CEER-A-005

PUERTO RICO NUCLEAR CENTER

ANNUAL REPORT

July 1, 1975 ~ September 30, 1976

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

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?TABLE OF CONTENTS

Office of the Director...

Organization Chart 1976

Organization Chart 1977

Senior Stat

Publications...

Papers Presented

Semina

?Training and Information

Radiation Oncology

Nuclear Medicine

?Medical Physics

Human Ecology

Marine Ecology

?Marine Pollution Studies

Bikini Atoll Project

and Dispersion of Organie Pollutants From

Tran

{an Oil Refinery Through Coastal Waters =

?Transfer of Particulate Pollutants, Including Sediments

Dispersed During Construction of Offshore Power Plants

Raft Culture of the Mangrove Oyster

?Terrestrial Ecology

Materials Science

Neutron Diffraction

?Tropical Agro-Sciences

10

"

16

7

19

2

a

a

37

83

2

103

mm

119

131

---Page Break---

---Page Break---

OFFICE OF THE DIRECTOR

(On July 1, 1976, the Puerto Rico Nuclear Center (PRNC) became the Center for Energy land Environment Resaarch (CEER) of the University of Puerto Rico. The 12-month period from July 1, 1975, through June 30, 1976, represents the final year of operation fof PRC, and therefore an Annual Report for this period is being published. This section indicates the reasons forthe transition and describes the new objectives.

CEER?s BASIC OBJECTIVES.

In harmony with the Action Memorandum* of April 11, 1976, ERDA's National Plan {for Energy Research and Development, and Puerto Rico's energy and environmental needs, ?the UPR Center for Energy and Environment Research has these principal objectives:

To aid in the national effort to achieve energy independence while contributing to Puerto Rico's own effort to achieve the same goal for itself.

To serve os focal point for energy and environmental research and training in Puerto Rico and to cooperate on research and training with other countries in the tropical and subtropical zones, particularly the Caribbean and Latin America

?To help Puerto Rico develop its manpower needs in energy and energy-ralated areas.

?To continue training programs in Puerto Rico for students and personnel from the Caribbean and Latin America.

In order to achieve these objectives, the Contor wil;

?Support sound research and training programs.

?Attract and develop University System talent in energy and environmental research.

Promote and coordinate efforts which draw on expertise wherever located in the University System,

Promote academic excellence in the development of energy curricula and thus help to

?promote cooperation between the University, industry, government, and the community at large.

?The Center's major research programs now encompass environmental sciences and medicine. The aim is to add to these a strong energy program which will emphasize con servation and solar sciences and engineering, including ocean thermal energy conversion and materials research and development. CEER also stands ready to provide the necessary technical support for ERDA?s proposed Energy Extension Service in Puerto Rico if the Governor designates the University for this role, or to play any supporting part in this ?rogram.

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PUERTO RICO?s ENERGY REQUIREMENTS

?A. Current Nowds

Puerto Rico's economy at present depends almost entirely (>99%) on energy derived ?rom imported petroleum. In 1975, the latest year for which comprehensive figures are available, the Office of Petroleum Fuels Affairs (OPFA) of the Puerto Rican Government reports that Puerto Rico imported 70.3 milion barrels of crude oil, mostly from the Middle East and Venezuela, and 31.9 milion barrels of naptha, mostly from other foreign countries, From these imports the Island's petroleum refineries and petrochemical plants produced practically all the fuel oil, gasoline, and other products used locally and exported substan? ?ial quantities, mainly to the United State.

?According to OPFA, local consumption of petroleum in 1975 amounted to 69.9 milion barrels. The Puerto Rico Water Resources Authority (PRWRA), a government corporation Which is the sole vendor of electric power in the Isiand, consumed 18.7 million barrels, oF nearly one-third; the manufacturing sector, 19.7; the transportation sector, 17.9 (including 14 in the form of gasoline for surface transportation); and others, including the agricultural sector, 3.6. Exports amounted to 38.3 million barrels.

Until the OPEC nations raised petroleum prices sharply in 1973, the value of Puerto Rico's total imports had been averaging 85 to 56% of the gross product (GP) in current dollars (Table 1). In 1975, a year of deep recession in which petroleum imports declined, the cost of total imports was 69.5% of the GP. The increase was caused principally by higher petroleum pricas.

NNear-Term Needs (1977-1985)

For the near-term Puerto Rico's energy system will continue to depend on imported petroleum to about the same extent that it dots now. The Puerto Rico Planning Board, the government agency responsible for indicative economic and social forecasting, estimates that, ifthe economic recovery haltingly begun in 1976 gains strength and continues, Puerto Rico's gross product could increase by an average of about 7%/yr during the next four oF five years, if very low rate of population growth is assumed (Table 1). On the basis of historical trends and the Planning Board's projections, OPFA estimates that, with 3 74/yr GP growth, petroleum consumption would increase by close to 10%yr, assuming no special effort to reduce energy consumption through continuing or new conservation programs or use of alternative energy sources or technologies. Thus, petroleum consump: tion could reach 98 milion barrels in 1980 and could be expected to rise through 1985

if GP continued to rise.

PRWRA forecasts of electric power consumption trends indicate that demand will increase at an average rate of about 6%/yr over the near-term. Thus, PRWRA petroleum consumption ?would increase steadily until atleast 1984. Nuclear power could begin to provide part of the electric energy supply in 1985 if the Puerto Rican Government decides within the next {few months to go ahead with construction ef « 600-MW plant previously planned and then ?postponed. For electric power alone, PRWRA estimates the petroleum need in fiscal year 1986 at 26.9 million barrels, costing $31 a barrol or $833 million, and, assuming the first nuclear plant goes into operation, the uranium need at ~-450,000 pounds, costing $45 10 ?$50 8 pound or ~$23 million. If nuclear capacity does not go into operation by 1985,

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the petroleum fuel requirement for electricity would be 33.9 million barrels, costing

51 billion; if this again represented about one-third of total energy, Puerto Rico's total Petroleum bill would exceed $3 billion.

?Whether energy consumption increases by only 6 or as much as 10%/yr, the impact of petroleum costs will be increasingly felt. The Planning Board's projection would give the {sland GP in 1980 of about $11.6 billion in current dollars compared with $3.3 billion in 1978. Coleulations based on OPFA estimates, PRWRA forecasts, and currently known OPEC intentions indicate that Puerto Rico could be spending between $1.5 and $2.0 billion for petroleum in 1980-81, or 13 to 17% of the GP. compared with 8.8% in 1975,

©. Mid~ and Long-Term Needs (1985-2000)

?The best projections now available are those of the PRWRA, which cover only electric ?power and are based on a steady 6%/¥r consumption increase into the 1990's. Assuming

that one nuclear plant can go into operation in 1985, PRWRA considers it feasible that three ?others, each of 800-MW capacity, could go into operation in the next few years so that by 1991 nuclear plants would be generating two-thirds of the island's electricity and ol-fired plants one-third, (At present, however, only one nuclear plant ste isin the process of being certified.) Ifthe projected nuctear capacity were realized, the PRWRA's need for petroleum ?would decline steadily after FY 1986, being for FY 1991, 15.3 million barrels of oil costing |$50 2 barrel, or a total of $753 million (plus ~ 1,750,000 pounds of nuciear fuel at $60, or

2 total of $106 milion); if not, the petroleum need would be 44.7 milion barrels costing

>$2.2 billion. Ifthe petroleum needed for electricity continued to be one-third of total usage, ?the total oil bill in 1991 would reach $6.6 billion. Assuming that GP could grow 6 to 7%/yr ?up to 1991, it would reach ~$20 billion. With exclusive reliance on petroleum, the cost of

cil imports could be 32% of GP. Considering the capital costs of replacing and/or adding oil-fired electricity generation capacity, plus the needs of other energy using sectors, itis obvious ?that reliance on foreign petroleum leads to disaster.

I ERDA?s programs for the development of synthetic liquid and gaseous fuels from coal and oil shale were successful, Puerto Rico might look to such alternative for 1985 to 2000 {and even beyond, but to count heavily on this possibility now would be unwise, It seems best to follow the conclusions ofthe recent interim report to ERDA of the National Research Counci?s Committee on Nuclear and Alternative Energy Systems, especially the emphasis ?on the potential for energy conservation

From the foregoing iti clear that anything Puerto Rico can do to inerease its conservation t?fforts and to develop energy alternatives that will reduce its dependence on imported petro-lum, while atthe same time striving to achieve @ good rate of economic growth and assuring protection of the environment, will be beneficial to the people of Puerto Rico and, directly ?or indirectly, to the United States, The energy situation and outlook in most of the island, societies of the Caribbean and the countries of Central America is similar to Puerto Rico's since they also lack significant fossil-fuel or uranium resources, and they would benefit from the same kinds of programs and policies as Puerto Rico.

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ENERGY STRATEGIES FOR PUERTO RICO

?A. Conservation

Energy conservation is a major factor in the development of strategies to meet future energy requirements. Conservation is listed as ERDA?s top priority in ane recent report.

In another a scenario is analyzed in which energy growth rate is kept at slightly less than 2sklye to the year 2000. Both show how substantial energy savings can be had with no appreciable change in life style. Both call for an enlightened, involved public aware of the

seriousness of future energy choices

Energy conservation is defintely on Puerto Rico's agenda and must remain there, with future efforts exceeding those of the past. The Island's industrial sector, including the oil refining and petrochemical industries, which are major direct consumers through their use of electricity, has already made some encouraging strides in raising energy efficiency and

?taking other stops.

?The new administration is, or soon will be, examining numerous energy-saving options. Recovery of municipal and industrial wastes for production of energy and industrial mate~ rials is one area of interest. Studies already completed show the value of processing and recovery of solid wastes. One study indicates that a pyrolitic recovery plant serving the SSan Juan metropolitan area could generate electricity from waste equal to that from >800,000 barrels of fuel oil a year by 1980. Such a plant would cost upwards of $42 million and, at present prices for imported fuel and recovered raw materials, would lose about $3 million a year; but at the petroleum prices forecast for 1980, it could pay for itself and begin to yield a net profit during the 1980's.

B. Alternative Energy Sources

Puerto Rico has long considered nuclear power as one of its best options. PRWRA was planning a 600-MW nuclear plant, had already purchased the components for it, and was planning to begin construction on a coastal site near the northern city of Arecibo when

the recession caused a drop in energy consumption, a decline in PRWRA revenues, and

2 dim outiook for the issuance of bonds in the capital markets. It therefore shelved construc-?ion plans and put the components up for sal, although itis proceeding with licensing of

the site. Ironically seismic studies during the site selection process raised the possibility

of petroleum reserves off the north coast, but confirmation of economically significant reserves will require time and highly expensive and sophisticated drilling technology.

?Whether such reserves would belong to Puerto Rico or to the Federal government remains

{8 question.

?With Puerto Rico's climate and geography, solar energy in its manifold aspects offers a potential attractive even in the near-term and substantial for the mid-term. The i
has high insolation, averaging >2500 hours/yr for San Juan and up to 2800 for other areas, particularly the dry southern and southwestern coasts, and for nearby islands such as Culebra and Vieques. One obvious option is to use solar energy for heating water for

residential, commercial, and industrial use. Another is to se it for aie conditioning, at PRWRA estimates that 20% of its electric output is used for this purpose.

?Although the higher areas of Puerto Rico need only a minimum of air conditioning, the Sen Juan area and the smaller towns, where most of the island's factories and business

---Page Break---

activity are located, need air conditioning most ofthe year for workers to be comfortable ?and productive. Conceivably flat-plte solar colactrs efficient enough to provide most

of the eneray for air conditioning systems might be developed. The principe! tactor limiting ?the adoption of solar energy in regions such as Puerto Rico isthe lock of well enginesred, economically manufactured, and adequetely distributed solar heat collectors innovative ?marketing concepts and general acceptance by both builders and owners also remain to

be realized

?The world?s fossil fuel reserves are the product of natural conversion of solar energy into plant materials through photosynthesis and subsequent concentration ofthe stored energy. The managed production of plant tsues such as tees, grasses, water plants, and ?ae with more efficient use of solar energy could provide additional plant materials,

her for direct combustion or for conversion to enriched ful. Other organic materials that could be used this way include the large amounts of wastes- agricultural, animal, industrial, and urban that are now serious environmental and political problems but are Potentially source of ener.

(Oceans, which cover 71% ofthe earth surface, constitute natural solar energy collact= rand storage system. As sources of usable energy, the tropical oceans are pertculrly attractive, In several hundred milion square miles of ocean between the tropies of Cancer and Capricorn the temperature dtference between the surface and subsurface level, where ?there ae cold currents emanating from the pola regions, is ~25°F. Theoretically, this, lm infinite heatsink crecty beneath a surface reservoir ata nealy constant 82°F could be ued to operate a heat engine with an efficency approaching 8% The Gulf Stream between Florida and Puerto Rico cartes 1000 to 1500 milion cubic fet per second of rnear-tropcal sea water. Within 8 SO0-mie length of that path the thermal efference be- ?ween surface and depths ranges from 28° to 38°F. Such a difference, with a surface temperature of ~71°F, would permit theoretical maximum conversion of hes into Useful work of 5%. Even operating at a more realistic 2%, a plant tapping this heat source could produce an annual energy supply of 0.7 X 10"*Btu. Since both the heat reservoir and the heat sink are replenished by solar energy, ths, in effect, represents an unlimited renewable resource.

Considering that Puerto Rico imported petroleum equivalent to 0.6 X 10°* Btu in 1974~ 75, if t could realize 5 10 10% of the available ocean thermal enery, it would gein a substantial contribution to its energy balance, Because of Puerto Rico's vulnerability to foreign oil prices, the economics of exploring ocean thermal energy conversion (OTEC) are much more favorable than forthe mainland U.S., which has many mare option. Within 1.6 miles from the southeast coast of Puerto ico, the thermal gradients are large ?enough to allow the cold water to be piped toa land based facility, which presents much fewer technical problems than a floating platform and more favorable economics In this ?unique situation the possibilty of coupling a nucear plant to an OTEC plant seems very promising.

?A much dicussed system for converting sunlight to electricity involves arrays of mirror. thot collect solar heat and transfer it to a working fluid for use in a Rankine-cycle turbine. ?The vast land areas required by such a system make it impractical for an island such a8 Puerto Rico with only 3400 square miles of land for nearly million people,

Wind generators may be a possibility, particularly in the western reaches of the sland. { Ie hasbeen shown that even medium and large size (>100-kW) wind-eleetric plants ean be built and operated successfully. If small systems of low cost and high reliability were

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avzilable, a sizable market could be developed for 2 network of them for individual home ?or small-enterprise use. The major problems would be siting environments, capital costs of components and systems, and environmental impacts

nally, from an environmental as well as an energy perspective, Puerto Rico should also bbe looking to the potential of electric and hybrid vehicles for surface transportation: of fuel cells and photovoltaic cells for a variety of applications; and of agricultural and marine food production systems using low petroleum inputs.

?Simple solar energy technologies will not provide a magical solution for Puerto Rico's energy problem. PRWRA, has estimated, for example, that if all ofits 227,000 electric hot ?water heaters were supplemented with solar collectors, total electricity demand would drop by ~6%, or the equivalent of 1.2 milion barrels of ol. Further savings could be gained by using solar air conditioners, and still more by substituting flat plate and concentrator collectors for process heat in manufacturing. Such savings, totaling perhaps 20 to 25% of

electric power demand, would certainly be worth making. But a substantial capital cost would have to be considered.

?The possibility of utilization of all options, including ll solar options, needs further study and analysis. This points up the need for the development of a regional energy model of the type proposed by OPFA. It would help to indicate, for example the extent to which Puerto Rico might be able to depend on energy derived from U.S. coal rather than on imported petroleum, which presents a balance of payments problem to the United States, ?2s well as an economic problem to Puerto Rico. The energy equation is also subject to ?reat variation at a result of population growth. Planning Board estimates of a very low rate of growth have to be weighed along with others that put Puerto Rico's population in ?the year 2000 at 6,000,000 or more. One is forced to conclude that Puerto Rico's time~ ?table for energy conservation and for the development of alternative energy sources and technologies is, if anything, more critical than that of the United States. The challenge for CER, for the University at the largest single pool of scientific and technical sills, for the Government, and for society at large is great and urgent.

PUERTO RICO?s STATE SYSTEM OF HIGHER EDUCATION

?The University of Puerto Rico, a member of the national system of stat
1nd-grand colleges, isan island-wide university with some 1,000 students. It has three

large campuses, two foursyear university colleges, and five community colleges, plus an

?agricultural research network and a cooperative extension service (see organization chart

?The top policy-making body is the Council on Higher Education, whose nine members

?are appointed by the Governor for staggered terms. The President isthe chief executive

officer. Chancellors direct the main campuses: Rio Piedras, Medical Sciences, and Mayagiez,

and the Regional Colleges Administration. They have a considerable degree of autonomy

in their own jurisdictions.

?The Rio Piedras campus, oldest and largest unit in the system, with roughly half the total enrollment, includes a large Faculty of Natural Sciences that has substantial laboratory facili ties and equipment for research in biology, chemistry, and physics. The campus aso includes ?large Computer Center and Schools of Architecture, Business Administration, Law, Planning yn. The Mayagiex campus includes the School of Engineering, the

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Faculty of Arts and Sciences, a Department of Marine Scienets, the Agricultural Experiment Station network, and the Cooperative Extension Service, Facilities and equipment for research are substantial including a unique pilot-plant facility for the biochemical conversion ?of biomass to fuels. The Medical Sciences campus, also a center for research, comprises the ?School of Medicine and six others, including the Schoo! of Pharmacy and the Schoo! of Medical Technology.

The Center for Energy and Environment Research operates under the Orfice of the President of the University of Puerto Rico System (see chart ERDA facilites associated with the CEER had an acquisition value of about $9 million. They are located at four sites on the Islan.

Rio Piedras Site: In the San Juan area are well equipped medically oriented facilites

located adjacent to the UPR Medical School. These facilities include

8 biomedical building, animal quarters, and maintenance shop.

Mayegtiez Site: The principal nucear facilities ofthe Center are located on 20 acres of Property adjacent of the UPR campus in the city of Mayaguez. These facilities include laboratories and several adjacent structures housing offices, nuclear engineering facilities, maintenance shops, and a greenhouse.

Comelia itl Ste: Near Mayaguez are the facilities housing the marine ecology program. ?These ae relatively new and well-equipped environmental analysis, laboratories located on the ocean adjacent to the pier.

Luquillo National

Forest Site: In the Luquillo Rain Forest there isa data acquisition laboratory which has recently been expanded,

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eld Separation in Multiple Portal Radiation Therapy?

Mayagiiez

Dr. Grafton D. Chase, Philadelphia College of Pharmacy and Science: ?Theoretical Model for Radioimmunoassay" (November 23, 1975)

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une 11, 1976). ?a

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Table 1: Enrollment in PRNC Training and Education Program from July 1, 1975 to June 30, 1976.

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TRAINING AND INFORMATION

?The Training and Information Division provides centralized direction and coordination {or the training and information activities of the Center for Energy and Environment Research formerly Puerto Rico Nuclear Canter). The Division Head serves as Educational Officer, ?Technical Information Officer, and Public Information Officer.

?Training responsibilities include registering students; maintaining centralized records on training activities; preparing reports for ERDA; scheduling the utilization of training fa providing audiovisual equipment; assisting inthe preparation of courses, seminars, symposia, ?and meetings; administering fellowship programs; and providing personal asistance to students in matters such as housing and immigration. The Division Head represents the Director on the Admissions Committe.

Information responsibilities include preparation of manuscripts for ERDA patent clear ance and publication release, maintenance of central files on allmanuscrpts and publications, Preparation of the Annual Report, providing editorial and translation assistance, operation ?of a Technical Reading Room, operation of an ERDA Film Library, operation of 3 Reproduction Shop, providing copying services, and asisting visitors,

TRAINING ACTIVITIES

Table 1 provides information on the enrollment in PRNC training activities from July 1, 41975 through June 30, 1976. OF the 259 students enrolled in taining courees offered at PRNC, 36 students were engaged in thesis research. Pertinent information on thesis research ?at PRNC during FY-1976 is provided in Table 2. The geographical distribution of PRNC students from FY-1970 through FY-1976 is shown in Table 3. The total number of students ?rained at PRNC since its founding in FY-1988 through FY-1976 listed by country of ?origin is presented in Table 4.

Fellowship Support

?The President's Office of the University of Puerto Rico provided finencial support for 'PRNC students through the PRNC Student Economic Aid Program. Table 5 presents information on the eleven trainees who were granted a total of $9,560 from this Program, ?Students also were supported by the ERDA Laboratory Graduate Participation Program

?and ERDA Undergraduate Research Trainee Program, both administered by the Oak Ridge

?Associated Universities. Two students from Venezuela were supported by the Gran

?Mariscal de Ayacucho Fellowship Program of the Venezuelan Government and four students from Brazil, Mexico and Peru had fellowships from the Organization of American States.

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?Table 2: PRNC - Thesis Research from July 1, 1975 through June 30, 1976.

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?Table 3: Geographical Distribution of PRNC Students, FY 1970 through FY 1976.

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?Table 4: PRNC Students by Country ? FY 1958-FY 1976"

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TECHNICAL REFERENCE ROOM

?The PRNC Technical Reference Room functions as an autonomous branch of the UPR Mayagiez Campus Library. During FY-1976 Ms. Iraida Oliver de Padovani and Ms. Ivette Lorenzo de Vélez were responsible for operations. Ms. Grace Quifiones, who had been serving as the Librarian-in-charge, was granted a sabbatical leave by the University.

?Tables 6 and 7 present brief summaries on the Technical Reference Room collection and. utilization during FY-1976.

STAFF

Mr. Frederick ?. Rushford, Educational Officer and Head of the Training and Information Division, briefed Dr. Arturo Morales Carrién, President of the University of Puerto Rico,

fon PRNC educational activities during his visit to the laboratory on September 11, 1975. (On May 6, 1976, he met with Mr. Harold Young, Dr. James Kellet Jr., and Dr. Lawrence ?Akers, at the ERDA Office of University Programs in Washington, 0.C. to discuss the proposed Education and Training Program for the Center for Energy and Environment Research of the University of Puerto Rico (CEER) scheduled to replace PRNC on July 1, 1976. On June 28-29, 1976, Mr. Rushford participated in the ERDA Laboratory Education land Training Program Workshop held in Germantown, Maryland. At the Workshop

Mr. Rushford was invited to serve as chaitman of the Administrative Procedures Panel

He also submitted a paper entitled "A Training and Education Program for Puerto Rico's Center for Energy and Environment Research,

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RADIATION ONCOLOGY

?The Radiation Oncology Division has had as its main objectives both to operate an

?cademic training program and to carry out research on radiation therapy of cancer. Since fiscal year 1975, following a directive from ERDA, increased effort has been given to research. The research activities have been complemented by the training program, which has been oriented towards producing radiation oncologists, giving physicians short-term ?experience in radiation oncology, and teaching medical students about clinical cancer and its radiation therapy. The purpose of the research effort isto improve present modalities ?of radiation therapy of cancer.

?As in previous years, the Division has operated as the Radiation Oncology Program of ?the Department of Radiological Sciences of the University of Puerto Rico School of Medicine. It has provided radiation oncology support to patients at the University Hospital and to academic programs of the University of Puerto Rico Medical Sciences Campus. The patients, in turn, have provided the clinial basi for the educational and research projects (of the Division.

Funding has been primarily from PRNC (~40%) and from National Cancer Institute ?rants channeled through the School of Medicine (~60%). Special inter-institutional relation-ships with the San Juan Veterans Administration Hospital and the Metropolitan Hospital in San Juan have permitted inclusion of patients from these institutions in the Division's research projects. Medical physics and radiotherapy consultations have been provided to the Radiotherapy Department of the VA Hospital

?The change in mission of the Canter from multidisciplinary to energy oriented, the ?gradual budget reduction (accentuated by inflation), and the scheduled elimination of National Cancer Institute training grants on June 30, 1976, have handicapped the programs and introduced considerable uncertainty and instability resulting in @ reduction of personnel.

This has affected both the training and the research objectives of the Division,

RESEARCH ACTIVITIES

A. Residents? Projects

Bagiation induced tumor rearession in carcinoma of the esopheaus. Dr. Gloria Arroyo ?continued this study. She entered 32 patients analyzed as to sex, age, survival after treat ?ment, and symptomatic and radiological appraisal of tumor rogression with and without ?carbogen (5% CO, + 95% oxygen) breathing. The results will be published.

B. Staff ? Intramural Projects

Floor of the mouth project. This previously reported project continues the gradual

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incorporation of follow-up information on close to 200 patients who have been treated by the staff of the Radiation Oncology Division, The material is pending analysis of factors which affect the survival of these patients

Effect of therapeutic iradiation of the lung studied by pulmonary function tests and {ung sean techniques. This project is being continued at a reduced tempo because of

jack of funding. Additional follow-up information on the previously registered patients

is gradually being incorporated,

Splitcourse radiation therapy of cancer. A total of 524 cases have been registered in this project as of June 1976. The patients with largest accrual have been those with base of tongue site, a total of 144. In June 1976 the study group decided to discontinue accession of patients with this site and to proceed with analysis and publication of the results during fiscal year 1976-77. Proliminary results based on the status of the study in june 1974 were published in 1975,

Radiation-induced tumor regression in a mouse chondrosarcoma. Jointly with the Human Ecology Division of the Center, various factors influencing tumor regression after irradiation are being studied in a mouse chondrosarcoma system. A shortage of funds and personnel has resulted in reduced activity, but resumption of work is expected as soon as the Comprehensive Cancer Center of the P. R. School of Medicine recruits the services of a radiobiclogict.

Radiation-induced liver damage. A project being done in collaboration with the Surgical Research Laboratory of the School of Medicine, the Nuclear Medicine Division of the CConter, and a private veterinarian (Dr. Carlos Gémez) is simed at determining the factors involved in radiation damage to the liver. Dogs are being subjected to irradiation of the liver to various dose levels ranging from 3000 rads in 3 weeks to 4000 rads in 4 weeks. Before irradiation, biopsy of the liver, liver scan, and chemical blood studies are done.

?After iradiation these tests are repeated, to determine the extent of liver damage. The formation gained should help in preventing radiation hepatitis in humans. A paper on

this subject was presented at an IAEA meeting and will be published in the proceedings.

. Extramural Projects

Garbogen study. As of June 1976 a total of 320 cases were registered, most of them from this Division, and accession of cases was stopped. The preliminary impression is that breathing carbogen (5% CO, + 95% oxygen) during radiotherapy does not improve the ?survival of patiants with cancer of the head, neck, and esophagus. Analysis of the resul will be finished during fiscal year 1976-77

?Treatment of brain metastases. The objective of this project is to determine optimal \ways of treating brain metastases with radiation. As of June 1976, accession of patients ?was interrupted, and the results are now being analyzed.

Treatment of brain gliomas. The purpose of this project is to determine optimal methods of treating brain gliomas. Various radiation dose levels are being tested, and also combina: ?tion with chemotherapy (BCNU). In June 1976 more than 100 cases had been registered,

Medulloblastoma. The objective is to compare survivals of medulloblastoma patients ?weated by craniospinal irradiation alone or in combination with chemotherapy, in order to improve survival. Since ths is a rare condition the Division has registered only one patient to the study during fiscal year 1975.76.

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B, Medical StudentsProjects

Bone scan in sarcoma of the prostate ? Néstor C. Tirade

Tymph node metastases 10ma of the breast ? Maria C. Cardona.

Carcinoma of the endometrium, stage Hl ? Noel Tott.

Sarcoma of the uterus ? Nayda Figueroa.

TRAINING ACTIVITIES

?The training program of the Radiation Oncology Division has included a residency pro-
?gram in radiation oncology for physicians, short-term radiotherapy training for persons
With previous experience in the specialty, in-service training for medical students (summer fellows) on cancer and radiation therapy, in-service training for radiological physicists and radiotherapy technician, and a lecture course on radiotherapy and cancer for third-year
?medical students. Because of a shortage of personnel and the change in mission of the Center, both the amount and the scope of the training activities have been reduced. The training in radiation oncology will be continued for a limited number of residents, but

the training of medical students willbe interrupted until the Division can acquire sufficient staff, Inservice training of physicians and radiological physicists will be continued.

Table 1: Training Acitivities of the Radiation Oncology Division, July 1975 to June 1976.

?Name Dates Present Position

?A. Radiation Oncology Resident

Dr. Jorge A. Moscol 7798-6776 2nd yr. resident

B. Training Course for Medical Students

Lis A. Almodévar ?dun-Jul 1975, Internship

Marta M. Cardona 3 a

Antonio G. Sotomayor

Néstor C, Tirado G

Noe! Totti tl 5

Francisco J. Vizearrondo

(Carmen D. Zorila 4th yr. medical student

Maria E. Vélez a Internship

Nayda Figueroa . ?

©. Short-Term Radiotherapy Course

Dr. Guillermo Guerrea 10/75 - 3/76 Returned to Colombia

Dr. Arturo Yadrach 276 - 4776 Comprehensive Cancer Center

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MEDICAL SERVICES

In fiscal year 1975-76 service was continued at the University Hospital for patients who required radiation therapy. This was necessary to provide the basis forthe teaching of ?medical students, residents, and short-term trainees in the Medical School and the Radio therapy Division. The staff of the Division participated in combined treatment planning conferences at the Medical Schoo! lasting at least 11/2 hr twice a week, to choose the cancer patient's plan of therapy and to select cases suitable for research protocols.

STAFF ACTIVITIES

A. Scientific Meetings and Courses Attended

Or. José M. Tomé ? Annual Mtg.Puerto Rico Medical Astoc., Nov. 1975, San Juan;

?rd Ann, Cancer Course for Physicians, P.R, Div. af Am, Cancer Soc., an. 1976,

?San Juan.

Dr. Jeanne Ubifis ~ Annual Mtg. Puerto Rico Medical Assoc., Nov. 1975, San Juan; 3rd Ann. Cancer Course for Physicians, P.R, Div. of Am. Cancer Soc., an. 1976, Sen Juan,

Dr. Juan Reusche ~ Semi-Ann. Mtg. Radiation Therapy Oncology Group, San Diego, CCA, Jan. 1976; 3rd Ann, Cancer Course for Physicians, P.R. Div. of Am. Cancer Soe., an. 1976, San Juan

Dr. Victor A. Marcial ? Cancer Ed. Committee Mtg. Nat, Cancer Inst., Jan. 1976, Bethesda, MD; Midwinter Radiological Cont, Jan. 1976, Los Angeles; 2nd Plenary Mtg. Scientific Program Committee 12th Int. Cancer Congr., May 1976, Toronto; ?Ann. Mtg. Am. Radium Soc., Mey 1978, Vancouver; Am. Cancer Soe. Nat. Cont. Radiation Oncology, May 1976, San Francisco; Cancer Ed. Committee Mtg. Nat. Cancer Inst, June 1876, Bethesda MD; Semi-Ann, Mtg. Radiation Therapy Oncology Group, June 1976, Hyannis, MA,

inguished Visitors

Or. James A. Belli, Harvard Medical School, Boston, Massachusetts

Mr. Thomas Ulmer, President Board of Directors, American Cancer Society.

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le 2: Case Load of the Radiation Oncology Division July 1, 1976 to June 30, 1976.

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Faucial arch 6 Kidney 1

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? ?Hypopharynx 6 Other and Unspecified Sites

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Pharyngeal wall 1 Brin 6

Nouroblstoma 3

Digestive Organs and Paritoneum pete ;

Esophogus 2» Meningioma 1

Stomach 2 Malignant paregangioms i

Rectum ? ?Thyroid 2

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Primary unknown 3

) Lymphatic and Hematopoietic System

7 5 Reticulum cell sarcoma. 3

/ Larynx 1 Lymphosarcoma 1

i Veal cords 8 Hodgkins ease 2

Langs 2 Eosinophil granuloma 1

conn Malignant tymphoma 8

eee t ?Multiple myeloma 4

Leukemia 8

Total New Cases 956

Toletherapy Applications (Co), Mev. XI Superficial 17045

? Follow-up 11964

Curietherapy Applications 26

) a

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?Table 1: Nuclear Medicine Division Training Activities, July 1975 ? dune 1976

(institutions given in parentheses are sponsors)

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Jot N: Gespe Cas, Verena PRN)

aa Shae Rolin, Ws Hem

2, BASIC NUCLEAR MEDICINE COURSE

?hs. = On. 31, 197 FA de 30,1976

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?et Mama, PC ?Carn Aton Ps, RINE etoye; tar)

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Map de Mo M.D, PRL, Radon regent don. Fb. 1976

Marea cesT MD, Argenta ~ Fb. 23-27, 1976

Maria J. Boo, M.D. 2. Radlogy recent ~ Mar 1-3, 1976

None Main in Harton Seo: Minin Eagoinatome

?5. NUCLEAR MEDICINE 109 (Elect)

[ie A a Var, PR. dre 6, 1078

2. HUMAN BIOLOGY t: Endornotaey

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NUCLEAR MEDICINE

?The Nuclear Medicine Division conducts clinical research in nuclear medicine and offers {raining in the medical applications of radioisotopes for physicians and technicians prin= cipelly from Puerto Rico (USA) and Latin America, Diagnostic and therapeutic services

2 offered for patients from University Hospital in order to ensure an adequate patient load for research and training.

RESEARCH ACT!

tes

?A. Work Completed

Vitamin By; Absorption in Pregnancy Followed Via « Whole-Body Counter ?

A. E. Lanaro and J. J. Corcino. The data have been analyzed and a paper isin preparation

?See PRNC-198, p.50,

Use of °? Te-DMSA for the Diagnosis of Myocardial Infarction ~ A. H. Sarmiento, AE. Lanaro, and A. Suirez. The results have been written up and submitted for

publication, See PRNC-198, p.50

Evaluation of Liver Detoxification with "*C Phenobarbital ~ A. Rodriguez Olleros,

R. Dietrich, E. Taveras, and A. E. Lanaro. The data have been analyzed, and « paper has been submitted for publication. See PRNC-198, p.50.

B. Work in Progress

Use and Usefulness of **Ga in Tumor Localization ? E. Vélez Garcia and A. E. Lanaro Data were collected on ~160 patients with different malignant and inflammatory diseases, Evaluation of the data is now in progress. Soe PRNG-198, pS

Effects of External Irradiation on the Normal Thyroid and Pituitary Gland ? A. E. Lanero. ?This study isan extension of the evaluation of thyroid uptake tests thet was done at PRNC several years ago. The purpose was to compare different laboratory methods for measuring variation of thyroid function after irradiation. Only a few patients were studied during this period because of budget restriction, and no conclusions have been reached. See PRNC-198, p51

Effects of External Iradiation on the Normal Lung ? A. ?. Lanaro. This study is an ?extension of work begun with special funds from the AEC program RX O103. Followup with perfusion scans is being done on patients seen during 1973-74 in order to determine late effects on lung tissue.

Followup on Hyperthyroid Patients Treated With lodine-131 ~ A. E. Lanaro,

Hyperthyroid patients treated with" at PRNC were again asked to come in for an annual check-up. Of the 104 patients given clinical examinations and thyroid uptake tests, 61 were authyroid, 34 hypothyroid, and 9 hyperthyroid. See PRNC-198, p. 51

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Follow-up on Thyroid Carcinoma Patients Treated With "I~ A. E. Lanaro. Patients treated for thyroid carcinoma were also requested to come in for a check-up. Of the 22 ?cases seen, 16 were positive and 6 negative. The positive cases will continue to receive ?treatment.

Radiation Injury to the Liver ~ ?. Santiago Delpin, V. Marcial, and A. E. Lanaro,

?A group of dogs was tested with sulfocolloid "Te and Rose Bengal "I liver scans, "Te kidney scans, and Rose Bengal "'| clearance. They were then irradiated with verious dosss to the liver. Some of them died, but the tests were repeated on the survivors. Mony [roblems were encountered, particularly distemper and worm contamination of the dogs. ?These problems are being worked on so that the study can continue. See PRNC-198, p.50.

Biological and Effective Half-Life of Radionuclides in Children ? A. E. Lanaro and,

4.Sifontes. A protocol was prepared and presented to the National Institutes of Health ?The study plan includes the determination of biological and effective half-lives of different

radionuclides in children submitted to routine nuclear medicine tests in the Division in order to establish the relation, if any, between these half-lives and other parameters such ' 50x, age, size, and biological situation. No radiaactive material will be administered to ?any child solely for this study; only children referred for specific tests will be stdie, ?The decay of the radioactive material will be followed in the whole-body counter through ?at least two haltsives. For normal controls, the data fram children with normal results in the tests requested and without pathology in the studied organ will be used

?Study of Hepatic Tumors in Women Taking Oral Contraceptives ? A. Fuertes de la Haba, ?A.E. Lanaro, and C. Rubio. The objective ofthis study is to determine the frequency of hepatic tumors in humans taking the pill for @ long period. The maternal health program Of the University of Puerto Rico Schoo! of Medicine has a large group of women who have used contraceptives for a long time, and also good controls, These women will be studied by Te sulfocolloid scans in the Anger camera

Digoxin Levels in Patients Submitted to Closed Cardiovascular Surgery ? A. Martinez Picd, J. Sinchez, A. E. Lanaro, and J. M. Caamafo, The plan is to determine digoxin levels in patients with congenital heart disease who undergo cardiac surgery without extra corporeal circulation. Samples will be takan one day before and ?after surgery. The effects of such surgery on digoxin levels and

TRAINING ACTIVITIES

The training activites of the Division are summarized in Table 1. In addition, Dr. Lanaro pretented a seminar on nuclear medicine to 24 nursing students from Sacred Heart University College in August 1975,

MEDICAL SERVICES

From July 1975 through June 1976 a total of 4517 diagnostic and therapeutic procedures ?were carried out in the Nuclear Medicine Division, 1 smaller number than for the preceding fiscal year because of limitation of the service exclusively to the University District Hospital. This limitation saves money and results in better scientific work. A close

relationship is maintained with the University District Hospital, which produces good clini-

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cal information and more complete studies, Even so, for some tests appointments are being given with a two-week delay

ble 2: Teaching and Service Procedures Carried Out July 1975 to June 1976

Teaching Clinical Teaching Service

Thyroid studies 89 272 706

Absorption studies 10 15 33

Hematology studies m4 4 9

Circulation studies 2 1 2

Total body water 2 ° 1

Liver studies 8 2 "

onal studi " 6 28

?Organ and tumor localization 46 296 859

Camara studies n ear 1268

Subtotal 283 1287 2007

Total 4517

STAFF ACTIVITIES

A. Attendance at Scientific Meetings

Dr. A. ?, Lanaro ? First Regional Workshop of North Area of Latin Am. Assoc. of Societies of Biology and Nuclear Medicine, Aug. 1975, Mexico; Second Latin Am. Regional Iitg. of Nuclear Biology and Medicine, Caxias do Sul, Brazil, Sept. 1975; Seminar on Endocrinology, Children?s Hospital, Buenos Aires, Oct. 1975; Lectures on Nuclear Medicine at VA Hosp. and at P.R. Soc. of Nuclear Medicine, Dec. 1975; Lectures on Ultrasound at

VA Hosp. Feb. 1976; Symposium on the Thyroid (Bayamon Committee of Continuing ?Medical Education and Hospital Meléndez, nc.), San Juan, Feb. 1976; Lectures on Immuno~biology at Medical Sciences Campus and at P.R. Med. Assoc., Feb. 1976; P.R. Soc. of Nuclear Medicine Ann. Convention, San Juan, May 1976; Planning Committee of Second Congr. of World Federation of Biology and Nuclear Medicine (attended as representative

(of Latin Am. Assoc. of Societies of Biology and Nuclear Medicine), Dallas, June 1976;

23rd Ann. Mtg. of Soe. of Nuclear Medicine, Dallas, June 1976.

?AH. Sarmiento ? Lectures on Ultrasound at VA Hosp, Feb. 1976.

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8. Changes in Staff

Appointment: Mr. Vietor Serrano, Nuclear Medicine Technician, Feb. 5, 1976.

Resignations: Mrs. Aida Avila de Medina, Nuclear Medicine Technician, Jan. 16, 1976;

Dr. Aristides H. Sarmiento, Senior Scientist 1, April 30, 1976;

Mrs. Olga Aponte, Research Assistant Il, June 30, 1976.

?Ad Honorem Appointees: See PRNC-198, p.55.

C. Distinguished Visitor

(On November 23 and 24, 1975, Dr. Grafton D. Chase, from the Philadelphia College of

Pharmacy and Science, who was in Puerto Rico as @ guest of PRNC and the P.R. Society

of Nuclear Medicine, visited the Nuclear Medicine Division

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Medical Physics

?The Medical Physics Section is concerned mainly with the solution of physical problems and the development of now techniques associated with the medical applications of lonizing radiations. It provides the physics support necessary for efficient functioning of the Radiation Oncology Division, including staff training, and also offers limited technical ?assistance to the Nuclear Medicine Division.

RESEARCH ACTIVITIES

ANomogram for the Estimation of an Average Tissue-Air Ratio for Rotation Therapy Planning ? A. M, Thompson and E. T. Agard. This work (see PRNC-198, p. 57) has been published.

Isocentric Dosimetry for 8-MV Photons ~ J, C. Pacheco and E. T. Agard. This work (see PRNC-198, p.57) has been writen up and submitted for publication.

Electron Dosimetry at 3, 7, and 11 MeV ? ?. T. Agard and J. C. Pacheco. This work (see PRNC-198, p.57) is being published.

Solution of a Dosimetry Problem Caused by @ Mercury Shutter ?~ A. T. Agard,

M. A. Gribble, J. C. Pacheco, and S. Gémez F. A paper on this incident, involving the malfunction and subsequent repair of the mercury shutter system of the PRNC Eldorado-A, ?cobalt unit, has been accepted for publication.

?A Technique for Contrast Enhancement in Portal Radiographs ~ M. A. Gribble, ?. T. ?gard, and J. Reusche. At the radiation energies used in treatment of radiotherapy patients, one of the serious drawbacks in the use of portal radiographs (check-radiographs ?exposed to the radiation of the treatment unit with the patient in the treatment position) isthe lack of definition of anatomical structures. Lead filters inserted into the radiation bbeam have been able to increase the radiographic image contrast by as much as 50%,

A paper describing this research has been submitted for publication,

Calibration of B-MeV Electrons with Thimble Ionization Chambers ~ J. C. Pecheco

?and E. T. Agard. A paper on this research is being prepared for presentation.

TRAINING ACTIVITIES

1. Inservice Training

Dr. Aifredo Moscol, Radiation oncology resident ? Oct.-Nov. 1976.

Ms. A. Caraballo, X-ray technician, PRNC ? Oct. 1975.

Ms. ?. Colon, X-ray technician, PRNC ? Nov. 1975,

2, Special Training in Medical Physics and Radiation Dosimetry

Ms, Azucena Garzén-Quiréz, Ecuador Atomic Energy Commission ? May-July 1976,

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3. MS. Course in Radiological Health

?This course was placed ?"in moratorium? becaute of @ lack of funding

4, Physics Seminars

From October 1975 to June 1976, weekly open seminars were held in the Medical Physics Section. Informal papers and discussions were presented by staff members of the Section and of the Health and Safety Division, on a wide range of physics-rlated topics. ?Average attendance was 6 to 10 persons.

STAFF

Dr. E. T. Agard, Head of the Medical Physics Section, attended the Second Latin ?American Conference on Medical Physics and Radiological Protection in Belo Horizonte,

Brazil, in July 1975 and presented a paper. In February 1976, he was elected President of the Puerto Rico Chapter of the Health Physics Society for 1976-1977. To the regret fof many people at PRNC, on June 30, 1976,Dr. Agard resigned both as Section Head ?and as Chapter President; he will head a department in 3 Medical Center in Dayton, Ohio.

?Mr. José C. Pacheco attended the International Conference on Computerized Transaxial ?Tomography in San Juan in March 1976

?Mr. Michael A. Gribble, a medical physicist with four years? experience, from the Poole General Hospital in England, joined the staff of the Medical Physics Section in August 1975. Mr. Gribble has B.Sc. Honours in Physics from the University of Aston, Birmingham, England, 1971; and an M.Sc. in Radiation Biology from London University, 1974.

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HUMAN ECOLOGY

?The Division of Human Ecology conducts research related to the impact on man?s health of energy production and subsequent ecological alterations, in the tropics. The program ?also includes work on the tropical disease schistosomiasis, supported by outside agencies.

?The juxtaposition of nuclear technology and tropical diseases affords @ unique opportunity +0 apply advanced methodologies to classical endemic diseases which have been dificult to control with traditional techniques. At the same time, the rapid industilization of Puerto Rico and several Latin American and Caribbean nations makes it necessary to find ?ways of minimizing the health impact of expanding energy production in the tropical ?environment. Utilization of such advanced technology in the tropical Americas requires training of scientists and students as methods are developed; therefore, the Division main

ternational education and training in the Caribbean and

RESEARCH ACTIVITIES

Hydroelectric Reservoir Project (M. Bhajan, A. A. Brown, M. Caballero, W. Jobin, and

V. Lopez)

The purpose of this project is to assess the environmental health impacts of proposed hydroelectric reservoirs and to develop methods of minimizing them. The ecology of existing hydrovlectric reservoirs in Puerto Rico is being studied in order to determine the factors that cause or prevent health problems related to them. The major health problem being investigated is schistosomiasis, Methods will be developed for predicting the extent fof disease transmission from new reservoirs being designed but not yet constructed. ?Alternative designs and other preventive or control measures will be studied.

In this first year of the project. major emphasis was on an ecological survey of all

reservoirs in Puerto Rico prior to selection of six for continued study in the next two years. A joint team from the Health Department and PRNC surveyed 28 reservoirs, two of which (Lakes Carite and Cidra) were intensively studied with additional help from the University College at Cavey.

Lake Carite was very fow in algal productivity (0.7 mg/liter per day). The lake was turbid but contained low populations of coliform bacteria and possible viruses. The high ?turbidity contributed to the low algal populations and reduced photosynthesis. Consequently, ?the population of primary herbivores such as mollusks was low, and the lake was generally low in biota. Biomphalara glabrata were found in the emergency spillway, but they were rot infected with schistasomes. The surrounding human population was very sparse and had little contact with the water.

In sharp contrast, the Cidra Reservoir had floating masses of water hyacinth, large snail populations including Lymnaea infected with Fasciola, and gross sewage pollution including coliform becteria and viruses, probably Coxsackie. The lake was surrounded by

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?Table 1: Snails and Vegetation in Major Lakes of Puerto Rico, 1976

Lake Water General

Non Nane Bet Me Te Pa Ph Ly Te Hyacinth Vegetation

1 Adjuntas = x - Sparse

2 Caonilies = : Sparse

3 Cartte x x : Sparse

4 Carraizo x x x Abundant

5 :

6 = x x

7 x

8 a on ox x

9 Comerio #2 = XX x

10 os Bocas XXX x

Moocaras XXX x e

12 Guajateca = XX ae

13 Guayabal = XOX ees:

1% Cuyo =X .

15 Guinmo = > Xx x x

16 Jordan > x 2

YW Plata > x x x Moderate

18 las Curiae = Xx . Spars

19 Weeo) > x x :

20 luehettt = xx x

21 Matrullas = x - Sparse

22 Patills = x x 2 sparse

23 Pellejas = _

2 Prieto =x : Sparse

25 Rio Blanco = :

26 Toa Vs am x x ot sparse

27 Toro iE

2 Tortuguero XOX x

2 ivi - x

30 Yahuecas >

* ge Biomphalaria glabrata

Me= Marten cornuartetis

?Tee Tarebia grantfora

Par Ponaces australis

Phe Physa sp.

Ly Lymnaes op.

?Tes Tropicorbis sp.

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hhousing developments and pasture containing horses and cattle. Algal populations were high ?3 were insect and bird populations.

In the other 26 surveys the primary emphasis was on water chemistry and snail popula tions. All reservoirs contained aquatic snails except four, which were extremely clear lakes

(of low productivity. Biomphalaria glabrata, the intermediate snail host of schistosomiasis, was found in five (Table 1), all of which are hydroelectric reservoirs except Tortuguero Lagoon,

The other predominant snail species were Marisa comuarets (in 18 reservoirs), Tarebia aranifera (in 14), and Physa cubensis (in 6). All the reservoirs that contained Biomphalaria ?labrata had at least one and usually two of there other specie. A large ampullarid snail, probably a species of Pomecea, was found in three lakes, two of which also contained large masses of floating wator hyacinth and showed gross evidence of eutrophication such {25 algal blooms and anaerobic bottom sludges. However, one lake (Dos Bocas) showed eutrophication with water hyacinth but no Pomaces.

The lakes in general tended to be clean with low. levels of phosphates and nitrates (Table 2) It is interesting that Cidra Lake, which is known to be heavily contaminated and whose shore is overgrown with water hyacinths, has barely detectable phosphates and about 0.2 mg/liter nitrates. This tends to support reports suggesting that the water hycinth is very efficient in removing nutrients from the water. Cidra Lake has more chlorides than ?most of the others; perhaps chlorides serve as an indicator of contamination. The iron samples taken from lakes early in the year was very low but in samples taken from other lakes during the winter it was much higher; this may reflect overturn of pre

Methods for Detecting Schistosome Cercariae and Miracidia in Hydroelectric Reservoirs

?The filtration method often used to concentrate and detect cecariae in the field is being used in the reservoir study program and has been quantitatively tested in the labora: ?ory. It is essential that 2 pump with @ good vaccuum be used for the filtration oF most Of the cercariae are lost under the filter paper, and there are unavoidable losses of cercariae ?on surfaces. The recovery rate in laboratory studies closely simulating field conditions was, a rather consistent 25%

?The results of using sentinel snails for detecting schistosome miracidia was compared with the results of coliform bacteria sampling in the Carraizo Reservoir and is tributaries ?on two occassions, and in Carite and Cidra Lakes. Twelve stations on Carraizo Lake were

found to have high coliform levels (10* to 10* per 100 mi) but no miracidia. Low numbers ?of coliform bacteria were found in Lake Carite (200 per 100 mi) and no miracidia. In Lake CCidra, despite high concentrations of coliform (10* per 100 mi) and the presence of enteroviruses, no miracidia were found. Although the sentinel snail technique was satisfec: tory from the practical standpoint, it must be tested during the dry summer transmission season when miracidia are more common. The preliminary testing this year was done with extremely high reservoir levels due to heavy rainfall

Methods for Schistowome Control in Hydroelectric Reservo

Whenever feasible, biological control methods are highly desirable because they are in

?general inexpensive and environmentally safe. This is especially true for schistosomiasis Control in Puerto Rico?s hydroelectric reservoirs because many of them are used also for hhuman water supply. Data from several sources have established thot the S. mansoni

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?Table 2: Woter Quality in Major Reservoirs of Puerto Rico, 1976

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No. of

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samples

10.142.0 0,0940.08 0.0440.01 0.0440.03,

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1841.0

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6.14.7

7 From 25 samples,

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Lajas Valley irrigation and hydroelectric power system.

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Imiracidium is attracted to its host by a simple chemical or chemicals. The attractant is

?not specific, and many classes of organisms including other sails attract the miracidia

in competition with the host snail. Ths finding can be utilized for schistosomiasis contro! by introducing another snail species into reservoirs where transmission occurs and thus decreasing the probability of successful sail infections. Four snail species, Maria, Pomacee, Tarebia, and Helisoma were tested as competitors in laboratory experiments in plastic Pools with ratios of decoy snails to B. glabrata of 0, 2, 5, and 10. All the controls were >90%é infected; the highest ratio of decoys reduced infection rates in the B. glabrata to zer0 in two cases and to 20% in the third. This result is highly significant since the method is ideal for use in hydroelectric reservoirs in Puerto Rico and may make it possible to open ?many of them for recreation in the near future.

Epidemiological Modeling Project (H. Negrén and C. M. Nai

In the development of new energy production faclities and in programs to reduce pollution from existing facilities, planners need tools for predicting the environmental ?and health impact of these changes. Since PRINC isin the tropics, a subject of special ?concern is the relationship of tropical diseases to hydroelectric impoundments, which in

Latin America and Africa have had considorable impact in spreading schistosomiasis, ?malaria, onchocerciasis, and other parasitic diseases. More subtle diseases caused by air pollution from oil-fred steam plants also occur in tropical areas, especially in those ?undergoing rapid industrial development, and these also merit attention. The purpose of this project is to develop epidemiological models that can be used to predict the changes in disease prevalence and incidence related to power facilities in Puerto Rico and other tropical areas.

Epidemiological Data for African and Brazilian Reservoirs

During the year site visits were made to Volta Reservoir in Ghana and Trés Maras, Furna, and Volta Grande Reservoirs in Brazil to gather engineering and epidemiological data, Data summaries wore also obtained for Lake Nasser in Egypt, Lake Kariba in Rhodesia and Zambia, Kossou Lake in the Ivory Coast, and Lake Kainji in Nigeria, Of these 10 hydroelectric reservoirs, the one having the most complete information available was Volta Reservoir in Ghana. Preliminary modeling was completed on one phase of Schistosomiasis transmission in the Afram arm of Volta Reservoir, where an epidemic of ?Schistosoma haematobium occurred soon after filling. Feld and laboratory data on disper-sion of schistosome miracidia and cercarige were analyzed and related to snail populations, ?and the effectiveness of a chemotherapy program was compared with that of a snail

control program. The latter was shown, by simple model analysis, to cause a much greater decrease in incidence rates for local inhabitants,

Survey of Schistosomiasis Prevalence in Puerto Rico

[As the basis for epidemiological modeling of schistosomiasis in Puerto Rico, an Island= wide prevalence survey was conducted by skin testing 8 25% random sample of al fifth-graders. Antigen was prepared from adult schistosome worms, standardized for nitrogen ?content, and sterilized. Public Health nurses skin-tested >18,000 children by the seme Procedure used in the surveys of 1963 and 1969, which provided reference data, In the area of eastern Puerto Rico where bilharzi is endemic, @ serious increase was found in the

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?Table

?Comparison of Bilherzia Prevalence in Eastern Puerto Rico in Areas With

and Without Control Effort, May 1976

Pos. Total Prov

Original Control Programs

1954-1976

Aibonito 40 443 90

?Arroyo 27 236 na

Guayama 31 ae. 141

Naguabo 63 281 262

Patillas a2 444 95

Vieques 30 156 193

Total 293 2168 135

New Control Programs

1969-1976

Gurabo 33 327 10.1

Humaceo 228 730 32

stuncos 120 464 259

Las Piedras 125 390 324

Maunabo 35 258 97

Salinas 3 426 10.1

Yabucos 214 708 302

Total 798 3303 242

?Areas Not Controlled

(Samples)

aguas 124

Ganovanas 453

477

187

50.1

Rio Grande-Total 372

Sen Lorenzo 68

Trujillo Alto 253

Weighted me 28.1

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?municipalities directly downstream and east of Lake Carraizo (Canévanas, Carolina, Rio Grande, and Luquillo), and the prevalence was generally higher in rural than in urban areas (Table 3). Preliminary analysis of the results of control efforts showed a significant {rop in the prevalence rate in the areas of the original control programs compared with ?that in untreated areas (Table 4),

Schistosomiasis Control Project (W. Jobin, F. Liard, and M. Bhajan)

This project, jointly sponsored by ERDA and the Edna McConnell Clark Foundation, was aimed at making a global survey of the best available methods for schistosomiasis control in the tropics (see Figures 1 and 2); it was completed in 12 months. The conch sions reached after review and analysis of 41 projects on schistosomiasis control through ?out the tropics included the following

1. Schistosomiasis control programs should combine chemotherapy, snail control, and provision of domestic water in that order of priority. Although chemotherapy is expensive,

it provides greater benefit than the other methods per unit cost.

2. Chemotherapy with Hycanthone for S. mansoni and Ambilhar for S. haematobium {is effective and costs $3.50 to $10.00 annually (1972 prices) per person in the endemic zone. Two newer drugs, Oxamniquine and Metrifonate may soon replace Hycanthone and ?Ambithar, respectively.

3. For snail control the universally accepted chemical is Bayluscide, and annual costs per 100 cubic meters of treated habitat are ~$20 in natural drainage systems and ~$3 in irrigation systems (1972 prices). Per capita costs have limited meaning in relation to snail control, ut were estimated as $0.40 to 7.40 per year.

4. Provision of adequate domestic water will be as effective as snail control if adequate health education is included in the program. Such a program, with high effectiveness, will cost ~$10 per capita per year.

?5. Of six major control projects, only one encountered a problem in meeting i objectives, and a change in strategy corrected it. This shows that the means and ability to Control schistosomiasis are generally available

6. Projects have been initiated in 23 countries, but successful national programs have been carried out only in Iran, Japan, Puerto Rico, and Venezuela, all relatively wealthy countries.

7. Global control of schistosomiasis, defined as prevalence of <1% in any nation, would cost about $3 billion, the major costs being $1 billion each for Brazil and Egypt, and

?would take ~20 years. (See Table 5.)

8. Because of international market considerations itis doubtful that cheaper drugs or ?cheaper chemicals for snail contrat will be found.

8. The most promising approach to reducing costs is to develop biological methods for controling snails and transmission, and environmental methods for controlling snail habitats land human contact with infected water. Such methods involve costs generally outside the international market structure, and they depend primarily on local materials and unskilled labor

10. The areas for most cost-effective control operations are the ones with the highest intensity of infection and the highest prevalence rates; these are Brazil for S. mansoni tnd Egypt for S. huemacobium,

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Figure 1: Programs for control of Schistosome mansoni in the Caribbean.

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igure 2: Programs for control of schistosomiasis in Afric,

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Air Pollution Project (J. M. Chiribogs and V. A. Lopez)

?This project i concerned withthe effect of pollution due to utilization of oil for eneray ?and other purposes in Puerto Rico. Several approaches are used to correlate air pollution levels with human and animal health. Epidemiological studies seek links between morbidity and mortality in populations with high and low risk. A small epidemiological study in Catafto and Guayanilla uses the Espirit Santo area asa control.The Catafio area has the Palo Seco plant, one of the major producers of both gaseous and particulate pollutants in Puerto Rico. ?recent change in the combustion system has reduced its particulate output by a factor of ten, and a correlation is being sought between this dramatic change and loeal health data ?The incidence of respiratory disease and asthma encountered in the emergency room at Catafo has been extraordinarily high (Table 6).

Biological Test System for Pollutants That Domage DNA

Biological test systems are being developed in the laboratory for detecting substances in ?the atmosphere that can damage DNA. In one system, the growth of an B. coli mutant eficient in DNA polymerase is inhibited by mutagens because the mutant cannot repair the damage to the DNA. The response of this mutant to benzopyrene and hydroxyurethane is being quantitated. In another system, cells are exposed to the toxicant and then examined for micronuclei. The sensitivity of the method is not very high, and an attempt has been

?made to enhance it by using irradiation (Table 7).

TRAINING ACTIVITIES

Participants in the Division's educational activities ae listed in Table 8.

?Thesis work is summarized below. An asterisk indicates that the work has been com~
pleted. All degrees were from UPR School of Medicine.

?The Etfects of Gamma Irradiation on Different Stages of Fasciola hepatica, José Luis
?Tortes (for M.S. in Anatomy? under Dr. J. Chiriboga). Study of the alteration in
of normal Fasciola hepatica metacercariae at a function of storage time at 4°C showed
a significant decrease only after 100 days. Comparison of the in vitro viability of normal
?metacercarie with that of those exposed to increasing radiation doses revealed two opposite
sttecte (a) activation of the excystation process by the lower radiation doses (1.5 and
25 kR) persisting up to the 14th day postradiation and (b) impairment of the process
starting on the 1th day by doses of 3.5 and 6.0 kR. Rats were used to study correlation
?between liver damage and radiation dose to metacercariae, up to 34 days after oral
inoculation, Hepatic parenchymal destruction was measured in terms of serum glutamic
pyruvie transaminase (SGPT) levels. Rats infected with 1.5-kR-irradiated metacercari
showed a greater increase in SGPT level than normally infected rats, which has been
tentatively associated with inability of the developing worms to find the liver ducts.
?Metacercariae irradiated with 2.5 and 5.0 kR produced only a sight elevation of SGPT.
Correlation wat good between SGPT level and macroscopic and microscopic liver lesions

in rats infected with unirradiated and irradiated worms.

Adult F. hepatica incubated in Hedon-Bleig solution for 6 hr release many types of proteins, some of which are neoformed judging by the incorporation of ?Se:methionine. ?These proteins were purified by Sephadex G-100 and gel electrophoresis. The Sephadex lution curve had two peaks, A and B. Peak B precipitates specifically with Fasciole~

?Table 6: Respiratory Ailments Among ~2000 Patients Seen in Emergency Room

?of Cataio Health Center, January 1976

Asthma 98 %

Other Respiratory 16

Allergy 2

Cardiovascular 2

?Table 7: Effect of Benzopyrone and Radiation on the Percent of Micronuclei in Bone

Marrow of Mice (For each group 1500 bone marrow cells were counted

from 3 mice)

Group ?% Micronucle!

Control oz

Benzopyrene (2 mg) 013

Benzopyrene + radiation (200 R}) 1.00

Radiation (200 R) 020

?Table 8: Participants in Educational Activities of Human Ecology Division

(From Puerto Rico unless otherwise noted)

Project Participants Date

Fasciola hepatica Dr. Rene Cardona 18Jun75 ? 2040175

?Schistosoimiasis, 15 Inspectors, Health Dept. 1Sep75 ~5Sep75

?Michael G. Ubrin (PA) 10ul75 ? 308ug75

Ange! Laracuente 1ul75 ? 30Jun76

Hydroelectric Reservoirs Martha Caballero (Peru) 1ul75 ? 31Dee75

4 Students, UPR-Cayey 1075 ? 314an76

?Ada L. Irizarry 1Jun76 ~ 304476

Luz E. Torres 1Jun76 ? 30476

?Amarilis Siva 1un76 ? 3044076

Parasitology vin Cartion 1475 ? 30un76

Fossil Fuel ?Ana L. Rodriguez 1475 ~ 30un76

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positive rat serum but not with normal rat serum, and ammonium sulfate precipitation showed a high specific binding. Each peak obtained was found to be a mixture of proteins. ?The electrophoresis pattern showed 4 bands in peak A and 3 bands in peak B. Protein synthesis in adult parasites irradiated with 1.5 and 2.5 KR increased; in those irradiated with 5.0 KR it decreased slightly.

1 was concluded that (1) metacercarial excystation is not hindered appreciably by storing at 4°C for <3 months but is greatly reduced by longer storage; (2) radiation doses (of up to 2.5 kR do not impair metacercarial excystation within 2 weeks postirradiation; (3) inocula of 2.5-kFitradiated metacercariae are capable of excystation in rats, some of ?the flukes reaching the liver and a few completing the normal trajectory through its parenchyma but never developing into normal adults; (4) protein synthesis by adult flukes ia not significantly affected by radiation doses as high as 6.0 KR,

Genetic Analysis of Microsporum sypseum Complex at the Molecular Level. José A.

Carrasco (for Ph.D. in Microbiology, under Dr. J. Colén). A new procedure for the isolation and purification of fungal DNA yields a highly purified and polymerized product. During development of the procedure 2 protamine-ike protein, oF nonhistone chromosomal protein, was discovered, tightly bound to the fungal DNA, which could have important implications in the genetic control of the fungus. The DNA was labeled with tritiated Uridine, giving counts of 1700 dls/min per jug ONA when the label was on carbon-S and ?4000 when it was on carbon-6, The incorporation of radioactive pyrimidines suggests that A gypseum contains thymidine phorphorylase, a trans-N-deoxyribosyl transferase, and thymidine kinase, These enzymes have been reported in Escherichia col! but not in [Neurospora crassa, Qualitative analysis of the DNA showed the usual purine and pyrimi-dine bates. The mole percent guanine cytosine found for the Microsporum gypseum complex was 44.6 in gypsea (+), 46. in gypsea (-), 46 in incurcata (-), 44 in fulva (+), and 40.8 in fulve (-). ONA hybridization on nitrocellulose filters showed a marked differ-tence between species and between donor and recipient strains. A high degree of homology ?ound between N-gypsea and N. fulva suggests that they are closely related. N. incurvata ?2ve less hybridization with gypsea than with fulva, even though incureata and gypsea fare supposed to be more closely related. The technique developed will be usful for classi-fication studies in mycology.

Multiplication of Sindbis Virus in L-Cell_ Monolayers. Nitza Magali Divila (for M.S. in Microbiology," under Dr. J. Colén). Chronie Sindbis vius infection in Leells was established in 14-day-old monolayers by changing the medium every 2 hr after virus Inoculation, and in 24:hr monolayers by changing it every 2 or 3 days. The 14-day-old LLeell monolayers were ?cured? of Sindbis virus primary infection by changing the medium every 2 oF 3 days. Chronically infected L-cell monolayers were cured by adding 220 units of interferon per ml to the system. ells produced a small amount of interferon on

primary infection with Sindbis virus, and none or undetectable amounts once chronically infected. Chronically infected L-cels were resistant to superinfection with homologous Virus, and with the heterologous viruses NDV and influenza A PRs. Doses of 1,000 and 10,000 rads of gamma radiation had no effect on the state of chronicity or on virus produetion. Spontaneously ?cured? L-cells behaved the same as previously uninfected Les. A review of the literature on interferons and their importance in persistence infections is included.

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Interferon Production in Viral Mutated L.cells. Mercedes Rodriguez (for M.S. in

?Microbiology,* under Or. J. Col6n). Interferon was isolated from irradiated chick embryo ?monolayers derived from hens grown in Puerto Rico. Chick interferon was shown to be synthesized very early in the growth cycle of Sindbis virus. A substance of protein nature ?that stimulates virus growth was also isolated in these monolayers. Monolayers prepared ?rom embryos from imported eggs were shown to be very poor producers of interferon and virus-stimulating protein. A rapid and efficient method was described for obtaining interferon antiserum in rabbits. Evidence was presented for the presence of two proteins With interferon activity in chick embryo monolayers infected with Sindbis virus. The anti interferon serum was used to demonstrate the presence of interferon in irradiated mono layers from imported eggs. Timing experiments with gamma radiation and exogenous interferon supported the proposed model for interferon synthesis and action. A review of the literature from the discovery of interferon in 1957 to 1876 was included.

Gamma Radiation and Virus Multiplication: Evidence for the Genetic Control of
Seren Deer ee Fe eee eed ee eee ee,
Eddy 0. Rios-Otivares (for Ph.D. in Microbiology, under Dr. J. Colén). The effect of gamma radiation and actinomycin D on Sindbis virus reproduction was studied in chick ?embryo fibroblast monolayers. Radiation doses of 1,000 rads or >25,000 rads, given 1 hr before infection, markedly inhibited viral reproduction, whereas a dose of 10,000 rads

ignificantly stimulated it. The increase after radiation was greater when a complex medium ?was used rather than one deficient in amino acids. The number of calls forming the mono-layer and the multiplicity of infection had no effect on the enhancement of virus growth, Treatment of monolayers, 2 hr before virus infection, with 2 ug/ml actinomycin D, also stimulated viral production at the early stages of the growth cycle. Treatment of normal calls with actinomycin D reduced uridine incorporation by 98°, whereas radiation (10,000 rads) slightly inhibited it. During the first 6 hr of infection, cells treated with 10,000 rads showed, {an increase in uridine and cells treated with actinomycin D showed a significant decrease. [Although not atthe same rate, Both 10,000 rads and actinomycin D decreased normal celular INA synthesis and consequently protein synthesis. These results suggest that both agents ?may act by inhibiting a collular constituent, perhaps a protein (interferonike, which regulates viral synthesis. The results indicate that changes in the capecity of chick embryo monolayers te support Sindbis virus growth after being exposed to different doses of radiation are media ?ted by the presence or absence of a protein similar to interferon.

?A model for genetic control of the interferon system has been proposed, in which the interfering activity of the cell on viral growth is probably regulated genetically by the ?action of four structural genes and their respective controls, operating through a combined negative and positive regulatory mechanism. Normally, when an exogenous inducer acts fon the control region of the interferon gene, interferon is produced and stimulates the transcription of the translation inhibiting protein, which creates the antiviral refractory state in the cell. When sufficient protein has been transcribed this process is stopped. Produetion of interferon and of this protein is terminated by a blocking protein coded by 18 gene, which could act as superrepressor or interferon gene repressor or at the level of translation of the interferon gene mRNA.

Proteolytic Enzymes in F hepatica. Genaro Ortiz (for Ph.D. in Biochemistry, under r=. Chiriboga).

Biological Methods for Testing Environmental Hazards. lette Ramos (for M.S. in ?Biochemistry, under Dr J. Chirbowsy.

54

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Loading Jon-boat for photosynthesis studies in hydroelectric reservoirs

Lake Dos Bocas in the Arecibo River below Utuado.

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Table 1: Monthly Mean of Daily Maximum and Minimum Tomporatures at Sites

Downstream From Power Plant Discharge

je STEIN Ses Ses

Mo.¥r Min. Max Min. Max. Min. Max. Min,

Moy 75 959-378 «4.2359 0B 2

Jun 75-356 570-330 5S 318332

wl 75 363-379 92384318 RB

Aug7S 376 390 59 75 GDB

Sep 75 368 384 354372319 86.

(Hurricane)

Oct 75 977-386) 351370 2320

Nov 75 360 37.7 «339-3585 309324

Dec 75 339 «347 «314-3268 29.3

Jan 76 309-230 «3A 27380.

Feb76 320 332 303-326 «289780 269 8.3

Mor 76-318 «331-300 31882272 HS BB

Aor 76 336 «35231933599 316.1405

Moy 76 960 375 335 252 24 308 293 08

Jun 763460361 2B 3473313 29.10

Figure 1:

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MARINE ECOLOGY

Marine Pollution Studies

The purpose of the marine pollution studies is twofold: (1) to investigate and evaluate ?the effects of stresses on the coastal marine environment associated with the continuing development of the largest energy-producing and petrochemical complex in Puerto Rico and (2) to determine the management alternatives for the wise utilization of energy and

The eneray complex (an oil refinery, 2 fossil-fuel power plant, and downstream petro chemical plants) lines the shores of Guayanilla and Tallaboa Bays, which are protected by offshore reefs end cays (Figure 1). The dominant current is from east to west, and it catres pollutants through Tallaboa Bay into Guayanilla Bay and then out to sea. Tallaboa Bay is fairly open to the sea, but water movement in Guayanilla Bay is restricted by a narrow channel, which favors the accumulation of pollutants from the energy complex on ?the eastern side of the bay.

?Many independent studies have been conducted in this are; but an integrated research ?approach is needed to investigate and evaluate the effects and fates of pollutants introduced nto Guaysnilla Bay.

?An integrated team approach will be used to investigate the interaction of physical, ?chemical, and biological systems in the Guayarilla-Tallaboa Bay area. The pollutants will

be identified and characterized, and their transport within and through the bay ecosystem

Il be determined. The stresses they impose on the biological systems will be measured and evaluated. Research programs for the next five years are the subject of a comprehen sive plan now being developed. The work done from July 1975 to June 1976 was Drimarity on the effects of the power plant's thermal discharge on the local marine ?commurity, and on surveying the trace metal contents of some of the organisms.

RESEARCH PROGRAMS

?A. Physical and Chemical Oceanography (M. D. Banus)

Extensive physical and chemical acesnographic data wil be required for en understanding ?of water movements and transport of heated effluents and pollutants in Guayanilla and ?Tallaboa Bays. The program to obtain such data was not initiated during the past year because of a lack of equipment and personnel, but some temperature monitoring was done 8 part of the study on the effect of thermal enrichment on mangrove survival and growth, ?The thermal monitoring program had two parts. (1) The surface water temperatue wos ?measured about once every two weeks for ten months at 12 to 18 sites (see Figure 1)

located in both Tallaboa and Guayanilla Bays and including the discharge both from the {coneo canals and from the 1100-MWie) fossil-fuel plant. Additional measurements were ?made during fish and benthic sampling periods. Because the power plant discharge was

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?Table 2: Percentage Breakdown of Monthly Zooplankton Counts st Guayanilla Power Station

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?Table 3: Total Standing Crop Values of Thala testudinum, 1976

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Station Date Crop.

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Tome ane aat09

Jobos

x wm 6183

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expected to have a large effect on the mangroves, four sites were continuously monitored ?with recording thermographs installed about 20 cm below mean low water.

Table 1 lists the monthly means of daily maximum and minimum temperatures. The ?drop in June 1976 resulted from shutdown of one 440-MW unit from 13 June until about 6 July 1976. At each site the diurnal variation is 1.5° to 2°C, probably due to decreased ower plant operation at night and to solar heating. Between Sites D and 3A is a A7 of -2°C.with a ar of -3°C to Site 5

Biweekly temperature measurements showed tht the temperature of the plant intake {Site R) was about 1° above the ambient in Guayanilla and Tallabos Bays, and that a7

through the plant varied between 8" and 12°C. The maximum temperature of discharge was 41°C, The entire cove receiving the discharge had temporatures within #0.2°C of the values recorded at Site D. A few vertical temperature profiles showed no variation from surface to bottom within the cove. An intrusion of cold water along the bottom appears {at the lagoon entrance (Site T) on some tides. The enclosed high temperature body of ?water is called the thermal lagoon (or cove) in the studies described below.

Temperature measurements in Tallaboa Bay showed a moderate thermal discharge from the canal (Site 1) flowing shouthwest along Pta. Gua 1nd having a AT that varies from 1.4? to 7.2°C with most values at 6°C. At night and in winter, weak N to NE winds let this watm effluent spread into the zone between H and Z, but in the daytime, strong E to SE winds compress it so that it stays within ~100 m of the shoreline. At H, in the daytime, AT is ~1°C, but at G (closer to shore) A7 is higher, 1.5° to 2.0°C. A transect from H to the shore showed an increase from 29.3°C (ar = 1°C) to 32.5°C by ~25 m from the beach. At the same time, G was 30.5°C. This warm water goes around Pia Guayanilla, with Site M being 0.5° to 1.0°C above the ambient in Tallaboa Bay, and it ?transports hydrocarbons from the canal and possibly heavy metals and other pollutants. |

B. Plankton Project in Guayanilla Bay 1975-1976 (Mary Nutt, Hilda Rojas, and J. Suarez Caabro)

?The research on thermal tolerance of plankton started by Youngbluth (PRNC-179, 'bs125) was continved. Acartia sp. was choten for study because itis the most common species of copepod in Guayanilla Bay. It was found that the live copepods in the thermal cove were not introduced by the cooling water of the Guayanilla Bay power plant.

?The question remains as to whether the Acarti sp. in the cove is tolerant to thermal stress or whether a separate population of Acartia sp. is undergoing thermal adaptation in ?the cove. The thermal cove Acarta sp. population collected in the winter (30° to 34°C) ?could not survive in vitro at 37°C and above,but the summer population (exposed to at least 37°C in the cove) could survive in vitro at 38°C for 2 hr and at 41°C for 10 min.

?Monthly sampling of the plankton population in Guayanilla Bay, begun by Youngbluth (PRNC?1796), was continued. Table 2 presents the results for the thermal cove and intake: Monthly sampling was also done in the shore and offshore areas.

Future research will include further tests of the thermal tolerance of Acartia sp. and ?measurement of parameters affecting their physiology, both in the laboratory and in the field. The qualitative and quantitative distribution of plankton, especially Acartiasp., in the thermal cove will be determined. The results ofall these studies will help clarify the physiological ecology of this copepod.

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Figure 2: Total standing crop of Thalassia at Jobos (A) and Guayanila(B) stations.

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Figure 3: Leaf width of Thalassia at Jobos (right) and Guayanilla stations.

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©. Ecological Evaluation of Tropical Seagrass Ecosystems in Industrially Disturbed and Undisturbed Environments (Vance P. Vicente)

Guayonilla Bay is an industrially disturbed marine environment. Many of its seagrass ?meadows (which are fragile tropical marine ecosystems) have not been studied; those that have, have not been compared with undisturbed meadows in Puerto Rico. A compar

tive study was therefore initiated in February 1976, Of the eight Thalassia beds being studied, four are in the industrially disturbed bay, two being continuously exposed to higher than ambient temperatures due to thermal effluents from power plants and two being at ambient temperatures but subject to other aspects of the industrial environment. ?The other four beds are in Jobos Bay, under natural environmental conditions. Visits were ?made to several additional Thalassia meadows around Puerto Rico to obtain data for ?comparison of specific ecological parameters.

?Thalassia beds in Guayanilla Bay at higher than ambient temperatures have suffered ?more deleterious effects than other beds, as shown by their low standing crop (SC) values, ?which include weight of roots, rhizomes, and shoots (Figure 2 and Table 3). The beds in undisturbed habitats in Jobos Bay have much higher SC values (up to about 25 9 dry wt per 0.02 m*), and Station & located close to the thermal effluents, showed the lowest, values (ess than 2 g). Low SC values have serious implications, since the SC value largely determines the physical and biological stability of » Thalassia bed ecosystem. The roots {and rhizomes provide physical stability by preventing soll erosion, and the amount of leat ?material isthe major factor in the amount of energy going to support upper trophic levels,

?Thalassia in Guayarilla Bay have shown other effects also. The two beds exposed to thermal effluents do not form sexual reproductive bodies, and the two at ambient tempera tre are practically inhibited from formation of buds, flowers, or seeds, probably by some type of pollution other than thermal; whereas the four beds under natural conditions in +4obos Bay showed prolific formation of reproductive bodies, seen on up to half of the shoots. Other beds around Puerto Rico were prolific also (see Table 4). Both the leaves and the rhizomes of Thalesia exposed to effluents are thinner than those of undisturbed Thalassia (see Tables § and 6 and Figure 3).

Other biological parameters measured for Thalassia seemed to be determined by genetic {factors or biotic factors such at grazing pressure and did not correlate with physical para meters. These are being investigated further

Besides the damage to the seagrasses due to thermal effluents and probably to other pollutants in Guayanilla Bay, effects are seen on the macroalgae and invertebrates of the floral and faunal assemblages. Table 7 shows that the macrosigae have a lower species diversity at Station 8 (exposed to thermal effluents) than at Station 7 (not so exposed), Reductions have been seen also in the typical Thalassia faunal assemblages at Stations 1 and 8. The urchin Lytechinus, the gastropod Tegula fascata, many bivalves such as Chione cancelletaand Codakia, corals such as Manicina areolata, and many other species Formally forming part of a Thalesia faunal composition have been killed, only recent fossils remaining.

Temperature, visibility, sani
presented in Tables 8 and 9,

and oxygen values for the Thalesis beds studied are

a

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Table 4: Percentage of Tholesia Shoots With Reproductive Bodies (Buds, Flowers, or Fruits)

in Seagrass Bods Around Puerto Rico, 1976

Site Location Date Chew

No. %

Laguite ME coast 5/22/76 ?0 10

P. Las Marine N const 8/22/76 so °

P. Arenas Weoast ? $/27/76 ?6 1s

las Croabas(migéle) E Coast 5/23/78 so 2 .

2 oboe st 5119/76 ?6 Py n

X Joboe st sige so ° uw

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10 Guayanitia sw sie so 2 .

8 Guayenilia SW sri7s so ° °

Sea. 7 cyayanilia SW srs so ° a

Ste, 1 Guyanitle srr so ° °

?Table S: Leaf Diameter Measurements of Thalassia Leaves, 1976

Station Date Diameter + $.0., mm

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obos (average of 25)

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Guayanitla

Rhizome Diameters of Thalassia testudinum, 1976

No. measured

Diameter + §.0., mm

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astos

210s

2eto4

az08

ssi04

az02

a203

az04

ase

apes

az0s

sae

asi08

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Table 7: Common Macroalgee (Including Seagrasses) in Thalassia Beds in Guayanilla Bay Exposed to Thermal Effluents (Sta.1) and at Ambient Temperature (Sta.7).

ee

Station 7 Station 1

Seaton ee

Hypnea spinela Thalesie testudinum

Holophileballonis Holophila ballonis

Caulerpa vertcilata ?Acanthophore spcifera

Chondria sp. Caulerpe vertcillata

Ceramium sp Cyanophyta (unid. sp.)

?Acanthophore spicifera Gracilaria sp,

Halimeda opuntie Enteromorpha

Gracilaria sp.

Caulerpa sertularoides

Caulerpa mexicana

(Ctudophore sp.

Dietyota bartaysesi

Caulerpa verticllata

?Thalasia testudinum

?Monthly Average Values, With Standard Deviation, of Temperature, Salinity, and

Visibility February to June 1976

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Jobos

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?Table 9: Temperature, Salinity, Visibility, and Oxygen Content in Guayanilla Bay

8 24?Hour Period, August 11-12, 1976 (TC = Thermal Cove)

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Oem ppm

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1. Mangroves (M.D. Banus)

1, Survival and Growth of Seedlings and Small Trees Under Thermal Stress

{In western and southern Puerto Rico most new mangrove seedling settlement is taking place in shallow water Thalassia beds protected by coastal coral reefs. The survival. root ing and growth of mangrove seedlings has been studied and reported (PRNC-198, p.92). Current research shows a survival from seedling to small tre of 54 after two years for 100 seedlings put in a 4_X 4-ft net cage with mud bottom in a moderately sheltered cove 4at Pta. Ostiones. Thirty-four of the trees had one or more prop-roots. These seedlings ?wore subjected to natural conditions (including a severe storm), but were protected from direct contact with boats, floating palm branches, and logs. The survival of another batch ?was only 35% because some seedlings were swept out of the net at eight months. Both ?batches are now overcrowded.

Seedlings are used in thermal stress studies both because they provide the means to regenerate the mangal and because often the juvenile form of an organism is more sensitive to stress than the adult. Seedlings from trees in the thermal lagoon at Guayanilla ?were found to be significantly shorter (20.6:4.1; 21.5+4.2 cm) than those from trees in ?other parts of Guayanilla Bay (29.426,9 em), in Boqueron Bay (30.7=5.0 cm), and in Pita, Ostiones (31.9:5,9 emi, and the differences were shown not to be related to tree height. They are probably due to thermal, not to other, stresses, The smaller seedlings

have much less chance of finding a location of the optimum water depth to survive and ?grow. The seedlings from thermally stressed tres,when held in a control area, were also found to have slower leat formation but slightly faster root formation than the seedlings ative to that area

?The effect of thermal stress was studied by comparing sub-bstches of 100 seedlings each: those from Site D and Site 3A being held either in the thermally enriched water or at the contro site at Pta, Ostiones; those from the control site being held either there or at Sites 1D and 3A (see Table 10). The seedlings from the thermally stressed tres did not survive 13s well in the heated water as they did in ambient water. Seedlings from trees in ambient ?water did very poorly in the heated water. The seedlings (local and control) at Sites D and 3A, placed in mud substrate on 12 September, showed little further growth, although ?many formed roots. By December at Site D and by February at Site 3A, even though the temperatures had decreased, all the seediings were dead except 16 of the control seedlings at Site 3A, which, starting in December, grew rapidly and well The results show that ?temperatures >37°C even for part of the day are eventually lethal for seedlings, and those between 35° and 37°C drastically inhibit root and leat formation and survival, but some seedlings from non-sressed trees can survive in the 35° to 37°C range and then grow when the range drops to 31° to 34°C.

?Small tres raised in water at ambient temperatures were planted in June 1975 at Site D, 25 with their roots always subtidal and 25 with roots bared at low tide. All were leafless in two weeks and dead in three weeks. The mean maximum daily water temperature was, ?37.5°C. The experiment was repeated in December 1975 with 33 trees planted at each site (D, 3A, and control), of which 20 were from seedings picked from Site D'and rooted fat the control site and 13 were from seedlings from Boqueron Bay (Table 11). At Site D

all but two survived and most grew within two months. At Site 3A, all survived and all

?were growing wel at three months, more vigorously than those at the control sit.

?New sub batches of 20 trees were planted at each site on 1 June 1976 (Table 12).

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Table 10: Water Temperature and Seedling Growth, June 12 to September 12, 1976

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LC, mean (range)

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Seedlings

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Max. Max. Min,

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?The survival at Site D was higher than the previous year, perhaps because of lower tem= pefatures in mid-June. During the 1 June to 20 July period, most of the December trees planted at Site D continued to grow

?established small tees if they are acclimated gradually. The loss of five trees at Site 3A ?was due to planting in water that covered them during part of every tide; growth of the small trees isnot inhibited at 35° to 36°C.

2, Uptake of Trace Metals by Mangrove Seedlings

?Mangal sediments and pore-water are the source of nitrogen, phosphorus, and the many for growth of the trees. These metals can be toxic if present at

8, Cu, and Cr), and other metals such as Cd and Hg are of no

known benefit to plants, The availability of trace metals to plants depends on their con-

the sediments and on the presence of compounds such as sulfides or chelators

in the pore-wate.

?The absorption of trace metals from sewege sludge by mangove seedlings has been under study for two years at PRNC as part of a larger EPA study (J. R. Montgomery et al., presented at 3rd ERDA Environmental Protection Conference, Chicago, September 1975). Rooted seedlings were grown to small tees in flowing seawater tanks, one containing sewage sludge and the other being a control. The roots, bottoms, growing shoots, and leaves from trees in both tanks were analyzed for C4, Cr, Cu, Ni, Pb, and Zn. In the first experiment, the roots of the experimental trees had Cr and Cu concentrations double those of the control trees after 125 days; they also had significantly high concentrations fof Ni, Pb, and Zn at 60 and 125 days; and the concentrations of both groups of metals increased with time. The data on the other portions of the trees show no significant increases for any metals.

Roots can act as a barrier to the movement of some trace metals into growing shoots, but this wat not demonstrated for mangrove trees by the present study because the experi~ ?ment was not run long enough

8, Trace Metals in Mangrove Leaves and Seedlings

?The leaves and seedlings from trees at several locations in the Guaysnilla-Tallaboa area and from trees in Baqueron Bay and Pra. Ostiones have been analyzed for the trace metals Fe, Mn, Cu, Zn, Cd, Pb, and Ni (Table 13). All sites have been sampled a second time but ?analyses are not yet complete. An unusual feature of the data isthe very high Mn values {for the Guayanilla leaves, the highest being for the leaves from apparently unstressed trees ?The very high Fe and Cu values for the Guayanilla heated leaves may be due to stress or to's higher metals content in the sediment. Agreement between results for different sampling batches is within the standard deviation for most elements and locations.

Typical batches of seedlings from all locations (Table 13) have a manganese concentra tion 3 to 4 times as high in the top asin the bottom, probably because of the photo- ?synthetic processes in the growing shoot, and Mn content is significantly higher in seedlings from the three Guayanila sites than in those from the other sites. Iron content is not significantly different in tops and bottoms, and is lower in the seedings from Pta. Ostiones ?and Tallabos, probably because these locations have the lowest agricultural and/or industrial inputs, The copper content is similar in tops and bottoms, and is significantly higher in ?the seedlings from the Guayanilla mangal inside and outside the thermal lagoon. The zine content is higher in tops then in bottoms of seedlings except those from Tallaboa,

?and is lower in thote from Tallaboa and Pta. Ostiones than in those from Boqueron and Guayanila,

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le 13: ?Trace Metals in Mangrove (ppm dry wt.), Mean + 8.0. of 10 Replicates

(6 tops and § bottoms for seedlings)

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0.13 2 0.08

<8 ost 2 0.18

ea 0.33 $0.08

0.08 $0.06 «0.7

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Figure 4: Italic numbers are foraminifers per sample; underlined numbers are individuals in the meiofaune other than foraminifers.

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The differences in trace metal content of leaves and seedlings from various locations

?may be due to diferent levels of the metals in the sediment, and evaluation of this factor will require sediment and pore.water analyses. Another possibility is that in some locations ?the metals are in forms more available to the mangrove roots. For example, the leaves {rom the small tres in the sewage sludge experiment (both control and treated) had much higher levels of Ca (1 to 2 ppm), Cu (6 to 7 ppm), Ni (3 to 4 ppm, and Pb (4 to 6 ppm) ?than leaves from the trees in Pta. Ostiones from which these small trees originated. Alter= ?atively, the vatious amounts of thermal enrichment to the trees in some areas of Guayanil Bay may affect the transport of metals to fruit and leaves. Zn, Fe, and Mn are all involved in various metabolic processes in plants; thermal enrichment may change the process rates and therefore the metal concentrations,

. Foraminifers of Guayanilla and Tallaboa Bays (George A. Seige)

?The purpose of this work is to study the foraminiferal assemblages in Tallabos and Guayanitla Bays in relation to the environmental effects of the effluents from the petro-chemical and power plants. The foraminiferal assemblages of Guayanilla Bay have been described by Seiglie (Rev. Esp. Micropaleontol. 7, 453-88, 1975). The dominant foraminifers ?are Ammonia catesbyana in the shallower parts and Fursenkoina punctata in the deeper parts; in the latter, an area 10 cm? with a depth of 1 em, the number of foraminifers was higher than the number of nematodes. Nematodes were far more abundant in Jobos land Mayagiez Bays. The length/width ratio of Fursenhoina punctata appears to be related 10 pollution.

Methods of Study

A modified Shipeck grab was used to take samples of the undisturbed surface of sedi-?ment, 10 em* and 1 oF 2 em deep, which were preserved in 30% ethyl alcohol and stained in the laboratory with Rose Bengal for about 8 hr and then washed in an 0.0625-mm-?mesh sieve. The various species of living and dead forami
Drecentages computed,

TTollaboa Bay

Tallaboa Bay is limited on the south by Palomas and Rio Cays. The longehore current ?transports part of the petrochemical plant effluents into the shallow waters (up to ~6 m) ?near the coast where the sediments are sandy. In the doepest part of the bay (6 to 9 m), between the shallow area and the cays, the sediments are sandy clays and clayey sands, and the water quality is affected by clean oceanic waters and by petrochemical effluents

?according to the pattern of currents indicated by M.D. Lair et al. (EPA Tech, Study ?TS.03-71-208-02, pp. 1-45, 1971). At the stations shown in Figure 4 in Tallabos Bay, 23 samples were taken.

. Gonzélez was the first to study the foraminiferal assemblages of Tallaboa Ba (UPR Master's Thesis, 1969). He found the dominant foraminifer in the deepest area to ?be Fursenkoina puncteta (x F. pontoni), with living specimens occurring in silty clays Containing visible amounts of oil; and he found no specimen of Bulimineliselegantssima.

{In samples taken in 1975 and 1976, the dominant foraminifer wat Fursenkoina punctata in the deepest part of the bay and Ammonia catesbyana in the shallowest part, and 59 species were found (see Table 14). The individuals in the samples were counted according 10 the major taxonomic units that occur in Tallaboa Bay: Foraminiferida, Gasteropods,

n

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?Table 14: Living Foraminifers in Tallaboa Bay

Amsobaculites cf, directus

ae saisus

Aawonia ?catesbyans

! Angulogerina, angulosa

| Astronsnion sp.

!

|

Vtalina lowmans

Striatule

ef, variabilis

sp.)

Gincris'sagra

Grltroeiphfdiua poeyanun

csp t

Gjeloayra invorvens

Discorbis? butbose

Eguerelia aff, advena

Eiphidiun advenun

HiSsurina pellucida

Hlorilus.gfateloupit

Fursenkoina complanata

Fe punceata

Gioborassitina subgiobesa

Glosospira goratatts

Hapie

Hopkins

Tanene nevis

Toxsstomum Lanceotatus

Mitiotinetta.subrotun

Nonioneli

Ne topina

No erkeitis

fragilis

n

Youris polysorphinoides

Parviteherina textularioides

Provelphidium ef; delicatuiun

Peeunodosaria torrida

Quinqueloestina bose tana

candes

Sef Tamarckiana

S thodiensis

> Seminulun

Subporvane

a]

spit

aps 3

Roophix caribeusis

Be hana,

R

fosalina. floridana

Sagrina cubsna

siihalenctte

Signo! topsis arenata

Spfriiitna densepunctata

Spirolocutina communis

ianina advens

Ti quadri tops

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Figure 5: Specific diversity.

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Figure 6: Location of fish gil-net stations (distribution of mangroves is also shown).

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Bivalvia, Amphipoda, Copepoda, Ostracoda, Nematoda, Polychaeta, and other worms. The ?numbers of foraminifers and other meiofauna are given in Figure 4. The specific diversities of the foraminiferal assemblages of Stations B and TAL-2 were calculated with different ?numbers of individuals counted (see Figure 6). f 80 or more individuals are counted, the specific diversity isthe same because the number of species increases with the number of Individuals per sample.

?The most significant characteristics of the foraminiferal assemblages are as follows (1) The mean diameter of Ammonia catesbyana in Tallaboa Bay is smaller than in Mayaguer, 4Jobos, and San Juan. (2) The living foraminiferal assemblages in the deep part of the Bay are larger than those in other previously described areas of Puerto Rico (Segle, op. cit: in Aguirre Power Project Environmental Studies 1971 Ann. Rept., pp. 54-7; Carib, J. Sch 14, No. 1-2, 168, 1974). (3) The total number per sample is larger for foram for nematodes at four stations in a line N-S of the concooutall, but the reverse is found.

In other parts of the Bay (see Figure 4). (4) Buliminellaelegantissima it relatively abundant in Tallaboa Bay.

BB. elegantissima occurs in the waters off Southern California (O.L. Bandy et al., Limnol. Oceanog. 9, 112-23, 124-37, 1964; 10, 314-32, 1965; Geol. Soc. Am. Bull 75, 403-24, 1964, in Ocean Sei. Eng.: Joint Conf. Marine Technol. Soe. and Am. Soe, Limnol. Oceanogr. Trans, pp. 55-76, 1965), off Central America, and in the Gulf of Carioca (Seigle and Bermidez, Unio. Oriente Bol. Oceanogr. 2, No. 1, 1-88, 1961), all of which have upwelling waters and abundant nutrients. It is found in large numbers also in lagoons of the Gulf Coast ?and in the Mississippi Delta (W. R. Walton, in Approaches to Paleoecology, pp. 161-237, Imbrie and Newell, ed., Wiley, 1964), where, again, nutrients are abundant. Since Gonzélez found no B. elegantissima in Tallaboa Bay in 1968, its presence - and the large foriminiferal Populations ~ are probably due to the increased nutrients from the CORCO outfall

F. Fish Studies in Guayanilla Bay (Joseph J. Kimmel).

During the past year fish samy

objectives:

1. Survey the fish quantitatively for not less than 12 months and observe seasonal

?changes and effects of temperature changes due to power plant effluents.

2. Compare condition of fishes in thermally stressed and unstressed zones.

3. Determine spawning time of fishes in thermally stressed and unstressed areas.

4. Examine food habits of fishes in and near thermally stested areas

5. Compare species diversity with that found in other studies

6. Record incidence of fish parasitism in fishing areas.

7. Determine thermal tolerances, including critical thermal maxima and preferred

temperatures, of soveral species of Fishes

8, Analyze fish muscle and viscera for heavy metal and possibly for hydrocarbon content.

8. Investigate life history and ecology of Lupinoblennius dispar Herre, a fish collected from Guayanila not previously reported from Puerto Rico

ing in Guayanilla Bay was initiated, with the following

Methods

Monthiy gilnet samples were taken in and near the termal cove inthe eastern sector of Guayarilla Bay (Figure 6). At each of the five stations « bottomrigged monofilament gill ?et, 40 X 2.5m with # 5-cm stretched mesh, was set for a period averaging 2.2 hr. Hal ?the sampling was done during the day, between sunrise and sunset. Except for the artificial temperature and chemical stresses, the stations are very similar

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?Table 16: Most Abundant Fishes in Gill Net Samples From Guayanilia Bay.

(Upper number shows number; lower number shows weight in grams)

Family out AUG SEP DEC JAN FEB OMAR MAY JUN JUL Tom

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Description of Stations

?The eastern part of Guayanilla Bay is bordered almost entirely by the red mangrove Rhizophora mangle, with minor populations of the black mangrove Avicenna nitida and ?the white mangrove Laguncularia ceria. Aquatic plant material is sparse compared with ?that in unstressed areas, and no turtle grass, Thalasia testudinum, grows at Stations 1,2,

oF 3. Another marine phanerogram, Halophila sp. is present at Stations 3, 4, and 5, but

in low abundance. Inside the thermal cove the only plant able to survive is an unidenti-fied bule-green alga, although during the cooler winter a green alga, Enteromorpha sp. ?may appear for a month or two. Within the thermal cove, mangrove root communities, Consist only of barnacies, isopods, @ few crabs, and the above algoe, but outside it they

?are normal, at described by Kolehmainen and Morgan (at 34th Ann. Mtg. Am. Soe. Limnol Oceanogr, Tallahassee, Mar. 1972)

?Water depths from station to station vary from 1.7 to 3.8 m. The bottom sediment at all stations is grey to black muds with small percentages of sand. Stations 2 and 3 have strong currents, approaching 2 knots at times; Station 1 has bottom currents of varying rections and velocities; Stations 4 and § have only low velocity wind-driven currents, Water temperature in the thermal cove (Station 1) ranged from 29.0" to 30.4°C with a Yearly mean of 36.3°C; since the cove is well-mixed, it varied no more than 0.4°C from

surface to bottom. At Stations 2 and 3, surface bottom temperature variations as great a5 88°C have been measured; Stations 4 andS show no temperature stratification, Dissolved ?oxygen measurements show complete oxygen saturation at al stations, due primarily to turbulence caused by consistently strong winds and/or prevailing currents.

The Catch

Bay. They represent 21 families and 43 species. The most abundant are listed in Table 15, Five species of mojarras (Fam. Gerridae) and four species of jacks (Fam. Carangidae) ?numerically represent 26.4 and 26.5% of the catch respectively. Among mojara, the most abundant species is Gerres cinereus; among jacks, they are Caranx latus and C. hippos. ?The families Sciaenidae (croakers), Sparidae (represented by a tingle species, Archotargus ?rhomboidali), Elopidee(ladyfishes and tarpon), and Mugilidae (mullets) numerically repre~ sent 11.8, 9.0, 7.7, and 6.55 of the total catch respectively. Ifthe fishes are ranked by biomass, the order is Carangidae (26.7%), Geridse (21.341, Elopidae (17.0%), Muglidee (9.341, Sciaenidae (7.1%), and Sparidee (5.2%

Although the gilnet survey is not complet, inferences about seasonal frequency of ?occurrence can be made for several families. Gerridae and Carangidae are present through

?out the year, with peak occurrence between December and July. Scisenidae are present through=
?out the year, but with varying species composition, the snake crosker, Ophioscion adustus,
being abundant from March to July, and the eroaker Bairdiella rhonchu from September
to February, with much overlap in occurrence. Archosargus rhomboidalis, Fam. Sparidae,
?abundant from February through July but virtually absent the rest of the year. Elopidae
?and Mugilidae are less abundent but are present throughout the year.

Cateh/Unit Effort (C/E)

Because of uncontrollable variables such as inclement weather, sickness, equipment
failure, etc., the field sampling efforts in studies such as these may vary from sample period
{0 sample period. A catch per unit effort (C/E) was therefore calculated for each sampling
trip at each station:

?

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?Table 16; Nocturnal (N) and Diurnal (D) Catch/Unit Effort (G/E), July 1975 to July 1976

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© Number or Weight of fishes sampled

?E = Sumber of gil nat sets X Average sampling time

?The C/E values discusted below are in units of number of fish/hr; with few exceptions, C/E valves as biomass/he show similar trends. On a monthly basis C/E for all stations was highest from December 1975 through June 1976, which indicates a positive correlation between high C/E and lower average temperatures,

?The data from individual stations show some interesting trends (Table 16). Staion 1, which isthe hottest because of proximity to the thermal effluent source, has the lowest

average C/E, at expected. Station 5, one of the two ?control? stations with consistently low temperatures, has the second lowest C/E according to the sparse data available. Station 4, the other ?control,? has a C/E that is third lowest but isan order of magnitude higher than that of Station 5, primarily because of the grester development of mangroves, ?which provide more protective cover and more potential food for fish. Stations 2 and 3 ?are both located in the mouth of the thermal cove and have water temperatures not greatly different from Station 1, but C/E values in some cases ae higher by many orders ?of magnitude,

?Temperature Effects

?Table 17 lists temperature and C/E at each station. The data for Stations 1, 4, and 5, show that C/E values in the heavily thermally stressed area are similar to those in unstressed ?areas; however, species composition is quite different. The Shannon-Weaver species diversity index within the thermal cove is much lower (3.66) than in outside areas nearby (4.86) (Kolehmainen and Morgan, op. ci; F. D. Martin and J. W. Patus, in Proc. 27th Ann. Conf. SSE Assoc. Game and Fish Commissioners, pp. 675-88, 1973).

Elevated C/E values at Stations 2 and 3 can be interpreted as indicating that fish are attracted to the hot water areat in large numbers but hesitate to venture into such areas for any distance of length of time. A possible attraction might be an abundance of nutrients, due to death of small organizms passing through the hot water, which may serve as a direct ?or indirect food source forthe fish. The data for Station 1 indicate that temperatures 38°C exclude all fish.

Diurnat-Nocturnat

?The C/E values at all five stations show diurnal-nocturnal differences (Table 16),

?greater abundance of fishes being captured at night

?during the day (between sunrise and sunset). This trend is not uncommon and is the basis

{or the timing of the field efforts

Limitation of Deta

?As seen from Tables 15 to 17, the data for July 1975 to February 1976 are incomplete.

During the early stages, certain planning decisions had to be made regarding station locations,

type of equipment, time of sampling, etc, that required preliminary data. The

are, however, important in interpreting the overall results.

Work in Progress

(Other studies of the Guayanilla population of fishes include evaluation of spawning in and around the thermal cove and correlation with temperature; observation of food habits; and planned work on temperature tolerance

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?Table 17: Temperature (°C) and C/E (No. of fish/he) for Each Station,

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July 1975 to July 1976

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G. Aquarium Laboratory (M.D. Banus).

?An aquarium laboratory equipped with running seawater was completed. It has an ambient-light experimental area of about 850 sq ft, a controlledііght room, an office, 2 large office laboratory, and a sample preparation and study area. A dual pumping system supplies seawater to a 10,000 gal tank from which the dual supply lines fed the various experimental areas. A system provided with titanium heat exchangers and control valves circulates 60°C seawater through the experimental area to various micracosmsm.of which sixteen 1-m* and two 2-m? are available. Control and measuring cireits are currently boeing installed

This laboratory. is now ready for experiments on the effects of elevated temperatures on single species of fish, benthic organisms, plants such as Tholassia and mangrove seedings, {and communities of organisms. Long-term expariments on optimum growth temperatures {and on effects of temperature on reproductive cycles and on survival of juveniles will be possible. Also, the effects of added trace metals and hydrocarbons can be studied either with or without elevated temperatures

EDUCATIONAL ACTIVITIES

A. Dr. Gary W. Smith of Furman University, Greenville, $.C., spent the summer studying fishes at CER. He investigated the effects of elevated temperature in combination with ?cadmium uptake for two species (Sphoeroides testudineus and Lutjanus apodus) He completed his field and laboratory Investigations but is still interpreting his results.

B. Theses

Osmotic Behavior of Acanthophora spicifere. Hilda M. Rojas de Morales (for M.S, UPR Mayaguez, under Drs. T. R. Tosteson and L. R. Almodévar) ? Acanthophore spicifera (Rhodophyceae) isa red alga asociated with the roots of mangroves in shallow weter ?long the southwest coast of Puerto Rico, and its habitat is subject to sharp change in tonicity due to rainfall, runoff, and evaporation. To study its osmotic behavior, the alga ?was incubatad in isotonic seawater and in seewater solutions ranging in tonicity from 700 {0 1300 mOsmol ?kg H; 0 for periods of 18 min to 18 hr at constant temperature (28°C) in the light and in the dark. The isotonic water content of A. spcifera was 10.886:0:3, 9 H;O/a dry wt, remaining constant over 18 hr of incubation and independent of the light regime, During osmotic equilibration for up to 18 hr, in both the light and dark,

in tonicities of 700 to 1300 mOsmol/kg H:, the mean fraction of the total water that \was osmotically responsive (43.11%) remained constant. The C1? content of the ?remained constant through all periods of incubation in the lght,and the estimated Cr concentration (6756.8 jzmole/¢ H:O) in the algal water remained constant through 18 hr ?of incubation in fotonic media inthe light, 35 did the Na content and estimated concentration (20426.1 jumole/g H,0). The K° content ofthe alga increased with incubation time in the light and the estimated average K° concentration in the algal water after 4 hr was

2721.9 jumole/g HO. This alge was found to have a higher CI? and K° and 3 lower Nit ?concentration than seawater, with the CI? and K' contents of incubated algae being de-Pendent on light but not the Nat content. On the basis ofthe Nat, CI, and K° contents,

?A. micifera appeared to be ina state of incipient plasmolyss. The data were consistent

at

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with the idea that this elge equilibrates otmatically by gaining or losing water. The experi ?mental conditions did not affect the alga?s subsequent viability,

Effect of Thermal Stress on Nitrogen Fixation in Guayanila Bay. Marilyn C. Kimball (for MS. U. of Miami, under M.D. Banus) ~ The objectives of this study are (1) to estimate the contribution of combined nitrogen from biological nitrogen fixation in the Sediments along a thermal gradient, (2) to characterize the nature ofthis fixation, and

(3) to describe the distribution of nitrogen chemical species in a thermally enriched portion fof Guayanilla Bay. Nitrogen fixation is a widespread occurrence in the sediments of

Guayanilla Bay, most of it from March to August apparently being due to non-photosynthetic bacterial activity. Rates of fixation by microflora inhabiting surface sediments were about the same at all in situ incubation temperatures during each month, but the rates increased from March to June and subsequently decreased. The mean monthly rates ranged from

"10 to 20 ng N/a. dry wt sediment/hr in April to 40 to 177 in June; the highest rates were found in the thermal cove in a mat composed predominantly of Microcoleus chonoto-

plastes, a non-heterocystous blue-green alga. Rates of fixation were correlated with develop rmant of the mat along a depth gradient. Mean monthly maximum rates ranged from

1893 jug N,/m/r in May to 1725 in August, with a maximum mean of 2065 in June in the intertidal and most developed portion of the mat; the rats in the least developed Portions at depths of 2 m ranged from 46 in May to 29 in August, with a maximum mean (of 230 in July. The data collected to August did not indicate a direct relationship between temperature and nitrogen fixation. Nitrogen-fixing microbial populations appeared to be Selectively stimulated because of thermal tolerance and/or elimination of less tolerant ?competitors. Synergistic effects with seasonal changes in light were also seen,

?The Effect of Thermal Stress on the Photosynthetic Potential of Mangrove Leaves.

Luise Ferrara, College of Mt. St. Vincent, New York (for summer project under M. D. Banus).

Comparative Ecology of Seagrass Bed Communities. William Allan Flynn, St. John?s University, Minnesota (for summer project under V. P. Vicente

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KINI ATOLL PROJECT (Ross J. Santiago, Fausto Mufioz-Ribadencira, M. Pérez-Padré, ?and G. Arocho)

?The purpote of this project isto determine the distribution patterns of plutonium and ?americium in the marine waters, sediments, and organisms of Bikini Atoll and the influence ?of physical, chemical, and biological parameters on their movements through the marine biogeochemical systems. The scope of the project includes clarification of the physical, chemical, and biological processes determining the movement of "Pu. ®? Pu, and

%* am from the sediments of the weapons craters at Bikini into the waters, plants, and ?animals, and also the distribution patterns of these radionuclides in the components of ?the system. This involves transfer rates and distribution patterns of Pu and Am from

water and sediments through specific planktonic, pelagic, and benthic ecosystems. The project was started in 1973 (see PRNC-176, pp. 124-9, pp. 106-11)

During this reporting period the 44 sediment samples (coarse and fine fractions) collec- ?ted during the October-November 1974 resurvey of Bikini Atoll and the C42 core from

?bravo Crater were analyzed for plutonium content. Determination of Am, Eu,

Sp, 19h, 7Cs, #?Bi, and *°Co in the sediment and core samples was caried out by ?gamma counting. A computer program for calculation of gamma analysis results was developed. The ten water samples collected in the 1974 resurvey were analyzed for Pu {and Am. Taxonomic classification of the 47 plankton samples collected at 38 different stations in'the Bikini Lagoon was completed,

RESEARCH COMPLETED

Plutonium Analysis

Sediment Samples. Sediment samples collected during the October-November 1974 resurvey of Bikini Atoll have been analyzed for plutonium content. The samples were collected with a pipe dredge at 44 different stations (see Figure 1) and brought to the PRNC laboratory for grinding, sieving, ond separation into fine and coarse fractions. For ?analysis, 500 mg of sediment wat spiked with Pu, dietolved in acid, and passed through

?two AG1-X8 anion exchange colurmns in nitrate form, The Pu eluate of the second column ?was repestedly evaporated to dryness with a mixture of HNO, and HCI; the residue was issolved in 1 M HNOs ; and TTA extraction was done to purify the plutonium, which was then electroplated for 05 hr on a stainless stel dsc at a current density of 1 amp/em* ?The results are given in Tables 1 and 2.

Core Samples. The bottom half of the core (C82) was analyzed for plutonium content from depth 105 to 207 em. The 306-cm-long core, taken from the Bravo Crater in 1972, was cut into 3-cm sections which were oven-dried and ground, and 500-mg portions were taken for Pu analysis by the same procedure as that used for the sediments. Table 3 shows the results. The frst half of this core, 3 to 105 cm, had been analyzed previously.

Gamma Analysis

?The contents of *! Am, "* Eu, "Sb, '**Rh, "Cs, ?Bi, and **Co in the sediment and core samples were determined by gamma counting, Homagenized and ground 80-9

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?samples were placed in 125-mi, 2-in.-dlam plastic jars and counted for 1000 min on a '30-cc coaxial Ge-Li detector housed in a lead cage to reduce background. All samples

?were counted at the same position relative to the center of the erystal with <5% dead ?time, and all spectra were read out on paper tape. The efficiency of the detector at different energies was determined by counting standards of known activity atthe same ?geometry as the sample and plotting calibration curves. Spectra obtained from counting ?the standards for 1000 min were inspected to find the principal gamme peaks for each nuclide of interest. Peaks that were free of interference (where possible) and containing sufficient counts to give reasonable statistics were chosen. The so designated channels {rom the spectrum of each standard were processed by the cAuwa computer program to find the area of each peak. The areas, or observed counts/1000 min, for each peak were averaged across the four standards.

?A graph plotting efficiency as a function of energy was made. Also plotted were previous results obtained from liquid standards prepared in an earlier attempt to determine detector efficiency. Although not directly comparable because of the slightly different self-absorbtion and geometry characteristics of the samples, the curves are in good agreement at energies, and give some idea of the reproducibility of the system. Two points on the

ny curve do not fit exactly: the "Sb peak at 463.5 keV and the "Bi, peak at 1063.7 keV. The fist discrepancy can probebly be attributed to poor statistics and to fan unidentified interfering peak or peaks; the second has not been explained. Since a standard for ' Rh was not available, the counting efficiency was read from the graph ?taken as 0.45 + 0.02%. There is some question whether this peak hae been propery ident fied in the samples.

?The standard activities and observed counts (interpolated in the case of " Rh) were suplied to the cauwa program along with appropriate portions of the spectrum of each

?experimental sample. Gana then calculated the areas of the specified peaks and the ?activites ofthe associated nuclides in picocuries/gram for each sample. The results for the sediments and core C#2 are shown in Tables 4,5, and 6.

Plutonium and Americium Analyses of Sea Water Samples

?The 10 water samples collected during the October-November 1974 resurvey of Bikini ?Atoll have been analyzed for Pu and Am content

?About 20 liters of filtered water wore collected at different stations (see Figure 1) and ?brought to PRNC, where each sample was acidified and spiked with Pu and 3 Am to ?check the chemical yield, and the transuranium elements were coprecipitated with ferric hhydroxide. The precipitate was dissolved; iron was removed by ether extraction; and Pu ?and Am were separated by ion exchange. The purified radioelements were electroplated ?on stainless ste! discs for alpha spectrometry. The alpha spectrometer system consists of ?our 300-mm* diode detectors, each sample is counted for 1000 to 2000 min to collect

?enough counts for acceptable statistics. The results are presented in Table 7.

RESEARCH IN PROGRESS

Analysis of fish samples for Pu, **Pu, and °*' Am is continuing in order to obtain additional information needed for defining the mechanisms causing the difference between uptake of **Pu and of Pu by marine organisms. The 45 plankton samples collected in

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1974 will be analyzed for the three radionuclides. The results will be related to the patterns (1) in Bikini Lagoon at present, (2) in the plankton samples collected in 1972, (3) in the 1974 water samples, and (4) in the bottom sediments

Analysis of the remaining sediment core samples from the Bravo, Tews, and Zuni Crates for radionuclides will be continued,

Figure 1: Chart of Bikini Atoll showing stations where samples were collected during October and November 1974. Top: sediment; bottom: seawater

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isintegrations/minutes per gram) of Fine Fractions (F)

?of Sediment Samples.

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"Fable 3: Plutonium Analysis (disintegrations/minute per gram) of C82 Core From

Bravo Crater (Bottom Half of Core)

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TRANSFER AND DISPERSION OF ORGANIC POLLUTANTS FROM AN OIL REFINERY THROUGH COASTAL WATERS

?The objective of this study is to determine the organic pollutant load in coastal waters {and sediments and its pathways from an oil refinery-petrochemical complex into Guaya rilla and Tallaboa Bays.

Research (M. D. Banus and J. A. Castrillén)

The total hydrocarbons in the sediments and water were measured during several sampling

periods over a wide grid in Guayania and Tallaboa (Sites A through R, Figure 1) by standard analytical methods. Triplicate 2-liter water samples were required for adequate precision. Duplicate analyses on large-surtace (1-cm-deop) sediment samples gave excellent Precision. The sediment levels indicated accumulated hydrocarbons, and the surface water Concentrations showed real-time distributions depending on wind and current action.

?The survey data suggested that the two major sources of hydrocarbons were seepage ?rom waste ponds through the mangroves into the adjacent lagoon waters (Sites C and D) ?and drainage from the discharge canal at Tallaboa (Site 1). Next to the main cooling Water canal in Tallaboa is a small parallel ditch that appears to be heavily contaminated with hydrocarbons. The mixing zone betwoen this ditch and the bay water was taken as {2 new sampling site, 1, ,, and asthe base of @ sampling grid including Sites 8, H, G, Z, ?and X. A second grid, based on Sites C and D next to the mangroves, was set up by ?adding Sites T, S, U, and J. Triplicate water samples were taken at the sites of each grid

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within a 2-hr period. Two soparate benthic samples were collected for each new site, and duplicate sub-samples were analyzed for total hydrocarbons. Table 1 shows the results.

?Table 1: Total Hydrocarbons in Sediment and Water Samples

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{In the mangrove lagoon area, Site is in the seepage area, and globs of oil float to the surface if the sediment is disturbed. The hydrocarbon values in sediment for S, T, and C ?are significantly lower than for J and U, being the lowest for S. This indicates that hydrocarbons leaving the lagoon or the burner area C accumulate in an area W to WSW of the sources. During the day winds are from the SE so that surface water flow is to the WNW. ?This is confirmed by the water analyses, which show significantly higher hydrocarbon concentrations in surface water at S and J. However, the daytime winds appear not to be very important to the hydrocarbon movement. Since the water at these sites is only 1 t0 2m deep, except for a deep narrow channel between J and, itis well mixed between surface and bottom by the winds.

?The grid based on the Tallaboa discharge canal shows clearly that the drainage ditch is 8 substantial source of hydrocarbons, although the ditch itself cannot be tested for hyeocarbon level and flow volume without trespassing on refinery property. Very little of the hhydrocarbon has moved east to Site B (near the mouth of a river running through the refinery) or over to the nearest mangrove island (Site X). The wind and wind driven current ?move the effivents from the canal and ditch SW along the shore of Punta Guayanilla During the daytime in the summer, when the wind is E to SE, the current is held close 10 the shore as shown by the hydrocarbon levels in the water. Site G is ~ 100 m from shore and site H, >300 m. Hydrocarbon levels in the sediment show that during the night: time and in winter, when winds are NE, the effluent plume has deposited substant amounts of hydrocarbons at H and lower amounts at G,

?The shape of the effluent plume has been followed by biweekly temperature measure ?ments as part of another study. The discharge from this canal is 5° to 7°C above ambient.

During the day the heated water is closer to shore so that Site H usually has a a7 of +1", but Site G almost always has a 7 of +1.5° to 2°C.

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In order to check the efficiency of the sediment extraction process, sediments which hhad been previously analyzed in duplicate were spiked with 60 mg of Diesel cil and re-?analyzed. The results (Table 2) show a mean recovery of 93% of the spike from three sadiments with low hydrocarbon levels and three with moderate levels.

?Table 2 Recovery of 60 mg Diesel Oil Spike From Sediment Samples

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?The data so far are for total hydrocarbons only. Identification of specific compounds and determination of relative amounts has not been done because of lack of equipment

?and personnel, but such information is necessary if the hydrocarbon levels in sediment

?are to be related directly to a particular source such as petroleum. The problem is compli

cated by the changes in hydrocarbons due to weathering and bacterial action. The hydro

carbons in surface water are probably of lower molecular weight than those in sediment,

and of a different class. Sediment hydrocarbon levels near the loading and unloading

docks (Sites N and R) were 0.06 to 0.10% in spite of obvious surface oil spills on several

?occasions. This ol did nat accumulate in sediments down wind: Sites O, P, and Q had {

levels of 0.05 to 0.07% by wt on samplings a month apart. Therefore, a careful study of

the compounds in both water and sediment, along with laboratory experiments on

weathering and sediment interactions, will be required for an understanding of sediment

burdens in rlation to inputs

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BASIN:

Figure 1: Cabo Rojo Study Area

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?TRANSFER OF PARTICULATE POLLUTANTS, INCLUDING SEDIMENTS DISPERSED DURING CONSTRUCTION OF OFFSHORE POWER PLANTS.

(Gary C. Goldman, Roberto Castro, and Gina Laite Sénchez)

?The purpose of this program is to determine the ecological effects that would result ?rom offshore construction of power plants in the Cabo Rojo Platform, an are a few kilometers offshore, west of Mayagiez. The primary effects would be those due to resuspension of the bottom sediments brought up into the water column during the Construction phase, The study, begun in January 1976, is expected to last one year. ?The major aspects are described briefly below.

?of Sediment. This must be determined in order to predict how much material ?would be disturbed by the construction. A literature search will be made; if this does not Provide the needed data, sub-bottom profiling will be done if possible.

Physical Properties of Sediment. The size distribution and shape of the particles and, it possible, their origin and mineral content will be determined. To accomplish this, cores ?will be taken and analyzed as a function of depth into the sediment. Sediment surface

samples will alzo be secured throughout the basin for analysis. Literature will be reviewed.

?_ Benthos. The bottomlving organisms will be sampled throughout the basin for identification and population analysis, and the literature will be searched for information on the tffects of resuspending the sediment. The study will be extended to adjacent areas if ?necessary and if time allows.

?Trace Matals. The amounts of potentially toxic trace metals may be increased by resuspension; therefore, their concentrations in the sediment and water at specific locations will be determined,

?Water Currents, For adequately prediction of the path of the resuspended load rem ing in the water column, the normal current patterns in the basin need to be determined.

Projected Trelectory. The probable path the resuspended sediment will take is projected (on the basis of settling rates, current patterns, and bottom topography. This is the mast

important part of the entire study.

"To date, the planning phate has been completed, with the program schedule determined. [A significant change in the program duration (reduction to one year) resulted in restriction (of the work to the Northern Basin of the Platform (Figure 1). Two cruises have been ?made into the study area.

?The first cruise, 25 March 1976, was made aboard the R/V Pelumbo (PRINCI, with the purpose of obtaining core samples. A piston corer was used to collect three 1.5-m-long ?cores to be analyzed for particle size and trace metals, as a function of depth. The results wil be compared with sub-bottom profiles available from the San Juan office of

The US. Geological Survey.

?The second cruise was made on 20 April 1976 aboard the R/V Medusa (UPR), to collect, water, sediment, and benthos samples and to make temperature and salinity measurements throughout the Northern Basin atthe stations shown in Figure 1. At each station (1) salinity and temperature were measured, (2) three benthos grabs were made, and (3) two bottom ?sediment samples were taken; water for trace metal analysis was taken at station C only.

?The temperature and salinity data (Table 1) were taken one mater below the surface, at mid depth, and one meter off the bottom.

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nisms have been identified (Table 2), but so few were collected by the dredging technique, that diver operations may be needed for further information

liminary work on size analysis of the sediment hae shown much of the material

to be in the range <64 microns. For this material, the pipette settling technique is applicable. The technique is being tried both with distilled water (for actual grain size analysis) and with seawater (for true settling velocities).

Water current measurements with current drogues ate being planned for later this

From the current information and the setling velocities, a particle trajectory will be ?estimated, as one step toward assessing the impact of the resuspension.

Educational Activities

Mr. Dennis G. Hall, A senior at Northern Arizona University, worked with the project from June to August 1976 as an ORAU Summer Trainee.

Table 1: Temperature and Salinity Data, Northern Basin of Cabo Rojo Platform, April 1976.

Station Sonic depth (m) Station depth (mn) Temperature (°C) Salinity (*/00)

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?Table 2: Cabo Rojo Platform Benthos, April 1976

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PILOT STUDY ON RAFT CULTURE OF THE MANGROVE OYSTER

(Kenneth W. Watters)

?The project on raft culture of the mangrove oyster (Crassostrea rhizophorea) in Puerto Rico wes concluded. In previous stages suitability of various organisms for mariculture

Was tested, and techniques for successful raft culture of the mangrove oyster wore developed, ?The objectives of the final stage were (1) to provide technical support to local fishermen engaged in a pilot raft-culture effort, (2) to obtain data from the pilot studies to enable ?wider use of oyster rafts, and (3) to prepare a pamphlet in Spanish and English explaining in simple terms the steps necessary to build and successfully operate oyster rafts.

METHODS

Building and Emplacement of Commercisl Seale Rafts

sn were recruited from the town of Boqueron, to construct and operate
scale (12 by 16 ft) oyster rafts, The rafts were constructed under the
supervision of project personnel from materials obtained from the Puerto Rico Department
?of Agriculture, and were emplaced in Laguna Rincén, Boquerén, on 26 June 1975. The
fishermen were instructed on building, maintaining, and harvesting the rafts. A ?demonstration
hharvest was made on an experimental raft on 10 July 1975, and the fishermen were allowed
to sall the oysters harvested.

During the remainder of the experimental period, project personnel assisted the fisher
?men (later, only one fisherman) by advising when to clean the cultch plates, when to make
?repairs, etc. They also inspected cultch plates periodically to determine rates of spetfall
?and fouling. When the rafts were harvested, in March 1976, they counted the marketable
?oysters and noted the proceeds of their sal.

Puerto Real Study. The lest experimental raft was removed from Boquerén in July 1975,
red up, and repaired. It was put into Puerto Real Bay with 20 cultch plates on

?8 August 1975 and then periodically monitored for spetfall, the cultch plates being cleaned

a8 necessary.

Preparation of Pamphlet. Material for the pamphlet was gathered throughout the year. Photographs were taken of every phase of each operation, including building the rafts and cultch, plastering the cultch, checking the cultch for cleaning, and harvesting. Procedures

that had been worked out on the experimental rafts were modified both at the fishermen?s ?suggestions and by further experience. Data gathered on harvest size and value were included, $0 that the recommendations in the pamphlet represented as closely as possible the experience of the users of the raft-culture system.

RESULTS

Commercial Ratt Experiments

By September of 1975, one of the two fishermen had abandoned his raft, but the other

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lone took it over. Significant spatfall on the rafts did not start until the middle of ?November 1975. The long delay was probably due to Hurricane Eloise, on 13 September, Which dumped enormous amounts of water, making tho lagoon virtually 2 froshwater lke for about a week and keeping salinities lower than normal for more than six weeks. By December, both rafts had considerable numbers of spat, © count on 12 December showing averages of 64 and 48 oysters per plate for the two rafts all of very small size. After ?monthly cleaning to remove fouling organisms, the two rafts were harvested in March 1976, vielding 2223 oysters from one raft, and 1512 from the other, The harvest data are summarized below.

Whole Broken Total Gross income

(doz) (doz) (doz)__ at $0.75/doz.

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aft 2 118 a 128 35.40

Both rafts yielded a mean of 46 oyster/frame, and the stated selling price was $0.75 per dozen. The gross income is some low because not al oysters were sold; some of those from the fist raft were taken for personal consumption, and ~70 dozen from the second raft were allowed to spol

?The initial cost of the materials needed to make one complete raft with cultch was $228.00. Eleven mar-hours were needed for construction and another hour for assembly and emplacement. Maintenance is estimated to cost about $36.00 per year for replacement of wiro, reinforcing rods, Styrofoam, ete.

Puerto Real Study. From August to December 1975, very litte spat settlement occurred on the raft in Puerto Real Bay, the mean count in early December being 2.5 spat per cultch plate. In late December an extremely heavy spatfall occurred, with most of the plates s0 heevly covered on both sides with oyster spat, in the size range 2 to 6 mm, that counts could only be estimated-the estimate was several hundred spat per side. By

fe March 1976, it was obvious that growth was very slow, few oysters being >15 mm size. Since no evidence was seen of a large mortality like that on mangrove roots in Puerto Real due to the oyster drill (Murex brevifron), itis clear that off-bottom culture denied this predetor access to the oysters. In April, half the cultch plates in Puerto Real

were cleaned of fouling and moved to Laguna Rincén in an effort to obtain better growth, ?but by the end of June 1976, this had not materialized. Oysters in both places were about ?the same size, probably because of crowding, and because the plates were moved when ?the oysters were more than three months old, well past their growth peak.

Preparation of Pamphlet

By April 1976, all of the date needed were at hand for preparation of a pamphlet in English and Spanish describing in layman's terms how to build and operate an oyster raft, Including lists of materials for raft and cultch, and photograph and drawings of the various stages in construction, harvesting, ec. The pamphiet, to be printed in August 1976, will be Volume VIII, No. 1, of the Agricultural and Fisheries Contribution of the Puerto Rico Department of Agriculture, and will be distributed by the PRDA Commercial Fisheries Laboratory

Discussion

Oyster culture has been brought to avery limited commercial scale in Puerto Rico. A ?method has been developed, modified, tested, and tried by local fishermen which will produce cultured mangrove oysters at 3 modest profit. However, the method at it stands {by no means ideal, nor isthe environment in which to carty it out. Only one area in Puerto Rico, Laguna Rincén, has been shown capable of producing oysters on a commer cial scale. Other areas, such as Puerto Real, show promise for obtaining spat, but spatfall {limited to certain times of the year, and is of unpredictable density. Even in Laguna Rincén, spatfll appears to be the major problem: its prediction is uncertain, and its timing and density even more so. This results in an unpredictable production of ?marketable oysters, a major problem for the culturst. Although theoretically oysters will ?grow to market size in three months on raft cutch, it might be six or eight months, as in the case of the pilot project, before sufficient oysters have set and grown to make harvest ing worth while

?Also, there is no guarantoee that the existing work force can be induced to become ?oyster cuturists. At present, since there is no way of demonstrating the entire system, ?the potential culturist has to take @ great deal on faith. Economic incentives have lost ?much of their meaning because of the high level of subsistence support available (primarily {food stamps). Such support encourages parttime work, which rafteculture, in contrast to ?oyster harvesting, is not. The main reason one fisherman dropped out of the pilot project vas that he was asked to do some work on a regular basis (clean culteh ance a month, fetc.), and he stated that this was repugnant to him.

?CONCLUSIONS

?The oyster culture studies have demonstrated several points: (1) Raft culture of the ?mangrove oyster is feasible, both technically and economically, in Puerto Rico. (2) Production, however, is very marginal if it must depend on natural recruitment of spat. (3) Although fan adequate work force exists to carry on culture of oysters, appropriate incentives and: ?demonstrations must be available for recruitment and training

Point (2) could be resolved by developing methods of operating a hatchery for the mangrove oyster; this isin the proposal stage. Point (3) could be partly resolved by develop: ing @ ?model oyster farm.? This would have to follow development of the hatchery, and it would demonstrate oyster culture from spawn to market. Finally, 2 marketing and distribution system would have to be developed to put the enterprise on a sound commer al footing

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TERRESTRIAL ECOLOGY

The main effort of the Terrestrial Ecology Division has been redirected to @ compre
hensive study of the Espirit Santo Drainage Basin located in northeattern Puerto Rico.
?The general objective are (1) to provide baseline ecological data for future environmental
?assessment studies atthe local and regional levels, and (2) 0 provide through an ecosystem
?pproach data for the development of management alternatives for the wise utilization of
energy, water, and land resources. The interolaionships among climate, vegetation, sols,
{and man, and their combined influence upon the hydrologic cycle will be deseribed and
evaluated,

Environmental management involves planning and decision making, and both require
?an adequate data base. At present, little is known about the interworkings of a complete,
integrated system such as @ drainage basin. A literature survey of the main research areas
?outlined in PRNC-198 confirmed thet, although many individual ecologically oriented
Studies have been carried out in @ tropical environment, few if any provide the data base
Fequited for environmental management. In view of rapidly changing socio-economic
Conditions and natural resoures limitations, management urgently requires data from
these systems: (1) physical (climatological), (2) biological, and (3) cultural. This integrated
?drainage basin study has been designed to provide such data

?The scope of this program covers the hydrologic cycle as it is affected by the interactions of the physical, biological, and cultural systems,

RESEARCH ACTIVITIES

?The activities this year have been directed toward the initiation of new projects, most ?of which are of one-year duration and will not be ready for reporting until FY-1977. The Projects that have been initiated are discussed briefly below.

Graduate student research has continued; it is reported under Training Activities.

cui

atology

?The climatology program was made an integral part of the terrestrial ecology pr to enhance the interdisciplinary approach to clarifying the ecosystem dynamics in a tropical

in forest. It was thought that, in conjunction with ongoing investigations in plant ecology, ?animal ecology, soils, and nutrient cycling in the forested area of the Upper Espiritu Santo ?drainage basin, climatic information consisting of data on temperature, humidity, insolation, Precipitation, and precipitation chemistry would be most useful in beginning to understand. the ecosystem dynamics of this montane rain forest. To this end, the following studies were Initiated during the report period

Upper Espiritu Santo Precipitation Distribution. (B. Holben, J.A. Colén, M. Canals,

F. Santos, and R.G. Clements), A storage rain-gage network was established in the Upper Espiritu Santo watershed to determine annual amounts of precipitation and the effect of topography on its distribution. The network consists of 20 storage rain-guges, each placed

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?equidistatly from adjacent one, forming a symmetric grid over the entire watershed. The

precipitation is collected in funnels mounted above the forest canopy, (Figure 1), and ?conducted by plastie tubing to storage containers on the ground.

Rain gages are monitored biweekly, and this will be continued until February 1977. Preliminary results indicate that the distribution is highly dependent on the direction of storm movement with respect to the orientation of mountain ridges. For example, a strong rain shadow is evident on nearly the highest point in the study area, and a precipitation ?maximum occurs on the leeward side of a low ridge. Eight months after the start of this study, the amounts of precipitation range from 140 to 230 cm (55 to 90 in.) over the 57 0-hectare (1400-aere) drainage area

Element Analysis of Precipitation. (B. Holben, A. Block, R.G. Clements, F. Santos, JA. Colén, and M. Canals). The purpose of this research is to gather baseline data on ?element inputs into the ecosystem by precipitation, in ordor to clarify the spatial distribu-tion of element input and its immediate dependence on precipitaion amounts. Samples ?are taken biweekly from each of the 20 storage rain gages. They are analyzed by atomic ?absorbtion for Na?, K?, Ca", and Mg?. No results will be available until after the storage rain-gage study Is finished in February 1977.

Temperature and Humidity Profiles Modeling in a Tabonuco-type Forest. (B. Holben

?and F.G. Clements). Six hygrothermographs were placed throughout the entie height

of a 72:ft tower in the Tabonuco Forest near the El Verde field station in order to deter-
?mine the principal characteristics of the temperature and humidity profiles and, if possible, to model them statistically for future use in studies of energy balance and bioclimatic relationships.

Preliminary results indicate a daily temperature and humidity lag which increases from the crown towards the ground and a dampening of the diurnal amplitudes of both variables in the same direction. An afternoon temperature maximum appears to occur slightly below the canopy crown. These results and other findins will be substantiated or rejected as the analysis continues,

Insolation Modeling. (B. Holben and R.G. Clements). A computer model to simulate the ingolation characteristics of the earth's surface ie being used to give a fret approxima tion of the solar energy input in the Upper Espiritu Sento forest ecosystem. Solar energy has long been recognized as a principal component in ecosystem dynamics. Since no dat ?are available for the Upper Espiritu Santo watershed, this model may reveal some interesting relationships with plant distribution, and with precipitation.

?The model simulates insolation on square cells of land in a grid totally covering the watershed. Each cell represents a slope and orientation characteristic of a specific area and

location of land. The model simulates insolation for land having the given characteristics a function of time of day, time of year, latitude, clea-sky atmospheric properties, and shading charactersties of adjacent topography.

For this study, insolation will be calculated for 1-hectare calls on a seasonal and annual basis.

?The Variability of Surface Characteristics as @ Function of Grid Density. (B. Holben)

Many meteorological investigations raquire « knowledge of the topographic characteristics Cf a portion of the earth?s surface. A very rapid and convenient method of approximating these is by programming a computer to manipulate a grid of elevations taken at regular,

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horizontal intervals from @ U.S. Geodetic Survey topographic contour map,

?The purpose of this study is to consider how map error and human error will affect

?computed surface characteristics at horizontal intervals (grid densities) of 100, 200, 400, and 800 meters on a 1:20,000 U-S.G.S. topographic map. Preliminary analysis of the slope characteristic unquestionably shows that variability for any given grid density is independent of changes in slope, but variability of the slope increases rapidly as the grid density increases from 800 m to 100 m.

Limnology

?The lack of limnological data for the freshwater streams of Puerto Rico has necessitated the initiation of a basic survey in the Espiritu Santo Drainage batin, The purpose of the survey is to characterize and describe the flora and fauna and to obtain preliminary measurement of selected physical and chemical parameters of the freshwater system, Since the ?estuary isan integral part of the system, it will be included. This survey will require

for completion, and the data obtained will be used in planning
ymological research in the basin. The studies now under way, and the preliminary data obtained, are reported below.

Water Quality Parameters of the Rio Espiritu Santo River System. W. Bhajan, M. Canals, 4. Colén, and R. G. Clements.) In November 1976, a survey begun of selected water quality parameters throughout the length of the main river and each of its three tributaries. ?The data were taken under bese flow conditions. Preliminary results are summarized in

Table 1, which presents the range of values found. Generally, pH and temperature increase from higher to lower elevations, and dissolved oxygen decreases.

Table 1 a

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Inthe estuary the lowest observed values for dissolved oxygen were found at the ?confluence of the Quebrada Juan Gonzalez, which drains a mangrove area containing an egret rookery and the mixing zone of the outfall from the Rio Grande sewage treatment plant. The O; values were 3.90 and 4.60 mg/liter, respectively.

The data on plantonic invertebrate larvae are presented in Table 2, along with prelimi~ nary results for deeapod crustaceans, molluscs, and fish. The crustaceans Aya lanipes, Xiphocaris elongata, and Machrobrachtum carcinus were observed both fresh and estuarine waters. The upper altitudinal limit for the first two species was 780m, but MF. carcinus was ?ot found above 623m. All other decapod crustaceans except M. ancanthurus were observed only in fresh water a

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?Table 2 The Altitudinal Distribution (in meters) of Planktonic Invertebrate Larvae,

Decapod Crustaceans, Molluscs, and Fishes in the Rio Espiritu Santo System

(Dash indicates species not observed.)

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Bioassay of Some Decapod Crustaceans for Salinity Tolerances. (W. Bhajan, M. Canals, J. Colén, and R. G. Clements). Very little is known about the ecology of the ten species ?of decapad crustaceans found in the Esptitu Santo River System. Chase and Hobbs, Bul. 292, 258 pp., Smithsonian Institute Press, (1969) suggested that @ marine phase is ?necessary for the family Atydae, but Gifford and Cole, A.S.B. Bull, 19(2):29 (1971) ?aed serious questions about this requirement.

Preliminary studies on the salinity tolerance of larvae, juveniles, and adults are being Conducted in preparation for life-cycle studies. Results to dato suggest that A. lanipes do ?not have an extended tolerance when salinity reaches GO% that of seawater, but the Of this species exhibited low tolerances, in the range of freshwater to salinity values 15% that of seawater. Juveniles of Xiphocaris elongata did not survive longer than 24 hr in Seawater, but when salinity was reduced to 80? that of seawater survival was 100%.

Plant Succession Study (R. G. Clements and ?. Cuevas). The radiation study on tropical rain forest by H. T. Odum at the El Verde site has presented a unique opportunity to study and evaluate plant succession in a forest of this type. Following the experiment

in early 1965, a yearly census of the 672 ane-square:meter plots wes made in 1966, 1967, 1968, and 1969. Beginning in 1971, the census was taken biannually, After the 1875 census, a start was made on tabulating and analyzing the succession that has taken place ?The transfer of data to IBM cards for analysis has been difficult because the early data ?wore not collected in a consistent format. However, the transfer is now ne and deta reduction, analyses, and reporting are expected to be completed in

?TRAINING ACTIVITIES

During this reporting period, four advanced degrees were completed and successfully defended; two doctoral and two for a Master of Science. Research investigation has been ?completed for another doctorate. Five additional students have initiated thesis research ?investigations for Master of Science degrees,

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?Thesis Abstracts

?The Contribution of Aquatic Hyphomycetes in the Decomposition of Submerged Leaf Litter (D. Padgett) abstract not available

Bcogeographic and Systematic Studies in American Cyatheaceae (D. Conant). This thesis deals with the biology of tree ferns. | have approached the study of this unusual group of plants by embracing aspects of their population biology, ecology, and their systematics and fvolution. The frst chapter of the thesis deals with spore dispersal, an important parameter ?to consider in relation to the breeding dynamics of tree fern populations. The second chapter is a study of the autecology of two tree ferns. Here aspects of the autecology of ?wo quite different species are compared to develop an understanding of the growth and ?adaptive strategies in these plants, The thied chapter is a systematic revision of the American ?species of the genus Alsophila. Specification in the Cyatheaceae is seen as an ecogeosraphic process, and the taxonomic revision applies the conclusions from the previous chapters 10

the problems of clasification of species. An unforseen aspect of the systematic studies has been evidence that interruption of ecological barriers between species has resulted in ?extensive hybridization which demonstrates that sterility barriers have not evolved between species.

[An Autecological Study of Palicoure riparia Benthan (Rubiaceae) (Maria Luz Lebron)

Present accelerated rates of destruction of tropical ran forests have resulted in renewed ?attention on the process of secondary succession in these areas. Although a number of ?studies of this topic have been conducted, there is only sight knowiedge of the behavior Of the ecologically important species participating in this process.

?The present study focuses on Paicoures riparia, an ecologically important species in disturbed areas of the tropical rain forest of Puerto Rico.

?Demographic studies show that P. riparia is important in disturbed areas in terms of density and that it is also present under mature forest conditions at reduced levels. Studies ?on seedling seasonality indicate that there are no significant variations in periodicity in the forest in terms of frequency or density. Germination studies indicate that, regardless of season, seed germination is always higher in open than in closed canopy areas. Reciprocal ?transplant studies reveal that there is no ecotypic differentiation in this species. Feld

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Photorynthesis values ore low but compare favorably with previous reports in the literature {or lowland tropical rain forest species. Undor controlled conditions, it was demonstrated that this species can carry out photosynthesis at light levels as low as 20 jue me ~!, and ?that increases in light intensity consistently enhance photosynthetic rates.

?The present study provides an important contribution towards the und ecologically important species in lowland tropical rain forest areas

On the basis of these studies, itis proposed that P. riparia be considered @ ?gap opportunist? ~ a species that can maintain itself under undisturbed forest conditions but which will benefit greatly from forest disturbances (Baur, 1964).

Changes in Water Quality as Influenced by Land Use Patterns (Elvira Cuevas). Biweekly ?measurements and samples were taken on the surface waters of the Espiritu Santo river and its tributaries Quebrada Grande, Quebrada Jiménez, and Quebrada Sonadora. The ?parameters studied were temperature, dissolved oxygen (00), pH, free carbon dioxide

ity, and the concentrations of sodium (Na), potassium (K), calcium (Ca),

?magnesium (Mg), and chloride (Ci). The results indicated a general increase in the values of all the parameters measured, from higher to lower elevations with the exception of DO which decreased slightly and was found to be near saturation at all times. CO, ranged within the normal values for natural surface waters as were the pH values which ranged ?rom 6.5 to 8.2 with a modal value of 7.0. The concentration of Na, K, Ca, Mg, and Ci were found to be below or near the accepted for drinking water standards. Significant differences were found between each river or tributary for the concentration of the elements ?mentioned above. No marked seasonal varabilites were observed during the period studied {except for the temperature of the water which reflected the lowering of air temperatures during the winter months.

?Some Aspects of the Ecology of the Freshwater Shrimps in the Upper Espiritu Santo River at El Verde, P.R. (F. Villamil). A survey was performed in the upper Espiritu Santo River to collect, identity and trace the distribution of the shrimp fauna. The species encountered were Atya lanipes, Xiphocaris elongata, Macrobrachium heterachirus and Atya innocous. ?Selected physical and chemical characteristics of the stream were measured {0 describe the habitat of each species and their effect on the distribution. The physical Parameters which affected the habitat selection and the distribution were, waterflov, Substrate type and elevation. No apparent relationship was found between the chemical characteristics and the distribution,

?The ecology of the species encountered was described. Intraspecific differences in habitat Selection was observed in Atya lanipes. Preference for sunlit areas in low-flow conditions and gravel substrate were observed for Xiphocaris elongata. Macrobrachium heterochirus ?was observed in shaded areas, residence under rocks and low-flow conditions. Selected ?anatomical characteristics were m

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MATERIALS SCIENCE

?The Materials Science Division is engaged in research on physical properties of materials. and the effects of radiation upon them. This involves solid state materals undergoing phase transitions, energy storing materials, and biomaterials. The Division also offers research facilities for M.S. and Ph.D. thesis work in the fields of physics, chemistry, materials, and radiation sciences in cooperation with the various colleges and departments of the UPR Mayagiez Campus. It is anticipated that it will serve ata catalyst in starting energy-related research programs in cooperation with UPR faculty, especially programs involving solar ?energy. To encourage and promote cooperative efforts, contact is maintained with former ?raduate students and with visiting scientists from Latin American research institutions,

RESEARCH ACTIVITIES

Energy Conversion Making Use of Thermal Differential in Triglyci

and R. Purcell

Introduetion. Recent work at PRNC and UPR (Gonzalo, Ferroelectrics, in press, 1976; Purell, PRNC Internal Report, 1975) on ferroelectric materials as energy converters, ving ® general thermodynamic approach, has yielded a general expression for the available work er cycle (between temperatures T;~7.-AT, and 7, =T,). From ths, the ideal efficiency

me Le) = Ee

where 4 is the mean field coefficient, M is the temperature derivative of the squared spontaneous polarization, » is the density, and AC} ond C? ae the ferroelectric and {otal (eroslectic plus ?background?? average speci heats respectively. ATs/Te_ is the Cermot factor, which puts an upper thermodynamic limit to the ideal efficiency. This the factor determining conversion performance i 1 /e¢").

?The operation of a single-stage ferroelectric converter (spontaneous process) was also examined. The differential equations governing thermal flow and charge flow involve res- Pectively a thermal relaxation time «7p and an electric relaxation time 1,. Optimure Bower output is obtained when the load resistance is equal tothe intemal resets of

rid the ratio of the thermal 1 the iil electric relaxation

is unity. The optimum thickness of the ferroelectric plate is given by

Sulfate (J. A. Gonzalo

4 = Were? const. x (r,/8T9)"

where isthe thermal conductivity of the ferroelectric plate and + = x7. = tee, in other

?words, itis determined by the maximum range a7, over which the performance factor

m

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remains ote ts maximum vole. From hr itis ay 0 determin the specific power

Cutout er unit mas), which an be expres

et (PR) (BY

If utstage conver re sed betwoan the xi ave .(100"K) and 00m

?temperature, taking (3M/C?) as 0.25, which is a not unreasonably high value in light of

the alle experimental tiene (Gna op.) fr feelers wth vanstons

SBove room temperature, oe come up with ea flee nthe 1% ane. Secfic

power outot estates fr thee fo ferrosets or which traraort parameter (ke)

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tmemoos nuh potovle al. At, freer converters donot requ singe

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fin along te fret al mich can probbly be produced more economy. To

tbtun Sacre power by thermcycling one must Kep the single-domain sate of the

ryt ra let Keep lager ation of he digas thd in one ofthe two possible

Girections, which can be dane in several way. unpoarentigyration ean be maintained

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Teporte here ae preliminary measurements of tlency and specie power output

in single esas of tigycine ste (TGS), with adtion Induced peered detion

forthe mpomaneas plas (Okade, Gono and River, Ph. Chem. Sl, 25,

Go, 1967, TOS cysts were chown to text the theory, no becase they wee the best

posible cancers Yor frost energy comers, bu because ofthe esl aezsble

Ene temperature an te avinty of -radated samples with net nonzero polation

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Experimental. The samples were old 7-irradiated TGS single-crystal plates with areas between 0.25 and 1 cm? and thicknesses between 0.6 and 2.5 mm, cut normal to the otlectrie axis and provided with gold-eaf electrodes on the main surfaces.

?On the screen of an oscilloscope using a Sawyer-Tower circuit, the 10-year-old {irradiated (with 2.5 Mad) TGS samples, which originally had presented a single biased hhysteresis loop, showed a double asymmetrical loop (the change presumably being due to spontaneous aging, through migration of charged free radicals under the spontaneous field. The ?wo partial loops, biased in opposite directions, had different heights, which meant

that at zero external field a net fraction of the spontaneous polarization was always pointing in one direction. With 2, and P, being the heights of the larger and smaller loop respectively the effective fraction of the spontaneous polarization was

= (PP) / ley + Pp) = 0.34.

Note that, ata given temperature F; +P; ~ gives the total spontaneous polarization,

?The value obtained for the resistivity (Rt) is 1.07 x 10" am.

?The thermal relaxation time of the sample holder with the crystal was about 20 see, 3 value larger than that estimated for a thin plate, rp (pc"iklé®, which, for d ~ 1 mm, ives + 2 sec; this indicates that the thermal resistance of the air between the cylindrical container and the sample, rather than that of the sample itself, was the limiting heat ?ansfer factor.

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Figure 1

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X10" Dynes em

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Results and Discusion. Comparison of measured and experimental values of effcieney

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(a)! Inene) % 082,

which indicates reasonably good agreement between calculation and experiment.

For the specific power output, the comparison isnot so straightforward, because the calculation (Gonzalo, op. cit.) hasbeen carried out completely only for the case when Fo ty = eqs whieh requires, fora given ATs, a specitic sample thickness determined by the electrical resistivity value, However, if zp and r,, are unequal but of the same order fof magnitude, the specifi power output calculated by Gonzalo (op. ct) could serve as & Useful estimate, The ratio of experimental to calculated power output was

sc lOV) gag! (Pa! PV agg % O75

In summary, rough experimental observations of the behavior of TGS as an energy converter indicate that theoretical estimates of the potential of ferroelectric converters are realistic. The experimental observations reported here were preliminary, and further systematic work is planned.

Brillouin Scattering of DTGS at Room Temperature and Through the Transition.
(F. Vazquez and J. A. Gonzalo).

By use of the Brillouin scattering technique, 10 of 13 elastic constants of deuterated tryglvcine sulfate (OTGS) have been obtained. They are (in 10"* dynes/em? I:
C11 = 5.08, Cz = 2.04, Cy = 205, Ca = 351, Cys = 240, Co = 1.10, Cy = 1.21
Cus = 0.73, and Cay = 0.03, The temperature dependence (30° t0 80°C) of some of the clastic constants has been studied, with emphasis on the transition temperature region.

Raising the temperature through T, caused a sharp increase of the Brillouin shift (See Figures 1 and 2) for the quasi-tranverse and quasi-longitudinal modes, but no pronounced change for the pure transverse mode. Fitting of the results with a velocity dispersion relation of the type of Landau and Khalatnikov,

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with +~* proportional to O7 = 7, ~ 7, gave a value 7! = (44 + 0.4) x 10!°(r,-7),

for TGS, Nevertheless the results could not be fitted with Eq, (1) for 7 close to 7. Careful measurements with 7, - T<0.1°C showed that the transition starts rather abruptly. This indicates thatthe simple relaxation formula, Eq. (1), does not completely explain the behavior of DTGS.

Elastic vs. Polarization Energy in TGS Near the Phase Transition. (J. A. Gonzalo and F. Vazquez).

?The elastic energy of ferroelectrics has been examined. If only @ harmonic contribution is considered, the spontaneous strain along the ferroelectric axis turns out to be proportional to the spontaneous polarization. This leads to an expression for the corresponding elastic constant in terms of the basic ferroelectric parameters. From it anomalies in several physical

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Properties, such as the ferroelectric axis linear expansion coefficient, can be estimated.

If an anharmonic contribution is also considered, an expression giving correct temperature dependence for the spontaneous polarization far from Tis obtained. The transition?s temperature and pressure dependence can also be obtained. Study of the elastic behavior ?of TGS (Second-order transition) along these lines gives estimates of various anomalies

in physical properties in reasonable agreement with observations. The elastic energy appear ?to be of the same order of magnitude as the purely electrostatic polarization energy.

Phonon Raman Spectra of Crystals Under High Pressure. (R. S. Singh).

?A high pressure pump to generate hydrostatic pressure (10kbar) has been procured.
?The pressure cell currently being built. The systems will be tested soon. A few solected crystals will be studied under hydrostatic pressure,

Phonon Raman Spectra of TGS and OTGS in Ferro~ and Paraelectric Phases. (R. S. Singh and 0. Matos)

Both TGS and DTGS are ferroelectric at room temperature and belong to the C3-Ps, space group with two formula units per cel. On the basis of group theory, the 45 zone-center optical phonons are distributed as 11A(T) + 12A(R) + 108(T) + 128(R), which areal IR as well as Raman active. In the paraelectrc phase, both belong to the Ciy~ Ps, space group with two formula units per cel, and the zone-center optical phonons" are distributed as 6AgIT), 6Ag(R) + 6BG(T) + 6BGIR) + 5A;4(T) + 6A;,(R) + 48,(T) + 6B,(R). Only g-types are active in Raman and u-types in IR, Polarized phonon Raman sepectra of single-crystal TGS and DTGS have been messured in the ferroelectric phase,

and nearly all the zone-center optical phonons have been identified. Measurements in the pparaelectric phase are in progres. The temperature dependence of the observable modes in ferro~ and paraelectric phases, and the nature of the interatomic forces, the mechanism ?of phase transition, and the thermodynamic properties are being studied. Work will be ?extended to test the mechanism postulated from the diffraction data.

Uniaxial Pressure Dependence of the Elastic Constants Around the Transition Temperature, (F. Vazquez)

Uniaxial pressure in the direction of the ferroelectric axis will be applied in order to observe the dependence and coupling of the acoustic modes. Uniaxial pressure may give important results because it breaks some of the symmetry selected properties of the crystal

Phonon Raman Spectra of Hydrogen-Bonded Ferroslactrcs inthe Para- and Ferrocloctric Phases. (R. S. Singh).

Phonon Raman spectra of TGSe, DTGSe, and TGFB are being studied in both the para- and ferroelectric phases. These crystals are isomorphic in structure with TGS, which has been studied recently. Further study of these may help in assigning ther lattice modes ?unambiguously and may shed further light on the mechanism of phase transition.

Brillouin Scattering of DTGS Around the Transition Temperature. (F. Vazquez).
?The elastic constants are known for TGS and are being obtained for DTGS. This will allow comparison of the effects of hydrogen bonds on the elastic properties. Studying the

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scattering through the transition temperature will provide insight into the dynamics of ?the second-order phase transition and late it with the results obtained with TGS. Data have been taken for the elastic constants and they are being computed,

EDUCATIONAL ACTIVITIES

?Thesis Research

M.S. theses being done under Materials Science Division auspices are listed below.

Students are from Puerto Rico unless otherwise noted

Radiolysis of Aqueous Solution of SulfurContaining Amino Acids

Luz del Mar Garcia (under Dr. R. A. Lee; completed 11/75).

Raman Scattering of Hydrogen-Bonded Ferroelectric Crystal.

Osvaldo Matos (under Dr. R. S. Singh, Physics; completed 12/76).

Phonon Raman Spectra of TGSe, DTGSe, and TOFBe.

Fernando Noriega, Guatemala (under Dr. R. S. Singh

?Study of Phase Transition in Crystals by Light-Seattering Techniques

Luis Mera Romero, Dominican Republic (under Or. R. S. Singh).

Dielectric Constants in TGS and DTGS With Uniaxial Pressure

Jorge Ortiz (under Dr. F. Vazquez, Physics)

Infrared Studies of the Bromine-Benzene Complex.

Roberto Torres (under Dr. T. C. Jao, Chemistry.

?Raman Scattering of Ribosomal RNA, Ribosome, and Some Antibiotics.

René S. Vieta (under Dr. Jao).

?Raman Scattering of Some Polyemino Acids, Peptides, and Proteins

Gloria 0. Marquez (under Dr. Ja).

Phase Diagram and Shift in Curie Point for Doped NaNO,

Mario Rojas, Colombia (under Drs. Jao, Vézquez, and M. |. Kay, Neutron Diffraction).

?Special Training

?Mrs, Claribel Velez has an ORAU undergraduate fellowship, and is working on the

project, Radiation Chemistry and Radioprotection of Biologically Important Compounds (Purines), under Prof. G. Infante of Catholic University, who holds an ad honorem appointment at CEER.

STAFF ACTIVITIES

International Conference

?The International Conference on Low-Lying Lattice Vibrational Modes and Their Relationship to Ferroelectrics and Superconductors, held in December 1975, was organized

by Drs. M. Gomez, J. A. Gonzalo, and M. |. Kay. They handled both the scientific program and the local organization, and are now editing the proceedings. Sponsorship was provided by UPR, ERDA (via PRNC), the International Union of Pure and Applied Physic, and the ?American Physical Society. Funding was by the National Science Foundation and the

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Office of Naval Research. The 150 physicists attending came from the U.S, USS.R., apan, Europe, and Latin America

Visitors

Dr. J. B. Cohen, Head of the Materials Science Department and Frank C. Engelhart Professor at Northwestern University, visited PRNC for two weeks, March 21 to April 4, 1976, to start an experiment on diffuse scattering fram TGS, now under way at PRNC, to study the details of correlation through the phase transition

r. Michael Butler of Sandia Corporation visited the Division on June 11, 1976, and ?gave 8 seminar.

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Figure 1: View of TGS looking down the short coaxis. Dashed lines indicate hydrogen bonds.

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Neutron Diffraction

?The Neutron Diffraction Program is funded by the National Science Foundation (Grant OMR-71-01785-A02) and is concerned with investigation of the structural changes in materials undergoing ferroelectric and antiferoelectrc transitions. The microscopic ?molecular structure of crystals defines their lattice vibrational and molecular spectra, determine their response to impressed fields. Thus, the crystal structure and its changes through phase transitions provide the basic information needed for predicting and interpreting transition mechanisms via their dynamics.

Ferroelectric, aniferroelectric, or more generally ferroic materials have been used as ?optical gates, infrared detectors, transducers, and optical memory devices. The application Of these materials, via the pyroelectric effet, as posible (solar energy converters is dealt With earlier in this report. It should be noted that the study of most materials and the

interactions with various force fields leads, in one form or another, to "energy conversion.? Certain solids have wear-term possibilities for use at superconductors, superionic conduc tors, and perhaps ferroelectrics, but almost all materials will react and respond to electro ?magnetic and mechanical inputs. As data are accumulated on these properties and interactions, {tis hoped that theories will be put to use in producing devices and ?effects for conversion, storage, and transmission of energy in its desired form.

RESEARCH COMPLETED

Deuterium Atom Positions in the Paraelectric Phate of DTGS ?M. |. Key, A Neutron diffraction study of deuterated trglycine sulfate (OTGS) has been carried out to determine ?the changes in position of the hydrogen atoms above the ferroelectric phase transition {temperature of 60°C. Since the hydrogen bonding scheme plays a critical role in stabilizing ?TGS, and in the transition, it was decided to attempt to determine the DTGS structure

above the transition. Since deuterium isa heavier scatter than hydrogen and has a lower incoherent cross section, a crystal whose exchangeable hydrogen atoms were deuterated (DTGS) was sued in place of TGS to increase the reliability of the determination even at

?the expense of an isotope effect which could distort a comparison with the ferroelectric phase

The final value of R= 2]? -F2]/2F,? from least-squares refinements was
0.062. The least-squares results were checked by three-dimensional Fourier and difference
?maps. A diagram of the numbering scheme in the ferroelectric phase is given in Figure 1
?To obtain the paraelectric phase itis necessary to imagine a mirror plane passed through
the planes of the sulfur atoms.

Comparison of the hydrogen bonds in TGS at room temperature and DTGS in the para
?electric phase (Table 1) shows that the donor to deuterium distance for the O-D, bond
Femains about 1.00 A and for the D-O, increases from 1.52 to 1.58 A above transition.

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?Table 1: Hydrogen Bonds (Ferroelectric Phase in Parentheses)

(r,= donor to hy sistance; toh distance

From Glycine | " 6 Angle

0-0-0, 1.01 (1.001 80501 rc)

N-d,?0. 102 (1.061 91899) teu)

N=, -o1 105 1.01 202196) 196 4136)

From Giycine II

Paes tot 1106208 200) 190 161)

From Glycine II

NM, (oss) 200) os

N= Huy 205 ws)

Ho Mo, ?098 (a0) as

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?The average H-H distance in the ammonium group is 1.01 A below the transition and

11.00 A above it. The H or D to 0 bonds are 1.86 A below the transition and 1.91 above it

For Glycine Il, the N-H distances average 1.01 as do the N-D distances, The D-0 distances

[excluding the bifurcated bond, which has low 0-D-0 angle of 126° and a long distance

fof 2.23 A and is probably almost completely electrostatic) increase from 2.00 to 2.05 A. ?The N-H bonds for Glycine III from an average of 1.02 to 1.01 (the same). The three wer-angle bonds average 1.97 below the transition and 2.05 above. Here the Ath bond

Increases in length from 2.06 to 2.19 A. Although one may doubt the precision of the structure, every bond does increase in length, The average magnitude of the increase is 0.06 A, which is larger than would be expected from an isotope effect in long hydrogen bonds. It is concluded that the hydrogen bonding weakens noticeably in the high tempera~ ture phase

Figure 1 also shows that the breaking of the N-D,-0" Il bond with polarization reversal is probably correlated with the OII"H- - O°Ill reversal. Ths effect should be visible to Raman spectroscopy and will be examined by R. S. Singh of ths laboratory.

Table 2: Comparison of X-Ray and Neutron Bond Distances (angroms), Anges end

Principal rms Amplitudes (U), With Standard Deviation in Perentheee

Nestron Xeay

Ao

Ao eae a saa

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Arsene

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Figure 2 (MaIMAD prod on he Bone

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?Table 3: Short Hydrogen Bond Geometry

All parameters

Ru

RwlF

0.037

084

131

ot

= 0.08

= 025

U, = 028 011 t0 0-0 bond

is ?8

x?

Figure 3: Fourier line through y = 0.16, z= 0.12, showing the short hydrogen bond, consisting of two oxygen atoms and the disordered half hydrogen atoms.

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?The Hydrogen Positions in Paraelectric Ammonium Dihydrogen Arsenate ? M. |. Kay.

?Ammonium dinydrogen Arsenate (ADA) is isomorphous with the phosphate. The material is antiferroelecric below its transition temperature of -B7°C. It goes from I-42d to P2,2,2,. The tetragonal lattice parameters are « = 7.69 and e = 7.72 as given by Kahn and Baur (Acta Cryst. B28, 2721, 1973). A projection of the structure is given in Figure 2. It is interesting to compare the neutron and x-ray results given in Table 2. The agreement startling for As, N, and 0. Table 3 presents the O-H--- 0 bond geometry. Although there is a great deal of uncertainty due to disorder, the hypothesis of a linear of centered bond can be rejected at the 0.05% probability level. Figure 3 shows a trace at y = 0.16, 2=0.12, the small double hump indicating two disordered hydrogen atoms. It fs somewhat ?unusual for an O-H-O bond of 2.5 A to be nonlinear. The effect seen is due to the receptor ?oxygen in the disordered system being displaced inward from the average potition toward) the As. Thus the H position should be shifted, as indeed it is. A detailed analysis of the transition mechanism will have to await an structure of the antiferrelectric phase. To thi fend crystals of deuterated ADA have been taken through its transition under uniaxial stress in an attempt to obtain a single domain crystal

WORK IN PROGRESS

Diffuse scattering data are being collected in the region of the forbidden OK0 reflections in DTGS to examine correlated motions through the transition

Mr. Mario Rojas is carrying out exploratory work on the KNO;-NaNO, work and because of possible uses of NaNO, in energy conversion

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?Table 1: Experimental and Predicted Argon-41 Concentration

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NUCLEAR ENGINEERING

?The Nuclear Engineering Division is engaged in both teaching and research, Staff members

teach both graduate and undergraduate courses at the UPR Mayagiez Campus and direct the thesis work of nuclear engineering students. They do research on their own projects land assist the staf of other PRINC divisions at the need arises. The scientists on the Division? staff all hold joint appointments at PRNC and UPR, and they make up the faculty of the UPR Nuclear Engineering Department, the Head of the PRINC Division

boeing also the Chairman of the UPR Department. The Division provides the classrooms, offices, laboratories and equipment, and most of the administrative personnel required

{or the education and training of the graduate students at the UPR Nuclear Engineering Department.

RESEARCH ACTIVITIES

?Method for Monitoring Environmental Argon-41.(D. S. Sasscer and C. Andreu)

?The Droft Standard for Restrictions on Radioactive Effluents From Research Reactors fof June 1974 recommends that the allowable ~oncentration of *" Ar in unrestricted areat be reduced by a factor of 60, to 8 X 107" jiCi/ec. The objective of this work was to develop @ simple and accurate procedure for *! Ar measurements in unrestricted areas when its concentration is significantly below the new recommended allowable concentra tion. The purpose of such measurements is to provide verification of the results obtained ?rom prediction models for the spatial variation of the concentration of gates released from a source. The ability to measure *"Ar at a concentration <2? of the previously

?allowable value required a high-sensitivity radiation detection system. A system was ?developed (Figure 1) in which a 4X4 in. and a 3X3- in. sodium iodide detector connected in parallel, concentrated samples of sir are measured in scuba tank filled to ?2200 psi by # high pressure pump, and the radioactive background is kept low by 6- in.-thick lead walls

?The argon concentrations measured at ground level and conwerted to atmospheric pressure are compared with the predicted ground level concentrations in Table 1. Run 1 was a background measurement taken before reactor startup, and the *' Ar concentration in the off gas system was zero. In Run 2 concentration could be measured but not predicted since the model does not apply when the sector wind frequency is low. The average difference between the experimental and predicted concentrations for the last ?our runds was 25%. The concentration in the off-gas system was ~10.3 x 10" ,Ci/ee at the 1000-kw power level. The radiation detection system determined a ground level

n of 6.0 X10 Cilce, which is <10% of the new recommended allowable concentration and indicates an attenuation factor of 2x 10!

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Figure 1: Schematic Diagram of the High-Sensitivity Counting System

?Methane Gas Production From Activated Sludge (K.P. Pedersen and A. L. Rivera)

During the 1950's several systems were described in which raw waste was mixed with a large anaerobic biological mass maintained in the digester for more efficient and rapid treat-

?ment. This was called an anaerobic contact process. A newer process for soluble wastes is

?wrmed the anaerobic filter process because it involves a system similar to a trickling filter ?The stabilization ofthe organic contents may be considered to be a function ofthe density Cf the microbial mass, which tends to form and grow in the spaces around and between the filter medium.

?The objective of this work was to evaluate the feasibility (under local conditions) of producing methane gas as an energy resource from city sewage by the anaerobic filter process. ?A bench scale unit capable of treating several gallons of sludge per day was installed in a lca sewage treatment plant, and its ability to produce gas continuously was evaluated by {928 and liquid analysis. The hydraulic retention time was varied, bia the liquid flow rate, to study its effect on the system's operational state. The temperature inside the filter was recorded by three probes at the bottom, middle, and top. The collected gas was tested for volume percent of methane gas chromatography and for gross eating value by burning @ known volume and recording the temperature rise of the heated water.

?After the anaerobic filter started producing gas, the feed to the system was initially anaerobic digester feed for about half a month and was then changed to the returned activated sludge normally fed to the aerobic digestor. The bench-scale unit had the dis ?advantages that the mixer had to be filled at time intervals depending oni the operations liquid flow rate and racked a control on the COD load fed to the anaerobic filter. The activated sludge used as raw material had to be filtered before being fed to remove the garbage that can clog the bellows-type metering pump. Because of these limitations, only {wo liquid flow rates were used.

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With a liquid flow rate of 94.5 ml/min, used for 12 days, the average equilibrium gas production was 5053 mi/day at STP this represents an average at a timewhen gas production does not change greetly from one day to another). With the liquid flow rate increased 10 157.5 mi/min, the average was ~18,539 ml/day

Land Sited Integrated OTEC~ Nuclear Facilites (D. S. Sasser and F. Ferrer.

?A major attraction of ocean thermal energy conversion (OTEC) systems is that they ?se the ocean for energy storage and therefore can produce power at a constant rate. ?An OTEC plant operates the temperature difference between the surface water and the deep water, which even under ideal conditions seldom exceeds 40°F, and therefore, has 2 low thermal efficiency which increases rapidly with increasing temperature difference.

?The location of OTEC facilities floating near the shore along warm ocean currents Involves technical dificulties and high costs associated with construction, maintenance, ?anchoring, and power transmission that raise doubts as to their engineering and economic {easbility and justify the investigation of alternatives. One proposal isto locate OTEC facilities on land in shoreline areas near deep ocean water. This not only would be more feasible but also would allow judicious integration with a conventional plant, which might

be cost effective because the waste heat from the latter could be used to increase the efficiency of the OTEC plant. The primary objective of this work is to determine the feasibility of land sited OTEC electrical power facilities integrated with conventional ones.

?The tropical waters around Puerto Rico have a year-round surface temperature of 75° 10 85°F, and, within 1.5 to 5 miles from shore, 40° to 45°F water is found at a depth of 2000 ft. A secondary objective, therefore, is to determine the feasibility of using a 8 Puerto Rico for field testing OTEC components (possibly as part of a Solar Energy Research Institute field station) of for setting up a demonstration OTEC facility (with or without « conventional plant). The first site selected for study, Punta Higuero, is on the west coast fof Puerto Rico, near Rincén; the second, Punta Tuna, in the southeast, near Yabucoa, and ?the third Barrio Islote, on the north coast, near Arecibo. The distance from shore to source of 40°F water at a dopth of ~-3000 ft i 5 to 7 miles for Punta Higuero, 1.7 for Punta Tuna, and 10 for Barro Islote. The 28 millskW-hr quoted by CMU for its floating ?OTEC model (a 100-MW independent module) was assumed to remain constant regardless Of site and power production level. At the Punta Higuero and Punta Tuna sites, the production cost of electricity for the land based systems would be less than for the floating CMU OTEC. At Barrio Islote, the land based systems would cost less except for the OTEC ?alone, which would cost more up to a power ratio of 1.16. Punta Tuna, the site nearest deop water, is the most advantageous for a land based system and Barrio Islote, the leat.

?THESIS RESEARCH

Seven students have completed all the requirements and been awarded the M.S. degree in Nuclear Engineering. Their thesis are summarized below.

Population Exposure to Natural Radiation in Puerto Rico. Antonio J. Gonzalez- Rodriguez (under Dr. A. E, Gilead). The average whole-body dose equivalent (DE) from natural radiation sources to an individual in Puerto Rico was measured by thermoluminescent dosimetry in 35 municipalities (covering 61% of the Island population) and found to be

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53:8 mrem/yr per person, ranging from 108216 in Ciales to 3425 in Carolina and Ponce. To check the results, personal dosimeters were worn by four volunteers; these gave an

average value of 5428. Within the municipalities surveyed, the cosmic component of the DE has been found to vary by only 3:3 mrem/yr per person; therefore, the DE variation was assumed to arise from the terrestrial component. The natural background activity level in Puerto Rico is one of the lowest known being 20% lower than in ?normal? areas and 59% lower than the best mean of all countries reported by UNSCEAR in 1962.

A Cost-Benefit Analysis of Condenser-Cooling Systems for Nuclear Power Plants in Puerto Rico. Juan M. Cajigas (under Dr. K. B. Pedersen). A cost-benefit analysis was done ?on systems including once-through cooling, cooling pond, wet cooling towers, and dry cooling towers. Computer programs were used to design the different alternatives, optimized to minimum cost. General environment impact was also studied. The results indicate that ?the once:through system is the heat rejection method bert suited to the cooling needs of Puerto Rico's future nuclear power plant. Its design total system cost was calculated to

?be 0.076 mill/kW-hr less than that of the closes competitors, mechanical draft wet cooling ?towers, and its environmental effects are within tolerable limits.

Determination of Argon-41 Dose at the PRNC Site Boundary. Carlos Andreu Vi (under Dr. D. S. Sesscer). The objective of this work was to determine the yearly average ?maximum concentration, needed for verifying the model used for calculating the attenuation factor between the off-gas stack outlet and ground level. The model uses the diffusion ?equation for average long-period concentration from a continuous point source. The Kane

?chamber, which isthe constant air monitor of the reactor off gas system, had to be calibrated ?0 allow accurate and easy determination of future concentration at any power level, and ?this was satisfactorily done, with a probable error of ~.5%. The system used allowed ?measurement of a ground level concentration lower by a factor of 6.75 Xx 10° than the Concentration in the off-gas stack, or to 1.6 x 10" Ci/ec, The average ratio of estimated to measured concentration is 1.1. This excellent agreement gives a high degree of ?confidence in utilizing the model to calculate the yeerly average maximum concentration,

?the largest value of which occurred during one-shift operation, dry season, at 125 m from the stack in the ENE sectors and was 2.69 x 10" Ci/m?, which i 33.6% of the allowable concentration.

Economic and Engineering Feasibility of Integrated Ocean Thermal Gradient and ?Nuclear Plants for the Production of Electric Power at Several Sites in Puerto Rico.

Frank Ferrer Almod6var (under Or. 0. S. Sasscer). The performance of three different land based integrated systems and a land based OTEC for the production of electric power \was analyzed to determine the optimum integrated system and its economical and engineering feasibility at several sites in Puerto Rico. Geometric programming was used as the optimization technique. The optimum integrated system wat one in which the heated water from the nuclear plant is used to raise the temperature of the turface ocean water. The trade-off between plant components showed that the piping is responsible for the major Pert of the cost followed by the pumping and then the heat exchangers, The best location for 8 land based system, integrated or not, was found to be Punta Tune.

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?Methane Gas Production From Returned Activated Sludge Using the Anaerobic Filter. ?Angel Luis Rivera (under Dr. K. 8. Pedersen). The objective of this research project was ?to evaluate the feasibility, for Puerto Rico, of producing methane gas as an energy resource from city sewage by the anaerobic filter process. The raw material was retured activated ?sludge, ond, once the system started, it produced gas continuously. Increasing the liquid flow rate trom 94.5 to 187.6 mimin resulted in fairly good gas production, v1.58 ft?

(at STP) per pound of total suspended solids removed on the average. This does not necessarily represent a maximum and/or optimum production, and further research is needed. At this flow rate the gas had an average methane content of 80% and a gross heating value of 601 Btu/tt?

Population Dose Due to Transportation of Irradiated Fuel From 2 Nuclear Powor Plant in Puerto Rico. Luis Reyes Medina (under Dr. H. Plaza). Calculations were made of the ?exposure dose from irradiated nuclear fuel to persons along the shipping route under normal ?conditions, and of the probabilities for the occurrence of various types of accidents during ?shipment. The dose to a person 20 ft from the centerline ofthe shipping route was con= servatvely calculated to be 7 x 10°? mem.

?Atmospheric Transport of Gaseous and Volatile Radioactive Effluents from the PRNC ?mica Reactor. Rolando Pérez Ortiz (under Dr. A. E. Gileadi). A computer code was <eveloped for evaluating certain radiological hazards associated with the discharge of gaseous and volatile radioactive effluents from the PRNC TRIGA-FLP research reactor, with use of actual operating parameters and local meteoroligcal data. The code is writen in ?ronrnan iv and executed on the POP-10 computer of the UPR Mayagiiex Campus. On the basis of the mathematical model of the generalized Gaussian plume, the code calculates the concentration of any isotope of interest at any given position with respect to the source, using such input parameters as position coordinates, source intensity, and clima-tologic data, with allowance made for effective stack height, reflection at the ground surface, and depletion by ground deposition and radioactive decay. The model is tested

EDUCATIONAL ACTIVITIES

[Master of Science Degree Program. UPR, in close cooperation with the PRNC Nuclear Engineering Division, offers a Master of Science degree in Nuclear Engineering, in which

12 graduate students were enrolled during 1975. The seven theses completed are summarized above. One student,Dick Carrero, is no primarily engaged in thesis research, and four in academic course work: Edmundo Martinez, César Pérez Arenas, Manuel Lépez, and

Milton Soto.

?Special Courses. Short courses (one week to three months) on a variety of topics related to nuclear engineering are offered approximately once a year for scients, engineers, and other intrested persons. In June a one-week Summer Workshop on Energy and the Environment was offered for high school science teachers, sponsored jointly by ERDA, RNG, the UPR Mayagie Campus, and the Puerto Rico Water Resources Authority, to provide these teachers with sufficient beckground to enable them to

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and communities towards a more fact

between energy and the environmen

and towns throughout Puerto Rico.

1d less emotional consideration of the trade-off

Puerto Rico, The 39 participants came from cities

?The staff of the Division taught ten semester-length graduate courses and one under-

?graduate course in the UPR Nuclear Engineering Department and eight undergraduate

sections in the Mechanical Engineering and Electrical Engineering Departments. (See Table 2).

Table

Course

Math 675 - Math of Modern Se. 1

NuEg 605 - Elem of Nuc. Eng.

NuEg 621 - Reactor Theory

NuEg 603 - Nuc. React. Meas. & Instr

NuEg 699 - Research

ME 340 ~ Thermodynamics

EE 311 - Elect. Eng

NuEp 622 - Adv. React. Theory

NuEg 625 ~ Nuc. Reactor

NuEg 626 ~ Reactor Laboratory

NuEg 616~ Seminar

NuEg 699 - Research

NuEg 551 - Intro. to Nue. Eng

ME 381 ~ Thermodynamics

EE 311 - Electrical Eng

?Summer Workshop

: Courses Taught by Nuclear Engineering Faculty

No. of Students ?Professor

rst Semester

Bovww

Second Semester

Bisco

Summer

9 Al Staff

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TROPICAL AGRO-SCIENCES

?The Tropical Agro-Sciences Division has two functions: conduct research on the impact, of air pollution on tropical agricultural and to provide training to UPR graduate students ?and visting scientists. Since the reorientation of the Center's interests under ERDA, the Division has directed its research activites, with particular emphasis on the effects of jtmospheric pollution on tropical agriculture in the Guayanila-Pefivelas region, which hes 8 fossil-fuel power plant, petroleum refineries, and associated industries. This new area of research is important to ERDA because the knowledge gained regarding the effects of

sir pollution related to energy technology on the agricultural environment and productivity will be useful in planning future energy developments. Information about the potential harm of air pollutants to man through the food chain and about ways of alleviating their Impact on agriculture are of practical importance. Studies of the mechanisms involved in Pollution injury, protection, and tolerance are of basic significance,

RESEARCH ACTIVITIES

Installation of a Field Station for Pollution and Climatological Monitoring. (F. K. S. Koo ?and J. Cuevas-Ruiz). At the beginning of this fiscal year, trip were made to Guayanile Pefiuelas area to survey the genera air pollution status, cropping system, vegetation, soils, and climatic conditions and to find localities suitable for field stations. Two locations were chosen for preliminary monitoring, and one of these was made into a field station. Financial tation precluded establishment of five stations on a pollution concentration gradient 8 aoriginaly planned. The preliminary monitoring indicates an irregular daily SO, disti- bution pattern differing at the two locations. In general, a heavy SO, influx lasting 1 to hr occurred one to three times a day, with concentrations ranging from trace to 0.5 ppm ?or more but usually about 0.2 ppm; it was thought to depend on wind direction. Additional ?monitoring will be done with all the instruments installed, including SO, analyzer/recorder,, ?otal sulfation collector, high-volume air sampler, dustall collector, wind speed and direction instrument, rainwater collector, hygrothermograph, etc. Planting of test material at the field station will begin in July 1976.

$0, Effect on Leat Fresh Weight and Net Photosynthesis in Phaseolus vulgaris seedlings (F. K. 8. Koo, J. Cuevas-Rulz, and J. Garcia-Villalobos). In experiments on the effect of SO, on 10-day-old bean seedlings (Phaseolus euigaire L.), seedlings in a sealed

12.5x9.5x 12-in. glass chamber were exposed for 1 hr to concentrations of SO; , generated by heating 10 mi each of 2.M HCI and 1 A K,S;O, in @ small polyethylene bottle and. injected into the chamber. The symptoms of injury and the protective effect of ascorbic ?acid have been reported earlier. The results of the present study suggest that the leat fresh-weight loss, presumably due to lea tissue injury, ensuing water lost, and lowered ?photosynthetic activity, ean be used asa criterion for measuring the extent of leat injury

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caused by acute SO, exposure. The weight loss 3 days after exposure at 5.6 ppm was not sppreciable, but at 14 ppm it was about 6% (compared with the control) and at 28 ppm increased to 29%. Net photorynthess, measured immediately after exposure and 24

and 48 hr later, showed @ marked decrease as the SO, concentration increased. Immediately after exposure at §.6 ppm, the decrease was about 18% (compared with the control); at

14 ppm it was 37%; and at 28 ppm it reached >80%. Various degrees of recovery in

photosynthetic activity were seen 24 and 48 he afterall treatments.

Trace Amounts of Heavy Metals in Higher Plants (J. A. Ferrer-Monge). The heavy metals Cd, Co, Ni, Cu, and Pb have been determined by atomic absorption spectrophotometry in the leaves of mango (Mengifere indica) and bird's nest (Tlandsa sp), and the latter was consistently found to contain much higher concentrations ofall of them. The results are given below as ug/g sample (dry weight).

Dilandsia 190,

ca oat 0.18

Co 231 1.80

Ni 7.35 283

cu 23.70 1226

Po 85.12 12:18

?Adgitional materials in both polluted and nonpolluted areas are being samples for further analysis.

?Availability of Methionine for Synthesis of Different Protein Fractions in Soybean Seeds During Development (B. F. de Riesco and F. K. S. Koo). The quantitive changes in nitrogen, {ree smino acid pool, total protein, three protein fractions (globulin |, globulin II, and

{ree methionine, and methionine in proteins were studied in soybean seeds, Glycine max

(L.) Merrill, at various stages of development. Total nitrogen remained relatively constant

(on a per unit dry weight of meal basis, but increased steadily on a per seed basis as 8

result of protein accumulation as the seeds developed. The level of free amino acids (FAA) was high in very young seeds and then decreased with a concomitant increase in protein synthesis and accumulation. Protein synthesis had two peaks, in 30 and 70-day-old seeds. ?The type of protein synthesized and accumulated varied during development. Albumins

?were relatively abundant in the Young seeds, then their synthesis slowed down until near maturity, when a slight increase in albumins per unit weight was observed. Globulin | was {very small fraction in the young seeds, but as development proceeded it was synthesized ?and accumulated very rapidly to form the bulk of the proteins in the mature seeds, The ?Globulin 1! fraction was relatively high in immature seeds and decreased slowly until maturity. ?Methionine in the FAA pool per unit dry weight of meal was high in the immature seed

land decreased as the poo! decreased. Methionine in terms of percent of total FAA wos

highest at 30 days and also slightly elevated at 70 days, times of increased synthesis of ?methionine-rich proteins. Methionine in the proteins was higher atthe early stages and decreased during development.

TRAINING ACTIVITIES

?The Division continues to provide instruction and training to students and to researchers at the graduate and postgraduate levels in the fields of agriculture and biology, frequently related to the Division's base research activities.

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During FY 1976, Division staff members holding joint or achonorem appointments in the various science departments of the University of P.R. taught the courses listed in Table 1.

?Table 1:_Courses Taught at UPR, 1975-1976

Course No. of students Professor

614 Ncw Teenie in Boge Remark D4. ComeRu an A Fer Monge

618 yep 3 LA Feestone

020 Ramesh 1 Rcwsenotaonee

(05 Nove Techie in Agel Rewach 3. Comer at

?Ao 418 Seco in Aaonay 1 RRS. Kee

Hort 085 Grows Reps in Agere 3A Caatontsdonsso

Bio 608 Rene 1 Res ee

Bot 698 Renee 1 La Fereratong

Thesis Research

During FY 1976, three undergraduate students were doing thesis research in the Division

Cytogenetic Effect of Insulin on Human Chromosomes. (Alice Ortiz, Puerto Rico (for MS. in Biology under Dr. J. A. Ferrer-Monge).

Effects of Cadmium on Some Photosynthetic Reactions of Isolated Chloroplasts. (Carmen Asencio, Puerto Rico (for MS. in Biology under Dr. A. Cedefo-Maldonado).

Availabilty of Methionine for Protein Synthesis in Soybean Seeds During Development. (Blanca Riesco, U.S. (for MS. in Biology under Or. F. K. S. Koo)

Special Training

?The Division has been active in technical and scientific training programs. During FY 1976 five traines (Table 2) under the sponsorship of (OAS) and of the Gran Mariscal de Ayacucho (GMA) Fellowship of Venezuela have received special training inthe fields of plant phy logy and application of nuclear techniques in agriculture.

?Table 2: Trainees, 1975-1976

Name Country ?Sponsor Date

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Fie Hiren eat ons ?AUG 75-1AN 76

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