REPORT OF
SEA GRANT PROJECT ACTIVITIES
1968-69

Publication No. 104
Texas A&M University Sea Grant Program
December 1969

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THE SEA GRANT PROGRAM: FIRST STEPS

Entering its second year of National Science Foundation Sea Grant support with the second highest institutional award in the nation, Texas A&M draws heavily on its history as a land grant institution in its approach to the sea. But where land grant emphasizes agriculture, sea grant looks toward transportation, mineral extraction, recreation and ocean engineering as well as food and mariculture.

The Texas A&M Sea Grant Program has five areas of action for marine resource development in Texas:

(1) *To draw together the separate programs of the university concerned with marine resource development.*
(2) *To work with industry, government, other universities, and other users of marine resources to identify the needs of the states and the region toward which academic competency should be directed;*
(3) *To establish and administer projects and programs that will serve the needs which have been identified;*
(4) *To stimulate the interests of academic personnel in applying their disciplinary knowledge to marine resource problems;*
(5) *To build working relationships with industry, state agencies, other universities, municipalities and individuals for advancing the total educational and research effort related to marine resources.*

To carry out this plan, the first year's activities involved 72 professional university staff members and 58 graduate students who participated in 27 Sea Grant projects, as shown in the accompanying table.

The program's activities are carried out through 18 academic departments and established organizational units from 6 colleges of the University, as well as Texas State Technical Institute and Galveston College.

UNIVERSITY INVOLVEMENT TEXAS A&M UNIVERSITY
SEA GRANT PROGRAM 1968-69

Activity	Professional Staff		FTE* Prof. Staff	
	Number of Projects	Man-months Prof. Staff		Student Participation
EDUCATION & TRAINING	5	13	44.0	3.66	3
ADVISORY SERVICES	2	7	29.3	2.44	2
RESEARCH					
Fishery Science & Marine Biology	4	10	33.9	2.83	12
Resource Management	3	14	31.0	2.58	8
Pollution	3	6	15.8	1.31	6
Coastal Engineering	3	6	22.0	1.83	5
Aquaculture	1	2	7.9	.66	6
Seafood Technology	2	5	13.6	1.13	9
Water & Sediment Analyses	3	8	9.4	.78	3
Acoustics	1	1	3.0	.25	4
TOTALS	27	72	209.9	17.47	58

*FTE - Staff Full-Time Equivalents

One objective of Texas A&M University is to develop an educational program in marine resources to qualify for designation as a Sea Grant College on behalf of the state of Texas and the Gulf Region. To accomplish this, the needs of the state for marine resources activities in education, research, extension, and advisory services must be identified. The University has established liaison with industry, governmental units and other users of marine resources and has begun to work with other regional institutions. The total talent available to work on marine resources development is being identified and the economic impact of existing marine resource industries in the coastal and near-inland cities and counties is being studied.

Organizing the Program

Although Texas A&M University received National Science Foundation funds in June, 1968, for its initial year's work, actual Sea Grant activities and projects did not begin until September, 1968. At the time of receipt of the grant letter, the majority of the summer programs of the University had already been implemented and facilities and staff were committed to other program An additional factor in the delay lies in the organizational and management problems associated with a program of the magnitude of the Sea Grant Program. The University took time to establish a careful accounting structure to assure that sources of matching funds had been identified and were available for expenditure. As a result, the projects carried out under the grant bear the same fiscal year dates as those of the University--September 1, 1968 to August 31, 1969.

The administrative structure for the program was formalized by establishing a Sea Grant Program Office. The Texas A&M Vice President for Programs was designated as Program Director on a part time basis. He is assisted by an Assistant Director who joined the staff part time in September, and a Program Associate who joined the staff full time in December, and an Editor who joined the staff in August to direct documentation and publication activities.

The Director and his staff administer the Sea Grant Program, preparing continuing proposals and reports on the program for NSF, and

stimulating the growth of the Sea Grant Program throughout the University and the marine communities of Texas. The Director works coordinately with all Deans, Directors and Department Heads to carry out the Sea Grant Program activities. He also initiates projects outside departmental and college structure when the sea grant activities cannot be done within an existing unit.

Coordination between the sea grant activities carried out on the Texas A&M University campus and those carried out at Galveston or at other university locations is also a function of the Director.

The Sea Grant funds are administered as a unit by the Director, with each use of funds examined from the point-of-view of the maximum interdepartmental cooperation, the greatest use of graduate students, the highest quality of staff, and the greatest consideration of problems thought to be important by marine industries, government agencies, and the public.

Sea Grant: Areas of Investigation

The first year's Sea Grant Program efforts were categorized by four major areas:

Program Development
Education and Technician Training
Extension and Advisory Services
Research Projects

Twenty-seven projects were carried out under the Program involving six colleges of the University and eighteen departments and/or divisions. Two other projects were conducted in conjunction with other institutions--Galveston College and Texas State Technical Institute.

Program Development

Early in the development of the University's Sea Grant Program, the need to provide direction and to develop additional guidance for marine resource activities was recognized. Program development in this context represents program planning which is not initiated as a direct contribution from individual sea grant projects. The responsi-

bility for the development of programs lies chiefly with the Sea Grant Program Office and the Marine Resources Program Committee, an advisory group made up of Deans and Department Heads whose University activities are associated with the marine environment.

Initial efforts in program development have concentrated on information services, inter-university programs, governmental agency cooperation, industrial activities, project identification and analysis of needs.

Information Services

Included in the development of information under the Sea Grant Program are publications, conferences, and seminars.

● The University Sea Grant Program has initiated a monthly newsletter, *The University and the Sea*, which is designed to:

> Keep the marine resources public appraised of the sea grant and other marine resource educational activities;
>
> Rapidly convey information on new techniques and methods in a useful form to potential users; and
>
> Encourage users to contact appropriate Sea Grant activity leaders to discuss their needs and problems in marine resource development.

Information on new techniques and methods will come not only from developments at Texas A&M University, but also from other Sea Grant Programs, industrial sources, state and national research programs, and other appropriate sources. A mailing list of some 2000 names has been developed for the newsletter, covering industry, state institutions, other Sea Grant Programs, state and national research laboratories, and others.

● In mid-January, 1969, the University held its first conference on "Texas Marine Resources and the Sea Grant Program." The program brought together more than 200 representatives of government, industry, and the university community to discuss problems of marine resources and their solutions in the areas of ocean technology, marine commerce, and education. Proceedings of the conference have been published and distributed to participants and other interested individuals.

● A handbook for the Sea Grant Project Leaders, outlining the Program and delineating guidelines for "in-house" procedures, is being put together for use during the second year. The handbook will answer many questions regarding University and NSF Sea Grant policies.

● In an effort to more accurately determine the needs of the region for marine resource development, during the first year of the Program a number of interest areas were identified and plans were begun for a series of small (30-40 participants) meetings which would provide the setting for bringing coastal issues and problems to the surface. The first of these meetings will be held in November, 1969, in Houston and involves petrochemical industrialists, government agencies and others.

A coastal land use conference is being planned through the Marine Advisory Service of the Extension Service, and a workshop on recreation and tourism land use is scheduled for the Corpus Christi area in January 1970. Other workshops have also been tentatively outlined which would include participation of fisheries and seafood industries, marine commerce representatives, and lawyers involved in coastal zone problems.

Interuniversity Cooperation

● The concept at Texas A&M University is that sea grant programs will be identified for the region. In order to do this, other academic institutions have been asked for their views. A general conference or workshop of Texas universities will be held in December, 1969, to discuss this subject. Representatives from Texas colleges and universities with interests in the marine environment will participate.

● The Technician Training Program has been transferred to a cooperative program with the Galveston College. The Director of the Technician Training Program is a staff member of Galveston College. Staff members of the Marine Laboratory are teaching a course at Galveston College that was designed under the Sea Grant Program.

● A cooperative program in ocean engineering is being explored with the University of Houston. Their engineering staff members have met with the staff at Texas A&M University. The Dean of Engineering at the University of Houston has presented a proposal to Texas A&M University as a basis for discussion. This is now being considered.

● Conversations have been held with Lamar College of Technology Beaumont, and a joint research project is funded under the second Texas A&M University Sea Grant Program.

● Sea Grant project workers in fisheries and aquaculture have maintained close cooperation with the program at Louisiana State University. Although there are no formal cooperative arrangements, the informal exchange is high. Sea Grant Project leaders have participated in the formation phase of a "World Mariculture Society" which is scheduled to hold its first formal meeting in January, 1970.

Governmental Agency Cooperation

Texas A&M University personnel have always maintained a close working relationship with government agencies. In the marine resource field, however, there has been no unified state agency voice. This situation is changing apparently, and during the first year Sea Grant effort a number of significant events occured.

● Projects participants in the University Sea Grant Program have made contacts with representatives of Federal and state agencies as a means of identifying areas of need and of cooperation ventures in marine resource development. The Wildlife Science Department, the Marine Laboratory, and Texas State Technical Institute are all working with the Bureau of Commercial Fisheries on various projects. The pollution study group is working closely with the Port of Houston and with state water agencies in its program.

● The Texas Interagency Natural Resources Council asked Texas A&M University to initiate a study to inventory the coastal area and the University's Department of Recreation and Parks prepared a coastal zone bibliography as a first step in the study. The project was financed partially by Sea Grant funds, and partially by state funds.

● A joint committee of the Legislature of Texas held hearings on Coastal Zone problems and offered new legislation to the legislature in the summer of 1969. That group asked the Director of the Sea Grant Program to appear before them in Houston to discuss the Sea Grant Program. The committee evidenced much interest and offered their support.

● During 1969, the Texas House of Representatives recognized the increasing importance of the State's ocean resources by establishing an interim study committee to study the feasibility of establishing an Institute of Oceanography. The 11-man committee has interpreted this, the word "institute," to include ocean programs as well as facilities. The Sea Grant Program Office has offered to assist the committee in its study. Before reporting to the House in January 1971, the committee plans monthly public hearings in order to obtain information on existing ocean programs and future needs.

● The Governor's Office asked Texas A&M University to form a University Panel on Natural Resources to work with the Interagency Natural Resources Council. The chairman of the Panel is Director of the Sea Grant Program. The Interagency Natural Resources Council has invited the Panel Chairman to attend meetings of the Council.

● The Governor of Texas asked the Director of the Sea Grant Program to represent the State of Texas at a conference, "The Sea and the States," called by Governor Kirk of Florida in November, 1968. The conference addressed itself to the particular problems of interstate cooperation in the marine resources fields.

Industrial Activities

Individual industrial contacts are being made continuously by project leaders and other associated with Sea Grant projects. Examples of the kinds of activities and discussions which are developing between the University and industrialists are given below in abbreviated form.

● Animal Science Department and Galveston College personnel have established contact with the Texas Shrimpers Association, in an effort to identify the needs and problems of the shrimping industry and to offer assistance of the Texas A&M Sea Grant Program. In December, 1968, the director of the marine technical program signed on for a short fishing trip with one of the coastal shrimpers to get a "first-hand" look at shrimping techniques and problems.

● The program also has developed an advisory committee composed of representatives of coastal industry to advise the Technician Training

Program staff. The technician training program has also benefitted from gifts of a boat and motor for their program.

- The Extension Service is receiving assistance from the Brazoria County Mosquito Control District, Texaco, and Dow Chemical Company in developing their experimental-demonstration shrimp culture ponds.

- In another area, Chicago Bridge and Iron Co. has agreed to supply a grant of $10,000 to the Coastal Engineering Research Laboratory. This grant is to be used to improve and expand wave tank facilities for coastal and ocean engineering research.

- Sun Oil Company has made a grant of $15,000 to the Activation Analysis Laboratory for determining minerals in the ulf of Mexico. This complements the work initiated by Sea Grant funds as a research option.

- In a conversation with representatives of the Animal Science Department, an official of the Todd Shipyard Compan of Galveston proposed to procure a cobalt-60 radioisotope source, to be located in Galveston, but shared with Texas A&M University. The source is proposed for studies of the effects of radiation on commercially valuable sea life, and for the study of other radiation effects, both harmful and beneficial.

Project Identification and Analysis of Needs

Part of the function of Progrmm Development is to identify needs which arise out of project work and to make arrangements to alleviate the problems if possible. During the first year's work it became increasingly apparent that some provision should be made for ship time for many of the project leaders. As a result the Sea Grant Director is working with industrial groups and others to arrange for additional funds to provide ship time for the project leaders during the second year.

Another area which has received attention from the Program Development activities involves specimen collection. A number of projects depend on the collection of samples from the Gulf and the transport of these specimen to the College Station campus for work. In some instances collection problems have arisen and plans are now being made to instigate a Sea Grant Program sample collection process which will prove more dependable and will provide a variety of samples to appropriate projects.

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SEA GRANT PROJECTS: PROGRESS REPORTS-- EDUCATION AND TRAINING

Five projects were concerned with Education and Training under the first year program which ended August 31, 1969. Thirteen professional staff members and three graduate students participated in this segment of the program, which accounted for approximately 18.7 percent of the program funds. Five new courses have been developed during the year involving 109 students.

The Marine Laboratory, Galveston

The Marine Laboratory's Sea Grant Program is primarily concerned with instruction, both undergraduate and graduate, and student research in areas related to exploitation and utilization of marine biological resources. Initially, the major objective of this project is expansion of the graduate instructional and research program so that students may complete in Galveston all or most course work and thesis research required for the Master's of Science Degree in marine-oriented biological sciences such as marine biology, marine fisheries, and biological oceanography. Courses and research programs will emphasize development and application of scientific information that may lead to more efficient utilization, as well as artificial cultivation, of commercially important marine organisms.

It is anticipated that the program will provide a marine outlet for students from inland universities in Texas and other states. Fellowships have been provided through the Moody Foundation to assist in the support of the program.

The Marine Laboratory is also providing offices, classrooms and laboratories for other Sea Grant projects at Texas A&M University. These projects include: 1) Oceanographic Instruments Technician and Deck and Fisheries Technician Training Program (part of the year); 2) Aquaculture Program of the Wildlife Science Department; and 3) Marine Advisory Services. In the future other academic entities of Texas A&M University will continue to use this seaside facility and its personnel in some phases of their Sea Grant projects.

Accomplishments During 1968-69 Academic Year

Educational Activities

1. Fall Semester 1969:

   A freshman-level course entitled "Marine Organisms of Commerce" (Biology 131, three semester hours) was developed and taught at Galveston College by Drs. Aldrich, Ray and Wilson. Nine students enrolled in the course, which was taught in the evening. Six students completed the course. This course was taught as a part of the curriculum of Galveston College and Texas A&M University allows transfer credit as a "biology elective."

2. Spring Semester 1969:

   During the spring semester there were seven graduate students in residence at the Marine Laboratory. Four students were enrolled in a graduate course, Biology 662 (Biology of the Mollusca), which was taught by Dr. Sammy Ray. The other students conducted research and/or wrote their thesis or dissertation. Two of these students completed their thesis research and were awarded the Master's degree in Biology at Texas A&M University. The third student expects to receive the Ph. D. degree in Wildlife Science during the fall semester of 1969. Also, the laboratory was used on a part-time basis by several students as a base for field trips in connection with thesis and problem research. One such student, who received a Master's degree in Biology, used

the laboratory as a base for conducting an ecological study of oyster reefs in West Bay.

3. First Summer Session 1969:

Thirty-six students enrolled for courses during the first summer session, one-half of them were graduate students and one-half were advance undergraduates (juniors and seniors). Eight of the graduate students were Ph. D. candidates. The courses offered included:

a. Marine Invertegrate Zoology (Biology 435) - Enrollment: 7 (28 hr)
b. Statistical Methods (Statistics 406) - Enrollment: 15 (45 hr)
c. Marine Ichthyology (Wildlife Science 312) - Enrollment: 4 (8 hr)
d. Problems (Biology 485) - Enrollment: 4 (8 hr)
e. Problems (Biology 685) - Enrollment: 1 (4 hr)
f. Research (Biology 691) - Enrollment: 2 (4 hr)
g. Problems (Wildlife Science 485) - Enrollment: 1 (4 hr)
h. Problems (Wildlife Science 684) - Enrollment: 1 (3 hr)
i. Research (Wildlife Science 691) - Enrollment: 11 (27 hr)

4. Second Summer Session 1969:

During the second summer session, there was a total of 42 students enrolled, with the distribution being 28 graduate and 14 advanced undergraduate students. Twelve of the students were Ph. D. candidates. The courses offered included:

a. Biology of the Mollusca (Biology 662) - Enrollment: 11 (44 hr)
b. Fisheries Survey (Wildlife Science 400) - Enrollment: 12 (48 hr)
c. Animal Population Dynamics (Wildlife Science 416) - Enrollment: 18 (54 hr)
d. Problems (Biology 485) - Enrollment: 3 (12 hr)
e. Problems (Biology 684) - Enrollment: 5 (16 hr)
f. Research (Biology 691) - Enrollment: 2 (8 hr)
g. Research (Education 691) - Enrollment: 1 (1 hr)
h. Research (Oceanography 691) - Enrollment: 1 (6 hr)
i. Problems (Wildlife Science 485) - Enrollment: 2 (5 hr)

j. Problems (Wildlife Science 685) - Enrollment: 2 (5 hr)

k. Research (Wildlife Science 691) - Enrollment: 11 (21 hr)

5. New Course Development

Two new graduate courses, one entitled "Estuarine Ecology" (Wildlife Science 611) and the other entitled "Mariculture" (Wildlife Science 615), were developed by Dr. David Aldrich for offering at the Marine Laboratory, especially during the regular school year. Although the Estuarine Ecology course was scheduled to be offered for the first time during the spring semester of 1970, neither of these courses cleared all academic hurdles in time to be offered during the 1969-70 academic year.

6. Student Support:

Beginning February 1, 1969, the Moody Foundation of Galveston awarded Texas A&M University $11,000 for each of two years to support graduate students in residence at the Marine Laboratory. During the spring semester of 1969, one Ph.D. student and one Master's student were supported by Moody Fellowships in Marine Sciences. Two Master's students were supported from the same source during the two summer sessions of 1969. The Moody award also provided $2,00 for library support.

The Aquaculture Project of the Wildlife Science Department has provided significantly to the support of graduate sutdents in residence at the Marine Laboratory. During the spring semester a doctoral and a Master's student were supported through this project. During the summer session, the student support was increased to include two Ph.D. and three Master's candidates.

Services Provided to Other Sea Grant Projects

1. Oceanographic Instrument Technician and Deck and Fisheries Technician Training Program:

The Director of this program, Captain H. A. Rowe, maintained an office at the Marine Laboratory from September 1968 through May 1969. Capt. Rowe moved his office when the program was transferred from the Texas State Technical Institute to the Galveston College.

2. Marine Advisory (Extension) Services:

During the summer of 1969, David L. Harrington, Area Marine Fisheries Specialist, established an office at the Marine Laboratory. The facilities and support personnel of the Marine Laboratory are available to Mr. Harrington in the conduct of this program.

3. Aquaculture Project of the Wildlife Science Department:

Much of the Aquaculture Project, which is under the direction of Dr. Kirk Strawn, is being conducted at the Marine Laboratory. Dr. David Aldrich of the resident staff devoted half of his time to this project. A large space (2200 sq. ft.) in the basement of the Marine Laboratory has been converted into an aquarium room for this project. Funds from the Marine Laboratory and Building and Maintenance budgets were used in providing utilities, compressed air and other items required to establish a functioning aquarium room.

Sea Grant Related Activities

Since the establishment of the Sea Grant Program at Texas A&M University, the Marine Laboratory's resident staff and the Director in particular have engaged in several conferences with College Station staff members who were initiating various Sea Grant projects. Our familiarity with marine and fisheries activities in the Galveston area has been useful in providing the contact between personnel on the main campus and state, federal, industrial and commercial fisheries organizations.

The staff of the Marine laboratory conducted tours and gave short lectures to several high school and college groups who wished to become acquainted with our program and to learn something of the career possibilities in marine sciences. One group came from Kansas and another from Missouri. Some biology classes from inland colleges and universities used the laboratory as a base for week-end field trips. We are receiving an increasing number of requests from high school and institutions of higher learning from inland areas to provide tours and lectures in the general area of marine science. Such activities are vital in stimulating an interest and awareness of importance of our marine resources.

The Director serves on the Oceanography and Education Committees of the Galveston Chamber of Commerce. Through such committee service, the Marine Laboratory maintains contact and exchanges information with the educational, industrial, state, federal and philanthropic institutions in the Galveston area.

Reports and Project Documentation

Research for three theses was conducted at the Marine Laboratory during the year. These are reported in Chapter 3 of this report, "Publications and Program Documentation."

Personnel Participation

Three professional faculty members participated in the Sea Grant Program of the Marine Laboratory for a total of 11.5 man months: Dr. Sammy Ray, Director of the Marine Laboratory; David V. Aldrich, Associate Professor, Department of Wildlife Science; and William B. Wilson, Assistant Professor, Department of Biology.

Technician Training, Galveston College

The technician training program is conducted by Galveston College through a contractual agreement with Texas A&M University and with the cooperation of Texas A&M University Marine Laboratory, Texas Maritime Academy, and the Department of Oceanography of Texas A&M University. Curricula included both theory and practice necessary to equip graduates to perform useful work aboard the increasing numbers of oceanographic vessels and fishing boats.

Training is conducted under two curricula: 1) oceanographic instrument technology and 2) deck and fisheries technology. The former are basically marine oriented electronic instrument technicians; the latter are marine oriented mechanics/welders/riggers.

Technicians in these two categories are trained to be useful in ship operations, in making emergency repairs to rigging, machinery, and electronics equipment, and in assisting scientists and engineers in operating instruments and in recording and reporting meaningful data.

Accomplishments During 1968-69 Academic Year

The expansion of the oceanographic effort in both size and scope has created a scarcity of trained oceanographic technicians. The rigors of the occupation result in a high rate of turnover in personnel. In a related area, the deck hands of the fishing fleets are largely composed of unskilled drifters. The importance of and the predicted expansion of food harvesting from the sea dictates that improved technology be offered to the fisheries workers.

Curricula Development

The technician training program was initiated on 1 September 1968 with the hiring of a director of Ocean Technician Training and clerical help. Offices were set up in the Texas A&M Marine Laboratory in Galveston under the administrative control of the Texas State Technical Institute, Waco, Texas.

Top level representatives of the major industrial employers of oceanographic technicians in the area were formed into an active Ocean Technician Advisory Committee to make our program responsive to the real needs and requirements of ocean related industries in the western Gulf of

Mexico. Specifically this committee represents the following:

Teledyne	Geophysical Exploration
United Geophysical	Geophysical Exploration
Shell	Petroleum exploration and production
Esso	Petroleum exploration and production
Divcon	Underwater construction and mining
Decca	Presision navigation and survey
Kelso Marine	Shell, sand, ship construction and operations
Manned Spacecraft Center	Oceanography
Marine Systems Engineering	Diving
Commercial Engineering Corporation	Specialized deck equipment

The absence of representatives of the fishing industry was not an oversight but rather was in line with the less than enthusiastic acceptance of this program by the fisheries industries in the area.

The curricula represents our view of the optimum training to meet industry needs within the budget restraints. They were developed with the help of the above Advisory Committee and included a study of other similar programs in this country. The two curricula were submitted to, and approved by the Texas Education Agency.

A fifty foot yacht was donated to Galveston Junior College District by William Van Conover. Two diesel engines were donated by Stewart and Stevenson to replace the less desirable gasoline engines. The Moody Foundation donated the funds for modification and re-fit.

Effective 1 March 1969 the administrative control of the program was changed from Texas State Technical Institute to Galveston College.

On 15 March a skilled ocean instrument technician, with 16 years experience in the military and industry, was hired as a full time instructor.

Student Recruitment

A study of the problem revealed three primary prospective sources of students: 1) military separation centers, 2) area high schools, 3) transferees from other colleges.

Recruitment methods included:

1) Press releases to trade journals and newspapers
2) Talks at business and other clubs
3) Personal rapport with high school counselors
4) Visits to separation centers.

The newness of Oceanography makes it difficult to attract students especially when the average couselor knows little about the subject, and only counselors in the immediate area know that such a program is available at Galveston College.

The Deck and Fishery program has failed to attract students at this point so it will be delayed until measures can be taken to recruit sufficient students.

A continuous recruiting effort will be maintained to develop the entire program.

Student Enrollement

The first class consisted of fourteen students; ten recent high school graduates and four transferees from other schools. Twelve enrolled in the Ocean Instrument Technology and two in the Deck and Fisheries Technology.

The first summer session was devoted to Introduction to Oceanography, Seamanship, and Navigation, Scuba Diving, Drafting and Water Safety.

At registration for the fall semester, eight of the original students were still in the program; however, ten new students were enrolled.

Reasons for the loss of six students at the end of the first summer were:

4	Transferred to four year colleges
1	enlisted in Navy
1	bought a shrimp boat and went to work

The six week summer session emphasized practical at sea work and included at least eight one-day cruises for each student.

Sea Grant Related Activities

In addition to a close working relationship with other departments of Galveston College and Texas A&M University, contact is maintained with industry, the U.S. Coast Guard, and the Bureau of Commercial Fisheries on a local level and similar training programs on a national level. As an example, five of our students have had a one week cruise on a U.S. Coast Guard buoy tender. This program is a continuing one, and it is planned to have every student make at least one Coast Guard cruise.

Exchange of information on curricula, recruiting, and training aids has been established with ten other institutions engaged in Ocean Technicians Training.

Reports and Project Documentation

The Technician Training program of Galveston College has received wide acknowledgement through newspapers, newsletters, and local television media. A brochure entitled "Marine Technology, Galveston College" was produced and distributed to high schools and other institutions as part of the recruitment effort.

Personnel Participation

Four professional staff members from Galveston College are involved in the Technician Training Program totalling 18.5 man months: Henry A. Rowe, Chairman, Department Marine Technology; John E. Hennigan, Instructor Marine Technology; Ken Yokum and R.W. Merrill, Galveston College.

Technician Training, Texas State Technical Institute, James Connally Campus

Underwater Welding is one of many technologies necessary to support man's quest of the sea. The myriad of underwater equipment and material along the Gulf Coast has created a critical shortage of skilled manpower to maintain, modify, operate, and install it.

Mr. R. B. Vann, Head of the Welding Technology Program at Texas State Technical Institute, has had experience in this phase of welding. Early in the acquisition of welding property and equipment, Mr. Vann visualized a program of this type which would utilize much of the equipment with very little modification. Steps were taken to provide some funding from existing welding programs and some funding was provided through the Sea Grant Program. Progress was much quicker than anticipated and by the end of the academic fiscal year, the program had a pre-enrollment of twenty students.

Accomplishments During 1968-69 Academic Year

An Advisory Committee was formed and enthusiastically supported the proposal. This Committee met September 20, 1968. It was composed of Hubert Crick, Rupert Key, J. J. Durham, Ralph White, Dick Oliver, Fred Salmons, Bill Johnson, J. H. Walker, and Doyle Short.

A fuel storage tank, 46' in diameter by 30' deep, has been converted into an excellent underwater welding laboratory. The conversion required sandblasting the interior of the tank, application of a primer, followed by a coat of epoxy paint. A walkway with guardrails has been constructed around the circumference of the top of the tank. This laboratory contains eight work stations with observation windows at each station for the instructor to observe students' progress and advise him of mistakes. Utilizing the "buddy" system of welder and tender, the laboratory will accomodate sixteen students at one time. This laboratory, as of August 31, 1969, was approximately 85 percent complete.

Portable compressors and equipment were purchased so that early stages of the training could be started in one of the campus swimming pools.

Student recruitment for this program has been no problem, perhaps due to the excellent employment record of the industrial welding tech-

nology graduates and to the able assistance of the members of the Advisory Committee.

The course curriculum has been organized to take the student divers into progressively deeper water and into more hazardous environments. Safety instruction, next to student proficiency is paramount. Each student's safety procedures will be closely monitored prior to entering subsequent phases of training.

Supplies and equipment totaling over $13,000 have been ordered to equip the underwater welding laboratory. Of this total, more than $9000 is to equip the eight work stations. From May to September, one instructor equivalent has been devoted to planning the program and insuring readiness of all facilities.

Oceanographic Technician Program

In addition to work on the Underwater Welding Program, considerable effort was expended in developing an Oceanographic Technician Program. Two Advisory Committee meetings were held in Galveston, Texas. Curricula and course descriptions were developed and brochures announcing the program were printed and distributed. In February, 1969, it was decided to drop this phase of the program at the Connally Campus. Negotiations were undertaken to transfer this effort to the Galveston College in Galveston, Texas. All inquiries and applicants have been referred to Galveston.

Personnel Participation

During the first year, two professional staff members of the Texas State Technical Institute were involved in the Technician Training project for a period of 4.2 man months: Jack E. Tompkins, Vice President, and R. B. Vann, Head, Welding Technology Program.

A Project in Maritime Geography

Preparation of a syllabus for a course on the geography of the oceans was undertaken in order to increase the spread of knowledge of the great and increasing importance of the sea for mankind.

Accomplishments During 1968-69 Academic Year

The goal of the project was the production of a syllabus of 35 to 50 pages that would be a guide to an undergraduate course in Maritime Geography. A bibliography was compiled, key material was xeroxed and a color coded card file completed. In addition, library orders for needed acquisitions were completed. This work was done by a full-time secretarial assistant.

SUMMARY OF BIBLIOGRAPHIC ACTIVITY

Articles xeroxed	233
Pages	2800
Titles assembled	690
Library orders	150

TEXTBOOK OUTLINE

Introduction to Physical Oceanography	24 pp. single space
Mineral Resources of the Sea	32 pp. triple space
Fisheries	154 pp. triple space
Men Beneath the Sea	9 pp. MS
Law of the Sea	40 pp. MS
Farming of the Sea	11 pp. MS
Ships and Shipping	32 pp. MS
Ports	15 pp. MS
	317 pp.
Converted to standard of double space (estimate)	240 pp.

The proposed 35 to 50 page course syllabus has grown into a digest of the assembled material that in outline form now approaches a textbook.

Educational Activities

An experimental course was taught (Geography 485, Problems). The major finding was that students exposed to the geography of the oceans (physical, economic, political) became extremely interested and were profoundly impressed with the importance of the subject.

A new course, Geography 315, Geography of the Sea, has been proposed by the department and will be taught when approved.

Sea Grant Related Activities

Dr. George F. Carter attended the University of Rhode Island Law of the Sea Institute, June 23-24, 1969. The contacts with men from law, navy, fishery, economics, and so forth were most valuable. Dr. Carter has been asked to return next year and requested to serve on the Oceanography Committee of the Association of American Geographers.

Reports and Project Documentation

None, other than the syllabus.

Personnel Participation

Dr. Carter was involved with this project a total of three man months during the year.

Development of Curriculum in Coastal and Ocean Engineering

One of the most significant factors in accelerating development of Marine Resources is to train qualified coastal and ocean engineers. There is no doubt that a great shortage of trained coastal and ocean engineers exists.

The purpose of the Ocean Engineering project is to strengthen the curriculum in Coastal and Ocean Engineering and develop new graduate courses in this field. The objective of the first year's program was to develop three new courses (1) Estuary Hydrodynamics, (2) Deep Ocean and Continental Shelf Dredging and (3) Coastal Sediment Processes. The first two of the courses were offered during the 1968-69 Academic year and the third course will be offered during the 1969-70 year. Graduate students conducted thesis research in coastal and ocean engineering as part of the program.

Accomplishments During 1968-69 Academic Year

The major effort of this project has been the development of curriculum in coastal and ocean engineering. The activities were varied and many: during the year several of the staff attended and presented papers at the meetings involving coastal and ocean engineering; seminars were held on the Texas A&M campus; new courses were offered or are being developed and new laboratory facilities designed and/or completed.

Educational Activities

In addition a tentative graduate program was established, and a brochure describing the program was developed and mailed to prospective students and to all engineering schools. New, qualified graduate students were attracted to the program, which has grown from one graduate student in 1966-67 academic year to about eighteen graduate students majoring or minoring in coastal and ocean engineering during the 1968-69 academic year. Two Masters Degrees were awarded in June 1968 to students majoring in coastal and ocean engineering. There are currently four students involved in a doctoral program.

1. New Course Development

(a) Three new courses have been developed under this program:

(1) Estuary Hydrodynamics - taught by Dr. Garrison

(2) Continental Shelf and Deep-Ocean Dredging - taught by Dr. Herbich

(3) Coastal Sediment Processes - to be taught by Dr. Sorensen

The first two courses were taught during the Spring Semester of 1969, and it is planned to teach the third course during the Spring Semester of 1970.

No course numbers are as yet available but "Requests for New Graduate Courses" were proposed and sent to the Curriculum Committee through the Graduate Council. The courses were taught under C.E. - Problems.

(b) In addition three courses initiated prior to the award of Sea-Grant Program were up-dated and are under further development.

(4) C.E. 675 Coastal Engineering I - taught by Dr. Herbich

(5) C.E. 677 Coastal Engineering II - taught by Dr. Herbich

(6) C.E. 676 Ocean Engineering I - taught by Dr. Sorensen

in Coastal Engineering I and II prior to the Academic Year 1968-69. It should be realized that no text books are available in Coastal and Ocean Engineering as yet, and a considerable effort has been made to develop these courses.

2. Course Description

(a) Estuary Hydrodynamics

A three credit hour graduate level course entitled "Estuary Hydrodynamics" was developed and taught during the spring semester of 1969. The intent of the course is to introduce the students to estuarine problems and to discuss some of the fundamental methods of analysis involved in dealing with estuarine processes.

An outline of the topics covered in the course are given below:

I. Tides and Harmonic Analysis

II. Tidal Dynamics in Estuaries

(a) Estuaries of Rectangular section

(1) Effect of friction

(b) Real Estuaries

(1) Harmonics

(2) Method of Characteristics

(3) Numerical Methods

III. Stratification and Diffusion in Estuaries

(a) The Mechanism of an Arrested Wedge

(b) Diffusion Processes in Stratified Flow

(c) Salinity Intrusion in Estuaries

(d) Pollution in Estuaries

IV. Sedimentation in Estuaries

V. Model Laws for Coastal and Estuarine Models

Also, in conjunction with this course a small density current flume was designed to demonstrate flow due to density stratification. Mr. Rahaman was involved in the design of this channel and Mr. Snider provided some assistance in the development of the course.

Five graduate students took the course during the spring semester of 1969.

It is intended to prepare a course manuscript for publication by June 1970.

(b) Continental Shelf and Deep Ocean Dredging

A three credit hour graduate level course entitled "Continental Shelf and Deep Ocean Dredging" was developed and taught during the spring semester of 1969. The intent of the course is to introduce the students to dredging problems, design and development of new and improved dredging machinery and methods.

A draft of course notes has been prepared. It is intended to complete the course manuscript for publication by June 1970.

Three graduate students took the course during the spring semester of 1970.

(c) Coastal Sediment Processes

An outline for the proposed graduate course has been developed; a large portion of the pertinent literature has been collected and is being read; the field trip has been partially planned; and a small number of lectures for the course have been prepared. The course outline has been submitted to the Graduate Council for approval and the course

will be presented during the spring semester 1970. Two graduate students have taken part of the material in this course during the summer of 1969 as C.E. 685.

Outline

COASTAL SEDIMENT PROCESSES

1. Literature sources
2. Definition of significant terms
3. Review (and lab demonstration) of necessary wave topics
4. Sediment properties, size distributions and their determination
5. Review of necessary stream sediment transport concepts
6. Classification of coastlines, physiographic units, geologic changes
7. Cliff erosion rates
8. Sources of littoral material, loss of material
9. Littoral current characteristics
10. Longshore transport, typical rates, measuring techniques
11. Littoral transport prediction equations
12. Transport past inlets (effects of jetties)
13. Tidal prism vs. inlet opening
14. Design of stable inlets
15. Location of inlets (w.r.t. canyons, headlands)
16. Case histories (Santa Barbara, Port Huenemen, Santa Monica Causeway)
17. By-passing techniques
18. Longshore size variations
19. Beach profile, seasonal and longshore variation, sediment movement normal to shore
20. Sediment tracing
21. Wind transport and beach stabilization
22. Artificial nourishment and beach rehabilitation
23. Shoaling in harbors and estuaries
24. Legal considerations
25. Field trip

First draft of the course manuscript will be prepared by August, 1970.

Sea Grant Related Activities

(1) Coastal Engineering Laboratory

A Coastal Engineering Laboratory has been established at Texas A&M University by the action of Board of Directors. A facility of this

type is a valuable tool as, in many cases, laboratory investigations offer the only method of finding solutions to serious problems such as those that exist and will develop in the bays and estuaries along the entire Texas coast. The Laboratory will be established primarily at the Texas A&M Annex utilizing existing runway aprons for the construction and testing of hydraulic models of the various bays and estuaries and for necessary supporting studies.

Hydraulic models of the tidal and estuary environment may be used to study a wide spectrum of problems; some of these which are significant in Texas are:

a. Flooding due to hurricane surges.
b. Efficiency of tidal mixing and resulting salinity distributions.
c. Diffusion, dispersion and flushing of waste discharges (sewage, chemical, thermal, etc.) in bays and estuaries and along the coast.
d. Shoaling and erosion in bays, navigation channels, coastal inlets, etc. due to deposition of dredging spoil and river and coastal sediment movement.
e. Improvement and verification of designs for navigation channels, estuary and coastal structures, fish passes, etc.

The broad scale plans are now being developed in cooperation with industry in Texas and Louisiana and possible sources of funds for establishing such a laboratory are being explored.

(2) Center for Dredging Studies

The University's Board of Directors approved the establishment of a Center for Dredging Studies. The Center is operated by the Civil Engineering Department and includes teaching, research information dissemination and operational activities. The proximity of A&M to the Gulf of Mexico and the capabilities of its staff make it appropriate that the University provide leadership in this field. It is felt that new and improved methods of dredging must be developed in the near future, in view of renewed interest in greater utilization and exploitation of marine resources and increased activities in estuaries along the shore and offshore.

A one-day Dredging Seminar was held on November 22, 1968. The Seminar speakers included Mr. M.J. Richardson (past President of World Dredging Association, California), Col. F.B. Moon (Galveston District

Engineer, U.S. Army Engineers), Mr. M.J. Cruickshank (U.S. Bureau of Mines, California), Mr. John Huston (Consulting Engineer, Corpus Christi), Dr. R. M. Sorensen and Dr. J.B. Herbich, Texas A&M University. Fifty-three participants of Industry, Government, Engineering firms, and Universities attended the Seminar.

Reports and Project Documentation

One thesis, four technical reports, and six professional meeting proceedings were prepared under this project. These are reported in Chapter 3, "Publications and Program Documentation."

Personnel Participation

Three professional staff members from Texas A&M University are involved in this Ocean Engineering Project for a total of 6.8 man-months: C.J. Garrison, J.B. Herbich and R.M. Sorensen. Three graduate students also participated a total of 18 man-months.

3

SEA GRANT PROJECTS: PROGRESS REPORTS-- EXTENSION AND ADVISORY SERVICES

Two projects were classified under the category of Extension and Advisory Services during the first year's work under the Sea Grant Program. Seven professional staff members devoted 29.25 man-months to this work and two graduate students were involved. Extension and Advisory Services activities accounted for approximately 14.8 percent of total program funds.

Sea Grant Advisory Program, Texas Agricultural Extension Service

During the first year of operation, the Sea Grant Advisory Program focused upon: (1) the determination of the feasibility of pond production of shrimp in natural and man-made marsh ponds (Mariculture segment), (2) development of an Extension education and assistance for the commercial fishing industry, (3) organization of committees of lay leaders to assist in determining program priorities and marine resource problems, and (4) conduction of training sessions for the field staff of the Extension Service.

The basic purpose of all segments was to increase, on an ecologically sound basis, the economic opportunity of marine resource users. More specifically, the mariculture segment proposed to investigate and demonstrate the potential of shrimp culture as a marsh resource use which would complement established marsh utilization by waterfowl and livestock. Historically, there has been little effort to extend and interpret accumulated research information to the commercial fishing industry. Thus, specific emphasis was also given to the initiation and development of an Extension information program designed to extend maritime informational services to the people who stand to benefit from its application.

Accomplishments During 1968-69 Academic Year

To facilitate reporting, this section is divided into (1) a mariculture segment, (2) a marine fisheries segment, and (3) a general segment which contains an array of activities.

Mariculture

Organization--The mariculture program is being conducted in an area of coastal marsh near Angleton, Texas, in Brazoria County. This site was selected primarily because it is the location of marsh utilization research project being conducted by Texas A&M University. The University's Departments of Wildlife Science and Entomology and the Angleton Experiment Station, along with the Brazoria County Mosquito Control District, the Dow Chemical Company and Texaco, Inc., are participating in a study with the objective of developing an economic marsh utilization program. Since our interests were closely allied with this objective, our participation in this cooperative effort was welcomed. This team approach should provide the data for evaluating the economic potential of marshland in terms of beef production, waterfowl utilization, mosquito control, and mariculture. Modification of the natural marshland environment should be minimal in these efforts.

A meeting of representatives of the above mentioned groups and the landowner, Texaco, Inc., was held on October 1. Permission was obtained to levee three natural marsh ponds and construct ten 1/2-acre reservoir type ponds to facilitate mariculture activities. The Director of the Brazoria County Mosquito Control District, Mr. J.C. McNeil, IV, was able to provide, through the cooperation of the Brazoria County Commissioners Court, the necessary equipment for pond construction. Levees were completed around the three natural ponds in April. These ponds measured 1-1/2, 1-3/4, and 2-1/2 surface acres. Construction of the reservoir ponds was completed in June.

Research--Demonstration Results--On April 16, the 1-1/2 acre natural pond was stocked with 17,000 postlarvae brown shrimp, *Penaeus aztecus*, (averaging 8 mm in length) provided by the Bureau of Commercial Fisheries Laboratory at Galveston. Based on previous research in Louisiana, it had been initially planned to stock all ponds at a rate of 20,000 per acre. These were, however, the only hatchery-reared shrimp available for stocking at that time, and the scarcity of shrimp in the

bays prohibited obtaining stock from the natural population. Although survival from this stocking was poor (about 2 percent), growth was exceptional (about 2 mm per day). Seventy days after stocking, these shrimp had attained a mean length of 130 mm and by 90 days had reached a mean length of 147 mm. This growth rate was dependent only on natural foods within the pond since no supplemental feed was provided. The market value of these shrimp at 70 days (they measured 30 count per pound, heads on) was $0.79 per pound and at 90 days (measuring 22 count per pound, heads on) was $0.85 per pound. These prices were quoted by a local processing plant on those respective dates.

These shrimp were removed from the pond on July 17 using a harvest flume designed by project personnel. The flume is essentially a flood gate through which water can be drained from the pond. A net was placed over the flume discharge and the shrimp were collected as they exited on the outgoing current. Brown shrimp appear to be very susceptible to this device and, according to studies on their migration habits, they react as if they are returning to the Gulf on an outgoing tide. Of those shrimp retrieved from the pond, 70 percent were collected at the flume during the first 30 minutes of harvesting and 95 percent were collected at the end of the two hours. Harvesting was continued for a total of four hours.

The remaining two natural ponds were stocked on June 13 with brown shrimp postlarvae supplied by the Bureau of Commercial Fisheries. The stocking rate in this instance was 20,000 per acre, but no survival was observed. The mortality was probably due to predation by fish.

In order to evaluate the effect of fish predation, all three natural ponds were stocked on August 4, 5, and 7 with juvenile white shrimp (averaging 60 mm) supplied from Galveston Bay by a local fisherman. A fish toxicant (rotenone) was applied to the 2-1/2-acre pond to remove predators, and Diuron was applied to control all aquatic vegetation. A commercial catfish food was introduced in each pond to supplement natural foods. Survival in all ponds has been good, but the growth rate was highest in the pond without predators. An accurate measure of survival will not be possible until the shrimp are harvested in October.

A number of questions have been raised concerning protein sources in artificial shrimp foods, and it is generally conceded by most researchers

that fish meal is desirable. The proportion of fish meal, however, is questionable. For this reason, an experiment was initiated in the ten 1/2-acre reservoir ponds to examine the quality of a high and low fish meal diet. The ponds were stocked on August 27, 28, and 29 with juvenile white shrimp (averaging 60 mm). In five of the ponds, shrimp were fed a 50-percent protein diet, of which 60 percent of the protein was fish meal, and in the other five ponds, shrimp were fed a 50-percent protein diet with fish meal accounting for only 20 percent of the total protein. In both diets the remaining protein consisted of a mixture of poultry by-products, blood, and bone meal in equal proportions. Survival and growth have been good in all ponds and preliminary findings indicate that the high fish meal diet is superior. These shrimp will be harvested during the latter part of October.

Most studies now in progress in shrimp culture are intended primarily to facilitate relatively low-density practices for use on inexpensive coastal lands--synonymous to pasture grazing practices in the beef industry. In order for industry to participate profitably, however, techniques for a high-density (intensive) culture system--along the lines of a beef cattle feeder lot--are needed. Both low- and high-density rearing practices are presently employed successfully in catfish culture and, with additional research, techniques for intensive shrimp culture should also be developed. In order to augment the present field efforts of the Texas Agricultural Extension Service, a proposal has been submitted by the Dow Chemical Company to explore the feasibility of an intensive shrimp culture system. Extension personnel presently involved in the mariculture program will cooperate with Dow in this effort and have access to the results of this research. Included in the proposal are (1) a food study directed toward the development of a total artificial shrimp food, (2) an ecology study designed to determine optimum environmental conditions for high-density yield, and (3) an engineering design and economics study for construction and maintenance of a high-density culture system.

Mosquitos in Texas coastal marshes are generally controlled with aerial applications of Malathion. Since mariculture ponds will be located in areas where such control techniques are presently underway, it was decided to study the effects of aerial applications of Malathion on

shrimp. These tests were conducted in cooperation with the Brazoria County Mosquito Control District and Texas A&M University's Department of Wildlife Science at two locations near the mariculture site. Results indicated that the standard aerial application of Malathion was toxic to both brown and white shrimp. Mortalities varied from 30 to 80 percent in a total of nine test cages, whereas no mortalities were observed in nine control cages. Overall, 80 percent of the mortalities occurred during the first 24 hours and no mortalities were observed after 72 hours.

The enthusiastic response from coastal landowners indicate a strong demand for information on shrimp culture in Texas. Many landowners have offered to build experimental ponds at their own expense because of the promising potential in this field. Efforts are presently hampered by the short and inconsistent supply of postlarvae for stocking purposes making it impossible to encourage this cooperation. An experimental hatchery, funded through this mariculture program, could satisfy this demand and in addition serve as a model on which private investment into a commercial hatchery could be encouraged. In view of the increasing demand by the consumer for shrimp and by the local landowner for food producing uses for his land, it is imperative that this program receive the fullest possible support from federal and state agencies.

Marine Fisheries

Only three man-months have been devoted to the initiation of development of the marine fisheries program, but considerable progress toward audience acquaintance has been made. During initial program development, emphasis was placed on establishing contacts within the marine community. These included fishermen, individual boat and fleet owners, processors, manufacturers of marine products, and the four major fisherman organization, namely: (1) Texas Shrimp Association, (2) Texas Bay and Gulf Fishermen Association, (3) Freeport Shrimp Association, and (4) Calhoun County Fishermen Association. In addition to these, contacts were made regarding cooperative work with the Bureau of Commercial Fisheries relative to gear research, exploratory fishing, and market news services. An extensive mailing list was developed to inaugurate an information and newsletter service for the fishing industry.

It was apparent that liaison was also needed between the fishing industry and manufacturers of fishing products. At the request of both steps were taken to initiate such communications with the intent to develop new and better products, to reduce boat operating costs, and increase production. Evaluations of several new products were made. Initial trials of modified shrimp gear were conducted an a commercial trawler. Procedures have been developed to program and test the use of a horizontal side flash scan sonar in shrimp fishing.

Personal conferences were held with the county agents of each of 17 counties along the Texas coast to acquaint them with the programs under development.

Sea Grant Related Activities

Three one-day training sessions were conducted for county agents of the 17 coastal counties of Texas. The purpose of the training session was to provide the County Extension staffs with in-depth information on the total Sea Grant Program and Extension's involvement in the new advisory services program. Follow-up training was carried out through newsletters and publications. News and research information involving coastal resources was forwarded to agents to keep them abreast of current developments.

The first of a series of advisory committees has been organized. The "Coastal Land Development" Committee is composed of citizens selected by their peers. The purpose of the committee is to insure local leader involvement in determining project priorities and program direction. The first meeting of the committee will be held in October, 1969.

The program for a Coastal Land Use Conference has been developed and will be conducted during January, 1970. Speakers and subjects are being confirmed at the present time. The objective will be to present detailed information to landowners and managers on the alternatives for utilizing marshlands in Texas.

Reports and Project Documentation

One magazine article and several newspaper articles have appeared this year concerning the mariculture project. See Chapter 3 "Publications and Program Documentation" for further descriptions.

Personnel Participation

Five professional staff members put in a total of 22 man-months under this project: J.E. Hutchison, Director, Texas Agricultural Extension Service; W.G. Klussman, Sea Grant Advisory Program Leader; Jack C. Parker, Marine Advisory Program Specialist; David Harrington, Area Marine Fisheries Specialist; and Jack Jones, Resource Development Specialist. In addition, Hoyt Holcomb, spent six man-months as Marine Advisory Program Assistant.

A Marine Resources Information Center

The primary goal of this project is to provide a campus focus for information relating to marine resources. Once the systems and procedures have been established within the campus, the operation can be expanded to provide significant information services to a larger marine oriented population.

Services are designed to provide support to individual advisory, education, training and research activities as well as the total program. The approach includes the identification of available marine resources material and procedures for making this core of information readily available to the various participants of the program.

Accomplishments During 1968-69 Academic Year

During the first year of this project the overall design of the Marine Resources Information Center has been completed. Activities of this center involve the establishment of five major data bases and methods for making this data available to the various user groups. Figure 1 provides an overview of the interaction between the various user groups and the information center. A description of the current status of each data base is given below.

1. Personnel Expertise Data Base: A mail questionnaire was designed and distributed to 987 individuals within the university. The primary objective was to identify those individuals to be included in the file and collect information relative to 1) expertise related to marine resources; 2) education (degrees and major fields; 3) work experience (type and number of years). To date a total of 221 replies have been received. The data has been converted to machinable form and programs have been developed to display this information in a variety of formats.

2. Facilities Data Base: A questionnaire has been designed and distributed to 23 facilities which have a potential for providing supporting services for the Marine Resources Program. To date, 11 replies have been received. Programs to make this information available are currently in the developmental stage.

3. Activities Data Base: A questionnaire has been designed for the collection of this information and material has been assimilated

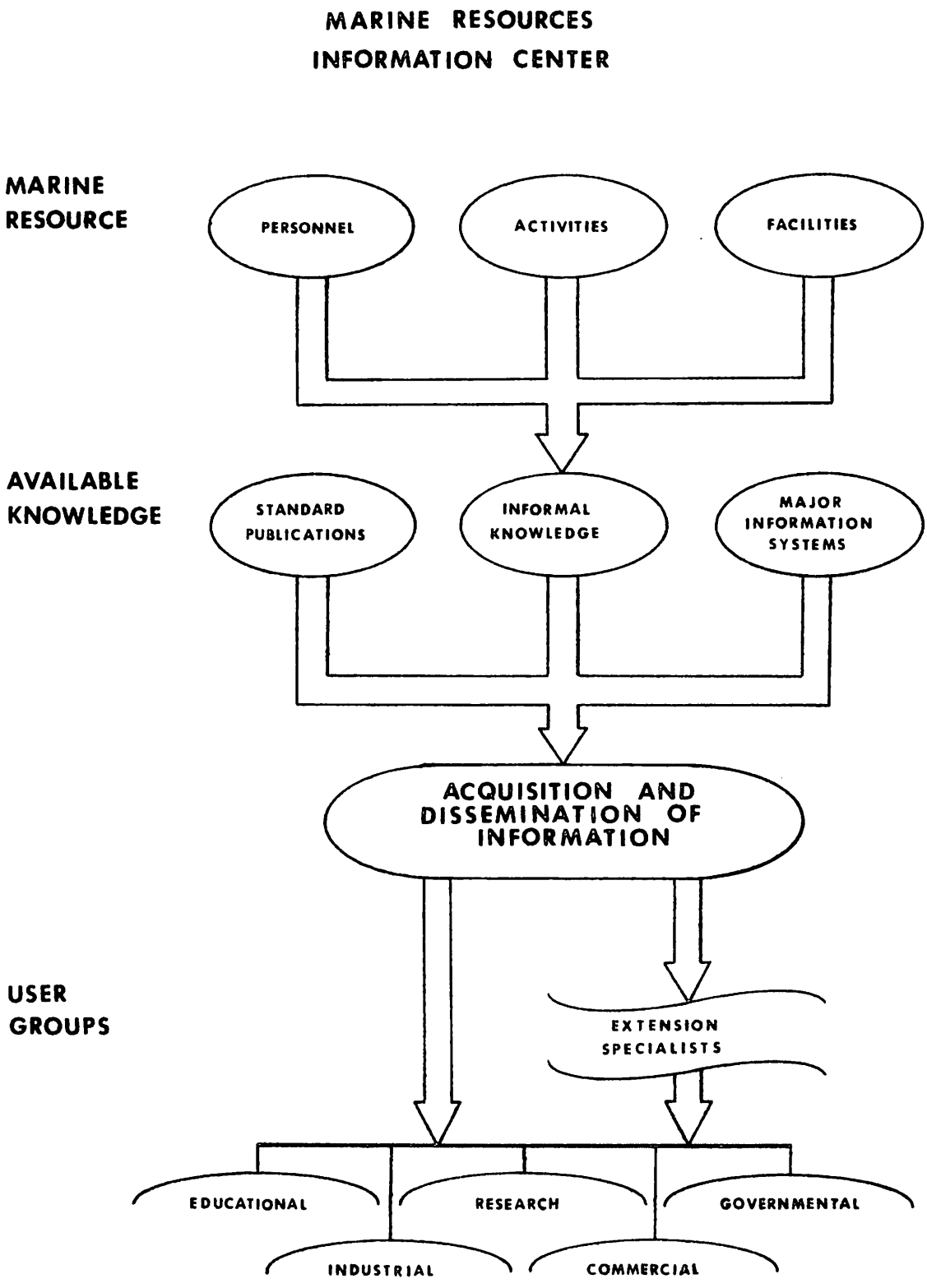

MARINE RESOURCES
INFORMATION CENTER
MARINE RESOURCE
PERSONNEL
ACTIVITIES
FACILITIES
AVAILABLE KNOWLEDGE
STANDARD PUBLICATIONS
INFORMAL KNOWLEDGE
MAJOR INFORMATION SYSTEMS
ACQUISITION AND DISSEMINATION OF INFORMATION
USER GROUPS
EXTENSION SPECIALISTS
EDUCATIONAL
RESEARCH
GOVERNMENTAL
INDUSTRIAL
COMMERCIAL

FIGURE 1

on 32 activities. Computer programs to process this data are currently in the developmental stage.

4. Technical Information Data Base: This data base consists of information in the form of microfiche cards. Two types of inputs are made to the system 1) material obtained from federal document reports and 2) material obtained and filmed locally. To date the collection includes 348 reports obtained from federal sources and 95 publications which were filmed in the local information laboratory.

Computer programs are currently available to provide various indexes for access to the microfiche files. One microfiche reader is currently available for use in the Marine Resources Information Center and one portable "Projector Type" reader is available on a loan basis. Several readers and a reader/printer are available in the Information Science Laboratory. Three additional readers will be purchased and made available within the next three months.

User Address Data Base: This file currently contains approximately 2000 names and addresses. Major modifications to the current program are in the final check-out phase. The new system will provide for 74 individual classifications of user groups and selection will be available on the basis of 35 categories which may be coded for each individual included in the listing.

General: This project was a co-sponsor to a conference titled "The Role of Micrographics in Modern Information Systems." This two day conference featured speakers of national prominence and the accent of the topics was on education of the uninitiated regarding the use of micrographic techniques. A total of 60 persons from across the country were in attendence.

Technical assistance was provided to Dr. Clare Gunn in the publication of a large bibliography on coastal zone activities. This assistance involved the conversion of data to machinable form and the processing of this data to obtain various indexes which provide user access to the entries contained in the bibliography.

Reports and Project Documentation

One technical report was prepared under this project. This is reported in Chapter 3, "Publications and Program Documentation."

Personnel Participation

Two professional staff members from Texas A&M University are involved in this project for a total of 7.25 man-months: E.B. Smith and G.H. Alani. Two graduate students also participated in this project for a total of 7.25 man-months.

4

SEA GRANT PROJECTS: PROGRESS REPORTS-- RESEARCH

Twenty projects were classified as Research Activities during the first year's Sea Grant work. Fifty-two professional staff members and 53 graduate students were involved in projects classified under seven broad categories: Fisheries and Marine Biology, Resource Management, Pollution, Coastal Engineering, Aquaculture, Seafood Technology, Water and Sediment Analyses, and Acoustics. Research projects accounted for approximately 57 percent of total program funds.

Fisheries and Marine Biology

Studies on the Labyrinthulae of Commercial Molluscs

A highly lethal disease of oysters was discovered in about 1949 and the parasite described in 1950 by Mackin, Owen and Collier. Mackin and Wray (1966) placed this parasite in the Labyrinthulales, a primitive fungal order. Andrews, using a diagnostic technique devised by Ray (1954) demonstrated that other bivalve molluscs carried the same or a similar parasite. Ray demonstrated that two of the molluscs parasitized by members of the group (genus Labyrinthomyxa) carried species which could not be the same as *L. marina*, and it was suspected that others were also different.

Mackin has recently demonstrated that the oyster itself has several species of parasites other than *L. marina* and that these may or may not be detectdd by Ray's diagnostic method. These new oyster parasites produced devastating destruction of oyster beds.

The present study is aimed at studying as many commercial molluscs of the Gulf of Mexico as possible to determine whether or not they harbor similar parasites, and if so, whether or not they are lethal parasites or harmless associates.

Accomplishments During 1968-69 Academic Year

To date the following molluscs of economic importance have been studied:

Name of host	Labyrinthomyxid parasites found	Pathogenicity	Remarks
Congeria leucophaeta	Yes	Not determined	Studies now in early stages
Tagelus gibbus	Yes	Pathogenic; probably highly destructive	Most of developmental stages worked out in culture
Thais haemostoma	Yes	Doubtful	This is apparently a commensal; work on development about completed
Crassostrea rhizophorae	Yes	Highly pathogenic	Work complete; cultures finished
Mercenaria mercenaria	No		Up to now no Labyrinthomyxids have been cultured from this host
Brachydontes recurvus	Yes	Not parasitic	At least one commensal species
Littorina ziczac	Yes	Doubtful	A commensal(?) in 100% of hosts
Donax variabilis	Yes	Probably parasitic but not highly pathogenic	Developmental cycle completed in culture

In order to clarify various developmental sequences, it was necessary to study some of the plant-associated species. These were found to be very common, some parasitic in the host plants, others appear to be saprophytes. We have cultured more species than have been described for the entire world. Three of these have been studied in great detail, and complete developmental cycles worked out for comparison with the molluscan types. We find some differences, but generally the plant associated species are very much like the molluscan

associated species. Most plant associated species are placed in the genus Labyrinthula, and those from molluscs are placed in Labyrinthomyxa.

It is of interest to note that since these studies began, a severe morality wave hit the Portuguese oyster, *C.angulata*. Arvy and Franc recently set up the new genus *Thanatostrea* to contain the parasite which they placed near the genus Labyrinthomyxa. It is possible that their genus may be accepted as containing the parasites discovered in this study, and it is possible that *Labyrinthomyxa marina* may be transferred to that genus. Arvy and Franc have not cultured the parasite.

Reports and Project Documentation

All reports, theses, and dissertations written under this project are reported in Chapter 3, "Publications and Program Documentation."

Personnel Participation

Dr. John G. Mackin has spent 6 man-months involvement in this project. He has been assisted by a photographic specialist for 4 man-months and by five graduate students for a total of 12.5 man-months.

Viral and Bacterial Diseases of Marine Species

This project includes research on the viral, bacterial, fungal and protozoan diseases of marine species. Emphasis is placed on spontaneous infectious diseases and the study of pathogenic microorganisms that cause disease in marine fish or may cause disease in man through consumption or contact with aquatic animals.

Accomplishments During 1968-69 Academic Year

Since September, 1968, when operational funds became available for the present project, the major accomplishments have been: (1) many U.S., as well as several foreign investigators interested in the field of marine microbiology and disease research have been contacted, (2) a repository of known available pathogenic bacteria and viruses has been initiated, (3) a comprehensive survey of the literature on diseases in marine animals has been made and will soon be organized for publication; a special section of the Veterinary Branch Library has been designated for a collection of literature on diseases of marine animals, (4) personal contact has been made with state and federal agencies and private groups to establish rapport and stimulate the exchange of information and materials and create in them an awareness of our interest in diseases of marine animals, (5) approximately 250 speciment have been examined culturally for certain pathogenic bacteria and several fish serum samples have been obtained for serologic studies, (6) studies on normal microflora of shrimp and crabs have been initiated to provide a baseline with which to compare diseased specimens, (7) a menhaden ichthyozootic was investigated and the causative agent (an unidentified bacterium) has been isolated and antiserum has been prepared for serologic studies. An undescribed disease of mullet was apparently transmitted to croakers by contact in a laboratory aquarium, a bacterial organism was isolated, and subjected to biochemical and serologic studies, (8) tissues from crabs and shad have been cultivated and cell types studied, (9) a repository of tissues from various poikilothermic (marine and fresh water) animals has been initiated, and (10) a

technician has been sent to an authoritative cell culture laboratory for intensive specialized training in culturing cell lines from poikilothermic animals.

Reports and Project Documentation

None.

Personnel Participation

Six professional staff members were involved in this project for a total of 24 man-months: Dr. L. C. Grumbles, Dr. A.I. Flowers, Dr. J. E. Grimes, Dr. D.H. Lewis, Dr. Stewart McConnel, and Mr. Milton D. Shult. Three technicians were also involved for a total of 27 man-months.

Pesticide Residues in Gulf Coast Fish

Texas A&M University has initiated efforts towards the development of the ocean for food production through the Sea Grant Program. The toxicology section of the Department of Veterinary Physiology and Pharmacology is contributing to the overall program by a study in pesticide residues in Gulf Coast fish. The initial objectives of the study are:

1). To investigate brain acetylcholinesterase levels of marine fish of the Gulf Coast waters.

2). To determine organophosphorus pesticide pollution by measuring the degree of inhibition of fish brain acetylcholinesterase.

3). To evaluate the potential public health hazard as a result of pesticide levels in marine fish and the esthetic aspects of public consumption of fish that may be affected by acetylcholinesterase inhibition.

Accomplishments During 1968-69 Academic Year

During the period ending August 31, 1969, procedures have been developed for the determination of brain acetylcholinesterase activity of Gulf Coast fish. Brains are removed from frozen fish that are collected in Gulf Coast waters and acetylcholinesterase activity is determined colorimetrically. The initial results of this investigation are:

1). Brain acetylcholinesterase levels have been determined on three hundred and sixty samples collected during May, June, and July of 1969. These samples were composed of eight species of Gulf Coast Fish collected from four locations.

2). Preliminary data indicates that brain acetylcholinesterase activity decreases as the brain size increases.

3). A sample of mullet collected on 6/25 in Aransas Bay shows a uniform inhibition of brain acetylcholinesterase activity below that of a prior sample taken at Rockport, Texas, on 5/27. Additional data will be required to determine the significance of this inhibition.

4). Brain acetylcholinesterase activity at a given brain weight is variable between different species of fish. Of these samples

angel fish and pinfish showed greater activity than others.

Reports and Project Documentation

Publication of results is expected at a later date.

Personnel Participation

D. O. Wiersig and J. D. McCrady were involved a total of 1.5 man-months in this project. Two students were also involved a total of 3.5 man-months.

Occurrence and Significance of Parasites in Commercial Ocean Food Fish

Much of the damage to fish due to parasites appears to be mechanical. Parasites may injure tissues and blood vessels by their burrowing or obstruct blood vessels entirely with their bodies or their eggs. Some actually ingest tissues, blood or body fluids. Some parasites are known to release toxic materials. Therefore, infections with parasites may contribute to mortality of fish directly by mechanical injury and indirectly by traumatic stresses that lower host resistance to environmental factors. Parasites reduce the value of fish as human food by producing pathologic conditions or by esthetic reasons.

There are a variety of agents found in fish and other food products taken from natural waters that may induce illness in the consumer. Fish and seafoods are known to be hosts of several parasitic diseases which involve man. The present scattered reports which incriminate fish as reservoirs or potential reservoirs of infections of man and domestic animals are sufficient justification, therefore, for giving far greater attention to this group of animals in the future.

The objectives of this study are:

1. To determine the extent, seasonal occurrence, geographical location and identification of parasites of commercial food fish.

2. To evaluate the effect of the parasite on the fish as it affects the fish for human food.

3. To study the relationship of the parasites of commercial food fish to mammals and birds.

Accomplishments During 1968-69 Academic Year

During the months of October and December in 1968 and during February, March and May of this year, 71 marine food fishes for complete parasitologic examination were obtained from the Texas Parks and Wildlife Department, Rockport, Texas, and the Houston Power Plant, Bacliff, Texas. The fishes (croaker, trout, flounder and mullet) were collected along the Gulf coast of Texas in Galveston Bay, Copano Bay, Aransas Bay, Mission Bay and Mesquite Bay.

During June, July and August, 332 fishes (croaker, trout, flounder, mullet, catfish, perch and whiting) for complete parasitologic examinations were collected along the Texas Gulf coast in the areas of Rockport, Freeport and Galveston.

The parasites which were recovered from different body organs have been prepared for identification. The techniques used to prepare the helminths and copepods for identification involved: (1) fixation and preservation of the parasites in a 10 percent formalin solution; (2) mounting of the menatodes in a lactophenol clearing solution; and (3) staining of the cestodes, trematodes and copepods in a carmine stain. Histopathologic sections were made of the parasitized tissues to determine the host-parasite relations. Organs and tissues most commonly infected with parasites were the alimentary canal, liver, body muscle, gills, mesentery and peritoneum. All preparations are presently being studied.

Personnel Participation

Dr. F. C. Faries, Jr. was involved in this project for a total of 2.4 man-months. He was assisted by five technical assistants for a total involvement of 3.65 man-months.

Resource Management

Marine Resources Activities in Texas

The survey was made to identify the organizations in Texas participating in marine related activities. In addition, an attempt was made to determine the nature of specific projects and programs being conducted by such organizations including annual expenditures. Organizations interviewed for information included port districts, educational institutions, research institutes and Federal and State departments and agencies. Findings from the survey are designed to bring into focus answers to the following questions:

1. What organizations are participating in marine activities in Texas?

2. What projects and programs are these marine-oriented organizations pursuing?

3. How much money are these organizations expending annually on marine related activities?

Obtaining answers to the above questions should provide an approximate index of the level of marine related activities in Texas. Similar research in future studies should provide a basis for comparative analyses with the initial study.

Accomplishments During 1968-69 Academic Year

For the period of time ending August 31, 1969, the report, "Marine Resources Activities in Texas," was prepared and submitted to the Sea Grant Office of Texas A&M University.

Gathering information for the project included extensive library research to obtain pertinent data from published documents and other sources; personal interviews with port administrators, college and university officials, research institutes and Federal and State departments and agencies. Interviews were conducted with electrical power companies and industrial firms in the study area.

A marine activities questionnaire was sent to 30 educational institutions in Texas to determine the level of marine related activity at each school.

Correspondence was directed to 20 Chambers of Commerce located in the Texas Gulf Coast area to obtain the names, activities and services being provided by individual firms participating in the marine environment.

Two staff members of the Industrial Economics Research Division participated in the first Texas Marine Resources and the Sea Grant Program conference held at Texas A&M University January 16-17, 1969.

1. Although many organizations in Texas are involved in marine affairs, there is no State of Texas department or agency responsible for the coordination and development of marine related activities.

2. Agencies and individuals contacted during the course of the study exhibited a high level of interest in the survey. Consensus was that such a study was needed and would be of great value to many organizations.

3. Organizations currently participating in the marine environment in Texas were identified including specific projects, programs and level of annual expenditures.

4. Findings of the original study are bench marks for comparative analyses when similar studies are conducted in the future.

Distribution of copies of the study is being made to those organizations and individuals participating in the study. copies of the study are available for distribution to other persons and organizations expressing an interest in the study.

Reports and Project Documentation

The study effort produced by this project is reported in Chapter 3 "Publications and Program Documentation."

Personnel Participation

Six professional staff members were involved a total of 13 man-months: Perry J. Shepard, Worth M. Blake, John Miloy, James R. Bradley, John Edd Tucker, and Nancy Sullivan. One student was involved for 1.5 man-months.

Estuarine Technology--An Annotated Bibliography of Resource Use of the Texas Gulf Coast

Early in the formation of the Gulf Coast Study Committee of the Texas Interagency Natural Resources Council there was recognition of the need for understanding the resource base of this important region. In December of 1968, this Committee requested a proposal from Texas A&M University (Sea Grant) for a comprehensive study that would investigate the region and make recommendation for its development. Members of the Recreation and Parks Department responded with a formal proposal utilizing a multidisciplinary approach for planned and coordinated resource use.

A first step of this proposal was to identify the current and past studies that pertain to resource use. This led to an agreement to prepare an annotated bibliography of all available materials.

The study objective was to search, locate, review, prepare annotation and classify all current (1969) and past studies (1950 through August, 1969) that pertain to resource use of the Texas Gulf Coast. The scope was kept very broad in order to allow as much useful material to enter the study as possible. The intent was to organize this material so as to be of greatest help to those who may be interested in either general or specific topics. The region stretched from Louisiana to Mexico, inland about 75 miles and into the Gulf about ten miles, and included all the bays and estuaries.

Accomplishments During 1968-69 Academic Year

Bibliographical search is a lesson in serendipity. Although a logical approach may be taken, at no time is there assurance of success in obtaining results. One is never sure of what publication he is seeking until after he has found it. The following steps were taken, believing that they included as broad a coverage as would yield results and within the time and money limits.

1. Identification of Sources. In an effort to identify existing studies, the first step was to contact those agencies, organizations, and persons most likely to have such material. Therefore, from lists, such as *Research Facilities in Texas*, form letter requests were mailed

to over 400 sources. Library listings, such as the Library of Congress monthly research titles, were reviewed. Bibliographies, such as *Galveston Bay Area Bibliography*, were reviewed for listings. The federal agencies, such as the Water Pollution Control Administration, were contacted to obtain their lists of recent bibliographical materials. All pertinent state agencies, such as highway, parks and wildlife, and health, were contacted for lists. These efforts were supplemented by actual visitation to the offices and libraries of many states agencies located in Austin as well as at many locations along the coast from Brownsville to Beaumont. Library referral and retrieval systems, such as the Science Information Exchange and the Wildlife section of the Denver Public Library were utilized.

2. Identification of Studies. The returns from these contacts varied greatly. Industry, for example, reported little because their studies are proprietary and not published for the public. The yield from universities was not as great as was anticipated. Other sources not only had prepared bibliographies but also had libraries that were well catalogued. Of several thousand studies searched, over 2,300 were identified as applicable to this project.

3. Review of Studies. In order to obtain annotation material it was necessary to retrieve the actual publication; a bibliographical entry was not sufficient. Each study was scanned, noting especially the objectives and important results. This was one of the more time-consuming aspects of the project.

4. Preparation of Annotation. There was no substitute for making longhand notes of the entire entry and the annotation inasmuch as the vast majority of the work was done in the field. There were prepared on special forms created for this task. These indicated the data needed in order to be as consistent as possible. Items included were: type of publication, author, title source, date, annotation, types of resource dependency, location by city and county, and federal estuary register number.

5. Classification of Entries. Well into the process of collecting the data, it was discovered that a computer program was being used by Sea Grant for identifying and microfilming materials. Considerable discussion finally produced a system of classification that would yield

several characteristics of the entries, making it useable for many approached desired by state agencies. Each entry was coded as follows: river basin, planning region, land use, author and sequence.

6. Preparation of Publication. A preliminary computer printout containing the following sections has been prepared: Annotated Bibliography List, arranged by code number; Author List, arranged alphabetically; Key Title Word List, arranged alphabetically; Resource List; City-County List; SC Estuarine Register List. It is now planned to prepare a published document, using computer printout material reduced so that the bulk of the publication will not be prohibitive.

Throughout this research, there was fine rapport established with many persons, institutions and organizations throughout Texas and particularly along the Gulf Coast. The personal interviews indicated that there was a serious concern over the future of the coast and that there was a real need for better methods of approach. It was evident, however, that problems identified by some are assets for others. The material revealed in this search should be of profound value to those who are intent upon making an objective analysis of the regions.

While the nature of this study was not such that many graduate students were involved, it was a part of the education effort of several persons now pursuing their graduate work at A&M.

The great advantage of placing the entries on data processing cards is the expansibility of the effort. As new items are located in the future, new entries can be added to the system at any time. At any future date, these can be run on the computer, producing an up-to-date list for any purpose.

Reports and Project Documentation

None other than Bibliography.

Personnel Participation

Five professional staff members combined their efforts for a total of 6.0 man-months in this project: Dr. Clare A. Gunn, Dr. Carlton S. Van Doren, Jack Jones, Carson Watt, and Eugene Smith. Two students were involved for 3.0 man-months.

Optimal Investment, Operations, and Inventory Controls for the Representative Competitive Firm in a Fishery Complex

In the proposed research, the first objective was to develop a dynamic economic model involving production, investment and inventory facets for the representative shrimp producer; the second objective was to derive the decision rules for optimal production, investment, and inventory control; and the remaining objectives were to estimate the functions in the model and to compute solutions to the problem. The proposed procedure was to formulate the problem in an optimal control setting, and to use the appropriate mathematical methods to describe the optimal control and stock variables. This set of results was then to be interpreted to obtain the qualitative character of the decision-making. Also, so that the model would be operational, efforts were to be made to develop appropriate algorithms and computer programs. In addition, estimates of the functions were to be made, and solutions for a representative shrimp producer were to be computed.

Accomplishments During 1968-69 Academic Year

In this research, an initial effort was made to review the related biological and economic research. This involved a study of the two different biological approaches to describing the dynamics of the fishery as developed by Beverton and Holt, on the one hand, and by Schaefer, on the other. It also involved a study of the economic theory for a fishery (incorporating, both economic and biological factors) as developed by analysts such as Crutchfield and Zellner.

Also, to become familiar with the shrimping industry in the Gulf Coast, we visited five of the large processors in the Brownsville-Harlingen area, the Executive Secretary of the Texas Shrimp Industry, one processor at Port Lavaca, one shrimp producer at Galveston, two large shrimp producers at Port Lavaca, and the U.S. Department of Interior Bureau of Commercial Fisheries Laboratory at Galveston. In addition, working relationships were established with a fairly large number of the Bureau's economic and statistical staff in Washington, D.C.; they have responded by providing us with up-to-date copies of all data available and possible helpful publications. Furthermore, rapport

has been developed with a sizeable number of leading fishery analysts across the United States.

With the conceptual and practical backdrop, the research program evolved as a three-stage effort. In the first stage, because of previous economic and biological work, a dynamic production-investment model for the sole ownership fishery (taking into account all cash flows and values thereof) was developed. In this effort, the biological differential equation developed by Schaefer was adjoined to the production-investment model analyzed by Thompson and George. In the model, the firm's objective is to maximize, subject to constraints, the discounted value of the savings from fishing operations over a fixed decision-making interval, plus the ending value of the fishing capacity. Savings at each instant of time equal the profits from fishing (taking into account the lay system) less the value of the investment in new fishing capacity and interest charges. The state variables are the fish biomass in the population, fishing capacity owned by the firm and the firm's net debt (indebtedness when positive and savings when negative). The control variables are the amount of the available fishing capacity that is used, and investments in new fishing capacity. The control parameters are the values of the three state variables at the end of the decision-making interval. The constraints consist of three differential equations, and two sets of inequalities. The differential equations describe the temporal rates of change in fish biomass, fishing capacity, and net debt. Both control variables are restricted to be non-negative and bounded from above.

Using results in control theory, the optimal controls for fishing effort use and investments in new capacity are being characterized. That is, a complete description of the decision rules for the optimal controls, which determine the ideal exploitation of the fish population , ownership of fishing capacity, and financial structure, is being completed. Following this characterization, an algorithm by which the controls may be computed will be developed. The problem has also been formulated and analyzed in an alternative way as a discrete-time optimal control problem. In addition, the special case of a competitively organized fishery is considered. It is shown how the undesirable

characteristics of the resulting equilibrium may be overcome by the imposition of a certain tax. The practicality of this policy possibility is discussed in light of the fact that solutions to the problem may be computed.

In the second stage, since the first one reflected the Schaefer biological model, a discrete-time optimal control model reflecting the Beverton-Holt biological approach was developed. In this model, the firm's objective is to maximize, subject to constraints, the savings from fishing operations plus the value of the final capacity. Savings in each year equal profits from fishing (taking into account the lay system) plus interest earnings less investments in new capacity, interest charges and taxes. (Each year is partitioned into subperiods representing the time per fishing trip.) In each year, profits equal revenues less all fishing costs. Per trip revenues equal the price per pound times the pounds of catch; the catch equals the number of fish caught time the weight per fish, where the latter may be obtained by use of the vonBertalanffy equation; fish caught involves fishing effort and the number of fish in the population. (Fishing effort is measured in screening ability--cubic feet of water screened per trip.)

The state variables are the number of fish in the population in period i of year t, the firm's indebtedness, and the firm's savings. The control parameters, which are the fundamental variables in the model, are initial fishing capacity, initial indebtedness and initial savings.

Initially, the firm cannot borrow more than a fraction of the value of its initial capacity. The remaining part of the investment must be paid for out of its original endowment.

In each year, the initial number of fish in the population is specified as given; thereafter, in the year, the population size decreases because of the catch and natural mortality.

Real estate and income taxes are taken into account. Income taxes are a fraction of annual fishing profits plus interest earnings less interest payments and depreciation. Depreciation is calculated on a straight-line basis. (The lay system is again taken into account.)

In analyzing this model, it was observed that the model was linear if only one average trip was visualized. The first possibility was regarded as a meaningful application for those shrimpers limiting their operations to the Texas Coast, and the second one was believed to reflect those operators fishing off the Texas Coast in one part of the year and fishing off some of the Latin American coasts in another part of the year. Since the first possibility is typical of more shrimpers than the second, and since linear programming methods are well-developed and understood, a one fishing trip model is presently being programmed for solutions. This has involved transforming the respective control model into a programming framework, the estimation of the respective parameters, and the development of an operational computer program. We have this work well-underway and are presently planning to have a set of solutions by mid-fall.

In both stages of the efforts described above, the models involve the projection of the fish catch per trip as a known input. This shortcoming does not allow for the effects of the randomness in the fish catch upon the determination of the optimal controls. To make the work more realistic, the third stage effort, which is now well-underway and is conceptually much more difficult than the first two stages, does allow for this possibility. Three levels of fish catch are visualized--high, normal, and small. Specific probabilities based upon historical observations are than attached to these levels. In the model, the firm's objective is to maximize, subject to constraints, the expected net worth of the firm over a finite discrete time period. The net worth represents the final value of the firm's fishing capacity plus interest earnings less operating, interest, and investment costs (in an expected value sense). The interest rate on savings is visualized as being considerably smaller than the interest rate on debt. The state variables are fishing capacity and net debt (savings when positive and indebtedness when negative); the control variable is investments in new fishing capacity. Investments are specified to be non-negative and less than an operational upper-bound.

In sequential decision-making, the optimal values for the control variables in period i need to be made dependent upon the actual values of the random variables observed up to period i. That is, in determining

the controls, we would not want to ignore the information coming forth as the values of the random variables are observed. This means that the controls in period i will not be simply a number, but a function of the state variables resulting from the previous actions and the values observed for the random variables.

Mathematically, this is a synthesis problem where the optimal controls are expressed as functions of the states. It can be solved computationally by the methods of dynamic programming provided the number of states and controls are less than four.

In this research, the problem has been formulated and analyzed for the three period problem--three years in the case of shrimp--described above. This involved the derivation of the recursive relationship from year three to year two to year one, and the mathematical determination of the optimal investment in fishing capacity in each period. The complete structure of all of the decision-making facets, which turn out to be relatively complex, has been delineated. This will provide a qualitative description of the economic problem faced by the shrimp producer in this type of situation. The model may be immediately adapted to any decision-making horizon (such as five or ten years). In the near future, this model will be programmed for application; and solutions to a number of meaningful problems will be computed.

Reports and Project Documentation

Reports are reported in Chapter 3, "Publications and Program Documentation."

Personnel Participation

Three professional staff members were involved a total of 12 man-months: R.G. Thompson, W.A. Brock, and R.B. Ekelund. Seven students were also involved a total of 35 man-months.

Pollution

Biological Response to Organic Chemicals in Estuaries

Many land based industries treat their wastes in a fresh water environment but discharge their effluent into water which has a cyclic variation in salinity, e.g., in the Houston area, Beaumont-Port Arthur area and Corpus Christi area. In many cases, effluent standards can be satisfied for those wastes which exert a significant BOD_5 (5 day Biochemical Oxygen Demand). For other organic wastes e.g. polymers which are classified as hard, refractory or "non-biodegradable", the residence time in the treatment unit is not sufficient to bring about complete removal. In such cases, the so-called hard organic carries over into the estuary environment and provides a food source for the biomass residing in the estuary. This type of organic material does not exert a BOD_5 but may exert a considerable COD (Chemical Oxygen Demand). In such cases, effluent standards may have to be altered to reflect discharge of organics which are not detected by conventional means. Regardless of whether additional effluent standards are imposed on industry, knowledge of the behavior of such compounds in both fresh water and saline water systems is necessary. This project will provide some guidelines by studying the fate of typical monomers i.e. ketones from polymeric organic wastes which are now being discharged into estuaries.

Accomplishments During 1968-69 Academic Year

Two reports have been submitted to the Texas A&M Sea Grant office describing the work on this project. These reports were submitted on June 23, 1969 and September 19, 1969. This work is summarized below.

During this past year, a heterogeneous microbial culture was acclimated to acetone, 1-butane and 2-pentanone, and maintained in a steady state condition in a batch reactor. A preliminary test was performed on this culture (labeled as culture "A") to determine its general microbial behavior and to test and correlate the results of the instruments involved in the analysis.

Culture "B" was obtained by acclimating a portion of culture "A" to a salinity of 5000 mg/l by increasing the reactor salinity by

500 mg/l daily. Acclimitization to higher salinities of 10000, 20000, and 35000 mg/l is now in progress.

The test series for "A" for microbial behavior were run to determine the effect of various salinity conditions on the metabolic behavior of a culture originally established in a fresh water media. A second series (Series B) of tests were run to determine the effect of higher and lower salinity conditions on the behavior of a culture originally acclimated to 5000 mg/l salinity.

Series "A" and "B" tests were run using batch reactors containing identical amounts of ketones and essential nutrients. The factor which varied was the salinity level of the media. Mixing and aeration were accomplished by using the environmental incubator shaker. Samples from each reactor were removed periodically and tested for:

1. Oxygen uptake rate using the Gilson Oxygraph
2. Rate and sequence of removal of substrate components using a hydrogen flame gas-liquid chromatograph
3. Total soluble organic carbon using Beckman Total Carbon Analyzer
4. Cell mass increase using Millipore Filter technique
5. pH using Beckman pH meter.

From the results of series "A" tests it could be concluded that:

1. The oxygen uptake rate, cell mass increase, and dissolved organic carbon removal rate for a culture established in fresh water (culture "A") were not affected significantly by salinity shocks of up to 10000 mg/l.
2. Salinity shock of 10000 mg/l reduced the oxygen uptake rate, cell mass increase and total dissolved carbon removal rate of culture "A" significantly.
3. Salinity shock of 35000 mg/l seriously reduced the oxygen uptake rate, cell mass increase, and total dissolved organic carbon removal rate of culture "A".

Series "B" tests results indicated the following:

1. The oxygen uptake of culture "B" was not noticeably affected when shocked by fresh water shock or 10000 mg/l salinity, while 20000 mg/l salinity shock did affect the oxygen uptake rate.
2. Cell mass increase of culture "A" was not significantly affected by fresh water shock while it is affected significantly

by shocks of 10000 and 20000 mg/l. The cell mass increase was altered drastically when a salinity of 35000 mg/l was applied.

3. Substrate rate of removal of culture "B" was not affected by the fresh water shock, while it decreased significantly when 1000 mg/l salinity was applied. The decrease was more obvious for 20000 mg/l salinity. 35000 mg/l salinity shock impaired the capacity of the culture to remove the substrate.

In both series of tests, "A" and "B", it was noticed that 2-butanone and 2-pentanone were removed first. The acetone removal started when the other two ketone concentrations reached low levels (approximately 5 mg/l).

The data from all test series indicate that the environmental incubator shake (purchased under this project) provided the best reactor system for aeration and mixing. Controlled constant temperature, uniform aeration, shaking and minimum stripping are the primary features provided by this piece of equipment.

Results of the gas liquid chromatograph and total carbon analyzer were correlated and found to be in good agreement.

Reports and Project Documentation

A presentation by Dr. Davis is reported in Chapter 3, "Publications and Program Documentation."

Personnel Participation

Dr. William B. Davis was involved for 1 man-month and was assisted by a student for the same length of time.

Bottom Sludge Accumulation and Oxygen Demand in a Polluted Estuary

Two major components in the analysis of the water quality in an estuary are the pollutant removal rate by sedimentation and the resultant oxygen demand of the bottom deposits. This project involves a study of the solids balance and the oxygen balance of an arm of the Houston Ship Channel to develop methodology for evaluating these parameters.

A study will be made of each of the components of the mass balances and a computer model constructed to duplicate the process taking place. A major field effort will be carried out as a part of the studies to evaluate the mass balance components and to demonstrate the validity and usefulness of the techniques.

Accomplishments During 1968-69 Academic Year

This project is one of two being carried out by the Estuarine Systems Project Research group within the Environmental Engineering Division of the Civil Engineering Department at Texas A&M University. The second project entitled "Management of Industrial Waste Discharges in Complex Estuarine Systems" is a joint Federal Water Pollution Control Administration--Texas A&M University effort. The two projects are managed together under the direction of Dr. Roy W. Hann, Jr.

The two projects are highly interrelated in that they share facilities, equipment and personnel. Those activities dealing with the evaluation of mass balance components and sedimentation rates are considered to be primarily sea grant project efforts along with the other specific activities spelled out in the sea grant proposal. Specific project accomplishments are documented in a series of Estuarine Systems Project Technical Reports with credit being given to both funded projects. A total staff ranging from 15-18 persons are associated with the Estuarine Systems Project.

The project technical activities carried out during the first project year may be divided into eight groups. Each is described in outline form below.

1. Equipment Specification and Design

Major project equipment including the Water Quality Monitoring System and the Tide Measuring System was specified, bids received,

orders placed and equipment received during the first project year.

Equipment acquisition was coordinated with the FWPCA project and FWPCA instrumentation personnel to assure maximum compatibility for training and maintenance purposes. The Automated Environmental Systems Water Quality Monitoring System which will be the heart of the benthal respirometer system has been received and is performing even better than expected. The Baylor Tide Measuring System has also been received and is undergoing calibration.

A large number of minor supplies and equipment which will support this project were specified and ordered. Funding was from both project funds and other funding sources.

An anaerobic digestion system was constructed and work was initiated on the current dependent integrated water quality sampler.

2. Facility Development

During the project year the field facility utilized by the estuarine systems projects was moved to higher ground and substantially enlarged and the 56' *R/V Excellence* was received and modified for project use. The field facility now consists of a 10 x 40 foot custom built laboratory trailer, a 10 x 26 foot auxiliary lab, a 10 x 20 foot field office and an 18' support trailer. The *R/V Excellence* has two cabins equipped for wet chemistry analysis and another cabin equipped for electronic instrumentation.

3. Literature Review

An extensive review of pertinent literature was made on our own campus and in the research library of the Corps of Engineers Waterways Experiment Station in Vicksburg, Mississippi. Pertinent articles were xeroxed and accumulated into a project library.

4. Laboratory Methodology

The bottom sludges found in the Houston Ship Channel and Barbours Cut differ considerably from the domestic and industrial waste sludges found in rivers. As a result acceptable procedures for collecting, storing, dividing and analyzing were not available and were thus developed by the project staff. The methodology was submitted to the

Galveston Bay Study staff and the FWPCA regional laboratory for suggestion and approval prior to use. Such tests as BOD, COD, total and volatile solids, hexane extraction and oxygen uptake are now being utilized. Nitrogen and phosphorous methodology is under development.

5. Barbours Cut Sampling

An initial field sampling program in Barbours Cut was initiated as part of the Estuarine Systems Projects routine sampling program. This program will provide background trend data when more extensive short term programs are established.

6. Anaerobic Digestion

An anaerobic digestion study was initiated to determine the anaerobic decay rate of the bottom deposits. It was found that at many points in the channel little or no decay takes place. Since it is known that the material in the deposits is biodegradable when diluted and exposed to nutrients and seed cultures in the BOD test it is believed that the bottom deposits are either nutrient deficient or have toxic constituents.

7. Sludge Profile

A sludge profile was made for the entire ship channel at two mile increments. The concentrations of organic material generally paralleled industrial and domestic waste discharge magnitudes. Over 1% of the sludge in the upper channel is hexane soluble indicating a very high oil content.

8. Deposition Rates

A detailed study has been initiated to utilize samples before and after dredging and 10 years of Corps of Engineers dredging project soundings to evaluate settling rates in different channel areas. Initial results show deposition rates as high as 4 feet per year in the lower channel and 2 feet per year in the upper areas. These values in connection with the organic concentrations will permit evaluation of the net loss of organic material to the bottom.

Project Coordination

The Estuarine Systems Projects are closely coordinated with other

organizations working with the Galveston Bay System. This cooperation works both ways with substantial input coming into the project from these groups and with a substantial contribution being made to their programs by our effort.

The specific coordination which has provided major input to our program are as follows:

1. A joint FWPCA-TAMU project to evaluate reoxygenation using tracer materials used in Barbours Cut as one test area.
2. Data has been received from:
   A. FWPCA
   B. Corps of Engineers
   C. Texas Water Quality Board
   D. USGS
   E. Weather Bureau
3. FWPCA labs have run heavy metal and pesticide determinations on our samples.
4. Methodology reviews and program assistance has been provided by FWPCA.

Our project effort has benefitted the following groups:

1. Other Texas A&M University Projects have been benefitted by the collection of samples by our field personnel and by transporting other project personnel on sampling runs.
2. Other Universities including Rice University, Prairie View A&M, and the University of Texas have had samples collected and have had faculty research workers, and students utilize our facilities for training and research.
3. Our field sampling program has collected all samples in the Houston Ship Channel above Morgan's Point for all agencies and Universities thus making any duplication of effort unnecessary. This has included carrying out 38 of the sampling programs for the TWQB Galveston Bay Study.
4. Special sampling runs have been made for the Corps of Engineers, TWQB and FWCPA both in the channel and in the Bay.

Educational Activities

During the year a large number of students benefitted from the project effort. This number included Texas A&M and Rice University

personnel, as well as employees of the Bureau of Reclamation. A summary of the student exposure to the project activities is as follows:

1. Forty-three employees of the Bureau of Reclamation attended a Water Quality Short Course utilizing project information and participated in a field trip to the field laboratory and a training cruise on the *R/V Excellence*.
2. Ten students from Rice University accompanied the field group on a sampling run up the Houston Ship Channel.
3. Sixty percent of the graduate students in the Environmental Engineering Division at Texas A&M University have participated in the sampling activities on the Houston Ship Channel.
4. Several University Instructors carried classes to Morgan's Point for sampling runs. The list includes Dr. Warren Trock of the Agricultural Economics Department, Dr. Tom Reynolds and Dr. Roy Hann, Jr. of the Civil Engineering Department.
5. Two graduate students, David Parmer and Sam Hutton, selected thesis topics from the project study and consequently conducted research in these areas during the year.

Reports and Project Documentation

The technical reports prepared under this project and participation in meetings are reported in Chapter 3, "Publications and Program Documentation."

Personnel Participation

Four professional staff members participated in this project a total of 11.5 man-months: Roy W. Hann, Jr., Richard Smith, Gene Gonsoulin, and Gary Smith. Two students were involved for 12 man-months.

Application of Bioengineering: Growth Characteristics of Marine Microorganisms

Data are to be obtained to predict economically optimal conditions for microbial production of protein and an enzyme system. Marine species to be examined are *Dunaliella* peircei and *Aeromonas* proteolytica. Toxin production by *Gymnodinium* breve is also to be examined for possible control in the natural habitat. The propagation facility and current theory for dynamics of microbial populations are general for microorganisms that can be grown in liquid suspension. Data from the facility will determine the capability of the theory to predict simultaneous values for (1) rate of growth of a microbial population; (2) production rates of endocellular components and of extracellular metabolites; and (3) assimilation rates of abiotic chemical species. Marine species of several genera are to be screened for probable biochemical production and waste disposal processes. The general predictive capability suggests that each such process can be economically optimized from data of the propagation facility. There, feasibility of each new process may be evaluated in the facility.

Accomplishments During 1968-69 Academic Year

Since the receipt of the initial NSF Grant (October 28, 1968), the analytical capability for protein, carbohydrate, urea, nitrogen and carbon analyses of biological materials has been developed for this project in the Chemical Engineering Laboratory. Methods of analyses for chlorophyll a, b, and c are being examined to select those most suitable to the project. Analytical methods for determining nucleotide content of biological materials as well as methods for determining activity of proteolytic enzymes are being developed in conjunction with Dr. Prescott, Department of Biochemistry and Biophysics.

Since the initiation of this project several marine species of microorganisms have been received and are being maintained in the culture collection. These include *Dunaliella* peircei, *Aeromonas* proteolytica, and *Gymnodinium* breve. In addition, stock cultures of *Chlorella* sp. C37-2 have been requested from the culture collection of the Biochemical Engineering Group at the University of Minnesota.

The propagation facility itself is under construction in the Olin E. Teague building. Growth of the above species is to be examined in

the facility by December 1969. Completion of auxiliary apparatus for propagator control is planned for March 1970; this will permit extensions of the kinetic and mass transfer studies so as to satisfy both the Research Council and NSF proposals for FY 1968 and FY 1969.

Computer programs for calculating design parameters from experimental data have been written and tested. These permit prediction of growth rates, metabolite production rates, and assimilation rates in terms of an initial state and environmental factors that can be controlled. Conditions may thus be calculated that are optimal (or minimal) for biomaterial or biochemical production or for disposal of an abiotic component. The calculated conditions can then be used to design a propagator to achieve the optimal result.

Reports and Project Documentation

Several papers were presented in connection with this project. These are reported in Chapter 3, "Publications and Program Documentation."

Personnel Participation

Dr. D. T. Hanson has spent 3 man-months involvement in this project. He was assisted by three students whose total involvement has been 4.5 man-months.

Effect of Surface Roughness on the Wave Forces on a Cylindrical Pile

The design of pile supported structures for the marine environment is of critical importance in the economical development of marine resources. The forces acting on a pile will generally increase as the surface roughness increases (due to the growth of marine organisms, natural roughness of the pile, etc.). The largest and most significant forces acting on a pile are those unsteady drag and inertia forces caused by surface waves. Indications are that steady flow drag forces alone can more than double with an increase in surface roughness over the range of roughnesses to be expected in the sea. Thus, unsteady drag forces as well as inertial and lateral forces should show a significant increase in magnitude as well as fluctuations in frequency for the range of roughnesses and wave conditions expected. At present, no information is available on the magnitude or variation of these forces.

The objectives of the first project year are (1) to perform a thorough literature survey of the problem of the effects of surface roughness on wave forces on piles, (2) to design, construct, install and calibrate a dynamically calibrated smooth model pile in the two-dimensional wave tank and (3) to begin a test program in which wave caused forces and moments are measured for a range of wave conditions and pile surface roughnesses.

Accomplishments During 1968-69 Academic Year

A literature survey of pertinent aspects of the general problem of wave forces on piles, the effects of surface roughness on steady and unsteady flow past circular cylinders, and design considerations for a dynamically calibrated model pile has been conducted.

Because of shortcomings in the standard Morison approach which assumes that the forces consists of two parts (a steady drag force caused by particle velocity and an inertia force caused by particle local acceleration) that can be added linearly, and the inability of present wave theories to adequately define particle velocities and accelerations as needed in the Morison approach, other methods to analyze the wave force and moment will also be used. It has been

recommended that wave forces on piles be analyzed by using dimensionless parameters derived from dimensional analysis. This will be attempted using an additional parameter of dimensionless roughness (surface roughness divided by pile diameter.) Also, the force and moment data for a range of wave and surface roughness conditions will be related to Iverson's Modulus which attempts to combine drag and inertia effects.

A 3.74 inch diameter, 36 inch long aluminum model pile and support frame have been designed, constructed and installed in the two-dimensional wave tank located in the Hydromechnics Laboratory. The pile and related electronic equipment were designed to provide instantaneous and continuous printouts of force, moment (and thus force location), and water surface time-history (for a record of wave characteristics). Other design requirements were (1) that the pile have a natural period several times greater than that of the applied wave or eddy forces so that no resonance develops and (2) that the maximum deflection of the pile be limited to less than 0.1 inches.

The pile is wired with eight strain gages that form two Wheatstone bridges. Four of the strain gages are located at the top of the pile near the frame support and give an output proportional to the moment about this point. The other strain gages, two at the top and two near center give an output proportional to the difference in moment between these points which leads to the total force. The bridges are connected to an amplifier-recorder for printout of moment and force after static calibration by a pulley and weight system. A capacitance-type parallel-wire wave gage is being used to provide surface time-history data.

The pile has undergone verification and calibration. Subsequent to this, the main testing program was started with the measurement of axial force and moment time-histories for a range of wave heights and lengths. This was repeated for four conditions of surface roughness obtained by glueing uniform sand of various grain diameters to the pile surface. Analysis of these data on the University IBM 360/65 digital computer system has been started. Essentially, this data reduction involves the determination of wave velocities and accelerations from the measured height and period of a series of waves and the calculation of drag and mass coefficients from the wave kinematics and pile force measurements.

Reports and Project Documentation

Two papers resulting from this research will be presented in the coming year.

Personnel Participation

R. M. Sorensen has spent 4.0 man-months involvement in this project. One student has been involved 6.0 man-months.

An Analytical Solution for the Dynamic Response of a Laterally Loaded Pile

Offshore exploration for petroleum products has been increasing at a steady pace for the last ten years. Drilling platforms are being located in deeper and deeper water in order to keep pace with the ever-present demand for oil and its by-products. Defense installations and weather retrieving devices are also being placed offshore for obvious reasons. This increase in offshore activity has met with an increase in design complexities as a result of the more severe sea conditions in the deeper water.

Many offshore structures are supported by piles driven into the bed of the ocean. Frequently, the critical factor in the design of these structures is lateral loads from wind and waves. It is noted that these types of loading are time-dependent and in some instances they exert impulsive forces on the structures, for example, the breaking wave or wind gust. In the past, very little consideration has been given to dynamic effects of these time-varying forces on the structural integrity of the platform.

To accurately compute the response of a pile-supported offshore structure subjected to wind and wave action, knowledge of interaction between individual piles and their soil and water environment is a prerequisite. That need formed a basis for this research.

The primary objective of the first year's work was to develop an idealized or mathematical model which would represent, within reasonable limits, the dynamic characteristics of the physical system, i.e., the pile-water-soil system. As part of the second year's work, the validity of the model will be determined.

Accomplishments During 1968-69 Academic Year

To construct the mathematical model, approximations and simplifying assumptions, which were consistent with generally accepted practices were made. By applying the laws of mechanics the differential equations of motion of the model were then formulated, and with the aid of matrix methods, numerical integration techniques, and a high speed computer a solution was obtained.

Shown in Figure 1 is a schematic of the pile-soil-water model employed. The distributed mass of the pile was lumped at nodal points and weightless springs served to interconnect the nodes. Force-de-

formation characteristics of the springs were determined by application of the widely accepted "stiffness" method in a finite element approach. Advantage was taken of recent developments in nonlinear analysis to account for the effects of axial load on the lateral stiffness of a beam element.

Because of its inherent simplicity, and in many cases its ability to represent the kinematics of water waves, the Airy theory is often used in the analysis of periodic wave problems. It was for these reasons that it was used in this study. With the Airy theory and the well known Morrison equation, the kinetics of the wave were defined. As shown in Figure 1, the distributed force of the wave, f(Z,t,), dependent on the depth Z and the time t, was resolved into resultant forces, $F_i(t)$, acting as the nodes. Interaction between the wave and pile was considered.

The rheological model selected to represent the dynamic properties of the soil is shown in Figure 2(a). Its force-deformation characteristics are shown in Figure 2(b). A similar model has been used successfully by researchers in describing the vertical response of piles during driving.

In the soil model, provisions were made to account for any permanent set that may occur as the soil is deformed. With reference to Figure 2(b), the permanent set on the positive side is represented by the distance ab, which equals oc, and similarly de, which equals of, on the negative side.

To solve the second order, nonlinear differential equations of motion of the system, different numerical integration schemes were attempted. Milne's Predictor-Corrector Method and the Runge-Kutta scheme are two that were utilized, with the latter offering the more acceptable means of solution.

Preliminary sensitivity studies were conducted in an effort to determine the relative importance of various parameters which affect the pile's response. Some of these were the effects of wave height and frequency, the effects of soil damping, and the effects of the degree of soil fixity. Conclusions concerning the results are deferred, pending the outcome of validation studies which are scheduled in the second year's work.

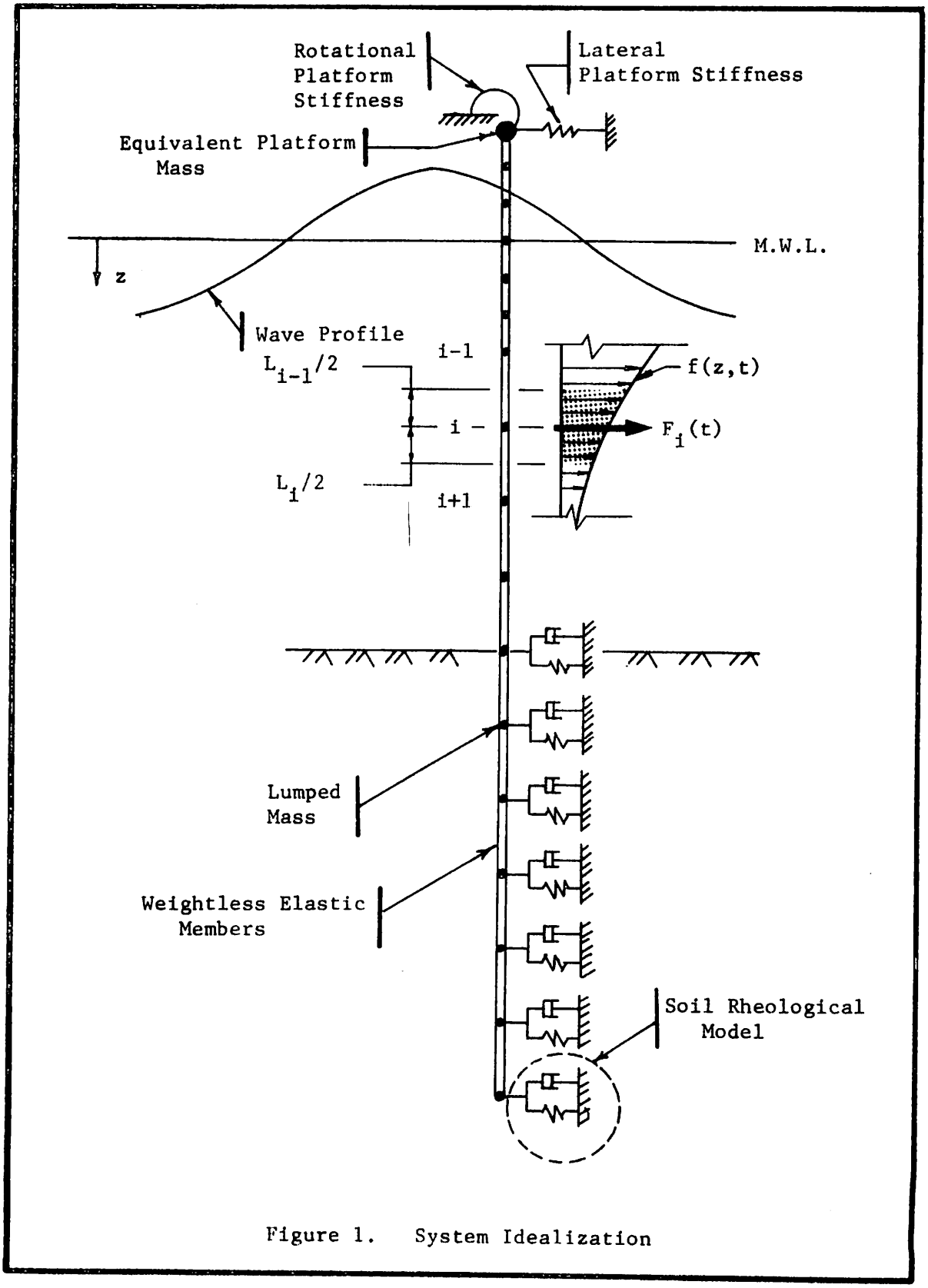
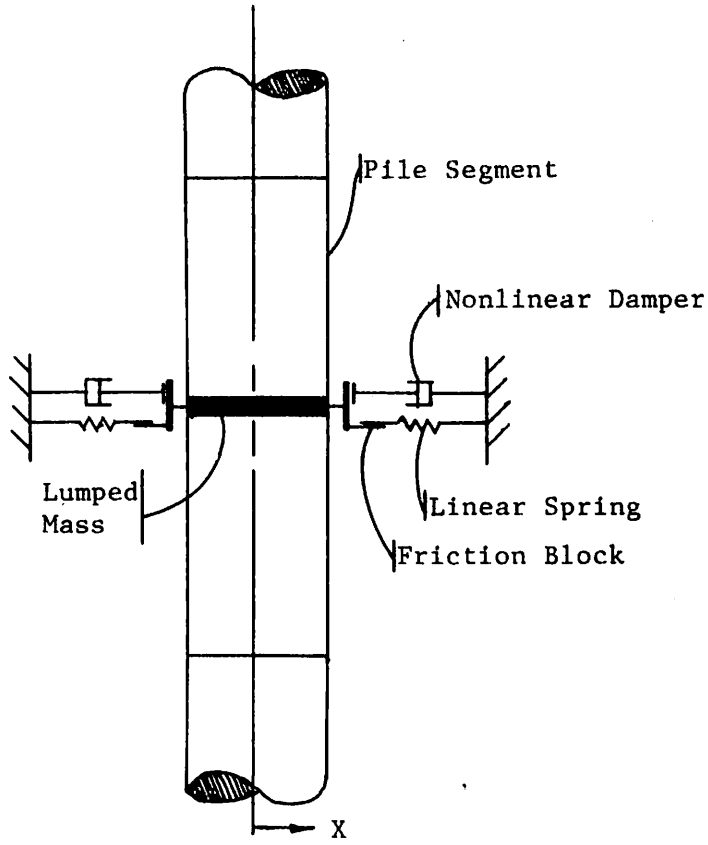
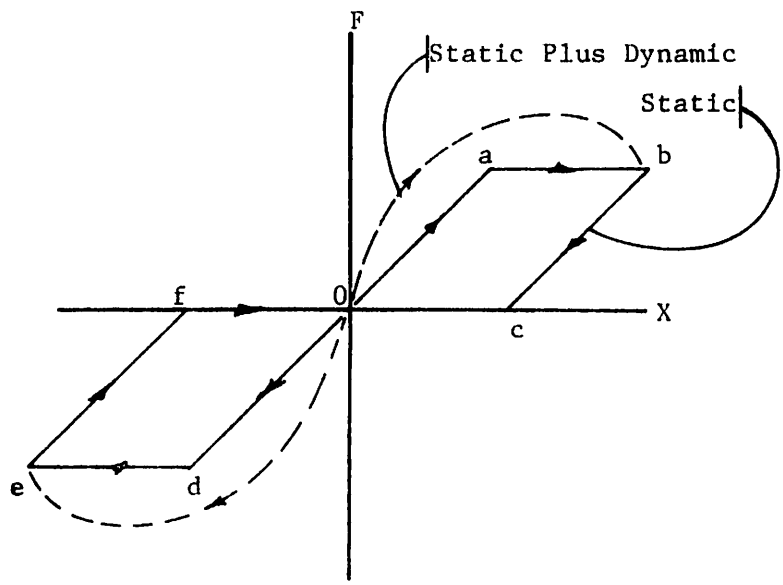


Figure 1. System Idealization



(a) Model Schematic



(b) Model Characteristics

Figure 2. Soil Rheological Model

With regards to participation by, and contact with, other groups, several representatives of the oil producing industry were contacted informally at the recent Offshore Technology Conference in Houston. They were questioned as to their interest in this research and the availability of experimental data which would be useful in validating the model. All felt that it was an important endeavor and would have meaningful application in their industry. It appears that they have no experimental data, at least none available for public use.

Reports and Project Documentation

Hayes E. Ross, Jr. intends to use this research in meeting dissertation requirements for a Ph.D. in Civil Engineering.

Personnel Participation

Hayes E. Ross, Jr. and T.C. Edwards were involved for a total of 7.0 man-months on this project. One student was involved for 0.1 man-month.

Effect of Fluid Viscosity of Non-Newtonian Fluids on Cavitation Characteristics of a Dredge Pump

Some of the engineering problems of sand, shell, and mineral recovery from the continental shelf and from the ocean floor require efficient dredge pump which will not cavitate. The object of the theoretical and experimental investigation is to determine the effects of non-Newtonian fluids on pump cavitation and to develop optimum inlet geometry for cavitation-free performance.

During the first year of study the test facility was designed and all the major components installed. It is anticipated that the facility will be in operation by October 1969.

It is planned during the second year to conduct experimental studies to determine the cavitation characteristics of the pump for two non-Newtonian fluids and for silt-clay-water mixture. An attempt will be made to develop an analytical method for predicting cavitation and comparisons will be made with experimental data. Inlet and impeller geometry will be varied to some extent depending on the available funds.

During the third year of the study, two additional non-Newtonian fluids as well as a sand-water mixture will be used. The optimum suction inlet and impeller geometry will be developed to minimize cavitation effects.

Accomplishments During 1968-69 Academic Year

Cavitation effects in hydraulic machinery and ship propellers are well known, and many investigations were conducted in the effect of cavitation on the performance. In almost all of these studies, water was used as the cavitating fluid and the results, consequently, can only be applied to water. In view of the wide use of non-Newtonian fluids and in view of solid-water mixtures, it is of great importance to determine first of all the effect, if any, of non-Newtonian fluids on cavitation and also the effect of viscosity of solid-water mixtures on cavitation.

During the first year of study, the test facility for cavitation investigation was designed and the major components ordered. Approximately 90% of the equipment has been installed in the addition to the

present building. The major components of the system are:

1) vacuum tank
2) pump and drive unit
3) piping system
4) instrumentation

The vacuum tank was designed for a capacity of 800 cu. ft. and a total vacuum. The vacuum pump to be used to create the vacuum in the tank is being shipped and will be installed as soon as possible.

The pump and drive unit for the first test has been installed. The drive unit is a 200-hp, 1,750 RPM, A.C. motor which will drive through a variable speed, constant torque, eddy-current coupling. The motor and coupling were bought as a unit and have been calibrated. This combined unit has a speed range of 50-1,750 RPM. Three pumps have been loaned or donated by the following dredge pump manufacturers:

a) Morris Machine Works, Baldwinsville, N.Y. and Werlla Co., Houston
b) Thomas Foundry, Birmingham, Alabama
c) Pekor Iron Works, Columbus, Georgia

Plexiglass volute sections and shrouds have been made for the first pump and installed, and the others will be made during the coming year. Several impellers for each pump are on hand and will be modified for use in the testing.

The piping system is approximately 50% complete.

The short loop has been installed and the long loop is ready for installation, except for the 8" line which has not been purchased. The loop consists of a 8", 6", and 4" pipe, with manifolds to connect the pipes to the tank and pump. There is also a magnetic flowmeter in the line from the pump to measure the discharge.

The instrumentation has been designed and is presently being installed. Several items need to be purchased, including pressure gage, pressure transducers, liquid level measurement in the tank and various fitting needed to connect the instruments to the pump.

The outstanding items to be bought are a 200-hp starter for the drive unit, 150' of 8" pipe and fittings for the completion of the pipe loop, and a torquemeter for measurement of the input shaft horsepower to the pump. Bids are being taken on these items now and hopefully these will be purchased as soon as possible.

Reports and Project Documentation

The Center for Dredging Studies publishes a bi-monthly Newsletter concerned with keeping the dredging industry up-to-date with the Center's activities and new publications available. Also, the Center provides a quarterly abstracting service for those who are in need of such a service. Technical publications by the Center are reported in Chapter 3, "Publications and Program Documentation."

Personnel Participation

Dr. John B. Herbich has been involved 3.0 man-months along with two students who have been involved a total of 6.25 man-months on this project.

Aquaculture

Production of Commercial Crustaceans and Fishes on the Upper Texas Coast

An increased need for protein foods coupled with the rapidly growing human utilization of estuarine areas has produced a critical need for new information which will permit the wisest use of land and water in the bay environment. Galveston Bay represents a good case in point, having a rapidly increasing human population in the immediate area, and supporting large natural populations of fishes and invertebrates, some of which sustain commercial fisheries. The conflicts of interest are heightening between real estate, navigation, mineral, fresh water and waste disposal needs on the one hand and fishery resource needs on the other. This type of conflict is also increasing as a result of growing demand for electric power, the production of which generates large volumes of "thermally polluted" water.

Lack of knowledge as to environmental requirements of commercially important species is at present an obstacle to intelligent resolution of these conflicting interests and needs. The research proposed here would provide such information for several fishes and crustaceans first in laboratory aquarium experiments and later in pond studies.

The present proposal represents a promising opportunity to exploit a waste product, heated water from a power plant, to the advantage of survival and growth of commercially important poikilothermal animals. The effective liason between the project investigators, a private power company, and the Bureau of Commercial Fisheries should make it possible to carry out such studies in an unusual atmosphere of cooperation between university, industry and government.

Accomplishments During 1968-69 Academic Year

During the first year of this project progress has been largely in the form of acquisition of materials and assembly of specialized equipment, and the involvement of graduate students in various facets of the research. However, several significant new biological findings have also resulted, and government-industry liasons have been brought about which should contribute directly to the future progress of this research into the field phase.

The "tooling up" process has included the construction of fifty 80-gallon insulated water tanks for the holding of fishes or crustaceans at prescribed temperatures during experiments on survival, growth, food conversion efficiency, and acclimation. Twenty-three 8-gallon tanks have been built to test survival times of experimental animals in the determination of upper temperature tolerances. Eight sensitive relays have been constructed to provide an integral part of the temperature control systems for both types of tanks. A refrigeration system has been specially designed and assembled to provide maximum flexibility and control of cooling for individual tanks where temperatures below ambient are required. Although the equipping of this project (still not complete) is a lengthy process, we consider it well worth the time and effort, for it will provide a laboratory setup which could not be obtained from commercial sources, and more important, one which is uniquely suited to the purposes of this project.

Enough of the physical requirements of the project have been assembled to begin some experiments, and six graduate students (three M.S. and three Ph. D. candidates) have become involved with various parts of the research, and several significant pieces of information have resulted:

(1) postlarval white shrimp (*Penaeus setiferus*) survive longer than larger speciments of the same species at lethal high temperatures;

(2) acclimation (holding) temperature has a dramatic effect on survival of postlarval white shrimp; animals acclimated to 34°C lived 20 times longer than animals from 29°C water when both groups were exposed to 39°C;

(3) a low salinity (5%) seems to depress the thermal resistance of postlarval white shrimp, even after acclimatio to low salinity;

(4) the resistance of postlarval brown shrimp (*P. aztecus*) to heat increases as photoperiod (length of illumination period per day) is increased from zero to 24 hours;

(5) in food selection studies postlarval white shrimp showed a preference for a natural item, brine shrimp larvae, over five artificially prepared diets;

(6) diet can have a marked effect on the resistance of postlarval white shrimp to heat;

(7) striped mullet acclimate to temperature increase as rapidly as 1% as at 5%;

(8) length of photoperiod has little, if any, effect on acclimation rate of the variegated minnow (*Cyprinodon variegatus*--a potentially valuable bait species) to increased temperature.

These findings are all pertinent to the ultimate objective of this project--to determine the potential for use of waste heat from power plants to maximize growth and survival of commercially valuable fishery species in aquaculture.

Reports and Project Documentation

Dr. Strawn attended a meeting of the Gulf States Marine Fisheries Commission, Mariculture Subcommittee, at Grand Terre, Louisiana. He and the graduate students involved in his project also participated in meetings of the World Mariculture Society and the American Fisheries Society. Dr. Strawn and one of his students presented a paper at the latter meeting.

Dr. Strawn arranged a meeting between officials of the Houston Lighting and Power Company and of the U.S Bureau of Commercial Fisheries to arrange for the provision of ponds with access to heated estuarine water from a power plant. Such ponds would be available for the application and testing of our laboratory findings under semi-controlled field conditions.

Personnel Participation

Two professional staff members, R. Kirk Strawn and David V. Aldrich, were involved a total of 7.86 man-months on this project. Seven students also assisted for a total of 21.5 man-months.

Seafood Technology

Role of Microorganisms in the Quality Deterioration of Seafoods

Samples of seafoods from the Gulf of Mexico include fish and shellfish, both crustacean and molluscan, will be examined for levels and types of microorganisms during various stages of handling, processing and storage. These studies will be carried out under both commercial and laboratory conditions. Special attention will be given to the effect of the plating conditions on the total number and distribution of the various species isolated from the samples. In this respect major emphasis will be placed on the role of the composition of the plating medium and temperature of plate incubation.

Accomplishments During 1968-69 Academic Year

During 1969 studies were carried out to obtain an accurate and current picture of the initial level and type of microbial population of shrimp. The number and types were also determined following one week of iced storage. Three different types of water were used in the growth media, regular seawater, artificial seawater and distilled water. Plate incubation was at 28° C for 2 days and at 5° C for 7 days. The bacterial counts of fresh shrimp varied greatly. With plate incubation at 28° C and on media prepared with distilled water, counts ranged from 1.3×10^3 to 6.8×10^5 per gram. When fresh shrimp was stored on ice for 7 days, the count usually increased 100-fold.

The count of fresh shrimp usually was somewhat higher with plate incubation at 28° C than at 5° C. With stored shrimp, however, the number of samples with similar counts at the two incubation temperatures increased. Comparision of the bacterial counts on the media with different waters indicated that the counts of fresh shrimp at both plate incubation temperatures usually were highest in media with distilled water or regular seawater and lowest on artificial seawater. Counts of stored shrimp usually were highest on media with distilled water. Plates incubated anaerobically nearly always showed lower counts than comparable plates incubated aerobically.

A generic distribution of the isolates showed that both fresh and stored samples contained predominantly coryneforms and *Micrococcus*,

Moraxella and *pseudomonas* species. A few species of *Achromobacter, Alcaligenes, Bacillus, Flavobacterium, Lactobacillus, Microbacterium, Staphylococcus* and *Vibrio* were also isolated. The percentage of *Pseudomonas* species in the stored samples was higher than in the fresh shrimp samples. This increase was accompanied by a decrease in the percentage of coryneforms. No consistent differences in type of bacterial flora were observed between the media prepared with seawater or distilled water.

The data obtained on the "pond shrimp" indicated that the bacterial counts of these samples were lower than from commercial shrimp. Counts on media prepared with distilled water and incubated at 28° C ranged from 3,200 to 79,000 per gram. Generic distribution of the isolates on seawater media showed that species of *Flavobacterium* and coryneforms predominated. On media prepared with distilled water, species of *Bacillus, Flavobacterium, Lactobacillus, Pseudonomas* and coryneforms were predominant in one or more of the samples. Individual isolates are now inoculated into washed shrimp and shrimp juice to study the effect of individual microorganisms on the deterioration of quality.

Results of the tests from the first organism, a fluorescent *Pseudomonas* species, are listed in Tables I and II and Figures 1 and 2. TVA production increased initially and then fell as TVN production increased. WSP and SSP (whole shrimp) increased in both the control and inoculated shrimp. NPN production increased in the whole shrimp (inoculated) but remained essentially constant in the shrimp press juice. Better methods of analysis are being investigated.

Reports and Project Documentation

One thesis resulted from this study and is reported in Chapter 3, "Publications and Program Documentation."

Personnel Participation

Dr. Carl Vanderzant and Dr. Bryant F. Cobb III were involved a total of 6.2 man-months on this project. Four students were involved a total of 11.35 man-months.

TABLE I

Shrimp Press Juice Inoculated with Fluorescent Pseudomonad

Sample	Day	(biuret) % Protein	(kjeldahl) % Protein	Meq x 10^3 TMN	Meq x 10^3 TVN	%TPN	*Molecular Species (%) I	II	III	IV
Control	4	0.74	1.36	0.65	0.84	0.11	26.7	20.2	9.4	43.7
	8			0.46	1.59					
	11			0.93	1.86					
	14	1.0	1.23	0.00	1.59	0.14	12.6	15.9	20.5	50.9
Inoc.	4	0.86	0.94	0.093	0.84	0.14	24.2	22.4	2.2	43.2
	8			0.00	1.59					
	11			0.18	2.80					
	14	0.94	1.45	0.00	7.93	0.10	18.1	10.9	11.7	59.3

* Determined by Sephadex Chromatography

TABLE II

Whole Shrimp Inoculated with Fluorescent Pseudomonad

Sample	Day	% WSP	% SSP	Meq x 10^3 TVN	% NPN	Meq x 10^3 TVA	% Moisture	Meq x 10^3 VRS
Control	4	4.1	6.35	*-0.01	0.63	0.59	78.4	0.17
	8			-0.045		3.12		0.22
	11			0.015		0.41		0.17
	14	5.0	16.6	6.65	0.63	-3.83	77.6	0.31
Inoc.	4	4.1	6.35	-0.91	0.63	0.37	78.4	0.22
	8			-0.93		4.95		0.27
	11			1.63		0.74		0.20
	14	15.6	12.0	36.32	1.40	-12.54	80.6	0.34

* Negative figures indicate that TVA production is high or vice versa

FIGURE 1

Shrimp Press Juice

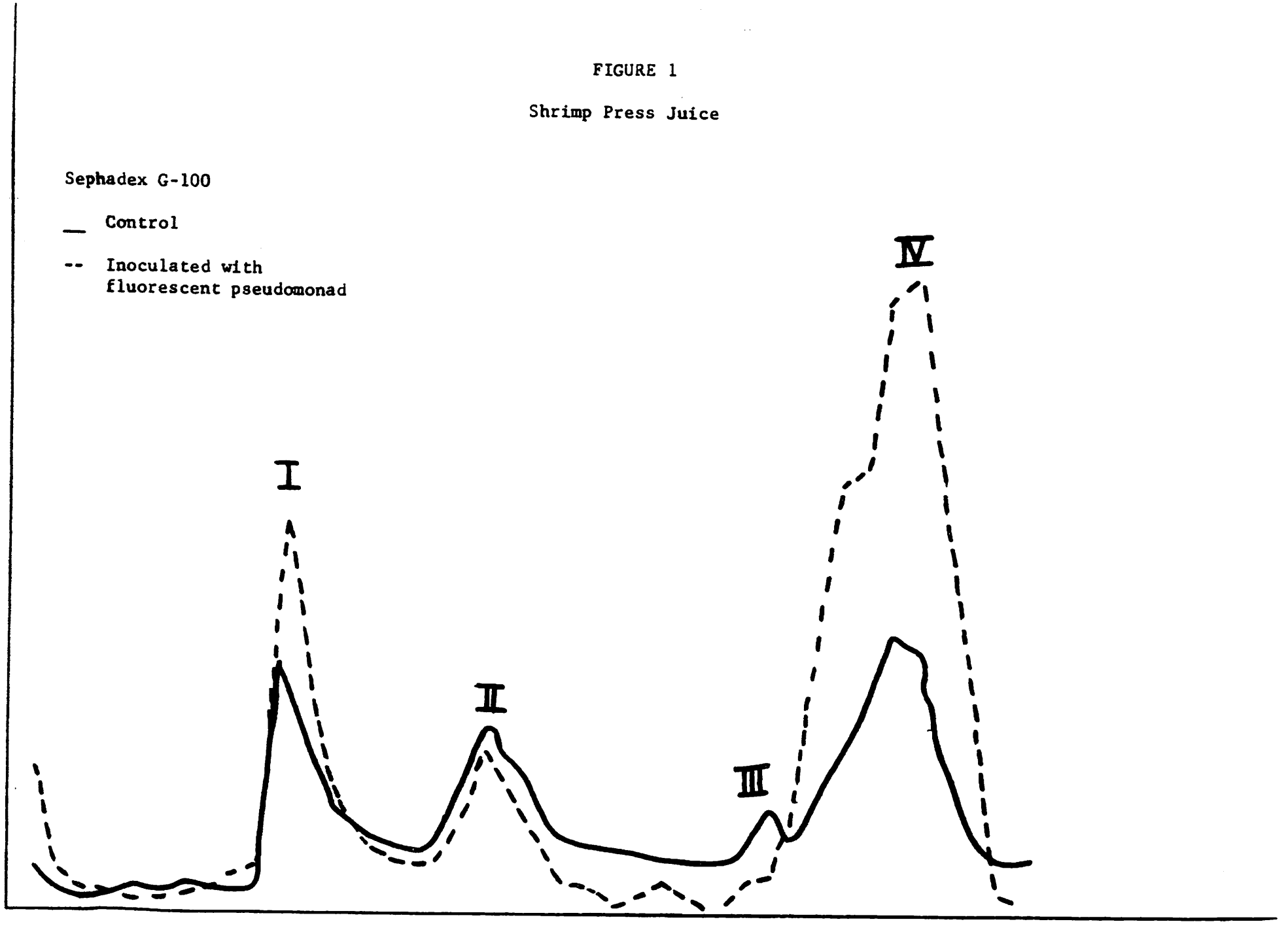
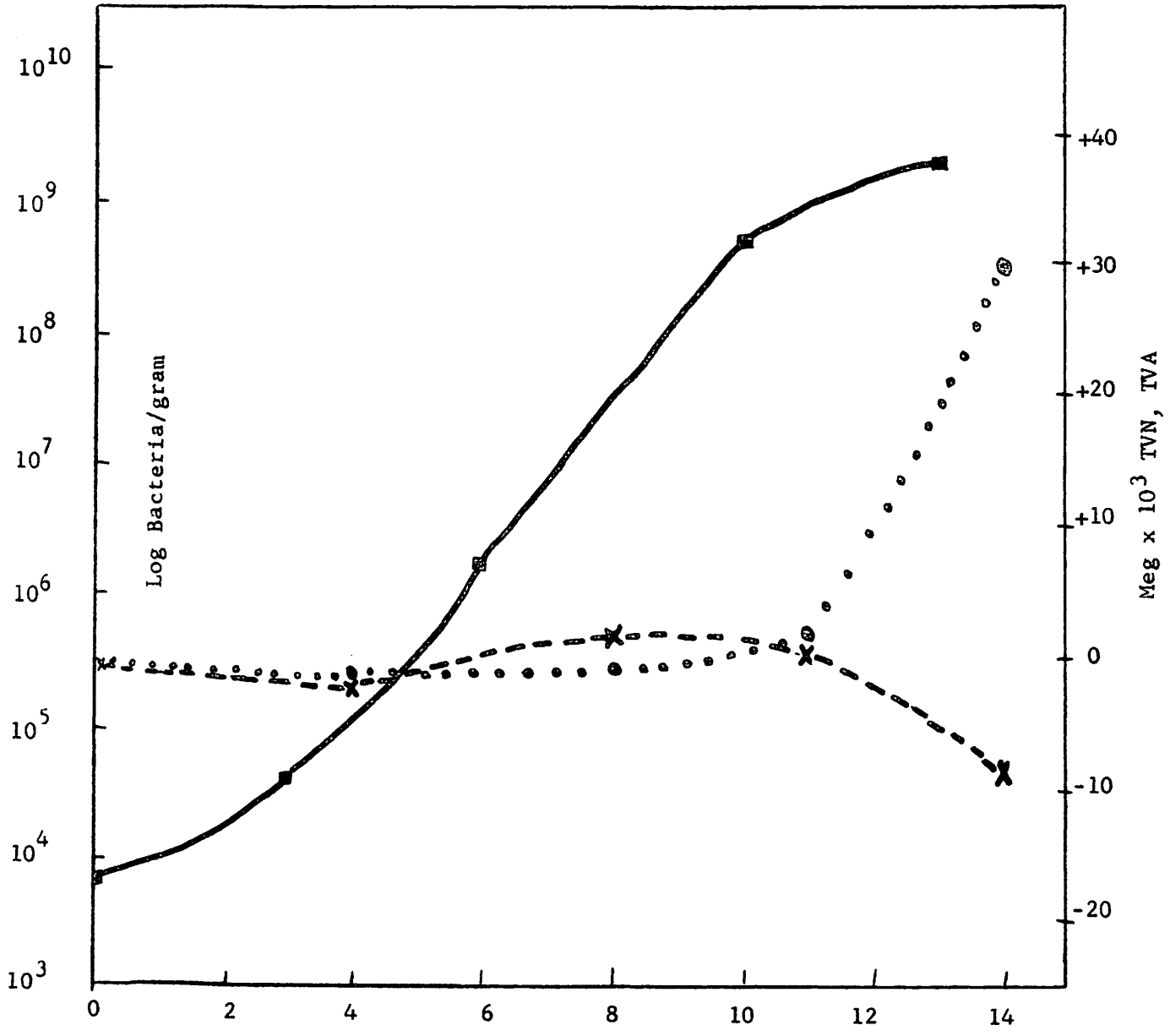


FIGURE 2

Production of TVA and TVN During Growth
of Fluorescent Pseudomonas Species



Values for TVN and TVA have been corrected for controls

x-----x TVA
●.....● TVN
Bacteria

Post-mortem Characteristics and Biochemical Properties Affecting the Organoleptic Quality of Fish Muscle

Biochemical and histological changes in post-morten muscle of food fish from the Gulf of Mexico will be determined. Differences in permeability of small molecules and salts in the muscle from physiologically distinct species of fish will be determined and, if possible, related to quality characteristics. The effects of ante-mortem stress, post-mortem chilling, freezing, and storage on the organoleptic properties of fish muscle will be investigated. The relationship of cathepsins to quality deterioration in fish and shellfish will be studied.

Accomplishments During 1968-69 Academic Year

Speckled trout (*Cynoscion nebulosus*) were placed on ice and allowed to spoil. Samples were analyzed for changes in WSP, SSP, TMN, TN, NPN, and in some cases eating quality (fillets from the opposite side of the fish were sent to Dr. Carpenter's laboratory for analysis). In Table III significant changes appear to occur in the TVN content prior to spoilage and TMN at the first signs of spoilage.

Projects designed to promote utilization of the mullet have been temporarily discontinued due to lack of samples. Initial results, however, indicate that rejection of the mullet on the Texas Coast may be a sociological rather than chemical problem.

Studies have been instituted to find uses for some of the 500,000,000 pounds of fish which are killed annually and tossed overboard by the Texas shrimp fleet. Specifically, the possibilities of using fish protein to make high quality sausages are being investigated.

In Dr. Carpenter's laboratory speckled trout fillets were analyzed for sarcomere length, fiber diameter, total pigment, protein turbidity, moisture content, fat content, soluble and insoluble collagen. Preliminary results in Table IV indicate that no significant changes are taking place in the iced fish.

A number of species of fish including both edible and rarely consumed species have been analyzed in the same manner as the speckled trout fillets (Table V). Three species of shrimp were also analyzed. Because of the difficulty in obtaining fishes of the same size, results are difficult to interpret. However, there is some indication that acceptance or rejection of these fishes by the American public may be due to the factors other than those included in Table V. The variability

TABLE III

Iced Speckled Trout

	---------Biuret---------			----------Kjehldahl----------				----------Conway----------			
								----------Meq x 10^3----------			
Day	H_2O Ext. Sol. Prot.	Salt Ext. Sol. Prot.		H_2O Ext. N_2	Salt Ext. N_2	Protein N_2	H_2O Ext. NPN	H_2O Ext. TVN	Salt Ext. TVN	H_2O Ext. TMN	Salt Ext. TMN
0	5.4%	9.4%	9.8% 11.8%	4.9	4.9%	20.1%		6.0	10.2	1.6	-2.2
4	5.4%	6.1%	8.7% 8.8%				1.4%	6.5	4.4	5.4	2.9
8	6.2%	14.2%	8.3%			19.3%		13.0	16.1	3.2	7.1
12	7.0%	3.4%	8.8%					24.9	2.2	15.7	5.1

TABLE IV

Iced Speckled Trout

Day	Sarcomere (Microns)	Fiber Diameter (Microns)	Total Pigment mg/gm	Protein Turbidity % T	Moisture %	Fat % Wet	Fat % Dry	Collagen mg/gm wet T. Total	Insol	Sol	%Sol
0	1.98	88.00	.054	4.5	79.71	0.41	2.00	5.319	1.223	4.096	77.0
4	1.83	115.06	.081	5.5	80.00	0.49	2.41	2.686	0.801	1.885	70.1
8	1.95	112.71	.054	5.0	78.91	1.22	5.78	4.686	0.952	3.734	79.6
12	1.87	124.94	.054	4.0	78.32	1.98	9.32	1.894	0.662	1.232	65.4
0	1.79	92.94	.162	4.0	78.50	1.14	5.27	3.115	0.725	2.392	76.7
4	1.84	87.06	.054	4.0	81.42	0.388	2.09	5.166	1.142	4.024	77.8
8	1.84	87.77	.054	10.0	82.41	0.192	1.09	1.798	0.566	1.232	68.5
0	1.88	102.59	.081	6.5	79.50	0.624	3.04	5.015	0.897	4.118	82.1
4	1.89	105.89	.054	4.5	79.97	0.856	4.28	5.582	1.051	4.531	81.1
8	1.90	102.36	.054	3.5	80.65	0.757	3.90	4.625	0.942	3.683	79.6

TABLE V

ANALYSIS OF DIFFERENT SPECIES OF FISH AND SHRIMP

Sample	Sarcomere Length	Fiber Diameter	Protein Turbidity	% Moisture	% Fat Wet	% Fat Dry	Total Pigment	Total	Insol.	Soluble	% Soluble
Edible Fishes readily accepted by the American public											
S. F.	1.90	74.36	9.5	76.27	2.44	10.28	-----	-----	-----	-----	-----
S. T.	1.91	72.7	5.5	79.09	2.02	9.68	0.596	2.950	0.616	2.334	79.12
S. D.	2.06	70.36	4.5	79.30	0.29	1.40	0.000	-----	-----	-----	-----
S.K.F.	1.95	76.0	3.5	77.84	4.20	18.96	0.000	2.084	0.489	1.595	76.54
G. T.	2.11	93.4	13.5	78.70	0.99	4.64	0.785	6.599	2.220	4.379	66.36
S	1.93	76.5	4.0	76.26	4.85	20.43	0.108	3.159	0.607	2.552	80.79
Edible Fishes largely rejected by the American public											
S.C.F.	2.02	82.59	9.5	80.60	1.18	6.06	0.000	-----	-----	-----	-----
R. F.	1.88	82.6	5.0	79.66	1.18	5.78	0.379	6.465	1.767	4.698	72.67
A	1.91	59.5	12.5	79.40	1.23	5.96	-----	-----	-----	-----	-----
C	1.84	67.86	4.5	80.84	1.06	5.54	0.244	4.698	1.109	3.589	76.39
Inedible Fishes											
B.N.S.	1.95	81.6	7.0	79.08	0.84	0.402	0.596	5.851	1.102	4.749	81.17
B.T.S.	1.99	53.41	5.0	72.23	0.410	1.98	-----	-----	-----	-----	-----
H.H.S.	2.20	84.24	3.5	77.92	0.83	3.75	0.514	1.319	0.73	0.616	46.70
Shrimps											
W. S.	1.78	- 58.89	5.5	76.68	0.92	3.96	0.244	3.709	2.121	1.588	42.81
R. S.	1.94	63.06	---	82.08	0.407	2.28	-----	-----	-----	-----	-----
P. S.	1.90	63.53	4.5	80.08	0.744	3.74	0.000	-----	-----	-----	-----

* Names of Fishes and Shrimps

S.F. - Spadefish (Chaetodipterus faber)
S.T. - Sand trout (Cynoscion arenarius)
S.D. - Sad Dabs (species not identified)
S.K.F. - Southern king-whiting (Menticinhus littoralis)
G.T. - Gatttopsail catfish (Bagre marina)
S - Spot (Leiostomus xanthurus)
S.C.F. - Sea catfish (Galeichtys felis)
R.F. - Ribbonfish (Trichiurus lepturus)
A - Anchovy (species not identified)
B.N.S. - Bonnetnose shark (Sphyrna tiburo)
B.T.S. - Blacktip shark
H.H.S. - Hammerhead shark
W.S. - White shrimp (Panaeus setiferus)
R.S. - Rock shrimp (Xiphopeneus kroyeri)
P.S. - Pink Shrimp - (Panaeus duorarum)

in solubility of collagen is considered interesting because of the variation in cooking method and ultimate texture of fish and fish products. The amount of extractable fat is important from the standpoint of possible storage temperatures and time because of variation in rancidity development.

The catheptic enzymes of mullet (*Mugil cephalus*) muscle tissues were extracted by salt precipitation. Protein determination was done by the Biuret method. Disc electrophoresis was used to check protein distribution in the samples. CBZ-Glu-Tyr, Benzoyl arginine amide and glycylphenylalanine amide were used as substrates for cathepsins A, B, and C, respectively. No cathepsin B was found in this extraction. The amounts of cathepsins A and C in the various fractions obtained in separating the enzymes are shown in the following table.

Cathepsin A

	Fraction	Protein conc. in mg/ml	Micromoles of TYR/ml/hr	Micromoles of TYR/mg protein/hr
Ammonium Sulfate	40-70	18.45	38.75	2.1

Cathepsin C

	Fraction	Protein conc. in mg/ml	Micromoles of NH_3/ml/hr	Micromoles of NH_3/mg protein/hr
Ammonium Sulfate	40-70	18.45	8.12	0.44
	G-100 (excluded)	13.68	28.20	2.06
	G-100 (retained)	13.14	1.52	0.16

Reports and Project Documentation

None

Personnel Participation

Zerle L. Carpenter, Bryant F. Cobb III, and W. A. Landmann were involved a total of 7.4 man-months. Five students were involved 11.5 man-months.

Water and Sediment Analysis

Marine Geochemical Analysis

The purpose of the work described in this report is to develop a new method for offshore exploration of natural gas and petroleum. This method is an outgrowth of basic studies conducted by the principal investigator and students on how the source, mechanism and conditions of formation of various naturally occurring organic materials, particularly natural gases and petroleum, can be determined by means of their isotopic carbon compositions.

Offshore occurrences of hydrocarbons are becoming increasingly important as a domestic source of supply. Because the investment of an offshore drilling operation is quite large, there is the need to develop exploration techniques that will increase the probability of finding accumulations. A sophisticated version of the oldest oil finding method, that of looking for oil seeps, is being tried by several companies. Essentially their method consists of measuring the amounts of light hydrocarbons in solution in sea water with the idea that concentration halos would be found around underwater seeps. The results of these surveys are not available because of company security regulations, but there is a hint that their surveys have not helped their exploratory well success ratio. Presumably the difficulty has been the inability of differentiating between a true hydrocarbon seep and bacterially produced hydrocarbons, particularly for the most abundant species--methane. Results of the aforementioned studies indicate that the isotopic composition of the methane dissolved in sea water will identify its source and possibly its age and conditions of formation. Systematic surveys of the amount and isotopic composition of the dissolved hydrocarbons at various depths in the Gulf of Mexico should provide valuable background information and lead to a method for identifying sub-bottom hydrocarbon accumulations.

Accomplishments During 1968-69 Academic Year

The development of this petroleum exploration tool can be divided into two distinct phases. The first is the detection of sub-bottom

hydrocarbon sources and the second is the characterization of these sources by isotopic techniques.

In regard to the first phase, continuous offshore surveys of the hydrocarbon content of surface waters are apparently being conducted by various companies. Because the layered nature of the ocean, especially noticeable in near shore areas in the summer and with increasing depth, interfere with the hypothetical migration of hydrocarbons from the sub-bottom up through the water column, surface water prospecting is presumably unreliable.

Only one hydrocarbon profile and that from the upper 500 meters has been published. In order to provide the necessary background for this program, two detailed profiles from the surface to the bottom and four near-bottom profiles from the western Gulf of Mexico have been collected and analysed. The data show large variations in methane, ethane and propane concentrations, especially near the surface and near the bottom. It is obvious from this study that only samples near the bottom should be used in prospecting for potential hydrocarbon resevoirs.

The second phase of this program is to characterize the dissolved hydrocarbons by means of their isotopic composition. In order to accomplish this objective it is necessary to build an apparatus for extraction of enough methane from sea water for analysis. Approximately two thousand liters of sea water must be processed for 1 cc (STP) of methane required. A prototype of one design was constructed and tried on Alaminos cruise 69-A-6. This attempt did not succeed because of the repeated failure of the diaphragm compressor that was used. Another system of different design and using other components will be constructed and tested in the coming months.

Reports and Project Documentation

William M. Sackett, D. J. Frank, R. Hall, and A. D. Fredericks are presently preparing a paper for submission to the Journal of the American Association of Petroleum Geologists entitled "Dissolved Light Hydrocarbons in the Gulf of Mexico."

Personnel Participation

William M. Sackett spent 2 man-months in research on this project. He was assisted by two students for a total of 9 man-months.

Electrical Logging in Marine Environments

Electrical logging technology has benefited from extensive oil-industry supported research and development. However, this well-developed technology has remained a relatively untapped source of methodology for the study of recent sediments. A few exceptions are found in the literature which reports recent work done to relate porosity, density and resistivity.

Electrical logs have a definable quantitative relationship with several physical, chemical, and mineralogical properties of sediments. When these relationships are developed, a means will be available for making in-situ determinations of the properties. The vast saving in time and man-power is apparent.

Zones of interest which have subtle property differences often remain unrecognized in cores. Clearly, the ability to quickly identify these zones is of immediate value both in the laboratory and at sea.

However, the potentially most immediately valuable advantage of electrical logging in recent sediments is in the ability to correlate horizons from one core (or station) to the next on a real time bases. In-situ logging will enable the establishment of the horizontal rate of change of sediments in a given area, thus providing a sound basis for designing a coring program. In addition, logs taken in conjunction with cores provide a positive quality control on the core by indicating which sections have been squeezed out.

Indeed, electrical logging should increase by a full magnitude the amount of information available from any given amount of effort spent on sediment sampling.

Accomplishments During 1968-69 Academic Year

Electrical logging is a well developed technology for use in well bores in consolidated rock material. A great deal of work was required in order to make the transition in both space (sample length) and material before a useable record could be obtained. Several generations of electrode type and configuration have been tested. A new system with quantitative capability is now under construction. A mechanical logging rack was developed to solve the problem of electrode recorder shychronization. Although significant improvement has been made in these methods,

it is recognized that each one suggests further improvements.

This project is being carried out as a separate part of the R&D activities of the Geologic Oceanographic section, Department of Oceanography. Every opportunity for cooperative effort is acted upon. The project has gained measurably by such cooperation.

Participation in the program has taken several forms. Well Reconnaissance, Inc. of Dallas, Texas has supplied matching funds and been responsible for the fabrication of special elements leading to the first and second generation of logging devices. Dr. George Heubner of the Department of Oceanography, Texas A&M has conducted design studies on special logging equipment. Dr. Richard Rezak of the Department of Oceanography has contributed many useful suggestions and participated in sea trials of some of the equipment. U.S. Geological Survey and NAVOCEANO indirectly supported the project by making available space and cores for logging operations on board the *USNS Kane* during the summer of 1969. Dr. Arnold H. Bouma of the Department of Oceanography has contributed vastly in both conceptual development and actual field testing. Several governmental agencies and industrial concerns have expressed interest in the project. Active support is anticipated from the industrial groups.

Although the program is still in the early stages, (initial funding during 4th quarter of 69) laboratory tests indicate that quantitative relationships may be developed between the electrical and several other properties of recent sediments.

Extensive data collection activities have taken place during the period 1 June 1969 to 31 August 1969. Two principle areas of activities occurred: The Research Annex at Texas A&M University, where model studies and initial technique development was carried out; and aboard two ships: Texas A&M's *R/V Alaminos* and *USNS Kane*.

Electrical logging techniques in the marine environment appear to have more extensive application than anticipated. Several water-column phenomena have been observed to cause an unexpected response on the logs.

Reports and Project Documentation

See Chapter 3, "Publications and Program Documentation," for the reports prepared under this project.

Personnel Participation

Three professional staff members participated in this project for a total of 3.75 man-months: Frank B. Chmelik, George Huebner, and Robert Meyer, Jr.

Nuclear Activation Analyses of Deep Core Samples

This project was directed toward the following objectives:

1. Develop analytical techniques, including the necessary computer methodology for carrying out qualitative and quantitative analyses of marine sediment samples using 14 MeV neutron activation.
2. Analyze selected samples of ocean floor materials using the techniques developed in 1, above.
3. Assess the potentialities of nuclear activation analysis as a method of large scale exploration for metallogenic provinces.

At the same time that this project was being initiated at Texas A&M, the NSF Sponsored Deep Sea Drilling Project began to yield cores from the deep ocean floors. Discussions with members of the JOIDES scientific staff led to a collaboration in which Texas A&M would carry out neutron activation analyses on selected core samples from the firsl legs of the JOIDES exploration in order to provide chemical composition data. The results of these analyses are to be included in the Initial Reports of the Deep Sea Drilling Project which are to be published by Scripps Institution of Oceanography after the completion of each leg.

Accomplishments During 1968-69 Academic Year

This project involved the use of 14 Me-V neutron activation analysis for determination of the major chemical elements composing deep sea sediment samples as well as the development of new methodology for improving the data quality and measurement efficiency. This method was chosen because of its ability to provide rapid, non-destructive analyses of a relatively large number of samples. The elements of interest were: oxygen, silicon, aluminum, magnesium and iron.

After several discussions and correspondence with scientists of the NSF sponsored Deep Sea Drilling Project, arrangements were made for the Activation Analysis Research Laboratory at Texas A&M to receive selected core samples from those recovered by the drilling ship *Glomar Challenger*. During the year ending August 31, 1969, a total

of 193 deep sea sediment samples were received as indicated below:

Leg	Quantity Received
I	11
II	38
III	82
IV	62
Total	193

Each core sample was first crushed and mixed to permit packaging in small polyethelene vials. From each crushed core sample, two subsamples weighing approximately 1 gram each were taken at random, weighed and placed in vials which were then heat sealed. Standards containing known amounts of O, Si, Fe, Mg and Al were weighed and encapsulated.

Each sample and standard was irradiated with a 14 MeV neutrons for two minutes, counted for two and ten minutes after cooling times of ten minutes and two hours, respectively. A pneumatic sample transfer and then to 3" x 3" NaI(Tl) detector coupled to a 400 channel pulse height analyzer for counting. A weighted least squares computer program which utilizes the information contained in the two spectra was used to resolve the radioactivity from the activation products of silicon, aluminum, iron and magnesium and to compute the amount of each element present.

Oxygen content was determined by a separate procedure which consists of five short irradiations and counts under standardized conditions. The observed activity is then compared to that of oxygen standards by a computer program written to facilitate the calculations.

The following table shows the important nuclear properties of the five elements under study in this project (see next page).

In order to improve the quality of the analytical results, a unique spectrum analysis method was developed and implemented in the form of a computer program KRIS.

KRIS, which offers the capability of resolving complex gamma spectra even when spectra of the individual components are quite similar, employs a scheme which allows for the use of half-lives as well as gamma-ray energies in the least-squares resolution of gamma spectra. Options are also supplied for averaging of repetitive counts, least-squares smoothing of the data, iterative improvement of the weighting factors used in the least-squares solution, and use of either live or clock

Table I. Nuclear Reactions With Fast Neutrons

Element	Nuclear Reactions	Half Life	Gamma-Ray Energy (MeV)	Relative Specific Activity (Photopeak)	Major Interfering Reactions
Aluminum	$^{27}Al(n,p)^{27}Mg$	9.5 m	0.84, 1.01	1,145,000	
	$^{27}Al(n,\alpha)^{24}Na$	15.0 h	1.37, 2.75	18,000	$^{24}Mg(n,p)^{24}Na$
Iron	$^{56}Fe(n,p)^{56}$	2.58h	0.84, 1.81, 2.11	86,000	
Magnesium	$^{24}Mg(n,p)^{24}Na$	15.0 h	1.37, 2.75	33,000	$^{27}Al(n,\alpha)^{24}Na$
Silicon	$^{28}Si(n,p)^{28}Al$	2.3 m	1.78	2,360,000	$^{27}Al(n,\gamma)^{28}Al$
	$^{29}Si(n,p)^{29}Al$	6.6 m	1.28		
Oxygen	$^{16}O(n,p)^{16}N$	7.35s	6.13, 7.12		

14 Mev neutron flux of 2 x 10^8 n/sec/cm^2
5-minute irradiation time
1 minute decay time
5 minute count time
Detector consisted of a 3" x 3" NaI (Tl) scintillation crystal

time counts. The number of control cards required for each sample has minimized to simplify input. KRIS is written in FORTRAN IV and is being run under Fortran G and the Watfor compiler on the IBM 360/65.

The accuracy of the method is primarily limited by the reproducibility of the irradiation and counting geometries. The contributions at present amount to about 5% relative error for the elements Si, Al, Fe, and Mg. The oxygen is determined by a separate short time irradiation and the errors associated with the method are generally less than two percent. Approximately twenty samples can be analyzed during an eight hour work day with the present system.

While KRIS was written for use in activation analytical applications, it is sufficiently flexible to be applied, with minor changes, to other counting regimes, such as fission product determination in environmental samples and routine gamma spectroscopy.

The results showing major element composition of the 193 core samples (1930 analyses) have been assembled and forwarded to Scripps Institution of Oceanography. No publications have been made in the open literature on the results of the JOIDES core analyses since all such publications must await the release of the initial report by the Deep Sea Drilling Project. The results clearly indicate significant variations in major element composition from hole to hole and also variations vertically in the same drill hole. Leg III results have been forwarded to Dr. Ken Hsu of Eidg, Technische Hochschule Geologisches Institut in Zurich and one of the Leg III scientists. Dr. Hsu reports that a preliminary study of our data supports his conclusion that the oldest sediments at each Mid-Atlantic Ridge site were deposited nearest to the ridge axis; that additional trace element determinations using reactor neutron activation will be very helpful in his stratigraphic synthesis work in the Mid-Atlantic Ridge region.

Some preliminary trace element determinations have been carried out on samples from holes 15 and 19 (Leg III) and results again show very drastic changes in trace element concentrations as a function of depth. It appears that results on as many as 15 trace elements can be determined in the JOIDES samples using reactor neutron activation and completely instrumental high-resolution gamma ray spectrometry.

Reports and Project Documentation

Reports are listed in Chapter 3, "Publications and Program Documentation."

Personnel Participation

Four professional staff members participated in this project for a total of 3.658 man-months: Dr. R. E. Wainerdi, Dr. L. E. Fite, Mr. W. E. Kuykendall, Jr. and Dr. E. A. Schweikert. One student assisted for 5 man-months.

Acoustics

Acoustic Communications

Underwater acoustic communications has the potential of providing those interested in the development of marine resources with new dimensions in the areas of data collection and control. While much military work has been done in this area over the past twenty years little has been done to make economic, reliable, and efficient systems available to oceanographers, fishermen, and others interested in marine technology.

In this study it is proposed to survey the present and future communications requirements of those engaged in ocean science, industry, and technology in order to specifically gauge the need for acoustic communications systems. A model for the underwater acoustic channel would then be formulated and used to study modulation, multiplexing, and signal processing techniques which satisfy typical communications requirements. From these studies, designs of practical systems would be developed. Cost effectiveness and trade off studies between competing designs would be conducted. In subsequent years, prototypes of the most attractive systems would be built and tested.

Accomplishments During 1968-69 Academic Year

During the first year work was broken up into three distinct areas: theoretical studies, development of practical systems, and assessment of future needs.

The theoretical studies began with an investigation of the transmission characteristics of the underwater acoustic channel when used as a medium for communications. Much information on the physical nature of the channel was found. This was used to develop basic criteria for the design of practical acoustic communications systems. Using these criteria, studies were made of three representative modulation schemes for the underwater acoustic channel: pulse position modulation, frequency modulation, and frequency shift keying. These techniques were compared and contrasted on the basis of system complexity, performance, and reliability.

While working on the study of modulation techniques a number of general theoretical problems were encountered and worked on. The first

of these is concerned with the threshold performance of a pulse position modulation system. Threshold is loosely defined as occurring when a slight decrease in received signal power results in a large decrease in performance. Knowledge of the location of threshold is a key factor in any practical system design since it determines parameters such as required signal power and maximum range. A technique for predicting the location of threshold and performance in the vicinity of threshold for a pulse position modulation system was developed and verified.

A frequency shift keyed signal when transmitted through the underwater acoustic channel is subjected to both time dispersion, that is the creation of echoes, and amplitude fading. No studies of signals subjected to both these effects concurrently are available, and hence a study of this problem and its amelioration has been begun. A few preliminary results on the effect of timing errors in circuits used to receive these signals have been obtained. It is planned to spend a considerable amount of time during the next year on this problem as its solution is of considerable theoretical and practical importance.

In order to gain a feel for the practical problems inherent in operating a communications system in an ocean environment the development of two prototype systems was begun. The first is a hybrid pulse position and pulse rate modulation system which can transmit one channel of analog and three channels of digital information. A laboratory model was first built and tested, and then a working engineering model built. The system is designed to provide information aboard ship about the status of a large underwater trawl and the rate at which it is being dragged along the bottom.

The electronic circuitry of the engineering model is shown in Picture 1. It is planned to test this at sea later this year.

The second system built was a laboratory model of a five channel analog pulse position modulation system. This model is shown in Picture 2. This model was used to verify the theoretical analysis of threshold performance in pulse position modulation systems. It is hoped that a working engineering model of this system can be built and tested in the near future.

In order to assess the future potential of underwater acoustic communications, contacts with people in oceanography and ocean related

industries were made. In oceanography one can find many instances where acoustic communications has the potential of increasing man's knowledge of the sea. Uses range from underwater television to simple remote measuring devices. The major problem that must be overcome is cost. Although one can in many instances show that efficiency, measured in terms of ship time saved, can be greatly increased by the use of such systems obtaining the funds to build, develop, or purchase the necessary equipment is not easy.

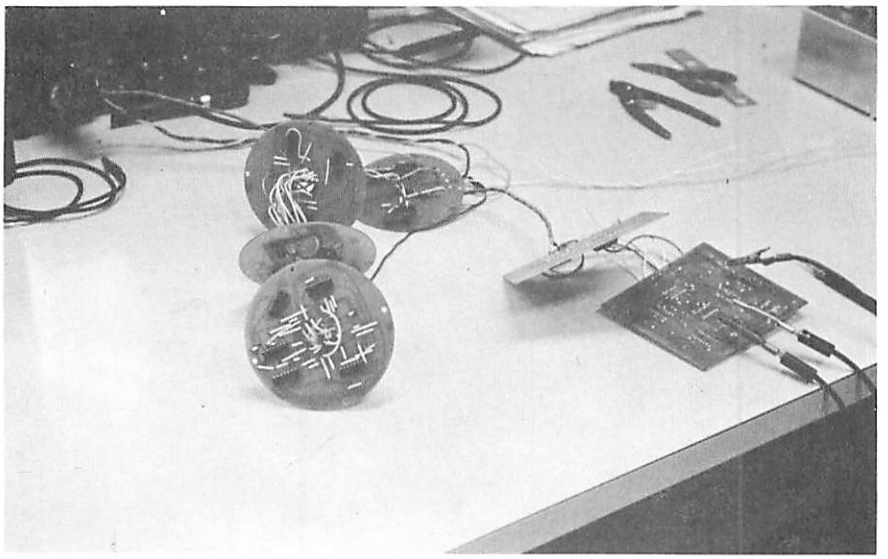
Of the industrial uses of acoustic communications investigated the most promising is the use of automatic control in offshore oil fields. A number of contacts with industrial organizations interested in this activity have been made. It is hoped that some type of joint venture in this area can be developed in the near future.

Reports and Project Documentation

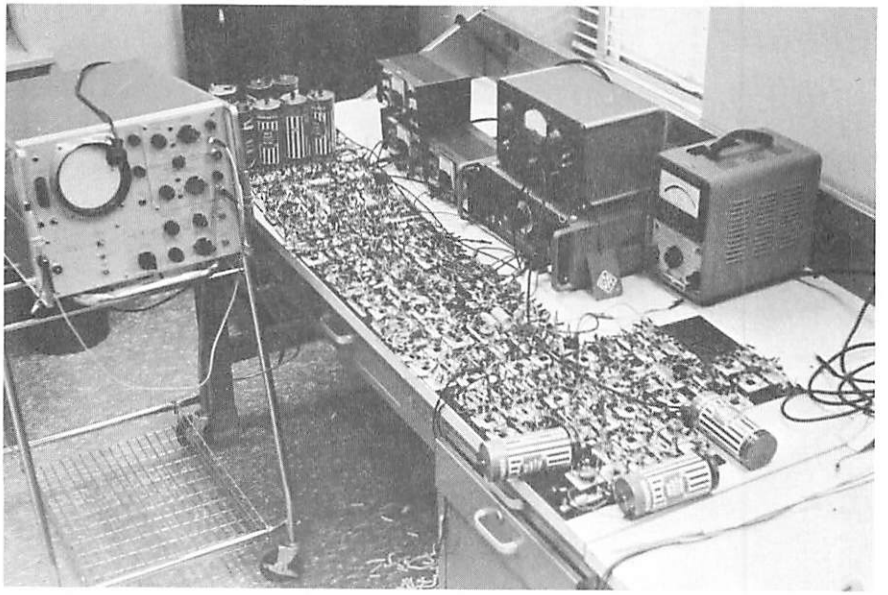
None.

Personnel Participation

Stephen Riter has spent 3 man-months involvement in this project. Four students have assisted him for a total of 4.1 man-months.



Picture 1
Electronics of Hybrid Underwater Communications System



Picture 2
Laboratory Model of Five Channel PPM System

5

PUBLICATIONS AND PROGRAM DOCUMENTATION

As set out in the National Sea Grant Colleges and Program Act of 1966, the National Science Foundation shall encourage and develop "programs consisting of instruction, practical demonstrations, publications, and otherwise, by sea grant colleges and other suitable institutes, laboratories and public or private agencies through marine advisory programs with the object of imparting useful information ..."

Through its research, education, and advisory services projects, the Texas A&M University Sea Grant Program has originated nineteen technical reports, contributed seven articles to professional and trade journals, and has contributed to the preparation of eleven theses by graduate students within various University departments. In addition, proceedings of conferences and meetings have been published, bibliographies have been compiled, and newsletters and media releases have been prepared to disseminate marine resource information to the general public.

Through the mass media, hundreds of column inches of newspaper copy have carried the story of the Sea Grant Program to the people of the state and radio and television broadcasts have created greater public awareness of the problems and promises of marine resources. Visual presentations, using 35 mm color slides and 16 mm color film, have been prepared for use by project leaders and others.

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