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MARINE RESOURCE PROGRAMS

at the

UNIVERSITY OF RHODE ISLAND

University of Rhode Island

ICMRD

MARINE RESOURCE PROGRAMS AT THE UNIVERSITY OF RHODE ISLAND

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MARINE RESOURCE PROGRAMS AT THE UNIVERSITY OF RHODE ISLAND

HISTORY AND COMPOSITE VIEW

Dr. Nelson Marshall

Director, International Center for
Marine Resource Development

and

Professor of Oceanography

The University of Rhode Island initiated in 1960 a significant shift from a marine sciences research activity with limited applied effort to a broad marine resources research program. This new approach included a proportionate increase in applied work accompanied by supporting work in the social sciences plus an awareness of the need for a marine extension or advisory component. This broadened marine resources program ultimately grew to include food technology and nutrition; various social sciences, including resource economics, sociology, anthropology and geography; political science, including Law of the Sea considerations and a wide scope of marine affairs and management interests; and ocean, coastal and environmental engineering. All of this activity unfolded in addition to the pursuit of the marine sciences, as focused in what is now the University's Graduate School of Oceanography, and in addition to participation by what we think of as the traditional science departments such as zoology, botany, bacteriology, geology, physics, etc.

In developing in this manner, the University of Rhode Island did not simply expand the faculty of its marine laboratory. Instead, the participation of faculty members was encouraged across departmental and college lines and, in a very real sense, marine resource interests unfolded throughout the entire academic institution. Thus the growing program has been interdepartmental, inter-college and interdisciplinary, with the participants oriented to their own academic areas yet cooperating, sometimes closely, in broad projects bearing on marine problems. This development at the University of Rhode Island was concurrent with a growing awareness throughout U.S. academia that marine resource concerns are very broad and require diverse capabilities for comprehension and handling. This appreciation found its most tangible expression through the establishment of the Sea Grant Program, a national program funded by appropriations from the United States Congress enabling universities to develop further in the manner initiated in 1960 at URI. As a concept the sea grant approach is not by any means limited to the Program bearing the title, as will be seen in our further elaboration on URI activities. The words "sea grant" came into favor, we might note, largely because they suggested a marine effort paralleling the successful work of the land grant institutions that had served U.S. agricultural development so well through research, education and extension on an interdisciplinary basis. The similarity between "land grant" and "sea grant" ends at this conceptual level for we do not have a grant program involving the assignment of actual ocean properties in support of the marine program.

The fulfillment of the sea grant concept, spanning diverse marine resources interests, does not in any way detract from our earlier focus limited to the marine sciences; in fact, the energy and interest directed to marine sciences have increased concurrently with our broader consideration of resources. We now appreciate, however, that the pursuit of marine sciences as an end in itself can miss the mark when isolated from any conscious concern for resource interests. At the same time we have become increasingly conscious of what science has to offer and what aspects of science must receive further support in behalf of resource concerns. Finally, we have developed a keener sense as to what disciplinary pursuits must be brought to bear on marine resource problems if useful solutions are to be found.

The expanded marine resource approach has been handled differently in different institutions in the United States. The University of Rhode Island illustrates one extreme, with coordination ranging very broadly across and throughout the university organization. At the other extreme might be the pattern found in the College of Marine Resources at the University of Delaware which brings the broad cross-disciplinary effort under the canopy of a single college. It is also interesting to note that outside the university system we see a parallel trend in research institutes and government agencies, with many broadening the scope of their involvement as they consider marine problems.

Having been associated in one capacity or another with about every organizational pattern being tried in United States institutions, I should be able to answer questions over a wide range; however, I will stress the URI example. The flow of authority, activity and responsibility is shown in Table 1. Table 2 indicates the scope and responsibility of the institute-like units functioning at the University. Tables 3 and 4 list degrees offered and representative departmental and project areas receiving attention which have marine resource implications. In the main the growth of the project areas, all bolstering the educational mission of the University, has stemmed from the initiative of the faculty. Thus the most basic need is to assemble a staff sensitive to overall objectives and capable of responding. Direction at the administrative level is subtle, with energies spent in catalyzing rather than overtly steering programs. To be sure the sources of funding in support of research have an influence on the projects that are proposed and pursued. Thus a faculty member seeking support for a basic inquiry would likely apply to the National Science Foundation, for a domestic applied problem to the Sea Grant Program, for an international development project to sources generated by U.S. AID. There are, fortunately, multiple and diverse sources, though never quite enough. Some project proposals, as for Sea Grant activities where we are backed by a lump sum for suitable internal use, are judged almost entirely within the University; some proposals are assessed entirely by outside peer groups; and there are

Table 1. Organization for Marine Programs - University of Rhode Island.

President

Vice President

Provost for Marine Affairs

Institutes, etc.

(Largely staffed by faculty members from departments in the various colleges.)

Coordinator: Sea Grant Programs

Director: International Center for Marine Resource Development

Director: Marine Experiment Station

Director: Marine Advisory Service and Information Program

Director: Coastal Resources Center

(Director: Law of the Sea Institute)

UNIVERSITY COLLEGES AND DEPARTMENTS*

Dean Arts & Sciences	Dean Engineering	Dean Oceanography	Dean Home Economics	Dean Resource Development	Dean Pharmacy
Biochemistry	Ocean	Oceanography	Food & Nutritional Science	Animal Pathology	Pharmacognosy
Botany	Civil & Environmental	Biological		Animal Science	Pharmacology
Chemistry	Electrical	Chemical		Community Planning & Area Development	
Economics	Industrial	Geological		Fisheries & Marine Technology	
Geography	Mechanical	Physical		Food & Resource Chemistry	
Geology				Plant & Soil Science	
Marine Affairs (administered by Geography Department)				Resource Economics	
Microbiology					
Physics					
Political Science					
Sociology & Anthropology					
Zoology					

*The departments listed are those with faculty members active in marine resource work; the degrees given by these departments are listed in Table 3.

Table 2. Role of Institutes or Institute-like Units on the Flow Diagram

Sea Grant Program

Promotes marine resources work through funding available under the National Sea Grant College and Program Act with some matching funds from the University.

International Center for Marine Resource Development

Promotes resource development activities overseas; funding from the U.S. Agency for International Development, the University and other sources.

Marine Experiment Station

Undertakes applied marine projects, often under contract agreements, requiring an experimental approach.

Marine Advisory Service

Offers advisory services to the fishing industry, to other marine enterprises and to the public in general; funded by Sea Grant, the University, and other sources.

Coastal Resources Center

Through the multiple capabilities of the University, advises the state's coastal zone authority and other state agencies in fulfilling their planning, decision making and administrative responsibilities; funded by Sea Grant, the federal Coastal Zone Act and other sources.

Law of the Sea Institute

Independent of URI, but administered through the University. It was organized to promote interest in and a greater understanding of international law of the sea problems.

Table 3. Participation - Marine Resources, by Department

Graduate School of Oceanography	M.S., Ph.D.
College of Resource Development	
Animal Pathology	M.S., Ph.D.
Animal Science	M.S., Ph.D.
Community Planning & Area Development	M.S.
Fisheries & Marine Technology	A.A.
Food & Resource Chemistry	M.S., Ph.D.
(Food & Nutritional Science)*	M.S., Ph.D.
Plant & Soil Science	M.S.
Resource Economics	M.S., Ph.D.
College of Engineering	
Department of Ocean Engineering	M.S., Ph.D.
Other Engineering Departments	M.S., Ph.D.
College of Arts & Sciences	
Biochemistry	M.S., Ph.D.
Botany	M.S., Ph.D.
Chemistry	M.S., Ph.D.
Economics	M.S.
Geography	M.A.
Geology	M.S.
Marine Affairs (administered by Geography)	M.M.A.
Microbiology	M.S., Ph.D.
Physics	M.S.
Political Science	M.A., M.P.A.
Sociology & Anthropology	M.S.
Zoology	M.S., Ph.D.
College of Pharmacy	
Pharmacognosy	M.S., Ph.D.
Pharmacology	M.S., Ph.D.

* This group is in the College of Home Economics but cooperates with Food and Resource Chemistry and other departments in graduate instruction.

Table 4. Representative Departmental and Faculty Project Areas Having Marine Resource Implications

Biochemistry

Biochemical properties of marine organisms.

Biological Oceanography

Numerous projects dealing with basic productivity, food chains, basic and applied ecology, fisheries and aquaculture.

Botany

Ecological role of algae in coral reef coasts.

Algae as indicators of water quality.

Chemical Oceanography

Hydrocarbon and trace element pollution along the coast and on the open ocean.

Nutrient chemistry as backgroundfor biological oceanography studies.

Electrical Engineering, also Physics

Applications of underwater sound transmission.

Environmental Engineering

Waste water treatment and pollution control.

Fisheries and Marine Technology

New net design development.

Testing of new fishing techniques.

Food and Nutritional Science; Food and Resource Chemistry

Processing and handling of marine food products.

Nutrition from marine food products.

Development and use of marine food products.

Geography (including Marine Affairs)

Offshore boundaries.

Coastal and international marine law.

Table 4 (continued)

Geological Oceanography
- Shoreline stabilization.
- Sedimentology and coastal and offshore mineral resources.

Ocean Engineering
- Breakwater construction.
- Ocean monitoring systems.
- Practical uses of underwater detecting devices.

Pharmacognosy & Pharmacology
- Search for, experimentation with, and testing of drugs from the sea.

Physical Oceanography
- Water exchange in relation to pollution.
- Current studies relating to biological problems.

Plant & Soil Science
- Functions of tidal marshes in coastal ecology.
- Dune stabilization.

Resources Economics
- Infrastructure related to fisheries development.
- Economic analyses of marine resources and their potential.
- Assessment of multiple use and conflict in the marine resource area.

Sociology & Anthropology
- Cultural characteristics and questions of adaptability of peoples in the fishing industry.

combinations within these extremes. The important need is to have varied and, hopefully, ample sources available to back activities found to have merit. Also important, in the viewpoint cultivated at URI, is to have sufficient on-going, assured support for the major staff positions, in our case the faculty, so the researcher, in his quest for research funding, is motivated by a sense of purpose and need and does not become trapped in a desperate hunt applying for the funding of his own position.

It is appropriate to close with comments about how work in marine resources at the University of Rhode Island relates to other research in the area and to government. First of all, the university program provides the educational services needed to help develop competency for filling the ranks of these other activi'ies. Next, the URI program constantly interacts with and complements government and other research. Reflecting on the broad spectrum of concerns to be dealt with in marine resource development, one can quickly identify responsibilities which are logically the province of government, research best carried out by regional organizations, and research best handled in a university setting. The fact that such divisions are not always clear or that some undertakings require a multiple impact can be an asset rather than a drawback as the overlap brings together the different participating organizations. Thus, at the University of Rhode Island some of us serve in an advisory capacity to the state's coastal authority (see notes on the Coastal Resources Center), some work on projects of the National Marine Fisheries Service, and some collaborate with contract and endowed research institutes in the region; while some of the staff from government and research organizations come to the University for advanced study or as senior staff in residence for specialized research or educational pursuits. In a few instances, where it is mutually beneficial, workers from groups outside the University are given adjunct faculty status in which they retain their primary affiliation yet are formally recognized as contributing members with respect to the University's educational responsibilities.

I can readily appreciate that there are a number of ways in which you might organize for the pursuit of marine resources work in Eastern Africa. My main objective has been to introduce the nature and scope of this work and to hope you will take it from there. Since long range and lasting gains will necessitate the development of competency in the region, I do hope you will tie your pursuits closely to the university structure of the region with effective links to both government and relevant research enterprise.

FISHERMAN TRAINING, FISHERIES BIOLOGY AND AQUACULTURE

Dr. Saul B. Saila

Director, Marine Experiment Station
Professor of Oceanography and Zoology

Background for Fisherman Training and Fisheries Biology

The time-honored objective of fisheries biology has been to determine what level of fishing will produce the maximum sustainable yield. Today fisheries biology--its objective and method--is recognized to be more complex. For example, interactions between living resources and their environment as well as interactions among various species of organisms must be taken into account. In addition, biologically acceptable objectives of management are being challenged by economists, and social values in the fishing industry are of considerable relevance. Finally, fisheries as well as other natural resources can be managed for many different purposes. In order to establish guidelines for management, appropriate criteria must be identified and applied to judge the effectiveness of alternative programs; the primary criteria relate to biological, economic and social aspects of the managed fishery within the context of regional needs. These criteria can only be developed cooperatively.

At present, it is believed, the major roles of the fisheries biologist are (1) to identify and describe the distribution and abundance of the resources and their variations in time and space, (2) to estimate the harvest that each resource or group of resources can sustain, (3) to understand the effects of man's activities (including fishing) upon the supply and to explain the effects of natural environmental variations,

(4) to forecast abundance and place and time of arrival upon the fishing grounds, and (5) to develop other information that can be used to increase the supply, reduce fluctuations in abundance, or otherwise reduce the costs of locating and catching fish. Our approach has been designed to try to meet these formidable tasks.

In addition to the classical approaches of the fisheries biologist in resolving the above problems, the presence of and cooperative relations with an enlightened, well trained population of fishermen is a necessity.

The University of Rhode Island Approach in Fisheries

The University of Rhode Island's program in fisheries has evolved over more than two decades in the light of this background, and currently is divided into two major categories: (1) a two-year undergraduate program leading to the Associate in Science degree, and (2) research and course work at a graduate level leading to the Master of Science or Doctor of Philosophy degree in oceanography or zoology with specialization in fisheries. This latter graduate program is considerably less structured than the associate program.

A listing of the course work offered for the Associate in Science degree is shown in Table 1, and its content is briefly described in this table. The Department of Fisheries and Marine Technology faculty of six is part of the College of Resource Development (formerly Agriculture), and their facilities include a training vessel as well as shore facilities.

A brief outline of the content of a graduate course in fisheries biology offered at the Graduate School of Oceanography is shown in Table 2. The content is not rigid and is designed to meet current needs. The objective of the graduate degree program is to produce competent scientists capable of handling diverse problems. Additional course work in several disciplines--including, but not restricted to, mathematics, economics, experimental statistics, various engineering disciplines, zoology, botany and chemistry--is required of degree candidates. Courses are tailored to individual requirements.

A wide range of problems has been chosen for thesis research. Some theses have resulted from an interest in extending the knowledge derived from fisheries-related course work and others have developed from grant or contractual work by university personnel. There has been no restriction

Table 1. Fisheries and marine technology course work at the University of Rhode Island

Two Year Program for the Associate in Science Degree

Seamanship

Basic shipboard terminology and orientation. Safety at sea. Characteristics and use of rope and wire, tackles, gear systems, stress factors. Shipboard maintenance. Ship handling. International rules of the road. Knots, bends, hitches, rope and wire splicing.

Vessel Operations

Practical laboratory course in the conduct and handling of vessels and small craft with emphasis on procedures and seamanship for safe and efficient operation. Work consists of actual operations in port and at sea.

Introduction to Commercial Fisheries

Commercial fisheries of the world, the United States and New England, including fishing grounds, resources, catch statistics and legislation. Introduction to fisheries biology with emphasis on the natural history of important commercial species and the food chain. Effect of fishing pressure and introduction to management of fishery resources. Utilization and principal catching methods for the various important commercial species, including vessels and gear.

Marine Technology

Application of basic physical principles of statics, dynamics, heat, light, sound, magnetism and electricity to problems encountered in vessel operation, fishing gear, navigation, fish finding, handling and storage of fish, engineering and electrical systems.

Shipboard Work I, II, III

Work aboard training vessels in port and at sea. Experience is gained in operating vessels and their equipment, in principal methods of fishing, in rigging and working common gear used in the commercial fishing industry, and evaluation of experimental fishing gear.

Fishing Gear I, II

Detailed study of bottom and mid-water trawls and other dragging gear. Emphasis on construction, repair and use of different rigs and net designs, including the seine net. Detailed study of the purse seine, gillnet, trap and longline. Emphasis on the construction, repair and use of the various arrangements and designs of each. Brief treatments of other fishing methods.

Fisheries Meteorology

Basic practical meteorology and weather forecasting for the mariner. The atmosphere, heat budget of the earth, hydrometeors. Fundamental

Table 1 (continued)

pressure systems, air masses, formation of fronts and associated weather. Precursory signs, tracks and vessel conduct for tropical revolving storms. Ice, icebergs and icing-up conditions. World meteorological organization, coding and decoding of weather reports.

Marine Engineering Technology I, II

Diesel engine operation, maintenance, testing, timing, and overhaul. Basic principles of diesel designs in common use, including fuel systems, combustion chambers, piston and liner assemblies, camshafts and crankshafts, cooling systems, and lubrication systems. Introduction to hydraulics, including operation, maintenance, troubleshooting, installation and applications. Study of basic hydraulic systems, design of common hydraulic components, and selection of components for various applications. Study and application of mechanical and hydraulic diesel powered drive units. Layout and uses of shipboard water pumps.

Marine Electronics

Basic electricity applied to fishing. Basic solid state and vacuum tube electronics, DC and AC machinery, ship wiring, communications, depth and fish finders, radar, electronic navigation systems. Noise control, siting and preventive maintenance of equipment.

Navigation I, II

Fundamental rules and methods of chartwork. Chart projections and types. Position fixing, wind and tide allowance. Variation, deviation and compass error. Principle of transferred position line and doubling angle on the bow. Use of sextant angles, radar, hyperbolic, and celestial position lines for chartwork. Tidal theories and calculations involving parallel, plane and Mercator sailings. Elements of astronomy and spherical trigonometry applied to celestial navigation. Kepler's laws, the solar system, star recognition and study of time; the altitude/intercept method and sight reduction by various techniques.

Fishing Operations Practicum

Practical fishing vessel operation; planning and working nearby fishing grounds for principal commercial species; rigging and handling gear and vessel. Conducted at sea in nearby waters.

Ship Technology

Principles of naval architecture and ship construction applied to smaller vessels, with special emphasis on fishing craft. Basic ship geometry and calculations, stability, powering and propellers. Construction methods and materials, vessel planning.

Fishing Operations

Commercial fishing procedures as they relate to the vessel operator, in the use of navigation, engineering, vessel layout, economics, marketing, fishing gear, accounting, and on-board fish processing.

Table 1 (continued)

Marine Transportation

Marine transport and the carriage of seaborne cargoes: trade and cargo patterns, ship types, international and governmental organizations, business, legal and insurance aspects, position of U.S. merchant marine, ports.

Fish Preservation

Introduction to microbiology and biochemistry of fish spoilage. Preservation methods at sea and ashore including icing, mechanical refrigeration, freezing, salting, smoking, dehydration, canning, plant sanitation and quality control.

Industrial Fishery Technology

Utilization of industrial fish; production of fish meal, fish oil, condensed fish solubles, fish protein concentrate; handling, packaging, storage and transportation. Nutritive quality, market value and demand relationships for fish proteins.

Table 2. The course outline currently used in Fisheries Biology at the University of Rhode Island.

Oceanography 568 - Fishery Biology

Highly recommended: Book -- Bartlett, M. S. and R. W. Hiorns. 1973. The Mathematical Theory of the Dynamics of Biological Populations. 352 pp.

Desirable: Manual -- Ricker, W. E. 1958. Handbook of Computations for Biological Statistics of Fish Populations. Fish. Res. Bd. Canada. Bull. No. 119, and Book -- Watt, K. E. F. Ecology and Resource Development. McGraw-Hill, 1964.

The course outline below will be used as a general guide for the course.

I. Introduction

1. World fisheries, historical development and current status
2. Concepts of fisheries science and population dynamics
3. Aspects of production and cropping
4. Physical environment related to life history

II. Analysis of Subpopulations--stock separation

1. Genetic--environmental aspects--general
2. Meristic comparisons
3. Morphometric comparisons
4. Combined data--bivariate and multivariate approaches
5. Movement measured by subpopulation studies
6. Tagging experiments
7. Group comparisons in space or time
8. Faunal associations and diversity

III. Empirical Considerations

1. Growth
   a. The nature of growth processes--use of hard parts
   b. Calculated, logistic, Gompertz, Von Bertanlanffy functions
   c. Growth estimates from marking
2. Length-weight relationships
   a. condition-allometry equation
3. Mortality estimation
4. Fishing power estimation
5. Mesh selection

Table 2. (continued)

IV. The Theory of Fishing

1. Fishing effects interpreted by mathematical models
    a. Model types
2. Optimum yield problem

V. Population Estimation

1. Principles
2. Single season experiments
3. Multiple season data

VI. Methods and Principles of Fishery Regulation

1. Size limits
2. Bag limits
3. Quota regulations

VII. Migration and Movement

1. Models and assumptions

VIII. Fisheries Hydrography

IX. Stock-Recruitment Relations

on the geographic location of field work, and some projects have been undertaken outside the United States.

The fisheries program attempts to respond to current problems and to use knowledge from other disciplines to further fisheries science to the extent possible.

There is already some parallel between the Fisheries and Marine Technology program at the University of Rhode Island and the fisheries training program in Tanzania. It seems desirable that some of the course work listed in table 1 might become incorporated into the Tanzanian fisheries training program in the future. The University of Rhode Island program in fisheries biology does not yet appear to have a counterpart at the University of Dar es Salaam. It is hoped that the description given above might aid in the decision to develop such a program.

Background for Aquaculture

The term aquaculture, as used here, refers exclusively to the controlled husbandry of economically important marine or brackish water organisms in coastal and brackish water regions.

The five major subtechnologies of aquaculture are considered to be (1) transplantation, (2) hatchery production and stocking, (3) retainers or attachments using natural feed (embayment culture), (4) ponds using supplemental feed and fertilizer, and (5) ponds or containers using no natural feed (intensive culture).

Progress in aquaculture in the United States is proceeding rapidly although commercial-scale operations are still limited in number. High-priced species (so-called luxury foods) are the prime targets of aquaculture efforts in developed countries. Candidate species from a technological viewpoint include those with good growth rates, conversion efficiencies, and hardiness, as well as those able to use available feeds and with relatively simple larval developmental stages. From an economic point of view market volume, price and price flexibility are important criteria for species selection.

The goals of aquaculture in the developing countries may be quite different from those suggested above. Here the need for increased protein may be the principal factor to encourage aquacultural development.

It seems that the major problems still facing the widespread application of available aquaculture technology in developing countries are capital investment, cheap feed formulations, predator controls, and the availability of technical assistance. The usual competitors of aquaculture in developed countries (agriculture, fishing and coastal zone development) are more supportive than competitive in the developing countries with agriculture providing fish feed, fishing providing spawning stock, and increased interest in coastal zone development helping to bring the infrastructure to aquaculture areas.

Aquaculture is not considered a panacea for malnutrition by being an almost unlimited source of protein. Rather it is suggested that greater consideration be given to aquaculture's potential contribution in raising the general levels of economic well-being in the developing countries including Tanzania.

University of Rhode Island Approach to Aquaculture

Aquaculture at the University of Rhode Island started in 1964 at the Marine Experiment Station in a very modest fashion. The prime interest was in enhancing growth and survival of pelecypod mollusks and in rearing salmonoid fishes. Aquaculture soon after became a significant part of the Sea Grant Program at the University. The program of controlled husbandry developed for sea grant projects included reproduction and hatchery culture of marine vertebrates and invertebrates, as well as studies in growth and rearing, environmental and predator control, phytoplankton and other food organism culture, demand elasticity, cost of production and opportunity cost.

In view of the fact that aquaculture was a relatively new program at the University, some of the initial work has been modified or terminated and new projects initiated. The five continuing sea grant aquacultural research projects involve nutrition of selected marine species (especially salmonid fishes), pathology of marine species, culture of marine invertebrates, bacterial aggregation and larval nutrition and economic analysis of the aquacultural potential of selected marine species.

The project dealing with nutrition of selected marine species is directed by a professor in the Department of Animal Science. The immediate objective has been to develop practical and economical diets for salmonoids and related species. Longer range objectives include the study of (1) interrelationships between dietary protein and energy requirements, (2) protein utilization as a function of environment, (3) the dietary interrelationships of certain unsaturated fatty acids, and (4) interactions among light, metabolism and temperature.

The project dealing with culture of marine invertebrates is directed by a professor of oceanography. Its objectives are (1) to develop techniques for culturing larvae and juveniles of economically important crustaceans and bivalve mollusks, (2) to determine ecological and physiological requirements for larvae, juveniles and adults, and (3) to apply knowledge gained from the above for development of methods and equipment for controlled production on a commercial scale.

A study of the role of bacteria--both beneficial (nutrient) and deleterious (inhibitory)--in larval development has been led by a professor of oceanography.

A marine fish culture-pathology project is directed by a veterinarian who is a professor in the Department of Animal Pathology. Its objectives include development of a clinical and histopathology laboratory and use of these facilities to study specific disease processes, and to aid investigators in related fields.

The economic analysis of aquaculture projects is directed by a resource economist with the objectives of projecting production costs for alternative technologies and food rations, assessing market potential for selected salmonid species and evaluating the economic feasibility of selected types of salmonoid aquaculture.

It is clear from the above that aquacultural research at the University of Rhode Island involves a coordinated multidisciplinary approach to the development of techniques and systems for commercial operations. However, it is also clear that there is no formal course work in aquaculture offered at the University. Instead, investigators in several disciplines have chosen to apply their knowledge to the solution of aquacultural problems.

There are obviously a number of interdepartmental relationships involved in a program such as this. In addition, international liaison with aquacultural researchers in other countries has already been established in the case of nutritional studies and pathological studies.

The plans and projections for this program seem to suggest that certain elements of aquaculture, such as nutrition, genetics and pathology, will probably continue to be carried out in a university environment. However, it is hoped that other aspects of this work will be carried out ultimately by entrepreneurs.

It is suggested at this time that the relationship of this program to any developing program in Tanzania is not very close. The University of Rhode Island program is directed toward high value north temperate species (such as salmon and northern lobster) and is aimed toward an intensive, virtually closed system culture involving a high level of capital investment and technology. It is also oriented toward conversion of one form of protein into another rather than toward increasing protein production. It is suggested that aquaculture might initially become a portion of the fisheries technology program in Tanzania in order to respond to the goal suggested in the background material, and that the University program evolved at Dar es Salaam be tied to the investigation of aquaculture problems brought to light by technological developments.

OCEAN AND ENVIRONMENTAL ENGINEERING

Dr. Saul B. Saila

Director, Marine Experiment Station
Professor of Oceanography and Zoology

Background

It is believed that engineering problems related to the oceans include at least four separable classes of problems: (1) availability and use of resources, (2) design and use of structures and machinery, (3) information gathering and transmission, and (4) pollution.

The first of these topics relates directly to the desirability of entering into any technological development that might exploit the sea. Some of the ocean resources to be considered for this development include petroleum and minerals such as phosphate rock, manganese nodules diamonds, and sand and gravel. The variety of organic products that can be made from living resources of the sea is impressive--fish for food, fish meal and flour; fish oils for diverse applications; seaweeds and industrial products from fish scales and mollusk shells such as pearl essence, poultry feed supplements and pearl buttons, and various other industrial products from the skin and bones of marine fish and mammals. All require engineering studies before and during operations.

The second major topic dealing with the design and use of structures and machinery is equally diverse. It includes a description and understanding of the static and dynamic forces that will be encountered when one places a structure (ship, submarine, undersea cable, undersea habitat) in the ocean and operates machinery there to do useful work.

The marine vehicles and structures include ships for bottom and deep-ocean work, platforms for oil and gas exploration and submersibles of various types, as well as various types of living resource exploitation systems. Design and use studies involve materials, propulsion systems and control systems.

The third topic, information gathering and transmission, is also very broad. It should be recognized that almost any spatially- or temporally-varying physical phenomenon in some sense is available as either a source or a mode of information transmission. The obvious types are acoustic and electromagnetic energy transmission and their diverse applications, such as echo sounding and magnetic anomalies on the sea floor.

The fourth topic, pollution, is of more recent interest. It is clear that if oceanic resources are to be developed to permit man to sustain himself and his productive activities, pollution must be managed in such a manner as to assure the continuing health of living resources including man. Pollution abatement and management involves both engineering and other skills, but certainly ocean engineers have an important role in this area.

University of Rhode Island Activities

The University of Rhode Island has based its program in ocean engineering on marine-oriented research capabilities in the College of Engineering. A Department of Ocean Engineering is located within the College and it presently has a faculty of 13. Table 1 shows the course work offered by the Department. It should be pointed out that this is a graduate program offering a Master of Science and a Doctor of Philosophy degree. There are currently more than 80 students enrolled in the graduate program in ocean engineering.

The area specializations of the Department of Ocean Engineering include a host of specific projects--desalination of sea water, physical properties of marine sediments, sediment transport, bottom profiling and penetration, estuarine pollution abatement and waste disposal, mathematical modeling of estuaries, guidance and control of underwater vehicles, hydrodynamics of floating and submerged bodies, and SCUBA safety and work effectiveness.

Table 1. Course offerings in ocean engineering at the University of Rhode Island

Basic Ocean Engineering

Introduction for non-engineering students to the classic engineering disciplines as they relate to marine affairs. Course is descriptive and deals with current engineering practice.

Hydrodynamics of Floating and Submerged Bodies I, II

Hydrodynamic principles associated with floating and submerged bodies: resistance, propulsion, static and dynamic stability. Problems of maneuvering, control, and motions in waves.

Materials Technology in Ocean Engineering

Requirements for ocean engineering materials. Material characteristics, fracture toughness, notch sensitivity, energy absorption, speed of loading and fatigue in salt water. Steel, aluminum, titanium, plastics, concrete, and applicable regulations will be discussed.

Marine Structural Design

Includes the design of marine structures, consideration of marine construction materials, waterfront structures, ocean towers and underwater structures.

Underwater Power Systems

Low output power systems. Overall considerations appropriate to the determination of power requirements for underwater systems.

Coastal Zone Power Plants

Overall systems consideration for coastal zone power plants. Consideration of factors such as political and legal problems, thermal pollution, and multi-use of plants (aquaculture, etc.).

Underwater Acoustics I, II

Wave equation, energy, pressure and particle velocity. Acoustic properties of the sea. Elementary sources, refraction, reflection, ray theory, normal modes and scattering, with emphasis on sound propagation in the ocean. Transducers, radiators and receivers, directivity (array structures), equivalent circuits, efficiency; piezo-electricity, magnetostriction, sonar principles, measurements and calibration.

Advanced Course in Underwater Acoustic Propagation

Analysis of propagation form a concentrated acoustic source in the ocean by methods such as advanced normal mode theory, numerical integration and fast Fourier transforms. Applications to ocean features such as surface ducts, shadow zones, deep sound channel, etc.

Table 1. Course offerings in ocean engineering (continued)

Nonlinear Acoustics

Topics in the nonlinear acoustics of fluids. Propagation and interactions of finite-amplitude sound waves. Parametric sonar. Sound generation by turbulence. Cavitation noise. Shock waves. Underwater explosions. Radiation pressure and acoustic streaming.

Coastal Engineering Geology

Discussion of the interaction of geological factors and coastal structures. Shore materials, energy-material relationships, and the interference of man-made structures with the natural regimen emphasized.

Submarine Soil Mechanics

Soil mechanics principles as applied to submarine slope stability, heaving, sinkage and anchorage problems with emphasis on effective stress principle and selection of shear strength of marine sediments.

Engineering Ocean Mechanics

Applied concepts of ocean flow processes; waves due to gravity, wind, and layered media; large and small scale turbulence; prediction of flow instability; wave forces on structures.

Advanced Design

Advanced course coordinating engineering principles and economics in the design of a complete ocean engineering device. Problem investigated individually with the guidance of one or more instructors.

Corrosion and Corrosion Control

Chemical nature of metals, electrochemical nature of corrosion. Types of corrosion, influence of environment, methods of corrosion control, behavior of engineering materials, all with special emphasis on the ocean environment.

Advanced Course in Corrosion

The various types of corrosion problems occurring in modern industry. In-depth comparison of the various methods available to avoid, reduce, or eliminate corrosion. Continuation of course above.

Environmental Control in Ocean Engineering

Application of the principles of thermodynamics, heat transfer, and fluid dynamics to the requirements of human survival and engineering operations in deep and shallow water.

Table 1. Course offerings in ocean engineering (continued)

Introduction to the Analysis of Oceanographic Data

Design of oceanic experiments to determine spatial and temporal sampling rates, precision accuracy, signal-to-noise ratio, etc. Description of typical ocean data collection and analysis systems. Development of relevant techniques.

Ocean Laboratory I, II

Measurements, experiments, and the development of apparatus in the ocean from research vessels. Topics covered include statistical theory, planning multi-variable and sequential experiments, checking of data, error-propagation in multi-sensor experiments in the ocean, and at-sea operations. Physical, chemical, and biological measurements would be undertaken as well as application tests on models or full-size apparatus in Narragansett Bay.

Planning long-term application or environmental experiments in the ocean. Carrying out a synoptic ocean measurement program over a month or more using vessels, buoys, underwater sensors, and locations of opportunity. The student would manage the experiment or measurement scheme so as to make a contribution to engineering or oceanographic knowledge in the area of operation. Preparation of a report on the experimental work.

Ocean Engineering System Studies

Systems engineering study of an advanced ocean engineering problem. Students will operate as a complete engineering team with specific subsystems designs done with individual faculty members.

Special Problems

Advanced work under supervision of a member of the staff and arranged to suit the individual requirements of the student.

Masters Thesis Research. Number of credits is determined each semester in consultation with the major professor or program committee.

Doctoral Dissertation Research. Number of credits is determined each semester in consultation with the major professor or program committee.

Ocean Engineering Seminar. Seminar discussions including presentation of papers based on research or literature survey.

Several of the faculty appointments are joint with electrical engineering, civil and environmental engineering, and chemical engineering. This is believed to be a strength rather than a weakness, because ocean engineering is a diverse subject. In addition there are other interdepartmental relationships. For example, a Sea Grant project, involving the Departments of Ocean Engineering and Resource Economics and the Graduate School of Oceanography in the development of an integrated model of Narragansett Bay incorporating physical, biological and economic submodels, has been in progress for several years. Cooperative research projects among ocean engineers and the Department of Fisheries and Marine Technology are also underway. These involve determination of the drag characteristics of common fish net sections and pressure measurements in the vicinity of the mouth of a mid-water trawl model.

The Marine Experiment Station of the Graduate School of Oceanography is involved in applied oceanography and in fisheries and environmental studies which often need ocean engineering skills. Again there is an element of inter-departmental cooperation in this program with the Department of Ocean Engineering as well as with other departments with marine-related interests.

Sponsored research at the Marine Experiment Station currently involves hydrographic and biological modeling studies in the vicinity of a nuclear power plant, artificial lobster habitat evaluation, development and evaluation of electrical guidance devices in both marine and brackish environments, design of benthic invertebrate sampling surveys, artificial culture of fishes, population dynamics studies of regional fisheries--including the yellowtail flounder and surf clams--dredge spoil and solid waste research, and studies of the endurance of marine organisms in flumes. The Marine Experiment Station has a small staff and uses graduate students in some of its projects.

The plans and projections in ocean and environmental engineering call for significant growth due to the increased activity anticipated on the continental shelf in the near future. This activity involves both petroleum and mineral exploration and extraction.

It seems that the University of Rhode Island program in ocean engineering and its Marine Experiment Station setup have directly transferable conceptual schemes for the University of Dar es Salaam. The mechanics and time schedule need to be resolved.

THE STRUCTURE OF FISHERIES ECONOMICS

Harlan C. Lampe
Professor of Resource Economics

One may take several points of view in classifying research in fisheries economics. As professional economists we may categorize projects according to their theoretical sophistication and potential for publication in learned journals, or as ranging from applied to pure. Or, we might classify research according to that part of the industry with which it deals, e.g., production, marketing, consumption, etc. Further, we could consider research according to its orientation to operating enterprises (public or private) or to policy issues at a higher plane. Or perhaps we could classify research according to its contribution to our current body of facts or to our development potential.

But since these criteria are all applicable and important in one circumstance or another, and circumstances change, a categorization of research activities may not prove useful. Nevertheless, there are several more or less distinct kinds of research in which we have been engaged and which contribute to different requirements of our fisheries.

For example, a major effort has been made to develop research activities that will contribute to resource management policy. These activities have been distinguished by our efforts to integrate biological and economic activities, and their purpose has been in the main to illustrate the failings of present systems or to suggest alternatives.

One of the more exciting projects in this vein addresses itself to the management of multi-species fisheries--a problem that has yet to yield to theory or practice. Specific management models have been completed for several species of fish and shellfish. An evaluation of world-wide pulsed fishing of tuna stocks has also been completed.

A project initiated this year that has implications for a number of areas deals with the economics of environmental improvement of lagoons for fish production. Specifically we are investigating the conflicts in water use for irrigation and shrimp production in Mexican lagoons.

We have long been aware that many fish production programs have failed due to lack of understanding of marketing and distribution systems. Hence, our earliest inroads into fisheries economics were directed toward these problems. This area of research has ranged from the rather sophisticated modeling required to estimate demand elasticities to more pragmatic assessments of marketing and distribution costs. We have, of course, focused attention on both export and internal markets. Our purposes have been numerous but, in general, we have seen a need to evaluate the consequences of changing production systems on market structures and to judge market potentials. In other cases, we have been concerned with the efficiency of these systems.

We are studying currently the use of fish in institutions and the markets for fresh fish in the region with a view toward developing a training program that will improve distribution efficiency. We expect to analyze transport networks for interested suppliers of fish in the region.

An important effort has always been maintained in production research, where we have assayed problems ranging from the influence of ownership on crew size and efficiency to the feasibility of various types of trawl nets. This work has been of value in judging investment potentials and the influence of price changes on fleet composition and has provided insight into difficulties faced by fishermen.

Considerable effort has been made to provide producers with the results of research on the production of underutilized species. Data has been provided with the cooperation of vessel owners in test fishing and handling of relatively unknown species. We have worked to develop uniform accounting and recordkeeping for fishermen to provide them with better information and to develop more useful information for research.

Another area that has become more important recently is what might be called "development economics"--both domestic and foreign. Research of this kind is concerned with the potentials of exploiting underexploited resources, increasing production of currently exploited populations, or making other changes in the system. It is characterized generally by the fact that it must assay the implications of change for the whole system from producer to consumer and that it is the most pragmatic part of our work. This activity has expanded to include a substantial amount of international work in recent years.

An aspect of our research that may not seem to have immediate relevance to fisheries is that of coastal zone management, although it is clear that research in this area would have value to local government units with or without fisheries. The development of controls over the unfettered exploitation of these coastal areas has become increasingly important. But with many of the environments in the area playing an often important role in fisheries ecosystems, control over their exploitation can be of important consequence to fisheries. It is under this rubric that we conduct our work on pollution problems, recreation and land use planning. Regional systems for water supply and waste disposal are being examined as is the economic impact of waste disposal in the marine environment.

The broad areas of research noted above have developed in response to perceived needs of industry and the community at large interacting with faculty interests. Our commitment to applied research is obvious and it is felt that the "payoff" has been significant. The emphasis on applied research is not maintained by any overt control over research activities, rather it is assured at the time of bringing in new faculty.

This is not to say that work without immediate application to policy or industry is not done. It is indeed, and it is an imperative ingredient in providing the intellectual leaven that any research group needs to maintain its vigor and momentum.

It should be obvious from the nature of our program that economists at almost every turn must rely upon the cooperation of their colleagues in other disciplines. When issues relating to resource management arise, the aid of fisheries biologists and/or ecologists is essential. When problems of marketing and distribution are researched, the food scientist often plays a role. These interactions help not only the economist but other disciplines as well, since we sometimes discover the lacunae in their research output that would benefit from additional effort. The integration of research activity of the several disciplines concerned with fisheries is necessary for reasonably efficient use of funds. This is not to argue that no discipline can ever work alone, but it is to argue that where decisions--either public or private--are at issue, the special talents of more than one discipline are almost always involved. It is often too late to amalgamate the products of individual research projects at a committee meeting held at the eleventh hour.

The mix of research outlined above represents the activities of nine men. This group was not assembled overnight. Research emphasis was first placed on marketing and demand; the next activity initiated was in production. With a firm footing in these areas, it was then possible to begin work on fisheries management; this was followed by coastal zone research and development economics, in that order. This list then is, in a sense, a view of priorities as they have appeared during the past 15 years. Were it possible to restructure this development, it is not clear that the priorities would have changed very much. Development economics would very likely arise earlier but it cannot be pursued effectively without many of the facts produced by marketing and production research. Hence, at best, development research can be pursued collaterally with these other activities but can hardly precede them.

One final consideration: it is not often a simple matter for one researcher to shift his activities from one area to another, even within economics. There are rare generalists, but they are difficult to find. A research program obviously is based upon the personnel who do it, and the selection and training of these persons will be indelibly stamped on any program as long as it is carried out by the same staff. Hence, it is dangerous to begin with ill-defined priorities or with those that claim our attention at the moment. These early mistakes can haunt us for years to come.

Education and Training Requirements

Different types of research in fisheries economics require different kinds of emphasis in education and training. However, whatever the research area, a minimum competence in intermediate micro-economic theory is necessary and for some activities advanced theory must be mastered.

The following summaries indicate the level of training and expertise required in several areas for an effective prosecution of research. Needless to say, experience often overrides academic qualifications.

Marketing and Distribution

Degree: M.S. desireable, B.S. with additional training or experience possible. For work in demand analysis, Ph.D. desireable, M.S. with experience.

Specialization: Fisheries marketing
Agricultural marketing

Training: Basic--Intermediate micro theory
Statistics (econometrics)
Agriculture or fisheries marketing

Desireable--Food technology
Consumer behavior
Business management

Production

Degree: M.S. desireable

Specialization: Farm management
Industrial engineering

Training: Basic--Intermediate micro theory
Statistics
Business management (farm management)

Desireable--Fishing methods and techniques
Fisheries biology
Marketing
Linear programming

Development Economics

Degree: Ph.D. desireable with experience.
M.S. or broad experience necessary.

Specialization: Fisheries economics
Agricultural Economics

Training: Basic--Advanced micro theory
Intermediate micro theory
Econometrics (statistics)
Linear programming and input/output analysis
Fisheries economics
Desireable--Marketing economics
Production economics
Some mastery or understanding of:
Fisheries biology
Food science

Fisheries Management

Degree: Ph.D. desireable

Specialization: Marine economics
Agricultural economics
Economics

Training: Basic--Advanced micro economics
Econometrics (statistics)
Mathematical economics
Desireable--Fisheries biology
Political science
Law of the sea

MARINE FOOD SCIENCE AND TECHNOLOGY

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General

Food from the sea has always given man satisfaction for both his nutritional needs and his gustatory appetites. Nevertheless, he continues to get only a small part of his food there--the present world catch of fish supplies about three percent of man's direct protein consumption, for example.

Protein malnutrition prevails in many developing countries. While animal source protein is lacking in these countries or is not used for direct human consumption, many of those countries have rich marine food resources which are not utilized or are improperly utilized. An example is the South American countries of Peru and Chile which have serious nutritional problems associated with lack of animal protein, while paradoxically, they are blessed with an abundance of that animal protein in the form of marine life off their shores. Most of that animal protein is exported from these countries in the form of fish meal to satisfy the demand of the already well-fed nations for poultry and livestock feed. It is thus obvious that the distribution pattern of marine food on a world-wide scale is abnormal.

Japan is an example of a country that has solved its animal source protein problem by utilizing fish caught in all waters of the planet. The Japanese are making the best use of most edible portions of marine species, from the jelly fish to the tuna, and processing this marine food in a variety of ways.

Man's endeavor should be to utilize efficiently all edible species of marine life--animal and plant--and to use them for direct human consumption. A continuous attempt should be made to discover improved methods of preservation, preparation and distribution.

The Research Program at URI

The main objective of the marine Food Science and Technology program at the University of Rhode Island is the utilization of marine species for direct human consumption and preservation of the marine foods obtained. The emphasis is on problems related to developing nations with rich marine food resources which are not being utilized. Both conventional and unconventional ways are being sought and developed in order to make marine species available and acceptable as food. Along with the utilization aspects, preservation is being studied from various points of view. Table 1 shows an outline of the general types of research that are being performed presently or are in the planning stages.

Table 1. Marine food science program at the University of Rhode Island.

Research

Conventional and non-conventional methods of utilizing marine species for food (emphasis on underutilized species)

a. Chemical
b. Biochemical
c. Microbiological
d. Processing
e. New product development

Conventional ways of processing and preparing fish are not generally acceptable to non-fish-eating populations. Furthermore, such processes are insufficient to accomodate an increase in fish consumption. Conventional methods of processing also tend to preserve the original identity of the raw materials. On the other hand, non-conventional processes which employ certain principles of marine food science can change the identity of the raw material, and the resulting new products may be palatable to people to whom the flavor of fish has not traditionally been acceptable.

A marine food product that would serve the purpose of not only developed countries but also developing nations is fish paste, similar to the Japanese gels but modified to suit western or other consumer demands. Fish paste has no basic fish flavor or odor but can be prepared with spices or flavorings. This flavored, functional product can be used either to improve protein deficient diets or to add variety to diets.

Another important research effort is being directed towards underutilized species; for example, extensive work is underway which explores new methods of utilizing the crab. An improved method of extracting the edible portion of the crab by use of a hydraulic press has been found which results in a per-animal yield of 50 percent or two and one-half times that obtained by handpicking. Other advantages of this press are that all sizes of crabs can be processed; even crabs which have been deformed and compressed during transportation can be used profitably. This inexpensive method can be used to supplement handpicking. The shellcase waste obtained can be dried, milled and homogenized to form a gritty powder which can be incorporated in feeds, fish meal or fish feed used in aquaculture.

Although the Japanese, as mentioned above, are using most of the available edible marine species, other countries are not, especially the developed and well fed nations. In the United States we are not yet accustomed to eating squid, octopus, small bony fish, mussels, shark, etc. Therefore, other studies dealing with underutilized species include investigations exploring uses of such creatures as the sand shark, the shark, squid, menhaden and other oily fish, mussels, etc.

One grave problem in the total utilization of fish is waste, which can approach 80 percent of production costs in many cases. Improper handling, processing, storage, and marketing can result in these high losses, which man can ill afford. Not only should every possible edible portion be used in some way, but new types of foods should be developed which mix plant proteins with fish, using fish scraps, fish heads and even fish viscera. Research is being carried on in this area.

Another of the more significant problems related to marine foods is rapid spoilage of fish flesh due to improper handling procedures that start in the boat and continue in the marketplace. Parallel to the utilization and preservation investigations, a program on the handling of marine species for food is being launched in Chile, where the fish handling situation is being studied and new approaches are being initiated to improve these procedures. Moreover, improved methods of utilizing fish are being introduced. These include especially unconventional ones, such as the addition of potato to fish to produce an acceptable product.

In a country such as Chile, artisan fishermen represent more than 60 percent of the fishing population of the country. The economic status of these fishermen is very low. While they provide 80 percent of the fresh fish catch of the country, they suffer tremendous losses through poor handling conditions. It is hoped that these fishermen will learn to apply modern methods of fish handling through extension and special short course educational programs. Table 2 outlines the program in Chile.

A thorough investigation is necessary to study the characteristics of each edible species from a marine food science standpoint and to find ways of utilizing them efficiently for human consumption. In Chile, a close collaboration is being maintained with government agencies, universities and research institutes in order to implement such investigation.

The University of Rhode Island is among the group of universities officially recognized by the United States Institute of Food Technologists as offering a curriculum in Food Science and Technology (see Table 3). Students accepted into the Food Science and Technology Program need a broad background in biology, microbiology, chemistry, physics and mathematics. This preparation provides the necessary basis and prerequisites for the food-oriented courses in the third and fourth years. The four-year academic program leads to a Bachelor of Science Degree (Table 3). The graduate program leads to a Master's Degree and then to the Doctor of Philosophy.

The areas of research are in marine food science and technology, industrial fisheries technology, human nutrition, nutrition surveys, new foods, food enzymology, food microbiology, carotenoids and food chemistry. The emphasis, however, is in marine food science and technology. Courses are selected from various departments to provide further competence in the area. The number of students in the undergraduate program is aobut 20, and in the graduate program, about 40.

The University of Rhode Island, through the International Center for Marine Resource Development (ICMRD) is actively involved in a consortium with four other universities in the United States in developing food science and technology in different countries that need it. Students from abroad study at URI and carry out research which is of importance to their own country. At times, this research is performed in the students' native countries.

Table 2. Outline of program in Chile.

Handling and Utilization of Marine Species for Human Consumption.

1. Studies on storage life of fresh fish according to species, season, method of capture, and storage conditions
2. Extension of storage life using various methods
3. Utilization of underutilized species
4. Non-conventional ways of utilizing fish
5. Educating the artisanal fisherman
    a) Workshops on fish preservation
    b) Seminars
6. Educating the consumer
    a) Seminars
    b) Television, radio, newspapers

Table 3. Food Science and Technology Program at the University of Rhode Island (Bachelor of Science)

1. Required Courses

   Biological Sciences:

   - Botany
   - Zoology
   - Microbiology

2. Chemistry and Physics

   - General Chemistry
   - Organic Chemistry
   - Physics
   - Analytical Chemistry

3. Mathematics

   - Algebra
   - Trigonometry
   - Calculus

4. Courses in Major Area of Concentration

   - Introductory Food Science
   - General Nutrition
   - Biochemistry of Foods
   - Food Processing
   - Food Analysis
   - Food Quality
   - Food Microbiology
   - Food Engineering

5. Other courses selected from different related departments

A Program in Eastern Africa

The need for technologists is great in almost all developing nations. In such countries, technology must replace the "traditional" way of doing things. To accomplish this, a training mechanism should be set up where the curricula will vary according to circumstances.

Training in marine food science would require a bachelor's degree program based on chemistry, physics, mathematics, microbiology, biochemistry and engineering. Specific instructions would be in the area of food technology, food analysis, food engineering, nutrition, quality control, food regulations, food sanitation and other related areas. A practical training program in the industry could also be part of the program. In addition to the above courses, short courses and seminars could be offered to fishermen, students, technicians, etc. Any such training program should be concerned with the specific needs of the country, and should include an extension service to assist in solving the problems that arise and also to analyze local conditions.

Universities that have established programs can assist in the development of similar programs in developing nations by providing visiting professors to lecture and initiate research projects. The ultimate objective would establish both a local faculty to take over after a relatively short time and a self-sufficient training program. The local teachers at such an institution should be well trained with master's or doctoral degrees, and they should be capable of continually updating their technological knowledge--an absolute requirement for education and for industrial development.

An institute of marine sciences as currently being considered in Tanzania should serve as a research station as well as a training center for technical staff, fishermen, extension workers, students and investigators from the region and from overseas. It is expected that the applied research to be carried out at the center, along with the intensive training and extension activities, will assist in the development of the fisheries industry in the region and in fisheries education at both the university and secondary education levels.

MARINE AFFAIRS PROGRAMS--
COASTAL MANAGEMENT, COASTAL RESOURCES CENTER, MARINE AFFAIRS CURRICULUM AND THE LAW OF THE SEA INSTITUTE

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Coastal Management

In other elements of this paper, specific actions and applications of coastal zone management appear. In this segment, the more general aspects of overall coastal management and its relation to the University of Rhode Island will be discussed.

A workable definition of the coastal zone is included in the U.S. Coastal Zone Management Act of 1972:

> "Coastal Zone" means the coastal waters (including the lands therein and thereunder) and the adjacent shorelands (including the waters therein and thereunder), strongly influenced by each other and in proximity to the shoreline and includes transitional and intertidal areas, salt marshes, wetlands, and beaches...seaward to the outer limit of the...territorial sea. The zone extends inland from the shorelines only to the extent necessary to control those shorelands, the use of which have a direct impact on the coastal waters.[1]

National concern in the United States for organized coastal zone planning was first voiced effectively in an organized sense in 1969 by a commission on marine science, engineering and resources (the Stratton

Commission). As late as 1972 progress to implement the plan was described as minimal.

With the passage of the Coastal Zone Management Act of 1972, the first tentative federal attempts at organization and direction were made. The federal role of guideline definition and startup funding, with state or regional implementation and control, appears to allow adequate participation of involved interests once the distribution of authority and responsibility is resolved in practice.

Several state plans, e.g., Rhode Island and California, explore the peculiar requirements of developed states with quite different physical, financial and human resources in widely spaced geographic locations. Both the specified definitions and control requirements do exhibit more similarities than differences.[2]

The University of Rhode Island has participated strongly in formulation of national and state plans and currently provides technical consultation and services to the state of Rhode Island through the URI Coastal Resources Center (described in detail in the following section), which draws its funding from continuing national Sea Grant support, University matching funds and a number of small project-oriented grants. The Center acts as the principal planning group for the state in the area of marine resource management and maintains liaison with the state's management organization, the Coastal Resources Management Council, and the Statewide Planning Program. The University continues to participate in both national and international planning primarily through direct involvement of certain senior faculty members and through interfaces established under programs such as the U.S. AID 211(d) grant which makes the URI International Center for Marine Resource Development possible, the Master of Marine Affairs program and Law of the Sea efforts.

A summary of the present state of technical coastal zone planning and implementation in the U.S. was prepared for the 1972 Marine Technology Society Conference entitled Tools for Coastal Zone Management. The majority of the systems described required as a base a thorough inventory of state resources which would include (1) a description including relationships of impinging interests; (2) definition and assignment of responsibility and authority; and, most importantly, (3) clear statements of objectives from the national, regional, state and municipal governments and the civilian participants involved. Adequate representation, legal precedence and necessary compensation were integrated with the above. Computer data retrieval systems and mathematical modeling of interrelating systems are both being pursued to the degree that funding permits.

With respect to international patterns, a UNESCO paper in 1972 entitled Uses of the Sea described worldwide aspects of the coastal zone. Excerpts from the conclusions of the report included the following:

> Overall growth rate of all coastal zone factors will increase the frequency of interacting operations. Potential conflicts will be concentrated in localized zones of intensive use--less than one percent of the total sea area. Conflict probability is increased by multiple area uses, degree of confinement, urbanization, industrialization, increased tourism and recreation, and close proximity between international neighbors. Specific resolution of local technical conflicts appears to depend on local marine conditions and economic priorities.[3]

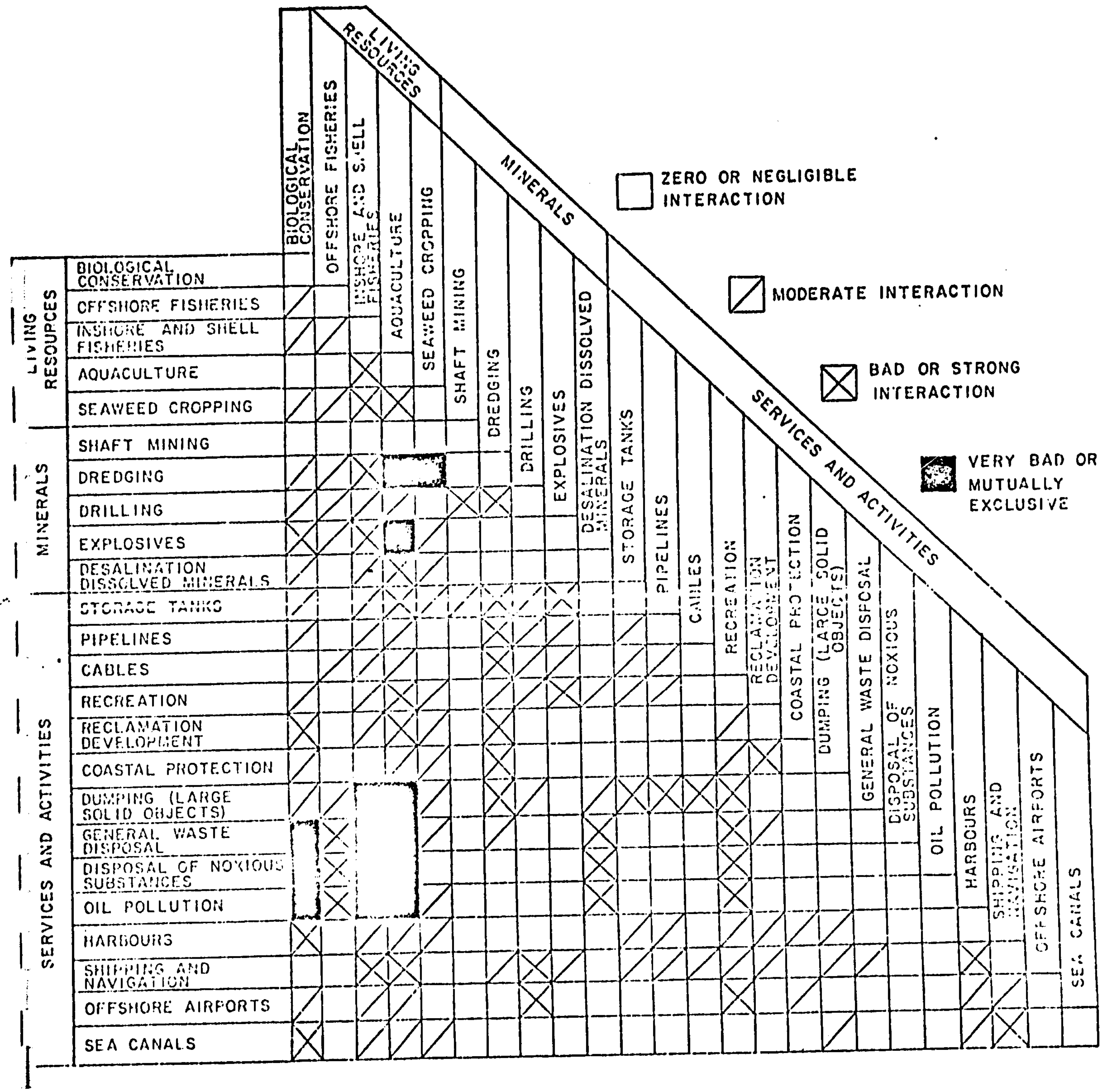
Table 1 describes, in a general sense, the degree of potential interaction or conflict for a typical national jurisdiction and, perhaps, provides a framework that one should seek to fill in conjunction with actual development of a Tanzanian coastal zone plan.

A 1971 study of technological development by Silverstein[4] listed prerequisites for national science policy and administrative development applicable to coastal zone control. Within the national context Silverstein feels that the decision-making elite must display a favorable attitude toward rational economic action, be convinced that lack of planning has serious negative consequences, and agree on operational goals and perceived needs for technological input to improve production. It must be possible to mobilize complementary inputs and institutions to apply the favored technology. An analysis of physical, financial and human resources in science and technology, as well as the presence of research centers, decision centers and research programs, is required.

According to the United Nations Advisory Committee on the Application of Science and Technology,

> Developing countries, faced by almost diametrically different conditions, will often find that a variant from the technology of the developed countries, and perhaps an altogether different technology, is more suited to their conditions. It is difficult for a developing country without a science and technology capacity of its own, and particularly without the trained people involved, to know what useful technology exists elsewhere, to understand it, to select it, to adopt it, to absorb, to repair and maintain, to operate.[5]

Table 1. Potential interaction of marine activities in close proximity.



Source: United Nations. 1972. Uses of the Sea

The University function bears a primary responsibility in building in-country competence, surveying available technology and management techniques and adapting them to satisfy national and regional goals. The management of the coastal zone provides an excellent focus for such efforts.

Among these techniques of coastal zone management are (1) setting up information-gathering on the pilot scale, (2) identifying participants and their viewpoints, (3) devising techniques for adequate interest representation, and (4) establishing the legal and decision-making processes and setting objectives for coastal zone management against future requirements. Cost-benefit projections may be balanced against less quantifiable options. Implementations of selected small-scale pilot operations in select areas representative of future problem classes and differing geo-political regimes may prove desirable.

With Eastern Africa's escalating coastal zone growth and increasingly incompatible multiple uses, there is little doubt that effective constraints in the availability of finances and technological skill, coupled with the need to accelerate development in order to survive and to narrow the techno-economic gap with the advanced countries, impinge on environmental or any other coastal zone control. Even if money were to be supplied by outside agencies, it could often be used more effectively in accomplishing deferred necessities.

If deemed necessary, preliminary studies, if internationally sponsored, could evolve into efficient planning for Eastern African coastal development with a minimum of country resource commitment, early enough to permit judicial involvement with on-going processes on a cost-effective basis, and in consonance with state and regional needs. A high degree of University contribution, local control and participation in the establishment of patterns of development of minimal coastal zone control required at different levels of complexity and different geographical locations should ensue.

Coastal Resources Center

The University of Rhode Island Coastal Resources Center, formed in 1971, is a technical unit assisted by the marine faculty of the University, the University's Marine Advisory Service and its Marine Experiment Station. The Center was conceived as a public service unit able to provide technical assistance in seeking solution of marine management problems for the state and its municipalities, and to take an active lead in the production of management plans for the Coastal Resources Management Council. The Statewide Planning Program, the state's chief planning agency, was designated to work with the Center so that all planning and scientific capabilities at the state agency and university levels could be coordinated.

The work of the Coastal Resources Center is supervised by an all-university executive committee consisting of the Provost for Marine Affairs, the directors of the Coastal Resources Center, the New England Marine Resources Information Program, the Marine Advisory Service, the Marine Experiment Station, and the International Center for Marine Resource Development, a professor of ocean engineering, and the Coordinator of the Sea Grant Program, all working through the Center's director.

Initial funding from the University Sea Grant program was used to obtain the services of two resource analysts to begin assembly of baseline data for a marine resources inventory required by the state's Coastal Management Act as a step toward a complete state program. Current sources include Sea Grant and matching contributions by the University, and state grants through the Department of Natural Resources and the Coastal Resources Management Council.

Two resource analysts with skills and training in resource economics and planning were added during the years of development of the state management plan. Other personnel are drawn from the University staff or outside consultants are obtained as needed for special projects to round out the Center's total technical capacity.

Under the partnership arrangement with the Statewide Planning Program, from one to two planners are assigned as needed to work in concert with the staff of the Center. It is anticipated that this arrangement, which insures compatibility of coastal planning with statewide land use planning, will continue. The federal government (National Oceanic and Atmospheric Administration) is expected to supplement the current Center support.

The work of the Coastal Resources Center is moving along two linked pathways. The major route is development of a marine resources inventory containing baseline information, supporting maps, charts and reference materials. Included in each section are suggested guidelines for management of the resource. Broadly, there are two major parts of the inventory: natural features and socio-economic features. Where appropriate, they are cross-referenced to illustrate impacts. The inventory is being published in segments to get as much information into the decision-making process as possible in the shortest period of time. The planning groups are aware that piecemeal release of material will necessitate continuous review of everything from management plans to regulations, but the dynamic pressures on the coastal region are such that delays are not deemed desirable.

The second pathway involves special reports on segments of the inventory material prepared in response to emergency situations or in anticipation of pressure before the total inventory and management plan has been developed and adopted. Reports of this nature are expected to continue throughout the planning process.

Table 2 shows the subject areas which are being covered in the Rhode Island marine resources inventory.

Marine Affairs Curriculum

Realization by the nation and the University of Rhode Island that academia, government, and industry had a growing interest in the complex interrelationships of the broadly ranging socio-economic, politico-legal and technological disciplines involved in management decision-making in ocean affairs, led to the establishment in 1969 of the University of Rhode Island's Master of Marine Affairs program.

This program seeks to educate to the master's degree level marine-oriented professionals, who are generally middle management, double-degree holders with present and planned professional capacities requiring interrelationships with other marine functions. The program focuses on marine policy problems at the local, state, regional, national and international levels. In considering the formulation of specific policies, students analyze factors central to the decision-making process;

Table 2. Rhode Island coastal resources inventory, major subdivisions.

I <u>Physical Features</u>

1. Marine geology of Naragansett Bay and sea floor beneath Rhode Island coastal waters
   a. Geologic history
   b. Topography and sediments
   c. Active processes, transportation and deposition of sediments
2. Hydrography of Narragansett Bay and Rhode Island waters
   a. Tidal characteristics
   b. Temperature and salinity distribution
   c. Nontidal circulation
   d. Waves
3. Chemical properties of Rhode Island waters
4. Climate
   a. Range and means of temperature, humidity, rainfall and sunshine
   b. Storms and hurricanes

II <u>Biological Features</u>

1. Plankton and benthos
2. Wildlife: marine and shoreline birds and mammals

III <u>Fish and Fisheries</u>

IV <u>Shoreline Features, Land Use and Land Ownership</u>

The value and characteristics of principle habits (marsh, coniferous forest, agricultural lands, etc.) also will be discussed

V <u>Environmental Quality</u>

1. Pollution
2. Refuse disposal
3. Appearance and design
4. Effects of geological and biological processes upon resource use

Table 2. (continued)

VI Recreation

VII Public Facilities and Utilities

1. Power, water supply, communications, sewage disposal, pipelines

VIII Commercial and Industrial Activities (excluding fishing)

1. Waterfront industry
2. Transportation and shipping
3. Ports

IX Regulation and Acquisition

X Research

1. What has been accomplished and is currently underway
2. Major needs present and future

XI Managing the Coastal Zone and Marine Areas

1. State of the art, problems and opportunities in Rhode Island

XII Rhode Island and the Southern New England Region

1. Integration of Rhode Island into the region's needs, problems and trends

these include interest groups, shared jurisdictions, the decision making agencies, bureaucratic obstacles, the formulation of viable alternatives, and the rationale behind final choices. With respect to implementation of policy, students consider the role of laws and institutions, the economic and social costs of implementation, and criteria for effective ocean management.

The competitively selected participants represent a broad spectrum of backgrounds--governmental (both civilian and military), and both U.S. nationals and foreign nationals (4 out of 29 in 1973, from France, Ghana, New Zealand, Chile). Specialists who have been in the program include oceanographers, ocean engineers, maritime lawyers, writers, businessmen, anthropologists, biologists, community planners, economists, financiers, fishermen, geographers, geologists, journalists, lawyers, marine cinematographers, marine transportation experts, marketing-management experts, naval architects, physicists, political scientists, public administrators, psychologists, sociologists and systems analysts. The interdisciplinary character of the program therefore is enhanced by the viewpoints and mature judgments of the participants as well as by the course content, seminar simulations and speakers. This interdisciplinary probing forces new considerations in the thinking of both faculty and outside speakers.

Core course work required of all students includes marine geography, marine resource economics, international law, ocean engineering, oceanography and a marine affairs seminar. Electives in the fields of particular interest include in-depth work in the core course areas as well as more expansive topics such as community planning, finance and political science. In most areas, considerable independent research is required, and an effort is made to tailor research to investigator's priority problem areas.

The marine affairs seminar, a two-semester effort with an accompanying major research paper, provides both a focus and a forum where the backgrounds, interests and course work are all brought to bear on marine issues ranging in scope from local to regional, national or international. Attendance at actual management sessions, as well as joint presentations by high-level, directly involved spokesmen representing widely divergent points of view, precipitates debate on timely critical issues. Questions and class discussions develop these issues.

Issue resolution is through simulated role-playing sessions in which both individual and organizational attitudes and positions are taken. For example, in 1973 simulations included a local coastal power plant siting decision and the probable British-Icelandic cod war outcome, if the International Court of Justice were asked to adjudicate the issue. In some cases, the projected decisions can be compared closely with subsequent developments after program completion.

While the program has been heavily oriented towards U.S. problems and approaches, a trend towards LDC (lesser developed countries) and international relationships and issues continues to grow. Consideration of LDC viewpoints from international students by attending U.S. nationals and vice versa permeates activities during the program and helps create close personal ties that are maintained.

The short length of time required for the program (nine months residence), availability of fellowships, and good post-graduate employment histories help to keep program interest high.

Planned evolution of the program includes both an undergraduate course and a doctoral program and an improved specialized library collection. Student papers have been published in the first issue of a marine affairs journal.

Participation by select Eastern African middle-high level management personnel in the URI type of program provides obvious advantages in present planning for and implementation of regional-national programs while laying a base for establishing a comparable, specifically tailored Eastern African version. The shift of emphasis and location to the Eastern Africa environment could help to concentrate teaching, learning, and research as significant factors in area development, enrich the institution faculty experience, and encourage cooperation and understanding among individual participants and their nations.

The Law of the Sea Institute

The Law of the Sea Institute was formed at the University of Rhode Island in 1965 to serve as a means for exchanging knowledge and ideas concerning the sea and its resources, principally through conferences, workshops and publications. The stated policy of the Institute is to take no stand on issues, but to encourage free and open participation, the exchange of ideas and information and the expression of divergent points of view.

The Institute's funding is based broadly in foundation and government sources. While housed and administered at the University, it is an independent organization guided by a distinguished executive board (see Table 3) of North American international attorneys, scientists, and educators in responsible controlling positions concerned with the totality of ocean activities. The Board sets objectives, approves and directs planning and reviews progress of all activities under executive control of its director.

The Institute meets each summer in the United States for a formal topical conference and convenes irregularly overseas to conduct regional workshops. It also publishes proceedings and bibliographies, distributes marine-related occasional papers, and maintains an extensive international mailing list of interested persons.

The themes of past conferences provide insight into the breadth and timeliness of topics:

1966 - Offshore Boundaries and Zones
1967 - The Future of the Sea's Resources
1968 - International Rules and Organization for the Sea
1969 - National Policy Recommendations
1970 - The United Nations and Ocean Management
1971 - A New Geneva Conference
1972 - The Needs and Interests of Developing Countries
1973 - The Emerging Regime of the Oceans

The 1972 conference, which was attended by 240 persons from 40 countries--indicative of both individual and national interest--discussed aspects of seabed mining beyond the limits of national jurisdiction; concepts in sharing of common heritage and wealth; allocation and exploitation of living resources of the sea; proposed international fishery regimes and the accomodation of major interests; and major problems, positions and viewpoints regarding needs and interests of the developing states.

The program of the 1973 Conference on the Emerging Regime of the Oceans (see Table 4) illustrates both the approaches taken and the breadth and level of forum participation; many of the participants are direct contributors at the United Nations Law of the Sea Conferences and subcommittees.

Table 3. The Law of the Sea Institute, executive board.

Lewis M. Alexander
Director, Law of the Sea Institute
University of Rhode Island

John King Gamble, Jr.
Associate Director, Law of the Sea Institute
University of Rhode Island

William T. Burke
School of Law
University of Washington

Francis T. Christy, Jr.
Resources for the Future, Inc.
Washington, D.C.

Thomas A. Clingan, Jr.
School of Law
University of Miami

Douglas Johnston
University of Toronto and
Canadian Institute of International Affairs

John A. Knauss
Dean, Graduate School of Oceanography
University of Rhode Island

Edward Miles
Graduate School of International Studies
University of Denver

Giulio Pontecorvo
Graduate School of Business
Columbia University

Marshall Shulman
Director, Russian Institute
Columbia University

Warren Wooster
Scripps Institute of Oceanography

Richard Young
Attorney and Counsellor at Law
Van Hornesville, New York

Table 4. Law of the Sea, Eighth Annual Conference, the Emerging Regime of the Oceans.

Bloc Thinking about the Oceans: Accelerating Pluralism?

Paper: John K. Gamble, Jr., Associate Director, Law of the Sea Institute

Panel: Leigh Ratiner (Chairman), Advisory Group on Law of the Sea, U.S. Department of Defense
Kaldone G. Nweihed, Simon Bolivar University, Caracas
Arvid Pardo, Ocean Studies Program, Woodrow Wilson International Center for Scholars
Duke Pollard, Perm. Mission of Guyana to the United Nations

How Will the Deep Seabed Regime Be Organized?

Chairman: John A. Knauss, Provost for Marine Affairs, URI

Paper: Andres Aguilar, Ambassador of Venezuela to the United States

Technology Transfer

Chairman: Giulio Pontecorvo, Director, Ocean Research Management Program, Columbia University

Paper: Surendra Patel, Transfer of Technology Branch, United Nations
C. Weiss, Jr., International Bank for Reconstruction and Development

Panel: Warren Wooster (Chairman), Scripps Institution of Oceanography
Dahmouche Amar, Mission of Algeria to the United Nations
Emmanuel Bello, Consultant, International Oceanography
Herman Franssen, Woods Hole Oceanographic Institution
Nelson Marshall, Director, International Center for Marine Resource Development, URI

International Organizations and Technology Transfer

Chairman: Giulio Pontecorvo, Director, Ocean Research Management Program, Columbia University

Paper: Ivan Silva, Indian Ocean Programme, FAO, Rome

Regimes for Special Situations

Chairman: Richard Young, Attorney and Counsellor at Law

Papers: "Islands"--Robert Hodgson, Geographer, U.S. Dept. of State
"Semi-Enclosed Sea"--Lewis Alexander, Law of the Sea Institute
"Superports"--Allen Hirsh, Marine Ecosystems Analysis Program, NOAA, U.S. Dept. of Commerce

Panel: Albert Koers, Institute of International Law, Univ. of Utrecht
H. Gary Knight, Louisiana State University Law Center
Richard Young, Counsellor at Law, Van Hornesville, N.Y.
John Bailey, Law of the Sea Section, Government of Australia

Table 4. Law of the Sea, Eighth Annual Conference (continued)

Consequences of Intensive Ocean Utilization

Chairman: Thomas A. Clingan, Jr., University of Miami School of Law

Papers: "Flow of Ships"--Charles Bates, U.S. Coast Guard
"Insurance Companies' Perspectives"--George W. Handley, Marsh and McLennan, New York
"Offshore Oil"--John Albers, U.S. Geological Survey

The Scientific Aspects of Ocean Pollution

Chairman: William T. Burke, University of Washington School of Law

Paper: John A. Knauss, Provost for Marine Affairs, URI

Panel: John L. Hargrove (Chairman), American Society of International Law
Earle E. Seaton, Puisne Judge, High Court, Bermuda
Branko Sambrailo, Yugoslav Academy of Science and Arts
Raul Bazan, Permanent Mission of Chile to the United Nations
Bernard Oxman, Office of the Legal Adviser, U.S. Dept. of State

Closing Speaker

The Honorable Edmund S. Muskie, United States Senate

The informal get-togethers and the anonymity of the working groups allow, and indeed encourage, free and open participation and exchange of ideas and information as well as expression of divergent and limit-probing ideas, often beyond the national or regional position expounded in more formal sessions.

While the intent of the Law of the Sea Institute Conference is truly international in scope, some bias towards topics of interest to the majoı contributors is inherent. A similar effort in Eastern Africa devoted to priority needs of the area with worldwide implications would be worth consideration. Campus participation and interest is encouraged by havinf the university as the site of such a conference; this in turn not only provides the conference a ready store of technological backup and interface, but enhances institutional prestige as well. Such a conference also furnishes a fertile site for implementation of programs to enhance institutional growth.

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3. United Nations. 1972. Uses of the Sea. UNESCO. N.Y. 39 pp.

4. Silverstein, H.B. 1971. Science and Technology for Development--The Egyptian and Israeli Cases. Paper presented Middle East Studies Assoc. Denver, Colorado. November 1971. 68 pp.

5. Quoted in Silverstein, Ibid.

MARINE RESOURCE ECONOMICS

Harlan C. Lampe
Professor of Resource Economics

As a discipline, marine resource economics is not well defined, nor does it represent--except at URI--a distinct program of study. However, more important than these facts is the rationale for the view that among economists we can hardly afford to be parochial in our concern for limited aspects of marine development, e.g. fisheries.

Very early in our research and teaching, it became clear to us that a large number of issues impinged on fisheries activities: pollution, transport, recreation, and even agriculture, to name but a few. Further, it is clear that these other marine oriented activities often conflict with one another (see earlier papers) and these conflicts cannot easily be resolved in either purely political, technical, scientific or economic terms. Hence, it appears imperative that we concern ourselves with a broad range of marine resource problems and that we train students to understand them.

Among the more difficult issues to which we have directed our attention are those that relate to land use in the coastal zone. The nature of land use obviously can directly influence neighboring ecosystems that have either economic importance or value of another kind. The nature of land use can indirectly affect environments through the production of waterborne wastes--domestic and industrial. While certain uses of land do not require marine oriented sites, once established, they may obstruct essential marine activity for generations. Offshore mineral production of oil, sand and gravel, etc, requires shore based sites; planning these needs and assessing their impact is also important. The requirements for shipping and a rational arrangement of ports are strangely enough often forgotten. The relation of agriculture to marine activity has often been ignored, although complaint has recently been publicly registered concerning insecticides. However, this is only one element of consequence--sediments, animal wastes and water diversion can be locally important.

You have seen a conflict matrix that concerns itself with marine uses only; it is clear that such a matrix could be extended to a broader range of uses.

To treat many of these issues, it is essential that the implications of change in the structure of the economy of coastal land use be understood. It is of equal importance to consider the implications for economic development and its structure of restraints upon land use, pollution, etc.

In order to consider effectively the impact of alternative economic development strategies, the linkages between marine and non-marine oriented sectors of the system must be developed and some notion of the dynamics of these systems evolved. This is not to say that any particular methodology--such as input-output analysis--is imperative but often a fairly clear methodological set is necessary for orientation of any analysis of alternatives.

We all recognize that imposition of restraints or their removal can, and most often will, result in some changes in relative costs to various sectors. It is necessary for us to construct a framework within which the economics of various alternatives can be assessed and this assessment must include recognition of the linkages among marine related activities and the economy as a whole.

SOCIOLOGY AND ANTHROPOLOGY APPLIED TO COASTAL COMMUNITIES

Dr. Richard B. Pollnac

Assistant Professor of Anthropology

It is only natural that a great deal of the effort expended in a marine resource development program is directed at biological, physical, technological and economic aspects of the marine environment. Nevertheless, it is essential that we do not overlook the human behavioral element in the developmental process. This element is the ultimate determinant of the success of any developmental scheme, and it must be taken into account if we wish to apply the knowledge we generate. The payoff in marine resource development comes only when people act on the new ideas--mere exposure does not guarantee action.

Sociologists and anthropologists have long been interested in the sociocultural concomitants of technological change (e.g., Barnett 1953, Bernard and Pelto 1972, Foster 1973, Rogers and Shoemaker 1971). Most agree that an effective program of technological change consists of the following essential and interrelated ingredients: (1) development by resource scientists of an innovation which is compatible with the target environment and economy; (2) effective communication of the new idea to the target population; (3) recognition by the target group that the new idea will fulfill a perceived need and will be, or can be, made consonant with existing beliefs, values, attitudes, and status and role relationships. These three key ingredients form the first stages in the diffusion of an innovation as depicted in Figure 1.

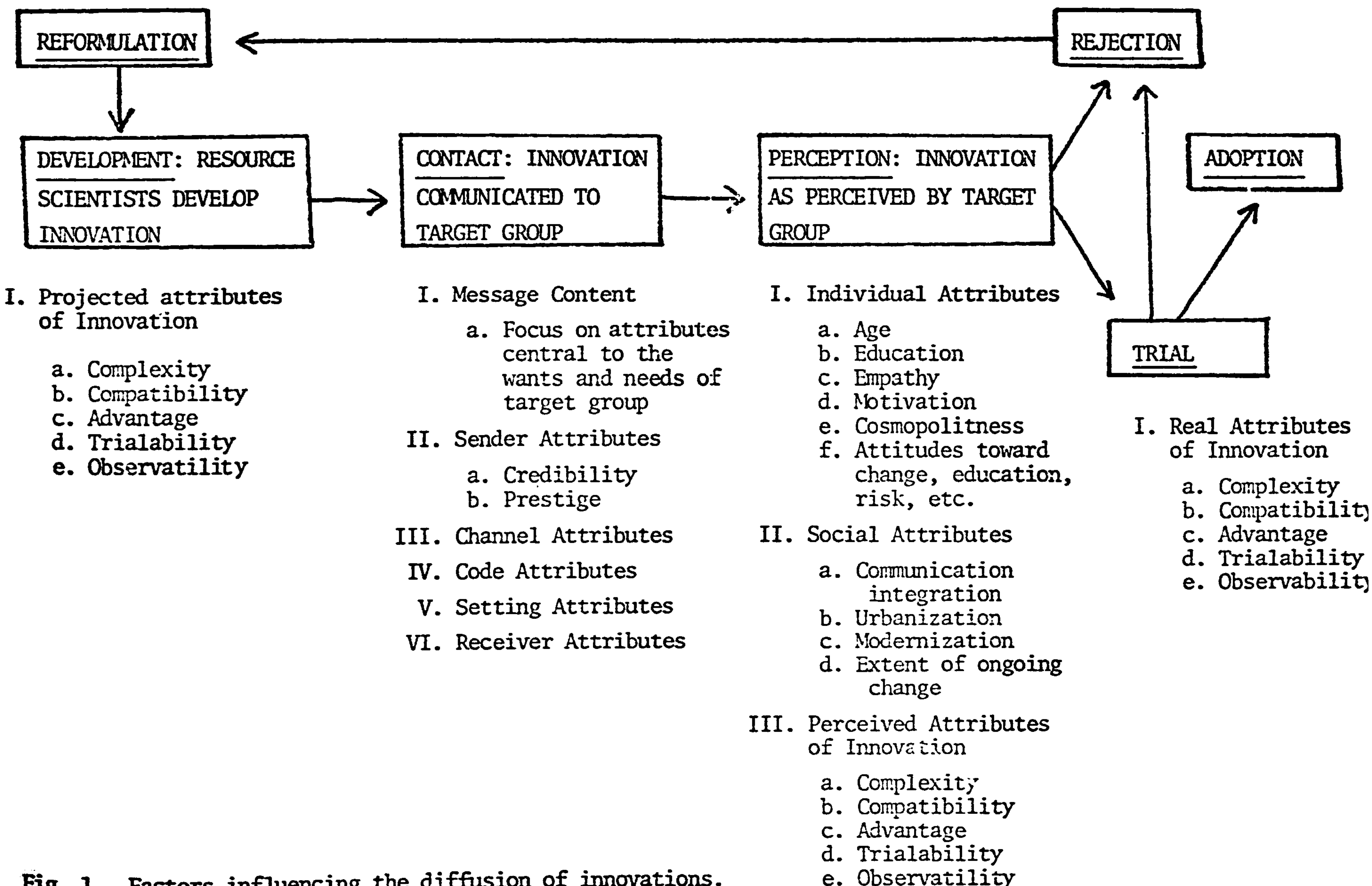

Fig. 1. Factors influencing the diffusion of innovations.

Figure 1 illustrates in diagrammatic form the factors which influence the diffusion of an innovation. Attributes of the innovation are listed at the starting point as well as under "perception" and "trial." In the first case they are the attributes projected by the development agents; in the second, they are those perceived by the target group, and in the third, those of the innovation undergoing trial. The more similar these three sets of attributes are, the more likely the developmental change program will be successful. One of the most crucial aspects of the role of the sociologist/anthropologist in the marine resource development program is to investigate the affected items in terms of their componential structure, in terms of the beliefs, values and attitudes associated with them, and in terms of their role in maintaining the social structure in the target group. This information is of great value in predicting the perceived attributes of the innovation and in adapting certain aspects of the innovation where necessary.

The sociologist/anthropologist also conducts investigations to determine the most effective techniques for communicating the new idea and pinpoints the most receptive audience. Finally, he investigates through time individual perceptions of the innovation during acceptance or rejection and relates this information to other resource scientists who will attempt modifications which could result in its successful adoption.

Sociology-Anthropology and Marine Resource Development at the University of Rhode Island

Consonant with the University of Rhode Island's interdisciplinary approach, we have integrated a concern for the sociocultural ramifications of marine resource development. At present we have four sociologists and two anthropologists conducting marine-related research. This research covers a wide spectrum of topics ranging from tourist utilization of Rhode Island beaches to a cross-national study of marine academy organization.

With respect to international research, a sociologist and an anthropologist have been involved in a fisheries and mariculture developmental project in Puerto Rico. The first stage of their research involved investigations of the interrelationships between attitudes toward change, occupational specialization and social stratification in a rural fishing community. A preliminary assessment of receptivity to change was found to be compatible with the projects's objectives.

Further research by the sociologist has been extended to several fishing communities representative of varying degrees of complexity. He is investigating the interrelationships between these communities as well as their ties with other Puerto Rican communities. The complex networks of resource use including tourism, fishing activities, and trade relationships are being investigated along with other sociocultural attributes related to change. He has demonstrated intercommunity variation in the commercialization of activities which is related to status groupings and consequently to economic motivation, an important factor in developmental change.

Other factors related to change were also evaluated (e.g., perception of adequacy of activities and situations, support systems, personal and social values, community identification, etc.) and found to vary both between and within the communities. In sum, the sociologist's research suggests that any evaluation of the area's potential for developmental change must take into account the differences between the various communities as well as their interrelationships and location in the regional network of resource use. The findings argue cogently for a regional approach to marine resource development, taking into consideration the resources of both land and sea.

Cross-national differences in merchant marine training organizations are being evaluated by two sociologists. They have found that distinctiv modes of nautical training are related to different social forces in the countries examined. These scholars have demonstrated the interrelationships between the merchant marine training institutions, the economic realities of the labor market and varying methods of organizational control and accountability. Their work clearly shows the responses of marine-related institution to macro-economic and political factors, and therefore indicates the necessity of taking these factors into account when establishing such institutions.

Turning to University of Rhode Island research efforts in the continental United States a sociologist is involved in investigating various social and psychological aspects of sport fishing and bathing beach use in southern New England where tourism forms an important part of the economy. His studies provide a great deal of valuable information which can be used in campaigns to increase the tourist trade and in predicting resource use.

Several other sociologists and anthropologists are studying sociocultural aspects of commercial fishing in southern New England. Their research was initiated in response to projected changes in the commercial fishing industry in the United States. Studies have indicated that in order to prevent depletion of fish stocks, current open access to the fishing occupation must be restricted. In addition, certain changes must be made in the commercial fishing industry to alleviate these problems, yet maintain an adequate harvest of fish. An investigation of the occupational subculture of fishermen provides sociocultural information which can be used in minimizing the strains resulting from the dislocation of fishermen. A sociologist and anthropologist have conducted detailed surveys in several representative fishing communities regarding the wants, needs and occupational aspirations of commercial fishermen. These studies are being used to design workable programs for the retraining of the commercial fishing labor force undergoing technological change and the recruitment, retraining and retention of displaced fishermen. Further studies of the organizational strategies of cooperatives, risk and ritual, and economic gratification patterns of fishermen in southern New England have added immensely to our knowledge of this sector of the labor force and can be used in planning its future development.

Overall, the University of Rhode Island has used the resources of both sociology and anthropology in the implementation of a viable marine resource development program. Sociology and anthropology have been actively involved in a wide range of activities and have provided significant input to the study of the planned change of marine communities.

Applications of Sociology-Anthropology to Marine Resource Development in Eastern Africa

The foregoing has outlined the important role that sociology and anthropology play in the development of marine resources. Plans for developing the fisheries, recreation and tourist attractions of the East African coast involve human interaction at all levels, from their inception to their effective implementation. As argued above, the human behavioral element will be the ultimate determinant of the successful application of these plans. The linguistic and sociocultural diversity of the peoples living on the East African coast add to the complexity of the situation. It is therefore essential that the sociocultural implications of these plans be investigated and taken into account to insure the ultimate success of the development of the marine resources there.

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