television, and press have been most cooperative. Press clippings have been forwarded to the Sea Grant Program editor at Texas A&M University.

Contact has been established with Mr. Ned Middleton at Brazosport College to coordinate the developing program in Oceanic and Marine Technology at Brazosport with the Marine Science Technology program at Del Mar College. The present philosophy is to avoid duplication of programs at the two colleges. Del Mar's curriculum is more academically oriented and the program at Brazosport will be more skill oriented.

Questionnaires have been completed to show listing of the Del Mar College-Marine Science Technology Program in University Curricula in the Marine Sciences and Related Fields as prepared by the National Council on Marine Resources and Engineering Development. The Del Mar program is currently listed in the Information Guide and Directory as published by the Texas Education Agency.

The Counseling and Testing Office at Del Mar College has continued to assist with this project. A mid-year report was received from C&TO and is duplicated below: (Note, "First group" refers to the pilot group as funded directly by NSF and the "second group" refers to the trailer group as funded by Sea Grant via Texas A&M.)

(REPORT BY DEL MAR C&TO (1/19/71)

I. SCREENING OF APPLICANTS:

All applications for enrollment in Marine Science Technology are duplicated and filed in the Counseling Testing Office on the Technical Campus. From the list of applicants individual interviews are scheduled before a committee made up of an administrator, a teacher, a counselor. The purpose of this interview is to select those students who because of background, aptitude and interest are considered most likely to succeed in the program. Data available to the committee includes:

Highschool grades
Any college grades
College entrance test scores
Application supplement information

Screening is a continuous process as interviews are conducted during each semester to determine if the students selected are making satisfactory progress.

II. COMMUNITY INTEREST IN THE PROGRAM:

The community interest in this program runs high among local highschool students who have had opportunity to take Marine Biology Course in their high schools. Equally impressive as

the local interest in the number of OUT-OF-DISTRICT Inquiries. TO DATE there are 20 CANDIDATES from either out-of-district or out-of-state for possible continuation of the program next September.

III. TESTING OF STUDENTS:

Either ACT or SAT-CEEB scores are available on all students.

First Group:	Average ACT 18.5	Range 05-25
Second Group:	Average 19.7	Range 12-24

All marine science students have been administered the 16 PF (Personality Factor) test. This test is an attempt to determine what personality factors are characteristic of students who enroll in Marine Science Technology and how students who persist in the program compare with students who wash out. At this time data is insufficient for meaningful information.

IV. FEEDBACK THROUGH COUNSELING:

First group has had a history of dissatisfaction with various phases of the program at one time or another.

Second group has had a significantly lower proportion of negative feedback. Most of the second group seem happy with their choice and the program as a whole.

V. FLEXIBLE CURRICULUM:

The change to a dual emphasis program seems to have contributed to improved attitude on the part of the students. By having greater choice they seem to be more highly motivated and productive. There is still some question as to whether the natural science option should be referred to as technical in nature and indeed as to whether the students who choose that option stand any increased chance for employment as technicians because of their two years at Del Mar.

VI. FUTURE OF PROGRAM:

The number of formal inquiries both locally and statewide, possibly regional or even national, indicates that interest in the field is high. There is every reason to believe that quality students will be eager to enroll in the immediate future.

VII. ADCOP:

We have gained a half dozen or so of ADCOP Personnel. These men are highly motivated students who have made a definite impact on all programs at Del Mar. Generally speaking, they cause classes to be more productive and instruction moves at a higher level. Weak students sometimes despair because of this while the better student is challenged to move with the group.

Following is a comparison of enrollments in Marine Science Technology courses between the pilot group (direct NSF support) and the trailer group (Sea Grant - Texas A&M University support).

Pilot Group

SEMESTER	COURSE NUMBER	ENROLLMENT BEGINNING SEMESTER	NUMBER COMPLETING	NUMBER COMPLETING AND PASSING
Fall '69	MST 301	26	21	19
Spring '70	MST 302	19	16	15
Spring '70	MST 113x	19	16	16
S.S. '70	MST 403a	9	9	9
S.S. '70	MST 405	7	7	7
S.S. '70	MST 403b	9	8	7
S.S. '70	MST 113y	8	3	3
Fall '70	MST 310	10	9	9
Fall '70	MST 414	9	9	9
Spring '71	MST 211	7	7	7
Spring '71	MST 216	7	7	7
S.S. '71	Figures not available. It is known that not one student completed the outlined curriculum and at least two students were certified for the Associate Degree in August 1970.			

Trailer Group

SEMESTER	COURSE NUMBER	ENROLLMENT BEGINNING SEMESTER	NUMBER COMPLETING	NUMBER COMPLETING AND PASSING
Fall '70	MST 301	23	20	19
Spring '71	MST 302	22	22	18
Spring '71	MST 405	22	21	20
S.S. '71	Practicum	12	11	11

Note: The sharp drop in beginning enrollment in the summer of 1971 is due to selected screening to allow the top 12 students to fill the positions available in the first summer practicum.

The concept of a "Summer Practicum" was developed and conducted. Professor T. J. Lambertson is primarily responsible for the outstanding success of this program. In the concept, Marine Science Technology students, in the summer between the freshman and sophomore year, are introduced to life in an operating research environment. The student serves as an apprentice technician, performing tasks as designated by scientists in area participating agencies. The student is obligated for thirty (30) hours per week for the summer and receives eight (8) hours of college credit. Agencies participating in the 1971 Summer Practicum included:

1. U.S. Geological Survey Office at Corpus Christi.
2. University of Texas - Marine Science Institute at Port Aransas.

3. Texas Parks & Wildlife Department (Corpus Christi station).
4. Texas Parks & Wildlife Department (Flour Bluff station).
5. University of Corpus Christi (CPL Cox Bay project).

In summary, the project can be characterized as significant in its accomplishments. The administration at Del Mar has decided that the project should not be continued at this time for incoming freshmen. When the project is reactivated, the knowledge gained by this project will serve as a useful instrument.

Technician Training (Underwater Welding) (Training)

Activity Leader: R. B. Vann, James Connally Campus, Texas State Technical Institute, Waco, Texas

Due to the critical need for qualified personnel in the underwater welding field, a comprehensive training program was instituted at Texas State Technical Institute in September of 1969. The underwater welding program will furnish quality welder divers for entry into the area of underwater maintenance and research. The objectives of the underwater program are as follows:

1. Develop the necessary skills for carrying on the underwater welding process.
2. To develop diving skills.
3. To develop skills in rigging and underwater maintenance.
4. To emphasize the safety and psychological aspects of underwater activities.
5. To develop through experience, a more efficient method in the training of welder divers.

Project Description and Report of Work and Accomplishments

Evidence gathered in the previous training classes indicated that earlier exposure of the students to deep tank operation was extremely successful. This same approach was used in the training of this group of students. The students were able to meet the initial objectives of the diving portion of program earlier in the term and allowed additional time to be spent practicing underwater welding techniques.

A dry habitat chamber was constructed and used in the later stages of the laboratory training. Methods for eliminating fog, smoke and gaseous fumes from the chamber were improved. This gave the students exposure to new underwater techniques that had not been available prior to this time.

Emphasis was placed on related underwater activities such as pipe fitting and hand tool operation, both manual and pneumatic.

During the laboratory sessions the students participated in scuba and hard-hat diving practices in the swimming pool, the 30 foot tank, and in Lake Whitney. The Lake Whitney phase lasted one week and took the students to a depth of ninety feet.

The final phase of training took place in the Gulf of Mexico with the students engaging in training exercises down to a depth of 150 feet.

The installation of four 18" diameter viewing ports in the 30 foot tank allows the students the opportunity to observe demonstrations and lab activities carried on at a depth of 30 feet prior to their entry into the tank.

Plans have been made to conduct two terms of underwater welding in the 1971-72 school year. One session will be from September 1971 to December 1971. The second session will be from May 1972 to August 1972. Sufficient student interest and pre-registration indicate that these sections will contain 15 students each.

PUBLICATIONS AND DOCUMENTATION

The following reports and papers resulted from Sea Grant work in Marine Resources Management during the 1970-71 reporting period.

Technical and General Reports

Bright, T. J. *Bio-Acoustical Studies on Reef Organisms From Lameshur Bay, St. John, Virgin Islands.* Bulletin Los Angeles Museum of Natural History. Los Angeles, California. 1971. In press.

Bright, T. J. *Bio-Acoustical Studies Using the Hydro-Lab Underwater Habitat.* Preliminary Report, submitted to Director of Hydro-Lab Project. Freeport, Grand Bahama. 1971.

Bright, T. J. *Marine Bio-Acoustics.* Lectures on Marine Acoustics, Volume 2. Texas A&M University Sea Grant Program. TAMU-SG-71-404. 213 pp. 1971.

Bright, T. J. and W. W. Schoreder. *Passive and Experimental Bio-Acoustical Studies on Marine Organisms in Their Natural Habitat.* Status Report Tektite II. U.S. Dept. of Interior. Office of the Secretary. October 1970.

Brown, R. A. and H. M. Coyle. *Soil Parameters Required to Simulate the Dynamic Lateral Response of Model Piles in Sand.* C.O.E. Report Number 145. TAMU-SG-71-219. 85 pp. August 1971.

Brown, R. A. and H. M. Coyle. *Soil Parameters Required to Simulate the Dynamic Lateral Response of Model Piles in Stiff Clay.* C.O.E. Report Number 144. TAMU-SG-71-219. 85 pp. August 1971.

Chesnutt, C. B. *Scour of Simulated Gulf Coast Sand Beaches due to Wave Action in Front of Sea Walls and Dune Barriers.* Master of Science Degree. Texas A&M University. June 1971.

Chesnutt, Charles B. and R. E. Schiller, Jr. *Scour of Simulated Gulf Coast Sand Beaches due to Wave Action in Front of Sea Walls and Dune Barriers.* C.O.E. Report Number 139. TAMU-SG-71-207. 54 pp. May 1971.

Chitwood, J. R. *Computer Model of Low-Flow Routing for the Brazos River.* Doctoral dissertation. Texas A&M University. August 1971.

Cooper, R. L., II. *The Effect of Sand Water Mixture on Characteristics of a Centrifugal Pump.* A thesis for Master of Science degree. In preparation.

Dominguez, R. F. and J. B. Herbich. *Revetment Stability Study for Puerto Yabucoa Harbor, Puerto Rico.* C.O.E. Report Number 134. January 1971.

Henderson, H. O. *Design Refinements and Support Systems for the Texas A&M Automatic Marine Corer.* Master of Science thesis, Texas A&M University. College Station, Texas. July 1971.

Herbich, John B. et al. *Status Report on Cavitation of Dredge Pumps.* Report Number CDS-147. July 1971.

Irvine, R. L. *C.E. 683, Estuary Hydrodynamics.* Institutional Grant GH-59 to Texas A&M University. C.O.E. Report Number 136. October 1970.

McClenan, C. M. *The Prevention of Oil Spreading on Water by Pneumatic Bubble Barrier.* Master of Science Degree. Texas A&M University. August 1971.

McClenan, C. M. et al. *Computer Programs in Ocean Engineering.* C.O.E. Report Number 131. TAMU-SG-71-405. 100 pp. 1971.

Machemehl, J. L. *Effects of Slope Roughness on Regular and Irregular Wave Run-up on Composite Beaches.* Doctoral dissertation. Texas A&M University. December 1970.

Machemehl, Jerry L. and John B. Herbich. *Effects of Slope Roughness on Wave Run-Up on Composite Slopes.* TAMU-SG-70-222. C.O.E. Report Number 129. 145 pp. August 1970.

Mason, C. *Properties and Stability of a Texas Barrier Beach Inlet.* Master of Science Degree. Texas A&M University. August 1971.

Mason, C. and R. M. Sorensen. *Properties and Stability of a Texas Barrier Beach Inlet.* TAMU-SG-71-217. 166 pp. August 1971. This report is essentially the Master of Science thesis by Mr. Mason under the direction of R. M. Sorensen.

Newbolt, L. E. and J. B. Herbich. *Hydrology of Coastal Waters.* TAMU-SG-70-225. C.O.E. Report Number 133. 91 pp. August 1970.

Rao, V. S. *Interaction of a Train of Regular Waves with a Rigid Submerged Ellipsoid.* Doctoral dissertation. Texas A&M University. June 1971.

Rao, V. S. and C. J. Garrison. *Interaction of a Train of Regular Waves with a Rigid Submerged Ellipsoid.* TAMU-SG-71-209. C.O.E. Report Number 142. 156 pp. May 1971.

Ross, H. E., Jr. *Dynamic Response of Laterally Loaded Offshore Piling.* C.O.E. Report Number 132. TAMU-SG-70-224. 111 pp. August 1970.

Ross, H. E., Jr. *Dynamic Response of Offshore Pilings.* Doctoral dissertation. Texas A&M University. December 1970.

Shay, M. T. *The Performance of Fading FSK Telemetry Systems with Bandpass Limiters.* Electrical Engineering Department. Texas A&M University. August 1971.

Spencer, Edmund B. and Robert M. Sorensen. *Set-up of Oil on Water by Wind.* TAMU-SG-70-220. C.O.E. Report Number 128. 145 pp. August 1970.

Ward, Michael. *A Method of Tracing Sediment Movement on the Texas Gulf Coast.* Master of Science Degree. Texas A&M University. December 1970.

Ward, Michael and Robert M. Sorensen. *A Method of Tracing Sediment Movement on the Texas Gulf Coast.* TAMU-SG-71-204. C.O.E. Report Number 138. 111 pp. December 1970.

Worthington, H. W. and J. B. Herbich. *A Computer Program to Estimate the Combined Effect of Refraction and Diffraction of Water Waves.* TAMU-SG-70-219. C.O.E. Report Number 127. 57 pp.

Conference Papers Presented

Bailey, E. I. *Development of an Automatic Corer.* OTC Paper No. 1365. Offshore Technology Conference. Houston, Texas. April 1971.

Basco, D. R. *Pneumatic Barriers for Oil Containment Under Wind, Wave and Current Conditions.* Oil Pollution Control Conference. Washington, D.C. June 1971.

Bright, T. J. *Acoustical Behavior of Certain Reef Fishes From Lameshur Bay, Virgin Islands.* American Society of Ichthyologists and Herpetologists. Los Angeles, California. 1971.

Chesnutt, Charles and R. E. Schiller, Jr. *Scour of Gulf Coast Beaches.* ASCE, Texas Section. College Station, Texas. April 1971.

Chesnutt, Charles and R. E. Schiller, Jr. *Scour of Gulf Coast Beaches.* OTC Paper 1352. Offshore Technology Conference. Houston, Texas. April 1971.

Coyle, H. M. and I. H. Sulaiman. *Predicted Behavior of Axially Loaded Piles in Sand.* Offshore Technology Conference. OTC Paper No. 1482. Houston, Texas. April 1971.

Dominguez, R. F. and R. W. Filmer. *Discrete Parameter Analysis as a Practical Means for Solving Mooring Behavior Problems.* Offshore Technology Conference. OTC Paper No. 1505. Houston, Texas. April 1971.

Herbich, John B. *Control of Oil Spills.* First West Gulf Regional Convention of the Propeller Club of the United States. Galveston, Texas. April 1, 1971.

Herbich, John B. and J. Machemehl. *Wave Run-up on Composite Beaches - Effect of Roughness.* Offshore Technology Conference. OTC Paper No. 1431. Houston, Texas. April 1971.

Herbich, John B. and Lynn Hales. *Remote Sensing Techniques Used in Determining Changes in Coastlines.* Offshore Technology Conference. OTC Paper No. 1448. Houston, Texas. April 1971.

Mason, Curtis and R. M. Sorensen. *Characteristics and Stability of a Natural Gulf Coast Barrier-Beach Inlet.* To be presented at the 13th International Conference on Coastal Engineering. Vancouver. July 1972.

Riter, S. *Applications and Limitations of Acoustic Telemetry.* 80th Annual Meeting. Acoustical Society of America. Houston, Texas. November 1970.

Riter, S. *Design Considerations for a PPM Underwater Acoustic Communication System.* 1970 IEEE International Conference on Engineering in an Ocean Environment. Panama City, Florida. September 1970.

Ross, H. E. *Dynamic Response of Offshore Piling.* Offshore Technology Conference. OTC Paper No. 1480. Houston, Texas. April 1971.

Schiller, R. E. and C. B. Chestnutt. *Scour of Gulf Coast Beaches Due to Wave Action.* Offshore Technology Conference. OTC Paper No. 1352. Houston, Texas. April 1971.

Schiller, R. E. et al. *The Hydraulics of Rainfall Induced Water Films.* ASCE, Hydraulics Specialty Conference. Iowa City, Iowa. August 1971.

Shay, M. T. and S. Riter. *The Performance of Fading FSK Telemetry Systems with Bandpass Limiters.* Southwest IEEE Convention. Houston, Texas. April 1971.

Sorensen, R. M. *'Sea Sweep' - Design and Evaluation.* Texas Section, ASCE. April 1971.

Sorensen, R. M. and Curtis Mason. *Characteristics and Behavior of Natural and Artificial Tidal Inlets on the Texas Gulf Coast.* To be presented at the World Dredging Conference. New Orleans, Louisiana. December 1971.

Worthington, H. W. and John B. Herbich. *Computer Prediction of Wave Heights in Coastal Areas.* Offshore Technology Conference. OTC Paper No. 1427. Houston, Texas. April 1971.

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Herbich, John B. *Comparison of Model and Beach Scour Patterns.* PROC. Coastal Engineering, Vol. III. Chapter 80. Washington, D.C. September 1970.

Herbich, John B. *Dredging Methods for Deep-Ocean Mineral Recovery.* PROC. ASCE. Journal of the Waterways. Harbors and Coastal Engineering Division. 1971.

Herbich, John B. *Non-steady Flow on Sloping Beach with Large Roughness Elements.* PROC. XIVth Congress of the International Association for Hydraulic Research. Paris, France. August 29 - September 3, 1971.

Herbich, John B. *Ocean Engineering Programs*. Engineering Education. ASEE. Vol. 61, No. 6. February 1971.

Herbich, John B. *Research: Engineering Resources*. PROC. Third Sea Grant Conference. Oregon State University. March 1970. June 1971.

Riter, S. and P. Boatright. *On Zero Crossing Shifts as a Detection Criteria*. Journal of the Acoustical Society of America. In press.

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Schell, J. et al. *Dereverberation by Linear Systems Techniques*. IEEE Transactions on Geoscience Electronics. January 1971.

Shank, G. E. and John B. Herbich. *Forces Due to Waves on Submerged Structures*. PROC. ASCE. Journal of Waterways. Harbors and Coastal Engineering Division. Paper 7870. Vol. 97, No. WW1. February 1971.

Sorensen, R. M. *Characteristics of Waves Broken by a Longshore Bar*. PROC Twelfth International Conference on Coastal Engineering, Washington, D.C. September 1970.

Sorensen, R. M. *Scour Around a Circular Cylinder Due to Wave Motion*. PROC. Twelfth International Conference on Coastal Engineering. Washington, D.C. September 1970.

Sorensen, R. M. and E. B. Spencer. *Two Dimensional Wind Set-up of on Water*. PROC. Journal of Waterways. Harbors and Coastal Engineering Division. ASCE, August 1971.

MARINE ENVIRONMENTAL QUALITY

Concern for the environment has prompted the development and continuation of marine environmental quality programs within the Sea Grant Program during the 1970-71 period. During this time one project was added involving the study of naturally occurring hydrocarbon seeps in the Gulf of Mexico. The others described here are continuations from the previous year. Reports and documentation resulting from these projects are listed at the end of this section.

Bottom Sludge Accumulation and Oxygen Demand in a Polluted Estuary (Research)

Activity Leader: Roy W. Hann, Jr., Environmental Engineering Division

The project "Bottom Sludge Accumulation and Oxygen Demand in a Polluted Estuary" has had as its primary purposes the evaluation of bottom sludge buildup in terms of volume and organic content and the evaluation of the oxygen balance components in analyzing waters.

In the initial project year, techniques for measuring sediment were developed, utilizing both field sampling methods and Corps of Engineers dredging profiles and records. These methods were tested in Barbour's Cut, a small arm of the Houston Ship Channel, and then utilized for the entire ship channel from Morgan's Point to the turning basin near downtown Houston.

Studies were also made in Barbour's Cut of sediment uptake rate, dye diffusion rates and other oxygen balance components. Expected detailed studies of the entire oxygen balance of Barbour's Cut did not materialize as a result of lower waste load levels caused by low water inflows during drouth conditions, reduced upstream waste loadings, high photosynthesis levels, and the deepending of Barbour's Cut into a deep draft port facility.

Project studies have been expanded to include sediment and oxygen balance studies in other estuaries on the Texas Gulf Coast; to examine the toxic nature of sediments and the biological life found therein; to include evaluation of toxic properties on estuary

polluted water marine organisms and the mechanisms of natural and mechanical aeration of estuarine waters.

Project Description and Report of Work and Accomplishments

The project "Bottom Sludge Accumulation and Oxygen Demand in a Polluted Estuary" is one of several carried out by the Estuarine Systems Analysis Research Group of the Environmental Engineering Divisions Civil Engineering Department. The group is currently carrying out five projects in addition to this one. One is a companion project entitled "Management of Industrial Waste Discharges in a Complex Estuarine System" which began at the time of this effort and the other four are a result of seed efforts initialed under the Sea Grant Program. These are:

Galveston Bay Sediment Analysis - EPA - TWOB
Galveston Bay Reoxygenation Study - EPA - TWOB
Corpus Christi Bay Pilot Study - TWOB
Remote Sensing of Water Quality Parameters - NASA - TWOB

Technical direction of the Sea Grant project is centered on the Texas A&M University campus under the guidance of the project director, Roy W. Hann, Jr. Field activities are centered at the Civil Engineering Department's Morgan's Point Water Pollution Research Laboratory.

During the third project year, project activities were divided into six major task areas. These were:

1. Field survey studies;
2. Sediment studies;
3. Oxygen uptake studies;
4. Reaeration studies;
5. Biological studies; and
6. Facility development.

Field Survey Studies. A series of pilot field survey studies was initiated with vessel operations in several Texas estuaries. These included the Neches and Sabine Estuaries. Chocolate Bayou, the Brazos Estuary (new and old channels), the San Bernard River and Estuary, and the Corpus Christi Ship Channel. All but Chocolate Bayou and the San Bernard Estuary were visited twice. Data were collected on waste loadings, inflow, salinity, temperature, conductivity, dissolved oxygen, organic materials, and sediment depth and type. Water and sediment samples were also collected and stored for later analysis. This data will be used in the verification of analytical models and in developing an understanding of the nature of these systems. Several problem and study areas have been identified as a result of this work.

Sediment Studies. The sediment studies initiated during the early project years were continued with primary emphasis on estuaries

other than the Houston Ship Channel.

Major analysis centered on organic fractions. During the year, laboratory capability for heavy metal determination was added and project effort was devoted to developing analysis techniques for such determinations.

Expanded sediment analysis is planned for the future in view of the recent acquisition of excellent gas chromatography and nutrient analysis capability.

Oxygen Uptake Studies. During the project year, an improved Clark cell oxygen uptake measuring system was developed by project staff members. This apparatus replaces oxygen utilized by biological action with that generated by an electrolysis cell. The current utilized for oxygen generation is measured and converted into mg/l of oxygen demand. This system shows much promise in measuring oxygen balance parameters. A system has been designed but not yet tested to measure algae oxygen uptake.

Reaeration Studies. Pilot literature studies were initiated during the year to examine the technology relating to mechanical aeration of estuarine systems. Such aeration shows promise as a failsafe quality control system in heavily industrialized Gulf coast estuaries. The initial survey has pointed out several areas for further research such as salinity and surface tension effects.

Biological Studies. Formal publication of the study of aquatic organisms in the area from Morgan's Point to the San Jacinto River was made during the project year. This study documented the location and species diversity of the aquatic community and showed, through respiration tests, that stress was exerted in fish by channel water even at high dissolved oxygen levels.

This indicates that the fish kills often encountered in this zone of the channel are probably caused by a combination of toxic material stress and dissolved oxygen deficiency.

A second biological study involves the collection, separation and identification of organisms in the sediments of Upper Galveston Bay and the zones of the Houston Ship Channel near Morgan's Point. Almost a year of monthly sludge samples have been collected from over a dozen channel and bay stations. Sediment organisms, primarily sludge worms, are being identified and examined and the distribution mapped in hope that they may be used as long term indicators of pollution change. Initial results are promising.

Facility Development. The field program in support of this and other Estuarine Systems Projects has been substantially expanded by the acquisition of two new research vessels. These are shown in Figures 1 and 2. These vessels, the R/V DUET, owned by the Environmental Engineering program, and the R/V MARINER, owned by the Sea

FIGURE 1

RV/DUET
Texas A&M University
Water Quality Research Vessel

FIGURE 2

RV/MARINER
Texas A&M University
Water Quality Research Vessel

Grant Program, were both donated for use in coastal zone projects.

Some Sea Grant project effort has been expended in rejuvenating and equipping these vessels to take an active part in Sea Grant program activities.

Project Coordination. During the project year, the project staff members have coordinated activities with the Texas Water Quality Board, the Environmental Protection Agency, NASA, the Corps of Engineers, and several other state, federal and governmental agencies.

Study of Naturally Occurring Hydrocarbon Seeps in the Gulf of Mexico (Research)

Activity Leader: Richard A. Geyer, Department of Oceanography

This report summarizes the major results of the logistics, scientific, public relations and fiscal portions of the first year of this program and includes a proposal for its continuation for next year.

The results are presented under the headings of the four aspects noted above.

Logistics. Four seasonal cruises of R/V ORCA totaling 29 days and covering 2000 miles in seven areas were conducted. Work statements appearing in the program outline based on the proposal of July 1970 were performed. The geographic extent of these field studies is shown in the attached figure as well as the location of the study of Mexican coastal oil (south of Tampico) conducted as a part of this program.

Scientific. Reports submitted for the period September 1, 1970 to August 31, 1971, are included in the section in Publications and Documentations at the end of this section. These include four preliminary and three final cruise reports, six scientific reports dealing with specific aspects of this program prepared by program personnel. Four special reports relevant to the project were also prepared by personnel outside Texas A&M University.

Several tar samples taken from the Gulf and its environs were analyzed. One sample was found floating as a large tar mat in West Cameron Block 368, while another sample was found near the Flower Gardens attached to a piece of sargassum weed. Other samples were obtained from the beach on Padre Island and from the Mexican coastal

seep near Tampico. One other sample was obtained for comparison from a seep site in the Gulf of Cariaco, Venezuela. On a final cruise during the last week in August, floating tar samples and tar lumps collected from sediments dredged from the bottom were obtained from an area about 40 miles south of Marsh Island, Louisiana, in 45 fathoms of water. These samples are undergoing chemical analyses at the present time.

A series of comparative chemical analyses and their significance as related to the objectives of this program are summarized in a special report. A well-defined correlation for some key chemical properties was observed for the tar samples obtained from the beach on the Mexican coast, as well as the one found floating in West Cameron Block 368, and from Padre Island.

In addition to the tarry material found and studied, a number of interesting dissolved hydrocarbon anomalies were measured in the water column at two locations in the Gulf over bathymetric highs. These anomalous values were reproducible and were measured on two cruises three months apart.

During the winter cruise the high concentrations of dissolved hydrocarbons was found to be fairly uniform throughout the shallow water column, whereas during the late spring cruise, maximum concentrations were found at depth. This can be explained by a study of the bathythermograph traces submitted in Cruise Report 3 where a well-defined thermocline is evident at 5 meters. This thermocline would hinder the upward migration of dissolved hydrocarbons in the water column above the thermocline and concentrate them near their source at the bottom. However, during the winter, with isothermal conditions prevailing from the surface to the bottom, no such barrier to migration of these hydrocarbons exists.

Very interesting shallow structures conducive to the upward migration of oil to the water column of the Gulf were mapped in detail with the high resolution subbottom profiler at a number of places studied. These included areas where tar blobs and high anomalous dissolved hydrocarbon values were observed. The detection at these locations of domal geologic features exhibiting widespread and well-defined fault systems demonstrates that readily accessible avenues for migration of oil to the surface exist forming natural seeps.

Detailed paleontological studies associated with the bottom and subbottom bathymetry described in final cruise reports, as well as the special report on this subject, serve as corroborative evidence for a geological history conducive to the formation of natural hydrocarbon seeps in these areas.

The reason for not finding more tar seep material can be attributed to three factors: the now well-demonstrated aperiodicity of natural oil seep activity in other areas, the limited field studies

available during the first year of this program because of the fiscal limitations on shiptime, and the difficulties encountered by the principal investigators in obtaining accurate positions and more precise locations of naturally occurring oil seeps in the Gulf.

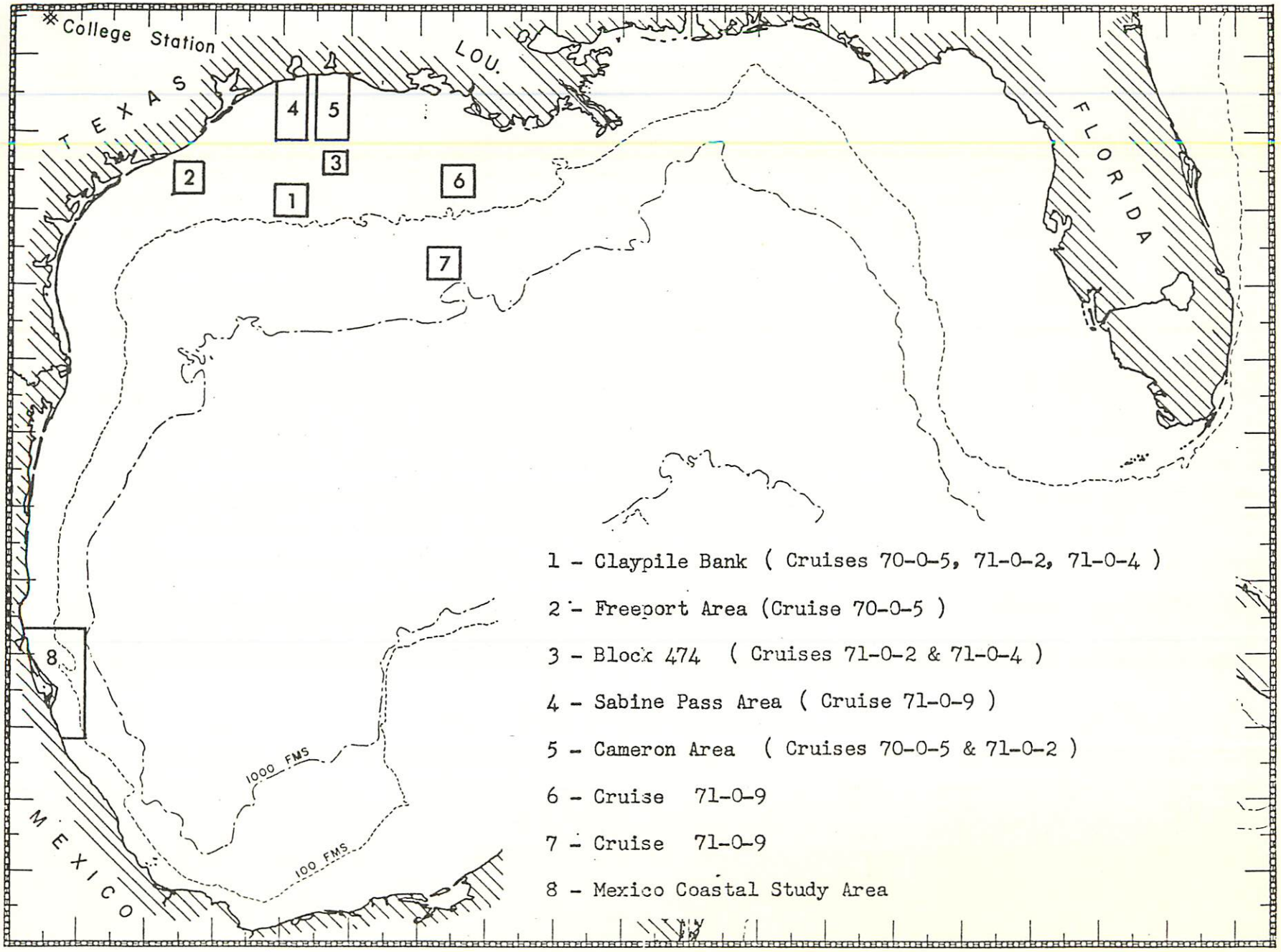
Public Relations - News Releases. Scores of news releases appeared in newspapers across the country with emphasis on those in the Gulf Coast area, as well as items in trade journals and government publications. That the results of these releases were tangible can be demonstrated by letters received from persons and institutions requesting additional information as to the activities of the program. An excerpt from one of these letters written by a Mr. Henderson from Corpus Christi, Texas on December 9, 1970 is interesting - "Prior to reading this particular story, I had thought that the tar on Mustang and Padre beaches had washed ashore from sources associated with the offshore oil production - in other words, it had either been dumped or allowed to escape at the offshore platforms. I have changed my mind and have since credited the source of this tar to offshore seeps."

A number of these releases were also carried in two Sea Grant publications; one, Coastscripts, directed specifically toward several hundred citizens, legislators and academic people in the Gulf Coast area, and the other, Sea Grant 70's, directed to the same type of audience having a widespread circulation throughout the country.

An active interest by a large number and wide variety of government agencies in this program was evidenced not only by correspondence but also by actual cooperation. For example, the U. S. Coast Guard helped in our drift card circulation studies over the past year and the Environmental Protection Agency, Division of Oil and Hazardous Materials, analyzed some of the tar samples. The U. S. Geological Survey also cooperated in our drift card study program and supplied us with their results. Other cooperative agencies were the Maritime administration and the U. S. Department of Interior, Park Service. These together with other work is summarized on the special report on this study.

Two papers are scheduled for presentation discussing the results of this program - one at the A.A.P.G. Convention in Denver, April 17-19, 1972; the second at the O.T.C. Conference in Houston, May 1-3, 1972.

The project was able to achieve first year objectives because of the excellent cooperation received from several of the oil companies in the way of special services to the program. This included Chevron Oil Company and Humble Oil and Refining Company supplying additional chemical analyses of tar samples; and the availability of the Gulf Oil Company equipment for measuring dissolved hydrocarbons in the water column and making these results available to the program.


College Station
TEXAS
LOU.
FLORIDA
MEXICO
1000 FMS
100 FMS
30°
25°
20°
95°
90°
85°
80°
1 - Claypile Bank (Cruises 70-0-5, 71-0-2, 71-0-4)
2 - Freeport Area (Cruise 70-0-5)
3 - Block 474 (Cruises 71-0-2 & 71-0-4)
4 - Sabine Pass Area (Cruise 71-0-9)
5 - Cameron Area (Cruises 70-0-5 & 71-0-2)
6 - Cruise 71-0-9
7 - Cruise 71-0-9
8 - Mexico Coastal Study Area

Marine Bioengineering
(Research)

Activity Leader: D. T. Hanson, Department of Chemical Engineering

This project is directed to the demonstration of methods that are necessary to new productive and assimilative usages as well as control of microflora which grow in fluid suspensions. The applications therefore entail large-scale material processes. Such applications are achieved in defined regions such as confined regions of natural habitats or within industrial systems. Achievement of useful new processes as well as improvements of existing ones require the following:

1. Accumulation of information on data which are appropriate to items 2 and 3 below;
2. Use of those data to describe problems which presently block the applications that are sought as well as to substantiate the full-scale applications that will solve those problems.
3. Constructions of the described full-scale applications which solve the problems posed and which thereby achieve the actual applications that are sought.

The third of the above is the set of desired results or objectives, and the first two are the accepted means to those objectives. Capacity to achieve the first two must be established in virtually any research which proposes new or improved processes. Claims to new applications cannot otherwise be validated. That is, the first two are necessary to establish existence and benefits of applications before applications are made. Contrary attempts at applications can be shown, by extensive examples, to produce costly full-scale failures.

The goals of this project have therefore been to demonstrate comprehensive methods that include the following:

1. Specifications of inputs that are necessary to results which will have applications in productive and assimilative usages as well as control of microflora that grow in fluid suspensions;
2. The use of efficient experimental designs of material inputs, experimental programming of process variables and determinations of desired responses to these as necessary to provide data that specify new full-scale applications and their economics;

3. The use of computational methods that are necessary to directly apply the data obtained to the logical selection and design of full-scale systems
   (a) which have applications
   (b) which optimize returns in desired responses for either given or minimum investments;
4. The location of users who will buy construction of the actual applications on bases of results sustained through the above.

It may be generally observed that applied research is not applied unless means sufficient to the actual applications are provided. Applied research cannot be applied unless necessities to those applications are provided. It is thus sought to show most efficient methods to both necessity and sufficiency in applications of both pure and mixed populations for large collections of microflora. This is consistent with optimization of actually useful objectives for minimal or given investments.

Project Description and Report of Work and Accomplishments

The past year's research represents one year's work of a two year proposal that was submitted. User's of applications have been located. Completion of this applied research is funded through sources other than the Sea Grant Program in the present year. Substantial results toward objectives of this project were, nevertheless, achieved in the past year.

Several important observations have been made in past years. Their necessity to applications as well as to most efficient applications do not seem uniformly well known. The observations have therefore been described by publication, presentation, and discussion in the past year for their use by others. This is consistent with the fact that applications are of limited usefulness unless they are useful beyond self. Observations that are important to productivity beyond numbers of publications and funds to produce these are therefore briefly reviewed first.

Work with living systems is normally work with systems in which the set of materials cannot be entirely identified in molecular terms. At the same time, a complete set of materials must be specified in reproducible terms for reliable applications to be described. New process applications in this light must entail solutions of several problems. Solutions are in the selection of microbial populations; selection of additionally required material inputs; demonstrations of reproducibility and repeatability of desired process responses to repeatable and complete input and process stimuli; definitions and improvements of large-scale processes

and their economics from results obtained; commitments of users to implement construction on the basis of applications thereby established. The problems are that the quantitative solutions are not entirely available with the initiation of applied research.

It is clear that methods of several disciplines are normally required in order to proceed from the problems to their solutions. A suitable set of disciplines from which defined methods must come have been established in prior reports. Methods from these disciplines have been coordinated in this project.

Most efficiency in the achievement of applications might be expected if use of strictly disciplinary methods were provided by individuals from those disciplines. This is generally true, however, only to the extent that there is commitment of individuals to common objectives, that each individual recognize the limitations of his own disciplines, and that each individual establish precisely where the methods of his disciplines will complement results of the others in the achievement of objectives. When this is done there is capacity to logically establish considerably greater extent of actual applications with greater efficiency than can be accomplished by a single discipline above. Interdisciplinary capacities would not otherwise be of particular value.

The suggested approach offers constructive alternatives to practices that are widely seen. That is, criticisms of methods of one discipline by individuals trained in others are often seen. This may be destructive to the individuals who offer the criticisms when they are not qualified in the discipline that they criticize. When invalid criticisms are accepted by others they tend to be more widely destructive to valid technical work.

Similar criticisms of interdisciplinary work are also seen by individuals of inappropriate disciplines. This frequently seems to result through inability from singular training to understand more extensive results or the means to them. Interdisciplinary capabilities would not be of value without extent beyond the capacities of a single discipline. Yet, efficient and technically valid interdisciplinary work is sometimes rejected in emotive rather than technical terms. This may be individually simpler than are either learning or seeking the corroboration or rejection through those who are properly qualified. Results of such singular rejections of valid technical work seem widely destructive.

It is felt that criticisms of results should be properly substantiated. Criticisms are generally more acceptable if constructive alternatives are also provided. Thus, as opposed to destructive results of interdisciplinary conflict, constructive cooperation has been suggested. Such cooperation and extensive applications which can be thereby achieved have been substantiated for demonstration in this project.

Constructive alternatives should also be offered for individuals who criticize technical work without proper qualifications to do so. There is often little time to indulge in the new learning required for technical rejection or corroboration. Consultation with individuals who have had benefits of interdisciplinary interaction would be a useful alternative. If this is not convenient, it would be useful to consult with individuals trained in the appropriate disciplines.

Further constructive observations that have been particularly useful in this work are described below.

Experimentalists often avoid variations in results caused by differing distributions in properties of materials. Operability of full-scale systems depends on what these distributions are. Thus, while the problems are often seen and avoided in small-scale experiments, the solutions are not seen unless provisions are made to determine effects of varying distributions with such experiments. These determinations are necessary to solve problems of scale-up as appear to be the only known alternatives to full-scale trials and full-scale errors. Neglect of these problems often produce inoperable or inefficient large-scale systems as well as claims that there are no solutions. Solutions of these problems require particular disciplinary experience as do the solutions to problems of measuring properties of the materials involved. Proper disciplinary methods have been included in this project.

Second, the usefulness of experimental results of actual applications normally requires the use of continuous systems. This is generally true of systems in which simultaneous reactions and mass transfer occur. Batch systems are known not to reproduce behavior of abiotic and biotic materials in continuous systems. Therefore, continuous behavior cannot be predicted from batch data alone (which seems most common). Microbial processes in natural habitats are known to be continuous processes. Most efficient industrial applications of microbial populations are frequently continuous processes. To obtain results which validly apply to these cases therefore requires the use of continuous systems. Appropriate continuous systems are used in this project. (These are neither simple chemostats nor simple turbidostats).

Third, in the objective of actual applications it is sensible to coordinate methods of required disciplines to simultaneous accumulation of data from the same systems. Work toward applications frequently requires costly duplication of efforts when such coordination is not provided. Further, most useful results otherwise obtainable are often not seen unless such coordination is provided. Such coordination has been provided in this research.

Finally, coordination of methods from several disciplines to

the same systems at one time produces efficient parallel efforts and results. It can be shown that there are specific and critical essentials to results. Beyond these, however, the parallel work eliminates blockage in results from one discipline by lack of results from the others. In contrast, collective results from mutually coordinated work can be shown to be mutually complementary and synergistic to extent of results and applications achieved.

Particular accomplishments of the past year are described below.

Substantiation of either new or improved processes requires that applications be shown which have not yet been applied. Neither experience nor results of others are entirely available in applications not yet applied. Substantiation of new applications must therefore be done through basic laws, principles of appropriate disciplines, and data. The laws and principles dictate data required for applications as well as how these are applied in large numbers of cases. Particular data will particularize the applications. The laws and principles, however, permit description of most efficient means to data accumulation for most extensive permissible scope of applications.

Thus, for large collections of microflora that grow in fluid suspensions it has been shown that multiple continuous systems are necessary to appropriate design and programming of experiments and resultant experimental efficiency. In such systems it has been shown that at essentially one time it is permissible,

1. to determine utilization rates of abiotic materials, production rates of extracellular metabolites, production rates of endocellular materials, production and utilization efficiencies, growth limiting conditions for multiple substrates, biomaterial concentrations and growth rates, and (in the case of photosynthetic microflora) photosynthetic quotients;
2. and that the simultaneous data permit prediction of the above in terms of a complete set of quantities that can be measured, constructed, and controlled.

The published results provide means necessary to solve the distributional problems that are inherent in the scale-up to full-scale systems. The predictive capacities which have been shown are necessary to effective design and control of large-scale microbial processes for either environmental control or for biomaterial and biochemical production. This is true for microbial processes of marine utility or origin as well as for other microbial processes. Feasibility of massive data accumulation required, data analysis, and testing of predictions are shown with particular

data obtained through prior work that was not funded through the Sea Grant Program.

Since the methods are widely useful they have been used during the past year with continuous cultures of the marine alga, Dunaliella percei. Process responses of particular practical interest are:

1. Production rates and efficiencies of endocellular proteins and carbohydrates as well as oxygen;
2. Utilization rates and efficiencies of nitrates, phosphates, and carbon dioxide.

Simultaneous data obtained provide information necessary to describe processes that optimize each desired response.

Since the methods are widely useful it is planned to use them with continuous cultures of the marine bacterium, Aeromonas proteolytica. Capacity to obtain required data for such particular systems has been shown in the past year. Completion of this work in this second year of proposed research requires funding from sources other than the Sea Grant Program. Additional responses of particular practical interest for these systems are production rates, efficiencies, and activities of enzyme systems.

To decrease investments of others in similar practical work that is necessary to applications it was felt desirable to show some additional methods. These methods directly use transient data of continuous cultures to describe both start-up and steady operating conditions of designed processes. Experimental time to given results are thereby expected to be reduced to less than 25% of that required by conventional procedures which require waiting out achievement of steady states. Neither turbidostatic nor chemostatic operations are suitable for these purposes. Savings are expected to be appreciable, particularly in cases where several hundred hours are required to show a single steady state. Data and procedures to test predictive capacities of these methods have been completed. Completion of tests is currently being supported through departmental funds.

To further decrease investments of others in similar practical work it was felt desirable to show that parametric mathematical models are unnecessary to predictions (as necessary to new applications). This is of value in eliminating costs and time of formulating new mathematical models which are of more restricted utility than the data obtained, for which there are no prior assurances of results, and for which the same data are required for rational formulation of such models. More direct applications of data are more efficient. It is also felt useful to contradict universal claims of mathematical models published but which have more limited scope of actual

applications than data which were obtained to formulate them. Procedures and data which demonstrate more constructive alternatives have been obtained. Completion of this work is being funded through other sources in the past year.

Since methods substantiated here are widely useful it has been permissible to show their direct applications to solutions of problems in chemicals discharged to marine and other natural waters. This has been widely accepted by technical representatives of those who must buy construction of applications described by such applied research. By showing practical solutions of problems in the present year (by methods of the past years) it has been shown permissible to work directly with

1. known materials of known toxicity levels that are presently discharged, which are not included in wastewater permit specifications, and for which present treatment technology appears to be unknown;
2. materials for which neither identification nor determination of their environmental effects are likely to be externally determined in the forseeable future.

By showing solutions it has been permissible to widely work with the internal materials that are necessary to the quantitative solutions. Necessary experimental controls are not otherwise available, and solutions of chemical-environmental problems cannot be substantiated without these. Substantial points of blockage which are either not widely recognized or for which solutions are not known are resolved by substantiating solutions. Procedures involved have been shown in prior reports to be quite consistent with poor economics of both pollution and treatment. Procedures improve the economics of treatment.

Development of Waste Treatment System (Research)

Activity Leader: Roy W. Hann, Jr., Environmental Engineering Division, Civil Engineering

The primary purpose of this project was to demonstrate the use of two concepts which are deemed suitable for use in shipboard waste treatment.

The problems of fresh sewage, intermittent loading, and ship roll limit the use of conventional waste treatment systems for shipboard waste treatment.

A pressurized system was to be used to increase oxygen transfer and to negate problems of ship roll. Starch was to be used as a substrate to simulate the colloidal nature of fresh sewage and cell disruption was to be used to improve the hydrolysis rate of the starch metabolism.

A secondary purpose of the project was to continue the evaluation of the effect of salinity on biological treatment processes and organic decay in the environment.

Project Description and Report of Work and Accomplishments

During the project year a bench seale pressurized batch process treatment system was developed and utilized for several study sequences. The simplified system flow diagram is shown in Figure 1.

The microbial starch hydrolysis rates for the systems with and without cell disruption were determined as was the determination of maltose and other hydrolysis product removal rates of an unpressurized pressurized system.

A major function of the system was the maintenance of a pressure of up to four times atmospheric pressure which materially increased dissolved oxygen transfer.

The individual process sequences tested are outlined below.

Phase I. Batch Tests

A. Determine colloidal and soluble carbon removal rates in a natural (i.e., unsonicated, unpressurized) system.
B. Determine the removal rate of solely soluble carbon in a natural system.
C. Determine the removal of soluble carbon from the system when enriched with hydrolysis products and nutrients.

Phase II. Sonication Test

Similar sequence as above but with the use of cell disruption.

Phase III. Pressure Tests

A. Measure the uptake of maltose in the pressurized system.
B. Same as A except for the addition of hydrolysis products.

Project results showed that pressure and cell disruption increase the hydrolysis of starch by from 15 - 30%. Final results

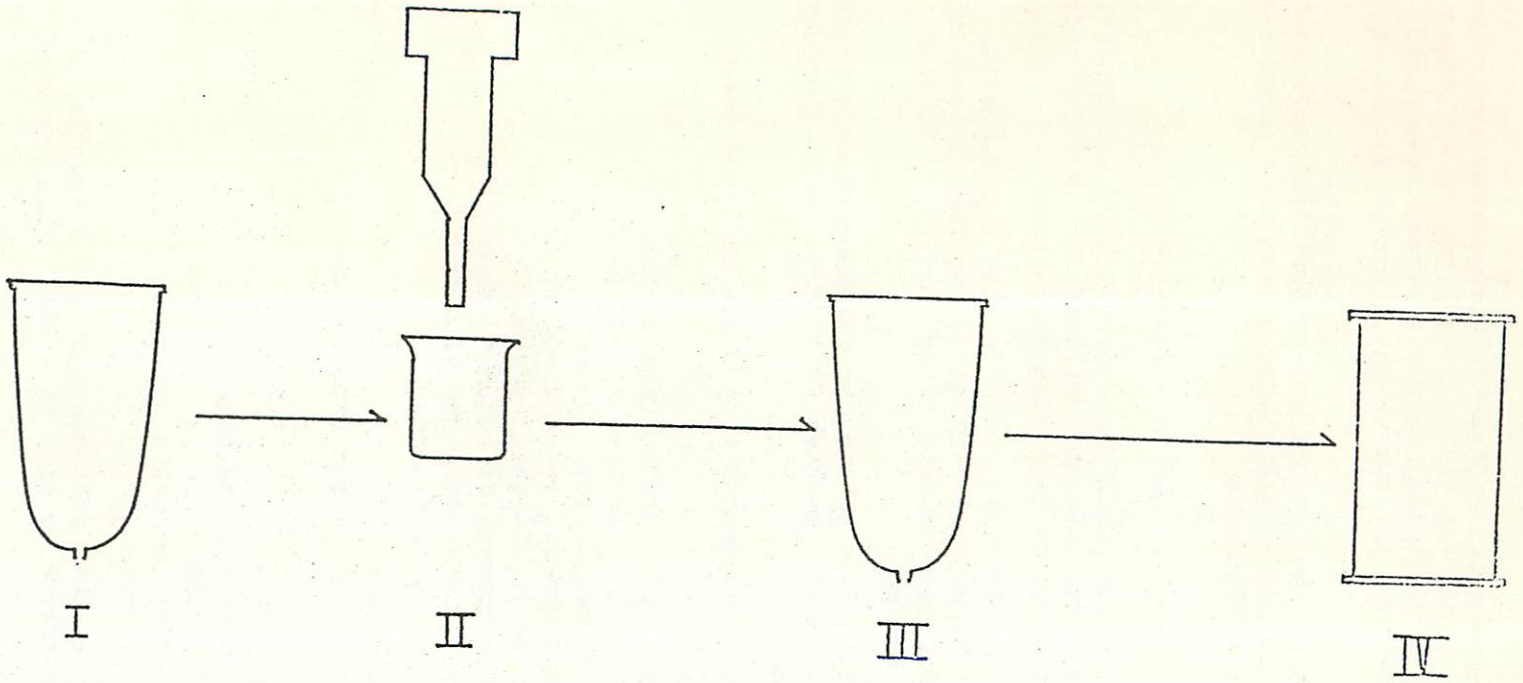


Figure 1. UNIT PROCESS

I Parent Culture Reactor
II Sonication
III Hydrolysis Reactor
IV Pressure Reactor

are being prepared for inclusion in a Ph.D. dissertation and a technical report.

The project examining the effect of salinity on the biological response to organic chemicals was substantially reported in a technical report, "The Effect of Salinity on the Removal of Some Aliphatic Keytones." Some concluding work was carried out during the current project year. The general project conclusions are as follows:

1. Decrease in organic substrate removal rates by mixed biological culture was observed and found to be proportional to the magnitude of the salinity shock.
2. The oxygen requirement per unit organic (ketone) removed increased for a culture acclimated to a certain salinity and shocked with lower salinities.
3. The biomass increase per unit organic (ketone) removed was higher for cultures established and tested at low salinities.
4. The results of long term salinity studies clearly indicated that cultures established in fresh water and low salinities have a higher rate of removal than the cultures established at greater salinities.
5. Selective organic removal was observed. Specifically the removal of 2-butanone and 2-pentanone occurred first in all test series. Acetone removal started when the concentration of the two ketones reached low levels.
6. The microbial species diversity was narrowed as the salinity level increased.

PUBLICATIONS AND DOCUMENTATION

The following reports and papers resulted from Sea Grant work in Marine Environmental Quality during the 1970-71 reporting period.

Technical and General Reports

Geyer, Richard A. *Evaluation of Data Analyses Reported for Cruise 71-0-2, February 22-27, 1971.* 89 pp. May 1971.

Jeffrey, Lela et al., B. Koons and S. R. Silverman. *Three Chemical Analyses of Hydrocarbons from the Marine Environment.* 19 pp. September 1971.

Mousseau, R. J. *Summary of Light Hydrocarbon Seep Study in Gulf of Mexico, 1970-1971.* Texas A&M University and Gulf Research and Development Company. Pittsburg, Pennsylvania. 20 pp. September 1971.

Parmer, David L., S. H. Hopkins and Roy W. Hann, Jr. *Biological Studies of the Houston Ship Channel.* ESP Technical Report No. 20. 151 pp. June 1971.

Parmer, David L., S. H. Hopkins and Roy W. Hann, Jr. *Selected Houston Ship Channel Studies.* ESP Technical Report No. 21 62 pp. June 1971.

Poag, C. Wylie. *Micropaleontology of Claypile Bank, Texas Continental Shelf.* 67 pp. August 1971.

Poag, C. Wylie and William E. Sweet, Jr. *Topography, Structure and Micropaleontology of Claypile Bank, Texas Continental Shelf.* In: Texas A&M University Oceanographic Studies, Vol II. Gulf Publishing Company. Houston, Texas. (In press).

Sweet, William E., Jr. *Evaluation of Data Analyses Reported for Cruise 71-0-4, May 24-30, 1971.* 27 pp. July 1971.

Sweet, William E., Jr. *Final Report of Cruise 71-0-2, February 20-26, 1971.* May 1971.

Sweet, William E., Jr. *Final Report of Cruise 71-0-9, August 23-27, 1971.* August 1971.

Sweet, William E., Jr. *Preliminary Report of Cruise 70-0-5, December 2-8, 1970.* 4 pp. December 1970.

Sweet, William E., Jr. *Preliminary Report of Cruise 71-0-2, February 20-26, 1971.* 9 pp. March 1971.

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Sweet, William E., Jr. *Preliminary Report of Cruise 71-0-9, August 23-27, 1971.* 8 pp. September 1971.

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Sweet, William E., Jr. *Water Circulation in Gulf of Mexico.* 11 pp. September 1971.

Sweet, William E., Jr. and C. Wylie Poag. *A Study of Natural Hydrocarbons in the Gulf of Mexico.* 25 pp. February 1971.

Wigley, Henry. *Temperature Effects on Unit Reaction for a Batch Microbial System Acclimated to Acetone in a High Salinity Medium.* Master of Science Degree in Civil Engineering. Texas A&M University. In preparation.

Zoellner, David. *Development of a Bench-Scale Pressurized Activated Sludge System Using a Colloidal Substrate.* Ph.D. Degree in Civil Engineering. Texas A&M University. In preparation.

Conference Papers Presented

Hann, Roy W. and Welford S. Hutton. *Organic Sludges in the Houston Ship Channel, Their Source, Nature, Effect and Removal.* Proceedings World Dredging Conference (WODCON III), Singapore. pp. 247-271. 1970.

Hann, Roy W. and Welford S. Hutton. *Source, Nature and Effects of Organic Sludges in the Houston Ship Channel.* Presented at the Texas section of the American Society Civil Engineers. El Paso, Texas. 1970.

Hanson, D. T. et al. *Continuous Propagation of Microalgae: Part III. Material Balance Relations.* Chemical Engineering Progress Symposium Series, Vol. 67, No. 114. American Institute of Chemical Engineers. New York. pp. 151-164. 1971.