LOUISIANA SEA GRANT PROGRAM

A Report on the Louisiana Sea Grant Program
for September 1, 1971 through August 31, 1973

LSU-SG-75-01

Center for Wetland Resources
Louisiana State University
Baton Rouge, Louisiana 70803

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TABLE OF CONTENTS

INTRODUCTION

Since Louisiana State University first participated in the National Sea Grant program in 1968, the University's concern for the state's marine sector has mushroomed. At the outset, marine-oriented research activities were scattered throughout several academic departments and the Coastal Resources Institute, but no central focus or unifying theme existed for these efforts. With the initial Coherent Project grant from the National Science Foundation, investigators from several departments joined in a coordinated field effort to assess the potential of Louisiana's vast coastal wetlands for large-scale shrimp mariculture. In rapid succession, biologists were joined by earth scientists, food and fishery technologists, engineers, lawyers, economists and others for whom the investigation, management, and development of coastal areas and resources held a special challenge.

Sea Grant responsibilities were transferred to the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, in 1970, and an immediate consequence was a renewed emphasis on practical research and application of that knowledge.

Sea Grant activities are designed to attack all facets of a problem--not just those aspects that appeal to individual scientists. Louisiana's program is concerned with management of all the state's coastal and marine resources. This has fostered extensive communications with groups and individuals representing state government, public education, and marine resource users. Planning and management of all Sea Grant education, research, and advisory service activities are undertaken with a prospective user's needs in mind.

When needed capabilities were already available in the university, they were incorporated into the program. In other instances, individuals having needed qualifications were recruited elsewhere. Several investigators in other Louisiana universities have received support for research on topics that meshed with overall program objectives. One of Sea Grant's main strengths is the spirit of multidisciplinary and inter-university cooperation that has characterized its activities virtually from the beginning.

Although funding from both federal and university sources is clearly essential for needed program continuity, other mission-oriented sponsorship is vital to insure the applied and pragmatic focus intended by Congress for Sea Grant activities. This means that people associated with university Sea Grant programs must be available to respond to problems articulated by others, and within time frames dictated by the information users. It also means that Sea Grant people must establish a presence in marine-related affairs outside the university, and aggressively seek out opportunities to transfer research findings into the mainstream of public affairs. Traditional university policies, practices and attitudes are somewhat inimicable to these activities--which may indeed detract from discipline-oriented, individualistic,

basic-research efforts--but we believe that society is demanding the kind of accountability from its institutions that Sea Grant is intended to provide for the marine sector. In this light, major projects that draw on the fund of knowledge and organizational capability generated with Sea Grant sponsorship--e.g., those by the U.S. Army Corps of Engineers, Louisiana Deep Draft Harbor and Terminal Authority, and the consortium of oil companies comprising the Louisiana Offshore Oil Port, Incorporated--become, in effect, integral parts of the Louisiana Sea Grant Program, and are treated as such in this report.

SYSTEMS ECOLOGY

Prologue

Louisiana's "fertile fisheries crescent" had long been taken for granted by its hardy residents, but the logistical difficulties and costs attending scientific field work had discouraged all but a few intrepid researchers before Louisiana's Sea Grant program started in 1968. Then, for the first time, LSU scientists could launch a multidisciplinary research effort in the coastal marshes on a scale that would justify the large and expensive logistical effort needed to support it. Sea Grant required a theme of practical importance, but that was easy--this region was acknowledged as the most productive nursery ground for commercial fisheries in the northern Gulf of Mexico, but no one really understood how or why it functioned. If scientists could unlock the secrets of its natural productivity, perhaps vast areas could be adopted in their natural state for shrimp culturing and other profitable enterprises, and perhaps these would suffice as economic incentives to stem the natural and man-made forces that threatened to destroy this wasting "last frontier."

So in early 1969 field activities finally began on the Barataria Bay Project, named for a major bay-marsh complex in southeastern Louisiana that Wild Life and Fisheries Commission personnel described as the state's most biologically productive estuary. Work during the first two field seasons might be called reconnaissance; samples, measurements, and studies at widely dispersed locations assessed factors that varied spatially, such as salinity and vegetative types, as well as those that changed with tidal stage and season. To aid in later correlation of these variables, stations were chosen to span a range of saline and brackish marsh types, and most data gathering was coordinated at these sites. Living organisms under initial scrutiny were animal populations, including fish, shrimp and bottom mud invertebrates; microbial flora of the water and bottom muds; marsh grasses, phytoplankton and epiphytic algae; and yeasts, fungi and bacteria. Chemical analyses of waters and muds concentrated on inorganic nutrients and total lipids. Instrumentation was installed on fixed platforms for continuous recording of key water quality and meteorological parameters.

Each day in the soupy marsh brought new problems, new experiences, and new appreciation of the difficulties inherent in marsh operations. But operational skills developed steadily, and Sea Grant researchers, faced with the absolute necessity for coordination of sampling trips and sharing facilities, began to develop the understanding of each other's work which is so vital to a truly interdisciplinary program.

Systems Analysis

Perspectives gained from the first several field seasons led to a reevaluation of the program's objectives, and investigators concluded that broader understanding of the total ecosystem would be needed before

comprehensive development plans--including those for increasing shrimp harvests--could be made. Meeting as a team under the tutelage of Ralph Pike and Bert Wilkins, system analysts from Chemical Engineering, investigators hammered out a detailed plan for study, synthesis, and operational research of the total estuarine ecosystem. Their formal characterization of this ecosystem called for a highly structured approach to the field studies, with syntheses of the system's trophic structure as a primary goal.

Since trophic relationships are concerned with flow of energy--as food--through ecosystems, they imply understanding of photosynthetic energy-fixing by plants, and subsequent utilization of that energy by various consumer species. For this purpose, biological studies of the various organisms that make up the complex estuarine food web must yield quantitative measures of their standing crop biomass, food consumed, energy lost through respiration, and utilization by species at higher trophic levels. To account for all energy flowing through the ecosystem, all quantities must be converted to carbon-equivalent measures. This synthesis of trophic relationships would integrate practically all the biological data gathered during previous years and provide a means of identifying gaps in the overall program to be filled by subsequent work. But most important, it would provide a scheme by which the relative importance of every consumer species in the marsh, as well as the marsh plants themselves, could be assessed in terms of its utilization by commercially important shrimp and fish. Equally important, through estimates of plant material not consumed on the marsh but flushed into the larger bays and open Gulf of Mexico, the contribution from coastal marshes, to the inshore and offshore aquatic consumer food chains could be examined. With informational inputs, scientists could apply advanced methods of simulation and analysis to evaluate alternate uses of the estuarine marsh and its living resources--problems that confront state resource agencies, legislators, planners, and environmentalists almost daily.

To implement this approach, field work was concentrated in the vicinity of Airplane Lake, selected as the "type" salt marsh location. Later, other typical wetland environments would be studied intensively, but the predominant importance of salt marsh as a nursery ground for many marine fish and shellfish gave it top priority.

Estuarine Productivity

Botanical studies measured net annual production of the marsh grass, Spartina alterniflora; epiphytes--represented by filamentous algae and diatoms; and the phytoplankton community of microscopic floating plants.

Spartina alterniflora is truly the salt marsh "staff of life"; it accounts for almost 90% of the marsh primary production on an annual basis, with filamentous algae attached to Spartina stems accounting for most of the remainder. In basic energy units, primary production values found for Louisiana salt marsh were significantly higher than those reported elsewhere, and exceeded reported figures for high-yielding agricultural crops. Seasonal differences in production and those related

to streamside versus inland locations were noted for each group, and rates of Spartina decomposition and export to the estuary were measured.

Growth and Physiology of Marine Organisms

How the marsh grass becomes available to higher trophic levels is a fundamental question, still poorly understood. Certainly microorganisms, including yeasts, fungi, and bacteria, play important roles in this process and the related matter of nutrient recycling. Sea Grant food scientists and microbiologists have teamed together since 1969 in field and laboratory studies on several aspects of this problem. Studied were the breakdown and enrichment of marsh grass by microbial activity; degradation and release of nutrients in chitin comprising the exoskeletons of, e.g., shellfish; and the microbial role in conversion of foodstuffs by shrimp. Investigators determined the biomass and species composition of the microscopic communities that occupy the Spartina stems and root zone (rhizosphere). High populations and a relatively small number of species were present--the rhizosphere is an extremely selective habitat. Investigators found that cellulolytic bacteria share the initial task of plant tissue breakdown with filamentous fungi, and measured the microbial biomass on Spartina in various stages of degradation.

Yeasts lack the necessary enzymes to attack cellulose directly, but nevertheless participate in the decomposition of intermediate carbohydrates and lipid constituents. Further laboratory study of the dominant yeast, Pichia spartinae revealed that it could play a key role in the large-scale, industrial production of single-cell protein from waste materials such as sugarcane bagasse--a process that could help to alleviate global protein shortages.

The metabolic breakdown of marsh grass by bacteria was examined in laboratory experiments designed to simulate natural conditions, and almost complete bacterial conversion of Spartina detritus in 30 days was noted. Such conversion produced an order of magnitude increase in nitrogen content, indicating that protein stored in the bacterial cells is a more important nutrient source to detritivores than the detritus itself. Knowledge of the amino acids and enzyme reactions characteristic of these bacteria was applied by microbiologist/food scientist Samuel Meyers in developing commercial shrimp rations for emerging maricultural enterprises.

Chitin turnover was verified as a principal means of recycling organic matter stored in the horny shells of such animals as shrimp, crabs, copepods, coelenterates, and protozoans. Although large populations of chitinaceous animals are present in the marsh, occurrence of their remains in the sediments is very rare because of bacterial decay. Chitin decomposing bacteria are very numerous in highly organic soil deposits, especially at microsites presumably created by deposition of dead exoskeletons, and they account for about 20% of the total bacterial population. Rates of chitin decomposition were measured in field experiments spanning a yearly cycle. Chitin may be an important factor in large-scale crustacean mariculture, where large quantities of shells, peels, and other wastes are produced during processing. Just as the farmer returns nutrients in barnyard manure to maintain productivity

of his land, those who undertake intensive crustacean culture in natural impoundments may profit from methods that return nutrient-rich chitin to their ponds. Louisiana firms that produce dried shrimp have found a ready market for chitinaceous by-product shrimp meal as garden fertilizers; its nitrogen content is comparable to general-purpose lawn fertilizer.

Universally, scientists recognize that brown and white shrimp in natural environments are bottom feeders with a predilection for soft, organic materials. Not so well understood, however, is what they look for in these areas. One theory holds that they feed indiscriminately on everything in their path--humus, bacteria, plant detritus, small animals, and whatever doesn't eat them first. Another postulates that they pick and choose, working over the bottom sediments to select the richest morsels. Stomach content examination cannot provide needed answers because of difficulty in identifying most of the materials. So Sea Grant researchers have attacked the problem from several viewpoints.

If shrimp ingest bottom organics indiscriminately, then amino acid spectra of the sediments and gut contents should be similar--but they weren't, at least in those selected for analysis by organic geochemist Clara Ho. But perhaps a rearrangement of the basic amino acids occurs in the shrimp digestive system. After all, certain types of bacteria possess this enzymatic capability. So graduate student Mary Hood added chitinoclastic bacteria commonly found in the marsh to prepared rations being fed to shrimp, and counted those that survived passage through the digestive tract. The resulting high survival rate was evidence that shrimp digestive enzymes may be relatively ineffective in breaking down the bacterial cell walls. Further, she found that both the bacteria and the shrimp produce enzymes (chitinase) which can convert ingested chitin into other products needed for growth and development of the shrimp.

Graduate student Richard Condrey tested assimilation efficiencies of several "natural" shrimp diets, along with prepared artificial diets. Highest conversion rates were found for diatom cultures, diatom-bacteria mixtures, and a commercial trout chow. The algal mat which occupies Spartina stems in the intertidal range was a moderately good food source, and, surprisingly, an experimental ration comprised of 30% shrimp meal ranked last.

Much of the conflicting evidence about shrimp feeding habits has been resolved by field investigations in Airplane Lake, carried out by zoologist Harry Bennett and graduate student Ralph Jones. Brown shrimp were trawl-sampled at nearshore and mid-lake stations during an entire spring season, and gut contents were compared with bottom sediments at these locations through analyses of total proteins, organic matter, and particle size distributions. Results showed that small juveniles--under 45 millimeters length--gobble up fine sediments indiscriminately, and at a very high rate. To compensate for the low organic nutrient value of this material, they manifest higher protein assimilation efficiency than their larger brothers. But the larger shrimp are selective feeders, and predatory as well, as evidenced by proportionately higher numbers of resistant animal parts found in their foreguts. They also attest to the fishermen's adage that "it takes big bait to catch big fish"--large

particles of detritus formed most of the foregut content of the large shrimp.

Chemistry

It would be virtually impossible to interpret the fabric of a coastal zone ecosystem without reference to its soil and water chemistry. In the Louisiana coastal zone, these conditions vary widely over the transitional salinity gradient bounded roughly by fresh water inland and full-strength sea water at the Gulf. Within this region exist complex zonations of plant communities and animal species, largely governed by their tolerance to saltwater.

Although salinity is the most conspicuous chemical variant in this environment, it is not by any means the only one of importance. Sea Grant investigators have studied many of these factors in their search for governors of biological populations. The early years emphasized development of techniques for handling large numbers of precise analyses on a production basis. These were needed to characterize the seasonal and spatial variability of many chemical parameters that affect growth and physiology of marine organisms. Reasonably complete chemical study of an estuarine site may require assays of dissolved nutrients, total organics, metal sulfides, carbonates, silicates, amino acids, and other chemical parameters.

Important differences in soil and water chemistry were found between zones of differing salinity, corresponding to distinct biological differences. One example is the higher total organic content of bottom sediments in a brackish zone, as contrasted with a more saline area, noted by chemist Clara Ho. Corresponding differences in the biomass and species composition of various micro-organisms were found. Seasonal variations in dissolved inorganic nitrogen corresponded with plant growth cycles, whereas dissolved inorganic concentration was apparently linked with recycling from heterotrophic organisms.

Nutrient Cycling

Where estuarine marshes get the nutrients to sustain their remarkable productivity remains an open question. One widely accepted theory holds that tidal flushing and filling pumps nutrient laden waters from the nearby Mississippi River into the estuary. Another maintains that a nutrient subsidy exists in the soil--perhaps a legacy from times when the river overflowed its banks prior to construction of artificial levees. Both sources may be important, but it is necessary to quantify their relative effects in order to maximize social and economic returns from the river. Investigators have pursued both lines of research.

With help from the Louisiana Wild Life and Fisheries Commission, Clara Ho has taken water samples across the great clockwise eddy that Mississippi River waters follow as they exit from Southwest Pass and spiral toward Grand Isle. Nutrient analyses corresponding to the river mouth, Barataria Bay inside the passes at Grand Isle, and intervening stations in the Gulf are being compared to assess the river's contribution of nutrients to the estuary at various river stages. Results so

far suggest this mechanism may be far less effective than previously believed.

Agronomist William Patrick and graduate student James Brannon looked at soil nutrient systems *in situ*. They found that availability of most elements required for plant growth is governed by seasonal changes in water level and temperature, which in turn regulate pH, bacterial activity, and redox potential--a measure of reducing conditions. The layer of sediments in the *Spartina* root zone is rich in many nutrients, including an estimated 500-year supply of phosphorus, and *Spartina* functions as a nutrient pump in mobilizing these materials. When the marsh soil surface is exposed to the atmosphere, a shallow oxidized zone develops in which elements including iron, manganese and phosphorus exist as insoluble minerals. But after prolonged tidal inundation, soil oxygen becomes depleted and minerals are transformed to soluble forms, available as plant nutrients. Presence of organic matter is also a vital factor in nutrient recycling.

Nitrogen for plant growth must be available in inorganic form, typically ammonia. Most of the nitrogen in marsh soils occurs as plant or animal tissue, of which a part is converted to ammonia during bacterial decay. Under anaerobic conditions this occurs very slowly, so the nitrogen supply becomes limiting to plant growth in the *Spartina* salt marsh. Investigators have found that available nitrogen is lowest during the spring when plant growth is highest, and highest in October and November when plant growth has diminished but bacterial decomposition activity is high. Nitrogen concentration drops with temperature during the winter months as bacterial activity diminishes.

Nitrogen uptake by *Spartina* and mineralization by bacteria were studied using 15^N as an isotope tracer. Despite the high existing primary production of Louisiana salt marshes previously noted, Patrick found that a 15% increase in grass yield could be achieved with supplemental inorganic nitrogen. Although it is difficult to imagine circumstances that would justify large-scale application of commercial fertilizer to stimulate plant growth, the finding has valuable economic implications for coastal cities and industries which must dispose of nitrogen-rich effluents. Indeed, based on the equivalent industrial cost of tertiary water treatment for removal of nutrients--which marsh systems accomplish naturally--LSU researchers James Gosselink and Robert Pope, with Eugene Odum, University of Georgia, found a value of $80,000 per acre. The energy subsidies provided by marshes may be far more important to mankind than fisheries, recreation, or other values recognized by society.

Lipid Studies

A poorly understood aspect of wetland ecosystems concerns the energy cycled through the system as lipids. After all, one never hears of a shrimp with "midriff bulge," and in nature the slow runners usually get eaten. Even so, since plants do synthesize lipids from basic building blocks including water, carbon dioxide, and energy from the sun, Robert Allen in the Biochemistry Department has sought to understand their role in the marine food chain.

Field studies have shown that lipids in sediments are most abundant where organic content is high. In the marsh waters, they are most abundant when phytoplankton are also present. On a dry weight basis, Gulf plankton contain 10-20% lipids; not so rich as those of arctic waters, which are renowned as the principal food of whales.

Aside from their usefulness as an energy source, the fatty acids present in lipids are essential in the diets of every higher animal. Their functional roles are yet unknown for shrimp, but comparisons with trout and other species suggest that they are necessary for growth, sexual maturation, reproduction. Shrimp feeding trials tested a variety of manufactured oils as lipid sources in experimental rations, but they failed to provide useful information about the animal's basic requirements. Future studies may start with fat-free diets and seek to identify resulting nutritional deficiencies.

Like other nutritive components of plant tissue, lipids may pass through additional stages of enrichment in the food chain before they are consumed by shrimp. Since yeasts abound in Louisiana marshes, researchers investigated their ability to use Spartina lipids as a food source. Results suggest that yeasts in the estuarine food chain may be more important than in other environments, but their role remains obscure.

Ecological Modeling and Simulation

Characterization of an ecosystem can take place at many scales, as disparate as the microsite formed by the discarded exoskeleton of a shrimp--and subsequently occupied by a colony of chitinaceous bacteria--or an entire estuarine bay marsh complex thousands of square miles in extent. The regional perspective seems most appropriate for studies designed to support management decisions, but it also implies a scope of scientific inquiry that surpasses our capacity for detailed measurement and observation.

The major problems inherent in the study of large-scale ecosystems relate to both spatial variability and dynamic process-response interactions between major components. A functionally useful description of such a system must take account of its biological, chemical, and physical components, and elucidate the causative relationships of primary importance. If it is to be employed as a management tool, it must have the added capability of simulating the dynamic behavior of the natural system--that is, to predict conditions or events which logically follow from changes in external driving functions, given the state of the system at some initial time. Mathematical development of these abstract models for the Barataria Bay system has been a primary effort of chemical engineers Ralph Pike and Bert Wilkins since 1969. These researchers view ecological modeling efforts as extensions of methodology employed in simulation of complex chemical process systems.

During the 1972-73 period, work was virtually completed on a computer model of transport phenomena in a generalized estuarine system. Features of this model are simulation of flow patterns and tidal fluctuations in a shallow bay system with arbitrary lateral boundaries; prediction of temperature distributions and energy transport; simulation

of salinity patterns in response to transient hydrologic inputs; and patterns of distribution for any other species hydraulically transported in the water column.

Applications for this model are numerous. To the extent that model results satisfactorily reproduce behavior of a real estuarine system as recorded at a few control locations, they can be considered valid approximations of natural conditions elsewhere in the prototype flow region. Thus, results from simulation experiments can be employed to predict currents that partially govern dispersal of post-larval shrimp and oyster larvae; to explain observed spatial distributions of salinity-dependent animals; to investigate sedimentation patterns; and to select sampling times and locations. The variability of water quality parameters in the estuary as affected by changes outside the system can be studied by observing model behavior; this information can in turn be used to develop valid and efficient sampling programs. Movements of fish and shellfish, as well as mortalities of delicate post-larval shrimp resulting from passage of cold fronts, can be better understood by studying water temperature changes predicted by the model.

Another model substantially completed during the reporting period simulates the growth and population dynamics of brown shrimp. Growth of young shrimp that enter the estuary from the Gulf of Mexico as post-larvae is greatly dependent on water temperature. Their migration waves are apparently triggered by fortnightly tidal cycles. Mathematical simulation of migration cycles, growth rates and mortalities corresponding to postulated seasonal climatic records affords a way to predict the size and abundance of harvestable brown shrimp at any time during their estuarine residence period. Comparison of model results with those obtained from biological sampling and landing records, and iterative refinement of functions used to model the basic population parameters, will lead to better understanding of brown shrimp populations dynamics. This will improve management of the shrimp fishery by the Wild Life and Fisheries Commission. A reliable predictive method would enable comparison of alternative management objectives, such as maximum economic return, maximum sustainable yield, or preservation of desirable sociological values and life styles, and thus contribute towards greater objectivity in coastal zone management practices.

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WASTE EFFECTS

On the average, a million acre-feet of water, carrying more than a million tons of sediment and untold amounts of dissolved chemicals, course through Louisiana each day via the Mississippi and Atchafalaya Rivers. Agricultural, industrial, municipal and residential wastes from almost half the nation pour into the Gulf of Mexico along Louisiana's shores; indeed Louisiana's low, deltaic coastal zone was built from soil and nutrients stripped from lands upriver.

So, one asks, how can a little more do any harm? But this question fails to recognize the changing character of the dissolved chemicals carried by the river during recent decades. Many of these chemicals originate in highly toxic wastes from the mighty industrial complex--dubbed the "North American Ruhr,"--along the river's lower reaches; others are residues from agricultural pesticides and herbicides washed from millions of acres of rich midwestern farm lands. Nor does it recognize the cumulative effect of thousands of seemingly inconsequential dribbles of crude oil, seeping unobtrusively into waterways of the marsh from leaky pipe joints, dripping valves, separators, sumps, and bleedwater lines, wherever oil is produced.

Waste Effects projects are seeking answers to some of these questions. Whereas the Systems Ecology program seeks to understand how the natural, "unstressed" ecosystem functions, Waste Effects projects apply that knowledge to assess the effects of man's waste disposal practices on natural systems--and eventually himself. This will insure that these systems are utilized most effectively, and any material benefits thus realized are properly imputed in assessing the value to society of such systems.

Marsh Disposal of Organic Wastes

Estuarine ecosystems perform valuable service to mankind through treatment of sewage effluents. Moreover, estuarine waste assimilation does not stop with "secondary treatment"--bacterial digestion of organic matter--but continues through the "tertiary" stage of inorganic nutrient removal and assimilation. Process technology to perform the latter function is extremely expensive; Gosselink, Odum and Pope estimated that tertiary water treatment performed by an acre of tidal marsh is worth $2500/year in monetary terms, yet nature does it "free."

Even so, direct discharge of waste effluents into Louisiana's coastal streams is not a viable solution. Most of these streams flow sluggishly, so waters oscillate back and forth during a tidal cycle with little net outflow. High water tables and impermeable soils complicate other waste disposal methods.

Vegetated areas of the marsh are more promising. Agronomist William Patrick found that anaerobic bacteria in flooded swamp and marsh soils can utilize substantial amounts of inorganic nitrogen, and thus create deficits in nitrogen available for plant use. Worded another way, marsh plants could use 15% more nitrogen. Tracts of coastal marsh

set aside for organic sewage disposal could assimilate large amounts of waste nutrients, converting them to additional plant tissue for subsequent detritus production to sustain other organisms.

To test this theory, ecologists John Day and Gill Smith initiated a cooperative study with the Zapata Haynie Corporation, whose menhaden processing plant at Dulac, Louisiana, produces large quantities of organic waste effluents during the fishing season. Situated along a navigable canal, the plant is adjacent to a large dredge spoil apron. The spoil bank supports a dense stand of roseau cane (Phragmites communis) on a surface sloping gradually away from the canal toward an extensive, unpopulated marsh.

A pump and spray discharge system was installed to deliver process effluents from a primary treatment pond to the naturally vegetated clay spoil bank, where it would trickle downslope through the surface plant cover and litter layer--a distance of 30 meters. Concentrations of organic carbon, nitrogen, and phosphorus are being monitored along the flow path. Vegetation growth and total coliform bacteria in the effluent are also being measured.

Preliminary results indicate that overland flow is a workable, low cost, safe, and environmentally sound solution to the waste disposal problems of food processing industries in south Louisiana. Conclusive findings to this effect would immediately benefit dozens of small seafood processors in this region, who may be forced to suspend operations unless relatively simple, low-cost measures can be adopted to meet new, stringent water quality standards. Almost all such enterprises are situated on the natural levees along maintained navigable waterways that form the habitable "skeleton" of this region, with convenient access to suitable disposal areas.

Cadmium Geochemistry

When sale of swordfish to U.S. consumers was banned four years ago by the Federal Food and Drug Administration, a new kind of environmental awareness swept over the American public. For years the dangers of lead paint had been a concern of health authorities and consumers alike, but suddenly a new, insidious hazard was revealed, and the whole gamut of heavy metals came under scrutiny.

One of those that attracted attention was cadmium. This is a relatively scarce element in nature--no cadimum minerals have been found in commercial quantities, and none are mined solely for their cadmium content. Yet cadmium recovered as a byproduct from zinc, lead, and copper ores has found many industrial uses that include corrosion-resistant coatings on iron, as a pigmenting agent in paint, and in long-life rechargable battery cells, so that presently the amount of cadmium used for technical purposes is more than double that of mercury. As its technical uses have grown, so has the discharge of industrial waste effluents carrying cadmium in trace amounts. Since 40% of the nation drains to the Gulf of Mexico via the Mississippi River, the amount of cadmium reaching the estuarine waters of coastal Louisiana must be large in relative terms.

Nobody knows the ultimate disposition of cadmium or related elements like zinc and indium once they reach the sea. Evidence indicates that their concentrations in the oceans are less than 1% of what has been supplied them over geologic time. Probably much of this material is precipitated as insoluble sulfides in oxygen-deficient zones of deep ocean basins. But similar reducing conditions are common near the sediment water interface in shallow coastal environments like Louisiana's fringing salt marshes. Here a delicate carbon-oxygen cycle is driven by photosynthetic production of oxygen from carbon dioxide by living plants, its consumption through respiration by higher life forms, and the oxidation or decay of dead plant tissue by bacteria. Oxygen depletion of estuarine waters occurs when vigorous aeration by wave action is lacking, and increases in severity near the water bottom, where available oxygen is used up by bacteria in the process of breaking down organic plant tissue.

Ray Ferrell of the LSU Geology Department investigated the geochemistry of trace metals in such an environment by means of theoretical phase relationships and stability diagrams.

He determined that the reducing conditions resulting from biochemical activity of bacteria near the sediment water interface would favor precipitation of cadmium and zinc from solution as sulfides. These metals could also enter the sedimentary column through concentration in living organisms, subsequent bacterial decay, and burial under reducing conditions as to insoluble sulfides.

Alternatively, metal cations in solution may be adsorbed on fine-grained particulate material which eventually settles to the bottom. Under suitable reducing conditions, cation exchange with more abundant elements in sea water could release these trace elements to be precipitated as insoluble sulfides.

The relative importance of these various metal "sinks" in an estuarine environment is being investigated through field experimentation at a test site in a small marsh lake near Caminada Bay. An experimental setup enabled measured amounts of cadmium to diffuse vertically through bottom sediments in an enclosure that limited lateral movement, yet allowed water levels to fluctuate normally with tides.

Small core samples taken monthly from bottom sediments inside the cylinder enabled workers to monitor reactions involving the cadmium as it diffuses into the sediments. Analysis of the data, still in progress, should ultimately yield evidence concerning the availablility of trace metals in sediments to detritivores and other benthic organisms; its subsequent concentration at higher trophic levels, where it could pose a hazard to humans; and possible release of such metals in the environment through changes produced by dredging and excavation.

Heavy metal release from marsh sediments is a question of profound concern to many individuals, environmental organizations and the U.S. Army Corps of Engineers, which sponsors or regulates virtually all dredging in the estuarine zone. Understanding of cadmium mobility in the estuarine environment would provide a basis for evaluating present regulation of dredging activities, and developing safer dredge-spoil

disposal practices, if needed. In turn, protection of human food sources would be an ultimate, obvious goal.

FISHERIES AND SEAFOOD INDUSTRIES

Louisiana is world-renowned as a gourmet's paradise, and the reasons stem from a fortuitous blend of the French culture with an unparalled natural beneficence of food from the sea. Maintaining the eminence of Louisiana fisheries and seafood products is a primary goal of many groups in the state, including Sea Grant.

Seafood Product Technology

The LSU Food Science Department has maintained a traditional emphasis on problems of the seafood industries, development of new products, refinement of process technology, basic nutritional studies, industrial standards for packaging and labeling, and consumer protection activities. Sea Grant support to Food Science through Arthur Novak, Department Head, has been partly institutional in character, providing funds to accelerate the department's total marine-related program. These cooperative efforts have explored many industrial problems including those following:

Louisiana crawfish have tantalized seafood canners since pond culturing was demonstrated more than 20 years ago. Taking a cue from the shrimp canning industry, efforts were made to pack crawfish tails--unsuccessfully, since the meat turned black in the cans. LSU researchers finally isolated the culprits--high iron content and sulfur-containing amino acids which react with the metal cans. Use of chelating agents--which tie up the metal that causes discoloration--eliminated this problem.

Frozen crawfish meat has a tendency to become rancid after a very brief storage period. Research pinpointed an enzymatic process in the "fat"--actually the hepatopancreas--causing the problem, a lipase activity that occurs even at -20C. Food science's latest advice to homemakers: wash all fat from crawfish tails before freezing. This may prove a painful suggestion to Louisiana consumers, who have always carefully preserved the fat for later recombination as a flavoring agent.

Mechanization of hand operations promise a great economic boon to seafood processing industries, where many innovations have already occurred. But all too often, products from mechanical operations lack the familiar form, taste, or texture desired by consumers. With crabmeat, mechanical picking is highly efficient, but the resulting shredded flesh lacks the "lump" quality desired for Crab Louie, Crab Newberg, and other delights. Researchers tested a variety of chemical binding agents to find a process for recombined "lump" meat with acceptable taste qualities.

The huge quantity of fish discarded by shrimp trawlers has long been a concern of fishery interests, nutrition experts, and resource managers. Although popular expectations for fish protein concentrate (FPC) to solve the worlds food problems peaked about five years ago, many experts believe its time is yet to come. Food scientists, examining the protein content and important processing characteristics of several abundant industrial fish species from the Gulf of Mexico, found squid an ideal candidate for both FPC and gourmet products. The versatile species, at times abundant, is high in protein, has excellent flavor, and very little waste.

Few departments at LSU have the enthusiastic off-campus support Food Science commands, a fact reflected by industry support through faculty honoraria, fellowships, test materials, and in-plant pilot process facilities. The Food Science program is relevant not only to Louisiana, but to the nation as well, and there is keen competition among major seafood laboratories and processors for fisheries-oriented Food Science M.S. and Ph.D. graduates. Sea Grant Food Science research is also effectively disseminated throughout industry and government, by graduate students serving internships in key quality control spots.

Food Science faculty are frequent participants in national advisory panels of industry and government, and are often contacted to trouble-shoot urgent problems via telephone or shirtsleeve sessions in-plant. Users of LSU's seafood technology are as broad-ranging as the research itself, and go from private citizens to national government. Industry is served through individual gratis consultation when problems of a specialized or sensitive nature arise, and through participatory efforts sponsored by such groups as the International Shrimp Council, Shrimp Association of the Americas, Shellfish Institute of North America, National Shrimp Breaders and Processors, and National Fisheries Institute.

Invertebrate Rations Development

Most mariculturists agree that the bare essentials for cultivation of any seafood species are good feed and good water. Samuel Meyers of the LSU Food Science Department has been developing feed recipes for crustacean culture continuously since 1969.

An initial approach was to look at the food consumed by shrimp in nature. This was a natural adjunct to Meyer's work in the Systems Ecology program, involving study of microorganisms that utilize marsh plant detritus as a food source and with it provide a principal natural food for shrimp. Information from those studies, with comparative data on digestive enzymes and bacteria isolated from shrimp, led to understanding of shrimp nutritional requirements and identification of ingredients to supply those needs.

Specification of nutritional components is a first step; the second and third involve developing just the right physical properties to insure water stability, acceptability by the animal, and formulation from low-cost materials. This is complicated by the fact that by-product materials considered waste one day may be valuable the next as

technology for their use becomes available.

Meyer's rations use 30% shrimp meal, developed by a departmental colleague, James Rutledge. The superior protein-rich fish meal is produced from shellfish processing wastes by removing up to 86% of the indigestible calcium carbonate. Thus a troublesome waste disposal problem has become a profitable by-product, also in demand for catfish, trout, and poultry rations.

Experimental rations, extruded in convenient spaghetti-like morsels, were widely circulated to mariculture research laboratories and commercial grow-out facilities. American lobsters, penaeid shrimp, macrobrachium shrimp, and crawfish have all thrived on it.

A commercial industrial feed producer is manufacturing the product in bulk quantities for a Mexican grow-out facility, and a new starch-bound, water-stable flake diet is undergoing testing with larval shrimp, crustacea, and bivalves.

When shrimp and lobsters from American fish-farms begin appearing in the supermarket, odds are that they will have been fattened on Sam Meyer's favorite spaghetti recipe.

Aquaculture...Promises, Promises

The pompano is a handsome, aristocratic fish, whose golden sheen is matched by the glitter of its price in the fish market, where it routinely brings a higher price per pound than filet mignon. But early Sea Grant efforts revealed that riches from pompano mariculture are likely to be fool's gold for the Louisiana entrepreneur who tries to satisfy its voracious appetite or maintain the rigorous standards of water quality that the beast demands. The red drum, a highly popular game fish in Gulf coastal waters, was also abandoned as a mariculture candidate after a brief exploratory study of feeding habits, because wild stocks are abundant and their commercial dockside value is too low to interest fish farmers.

Catfish Reproduction

The search for economically viable species to culture in the vast brackish water marshes turned back to more familiar ground. During the period 1968-71, Sea Grant researcher James Avault demonstrated success in brackish water grow-out of fresh-water channel catfish. Apparently these animals thrive in brackish water, but cannot reproduce there. Since knowledge of the channel catfish' reproductive physiology was too meager to assess environmental limits for successful spawning, studies of catfish sperm, including its salinity and temperature tolerance, were initiated by Avault and graduate student Monte Jaspers.

Guthrie Perry, biologist with the Louisiana Wild Life and Fisheries Commission, subsequently verified through pond breeding experiments that the highest water salinity level in which channel catfish could reproduce successfully was 1.8 parts per thousand, as Jaspers had predicted.

Jaspers' data on temperature tolerance was applied in turn by fisheries graduate student Clell Guest. He cryogenically maintained frozen catfish sperm for more than a month, and noted upon thawing that they were still alive and active--a sign that their viability had not been impaired. His findings indicate the feasibility of "sperm banks" for selective fish breeding purposes and offer promise of the same benefits to fish culturists that livestock breeders have realized through artificial insemination programs for many years.

Catfish Culture in Brackish Water Canals

Recognition of Avault's success in brackish water catfish culture soon attracted interest in its commercial possibilities. Sea Grant researcher Alva Harris, Nicholls State University, secured cooperative assistance from the Louisiana Land and Exploration Company for catfish demonstration projects in pipeline canals that criss-cross the company's coastal land holdings.

Dr. Harris' first year efforts demonstrated an important maxim: that research findings, however valuable, must still be tested in practice. The first season's crop, stocked in bulkheaded canal sections and raised on feed almost to harvestable size, escaped or fell victim to predators when hurricane tides overflowed the canal banks. This lesson dictated use of floating cages the next season--more costly, but self adjusting to water level changes. However, under the crowded conditions typical of caged systems, a parasitic infection destroyed almost one-fourth of the stocks--and absence of parasitism had been noted as a potential advantage of brackish water catfish culture in Avault's research. Hasty improvisation of an antibiotic treatment regimen demonstrated that the infection could be controlled and enabled the experiment to be continued till harvest time in the fall.

The success of these pilot projects has attracted considerable local interest: so much in fact, that 24-hour surveillance by a resident caretaker has been initiated to control poaching from the vulnerable floating cages. With the practical experience gained to date, Harris feels that local people can use his findings to raise catfish successfully in leased canals as soon as escalating feed prices stabilize at a level that will afford them a profit opportunity.

Spell Them Crawfish

Catfish occupy a well-established niche in Louisiana's cultural and economic picture--Arkansas, Mississippi, and Louisiana account for 80% of the nation's commercial catfish production, but most activity is located in the inland flood plain of the Mississippi River. The semantical difficulty in categorizing this mainly freshwater fish with other "marine" resources under Sea Grant's purview is a bugaboo that for years discouraged catfish research in the National Marine Fisheries Service. Logic dictated that Louisiana Sea Grant aquacultural efforts should focus on an animal with demonstrated marketability, near-term economic potential, a simple life history, tolerance to environmental conditions of coastal Louisiana, and under-exploited research potential.

The animal chosen for this role was the lowly crawfish, also a freshwater species but one that also thrives--and reproduces--in brackish coastal waters.

For help in selecting research objectives James Avault turned to the Louisiana Crawfish Growers Association. Cited for immediate action were problems that affect profitability of pond growing operations most acutely: control of predatory fish, information on population dynamics, and maintenance of water quality through utilization of crawfish processing wastes.

Tests in crawfish rearing ponds at LSU's Ben Hur Farm established proper treatment levels to poison without harming juvenile crawfish. Postlarval crawfish stocked at rates of 36,000 per acre produced highest yields of market-sized crawfish.

The gleam in a crawfish farmer's eye may just indicate he is contemplating the profits he could reap from softshell crawfish sold for fish bait--if only he could induce molting to maintain adequate supplies for the market. "Soft craws" are in great demand by sport fishermen, with prices exceeding $10/pound live weight not uncommon. So Avault and graduate student Jay Huner are studying the physiology of natural molting in the hope that growers may eventually be able to stimulate this process at will, perhaps by manipulating salinity and water hardness, or introducing hormones and enzymes similar to those produced in the natural molting process.

Pathogens in Marine Organisms

Looking to the future when disease control may be a problem in crowded shrimp rearing ponds, Dwayne Kruse, parasitologist at Northwestern State University, Natchitoches, investigated microsporidiosis. Shrimp fishermen recognize the condition produced by this epidemic disease as "cotton shrimp." Although it is not a serious problem in wild stocks, any disease is a potential threat to animals stressed in intensive culture systems. Study of infected animals has contributed new information about this condition and revealed infections by three other parasites, but efforts to produce infected animals under experimental conditions for laboratory study purposes were not successful.

Ecology of Loxothylacus texanus was the subject of studies by James Ragan, Nicholls State University, Thibodaux. This is a common parasite that infects the blue crab and other species of the Gulf and Atlantic regions, inhibiting molting and stunting growth. Like the microsporidiosis study, interest in the infection stemmed from its potential threat to intensively managed systems, although Ragan's evidence indicates moderately high rates of infection in native stocks. Crabs taken from waters of differing salinity varied in incidence of infection; virtually none was detected in crabs from fresh and low-salinity waters. This suggests one reason why such areas account for a major share of commercial crab production, in contrast to the larger moderate-to-high salinity estuaries. Knowledge about parasitism in commercially important species adds another dimension to estuarine water management, and could eventually prove useful in crab-farming efforts. The parasite itself may also be useful as a biological control in

fisheries nursery grounds, where adult-size crabs are potentially troublesome predators of other stocks.

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Environmental Analysis for Coastal Zone Planning

Hardly any place on earth remains unexplored. Even the most remote and inaccessible corners have been probed by high-altitude cameras and underwater soundings. Yet the earth's surface and its living populations present dynamic patterns of change, coming more and more under scrutiny as the need to conserve and develop every resource becomes increasingly acute.

Studying patterns of change in order to anticipate needed services, controls, and remedial actions is the essence of the planning process as carried out by public works officials and administrators at virtually every governmental level. As competition among conflicting uses of coastal areas and resources becomes more intense, planning and analysis for future usage must become more comprehensive if socially equitable resource allocations are to result.

Historical data to assess important environmental changes and to study cause-and-effect relationships are rarely available in convenient formats for planning because such uses were not anticipated in earlier times. An information base for coastal zone planning should include a collection of displays pieced together from many data sources to illustrate significant aspects of regional development vis-a-vis the natural environmental setting. The compiler's task is complicated by sparse hydrologic and meteorological coverage; incomplete or inaccurate coverage of mapped index properties; differences in map scales, resolution, and sampling frequency; and incongruence between political boundaries used for aggregating economic or demographic factors and natural boundaries of functionally useful physical units. Desired answers must frequently be extracted from surrogate information.

Geographer Sherwood Gagliano and his associates sifted through data from many sources to prepare a series of annotated map sheets that illustrate key cultural and environmental elements of southeastern Louisiana's estuarine wetland systems. The resulting Environmental Atlas and Multi-use Management Plan for South-Central Louisiana is the culminating product of a program entitled "Hydrologic and Geologic Studies of Coastal Louisiana." The work was initiated for the U.S. Corps of Engineers, New Orleans District, in 1969, and subsequently augmented by Sea Grant support in order to extend the scope of geographic coverage to include the Barataria Basin.

Data sources included files of the U.S. Corps of Engineers, Louisiana Wild Life and Fisheries Commission, published maps and literature, unpublished theses and dissertations, aerial photographs, and personal contacts with individuals. Although field data input was limited, some information was developed by simulating key features of regional hydrologic systems on a large digital computer. The uncertainties inherent in maps derived from model calculations based on limited input data from widely separated base stations typify the

inexact character of methodology available for regional planning purposes--and reinforce the need for experienced scientific judgment in formulating regional development strategies and goals.

The planner's work is never done, because developmental initiatives, scientific understanding, and environmental sensitivity advance relentlessly. Graphic products like the environmental atlas are useful as end results of research because they summarize presently known facts and hypotheses in formats that can be used efficiently by interested laymen, professional planners, administrators, educators, and other scientists. In effect, such graphic displays bridge the gap between the scientific researcher and a diverse community of information users--perhaps more effectively than any other media.

Louisiana Superport: Progressing with Care

In the beginning . . .

Sea Grant "homework" in the salt marsh was proceeding nicely when the Superport clamor started in February 1972.

Overnight Louisiana was alive with conjecture and debate on superports: they would pour new life into the economy; they would solve the energy crisis; they would destroy the wetlands; and so on. Needed in a hurry were objective, factual studies on vulnerability of wetland environments; site feasibility and conceptual design; economic characteristics of commodity flows; and the legal aspects of construction in and close by Louisiana's territorial seas. For answers, the select superport committee appointed by Governor-Elect Edwin Edwards promptly turned to LSU's Center for Wetland Resources, already managing a spectrum of Sea Grant-funded research projects that anticipated just such a development.

Quick reaction within the schedule dictated by the task force was a must; there could be no time during this initial organizational phase for baseline field data-gathering or its scholarly contemplation.

Preliminary recommendations would need to incorporate the collective knowledge and experience of Sea Grant's Systems Ecology team, amassed during the three preceeding years, and the data synthesis capabilities of its Coastal Zone Planning and Development team.

Factors needing consideration were (a) stresses, ways that facility construction, operations, and secondary developments affect natural productivity and other unique characteristics of an area; (b) natural constraints, such as unstable foundations and strong currents; and (c) the advantages of one location over another.

Natural productivity and hydrologic setting of each environmental management unit would require study to rank its suitability--or vulnerability--to the planned development. A regional perspective, attained through studies of the entire coastal zone, would reveal ways to minimize adverse impact on coastal ecosystems and even stem the tide of wetland deterioration through compensating diversions of nutrients, water and sediments from the Mississippi.

Sea Grant lawyers Marc Hershman and Gary Knight, with law student Armand Moeller, Jr., sifted through state, federal, international, and environmental laws to develop a plan for setting up the new superport organization. Laws and organizational schemes affecting Louisiana's 36 existing port authorities, and a sampling of port districts in other states, gave a wealth of legal and political insights. The attorneys concluded that a new state authority should be created by statute, to hold exclusive authority for superport development and operation in Louisiana.

A unique, important feature of their recommendations was a tightly worded proposal for development of an environmental protection plan, to be followed step by step during each phase of port development. These and other legal recommendations covering powers, organization, and environmental responsibilities of a Louisiana superport authority were incorporated in the Deep Draft Harbor and Terminal Act of 1972 (La. R.S. Title 34, Chap. 35).

Structural engineers led by Charles Whitehurst, Division of Engineering Research, reviewed the design of existing superport facilities around the world. A variety of structural configurations were reviewed and summarized for suitability in terms of local site constraints and environmental stresses. Single-point mooring buoys were found superior for an oil and gas handling facility, but later phases involving transshipment of bulk solids and liquids will call for large semi-submerged platforms composed of modules an acre in extent. Alternatively, large concrete storage platforms extending to the ocean floor--with sufficient bearing area to minimize sinkage or shifting and presumably ballasted to overcome any floating tendency--could be constructed.

David Johnson of the Economics Department tackled an analysis of economic factors that could argue for-or-against a Louisiana superport.

Beyond the well-documented economies of scale which superships afford, he identified many social, political, and economic uncertainties that could cloud the long-run economic picture even more than technological advances. Competing facilities on the Gulf and Atlantic coasts, incremental changes in East Coast refining capacity, short-run vs. long-run environmental costs, federal policy concerning user charges for inland waterways, and changes in the discount rate used by federal agencies to evaluate water resource projects, all were factors that could have a material impact on superport revenues and usage.

Despite such uncertainties, Johnson found powerful arguments favoring the Louisiana proposal. Of total waterborne commodity flows from the Central Gulf region (1970), 73 percent are outbound shipments, dominated by crude oil, petroleum products, and grain--all amenable to handling aboard superships. Further, the major inbound cargoes are metallic and non-metallic ores, also suitable for large carriers. A strategic advantage of port sites near the Mississippi River mouth stems from the fact that 78 percent of total oceangoing volume from the region between Lake Charles, Louisiana, and Mobile, Alabama, travels on the Mississippi--much of it crude oil and refined petroleum products from Louisiana,destined for the east coast, and midwestern grain for overseas export.

Hastily gathered and necessarily tentative findings were summarized in A Superport for Louisiana, published by the Superport Task Force only four months after studies began. A more detailed technical report Preliminary Recommendations and Data Analysis followed in August 1972--the first of a series of Louisiana Superport Studies published by LSU as a comprehesive history of superport environmental protection studies.

Federal Interest: CEQ Study

In September, 1972, the federal Council for Environmental Quality requested a detailed predictive study of environmental impact for superports at two southeastern Louisiana offshore sites. Administered as a grant modification through the National Sea Grant Program, the study involved further extrapolation of data previously collected by investigators in the Systems Ecology and Coastal Zone Planning and Development programs.

A project team directed by marine ecologist James Stone prepared a detailed environmental inventory of wetland areas in southeastern Louisiana that could be affected by major oil spills at the hypothetical port locations. Surface currents and oil spills in the Louisiana Bight, roughly bounded by the Mississippi delta, Grand Isle, and the mouth of Bayou Lafourche, were mathematically simulated to study dispersal patterns for typical wind and hydrographic conditions.

The geometry and movement of an offshore spill depend on several factors, including spill size and duration, wind direction, local tides, bathymetry, and dispersion period. Such models only approximate real events, but they can reveal information about the expected range of variability that could be observed in nature only at great financial expense. Conditions that drive a simulated spill inshore and impinge on vulnerable coastal ecosystems are rated potentially hazardous in proportion to their statistical probabilities of occurrence.

Computer plots for simulated spills showed areas most likely to be affected. From knowledge gained through previous Sea Grant studies of the marsh ecosystem, researchers enumerated the most vulnerable species and estimated the severity of damage from spills of varying intensities. Information gaps were brought into better focus too. They include the virtually unknown offshore spawning areas of major fishery species, where delicate eggs and larvae could be damaged by even very small, routine spills, if sufficiently frequent over an extended period.

Results of the CEQ study were published as Preliminary Assessments of the Environmental Impact of a Superport on the Southeastern Coastal Area of Louisiana, Report 2 in the Louisiana Superport Studies series.

State Environmental Protection Plan

In rapid succession the Superport Task Force presented its recommendations to the people of Louisiana, the Legislature passed an act creating the Deep Draft Harbor and Terminal Authority, commissioners were appointed, and an Executive Director was named to head the new agency.

If the superport was to rapidly become a reality, work on the Environmental Protection Plan, required by legislation, would have to begin immediately. Louisiana State University's multidisciplinary team of marine and wetlands specialists, cultivated under Sea Grant auspices, and thoroughly versed in the superport's environmental aspects, was ready.

> The Environmental Protection Plan means a written document, prepared in conformity with this law, which shall be a regulation of the Deep Draft Harbor and Terminal Authority which establishes those steps to be followed to insure the protection of the environment throughout all phases of the Authority Development Program," (La. R.5.34:3102[3]).

Much preliminary information was gathered to support the need for such a plan, but tasks yet remaining were specification of detailed data requirements and format, the design of field data acquisition programs to fill gaps in existing information, and a system to monitor environmental changes during construction and operation of the facility.

Researchers compiled a detailed inventory of every known physical and biological factor that could affect, or be affected by, a superport. Also included were pertinent socio-economic considerations, selected recreational features, and unique environs.

Environmental histories of other oil ports and terminals served as background for discussion of stresses that might occur in the Louisiana situation.

From this comprehensive background, detailed guidelines for site selection, design, construction, and operations were recommended that would minimize risk of environmental damage. If damage should occur despite all precautions, the act stipulates that compensatory projects are to be funded; to assure equitable compensation, two environmental cost assessment techniques were proposed, and a variety of compensatory provisions were analyzed.

Proposed activities that are potentially detrimental to the environment must be reviewed by a great many public agencies, and coordination of environmental affairs has mushroomed into a major occupation. To insure that environmental safeguards implemented by the superport developers would meet requirements of all other agencies having jurisdiction, but not duplicate other statutory responsibilities, Sea Grant lawyers analyzed the pertinent legal requirements of every public organization known to hold such responsibilities. The lengthy list of international, federal, state, and local instrumentalities thus compiled will serve as a mailing list for the Environmental Protection Plan, to obtain review and comment prior to its formal adoption by the authority. This task was greatly expedited by comprehensive studies of 23 Louisiana agencies, already on file from Sea Grant Legal Program staff work previously incorporated in Louisiana Government and the Coastal Zone--1972, annual report of the Louisiana Advisory Commission on Coastal and Marine Resources.

Study results were passed along to lawyers retained by the Authority for translation into proper "legalese." During this translation phase the draft document was intensely reviewed and modified by directors of the Deep Draft Harbor and Terminal Authority, Wild Life and Fisheries Commission, and Center for Wetland Resources as mandated by the legislature. The Superport Environmental Protection Plan was published by the Authority and promulgated on January 26, 1974. The LSU scientific manuscripts were incorporated in Recommendations for the Environmental Protection Plan, being published as Reports 3 and 4 in the Louisiana Superport Studies.

Louisiana Offshore Oil Port

A noteworthy aspect of Sea Grant's role in Louisiana's superport saga was the heavy reliance on scientific judgement and data gained through earlier, Sea Grant-sponsored field work. The Systems Ecology program--though often criticized for lack of unequivocal, practical objectives--was the backbone of that preparatory effort. But superport researchers could not continue forever extracting new deductions from existing data--indeed they welcomed the new opportunity that came in early 1973 to extend earlier studies in the coastal salt marsh to other ecological settings further inland.

Louisiana Offshore Oil Port, Incorporated, a consortium of major oil companies that proposed to build Louisiana's superport, required a detailed environmental assessment of all the areas to be affected by their proposed facilities. These would span a continuum of environments--from offshore waters into the salt marsh, and thence through brackish, intermediate, and fresh water marshes into the cypress-tupelo swamps along the coastal basins' inner fringe.

Never before has there been such an opportunity to study so extensive a coastal ecosystem in its entirety--nor was there ever such urgency to expedite the work. LOOP needed baseline information to comply with the Authority's Environmental Protection Plan as a first step toward facilities they wanted to be operational by 1976. LOOP would even gamble on such a study, since the crucial federal superport law was still being debated in committee. One year of measurements and sampling activities began during the summer of 1973. A team headed by Alva Harris, at Nicholls State University, handled offshore biological sampling and water-quality measurements. William Wiseman and Stephen Murray of LSU's Coastal Studies Institute monitored the offshore currents, and a multidisciplinary team headed by James Gosselink, LSU's Department of Marine Sciences, performed onshore environmental assessments. Almost every living resource of the area, from microorganisms to birds and mammals, was inventoried on a seasonal basis, with accompanying measurements of water chemistry and quality. Other information was developed on archeological sites, recreational use, and unique environs.

When complete in late 1974, the overall LOOP study, being managed by Sea Grant Associate Director Ted Ford and monitored for LOOP by Kenneth Ring, will represent a giant step towards a Louisiana superport. Many will use the resulting documentation, to be edited and published as a Sea Grant information product, as a model for similar undertakings. In Louisiana the entire superport chapter will serve as a successful

example of university-government-industry cooperation--with Sea Grant as a major participant.

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LAW AND SOCIO-ECONOMICS

New technology and information transfer all too often fail because they are not accompanied by corresponding changes in human attitudes and social organization. Understanding and overcoming such barriers is the task of Sea Grant lawyers, economists, and social scientists.

Planning and Management for Louisiana's Coastal Zone

In 1971, a milestone in Louisiana marine affairs was passed with the legislative act creating the Louisiana Advisory Commission on Coastal and Marine Resources. Sea Grant lawyers Gary Knight and Marc Hershman had assisted state legislative and administrative units seeking such action since 1969, and drafted the legislative articles upon request of the Joint Legislative Committee on Environmental Quality. The ten-member commission appointed by then-Governor McKeithen included Sea Grant Program Director Jack Van Lopik and Alva Harris, principal investigator from Nicholls State University. Mr. Marc Hershman, Sea Grant law researcher, was appointed executive director for the body.

The commission's two-year life spanned the period September 1971 - August 1973. During that term almost every facet of the Louisiana Sea Grant program contributed to the commission's deliberations. Much Sea Grant research material was incorporated in texts of commission reports and by reference. Assistants in the Sea Grant legal program gained valuable governmental relations experience by providing staff support to committees of the commission, and preparing a sample act to implement a state coastal zone management program. This sample act, as Chapter 5 of the commission's final report, was subsequently introduced for discussion by appropriate legislative committees.

The Sea Grant legal team played a major role in state and privately funded efforts to define problems associated with the establishment of a Louisiana superport. Members researched federal law affecting deep water port development and prepared draft legislation creating the state superport authority; made substantial contributions to the authority's environmental protection plan; and provided input that included analyses and recommended changes in federal bills.

The broad scope of Sea Grant legal work has also included preparation of (a) draft administrative regulations to implement the state's Natural and Science Rivers Act, requested by Louisiana's Wild Life and Fisheries Commission; (b) draft of a vigorously debated shrimp law, requested by the Louisiana Shrimper's Association; (c) a memorandum on ownership of water bottoms in Lake Pontchartrain, requested by the State Registrar of Public Lands and adopted as an opinion of the Louisiana Attorney General; (d) a reorganization plan for state environmental and natural resource agencies, debated by the legislature; and (e) three memoranda presented to the Louisiana Constitutional Convention '73.

Legal Aspects of Ocean Resources Law

International ocean policy, the 3d Law-of-the-Sea Conference, and their effects on Louisiana's fisheries and maritime commerce were major research interests of H. Gary Knight, Sea Grant Legal Program Coordinator. Mr. Knight's service with the Advisory Committee to the Interagency Law-of-the-Sea Task Force has given Louisiana and the National Sea Grant Program a participant in the nation's highest policy body for these international proceedings.

Human Factors in Wetland Resources Development

Rural sociologist Alvin Bertrand analyzed the demographic composition and attitudes toward coastal management that characterize Louisiana coastal residents. The study was initiated because these factors--more than technology or scientific understanding of natural ecosystems--will ultimately determine the fate of Coastal Zone Management in Louisiana. The first phase of Bertrand's three-year study highlighted important differences in the state's coastal and noncoastal populations, their natural resource dependencies, and projections of future demand for marine-related recreational activity.

Marine Economics

An important measure of social impact is economic development; thus an initial task of LSU economist Lamar Jones was compilation of baseline data to assess the state's economic dependency on its coastal resources. Emphasized were biological resources and maritime transportation, natural assets that must continue to sustain Louisiana's coastal populations long after the rich mineral reserves are exhausted.

Institutional relationships established through these studies, led to participation of Economics Department researchers in the previously cited superport studies. These were notable as an example of university participation in a major state development and a model of Sea Grant involvement.

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EDUCATION AND TRAINING

If the rich natural productivity of Louisiana's coastal wetlands--and unspoiled coastal ecosystems everywhere--is to be maintained in spite of encroaching civilization, the diverse resources and human activities that impinge in these regions must be institutionalized. The parallel with America's no. 1 success story--its last hundred years of agricultural development--illustrates the lead role that education must take in full development of coastal and marine resources.

The great extent of her coastal wetlands, her economic dependence on them, and the acute nature of resource conflicts within them give this special meaning for Louisiana. Yet, in contrast to many other coastal states, Louisiana lacked strong educational programs in oceanography or marine science on which to build a Sea Grant program--much less train scientists and managers with the creative insights needed to mobilize balanced programs of resource conservation and development.

Launching such a program had to be first-priority business. An important step toward institutional excellence in marine studies was taken with the creation of LSU's Department of Marine Sciences in 1968. This department, planned and underwritten by the fledgeling Sea Grant project, has provided a medium for academic involvement of research scientists from the Coastal Studies Institute and faculty from other departments in multidisciplinary graduate programs emphasizing marine technology and resource utilization.

The administrative merger of Coastal Studies Institute, Department of Marine Sciences, and the Office of Sea Grant Development into the Center for Wetland Resources, in October 1970, provided additional visibility for university marine and wetland affairs and stronger links with discipline-based marine interests of other academic units.

Proposed M.S. and Ph.D. degree programs were approved by the Louisiana Council on Higher Education in January 1970 and marine science courses began that same year. The first regular class of marine science students graduated in May and August, 1973, including four M.S. and five Ph.D.'s. Sea Grant's preoccupation with coastal wetland ecosystems was reflected in theses concerned with chitin degradation, fish biomass, shrimp biomass, and community respiration.

During the 1971-1973 grant period, advanced degrees involving marine research topics were awarded by the departments of Food Science (10), Biochemistry (1), Botany (2), Zoology (3), Chemical Engineering (2), Extension Education (1), and the fisheries section of the School of Forestry and Wildlife Management (5). Most resulted from work on Sea Grant projects led by participating departmental faculty. This interaction among specialists from several disciplines has characterized the development of marine science courses and curricula at LSU.

Sea Grant funds also supported development of new courses in other departments. In Fisheries, James Avault and Frank Truesdale initiated

graduate courses on "Fisheries Hydrography," "Shellfisheries Biology," and "Mariculture." Samuel Meyers developed Food Science graduate courses on "Marine Food Resources" and "Food Microbiology and Toxicology." Chemical Engineers Ralph Pike and Bert Wilkins introduced "Ecosystems Analysis" and "Mathematical Analyses and Optimization of Natural Systems," based in part on their Sea Grant research background.

In the Law Center, H. Gary Knight, Campanile Charities Professor of Marine Law, has taught "Marine Resources Law" each year since 1969. Marc Hershman teaches the popular Sea Grant-sponsored "Seminar on Coastal Zone Management" which has attracted students from Law, Engineering, Fisheries, Geography, Environmental Design, Marine Sciences--and even heads of state and local government agencies. These law courses are cross-listed with marine sciences. Although Sea Grant funds cannot be used to provide salary support for teaching, they were vital in course development.

William Patrick, Sea Grant researcher in the Agronomy Department, initiated a course in "Chemistry and Microbiology of Flooded Soils and Sediments." In the College of Engineering, Charles Whitehurst spearheaded efforts to establish marine specialty options in several engineering fields; master's degree options in "Environmental Engineering" and "Ocean Engineering" will be offered starting spring semester, 1974.

Greater citizen awareness of marine sciences is the goal of James Schweitzer, Education Specialist in the Center for Wetland Resources. High school General Science is usually taught from a land-based perspective, but presenting the same body of knowledge in a marine framework has great appeal for youngsters and teachers alike. Dr. Schweitzer has conducted several training institutes to equip science teachers for this approach and similar workshops for high school students. Approximately 70 teachers have been trained to use his materials, which in turn are being expanded and modified to ultimately become a complete eighth-grade course in marine and wetland ecology.

Several hundred classroom teachers throughout the nation have developed marine science courses. These represent an important fund of knowledge and experience that can be shared. To facilitate the needed dialog between teachers, Dr. Schweitzer prepared a Directory of Marine Science Education listing more than 400 teachers interested in marine science education.

As an outgrowth of the University's traditional concern for the state's total educational program, Marine Science faculty developed recommendations for the Louisiana Advisory Commission on Coastal and Marine Resources concerning future marine instructional needs. Cited as priority educational goals were inclusion of marine and coastal resource subject matter in formal instruction as early as the eighth grade, and acceleration of career education for marine-oriented technical workers, including boat operators and marine craftsmen. Other needs are an Offshore Marine Academy for maritime professional training, and a first-class marine science teaching and research laboratory for use by personnel of any state university.

Public Service--Leading the Horse

Everyone knows the old bromide about leading a horse to water. Just about as trite is the metaphor describing universities as "well-springs of knowledge."

But bringing diverse communities of information users into contact with academic subject matter specialists, or helping them to apply information produced and archived by the university, remains an important, if sometimes neglected, task.

The National Sea Grant Program Act provides for measures to expedite the application of research findings through specialized advisory services. However, any pragmatic implementation of advisory services is partly dependent on the audiences to be served, on established precedents, and on available funding. Developing optimal arrangements for advisory services in Louisiana has been a major concern of Louisiana's Sea Grant management team since the program received institutional grant status in 1971.

Initial research efforts naturally built on available university-based competence, and focused on the state's vast coastal wetlands. The most urgent pragmatic issues that surfaced were related to public administration of these vast areas. Institutional, rather than interpersonal, arrangements were best suited for translation of scientific facts and opinions into official statements of public policy. Characteristic activities were Sea Grant support of the Louisiana Advisory Commission on Coastal and Marine Resources; work for the Louisiana Deep Draft Harbor and Terminal Authority and U.S. Army Corps of Engineers; participation in forums such as the Coastal States Organization, Gulf States Marine Fisheries Commission, and Louisiana Shrimper's Association. Such contacts are typically implemented by senior researchers and administrators, rather than advisory personnel.

Success in responding to needs of state government suggested similar involvement with trade and industrial associations. If spokesmen for industrial groups could articulate major technical concerns, university researchers could work on solutions, and thus achieve economies of effort that could not be obtained on a company-by-company basis. So far, success with this approach has been lackluster, despite continuing efforts to elicit interest. Individual companies are understandably reluctant to cooperate in any area where they hold a competitive advantage, or reveal existence of technical deficiencies. Exceptions are industry-wide problems created by governmental fiat--e.g., waste discharge standards, packaging and labeling standards, occupational health and safety measures. In these circumstances, the university often serves as a "middle ground," helping to find accomodations between official policy and economic feasibility, in addition to carrying out specialized research assignments.

The person-to-person approach embodied in traditional extension activities was not overlooked during this period, but--because of funding limitations and immediate needs--it was not rapidly developed. Rather, modest support was provided for surveys to define the demographic cultural and socio-economic make-up of Louisiana fishermen, as a prelude to implementing successful extension services.

Although the following paragraphs summarize those activities explicitly identified as advisory projects, the full measure of advisory service must take into account related research output and the public service activities carried out informally by individual researchers.

Gulf Seafood Industries

Providing advisory assistance for seafood industries--along the Gulf coast and nationwide--has long been an established function of the LSU Food Science Department. Under the supervision of department head Arthur Novak, these public service activities are closely integrated with the department's instructional and research functions. Benefits accrue to industry and departmental personnel alike: laboratory research facilities can be used to explore a variety of industrial problems; industrial facilities can be made available for scaling-up laboratory processes; and graduate students can obtain valuable problem-solving experience at on-site seafood processing plants and laboratories of federal and state agencies.

Problems of the shellfish processing industry have been Novak's special concern. He and his staff routinely provide information and assistance to shellfish plants on maintenance of quality in products during storage, handling, processing and shipping. The department has developed a variety of rapid microbiological procedures suitable for in-plant use, and these undergo constant review and improvement. Personnel are always available to help with problems in plant sanitation, prevention of contamination, adulteration, decomposition control, labeling, and packaging.

As federal standards for industrial affluent discharge have become more restrictive, attention to by-product recovery and water treatment have increased. Technology for improving the protein content of shrimp, blue crab, and crawfish meals has gone hand-in-hand with economic evaluation of new markets for these products, with direct benefits to processors and the environment.

Cooperative arrangements with several processors have enabled selected graduate students to serve internships in key quality control spots. Student exposure to operational problems of industry, and experience in solving them under faculty supervision, has been a highly successful educational approach. Through such introductions, several food science graduates have risen to prominence in various companies.

Federal agencies are advisory service recipients too. The department has assisted in interpretation and review of the Food and Drug Administration's guidelines for good manufacturing practice (GMP's) for the shrimp industry, and has conducted FOA-mandated workshops for personnel who supervise seafood canning operations. Gulf shellfish are

routinely monitored for presence of heavy metals and other toxic substances, in cooperation with the U.S. Food and Drug Administration, Public Health Service, and Atomic Energy Commission. The Armed Forces Food and Container Institute has been a regular recipient of assistance on packaging and nutritional labeling problems.

Liaison Services

In a recent address, National Sea Grant Program Director Bob Abel[1] observed that six major organizations exist to collectively represent farming interests, while a far smaller number of fishermen and processors require a kaleidescopic assortment of more than 250 to get their points across. Louisiana's shrimp fishermen alone are splintered into at least five groups, no two of which are apt to agree on a common policy or course of action.

In the face of such formidable clashes of interest, management of public fisheries is a challenging and delicate task, entrusted to the Louisiana Wild Life and Fisheries Commission.

Ted Ford occupied the commission's "hot seat" for many years, before joining the Louisiana Sea Grant program as Associate Director in 1970. Understanding the diverse views of people in the fisheries, and reconciling their legitimate self-interests with biologically sound management practices--and state law--is an art which he can effectively utilize in his present job. Now, instead of mediating arguments, Ford devotes his energies to coordinating Sea Grant capabilities with the priority needs of state agencies and commercial interests.

Louisiana's menhaden fishery has been one of Ford's particular interests. This industry accounts for a lion's share of the industrial fish landed in Louisiana, but the processing plants where the catch is rendered have been especially vulnerable to charges of environmental pollution. Meeting with spokesmen for companies that operate in the state, Ford assisted in organizing the Menhaden Advisory Council of Louisiana, to collectively attack their mutual problems. Through the council, matching funds were channeled to researchers Ralph Pike, Chemical Engineering, and Ramachandra Rao, Food Sciences, for work on pollution abatement and by-product utilization in the menhaden industry.

As a trusted spokesman for Louisiana's fishery interests, Ford chairs the Technical Coordinating Committee of Gulf States Marine Fisheries Commission, which helps coordinate technical and administrative problems of industry in the northern Gulf. In 1973, he was appointed to the Marine Fisheries Advisory Committee (MAFAC) which advises the Secretary of Commerce, and presently heads a subcommittee responsible for review of the National Fisheries Plan.

Since special legislative appropriations were made for Sea Grant matching purposes in 1971 and 1973, assuring technical accountability to

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[1] Abel, Robert B.; address to Gulf States Marine Fisheries Commission, Biloxi, Mississippi, October 18, 1974.

members of the legislative is an important function. With his long experience in marine resources management, broad overview of state, regional, and national fisheries problems, and associated parliamentary skills, Ford has been highly effective in this liaison role.

Extension Service

Louisiana may yet have a marine extension service.

Although funding emphasis was given to environmental studies urgently needed as input to coastal zone planning and superport development--instead of marine extension services--an extension planning phase was initiated in 1971.

Directed by Lynn Pesson, then Cooperative Extension Service training specialist, field agents in every coastal parish conducted detailed interviews with 500 commercial fishermen. For many agents, this was their first professional contact with fishermen; others had some previous experience with fishermen's families through 4-H activities and other community programs. The resulting profile of Louisiana fishermen included demographic characteristics, attitudes, practices and responsiveness to change; results differed significantly from audiences previously served by the Cooperative Extension Service. Useful insights concerning staff needs and organization for extension work with fishermen were obtained, but most valuable was the first-hand contact by field agents with a "forgotten" segment of Louisiana society.

Field agent services will get underway in 1974, with an agent based in Houma serving fishermen in Terrebonne, Lafourche and St. Mary parishes.

Legal Advisory Services

The mainstay of Louisiana Sea Grant's legal advisory service project is a newsletter, "Louisiana Coastal Law." Published bimonthly since September 1971, the newsletter is sent to more than 3000 individuals and organizations in 28 coastal states and 7 foreign countries.

LCL was instituted as a medium for interpretive reporting of state legislative and administrative developments in coastal zone and environmental affairs. Information was drawn from case studies performed by the Sea Grant legal research staff for state agencies, water districts, and other public administrative units; presentations to the Advisory Commission on Coastal and Marine Resources; and activities in the private sector that involved significant questions of environmental law.

The publication's scope broadened to include national and international developments as federal interest in coastal zone management and Law of the Sea grew. Analyses of federal legislation, prepared by Editor Marc Hershman for the Coastal States Organization, proved just as useful for the varied LCL audience, which includes government officials, landowners, environmentalists, and educators, along with spokesmen for fisheries, transportation, and energy industries.

The LCL staff functions as an information center and clearing house, responding to a limited number of individual requests for

information relating to marine resources and environmental law. Advocacy positions are not taken and activities that might be continued as practicing law are avoided.

Publications and Information Dissemination

Sea Grant communications isn't your typical university information program. For one thing, nobody--but nobody--has such a mixed bag of challenges. Our lucky people, in the course of a day's work, may have opportunities to:

tourafishfarm photographanoffshore structure getseasick interviewaturtlefarmer editatechnicalmanuscript composeaspeech writeanewsletter layoutacareerbrochure getchewedoutbytheWash.office(lateannualreport) mailahundredpoundsofbooks arrangeaworkshop sendakidallweknowaboutoceanography(bytuesday) runtotheprintshop parryacopymachinesalesman rapwithacongressman popularizelipids trainastudentworker servecoffee rewriteafeaturestory glamorizephotosynthesiscoveralatebreakingstoryonasitevisitlicklabels typeinvoices openmail designalogo writeaproposal movetheoffice tactfullydeclineadeadsturgeon rushtothepostoffice immortalizefishbait proofreadathesis maintainpublicationstatistics posewithawhiteeyed crawfish skiplunch tourasewagelagoon catchredbugbitesinaroseeaucanepatch andKEEPSMILING

Sea Grant Program Publications

Technical Reports

LSU-SG-72-01 THE BLUE CRAB FISHERY, BARATARIA BAY. Eugene Jaworski.

LSU-SG-72-02 AN ECONOMIC BASE STUDY OF COASTAL LOUISIANA. L. B. Jones and G. R. Rice.

LSU-SG-72-03 REPORT 1, LOUISIANA SUPERPORT STUDIES: PRELIMINARY RECOMMENDATIONS AND DATA ANALYSIS. J. H. Stone, M. J. Hershman, H. G. Knight, A. J. Moeller, Jr., D. B. Johnson, S. M. Gagliano, J. W. Day, Jr., C. A. Whitehurst, W. T. Durbin, Jr., Greg Matherne, David Modlin.

LSU-SG-72-04 COMMUNITY STRUCTURE AND CARBON BUDGET OF A SALT MARSH AND SHALLOW BAY ESTUARINE SYSTEM IN LOUISIANA. J. W. Day, Jr., W. G. Smith, P. R. Wagner, W. C. Stowe.

LSU-SG-72-05 REPORT 2, LOUISIANA SUPERPORT STUDIES: PRELIMINARY ASSESSMENTS OF THE ENVIRONMENTAL IMPACT OF A SUPERPORT ON THE SOUTHEASTERN COASTAL AREA OF LOUISIANA. J. H. Stone.

LSU-SG-72-06 CIRCULATION AND SALINITY DISTRIBUTION IN A MARSH SYSTEM OF COASTAL LOUISIANA. B. J. Kjerfve.

LSU-SG-73-01 THE MICROBIAL DEGRADATION OF OIL POLLUTANTS. D. G. Ahearn, S. P. Meyers.

LSU-SG-73-02 AN ANNOTATED KEY TO CRABS AND LOBSTERS (DECAPODA, REPTANTIA) FROM COASTAL WATERS OF THE NORTHWESTERN GULF OF MEXICO. D. L. Felder.

LSU-SG-73-03 REPORT 3, LOUISIANA SUPERPORT STUDIES: RECOMMENDATIONS FOR THE ENVIRONMENTAL PROTECTION PLAN. J. H. Stone, Michael Robbins.

LSU-SG-73-04 AIR CUSHION VEHICLES IN THE OFFSHORE OIL INDUSTRY: A FEASIBILITY STUDY. J. M. Pruett.

LSU-SG-73-05 1973 DIRECTORY OF MARINE SCIENCE EDUCATION. J. P. Schweitzer.

Newsletters and Pamphlets

LOUISIANA MARINE SCENE. Compilation of newspaper clippings sent to some 400 Louisiana teachers on happenings in the marine world. Bimonthly.

MARINE SCIENCE TEACHING AID. Marine-related concepts that can be taught in typical high school science classes. Includes background material and suggested activities. Four to six issues per year, for teachers.

AQUANOTES. Primarily for residents of Louisiana, or those interested in Louisiana. Ranges in subject matter from research projects to just-for-fun reading with an informative slant. Always relates to Louisiana wetland resources. Bimonthly.

LOUISIANA COASTAL LAW. Deals with state and federal legal developments on coastal and marine law and affairs. Primary focus on Louisiana. Bimonthly.

SEA GRANT PROGRAM EXPENDITURES

	1971-72 NOAA Funds	1971-72 Matching Funds	1972-73 NOAA Funds	1972-73 Matching Funds
Marine Resources Development				
Aquaculture	51,972	74,288	74,352	62,445
Living Resources Other than Aquaculture	34,556	30,743	67,775	33,300
Marine Law and Socio-Economics	64,904	45,180	83,796	80,509
Marine Technology Research and Development				
Resources Recovery and Utilization	28,977	32,100	31,471	18,734
Transportation Systems	6,725	16,340	15,406	--
Marine Environmental Research				
Coastal Zone Management	27,591	44,150	34,775	30,439
Ecosystems Research	174,403	147,700	117,457	33,988
Pollution Studies	--	--	34,650	15,401
Environmental Models	39,718	24,170	47,533	21,734
Marine Education and Training				
College Level	50,136	80,580	27,017	45,409
Advisory Services				
Extension Programs	9,970	8,740	11,236	30,720
Other Advisory Services	58,833	35,323	84,624	59,061
Program Administration and Development				
Program Administration	68,694	69,460	163,308	68,077
Program Development	--	5,730	--	--
Totals	$616,479	$614,464	$793,400	$499,817

LOUISIANA SEA GRANT PROJECT STATUS

SYSTEMS ECOLOGY	71-72	72-73
Experimental Ecology Gosselink, Smith, Ho, Meyers, Allen, Loesch, Bennett, Patrick	C-S	
Estuarine Productivity Gosselink, Day, Ho, Smith, Patrick		S-C
Growth and Physiology of Marine Organisms Meyers, Allen, Ho, Srinavasan, Meier		S-C
Crustaceans and Fishes of Caminada Pass Truesdale	C-S	
Migration and Distribution of Fishery Resources Truesdale, Loesch, Bennett		S-C
Mathematical Ecology Pike, Wilkins	C-S	
Synthesis: Models and Simulation Pike, Wilkins, Day, Gosselink, Smith		S-C
Systems Analysis Pike, Wilkins	N-T	

WASTE EFFECTS		
Enrichment of Marsh Habitats Smith, Day		N
Geochemistry of Cadmium in a Salt Marsh Ecosystem Ferrell		N

FISHERIES AND SEAFOOD INDUSTRIES		
Development of Gulf Fisheries Products Novak, Grodner, Meyers, Liuzzo, Hoskins, Rao, Rutledge	C	C
Nutrition of Penaeid Shrimp and Invertebrate Rations Development Meyers	C	C
Menhaden By-Product Development and Pollution Control Rao, Pike		N
Culture of Finfish and Crustaceans Avault	C-S	
Finfish Culture Avault		S-T
Crustacean Culture Avault		S-C
Microsporidiosis in Commercial Shrimp Kruse	T	
Aquaculture and Resource Utilization in Pipeline Canals Harris, Kilgen	N	C
Loxothylacus Texanus in the Blue Crab Ragan	N	C

COASTAL ZONE PLANNING AND DEVELOPMENT	71-72	72-73
Environmental Analysis for Coastal Zone Planning Gagliano, Shlemon, van Beek		C
Urban Encroachment in the New Orleans Area Gagliano		N-T
Louisiana Superport Feasibility Studies Stone, Johnson, Gagliano, Whitehurst		N
LAW AND SOCIO-ECONOMICS		
Planning and Management in Louisiana's Coastal Zone Hershman, Knight	C	C
Legal Aspects of Ocean Resources Exploitation Knight	C	C
Economic Base Study of Coastal Louisiana Jones, Rice		R-T
Economic Study of Louisiana Coastal Resources Johnson, Jones, Rice		R-T
Human Factors in Wetland Resources Development Bertrand		N
EDUCATION AND TRAINING		
Marine Sciences Van Lopik, Schweitzer	C	C
Marine Resources Law Knight	T	
Fisheries and Aquaculture Truesdale	N-T	
Coastal and Estuarine Engineering Whitehurst	C-S	
Transportation Engineering in the Coastal Zone Whitehurst, Yannitell, Modlin		S-T
ADVISORY SERVICES		
Publications and Information Dissemination	N	C
Extension Needs for Wildlife and Fisheries Production	N	C
Liaison Services for Wildlife and Fisheries Interests	C	C
Advisory Services to Gulf Seafood Industries	C	C
Legal Advisory Services		N
MANAGEMENT AND DEVELOPMENT		
Program Administration	C	C
Field Logistic Support		N

N = New Project
S = Split Project
C = Continuing Project
R = Redirected Project
T = Terminated Project