AQUACULTURE IN SOUTH CAROLINA

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AQUACULTURE IN SOUTH CAROLINA

by

The Ad Hoc Aquaculture Committee

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EXECUTIVE SUMMARY

Most traditional fisheries in the United States are currently being harvested at or near their maximum sustainable yields. Yet, the demand for seafood continues to rise. To supply this expanding market for seafood products, seafood imports have become increasingly important. In fact, imported seafood currently accounts for over 60 percent of the seafood consumed in America and is the third largest component of the trade deficit. Given these factors, aquaculture can have a significant economic impact in America in the future. As aquaculture activity expands, seafood imports should be reduced, jobs created, and the national trade deficit decreased.

In South Carolina, an organization has formed to address statewide issues affecting aquaculture. This group, the Ad Hoc Aquaculture Committee, requested the compilation of a document to provide a concise overview of the state's aquaculture potential. This report resulted from that request.

Aquaculture, the controlled cultivation of aquatic plants and animals, is not a new concept to South Carolinians. It originated in the state during the late 1700's with rice cultivation. Oysters, terrapin, shad, and other finfish have been cultured here in the past. Species presently under cultivation include catfish, crawfish, trout, striped bass, marine shrimp, clams, freshwater prawns, oysters, and several others. The recent resurgence of the aquaculture industry has provided the state with a new opportunity for economic development. As an industry, aquaculture is compatible with the conservative management of the state's natural resources.

With its abundant natural resources and quality institutional support, South Carolina is now becoming a national leader in aquaculture research and development. The reasons for this are as diverse as the number of species produced. First and foremost, South Carolina is a good location for aquaculture. The state's climate is generally mild and can provide optimal temperatures for warm-water species for at least a portion of each year. In regions of the state where seasonal temperatures result in a shortened growing season, cultivation of a warm-water species may not prove profitable by itself; here a second cool-water species produced during the fall and winter months may be feasible.

Rainfall, which averages over 40 inches annually, combined with South Carolina's plentiful supply of clean ground and surface waters, should provide an ample freshwater supply for aquaculturists. Additionally, over 200,000 acres of bay and estuarine waters along with 74,000 acres of wetland impoundments are potentially available for culture. Unfortunately, about 30 percent of the state's bay and estuarine waters are closed to shellfish harvest due to bacterial pollution.

South Carolina also has the proper soils for aquaculture. Studies indicate that around 70 percent of the state's soils rate as fair or good for pond construction.

Numerous institutional resources are available in South Carolina to aid the aquaculturist. These include: the South Carolina Sea Grant Consortium, the Marine Extension Program, Clemson University, the University of South Carolina, the Small Business Development Center, the South Carolina Wildlife and Marine Resources Department and the Soil Conservation Service. In addition, the Marine Resources Research Institute of the Wildlife and Marine Resources Department has begun construction of the James M. Waddell, Jr. Mariculture Research and Development Center. This facility will allow the state to bridge the gap between laboratory and commercial aquaculture.

Although the state's natural and institutional resources are conducive to aquaculture development, the regulatory environment in South Carolina is often confusing to individuals first encountering its complexities. Many of the laws currently regulating the industry were written prior to the latest surge in aquaculture development. As a result, they often fail to recognize that aquaculture is basically a "clean" industry and instead, place inappropriate constraints on its development. In addition, permitting for many aquaculture activities lacks a streamlined mechanism and thus requires considerable investments of time and effort to accomplish. This may serve as an entry barrier to individuals considering aquaculture investments. A list of the state and federal agencies which may be involved in the permitting process include: 1) the S. C. Coastal Council, 2) the S. C. Budget and Control Board, 3) the S. C. Water Resources Commission, 4) the S. C. Wildlife and Marine Resources Department, 5) the S. C. Department of Health and Environmental Control, 6) the U. S. Army Corps of Engineers, and 7) the U. S. Coast Guard. If aquaculture is to prosper in the future, permitting must be streamlined and unnecessary regulatory constraints removed. Additionally, the benefits and

protection provided by law to other commercial activities such as agriculture and commercial fishing should be made available to aquaculture.

In addition to changes that would ease regulatory limitations and improve permitting procedures, aquaculture would benefit if additional capital could be made available. Until recently, capital requirements have been met primarily by private investors. Because of the limited track record of many aquaculturists, other sources of financing have been difficult to obtain. Without government guarantees, most lenders set extremely strict requirements for aquaculture, a venture with which they are unfamiliar. Lenders that may presently provide loans to aquaculturists include: 1) the Cooperative Farm Credit System, 2) the Small Business Administration, 3) commercial banks, 4) the Farmers Home Administration, and in the future, 5) South Carolina's Family Farm Development Authority and Jobs-Economic Development Authority.

After production, aquaculturists must market their harvest. In South Carolina, marketing aquaculture is presently quite simple. Most producers rely on sales to local wholesalers and retailers or on pondside retail sales. These markets are adequate for the current level of production but will be saturated as production increases. Aquaculturists will need to search for new channels where their method of timed harvest allows them a comparative advantage. An organization of industry members would likely be helpful in reaching markets unavailable to individual members.

Aquaculture in South Carolina is composed of a small group of diverse industries. These enterprises, by using the inherent richness of South Carolina's natural resources, provide an economically productive and environmentally sound activity for coastal and inland areas alike. Constraints to the industry currently include 1) regulatory problems, 2) permitting difficulties, 3) capital unavailability, and 4) numerous unanswered technological questions. Yet, with continued backing from the public sector and support from private business, aquaculture will grow as a sound investment in South Carolina's future.

FOREWARD

During the compilation of this document, I had the opportunity to meet and work with a number of individuals who are involved either directly or indirectly in the developing aquaculture industry. First and foremost, I would like to thank the Ad Hoc Aquaculture Committee. They provided direction and assistance in the preparation of this report. Without their help in planning, writing, and editing, this document could not have been completed. The Committee includes:

Dr. Jesse Chappell - University of South Carolina
Ms. Margaret Davidson - South Carolina Sea Grant Consortium
Mr. Rick DeVoe - South Carolina Sea Grant Consortium
Dr. Jeffrey Foltz - Clemson University
Mr. Jack Kendree - Georgetown County Development Commission
Mr. Bill Melven - U.S. Soil Conservation Service
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Dr. Paul Sandifer - South Carolina Wildlife and Marine Resources Department
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Mr. Jack Smith - South Carolina Coastal Council
Dr. Keith Taniguchi - University of South Carolina
Mr. Mac Watson - South Carolina Wildlife and Marine Resources Department
Mr. Jack Whetstone - Sea Grant Marine Extension Program, Clemson University

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Ms. Ann Nolte

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South Carolina Sea Grant Consortium
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Trident Seafarms
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University of South Carolina
- Dr. John Dean

PREFACE

With the passage of the National Aquaculture Act of 1980, Congress for the first time declared a policy to promote aquaculture development in the United States. This Act required the formulation of an aquaculture plan by the Departments of Agriculture, Commerce, and Interior and provided for the coordination of all federal activities relating to aquaculture. During the previous ten years, similar bills had been introduced in Congress, but each had met with substantial opposition from special interest groups and from Congressmen concerned with the designation of a lead agency. In 1978, a bill sponsored by Congressman Robert Leggett passed both Houses of Congress and went to the President as the National Aquaculture Act of 1978. Because of the financial demands of the Act, President Carter pocket vetoed the legislation and slowed its momentum until 1980.

The National Aquaculture Act of 1980, which has never been funded, (although funding was authorized in the enabling legislation), was to be reauthorized in 1983. Legislation providing for its reauthorization is currently before Congress, but its future is uncertain.

In South Carolina, interest in aquaculture has increased dramatically during the past decade. The state's numerous resources make aquaculture an attractive opportunity, but unfortunately, most of the state's laws and regulations were written prior to the industry's recent development and thus do not consider its needs. This constraint, when combined with the large monetary outlays necessary for commercial scale aquaculture, has created substantial barriers for entrepreneurs attempting to enter the industry.

This document was compiled at the request and with the assistance of the Ad Hoc Aquaculture Committee, a group formed to address the problems of aquaculture statewide. It provides a comprehensive, concise overview of the aquaculture potential within the State. Included in the report is a summary of the opportunities and constraints which face this developing industry.

AQUACULTURE IN SOUTH CAROLINA

I. Introduction

Aquaculture, in the simplest sense, is merely agriculture that is taking place in an aquatic environment. More precisely, it may be defined as the controlled cultivation and harvest of aquatic plants and animals. Today, in South Carolina, aquaculture is being practiced in 33 of 46 counties. Species under cultivation in these counties include largemouth bass, bluegill, carp, catfish, crawfish, clams, crabs, prawns, shrimp, tilapia, trout, as well as several others.

Why the current nationwide interest in aquaculture? First and foremost, it seems to be an industry where future growth and profits are likely. Although the value of South Atlantic fishery products has increased over the last decade, the absolute catch has remained essentially stable. This has resulted in foreign markets becoming increasingly important in supplying our seafood and fish product needs (imports, which supply over 60 percent of the U. S. seafood consumed, reached a value of 4.2 billion dollars in 1981). As demand continues to grow for these products while the natural supply remains relatively constant, commercial aquaculture should find ample opportunities to fill this expanding market. Increased domestic aquaculture production should minimize our reliance on imports, provide jobs in new industries, and reduce the national deficit in trade. Each of the above factors has influenced attitudes toward aquaculture nationwide, and consequently have fostered its development.

At the state level, some South Carolina interests regard aquaculture as a type of commercial activity which is productive and environmentally sound; they therefore encourage its development. Others in the state view this industry as a means by which farmers can diversify their investments and achieve a more stable level of earnings. In addition, aquaculture, as a concept, is not new to South Carolinians. Commercial rice cultivation was practiced along the Carolina coast during the latter half of the 18th and into the 19th century. Other species such as oyster, terrapin, and shad have each been cultured at some point in the past. These elements, along with the previously mentioned factors, play important roles in the national and statewide interest in aquaculture. Yet despite this interest, numerous constraints and barriers face aquaculturists attempting to begin commercial operations. These obstacles, which exist on both the federal and state

level, must be minimized if aquaculture is to reach its full potential as an industry.

Although its recorded history can be traced to around 460 B.C., modern aquaculture's development has lagged dramatically behind the technological advancements of other industries. Today, aquaculture supplies only three percent of the total U.S. consumption of fishery products. Yet, the success of aquaculturists with certain species demonstrates the potential this industry has when supplied with the appropriate technological tools. Private aquaculture currently produces approximately 50 percent of the catfish and crawfish consumed in the U.S. and nearly all of the rainbow trout sold for consumption. Other areas of U.S. aquaculture include: (1) production of baitfish, marine baitworms, and tropical aquarium fishes; (2) stocking for enhancement of natural populations of sport fishes such as striped bass, largemouth bass, and trout by federal and state hatcheries; (3) experimental studies with species such as pompano, salmon, lobster, eel, abalone, bay scallop, clam, and others.

Catfish farming, the largest aquaculture industry in the United States, occurs in 14 South Carolina counties. In recent years, production and consumption of catfish has increased at a yearly rate of nearly 20 percent in the United States. In 1982, South Carolina aquaculturists produced about 50,000 pounds of catfish.

Crawfish, which have been farmed successfully in Louisiana and Texas for years, are being grown in 17 South Carolina counties. The Louisiana farm harvest usually exceeds 25 million pounds per year while Texas produces around 3.5 million pounds annually. These harvests are valued at approximately $21 million and $5 million respectively. In South Carolina, production is negligible with the 1982 harvest estimated at 80,000 pounds. However, interest in the commercial production of this species is growing. In Georgetown County alone, 310 acres have been added to production in the last 12 months, and the 1984 harvest will likely exceed 300,000 pounds.

Three private companies are culturing marine shrimp in the state. With Americans consuming over 500 million pounds of shrimp annually, this market could provide a considerable return for individuals investing in the culture of this high value species, assuming technological problems can be overcome.

A firm in the Charleston area has invested substantially in hardshell clam culture. With New York, which until the mid-1970's supplied about one half of the hardshell clams consumed in the U.S., experiencing a decline in its resource (due to overfishing and pollution), this market appears promising for South Carolina producers. Other states have responded to the surge of interest in aquaculture in a variety of ways. Rhode Island, Hawaii, Texas, and Maine have all completed aquaculture development plans. Their respective reports provide guidelines for directing the growth of aquaculture within each state.

California recently enacted legislation that is a landmark in the history of aquaculture in the United States. This Act, passed at the request of the California Aquaculture Association with strong support from the California Department of Fish and Game, declared as an official policy of the State of California the encouragement of commercial aquaculture development. It further defines aquaculture as a form of agriculture. This provides benefits to aquaculture wherever state laws provide for the advancement and protection of agriculture. Aquaculture laws were also incorporated into a new and separate section of state statutes, exempted from commercial fishing regulations.

II. Summary of Resources

1. Human and Institutional Resources

Numerous institutional resources are available in South Carolina to aid the aquaculturist. The South Carolina Sea Grant Consortium has played a major role in supporting aquaculture research and education efforts in such areas as biology, genetics, economics, legal and policy analysis, and technology development. This has been accomplished by making efficient use of the expertise possessed by the faculty and staff of its seven member institutions: The Citadel, Clemson University, the College of Charleston, the Medical University of South Carolina, South Carolina State College, the University of South Carolina, and the South Carolina Wildlife and Marine Resources Department. The major benefit of the Consortium approach has been its ability to encourage the assembly of research teams from different institutions and disciplines to address aquaculture problems.

The Consortium provides technical assistance through its Marine Extension Program (MEP) which is administered by the Clemson Cooperative Extension Service.

MEP's primary mission is to provide timely information and technological assistance to the coastal public of South Carolina. The MEP aquaculture effort is directed at the initial stages of aquaculture development. This includes developing and instituting simple, practical, and known methods for pond start-ups; helping organize agencies and private organizations into a single common voice; and providing a strong feedback system for on-going research techniques in the field. The Cooperative Extension Service, through the Department of Entomology, Fisheries, and Wildlife of Clemson University, is itself a valuable source of aquaculture information. With offices in every county, the program's effort is directed at providing technical assistance to help solve aquaculturists' problems both with farm ponds and commercial ventures. The Agricultural Experiment Station maintains 12 experimental warm-water fish ponds and has completed research in catfish, prawn, and crawfish production and economics.

The University of South Carolina (USC) through the Department of Biology, the Marine Science Program, and the Belle W. Baruch Institute conducts aquaculture research and can provide technical information to interested parties. While the entire range of academic expertise and support services available at USC can be brought to bear on a given aquaculture project, a unique integration of aquaculture business and science expertise is embodied in the South Carolina Aquaculture and Mariculture Project International (SCAMPI) Team. The SCAMPI program integrates scientific, technical, and business expertise to provide a consulting team with a holistic view of aquaculture ranging from the growing of commercially important species to their marketing and export.

Another information source for aquaculturists is the Small Business Development Center. This group, which has offices at Clemson University, U.S.C., S. C. State College, Winthrop College, and College of Charleston, can provide business management assistance to entrepreneurs.

South Carolina Wildlife and Marine Resources Department (SCWMRD) provides assistance to interested aquaculturists in a variety of areas. The Marine Resources Research Institute's (MRRI) programs are directed at providing scientific information essential for making management decisions which maximize the benefits received from South Carolina's marine resources. Research to develop mariculture technology is being conducted on a variety of organisms, including fish, mollusks, and crustaceans. Commercial potential is the focus of these research

programs, and, therefore, several cooperative mariculture studies are being conducted with private individuals or groups.

In 1982, the MRRI began constructing a center for aquaculture research and development. This facility, the James M. Waddell, Jr., Mariculture Research and Development Center, will allow the state to bridge the gap between laboratory work and full-scale commercial aquaculture. Both Clemson University and the University of South Carolina will participate cooperatively in research in the facility. Additionally, the Center will conduct mariculture training classes for local farmers, educators, biologists, and advisory personnel.

Within the Office of Conservation, Management, and Marketing of SCWMRD, the Seafood Marketing Services Section is attempting to (1) develop and improve markets and marketing channels for South Carolina seafood products; (2) promote the use of South Carolina seafood products, emphasizing underutilized species; and (3) assist in the development and improvement of fisheries based on underutilized and traditional resources. This Section is engaged in market development and product promotion at the local, national, and international levels. There is a constant need for information concerning specific markets which may be of use to South Carolina wholesalers, or in-state dealers who might be sources of supply for out-of-state buyers.

SCWMRD also operates the Dennis Wildlife Center in Bonneau, South Carolina. This facility produces both striped and hybrid bass for stocking in the state and throughout the nation for recreational fishermen. Also available for stocking from the Department are bass and bluegill fingerlings.

Another agency assisting aquaculturists is the United States Soil Conservation Service (SCS). SCS aids conservation districts, communities, watershed groups, federal and state agencies, and other cooperators with erosion control and water management problems. This agency's mission is to conserve soil and water resources and reduce damage caused by floods and sedimentation. With field offices in all South Carolina counties, the SCS works directly with interested landowners and operators whose farm resources indicate a satisfactory opportunity to undertake some aspect of aquaculture.

State and county development groups have been supportive of efforts to initiate aquaculture ventures in South Carolina. For example, the Georgetown County Development Commission, which sponsors the annual Wampee Aquaculture-Mariculture Seminar, is currently involved in a joint venture crawfish marketing program with the S. C. Department of Agriculture, the South Carolina Wildlife and Marine Resources Department, and the Division of Research, College of Business Administration, USC. This effort is aimed at identifying markets in North Carolina, South Carolina, and Georgia as well as providing an analysis of the international marketing potential of crawfish.

2. Natural Resources

A. Climate (adapted from Foltz and Smith, 1983)

Climate plays a critical role in the productivity and therefore profitability of most aquaculture operations. Of particular importance are temperature range and water availability. These factors must be thoroughly examined when considering a potential site. In addition, evaporation, a function of both humidity and temperature, must be considered in planning water budgets for a facility.

South Carolina's climate is generally mild and provides plentiful rainfall. Most areas of the state receive more than 40 inches of rain annually with sections of the Blue Ridge Mountains receiving twice this amount (Figure 1). With such plentiful rainfall, aquaculturists in all regions of South Carolina can supply at least a portion of their freshwater requirements with surface runoff. For most, however, a more predictable water source (ground or surface water) should be available to supplement runoff.

Primary factors influencing temperature in South Carolina are elevation, latitude, and distance inland from the coast. These variables cause average annual temperatures in the state to range from 52.2°F at Caesars Head in the Blue Ridge to 66.2°F along the southern coast (Figure 2). Because of the generally mild temperature regime found in the state, aquaculture will be largely restricted to warm-water species. These species are defined as having temperature optima at or above 77°F. Areas with mean annual air temperatures above 65°F are potentially well suited for warm-water aquaculture although certain species (e.g., Tilapia) may require overwintering facilities to prevent cold death. Areas with mean annual air temperatures between 61°F and 65°F can successfully produce warm-water fishes, but because of a shortened

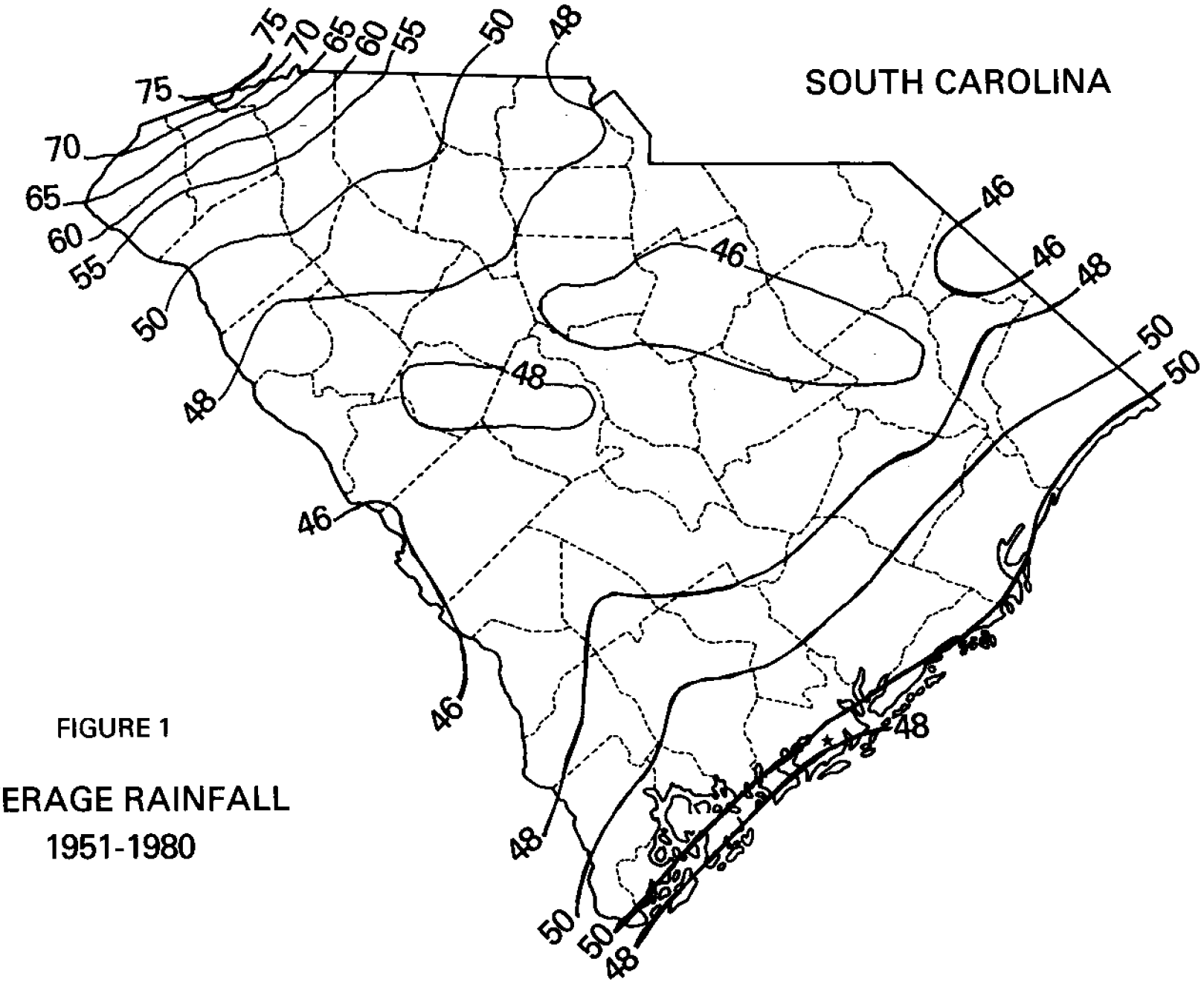

FIGURE 1

AVERAGE RAINFALL
1951-1980

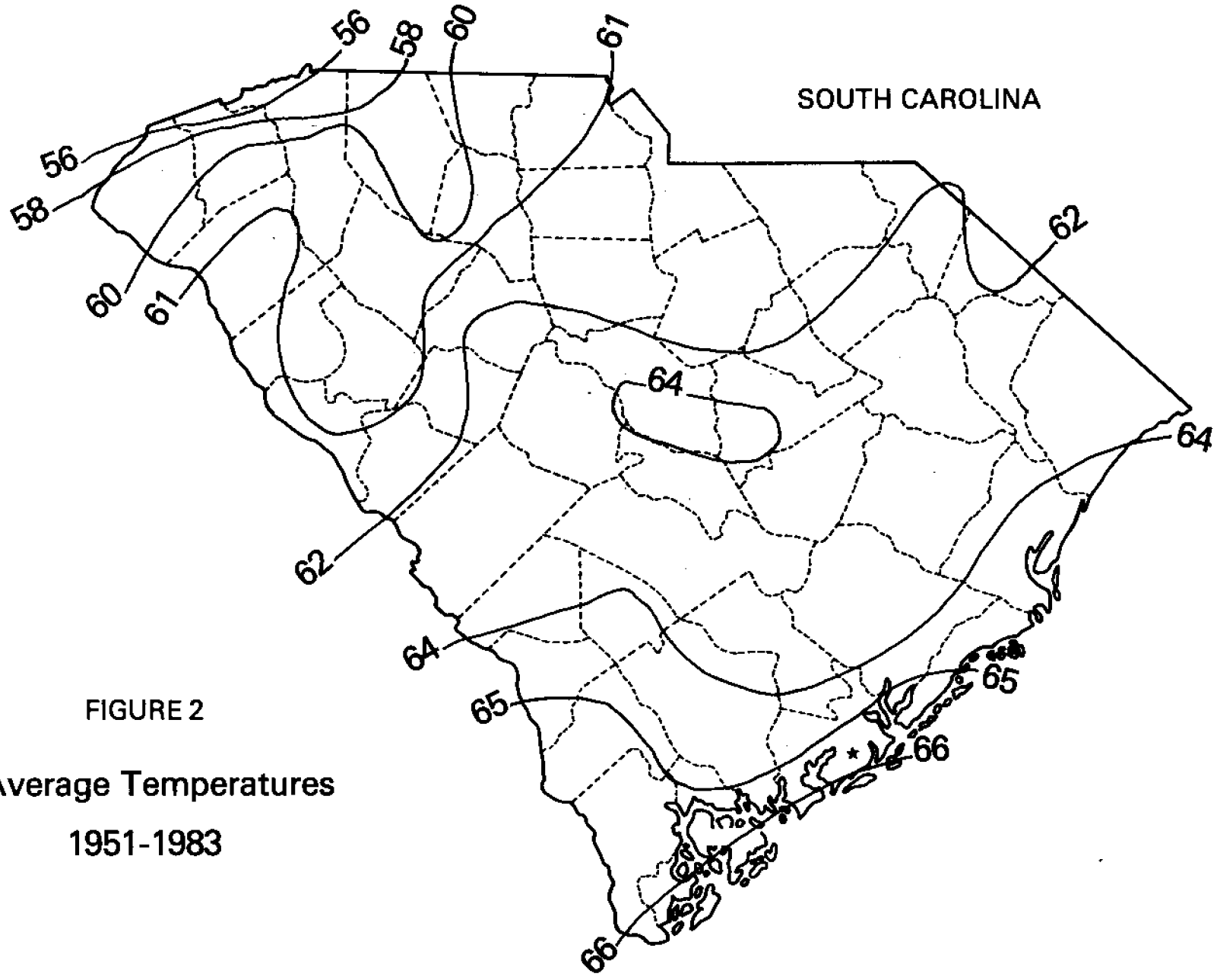

FIGURE 2

Average Temperatures

1951-1983

growing season, production per acre will be reduced. However, this constraint can be overcome by producing cold and cool-water species during the late fall to early spring months when warm-water fish either cease to feed, feed at very low levels, or have been removed. The Blue Ridge, foothills, and upper Piedmont have some areas suitable for cool-water aquaculture if adequate flow rates and temperatures can be maintained during the warmest summer months. However, if water temperatures exceed 72°F, the site is not suitable for cool-water species such as rainbow and brown trout.

B. Land Resources(adapted from Foltz and Smith, 1983)

Proper soils for aquaculture are important when pond construction is required; seepage can be a serious problem in pond management. When existing ponds of demonstrated ability are to be used, soils are of little concern. However, South Carolina has a wide variety of soils, and quite different soils often exist in close proximity. Suitable soils for ponds may be adjacent to very permeable, sandy soils that are unsuitable. This is particularly true in the coastal plains and on some flood plains within the state. Thus, in pond construction or expansion, quality of soils is of importance in site selection. Prospective aquaculturists should have soils evaluated prior to purchase and construction to ensure the soils on a specific property are suitable. Soils with 25 percent or more clay are usually satisfactory for some type of pond construction.

While ponds have been built in areas with permeable soils, costs involved in pond lining or other methods of sealing are often prohibitive. Difficulty in packing, seepage, or piping may cause problems in soils used for embankments, dikes, or levees.

The geographic distribution of soils with respect to suitability for aquaculture is shown in Figure 3. Ratings reflect the suitability of soils for construction of embankments, dikes, levees, and excavated aquifer-fed ponds. Approximately 70 percent of soils in South Carolina have good or fair potential for pond construction. The majority of soils rated good are located in the coastal plains. Approximately 77 percent of the soils of the Piedmont are fair for large scale aquaculture; unsuitable soils in the Piedmont are mostly too steep.

C. Water Resources

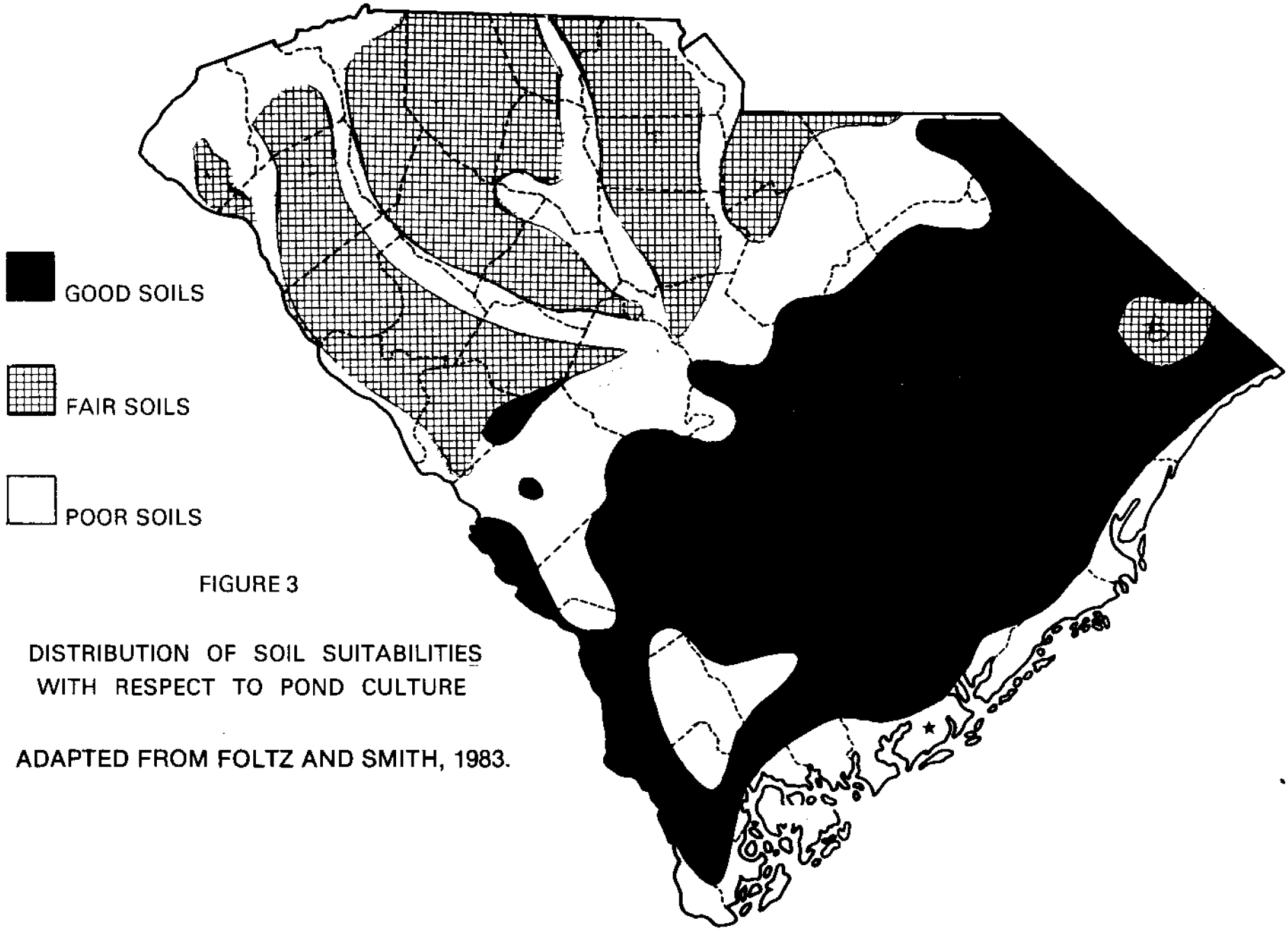

FIGURE 3

DISTRIBUTION OF SOIL SUITABILITIES WITH RESPECT TO POND CULTURE

ADAPTED FROM FOLTZ AND SMITH, 1983.

(1) Surface Waters

South Carolina is divided into four major river basins: the PeeDee, Santee, Ashley-Cooper-Edisto, and Savannah. These waterways, along with lakes, ponds, and coastal waters, provide South Carolinians with recreational areas, transportation routes, hydroelectric power, public water supplies, industrial water supplies, and water for irrigation. River streamflow, which averages 33 billion gallons per day, varies geographically, seasonally, and yearly. Throughout the state, streamflow is generally highest during late winter and early spring and lowest during late summer and fall (WRC, 1983).

In addition to its flowing waters, South Carolina has about 596,000 acres of large inland lakes (SCS, personal communication), 74,000 acres of wetland impoundments, and thousands of small, privately-owned farm ponds. Nearly all of these habitats are potential sites for aquaculture if managed properly.

The bay and estuarine waters in the State also appear to have considerable aquaculture potential. Over 216,000 acres of these highly productive environments are found along the South Carolina coast. These waters, which are extremely important in the life cycle of numerous commercially valuable fish and shellfish, could in many cases be used by aquaculturists without reducing the natural productivity of the system.

Not only is the quantity of water available to aquaculturists important, but water quality must also meet high standards. The chemical, physical, and biological integrity of surface waters particularly, must be scrutinized before such waters are used in aquaculture operations. Agriculture practices (e.g., pesticide application) on adjacent or upstream areas must be taken into consideration during site selection. According to the S. C. Department of Health and Environmental Control, the agency primarily responsible for protecting and maintaining the quality of South Carolina's water resources, 84 percent of the state's major river miles meet the 1982 federal goal of "fishable/swimmable" waters (Class A waters) (WRC, 1983). In addition, approximately 72,000 acres, or one third, of the state's estuarine waters are currently closed to shellfish harvesting because of bacterial pollution.

(2) Ground Water

Knowledge of South Carolina's six major aquifer systems varies according to the geographic location of the aquifer within the State. For many areas, the groundwater potential is unknown, yet the quality of groundwater is predominantly excellent. In some local areas, groundwater has become contaminated as a result of man's activities. Pollution has resulted from mismanagement and undesirable siting of septic tanks, landfills, animal feed lots; from the misapplication of fertilizers and pesticides; and from mining operations and overdevelopment of the resource (DHEC, 1983). Currently, South Carolina has several capacity use areas where permitting by the Water Resources Commission is required prior to substantial withdrawals of water. In such areas, prospective aquaculturists should be particularly aware of the quantity and quality of groundwater available before relying on this source.

In general, South Carolina has suitable natural resources for aquaculture development. The state's ample rainfall, coupled with its surface and groundwaters, provide a water source that will meet most aquaculturist's needs. Many regions of the state have soils which are impervious enough to resist excessive seepage, and, as a result, would be satisfactory for pond construction. And, while only the southern coastal plain has temperatures well-suited to warm-water aquaculture year round (they have an annual mean temperature above 65°F), other parts of the state can provide a suitable thermal regime for warm-water species for at least a portion of each year.

III. Regulatory Environment (adapted from DeVoe and Whetstone, 1984)

1. Introduction

The development of aquaculture in South Carolina has been hindered in part by the confusion over the number of permits required and the time-consuming permitting process. The major reason for this confusion stems from the lack of a streamlined mechanism for permitting aquaculture activities at the local, state, and federal levels. Depending on the type of aquacultural activity proposed, a series of permits, certifications, and licenses may be required from a variety of regulatory agencies.

Aquaculture involves the use of the water column and/or the bottom of a water body. It also requires an onshore base of operation. Thus, many aquaculture ventures involve the use of resources normally considered part of the

public domain, as opposed to the privately-owned lands used in agriculture. Both small and commercial scale aquaculture operations face the unusual problem of requiring semi-exclusive and, in some cases, exclusive access to high quality waters of the state. In addition, the needs and pursuits of others who wish to take advantage of these waters for their livelihood or recreational enjoyment must be met. Thus, local, state, and federal regulatory bodies seek to balance these needs through permitting procedures involving both agency and public comment.

The complexity of the permitting process varies with respect to the type of water to be used -- fresh, brackish, or salt -- and with respect to geographic location -- highland or open water culture. Highland, freshwater culture of catfish, minnows, freshwater prawns, and trout in farm ponds and tanks does not involve the public domain and requires few permits. Cage or pen culture of certain species such as catfish and trout in public waters (lakes and streams) involves several permitting and liability questions and has not been practiced to any extent in South Carolina to date. The use of the inherent productivity found in fresh, brackish, and saltwater impoundments -- presently managed and with no ownership-related problems -- offers some degree of hope as culture systems for crawfish, blue crabs, penaeid shrimp, and fish. The permitting process for proposed aquaculture use of these impoundment systems is relatively problem-free. However, leasing and ownership questions in open marshland, partially-diked impoundments, and open coastal waters make permitting of aquaculture in these areas considerably more challenging.

This document, by design, provides merely a synopsis of aquaculture permitting requirements in the state. For a more thorough analysis, DeVoe and Whetstone (1984) should be consulted.

2. Local Permit Requirements

Local zoning ordinances may not allow certain aquaculture activities in particular locations. Localities (i.e. cities, towns, municipalities, and counties) have the authority to control land use down to the mean high water mark (in most cases). These units of government usually establish land use requirements and zoning ordinances within their geographical boundaries. Zoning ordinances commonly classify land uses into Residential, Commercial, Industrial, Agricultural, and Conservation/Preservation districts. Of course, each locality has its own zoning ordinance and land use standards -- plans should be discussed with the local

planning and zoning office prior to any commitment of resources to an aquaculture project.

3. State Permit Requirements

A. Introduction

Before a detailed outline of the state permit process can be presented, the jurisdictional boundaries of the state's permitting agencies must be understood. The accompanying map illustrates these boundaries (Figure 4). Area C represents the "critical area" as designated under the South Carolina Coastal Management Act (Act 123) of 1977. The S. C. Coastal Council has jurisdiction within the "critical area" and a Council permit is required for any activity or alteration proposed on tidal wetlands, beaches, and sand dunes, or in coastal waters. Activities proposed in the waters and wetlands found within Area B must be permitted by the S. C. State Budget and Control Board through the S. C. Water Resources Commission, and be certified as consistent with the state's coastal zone management plan as determined by the Coastal Council. Similar activities planned throughout the remainder of the state (Area A) fall only under the jurisdiction of the Budget and Control Board.

B. South Carolina Wildlife and Marine Resources Department

In determining the location of a potential aquaculture operation, not only may an onshore base of operation be needed, but also semi-exclusive or exclusive use of the adjacent water bottom may be required; therefore, the approval of the S. C. Wildlife and Marine Resources Department is required to lease (or sub-lease) that area of state water bottoms. In addition, the Department requires that various permits and/or licenses be obtained for the particular species to be cultured. Under current law, the Division of Marine Resources has general jurisdiction over all fish, fishing, and fisheries in the coastal saltwaters of the state. The Division also reviews and makes recommendations on all permit applications for coastal alterations issued through the U. S. Army Corps of Engineers, S. C. Coastal Council, and the U. S. Coast Guard.

The Division of Wildlife and Freshwater Fisheries, while not having established regulations for freshwater aquaculture in the state, still requires permits to: (1) collect organisms for harvesting and/or propagation of freshwater species for the purpose of science and/or

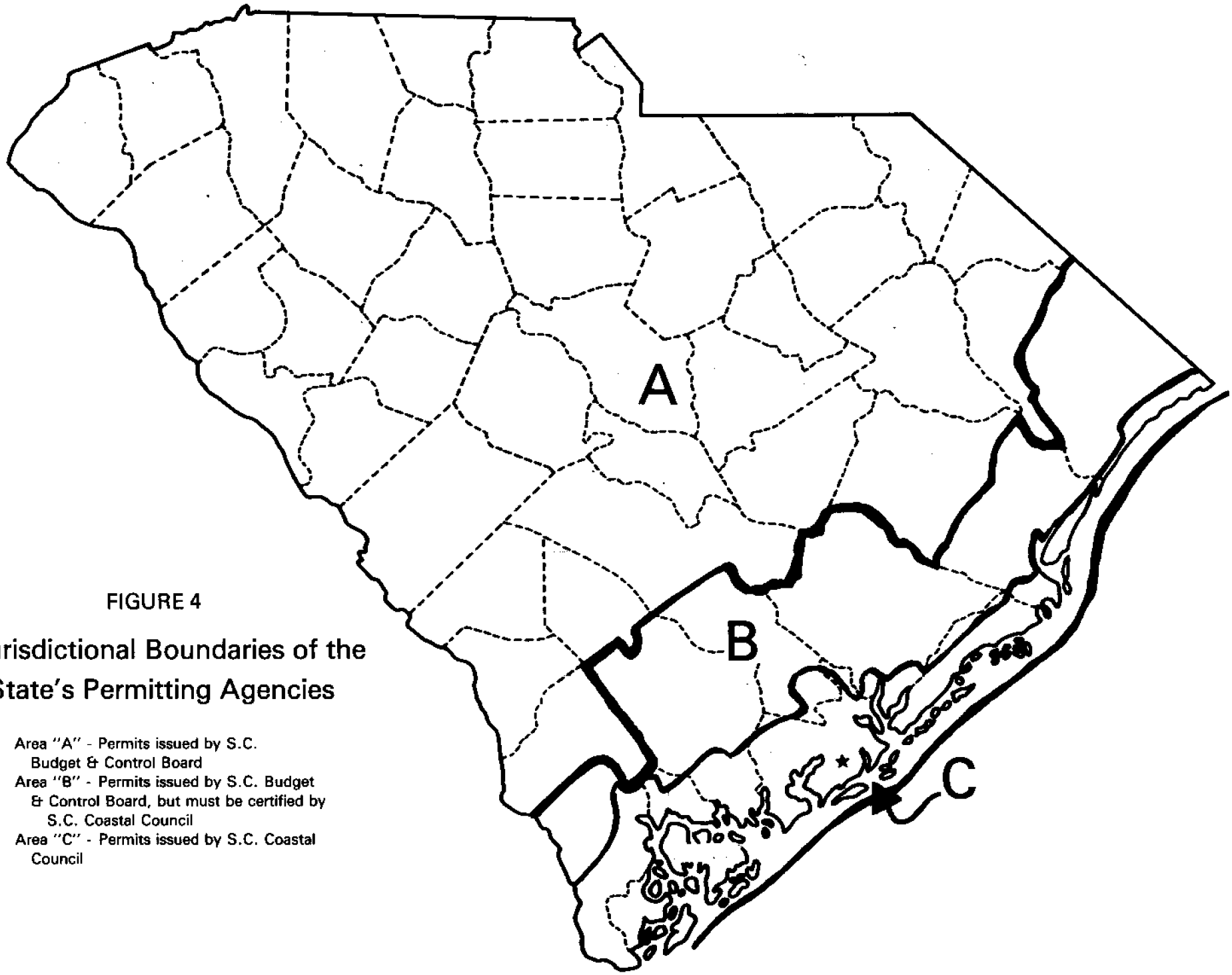

FIGURE 4

Jurisdictional Boundaries of the State's Permitting Agencies

Area "A" - Permits issued by S.C. Budget & Control Board
Area "B" - Permits issued by S.C. Budget & Control Board, but must be certified by S.C. Coastal Council
Area "C" - Permits issued by S.C. Coastal Council

research; and (2) import non-native species and/or transplant native species from one site to another.

All non-controversial permit applications are decided upon by the Division and the final decision can usually be made within two to three weeks. Applications which are controversial may require a decision by the S. C. Wildlife and Marine Resources Commission - a process which may take two to three months.

C. South Carolina Coastal Council

The S. C. Coastal Council has the responsibility of promoting the economic and social welfare of the citizens of the state while protecting the sensitive and fragile areas of the coast. Any aquaculturist who wants to erect any structure, fill, remove, dredge, drain, or in any other way alter any tidal wetlands, beaches, dunes, or coastal waters in the "critical area" (see Figure 4, Area C) must obtain a permit from the Council. If the intended site of an aquaculture operation is in the "critical area," applicants are encouraged to first submit an aquaculture plan to the Council office in Charleston for preliminary review. This will allow the Council to assist the applicant in expediting the permit process. The Council will also determine if a U. S. Army Corps of Engineers permit is required. If so, the applicant will be directed to the Corps office to file a joint Coastal Council - Corps permit application. If a Corps permit is not required, the applicant need only file a Coastal Council application.

D. South Carolina Water Resources Commission

The S. C. Water Resources Commission administers the permit process of the S. C. State Budget and Control Board. When an aquaculture operation outside of the Coastal Council's "critical area" involves or will involve (a) the use of any land below the mean high water line in tidal areas or (b) any land below the ordinary high water mark of non-tidal, navigable waterways, aquaculturists must obtain a permit from the Board for any construction, alteration, dredging, filling, or other activity associated with such an operation. The permit application procedure is similar to that of the Coastal Council. One must first contact the U.S. Army Corps of Engineers office in Charleston to determine whether a federal permit will be required. If so, the permit application of the Corps serves as a joint application with the Commission.

In addition, if the operation is to be sited within the eight coastal counties of the state, the project must be certified by the Coastal Council as consistent with the state's coastal zone management plan prior to the issuance of a Board permit. Further, a water quality certification may be required from the Department of Health and Environmental Control to assure that the state's water quality standards will not be violated by or through the proposed aquaculture operation.

The Water Resources Commission is also responsible for overseeing the use of the state's groundwater resources. If an aquaculture operation involves the use of groundwater, is located in a "capacity use area" of the state, and requires the withdrawal of more than 100,000 gallons of water per week on any given day, a permit is required. In areas of the state outside of "capacity use" regulations, aquaculturists using more than 100,000 gallons of surface, saline and/or ground water on any given day are required to submit a use report to the Commission on a quarterly basis.

E. South Carolina Department of Health and Environmental Control

The S. C. Department of Health and Environmental Control is responsible for ensuring the health and well-being of the citizens of the state and sustaining the quality of the state's air and water resources. Thus, aquaculturists will require permits from this Department before beginning operations. All aquatic animal production projects require a permit from the Department's Division of Industrial and Agricultural Wastewater. A detailed plan describing the scope of the project must be submitted to the Division for review prior to issuance of the permit.

Some concentrated aquatic animal production facilities may be designated as point-sources of pollution by the Division and subject as a result to the National Pollutant Discharge Elimination System (NPDES) permit program. A hatchery, fish farm, or other facility is subject to an NPDES permit if it contains, grows, or holds aquatic animals in either of the following categories:

1) Cold-water fish species and other cold-water animals in ponds, raceways, or other similar structures which discharge at least 30 days per year, and produce at least 20,000 pounds of aquatic animals per year, or feed more than 5,000 pounds of food during the calendar month of maximum feeding; or

2) Warm-water fish species and other warm-water animals in ponds, raceways, or other similar structures which discharge at least 30 days per year, and produce more than 100,000 pounds of aquatic animals per year. A NPDES permit is not required for closed ponds which discharge only during periods of excess runoff.

The Division of Water Quality Assessment and Enforcement is responsible for administering the Section 401 Water Quality Certification Program for the state. This certification, which is required for any activity which may result in discharge into the waters of the United States, ensures that the discharge does not violate water quality standards.

Additionally, the Department, through its Division of Shellfish and Recreational Waters, is responsible for monitoring and regulating proper safety and sanitary conditions for the growing, harvesting, shipping, and selling of shellfish, shellfish products, and other seafood products. There are several permits and/or certifications that must be obtained prior to any processing or sale of aquaculture products.

4. Federal Permit Requirements

A. U. S. Army Corps of Engineers

The U. S. Army Corps of Engineers is responsible for permitting any activity that involves the location of a structure in the navigable waters throughout the United States. In addition, any excavation or discharge of dredge or fill materials associated with a particular activity in the navigable waters requires a Corps permit. If an application involves both kinds of activity, one comprehensive permit is issued.

If the proposed aquaculture operation involves either of these activities, a Corps permit must be applied for. A Corps permit application must be completed and can constitute a Joint Application with either the S. C. Coastal Council or the S. C. Water Resources Commission (as described earlier), depending upon the location of the proposed operation.

B. U. S. Coast Guard

The U. S. Coast Guard is responsible for enforcement and regulation of various activities in the

navigable waters of the United States. If aquaculturists plan to locate structures in the navigable waters as part of their operation, marking of the structures may be required.

5. Regulatory Summary

Aquaculture in South Carolina suffers from a lack of formal recognition by state regulators. The permitting process is often confusing and time-consuming. Without a streamlined mechanism for permitting, aquaculturists must invest considerable time and effort in acquiring the necessary operating permits. While other commercial operations such as agriculture and commercial fishing, receive specific benefits and protection under state law, these are not available to the aquaculturist. If the industry is to prosper in the future, its unique requirements must be addressed by local, state, and federal officials.

IV. Financial Environment

1. Current Status

Aquaculture in South Carolina is a small but developing industry. Its capital requirements have been met in the past primarily by private investors and entrepreneurs. As a result, most operations are rather limited in scale. However, as the industry develops, more conventional sources of financing will become important.

2. Credit Needs

Credit is used in aquaculture for a variety of purposes. Operating credit tends to be used at times of heavy expense -- to pay for inputs until harvest time. Short-term loans are appropriate for financing this need. Capital improvement credit is required to purchase or improve land or buildings. Long-term loans should be used in acquiring these long-lived assets. Still another type of credit need arises from disasters, as when aquaculturists lose their crops due to weather problems or natural disasters. Typically, disaster credit needs can be met in substantial part through emergency credit programs of the Farmers Home Administration or of the Small Business Administration.

3. Loan Sources

Loans for aquaculture operations are available from a variety of sources. Unfortunately, many

aquaculturists fail to qualify for financing due to the strict requirements set by lenders. Members of the financial community are naturally adverse to lending to ventures where the risks are high and the profits uncertain. With aquaculture's limited track record and past history of business failures, potential aquaculturists must be reasonably financially secure in order to obtain business loans. On the other hand, established aquaculturists may often qualify for credit from various lending institutions. Common sources of credit for aquaculture operations include:

(1) the Cooperative Farm Credit System (FCS), which consists of three different entities: the Federal Land Bank, the Federal Intermediate Credit Banks (with their local Production Credit Associations), and the Banks for Cooperatives. All of the FCS banks are wholly-owned farmer cooperatives. Rates charged by the FCS are generally lower than those of other lenders because of the FCS's loan pricing practices. However, due to their low interest rates (and low risk premiums), they are conservative in their lending, and demand relatively risk-free loans. Yet, for the aquaculturist with a solid track record and ample collateral, they remain a good supplier of capital.

(2) Commercial banks have concentrated their lending in non-real estate, shorter maturity loans. This source of private sector financing often requires loan guarantees which assure the lender that a certain percentage of the loan will be repaid. These lenders, along with most others, have had difficulty in monitoring the performance of aquaculture businesses when standard credit analyses are inappropriate. As a result, they are often quite restrictive in their lending practices.

(3) The Small Business Administration (SBA), through its Office of Advocacy, provides credit to aquaculture businesses unable to obtain credit in the private sector. At present, operations with gross annual receipts under $1 million may be eligible for SBA loans. In addition to making direct loans, the SBA may participate in loans with private sector banks and guarantee loans.

(4) The Farmers Home Administration (FmHA), which was created by Congress in 1946, provides credit assistance to rural residents who are unable to obtain credit from private lenders. FmHA programs of interest to aquaculturists are (a) Farm Ownership Loan Program, (b) Operating Loan Program, (c) Emergency Disaster Loan Program, (d) Economic Emergency Loan Program, (e) Recreational Loan Program, and (f) Business and Industrial Loan Program. Through these

programs, FmHA can provide direct loans or guarantee loans for creditors of commercial banks.

(5) The State of South Carolina's Family Farm Development Authority may in the future become a source of financing for aquaculturists. The Authority, which was created to aid and encourage family farmers (and aquaculturists) by providing low interest loans, is ready to proceed except pending Federal Legislation which may restrict the authority's financing options.

With the recent passage of the South Carolina Jobs-Economic Development Fund Act, aquaculturists should be aware of the South Carolina Jobs-Economic Authority. This Authority's mission is to promote business development by encouraging and assisting businesses with loans, investments, research, and technical and managerial advice. Due to its recent formation, the Authority's impact on aquaculture and aquaculture-related activities is uncertain.

(6) Perhaps the most appropriate method of financing a new aquaculture operation is by attracting outside equity capital. In som cases, this capital may reduce the control an operator has over his business, but it also spreads the risk of the enterprise among more investors and reduces the financial risk by lowering the debt burden. There are several approaches to attracting outside equity capital into an aquaculture business. The selection of a method should result from a thorough analysis of business needs and tax consequences.

4. Risk

Aquaculture continues, in most cases, to be considered a risky investment. For the individual involved in or contemplating involvement in an aquaculture investment, risk management is of obvious concern. Producers should attempt to manage two major types of risks in aquaculture. The first is biological risk which is due to the variability in output levels caused by weather, predators, disease, or other factors. The second type is market risk which results from fluctuating product prices at harvest time. An integral part of any aquaculturist's business plan should be the examination of all risks involved in his business.

To control risk, several strategies are available. Purchasing insurance allows the aquaculturist to substitute a small, known loss (insurance premium) for the possibility of a larger, unknown loss. Unfortunately, federal

insurance, such as that available for agricultural crops through the Federal Crop Insurance Program, is not available for aquaculturists in South Carolina. If, in the future, sufficient actuarial data becomes available on which to base an insurance schedule, this program may be expanded to cover aquacultural commodities.

In the private sector, insurance coverage of aquaculture operations is available but current prices are quite high. As the industry develops and the asset value of firms grows, adequate insurance protection will become increasingly important.

Other techniques that may be used to reduce risk include: (1) diversification -- here an individual spreads the risk of loss by producing more than one commodity (i.e. a farmer producing typical agricultural crops as well as crawfish); (2) flexibility -- when uncertain of the conditions that may occur in the near future, a flexible production and marketing program may provide risk reduction; (3) liquidity -- since many of the aquaculturist's production tools are not readily convertible into cash (there is no market), maintaining a larger than normal cash balance may be useful. Leasing land and equipment instead of purchasing may be helpful; and, (4) use of contracts -- forward price contracts can remove some of the speculation by fixing the selling price. New operations in particular may need this marketing security in order to assure debt payment.

V. Market Environment

1. Production

Little information is currently available on the costs associated with production of aquaculture products in South Carolina. Most operations have only recently begun production or are still in experimental stages. Thus, with their limited track records, most have insufficient data to provide adequate documentation for reliable cost analysis. Operations with somewhat longer histories have often been run in conjunction with other ventures (i.e., farming or waterfowl management), and accurate accounting records for the aquaculture portion of the business are not available. However, as one might expect, economies of scale have been found within the catfish industry; an industry where good production records do exist. As the remainder of the industry matures, reliable cost data must be generated to provide information for future business investment decisions.

2. Marketing

After production, aquaculturists must concern themselves with marketing their product. The profitability of aquaculture is greatly influenced by available marketing alternatives, and selecting markets is an important part of aquaculture management. Unlike manufacturers, aquaculturists operate within a system where productive resources are typically fragmented. In large part, they lack control over consumer marketing, product pricing, and total output. With many species which rely on natural harvest as well as aquaculture production, the supply is frequently determined to a large extent by weather rather than aquaculturists' management decisions. In South Carolina, most producers currently depend on sales to local wholesalers and retailers, or on pondside retail sales to market their product. These sales transactions are characterized by small sales where little information is used to determine a buying or selling price. While adequate for the small volume of aquaculture production presently found in the state, if production increases in the future, other markets should be identified and developed in order to maximize industry profits. Initially, marketing channels used by the commercial fishing industry will provide buyers for the state's aquaculture production. However, producers should not be content with these markets alone, and should instead search for channels where their method of "capture" allows them a comparative advantage. (A production advantage arising from seasonal timing, desirable size distribution, or reliability of production.)

3. Processing

Currently, there is little processing of seafood or agricultural products in South Carolina. If aquaculture production in the state grows to appreciable levels, undoubtedly the value received from the production could be increased by having some in-state processing.

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APPENDIX I - SPECIES OVERVIEWS

NAME - Crassostrea virginica - American Oyster

BIOLOGICAL REQUIREMENTS

The American oyster, Crassostrea virginica, is adapted to an existence in waters having considerable variation in salinity and temperature. Its optimum salinity range is roughly 10 o/oo - 28 o/oo, but it can survive periods of extended freshets. The sexes are separate and hermaphrodites are rare. Eggs and sperm are discharged into open waters, where fertilization occurs. The length of larval life is approximately two weeks, depending on food, temperature, and other environmental factors. The pre-setting period is most critical, for the oyster will die unless suitable substrate is found. Oyster shells are the most common cultch (substrate) material. Food consumed by oyster larvae includes microscopic phytoplankton, plant detritus, and bacteria.

Generally, oyster setting in South Carolina occurs from early May through early October, plus or minus two weeks. Slightly more than one percent of spat fall occurs at other times during the year. Two setting pulses are usually noted each season. The highest settlement occurs from early June through July, and a second and lesser peak takes place during August or early September.

Generally, oysters in South Carolina grow throughout the year unless exposed to extreme temperature or other adverse environmental circumstances. In South Carolina, approximately 95 percent of the oyster standing crop is intertidal.

CURRENT STATUS

Oyster culture is currently practiced along North America's East, West and Gulf coasts in trays, rafts, suspended string cultures, and other methods. In South Carolina, cultivation of intertidal oysters is the only large-scale economically viable form of mariculture currently being practiced. Oyster leaseholders are required to plant 65 South Carolina bushels (123 U. S. bushels) of seed or shell annually for each acre under lease. The State currently leases 5,169 acres of intertidal oyster grounds to 64 individuals or shellfish businesses.

OPPORTUNITIES AND CONSTRAINTS

The cultivation of high value, well-formed subtidal oysters may be feasible in the state. However, most of South Carolina's naturally occurring oysters are intertidal. These oysters, while quite abundant, are of low economic value. Greatest demand is for oyster roasts and canning purposes. Mechanical innovations for harvesting and processing this abundant resource would be of greatest benefit to the industry.

NAME - Marine Bait

Fundulus sp. - mud minnow, mummichog
Penaeus sp. - live shrimp
Glycera dibranchiata, Ehlers - blood worm
Arenicola crustata, Stimpson - lug worms
Mugil sp. - mullet

CURRENT STATUS

Marine bait sales total over seven million dollars annually in South Carolina. However, there is a very small bait fishery in the state. With the exception of local anglers who usually catch their bait, and some small bait dealers who catch mud minnows, marine bait sold in South Carolina is almost exclusively imported from other states, primarily Florida. The importation of marine bait products adds freight costs to these products, and out-of-state sources do not always provide consistent quality products.

OPPORTUNITIES AND CONSTRAINTS

In March of 1982, with support from S. C. Sea Grant Consortium, a marine bait survey was conducted by the Marine Resources Research Institute. This survey identified two specific areas of need in the state's marine bait industry: First, although the marine bait industry has a sizable impact on the state's economy, there are no local suppliers for marine bait in South Carolina; and secondly, because many dealers have no access to seawater and because most recirculating bait holding tanks are quite expensive, only a few dealers handle live bait, even though the market supports such a product.

Since the 1982 survey, an interested bait dealer has developed an inexpensive bait holding system. This system may soon be made available for purchase. However, a need still exists for a local supplier of marine baits. The possibility of culturing many of these bait species should be considered. Culture techniques exist for some species, and simple adaptation to our area is all that may be required. Other species will require more research to determine their culture potential.

NAME - Macrobrachium rosenbergii - Freshwater Malaysian Prawn

BIOLOGICAL REQUIREMENTS

The freshwater prawn is best cultured in fresh water, however, low levels of salinity are tolerated. Because of its tropical nature, the prawn prefers warm water (73-90°F) and cannot withstand winter temperatures in South Carolina. The hatchery phase of this animal's life requires brackish water, preferably between 10 o/oo and 14 o/oo salinity. When cultured in South Carolina, supplemental feed is required as the natural nutrient load in the water is not sufficient to provide adequate growth rates. However, with formulated diet supplements, production ranges between 900 and 1,200 lbs. per acre in the relatively short (5-6 months) growout season.

CURRENT STATUS

After several years work, this species shows reasonable potential for culture in South Carolina. Work is currently being done to improve the nursery systems. Additionally, artificial insemination and in vitro fertilization techniques are being developed in hopes of eventually domesticating the prawn.

OPPORTUNITIES AND CONSTRAINTS

The potential for culturing freshwater prawns as a viable food crop in South Carolina is good. However, because of our climate and the fact that animals need to have warm water, production is limited to one crop per year. Additionally, the present cost of seed stock ($20-$80/1,000 postlarvae plus shipping) decreases the profit margin considerably. The establishment of a hatchery in the southeastern United States would provide a more consistent and less expensive source for seed stock and increase the chances for having a successful business.

NAME - Procambarus clarkii - Red Swamp Crawfish
Procambarus acutus acutus - White River Crawfish
Procambarus (scapulicambarus) troglodytes

BIOLOGICAL REQUIREMENT

Crawfish need three basic requirements for good growth:

(1) A good supply of highly oxygenated freshwater less than 8 o/oo (2) a soil type that is at least 20 percent clay and drainable for successful burrowing and reproduction, and (3) an adequate food supply through either management for natural aquatic weeds such as alligator weed and smartweed, or through cultivation of rice or millet.

CURRENT STATUS

Commercial culture of crawfish in South Carolina began in the mid-1970's and the industry has enjoyed a steady growth to over 500 acres in production for the 1983-84 season. Culture is practiced throughout the state but the majority is found in the Berkeley and Georgetown County areas. Culture can be successful in either upland or rice impoundments with yields of 1,000 pounds per acre possible. The native species, P. troglodytes has not been investigated for commercial purposes.

Louisiana, Texas, and Mississippi have viable crawfish industries. Louisiana at present has 100,000 acres in cultivation while Texas has 3,000 acres and Mississippi has 2,000 acres.

OPPORTUNITIES AND CONSTRAINTS

South Carolina and Louisiana have similiar soil and climate conditions. The availability of thousands of acres of old rice impoundments on the coast gives promise for relatively easy expansion due to reduced construction costs. Many inland areas with adequate water supplies, good clay soils, and level topography will be very productive, perhaps offering landowners an alternative source of income.

Constraints include the introduction of crawfish as a food item to large numbers of South Carolinians, setting market distribution channels for large quantities of crawfish to markets both within and outside of the state, and permitting constraints on the utilization of coastal impoundments for culture.

NAME - Morone saxatilis and its hybrids; striped bass, rockfish, hybrid bass

BIOLOGICAL REQUIREMENTS

The striped bass and its hybrids are euryhaline and eurythermal. They survive and grow under a broad range of environmental conditions. Spawning of wild-caught fish and hatchery techniques are well established.

CURRENT STATUS

The striped bass is a very popular commercial food fish and recreational species in many areas of the U.S. Likewise, the hybrids are also an exceptionally desirable fish. In 1981, 12 states produced nearly 200 million striped bass and hybrid larvae. These larvae were supplied to state and federal hatcheries in 36 states where approximately 40 million fingerlings were produced for stocking purposes. In South Carolina, the striped bass is listed as a sport fish with no commercial fishing activities permitted. From a recreational standpoint, the striped bass and its hybrids are one of the most desirable fishes in our fresh water lakes. Neighboring states do permit commercial capture and sale of striped bass.

On the Atlantic coast, most populations of striped bass have been substantially reduced. During the past ten years, total landings have decreased from about 14 million lbs. to two million lbs. annually.

OPPORTUNITIES AND CONSTRAINTS

This state already is heavily involved in stock enhancement/replenishment activities with striped bass and its hybrid, especially in freshwater lakes. Such activities support major recreational fisheries. The potential for aquaculture of this species is substantial. This is especially true for the hybrids which grow faster, are hardier, and can be reared under crowded conditions. Such hybrids can be distinguished from the stripers both visually and biochemically. Preliminary aquaculture work in this state and elsewhere indicates that the hybrids are an excellent candidate for commercial aquaculture development. Market value is high and these fish can be reared to pan-size at high production rates both in ponds and in cages in saltwater in less than a year. A company in California is successfully producing and marketing the hybrids and striped bass and is expanding its production facilities.

A major constraint to commercially producing these fish in South Carolina is the restriction in marketing. If identification and certification procedures can be developed, the marketing of a domestically produced product could offer substantial economic benefit to this state.

NAME - Cynoscion nebulosus - Spotted Seatrout

BIOLOGICAL REQUIREMENTS

This species' range includes the Western Atlantic Ocean from Cape Cod, Massachusetts, to the Yucatan Peninsula of Mexico. However, the spotted seatrout is most abundant in Florida, Louisiana, and Texas. The spawning season is generally from April to October. Post-larval and early juveniles occur in grassy areas and oyster bars in shallow areas of estuaries and bays with depths less than one meter. Adults prefer estuaries and bays. They do not migrate, but they exhibit movement to passes and inlets during winter in some states.

CURRENT STATUS

The mariculture of spotted seatrout has been studied for about 15 years. No states have large mariculture projects for this species, although Texas and Louisiana have been managing their wild stocks. Presently, the spotted seatrout is not as popular for mariculture as compared to the red drum. It is a little more sensitive to hatchery handling and not as tolerant to low temperatures as is the red drum.

OPPORTUNITIES AND CONSTRAINTS

The spotted seatrout is a very easy marine fish to culture if careful attention is given to the feeding of early juveniles. They tend to cannibalize siblings if larger live food is not adequately provided until the fish reach 40-50 mm, when they naturally begin to school and lose their cannibalistic tendency.

This species is ideally suited for cage and impoundment culture. It is easy to spawn, much like the red drum, and it can be maricultured for the same purposes as red drum: 1) to enhance the recreational fishery in South Carolina, and 2) to establish pay fishing lakes. The advantage of spotted seatrout is that they prefer estuaries and do not migrate. Hence, South Carolina could enhance the sport fishery, and tourist appeal, for this species. This could be significant to the state since this species is ranked nationally as the second most important sport fish caught (by weight of recreational angler landings), being exceeded only by sport-caught bluefish.

The constraints to seatrout mariculture are mainly legal or political. Conflicting or unresolved issues concerning title to and development of wetlands, leasing of submerged lands, and the use of public waters and public resources must be resolved.

NAME - Sciaenops ocellatus - Red drum, Spot-Tail Bass

BIOLOGICAL REQUIREMENTS

This species' range includes the Western Atlantic Ocean from the Gulf of Maine to Tuxpan, Mexico, but is rarely found north of New Jersey. It is most abundant in Florida, Louisiana, and Texas. The spawning season varies by area, ranging from July to February with peak spawning from August to mid-November, and occurs in coastal nearshore waters. Post-larvae and early juveniles occur in grassy areas and oyster bars in shallow areas of estuaries and bays with depths less than two meters. Normally adults occur in coastal waters. They are euryhaline and eurythermal and have been captured in 0-50 ppt salinities and 36-92°F temperatures.

CURRENT STATUS

The mariculture of red drum has been studied for about 15 years. The species is excellent for mariculture and the technology is available. The Gulf Coast states have the largest management and aquaculture projects. Texas is the leader in red drum mariculture, hatchery technology, and in commitment to managing their stocks. They began to manage their stocks and the commercial fishery in the early 1900's. They added stock enhancement projects to their management program about 1975, and expanded their stocking program in 1983 by approving funding for a new red drum hatchery. Texas sharply curtailed commercial fishing and is now managing red drum for recreational fishermen.

The Atlantic states have done very little to manage red drum stocks. Very few or no legal restrictions control the commercial or recreational fisheries in these states.

OPPORTUNITIES AND CONSTRAINTS

Red drum mariculture can be applied profitably in at least two ways in South Carolina: 1) a state program to enhance the natural stocks for recreational and commercial fishermen, and 2) private aquaculture to establish pay fishing lakes in coastal impoundments. It appears the present price paid for commercially netted wild red drum is too low in South Carolina to permit the species to be profitably aquacultured for commercial seafood sales.

The constraints to South Carolina red drum mariculture are mainly legal or political. Conflicting or unresolved issues concerning title to and development of wetlands, leasing of submerged lands, and the use of public waters and public resources must be resolved.

NAME - Ictalurus punctatus - Channel Catfish

BIOLOGICAL REQUIREMENTS

This species is naturally found in fresh waters of the U.S., west of the Appalachains to New Mexico and from northern Mexico to southern Canada. Channel catfish have been introduced throughout the U.S., and now are cultured mainly in Arkansas, Mississippi, and Louisiana. Spawning in captivity is well understood. This species will mature in a minimum of 18 months under culture conditions. Under natural conditions, zooplankton, fish, insects, benthic arthropods, molluscs, and aquatic plants are eaten. In an artificial environment, pelleted 35 percent protein feed is required. More nutritionally complete food is needed for the more intense forms of culture. Food conversion ranges from 1.3 - 2.0.

CURRENT STATUS

This species is the most widely cultured catfish in the U.S. About 70 percent of the domestic harvest comes from Mississippi. Rapid expansion in production has caused a temporary glut of farm-raised catfish, however, as the market develops, supply and demand should reach an equilibrium. There are a few scattered, small-scale catfish production operations in South Carolina. The catfish produced are marketed through local restaurants, or live, through recreation fishing operations.

OPPORTUNITIES AND CONSTRAINTS

The culture of the channel catfish is well understood and its economic feasibility is proven. South Carolina has the soils, climate, and waters necessary for the production of this species .

Unfortunately, markets for South Carolina channel catfish are not well-defined. Current production is marketed locally with little emphasis on market development. As additional markets become available, production of this species should increase.

NAME - Callinectes sapidus - Blue Crab

BIOLOGICAL REQUIREMENTS

Blue crabs inhabit estuarine and nearshore waters of the western Atlantic from Nova Scotia to Uruguay including the Gulf of Mexico, and have been introduced to European waters. These crabs attain maturity in 1-1.5 years, with mating taking place in the brackish waters of the estuary following the terminal molt of the female. After mating, females return to higher salinity waters to spawn.

CURRENT STATUS

Blue crabs support a valuable fishery from Delaware to Texas; landings in 1981 were valued at 46.4 million dollars. The fishery for blue crabs in South Carolina is the state's second most valuable fishery. The softshell crab fishery in South Carolina was dormant from the mid-1950's until 1979 when several individuals began experimenting with shedding blue crabs. This fishery requires holding premolt crabs and may be of interest to aquaculturists.

OPPORTUNITIES AND CONSTRAINTS

Softshell blue crabs bring a much higher price than do hardshell crabs ($12-20 per dozen). The market for this product is well-defined and harvesting will have a negligible affect on the population. Holding techniques need not be elaborate (low entry cost) and after harvesting, only simple processing is required (freezing).

Most active crabbers in the state are ignorant of methods of identifying, catching, and handling premolt crabs and thus, softshell crab operations have suffered from an inadequate supply of peelers. Additionally, softshell crab operations are labor intensive and seasonal.

NAME - Micropterus salmoides - Largemouth Bass

BIOLOGICAL REQUIREMENTS

This species ranges throughout the U.S., southern Canada, Mexico and South America, and has been introduced throughout Europe, Asia, and Africa.

Bass spawn at age one with good growth. The optimal spawning temperature is from 59-75°F.

Primarily piscivorous, bass will also eat tadpoles, crawfish, as well as other vertebrates, and invertebrates. This species can be trained to accept artificial food pellets.

CURRENT STATUS

South Carolina Wildlife and Marine Resources Department currently provides fingerlings for stocking recreational fishing lakes for $30 per acre for the first ten acres and ten dollars per acre for each additional acre. No private individuals are raising largemouth bass for sale at this time.

OPPORTUNITIES AND CONSTRAINTS

Few opportunities currently exist with this species for private aquaculturists. Gamefish, such as the bass, may be sold only for restocking purposes. Fish sold must be less than four inches long, and the seller must have a fish propagation breeder's license from the S.C. Wildlife and Marine Resources Department. With this Department selling this species at or near cost, the potential for profit for private aquaculturists seems limited.

NAME - Salmo gairdneri - Rainbow Trout
Salvelinus fontinalis - Brook Trout
Salmo trutta - Brown Trout

BIOLOGICAL REQUIREMENTS

Trout are found naturally in Oconee, Pickens, and Greenville Counties and have been stocked into Lake Hartwell Tailrace (Anderson County) and Lake Murray Tailrace (Lexington County). The factor most responsible for the limited trout culture in South Carolina is water quality; the two most important parameters being water temperature (should not exceed 68°F) and oxygen concentration (should not be below five ppm).

CURRENT STATUS

Two facilities currently rear trout in South Carolina: 1) Walhalla National Fish Hatchery (Oconee County) and 2) Black Mountain Trout Farm (Oconee County). The majority of fish cultured are used for recreational purposes.

OPPORTUNITIES AND CONSTRAINTS

There is little water suitable in South Carolina for the production of trout by private individuals due to the stringent water quality requirements of trout. Nearly all suitable water is found on federal, state, or public utility lands. One possibility however, is a two crop system where trout (winter) are alternated with some other suitable species such as catfish (summer). This is being practiced in several southern states.

NAME - *Tilapia aura*)
Tilapia nilotica) - Tilapia
Tilapia zillii)

BIOLOGICAL REQUIREMENTS

These species are natives of tropical Africa and require high water temperatures. They are basically vegetarian, eating phytoplankton, small algae, and some macrophytes. Spawning may occur as early as two to three months, and adults spawn from six to eleven times per year. In naturally occurring populations, spawning occurs at temperatures greater than 77°F. When being cultured, breeding stocks are typically held in ponds where natural breeding can occur. When access to high temperature natural waters is limited, Tilipia may be cultured in raceways receiving naturally or artificially-heated waters. When being fed floating prepared fish food, Tilipia can usually be harvested in 10-12 months.

CURRENT STATUS

Cultured extensively in Africa and other tropical areas, interest in these species is expanding in this country. Currently, Santee-Cooper is culturing Tilapia by using the heated effluent from its electric generating facilities.

OPPORTUNITIES AND CONSTRAINTS

These species will withstand a wide range of water quality conditions and can be cultured in intensive, high density systems. They exhibit high growth rates when provided with artificial feed and may be marketed as food (*T. aura* and *T. nilotica*) and for aquatic weed control (*T. zillii*).

Unfortunately, the current market for these species is limited and prices are low. In addition, they require high water temperature for survival and may overpopulate ponds if not managed properly.

NAME - Anguilla rostrata - American Eel

BIOLOGICAL REQUIREMENTS

This species requires freshwater with optimium temperatures ranging between 73°F and 82°F. Ponds should be constructed with a drainage basin and should have concrete lining along sides to prevent burrowing. Food is available for all stages of eel culture. In Japan, food consists primarily of trash fish.

CURRENT STATUS

Holding eels at any stage of their lives is considered culture. Currently there is a small level of effort directed at eel culture in South Carolina. Surrounding states including Florida, Virginia, and North Carolina are involved in eel culture.

OPPORTUNITIES AND CONSTRAINTS

Marketing opportunities for adult eels and elvers include exporting to Japan and China, sale for bait, and sale for stocking purposes. This species is a candidate for polyculture with planktivorous fishes .

Constraints include difficulty in obtaining individuals for growout. Currently there are no methodologies for spawning, and elvers are hard to obtain. During growout, aquaculturists face high food costs and disease problems. After harvesting, sales are primarily to foreign markets which leads to competition with traditional producers who are more familiar with these markets.

NAME - Mercenaria mercenaria - Hard Clam, Northern Quahog, Round Clam. Also known by its commercial size gradings as littlenecks, cherrystones and chowders.

Mercenaria campechiensis - Southern Quahog, Southern Hard Clam. Confused with and sold as the northern quahog.

BIOLOGICAL REQUIREMENTS

The hard clam has a high tolerance for temperature and salinity allowing it to have a very wide geographical distribution. It is found intertidally and subtidally from Maine to Florida and grows best at high salinities (>25°/oo) and relatively high temperatures (68-82°F). The waters of coastal South Carolina offer an almost ideal environment for the hard clam. The state has over one million acres of marshland producing a rich estuarine milieu of nutrients. This combination of relatively high water temperatures and rich coastal productivity allows the growout of hard clams in two years as compared with four to five years in northeastern states.

CURRENT STATUS

The hard clam is harvested in 16 states and in terms of value and employment, is the largest clam fishery in the United States. The true value of the fishery is over $256 million if standard multipliers are applied. Natural harvests have decreased considerably over the last 30 years - from nearly two million bushels in the early 1950's to approximately 1.2 million bushels in 1981. Decreasing supplies have stimulated price increases to the extent that deflated (by CPI) clam prices have tripled over the last 20 years. Declining harvests have resulted primarily from overfishing, pollution (closing of productive grounds) and poor resource management policies.

OPPORTUNITIES AND CONSTRAINTS

The hard clam is a prime candidate for imminent commercial aquaculture success in the United States. Consumer acceptance and demand are high and extensive transportation and marketing channels are in place. Techniques for culture have been developed and optimized in recent years and commercial quantities of seed are available from a number of existing private hatcheries. Recent developments in technology have proven the economic feasibility of intensive, high density, nursery and field culture protocols and new materials are making these methods highly cost-effective.

Constraints include natural and environmental restrictions (e.g. environmental limitations, predators, etc.), imposed or regulatory restrictions (fishery management policies, land use regulations, lease laws, etc.), and constraints rooted in data gaps or unfulfilled research needs (genetics, nutrition, disease control, etc.). Many aquaculturists, from both the public and private sectors, believe the greatest present need in aquaculture is financial, i.e., low interest and/or guaranteed loans, tax incentives, subsidized crop insurance, etc., would do much to encourage investment in aquaculture.

NAME - Indigenous species: Penaeus setiferus - White Shrimp
Penaeus aztecus - Brown Shrimp

Introduced species: Penaeus stylirostris
Penaeus vannamei

BIOLOGICAL REQUIREMENTS

Shrimp mariculture consists of two primary phases: 1) production of young seed (postlarval) shrimp and 2) growing of the postlarvae to market size. Seed production may be approached in different ways, the simplest of which is to capture wild juvenile shrimp from estuarine waters and transport them to rearing enclosures (e.g., ponds, impoundments, tanks). In areas of temperate climate where the wild supply of juveniles is markedly restricted on a seasonal basis, this approach is not very reliable. In such areas, and wherever the shrimp farmer wishes to exert a high degree of control over his seed supply, hatchery production of postlarvae is recommended. Rearing of postlarval/juvenile shrimp to market size may be accomplished in a variety of enclosures, but the most commonly used for commercial purposes are ponds. Shrimp ponds should be located in coastal areas with good soils for water retention, and where salinities are generally > 10 o/oo. Temperatures should be in the range of 72-88°F, with 82°F being considered optimal.

CURRENT STATUS

Shrimp mariculture has been established as a commercial business for some time in Southeast Asia, particularly Japan and Taiwan. It has developed rapidly in Central and South America in recent years, especially in Ecuador, Panama, and Brazil. In Ecuador, production of pond-reared shrimp has increased from approximately 1.8 million lbs. (tails only) in 1977 to an estimated 28 million lbs. in 1982. In the U.S., major centers of shrimp R&D activities are in Texas, Hawaii, and formerly in Florida. Considerable interest is developing in South Carolina.

OPPORTUNITIES AND CONSTRAINTS

South Carolina has thousands of acres of salt water wetland impoundments that may prove suitable for rearing shrimp with appropriate modifications of dikes, canals, and flood gates. There is a heavy demand for shrimp (over 60 percent of the U.S. consumption is currently imported). It commands a high price and no market development needs to be done. However, there remain major socio-economic and technological obstacles to development of shrimp mariculture. The former include such factors as competitive uses (e.g., resort development, waterfowl management, etc.) of the lands and water supplies needed for shrimp culture, difficulties in obtaining necessary permits for construction activities in the coastal zone, and difficulties in obtaining financing for high-risk, unproved business ventures. Technological constraints include (especially) the lack of a predictable source of juveniles (seed shrimp) for stocking, an insufficient understanding of how best to manage culture environments (e.g., ponds, impoundments, tanks) to achieve maximum yields on a routine basis.

NAME - Ctenopharyngodon idella - Grass Carp

BIOLOGICAL REQUIREMENTS

The grass carp is a temperate zone minnow adapted to graze on aquatic plants. Originally from eastern China and Russia, the grass carp has been introduced into over 60 countries for weed control, food production or experimental aquaculture. Grass carp spawn naturally in rivers during late spring or early summer (temperatures 72-78°F). River current velocity and length must be sufficient to permit proper egg development and hatch. Egg larvae and small fingerlings are extremely vulnerable to predation.

CURRENT STATUS

Grass carp were introduced in the U.S. in 1963 for experimentation in the control of noxious aquatic vegetation. They have been shown to do this job well at concentrations of 15-25 fish per acre. In 12 states in the southeastern U.S. grass carp are being used successfully and legally to control weeds. Other states, fearing spawning and over-population, do not allow use of grass carp in public or private waters. Policy in South Carolina is currently against the use of grass carp because potential spawning areas exist in the state. It is felt that if these fish reproduce successfully, their fry may compete with striped bass fry for food and thereby, harm the recreational striped bass fishery.

OPPORTUNITIES AND CONSTRAINTS

Recent developments in culture technology of grass carp have produced fish which are sterile and may be stocked in known numbers in lakes, ponds, and rivers. The sterilization process has been accomplished in a number of ways but only two methods seem suitable for large scale production of quality sterile fish. One involves hybridization with bighead carp and the other requires manipulation of eggs to produce sterile triploid grass carp. These methods are still under study for refinement. An opportunity for cultivation would exist if sterile grass carp or sterile hybrids were legal to use in this state for aquatic weed control.

Name - Freshwater Live Bait
Notemigonus crysoleucas - Golden Shiner
Pimephales promelas - Fathead Minnow

BIOLOGICAL REQUIREMENTS

These temperate zone minnows are routinely spawned and grown under commercial pond conditions. The hatchery techniques are well-established and refined.

CURRENT STATUS

Bait minnows are currently produced in Arkansas and Louisiana and trucked to all parts of the U.S. South Carolina receives about 2 million pounds of bait minnows annually. Value of this bait at the retail level is about 20 million dollars.

OPPORTUNITIES AND CONSTRAINTS

The freshwater live bait industry is complex and competitive. However, opportunities exist for production and sale of minnows in South Carolina, Georgia, North Carolina, and Florida. We are in the center of a large marketing area where distances to market centers and distribution points are short. Transportation costs would be low and the quality of the product at market would be high.