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THE
STRATEGIC PLAN
FOR
AQUACULTURE DEVELOPMENT
IN
SOUTH CAROLINA

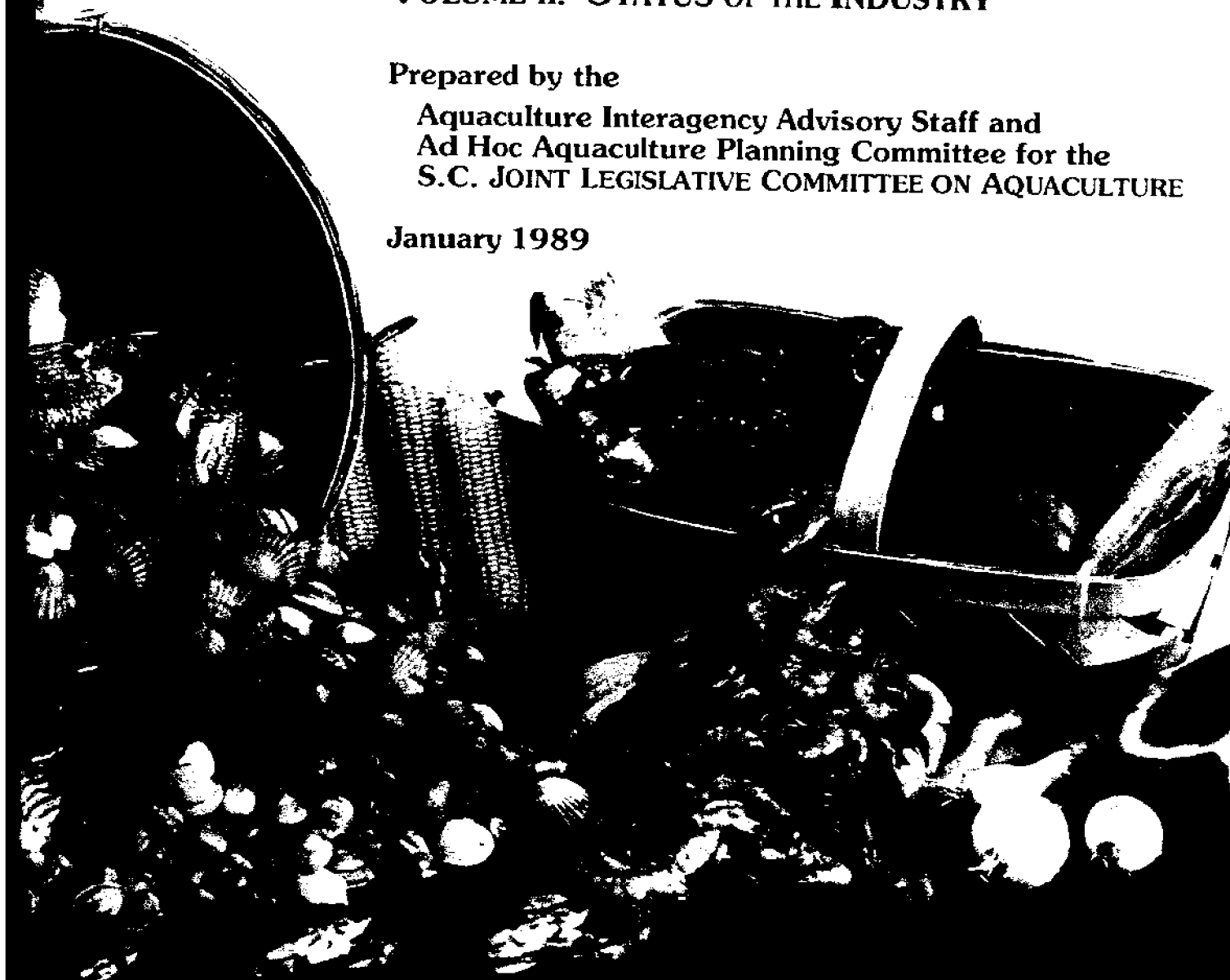
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VOLUME II: STATUS OF THE INDUSTRY

Prepared by the

Aquaculture Interagency Advisory Staff and
Ad Hoc Aquaculture Planning Committee for the
S.C. JOINT LEGISLATIVE COMMITTEE ON AQUACULTURE

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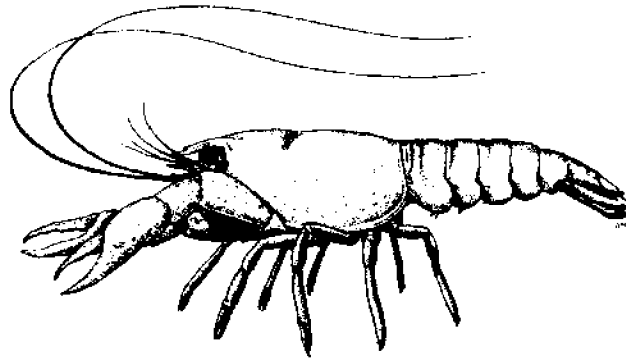
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I. STATUS OF AQUACULTURE

AQUACULTURE WORLDWIDE

Aquaculture has a long history. Egyptian tomb carvings illustrate that fish culture existed in the Nile delta as long ago as 2000 B.C. (Borgese, 1980). In western civilizations fish and shellfish farming date back to the early Greeks and Romans. The need for food in the growing ancient civilizations of China and Southeast Asia stimulated development of intensive fish farming, an industry that has grown in modern times (Shupe, 1982). Aquaculture practices vary widely, depending on the species, geographic area and economic and political considerations. In all cases, however, some degree of control is exercised over the life cycle of the cultivated organism in order to increase production or reduce costs.

The world demand for aquatic products is increasing rapidly, while production from the world's fisheries remains relatively constant. Many aquatic resources are being harvested at or near a maximum level, while others are actually declining due to overharvesting, pollution or habitat disturbance. Aquaculture offers a means of augmenting and expanding production from traditional capture fisheries.

Worldwide aquaculture production appears to have increased rapidly; 7.3 million tons of seafood products were produced in 1975. In 1985, aquaculture production approached 14.8 million tons, representing more than 13 percent of the world harvest of fishery products. The Food and Agriculture Organization of the United Nations predicts that aquaculture production will increase by an average of 5.5% annually, reaching 24.2 million tons by the year 2000 (Nash, 1987).

Production figures were collected for 136 countries in 1984 and 1985 by FAO; Table 1 shows aquaculture production of leading countries in 1985. Table 2 provides 1985 aquaculture production figures by continent and species group: fin-fish accounted for 44.5 percent of all cultured products; crustaceans 2.5 percent;

molluscs 26.5 percent; seaweeds 26.2 percent; and others 0.3 percent (Nash, 1988). Both tables illustrate the dominance of Asia and Asian countries in the production of fisheries products through aquaculture.

Some countries, such as China, already rely upon aquaculture for over 40 percent of their total fisheries supply. It is evident that aquaculture is a large and growing industry throughout much of the world.

Table 1: Aquaculture Production of Leading Countries In 1985 (in Tons)¹

Country	Total	Finfishes	Crustaceans	Molluscs	Seaweeds	Others
China	5,202,200	2,392,800	42,700	1,120,000	1,646,700	3,400
Japan	1,184,300	283,900	2,200	359,800	530,000	
Korea, Rep.	790,200	3,700	100	369,000	397,800	19,600
Philippines	494,400	243,700	29,900	37,900	182,900	0
U.S.A.	353,200	195,200	29,800	128,000	0	0
U.S.S.R.	296,000	296,000	No Info	No Info	0	0
Indonesia	309,900	271,900	38,000	0	0	0
Others	250,800	164,000	21,000	55,500	10,100	200
France	215,800	34,000	200	181,600	0	0
Viet Nam	204,000	191,000	13,000	0	0	0

Source: Nash, 1988.

Table 2: World Aquaculture Production (in Tons) by Continent and Major Resource Group - 1985

	Finfishes	Crustaceans	Molluscs	Seaweeds	Other
Africa	60,600	100	400	0	0
America, North	197,800	3,800	160,800	200	0
America, South	28,500	32,900	1,900	4,900	0
Asia	3,792,600	198,500	2,120,000	2,767,500	28,200
Europe	340,800	300	495,000	4,500	0
Oceania	1,200	100	20,500	100	100
USSR	296,000	0	0	0	0
Totals	4,717,500	265,700	2,798,600	2,777,200	28,300
Percentage (%)	44.5	2.5	26.5	26.2	0.3

GRAND TOTAL: 10,587,300 Tons

Source: Nash, 1988.

AQUACULTURE IN THE UNITED STATES

Aquaculture has been practiced in the United States for well over 100 years, beginning with salmon release programs designed to augment natural stocks. In comparison with the rest of the world, however, aquaculture in this country is relatively new and undeveloped. Production in the U.S. accounts for a little over six percent of world aquaculture production. In the last two decades, however, aquaculture in the United States has experienced considerable growth. In 1975,

U.S. production of aquaculture products was 78,000 tons. By 1980, this figure had reached 101,500 tons, and by 1987 production had exceeded 375,000 tons (USDA, 1988).

Aquaculture is the fastest growing sector of the agricultural economy in the United States, increasing at an annual rate of 20 percent (USDA, 1988). Despite this recent growth, aquaculture production does not meet the domestic seafood demand. Presently, more than 60 percent of the seafood consumed by Americans is imported, resulting in an annual trade deficit in excess of \$4 billion (more than 10 percent of the total annual trade deficit). Our wildstock fisheries are suffering from overcapitalization and poor returns to fishermen, indicating signs of overharvesting. Aquaculture could supplement these fisheries, increase our seafood production and provide stability for the seafood industry.

A significant portion of the U.S. supply of some species is now produced by aquaculture. Private aquaculture produces over 40 percent of our oysters, most of our catfish and crawfish, nearly all of our rainbow trout, and small quantities of several other species (Joint Subcommittee on Aquaculture, 1983). Virtually all sportfishery production of trout and salmon come from state-supported aquaculture programs.

During the 1970's numerous technological breakthroughs have increased the potential of aquaculture in the United States: the development of net-pen culture and ocean ranching of salmon in the Pacific Northwest; the establishment of abalone culture in California; the introduction of Malaysian prawn culture to Hawaii; the improvement of raft culture of blue mussels and oysters in New England; the proliferation of oyster hatcheries in the Pacific Northwest and the Atlantic states; and the establishment of marine shrimp farms in Central America and in this country by U.S. firms.

Table 3: U.S. Private Aquaculture Value and Production Data for 1980 and 1986

Species groups	Value (\$1000)		Thousands of pounds ¹		Percent of total	
	1980	1986	1980	1986	1980	1986
Baitfish ²	44,000	51,522	22,046	25,047	10.9	4.0
Catfish	53,572	228,886	76,842	326,979	37.8	52.7
Clams	2,295	8,307	561	2,506	0.3	0.4
Crawfish	12,951	48,750	23,917	97,500	11.8	15.8
Freshwater prawns	1,200	893	300	178	0.1	<0.1
Mussels	NA	1,725	NA	1,206	-	0.2
Oysters	37,085	42,797	23,755	24,090	11.7	3.9
Pacific salmon	3,400	32,751	7,616	74,399	3.7	12.0
Shrimp	NA	3,408	NA	1,354	-	0.3
Trout	37,474	55,590	48,141	51,000	23.7	8.2
Other Species ³	NA	21,700	NA	15,500	-	2.5
Totals	191,977	496,329	203,178	819,959	100.0	100.0

(Source: U.S. Department of Agriculture, 1988)

¹ Data shown are live weight harvests, except for oysters, clams and mussels which are meat weight. Excluded are eggs, fingerlings, etc., which are an intermediate product level.

² Not used for food consumption.

³ Includes species such as sturgeon, paddlefish, carp, tilapia, mullet, abalone, etc.

NA = not available

Annual aquacultural production in this country is about three percent of U.S. fishery landings or two percent of total consumption of fishery products. In 1987, U.S. private aquaculture production had an estimated value of \$650 million and a retail value of more than \$1 billion (Table 3; USDA, 1988). The National Research Council estimates that with proper support, production could reach 1.2 million tons by the year 2000 (in USDA, 1988).

POTENTIAL OF AQUACULTURE

Demand for seafood products nationwide is increasing while the capacity to meet this demand by traditional fishery methods is declining. At the same time, the per capita annual consumption of fish products continues to reach record highs; in 1987, the average American consumed 20.2 pounds of seafood (USDA, 1988). Rates of consumption increased 18 percent over the past seven years. Meanwhile many traditional world fishery stocks have been declining or have collapsed due, at least in part, to overfishing. For example, the aquaculture production of shrimp increased 75 percent between 1979 and 1983 while the fishery catch of shrimp increased only seven percent over the same period. All of which suggest that seafood prices will increase for the foreseeable future.

There are several other factors that suggest that aquaculture will become an important and profitable venture in the near future. The United States is a major consumer and importer of luxury seafoods. In 1987 the net trade deficit in seafood products was \$6.1 billion (U.S. Department of Commerce, 1988). This deficit can be expected to worsen since the major fishery export of the United States was salmon, which is threatened by imports of Norway and Scotland's cultured Atlantic salmon (cultured salmon are generally preferred to fished salmon because the cultured product is of uniform size and quality and is typically fresher). Therefore, the United States can expect stiff competition from foreign aquacultured products in the future, a situation which could deepen our trade deficit in these commodities. These trends represent major opportunities for aquaculturists both domestically and abroad.

The advantages of aquaculture over traditional fisheries are significant. Even relatively primitive culture practices involving little technology and limited control have advantages over traditional harvesting practices. Some of these advantages include: (1) efficiency - controlled cultivation can provide significant savings in time and effort and a reduction of capital investment and operative costs; (2) absolute production - the application of intensive culture techniques can increase fishery harvests many times over; (3) ecosystem enhancement - rather than exploiting natural stocks and often damaging habitat by intensive harvesting practices, aquaculture can supplement natural resources and in many cases co-exist with critical wetland and other aquatic habitats; and (4) high product quality and the ability to "tailor" product to market demands.

As mentioned with salmon, the capacity for aquaculture to deliver a uniform, high-quality product has provided a competitive edge in many markets. This, coupled with the capacity to harvest cultured crops when market prices are greatest, lends aquaculture important advantages over traditional fisheries. Additional reliance upon cultured products can be expected since there are increasing political pressures in most states from environmental concerns and sportsmen's groups to restrict conventional commercial fishing. These trends indicate that aquaculture will be an expanding industry in the near future.

INCREASED INTEREST IN AQUACULTURE

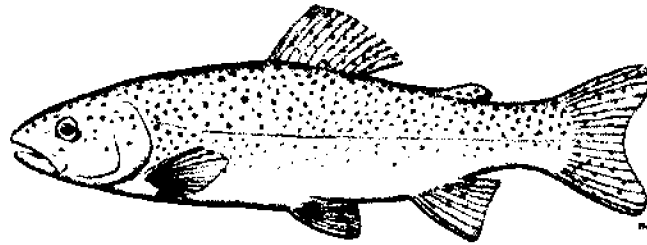
At the federal level, some of the first legislation addressing aquaculture was the 1871 act creating the U.S. Commission of Fish and Fisheries. One of the first pieces of federal legislation to mention aquaculture specifically was the National Sea Grant College and Program Act of 1966 (33 USC sec 1121 et seq.), which recognized "that aquaculture, as with agriculture on land, . . . can substantially benefit the United States" (33 USC sec 1121 (c)) (Newton, 1978). Other early federal legislation concerned propagation of mussels (16 USC 750-751 in 1922) and the establishment of the Milford, Connecticut federal shellfish research laboratory (16 USC 760h in 1961).

The Agricultural Research Act of 1977 (signed into law as 7 USCA sec 3122) gave the U.S. Department of Agriculture (USDA) responsibility to coordinate, identify, and fund agricultural research and extension needs. Aquaculture is specifically mentioned as one of the research areas in the USDA Competitive Awards Program. Although the USDA initiated some research, it had been limited by funds and primarily focused on freshwater species (Newton 1978). More recently, however, USDA has been appropriating significant resources to research and development of species such as penaeid shrimp and hybrid striped bass.

The first United States law to specifically address the problem of and need for aquaculture development in this country and the coordination of federal government support is the National Aquaculture Act of 1980. In its "Findings," Congress recognized the potential for aquaculture to expand in the U.S. and fill the need for increased fishery products, leading to a decrease in the trade deficit. While Congress affirmed that the primary responsibility for the industry's development rests with the private sector, the legislators found that the industry has been inhibited by many economic, legal, and regulatory factors.

The 1980 Act established a national policy to encourage aquaculture in the United States and called for a national development plan to be put together by the Secretaries of Agriculture, Commerce, and Interior (Joint Subcommittee on Aquaculture, 1983), and for a continuing assessment of aquaculture in the United States thereafter by the three Secretaries. As prescribed by the law, the Secretaries have conducted studies of the capital requirements for the aquaculture industry as well as of regulatory constraints on industry development. In addition, all aquacultural support activities are coordinated through an interagency coordinating group, operating as the Joint Subcommittee on Aquaculture of the Federal Coordinating Council on Science, Engineering and Technology.

The National Aquaculture Act of 1980 was reauthorized as the National Aquaculture Improvement Act of 1985. The Secretary of Agriculture has been placed in a lead role with respect to coordination and implementation of various functions of the federal government under the Act. It also establishes and outlines the functions and operations of a National Aquaculture Information Center. The Act authorizes appropriations of \$1 million for the U.S. Department of Agriculture (USDA), \$1 million for the U.S. Department of Commerce (USDOC), and \$1 million for the U.S. Department of the Interior (USDOI) in each of fiscal years 1986, 1987, and 1988. This represents a \$1 million annual reduction of the existing authorization levels for USDA and USDOC and level funding for USDOI. However, appropriations have not been made in accordance with authorized levels.



II. AQUACULTURE IN SOUTH CAROLINA

HISTORY OF AQUACULTURE

Freshwater Aquaculture

Aquaculture is by no means restricted to commercial food production. Fish hatcheries have been utilized in South Carolina since the early 1900s to produce a variety of freshwater gamefish for stocking in public waters to supplement "wild" stocks. In 1948, the South Carolina Game and Fish Department had in operation ten fish hatcheries producing largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis microchirus*), shellcracker (*Lepomis microlophus*), redbreast (*Lepomis auritus*), smallmouth bass (*Micropterus dolomieu*), brown trout (*Salmo trutta*), and rainbow trout (*Salmo gairdneri*).

By 1960, the U.S. Fish and Wildlife Service had constructed and was operating three fish culture facilities in South Carolina: Walhalla, Cheraw, and the Orangeburg National Fish Hatchery. As of 1982, the Cheraw and Orangeburg National Fish Hatcheries were supplying largemouth bass, bluegill, shellcracker, and channel catfish (*Ictalurus punctatus*) fingerlings for 80 percent of the private pond stockings in South Carolina (a total of 1,200 ponds stocked annually). In addition, both hatcheries supplied fish to the S.C. Wildlife and Marine Resources Department for fish stocking enhancement programs in state waters.

In 1983 the U.S. Fish and Wildlife Service, under a restructuring of priorities within its hatchery program, leased the Cheraw Hatchery to the South Carolina Wildlife and Marine Resources Department and drastically changed the fish production requirements at the Orangeburg Hatchery. The Orangeburg National Hatchery's present production goals are to produce, distribute and stock striped bass (*Morone saxatilis*), hybrid striped bass, redbreast, and shortnose sturgeon (*Acipenser fulvescens*) to public waters for stock enhancement. The Walhalla Hatchery continues to produce rainbow, brown, and brook trout (*Salvelinus fontinalis*).

The construction of the Dennis Wildlife Center in Bonneau, South Carolina in 1972 by the S.C. Wildlife and Marine Resources Department, and the subsequent culture and rearing of striped bass and hybrid bass, increased state fish production of these two fishes to more than 1.5 million fish per year. The added production of these valued freshwater gamefish doubled the number of fish provided to the department's stock enhancement programs annually. Public and private demands for these fish are presently being met from the state and federal fish hatchery systems. The private production of freshwater gamefish species has been almost non-existent in South Carolina when compared to that of other Southeastern states.

Aquaculture, from a private fish hatchery perspective in South Carolina, has been limited to the production of "bait" fish species, "ornamental" fish species, trout and a fledgling channel catfish industry.

Marine Aquaculture (Mariculture)

Oysters One of South Carolina's earliest references to aquaculture recalls Charleston's once famous "Mill Pond Oyster." However, a lack of understanding about the life cycle of the Mill Pond Oyster eventually led to its disappearance in the 1870s.

Nevertheless, the suitability of South Carolina's coastal environment for oyster cultivation led to additional experimentation. By 1890, a number of successful commercial endeavors were underway in Winyah Bay, Bull's Bay, Santee Pass Creek, Lighthouse Creek near Folly Island, and in Bailey Creek near Edisto. The Maggioni Oyster Company of the Beaufort and Savannah area is an outgrowth of some of these early endeavors in oyster cultivation. Extensive cultivation techniques included the planting of seed oysters and shell, and culling of the beds for predators.

Oyster cultivation was encouraged by the S.C. Board of Fisheries, which was created in 1906. Mandating in 1908 that a percentage of harvested shells be replanted, the Board claimed to have been successful in doubling the average weight per bushel in three years. Extensive cultivation, including the replanting of shell and regulation of harvest, has kept the oyster industry alive in South Carolina despite the closing of many areas because of coastal pollution.

Shad The center of South Carolina's shad fishery has traditionally been in the Winyah Bay area. When the S.C. Board of Fisheries was formed, the shad fishery was second only to oysters in commercial importance. Catches were generally good until the 1920s, when the Board of Fisheries began to express concern over the effects of increased coastal growth on the indigenous shad population. Pollution of spawning waterways by sawmills, sewage outfalls, and an alcohol plant was partly blamed for the declining population. Anchored nets offshore were thought to cause unnecessary waste when fish were snagged and lost to predators in irregularly harvested nets.

In 1929, at the request of the Board of Fisheries, the State Legislature granted funds for the construction of two hatcheries, one on the Edisto River at Jacksonboro and one on the Black River above Georgetown. Both were operational in 1930, and were run in cooperation with the U.S. Bureau of Fisheries. At that time, the S.C. Board of Fisheries encouraged the use of abandoned rice fields as shad nurseries to increase survival rates. The U.S. Bureau of Fisheries recognized South Carolina as a leader in this type of shad aquaculture.

Despite the success of the Edisto hatchery (the Black River hatchery was closed because of excessively saline waters), the Board of Fisheries was still concerned about the declining shad fishery. In the 1890s, the State had a shad catch of about 600,000 pounds annually; by 1932, the catch dropped to approximately 125,000 pounds.

Calling for stricter regulation of the fishery again in 1940, the Board of Fisheries decided to close the Edisto hatchery, since it appeared that even with the stock enhancement program, shad numbers were significantly dropping. In 1949, the Board reported: "Shad fishing has nearly disappeared in the State."

Today, however, South Carolina's shad fishery harvest averages approximately 250,000 pounds per year. Although indications are that the population is once again stable, other fisheries have superseded the shad fishery in commercial importance. There are no shad hatcheries currently operational in South Carolina.

PRESENT STATUS OF AQUACULTURE

Private Production - Freshwater Species

South Carolina has the resources - land, water, climate and human - to become a leading aquaculture-producing state. Development of commercial catfish and crawfish farming on a good portion of the 50,000-plus farm ponds in South Carolina has the potential to supplement declining farm revenues. There are approximately 35,000 acres of suitable commercial catfish and crawfish sites in South Carolina. Additionally, a significant number of the 70,000 acres of impounded rice fields have potential for crawfish farming.

Catfish In 1986 a research project was conducted to determine the current level of catfish production in South Carolina (Pomeroy and Kahl, 1987a). The research revealed that 40 catfish producers were part-time and approximately 20 of them sold catfish commercially. In 1985-86, about 200 acres of catfish ponds were in production, with an additional 13 acres of brood fish ponds and 30 acres of fingerling ponds. Both extensive and intensive (cage culture) systems were used. Production in the commercial ponds averaged 1,000 pounds per acre. It was estimated that the total production of catfish in South Carolina in 1985-86 was approximately 200,000 pounds, with an estimated total value of about \$170,000 (the total value figure includes the estimated value of fingerling sales). During this period the producer price received for live catfish ranged from \$0.70 to \$0.90, with an average price of \$0.78. This price was slightly higher than the national average price paid to producers (\$0.74).

In 1988, South Carolina became home for a major integrated production/processing catfish operation. Located in Estill, SC (Hampton County), the Lowcountry Aquaculture Corporation plans to construct 1,000 acres of ponds and a processing plant. Already, the facility is producing fish: expectations are that some 20,000 pounds of liveweight catfish per day will be initially processed.

Catfish production increased significantly since 1986 (Pomeroy, 1988). An estimated 400,000 pounds of fish were produced, with an estimated value of \$300,000. More than 200 producers were involved in the industry, raising catfish in some 500 acres of ponds. Production per acre averaged 4,500 pounds. It is expected that as current producers gain more experience growing catfish, yields will increase.

Pomeroy (1988) predicts that 1989 will be an expansion year for the catfish industry in South Carolina because of the increased availability of processing, agribusiness support, and fingerlings and feed.

Crawfish In 1986, crawfish remained South Carolina's largest aquaculture industry. A survey of crawfish producers conducted in 1986 (Pomeroy and Kahl, 1987b) revealed that there were 39 crawfish producers in South Carolina, located in 22 counties. All of the current producers were part-time. It was estimated that there were 825 acres of stocked ponds in 1986 with a total production of 400,000 pounds of crawfish valued at \$460,000. Average yields in 1986 were 565 pounds per acre. Stocked ponds increased by about 50 acres during the year. Total production was also up from 1985, due primarily to improved management practices by producers. Again this year, South Carolina prices were much higher than those received by Louisiana producers; the average S.C. price was \$1.45 per pound, while Louisiana producers got \$0.20 to \$1.00.

In 1986, according to the crawfish producers, demand for South Carolina-produced crawfish exceeded the supply. Since there were no crawfish processing facilities in the state, all crawfish were sold as live, whole animals. Approximately 70 percent of the production was sold directly from the producer for in-state consumption. Much of this went to local restaurants, crawfish festivals, fish markets, and to individuals buying at pondside. The remaining 30 percent was shipped out-of-state to markets in the Baltimore and Washington, D.C. area, and as far away as Chicago.

In 1988, over 1,100 acres of crawfish were harvested in South Carolina, an increase of 10 percent over 1987 (Pomeroy 1988). Some 35 commercial growers accounted for this production. More than 500,000 pounds of crawfish were harvested, with a value of about \$600,000; yields averaged 550 to 600 pounds per acre. Prices received ranged from \$1.00 to \$1.50 per pound for live, whole animals, remaining higher than Louisiana, but lower when compared to the \$1.75 received in North Carolina and \$2.00 in Maryland.

Consumer interest in crawfish both within and outside the state will remain high with markets continuing to expand. More South Carolina crawfish continue to be shipped out-of-state to serve these expanding markets.

Other Species There are several other freshwater aquaculture species being grown in South Carolina, including about 20 acres of carp, 5 acres of tilapia (*Tilapia* spp.), 5 acres of trout, and 3 acres of freshwater prawns (*Macrobrachium rosenbergii*). A map showing species cultured by county is presented in Figure 1.

Private Production - Marine Species

Penaeid Shrimp Interest in penaeid shrimp mariculture continues to grow in South Carolina. Shrimp production is concentrated in the Edisto/Charleston and Georgetown areas. There are currently five producers using intensive/semi-intensive (active feeding and management) systems in the state, and five producers using extensive (low tech, no feeding) systems. The intensive producers are averaging yields of nearly 6,000 pounds per acre in a total of 40 acres of ponds, semi-intensive producers are getting about 2,000 to 4,000 pounds per acre in 160 acres of ponds and the "extensive" producers are getting yields of 1,500 pounds or less per acre in 80 acres of ponds (Pomeroy 1988).

There are approximately 280 acres of ponds and another 1,700 acres of impoundments in private intensive, semi-intensive and extensive culture with a total pro-

Figure 1. Aquaculture Production by County in South Carolina



duction of about 560,000 pounds and a value of almost \$1,120,000. The average price received for whole shrimp ranged from \$1.50 to \$2.50 per pound. The producers are receiving a premium price for their shrimp of about \$0.10 to \$0.25 per pound more than wild-caught or imported shrimp. The shrimp are marketed directly to retail outlets, such as grocery stores and restaurants, and through existing shrimp marketing channels. In addition, several producers contracted with out-of-state processors, and also used IQF (individual quick freeze) processing for sale through existing markets.

It is expected that the shrimp mariculture industry in South Carolina will expand slowly in the coming year. New acreage will be added and private farm yields will continue to increase as producers gain more experience and use higher stocking densities and routine aeration. While prices have increased in the past, it is expected that prices for shrimp will stabilize. Producers have established their own market for their cultured shrimp and these markets, primarily for a fresher, higher quality product, will expand.

Hard Clams Few marine species are as well suited as hard clams for commercial aquaculture development in South Carolina. Although no large-scale commercial clam culture exists within the state at present, one large company is seeking a location for such a facility, and several independent clambers are field testing various growout techniques on mariculture leases with hatchery-produced seed clams. A commercial pilot-scale hard clam mariculture operation was initiated in August 1980 and together with the state (through the SCWMRD-Marine Resources Division and the S.C. Sea Grant Consortium) developed appropriate nursery and field growout techniques for hard clam culture in coastal waters. Unfortunately, the company experienced severe financial setbacks in 1983 when planned levels of capitalization were not realized. However, through this cooperative activity a successful hard clam mariculture protocol was developed for South Carolina.

The potential for hard clam mariculture is strong. Current research is geared to enhance the biological and technological potential of the hard clam; however, a number of legal and institutional problems must be resolved before significant investment occurs.

Public Aquaculture Production

During 1986, 4,790,827 fish (Table 4) were produced at South Carolina Wildlife and Marine Resources Department (SCWMRD) freshwater hatcheries and 1,218,750 fish (Table 5) were produced at U.S. Fish and Wildlife Service (USF&WS) freshwater hatcheries. Table 6 provides a list of the SCWMRD fish stock enhancement programs conducted during 1986.

In addition, some 40,000 channel catfish fingerlings were produced by Clemson University that same year and used primarily for research and education purposes.

POTENTIAL FOR AQUACULTURE DEVELOPMENT

South Carolina is well suited for aquaculture. Along the coast, a portion of the 200,000 acres of estuarine area and 70,000 acres of wetland impoundments are potentially available as production sites. The mild climate makes the culture of warm-water species feasible. Freshwater supply from rainfall, ground and surface waters is ample, and 70 percent of the state's soils are rated as fair or good for pond construction (Figure 2; Foltz and Smith, 1983).

Table 4: SCWMRD Freshwater Fish Hatchery Production for 1986

Species	Fingerlings Produced
Largemouth Bass	404,000
Bluegill-Shellcracker	2,200,000
Channel Catfish	43,200
Blue Catfish	8,415
Smallmouth Bass	2,867
Striped Bass	1,761,709
Hybrid Bass (white bass x striped bass)	<u>370,636</u>
Total Fish Production	4,790,827

Table 5: U. S. Fish & Wildlife Service Hatchery Production in South Carolina - 1986

Species	Number Produced for Stocking ¹
Redbreast	273,000
Striped Bass	381,620
Bluegills	111,200
Short-nose Sturgeon	30
Brown Trout	204,800
Rainbow Trout	<u>248,100</u>
Total Fish Production	1,218,750

¹These fish were utilized for: (1) stock enhancement programs (public waters); (2) "put and take" stocking (public waters); and (3) private pond restocking.

Criteria for fish stock enhancement programs (SCWMRD and USF&WS) are: (1) stocking of species where natural reproduction success is non-existent or impaired; (2) stocking of species as mitigation, where federal or state projects have impacted on the fishing; (3) stocking of species to replenish a fish population affected by a fish kill, pollution, etc.; (4) stocking to introduce a fish species not native to the fishery; and (5) stocking to maintain or improve an existing endangered fish species population.

Climate

There are some geographical areas in the state better suited than others for aquaculture due to climatic conditions (Foltz and Smith, 1983). Regions with longer growing seasons (temperatures above 61°F [16°C]) are preferred. However, climate is not a limiting factor for commercial aquaculture operations in most of South Carolina (Figure 2a).

Records from the Office of the State Climatologist indicate that for areas along the coast, 61°F temperatures start about April and end at the beginning of November. For the middle part of the state, 61°F temperatures start around April 5 and end about October 26. This is a six- to seven-month growing season which suits most of the current aquaculture species being produced, although it is far from optimal.

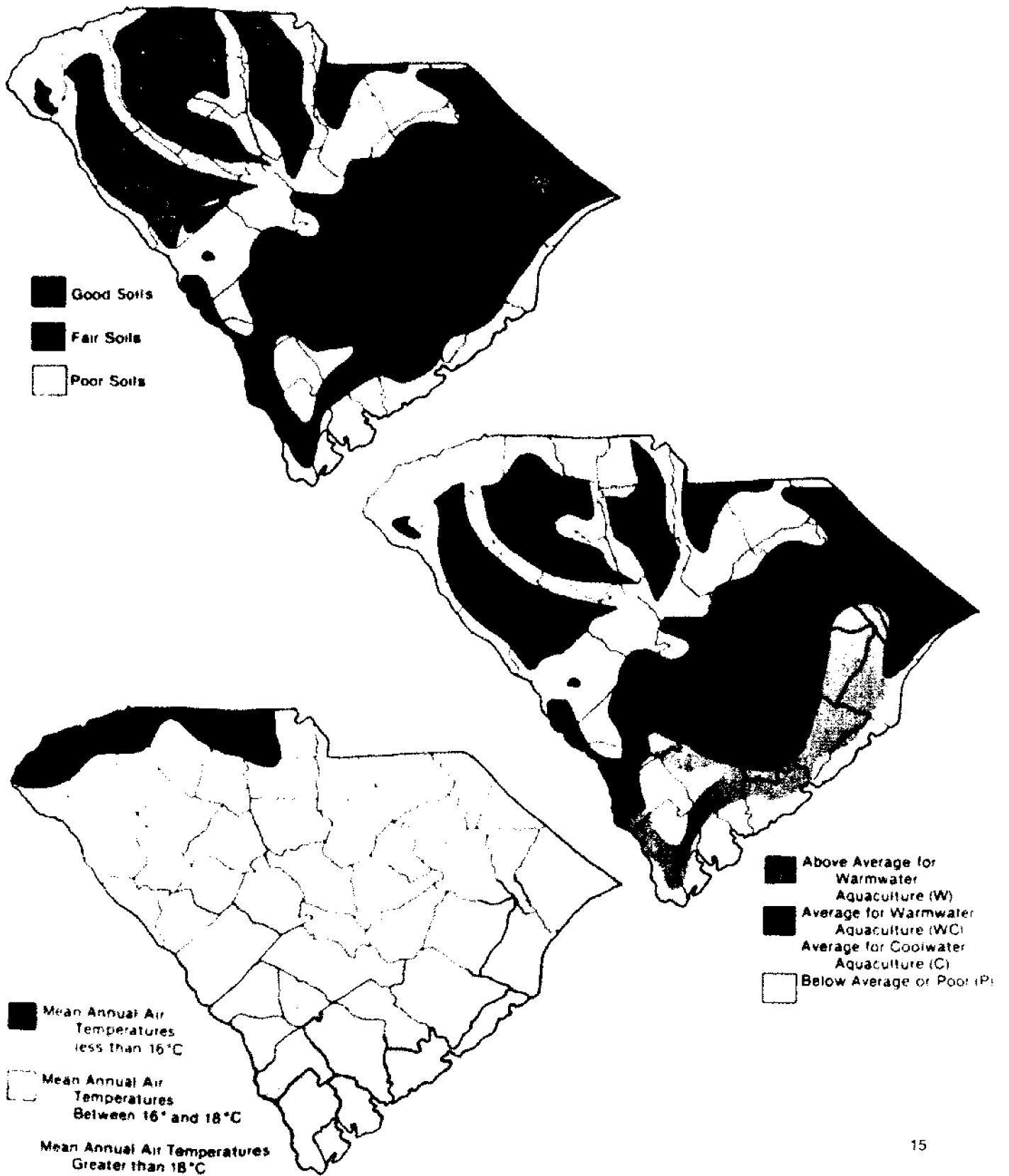
Primary factors influencing temperature in South Carolina are elevation, latitude, and distance inland from the coast (Foltz and Smith, 1983). These variables cause average annual temperatures in the state to range from 52°F at Caesars Head in the Blue Ridge Mountains to 66°F along the southern coast.

Table 6: SCWMRD Fish Stock Enhancement Programs Conducted During 1986

STOCKING LOCATION	SPECIES	NUMBER OF FISH STOCKED
Lake Hartwell	Hybrid Bass	282,991
Clarks Hill	Hybrid Bass	87,645
Lake Secession	Striped Bass	198,090*
Lake Wateree	Striped Bass	687,076*
Lake Murray	Striped Bass	228,360
Lake Moultrie	Striped Bass	735,663*
Santee River	Striped Bass	154,558
Cooper River	Striped Bass	42,698*
Catawba River	Striped Bass	40,000
Saluda River	Striped Bass	4,224*
Combahee River	Striped Bass	16,123*
Edisto River	Striped Bass	9,592*
Ashepoo River	Largemouth Bass	7,900
Edisto River	Largemouth Bass	9,000
Waccamaw River	Largemouth Bass	22,500
Scraphole Swamp	Largemouth Bass	5,000
Lake Murray	Largemouth Bass	24,750
Saluda River	Largemouth Bass	30,000
Appalache Lake	Largemouth Bass	5,000
Pea Dee River	Bluegill-Shellcracker	200,000
Lake Eureka	Bluegill-Shellcracker	25,000
Lake Dogwood	Bluegill-Shellcracker	10,000
Tyger River	Bluegill-Shellcracker	12,500
Enoree River	Bluegill-Shellcracker	12,500
Hollow Creek	Bluegill-Shellcracker	80,000
Lake Cherokee	Blue Catfish	450
Wateree River	Blue Catfish	15,700
Lynches River	Blue Catfish	425
Lake Ashwood	Blue Catfish	600
Lake Wallace	Blue Catfish	2,000
Lake Brown	Blue Catfish	400
Lake Warren	Blue Catfish	600
Lake Long	Blue Catfish	500
Lake Koowee	Smallmouth Bass	2,867
N Edisto River	Redbreast	126,000
S. Edisto River	Redbreast	63,000
Cooper River	Shortnose Sturgeon	301
	Total	3,224,242

* Full or partial assistance in stocking from the Orangeburg National Fish Hatchery.

Figure 2. Natural Resources Potential for Aquaculture



Because of the generally mild temperature regime found in the state, the culture of warm-water species has great potential. Aquaculture of cold-water species (e.g., trout) can be successful in the Blue Ridge and Foothills of the Upstate. Additionally, ponds in the Piedmont and Upper Coastal Plains can be used to culture coldwater fishes from late fall to early spring.

Land Resources

Topography and soils are important considerations for aquaculture development (Foltz and Smith, 1983). A gently sloping topography with soil characteristics suitable for embankments or dikes are usually sought. Embankments require soil materials resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength, and compaction characteristics. The presence of stones or organic material in a soil are among factors that are unfavorable. Approximately 70 percent of the soils in South Carolina have a good or fair potential for pond embankment construction (Figure 2b).

Water Resources

Aquaculture requires a source of high quality water to ensure healthy and marketable products. Where most industries must undertake significant measures to meet water quality standards, aquaculture operations can almost be a guarantee that adjacent water quality will be maintained.

South Carolina receives a mean annual rainfall of at least 40 inches throughout the state, reaching 68 inches in the Blue Ridge Mountains. Much of this water runs off the surface and eventually finds its way into the state's watersheds. A large part of the remainder is lost to the atmosphere through evapo-transpiration, and some makes its way downward to replenish aquifers.

Surface Water South Carolina is divided into four major river basins: the Pee Dee, Santee, Ashley-Cooper-Edisto, and Savannah. In addition to its flowing waters, there are about 596,000 acres of large inland lakes, 70,400 acres of wetland impoundments, and over 50,000 small, privately-owned ponds and small lakes. These water resources provide ample opportunities for aquaculture development in South Carolina.

The bay and estuarine waters in the State have considerable aquaculture potential. Over 216,000 acres of these highly productive environments are found along the coast. These waters, which are extremely important in the life cycle of numerous commercially and recreationally-valuable fish and shellfish, could in many cases be used by aquaculturists.

The coastal waters are of high quality. The S.C. Department of Health and Environmental Control's (SCDHEC) biennial water assessment states that of the state's coastal waters, 79 percent are designated Class SA and SAA, 9 percent are Class SB; and 12 percent are Class SC (Classes SB and SC are not suitable for shellfish harvesting) (Knowles, 1988). Of those waters designated Class SA or SAA (protected for shellfish harvesting), 94% are unconditionally approved for shellfish harvesting (See Table 7).

Ground Water Ground water conditions in the Sandhills and Coastal Plain contrast sharply with those in the Piedmont and Blue Ridge. Greater yields can be anticipated in the Sandhills and Coastal Plain and depths to these anticipated yields can be more nearly predicted.

Chemical content in waters from the Coastal Plain is more diverse than from the

Blue Ridge or Piedmont, with various amounts of iron, calcium, fluoride, chloride or other constituents being recorded.

Currently, South Carolina has several designated capacity-use areas (Horry, Georgetown, Colleton, Beaufort and Jasper Counties) where a permit from the S.C. Water Resources Commission is required before substantial amounts of ground water can be withdrawn (See Section III). Aquaculture developments require large amounts of water. In capacity-use areas, prospective aquaculturists should be particularly aware of the quantity and quality of ground water available.

Economic and Employment Opportunities

The current financial crisis facing agriculture in South Carolina and throughout the United States has had many farmers looking at alternatives to traditional agriculture. Aquaculture has been seen as a viable alternative for farmers and as a profitable single enterprise investment.

Markets for aquaculture products are currently expanding. Increasing concern about nutrition has Americans substituting fish for red meat in many diets. The popularity of catfish has increased not only in the South but throughout the nation. Interest in Southern cooking, particularly Cajun-style, is on the rise, leading to more recipes using catfish, redfish and crawfish. Foreign markets, especially in Western Europe, are also expanding for catfish and crawfish. The growing consumer demand for shrimp ensures a ready market for the farm-raised product.

Aquaculture is also compatible with rural economies and life-styles. Its basic nature is very similar to agriculture and, thus, is compatible with traditional economic activities in many rural areas. Also, aquaculture can be conducted on land that is not suited for agriculture, and fish have a much higher feed-to-meat conversion ratio than do other livestock or poultry commodities. Aquaculture is generally compatible with the environment, causing relatively minor environmental impacts.

Aquaculture can become a major income and employment generating sector in many rural areas. For example, it is estimated that the production of every 4.8 tons of catfish requires one full-time job. It is also estimated that many private farm ponds in South Carolina have the potential of producing positive profits for farmers and landowners. Thirty-five thousand acres of suitable commercial catfish sites have been identified in South Carolina, representing over \$100,000,000 of potential income if fully developed (Pomeroy, pers. comm.). These estimates are only for one species, but a variety of species are compatible for production in fresh-, brackish- and salt-water environments in the state.

Aquaculture is not just a production industry. As it expands, other support services will develop. These will include processors, wholesalers, feed mills, equipment manufacturers and suppliers, and others. A conservative estimate indicates that aquaculture and related businesses could generate more than 3,800 jobs in the state by 1993 (Rhodes and Pomeroy, unpublished report, 1988). While aquaculture will bring direct economic benefits to the state from production of various fish and shellfish species, the indirect or secondary benefits will be equally substantial.

Table 7: Water Quality Standards for Tidal Salt Waters (DHEC Regulation 61-68, 1985)

Item	Class SAA	Class SA	Class SB	Class SC
Refuge, garbage oil, ashes or sludge dumping	Prohibited	Prohibited	Prohibited	Prohibited
Treated & toxic wastes, or thermal discharges	Prohibited	Cannot harm shellfish	Cannot impact primary use	Cannot impact primary use
Dissolved Oxygen Content	Natural levels only	mean >5mg/l min >4mg/l	mean >5mg/l min >4mg/l	>4mg/l
Organisms of Coliform Group ¹	Natural levels only	mean MPN <70/100ml max MPN <230/100ml	mean MPN <200/100ml max MPN <400/100ml	mean MPN <1000/100ml max MPN <2000/100ml
Acceptable pH Range	Natural levels only	No more than + 0.3 unit from natural level	No more than + 0.5 unit from natural level	No more than + 1.0 unit from natural level
Temperature Limit	Natural levels only	As proscribed by permit	As proscribed by permit	As proscribed by permit
Turbidity Limit	Natural levels only	As proscribed by permit	As proscribed by permit	As proscribed by permit

Description of Classification and Uses:

- SAA - Outstanding recreational or ecological resource waters suitable for uses that require absence of pollution
 - SA - Suitable for harvesting of shellfish for human consumption
 - SB - Suitable for primary contact recreation
 - SC - Suitable for secondary contact recreation, crabbing and fishing.
- ¹MPN = most probable number

THE FUTURE OF AQUACULTURE IN SOUTH CAROLINA

Promising Species

It is believed that hard clams and hybrid striped bass will be incorporated into full-scale production within an immediate- to near-term timeframe. Production of cultured species of penaeid shrimp, catfish and crawfish, discussed earlier, could be increased within the same time frame.

Penaeid shrimp culture in the state is moving towards full commercialization. As mentioned, three major types of culture techniques are employed: extensive, semi-intensive, and intensive pond culture. The Waddell Mariculture Center recently demonstrated intensive culture yields in excess of 20,000 pounds per acre of whole shrimp. To raise shrimp on such an intensive basis is expensive; large companies appear best positioned to culture shrimp in this fashion. The Waddell Mariculture Center is targeting research toward increasing yields via intensification and genetic improvement of stocks. Ten shrimp operations of varying intensity are in production today.

Hard clams are excellent candidates for aquaculture in the state's warm, highly productive coastal waters. Demand for hard clams is high and prices have increased due to a decline in production from natural stocks in many areas. Aquaculture technology for the hard clam is well-established and profitability appears high as evidenced by successful enterprises in other sections of the country. The present status of development in South Carolina is at the demonstration/pilot plant level, although a major firm is exploring commercialization at the present time. Genetics researchers are attempting to improve brood stocks and create faster growing clams.

Striped bass is nationally recognized as an excellent food fish with high market demand. The striped bass hybrid (striped bass X white bass cross) can be grown in a broad range of environmental conditions. Research to date has focused on all aspects of the production cycle, including development of domesticated brood stock, nursery and grow-out systems, and marketing and processing characteristics. The hybrid fish is an excellent candidate for aquaculture development now that political concerns and legal barriers concerning its gamefish status are being resolved.

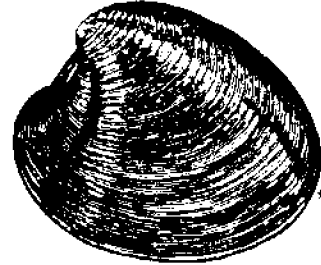
Other Species

There are many species that offer good aquaculture potential and could be exploited. The success of these species depends upon the establishment of a stable aquaculture industry in the near-term. Constraints upon development fall within two broad categories: limited market potential and limited culture technology not yet ready for commercial implementation. Species that offer limited market potential are those that currently appeal only to a small portion of the population or have specialized uses, such as aquatic weed control, stock enhancement, etc. Species that fall into this category include: grass carp, tilapia (nile perch), freshwater prawn, sturgeon, and marine bait. Species that require additional research before they may be fully exploited on a commercial scale include: largemouth bass (currently designated a gamefish and therefore illegal to sell), spotted seatrout (*Cynoscion nebulosus*), redfish or channel bass (*Sciaenops ocellata*), shortnose and Atlantic (*Acipenser oxyrinchus*) sturgeon, blue crab (including soft-shell), bay scallop (*Argopectin irradians*), and American oyster.

Table 8 presents an informal summary of the aquaculture development potential of selected species in the near- and long-term.

Table 8: Aquaculture Development Potential of Selected Species in the Short and Long Term

Species	Short Term (to 2000)		Long Term (beyond 2000)	
	Low	High	Low	High
Freshwater Finfish:				
Grass Carp	X			X
Titapia	X		X	
Trout		X		X
Largemouth Bass	X		X	
Striped Bass Hybrid	X		X	
Channel Catfish		X		X
American Eel	X		X	
Shellfish:				
Freshwater Prawns	X		X	
Hard Clam Hybrid		X		X
American Oyster	X		X	
Bay Scallop	X		X	
Blue Crab (Soft-Shell)	X		X	
Shrimp		X		X
Crawfish		X		X
Marine Finfish:				
Spotted Seatrout	X		X	
Redfish		X		X
Sturgeon	X		X(?)	
Striped Bass Hybrid	X		X	
Dolphin (Mahi-Mahi)	X		X	
Bottom Fishes	X		X	
Marine Baitfish:	X(?)		X(?)	
Other Species:				
Alligator	X		X	



AQUACULTURE: THE REGULATORY ENVIRONMENT

INTRODUCTION

Aquaculture may involve the use of the water column and/or underlying bottom of a water body. It also requires an onshore base of operation. In some cases, aquaculture ventures require 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. These requirements illustrate the uniqueness of aquaculture as a relatively new use of coastal and inland waters, and also the problems facing the new industry as it seeks to become established in South Carolina.

The complexity of the permitting process varies with respect to the type of waters in which the aquaculture operation will be conducted - fresh, brackish, or salt water - and the geographic location of the operation - highland or open water culture (see, for example, DeVoe and Whetstone, 1987). Highland, freshwater culture of catfish, minnows, freshwater prawns, and trout in farm ponds and tanks does not involve the public domain and requires relatively 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 yet been practiced to any extent in South Carolina. The use of the inherent productivity found in fresh-, brackish-, and salt-water impoundments (presently managed and with no ownership-related problems) offers some degree of opportunity as culture systems for crawfish, blue crabs, penaeid shrimp, and several species of finfish. The permitting process for the use of actively-managed impoundment systems for aquaculture is relatively problem-free. However, extant leasing and ownership questions in open marshland, partially-diked impoundments, and open coastal waters make permitting of aquaculture in these areas considerably more challenging.

ACCESS TO STATE LANDS AND NAVIGABLE WATERS

Shellfish Leases

Unless aquaculturists have a property interest in the area in which they wish to establish their operations, the law will provide little, if any protection (Owen, 1978). Although the federal government may frequently impose constraints on aquaculture development through its interests in navigation and pollution control (among others), the property rights of aquaculturists rest primarily with the state. Lease arrangements are a form of property interest most often granted by states to confer certain rights. The conditions upon which a lease is issued determine to a large extent the degree to which an aquaculturist has protection, and the associated "costs" of such protection. This "level of exclusivity" is a major factor in the decision of an entrepreneur or corporate entity to engage in such a high-risk industry as aquaculture.

Another important factor in leasing provisions is the type of area that may be leased. A major limitation to existing legislation in many states is that it only provides for leasing water bottoms (submerged lands), and does not address the water column (Owen, 1978; DeVoe and Mount, in press). This situation does not recognize the advances made in aquaculture technology; the potential of raising finfish in net pens and shellfish in floating rafts or on hanging strings greatly expands an area's productivity by utilizing both the bottom and water column. Additionally, most submerged lands legislation does not acknowledge other water-based activities which could negatively impact culture systems found on the bottom.

Two other considerations require mention. Under leasing provisions, certain guarantees should be included that protect an existing aquaculture operation from the siting of an operation which could affect the water quality of the area, and potentially the aquaculture operation itself. The duration of the lease, and the terms for renewal, are equally important. An aquaculturist who decides to invest time and effort in developing expertise with a certain species, and capital to initiate an operation, needs reasonable assurances that the lease will be of sufficient duration for the investment to be worthwhile. The state must balance the needs of the culturist with its interest in preserving its options as to how the water bottoms and columns will be used (Owen, 1978).

Submerged Lands Policy in South Carolina

In South Carolina, a shellfish leasing system was in place from 1924 to 1986. The South Carolina Wildlife and Marine Resources Commission (SCWMRC), through the Division of Marine Resources, had the authority to lease to any state resident submerged lands owned or controlled by the state, for the purpose of commercial shellfish (oyster) culture, up to 1,000 acres for a period of no longer than five years (50-17-710, S.C. Code of Laws). Under the same provision, for those state residents who wished to lease lands for non-commercial oyster production, the SCWMRC had the authority to lease as many as two acres. In each situation, the lessee had to pay an annual lease fee of \$1.50 per acre to retain rights to the submerged lands. Further, any such lease could be renewed at the option of the lessee for an additional term of five years at the same yearly rental. These leases came with provisions requiring the lessee to plant sixty-five bushels of shell or seed oysters for every acre under lease and to effectively cultivate the area of the lease (by threat of revocation), and required written permission from the SCWMRC to transfer a lease to another party.

This system was significantly modified in May 1986 (50-17-710 et seq) with the enactment of amendments which allowed for:

"...increased recreational opportunities for the citizens of this state and increased opportunity for participation in the commercial harvesting of shellfish."

The State of South Carolina modified the shellfish program by replacing the leasing system with a permitting system. Prior to May 1986, the state recognized shellfish culture (the extensive culture of the state's commercial oyster grounds) as the only type of aquaculture allowed in public waters. The statute did not provide sufficient flexibility for the SCWMRC to issue leases for other types of aquaculture, such as finfish or plant; it also did not apply to any activity occurring in the water column. It did provide certain protections in that "no other lease for the gathering of oysters within the perimeter boundaries of such area leased shall be made during the term of such lease."

Today, any state resident may apply for a five-year, renewable permit to "the exclusive portions of the intertidal and subtidal bottoms owned or controlled by the State, for the purpose of shellfish culture or mariculture for commercial purposes, not exceeding [500 acres to any one entity]..."

Several key provisions of this law raise serious questions for the prospective aquaculturist. According to 50-17-720, if the state authorizes any activity or use that requires the permanent closure of shellfish grounds, the Commission may remove the effected portion from the permitted area, with an appropriate adjustment to the annual fee, now set at \$5.00 per acre. The new provisions also call for mitigation or compensation measures in the event that a project causes the closure of any shellfish grounds. The effects of this new legislation on the exclusive use of public areas afforded to aquaculturists remain to be seen.

Other provisions of this legislation raise legitimate questions. The new regulations state that "No other permit for shellfish culture on the bottoms delineated within a plat or permit may be made during the term of the permit provided the Division has the authority to issue permits for mariculture [defined in Section 50-17-860 as 'the controlled cultivation in confinement of marine and estuarine organisms']... within the perimeter boundaries of an existing permit if it is determined by the Division that the mariculture operation will not interfere with the harvesting and cultivation of shellfish by the permittee" [emphasis added]. Therefore, will the state permit mariculture operations only on submerged lands designated as commercial shellfish grounds? Does this provision imply that potential aquaculturists can receive a permit to use the waters overlying permitted shellfish grounds? What degree of exclusivity (and confidentiality and protection) can either party be assured through the permitting system?

Another provision which appears vague states, "The Division is authorized to specify the terms and conditions on any permit issued for the purpose of shellfish mariculture." Again, no mention is made of finfish and algal aquaculture. A prospective aquaculturist would be interested in the terms and conditions of the permit far ahead of any decision to locate in South Carolina.

Further complicating this situation is the fact that, while the SCWMRC regulates shellfish grounds, the S.C. Budget and Control Board and the S.C. Coastal Council also have jurisdiction over submerged lands. Their regulatory mandate is to consider permit applications for proposed activities in the waters and lands

of the State. Indeed, the S.C. Coastal Council staff have explored the possibility of establishing a submerged lands leasing program to be administered by the S.C. Coastal Council.

PROTECTION OF NAVIGATION AND WATER RESOURCES

Federal Regulations

Placement of Structures and Dredge and Fill in Navigable Waters The U.S. Army Corps of Engineers (USACOE) regulates the placement of structures and dredge and fill activities in navigable waters of the United States. A prospective aquaculturist whose operation will involve locating a structure or dredging in navigable waters must first obtain a permit required under Section 10 of the Rivers and Harbors Act of 1899. If the activity involves the discharge of dredge or fill materials into navigable waters, a permit is required under Section 404 of the Federal Water Pollution Control Act of 1972, as amended. In cases where both permits are required, the applicant may file for them jointly through a single application.

Statutory exemptions of the discharge of dredge and fill material from various farming and silviculture activities include discharges from the "construction and maintenance of stock ponds" (Section 404(f)). The USACOE's identification of permitted dredge material disposal sites must follow guidelines set by the Administrator of the U.S. Environmental Protection Agency (USEPA). These actions are subject to the Administrator's veto or restriction if the discharge results in "an unacceptable adverse effect on municipal water supplies, shellfish beds and fishery areas (including spawning and breeding areas), wildlife, or recreational areas" (Section 404 (b),[c],[g]). The USEPA has exercised this power rarely; however, in South Carolina, several Section 404 permit applications for the reconstruction and repair of coastal wetland impoundment structures for waterfowl and aquaculture were subjected to USEPA's authority.

The application for USACOE permits may also serve as a joint application for either the S.C. Coastal Council (SCCC) or the S.C. Budget and Control Board (SCBCB) permit required under state law. For Section 404 permits, a Section 401 Water Quality Certification must be obtained from the S.C. Department of Health and Environmental Control (SCDHEC) prior to a final decision. The 401 Certification (described below) is a mechanism to ensure that water quality standards and classified uses, such as shellfish harvesting, are protected.

Navigational Aids The U.S. Coast Guard is responsible for enforcement and regulation of various activities in the navigable waters of the United States. If aquaculture-related structures are to be located in navigable waters, they must be marked with lights and signals to ensure the safe passage of boats and ships (33 CFR, Part 62). The aquaculturist is responsible for installing and maintaining the markers as long as the structures are located in navigable waters.

State Regulations

South Carolina "Critical Areas" The "Critical Areas," as defined under the South Carolina Coastal Management Act of 1977, include the coastal waters, tidelands, beaches, and primary oceanfront sand dunes seaward of the critical area boundary line as determined by the S.C. Coastal Council (SCCC). The SCCC 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 person who wants to fill, remove, dredge, drain, erect a structure on, or in

any way alter the "Critical Area" must first obtain a permit from the SCCC.

Any aquaculture operation which may impact the "Critical Area" must be permitted by the SCCC. As previously mentioned, if an USACOE permit is also necessary, the applicant will be directed to file a joint SCCC-USACOE permit application. An important stipulation of the SCCC regulations state that a detailed management plan, mandatory for applications to redike former impoundments for aquaculture, may be required and must describe management and operational protocols to be employed, the species to be cultured, cost and revenue projections (for commercial operations), and other information. An applicant should expect the process to take from 45 to 120 days from filing the application to decision. For commercial operations, an application fee of \$200.00 is required.

"Non-Critical Areas" of South Carolina A S.C. Budget and Control Board (SCBCB) permit is required for any construction, alteration, dredging, filling, or any activity significantly affecting the flow of any navigable water associated with a proposed aquaculture operation, when such activity involves the use of (a) any land below the mean high water line in tidally-affected areas, or (b) any land below the ordinary high water mark of any non-tidal, navigable waterway within the state outside of the SCCC's "Critical Area." The S.C. Water Resources Commission (SCWRC) administers the permit process for the SCBCB. The permit application procedure is similar to that of the SCCC. Contact with the USACOE office in Charleston, S.C. will determine if a federal permit will also be required. If so, the permit application to the USACOE serves as a joint application with the SCWRC.

If the aquaculture activity is to be located within any of the eight coastal counties of the state and outside of the Critical Area, it must be certified by the SCCC as consistent with the state's Coastal Management Plan before the SCBCB permit can be issued. Also, the SCWRC requires a water quality evaluation from the SCDHEC.

An applicant should expect the process to take anywhere from 60 to 120 days and, for commercial operations, an application fee of \$500.00 is required.

Use of Water Resources Aquaculturists naturally use large volumes of water in their operations. The State of South Carolina, through the SCWRC, regulates the use of water by all commercial, municipal and agricultural operations, including aquaculture.

A **Groundwater Use Permit** is required for any operation which involves the use of a groundwater well capable of producing more than 100,000 gallons of water per day, on any given day, in designated "Capacity Use Areas." Currently, the SCWRC has designated Horry, Georgetown, Colleton, Beaufort, and Jasper Counties as "Capacity Use Areas." The approximate time required for processing of a groundwater use permit is 30 to 45 days; up to 60 days may be required if a public hearing is necessary.

Throughout the entire state, a **Water Use Report** must be filed quarterly with the SCWRC if the single day maximum water use will exceed 100,000 gallons per day. A one-time only System Description Form must also be completed. This reporting program encompasses the use of surface freshwater, surface saline waters, groundwater, and water purchased. Those that submit groundwater use reports under the Capacity Use Program need not duplicate reporting to this program. No permit processing is necessary.

ENVIRONMENTAL CONTROLS

Federal Regulations

The federal government regulates the discharge of effluents into navigable waters under the Federal Water Pollution Control Act of 1972, as amended, and the National Environmental Policy Act of 1969. Permits are usually required by the USEPA to regulate discharges; this authority has been delegated to the state of South Carolina and is administered by the SCDHEC.

The Administrator of the USEPA may "permit the discharge of a specific pollutant or pollutants under controlled conditions associated with an approved aquaculture project under Federal or State supervision" (see: 40 CFR sec. 125.10). Again, this authority may be transferred to the state itself for aquaculture if approved by the federal administrator.

State Regulations

The State of South Carolina, through the SCDHEC, has adopted a policy which ensures the health and well-being of the citizens of the state and sustains the quality of the state's air and water resources.

Discharge of Effluent into State Waters All prospective aquaculturists must submit a National Pollutant Discharge Elimination System (NPDES) permit application to the SCDHEC. In applying, the prospective aquaculturist must submit a detailed plan describing the scope of the operation, including: location of project; location of upstream and downstream discharges or users; facility size; species to be cultured; projected annual production; type and amount of feed; operational protocol to be employed; and the type, amount, and frequency of effluent discharges. Additional information is required if the project involves the reimpoundment or repair of old rice fields for aquaculture, including a description of the dredging operation, rediking activities, and the methods of lowering and raising water levels.

The application is reviewed by the SCDHEC staff for a determination on whether a NPDES permit is necessary for the proposed aquaculture facility. The determination is based in part on federal regulations 40 CFR 122.24 "Concentrated Aquatic Animal Production Facilities" and 40 CFR 122.25 "Aquaculture Projects," and an evaluation of the proposed discharge for water quality impacts. According to USEPA regulations, a hatchery, fish farm, or other aquaculture facility is subject to a NPDES Permit if it contains, grows, or holds aquatic animals in either of the following categories:

- cold-water fish species and other cold-water animals in ponds, raceways, or other similar structures which discharge at least 30 days per year or produce more than 20,000 pounds of aquatic animals per year, or are fed more than 5,000 pounds of food during the calendar month of maximum feeding;
- warm-water fish species and other warm-water animals in ponds, raceways, or other similar structures which discharge at least 30 days per year or produce more than 100,000 pounds of aquatic animals per year.

If the proposed aquaculture facility falls under the USEPA regulations or causes unacceptable water quality impacts, a NPDES permit will be required by SCDHEC. The NPDES permit contains monitoring requirements for constituents of concern. Of course, the aquaculturist should be aware that conditions and

stipulations will be attached to the NPDES permit requiring monitoring and site inspections.

Aquaculturists divert, pump, and/or circulate water through their systems in order to maintain species survival and enhance growth. Any such use, except consumptive use of water, is categorically considered as a point source discharge of effluent. However, the SCDHEC requires NPDES Permits from part-time culturists using ponds and impoundments as their production "facilities," even though no data have been analyzed to identify aquaculture operations as prime sources of "contaminants." Further, the phrase "... an evaluation of the proposed discharge for water quality impacts" does not offer the prospective aquaculturist any initial guidance as to what may or may not be examined or required. The normal processing time for a NPDES permit is three to four months (Table 9). However, if the permit is adjudicated, then a longer period of time will be required (see Figure 3). This situation cannot easily be accommodated by the aquaculturist, who needs to deal with investors interested in quick returns and lenders who demand a certain level of predictability.

Table 9: Approximate Time Schedule to Obtain an NPDES Permit

ACTION	TIME (Days)	TOTAL (Days)
1. Submittal of a completed NPDES application form to SCDHEC	0	0
2. Process permit application	5	5
3. SCDHEC drafts NPDES permit and submits to applicant for review	30	35
4. Applicant reviews draft and submits comments and/or acceptance to SCDHEC	30 ¹	65
5. Draft permit goes through Public Notice period	40 ²	105
6. Administrative action; permit issued	5	110
7. NPDES permit effective	15	125

¹Time may be reduced or increased, depending on the length of time to obtain mutual acceptance of the permit.

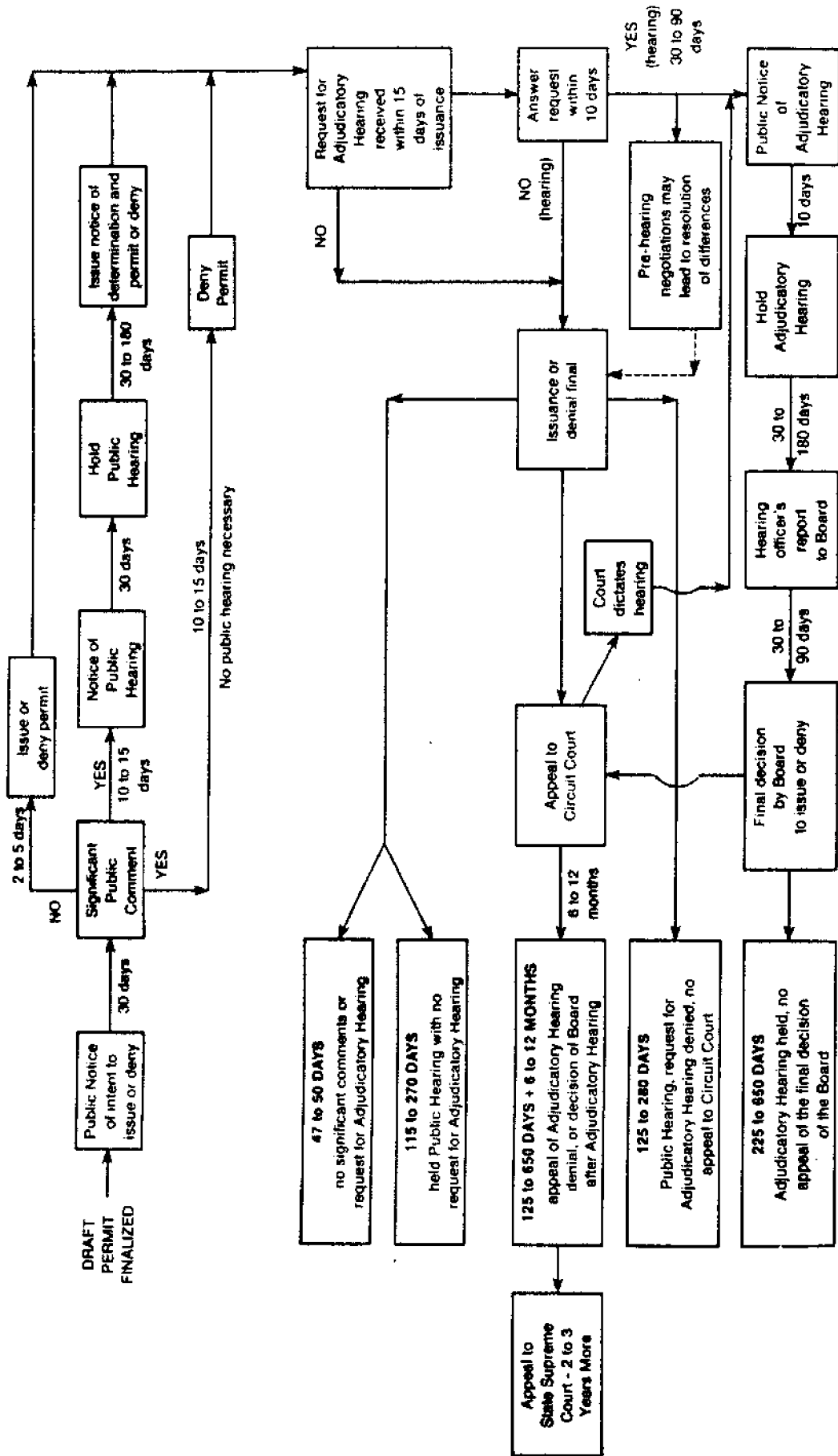
²When the NPDES permit goes on public notice, the general public has the opportunity to comment. If a public hearing is requested and/or the permit is adjudicated, the time frames above will be prolonged.

Construction of Wastewater Treatment Facilities (Construction Permit)

If unacceptable water quality impacts are predicted, the aquaculturist may need to provide pollution control abatement equipment to treat the wastewater from the aquaculture facility to an acceptable quality. The South Carolina Water Pollution Control Act (Section 48-1-110) requires that a Construction Permit be obtained for pollution control abatement equipment. Applications for permits to construct, along with preliminary engineering reports, are submitted to the SCDHEC for consideration.

Water Quality Certification The SCDHEC is also responsible for the Section 401 Water Quality Certification Program under the Federal Water Pollution Control Act of 1972, as amended. Any applicant for a federal permit for the construction or operation of any activity which may result in any discharge into the waters of the United States must provide the permitting agency with a certificate from SCDHEC that such discharge will not violate the State Water Quality Standards or applicable effluent limitations. The aquaculturist must realize that no federal permit will be granted until the required certification has been obtained, nor will the permit be granted if the certification has been denied. The SCBCB requires SCDHEC certification and the SCCC may require it prior to

Figure 3. Possible NPDES and No Discharge System Permit Processing Pathways with Estimated Time Frames Shown



issuing permits even if it is not required by the federal agency. Application for the 401 Water Quality Certification is administered through a joint procedure with the USACOE.

Selection and Harvesting of Aquatic Organisms

The Division of Marine Resources of the S.C. Wildlife and Marine Resources Department (SCWMRD) has general jurisdiction over all fish, fishing, and fisheries in the coastal saltwaters of South Carolina; this includes permitting and licensing authority over a variety of marine finfish, mollusks, or crustaceans which may be selected for culture.

Several permits and licenses may be required for an aquaculture operation. Permits to import exotic species, to harvest shellfish, to use mechanical harvesting equipment, to harvest, have in possession, and sell shellfish at any time of the year, and to use shell from natural deposits for mariculture are all available through the Division. Permits are now also required for the culture of spotted seatrout and red drum (channel bass). No other permit requirements exist for crustacean and finfish mariculture (except disease-free certification to import exotic species) at this time. The Division also requires a license for the use of any self-propelled boat or vessel and for the harvest of shellfish for commercial purposes from state bottoms not under permit as provided under the shellfish permitting regulations.

In addition, specific regulations have been promulgated by the Division covering mariculture of hard clams. Mariculture operations may possess, package, sell, or transplant clams of less than the legal size limit (one-inch thickness) for nursery or growout purposes and may harvest, have in possession and sell shellfish at any time of the year upon obtaining special permits from the Division. Other species of shellfish apparently are not included under this provision.

The Division of Wildlife and Freshwater Fisheries of the SCWMRD regulates fish, fishing, and fisheries in all freshwater lakes, rivers, and streams of the State. There are two instances where permits from the Division are necessary for aquaculture: (1) to collect organisms for harvesting and/or propagation of freshwater species for the purpose of science or research, and (2) to import non-native species or transplant native species from one site to another. Additionally, a Gamefish Breeder's License is required in order to sell, offer for sale, barter, and transport gamefish for strictly stocking or restocking purposes.

This last point is important because it illustrates the current debate regarding commercial aquaculture of game species as defined by South Carolina law (an excellent summary of the current situation is presented in Jenkins, 1986). Several states recognize the distinct differences between wild fishery products and aquaculture products, and allow the sale of farm-reared fishery products while prohibiting sale of animals taken from the wild (e.g., Florida and California). Still others allow the sale of wild or cultured fish (e.g., North Carolina). On the federal level, the Lacey Act regulates the interstate sale and shipment of wildlife products, with no distinction between wild or domesticated animals. However, in South Carolina as in some other states, certain fish are considered game species and cannot be sold. Aquaculturists who are interested in commercially culturing species designated as gamefish must locate their operations outside the borders of South Carolina, where it is legal. Some progress has been made, however, with the ratification of legislation in 1988 to allow the commercial culture of reciprocal hybrid striped bass in the state.

Several permits may also be required by the SCDHEC. These regulations are intended to protect the public health with respect to the consumption of shellfish products. Permits are required to transplant (relay) shellfish from closed to approved harvesting waters, to condition shellfish from approved harvesting areas, and to hold shellfish in floating or wet storage devices. A permit is also required if the operation will involve the artificial cleansing or mechanical depuration of shellfish taken from moderately polluted water (restricted harvesting areas).

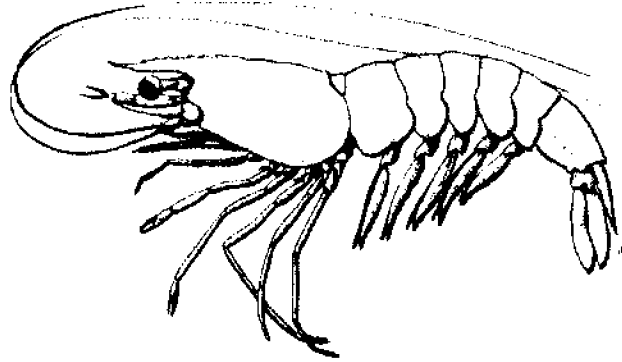
Processing and Sale of Aquaculture Products

There are three South Carolina agencies charged with permitting and licensing of seafood dealers and processors and inspection of seafood processing facilities.

The Division of Marine Resources (SCWMRD) has the responsibility of issuing licenses to sell and wholesale seafood products. A Land and Sell License is required for the sale of fish and fishery products to wholesale dealers. A Wholesale Seafood Dealer License is necessary for the buying, bartering, shipping, shucking, processing, or selling at other than retail, any fish or fishery products.

However, before the Division will issue these licenses, a Dealer/Processor Certification must be obtained from the SCDHEC for wholesale processing and sale of bivalve shellfish and finfish. If a retail market is to be established, a Food Service Establishment Permit or a Retail Food Store Permit must be obtained from the local County Health Department.

Although it does not have direct regulatory responsibilities, the Food and Cosmetic Section of the Division of Laboratories at the S.C. Department of Agriculture is responsible for ensuring that facilities used in the processing of seafood products are in compliance with Good Manufacturing Practices established under the Federal Food, Drug, and Cosmetic Act by the U.S. Food and Drug Administration. The Section has the authority to conduct facility and product inspections at any time to ensure compliance.



IV. THE FINANCING OF AQUACULTURE

THE COSTS OF AQUACULTURE

Aquaculture can be a very capital-intensive venture depending upon the scale and type of operation. The capital investment necessary for aquaculture can range from several thousand dollars for a one-acre catfish operation to several million dollars for an intensive shrimp hatchery, nursery and grow-out facility. The investment and operation costs for an aquaculture operation vary by species, culture technology, and location (NYSGI, 1985).

Aquaculture systems can be categorized by the level of management intensity required to meet production goals, and by the type of aquatic system used for production. As discussed earlier, aquaculture operations can be categorized as intensive, semi-intensive and extensive. The more intensive an operation, the more product is produced per unit area; however, more energies are required and the likelihood of disease epidemics increase (NYSGI, 1985). For example, a semi-intensive penaeid shrimp culture operation in ponds can produce up to 4,000 pounds per acre of heads-off shrimp versus 1,500 pounds per acre (or less) from an extensive rice field impoundment operation, but the operating costs can be over eight times as great and the investment cost almost double in the semi-intensive system. Intensive systems require higher levels of management to maintain a healthy crop; constant attention to feeding and aeration is critical. Nevertheless, fish and shellfish raised in intensive operations are more susceptible to disease and illness than those raised under conditions of lower density in extensive operations.

CREDIT NEEDS FOR AQUACULTURE

Aquaculturists will need loans for a variety of purposes and of varying maturities. Simply stated, short-term loans (three years or less in maturity) will be necessary for working capital; intermediate-term loans (one to ten year maturity) are

usually drawn for equipment purchases; and long-term loans (maturity in excess of ten years) will be needed for land improvements and/or purchases. Additionally, disaster credit may be requested if the aquaculturist loses his crop to disease, severe weather, or some other calamity. Disaster credit can often be met in part through emergency credit programs from the federal government.

Credit needs will usually be dictated by the intensity of the aquaculture venture. The extensive producer tends to use his own capital and borrow limited amounts from conventional lending sources. The semi-intensive producer may rely on conventional lending sources similar to what he may use for his agriculture operation. On the other hand, the intensive producer will vary his lending sources, which can include venture capital, government bonds, large financial institution lending, and conventional sources. While each aquaculture operation in the state will be somewhat unique, it is apparent that the demand for aquaculture credit from a variety of sources will grow.

SOURCES OF FINANCING

The financial community is usually conservative in its lending practices when it perceives that risks are high. Aquaculture is a relatively new industry in South Carolina without a long and proven track record; bankers and investors tend to be especially cautious about financing aquaculture ventures. Potential aquaculturists must be reasonably secure financially and be able to demonstrate aquaculture management skills, including product marketing, in order to obtain loans. Established aquaculturists will find it easier to obtain credit because of their experience and perceived skill. Loans for aquaculture operations are potentially available from a variety of sources at the federal, state and private levels.

Current trends suggest, however, that many start-up aquaculture ventures will depend to a great extent on equity capital. To attract capital for new operations, a strong, carefully-organized and properly-timed effort to directly educate potential investors must be made. All communication to potential and actual investors must be made in strict compliance with state and federal securities law.

Sources of Debt Capital

Federal Financing A number of federal programs provide financial support for aquaculture:

Farmers Home Administration: The FHA has a variety of loans for aquaculture purposes. These include:

- (a) Farm Ownership Loans - to help eligible applicants purchase and develop family farms;
- (b) Operating Loans - to operators of family farms for financing and refinancing equipment, fish and shellfish, land and water improvements, and operating expenses;
- (c) Emergency Loans - to counties which have suffered a natural disaster or other emergency;
- (d) Soil and Water Loans - to finance land and water development and improvement;
- (e) Recreational Loans - to assist eligible persons to convert all or a portion of a farm or aquaculture operation to an outdoor income-producing recreational enterprise;
- (f) Business and Industrial Loans - to promote development of business and industry, including aquaculture (these loans can be used for production, as

- well as for aquaculture-related businesses);
- (g) Resources Conservation and Development Loans - for conservation, development and utilization of water for aquaculture purposes; and
- (h) Farm Labor Housing Loans - to provide housing-related facilities for domestic farm labor.

Federal Crop Insurance Corporation: The FCIC provides crop insurance, which can include aquaculture species.

Federal Cost-Sharing Programs: Within some districts of the Agricultural Stabilization and Conservation Service and the Soil Conservation Service of the USDA, there are active cost-sharing programs whereby funds may be provided for conservation measures which could directly or indirectly benefit an aquaculture enterprise.

Bureau of Indian Affairs: The Bureau of Indian Affairs within the Department of the Interior provides capital construction funds for aquaculture.

Economic Development Administration: The EDA makes loans or grants to the aquaculture industry to provide development and operating capital.

Small Business Administration: The SBA makes guaranteed, immediate-participation and direct loans to aquaculture operators. SBA loans may be used for purchase and improvement of land or building, construction, machinery and equipment, operation expenses and refinancing of debts. SBA also provides disaster loans in authorized areas.

State Financing The State of South Carolina has but a few established loan and financial assistance programs which are potential sources of funding for aquaculturists. The most notable is the South Carolina Jobs-Economic Development Fund Authority. The Authority's mission is to promote business development by providing financial assistance and has two major programs for aquaculture development. The Industrial Revenue Bond program provides loans for capital investment, while the Community Development Block Grant Program provides direct loans for capital investment and, in certain cases, operating capital. The program limits participation to 40 percent of project costs. The Authority has made loans to aquaculture production and processing operations in the state.

Private Financing A variety of private sector sources are available to consider loan applications for aquaculture.

Commercial Banks: Loans for capital improvements and operating expenses can be obtained from commercial banks. To receive such financing a loan guarantee is sometimes needed. The guarantee, usually offered by state or federal programs, assures repayment of a certain percentage of the loan. The Farmers Home Administration and the Small Business Administration, for example, guarantee loans for up to 90 percent of their value.

Farm Credit System: Banks and associations that comprise the Farm Credit System (FCS) provide credit and related services to farmers, ranchers, producers and harvesters of aquatic products, agricultural and aquacultural cooperatives, rural homeowners and certain businesses. The banks and associations are examined by the Farm Credit Administration. A Federal Credit Bank (FCB) exists in Columbia, South Carolina.

The Farm Credit System has three different entities: The Federal Land Bank, the Federal Intermediate Credit Bank, and the Banks for Cooperatives. All of the FCB banks are wholly-owned farmer cooperatives.

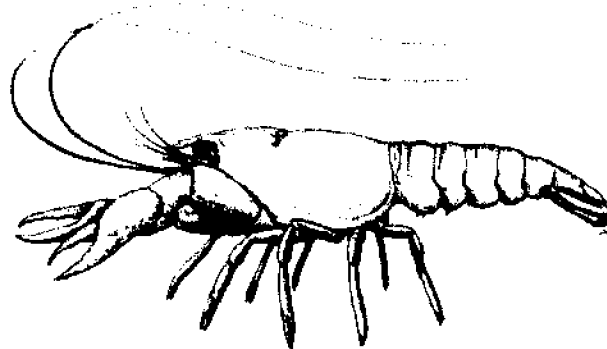
Federal Land Banks make loans with terms from 5 to 40 years through Federal Land Bank associations. These loans are secured by first liens on farm and rural real estate. Federal Intermediate Credit Banks provide loan funds through production credit associations, and they discount notes of eligible borrowers given to certain other institutions that finance producers. Production credit associations make loans to producers and harvesters of aquatic products for terms of up to 15 years. Banks for Cooperatives serve marketing, supply and service cooperatives within their district. Rates charged by the FCS are generally lower than those of other lenders because of the FCS's loan-pricing practices.

Corporations: An important source of funds for aquaculture in the United States has been major corporations. A variety of corporations from insurance companies to agribusiness firms have invested in aquaculture operations such as shrimp farming, salmon ranching and hard clam mariculture. However, recent changes in U.S. tax laws could bring about changes in corporate investment in aquaculture.

Sources of Equity Capital

Venture Capital Venture capital is an appropriate method of financing a new aquaculture operation. Although changes in the tax law may affect the availability of venture capital, it does remain an important source of funding. This capital, in some cases, 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 debt burden. The selection of venture capital should result from a thorough analysis of business needs and tax consequences.

Stocks Equity capital may be a most promising source of financing. The outlook for aquaculture funding may continue to be characterized by a high equity to debt ratio (e.g., 60% equity capital) due to several factors, including the major financial losses on agricultural loans incurred by the Farm Credit System and private lenders, and the low collateral value of aquaculture assets due to the poor resale value of aquaculture equipment and lack of alternative uses from aquaculture improvements.



V. MARKETING AQUACULTURE PRODUCTS

SEAFOOD DEMAND

Seafood is becoming more of a staple in the diet of U.S. consumers. Americans consumed more than 20.2 pounds per capita of seafood in 1987, a rise of 18 percent since 1980, after a rise of 7.5 percent during the 1970's (U.S. Department of Commerce, 1988). More recently, per capita consumption has grown at an annual rate of more than 5.0 percent, reflecting the record-breaking rate increases that occurred in each of the last three years. This growth is projected to increase from between five and seventeen percent above the 1986 base of 14.7 pounds by the year 2000 (USDA, 1986). These trends, coupled with an 18 percent population increase over the last three years in the United States, should assure a continued strong demand for seafood.

Increases in consumer seafood consumption patterns reflect changes in the diets of Americans. U.S. consumers are eating more fish and shellfish products, vegetables, white meat, poultry, fruit and lowfat milk. Consumer interest in seafood continues to grow even though seafood prices have been outpacing competing meat and poultry prices over the last 15 years. (The typical U.S. household consumes primarily four seafood species - tuna, shrimp, cod, and flounder - which makes up over 50 percent of the value and volume of edible seafood products imported in 1985.) This trend suggests that factors other than price must be involved in consumer demand for seafood products. Recent studies published by the *New England Journal of Medicine* (Volume 312: Number 19; May 19, 1985) have linked the consumption of seafood with improvements in health, and it appears that the consumer, increasingly nutrition-conscience, is responding. Additionally, consumer income plays an important role. Consumer income (per capita) has risen steadily in recent years; consumer expenditures away from home have exhibited similar trends.

The rapidly growing population in the Southeast and increased per capita consumption of seafood should have an important effect on the growth of South

Carolina's aquaculture industry. In South Carolina today, aquaculture products are produced and sold primarily by small enterprises. In general, cultured seafood is sold fresh, as product differentiation through processing has not been pursued as a marketing strategy. However, South Carolina boasts great potential as a location for the culture of species such as catfish, trout, crawfish, striped bass hybrids, hard clams, redfish, sea trout and marine shrimp. The development of the aquaculture industry for these and other species is going to greatly depend on the availability of product and the needs of the marketplace.

CURRENT OUTLETS FOR SOUTH CAROLINA SEAFOOD

Current production and market channels for South Carolina seafood products are not well understood. Landings of all South Carolina marine fishery products totaled over \$22 million in 1987, falling within the annual average range of the last 20 years of about \$20 to \$25 million. Shrimp landings made up approximately 53 percent of this total, oyster landings 5 percent, blue crab landings 10 percent, other shellfish landings 5 percent, and finfish landings 23 percent (Fisheries Statistics Section, S.C. Wildlife and Marine Resources Department, December 2, 1988). At that time, some 3,947 commercial fishermen and 162 processing and wholesaling firms (employing over 1,200 workers), were engaged in the industry. Despite these figures, there is actually very limited documented information about the operation of the seafood marketing system in South Carolina.

Only two studies have attempted to assess the condition of the seafood marketing system in the state to date. In 1975, Laurent et al. prepared a descriptive analysis of the marine fisheries industry. This research reported that consumers who entered supermarkets in almost any part of South Carolina (including various areas along the coast) to purchase seafood products found few, if any, South Carolina seafood products available. The 1974 market pattern for seafood in South Carolina appeared to involve shipments to out-of-state markets (primarily New York and Florida) by local dealers and purchases from out-of-state markets by local wholesalers. As a result, there was considerable cross-hauling which caused inefficiencies in the marketing patterns of South Carolina seafood products.

Marketing practices have changed considerably in the state since the Laurent et al. study (Will Lacey, Marketing Specialist, SCWMRD, pers. comm.). There are now at least nine companies that process and distribute seafood from South Carolina and other parts of the country and world. These operations distribute fresh product primarily to the food service industry and the retail trade (chain stores). These companies process whole fresh fish (of high value, such as grouper, snapper, swordfish, tuna, etc.), and fillet and portion the fish to their customers' specifications. They also distribute other South Carolina value-added products such as fresh, frozen, and pasteurized crab meat, soft-shell crabs, soft crawfish, wild stock catfish and, to a degree, shucked oysters. To meet demand, they import additional products from around the United States (West Coast and New England) and the world (salmon from Norway and shrimp from Ecuador). These processors now supply the majority of the in-state market, and also distribute their products to other states in the region (Northeast and Midwest). A more recent study by Pomeroy and Lamberte (1988) found that South Carolina seafood dealers now perform more than one function; indeed, nine firms operate as primary buyers, primary wholesalers, processors and retailers, while another nine are engaged as primary wholesalers, processors and retailers.

The 1975 report found that South Carolina seafood dealers handled relatively small volumes of product. The problem was complicated by the fact that the industry had not developed a brokerage system or storage facilities to allow the assemblage of large quantities of seafood products. Recently, a fresh seafood brokerage and trading company has been established in South Carolina. Seafood caught and landed in the state now are brokered by this company. In addition, the New Orleans Cold Storage Company now operates a frozen storage facility in South Carolina.

The seasonality of the South Carolina seafood industry is another problem. Major South Carolina seafood products are available on a fresh basis during certain seasons, and even within seasons there is considerable week-to-week fluctuation in the volume of any given handler. Thus, most individual coastal handlers cannot supply the needs of relatively small volume users, such as restaurants, because they cannot assure a constant supply of uniform quality.

Product, whole and processed, is brought back to South Carolina for distribution and local consumption when local demand exceeds supply. Those companies may also be able to buy product of comparable quality at better prices from other markets, such as the Fulton Fish Market in New York or from a producing state such as Florida.

Pomeroy and Lamberte (1988) report that the seafood marketing system in South Carolina has experienced change and growth over the last 13 years. Seafood dealers have expanded their operations to include processing and retailing as well as buying and wholesaling. Many existing markets for buying and selling are exploited, and new markets are being developed.

PROSPECTS FOR MARKET EXPANSION

Although it is clear that much of the demand for seafood products continues to be met by the traditional seafood industry, aquaculture will play an ever-increasing role in the supply of certain species (product) types which are now at the point of maximum harvest by commercial fishermen. Indeed, average production of the South Carolina marine shrimp industry has not increased over the last 12 to 15 years (D. Theiling, Fisheries Statistics Section, SCWMRD, pers. comm.). In 1971, the commercial harvest of penaeids reached some 6.9 million pounds (heads off). Recent harvests have not been able to match that figure; indeed, whereas the state issued over 1,500 trawling licenses in 1980, only 780 licenses were issued in 1987 (A. Applegate, Fisheries Statistics Section, SCWMRD, pers. comm.). Aquaculture offers an exciting opportunity to restore the availability of these and other species to even higher levels. A critical factor will be the development of market channels.

Now, as in the past, the demand for shrimp in the United States remains high (over 60 percent of the shrimp consumed in the U.S. is imported). Shrimp command a premium price and no market development is required. Because of this, the number of shrimp mariculture operations have continued to increase, especially in Central and South America. Their production, along with that of China and Taiwan, continue to supply the export market of shrimp to the United States. In South Carolina, ten major producers currently culture penaeid shrimp, with a combined production value of \$1,120,000 (Pomeroy, 1988). The shrimp are marketed directly to retail outlets, such as grocery stores and restaurants, and through existing shrimp marketing channels.

Similarly, the hard clam fishery in South Carolina has ranked in the top five in terms of value. Only 2,000 South Carolina bushels were harvested in 1950; in 1982, this figure increased to over 33,000. However, at the national level, production numbers for hard clams have seriously declined; in 1950, 1.91 million U.S. bushels were produced, as compared with less than 1.1 million in 1982. Nevertheless, their landing value has soared over the same period of time, from \$7.3 million in 1950 to over \$52 million in 1982. South Carolina's primary hard clam fishery is located in the Santee Delta region; however, with the recent (1985) redirection of approximately 80 percent of the Cooper River flow back into the Santee River system, a significant reduction in hard clam production is anticipated, due to the lowering of salinity in the waters overlying the clam beds.

Paralleling marine shrimp, the demand for hard clams is increasing due to their popularity and the diminishing supply provided by traditional harvesting. A number of hard clam aquaculture operations have located in northeastern and northwestern sections of the United States; however, few are now found in the Southeast. One operation, Trident Seafarms, Inc. of Folly Beach, S.C., successfully produced hard clams on a pilot scale for market from 1980 to 1984; difficulties with the investment team prohibited the operation from fully developing. Nevertheless, South Carolina provides an ideal location for the culture of a premium shellfish product, the hard clam.

As discussed, crawfish remain South Carolina's largest (by volume) aquaculture industry. Table 10 shows that in the past eleven years the crawfish aquaculture industry has grown from 22 acres producing 5,500 pounds with a value of \$6,900, to 1,100 acres producing 500,000 pounds valued at \$600,000.00. The average price received was \$1.20 per pound in 1988, well over that paid to Louisiana producers (who receive less than \$1.00 per pound).

Table 10: Estimated Crawfish Production In South Carolina, 1978-1988

Year	Acres of Stocked Ponds	Production per Acre (pounds)	Total Production (thousands of pounds)	Value of Production (thousand \$)
1978	22	250	5.5	6.9
1979	22	250	5.5	6.9
1980	22	250	5.5	6.9
1981	22	285	6.25	7.8
1982	125	300	37.5	46.9
1983	250	300	75.0	93.8
1984	525	476	250.0	312.5
1985	800	375	300.0	375.0
1986	825	485	400.0	460.0
1987	1000	485	485.0	558.0
1988	1100	455	500.0	600.0

Source: Estimated by Jack Whetstone, South Carolina Marine Extension Specialist, S.C. Marine Extension Program, after personally communicating with producers.

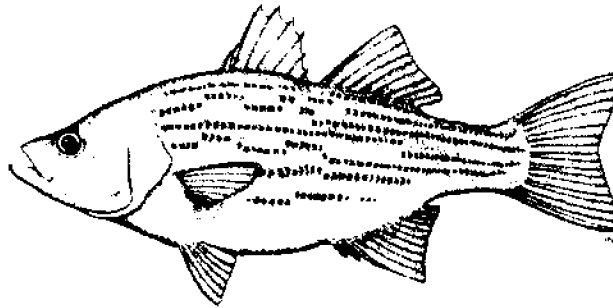
Approximately 70 percent of the production was sold in-state, directly from the producer, to local restaurants, crawfish festivals, fish markets, and "pond-side

buyers." The remaining 30 percent was shipped out-of-state to markets in the Baltimore, MD, Washington, D.C., and Chicago, IL areas. Projections indicate that markets within and outside South Carolina will continue to require product, at least in the near future (Pomeroy and Kahl, 1987b).

Catfish have been raised for family use in farm ponds in South Carolina since the early 1900s. Improved technology in the 1950s and 1960s made feasible the commercial culture of catfish, but processing problems in the 1970s essentially stopped the growth of this promising enterprise. Although there are no historical data to document the early growth of the industry in South Carolina, there are data for recent catfish production in the state.

The catfish culture industry has recently benefitted by the development of a large integrated production and processing catfish operation in October 1988. With its establishment, South Carolina farm-raised catfish should enter the national market and offer an outlet for small producers previously unable to produce the large quantities needed to expand their market. Several other operations are on-line, including the adaptation of a poultry processing plant to process catfish and the production of catfish feed at a local feed mill in Orangeburg.

Production of other aquaculture products can be expected in South Carolina. As mentioned, potential exists for species such as hybrid striped bass, tilapia, baitfish, and red drum (channel bass) in various locations of the state. Also, shellfish hatchery operations could provide "specialty items" such as seed stock and show good promise due to the state's good climate, high water quality and supply, and excellent facilities to provide research, development and technical assistance support. The market within and outside South Carolina for different types of seed stock is strong.



VI. AQUACULTURE RESEARCH, EDUCATION AND TECHNICAL ASSISTANCE

NATIONAL PROGRAMS

Sources of public funds for aquaculture research have been limited although, more recently, significant funding has been made available through the U.S. Department of Agriculture. Nevertheless, the United States government has funded a broad spectrum of programs through other agencies such as the Department of Commerce, Department of the Interior, Agency for International Development, Army Corps of Engineers, Department of Energy, Department of Health and Human Services, Environmental Protection Agency, the National Science Foundation, Small Business Administration and the National Institutes of Health (see: Joint Subcommittee on Aquaculture, 1983). Several of these programs are described below.

The Department of Agriculture (USDA) provides a variety of aquaculture services through its existing organizational structure. With the passage of the National Aquaculture Improvement Act of 1985, the USDA has been designated the lead agency for the development of aquaculture in the United States. Since then, USDA has appropriated millions of dollars to establish five Regional Aquaculture Centers in Hawaii, Mississippi, Massachusetts, Washington and East Lansing, MI/Ames, IA, and to support research and demonstration efforts with both freshwater and marine species.

The Cooperative State Research Service provides formula funding of aquaculture research at state institutions and land grant colleges. The Aquaculture Marketing Service (AMS) provides matching grants to states to conduct marketing assessments.

The Extension Service, through state cooperative offices, interprets new aquaculture research, informs scientists of research needs, and educates aquaculturists about new technological advances in the industry. The Soil Conservation

Service also provides technical assistance to aquaculturists, including resource assessments on soils, water, and facility design.

The Farmers Home Administration provides credit to aquaculture operations through direct, guaranteed, and emergency loan programs. The Federal Crop Insurance Corporation is working towards the development of an all-risk crop insurance program.

The National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce spends about \$2 million annually through the National Marine Fisheries Service (NMFS). The NMFS performs diverse aquaculture research with in-house scientific expertise scattered in several laboratories across the country. The NMFS-Seattle (WA) laboratory engages in salmon research, NMFS-Oxford (MD) focuses on shellfish disease, and NMFS-Milford (CN) researches mollusk aquaculture.

About \$4 million is annually provided for aquaculture through the National Sea Grant College Program, NOAA, which supports research and extension through 30 cooperating state Sea Grant Programs. Species under study include salmon, striped bass, penaeid shrimp, abalone, hard clams, oysters and kelp.

The passage of the National Aquaculture Improvement Act of 1985, while reaffirming the nation's support for aquaculture, reduced the Commerce Department's aquaculture authorization by \$1 million. Both the National Sea Grant College Program and the aquaculture programs of NMFS have been scheduled for termination by the current administration in each of the last eight years; action by the U.S. Congress has always restored the programs.

The Department of the Interior does support freshwater fish culture research through the U.S. Fish and Wildlife Service (USF&WS), but funding is limited. The National Aquaculture Improvement Act of 1985 provided level funding authorization of the Department's aquaculture programs.

Nevertheless, the USF&WS is engaged in a comprehensive program of freshwater fish production. The USF&WS's National Fisheries Center, located in Leetown, West Virginia, has eight laboratories and field stations and five cultural development centers engaged in research on disease control, fish biologics, nutrition, fishery drugs registry, cultural methods improvement, genetics and breeding, wastewater treatment and residue, and evaluation of non-indigenous species for culture.

The USF&WS operates the National Fish Hatchery System. The hatcheries produce and distribute five species of trout, seven species of salmon, and other warm-water and cool-water fish species. One of these hatcheries is located in Orangeburg, South Carolina. The Fishery Academy at Leetown, West Virginia provides training for hatchery personnel and acts as a clearinghouse for information. USF&WS facilities are used as aquaculture demonstration sites, personnel are on-hand for assistance, and many publications are available.

The U.S. Environmental Protection Agency (USEPA), the National Science Foundation (NSF) and the National Institutes of Health (NIH) provide financial support for aquaculture research to the academic community. The USEPA focuses on studies that support its role in monitoring and maintenance of high water quality in culture systems. The NSF makes research grants that support basic biological studies that may be of value to aquaculturists. This is also the

philosophy of the NIH, which funds research studies that improve our understanding of basic biological processes that focus on animal diseases of potential significance to public health (NYSGI, 1985).

STATE PROGRAMS

Research Capabilities

Natural Resource Agencies The State of South Carolina has already made several commitments to aquaculture research at both governmental and academic levels. The South Carolina Sea Grant Consortium sponsors research in aquaculture and acts to facilitate projects with its seven member institutions. Current research on hard clam genetics and the commercial feasibility of hybrid striped bass involve scientists and students from throughout the state. The Consortium also supports the South Carolina Marine Extension Program in partnership with Clemson University; both the S.C. Marine Extension Program and Clemson's Cooperative Extension Service transfer technical information to aquaculturists throughout the state.

The Division of Marine Resources of SCWMRD is responsible for the administration of marine aquaculture programs at both the Marine Resources Center at Fort Johnson on James Island in Charleston and the James M. Waddell, Jr. Mariculture Research and Development Center at Bluffton. A stated objective of the Division is to develop aquaculture as a commercial enterprise and resource management tool. The Marine Resources Center evaluates candidate culture species and develops techniques for use by the aquaculture industry in the state. The Waddell Mariculture Center, in turn, expands feasibility studies to the commercial scale. The Waddell Mariculture Center also serves as a training facility for extension workers and farmers. It provides short-term training for technicians and research opportunities for graduate students. The Waddell Mariculture Center is a nationally-recognized information resource for mariculture.

Universities and Colleges Aquaculture research is also underway at several of the state's universities and colleges. Clemson University, primarily through programs within its College of Agriculture, researches methods and techniques in support of freshwater aquaculture development, especially of catfish and crawfish. Collaborative efforts of scientists from Clemson and the SCWMRD are enhanced through a formal cooperative agreement between the two institutions.

Research on aquacultural genetics is conducted at the College of Charleston, while the Medical University of South Carolina concentrates its efforts on species reproduction and development.

Extension and Technology Transfer

The state of South Carolina maintains direct contact with coastal aquaculturists and the general public through information feedback programs that link researchers and aquaculturalists. Faculty and staff of Clemson University's Cooperative Extension Service, the South Carolina Marine Extension Program (SCMEP), SCWMRD's Division of Marine Resources and the University of South Carolina's SCAMPI assure that the problems and needs of those in the industry are accurately identified, research projects and programs are effective in providing the necessary information requested, and the information is delivered in a timely and "usable" fashion.

Joint projects assembled by these programs assist commercial aquaculture oper-

ations in the areas of production, economics, and marketing. Education and training programs have been organized to develop aquaculture production manuals, workshops, and on-site demonstration projects.

The Clemson University Cooperative Extension Service has offices in each county to serve the agricultural community. Extension specialists, including those supported by SCMEP and the Clemson University/SCWMRD Cooperative Fisheries Unit, assist county staffs and offer clientele an excellent opportunity to utilize aquaculture information. The U.S. Soil Conservation Service has a similar program of county conservationists and statewide specialists who offer technical assistance to aquaculturists for such activities as pond layout and construction.

The University of South Carolina, through SCAMPI, has received a \$1.7 million, three-year Peace Corps Aquaculture Training Grant to train Peace Corps volunteers in aquaculture. Besides adding a significant new dimension to research and training aquaculture at the University, such activities will focus more national attention on the State of South Carolina in this growing field.

Education and Training Capabilities

Undergraduate Degree Programs A Bachelor of Science degree provides a broad-based academic program suitable for students, regardless of whether they pursue graduate degrees, to develop skilled mid-level operators and managers for the aquaculture industry. Most of the state's public and private universities and colleges offer well-rounded undergraduate biology curricula from which a limited aquaculture emphasis can be taken.

Clemson University is modifying existing programs in Aquaculture, Agricultural Economics, Agricultural Engineering, and Food Science to formulate an Aquaculture emphasis in a Fish and Wildlife Biology Bachelor's degree program. A concentration in Aquaculture and Fisheries is now approved and available.

The University of South Carolina offers a Bachelor's Degree in Marine Science or Biology with an emphasis on aquaculture. Courses are available that cover various aspects of the aquatic environment, including an undergraduate research apprenticeship program in aquaculture.

Other institutions, such as USC-Coastal Carolina College and the College of Charleston, offer individual courses on topics related to aquaculture.

Graduate Degree Programs The development and implementation of graduate level degree programs can provide scientific training in all aspects of the aquaculture industry and produce skilled research and managerial personnel for the industry.

Clemson University offers a Master's program in Wildlife Biology with an emphasis on aquaculture. Individual research programs in agricultural engineering, botany, and zoology can be directed in the aquaculture field and lead to advanced degrees. Clemson is well-equipped to provide field experience with facilities that include: the Cherry Hill station, with 10 ponds, 40 pools, and laboratories; the Bottoms Station, with 32 ponds, 4 raceways, and laboratories; and the Hampton County demonstration facility, with 7 ponds. The Agricultural Experiment Stations of Clemson University in Clemson, Florence, Charleston, Edisto, and Columbia are available for research but only the Clemson Station is

presently in use for aquaculture. These stations do offer excellent locations for freshwater aquaculture research.

The University of South Carolina is in the process of developing a Master's degree program in aquaculture, primarily in mariculture in association with its internationally-recognized Marine Science Program. Masters and Ph.D. degrees are offered in biology and marine science, and individual research programs in these curricula can be directed in aquaculture.

The South Carolina Aquaculture and Marine Programs International (SCAMPI) is located on the USC campus. The program offers training and institutional development in aquaculture. The program's research emphasis is on impact of broodstock selection and water quality on tilapia. The University's facilities include the Belle W. Baruch Institute at Georgetown, and 60 ponds of various sizes constructed at the Wedge Plantation on the South Santee River.

The Graduate Program in Marine Biology, coordinated by the College of Charleston, utilizes the expertise and facilities of The Citadel, the Medical University of South Carolina, the S.C. Marine Resources Research Institute (SCWMRD) and the College of Charleston to develop individual research programs that emphasize aquaculture and lead to a M.S. degree in Marine Biology from the College of Charleston. Research facilities are located at the Fort Johnson Marine Resources Center.

Technical Training South Carolina has one of the most advanced technical school systems in the United States. Sixteen technical colleges are located throughout the state, with seven offering agricultural technology programs. Recently, Florence-Darlington Technical School updated its curriculum to include aquaculture. In addition, the Technical College of the Lowcountry (formerly Beaufort Technical College), has initiated a Technical Certification Program in Aquaculture Operations, which provides training in pond and impoundment construction, mechanization and fabrication, water quality and disease control, feeding and growout management, and production and processing operations. In addition, the Technical College, through its Title III program, has proposed the construction of an aquaculture demonstration site at the main campus for cage culture of marine shrimp and spottail bass.

State Agency Programs The South Carolina Sea Grant Consortium initiated the Scientist Exchange Program in 1985 to bring outstanding aquaculture scientists into the state to study at its research facilities, interact with professionals, and provide parallel opportunities for South Carolina scientists. Additionally, the Consortium considers applications for the support of post-doctoral candidates to enhance the state's research programs in aquaculture.

The SCWMRD's Division of Marine Resources is headquartered at Fort Johnson in Charleston where it is engaged in a variety of feasibility studies focused on crustaceans, mollusks, and finfish. Personnel include 50 scientists and technical staff, as well as participating graduate students from across the state. Research facilities at the Division's Marine Resources Research Institute include 50,000 sq. ft. of laboratory space, 2 wet labs, outside tanks, a 150-seat auditorium, library, computer center, staff offices, and a boat slip for the Center's four research vessels.

The James M. Waddell, Jr., Mariculture Research and Development Center is engaged in expanding feasibility studies to commercial scale for crustaceans, mollusks, and finfish. The Waddell Mariculture Center is located on 150 acres

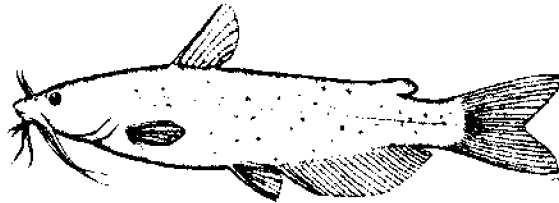
of state-owned land at Victoria Bluff on the Colleton River. The complex consists of a 10,000 sq. ft. research building, a 2,600 sq. ft. fish and shrimp maturation building, a 25,000 sq. ft. outdoor pad for tank culture, three one-and-one-quarter acre ponds, nine half-acre ponds, 12 quarter-acre ponds, and visiting staff quarters and conference building. A 265-foot pier with a floating dock to support cage and tray culture systems also allows small boats to launch and dock in the adjacent Colleton River. The Center is operated by the South Carolina Wildlife and Marine Resources Department for use by its staff and, through working agreements, that of Clemson University and the University of South Carolina.

Other facilities operated by the SCWMRD are the Marine Resources Research Institute in Charleston, the Rembert C. Dennis Center in Bonneau, and state fish hatcheries in Columbia and Cheraw.

PRIVATE SECTOR SUPPORT

The future of private sector research in South Carolina shows great promise. Current research efforts at commercial shrimp culture facilities at Edisto Shrimp Company on Edisto Island and at Richardson Plantation in Green Pond involve the testing of a variety of aeration methods. Demonstration projects for crawfish aquaculture using different draw-down schemes are being evaluated at Carolina Ecrivresse in Moncks Corner and Hawthorne Farm in Sumter by Clemson University scientists. Cooperative public-private trials are being developed to refine grow-out techniques for the recently-legalized hybrid striped bass.

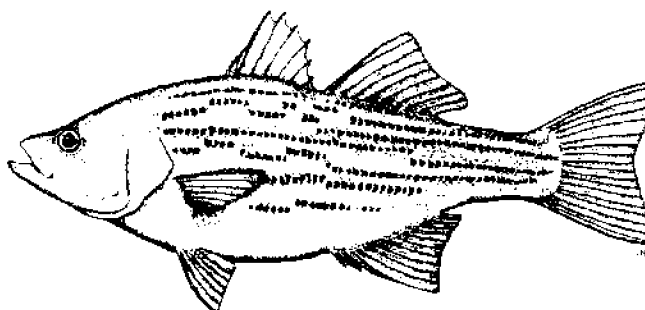
As the aquaculture industry expands, the level of private sector support for research and development will increase, due to the need for a culturist to stay ahead of the competition. But until that time, the aquaculture industry in South Carolina will depend on the public sector for its information and assistance.



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APPENDIX: LIST OF ACRONYMS USED THROUGHOUT THE PLAN

FEDERAL AGENCIES

USDA	U.s. Department of Agriculture
USDOC	U.S. Department of Commerce
USDO	U.S. Department of the Interior
USF&WS	U.S. Fish and Wildlife Service
USACOE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
FHA	Farmer's Home Administration
FCIC	Federal Crop Insurance Corporation
EDA	Economic Development Administration
SBA	Small Business Administration
NOAA	National Oceanic and Atmospheric Administration
GAO	General Accounting Office
NSF	National Science Foundation
NIH	National Institutes of Health

STATE AGENCIES


SCSGC	S.C. Sea Grant Consortium
SCWMRC	S.C. Wildlife and Marine Resources Commission
SCWMRD	S.C. Wildlife and Marine Resources Department
SCMRRI	S.C. Marine Resources Research Institute
SCDHEC	S.C. Department of Health and Environmental Control
SCCC	S.C. Coastal Council
SCBCB	S.C. Budget and Control Board
SCWRC	S.C. Water Resources Commission
SCMEP	S.C. Marine Extension Program
SCAMPI	S.C. Aquaculture and Marine Programs International
SCBTCE	S.C. Board of Technical and Comprehensive Education

OTHER

NPDES	National Pollutant Discharge Elimination System
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