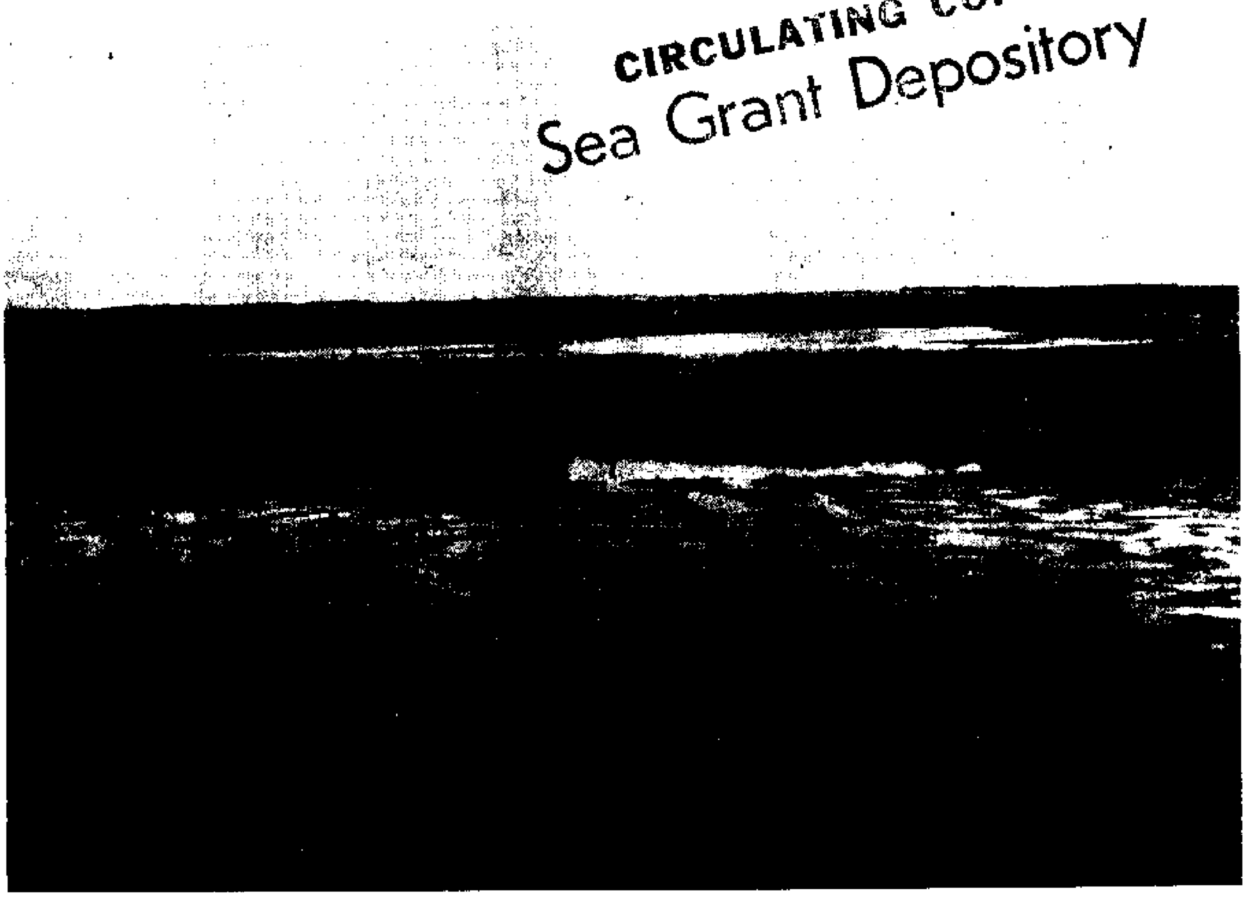
Coastal Land
RESOURCES



CONFERENCE PROCEEDINGS

June 16-17, 1970

TAMU-SG-71-101

September 1970

COASTAL LAND RESOURCES CONFERENCE

CONFERENCE PROCEEDINGS
June 16-17, 1970
Galveston, Texas

TEXAS AGRICULTURAL EXTENSION SERVICE
IN COOPERATION WITH
THE
SEA GRANT PROGRAM
OF
TEXAS A&M UNIVERSITY

TAMU-SG-71-101
September 1970

FOREWORD

Public Law 89-688, known as the Sea Grant College and Program Act, was passed by the Congress of the United States on October 15, 1966. This act was modeled after the Morrill Land Grant Act of 1862 through which the land grant colleges of this nation were established. Texas A&M University is proud to be the designated land grant university for the State of Texas.

The Texas Agricultural Extension Service of Texas A&M University has a long history of furthering agricultural development in Texas. The Sea Grant and College Act has afforded the Texas Agricultural Extension Service the opportunity to serve the people of Texas in new and broader ways by developing new educational programs for coastal development. Currently the Extension Service is conducting shrimp aquaculture demonstrations at marsh ponds in Brazoria and Orange Counties. Extension fishery specialists are working with the fishing fleet operators to develop new techniques and gear for increased fish and shrimp harvests. Still other Extension specialists are working to maximize the use of coastal beaches for orderly recreation development.

This proceeding is an overview by scientists and government specialists of activities, problems, and opportunities associated with the Texas coastal areas, and we trust that it will prove helpful to all those concerned with coastal land use.

John E. Hutchison
Director
Texas Agricultural Extension Service

TABLE OF CONTENTS

THE SEA GRANT PROGRAM AND COASTAL DEVELOPMENT

JOHN C. CALHOUN
Vice President for Programs
Director of Sea Grant Program
Texas A&M University

I am very pleased to be here this morning to join with the Texas Agricultural Extension Service in welcoming you to the Coastal Land Resource Conference. The Sea Grant Program at Texas A&M works through many different departments and organizations, and in this particular case, we are joining hands with our co-workers from the Agricultural Extension Service to address an area of common interest.

Although some of you may have heard about the Sea Grant Program, others may be unfamiliar with it, so I would like to take a few minutes to describe the program.

The name was adopted as a parallel to the Land-Grant Program which was the basis for establishment of land-grant universities. Congress passed the Sea Grant College and Program Act of 1965 in order to create a program that would turn the talents of the universities toward accelerating the development of marine resources. The reasoning was that a system of support which had worked so well to advance agriculture might also work to advance our uses of the sea. Congress assigned this program to the National Science Foundation for administration.

Although there have not yet been any Sea Grant Colleges designated, the National Science Foundation has established eight institutional awards. These have been granted to universities willing to involve all of their academic programs and scientific talent in the activities of marine resources development. Institutions which have received these awards are the University of Rhode Island and the University of Miami on the East Coast; the University of Wisconsin and the University of Michigan on the Great Lakes; the Oregon State University and the University of Washington on the Pacific Coast; the University of Hawaii in the Pacific; and Texas A&M on the Gulf Coast. The first award was made to us in the summer of 1968, so our program began September 1, 1968, and is less than two years old.

Our current grant from the National Science Foundation is $750,000 for 1969-70. Texas A&M must contribute supporting funds in the amount of one-half of this grant. This means that our approved programs must closely parallel activities which are already underway and for which we have legislative support.

Our activities under the Sea Grant Program involve approximately 44 projects, so that the average size of the individual projects is not large. We have involved over 90 faculty persons in the program in some form, and we have more than 70 student participants in the current year. During the current year, the distribution of our funds is approximately 57 percent toward research projects, 19 percent toward education and training, 15 percent toward extension and advisory services, and 9 percent toward program direction and program development.

In keeping with the concept of focusing the talents of universities on priority problems related to the development of a resource, the individual activities of the program may include the development of new courses and curricula, extension activities, advisory services, or dissemination of information to the public as well as research. Under our program, we have developed graduate courses in coastal engineering, ocean engineering, sea-food technology, underwater acoustics and special areas of marine biology. We carry on technician training programs in several locations. We have developed short courses in such areas as dredging and special instruction in areas such as deep-sea diving.

Research projects related to fish diseases and handling of marine animals have been initiated through our College of Veterinary Medicine. Projects in economics have been started through our Industrial Economics Research Division and Institute of Statistics. Projects in pollution are being conducted under the environmental engineering program. Activities on the pond culture of shrimp are done through the Agricultural Extension Service. In addition, we have research projects or other educational activities in oceanography, in marine biology, in wildlife science, in animal science and in industrial economics--to name a few of the involved departments.

Our program also includes projects with other institutions. Our cooperative work this year included a research program with Lamar College of Technology, a technician training program with Galveston College, a technician training program with the State Technical Institute and an exploratory conference with the University of Houston Law College. During the coming year, we expect to have cooperative programs with the University of Houston Law College, with Brazosport Junior College at Freeport, with Del Mar College in Corpus Christi and with the Dow Chemical Company, in addition to those which are active this year.

So far as extension and advisory services are concerned, we publish a number of bulletins and a monthly newsletter; we have a fishery specialist located in Galveston for working with the fishing industry and during the coming year, we hope to add other extension specialists on particular kinds of activities. Available at the conference door are copies of "Marine Affairs in Texas," a report of our program for its first year, and copies of other publications which are available for general distribution.

One of the first things we found was that it was difficult to obtain an overall view of the marine resource industries of Texas. We were able to establish local contacts with the fishing industry, with the oil industry, with the marine transportation industry and with others, but we found no one place from which we could obtain a summarization of total marine resource related activities. Consequently, one of our early projects was an attempt to inventory these industries. We have produced a report entitled "A Summary of Coastal Activities," copies of which are available outside the conference room.

In launching a program of this nature, it is quite important that we understand the needs of the State for educational and research activities. It is our goal to design programs in specific response to those needs. In fact, we have agreed with the National Science Foundation that our program will assess the needs in this region and bring into being programs that are responsive wherever we may find the talent to do so. At Texas A&M, we started with some assessment of these needs and we launched programs along the lines we thought most fruitful. However, we also immediately embarked upon a program to consult with state agencies, industries and other groups in order to refine this picture. The conference that we are holding today is one in a series of conferences which have been designed in order to further this purpose. From this conference, we hope to obtain the views of marine resource users as to the top priority problems in coastal land development.

Last fall we held a workshop in Houston for discussing marine resource needs and desirable educational programs with leaders of industry, particularly the oil and gas industry. From that, we published a report called "Texas Marine Resources: The Industrial View," copies of which are available at the conference door. A second workshop was held with educators and the summary is published as "Texas Marine Resources: The Educational View." I have a copy here with me, but do not have copies available for distribution. Additional topical workshops, which have been held and on which we are preparing publications, include a workshop on recreation and tourism, which was held in Corpus Christi; a workshop on marine law, which was held in Houston; and a workshop on marine transportation, which was held in Port Arthur. We have one or two other workshops planned before the year is through. From each of these workshops and conferences, we expect to publish summaries which outline the principle points that have been brought up.

At some time in the future, we will bring together the views of these various groups to arrive at an overall plan for the Sea Grant activity. We hope that we can achieve this partially through a conference which has been called by Governor Smith. On September 10 and 11, there will be a conference, "Goals for Texas in the Coastal Zone and the Sea." The Sea Grant Office is assisting in organizing this conference. From it we hope to obtain a focused view on marine resource needs and on educational programs designed to fill those needs.

The Sea Grant Program is interested in coastal land development, although not necessarily in all its aspects which are germane to the interests of agriculture. Marine resources are defined very broadly so far as the Sea Grant College Act is concerned. This definition includes anything on the seabed, in the water column or contiguous to the sea. It even includes those things pertaining to the interaction with the air above the water. Furthermore, the definition of the marine area was made broad enough to include not just the open ocean, but the shoreline, the estuaries and even the Great Lakes. The National Science Foundation would raise question, I am sure, if we suggested projects that involve waters too far inland. However, it is clear that the intent of the program is to consider those things that have a direct bearing on the development of marine resources. Certainly, this includes the use of the land immediately adjacent to the coast, particularly as this land may be for the purposes of developing marine resources or for making use of the sea.

The coastal zone itself is an area of intense concentrations. Man is attracted to the coastal region as a place to live, work and play. It is a good place to locate industry. It usually has a favorable climate and it is a good place for recreation. In order to make use of water transportation, it is necessary to have access to the ocean. If we would have commercial transportation by water with other nations, seashore activity is a necessity. One needs only to look at a map of the United States to appreciate the manner in which people have congregated along the shoreline. Some estimates say that by the year 2000, more than two-thirds of our people will be living in the coastal strip.

The coastal region is limited in extent. It isn't limitless, and there is no way to make a new sea-land interface. Consequently, the region which we have must be used wisely. From the land side of this coastal region, it appears that control and regulation will be through the means we use to control the use of the land.

So far as the seaward side of the ocean-land interface is concerned, it appears that the critical element is the biological system. People live on one side of the interface; fish and other marine forms live on the other side. The marine organisms seem to like the coastal region just as well as man does. It apparently gives them shallow grounds for spawning, protected areas for population development, and a source of enriched nutrients and food.

Consequently, the Sea Grant Program is deeply interested in how coastal lands are used. Marine resource development cannot proceed without an allocation of coastal lands to those purposes which are germane to or have high priority for marine resource development. If the principle marine resource is recreation, we must take this into account in the allocation of coastal lands. If the principle marine resource development is transportation, this must be taken into account. If the principle marine resource happens to be minerals, this must be taken into account. In short, there is a close coupling between the priorities assigned for marine resource development and our uses of coastal land. Hence, Sea Grant is interested in this conference. We are anxious as to what you can tell us on the design of research programs and educational activities that will assist you in making effective use of coastal regions.

A PERSPECTIVE OF COASTAL LAND UTILIZATION

DANIEL C. PFANNSTIEL
Assistant Director
Texas Agricultural Extension Service
Texas A&M University

"In spite of their tremendous natural value for wildlife, for sport and commercial fish and shellfish production, for recreation, and for scenic beauty, the coasts and estuaries are constantly being surrendered to other uses."

"The nation's priceless coastlines and estuaries are in trouble. They are being mismanaged, misused, and degraded."

"While some progress has been made in recent years, the nation lacks an effective system for managing its coasts and bays and estuaries. Efforts are being made in Congress, and in some states, to solve the problem. But meanwhile these natural resources, which are of great value to the general public, remain in a state of siege."

"Private interests and even government agencies demand that they be dredged and filled and built upon -- to make profits, to promote industry and expand the tax base, and to accommodate a population that is growing and shifting to cities."

"Housing poses a major demand, and not only for basic homes and high-rise apartments alone. The second-home market continues to mushroom, fed by corporate conglomerates operating on an unprecedented scale, often in ecologically sensitive coastal areas. There is pressure for expansion of ports and their facilities, to handle jumbo tankers, containerization and growing tonnages; for building and expansion of airports, to accommodate greater traffic and larger planes; for highways, causeways and bridges; for electric power generating plants at sites with abundant cooling water; for garbage dumps; for marinas and other recreation facilities; for navigation; and for extraction of more oil, sand, gravel and other minerals."

These statements were taken from the May 1970 monthly letter of The Conservation Foundation. They express rather succinctly and eloquently the pressing problems that we are facing in our coastal regions and offer an excellent introduction to the subject which has been assigned to me here this morning, "A Perspective of Coastal Land Utilization."

According to some recent studies (National Estuary Study - Fish and Wildlife Service of the Interior Department, January 1970, and National Estuarine Pollution Study - Federal Water Quality Administration of the Interior Department, November 1969), there are some 21,724 miles of recreation-type shorelines in the 28 mainland coastal and Great Lake States of which 19,934 miles are privately owned. It was also indicated that while the national population grew 46 percent in the three decades from 1930 to 1960, the estuarine areas experienced a 78 percent growth during the same period. U. S. coastal counties contain only 15 percent of the land area of the United States but they have 33 percent of the Nation's total population.

It was interesting for me to note that Texas ranks only second to Florida in the terms of overall miles of beach for recreational purposes.

There is, of course, no need of pointing out to the members of this particular audience the significant importance of coastal land resources to the total economy of the State of Texas. We could spend a lot of time looking at statistics which would indicate the relative importance of the various land uses of the coastal area, but I see no particular point that this would serve. I do feel, however, it might be useful to keep in mind the myriod of uses that are made of our coastal lands and waters. I suppose there are all kinds of lists that could be developed, but one I would make would run something like this:

1. Industry (manufacturing, processing, etc. - proximity to raw materials as well as shipping)
2. Mining (oil, gas, sulfur, shell, and other extractions)
3. Ports
4. Transportation (shipping)
5. Recreation (boating, fishing, contemplation, swimming, surfing, etc.)
6. Fisheries (commercial and sports)
7. Aquaculture
8. Farming and ranching
9. Waterfowl and other wildlife
10. Dwellings (primary and secondary housing)
11. Dumping ground

Each of these uses is by no means a mutually exclusive one - as for example, fishing and recreation. But a mere recitation of all of them does make one realize the great variety of uses to which our coastal lands are put. And we would recognize that many of the specific ones are diametrically opposed to one another. Many of them - indeed most of them - are also in direct conflict with the delicate ecological system which our bays and estuaries sustain.

The competition among all is often fierce - a sort of jungle, if you will - but unlike the law of the jungle, even the "fittest" that survive may find the victory quite hollow - if in the process the base itself is destroyed. Economics plays an overriding influence in the interplay of uses. Somehow we must find and channel the uses to those which are economically feasible while at the same time insuring the base itself will not be destroyed irreversibly.

Dr. Calhoun has given you an overall perspective of the Sea Grant Program of the Texas A&M University and its relationship to coastal development. I would like to follow this with some comments about how the Texas Agricultural Extension Service, as a part of Texas A&M University, is involved in carrying out the Extension and Advisory Function of the total Sea Grant Program of Texas A&M University. One reason that we have become involved in this operation is that we already have located in virtually all the counties of the State professional educators known as county Extension agents, such as county agricultural agents and county home demonstration agents. Many of you recognize, I am sure, that both we and our sister agency, the Texas Agricultural Experiment Station, have been involved many years in certain aspects of coastal land use, particularly that relating to agriculture involving both ranching and farming, wildlife development and utilization, and recreation. We have welcomed the opportunity that the Sea Grant Program is providing us to intensify our efforts not only in some of the areas that we have been working in for some time but also to get involved in some of the newer ones.

The primary objective of the Sea Grant Extension and Advisory Program is the interpretation and dissemination of research findings to owners, managers, and users of maritime resources. We are utilizing basic Extension teaching methods such as publications, mass media, applied research, demonstrations, and individual assistance to achieve these objectives.

Phases which we feel offer some potential opportunities for economic utilization of resources along the Texas Gulf Coast include the following:

1. Commercial production of marine species of life.

2. Orderly, attractive, and efficient development of beaches and associated lands and waters for outdoor recreation.

3. Habitat maintenance and improvement of coastal marshes for waterfowl, furbearers, and other wildlife.

4. Provision of special technical informational services for training and education programs to the:

    Commercial fishing industry,

    Dredging industry,

    Port facilities and shipping industry,

    Petroleum and chemical industries whose basic source of raw materials is derived from the sea or the ocean floor.

5. Coordination of industrial and municipal needs with those concerning biological aspects of the marine environment.

6. General understanding by the public of the contributions of the marsh, estuary, and bay system toward present and future commercial and sport fishing, shellfish production, waterfowl hunting, and other recreational or commercial uses.

As we got into this program actually just a little over a year ago, we recognized that one of the big threats to the coastal areas was the ultimate destruction of the natural eco system. We recognized that the pressures for developments which interfere with such eco systems were very great. It was reasoned that if there were to be a realistic hope of preserving many of these areas, it would lie in trying to find economic uses of the land which would still preserve the basic natural character. This is why we have focused very early on the efforts to determine the economic feasibility of the production of marine species of life, principally shrimp. We have had one year's experience in conducting shrimp production demonstrations in Brazoria County which suggests that there is a potential for the commercial production of shrimp. If an economically viable industry can be established, it will make a major contribution preserving our estuaries and bay systems.

One of the basic tenets in Cooperative Extension work has been and continues to be the involvement of people locally in helping to identify the important problems that should be the focus of our educational programs. In the counties, we call this the program building process whereby the key leadership in a county is involved in a formal way in taking a look at all facets of the economy and society of the county to identify the significant problems and to establish goals which will contribute to the solution of those problems. In getting into these expanded areas of work made possible by the Sea Grant Program, we felt that it would be most important to have a group of knowledgeable individuals work with us in identifying the key problems on which we should be working. There are so many things that need to be done that priorities need to be established.

We asked the county agricultural agents serving the 18 coastal counties of Texas to gain the counsel of their local county program building committees in identifying outstanding leaders in their areas who could make a significant contribution by serving on a Coastal Wide Land Resource Committee. Nineteen individuals were selected through this process and this committee was invited to organize itself last fall. I would like to indicate to you the present membership of the Coastal Land Resource Advisory Committee.*

We would encourage those of you that have particular concerns and ideas about things we ought to be working on to convey these to one of the members of this committee. There is at least one member from each county or at least each two-county area. I might also point out that the committee in its organizational meeting decided to establish an executive committee of five individuals. Mr. Joe Lagow of Anahuac is serving as Chairman, and Mr. James McFaddin, Jr., of Beaumont serves as Vice Chairman. Representing the upper coast from San Luis Pass to Sabine River is Mr. Paul Hopkins of Galveston. Representing the middle-coast area from San Luis Pass to Palacios is Mr. John P. Gayle of West Columbia, and representing the lower coast from Palacios to Brownsville, Texas, is Mr. O. P. Little of Rockport.

At a meeting of the Executive Committee several months ago, several specific recommendations were made by the group. Among these were the following:

1. That the economics of waterfowl hunting and income production of waterfowl hunting to coastal land owners be examined and that such information be published and distributed widely.

2. That the problems of coastal pollution should be examined and methods suggested for protecting people from contaminated sea foods.

3. That the effects and utilization of hard insecticides in or near coastal waters should be examined with a possible view to the elimination of such insecticides.

4. That the orderly growth of recreation and tourism in the coastal zone be promoted. Methods of controlling unsightly growth should be examined and recommendations be made as to how best to control this should be made to responsible officials.

5. That the effects of shrimping in bays of Texas on juvenile shrimp populations be studied.

6. That the effects of land filling in Texas' bays on crustacean habitat should be examined.

*List attached.

7. That the Texas Agricultural Extension Service sponsor a land resource conference so that an examination of some of the major problems of the coastal land could be explored. This very conference is a direct consequence of that particular recommendation of the committee.

I want to say how very much we appreciate the willingness of this group of distinguished gentlemen to serve on the Coastal Land Resources Advisory Committee. Again we would urge any of you who have particular thoughts and concerns to communicate these to any members of the committee for consideration by the total group. We look forward to having this group serve as a sounding board and to help determine the significant problems that need to be worked on in the future.

We hope you will find your participation in this conference to be a worthwhile experience.

COASTAL LAND RESOURCE ADVISORY COMMITTEE

Mr. John P. Gayle
Brazoria County
County Commissioner, Precinct 2
P. O. Box 712
West Columbia, Texas 77486

Mr. P. G. Harrison
Brazoria County
Route 1, Box 440
Angleton, Texas 77515

Mr. O. P. Little
Aransas County
90 South Austin
Rockport, Texas 78382

Mr. Alvin A. Hahn
Calhoun County
Route 2, Box 220
Port Lavaca, Texas 77979

Mr. Ted R. Hunt
Cameron County
P. O. Box 157
Port Isabel, Texas 78578

Mr. Joe L. Lagow
Chambers County
County Commissioner
Anahuac, Texas 77514

Mr. Walter D. Grover
Galveston County
Manager of Jamaica Beach Corporation
1314 Rosenberg Street
Galveston, Texas 77550

Mr. Paul Hopkins
Galveston County
County Commissioner
County Building, Highway 3
Dickinson, Texas 77539

Mr. Bill Elliott
Harris County
County Judge
720 Family Law Center
1115 Congress
Houston, Texas 77002

Dr. C. M. Dugger
Jackson County
P. O. Box 550
Edna, Texas 77951

Mr. James McFaddin, Jr.
Jefferson County
P. O. Box 2612
Beaumont, Texas 78704

Mr. Rex Wright
Kleberg County
802 East Ragland
Kingsville, Texas 78363

Mr. Bert Huebner
Matagorda County
P. O. Box 566
Bay City, Texas 77414

Mr. W. F. Green
Matagorda County
P. O. Box 425
Bay City, Texas 77414

Dr. Phil Oetking
Nueces County
P. O. Box 2604
Corpus Christi, Texas 78403

Mr. Sam Parish
Orange County
P. O. Box 1576
Orange, Texas 77630

Mr. Lawrence Wood
Refugio County
P. O. Drawer AA
Refugio, Texas 78377

Mr. J. C. Ermis
Refugio County
Star Route
Woodsburo, Texas 78393

Mr. C. R. Patterson
Executive Vice President
Esso Production Research Company
P. O. Box 2189
Houston, Texas 77001

SHRIMP MARICULTURE AT THE BUREAU OF COMMERCIAL FISHERIES BIOLOGICAL LABORATORY

CORNELIUS R. MOCK
Fishery Biologist
Bureau of Commercial Fisheries Biological Laboratory
Galveston, Texas

Since 1950, shrimp consumption in the United States has increased from 118.3 million pounds (heads-off weight) to 336.8 million pounds. This represents a 6% annual increase. Shrimp consumption increased from 0.8 pounds to 1.7 pounds per person in that period, a 115% gain. In comparison, during 1950-68, per-capita consumption of meat, poultry, and fish combined increased 19%.

In 1950, shrimp imports were only 40% of the domestic landings; since 1961, imports have been greater than total domestic landings (Table 1 and Fig. 1). According to Cleary (1970), two important observations can be made:

1. Each 1% gain in per-capita real income tends to be accompanied by a 1.8% increase in per-capita shrimp consumption.

2. Each 1% increase (relative to general price level) in the retail price of shrimp is accompanied by a 0.5% decline in per-capita consumption.

With these data, we can predict with some reliability what demand and consumption are likely to be in the future. Present world production is slightly more than 1 billion pounds. U. S. consumption of shrimp in 1968 was 337 million pounds, or about one-third of the world production. If production increases as anticipated, the total world catch will reach 1.9 billion pounds by the late 1970's.

There has been considerable speculation concerning the development of a shrimp farming industry in this country. Although the technology for shrimp farming has not been developed, we do anticipate commercial activity in some phases of shrimp culture in the near future. The first profitable commercial operations will probably be the culture of shrimp for the live bail markets. The relatively high price paid for live bait will permit

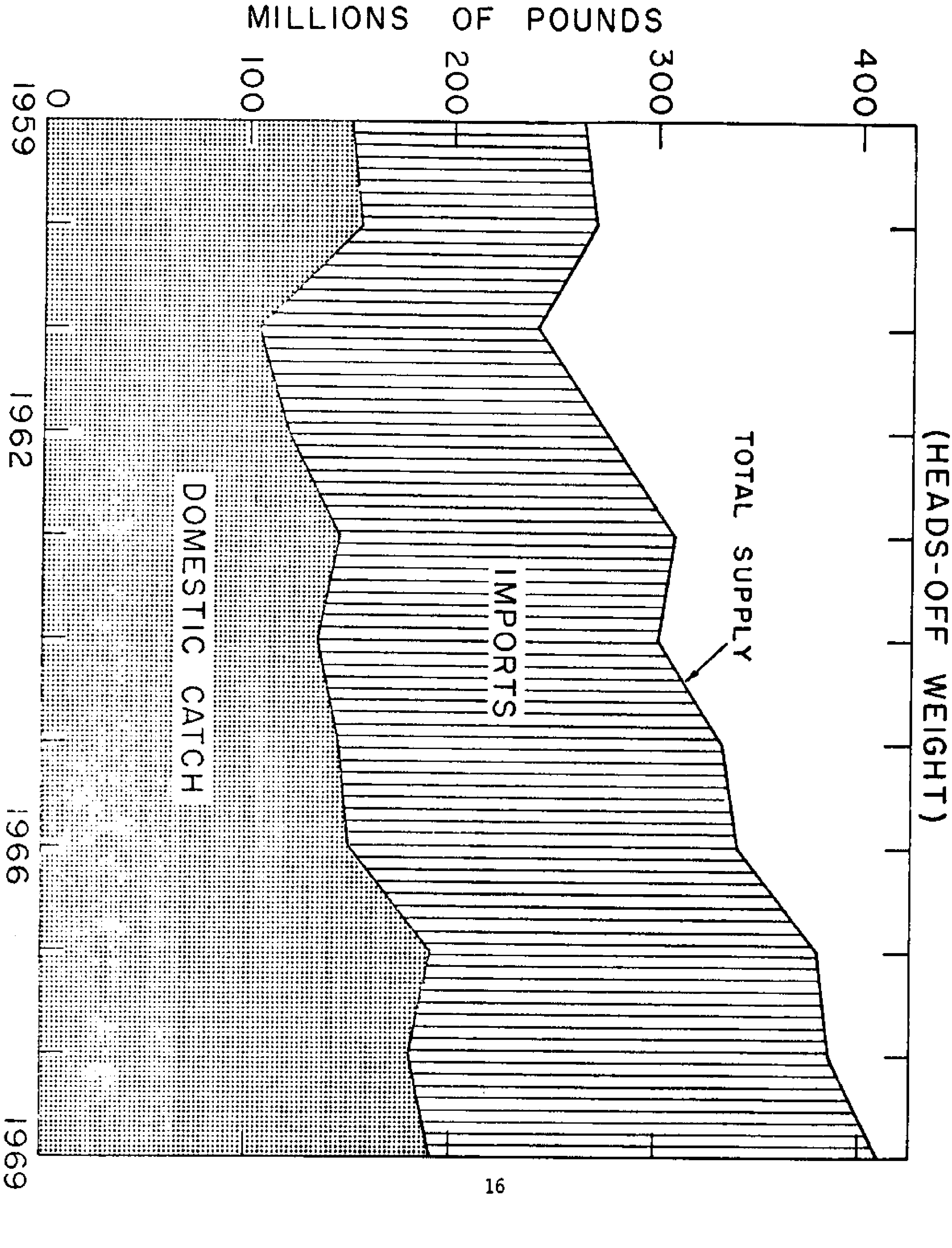
Table 1. U.S. catch and imports of shrimp by years 1/

Year	U. S. catch			Imports 2/			Total Heads-off
	Heads-on	Heads-off	Percent of total	Import Weight	Heads-off	Percent of total	
	Thousand pounds	Thousand pounds	Percent	Thousand pounds	Thousand pounds	Percent	Thousand pounds
1959	240,182	142,965	56	106,555	111,704	44	254,669
1960	249,452	148,483	55	113,418	119,139	45	267,622
1961	174,530	103,865	44	126,268	134,564	56	238,429
1962	191,105	119,154	44	141,183	152,504	56	271,658
1963	240,478	150,737	47	151,530	167,344	53	318,081
1964	211,821	133,113	44	154,577	169,510	56	302,623
1965	243,645	152,346	46	162,942	178,955	54	331,301
1966	239,046	148,255	43	178,549	194,946	57	343,201
1967	307,787	189,972	48	186,073	202,105	52	392,077
1968	291,600	179,430	46	189,455	209,342	54	388,772
1969	*317,100	195,500	47	*193,741	220,100	53	*415,600

1/ From Fisheries of the U.S. 1969, U. S. Department of the Interior, CFS No. 5300, 50 pp.

2/ Imports for 1959-69 were converted to heads-off weight on the basis of available data on the actual condition of the imports. *Record.

Figure 1. U. S. catch and imports of shrimp by years. (From Fisheries of the U. S. 1969, U. S. Department of the Interior, CFS No. 5300, 50 pp.).


MILLIONS OF POUNDS
(HEADS-OFF WEIGHT)
0
100
200
300
400
1959
1962
1966
1969
TOTAL SUPPLY
IMPORTS
DOMESTIC CATCH

profitable production of small shrimp in ponds despite the fact that efficient culture techniques are not available. Under normal weather conditions, two crops per acre could be harvested annually. However, if heated effluent from a power plant was used, six crops could be harvested. Commercial production of postlarval shrimp will develop hand-in-hand with the bait shrimp operations.

Table 2 lists the poundage and value of food and bait shrimp harvested from 1966 to 1969 from the Galveston Bay system. This is only a portion of the total Texas catch. Of particular interest is the relative size of catches made by the bait shrimp industry. Although the supply of live bait varies from year to year, the average price paid per quart is $2.75; dead bait brings only 50¢ a pound. Generally speaking, the bay-caught shrimp are the size that can now be reared economically in ponds.

The second commercial application of shrimp-rearing know-how, which will be possible from the technical standpoint, is that of stocking. Stocking of artificially reared shrimp in natural waters may be desirable in areas where natural production is always poor or at times when natural reproduction is poor because of environmental fluctuations. We do not know whether stocking will be economically beneficial. A careful evaluation of costs and benefits is needed before decisions can be made in this area.

The third type of commercial development will probably be farming of shrimp in ponds for sale as food. Several problems have prevented the development of shrimp farming for the food market. These are (1) the high cost of obtaining young shrimp for stocking, (2) the fact that no efficient foods are available, and (3) the low price per pound paid for shrimp of the small sizes which can be raised in ponds.

Research objectives at the Bureau of Commercial Fisheries Biological Laboratory in Galveston, Texas, are planned to aid commercial development on a long-term basis. These include the refinement of hatchery techniques so that operating costs will be reduced and the survival of larval shrimp will be increased. Additionally we hope to determine the nutrition requirements of shrimp and to formulate suitable artificial foods for shrimp of all sizes. Considerable effort will be directed toward maturation of shrimp in captivity. When methods are developed for holding shrimp through their entire life cycle, selective breeding will begin, and true farming will be possible.

Shrimp culture work at the Galveston Biological Laboratory consists of collecting live female shrimp in spawning condition, spawning them in the laboratory, hatching the eggs, and rearing the larvae. Female shrimp are collected in the Gulf of Mexico and are held at low temperature until their arrival at the laboratory. In the laboratory the gravid females are acclimatized to warmer water temperatures. Spawning usually occurs within 48 hours if the shrimp are in a ripe condition. Shrimp are spawned in 5-gallon carboys, and the eggs are transferred to 250-gallon tanks.

Table 2. Galveston Bay shrimp landings

Year	Bait shrimp catch 1/		Food shrimp catch 2/		Combined value
	Weight	Value	Weight	Value	
	Pounds	Dollars	Pounds	Dollars	Dollars
1966	785,900	872,900	3,677,300	2,803,400	3,676,300
1967	1,087,900	1,271,800	6,200,600	3,581,600	4,853,400
1968	1,102,600	1,336,800	4,740,100	3,767,100	5,103,900
1969	1,007,500	1,259,375	5,629,500	4,579,000	5,838,375

1/ K. N. Baxter, personal communication, Bureau of Commercial Fisheries, Biological Laboratory, Galveston, Texas.

2/ J. W. Morgan, personal communication, Bureau of Commercial Fisheries, Biological Laboratory, Galveston, Texas.

The eggs hatch in about 12 hours, provided conditions in the water such as temperature, salinity, and pH are maintained within a narrow range suitable for the species. Conditions within the rearing tanks also are critical for the larvae which are reared to an age of about two weeks. The larvae are fed diatoms cultured in the laboratory during the early stages and brine shrimp (*Artemia* sp.) nauplii during the later stages.

By the age of two weeks, shrimp have reached the post-larval stage and can be transferred to brackish water ponds where they will grow to a length of about four inches utilizing natural foods. Rapid growth can be encouraged by adding fertilizers or feed to the ponds. In our ponds, growth diminishes as the shrimp approach the sizes at which they normally leave the estuaries and move offshore (3½ to 4½ inches). Although some male shrimp will mature sexually in the ponds, none of the females will.

As the demand for shrimp increases, not only in the United States but all over the world, shortages of natural stocks will focus more attention to mariculture. In 1968, Lindner and Cook (in press) indicated that shrimp culture had not reached the stage where they would recommend commercial hatcheries because of the lack of technology. Just 2 years later, a number of private companies have built hatcheries for the express purpose of growing and selling young shrimp for stocking.

Shrimp research at the Galveston Laboratory will continue to help solve the problems encountered in this commercial venture. Table 3, although speculative, illustrates what we think can now be done in ponds.

Table 3. Theoretical yields from 1-acre shrimp ponds based on an assumed mortality of 50%

Stocking Rate	20,000 postlarval shrimp/acre	
Stocking Cost	$7.50/1,000 postlarval shrimp $150.00/acre	
Growing Period	65-80 days	100-125 days
Mortality	50%	50%
Harvest	10,000 shrimp/acre or 100 lb./80-100 count	10,000 shrimp/acre or 250 lb./31-40 count
Live Bait		
(1½lb./qt.)	66 qt.	166 qt.
($2.75/qt.)	$181.50	$456.50

LITERATURE CITED

Cleary, Donald P.

1970. World demand for shrimp and prawns may outstrip supply during next decade. Commer. Fish. Rev., 32(3):19.

Lindner, Milton J., and Harry L. Cook

(In press) Progress in shrimp mariculture in the United States. In Proceedings of Symposium on Investigations and Resources of the Caribbean Sea and Adjacent Regions, Willemstad, Curacao, Netherlands Antilles, 18-26 November 1968.

SHRIMP FARMING--TEXAS STYLE

JACK C. PARKER
Marine Advisory Program Specialist
Texas Agricultural Extension Service
Texas A&M University

Shrimp farming may have a future in Texas. Researchers will soon find out through Texas A&M University's Sea Grant Program which will study the economic potential in raising the delicacy on Texas' coastal marshlands and bay shores.

Combined efforts of the Texas Agricultural Extension Service, Agricultural Research Station at Angleton, Brazoria County Mosquito Control District, Commissioner's Court, Texaco and Dow Chemical Company have made possible examination of the feasibility of shrimp farming in Texas on a commercial basis.

There is more enthusiasm for the possibilities of commercial culture of crustaceans than of any other kind of seafood. The market demand for shrimp in the United States, for example, seems insatiable. In 1968 the United States imported 209.5 million pounds of shrimp, almost 30 million more pounds than it produced. In Japan there is a high and growing demand for shrimp, and the Japanese are buying large quantities from many parts of the world.

This strong demand has raised the price of shrimp to high levels. In 1969 the retail price of edible shrimp in Texas ranged from about $1.20 to $1.70 per pound (heads off) and for live bait from $3.00 to $4.50 per pound. Consistently high market value encourages the hope that profitable culture operations may be possible.

Farm Established

Funds were made available to the Texas Agricultural Extension Service in September 1968. Texaco provided the site, a marshland area on the West Galveston Bay shore in Brazoria County. Construction of pond levees began in February 1969 with equipment provided by the Brazoria County Commissioner's Court under the direction of J. C. McNeill III, Director of the Brazoria County Mosquito Control District. Natural marsh ponds or "potholes," as well as small reservoirs ranging from 1/2- to 2 1/2-acres, will be used in the study.

Texas' 200,000 acres of coastal lowlands and marshes are especially suited for pond culture because of the high clay content in the soil. Using bulldozers or draglines, ponds can be leveed which will hold water, allowing very little seepage.

Research shows enough shrimp can be raised in ponds of this type for commercial production. However, pond construction costs and harvest techniques, so far, have hindered production. This new program will attack these problems and evaluate stocking rates and food supplements, while looking for economically sound shrimp farming practices.

Initially, ponds will be stocked with postlarvae shrimp (about 1/4- to 1/2-inch long) at a rate of 20,000 per acre. From 80 to 120 days are required to produce a marketable crop. In that time, the shrimp grow to between 5 and 6 inches (25 to 30 shrimp per pound) and yields in experimental ponds in Louisiana have ranged as high as 800 pounds per acre. The "growing season" is expected to last from late March through early November. Ponds, therefore, can be stocked at least twice during the year.

Potential Good

Three species of shrimp are harvested commercially on the Texas coast: brown shrimp, *Penaeus aztecus*; white shrimp, *Penaeus setiferus*; and pink shrimp, *Penaeus duorarum*. All have farming potential, are marine species and require salt water. With proper acclimation, however, waters of low salinity are suitable for farming.

All three species spawn in the Gulf. The eggs hatch there and pass through three larval stages before emerging as postlarvae which are essentially miniature adults. The postlarvae move into the bays in the early spring. They utilize these waters as a "nursery area" and return to the Gulf to mature.

Seed Stock Production

Postlarvae seed shrimp for experimental farming purposes are provided by the Bureau of Commercial Fisheries at Galveston from female shrimp spawned under artificial conditions in the laboratory. One female shrimp may produce as many as 200,000 postlarvae. Hatchery-reared postlarvae are not presently available on a commercial scale, however, a pilot hatchery operated by the Dow Chemical Company should be producing seed stock for experimental purposes this year. It is hoped that this hatchery will be the forerunner to our first commercial operation.

Many pond culture experiments have been conducted using small shrimp captured from the bays, but this method of obtaining seed stock would not be commercially practical because of the necessity to conserve the natural stock for the perpetuation of future generations.

Research--Demonstration Results

Following is a brief summary of the first year's experimental pond culture results.

On April 16, a 1 1/2-acre natural pond was stocked with 17,000 postlarvae brown shrimp (averaging 1/4-inch in length) provided by the Bureau of Commercial Fisheries Laboratory at Galveston. Based on previous research in Louisiana, it had been initially planned to stock all ponds at a rate of 20,000 per acre. These were, however, the only hatchery-reared shrimp available for stocking at that time, and the scarcity of shrimp in the bays prohibited obtaining stock from the natural populations. Although survival from this stocking was poor (about 2 percent), growth was exceptional. Seventy days after stocking, these shrimp had attained an average length of 5 1/2-inches and by 90 days had reached an average length of 6-inches. Growth was dependent only on natural foods within the pond since no supplemental feed was provided. The market value of these shrimp at the processing plants in Freeport after 70 days growth (they measured 30 count per pound, heads on) was $0.79 per pound and after 90 days (measuring 22 count per pound, heads on) was $0.85 per pound.

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

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

Predator Control

In order to evaluate the effect of fish predation, two natural ponds measuring 1 1/4-and 2 1/2-acres were stocked on August 4, 5, and 6 with juvenile white shrimp (averaging 2 1/2-inches) supplied from Galveston Bay by a local fisherman. A fish toxicant, Chem Fish Collector, which contains rotenone, was applied to the 2 1/2-acre pond to remove predators, and Diuron was applied to control all aquatic vegetation. A commercial catfish food (sinking variety) was introduced in each pond to supplement natural foods.

Survival was good in both ponds. Over a 70-day period, shrimp in the pond without predators averaged 5 1/2-inches while those growing with predators averaged only 4 1/2-inches. Using a 150-foot seine, 350 pounds per acre were harvested from the larger ponds. Attempts to harvest these shrimp via the drain flume in the manner described above proved unsuccessful for white shrimp. Harvesting was terminated in this pond because cold weather necessitated a redirection of effort. At that time, an estimated 100 pounds per acre still remained. Before further attempts could be made to complete harvesting these ponds, the crop was destroyed as a result of a killing freeze on November 15th. It was evident from the data obtained, however, that it is necessary to remove all shrimp predators before stocking. These organisms not only prey on the shrimp but also compete with them for food. Predators can be removed easily and effectively with rotenone at a concentration of 2 parts per million.

Feeding

A number of questions have been raised concerning protein sources in artificial shrimp foods, and it is generally conceded by most researchers that fish meal is desirable. The proportion of fish meal, however, is questionable. For this reason, an experiment was initiated in ten 1/2-acre reservoir ponds to examine the quality of high and low fish meal diets. The ponds were stocked on August 27, 28 and 29 with juvenile white shrimp (averaging 2 1/2-inches) at a rate of 20,000 per acre. In five of the ponds, shrimp were fed a 50-percent protein diet, of which 60-percent of the protein was fish meal, and in the other five ponds, shrimp were fed a 50-percent protein diet with fish meal accounting for only 20-percent of the total protein. In both diets the remaining protein consisted of a mixture of poultry by-products, blood, and bone meal. These diets were submitted to the shrimp in 1/4-inch diameter pellets (sinking variety).

Survival in these ponds varied from 20-80 percent, and production varied from 145-300 pounds per acre. The growth period covered approximately 45 days, and the shrimp ranged in size from 35-45 count per pound (heads on) at time of harvest.

The results of these feeding experiments were inconclusive as far as evaluating the amount of fish meal was concerned. The diet lowest in fish meal appeared to significantly increase growth. It is doubtful, however, that the protein content was the causative factor. Rather, the differences in weight gain were probably due to the different consistency of the pellets in water. When immersed, the high fish meal pellets disintegrated rapidly; consequently, they were available to feeding shrimp for a much shorter time. Since the nutritive content of the feed affects the pellet consistency, it is doubtful that much will be gained from nutrition studies in ponds until suitable tightly bound pellets are available. Efforts are being made to interest commercial feed producers in assisting us in developing suitable feeds.

No significant growth in any pond was observed after October 15th. At that time, water temperature dropped below 60°F. Although higher temperatures were recorded thereafter, it appeared that warming was not sufficient to produce adequate temperatures for significant growth.

The biggest problem in experiments to date has been inability to maintain adequate survival of seed stock. This is especially true when stocking hatchery-reared postlarvae. Commercial participation should not be encouraged until suitable methods of insuring good survival (at least 75 percent of seed stock) are developed.

New Research

Most studies now in progress in shrimp culture are intended primarily to facilitate relatively low-density practices for use on inexpensive coastal lands--synonymous to pasture grazing practices in the beef industry. In order for industry to participate profitably, however, techniques for a high-density (intensive) culture system--along the lines of a beef cattle feeder lot--are needed. Both low- and high-density rearing practices are presently employed successfully in catfish culture, and with additional research, techniques for intensive shrimp culture should also be developed. In order to augment the present field efforts of the Texas Agricultural Extension Service, a cooperative project with the Dow Chemical Company will explore the feasibility of an intensive shrimp culture system. Extension personnel presently involved in the mariculture program will cooperate with Dow in this effort and have access to the results of this research.

The possibilities look good to those associated with research in this field. Undoubtedly, many problems will arise as research progresses, but success in these initial experiments could lead the way toward development of a new means of food production and an additional means of utilizing our coastal marshlands.

WATERFOWL MANAGEMENT AND HARVESTING

JOE LAGOW
County Commissioner
Chambers County

Picture in your own mind the thousands of acres of marshes and estuaries on the upper Texas Coast, teeming with its millions of waterfowl that migrated South each fall to spend the winter where lush food, water, and shelter prevailed for them, before man started alterations and destruction of this area. This was an area of wide-open spaces, very few people, no roads, nor fences. Cattle roamed the prairies and grazed on the green lush growth in the marshes. This was the area where market hunters came to slaughter ducks and geese by the thousands, shipping them by the barrels to a waiting market in the cities of the Northeast United States. This was a thriving business in the early days.

Canvasback ducks sold for $5.00 per pair; Greenhead Mallards and Pintails sold for $3.50 per pair.

Now, picture the same area as of today, with its thousands of people living in and around these marshes; blacktop roads leading in all directions from one area to another; one city to another; railroads running across the area; drainage ditches cut throughout the upper coast; land fenced with barbed wire, cattle confined to certain pastures; large rice farms where marshes used to be, before drainage; large canals cut through the marshes, with tug boats pulling and pushing several sections of barges up and down the canals. Telephone and power lines running throughout the area; airplanes flying overhead; large cities surrounding the area; large industrial plants operating and building more of them, oil fields developed in and around these areas, pipelines laid through the marsh, automobiles and trucks speeding to and from, spraying of insecticides and pesticides used freely on crops and cattle. The waste and pollution from all the mentioned above, flowing into our lowlands, marshes and estuaries and bays. What a wonder, that we still have waterfowl continuing to use such an area. Will they continue? This will depend on good waterfowl management.

Good sound management is necessary if we expect to hold the great number of waterfowl that migrates our way each fall. The marshes and estuaries on the upper Texas Coast with the surrounding of vast rice farms, still afford the most inviting wintering grounds for waterfowl.

The success or failure of a waterfowl area depends on its plans and management, followed by the owner or leaseholder.

The plan we have been using on the 25,000 acre Barrow Ranch for the past twenty-five years, has been successful for me and the Barrow family.

The management can be very complicated, or simple, expensive or not so expensive, depending on the location of the area and its existing conditions.

Due to civilization moving in, many changes were brought about with roads, drainage programs, canals, rice farming, excess water at times, and shortage of water at other times.

Our first step was to make plans to control the water levels in our marshes, since the big drainage program came about. It was necessary to cut some canals to carry excess flooding, which was putting up to three feet of water in our marshes at times; this was bringing on some drastic changes in our vegetation and duck food that formerly grew in our marshes. A survey was made as to the highs and lows in our marshes, and water gates were installed to regulate the water level, as near as possible, as it was before the county-wide drainage program was initiated. It has been neccessary to keep a certain amount of salt water coming into our marshes, with high tides to keep the water in a brackish form to restore the type of vegetation that formerly grew here. This has been successfully accomplished. It's necessary to drop our water gates to a closed position when we get weather reports, that a Norther is on the way; otherwise our marshes will be drained dry by a strong north wind, causing the tides to drop. It is necessary to maintain about 3 inches of water over the marshes at times to provide the growth of vegetation that produces the better duck food.

We also have a 475 acre reservoir that gives plenty of open water for ducks and geese, which is especially good during dry season.

Beginning with the 1970 season, we will be able to flood some 2,000 acres of rice stubble with pumps. These pumps have been installed for rice farming the higher areas of our ranch. They will be used to flood the rice stubble for waterfowl use, thus making much better hunting.

Roads have been constructed and shelled to the East, middle, and West side of our ranch to the marsh areas, thus making the ranch accessible for hunters, reducing the walking distance to reach their desired hunting area. In addition we have cattle walkways extending into the deep marshes throughout the ranch; these provide solid footing and easy walking into the deep marsh, where we have built over sixty duck blinds. Our duck blinds are rebuilt each fall and are avialable to hunters on first-come-first-served basis. We build our blinds on some of the open water ponds and lakes a safe distance from one another to prevent accidents and avoid one hunter disturbing ducks going into another blind, where decoys are used.

Many of the lakes and potholes have natural cover that provides natural blinds for hunters. The ranch being 7½ miles in length, 4½ miles in width, with canals and bayous in and around the sides, provides boat owners the opportunity to get to some of the better hunting areas, where it's most difficult to walk. Most hunters use hip boots or waist waders to hunt the marsh area, since all marshes and lakes can be waded in hip boots without going over them. Those hunting the rice stubble can use knee boots; in some areas where they are dry, they are hunted in low-quarter shoes or what have you. About half of the ranch is marsh, where mostly duck hunting is done. The other half consists of rice stubble and prairies, where mostly geese are hunted. But it isn't unusual to get your limit of duck or geese in either marsh or rice stubble, depending on the type of weather.

We have about 300 acres, set aside as a rest area, where hunting isn't permitted. This provides an area where the game may rest, feed, and not be bothered during hunting hours. This has been helpful in keeping great numbers of waterfowl on the ranch.

Another ranch regulation that has been helpful is hunting until 12:00 noon only, thus giving the game all afternoon and night to return throughout the ranch to feed, rest, and shelter from hunting done on adjoining ranches and marshes.

Permits are sold to hunters beginning at 3:00 A.M.; here they are checked for hunting licenses and migratory bird stamps; then issued a permit with a number, date, name of hunter, license number, and hometown. A stub is filled out the same to provide information to record in the Texas Game Record Book, which we have to record information from the stub. After the hunt is over, the hunter returns to the check-out gate where his permit is picked up, and a record of his kill is recorded on the permit. This information is later recorded in the record book. The permit checking out gives us the information needed to know when all hunters have checked out. We require hunting to stop at 12:00 noon and all hunters to be out of the gate by 1:30 P.M.

With the information in our record books, we are able to know the exact number of hunters we have had for the season, and the number of geese and ducks killed on the ranch for the season.

All hunters are retained at the gate after checking in for permits. We have an aerial picture of the ranch, which I explain and point out the location of blinds, how to reach the various areas of the marsh or rice fields, where duck and geese have been feeding the evening before. The hunters decide themselves, as to where they want to hunt, they have a free choice and move to another area if not satisfied with frst choice, or see the game working in another area. The hunters move to suit themselves; no assignments are made, unless they are asked for. Thirty minutes before legal shooting time, the gate is opened, they drive to the area of their own choosing to hunt. If someone beats them to their choice hunting spot, they move on to another.

Guides are available for those desiring such service, which is recommended if they can afford it, and especially if this is their first time here. The guides know the best hunting areas, furnish decoys, do the calling for them and assist in any manner to see that they have a successful hunt. They then draw the game for them before leaving the ranch. Those not familiar with duck or geese hunting are given information on laws and a guidebook for identification of waterfowl. I also have a colorful picture on the wall of our gatehouse for hunters to learn the different species of ducks and geese, which is necessary, since game laws regulate the killing of various species by numbers. We charge a fee for hunting privileges, and the ranch is open to the public, as long as they abide by game laws, and ranch regulations governing hunting. Some areas of the ranch are not accessable for hunters checking in at the gate, so we lease these areas out to small groups, who have to travel by boat to their lease for hunting; these are called private leases. We have about ten such areas we lease for a set fee, prices depending on the size of the area. These leaseholders have the same regulations required of them as those hunting by the day, going through the front gate. Violations by members of a lease can cause a forfeit of their hunting privilege or loss of lease.

We are most fortunate in having about as many geese as we have ducks using our marshes. This enables a hunter to kill limits of both geese and ducks, if lucky, or a good hunter. All species of ducks and geese that migrate to Texas are found in our marshes. In addition, we have the Mottel duck, or Black Mallard, that is a native of our area, which doesn't migrate. This duck is considered one of the favorite larger ones, that affords good hunting at the beginning of the season. It is slightly smaller than our Northern Greenhead Mallard, but cooks equally as well.

The Mottel duck will thrive well, if given a little protection, and produce a clutch of seven to twelve little ones if adequate nesting and rearing cover.

Our marshes and rice fields provide excellent areas; with an adequate breeding stock will produce a large quantity of ducks. They must have a good supply of fresh water, food and cover. Predator control is important in the production of the Mottel duck. This duck provides us with many thousands of additional ducks besides those that migrate to our marshes from the North.

Duck food is a very important factor in waterfowl management. Without adequate food, ducks and geese move on to other areas. The principle plants furnishing food for our waterfowl are as follows: Wigeon grass, Millet, Smartweed, Spike Rush, Delta Duck Potatoe, Water Primrose, Duck weed, salt grasses, cordgrasses, watershield, three-square or rat grass, and salt water Bermuda grass, along with cultivated rice, small grains, and soybeans being produced throughout our area.

Another important factor in management is <u>marsh burning</u>. It is important for controlling undesirable grasses, weeds, and excess growth vegetation. Burning also stimulates growth of desirable plants and provides a certain amount of fertilizer. The season for burning is important, for certain grasses afford excellent food and grazing, when burned in latter part of September. Geese and ducks feed on the fresh, green, tender sprouts that spring up after burning. Burning also destroys the dense growth that provides hiding places for predators. This is also excellent for grazing cattle throughout the winter months.

Adjoining the ranch, to our West, is the location of the Anahuac Wildlife Refuge, which provides excellent resting, water, shelter and feeding grounds for waterfowl coming into our area. With such provisions as this refuge, waterfowl will remain in the area when hunting pressure is on them. It consists of approximately 10,000 acres, with no hunting allowed. Also, East Galveston Bay adjoins to the South, which provides resting areas when under pressure. The ducks and geese bagged on this ranch each year will run between 16,000-20,000 ducks and 8,000-10,000 geese, which makes a very good average per person that hunts this ranch.

In addition to our public hunting we have about 3,000 acres leased out for rice farming, trap muskrat, run about 4,000 head of cattle on the ranch, fishing in our reservoirs, raise some small grain, and hay. We plan to experiment with shrimp farming and perhaps crab farming in the future.

Needless to say, such operation as this isn't all pleasure and glory. It has its headaches as well. I will list a few of our problems that we encounter.

Trespassing is always a problem with an area this large, lack of hunting knowledge, careless use of firearms, hunting improperly dressed, coming hunting with inadequate equipment, shooting game and not retrieving them, unable to find game shot down; shooting wildly at game out of shooting distance known as sky-blasting, driving off of roads getting stuck, shooting game before legal shooting hours; hunting near another and shooting over his decoys, lack of ability to identify game, law violations such as shooting unplugged guns, killing more than law allows, or too many of the species that are controlled by law. Hunters come in without licenses, or duck stamps; men in U. S. Armed Service, some who have the opinion they are not required to have hunting licenses and stamps; shooting cattle, windmills, equipment and signs; getting lost, unable to judge shooting distances, opinions concerning use of Magnum guns and Magnum shells; some market hunting still exists; Nutria rats destroying vegetation and inexperience in use of duck or goose calls.

By good management, we can preserve our marshes and estuaries, by demonstrating the multiple uses and the economic values derived from them. Thus, we hope other owners of marsh areas will observe our operation and assist in the preservation of such valuable areas, which will mean so much to our future, and the generations to follow.

J. C. McNEILL, IV
Director
Brazoria County Mosquito Control District

Today I have been asked to make a presentation on mosquito control activities in the State of Texas. I would like to do this in two segments. First, I would like to show you a few slides and give you a basic idea of the problems of mosquito control along the Gulf Coast of Texas and to explain a few of the procedures and techniques now employed by organized mosquito control in Texas. Basically, most all districts are doing adulticiding. We do not like this because this is the poorest type of mosquito control in that it is very temporary, but it is the type that the public demands first. When the general public establishes or organizes a mosquito control district, they expect to see immediate results, and this can be obtained only by adulticiding. Most of the districts do some limited amount of larviciding and very little permanent control, which is the ultimate. It is our belief that cooperative research such as the marshland utilization project we now have at Texas A&M University is a step toward permanent control of mosquitoes.

Second, I would like to pass out and discuss a few of the Texas Mosquito Control Association's "Statement of Policy" and "Recommended Procedures of Chemical Control of Mosquitoes in Texas." We are regulated by several State and Federal agencies, but as a group are quite concerned by the misuse of insecticides in agriculture as well as in small municipalities where the person responsible for dispensing these insecticides, whether it be for mosquito or fly control, is not trained in this field, so let us briefly look at this policy.

RECOMMENDED PROCEDURES FOR THE CHEMICAL CONTROL OF MOSQUITOES IN TEXAS

Appendix I to Remarks of
J. C. McNeill, IV

I. **Larviciding - As a general rule, programs aimed at killing larvae should not utilize materials employed as adulticides.**

A. Ground Application - By hand

1. The application of larvicidal agents with hand-powered equipment is the method of choice for relatively small, inaccessible breeding areas which cannot otherwise be treated.

2. The following organic phosphates and petroleum hydrocarbons may be used:

(a) No. 2 diesel oil with a biodegradable spreading agent such as Triton X-45 (1 part of spreading agent to 200 parts of oil) applied at a rate not to exceed 20 gallons per acre, using a portable, compressed air sprayer.

(b) FLIT MLO applied at the rate of 1-5 gallons per acre. This rate may have to be increased in septic water to 3-5 gallons.

(c) Organic phosphates may also be used for larval control. These chemicals should only be used in situations where petroleum hydrocarbons are not practical. Materials that may be used are:

(1) Abate

(2) Baytex

(3) Dursban

Extreme precautions should be taken to avoid hitting non-target organisms. Label recommendations of the insecticide of choice should be strictly followed.

B. Ground Application - By truck

1. Petroleum hydrocarbons - apply as above mentioned materials at rates indicated using power sprayers.

2. Organic phosphates - as mentioned above.

C. Aerial Application

1. Petroleum hydrocarbons - as above.

2. Organic phosphates - as above.

II. <u>Adulticiding</u> - Programs aimed at killing adult mosquitoes should utilize one or more of the organic phosphorus insecticides. Chylorinated hydrocarbon materials should not be used. In all ground and aerial adulticiding operations extreme precautions should be taken to avoid hitting non-target organisms. Label recommendations of the insecticide of choice should be strictly followed.

A. Ground

1. Fogging Concentrations - any of the following agents may be used:

(a) <u>Baytex</u> (0.70 oz. actual per gallon) in No. 2 diesel oil applied at the rate of 0.015 lb. actual per acre.

(b) <u>Malathion</u> (8 oz. actual per gallon) in No. 2 diesel oil applied at the rate of 0.1 lb. actual per acre. Thiosperse (1 quart) may be added to every 1,000 gallons of mixture or as needed.

(c) <u>Ortho Dibrom-14</u> (1.75 oz. actual per gallon) in No. 2 diesel oil applied at the rate of 0.02 lb. actual per acre. Ortho-Additive (2-4 quarts) may be added to every 100 gallons of mixture.

Normally, these insecticides are fogged with a Leco 120 or a Todd Tifa (at the rate of 40 gallons per hour) mounted on a truck moving 5 miles per hour. Fogging equipment such as the London, Burgess, and others can also be used.

Provided that conditions warrant it, the truck speed may be increased as long as the insecticide output rate is kept at 8 gallons per linear mile.

2. Dusting and Misting

Truck-mounted dust and/or mist equipment utilizing organic phosphorous insecticides outlined in No. 1 above can also be used for adulticiding purposes. Mists (usually a water emulsion formulation) are dispersed at rates of 7-25 gallons per mile at a vehicle speed of 5 miles per hour based on the actual pound/acre recommendation of the insecticide used. Dusts can also be used based on actual pound/acre application rates. Mist and dust equipment is available commercially from the Buffalo Turbine Equipment Company, John Bean Spraying Equipment Division, Hardie Aero Mist, Thuron Industries, and others.

B. Aerial

1. Ultra low volume (ULV) application of the following insecticides may be employed:

   (a) Baytex - 0.05 - 0.1 lb. per acre 0.7 - 1.3 fluid oz./acre.

   (b) Dibrom-14 - 0.05 - 0.1 lb. per acre 0.5 - 1.0 fluid oz./acre.

   (c) Malathion - 0.2 lb. per acre 3 fluid oz./acre.

   These insecticide concentrates are applied by a suitable aircraft equipped with three 80015 nozzles (Spraying Systems) flying at 90-95 miles per hour, with a pump pressure of 40-52 p.s.i. and flying at an altitude of 30-150 feet, or other designed systems calibrated to deliver the above dosages may be used.

III. Special Applications

A. Dichlorvos Resin (one strip, 8 inches long) may be suspended above water in catch basins. Commercial-size strips may be used if drum lot purchases are not practical.

TEXAS MOSQUITO CONTROL ASSOCIATION
STATEMENT OF POLICY

Appendix II to remarks by
J. C. McNeill, IV

The Texas Mosquito Control Association is a nonprofit, technical, scientific, and educational association of mosquito workers, entomologists, sanitarians, biologists, medical personnel, engineers, chemists, public health officials, military personnel, conservationists, and laymen who are charged with, or interested in, mosquito control and related work.

OBJECTIVES

The objectives of the TMCA are as follows:

1. To protect the public health and promote the general welfare through effective mosquito control programs wherever they are needed at the national, state, and local levels;

2. To promote close cooperation among those directly or indirectly concerned with, or interested in, mosquito control and related work to achieve the highest standards of efficiency in such work;

3. To stimulate and encourage research in all aspects of mosquito control, including joint research among personnel concerned with mosquito control, conservationists, and other specialists and groups on problems of mutual interest;

4. To disseminate information about mosquitoes and their control;

5. To work for understanding, recognition, and cooperation from the public, public officials, and other organizations directly or indirectly concerned with mosquito control and related activities;

6. To support legislation providing for a sound, well-balanced program of mosquito control work suited to local conditions wherever needed; and to support legislation providing funds for research relating to mosquito control;

7. To encourage the use of integrated mosquito control measures that achieve effective control with the minimum hazards and the maximum benefits to wildlife, agriculture, and other affected interests.

GUIDELINES

In working toward the achievement of its objectives, the TMCA recommends that workers involved in mosquito control follow these guidelines:

1. Mosquito control personnel at each administrative, technical, and operational level are required to meet satisfactory qualifications of training or experience in a field or specialty commensurate with the duties of the position.

2. The need for specific permanent or temporary control measures is to be determined by adequate scientific survey or surveillance procedures.

3. Consideration is to be given to all feasible control methods before deciding on the most desirable method to use in any instance. Research on the adaptation of currently-used or new control methods to local conditions is encouraged.

4. Mosquito control methods are to be coordinated with other current efforts to conserve beneficial animal and plant life, to conserve water and manage its use for the maximum benefit of all affected interests, and to achieve other desirable objectives in the affected areas.

5. High priority is to be given to permanent mosquito control procedures in all mosquito control programs.

6. High priority is to be given to the use of biological control of mosquitoes wherever feasible in preference to the use of chemicals.

7. Wherever chemical control methods are necessary, only those chemicals, those amounts of each chemical, and those modes of application that have been tested and recommended by recognized federal, state, or academic research laboratories are to be used. Adequate records of use should be maintained.

8. When and where chemical control is deemed necessary, consideration is to be given to effectiveness, toxicity, and economy. Practical and legal considerations of toxicity shall include potential toxicity for man, domestic animals, fish and wildlife, and beneficial plants, and are to take into account not only the contemplated dosages to be applied, but also the unplanned potential dangers that may result from misuse, mistakes made by personnel, contamination of non-target areas, and disturbance of insecticide containers in the field by storms, livestock, or uninformed persons.

9. As a general rule, chemicals having a short residual life in nature are to be used in preference to persistent pesticides, to avoid a buildup of deleterious substances in the environment. (Periodic tests of residue levels in mud, water-plants, crops, wastewater, etc., are also encouraged.)

10. As an essential element in the selection of insecticides, periodic tests are to be made to determine the susceptibility of the mosquitoes under attack to the chemical or chemicals being used.

11. As a general rule, to minimize the possible development of resistance, the same insecticide group is not to be used concurrently as an adulticide and a larvicide in the same area.

12. Mosquito control workers will strive to organize state and local coordination committee, the membership to be composed of mosquito workers, fish and wildlife workers, conservationists, water management workers, and representatives of sportsmen's groups, public news media, wildlife groups, agriculture, and other related interests, to provide a continuing mechanism for the presentation and consideration of operational problems of mutual interest and to insure joint participation in research on the solution of mutual problems.

13. Mosquito control programs are to be based at all times on the highest standards of scientific procedure and professional integrity. Information on all phases of mosquito control activities is to be freely available to the public. Mosquito control workers are to actively pursue a factual public information program on their activities.

COASTAL INDUSTRIAL DEVELOPMENT

PAUL D. LUDWIG
Agricultural Director
Dow Chemical Company
Freeport, Texas

The Texas Gulf Coast offers great potential for development of many different avenues of endeavor. It can span the gamut from hugh industrial complexes to catfish farms - all utilizing one or several assets of the vast land resources of the coastal area.

On the Texas coast from Beaumont to Corpus Christi, we find huge complexes created by the chemical industry, making many different products, based primarily upon the resources of the area. You will recall that there are several chemical plants in the Freeport area: The Dow Chemical Company, Monsanto Chemical Company, Lavino Division of IMC, Nalco Chemical Company, A. P. Green Refractories Company, Freeport Sulphur Company; all utilizing the area resources either directly or indirectly.

The Dow Chemical Company chose to locate one of its large manufacturing plants here to avail itself of particular resources - natural gas, oyster shell, and salt water. From these simple products, complicated inorganic and organic structures can be synthesized. But once these molecules are developed, we need some way to determine if they are of value for the public. This is our job in agricultural research. We evaluate these organic materials through a series of tests to determine their utility. If we discover one that possesses the correct attributes, we develop it into a commercial product.

We have research designed to discover new products for the control of internal and external parasites of livestock. We are also interested in the development of feeds for livestock. We test a large number of compounds each year and assay them for their utility as new products for agriculture.

In the process, we must also study the candidate material thoroughly for all effects - overt and hidden - to assure its role and effect on the ecosystem. We feel we have the adequate technology to accomplish this task, but the biosystem in which the work is undertaken is extremely important. We feel that along the coastal area of the U. S. we find some of the most complex ecosystems that exist today, and that these areas are ideal for evaluating the direct and subtle effects on the biosphere.

The following paragraphs will illustrate some of the activities that we initiated to give us an understanding of the pesticide activity in the environment.

Once the pattern of a new compound has been indicated by laboratory studies, it is necessary to apply the material under practical field conditions to ascertain its value in pest control. It is at this point in the development of an insecticide that the scope of the evaluation must be greatly enlarged. Not only must the material be evaluated for the desired effect on target species, it must be evaluated also for persistence and biological effects on other forms of life in the biotic community.

A study was conducted in a marsh habitat to evaluate the effectiveness of a new insecticide on the salt-marsh mosquito, Aedes sollicitans (Walker), and to determine the persistence of residues resulting from the application. The gross effects of the insecticide on marine and terrestrial fauna normally living in these intensive mosquito-breeding areas also were evaluated. Included in this marsh area were many non-target species: birds, fish, crabs, oysters, shrimp, spiders, and insects other than mosquitoes. Numerous techniques have been developed for measuring efficacy of materials against mosquitoes, but little is known about properly measuring effects on associated biological species. The studies were designed to develop sampling and analytical techniques, as well as procedures that could be used in other fundamental studies to elucidate the relationship of candidate insecticides to non-target species.

To examine fully the scope of the biological activity of a pesticide, it was desired to find a remote marsh area that had an abundant fauna. Such an area was located after an aerial survey of the marshland of Brazoria County, Texas. The site selected was situated on the south side of Cox's Lake. This marsh was only a few inches above the normal high tide and was dotted by many small, shallow, permanent ponds. These ponds were connected to one another and eventually emptied into a permanent drainage ditch by a series of natural ill-defined drainage canals. The Brazoria County Mosquito Control District had collected records for eight years which showed that the location was a heavy mosquito-producing area. Observations of this area showed an abundant supply of birds, crabs, oysters, fish, minnows, insects, and spiders. Since the topography and biologic community appeared to be ideal, this site was chosen for the application of a new pesticide.

After application of the pesticide, much activity remains to be done. Samples of water, silt, and oysters were selected for analysis. Observation of other non-target insects and fish, shrimp, and birds had to continue many days after application of the pesticide, all this to insure no permanent damage to the environment.

We also conduct experiments on chickens, swine, sheep, and cattle, trying to find new materials that will enable the farmer or rancher to produce his specific product free from the ravages of disease, internal parasites, and insects.

One new endeavor that we have undertaken is the rearing of catfish, and this activity has aroused great interest in the coastal area. We have 50,000 fingerlings in the Brazoria reservoir, all in cages. We chose the cage culture technique because we had a 1900-acre body of water and it would be virtually impossible to recover the fish from this amount of water.

To date we are encouraged with the results, but we are experiencing a siege of external parasites. But this is the reason we wanted to rear catfish - to find what problems are involved, and can we find an answer to these problems. Most of the treatment for diseases and parasites are archaic, and new materials are needed to control these pests of catfish.

These examples of our activities indicate why we are located in the coastal area - because this is where the problems in animal agriculture exist. We are here because we want first-hand knowledge of the problems so we may attack them more directly. Basic knowledge of the biology and life cycle of the parasites is of great help in bringing these pests under control.

This discussion has been directed toward indicating the rational for coastal industrial development. We, indeed, have ranged from industrial complexes to catfish, but I feel that this is only a brief look at the total assets of our coastal area. It is obvious that the development of the coastal area will continue because of the unique resources that this area possesses.

Aerial view of Plant A, Texas Division of the Dow Chemical Company, Freeport, Texas

Aerial view of Plant B, Texas Division of the Dow Chemical Company, Freeport, Texas

The author and co-worker evaluating effects of a pestidice on non-target species such as shrimp and fish

Demonstrating the use of a systemic insecticide for control of parasites of cattle

BEEF CATTLE PRODUCTION ALONG THE GULF COAST

MARVIN E. RIEWE
Associate Professor in Charge
Texas A&M University Agricultural Research Station
Angleton, Texas

The cattle industry in Texas apparently began as a result of cattle being placed in river bottoms along the coast of the Gulf of Mexico by Spanish explorers in the 16th Century. The evidence suggests that a bull plus one or more cows were left at major waterways. Wherever possible, the cattle used the thicket of the bottomlands for shelter. As the size of the herds grew and grazing became more scarce near the rivers, the cattle were forced to range further and further away onto the prairies. Seasonal grazing patterns developed, particularly along the coast.

After cattle became identified with certain owners through branding, grazing was more controlled. However, seasonal grazing patterns were prevalent until the advent of fencing. The marsh ranges, consisting primarily of perennial cool season grasses, were the primary wintering area where cattle grazed from mid-fall until mid-spring. The cattle were grazed on the Gulf Coast Prairie ranges from mid-spring to mid-fall, where the primary grasses were the bluestems, indiangrass and switchgrass, all perennial warm season grasses.

MARSH RANGES

The vegetation of the marsh ranges consists primarily of species able to tolerate some degree of salinity. The dominant grass specie is Spartina spartinae, known commonly as saltgrass, chordgrass, or salt chordgrass. It is perennial cool season grass.

Soils of the marsh range are extremely variable, ranging from sands to clays. The mineral content of the soil is also quite variable. Phosphorus is usually deficient, although isolated sites can be found with fair levels of phosphorus. The calcium content of the soil is extremely variable with some soils having a low calcium content. Potash is generally adequate for the level of forage production attained on these sites. Trace minerals such as iron and zinc appear adequate in most soils.

The level of forage production is generally low, although variable. Forage production ranges from about 2000 to about 5000 pounds of dry matter per acre per year depending upon the site. Forage growth is fairly slow in the fall and winter with the best forage production coming in March and April to mid-May. The saltgrass ranges are fairly dormant during July, August and September.

It is difficult to breed cows nursing calves on these ranges, particularly if the cows are under five years of age. The reason is primarily because of insufficient levels of digestible energy in the forage to meet the need of the cows to produce milk, provide for growth in case of young cows, and allow the cows to cycle. Cows capable of producing considerable amounts of milk, even though older than five years, are also difficult to breed while nursing a calf. Consequently, the calving interval for cows maintained most or all of the year on a marsh range is 18 to 24 months, even for cows that under more ideal conditions would be regular breeders.

Protein content of the forage would generally be adequate in all except the summer months if the level of digestible energy were adequate. During at least a major part of the year, the protein intake by cattle is insufficient because cattle do not consume enough forage and this is primarily due to the low digestible energy content of the forage. Consequently, supplementing with protein supplement only is not as efficient as it would be if adequate levels of digestible energy were supplied.

The phosphorus content of the forage is inadequate to meet the needs of grazing cattle. Phosphorus is particularly important in the efficient utilization of digestible energy. A high reproduction rate also requires that adequate amounts of phosphorus be supplied.

Weaning weights in excess of 400 pounds are all too rare. The average weaning weight, on a herd basis, is 250 to 350 pounds per calf.

The area is heavily infested with mosquitoes, horn flies and horse flies. It is a matter of record that these do irritate the cattle. It is more difficult to estimate the economic loss due to these external parasites. The difficulty in establishing the magnitude of the economic loss appears to be primarily due to the low level of production attainable with cattle on these ranges, regardless of the degree of irritation by external parasites. It is probable that, as the level of production per animal is increased, the economic loss due to external parasites will be of greater consequence.

GULF COAST PRAIRIE

The soils of the Coast Prairie are clays to sandy loams with the sands dominating in a few isolated areas. Phosphorus is deficient in all but some bottomland soils. Phosphorus fertilization is a prime requisite to the successful production of improved pastures. Potash is usually adequate and lime is adequate in most instances. Iron and zinc are required in a few areas for maximum production but generally the trace element content of the soil is adequate.

Much of the land on the eastern Gulf Coast Prairie has been in cultivation at one time or another for the purpose of growing rice. The better soils on the western Gulf Coast Prairie and in South Texas are used for growing cotton, grain sorghum and other row crops. Ranges never cultivated have been largely overgrazed.

Production per cow on unimproved ranges of the Gulf Coast Prairie, particularly those that have been overgrazed for many years, is low. Calving percentage is generally 60 to 70% with weaning weights averaging 350 to 425 pounds. The high production potential expected on improved pastures is not realized on the native ranges. Forage production on the native ranges is best in April and May and declines through the summer months. Forage production is usually somewhat better in the fall, particularly if the climax grasses still exist. Growth ceases with frost. Supplemental feeding of the cattle during the winter months is generally required. Forage is about adequate in digestible energy in the late spring but inadequate to support high production in the summer and fall. The forage is usually deficient in phosphorus, and protein is often deficient.

Native ranges are being increasingly replaced by well fertilized improved pastures capable of carrying at least three times as many cattle as the best native ranges. These improved pastures are capable of providing the level of nutrition required by cows to produce weaning weights 20-25% heavier than is possible on even the best native ranges. Calving percentages are improved over that possible on good native ranges and up to 50% higher than is possible on the overgrazed ranges so common to the area.

The highly productive improved pastures in the Gulf Coast Prairie have a carrying capacity of at least five times that of the marsh range with the cows producing 80 to 90% more calves with 80 to 100% heavier weaning weights. Improved pastures consisting primarily of dallisgrass and white clover in the eastern Gulf Coast Prairie do a much better job of providing the energy requirement of the cow. Coastal bermudagrass and Pennsacola Bahiagrass have proven useful in cow-calf programs on more droughty sandy loam soils. Phosphorus deficiency is alleviated by phosphorus fertilization of the pastures. Generally such pastures do not provide adequate forage from mid-December until mid-March. Thus, cattle require some supplemental feeding during the winter.

SPECIFIC RESEARCH

Texas A&M University has a number of specific research programs underway focusing directly on the problems associated with beef cattle production on the marsh ranges as well as on the prairie.

Texas A&M University's College of Veterinary Medicine has long been active in research in diseases affecting cattle along the Gulf Coast of Texas. Progress has been made. The recent development of a vaccine to control anaplasmosis is an example. Vaccination of bulls to prevent anaplasmosis is a step forward, although the vaccination of cows is not recommended at the present time. Vaccination of bulls against anaplasmosis may be sufficient in itself to permit the use of purebred bulls in a systematic crossbreeding program on the marsh ranges.

The cattle on the marsh ranges generally possess both Brahman and British blood but, by and large, this is the result of mongrelization rather than systematic crossbreeding. Because of the susceptibility of purebred English bulls to anaplasmosis, crossbred bulls have been popular on the marsh range. However, the use of crossbred bulls dissipates hybrid vigor. Systematic crossbreeding programs using purebred bulls have been developed that alone would be expected to increase production per cow at least 25 percent.

Current research at our Research Station at Angleton is designed to develop economically feasible methods of growing out light weight calves characteristic of the marsh ranges. Other research begun this winter is to wean the calves early, at two to three months of age, and grow these calves out on high quality ryegrass and clover pastures. This is adaptable for cows on poor quality pastures. The purpose of this is to relieve the cow of the burden of nursing the calf early enough to allow her to improve in body condition sufficiently to come into heat and breed. Calving percentage should increase sharply. On the other hand, cows on high quality improved pastures can carry calves until 9 to 10 months of age with the calves having weaning weights of 600 pounds or more.

Texas A&M University has an extensive forage research program. It involves determing the adaptability of new species and varieties as well as evaluating their ability to meet the nutrient requirements of beef cattle. Much of this work is being done at the Research Station at Angleton. Two new forage species now on the scene, both perennial warm season grasses, show promise of being adapted at least to the higher elevations of the marsh ranges. These are Kleingrass, jointly released by the Texas Agricultural Experiment Station and Soil Conservation Service,and Coastcross 1 bermudagrass, recently released by the Georgia Agricultural Experiment Station. These two species along with Pennsacola Bahiagrass and Coastal bermuda are expected to be grown successfully on soils with a low salinity hazard. The successful production of perennial warm season forage is essential if the nutritional requirement of beef cattle on marsh ranges is to be more adequately met.

FUTURE OUTLOOK

In the future, beef cattle production on the Gulf Coast Prairie will increase sharply. Much of this increase will come from increased production per cow. This will require understanding clearly the nutrient requirement of the beef cow and developing pasture and feed resources to meet these requirements. It will be made possible with systematic crossbreeding programs, highly productive, well fertilized pastures of adapted grasses and legumes, and good disease and parasite control. Intergrated programs, whereby the producer controls the product from time of breeding until the carcass hangs on the rail, will become commonplace.

Progress in beef cattle production on the marsh ranges will be much slower. Presently, the marsh range cattle operation is characterized by large acreages with relatively large number of cows handled in a single unit. Immediate progress can be made simply by dividing the cows into smaller groups, managing each group as a unit in itself even though all cows belong to one owner. This will also facilitate the use of systematic crossbreeding programs, which should increase production per cow at least 25 percent. Developing programs which allow early weaning to relieve the cow of the burden of nursing in sufficient time to permit rebreeding and yet permit the producer to grow out the calves to a much heavier weight before they are sold should prove useful. Most marsh range producers have land available of the kind required to make this practical. Beyond this, at least at higher elevations, perennial warm season grasses, considerably more nutritious than saltgrass from mid-spring until mid-fall, will be grown.

Finally, although cities along the coast are expected to grow and will require increasing land acreages and some land will be used for such enterprises as shrimp or catfish culture or for developing additional recreational opportunities, far greater acreages will be used in the future for cattle grazing than for any other purpose. It shoud also be noted that the production of cattle, or shrimp or catfish culture, or developing additional recreation opportunites for a growing population need not be mutually exclusive.

ECONOMIC IMPACT OF RECREATION--WHO GETS WHAT?

IVAN W. SCHMEDEMANN
Associate Professor
Department of Agricultural Economics
Texas A&M University

Recreation is one of the growth industries of the 20th century. A few years ago people were surprised at statistics indicating that consumers were spending billions of dollars annually for recreation goods and services--today such statements are considered passe. We have grown callous to seeing multi-million dollar recreation complexes spring up within reach of the large urban populations, in terms of both time and cost.

This surge in consumer demand has stimulated large investments in new plants and facilities for the production of recreation goods and services. Recreation innovations seem to be as endless as the consumer's desire for more. Ten years ago who would have thought that modified motorcycles would be used by deer hunters in Texas and 5 years ago that snowmobiles would become a standard item of recreation equipment in the north. Or for that matter, how many of you visualized 20 or 30 years ago the scene that we have out of our motel windows here in Galveston, that being, a multi-million dollar yatch basin providing facilities to owners of the millions of dollars worth of pleasure boats located here. Table 1 further illustrates the interest in recreation boating which of course is one of the major activities found along the coastal region of Texas.

With this background of events there is little question that recreation is one of the significant factors in the Texas economy; also, it explains why more and more communities are taking a look at recreation as a possible opportunity for stimulating growth of their local economies. However, there is a part of the economic picture about which little has been said or written; this is the incidence of economic benefits or more directly, who gets what?

Assumptions

The following assumptions concerning economic benefits from outdoor recreation have been set forth to provide a framework for thought:

TABLE 1. ESTIMATED NUMBERS OF RECREATION BOATS IN USE IN THE UNITED STATES, 1904 - 65. */

Year	Number of Boars
1904	15,000
1913	400,000
1930	1,500,000
1947	2,440,000
1951	3,710,000
1961	7,175,000
1963	7,678,000
1965	7,865,000

*/ Boating, 1965, National Association of Engine and Boar Manufacturers and the Boating Industry, 420 Lexington Avenue, New York, New York, p. 8.

1. Recreation consumers or participants can be classified into four demand groups based on their investment and expenditure patterns for recreation goods and services.

2. Economic impact of recreation on a community or area will, for the most part, depend on the degree of business or economic integration characterizing its economy.

3. The major portion of the economic benefits from recreation expenditures will accrue to the highly integrated economies of the large metropolitan centers.

Recreation Demand Groups

As indicated in the first assumption by systematically relating investment and expenditure patterns to recreation types it is possible to classify all recreation participants into four broad demand groups. For classification purposes purchases of equipment, real estate, etc. are considered "investments" and purchases of food, beverages, gasoline, lodging, bait, etc. are included in the "expenditure" category. The four demand groups are as follows.[1/][2/]

1. Group I, High Investment-Low Expenditure

   Group I individuals are characterized by their willingness to invest large sums of disposable income into recreation equipment and in some cases real estate and facilities. In contrast to their propensity to invest is their unwillingness or lack of need to spend while away from home for recreation purposes.

2. Group II, High Investment-High Expenditure

   Group II consists predominately of individuals in high income brackets. Their investment patterns are similar to those in Group I. However, they normally purchase considerably more real estate for recreation or consumptive uses and are willing to purchase recreation goods and services, when available at or near recreation sites.

1/ Ivan W. Schmedemann, "Contributions to the U. S. Economy from Recreational Development in the Great Plains," Seminar on Resource Development, Sponsored by the Great Plains Resource Economics Committee, Oklahoma State University, Stillwater, Oklahoma, April, 1970.

2/ Ivan W. Schmedemann and John G. McNeely, Impact of Recreation on Local Economies, TA-6076, Texas Agricultural Experiment Station, and proceedings: Western Farm Economics Association meeting, Las Cruces, New Mexico, July, 1967.

3. Group III, High Expenditure-Low Investment

Group III individuals are characterized by an almost complete reliance upon others to provide recreation goods and services. As a result, their expenditures are quite high at the point where the recreation is provided. Further, they have virtually no investment in equipment, real estate, and other items used primarily for recreation.

4. Group IV, Low Expenditure-Low Investment

Group IV is of the least economic significance. Many individuals in this group do not engage in outdoor recreation; however, there are members who engage in a wide array of recreation activities, but because of income constraints or personal preferences they own little or no equipment and purchase few recreation goods and services.

Much of the recreation participation in the coastal areas of Texas, especially in and around the smaller communities is derived from demand Group I, high investment-low expenditure. Weekend boaters and campers certainly can be classified as such.

The large recreational complexes such as the ones found in Galveston will attract participants from all groups but probably draws most heavily from demand Groups I and II at present. Most of the individuals using the previously mentioned yatch basin can be classified in recreation demand Group II, high investment-high expenditure. And of course, some of the individuals who are staying in the luxury hotels with a fine array of facilities and services can be classified in Group III, high expenditure-low investment.

However, when looking at tourists based on the data in Table 2, Texas, in general, seems to primarily draw tourists from Group I. The average daily expenditure per tourist was $7.85, one can readily see the difference in expenditures among demand groups when comparing this amount to that spent in Hawaii and Florida which was $30.80 and $15.76 respectively. Both of these states have many highly developed recreation complexes which cater strongly to individuals in recreation demand Groups II and III, especially Group III, high expenditure-low investment.

Economic Impact

The second assumption concerns the factors which affect or determine the impact that recreation expenditures will have on a community or area; namely, (1) the size or amount of the recreation expenditures (2) the leakage rate, which is the rate at which money leaves an area to pay for imports, and (3) the multiplier, which determines the number of times a dollar turns over before complete leakage occurs.

Large metropolitan areas such as Houston have highly integrated economies with characteristically low leakage rates and high multipliers.

TABLE 2. TOURIST EXPENDITURES FOR LODGING, FOOD, TRANSPORTATION AND OTHER PURPOSES ACCORDING TO 16 STUDIES*

Location of Study	Lodging	Food & Meals	Transpor- tation	Other Purposes	Average Daily Expenditure
	Percent	Percent	Percent	Percent	Dollars
Arkansas	20.7	33.7	23.1	22.5	$ 5.37
Colorado	24.4	27.1	24.2	24.3	9.30
Florida	23.6	27.5	8.9	40.0	15.76
Hawaii	19.9	22.7	2.6	54.8	30.80
Kansas	20.3	27.5	40.0	12.2	6.08
Minnesota	28.2	21.2	24.5	26.1	7.11
Missouri	13.1	28.0	29.1	29.8	7.50
Montana	27.0	28.2	33.6	11.2	9.85
North Dakota	25.9	30.0	23.0	21.1	6.71
Oklahoma	32.6	16.3	32.5	18.6	6.27
South Dakota	16.9	31.0	24.8	27.3	7.91
Texas	24.0	27.0	30.1	18.9	7.85
Utah	20.3	20.0	16.5	43.2	13.07
Washington	19.0	27.9	28.2	24.9	7.99
Californians, Inc.	22.0	30.7	16.4	30.9	not available
N.A.T.O.	21.0	27.0	22.0	30.0	not abailable
Average of 16 Studies	22.4%	26.6%	23.7%	27.2%	

*Arthur D. Little, Inc., Tourism and Recreation, Prepared for Economic Development Administration, United States Department of Commerce, Washington, D. C., 1967, p. 30.

The opposite is normally true for the smaller cities and communities; in other words, a dollar spent in a small city is, in a sense, worth less than a dollar spent in a large metropolitan area having a high degree of business integration. The reason for this is that in any economy production serves both the local and export markets; the money received from the export market is new money and its impact will depend on the amount of the money and the size of the multiplier. The size of the multiplier in turn depends on the amount of business integration within the economy. An opposing factor to the entry of new money is the leakage of such income from the area. Since importation is necessary for every economy, it can be assumed that all basic dollars will eventually go to pay for imports, except for those paid out for taxes and savings. The multiplier effect of basic dollars depends on the number of times they turn over before complete leakage occurs.[1/]

Significant purchases by recreationists normally consist of food, lodging, transportation and equipment. Studies in New Mexico[2/], Oklahoma[3/] and Wyoming[4/][5/] have shown that the multipliers for these items seldom exceed 2.0 and in some cases are considerably less. One of the Wyoming[6/] studies indicated that "gasoline service stations," "food and beverage establishments" and "the other retail" were the sectors most affected by recreation visitor expenditures. Of these groups the gasoline service station sector received the largest total amount of dollars of any sector. But, that . . . "a single dollar spent in gasoline service stations returns less income to the economic system than it would if spent for food and beverages or for other retail items."[7/]

1/ Charles M. Tiebout, The Community Economic Base Study, Supplementary Paper No. 16, Committee for Economic Development, New York, December, 1962, pp. 57-61.

2/ James R. Gray and Garrey E. Carruthers, Economic Impact of Recreational Developments in the Reserve Ranger District, B-515, Agricultural Experiment Station, New Mexico State University, Las Cruces, New Mexico, November, 1966.

3/ Harry P. Mapp and Daniel D. Badger, "Input-Output Analysis of the Economic Impact of Outdoor Recreation in a Low Income Area," Department of Agricultural Economics, Oklahoma State University, Stillwater, Oklahoma, 1970.

4/ G. R. Rajender, Floyd K. Harmston and Dwight M. Blood, A Study of the Resources, People, and Economy of Teton County, Division of Business and Economic Research, Laramie, Wyoming, February, 1967.

5/ Rodney C. Kite and Willard D. Schutz, The Economic Impact on South-Western Wyoming of Recreationists Visiting Flaming Gorge Reservoir, RJ-11, Agricultural Experiment Station, University of Wyoming, Laramie, Wyoming, August, 1967.

6/ Ibid., p. 8.

7/ Ibid.

The reason given for this was the preponderance of transactions between gasoline service stations and general wholesalers; for each dollar spent at gasoline service stations 37 cents were in turn spent by service stations in general wholesale. The general wholesale sector spends 84 cents of each dollar on imports. This illustrates the problem created by a high leakage rate and a small multiplier.

Another important factor to consider is the size of the recreation expenditure and where it occurs; this factor is related to the third assumption of this paper. Equipment purchases for recreation represent the largest drain on the recreation consumer's disposable income--certainly, for those individuals who can be classified in recreation demand Groups I and II and they are the important ones when considering water-based outdoor recreation. Recreationists tend to purchase most of their equipment in their home communities or from mail order houses and other businesses located in the metropolitan areas. In either case the bulk of the economic benefits flow to the large metropolitan centers; even when expenditures do occur in the smaller cities and communities they do not benefit to the same degree as do the metropolitan centers because of the lack of economic integration.

Results from a Colorado study[1/] illustrate the pattern in the case of boat purchases and there is no particular reason to believe that purchasing patterns are different for other major items of equipment. Of the boat owners interviewed at Horsetooth Reservoir only nine percent purchased their boats within 25 miles of the reservoir. "This indicates that Horsetooth Reservoir inspires the purchase of about six times as many boats in Denver and elsewhere than in the Fort Collins area."[2/]

Further evidence of the propensity of recreationists to purchase a high percentage of goods and services near their home is found in Table 3. Equipment purchases other than "auto" ranged from 60 to 80 percent in the home community. Sixty percent of the gas and oil and 85 percent of the groceries required when recreating at Federal reservoirs was purchased at home. A survey conducted by the United States Department of Labor of all non-farm families and single consumers in the United States reported that 97.5 percent of consumer expenditures for recreation was made in the home city.[3/]

1/ J. Gordon Milliken and H. E. Mew, Jr., Economic and Social Impact of Recreation at Reclamation Reservoirs, Denver Research Institute, University of Denver, Denver, Colorado, March, 1969, p. 54.

2/ Ibid.

3/ National Industrial Conference Board, Expenditure Patterns of the American Family, Survey by the United States Department of Labor, New York, 1965, p. 132.

In a survey of camping households in eight public recreation areas of Texas, 1965, respondents indicated that they spent an average of $8.85 per household per day for food, beverages, gasoline, insect repellent, bait, permits and other items purchased for the trip. Equipment purchases were not included. Of this amount about two-thirds was spent in their home county and the balance at the recreation area or enroute to and from the area. The actual amount spent at the recreation site was small. By comparison, the investment in camping equipment by households residing in the Houston SMSA in 1965 was estimated to be slightly less than $60 million.[1/] These studies strongly reflect the traits characterizing recreation consumers found in recreation demand Group I, high investment-low expenditure.

To further illustrate how metropolitan areas are able to benefit economically from all forms of recreation and the difference between the expenditure patterns of recreation demand Groups I and III the Houston Astrodome was considered. Nearly 9,000,000 people visited the $45,000,000 Astrodome in its first 30 months of operation. About one-half of the attendance was from outside the Houston area and they spent an average of $40 per person per day; these individuals logically fall into recreation demand Group III, high expenditure-low investment. It is also interesting to note that the investment in equipment by camping households residing in the Houston SMSA in 1965 exceeded the cost of the Astrodome by $15 million; in both cases it was the tremendously large Houston metropolitan center that received the lion's share of the total recreation dollar.

Conclusions

From the preceding discussion it seems logical to conclude that the second and third assumptions concerning who gets what are valid. This should not be construed to mean that net economic benefits do not accrue to small cities and communities from the development of the recreation resources; they do benefit from such development. Examples of these benefits are increases in land values, tax revenues,[2/][3/] business sales and new jobs; but, relatively speaking the metropolitan areas are the ones that benefit most.

1/ Ivan W. Schmedemann, "Consumer Preferences--What Consumers Want in Recreation," Proceedings: First Annual Oklahoma Outdoor Recreation Conference, Oklahoma State University, Stillwater, Oklahoma, March, 1967, p. 37.

2/ J. Gordon Milliken and H. E. Mew, Jr., Economics and Social Impact of Recreation at Reclamation Reservoirs, Denver Research Institute, University of Denver, Denver, Colorado, March, 1969, pp. 87-88.

3/ Frank W. Suggitt, "Impact of Reservoirs in the East Texas Piney Woods Region," TA-8428, Texas Agricultural Experiment Station, College Station, Texas, March, 1970, pp. 1-2.

Small cities and communities should not be discouraged from developing their recreation resource base, quite to the contrary; many of the local areas have unique recreation resources which if properly developed and managed will compete favorably in the recreation marketplace. In some cases it will require a combination of public and private investment to provide the consumer with the package of recreation goods and services that he most desires. In every case a careful and thorough study should be made of potential recreation markets, keeping in mind the four outdoor recreation demand groups, before entering into a development scheme.

TABLE 3. PERCENTAGE DIVISION OF VARIOUS KINDS OF RECREATION EXPENDITURES ACCORDING TO TYPE OF RECREATION AREA AND LOCATION OF EXPENDITURES *

Item	National parks			National forests			State parks			Federal reservoirs		
	In or near park	En route	In home commu-nity	In or near park	En route	In home commu-nity	In or near park	En route	In home commu-nity	In or near park	En route	In home commu-nity
1. Cash outlays												
Food												
in restaurants	40	60	0	50	50	0	65	35	0	65	35	0
groceries	35	50	15	25	15	60	10	5	85	10	5	85
Lodging	45	55	0	65	35	0	60	40	0	60	40	0
Transportation												
gas and oil	30	60	10	30	40	30	20	10	70	25	15	60
other	30	60	10	30	40	30	20	10	70	25	15	60
Miscellaneous	50	40	10	20	40	40	50	15	35	50	15	35
2. Equipment charge												
auto	2	3	95	2	3	95	2	3	95	2	3	95
other	15	5	80	5	20	75	10	20	70	20	20	60

*Marion Clawson, "Private and Public Provision of Outdoor Recreation Opportunity", Economic Studies of Outdoor Recreation, ORRRC Study Report 24, Washington, D. C., 1962, p. 88.

REFERENCES

Arthur D. Little, Inc., Tourism and Recreation, Prepared for Economic Development Administration, United States Department of Commerce, Washington, D. C., 1967.

Gray, James R. and Garrey E. Carruthers, Economic Impact of Recreational Developments in the Reserve Ranger District, B-515, Agricultural Experiment Station, New Mexico State University, Las Cruces, New Mexico, November, 1966.

Kite, Rodney C. and Willard D. Schutz, The Economic Impact on South-Western Wyoming of Recreationists Visiting Flaming Gorge Reservoir, RJ-11, Agricultural Experiment Station, University of Wyoming, Laramie, Wyoming, August, 1967.

Mapp, Harry P. and Daniel D. Badger, "Input-Output Analysis of the Economic Impact of Outdoor Recreation in a Low Income Area," Department of Agricultural Economics, Oklahoma State University, Stillwater, Oklahoma, 1970.

Milliken, Gordon J. and H. E. Mew, Jr., Economic and Social Impact of Recreation at Reclamation Reservoirs, Denver Research Institute, University of Denver, Denver, Colorado, March, 1969.

National Association of Engine and Boat Manufacturers and the Boating Industry, Boating, 1965, 420 Lexington Avenue, New York, New York.

National Industrial Conference Board, Expenditure Patterns of the American Family, Survey by the United States Department of Labor, New York, 1965.

Rajender, G. R., Floyd K. Harmston and Dwight M. Blood, A Study of the Resources, People, and Economy of Teton County, Division of Business and Economic Research, Laramie, Wyoming, February, 1967.

Schmedemann, Ivan W., "Consumer Preferences--What Consumers Want in Recreation," Proceedings: First Annual Oklahoma Outdoor Recreation Conference, Oklahoma State University, Stillwater, Oklahoma, March, 1967.

________________, "Contributions to the U. S. Economy from Recreational Development in the Great Plains," Seminar on Resource Development, Sponsored by the Great Plains Resource Economics Committee, Oklahoma State University, Stillwater, Oklahoma, April, 1970.

Schmedemann, Ivan W. and John G. McNeely, Impact of Recreation on Local Economies, TA-6076, Texas Agricultural Experiment Station, and Proceedings: Western Farm Economics Association Meeting, Las Cruces, New Mexico, July, 1967.

Suggitt, Frank W., "Impact of Reservoirs in the East Texas Piney Woods Region," TA-8428, Texas Agricultural Experiment Station, College Station, Texas, March, 1970.

Tiebout, Charles M., The Community Economic Base Study, Supplementary Paper No. 16, Committee for Economic Development, New York, December, 1962.

DICK WHITTINGTON, P. E.
Director of Field Operations
Texas Water Quality Board

Within the time allotted, it is my intention this morning to convey to you something about the water quality in the coastal waters of the State of Texas, and to the best of my ability the meaning of this water quality as it relates to the main topic under consideration at this conference.

Water Quality Data and Their Meaning

When we speak of water quality, normally we mean physical, chemical, and to a certain degree biological measurements on the water itself or the biota contained therein, determined for the purpose of describing the water. The chemical measurements may consist of a complete mineral analysis of the water listing all the ions present, although this is not normally done in coastal waters for water quality measurement purposes. More commonly, the chemical data secured include an indirect measurement of total dissolved solids, that is the weight of dissolved minerals present in the water; measurements relating to the oxygen resources of the water, normally dissolved oxygen and biochemical oxygen demand; measurements of plant nutrient concentrations, nitrogen and phosphorus; and the measurement of heavy metal concentrations, usually copper, zinc, iron, lead, arsenic, and mercury. In addition, the pH of the water is usually measured. When there are reasons to believe that other chemical contaminants are present in the water, measurements of these specific contaminants are also measured. Physical measurements of water quality which are normally made are temperature, turbidity, and observations upon the presence or absence of floating debris, oil, or other foreign substances. Biological measurements of bacterial density, specifically, the density of coliform organisms. This, in my judgement, is unfortunate, since I believe biological measurements to hold great promise in defining water quality problems which may otherwise go undetected when only the chemical and physical characteristics of the water are considered. In our next budget, we propose to correct this. The data which the Texas Water Quality Board collects at our coastal monitoring stations are illustrated by our Coastal Water Quality Sample form shown in Figure 1.

Water quality data, to a considerable degree, are meaningless unless they are considered in the context of the intended or actual use of the water. In the specific instance of Texas coastal waters, the Texas Water Quality Board adopted in June, 1967, the Texas Water Quality Requirements (1) which enumerate both the known uses and intended uses of the coastal waters within the State. With a few exceptions, all coastal waters are deemed suitable for the following uses: contact recreation, propagation of fish and wildlife, fishing, esthetics, navigation, and industrial cooling water. Certain coastal waters are also used and are suitable for the recovery of minerals. Examples of water uses for Texas Coastal Waters are illustrated by a page from the Texas Water Quality Standards Summary (4) shown in Figure 2.

These uses require that the coastal waters of the State, with the few exceptions previously noted, be maintained in such a condition as to permit the propagation of fish and wildlife. While this is a complex and not fully understood requirement, the minimum water quality conditions which must prevail are an adequate range of salinities to permit the estuarine dependent species of marine animals to propagate, temperature levels consistent with the survival and propagation of marine animals, adequate levels of dissolved oxygen, and the absence of toxic materials in concentrations sufficient to interfere significantly with aquatic life or to render edible aquatic animals unsuitable for consumption.

For a shellfish growing area to be designated as approved for shellfish harvesting according to the National Shellfish Sanitation Program (2), the following conditions must prevail:

a. A sanitary survey must reveal that pathogenic organisms, radionuclei, and/or other harmful industrial wastes are not apt to reach the area in dangerous concentrations,

b. The water quality is verified as suitable by laboratory findings.

With respect to the latter requirement relative to the presence of pathogenic organisms, the standards state briefly that the coliform median MPN of the water shall not exceed 70 per 100 milliliters, and not more than 10 percent of the samples ordinarily exceed an MPN of 230 per 100 milliliters. The standards are qualified by the following statement, "The foregoing limits need not be applied if it can be shown by detailed studies that the coliforms are not of direct fecal origin and do not indicate a public health hazard." It should be understood that the bacteriological quality standards placed on shellfish harvesting areas are extremely stringent. The low bacterial densities which are permissible can be readily understood when it is considered that shellfish are commonly consumed raw.

Most of the coastal waters are used for contact recreation and they must be maintained suitably for this use. Usually the suitability of a water for this purpose is controlled as in shellfish waters by bacteriological quality. The report of the National Technical Advisory Committee on Water Quality (3) to the Secretary of the Interior dated April 1, 1968, recommends that the fecal coliform content of contact recreation waters not exceed a logarithmic mean of 200 per 100 milliliters nor shall more than 10 percent of the total samples during any 30-day period exceed more than 400 per 100 milliliters. By way of contrast with the shellfish standard, assuming the fecal coliform density to be 20% of the total coliform density, a typical although not a fixed or rational percentage, the requirements for shellfish harvesting are approximately 16 times more restrictive than water contact sports.

With respect to esthetic use, obviously the water must be maintained in an attractive condition. Probably, in the State of Texas, the esthetic value of our coastal waters is marred most frequently by oil, debris, and other foreign solid materials. In this connection, a close second would be picnic litter on our beaches.

In considering water quality and its relationship to water use, it should be recognized that water may be perfectly satisfactory for one use and not for another. For example, Gulf water may be perfectly satisfactory for swimming and surfing, yet be totally unacceptable in an estuary undiluted with fresh water as it would prevent the propagation of estuarine-dependent species of marine animals. Similarly, water which contains sufficient dissolved oxygen to prevent nuisance conditions may be perfectly satisfactory for navigation purposes and again be totally unsuitable for the propagation of marine life. In the main, however, if the water quality in the various bodies of water composing the coastal waters of the State of Texas is maintained in a condition suitable for the propagation of marine life and water contact recreation, it will be suitable for all the other uses listed.

Texas Water Quality Requirements

To facilitate the objective of maintaining the coastal waters in a condition suitable for the water uses enumerated, the Texas Water Quality Board has adopted numerical requirements for the various coastal water bodies. These requirements enumerate the conditions which will be maintained in various coastal bodies of water within the State. Requirements are illustrated by a page from the Texas Water Quality Requirements. In the use of these requirements, it is necessary that they be interpreted in the light of the general statement, an integral part of the water quality requirements. This statement clarifies the manner in which these numerical requirements will be applied. The values shown are applicable at approximately the midpoint of the zone or the body of water under consideration with reasonable gradients to the next zone where the water quality requirements may change. In general, the requirements are to be applied to the arithmetic average conditions over a period of one year. In certain instances, where average values do not provide the necessary degree of understanding or regulatory base, maxima for some water quality parameters are provided. In the instance where the body of water receives a waste discharge, the requirements only apply after the wastewaters are mixed within the receiving body of water. That is, they do not apply to the wastewater stream itself.

Water Quality Data Available

As many of you here today are aware, water quality data are collected by a number of groups including universities, industries, and local, State and Federal agencies. Many of these data gathering efforts are limited in scope by the interest and purposes of the entity gathering the data. At least four groups, to my knowledge, are collecting data along most, if not all, of the Texas coast. These groups are the Texas Water Quality Board, the Texas State Department of Health in connection with their Shell Food Sanitation Program, the Texas Parks and Wildlife Department, and the Texas Water Development Board in cooperation with the U.S. Geological Survey. Quite possibly, other groups are also collecting data along the entire coast. The water quality data being collected by the Texas Water Quality Board has been gathered in connection with the three projects: the coastal water quality monitoring network; the Galveston Bay Project; and the Neches River Estuary Study.

The coastal water quality monitoring network was established to insure that the Texas Water Quality Board possess knowledge of the water quality existent in the various zones established by the Texas Water Quality Requirements. At least one station is located in each body of water for which water quality requirements have been established. This network has been in full operation only since June of 1969. We have not fully ironed out all our problems in connection with the operation of this network, particularly as related to bacteriological water quality. The data secured by this effort is being placed in a digital computer bank. Each quarter, the data is retrieved in the form of a computer printout. The computer is programmed to compare the water quality data collected with the water quality standards to identify those bodies of water which have a trend toward noncompliance with the water quality standards. A page of our first computer printout showing the data collected on each day is shown in Figure 3.

The Galveston Bay Project, a comprehensive study of the Galveston Bay complex, has collected data on the water quality existent in the Galveston Bay complex since 1967.

The Neches River Estuary study, which has been concluded, consisted of the development of a steady State water quality mathematical model of the Neches River Estuary, that is, the portion of the Neches River above Sabine Lake, subject to tidal influence. During the conduct of this study, a considerable body of data was collected on the water quality in this river zone.

Coastal Water Quality - A Brief Review

Within the time allotted, it is apparent that I cannot in any definitive sense convey to you the water quality conditions existing within the coastal waters. I would, however, like to go over briefly with you our findings up to this point.

In the Sabine Lake complex, we have a water quality problem in the Neches River Estuary and in Taylor's Bayou. The poor water quality in the Neches River Estuary is primarily that of oxygen resources, excessive temperatures, and at times the presence of excessive quantities of oil. The Neches River Estuary Study was directed at this problem, and it is anticipated that a solution will be effectuated within the reasonable future. The Taylor Bayou problem is related almost exclusively to oxygen resource problems.

With respect to the Galveston Bay complex, the data which we possess show in general that the waters of the Galveston Bay complex are in compliance with the water quality standards. Notable exceptions to this general statement are the Houston Ship Channel Zones. The waters of the Houston Ship Channel are not in compliance with the Texas Water Quality Standards as they relate to bacteriological quality and oxygen resources. It would appear that the violations with respect to bacteriological quality are largely attributable to domestic sewage discharges into the upper Houston Ship Channel, with the City of Houston obviously being the largest domestic sewage contributor to the channel. As many of you may recall, earlier this year the Board directed the City of Houston to commence the disinfection of its treated sewage effluents. It is our expectation that this action will result in a considerable reduction in the bacterial density in the Houston Ship Channel. The problems in the Houston Ship Channel are compounded by the unusually rapid expansion in population and industrial development which has been experienced in the watershed of Buffalo Bayou.

Proceeding down the coast, our data indicate that no major water quality problems exist. Our limited data do indicate that we do have a water quality problem in Los Olmos Creek, a tributary to Baffin Bay, and that this problem is also affecting, to some degree, Baffin Bay. Similarly, a problem exists in Chiltipin Creek, also a tributary to Baffin Bay. Both of these creeks receive waste from oil field operations. The problems which exist are those of excessive mineralization of the water, low dissolved oxygen levels at times, and occasional high biochemical oxygen demand values.

I do not mean to imply that these are the only water quality problems which exist in the coastal waters of the State because this is not the case. These are, however, the major problems of magnitude and problems which affect large areas. We do recognize, however, that water quality problems do exist over limited areas in the vicinity of waste discharges throughout the State, and we are working, as time permits, on a solution to these problems.

In the main, the water quality conditions which exist in the coastal waters of the State of Texas are good. Polluted waters are very much the exception rather than the rule. The Texas Water Quality Board is working, and we think diligently, to keep it this way.

REFERENCES

1. Texas Water Quality Board, June, 1967.
   Water Quality Requirements, Volume II, Coastal Waters.

2. U. S. Public Health Service, 1965.
   National Shellfish Sanitation Program Manual of Operations, Part 1, Sanitation of Shellfish Growing Areas, 1965 Revision.

3. Federal Water Pollution Control Administration, April, 1968.
   Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior.

4. Federal W. P. C. A., September, 1969.
   Texas Water Quality Standards Summary.

COASTAL SAMPLE

Station No. ___ ___ ___ ___.___ ___ ___ (1 2 3 4 5 6 7)

Date ___ ___ / ___ ___ / ___ ___ (8 9 / 10 11 / 12 13)

Sta. Description: ____________________

Depth	pH	Conductivity	B.O.D.$_5$	Chlorides
1/14 15 16 17	18 19.20	21 22 23 24 25 26	27 28 29.30	31 32 33 34 35

NH3-N	NO_3-N	Sus. Solids Total	Sus. Solids Vol.	T-PO_4	Sulphate
36 37.38 39	40 41.42 43	44 45 46 47	48 49 50	51 52.53 54	55 56 57 58 59

MPN Collected (✓) Yes____ No____

Depth	- COLIFORM - Total	- COLIFORM - Fecal
2/14 15 16	17 18 19 20 21 22 23 24	25 26 27 28 29 30 31 32

COMMENTS: ____________________

FIELD DATA

Depth	Conductivity	D.O.	Temp. °F	Turbidity	Wind	Flow	Tide	Time
3/14 15 16	17 18 19 20 21 22	23 24.25	26 27 28	29 30 31 32 33	34	35	36	37 38 39 40
4/14 15 16	17 18 19 20 21 22	23 24.25	26 27 28					
5/14 15 16	17 18 19 20 21 22	23 24.25	26 27 28					
6/14 15 16	17 18 19 20 21 22	23 24.25	26 27 28					
7/14 15 16	17 18 19 20 21 22	23 24.25	26 27 28					
8/14 15 16	17 18 19 20 21 22	23 24.25	26 27 28					
9/14 15 16	17 18 19 20 21 22	23 24.25	26 27 28					

FLOW

- D - Dry
- L - Low
- N - Normal
- H - High
- F - Flood
- X - Not Applicable

WIND VELOCITY

- 1 - Slick (1k)
- 2 - Calm (1-6k)
- 3 - Smooth (7-10k)
- 4 - Slight (11-16k)
- 5 - Moderate (17-21k)
- 6 - Rough (22-27k)
- 7 - Very Rough (28-33k)

TIDE

- I - Incoming
- O - Outgoing
- S - Slack Tide
- U - Not Known

SAMPLE DEPTH

- C - Composite
- B - Bottom
- S - Surface

Date Shipped____________ Signature____________________

Date Received____________ Laboratory Number____________ Date Completed____________

Form No. G-155 (WQB-45)
Revised 6-1-70

TEXAS WATER QUALITY BOARD
Coastal Reporting for 1970

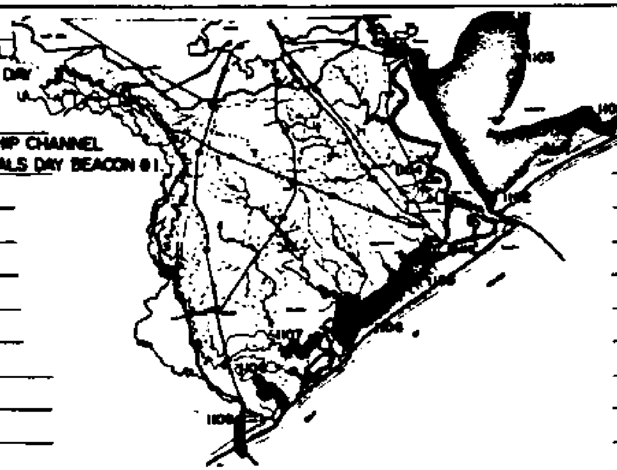
TRINITY RIVER--COASTAL

DEPTH	CONDUCT	DO	TEMP	TURBID	WIND	PH	CONDUCT	TDS	8005	CHLORIDE	NH_3	NO3	S.SOLIDS TOTAL	VOL.	T-PO4	SUL-PHATE
EAST BAY																
			0707.8			SHD SAMPLE PT EAS-00170					07					
7-30-69																
01	6700	5.4	86	65	20	7.8	9200	4600	3.0	2440	.54	.20	36	10	.55	
03	6700															
05	7100															
9-24-69																
01	25500	7.8	80	10	10	8,2	41216	20608	1.5	9520	.08	.11	34	15	.33	
03	24000	7.6	79													
05	24000	6.8	79													
06	24000	5.8	78													
1-16-70																
01	18200	8.2	47	25	50	8.7	42560	21280	5.5	11100	.83	.32	36	15	.50	
03	18200		46													
05	18200		46													
3-24-70																
01	9000	7.0	60	35		8.6	21504	10752	1.0	5430	.20	.24	73	15	.59	
03	9000															
05	9000															
AVE		7.1				3.4		14310	2.7	7122						
FREQ.		6.0				7.0-9.0		25000	3.0	12000						1200

FIGURE 1

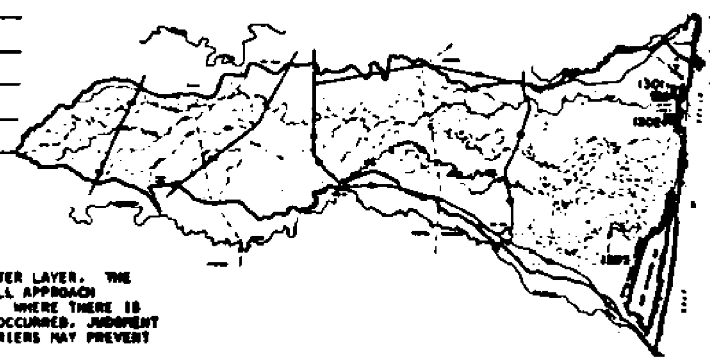
TIDAL WATERS

SAN JACINTO - BRAZOS COASTAL BASIN



STREAM		CONTACT RECREATION	NON-CONTACT RECREATION	PROPAGATION OF FISH & WILDLIFE	FISHING	AESTHETICS	NAVIGATION	INDUSTRIAL COOLING WATER	MINING & RECOVERY OF MINERALS
1101	EAST BAY	X	X	X	X	X	X	X	
1102	GALVESTON BAY - EAST OF HOUSTON SHIP CHANNEL, BOUNDED BY CHANNEL MARKER 68, FISHER SHOALS DAY BEACON # 1, LONE OAK BAYOU, SMITH POINT, HANNA REEF & BOLIVAR PENNINSULA.	X	X	X	X	X	X	X	
1103	TRINITY BAY & GALVESTON BAY EAST OF HOUSTON SHIP CHANNEL & NORTH OF CHANNEL MARKER # 68 & FISHER SHOALS DAY BEACON # 1	X	X	X	X	X	X	X	
1104	GALVESTON BAY - WEST OF HOUSTON SHIP CHANNEL	X	X	X	X	X	X	X	
1105	WEST BAY - EAST OF KARANKAWA REEF	X	X	X	X	X	X	X	
1106	WEST BAY - WEST OF KARANKAWA REEF	X	X	X	X	X	X	X	
1107	BASTROP BAYOU TIDAL*	X	X	X	X	X	X	X	
1108	OYSTER CREEK TIDAL*	X	X	X	X	X	X	X	
1109	BRAZOS RIVER TIDAL*	X	X	X	X	X	X	X	
1100	OTHER WATERS	THOSE	USES	DETERMINED	TO	BE IN	THE	PUBLIC	INTEREST

BRAZOS - COLORADO COASTAL BASIN



STREAM		CONTACT RECREATION	NON-CONTACT RECREATION	PROPAGATION OF FISH & WILDLIFE	FISHING	AESTHETICS	NAVIGATION	INDUSTRIAL COOLING WATER	MINING & RECOVERY OF MINERALS
1301	SAN BERNARD RIVER TIDAL*	X	X	X	X	X	X	X	
1302	CEDAR LAKES	X	X	X	X	X	X	X	
1303	EAST MATAGORDA BAY	X	X	X	X	X	X	X	
1300	OTHER WATERS	THOSE	USES	DETERMINED	TO	BE IN	THE	PUBLIC	INTEREST

*THESE REQUIREMENTS RELATE TO THE SURFACE WATER LAYER. THE SALINITY OF THE UNDERLYING SALINE WATERS WILL APPROACH THAT OF THE CONTIGUOUS BAY OR COASTAL ZONE. WHERE THERE IS NO SURFACE WATER LAYER OR WHERE MIXING HAS OCCURRED, JUDGMENT MUST BE APPLIED. IN SOME STREAMS, SALT BARRIERS MAY PREVENT THE INSTRUSION OF MARINE WATERS.

EAST BAY

1101

(THE GENERAL STATEMENT IS AN INTEGRAL PART OF THE FOLLOWING REQUIREMENTS.)

A.	Chloride, average not to exceed	12,000 mg/l
B.	Sulphate, average not to exceed	1,200 mg/l
C.	Filterable Residue, average not to exceed (Total Dissolved Solids)	25,000 mg/l
D.	B.O.D., average not to exceed	3.0 mg/l
E.	Dissolved Oxygen, not less than	6.0 mg/l
F.	pH Range	7.0-9.0
G.	MPN, logarithmic average not more than	70/100 ml

H. Temperature (See General Statement). Fall, winter, and spring, not to exceed a 4°F. rise in the representative temperature above natural conditions. Summer, not to exceed a 1.5°F. rise in the representative temperature above natural conditions.

This temperature requirement is a requirement of the Federal Water Pollution Control Administration.

I. Toxicity and Toxic Materials—These waters shall not exhibit either acute or chronic toxicity (or other harmful effect) to human, animal, or aquatic life to such an extent as to interfere with uses of the waters. (See General Statement)

J. Free or Floating Oil—Substantially free from oil.

K. Foaming or Frothing Material—None of a persistent nature.

L. Other—The control of other substances not heretofore mentioned will be guided by the U.S. Public Health Service manual "Sanitation of Shellfish Growing Areas", 1965 revision. Where waters are not shellfish growing areas, it is required only that waters entering or contiguous to a shellfish growing area not interfere with the shellfish growing area.

M. Radioactive Materials—Levels of ionizing radiation and radioactive materials of all kinds, from both dissolved and suspended matter, shall be regulated by the Texas Radiation Control Act, Article 4590 (f), Revised Civil Statutes of Texas, and the Texas Regulations for Control of Radiation issued thereunder.

THE COASTAL RESOURCES MANAGEMENT PROGRAM OF TEXAS
A New Approach for Environmental and Human Dignity

JAMES T. GOODWIN
Coordinator
Governor's Office of Natural Resources
Austin, Texas

I am very pleased to be in Galveston since I am a native of this area. The Island has changed considerably since my boyhood days in Houston. Changes wrought by man in the coastal zone have affected our environment in many ways that are beyond our understanding. Since we tend to fear those things which we don't understand, the Governor's Office has embarked upon the development of a Coastal Resources Management Program under the auspices of the Texas Natural Resources Council.

Senate Concurrent Resolution #38 was the product of the last session of the Legislature which requested the Texas Natural Resources Council to conduct a comprehensive study of the Coast. Funding for the study was provided in the Governor's budget at the rate of $100,000 per year for the biennium. The Resolution provided for an interim report to the Legislature in December, 1970, with a final report due by December, 1972.

Since passage of the Resolution, the study concept has been modified within the flexible framework of the Resolution. The Governor feels that pressures upon the environment have reached far beyond the talking or study stage and that the Coastal Resources Management Program must culminate in a program for action which can be implemented quickly.

It is one thing to attempt a balanced study of our environment, but quite another to tie studies together in a program which can be implemented. The Coastal Resources Management Program contains elements of a plan and study, but the unique factor which makes it a program is an implementation vehicle.

When I came on board in May as Coordinator of Natural Resources, my major charge was to *coordinate with* the Texas Natural Resources Council in developing the Coastal Resources Management Program. I was aware of several key words which needed full consideration: *balance between man and nature; good environment; preservation; conservation; ecology; development without degradation.* My first task was to attempt to define those key words and phrases. Discussions were held with conservationists, industry, financial advisors, universities, state agency heads, etc., to attempt the formulation of an approach which would satisfy most, if not all, of the groups in the coastal environs.

Fortunately, many studies have been conducted in the coastal zone which provide us with a good starting point. Other studies are currently underway independent of the Coastal Resources Management Program which will provide us with significant inputs. However, the means by which to study the implementation vehicle and arrive at concrete recommendations was of some concern. We finally solved that problem in a unique fashion which will give the Coastal Resources Management Program a better chance for being an "action" program than other studies of a similar nature.

I believe that the foregoing has served to introduce the Program. I would like to use my remaining time in explaining the philosophy of our approach as well as the specific tasks underway.

When discussing the environment in terms of generalities, society tends to accept and view those generalities in terms of its own concepts. *Balanced environment,* for example, is a good phrase which means something different to a conservationist or a land developer. If defined, however, both may be offended. I will attempt some definitions and explanations that will probably offend some of you at times and the rest of you at other times. The only time all of you will agree with me is when I talk in very nebulous terms.

Ideally, when man bands together in community environments, he does not affect the natural environment. This hope is well reflected in the motto of the Texas Speleological Society, "Take nothing but photographs, leave nothing but footprints." Unfortunately, the real world has never acted that way. Man, in groups, has always impacted his natural environment.

The objective of the Coastal Resources Management Program is to determine that environment which will enable man to live in dignity with himself and the rest of nature. We speak of a balanced environment which will provide protection for those resources which must be preserved, wise use of those resources which should be conserved and the orderly development of those resources which man requires for his industrial, commercial and urban needs.

Texas is fortunate in having a long and valuable coastline with the Gulf of Mexico. We are even more fortunate in that our coastline is relatively undeveloped. This was brought home to me several weeks ago when the Bureau of Economic Geology at the University of Texas in Austin laid out a mosaic of topographic scale photographs on the floor of the ballroom at the Student Union. This mosaic represented the entire Texas Gulf Coast from the Sabine River to Boca Chica on the Rio Grande. The area covered was approximately 100 feet by 20 feet and provided impressive amounts of detail for the scientists who were interpreting physical features. The geologists, biologists and botanists took me on a walking tour of the Coast which lasted 1 1/2 hours and provided me with insights concerning our Coast which were quite new to me. The most important point to flash across my mind was how unspoiled the majority of our coastline appeared. While the Houston-Beaumont area is intensively developed, the expanse from Freeport south is only sporadically broken by development. Many areas remain which can be preserved for future generations and for the maintenance of species of flora and fauna that give our Coast its unique scientific and social values.

The Coastal Resources Management Program is thus concerned with preservation, conservation and development, a three pronged program to dignify our environment. Developers sometimes criticize us when we speak of preservation, and conservationists criticize us when we speak of development. Unfortunately, pollution and the degradation of our environment knows no artificial barriers such as fences or political boundaries. If we concern ourselves only with preservation without worrying about the development which might occur around preserved areas, we may be permitting the destruction of the resources we want to preserve.

The conceptualizing of a program as complicated and far-reaching in scope as the Coastal Resources Management Program requires the assistance and inputs of many individuals and groups. After discussions were held with state agency heads, industrialists, conservationists, etc., as mentioned earlier, a thinking outline was prepared. This "thinking" outline was an attempt to organize the bits and pieces of information that represented the thinking of informed people on the ways to approach a Coastal Resources Management Program.

A "thinking" outline is a very useful tool which can enable you to prepare your methodology in attacking the program goal. It can also help in goal definition prior to development of a "writing" outline. Too many people tend to try to determine what is available in terms of data and/or studies without first considering needs to meet a single objective. As a result, most people end up not only with more information than necessary, but more information than they understand how to use. The "thinking" outline enables you to define your needs more efficiently and therefore avoid costly and unnecessary data collection.

The "thinking" outline enabled us to identify resources and resource uses as well as institutional factors which encompassed the environment of the Coast. We identified 21 task areas which were separate subjects, but whose linkages with and impact upon the other task areas would represent the complex interactions of the Coastal Zone. This identification was not only necessary for planning and study activities, but provided us with the idea for development of the action part of the Program, the implementing vehicle. I will discuss this at length later in the presentation.

The 21 task areas were assigned to 21 task groups which were charged with identifying and describing the applicable coastal resource, alternative uses of the resource, problems related to those alternative uses of resources and means by which solutions could be studied. The first reports will be due by October 1 and their results will be assimilated into the report to the Legislature which is due this December. The task group leaders are also specifically charged with identifying linkages and interactions between their task area and all other areas, as well as their ideas concerning recommendations to be made to the Legislature.

An additional input will be provided by the Governor's Conference on Coastal and Marine Resources to be held in September at the Rice Hotel in Houston. The Conference, co-sponsored by the Governor's Office and the Sea Grant Program at Texas A&M University, will examine Texas' goals in the Coastal Zone and the Sea. Results of the Conference will be used by the Governor's Advisory Committee on Marine Resources in making recommendations to the Governor concerning marine resources. Needless to say, we who are working on the Coastal Resources Management Program are anticipating the Conference as providing the Program with additional expert contributions.

The most serious problems which beset us related to the legalistic side of the Program including a possible vehicle for implementation. While we could identify factors related to planning and study, the integration of the action vehicle was something else. Fortunately, other people had been giving some thought to developments in coastal and marine law. The University of Houston Law School is in the process of developing and Institute of Coastal and Marine Law which would involve a consortium of the State's law schools in matters pertaining to coastal and marine law. The Institute can be an excellent organization for obtaining top legal minds for work on the implementing vehicle for the Coastal Resources Management Program.

While the 21 project leaders of our task groups are examining the technical information and problems relative to those task areas, the legal scholars will be examining each task area in a slightly different manner.

The legal scholars will examine each task in terms of the responsibility and authority given to political sub-divisions of the State concerning that task area. An examination of statutory authority and responsibility will identify overlapping or duplicating responsibilities as well as the most obvious gaps where responsibility and authority are not identified. After the initial legal surveys are completed, various alternative means of using existing institutions to eliminate the overlapping features or gaps will be studied. The creation of new institutions both along functional and areal lines will also be studied. Finally, a recommendation will be made, together with enabling legislation, on the alternative considered to be the most efficient vehicle for implementing the Program. The Legislature will be provided with an analysis of each alternative for their consideration as well as the analysis of the recommended alternative. This step will tie together the identification of problems and possible solutions with a means of implementation, in other words, give the State a total program.

It will be impossible for us to identify all the problems of our coastal resources, much less work out their solution. However, we hope through the new approach to identify the most important first steps necessary to provide Texans with a coastal environment of which they can be proud and within which they can live with dignity. This is the goal for which the Governor and the Texas Natural Resources Council are working.

THE COASTAL INTERFACE[1]

RICHARD J. HOOGLAND
Fishery Biologist
Bureau of Commercial Fisheries Biological Laboratory
Galveston, Texas 77550

Even though landings of commercial fish from U.S. waters have not increased in recent years, there has been a shift in the source of supply. An example of this is the increase in fishery production from the Gulf of Mexico. In 1940 the Gulf contributed only 6% (250 million pounds) of the total U.S. production, whereas in 1968 the Gulf contributed 31% (over 1.2 billion pounds). Likewise, the commercial fishery in Texas is expanding. In 1968, fishermen caught 149 million pounds valued at more than $44 million from the coastal waters of Texas. Remember that this is dockside value and when projected to consumer level it would assert a capital input to the economy several-fold greater. While Texas ranked only 10th nationally in terms of volume, it ranked 3rd in the value of the catch because of its shrimp resources. Principal species in the commercial harvest from the Gulf area were shrimp, menhaden, oysters, and crabs. These four species accounted for about 90% of the total value.

Saltwater sport fishing is becoming very popular. To help illustrate the value of the sport fishing industry, a 1965 National survey found that saltwater sport fishing generated nearly $800 million of gross business activity. It was comprised primarily of: fishing equipment, auxiliary equipment, food and lodging, transportation, licenses, bait, guides, and other miscellaneous items.

Statistics indicated that saltwater anglers on the Gulf coast spend, on an average, nearly $8.00 per day. It was estimated that the coastal waters of Texas provide over 8 million man-days of sport fishing annually. With expected population growth, more leisure time, and better transportation and equipment, considerable increase in recreational fishing is anticipated. Again referring to the National survey, 10-year trends of increasing participation in saltwater fishing were compared with the population growth trend of the entire United States. Saltwater angling

---

[1]Contribution No. 306 from the Bureau of Commercial Fisheries Biological Laboratory, Galveston, Texas 77550.

increased at an average rate of 6% per year while the total U.S. population grew at an average rate of only 2% per year.

As you can well see, the value of sport fishing alone to the Texas coast is big business and contributes significantly to the economy of the State. The more popular species sought after are sea trout, redfish, flounder, croaker, black drum, and others.

Each of the commercially important species mentioned earlier and each of the sport fishes just named have one thing in common--they are all estuarine dependent. This means that they are required to spend either all or part of their life cycle in an estuary. Most of these estuary-dependent species spawn in the Gulf. The young enter the estuary when very small, inhabit areas to which they are best suited, and proceed to grow very rapidly. They return to the Gulf in a few weeks or months and complete their development. For example, brown shrimp spawn offshore in the Gulf and the young are about 1/2 inch long when they enter an estuary in the spring. By late May or early June they are about 4 inches long and return to the Gulf where they complete their development and the cycle.

For those of you who may not be acquainted with the term estuary, I will give you a very brief definition. The typical estuary is a coastal body of water that is semienclosed and has an input of fresh water at its head and tidal exchange with the sea or gulf. It usually has a well-defined salinity gradient between the river and the sea and is therefore unique in that it is neither like the river nor the sea. It is usually characterized by a broad spectrum of conditions throughout which many species requiring different environmental conditions can be accommodated simultaneously.

Those of you who are sport fishermen or duck hunters have heard a great deal about estuaries lately. Unfortunately, there are many well-intentioned people who have traditionally looked on wetlands as wastelands or lands that are sitting there doing nothing and serving no purpose. The layman often views the marshes as areas of muck, shifting sands, pungent odors, mosquitos, creeping and crawling creatures, strange sounds in the night, and lonely solitude in the day.

The fact of the matter is that estuaries are among the most fertile areas in the world. For example, a production or crop of 10 tons of dry organic matter per acre per year can be expected from marshlands. In comparison, world wheat production is only 1 1/2 tons per acre (whole plant) and only certain, very rich sugar cane and rice areas produce as much as our fertile marshlands and estuaries, and the marshes are not fertilized artificially.

Plant life occurs in the estuarine zone as attached grasses, algae, and phytoplankton. The plant production, although of little use to man directly, supplies basic food for the young and small fishes and invertebrates. The larger plants die, are detached, decomposed, and broken down by bacteria into detritus. Animals at the bottom of the food chain feed by filtering this detritus from the water in great quantities. These are the shellfishes, the planktonic crustaceans, and the schooling bait fishes. These, in turn, are eaten by large fishes, crabs, and so forth through the complex food chain.

Another obvious value of the estuarine zone, and one that it alone can supply, is enrichment of the open coastal waters. There is good reason that fish and shellfish are most abundant near the coasts of our oceans.

Nature has contrived to fill all the available living space in creating life in the sea. In the shallow estuarine zones she has been particularly ingenious. Over eons of time, nature has perfected fish species to take advantage of every variety of inshore habitat. Because each marine fish species has adapted its life cycle in a special way to fit special conditions, it has lost the ability to prosper in any other habitat. This specialization is a one-way street leading to success for the species only as long as there is no catastrophic change in its living area.

The survival technique adopted by each species to thwart its natural enemies is not worked out at the time of danger but rather it is an automatic, instinctive reaction. For any organism the strategy evolves, in general, from its whole life history pattern, but more specifically from the special type of habitat to which it is adapted.

Man's historic economic development has been closely linked to estuaries because of their strategic location, and, as a result, they are being extensively altered or destroyed. The Gulf Coast of Texas is experiencing exceptional economic growth. The problem is basically people. As more people occupy the coastal zone, the problems intensify. As our technology grows, the characteristics of the waters are being changed by domestic, agricultural, and industrial uses. The effects of various chemical changes, which produce massive fish kills that can be seen and smelled by the layman, often stirs up sufficient public opinion to initiate remedial action. However, we are as much or more concerned with some of the more subtle effects of pollution. We readily admit that much is yet to be learned about the effects of pollution, but small pieces of evidence from individual scientific experiments tell us that the foreign substances added to the water can affect marine life in many ways without killing. Changes in water quality may affect growth rates, length of life, reproductive capacity, and resistance to diseases, just to mention a few. In the long run, these inconspicuous effects may be more disastrous than those which pile up masses of dead fish on a beach.

I would also like to point out our concern with the many physical alterations taking place in estuaries. Specific activities which pose a threat to the coastal environment include bulkheading and filling; dredging of channels and fossil shell deposits; stream diversions; and restriction of tidal exchange and fresh-water runoff. Effects from a single one of these is usually small, but because they are so numerous, their compound effects are unquestionably producing major environmental changes.

Like the effects of pollution, some environmental alterations have obvious detrimental effects on marine life. It is not difficult to recognize the adverse effects of silt deposition on an oyster bed. For instance, the living oysters are smothered and die, and the bottom is made unsuitable for future generations of oysters. Nor is it difficult to recognize the adverse effects of spoil deposition or land fill that physically displaces habitat or acts as an isolation barrier and prevents utilization by marine organisms. Some of the effects of engineering activities have much of the subtleness found in agricultural, industrial, and domestic pollution. Environmental changes that are less dramatic would be alteration in water circulation patterns, changes in salinity or temperature of the water, as well as numerous other conditions which may or may not be harmful to fishery resources. For example, water temperature and salinity are two of the more potent physical factors in the life of marine and brackish water organisms. There is a complex correlation between the biological effects of temperature and salinity. Temperature can modify the effects of salinity on an organism, i.e., salinities tolerated by an organism at a high temperature may vary from those tolerated by the same organism at a low temperature. Conversely, salinity can modify the effects of temperature.

Biologists are not against progress and development. In fact, I do not know of any true conservationist who is against them. But many of the estuarine modifications undertaken in the name of progress are not really progressive. Much of the environmental destruction and pollution can be avoided. I feel that progress need not be despoliation or degradation; development can be guided to protect maximum overall values.

There are alternatives or other ways for municipalaties, industries, farmers, engineers, and planners to develop their goals or meet their objectives. Development can take place without the sacrifice of natural values and esthetics. However, once a natural resource has been despoiled and altered, the change is usually irrevocable.

The incentive for anyone to try to alter these coastal areas, almost without exception, is the fast dollar. The fate of our total natural environment is under constant economic pressure. For too long we have scrambled furiously for the dollar, which represents comforts, conveniences, and fun, without pausing to total up the cost. The economic benefits of most dredging, filling, and polluting operations are recognizable and are fairly easy to measure. But the economic losses are difficult to assess. We do not yet know how to determine and assign values to the intangibles of a quality environment such as natural beauty, recreation, fish, wildlife, etc. We remain at the mercy of development accounting which measures costs against benefits and excludes the cost of degrading the environment or the benefits of leaving the environment alone.

Increasingly, people are building resort or vacation homes in this area to enjoy the hunting, fishing, and esthetics provided by the natural estuarine environment and its associated marshes. These building developments usually depend on the dredging of marshes for access channels and utilization of the spoil to fill lowlands to such an elevation that it can be sold as building lots. It is conceivable that after the developments are all completed, the occupants of the houses will have a waterfront view and a cool breeze to enjoy, but the fish and waterfowl could be gone forever.

These estuarine wetlands and tidal areas are owned by the public and their rights and interests should take precedence over the rights of private individuals to profit at public expense. This is not to say, for example, that some lands should not be filled or wetlands converted to the culturing of a single species. Such projects, however, should be carefully considered and held to a bare minimum, strictly controlled, and approved only after clear-cut demonstration that they will advance or maintain the public good. It may often be better to postpone shoreline or tidal area developments or to divert them to inland areas than to cause permanent damage in haste.

The effects of resource development on fish and wildlife have received some national recognition, and legislation was enacted to provide a means for considering these resources in all Federally planned and Federally authorized water-development projects. Implementation of this legislation authorized and obligated the U.S. Fish and Wildlife Service to assist and cooperate with other Federal, State, and public or private interests in planning the development of our water resources. The Bureau of Sport Fisheries and Wildlife, Division of River Basin Studies (DRBS) was designated the representative of the U.S. Fish and Wildlife Service in connection with Federally planned and authorized water-development projects.

Work contemplated by private or non-Federal interests in navigable or tidal waters requires a permit from the U.S. Army Corps of Engineers. In accordance with the previously mentioned legislation, the Fish and Wildlife Service is responsible for advising the Corps of possible adverse effects that the proposed work might have on fish and wildlife resources. Since the DRBS represents the interests of both Bureaus of the Fish and Wildlife Service, it is imperative that it cooperate closely with the Bureau of Commercial Fisheries whenever significant commercial fisheries are involved.

Our primary goal in BCF is to assure that estuary-dependent fishery resources receive consideration and protection during project planning. To achieve this goal we review each of the Federally planned as well as privately planned projects (over 400 annually) that potentially affect the estuarine zone in the western Gulf of Mexico. When warranted, we recommend measures to reduce adverse effects and where practical recommend changes whereby the environment would be enhanced for fishery resources. To develop the best possible evaluation of each proposed project, we obtain assistance from other BCF scientists, economists, and statisticians, as well as all other available sources of information.

Because fishery resources are, in general, the property of the State, we consult directly and work closely with the appropriate conservation agency relating to technical aspects of fishery investigations associated with water-development projects.

Upon receipt of our recommendations, the Corps reviews them with the applicant to insure that they are encorporated in his plans. Developers often come to us for suggestions prior to submitting their application to the Corps. This procedure usually saves the developer much time because he is made aware of our views before he actually submits his application.

We also have another estuarine program studying the basic estuarine ecology. General objectives of the program are to:

(1) Compare productivity of natural estuarine habitats with areas altered by dredging, spoiling, bulkheading, and filling.

(2) Document the effects of specific types of construction on the estuarine environment.

(3) Develop techniques for managing estuarine habitats for increased fishery production.

(4) Develop methods for rehabilitating altered habitats so that productivity can be reestablished.

If the estuarine areas so necessary for perpetuation of the sport and commercial fishing industries are to be preserved, it is important that action programs be implemented immediately to protect the natural qualities of estuaries and their contiguous zones. Presently, there is a battle going on between preservation-conservation and development in most of our estuaries. Development is proceeding so rapidly that there will be little left to preserve and conserve when we finally learn how to manage estuaries for multiple use.

Closer coordination and unanimity of purpose among agencies of all levels of government with interests in these areas must be encouraged. The public sector must take the initiative to develop plans and enforceable regulations that can cope in an orderly fashion with the increasing demand for alteration of land and water in estuaries. Also, there must be an informed public, willing to support policies and costs that lead to the sound management of our estuarine and coastal zones.

RAISING CATFISH IN BRACKISH WATER

W. GUTHRIE PERRY, JR.
Louisiana Wild Life and Fisheries Commission
Grand Chenier, Louisiana 70643

ABSTRACT

This paper includes a discussion of catfish culture studies conducted on Rockefeller Wildlife Refuge in the brackish marshes of Southwest Louisiana.

It points out that channel, blue and white catfish may be grown in coastal waters too saline for other agricultural crops. The channel catfish proved to be the most hardy of the three species, contrary to common belief, and would give the best returns to future fish farmers in coastal areas for one to two years growth.

This data along with that of other workers indicate that it will be necessary to keep the salinity below 8.0 ppt if young fingerlings or fry are reared. Older fingerlings may be grown in salinities up to 11.0 ppt. The highest salinity that we know catfish will reproduce in is 2.0 ppt.

INTRODUCTION

Fisheries research is relatively new to the Refuge Division of the Louisiana Wild Life and Fisheries Commission. Wildlife studies, consisting mainly of waterfowl and alligator projects, have been conducted by this division for several decades and numerous projects have been conducted and are presently underway concerning the various stages of marsh ecology, development and management for wildlife. The uniqueness of this area, the scarcity of fisheries research in this type environment and the excellent facilities prompted the initiation of fisheries work at Rockefeller Wildlife Refuge.

Six years ago, the Louisiana Wild Life and Fisheries Commission in cooperation with the Louisiana State University Agriculture Experiment Station began exploring the possibilities of producing freshwater catfish in brackish coastal waters. It was felt that the warmer climate of our vast fertile coastal lands should offer longer growing seasons and possibly thousands of acres of marshlands now idle may possess a potential to fish farmers. If catfish could be grown in brackish waters unsuitable for anyother crop, then a whole new industry awaits coastal waters. Also, potential inland fish farmers with wells containing certain amounts of salt may be more fortunate than we once believed as this may prove to be acceptable for fish culture and may have some degree of therapeutic effect. The old practice of "salting" diseased fish has been used as a treatment for external parasites since the initiation of fish farming.

Species selected for our studies were channel, *Ictalurus punctatus*, white, *Ictalurus catus*, and blue catfish, *Ictalurus furcatus*. Until these studies were initiated, the production of catfish in brackish water ponds on an experimental basis had not been tried. The initial pilot study was in the form of a master thesis, Perry, 1967. This indicated that under natural conditions both blue and channel catfish were present in the marsh waters having salinities ranging up to 11.4 ppt (parts per thousand). It was also found that blue catfish were more common in the more saline waters. A ratio of 2:1 existed between the blue and channel catfish in the study area. In a literature review, it was revealed that blue catfish were also dominant in the estuarine waters of the extreme southeastern portion of Louisiana (Kelly, 1965). This data gave us reason to believe that the blue catfish would be better adapted than the channel catfish to saline conditions and may give better growth in brackish ponds.

The white catfish, also a freshwater species was considered for brackish water pond culture studies. This fish is not native to Louisiana, but is found in the coastal Atlantic states, ranging southward from New York to Florida. It is also found in the mid-west and has spread into Nevada and California. The white catfish is reported as being adaptable to a variety of habitats including brackish waters. This fish spawns readily in ponds and responds to supplemental feeding giving a high production per acre (Prather and Swingle, 1960).

The purpose of the pond studies was to determine if these more commonly accepted freshwater catfish could be successfully grown in saline waters and to determine the effects of these marsh waters upon growth, survival, food conversion and palatability.

STUDY AREA

The research ponds used in our experiments are located on Rockefeller Wildlife Refuge in the coastal marshes of Southwest Louisiana (Figure 1). The refuge encompasses 84,000 acres and is owned by the Louisiana Wild Life and Fisheries Commission. This area borders the Gulf of Mexico for 26.5 miles and extends six miles northward to the stranded beach ridge complex of Grand Chenier, Louisiana. The Rockefeller marsh has an average elevation of 1.1 feet above sea level and a tidal fluctuation of approximately 18 inches between mean low and high tides. The salinities of the refuge waters range from 0.1 ppt to 30 ppt. The typical salt

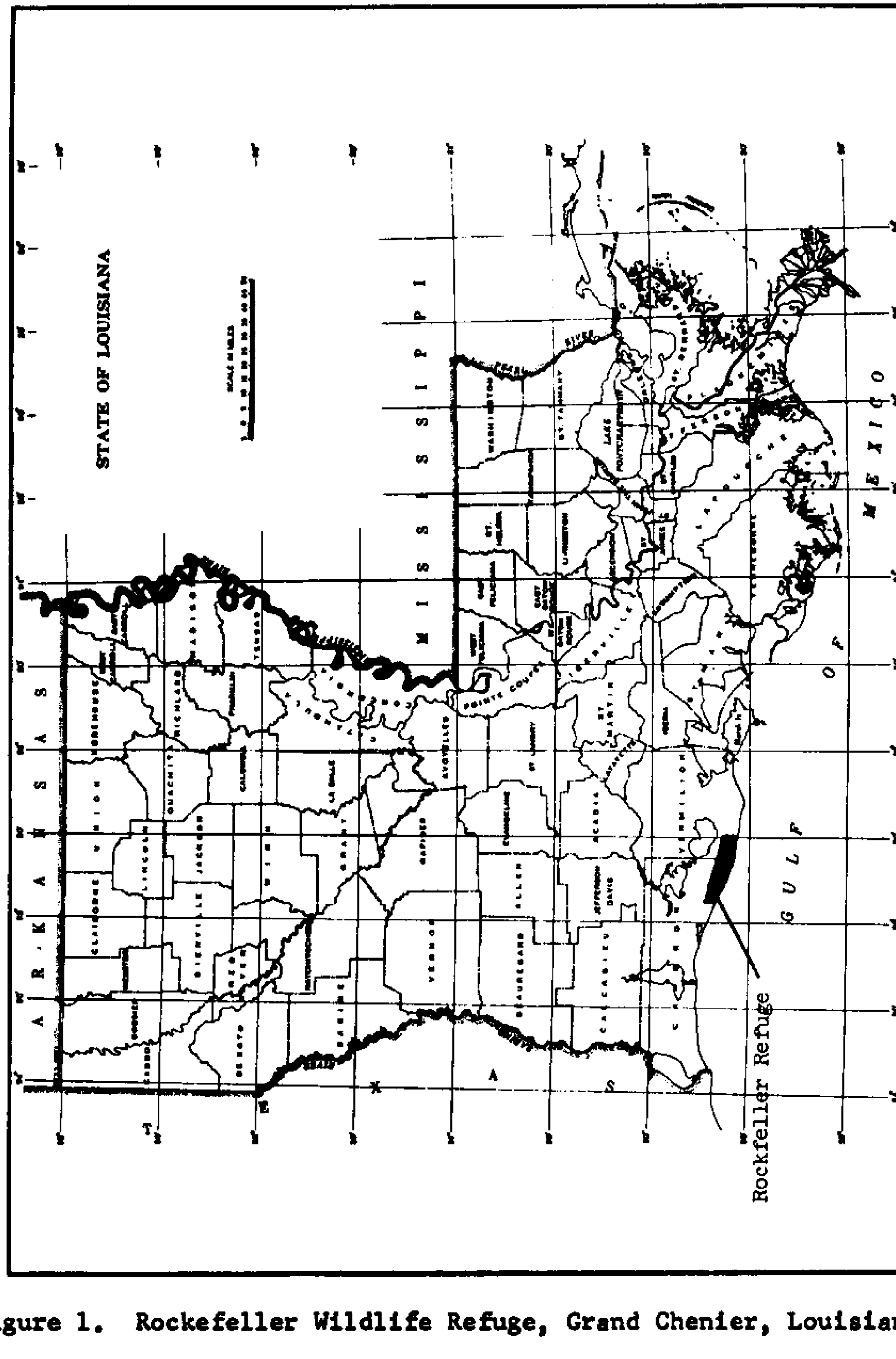


Figure 1. Rockefeller Wildlife Refuge, Grand Chenier, Louisiana

marsh flora of wiregrass, Spartina patens, saltmarsh grass, Distichlis spicata, is dominant in the nonimpounded areas of the refuge.

The research ponds, one-tenth acre each, are arranged in such a manner as to allow salinity manipulations in order to obtain desired concentrations (Figure 2). The average depth of the ponds is four feet. Pond bottoms have a high organic content identical with the surrounding Chenier Plain marshes (Table 1). Soil classification should probably be termed as a muck-mineral type (Chabreck, 1970). Some of the earlier ponds were dug into the marsh floor; however, this presented two very definite problems which will be discussed later.

STUDY METHODS

Stocking

The initial pond experiments began in 1967 when nine one-tenth acre ponds were stocked at a rate of 2,000 fish per acre (Perry and Avault, 1968). In the spring of 1968, the study was repeated with the three species (Figure 3), but with a higher stocking rate of 2,500 fish per acre (Perry and Avault, 1969). Only one species was placed in each pond resulting in three replications. All of the catfish stocked originally came from freshwater hatcheries and were stocked into the brackish water ponds with an equal amount of acclimation. Also, a prophylactic treatment of 15 ppm (parts per million) formaldehyde and one ppm acriflavine was given to the fish during transport to the ponds.

Feeding

Each year the fingerling catfish were started on a 10 per cent body weight ration until they were observed taking feed. At this time the feeding rate was dropped to the standard 3 per cent body weight. In 1967, a sinking ration was used; however, in 1968 a floating ration was fed. A good portion of the sinking type was not eaten by the fish, due to the very mucky nature of the pond bottom and because of the presence of a possible oxygen deficient or dead layer in the deeper areas.

A 5-foot 3/8-inch square mesh treated nylon cast net was found to give best results in obtaining fish for the recalculation of feeding rates.

Water Chemistry

Initially, salinity data was taken monthly using the Mohr method in which water samples were titrated with a standard silver nitrate solution using chromate as the end-point indicator (American Public Health Association, 1960). A model R-S-5 Beckman salinity meter was obtained and was used during the latter part of the 1968 study. A Precision Galvanic Cell oxygen analyser and the Winkler titration methods were both used in

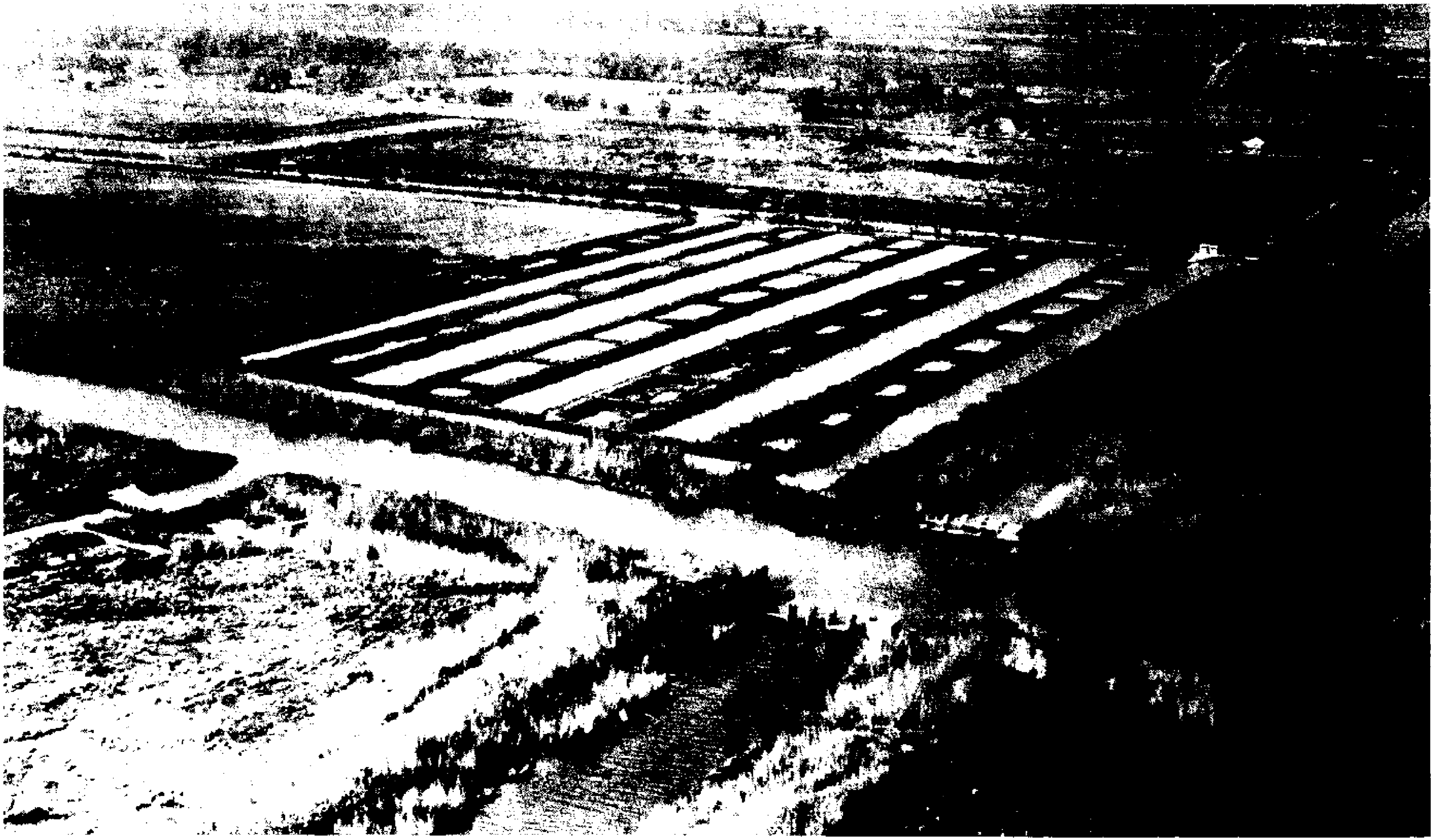


Figure 2. A total of 51 ponds have been constructed on the Rockefeller Wildlife Refuge for fishery studies. These ponds, ranging in size from 0.1 to 5.0 acres, are constructed in such a manner as to allow salt water collection from a tidal bayou leading to the Gulf of Mexico or fresh water from a canal draining the fresh water marshes.

Table 1. Variations in composite top soil analysis taken periodically from Rockefeller Wildlife Refuge Study Ponds.

Phosphorus	166 - 323 ppm
Potassium	455+ *
Calcium	1080 - 2440 ppm
Magnesium	1000+ **
Organic Material	2.3 - 11.2 %
pH	6.5 - 8.0

* laboratory ran one sample complete which equaled 1280 ppm

** laboratory ran one sample complete which equaled 2640 ppm

Figure 3. Species selected for our studies were blue, channel and white catfish (pictured from top to bottom). These fish were stocked into the brackish water ponds with an equal amount of acclimation.

Table 2. Salinity data in ppt of catfish ponds, Rockefeller Wildlife Refuge, 1967 - 1968.

1967

Pond	April	May	June	July	August	September	November	January	Average per pond
B 7	2.4	3.3	7.8	7.9	6.7	10.1	11.2	7.9	7.2
B 8	1.8	2.5	7.8	8.9	7.9	10.1	10.1	7.9	7.1
B 9	2.2	2.9	5.6	7.9	7.9	8.9	9.0	6.7	6.4
B 10	2.0	2.7	7.8	7.9	7.9	10.1	8.0	7.9	6.8
B 11	1.8	3.5	8.9	7.9	6.7	8.9	9.0	7.9	6.8
B 12	2.2	3.7	6.7	7.9	6.7	10.1	9.0	7.9	6.8
B 13	2.0	3.2	7.8	7.9	6.7	8.9	9.0	7.9	6.7
B 14	2.2	3.2	7.8	11.2	9.0	10.1	10.1	7.9	7.7
B 15	1.8	3.2	7.8	10.1	6.7	10.1	10.1	7.9	7.2
Monthly Average	2.0	3.1	7.6	8.6	7.4	9.7	9.5	7.8	7.0

Table 2 continued.

1968

Pond	March	April	May	June	July	August	September	October	November	December	Average per Pond
B 7	7.0	6.5	6.3	6.1	6.0	5.7	4.4	4.6	4.1	3.8	5.4
B 8	5.9	6.4	6.9	7.1	6.8	6.9	5.5	4.6	4.0	3.7	5.8
B 9	6.0	6.6	6.5	6.1	5.9	5.9	4.9	4.7	4.5	4.0	5.5
B 10	6.1	5.9	5.9	6.1	6.2	6.1	5.9	4.5	4.1	3.9	5.5
B 11	6.0	6.4	6.6	7.0	7.0	7.1	6.9	4.7	3.9	4.3	6.0
B 12	6.0	6.3	6.5	7.1	7.2	6.9	5.8	4.8	4.3	4.3	5.9
B 13	-	5.9	6.6	7.1	6.9	6.9	5.8	5.1	4.0	4.1	5.8
B 14	-	7.1	6.9	7.2	6.9	7.1	7.0	6.9	4.1	4.4	6.4
B 15	-	6.9	7.0	7.1	6.7	6.6	6.7	6.1	3.9	4.0	6.1
Monthly Average	6.2	6.4	6.6	6.8	6.6	6.6	5.9	5.1	4.1	4.1	5.8

periodic oxygen determinations. A Rayon Model D submersible 30-day temperature recorder and a Taylor Model 76J temperature recorder both were used during the study. Records of the minimum-maximum temperatures were recorded at a depth of 3.5 feet below the surface. This was done to get a more accurate picture of the termperature that the fish actually experienced. Portable colorimetric Hach pH test kits No. 17N and 17H were used for pH determinations. A standard secchi disc was used for the turbidity measurements. Pond waters were chemically analyzed by the Louisiana State University Feed and Fertilizer Laboratory.

Harvest

The water had to be pumped from the ponds since they were constructed below sea level. The fish were collected and held in separate holding tanks until the ponds were empty. Then, total and standard length were measured to the nearest millimeter and weights were recorded to the nearest gram for a comparison of the catfish species.

RESULTS AND DISCUSSION

Harvest

Pond waters were generally less saline in 1968 (Table 2). The average pond salinity was 6.2 ppt when the fish were stocked. An average high of 6.8 ppt existed in June which declined to 4.1 ppt at harvest. The 1967 average salinity was 2.0 ppt when the fish were stocked. In the months of September and November the average rose to 9.7 ppt and declined to 7.8 ppt at harvest. The two highest readings for the entire study were recorded in July when two ponds contained 11.2 and 10.1 ppt. The average salinity per pond was rather constant among the ponds although there was a wide monthly variation. This wide variation in salinities was a result of rainfall, the number of times the ponds had to be refilled due to evaporation and because of water replacement in oxygen deficient ponds.

The water temperatures of the relatively shallow ponds tended to fluctuate rather closely with atmospheric temperatures both years (Figure 4). Temperatures were always above 41° F. and below 85° F. Pond pH values varied from 7.5 to 9.0. The readings were constantly in the 8.0 to 8.5 range. The waters of the ponds were quite turbid with secchi disc readings ranging from 4 to 13 inches. Chemical analyses of the pond waters revealed a rather constant relationship of the elements which showed some variation (Table 3).

In 1967 with supplemental feeding the channel, white and blue catfish gave a net production of 1,344, 890, and 430 pounds per acre, respectively (Table 4). The channel catfish outgrew the rest averaging 1.3 pounds. The white and blue catfish averaged 1.0 and 0.6 pounds.

Figure 4. Monthly minimum-maximum range of temperatures recorded 3.5 feet below the surface of Rockefeller Research Ponds, 1967 - 1968.

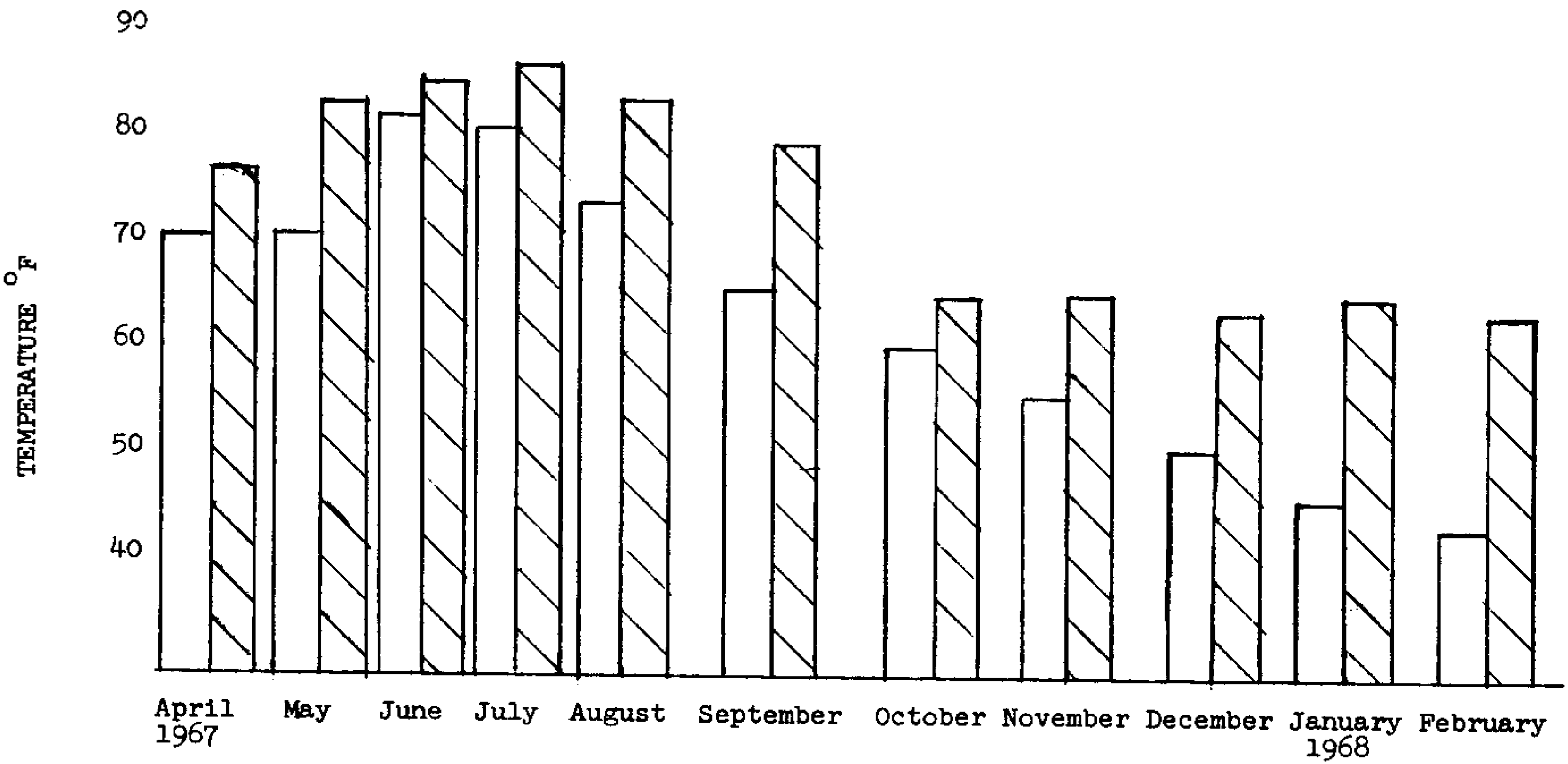


Figure 4 continued.

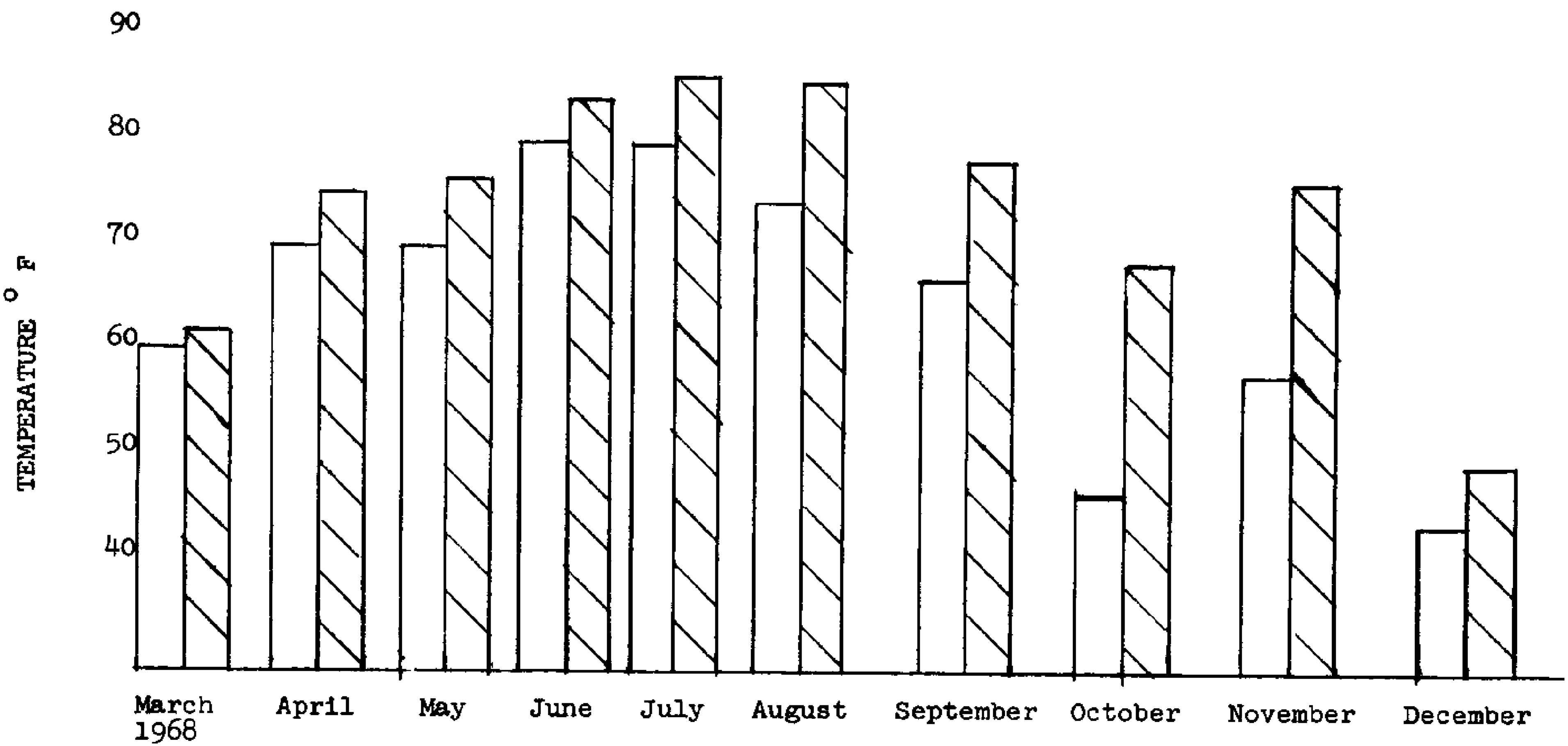


Table 3. Chemical analysis and variation of pond waters from Rockefeller Wildlife Refuge.

Nitrogen	8 - 20 ppm
Phosphorus	0.4 - 11.5 ppm
Potassium	30.0 - 94.0 ppm
Calcium	33.0 - 107.0 ppm
Magnesium	125.0 - 245.0 ppm
Total Hardness	760 - 1480 ppm
Salinity	1.8 - 11.2 ppt
pH	7.2 - 9.0

The S-conversion factors averaged from a low of 3.2 calculated for the channels to 5.8 and 10.1 for the white and blue catfish. The channel catfish also had the highest per cent survival with the blues having the lowest.

The 1968 results followed the same general pattern. However, the average sizes were smaller due to the fact that the 1967 fish were held in the ponds over a longer period of time. The channel catfish averaged 0.8 pound, the white catfish averaged 0.7 pound and the blue catfish averaged 0.6 pound. The channel, white and blue catfish gave a 1968 average net production of 1,808, 1,511 and 1,121 pounds per acre, respectively. Per cent survival was highest for the channel catfish, 91.2 per cent, and lowest for the blue catfish, 46.4 per cent. S-conversion factors averaged from 2.3 for channel catfish to 2.9 and 4.0 for the white and blue catfish.

It should be pointed out that the difference in sizes of fingerlings at the time of stocking did not effect the results appreciably in these studies. In 1967, the average weight of the blue, white and channel catfish stocked was .028, .040 and .036 pound each (Table 4). In 1968, the average weights of the blue, white and channel catfish was .043, .036 and .029 pound. In 1967, the blue fingerlings were smaller than the other fish and the next year they were a little larger. Both years they gave the least amount of production.

Figure 5 illustrates the comparative growth of the species and the monthly average salinities. We found in our sampling for the adjustment of feeding rates that some months had negative or little growth. There was no way of measuring the same fish each sample period and it is highly possible that runts and hogs were included in the samples.

Laboratory Studies

Our results have recently been supported by controlled laboratory experiments conducted at Louisiana State University (Allen and Avault, 1969). In this study channel catfish eggs and yolk fry were tested for survival. Fingerlings and yearlings were tested for food consumption, growth, food conversion and survival. It was found that eggs three days old and older tolerated up to 16.0 ppt total salinity. Upon hatching the tolerance dropped to 8.0 ppt. Allen and Avault reported that after yolk absorption there was a slight increase in tolerance to 9.0-10.0 ppt. Five to six month old fingerlings had another increase in tolerance of 11.0-12.0 ppt. They reported no further increase in tolerance beyond six months. It was also found that the acclimation of fish to salinity resulted in only a slight (0.5 ppt) increase in salinity tolerance.

In a study of food consumption, growth and food conversion of fingerlings, Allen and Avault found the results to be almost equal in salinities up to 5.0 ppt. In the test conducted in the 5.0 to 10.0 ppt

Table 4. Growth data for blue, channel and white catfish grown in 0.1 acre brackish water ponds, Rockefeller Wildlife Refuge.

	White Catfish		Channel Catfish		Blue Catfish	
	1967	1968	1967	1968	1967	1968
Number Stocked per Pond	200	250	200	250	200	250
Average Weight Stocked (lbs.)	8.0	9.0	7.1	7.3	5.6	10.8
Average Size Stocked (lbs.)	.040	.036	.036	.029	.028	.043
Average Weight Recovered (lbs.)	80.9	151.1	134.4	180.8	43.0	112.1
Average Size Recovered (lbs.)	1.0	0.7	1.3	0.8	0.6	0.6
Survival Percent	39.3	86.0	53.6	91.2	34.0	69.6
S Conversion	5.8	2.9	3.2	2.3	10.1	4.0

Figure 5. Growth curve of blue, channel and white catfish grown in Rockefeller Research Ponds, 1967 - 1968.

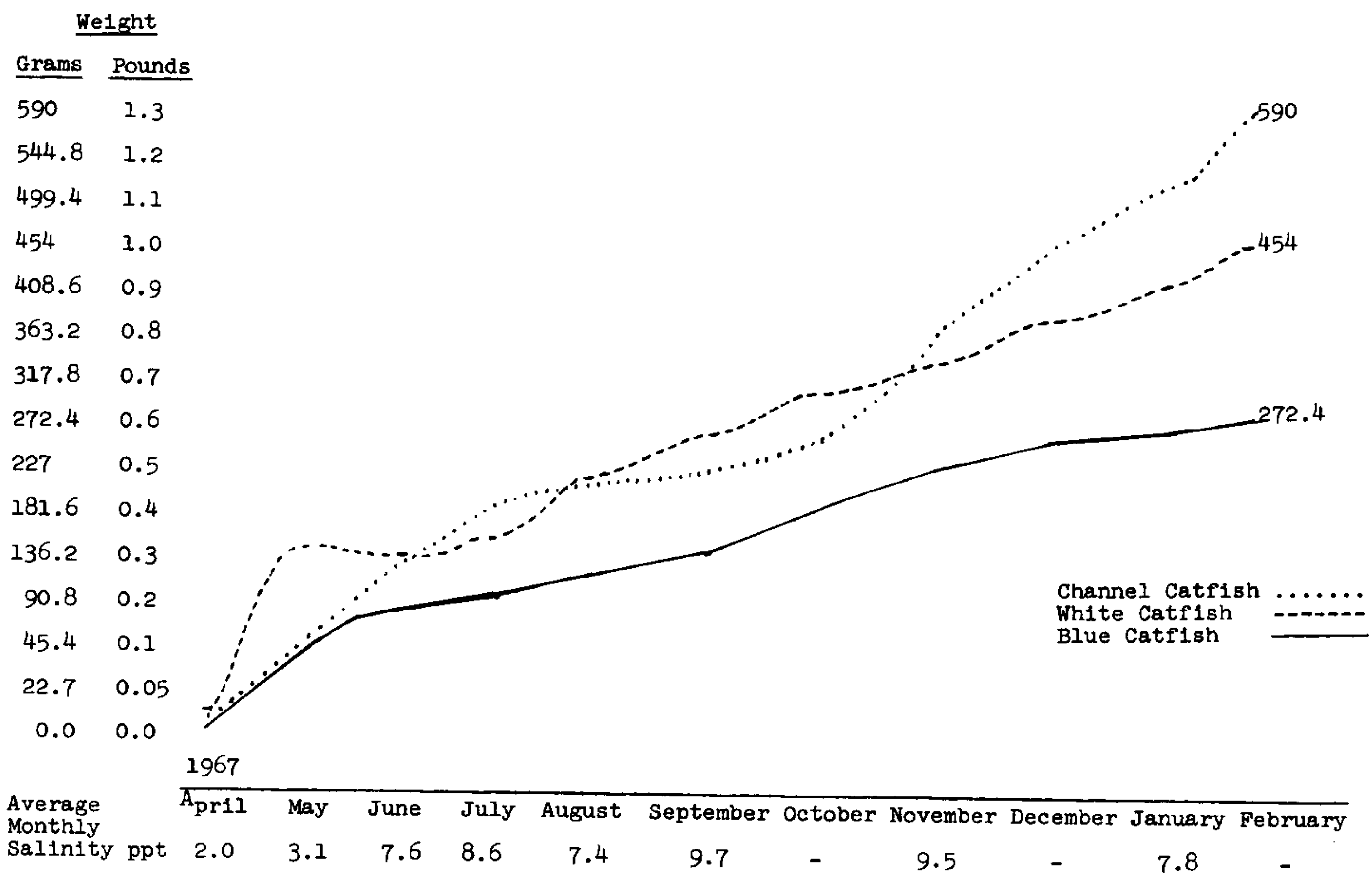
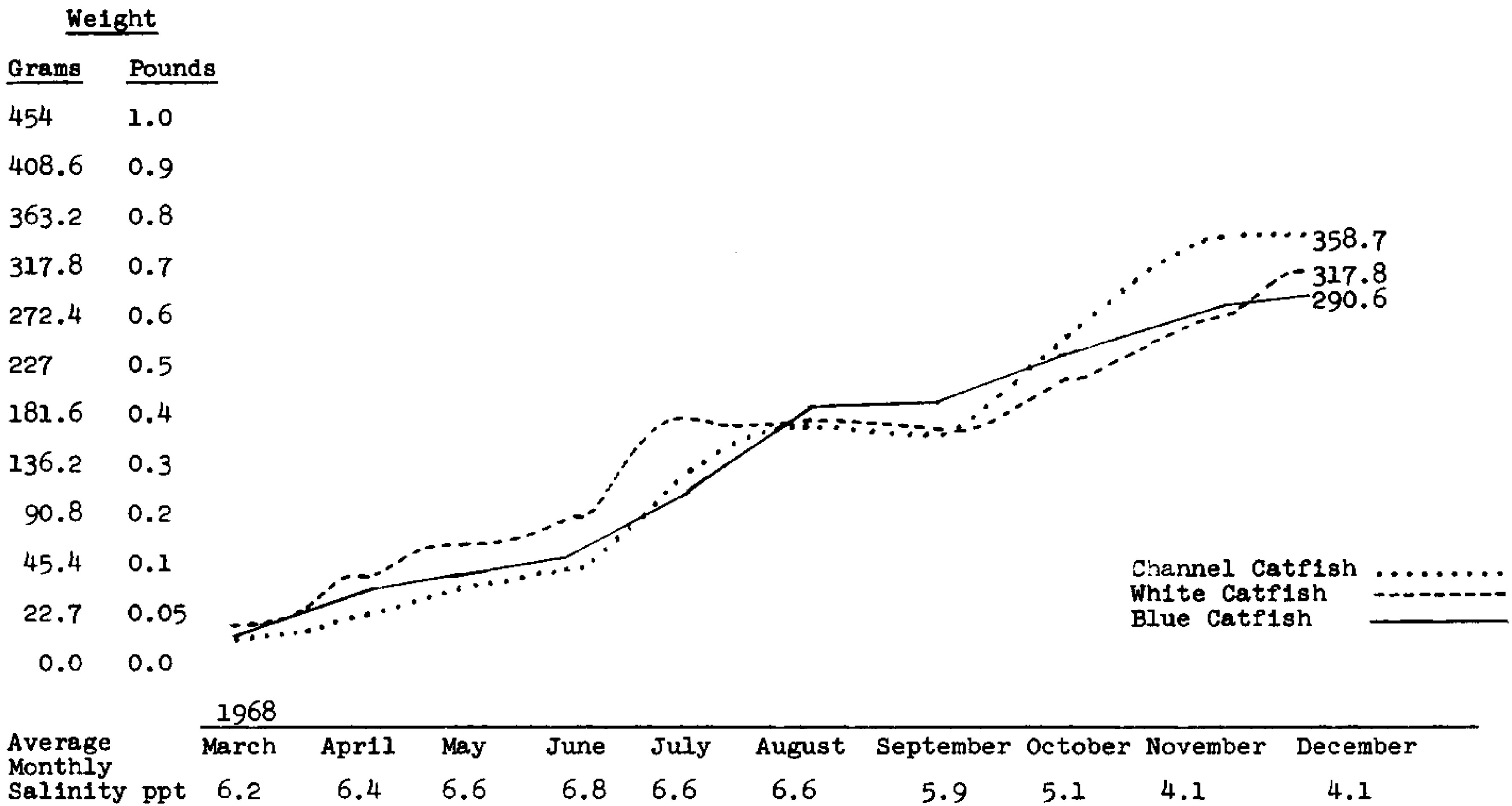


Figure 5 continued.



range the fish did poorly. However, it was mentioned that this could have been due to a gill infestation before it was controlled. Salinities of 0 ppt through 11.0 ppt did not seem to have any detrimental effect on 11-14 month old yearling fish when tested for food consumption, growth and food conversion.

Data is still too inconclusive to give results of salinity upon actual reproduction. Experiments are now underway to observe hormoned brood fish in different salinity concentrations. We may find that the fish will not attempt to spawn or that the sperm will not survive in saline waters. However, fish population data collected in connection with other studies and actual observed spawns in our research ponds indicate that channel catfish can spawn in salinities up to 2.0 ppt. Also, one northeast Louisiana catfish farmer whose operation we have recently been observing had reproduction last year in a pond which contained 1.6 ppt salinity.

The effect of sea-water concentration on the reproduction and survival of catfish may follow the same pattern as that described for largemouth bass and bluegill (Tebo and McCoy, 1964). They pointed out that approximately 10 to 12 per cent sea water (3.6-4.3 ppt) was the maximum concentration at which bass and bluegill could successfully reproduce. Fingerlings were found to survive concentrations of 29 to 38 per cent sea water (10.3-13.4 ppt).

Therapeutic Value

Numerous early observers of our studies suggested that catfish grown in saline ponds may be free of the more common freshwater parasites and diseases, possibly because of a therapeutic effect of salt on the fish. Thus far, we have not had any problems with diseases. However, Dr. R. M. Overstreet, parasitologist with the Gulf Coast Laboratory in Ocean Springs, Mississippi has reported some forms present on our fish that could cause problems if more common. He reported that the only parasite found in our white catfish was a small unidentified helminth cyst in the mesenteries. A light infection of *Trichodina sp.* and *Cleidodiscus sp.* was found on the gills of a blue catfish. Also, he found one copepod, *Ergasilus sp.*, on the gills of a blue catfish and two immature cucullanid nematodes in the intestine. A cestode, *Corallobothrium sp.*, was taken from the anterior intestine of both a blue and channel catfish. A few *Trichodina sp.* were also found on the skin and gills of a channel catfish. None of these were frequent enough to cause alarm.

The only parasite present that has caused us concern was the myxosporidian, *Henneguya sp.* In March of this year, 1970, it was found in a holding pond on approximately 8 per cent of the blue catfish. This myxosporidian is not new to us as it has been seen on native channel catfish taken from the brackish waters of the refuge.

Taste Test

The pond-reared catfish are generally considered one of the most delicious of freshwater fish. Catfish obtained commercially often tend to have a strong or fishy taste reflecting the environment from which they were taken. With this in mind we prepared some of the fish at the termination of the study in order to find if any of the fish possessed an odor characteristic of the marsh. The results of the test were excellent and none of the fish had a marshy taste or odor.

Marsh Pond Construction

Catfish culture in the marsh has its problems like anything else. Two of the major problems that we encountered included pond construction and levee erosion. Levees had to be built using either pontoon draglines or conventional draglines on mats, because of the semi-fluid nature of the soil (Figure 6). Our particular area necessitated that we build the levees with soil obtained from outside the ponds. Disturbing the pond floor resulted in a bog in which it was impossible to work. During harvest this was particularly a problem (Figure 7). A maximum levee height of three to four feet during the initial spoil placement was adhered to in order to prevent excessive weight from damaging the foundation of the levee. Also, a berm of at least 12 feet was left on the canal side of the levee to prevent the levee from sluffing. The new levees were permitted to dry for approximately one to two years before they were reshaped and dressed. A finished grade of four to five feet above marsh level with a three to one slope on the pond side and at least a 10-foot crown was found adequate. New levees experience as much as 60 per cent shrinkage due to the semi-fluid nature of the soil. This is a factor which must be considered before any permanent water lines are laid. Maximum shrinkage was during the first two years.

The erosion of levee soil was our second concern. The planting of common Bermuda seed and the sprigging of coastal Bermuda grass seemed to give best results in holding the soils together.

Gravity drainage was practically impossible in ponds equal to or below sea level. Thus, in the harvest of the old ponds it was necessary to go to the expense of pumping. All of our newer ponds are above marsh level.

Predation

Predation was another problem to us on the wildlife refuge. Otters, mink, frogs, snakes, aquatic insects and fish-eating birds made serious inroads on the fish. The alligator predation problem was not as serious as we thought it might be. This animal is a very inefficient feeder. Of the animals listed, otters were the most detrimental to our fish.

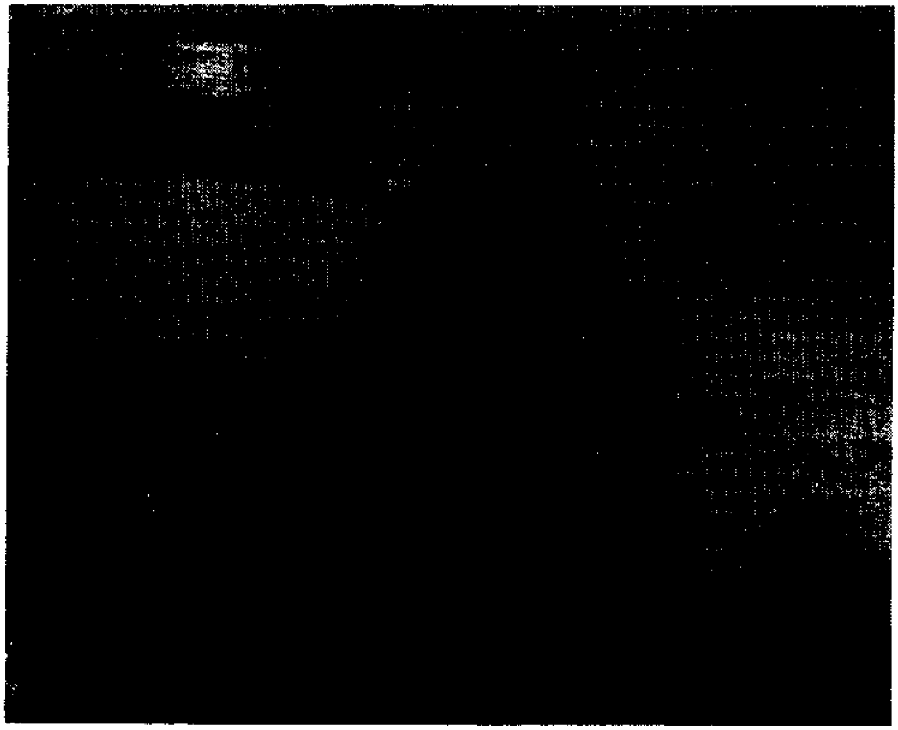


Figure 6. In our particular area it was necessary to build the levees with soil obtained from outside the ponds. Disturbing the pond floor resulted in a bog in which it was impossible to work. During harvest this was particularly a problem.

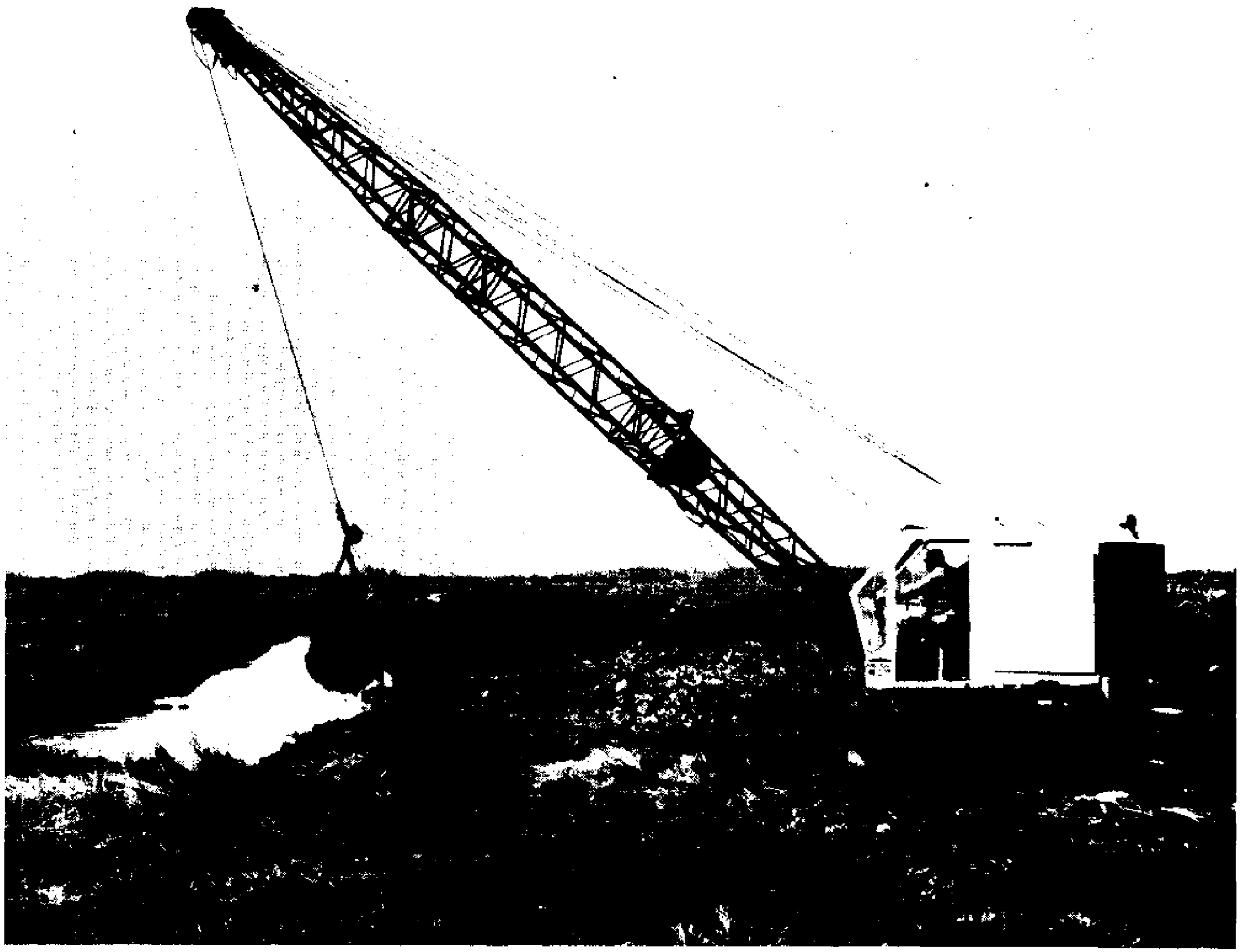


Figure 7. One of the major problems encountered was pond construction. Ponds had to be dug, using either pontoon draglines or conventional draglines on mats (shown above) because of the fluid nature of the marsh soil.

Predation by otter was most serious when the fish were sluggish during the colder months. Otters would catch the fish at night and eat everything posterior to the dorsal spine. At first we found from one to five heads on the levees per day. This would develop with time until as many as 20 fish heads could be found on a single levee. Naturally, this hurt our harvest results considerably since we initially stocked 200 - 250 fish per pond.

SUMMARY

In summary, our studies indicate that channel, blue and white catfish may be successfully grown in coastal waters. The channel catfish proved to be the best suited for commercial production in coastal areas for one to two year old fish for the following reasons: (1) the channel catfish proved to be the most rapid growing and the most hardy; maximum production of almost one ton per acre was in a pond containing channel catfish, (2) the channel catfish had the lowest food conversion value of the three, (3) survival was highest for the channel catfish, (4) it is already accepted as a commercial pond specie and is also tolerant of many of the conditions experienced in coastal waters. (Figure 8)

The blue catfish will probably surpass the others in its second or third year. And, if larger fish are desired this specie should be considered. The white catfish, possessing features of both channel and bullhead catfish, might be harder to sell to the public. Some of our older white catfish (2.5 - 3 year old) seem to be developing an unusually large head in proportion to their body. This is a feature desired by only a few of us who enjoy catfish couvillion.

Data is still incomplete as to the effect of salinity on catfish reproduction. The only salinity that we know catfish will reproduce in is below 2.0 ppt. However, this is probably a little low. It will be necessary for a coastal fish farmer to keep his water salinity below 8.0 ppt if he has young catfish fingerlings or fry. If his salinities range from 8 - 11 ppt he will have to start with older fingerlings or yearling catfish.

A prospective coastal catfish farmer will have to know what his yearly salinity variations will be. He must also keep in mind that his pond salinities may increase with summer evaporation and he will have to dilute this with less saline water.

THE CAGED CULTURE OF CHANNEL CATFISH

H. R. SCHMITTOU
Fisheries Specialist
Texas Agricultural Extension Service
Texas A&M University

Interest in the commercial production of channel catfish over the entire Southern half of the United States has upsurged at an unbelievable pace during the past several months. The interest in Texas has probably been greater than in most states. Perhaps the reasons for this lie in the tremendous potential for commercial catfish culture in Texas. To visualize that potential, compare conditions in other states with Texas' long growing season, large land holdings, population size, acceptance of catfish as a food fish and the generally good water supply over much of the state. At present, only about ten percent of the total production of farm-raised catfish are raised in Texas, but the state has potential to produce in excess of 25 percent of the national total. Regardless of what production level Texas will claim in the future, it is obvious that the waters along the coast within 50 miles of the Gulf will contribute a high proportion of the total state production. Of course, the potential for catfish farming along a 50-mile radius of the coast is enhanced by the excellent climate, soil and water supply.

The caged culture system for raising catfish will play an increasing part in the growth of the catfish industry in Texas. Raising catfish in cages (see figure) is a relatively new system for feeding out fingerling catfish to food-fish size. In practice, fingerlings are stocked in early spring in suspended cages; a nutritionally complete feed is given daily until the fish have grown to the desired harvest size. This system of raising catfish applies to both the commercial level and individual operations where fish are raised simply to produce food for the family.

Factors regulating limitations of cage farming of fish are essentially the same as those governing the intensive or crowded cultures of chickens, cattle or other livestock. In culturing fish in cages, a feed that supplies all nutritional requirements is necessary. Since the fish are confined and crowded in cages, the potential for parasites and diseases is high. Also, crowding of fish creates a serious problem of waste elimination. Waste products of carbon dioxide, ammonia, urea and feces build up rapidly. They must be eliminated before reaching concentrations that threaten the well-being of the fish. Proper water quality within the cage can be maintained only by frequent replacement of dilution of water in the cage with water of the surrounding environment. In cages suspended in ponds, water exchange is dependent on wind-induced currents or currents created by the fish themselves. No information is available yet on raising catfish in cages suspended in large reservoirs or in flowing water. Theoretically, production per unit of cage could be increased considerably in running water over that in ponds, because the continuous water exchange would remove wastes from the cages before their accumulation reached an inhibiting level. Essentially, the same reasoning applies to large reservoirs where water currents from gravity flow and/or wind action are more probable than in ponds.

During periods of low oxygen, when fish are forced to the surface waters for respiratory needs, fish in cages are likely to die while fish loose in the pond are able to survive. The difference is in surface area available to the fish in the two environments. Since the fish are confined to a small area, optimum water quality must be maintained during periods of low oxygen by agitating or the addition of high-quality water to the immediate area of the cages. Also, as a last resort to save the fish, the cages could be moved quickly and easily to another pond.

Advantages

The advantages of the cage culture system over other systems of catfish farming are numerous. Some of the more important include:

1. Easy, complete harvesting. Simply lift the cage from the water. A stronger, more durable cage than the one illustrated in figure 3 would be necessary for cage-lift harvesting.

2. Harvest manipulated to fish market. For example, different-sized fish may mature simultaneously in different cages in the same environment, thus allowing the farmer to harvest at predetermined intervals.

3. Reduced harvest equipment. Seines are not required; holding tanks are not needed as cages serve as holding facilities.

4. Weighing fish for sale or for adjusting feed rates without removing from cage. The cage may be lifted with boom (scales attached) mounted on a tractor.

5. Harvesting without draining, thus conserving water.

6. Combination of cultures. Channel catfish may be raised in cages where bass and other fishes are raised loose in the open water.

7. Adaptability to all types of water environments; ponds, lakes, mining pits, reservoirs, streams, irrigation canals, estuaries, tidal streams, bays and other waters.

8. Intensive cultures. Otherwise, only a lesser level of culture would be feasible.

9. Closer observation of feeding activity. This helps to determine the general health of the fish.

10. Easier, cheaper and more effective parasite treatments. Simply enclose the affected cages in a plastic bag, and apply treatment material inside the enclosure.

11. Use of graders to harvest faster growing fish, thus allowing more equal distribution of feed among remaining individuals.

Cage Materials

The best cage materials have not been determined. Frames of wood, plastic pipe, angle iron, aluminum and other materials have been used. Frames are not necessary, but where used the metal materials appear much superior to the other types. Enclosures of hardware cloth, nylon and welded wire have been tried. Of the materials tested, galvanized welded wire fabric coated with an asphalt base paint appears to be the better enclosure material. Only a 2" x 2" wooden frame around the top is required if welded wire of 16 gauge is used.

Mesh size should be 1/2" x 1/2" or 1/2 " x 1". This size mesh will contain fingerlings 4 1/2 inches and larger. Small meshes tend to restrict proper water exchange, and have been shown to be less productive than 1/2 inch mesh.

Cage Size

No research information is available comparing cage design with production. Constructing the cage similar in dimensions to the one illustrated may be preferable. It has a total volume of 36 cubic feet. Only four or five such cages are required for stocking 2,000 or 2,500 fish per surface-acre pond. A farmer may choose the cage design that suits his preference. In cages stocked at equal densities per unit volume, waste removal and dilution should be more rapid in small cages than in large ones, for the surface area of a small body is greater per unit volume than that of a large body. Also, handling problems increase as cage size increases. Consequently, cages can be made so large that the advantages of cages are diminished or lost.

Cage Covers

Cage covers were considered necessary to prevent predation. Covers with locks may be necessary to prevent theft. Opaque covers are recommended, for fish feed better and may respond to management better when overhead light is reduced. Aluminum siding attached to a 2" x 2" frame has been used satisfactorily.

Feeding Ring

A "feeding ring" is an enclosure built into the cage cover or otherwise held in position on the water surface in center of the cage to hold floating feed. Feeding rings should have surface areas of about 300 square inches for 36 cubic foot cages. A typical feeding ring would be a rectangular box, 15" x 20" x 20" deep, with top and bottom open. About 12 inches of the ring should be below water level to prevent feed from being carried out from beneath the ring by fish-induced currents. The remaining 8 inches of ring above water prevents splashing of feed out over the top. Aluminum siding shaped and constructed into the cover is satisfactory.

Cage Placement

Research has shown that the placement of cages in a pond, relative to other cages and to vulnerability to water currents, affects production in those cages. Position is apparently a reflection of water exchange and water quality. Best production was obtained in ponds in cages with the most surface area exposed to open water. In ponds, cages should be placed in open water away from obstructions that would prevent water currents from any direction from passing through the cages. Also, individual cages should be a minimum of 3 feet apart so that waste products from one will not contaminate and inhibit growth in another. Adequate spacing of individual cages should not be a problem since only four or five cages, 36 cubic feet in volume, are required for raising 2,000 to 2,400 pounds of catfish per surface-acre of pond.

Cages should be suspended on the water surface with the cage bottom separated from the pond bottom by at least 1 foot. This may be an important factor in helping to prevent parasite-disease problems.

Cages should be suspended with about 4 inches of cage above water. A boardwalk leading from shore to the cages is convenient for attachment of cages and for servicing the cages as well. The boardwalk will support one side of the cage and styrofoam or other bouyant material is necessary to support the other side. Cables or strong wires strung across the water can be used to position and help support cages. Floats are necessary to fully support the cages and may be attached directly onto the cages as illustrated, or attached beneath the cables. A boat would be necessary to service the cages positioned in this manner.

A cubic foot of styrofoam will displace 60 pounds of water; therefore, fully used, a 1 cubic-foot block would be the minimum amount of styrofoam material required to float a 60-pound cage. Twice that amount is recommended (i.e., use 1 cubic foot of styrofoam for each 30 pounds of cage). Fish inside the cage are supported by the water, and not by the cage.

Stocking Density

The number of fish to stock per unit volume of cage will depend primarily on the environment in which the cages are to be placed and on the size of fish expected at harvest. To raise fish to about 1-pound average size in 36 cubic-feet cages in ponds, it is recommended that five hundred fingerlings be stocked per cage. A higher density probably would be appropriate for cages suspended in large reservoirs, in flowing water or in ponds where agitators or similar equipment are used. The so-called "space factor" in cage culture is more a reflection of waste disposal than that of confinement. Fish densities in cages may be increased within reason without diminishing production, as long as waste products are eliminated and good water quality is maintained within the cages. The number of fish to stock in cages per unit area of pond depends upon the carrying capacity or pounds of fish that can be produced safely in that pond. The maximum expected production of channel catfish in cages suspended in ponds is about 2,000 to 2,400 pounds per acre. As much as 400 pounds of fish may be raised loose in the pond outside the cages. The latter are not fed, but grow satisfactorily by feeding on insects and other natural food organisms produced in the pond. However, the combined production inside and outside of cages should not exceed 2,400 pounds per acre.

Based on aforementioned production potential per acre of pond, a farmer may raise fish to a 1-pound average by stocking each of four cages of 36 cubic feet volume with 500 catfish fingerlings. He could stock the surrounding water with an additional 400. To harvest fish 0.8-pound average, 500 fish would be stocked in each of five cages and an additional 500 loose in the surrounding water. It is not necessary to stock fish loose in the pond, but approximately 400 pounds production per acre is possible there from natural foods and without additional feeding or fertilizing. However, treating for parasitized fish loose in the pond would require treating the entire pond. Also, to completely recover loose fish would require draining the pond. If the pond already contains a fish population, the total weight of that population should be considered as part of the carrying capacity.

Catfish have been grown in cages to 1-pound average in 146 days, but about 180 days is the expected amount of time required.

Feed and Feeding

Nutritionally complete feeds are rare and expensive; a label on a feed bag calling it "catfish feed" does not mean the feed is nutritionally complete or acceptable for use in cages. Floating pelleted feeds are most desirable. They are easily contained on the water surface within feeding rings and, thus, are available to the fish with no feed loss.

Fish should be fed at least once daily. Better feed efficiency would be obtained if each day's ration were divided into portions fed two or more times per day, but this is not necessary. In ponds, the total weight of feed fed in all cages should not exceed 30 pounds per acre per day. At each feeding, the fish should consume the feed within less than five minutes. Failure to do so is indicative of overfeeding, poor water quality (low dissolved oxygen) or parasite-disease infestation.

No fertilizers should be added to ponds where fish are being raised in cages.

The following feeding schedule may be used as a base.

Culture days	Average weight* range (lb.)	Daily feeding rate (% of total weight)
1 - 30	0.05 - 0.10	3.50
31 - 50	0.10 - 0.15	3.00
51 - 70	0.15 - 0.20	2.50
71 - 90	0.20 - 0.30	2.25
91 - 110	0.30 - 0.40	2.00
111 - 130	0.40 - 0.55	1.75
131 - 150	0.55 - 0.70	1.50
151 - 180	0.70 - 1.00	1.25

*Fish smaller than 0.05 pound minimum average should be fed at four percent until they have reached an average 0.05 pound each.

Handling Fish

Handle fish as <u>gently</u> <u>and</u> <u>infrequently</u> as possible. Success or failure of cultures often depend on how the fish were handled at stocking. Fish stress easily, and this makes them susceptible to parasite-disease infestation. Evidence of these infestations may not appear for one or more weeks depending on temperature and other factors. Fish should be stocked in cages before the water temperature has warmed above 55°F;

they should not be handled unless absolutely necessary from stocking until harvest; they should be fed daily with the proper quantity and quality of feed.

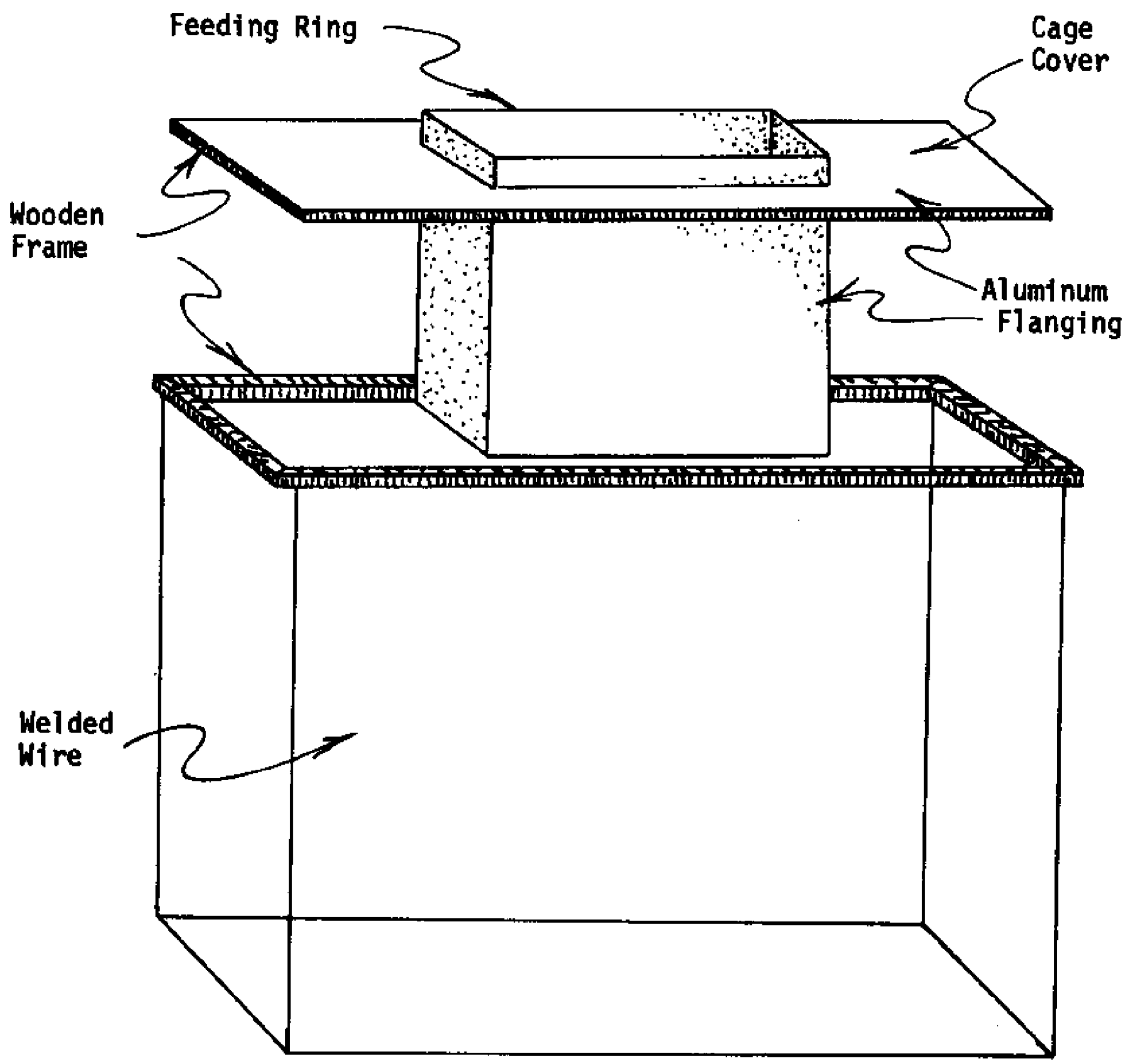
Parasites-Diseases

Increasing fish density increases the probability of parasite-disease problems. Most bacterial diseases, including Aeromonas and cottonmouth (columnaris), may be treated by adding 1 gram of water-soluble terryamycin per pound of feed. Dissolve terramycin in water (1/2 pint of water per 10 grams of terramycin) and spray it evenly over the feed. Allow the feed to dry before using. The medicated feed should be fed daily for 10 days.

External parasites are easily controlled by enclosing the cage in a plastic bag and applying formalin for a short-term treatment. At temperatures below 60°F, 200 ppm formalin for one hour is recommended. Above 60°F, use only 160 ppm formalin for one hour. Aerators or agitators may be necessary during treatment to maintain water quality inside the plastic bag enclosure. As a base for parts per million (ppm):

0.028 cc = 1 ppm in 1 cu. ft.
1.0 cc = 1 ppm in 36 cu. ft.
30.0 cc = 1 liquid oz.

A formalin treatment should be given the fish prior to stocking in cages as a routine procedure.



A TYPICAL CAGE

Dimensions	:	3 ft. wide x 4 ft. long x 3 ft. deep = 36 cu. ft.
Enclosure	:	16 gauge, 1/2 in. x 1 in. welded wire
Frame	:	2 in. x 2 in. wood
Cover	:	Aluminum flanging with feeding ring built in
Feeding ring	:	15 in. wide x 20 in. long x 20 in. deep aluminum flanging