 85 minutes after irradiation. In this sample, the amount of manganese was easily determined from the spectrum. Calcium could have been determined simultaneously had a calcium comparator standard been included with the manganese standard. Bismuth: A method for rapid analysis of bismuth in many types of samples has been developed as a result of work done this year in an area of research not directly concerned with the marine biology program. During August 1964, two members of the marine biology program of PRNC, Radi McLin and Frank G. Lowman, participated in a resurvey of the Pacific Proving Ground at Enewetak and Bikini Atolls in the Marshall Islands. The survey was under the 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 reefs by the firing of thermonuclear weapons during the weapons test program. Gamma spectrometric analyses of the crater samples showed Co-60 to be the dominant radiocontaminant and Bi-210 to be second in disintegration rate (Fig. 454). The only reference to the occurrence of Bi-207 known to the writer is that of Lowman and Palumbo (1962). Two 20 gram samples of crater sediment were dissolved in aqua regia and dried. One sample was dissolved in 0.26 HCl and the bismuth separated from a Dowex-50 column (Lowman and Palumbo, 1962). A gamma spectrum from the leading fraction of the elution peak is shown in figure 45 (A). The other sample was subjected to the following treatment: (1) The sample was counted in the gamma spectrometer, then redissolved in 100 µl of triple distilled water. (2) The solution was poured into a separatory funnel and 100 µl of 0.1 M Tri-n-octylphosphine oxide (TOPO) in cyclohexane were added to the funnel. (3) The separatory funnel was shaken for 15»

minutes on a mechanical shaker. (4) The phases were separated and two more extractions with 100 µl of 0.1 TOPO. (5) The fractions were counted and a 99.3% yield was achieved. ---Page Break--- 98 108 1} neutron-activated manganese (heitite 26 ne) 4 4 10° 4 = TR og & i 2 30 3 om how 8, § hi gs rei eB ae 108 : me 23 ae 4 eh oee VI 1 fe i The haematite of dis 9 minutes. The half-life calculated from the above curves was 9.0 minutes. 0304 0808 1012 14 1618 20 3.0 eV FIG. 44 Gamma spectrum from 0.19 of red sandstone made 30, 60 and 85 minutes after irradiation for 30 seconds in a neutron flux of 2.5210^n/cm²/second. Also shown is the spectrum of a comparator standard of 5.09 of manganese which was activated with the sample. ---Page Break--- 99 1 unoys 4a our puo eon vt ol so 90 vo 20100 ize! howwavaas Noi vax OINGH WO oe! z 2 % TUL poz¥d O—— toe! 220 Nolwavd 3s 3ONUHOXS NOIWOHS jo2!8 % “NINOb/9 <0! yo! ---Page Break--- 109 (6) The bismuth was back extracted into 7M HCl for a final overall yield of 99%. (7) The bismuth is measured by atomic absorption methods. The method has been adapted to analyses for bismuth in biological, sediment, and mineral samples. The yield is determined with carrier-free Bi207 and the limit of detection (+ 10% at the 95% confidence level) is 1 µg Bi/g of sample, using one gram samples. Lithium: An adaptation of a published method for the analysis of Lithium in seawater has been tested and is in use. The procedure is as follows: (1) An ion exchange column (1.55 x 40 cm) was prepared from 50-100 mesh Dowex-50 x 8. The column was treated with 100 µl of 6M HCl followed by 200 µl of triple distilled water. (2) Twenty µl of seawater were added to the column. (3) The column was eluted at a flow rate of 0.5 ml/minute with 25 ml of distilled water and 500 ml of 0.2N Cl. The eluates were discarded. (4) Five hundred µl of 0.5N HCl was added to the column and the first 135 µl of solution collected (this fraction contained the Lithium) (Fig. 46). (5) The solution containing the Lithium was dried in a

quartz or platinum crucible and the Lithium redissolved in one ml of 0.28 Rel. (6) The Lithium content was measured by atomic absorption and flame spectrophotometry. The Lithium in 20 nl of sea water may be measured with an accuracy of ± 5% (95% confidence level). Complete separation of Lithium from sodium was achieved. Zinc: A method for measuring zinc in sea water has been developed for analyzing large numbers of samples collected off the outflow of the Afasco River. The method is amenable to simultaneous analyses on several samples, by one technician. In brief, the method consists of precipitating the zinc from the sea water with a ferric hydroxide scavenge, rinsing the sodium chloride out of the precipitate, separating the zinc from the iron on a Dowex-1 ion exchange column and measuring the zinc by atomic absorption spectrophotometry. The principal source of error in the technique is caused by reagent contamination with zinc. Triple distilled water is used and the last stage of distillation is done with a polyethylene condenser. The iron chloride reagent is freed from zinc by an ion-exchange-chloride complexing method (Kraus and Moore, 1953). HCl and ammonia vapor are used rather than the liquid reagents except in the ion-exchange procedure. The procedure is as follows: a zinc tracer (containing less than 0.001 µg of stable zinc) was counted in the gamma spectrometer, then added to 500 ml of sea water in a polyethylene beaker. The water was acidified to a pH of 2 with HCl vapor and iron chloride (5 mg Fe) was added. One-half of the water was added to another polyethylene beaker for a magnetic mixer and the solution stirred while ammonia was bubbled into the liquid until a pH of 9 was achieved and the iron was precipitated. The ferric hydroxide precipitate was centrifuged and the supernatant decanted. The precipitate was redissolved by the

addition of HCl vapor and steps 3 and 4 repeated on the remaining one-half of the sea water. The supernates from steps 4 and 5 were again acidified to a pH of 2 with HCl vapor. Added to one of the acidified and steps 3, 4 and 5 were repeated. Iron hydroxide (5 mg Fe) was superna The precipitates were combined and dissolved in 2 ml of redistilled 6N HCl (a quarter condenser was used). The iron solution was placed on a Dowex-1 (100-200 mesh) ion exchange column (8.2 cm x 260 cm) which had been previously treated with zinc-free water and 6N HCl. The column was rinsed with 10 ml of 6N HCl, 20 ml of 0.6% HCl. The column was eluted with 20 ml of zinc-free water which was collected in one ml aliquots. Each aliquot of water was counted for Zn-65 and the stable zinc was determined by atomic absorption spectrophotometry. The counts from Zn-65 were plotted against micrograms of stable zinc in each aliquot (Fig. 47). Any point which fell to the right of the line shown in the figure was considered to have been contaminated by environmental stable zinc. The total counts of Zn-65 added to the sea water were equated to the corresponding amounts of stable zinc detected by the atomic absorption method (Fig. 47). ---Page Break--- 103 of 00.1 0.2030405 10 15 20 µg Zn Figure 47. A comparison of the activity of a Zn-65 tracer and the stable zinc separated from one liter of sea water collected off the west coast of Puerto Rico. The high specific-activity Zn-65 (0.001 µg of stable Zn in the tracer) was added to the sea water and the stable zinc plus tracer separated by a combination precipitation ion exchange method. The values shown are those of one ml fractions which were collected from the Dowex-1 ion exchange column.

---Page Break--- 104 References Lowman, F.C, and R. F. Palumbo. 1962. Occurrence of Bismuth -207 at Enewetak Atoll. Nature 193:796-797. Kraus, K. A. and G. B. Moore. 1953. Ion exchange studies. VI. The divalent transition elements manganese to zinc in hydrochloric acid. Anal. Chem, 75:1460-1462. ---Page Break--- 105 DATA STORAGE AND

RETRIEVAL system for storage and rapid retrieval of data has been collected to handle the volume of information generated by the Marine Biology Program. Information is punched as IBM cards in two forms: coded descriptors indicating items such as sex, location, date of collection, sample type, species, etc., and raw data such as temperature, salinity, weight of sample, amount of stable elements present in ash, wet weight, and dry weight, etc. Space is reserved on each card for a specific piece of information (Fig. 44). Each card has the basic descriptive information pertinent to a sample plus either ecological or laboratory fragment data for a given series of elements analyzed from that sample. By making use of the IBM Sorter and Accounting Machine, this system provides an opportunity to make quick comparisons in addition to a rapid print-out of all data. Gross correlations between elements of trace sediments contained in organisms in relation to gradients of temperature, sediments, or salinity may be quickly assessed, along with differences in stable element content between geographic locations or between organs within the same animals. It also analyzes stable element content between or within species or physiological states. In this sense, it has a built-in first step toward data reduction, providing a means for entering data directly about whatever program may be desired. The selection, handling, and method of recording data will greatly facilitate the handling and analyses of information collected for the Marine Biology Program. ---Page Break---

sebesseessessDeses prrsrraara rear aA seumenatieniiae senaessenenenу secneoneny sDeats npeba ait anaas ene eneaa ERE SESEAL ESA RELARESD ATRRS CEE eeee et ecesssescssesseess E FE 1a g othe feos 5, 34 § 5 gaads. Goya 384 eal yo Sas eg RoR aos hea oF G 2] Pubes? EAdES Gad ores UIUTTUATAEEITTTTETEDUATUTUUSE TUTTE AT ETTTABT EIB ae ann ahaaaanng agra gh enyaayg 0 2002020222222222292222222222222222222222222229222 2007 9299903929998 939 3 9939599939999950999991959999393999990999299290929 9 A eceeceeceeninenns AUC Bd SussssnssssssussssssMsssssessasssssesssssssssssssssssssssssssssossssssssos SOGGUSSOESOUGEESSSEGREGEESEEGGEEGOESEEOEEGAUGHSEGSEESSOSEOSEGESSOESG ESSE devarvar raven yaanraa yaaa area aaa ustrat ion of Card Punching System for Storage und Retrieval 0: ---Page Break--- io” 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 occur. 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 second one, 45 KV and 35 MA is used. The diffraction pattern is run from 2 equals 2° until 2 equals 80; running it at a chart speed of 1°/minute. The 2θ angles and intensities are then read from the pattern for each peak that appears. With the 2θ readings, the interplanar spacings or "d" values are determined from tables prepared previously according to the Bragg equation n = 2d sin θ where n is considered to be 1, λ is the Ka radiation characteristic of the target used, and θ is one-half of the total angle of deviation of the incident X-ray beam. 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 are 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 is 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 made (Fig. 49). The present program utilizes only the observed "D" values. The intensities for each peak must be checked manually. The program is being rewritten so that both the observed "D" values and intensities will be checked by the computer. Then, computer printout will include only those peaks and intensities occurring in the prescribed ratios for known compounds. The spectra of elements are obtained by using X-ray fluorescence instead of X-ray diffraction, and elements are identified in the tables for fluorescence using the 2θ angles readings and intensities only. Several elements have been identified and others corroborated using this method. The more than 50 compounds identified to date, both positively and tentatively, appear in Table IX. The utilization of these techniques should provide basic information as to the compounds through which stable elements are either locked into the physical environment or made available for the diverse biological pathways. ---Page Break--- 108 program Sample Programmed "D" values Programmed ASTM record reference no. cate, 1.97 3.21 2479 1CO CHO 040 9-b4 CuS-Cu,S copper ores 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 s3et-t ito too O88 Score eatr Teo too oso covet PMMA plana Gates 2034 teo~too~ aee-3-07er. om 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 sass 31> 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) Kapoite (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 (II) Sulfide (hexagonal) 3) 7 imyzn, Ca) 0.3 510.8 Toucophonite 4) Cayna, Ped2Taz. (0.08, F)7 Microtite 5) Fe38y Saythite 6) 1g20 Cl Terlinguate 7) 0, 8) Samarskite 9) Sauconite 3(zn, Ms, Pe, 41)0.4 (54, 4190) .2820 10) Fe 8 tron (II) Sulfide NY nyt, Fe).(Fe.t)20, Franklinite 12) MgO, Manganese Oxide 12) Pb5(PO4)5 OH Lead Hydroxide Phosphate 4) HO Mercury (II) oxide Table 9. 35) 36) 37) 38) 39) 40) a 4) 43) 4a) 45) 46) a7) 48) 49) 50) 5 52) 53) say 55) se) 57) 38) 59) 60) on 62) 63) 64) 63) 66) 0.83 MaAISI0g, 0.16 CaAlySt90q ~ sodium Ca, Al, Silicate (8e.00), 6 48 'S1 Maco Magnesive Carbonate caceg At) (alg 884] .220,9(OH)y Xanthoph {2 1it. BeO Beryllium Oxide; Bromelite (Wag6ay9) (A109) 996510,)6(0p) 9 (s0)12 » 1610 Viseite (ve Fe) (Ce, A1), 0, Magnetochronite 2 Fe'' Feq'''' (80,)q (OH)s Baste Iron Phosphate Gu 5.4 Cups Copper Sulfide; Digentte Pd Palladium Au Ag Teg Sylvanite BigTeS, Bismuth Telluride Sulfide; Geuenlingize (inFe), 0, Iron Manganese Oxide 5 MgO.A1905.3 S40) .4H,0 Penninite (above 600°C) Mey rALSFeSt, 049 40H,0 Vermiculite Ni,5 Nickel Sulfide; Va e003 Iron (II) Carbonate NeSb.0g, Bystromite CupagSt Berzelianite cal002)2 (P0,,)p-8-128,0 Catetum Ur Phosphate Hydrate Me(OH), Magnesium Hydroxide K, Cu(50,)p .6H0 Potassium Copper (II) Sulfate Hexa Hydrate ‘Ag Fe,5q Silver Iron Sulfide; Argentopyrite Cig Te Copper Telluride (x = 0.6) Coat, Cobalt Arsenide; Skutterudite (Pe, (Ta,%), 0, Tapiolite FeO. (Cr, A1)203 Chromite (co, Fe) As § Cobalt Arsenide Sulfide cohaitite &e Copper 8 6x0, Copper (II) Chromite came (5103) Calcium Magnesite eta silicate Me Fe,0, Manganesite (oynthette) ste a Iron Oxide; Jacob- Compounds tentatively or positively identified in Anasco Bay Sediments ---Page Break--- 119 New Facilities During April, 1965 two buildings for use in the Marine Biology Program will be completed. A new building, located on the grounds of the Puerto Rico Nuclear Center, Mayaguez, is a two-floor structure and will house an instrument laboratory (including 4 low-background facility)

On the first floor and two chemistry laboratories on the second floor to be used for trace element analysis of seawater. The other building is located on the BONUS site at Pea Higuero and is being converted into a marine biological laboratory. The building at the BONUS site was purchased from the U.S. Navy by the U.S. Atomic Energy Commission. The AEC also allowed $4000 for conversion of the building for use in the marine biology program. The building, as purchased, was 40 by 20 feet in length and width, and 13 feet high with a pitched roof. It was constructed on a concrete slab with steel framing covered by 1/2 inch thick asbestos-cement panels. It was completely insulated with fiberglass batts, was 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 work on the building is almost completed and includes the following project: (1) Purling strips were bolted to the inside of the steel frame and the interior of the building was paneled with sheetrock. (2) A stairway was built to the space over the shower and toilet for access to the storage area. (3) The garage-type doors were removed, steel framing installed in the opening and the opening was paneled on the outside with asbestos-cement board and on the inside with sheetrock. A regular exterior door was installed in this wall. (4) An instrument laboratory 12' x 12' was constructed in one corner of the building and an air conditioner was installed. The walls between the instrument laboratory and the main laboratory were provided with windows. (5) Sleeping and cooking accommodations for four researchers were constructed. Because the building will be used for uptake experiments and other marine biological work which often require 24 hours attention, these facilities are necessary. (6) A saltwater system was installed with pumps, a settling tank, a saltwater table and running saltwater. (7) A total of 60 feet of laboratory benches.

were constructed in the two laboratory rooms (8) 4 protective cover was built for the air conditioner. (9) The building was painted. ---Page Break--- In early 1965 construction was started at the Puerto Rico Nuclear Center, Yauco on a new building for use as a chemistry and instrument laboratory in the marine biology program. The structure is built of reinforced concrete, is thirty-two by twenty feet in length and width and is two stories high. The new building is located 300 feet northeast of the main PRNC building. The new building is constructed on the side of a hill. The second floor of the building coincides with the outside ground level on the side facing the main PRNC building - on the opposite side of the new building the lower floor is at ground level. Thus the radiation counting equipment, which will be placed on the first floor, will be shielded from the research reactor and gamma source in the main PRNC building by more than 300 feet of foil. Entry to the instrument room is gained through an office with dimensions of approximately nine by twelve feet. The second floor of the building contains a central office and storage room with dimensions of approximately thirteen by twenty feet. A lavatory and toilet are built into one corner of this room. On opposite sides of the office are two chemistry laboratories to be used for trace element analyses of seawater. 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 passing through the length of the office from the outside office door. The laboratories are thus isolated from direct entry from outside the building. The two chemistry laboratories and the central office are serviced by separate air conditioners and the outside air which is supplied to the laboratories is subjected to special filtration. Each laboratory is supplied with a stainless steel hood and the ordinary chemistry laboratory furniture. ---Page

Break--- 112 STABLE ELEMENT 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 included because the calculations are not yet completed. The 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 does not 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 analysis and the remainder by atomic absorption or flame spectrophotometric measurements. The activation analysis methods are described elsewhere in this report. Samples were prepared for emission and absorption spectrophotometry in the following manner: (If necessary, specimens are frothlessly processed). The specimens are wet weighed, dried, and then heated to a temperature of 450°C. An aliquot of 0.25 grams of ash is dissolved in aqua regia and warmed on a hot plate. It is filtered by vacuum through two thicknesses of glass filter paper and washed three times with 0.2N HCl. The filtrate is brought to a final dilution of 1/100 (weight/volume) by adding distilled water. The filtered sample is analyzed for the 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 interference errors in the types of samples used in the present work. Interference effects have not been found. However, this method is also used for the determination of magnesium, calcium, and strontium, and for these elements, interferences do exist if large amounts of phosphate, silicate, or aluminum are present in the sample. These effects may be eliminated by the addition of excess lanthanum to the samples ---Page Break--- on page 6 dot 16 a day. wm s report. cost of stat, * work » dot 4 » cost of oat. oz of ge out 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

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2.1 43 ---Page Break--- Terrestrial Scientific Gracilaria ‘caudata A-10 Mixture of ‘Acantophora spicifera & 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 bottom 20 ft. 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 sample 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 (sponge) Doniriella 22 13 24 ---Page Break--- 126 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 Mollusca Anadara sp. ” eM ” Pitar sp. ” 565858788 : " “2 55 5997s a6 Echinodermata Luidéa senegalensis 1327 3648100130 2 35 46 mH ---Page Break--- Type of Plankton Invertebrate (sponge) Invertebrate (Gorgonian) Invertebrate (sponge) Invertebrate (Gorgonian) Scientific Mixture Lot of picoplankton Mixture Treinia fasciculata Purple sponge Halimeda, Small grey sponge Buniopsis Peerogorgia Dycitopteris justit Coraline Padina Collection va ce Mona Isl, O82 42 5 win, west 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 albacore (skin & scales) Ghana, Africa 7.5 27 75 Algae Gracilaria. wo 18 " Bryothamniun triquetrum ” O80 500 9 " Coddon taylorii ” Not 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 Scientific 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--- 29 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 collection 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 TauaTIg 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 —Scientific 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 collection Pave m 150 1,200 36 01,600 8. of \teqes 67 86021, 000 Sponge bank 721,100 1,900 3 mt. south of Desecheo Isl, 8 7%, 180 Negro Reef 2 701,300 12 acres 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 Views 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 " Opisthonema 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 Plankton 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 Scientific 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--- 149 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 Chlorosconbrus Fel 2 F6 9 P10 chrysucue F-2 el Sugar Cane South of La Bogitlla Coconut areas 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 Plants Scientific Mangrove leaves Mango leaves Tamarindo leaves Coconut hard shell & meat Mangrove aerial roots Pajuil Rojo Chucho Brazil rubber 'Alaonds Sugar cane Teaver Enteronorpha Acanthophora sptciters Mixture of Acantho spisifers & Spyridia £1la- Gracilaria caudata codium taylorit Thalassia Spyridia Filasentos Not 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 Scientific 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

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9" va sonbyzug adap“ oz. su, . cy oe vor. 6 TE 62 Sty ooeeny wader @ ost ody “ oO ce et 8 od © vz st cw ooseuy = Boasg at “ ee 6 0 9TE . a ogte tn " ee 6 corer " OL" Sy “a sonbyaug 9-1 “pes dap “© gz eo330q FAS re et Bott . Ue et “eoseeuy 9 zen 3308 ace 9309 Noaesa « er et Tot . or se on 269 eprsuy 03309 vag “ west 6 HOE y . 2% 9°9 S°9—exonBzeg tax 81003 saosiuen 290g ” ry we rote Ort ot 86 anttekng 6-at owua ofa trnfea . SE 22 ossmuy 330 x OTHE “pas O'% zt ooseuy 3309 gtk “pos oop “© Eye —ax09 uoaeyg Teyaeaaz0r oop “@ Eye 9203 woasyg eT a2e0A20r YG ar ae ae saa RY ae ar srsaes TST HHT worssoqte9 — atgtauerss go ad EH BT —vovazotton —aggsauatog go od ' © © © © © @ © © © © © © © § gia ---Page Break--- 162 eT sort “ or ce oS . ve 6 HORT . ee ot 96rE “ vt 6 D0mE » v9 ve oR 6tE ot 6 FORT . vy ee Gert . 0°z ooeeuy 330 dep 8156 907-1 . vs ove 6 96tE ve 6 RErE . 99 9° costar 330 dope tev ott . ez TEE 7 ve 6 DeTE “ oz eo ve ez 6 ROE oz 6 £6 . es oy 6 9 8teE Xord . ee 92 ote “ 92 "wos Fed . US 2 opeewy 330 370 ete 40 "899 VEIL “ vt saat, “ 02 LT comepy 330 doop BEEK OTL w ey VE . 59 Se oxae e009 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 SPT woavertey —oygtaweyog go od orsrqustog 30. addy ---Page Break--- EL St 6s saKenSeH —1E-¥-9¢000 eyaundo : er 0 PpeRt TH WE YORE . ce ez Ory “ er-w-acooe en syz0ador39kq ony el oe 8h “ os =e 79 —BaTUEND oC -¥-SS00N wurpea » oe ot 6 PRE 7 OE eS OL BartEMg —gz-¥-yS00N ‘onssw805 » eT Ot 6 RT “ e's 8 Oy exonaeg 2 sa 290s} 289) neg v ted 8 4 zona} 209K st st . wt ow “Tuy si ve wrTembon w1 —cy-a-no008 yo yanos —wrafusaey sourta we a . re ve

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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 Scientific Collection 1e 'Terrestrial Plankton 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 . Bryothamne {on " a7 Rm ow " 'uphiroa " 7 mo Miscelanous sediment & algae " soa? 2.0 alge Penicitlus " wow 15 Marine angiosperm . 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 Dictyota " 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 " Peniecilus 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 esculentus 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 Echinoderms —Tripneustes esculentus 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 Scientific Collection s_ Sx) seple nae site Wet pry Ash _Wee bey ah Echinoderm — Tripneustes 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 Reef = 7.719 2h ol 12 6 " " OFF Guanajibo Pe. 17 206 9 3 oT Coelenterate 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 Culebrinas River 100 2.00 20 5252 Mollusk Strombus pugilis, Ville cofrest 22023 . " ” We 25] aaa . " . 32am " : 80" depen, Off Culebrinas R27 27282 " “ " 000 00 Oat " ” " 9 2.020096 990 ” Strombus costatus " M7? oe. Crustacea —_Paguristes sericeus Villa Coftesi Boe ae ---Page Break--- ‘Type of Scientific Collection 8 e/a eg Sr/e sample nase aite ee ey wet_—bey ash Crustacea —_Paguristes sericeus cofrest 250 78 26 ese . . 443 wer aw Yollusk Paguristes Off Culebrinas sericeus River - 10 2 ele " Petrochirus diogenes . 3285-2 aos Porifera liable cup sponge u/ spicules dis- OFF Anasco dissolved 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 dissolved Negro Reef 063.607. "Ireinia strobilina w/epicules dissolves Parguera 67 3.9 9.2 038 225." Spheciospongia Off Anasco vesparia River 1082.37 1.1 or petecersD "Pliable cup Off Culebrinas sponge River 15 70000 28 Hm.” Brittle cup sponge "125.300 9.6 Hw.” "Off Anasco R. 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 Parguera 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 "Opisthonemus 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 La Moqilla 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--- 456 '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 Species 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 aneri- cana " 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 angiosperma testudinum 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 Sargassum lentigera Pea, Higuero 9.3 48 130 " Sargassum " 6.6 28 88 77 1.0 " Gracilaria dodecansis Rincon 2% 9% 70 10 bao " Bryothamnion cecquetrum " 20092 17h Ha " Padina " 37% 1s 37.9 " Penicillus : 2 56 8 2 " Padina Rincon " 139 26 5.2 " Dictyopteris = 2.926 49 85 5 ay " Penicillus " 158340 " Galaxaura 7 8 ao " Auphiroa fragilissima 2 73° 91.80 2.02 “ Bryothamnion erlgietrun " 55 M0 1605 LL? " Padina “ 7.876 290 18 1.767 “ Dictyota " 5.8 80 410 18 25.3 Marine Thalassia angiosperma testudinum " 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 Amphizoa 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 favelosa . 7 20 0 7s 5,272.0 " Cynopolia " 99 150 200622 2.9 " Dictyopteris Justi " 27 100 707.8 " Amphiroa 5357690 " Dictyosphaeria 60 230 260 16 6.2 6.8 " Cynopolia " Bl 2 49 66 26h " “ Amphiroa . Mo 130 1506.2 7.3 Be " Penicillus " 88 190 240 " Cymopolia W596 90 2a " Caulerpa " 7% 120 180 " Dictyota dentata " 25 80 150 " Bryothamnion 130 200 260 Miscellaneous ‘sediments & algae " 120 160 180 Alga Codium " 49 70 230 " Penicillium " 73 130 170 Marine Thalassia angiosperma testudinum " 66 85k Alga Dictyopteris justi " wo wo 8 49 89 Marine Thalassia angiosperma —testudinum . 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 Piston core sed. Te? A hue nine Tae Piston core sed. TB a Tee Piston core sed. 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--- 204 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 Iatus 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 Ghiorosconbrus 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 collection 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--- 207 Type of Scientific 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 . Species 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 mile 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--- 210 Type of —=Scientific — 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 Collection 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--- 212 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 —Scientific 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 squamosus 10 1-46 ‘Acanthopleura granulate Hs Nudibranchs Ts Species 772 1-33 crab White sea urchin Collection 2 Pe /g rt ee be aah 1/2 mile Pra, Biguero oO 46 3 " 3.3 15 a * 27 16 “8 Joyuda beach 0.612.6 27 Desecheo L764 9 1/2 mile off Pea. Higuero 0.75 3,321 ” LS 66 27 Bonus Nuclear Plane ww 49 3 et. from Pea. Are Mayaguer, Ls 36 a Rta, Higuero 5,723 2 1/2 mile off Riguero 28 4a, 6 . O37 7 5 Bonus Nuclear Plane. moe 36 Cayo Turrenote 0.41 4.0 13 1/2 mile 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 argus 1-22 Joyuda beach 0.56 4.3 * Species 767 1/2 mile 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 mile off TAL Pea. Higuera 2743 36 Invertebrate Panulirus argus 1-17 Joyuda beach = 1.7 7-15, Brown sea urchin I-13 Cayo Turrenote 2349 35 " Species 774 1/2 mile off sponge 1-42 Pea. Higuero 2.110 » Algae Galaxaura cylindrica Guanica no 46 56 . Bryothamnion triquetrum Guánica 46 28 50 . Gracilaria " L718 31 " codium taylori " La 8 28 " Penicillus capitatus ” nM 38 " viva tactuca " 21 8 ey " hypnea musciformis " 2.30027 6 . Spatoglossum schroederi " 3.1 26 36 " Laurencia papillosa . 3.0 2 6 Hypnea musciformis ” 20 5.0 4h ---Page Break--- 218 Type of Scientific Collection ig Pb / sample name site Set bry Algae Cayo Turrenote 2.1 25 6s Laurencia obtusa a5 Cayo Enriquez 1.3 15 29 ” Lyngbia mayuscula A-2 Cayo Turrenote 2.333, oo Valonia ventricosa a3) Cayo Enriquez 2.5 48 cy " Gracilaria caudata A-10 Guanica 0.79 7.00 1s . Mixture Acantophora spicifera & Spyridia filamentosa cayo Enriquez 1.8 18 36 ” Enteromorpha Not DETECTED codium Taylors Guánica 62 73 150 " Malinaceae cayo opuntia Enriquez 45 - Laurencia papillosa guanica 139.0 ae . Gracilaria angustifolia ” 2.6 24 56 " ‘Thalassia testudinum oe 5.6 th " Spyridia filamentosa Enriquez lao 26 ”

Acantophora spleifere, om 7 au Terrestrial Mangrove subt. roots Parguera 220022 0.9 " Pueraria hireuta RNC Le 5.479 " Mangrove aerial roots Parguera 0.071 0.29 14 ---Page Break--- | 219 t Type of Scientific Collection ug Pb 253 name eee a Terrestrial Alands 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 Sugar Cane coconut area stens Rincon MoT DETECTED " ‘Tamarindo leaves RNC 26 91 120 chucho coconut 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 miles off Point Brea Parguera La 45 300 “ "p13 78 sever depth Amasco R, mouth 4.7 35 a1 " "pig 3. miles south 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 esculentus “ 0.53 0.55 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 Acanthopleura granulate clear Plant 1.10158 ‘sponge 18 2B 6s 960 Invertebrate Panulirus argus 1-22 4 0.13 0.98 100 " Acanthopleura granulate 6-H 59 831,000 Species 746 12 miles 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 mile of Tha Rta, Higuero 51 © 801,200 Invertebrate Acanthopleura granulate He Plan 310 420 4,800 Panulirus Joyuda argus 1-17 beach 0.38 1.6 120 Species 773 1/2 mile of (sponge) 1-47 Pea, Higuero 9.4 56 1,300 Invertebrate Panulirus Joyuda argus 1-18 beach 0.23 0.95 100 Alga Enteromorpha Cayo Eari- wes 2006

0.11 3,3 ---Page Break--- Type of Marine angiosperm ala Plankton Fishes Terrestrial Scientific Thalassia Dictyota divaricata Acanthophora spicifera Codium isthmocladum Caulerpa Penicillus capitatus Caulerpa Mixture of shrimps & isopods Mostly shrimps Mostly isopods Plankton 6 river sed. Cyprinotus cyanopterus PV. (akin & scales) Abdominal: inner gills 4G, muscle Piston core sed. 7-20 E “miss 222 Collection Cayo Bari view, Belvedere cayo Brinquero Belvedere Parque Yona Toland 3 at. outside Pea. Avenue: South of Vieques, Culedrinae Bay 351 a. depth off Aguas 31m. depth off Aguas R. 2 Re 2 Sela wee aa 012 0.077 5.2 0.015 0.11 10 0.07 3.2 0.82 13 250 13 10 8.00 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 "nine m “mara “nize "nize "nip “nine Collection 343 a, depth off Aguas R. 351 a, depth off Aguas 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 Aguas R. 2.5 4g ” " ninoK " 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 Aguas 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 mm depth sed. 7-20 B off Aguas 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 anasco R. 40 280 400 "ne" 190 =. depen anacco R, 70 310 330 "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. 150 290 310, ---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 86 300 570 "47" war 340 990 1500 Mollusc anadara sp. "0.03 0.04 0.04 150 200 220" Piear Sp. No ScaNpnUM 150 160 160 0.07 0.18 0.20 38 © 93100 "No ScaNDrUM 150 150 160 Echinoderasta Lidia jenegalensis = "21 45 6.0 7150200 0.08 0.23 0.31 81230300 96 270 390 86 240 350 * "100 270 390" "Cleaheaes 046 047 0" 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 "279 9580 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---