Management and Development of the Shellfish Industry in South Carolina

Robert C. Gracy, Willis J. Keith
and Raymond J. Rhodes

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ABSTRACT

This report resulted in part from a three year project, the major objective of which was to effectively increase South Carolina molluscan (shellfish) production through proper management, development and utilization of these renewable resources.

Until recently, the oyster fishery of South Carolina was the second most valuable commercial fishery in the State. Since early in this century, however, oyster production has exhibited a steady downward trend. Harvesting intertidal oysters is currently the dominant practice within the industry. Lack of mechanization continues to ensure low productivity.

Previous leasing arrangements have been unduly complicated. Recent realignment of leases has resulted in the establishment of well-defined boundaries.

Aerial photography was evaluated as a method of updating intertidal oyster inventories. As the state-of-the-art advances, false color infrared photography may hold promise as an inventory method; however, this method is not economically feasible at present.

State managed oyster bottoms have been established in several areas, providing an additional source of intertidal seed for planting. The substantial seed beds of the Santee and Wando Rivers have been resurveyed to provide a basis for formulating a management program to promote commercial use of these seed oysters.

From March 1973 until June 1975, a hard clam survey was conducted on the unleased subtidal bottoms of the State. Upon completion, more than 18,000-square yard samples had been collected and recorded. Coincident with the field survey, a growth and survival study of clams was completed in specific areas.

Four extensive clam beds were located in the Santee estuary. These contained enough clams to warrant commercial harvesting by means of hydraulic escalator harvesters. Substantially more clams were harvested in 1975 than in any previously recorded clam season.

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INTRODUCTION

Since the early 1900's, the American oyster *Crassostrea virginica* (Gmelin) industry in South Carolina has exhibited large fluctuations in production. After 1965, reported annual oyster production generally declined and stabilized near one million pounds in the 1970's. Despite this trend, it is believed that the state's oyster industry has the potential of returning to its former production of the 1950's and early 1960's. Revitalization of the industry is largely dependent upon technological improvements related to culture and harvesting, a more effective state management program, and maintenance and protection of leases.

A three year (1972-1975) project, the results of which constitute a portion of this report, was undertaken to obtain information necessary for the management and development of the shellfish industry in South Carolina.

The project's primary objectives were to increase the economic benefits of South Carolina's shellfish[1] industry by increasing the productivity of leased grounds, reducing regulatory constraints, encouraging the harvest of underutilized shellfish stocks and generally improving management practices. Ancillary objectives included increased understanding of the hard clam, *Mercenaria mercenaria* (Linne'), its population dynamics and determining problem areas for future research, management and development.

Previous leasing arrangements in South Carolina have been complicated by poorly defined boundaries resulting in management and enforcement problems. This unmanageable situation led to a program of lease realignment (block-leasing) (Gracy & Keith, 1972) and improved acreage inventory methods. Aerial photography was investigated as a technique for surveying oyster resource areas but was determined to be impractical at the time because of economic constraints.

The continued use of subtidal seed oysters from the Wando and Santee Rivers was encouraged during the project. In addition, a new assessment of the Wando River seed oyster beds was completed to document its potential as a harvestable seed resource.

A survey of major subtidal bottom areas was undertaken to locate and assess underutilized clam stocks. The utilization of these stocks was encouraged by permitting Maryland-type escalator harvesters to operate on the clam beds in the Santee River estuary.

Regulations and policies relating to shellfish seasons were revised. The use of washed shell as a potential source of cultch material was investigated. Leasing practices and gear methodology were investigated.

When preparing statutory and policy recommendations for the South Carolina Wildlife and Marine Resources Department, the economic and social impact of improving the oyster industry's productivity without compromising recreational shellfish development was considered.

Historical Trends

Apparently the earliest extensive commercial use of molluscs in South Carolina originated with the burning of oyster shells in kilns to produce lime. This product was used as a binder in the local construction cement known as "tabby". It was not until the final thirty years of the nineteenth century that the sale of oysters as seafood became commercially significant in South Carolina.

Commercial oyster canning did not commence in South Carolina until the last quarter of the nineteenth century. Prior to 1892, Oemler Oyster Company in Savannah, Georgia, purchased oysters from a Beaufort producer who used a steam dredge to obtain select oysters. Elmo Cetchovitch is believed to have started the first commercial raw shucking operation around 1885 in Beaufort or Jasper County. By 1890, Bull Bay and Edisto Fish and Oyster Companies had cultivated subtidal oysters growing in Santee Pass Creek near Capers Island and Bull Bay (Keith and Gracy, 1972).

Until recent years, commercial clam harvesting has not been extensively practiced in this state. Newspapers indicated that 1,120 bags of clams were shipped by steamer from Charleston to New York from March 2 through April 13, 1900 (Lunz, 1949). With the exception of harvesting mussels for the production of a "chemical substance" (e.g., vitamin concentrates), there has been no known commercial mussel operation in South Carolina (Lunz, 1944).

Available records indicate that from about 1888 to 1908, oyster landings increased from less than one million pounds to over seven million pounds of meat. This peak in production has never again been equalled. Although approximately four million pounds of meat pro-

[1]Within the context of this report "mollusc" and "shellfish" will be equivalent in definition.

duction was reported in the late 1920's and again in the mid-1960's, production has generally declined since 1908 (Figure 1).

In the early 1890's, Henry Merritt, who planted oysters near Folly Island, commented, "A scarcity of reliable labor interferes with the increase of business..." (Keith and Gracy, 1972). Apparently, problems associated with employment of skilled "reliable labor" and labor-intense cultivating costs shifted commercial endeavors toward canning plants. Reportedly, sixteen steam canneries operated in South Carolina between 1890 and 1905 (Keith and Gracy, 1972). In 1919, there were five canneries in Charleston and six in Beaufort (Churchill,1920). Canning operations are able to utilize the abundant intertidal or "coon" oyster despite its irregular shell morphology and low meat yield. Historically, efforts to develop and expand subtidal oyster beds using cultivation practices like those in the mid-Atlantic States (e.g., Bailey & Biggs, 1968) have had only marginal success in South Carolina (Gracy and Keith, 1972).

By 1939, 86% of all oysters harvested in South Carolina were canned, and only 14% were raw shucked or sold in the shell (Lunz, 1944). According to Lunz (1950), cannery production increased between 1926 and 1933 due to a decrease in labor costs. It declined again during 1939-45, presumably due to competition from World War II-related jobs (Figure 2).

Despite the adoption of mechanized shaking and floating methods of steam canneries in the mid-1950's (Lunz, 1960), processing and harvesting costs have reduced oyster processing in South Carolina to one cannery with an accompanying decline in oyster landings (Figure 1). In addition, Lunz (1950 and 1967) implied that the lack of "cultivation practices" may have been partially responsible for the gradual decline in oyster landings. He suggested that the decline in meat yields after 1939 was a symptom of oyster bed depletion through overharvesting by canneries (Lunz, 1950). However, other possible reasons for this decline include physical deterioration of the oyster environment because of (1) drainage of coastal wetlands which may increase siltation and promote rapid fluctuation of salinities; (2) destruction of subtidal beds due to radical salinity changes resulting from the construction of the Atlantic Intracoastal Waterway; and (3) closing of productive bottoms due to E. coli pollution. Continued loss of harvesting labor to higher paying employment and lack of practical harvesting mechanization have further reduced production capacity.

Current Status of the Fishery

In the last three years, South Carolina's oyster production exceeded that of other South Atlantic States (Table 1). Oysters were predominantly harvested in the intertidal zone. In 1975, pounds of oyster meat production in South Carolina were over twice that of North Carolina and more than twenty times that of Georgia. Only Florida's west coast production of subtidal oysters placed its total production above South Carolina.

The Marine Resources Division is an organizational unit of the South Carolina Wildlife and Marine Resources Department. By law the Division is empowered with jurisdiction over all marine fish, fishing and fisheries. This includes shellfish, which are defined in the South Carolina Marine Fisheries Laws as "...oysters, clams, mussels and escallops and all immobile fish having shells...". Bottoms including the tidelands of the State lying below the ordinary high water mark are deemed oyster beds, and are managed and regulated by the Division. Consistent with English common law, riparian upland owners have been accorded prerogatives to the shellfish as stated in Section 50-17-720.

Under Section 50-17-1250, the State "...may lease all or part..." of bottoms owned or controlled by the State, "...for shellfish cultivation...". It is not known when this type of leasing was first considered, although at the end of the nineteenth century, control of a tidal bottom could only be granted to an individual through a special act of the State Legislature (Battle, 1890). About 1915, a rental or leasing system was devised to give individuals control over bottoms suitable for oyster culture (Keith and Gracy, 1972).

South Carolina could lease large subtidal areas such as the Wando River seed bed, but the trend has been otherwise. No subtidal bottoms containing natural populations of oysters have been leased. Henry (1970) suggests this policy originates from historical dependence on subtidal shellfish beds as a common property resource.

Although Section 50-17-1260 asserts the Division of Marine Resources "...shall maintain and keep open areas not to exceed fifty acres..." per county for recreational harvesting, not until the 1970's has a significant management effort been allocated to these grounds (Gracy and Keith, 1972). Changing economic conditions and public demands have resulted in procurement of additional acreage for recreational shellfishing. Currently, there are twenty-two areas designated as recreational shellfishing areas (Cupka and Pridgen, 1976).

Harvesting techniques have changed little since the nineteenth century. With the exception of the "factory" as a major buyer, Lunz's 1944 description of harvesting is still accurate in the 1970's (Lunz, 1944):

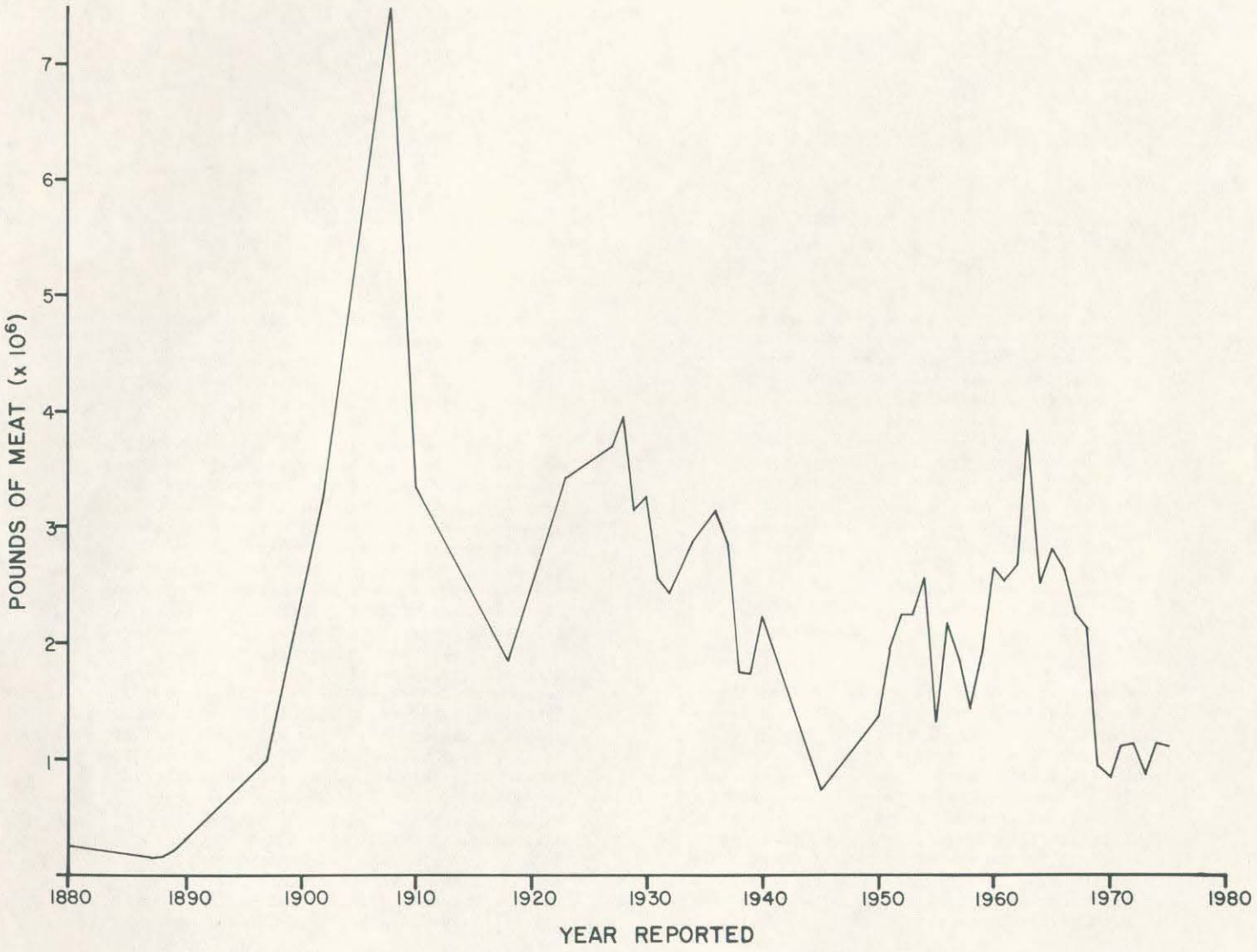

Figure 1. South Carolina Oyster Production (pounds of meat) 1880 to 1975.

Table 1. Pounds of meat and ex-vessel value (dollars) of oysters harvested in four South Atlantic States from 1973-1975,

STATE	1973 POUNDS	1973 DOLLARS	1974 POUNDS	1974 DOLLARS	1975 POUNDS	1975 DOLLARS
North Carolina	548,431	$ 446,485	558,821	$ 435,804	424,831	$ 329,794
South Carolina	878,014	505,362	1,119,021	657,308	1,036,401	616,549
Georgia	105,998	65,122	64,664	36,040	44,062	25,613
Florida-East Coast	122,389	98,505	97,724	85,523	79,417	76,891
Totals	1,654,832	$1,115,474	1,840,230	$1,214,675	1,584,711	$1,048,847

[a]Data from National Marine Fisheries Service, N.O.A.A., Dept. of Commerce.

> "...a power launch tows fifteen to twenty flat bottom barges sixteen to eighteen feet long from the factory to the oyster grounds. The oyster pickers then spread out over the beds picking by hand or with grabs from half ebb tide through low water and until tide becomes too high for further gathering. The oysters are unculled and are loaded into the "Butt-head" (sic) bateaus, just as they come off the banks. When the boats are filled to capacity, they are again towed to the factory or occasionally unloaded on the spot into large lighters which are towed to the factory."

Conventional "box" or oyster dredges (Dumont & Sundstrom, 1961) have been traditionally used for harvesting subtidal oysters. Mechanical harvesting of intertidal oysters has been limited by (1) legal restrictions due to potential ecological damage; (2) physical accessibility to intertidal grounds and (3) experimental investment risks (costs) within a declining industry. In the past four years, the state's only remaining cannery has invested heavily in the development of a mechanical oyster harvester with marginal success.

Presently, South Carolina oyster production can be classified into three major intertidal oyster marketing or processing categories: (1) canning; (2) raw shucked/bushel oysters; and (3) bushel (shell stock) oysters. The Lady's Island oyster canning operation (Ocean, Lake and River Fish Company) accounts for approximately 50% of the oysters commercially harvested in South Carolina. This operation is characterized by a high degree of vertical integration from harvesting to wholesale inventory control. Shell obtained from canning operations is planted by using high-pressure water hoses to wash the shell overboard onto leased bottoms. Low meat yield intertidal "cluster" oysters are bought from fishermen working on the company's leases or other leases. It is not uncommon for oyster fishermen to cull larger and more desirable single intertidal oysters for retail and wholesale bushel (shell stock) oyster sales in the Beaufort area.

The second category, raw shucked/bushel oysters is basically dependent upon two types of market demand: raw shucked container and bushel oysters in the shell. These seafood firms are characterized by horizontal integration --especially the wholesaling of shrimp. It is not uncommon for laborers employed in raw shucking operations to be used in shrimp unloading and packing services. These shucking enterprises will sell oysters in gallon and pint containers to retail stores (e.g., supermarkets) and directly to consumers (Rhodes, 1974). In the period 1960-1972, production in this segment of the industry ranged from a low of 21,311 gallons in 1972 to a high of 161,200 gallons in 1967 (Table 2). The raw shucked/bushel oyster enterprises will sell oysters in U. S. bushel bags to wholesale and retail stores, and individuals. A bushel of oysters is usually sold in two grades: (1) cluster or (2) singles. Cluster oysters are smaller than singles and have a lower meat yield. Larger subtidal oysters are also sold as single oysters.

Leaseholders involved in the second category generally have access to small self-propelled barges or equipment from other fisheries (e.g., shrimp trawlers) to assist in planting operations on the leases. These firms, especially in the McClellanville area, employ boats and outboard motors that are furnished by the lessee for harvesting. Often the raw shucked/bushel oyster businesses are family owned and have been involved in commercial fishing for a rather long period of time.

Table 2. Gallons of meat and value of shucked oysters produced by South Carolina from 1960 through 1972.

	Gallons	Ex-Vessel Value
1960	90,766	$ 477,084
1961	45,553	277,994
1962	61,029	366,349
1963	87,415	546,124
1964	92,274	572,473
1965	97,079	591,028
1966	107,395	727,823
1967	161,200	1,272,493
1968	118,024	898,716
1969	61,048	475,876
1970	27,573	215,545
1971	31,760	262,242
1972	21,311	170,488

Fishermen involved in the shell stock category of commercial harvesting and marketing may or may not have dock facilities, and in some cases they may simply be an independent commercial fisherman who will work for different leaseholders periodically during the oyster and clam season. These independent harvesters generally do little processing and will take special orders for private parties and retail stores. In some cases they may be involved in illegal harvesting and raw shucking operations.

A special category of operations has developed in the Murrells Inlet area, which provides oysters for the half-shell market. These oysters are harvested from leases within the Murrells Inlet area and sold in the leaseholder's restuarant.

During the period from 1971 to 1975, there was a slight increase in the number of persons engaged in the oyster industry (Table 3). The industry's total investment increased by an estimated $297,000 (Table 3) during this same period. This latter situation resulted from an appreciation of waterfront real estate owned by most local oyster companies and not from the purchase of new equipment or property.

Continued use of older labor-intensive technology, especially in harvesting, hampers the industry's attempts to increase production at all levels. The labor shortage apparently emanates from competition with non-seasonal employment and welfare programs (Gracy & Keith, 1972). A comparison of estimated hourly wages to welfare income (Table 4) would suggest that other factors may also be influencing the oyster industry's labor supply. The industry has almost no recruitment into the labor pool (Table 5). The physical requirements, long hours and production oriented wages may also be discouraging young laborers from employment in the industry.

The decline in oyster harvesting effort in recent years due to increased labor costs and other factors has apparently forced lessees toward minimization of shell planting and cultivation costs. Consequently, compared to lease management efforts of the Chesapeake Bay area, most leaseholders in South Carolina do not intensively cultivate or supervise harvesting on their leases.

PART I. IMPROVING THE LEASING SYSTEM

Improving the Lease Boundaries

In recent years, proliferation of numerous small oyster leases with poorly defined boundaries has been a significant management problem. As an example, one oyster producer would acquire many small parcels of bottom, and on occasion, one lease would be entirely surrounded by one or more other leases belonging to different leaseholders. In such cases, legitimate harvesters had to cross boundaries of adjacent leases to reach their harvesting location. This encouraged illegal harvesting to the extent that some leaseholders would cease minimum cultivation practices in certain leased areas. Law enforcement personnel found it impossible to adequately patrol leases and enforce lease laws. Verification of shell and seed-oyster planting was very difficult.

Beginning in 1970, a program to rectify some of the complex lease problems was implemented by the Office of Conservation and Management (Gracy & Keith, 1972). Guidelines for restricting the leasing system were relatively simple. They involved the utilization of natural topographic features (e.g., creeks, rivers, etc.) instead of the previous artificial ones (i.e., stakes), and therefore confined a single lease to a naturally defined geographical area. A pilot "block-leasing"

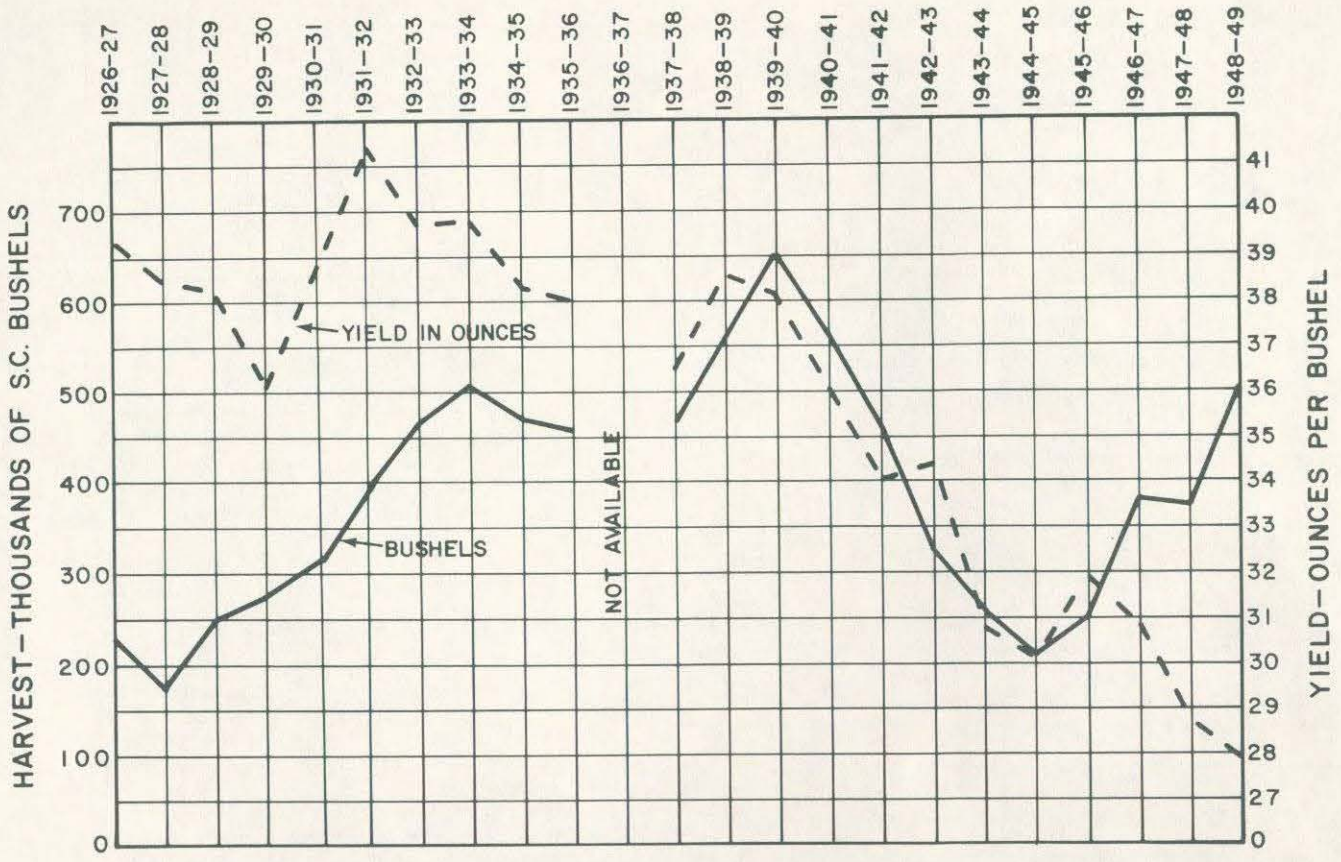

Figure 2. Harvest and Yield of Three Oyster Canning Factories in South Carolina - 1927-1948. (Adapted from Lunz, 1950)

system was then established in the relatively large area extending from the north shore of Charleston Harbor to Alligator Creek. This area was approximately 30% "rezoned" by early 1972 and the block leasing system was completed by May, 1973.

During the winter of 1973, preliminary steps were initiated to bring the extensive area south of Charleston Harbor under the new "block-leasing" system. In May 1973, the Shellfish Management Unit and Leasing and Licensing Section personnel began negotiating the necessary transfer of leased oyster bottoms among leaseholders. After all exchanges had been successfully negotiated and arranged, new lease plats were prepared by the Division. After inspection and final approval by each leaseholder, all of the revised plats were recorded in the courthouses of the respective counties.

Table 3. Capital Equipment and Personnel Used by Commercial Oyster Producers, 1971 and 1975.[a]

EQUIPMENT			PERSONNEL		
	1971	1975		1971	1975
Canning Plants	1	1	Boat operators	15	13
Docks	24	27	Misc. Personnel	51	69
Gathering boats	179	184	Pickers	150	173
Mechanical harvesters	1	2	Shuckers	101	129
Outboard motors	101	126	Total Personnel	317	384
Shucking houses	19	10			
Tow boats	21	9			
Vehicles	34	59			

Estimated value of real personnel and company assets

$3,290,000.00 (1971)
$3,587,000.00 (1975)

[a] Based upon field interviews in 1971 (see Gracy and Keith, 1972) and 1975.

Table 4. Comparison of oystermen's[a] and shucker's[b] estimated hourly wages vs. usable income of wage earners equal to usable income of welfare families.

	Hourly Wages	
Employment Category	Estimated Industry wages[c]	Income of Welfare Families[d]
Oystermen	$3.00	$2.60
Shuckers	$2.50	$2.60

[a] Fishermen who harvest oysters for the leaseholder and are paid according to the number of bushels harvested.

[b] Laborers who manually remove the meat from the oyster and are paid according to the number of pints or gallons they shuck.

[c] Wages for oystermen based on weekly averaging from Rhodes' (1974) oystermen harvesting data in Table 2C and model labor costs in Tables 29 and 30. Data on average hours spent harvesting and shucking, and on shucking rate (nearest gallons per hour) were estimated by R. B. Leland, Carolina Seafood Company, Inc., McClellanville, S. C.

[d] Taken from Nordquist & McAlhaney (1974) Table 7, family size equal to 4.

Table 5. Ages and years of seafood producing experience for South Carolina oyster lessees,[a] oyster fishermen, and shuckers based upon lessee interviews in 1975.

	Age Group						
	12-20	21-30	31-40	41-50	51-60	61+	Total
Lessees	0	1	9	5	10	3	28
Percent	0%	3.7%	32.1%	17.9%	35.7%	10.7%	
Shucker	0	0	0	56	73	0	129
Percent	0%	0%	0%	43.4%	56.6%	0%	
Fishermen	0	0	42	95	34	2	173
Percent	0%	0%	54.9%	54.9%	19.7%	1.2%	
All Groups	0	1	52	157	116	3	330
Percent	0%	.3%	15.8%	47.6%	35.2%	.9%	

	Experience Groups (Years)								
	0	1-4	5-8	9-12	13-16	17-19	20-25	26+	Total
Lessees	1	1	1	2	2	0	8	13	28
Percent	3.6%	3.6%	3.6%	7.1%	7.1%	0%	28.6%	46.4%	
Shuckers	0	0	0	0	30	0	99	0	129
Percent	0%	0%	0%	0%	23.3%	0%	76.7%	0%	
Fishermen	0	0	13	22	13	0	96	29	173
Percent	0%	0%	7.7%	13.1%	7.7%	0%	57.1%	16.8%	
All Groups	0	1	14	24	45	0	203	41	330
Percent	0%	.3%	4.3%	7.4%	13.9%	0%	62.8%	12.4%	

[a]Company representatives or lease managers were interviewed if the lessee was not available.

By May 1974, the entire coastal area of the State had been brought under the "block-leasing" system (Appendix I). Statewide, the total number of leases was reduced by approximately 66% (Table 6).

The reduction in recorded lease acreage by 996.71 acres resulted after all "block-leasing" was completed. This reduction was probably due to the improved accuracy of the resurvey performed for each revised lease. In some cases

Table 6. Oyster Leases and Production in South Carolina, 1970-71 and 1974-75.

	1970 - 1971	1974-75
Number of leases	174	60
Acres under lease	7119.10	6122.39
Total Production (U. S. Bushels)	344,255	308,174
Average Per Acre Production (U. S. Bushels)	48.36	50.34

the original lease had contained less than the acreage actually recorded. In other cases, the leaseholder requested the deletion of marginally productive lease areas.

Improving the Shellfish Survey Methods

Under Section 50-17-730, S. C. Code of Laws, the Division is required to determine the acreage capable of producing shellfish within a lease. This regulation also specifies:

> "If any additional area suitable for the cultivation of oysters shall be found within the perimeter boundaries...the original lessee shall have first opportunity to lease such area..."

Consequently, the Division has the responsibility of assessing the potential shellfish acreage of new areas to be considered for leasing and locating new productive grounds within an established lease.

Due to coastal topography, accurate determination of shellfish acreage presents methodological problems. In other states, three basic categories of survey methods have been employed: (1) compass and chain; (2) plane table; and (3) compilation from aerial photographs, maps, charts and previous plats. (Dow, 1965).

In South Carolina, the most common assessment of intertidal beds has been based upon the plotting of oyster beds on charts drawn to scale from aerial compilation photographs (Lunz, 1943; McKenzie and Badger, 1969).

In 1970, an effort was made to apply aerial photographic and mapping techniques to the survey of intertidal oyster bottoms (Gracy and Keith, 1972). This investigation indicated that both commercially available false color infrared and natural color photography often could be used to identify oyster beds on exposed mud flats and in other open areas, but it was not possible to accurately delineate oyster aggregations growing on creek or river banks or in areas immediately adjacent to saltwater marsh grasses.

In 1972, U. S. Dept. of Agriculture panchromatic black and white photographs were re-examined and it was concluded that they have only limited value for delineation of intertidal oyster beds. This was due to lack of precise detail. Aerial color prints, color transparencies and false color infrared transparencies (Kodak Aerochrome Infrared 2443) obtained from the U. S. Air Force and from private firms conducting ecological inventories in coastal South Carolina were also examined. Oyster beds on mud flats were usually visable on false color infrared, however, intertidal beds bordering creeks were often indiscernible when verified by ground truth observations. In addition, it was impossible to distinguish living oysters from dead oyster shells in many situations.

In March 1975, during another estuarine survey by the Division, false color infrared photographs (Kodak Aerochrome Infrared 2443) and water penetration photography (Kodak Water Penetration Color SO224) were taken by the Division with a modified Military K-17 aerial camera in cooperation with the Department of Civil Engineering and the Department of Forestry, Clemson University. Photographs using the two types of film were exposed at altitudes of 3,000 feet (1:6,000 scale) and 6,000 feet (1:12,000 scale). Limited numbers of infrared photographs were also taken at an altitude of several hundred feet. Apparently, this type of film will not adequately penetrate the silt laden waters usually found in coastal South Carolina. At the lowest altitudes, oyster beds could be identified on infrared photographs. Subsequent verification by ground truth observations indicated that a reasonable assessment of oyster beds could be performed from these photographs.

An opportunity to observe the results of aerial photographic survey techniques in a specialized oyster survey application was presented in 1975. Under a study funded by the U. S. Army Corps of Engineers, the Division was contracted to prepare an environmental report on a portion of Murrells Inlet, S. C. (Calder, et. al., 1975). This report was designated to provide baseline information on a proposed navigational project in the area involving dredging and construction of a jetty system. A primary objective included a survey of all intertidal oyster bottoms 0.5 miles from the centerline of the proposed channel.

Locations and quantitative estimates of oyster beds were recorded in the field on U.S. Department of Agriculture panchromatic black and white photographs and later transposed to map overlays. Aerial infrared photographs were utilized to provide supplemental information relative to the size and location of oyster beds on intertidal flats and inaccessible areas. Approximately 22 acres of oyster beds were located in the study area. This application of aerial photography proved to be useful, but only as a supplement to established field survey methods.

From various observations, it appears that when used exclusively, false color infrared photographs demonstrate the most promising methodology for aerial intertidal oyster surveys. Using this technique at very low altitudes (500 to 1000 feet) would currently incur high costs. Until infrared or thermal imagery techniques are further enhanced to accurately distinguish oyster beds from higher altitudes with better resolution, it would not be economical to use only photography to inventory intertidal oyster

resources in South Carolina. At present, field observation methods to determine the quality and quantity of intertidal oysters (Mckenzie & Badger 1969) are still the single most economical means available. However, the accuracy of ground observation can be enhanced by use of aerial observations and photography.

PART II. SURVEY OF THE MAJOR UNLEASED CLAM AND SUBTIDAL OYSTER BEDS.

Sampling Equipment and Procedures

Hydraulic patent tongs were used to assess subtidal oyster beds in the Wando River and Santee estuaries and the clam resources of unleased inshore bottoms. The patent tongs were mounted on a 20 x 8 foot boat with a center line tunnel extending the length of the hull. Propulsion was provided by a 65 horsepower outboard motor mounted within an interior well. The spring-steel patent tongs were designed to accomplish square yard sampling. The tongs were suspended from a right angle pedestal boom affixed to the boat's deck five feet from the stern. The arc of transverse was 270 degrees. A nine horsepower gasoline engine powered the hydraulic pump. The patent tongs could be raised and lowered to a maximum depth of 40 feet by a hydraulic winch. Opening and closing was accomplished by a hydraulic piston. The boom's rotation was produced by a low-speed hydraulic motor. Samples were dropped on a conveniently mounted sheet steel culling table for sorting and counting.

Proposed sampling locations for clams on major unleased bottoms were selected from recommendations of commercial fishermen, field observations by Division biologists and the results of studies in other states (Godwin, 1968). Transected maps were designed for sampling locations and equidistant stations were located along each transect station. When clams occurred, two replicate samples were taken. Three replicate samples were taken on each station if intensive sampling was desired. Intensive sampling was conducted in areas where clams were found or in areas where clams were thought to be abundant.

Information recorded at each station consisted of the number of clams sampled, commericial grade size, bottom type, and water depth. Daily log sheets were kept with information subsequently transferred to Hollerith cards for future analysis. Clam populations of suspected commercial densities were delineated on maps prepared by the Division and filed for review by interested parties.

The North and South Santee Rivers were surveyed using the above methods during 1973 and 1974 for both clams and subtidal oysters. The subtidal oyster beds of the Wando River and its tributaries were surveyed in July 1975, using a slightly modified sampling plan. Survey charts were drawn of the area and transects established every 600 feet. Square yard samples were taken every 200 feet along each transect. Data recorded at each station consisted of: oyster density, shell volume, bottom type and water depth.

Clam Beds on Major Unleased Bottoms

Areas sampled for clam populations included Calibogue Sound, Port Royal Sound, Trenchards Inlet, North and South Edisto Rivers, Wadmalaw Sound, Stono Inlet, portions of the Intracoastal Waterway, Bull Bay, North and South Santee Rivers, Winyah Bay and the Little River area.

Sampling was initiated in St. Helena Sound during the fall of 1973. However, commercial quantities of clams were not found in this area. During previous subtidal oyster surveys, clam populations had been observed in the North and South Santee Rivers; therefore, the clam survey was moved to this area. An area of 710 acres was estimated to contain clams in the Santee estuary (Figures 3 and 4).

During the statewide survey, 18,272 square yard samples were taken and of these 2,772 samples (15.2%) contained clams. This represents approximately 1,010 acres of clam populations located and charted during the survey (Table 7). The lower North Santee and South Santee Rivers had an occurrence of 33.7% and 35.8% of clams, respectively, for the stations sampled. Samples in the Little River area and Bull Bay had the next highest percentages. No clams were found at stations sampled in Calibogue Sound, South Edisto River, and the Stono River.

Since the sampling effort has been renewed under PL 88-309 Project 2-265 ("Survey of South Carolina's Clam Resources) only a general discussion of previous results is presented. The clam survey data will be analyzed in the current project's final report. In addition, data collected during this investigation (Project 2-179-D) were sufficient to consider the feasibility of mechanically harvesting the clam beds. No previously published data concerning surveys of *Mercenaria mercenaria* stocks in South Carolina exists, although Lunz (1944) stated that the state has an abundant supply of natural clam beds. He also recommended that offshore clam beds be surveyed (Lunz, 1949).

Following an investigation of subtidal and intertidal clam beds in Georgia, it was reported that clams were found in 9.5% of the 432 stations sampled (Godwin, 1968). Small intertidal clam populations accounted for the majority of clam beds located. Clams were not present in most samples taken from large open areas. A similar condition probably exists for South Carolina where St. Helena, Port Royal, and Calibogue Sounds are considered to be comparative areas.

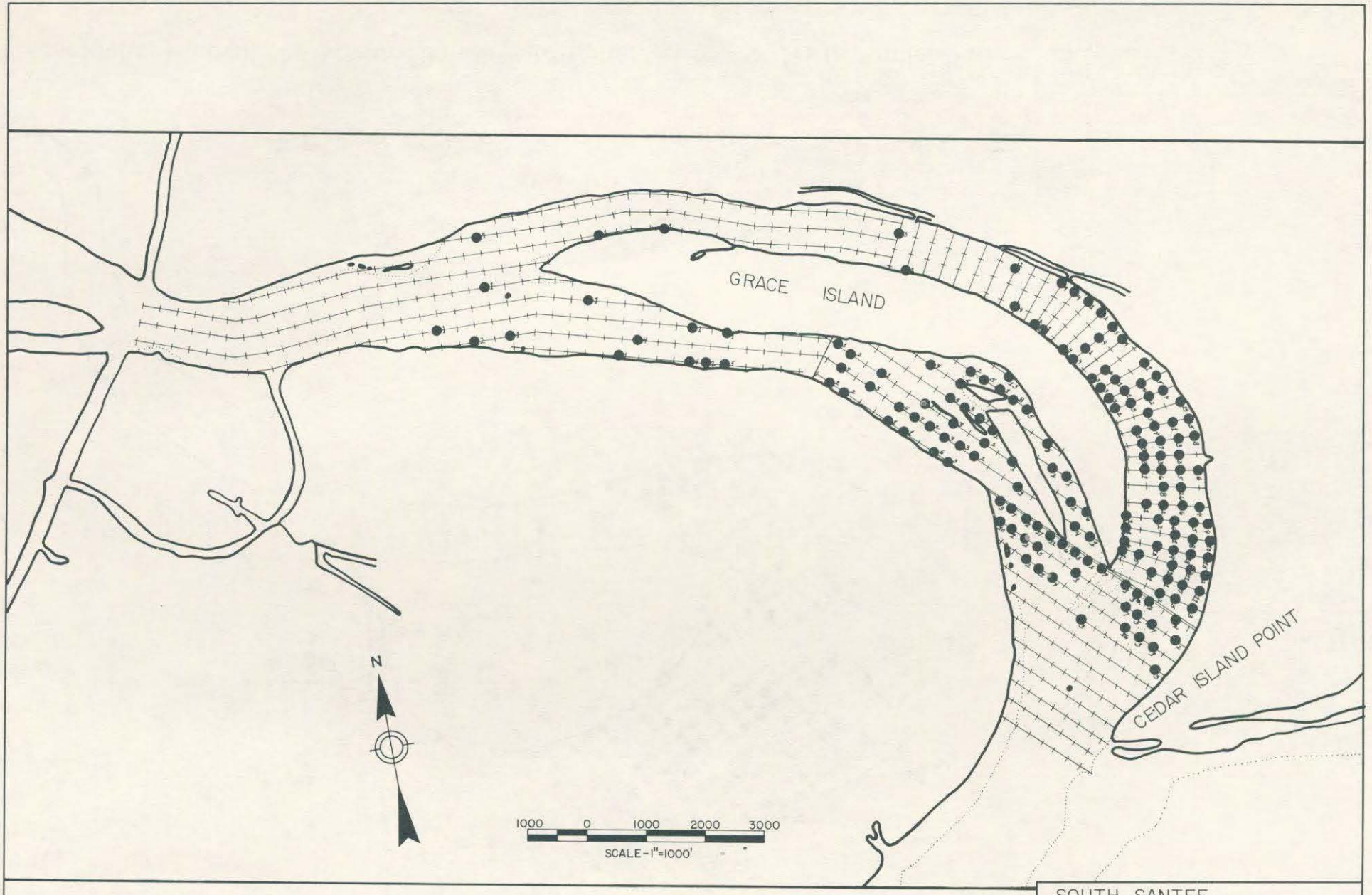

Figure 3. Locations Where Clams Were Collected in the South Santee River.

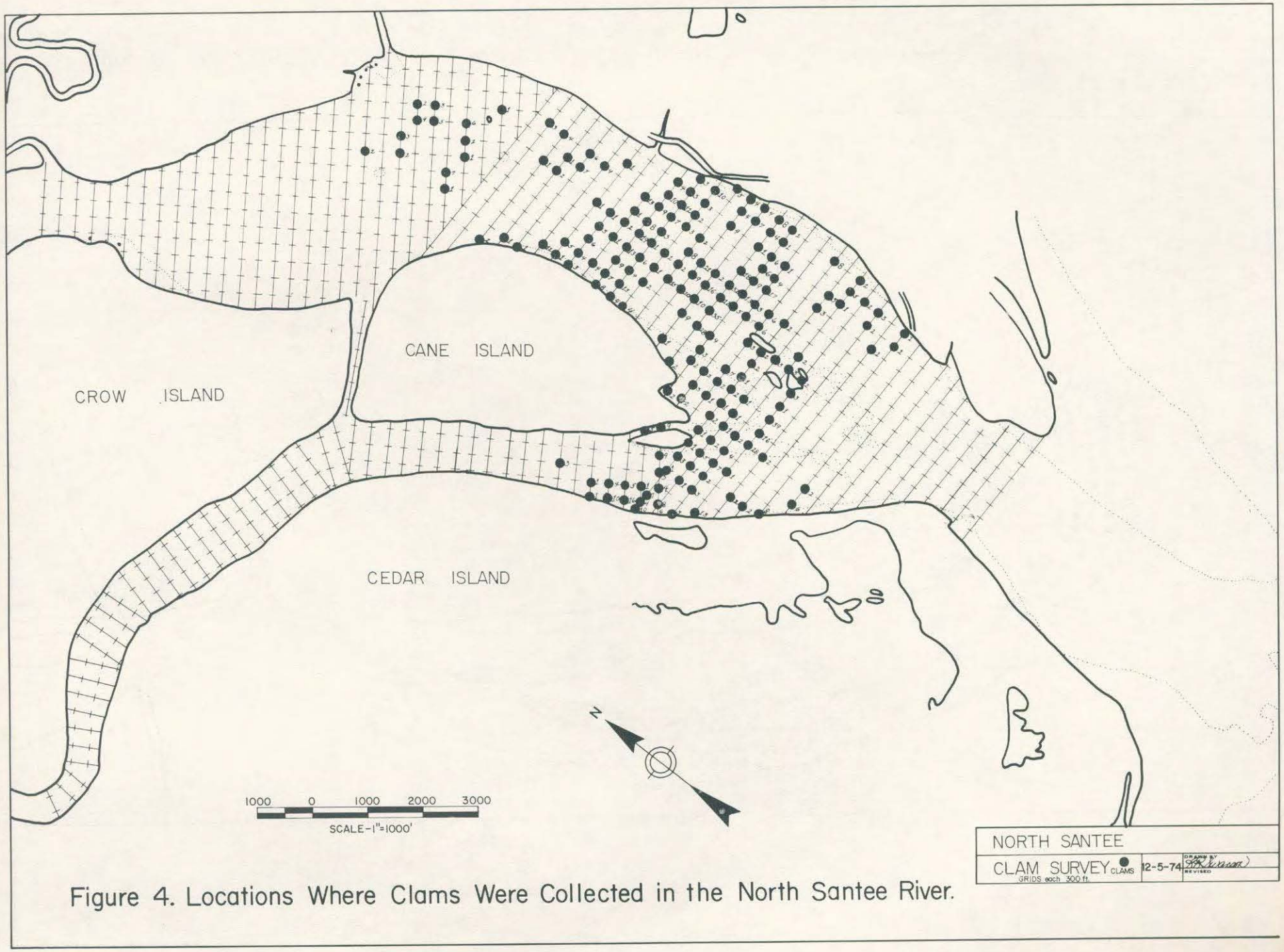

Figure 4. Locations Where Clams Were Collected in the North Santee River.

Less than two percent of these stations contained clams (Table 7).

Santee Estuary Subtidal Shellfish Beds

Approximately 710 acres of clam producing bottoms and small scattered areas of seed oysters were charted in the North and South Santee River estuaries. The largest concentration of seed oysters was found in a 93 acre bed in South Santee. This bed is located within a 194 acre state managed tract (Figure 3) reserved for seed oyster harvesting. In addition, 70 acres of bottoms were located which may be suitable for planting oyster cultch to expand the natural subtidal bed.

Table 7. Major estuaries where sampling was conducted for hard clams, *Mercenaria mercenaria*, in South Carolina.

LOCATION	TOTAL SAMPLES	SAMPLES CONTAINING CLAMS	PERCENT	ESTIMATED ACRES OF CLAM BOTTOMS
Little River	969	153	15.79	50
Winyah Bay	1,629	9	.55	18
North Santee	3,293	1,111	33.74	349
South Santee	2,957	1,059	35.81	361
Bull Bay	3,637	368	10.12	88
Stono River	119	0	.00	0
North Edisto	272	2	.74	4
South Edisto	374	0	.00	0
St. Helena Sound	1,385	18	1.30	36
Port Royal Sound	2,993	52	1.74	104
Calibogue Sound	644	0	.00	0
TOTALS	18,272	2,772	15.17	1,010

The Wando River Subtidal Oyster Beds

A total of 985 square yard samples were collected in the Wando River and its tributaries with 269 samples containing live oysters. It was estimated that 584 acres of subtidal oyster beds containing 245,583 U. S. bushels of seed oysters were present in the Wando River (Table 8) (Appendix I).

A 1964 Bears Bluff Laboratories survey (Bears Bluff Laboratories, 1964) estimated that 390 acres of subtidal oyster beds were present in the Wando River. The 1964 effort did not include the tributary creeks. The estimated acreage in 1975 of 439 acres in the main chan-

Table 8. Subtidal Oyster Survey of the Wando River and Tributaries (1975).

LOCATION	STATIONS	STATIONS WITH OYSTERS	ACRES OF OYSTER BEDS	OYSTERS COLLECTED VOL. U.S. BUSHELS	ESTIMATED TOTAL U. S. BUSHELS
Wando River	641	199	439	17.0	181,512
Beresford Creek	60	15	41	2.0	26,458
Horlbeck & Boone Hall	80	22	44	3.0	29,040
Guerin Creek	56	18	47	0.4063	5,134
Toomer Creek	20	4	3	0.3125	1,135
Wagner Creek	32	4	3	0.3438	1,247
Hobcaw Creek	60	6	6	0.1875	907
Foster Creek	18	1	1	0.0313	151
Deep Creek	18	0	0	0.0	0
Totals	985	269	584		245,583

nel of the Wando River (Table 8) was only 11% higher than the 1964 survey. Since different sampling gear was used in 1964, the 11% difference may be due to the equipment or methodology. In addition, the 1964 survey results indicated that 213 U. S. bushels per acre were found compared to an estimated 420.5 bushels in 1975.

PART III. IMPROVEMENT OF SUBTIDAL AND INTERTIDAL OYSTER CULTURE AND HARVESTING TECHNIQUES.

Oyster Culture Techniques

Although the South Carolina oyster industry may have the potential of increasing its productivity through the development of off-bottom oyster culture and intertidal harvesting mechanization (Burrell, 1976), the industry has been reluctant to adopt established culturing techniques. Reluctance has originated from the lack of dependency on intensive culture techniques (Churchill, 1920; Lunz, 1967) for cannery processing stock and because of legal restrictions on harvesting oysters in less than 12 feet of water (Lunz, 1951; Keith and Cochran, 1968). Factors which may have contributed to this reluctance include illegal harvesting on leases, lack of knowledge concerning established culture techniques, and reduced capital from oyster processing (canning and raw shucking) operations to support culture techniques.

Although seed oysters have been previously harvested for shipment to Virginia (Lunz, 1959), the culturing of subtidal oyster beds probably represents the most neglected potential by South Carolina leaseholders (Gracy and Keith, 1972). Keith and Cochran (1968) attempted to identify and evaluate factors influencing the survival of subtidal seed oysters transplanted from well-developed subtidal beds (Wando River) to other areas (Cape Romain Harbor).

Improving Oyster Cultivation Techniques on Commercial Leases

Commercial oyster leaseholders were encouraged to utilize available subtidal seed oysters from the Wando and South Santee Rivers. Guidelines developed by Keith and Cochran (1968) were employed when advising the lessees. Subtidal seed oysters were collected with oyster dredges. Field observations of intertidal shell planting were recorded when scheduling permitted.

During the summer of 1975, a seasonal aid hired by the Division monitored shell planting in the Beaufort area. This individual also assisted Beaufort County's major shell planter, Ocean, Lake and River Fish Company, in selecting and delineating intertidal planting areas.

During 1973 and 1974, leaseholders in the Murrells Inlet area were encouraged to separate seed oysters located near mean high water and transplant nearer mean low water. Lunz (1960) suggested practice of this method in Georgetown and Horry Counties where subtidal oysters were scarce.

Shell and seed planting records (Table 9) show a reduction in quantities planted during the 1970's, with lowest volumes during 1971 and 1973. Since the low planting volume of 1973, project personnel have attempted to improve planting efforts. Several leaseholders were advised that unless they planted their minimum quota of shell or seed, their lease could be revoked under Section 50-17-810 of South Carolina's Marine Fishery Laws. This advisement generated additional effort by some leaseholders. Reported seed and shell planting totals in 1974 increased by 53% total and 92% in 1975 (Table 9) compared to 1973.

Table 9. South Carolina Oyster shell and seed planting totals as reported to the South Carolina Wildlife and Marine Resources Department, Charleston, South Carolina.

YEAR	SHELL (bu.)	SEED (bu.)	TOTALS	PERCENT CHARGE[a]
1969	329,572	28,637	358,209	100%
1970	271,189	36,738	307,927	86%
1971	164,368	51,009	215,377	60%
1972	177,668	77,387	255,055	71%
1973	80,154	72,865	153,019	43%
1974	143,280	90,396	233,675	65%
1975	225,905	67,354	293,259	82%

[a]Percent compared to the 1969 planting totals.

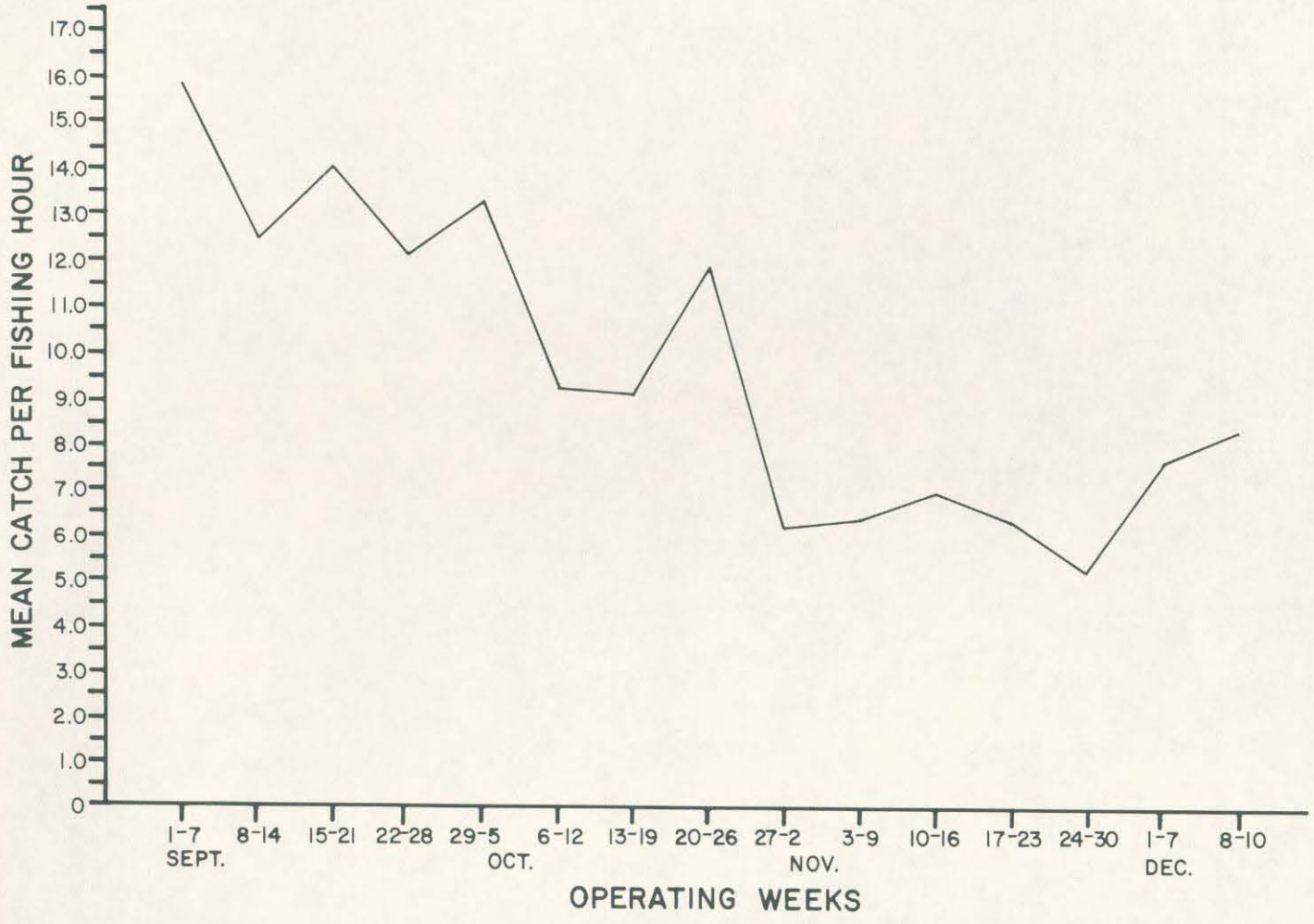

Figure 5. Commercial Clam Harvest in South Santee River in South Carolina, September-December, 1974.

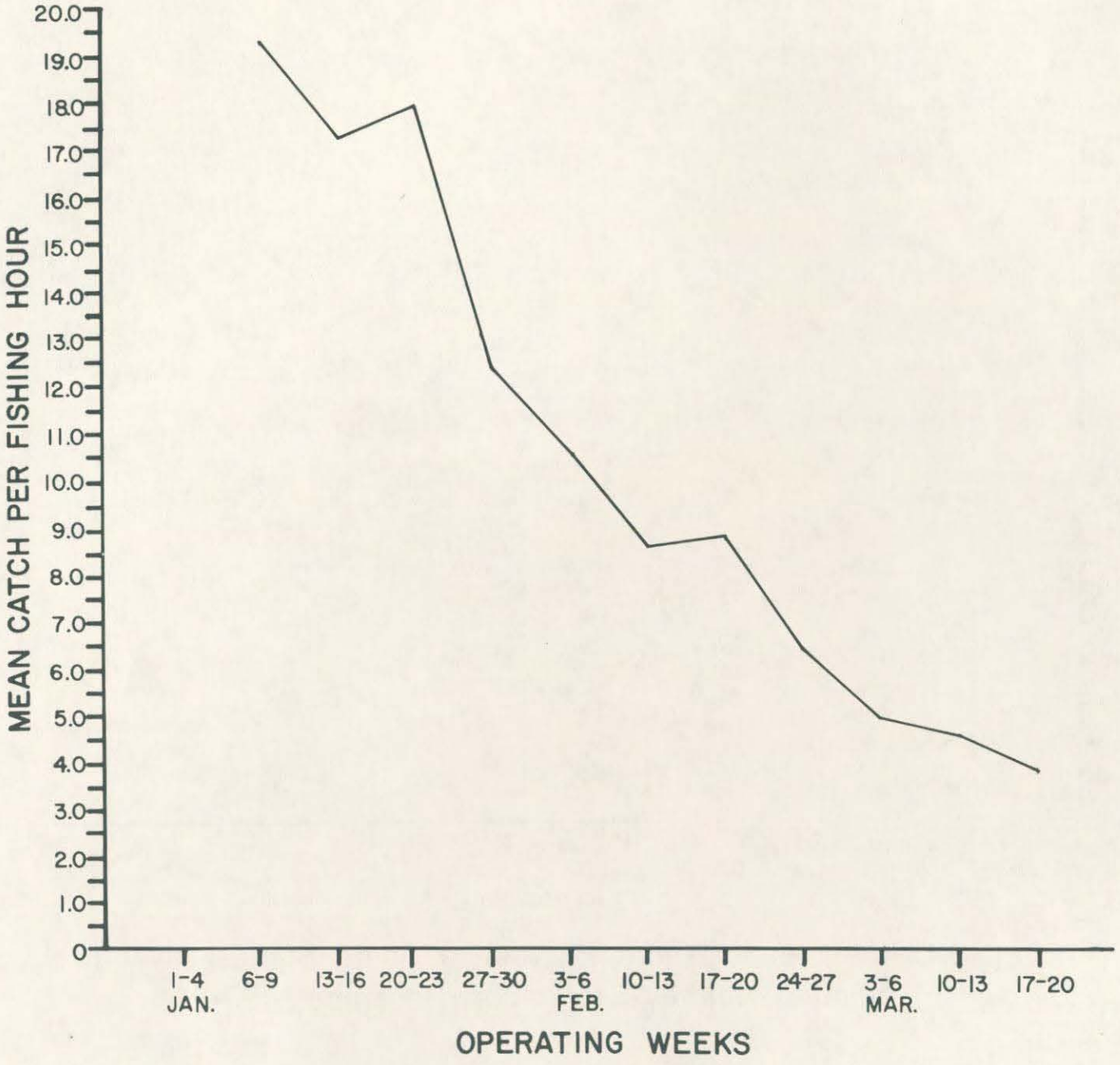

Figure 6. Commercial Clam Harvest in North Santee River in South Carolina, January-March, 1975.

Improvement of Commercial Oyster Harvesting

This project was not designed to fund development of mechanical harvesting technology. However, experimentation with harvesting equipment designed in other states was encouraged. This concept is consistent with previous recommendations (Gracy and Keith, 1972) of giving "...all possible support to development of a method of safely harvesting, by mechanical means, intertidal oysters". Since the publication of Project 2-105-R recommendations (Gracy and Keith, 1972), the Division's Marine Resources Research Institute and Clemson University have conducted experimentation with mechanical oyster harvesters. Field tests of a prototype head adapted to a hydraulic escalator clam harvester have been completed in the McClellanville area.

The prototype mechanical harvester utilizes two conveyor belts with flexible steel teeth set at a leading angle of approximately 15 degrees. In operation, it passes over the oyster bed, oysters are lifted off the bottom and transported to the escalator, which delivers them to the vessel. Oysters are lifted mechanically rather than hydraulically, similar to the soft-clam harvester. Initial observations indicate that this lifting procedure should produce insignificant damage to remaining live oysters and the underlying shell matrix.

The mechanical oyster harvester head is being designed for use on hydraulic clam harvesters with minor modifications of the clam escalator. This approach would permit a vessel and its associated hydraulic equipment to be utilized in two different fisheries (Andrew Jordan, personal communication, Clemson University).

Ocean, Lake and River Fish Company has been developing a large self-contained mechanical harvesting system since 1971. The owners have experienced varying degrees of operational success since the system's inception, and during two seasons enough oysters were harvested to be utilized in the steam-canning operations of the company. This type of harvester is suitable for a large organization, but would be prohibitively expensive for the average commercial oyster leaseholder.

A less sophistocated harvester has been in limited use by the Sullivans Island Seafood Company, Sullivans Island, South Carolina. The design concept utilizes a commercial hydraulic log lifting apparatus. The logging claws have been replaced with a three bushel capacity tonghead of conventional design and mounted at the extremity of an articulated 24 foot steel boom. The entire unit is mounted on a towed, steel-hulled round-bottom barge.

In the late summer of 1974, Sullivans Island Seafood Company began operation with its boom mounted harvester. Initially, it was successfully used in gathering "washed shell" from deposits along the Intracoastal Waterway for use as cultch material.

During the fall of 1974, this harvester was used to gather cluster oysters, however, the company's seasonal cluster oyster production was relatively low. It may also be useful in harvesting subtidal oysters and hard clams in shallow waters. Field observations indicate that an experienced operator can use it without significant damage to the oyster matrix.

PART IV. MANAGEMENT AND UTILIZATION OF UNLEASED INTERTIDAL AND SUBTIDAL AREAS.

Unleased Intertidal Grounds

Intertidal state grounds have been designated at several locations for public use. Although these bottoms have never been subjected to a thorough survey, they are estimated to total several hundred acres.

On state grounds, leaseholders have been permitted to remove seed oysters to their leases. Seed removal is usually monitored by either a fisheries biologist or a conservation officer.

In addition to recreational areas, the public is allowed access without permits to other state managed grounds. This arrangement of allowing limited recreational harvesting on all state controlled bottoms greatly increases the acreage legally available to the public. Both clams and oysters may be taken within legal limitations.

Utilization of Washed Shell

Less than 20 years ago, South Carolina had an annual surplus of approximately 250,000 U. S. bushels of steamed oyster shell suitable for use as cultch material (Lunz, 1958). Gradually, steam canneries have ceased operations until the one remaining cannery seldom produces enough steamed shell to fulfill its own yearly planting quotas. Leaseholders generally attempt to meet their quotas by utilizing raw shucked shell and seed oysters either from within their own leases or from unleased state grounds.

The state's ten raw-shucking houses provide some transplantable shell. However, this amount, even used in conjunction with seed oysters, is not usually adequate for most leaseholders annual quotas. Export sales of shell stock oysters removed 12,974 S. C. bushels of shell from the state in 1974-75. This loss of shell will probably continue in the future. Since shell return is not required by state law, only very

small quantities are ever returned. With the closing of nine shucking houses since 1971, less shell is available from local processing.

It well substantiated that oyster spat will set on a number of materials. Many substitutes have been used as artificial cultch in local waters, but they have usually proven impractical, prohibitively expensive, or subject to legal constraints. A possible substitute cultch may be found in the utilization of dead oyster shell, commonly known as "washed shell", the less resilient, partially eroded oyster shells that have accreted on the banks of sections of the Intracoastal Waterway and along many river banks.

Previous experimental plantings by Bears Bluff Laboratories indicated that washed shell may be a suitable cultch material if not planted on very soft bottoms. Earlier investigations illustrated that washed shell caught only half as much spat as steamed shell (Lunz, 1958). Use of washed shell for intertidal cultch collections may possibly inhibit overcrowding of spat, a common occurrence with South Carolina oysters. As intertidal spawning in South Carolina waters is of long duration and varying intensity, a reduced catch may be more desirable.

In 1974, the Sullivans Island Seafood Company transplanted approximately 5,070 S. C. bushels of washed shell from the Intracoastal Waterway near Dewees Inlet to selected areas of their leased bottoms. Gathering shell proved to be practical, utilizing their mechanical oyster harvester. Planting was accomplished from conventional boats and barges, although it was not done in recommended areas. Much of the shell settled in deep water, and as subtidal washed shell cultch, produced few subtidal seed oysters.

Subtidal Clam Harvesting

Results of the Santee estuary clam survey indicated that the mouth of the South Santee River and North Santee Bay could be opened for limited commercial clam harvesting using Maryland-type hydraulic escalator harvesters. During February, March and April 1974, two permits were issued. North Santee Bay was opened in May 1974 under special Division permits. Operators were required to record daily catches on standardized daily log forms. This experimental harvesting effort afforded an opportunity to determine the commercial feasibility of subtidal mechanical clam harvesting. Approximately 2,589 bags (250 ungraded clams per bag) were harvested from these areas.

Since the owners of the two escalator harvesters indicated that harvesting of clams with this gear would be profitable at least on a short term basis, the South Santee River (Figure 5) was reopened on September 1, 1974, and closed on December 10, 1974. During this period, a total of 15,312 bags were harvested from the South Santee River (Table 10).

Each vessel harvesting clams was required to complete a daily log form (Appendix II). Information collected included harvesting hours and quantity of clams harvested. These log forms were submitted to the Licensing and Leasing

Table 10. Commercial clam catches, fishing time, and mean catch per fishing hour in the South Santee River for September thru December, 1974.

OPERATING PERIOD	CATCH (bags)[a]	FISHING TIME[b] (Hours)	MEAN CATCH PER FISHING HOUR
9/1-9/7/74	1480	93	15.9
9/8-9/14	1319	106	12.4
9/15-9/21	1558	111	14.0
9/22-9/28	1411	115	12.3
9/29-9/31	1793	134	13.4
10/6-10/12	1330	143	9.3
10/13-10/19	512	56	9.1
10/20-10/26	1344	113	11.9
10/27-11/2	305	50	6.1
11/3-11/9	308	48	6.4
11/10-11/16	863	125	6.9
11/17-11/23	973	152	6.4
11/24-11/30	635	119	5.3
12/1-12/7	1185	152	7.9
12/8-12/14	296	35	8.4
Totals	15,312 bags	1,552 hrs.	9.9

[a]250 ungraded individual clams per bag.
[b]Estimated hours spent searching for or capturing clams but not including travel time to and from the general fishing area.

Section of the Division within seven days following each harvesting week. Failure to comply with the above was a basis for cancelling the harvesting permit of the delinquent boat.

Weekly inspections of clams and other organismson the conveyor belt were performed by project personnel. Length data on commercial size clams were obtained during these inspections.

A graph of the mean catch per operating hour (Figures 5 and 6) for both rivers suggests an expoential-type curve. Total hours expended by vessel operators in fishing per week (Table 10 and 11 and Appendices III and IV) varied apparently due to a decrease in commercial-size clams available for harvesting. Except for a few weeks during the fall and spring, variable operating costs vs. ex-vessel prices were not considered important factors influencing fishing effort.

Several operators experienced mechanical failures which seriously limited their actual harvesting time. Most of these vessels had previously been employed for clam harvesting in North Carolina and the Chesapeake Bay area. In some cases, the original captains and crews continued to operate the vessels until the owners could replace them with resident crews.

Through introduction of mechanical harvesting, South Carolina was able to produce a larger clam harvest than in any previously recorded year. During the 1974-75 season, 42,220 bushels of clams were harvested (Table 12). This harvest nearly equalled the total harvest of clams in the state for the past four seasons.

PART V. RECOMMENDED SOLUTIONS FOR PROBLEMS HINDERING MOLLUSCAN FISHERY MANAGEMENT AND DEVELOPMENT.

In addition to the need for exploiting current technology, developing new technology and utilizing unexploited species, there are other problems in South Carolina directly associated with the shellfish leasing system.

Fishery economists have described the effects of stock depletion attributed to common property legal structures (Gordan, 1954; Smith, 1969). In general, the common property legal framework can lead to fish stock over-exploitation since it does not ensure that total costs of each producer's exploitation of the resource are borne completely by him. In contrast, a private property legal system forces the producer to internalize his exploitation costs in return for securing all benefits. Common property legal systems also tend to protect obsolete technology and associated capital in order to forestall

Table 11. Commercial clam catches, fishing time, and mean catch per fishing hour in North Santee River for January thru March, 1975.

OPERATING[a] PERIOD	CATCH (bags)[b]	FISHING TIME (hours)	MEAN CATCH PER FISHING HOUR
1/5-1/11/75	2762	143	19.3
1/12-1/18	2353	135	17.4
1/19-1/25	2385	133	17.9
1/26-2/1	2045	165	12.4
2/2-2/8	1303	124	10.5
2/9-2/15	1587	185	8.6
2/16-2/22	1611	181	8.9
2/23-3/1	712	110	6.5
3/2-3/8	711	145	4.9
3/9-3/15	526	114	4.6
3/16-3/22	231	60	3.9
TOTALS	16,226	1,495	10.9

[a] Only four operating days per week were permitted by South Carolina Wildlife and Marine Resources Department rules.
[b] 250 ungraded clams per bag.
[c] Estimated hours spent searching for or capturing clams but not including traveling time to and from the general fishing area.

depletion of the resource stock. A recent empirical analysis (Agnello and Donnelly, 1975) suggests that oyster stock depletion is a less serious problem in the Delaware Bay states where private leasing of oyster grounds is more prevalent compared to the Chesapeake Bay states.

Management experience in South Carolina has indicated that the institutionalizing of private leasing does not erase the problem of over-exploitation. In recent years, leases have been revoked due to obvious depletion of the lessee's oyster grounds without any apparent effort to restore (i.e., planting shell or seed oysters) the harvested areas. Section 50-17-790 of the South Carolina Marine Fisheries Laws provides standards for judging minimum acceptable maintenance of leased state grounds.

The administration of a leasing system does not address the recreational harvesting needs of the general public. Previous experience suggests that fiscal benefits (oyster taxes and leasing fees) of the leasing system have persuaded administrators to allocate more effort to the private leasing system at the expense of developing and maintaining recreational grounds. In addition, the leasing system tends to neglect commercial fishermen who wish to harvest oysters without contracting with a leaseholder.

Maintaining the Shellfish Cultivation Benefits of Leased State Grounds

Previous alterations of South Carolina wetlands have influenced the productivity of commercial shellfish producing areas. Since improvement of the Intracoastal Waterway during the 1930's, and alterations in highland drainage systems, it is apparent that the number of acres capable of producing oysters has decreased due to destruction of areas by siltation and salinity changes. More recent changes include the destruction of oyster beds due to wake action of boat traffic (G. J. Maggioni, personal communication). An additional problem continues to be the contamination of oyster growing areas by domestic sewage, trace metals and other pollutants. Although polluted areas may be capable of producing oysters that can be transferred to non-polluted sites for depuration, water pollution has resulted in the closure of hundreds of acres of shellfish growing areas in the state.

Previous Division of Commercial Fisheries policies included close supervision of shell and seed oyster planting on major leases. Recently, the Department has reduced its allocation of personnel to monitor oyster planting activities. It is recommended that the seasonal effort allocated to verify oyster planting activities be increased.

Although the leasing system should be supported as the most productive and economically efficient fishery, it does not necessarily resolve conflicts from other user groups. Under Section 50-17-1210 of the S. C. Marine Fisheries Laws, lessees can permit the public to harvest oysters from their leases. In the past, leaseholders have been seriously concerned with the general public harvesting on their leases (Lunz, 1951). Recently leaseholders have become more critical of general public harvesting on their leases because the demand for this type of activity has increased with population growth. Illegal commercial harvesters may claim that they are only harvesting for recreational purposes when confronted by conservation officers.

At present there are approximately 100 acres of shellfish bottoms identified for recreational harvesting. Furthermore, there is limited statutory authorization for the Division to maintain significant acreages of public grounds. The condition of these grounds has generally been poorer than those within the boundaries of leases. This is due to two factors: (1) public grounds have been obtained from revoked leases and consequently have been chronically neglected, and; (2)

Table 12. Reported South Carolina Clam Landings, 1970 thru 1975.

	HAND HARVESTED (U. S. Bushels)	MECHANICALLY HARVESTED (U. S. Bushels)	TOTAL ALL METHODS (U.S. Bu.)	TOTAL EX-VESSEL[a] VALUE
1970-71	Unknown	Unknown	19,478	$ 12,064
1971-72	5,296	0	5,292	17,370
1972-73	11,292	0	11,292	44,273
1973-74	4,594	2,582	7,176	45,339
1974-75	11,303	30,917[b]	42,220	213,382

[a] S. C. Landings, National Marine Fisheries Service, Monthly Bulletin, 1970-1975
[b] 1974-75 season clams reported at 250/bag equalling approximately one U. S. bushel.

the recreational harvester is not subjected to a cultivation requirement. Another disadvantage of recreational acreage is that some areas have poor accessibility (David Cupka, personal communication). The demands of recreational users are even further complicated by the lack of current information concerning conditions of public grounds and their degree of utilization.

Concurrent with the increasing demand for recreational use has been an increase in illegal harvesting activities on commercial leases. Similar to experiences in other states, in South Carolina there may be an increasing demand from individuals seasonally employed to participate in commercial harvesting of oysters without arrangements with leaseholders. This type of illegal harvesting has been complicated by the lack of a "prima facie clause" under Section 50-17-1210 of the S. C. Marine Fisheries Laws. Leaseholders have been reluctant to prosecute since the leaseholder may require the employment of the illegal harvester in the future due to the limited labor supply. Illegal harvesting sometimes generates unsanitary oyster processing conditions.

To meet the rising demand for public grounds for recreational and commercial users, it is recommended that such grounds be improved by seed planting. In contrast to present policies of limiting public grounds to recreational use, consideration should be given to include use by commercial oyster harvesters. This type of arrangement has been partially successful in Florida (Whitfield, 1973). In Franklin County, Florida, shell planting funded by federal grants resulted in nearly 4% of the state total oyster production. Whitfield (1973) estimated a one to five cost-to-benefit-ratio using the oyster potential retail value in Florida.

Consideration should be given to the establishment of individual licenses for both recreational and commercial shellfish harvesting. This would facilitate identification of participants, and support the cost for maintaining such grounds. On combined recreational and commercial grounds there should be limitations on gear efficiency. For example, only hand tongs or rakes should be allowed in order to maximize participation without depleting the resource. Other management strategies in these areas should include site selection which permits rotation of grounds within a geographic area.

The fiscal disadvantage of public shellfish grounds would be the cost of maintaining sufficient acreage to meet the demands of recreational and commercial users. Additional costs would be incurred by the initial investment of bringing these grounds up to a productive level which will satisfy user demands. Since securing shell will be one of the highest costs incurred in developing and maintaining public grounds, it is suggested that the state seek other sources of shell than those identified under Section 50-17-790 of the South Carolina Marine Fisheries Laws. According to this Section, a shucking house or cannery may be required to contribute 5% of their annual shell quota to be planted on state oyster bottoms. This may have been desirable when canning operations generated large quantities of shells, but current practices have reduced their shell supply. It is therefore recommended that this clause pertaining to "canneries and raw shuck houses" be deleted.

Legitimate needs are receiving more attention than in the past. However, the "corner stone" private ownership of the leasing system must not be neglected in this effort. Recent legislative efforts to allow public harvesting on leased grounds can only amplify other economic problems confronting the leaseholder.

It is recommended that present regulations and statutes be reviewed to establish the leaseholder's legal prerogatives without comprising the state's ownership. A revision of Section 50-17-1210 of the Marine Fisheries Laws concerning possession of shellfish should increase the risk of illegal harvesting. Under this section, it is suggested that possession of oysters exceeding the limit should be prima facie evidence of illegal harvesting. Also, regulatory or statutory changes should be made to clarify responsibility when illegal harvesting is occurring on a lease because the harvester has not been authorized to harvest on that particular day. For example, according to Rule No. 13, a harvester may work for any lessee even though the contracting lessees have adjacent leases. In certain instances, harvesters have changed their permit number when questioned by officers in the field to coincide with the lease being harvested.

Improving Molluscan Cultivation and Harvesting

As Smith (1974) has described, not all of those participating in commercial fishing and seafood marketing activities place monetary goals as the highest priority. In some cases, non-monetary goals may have equal if not higher priority than monetary goals.

Until Sea Grant findings in the 1970's, the only published study pertaining to commercial intertidal oyster cultivation in South Carolina estuarine areas (excluding impoundments) was reported by Smith (1949). Improvement of intertidal oyster cultivation appears to warrant further investigation, especially since standing intertidal oyster crops are not limited by natural recruitment (Lunz, 1943). It is also recommended that additional investigations of environmental factors concerning site selection

for planting cultch material be performed. Optiminization of intertidal oyster cultivation techniques probably depends upon the cultivator's ability to reduce the risks in site selection, cultch and other cultivation practices.

Hard clams *Mercenaria mercenaria* raised in South Carolina have shown excellent growth rates (Eldridge, Waltz, Gracy and Hunt, 1976). It is therefore suggested that an empirical investigation into growing seed clams within leased areas be considered. A study in North Carolina has shown favorable results with this type of approach (Walter Godwin, personal communication). It is also suggested that substrates which encourage or permit natural recruitment and predator protection of clams be investigated. When considering improvement of cultivation practices the question of hatchery production is raised. It is recommended that the economic feasibility of a clam hatchery be investigated. A clam hatchery may be useful for supplying juvenile stages of shellfish for leased and/or state grounds.

The development of improved harvesting methods cannot be separated from the cost and technology of improving cultivation practices. Improving harvesting methods depends upon the objectives of private or public sector activities. In addition, variability of horizontal and vertical integation of the oyster industry in South Carolina may present different technology harvesting needs. Some leaseholders may wish to maintain a certain level of employment for harvesting in order to retain control of a minimum number of laborers for other seafood activities (e.g., shrimping) and therefore do not consider mechanization as being desirable as it would reduce their economic ties with the labor force. In other cases, the current lessees may not have the necessary capital for the initial investment in mechanized operation (McKenzie, et. al., 1976). It is suggested that the mechanization of commercial oyster harvesting continue, but this effort should include scaling the engineering approach for several levels of investment and should also include multiple use of harvesting equipment for both oysters and clams. Additional studies are also needed for determining the acreage of leased grounds required to support various levels of mechanical harvesting. In conclusion, the mechanization of harvesting equipment must be developed in a flexible, legal environment, but must not pre-empt the socio-economic objectives of industry members.

Potential Shellfish Resources

There has been very little utilization of molluscs within polluted areas of South Carolina. It is recommended that leaseholders be encouraged to consider the feasibility of relaying polluted molluscs to unpolluted grounds. The Division should support this effort by assisting in the selection of the site for holding until depuration.

Although extensive transplanting of subtidal seed oysters has been accomplished by the Division, there has been limited commercial use of naturally occurring seed oysters in the Wando River and the Santee estuary. There are probably several reasons for this. Certain economic constraints concerning the use of these seed oysters exists, which include costs of transplanting, mortality and suitable subtidal grow out areas. It is recommended that additional efforts be made to inform lessees of the results of transplanting studies of subtidal oysters. It is also suggested that other factors (e.g., transplanting costs) restricting the use of subtidal beds be considered.

Washed oyster shell is found in natural deposits along many waterways and tidal rivers in South Carolina. Each storm or series of high tides tends to wash additional shell from the bottom onto the exposed piles thus increasing the deposits (Lunz, 1958). Presently, no State agency has been given specific legislative authority over these shell deposits.

It is recommended that the S. C. Wildlife and Marine Resources Department investigate the feasibility of acquiring jurisdiction over these naturally occurring shell accumulations through administrative or legislative directives. Emphasis should be placed upon determining the practicality of using washed shell as intertidal and subtidal cultch and matrix for leased and public grounds. User fees should be considered for those not directly employing the shell in molluscan cultivation.

Several species of shellfish which are utilized commercially in the United States and other nations are found in South Carolina waters. These include conchs, species of *Busycon*, Rangia, *Rangia cuneata*, common razor clams, *Ensis directus*, giant Atlantic cockle, *Dinocardium robustum*, and mussels, *Modiolus demissus*. At present, little is known about standing stocks and distribution of these species in the state's waters. There has been only limited examination of the calico scallop, *Argopecten gibbus*, stocks off South Carolina and Georgia (Cummins, 1971). In South Carolina, cockle and conch shells are commonly found on some beaches, and occasionally live cockles will be observed in intertidal areas following a northeasterly wind (Louis Jamison, personal communication). Conchs appear to represent a potential resource, since commercial processors have expressed interest in processing South Carolina conch meat. The standing stock size and distribution of these species and possibly other species should be investigated.

Special Problems

An important precedent requiring daily catch and effort data was established when issuing mechanical hard clam harvesting permits for the Santee estuary. It is recommended that this procedure also be applied to other molluscan permits issued in the future. If public grounds are to be adequately maintained for commercial oyster fishermen, then mandatory reporting will be necessary to estimate the utilization and impact of public ground use. Catch and effort information would be useful in evaluating the benefits (e.g., harvesting days) of such public grounds. A list of suggested data to collect has been prepared (Appendix V).

The proposed FDA and EPA regulations will obviously increase the cost of harvesting, processing and distributing seafood in the future. With the exception of the oyster canning operation in Beaufort, South Carolina, the oyster industry is characterized by relatively small businesses. Jordening and Eyestone (1975) anticipate that these types of businesses will probably suffer the most economically due to their lower profit margin and higher per unit cost of waste treatment if they attempt to comply with EPA regulations for 1977 and 1983.

The Division should assist commercial fishermen, seafood buyers and processors in understanding and adapting to federal and state regulations affecting shellfish products, harvesting, handling, processing, plant and vessel sanitation, wastewater treatment, etc.

The Division should also take an active role in evaluating the economic impact of proposed and existing regulations upon the harvesting and processing sectors. Special attention should be given to the advantages of a centralized seafood port (McKenzie, et. al., 1976) in overcoming capital and operational costs due to new sanitation and pollution regulations.

Processing and Marketing of Clams and Oysters

Past studies have shown that the current marketing arrangements in South Carolina could be more efficient. Marketing alternatives for South Carolina have been described in a previous study (Laurent, et. al., 1975). In general, greatest demand for seafood comes from institutional markets (i.e., supermarkets) and the most desirable product would be frozen. Frozen products facilitate handling and increase the shelf life of the product itself. In addition, large retailers feel that the frozen products are more amenable to differentiation in packing and advertising. Processing and marketing of products such as frozen clams and breaded oysters in South Carolina may have some potential and should be investigated.

It is recommended that regulations and statutes be administered and enforced in a manner that maintains flexibility for alternate marketing arrangements. This flexibility should also include other state (e.g., DHEC) and federal agencies. For example, the state's food sanitation regulations have been oriented toward the agricultural sector, and consequently misunderstandings concerning the unique marketing and sanitary problems of seafood products have developed (Kenneth Roberts, personal communication).

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APPENDIX I. Not attached - four statewide oyster lease and subtidal seed oyster bed maps. (Under separate cover).

Logbook Form
2/25/75

MECHANICAL HARVESTER
CATCH LOGBOOK

PERMIT NUMBER 321 NAME OF OPERATOR John Doe

DATE 8/3/75 LOCATION South Santee River

GEAR _____ Area A (See Remarks)

START FISHING TIME 9:00 A.M. END FISHING TIME 5:30 P.M.

CATCH INFORMATION

Ungraded Clams	Count		BU*		Wt.	
Little Cherrynecks	Count		BU*	40	Wt.	
Cherrystone Clams	Count		BU*	20	Wt.	
Chowder Clams	Count		BU*	10	Wt.	
Single Oysters			BU*		Wt.	
Cluster Oysters			BU*		Wt.	
Conchs, Smooth			BU*		Wt.	
Conchs, Knobbed			BU*		Wt.	

Remarks IF YOU CHANGE AREA (SEE CHART) YOU MUST FILL OUT A SEPARATE LOGBOOK FORM FOR THAT AREA.

(Estimate time spent for the following activities: repairs 1 Hr, location changes ½ Hr.

* 75 lb. Bushel

Please mail logbook pages on Friday of each week to:
S. C. Marine Resources Center, License & Leasing Section,
P. O. Box 12559, Charleston, S. C. 29412

If you have any questions concerning your permit or logbook call Ray Rhodes (collect 795-6350, Extension 291)

APPENDIX III. Clam Catch[a] and effort (hours and days) in North Santee River from January, 1975 thru March, 1975 using Maryland-type escalator harvesters.

	Permit Number 301				Permit Number 302			
OPERATING WEEK	WEEKLY CATCH	HARVESTING[b] DAYS	HOURS OPERATED	HOURLY[c] CATCH	WEEKLY CATCH	HARVESTING[b] DAYS	HOURS OPERATED	HOURLY[c] CATCH
1/1-1/4	539	3	21	25.7	58	1	6	9.7
1/5-1/11	557	4	27	20.6	161	3	16	10.1
1/12-1/18	404	3	20	27.8	279	3	19	14.7
1/19-125	233	2	13	17.9	29	1	8	3.6
1/26-2/1	310	4	26	11.9	34	2	10	3.4
2/2-2/8	280	4	26	10.8	22	1	8	2.8
2/9-2/15	257	4	29	8.9	46	2	14	3.3
2/16-2/22	231	4	29	8.0	7	1	2	3.5
2/23-3/1	228	4	36	6.3	15	1	9	1.5
3/2-3/8	194	4	36	5.4	20	1	9	2.0
3/9-3/15	73	4	26	2.8				
3/16-3/22								
3/23-3/29								
3/30-4/5								
Total Catch		3,306				671		
Total Days		40				16		
Total Hours		289				101		
Mean Daily Catch		86.6				41.9		
Mean Hourly Catch		11.4				6.6		

[a]Clam quantities expressed in "bags" containing approximately 250 clams regardless of commercial size grading.
[b]The number of days spent harvesting during the week indicated in this table.
[c]The average quantity of clams harvested per harvesting hour (excluding repair, lunch time, etc.).

	Permit Number 303				Permit Number 304			
OPERATING WEEK	WEEKLY CATCH	HARVESTING[b] DAYS	HOURS OPERATED	HOURLY[c] CATCH	WEEKLY CATCH	HARVESTING[b] DAYS	HOURS OPERATED	HOURLY[c] CATCH
1/1-1/4								
1/5-1/11					93	1	7	13.3
1/12-1/18					235	3	18	13.1
1/19-1/25					185	4	12	15.4
1/26-2/1	271	3	21	12.9	168	3	15	11.2
2/2-2/8	134	3	15	8.9	221	3	18	12.3
2/9-2/15	160	2	11	14.6	213	3	23	9.3
2/16-2/22	124	2	11	11.3	156	3	21	7.4
2/23-3/1					87	3	17	5.1
3/2-3/8					114	4	30	3.8
3/9-3/15					54	3	14	3.9
3/16-3/22								
3/23-3/29								
3/30-4/5								
Total Catch		689				1,526		
Total Days		10				30		
Total Hours		58				175		
Mean Daily Catch		68.9				50.9		
Mean Hourly Catch		11.9				8.7		

[a]Clam quantities expressed in "bags" containing approximately 250 clams regardless of commercial size grading.
[b]The number of days spent harvesting during the week indicated in this table.
[c]The average quantity of clams harvested per harvesting hour (excluding repair, lunch time, etc.).

APPENDIX III. Clam catch[a] and effort (hours and days) in North Santee River from January, 1975 thru March, 1975 using Maryland-type escalator harvesters.

	Permit Number 305				Permit Number 306			
OPERATING WEEK	WEEKLY CATCH	HARVESTING DAYS[b]	HOURS OPERATED	HOURLY CATCH[c]	WEEKLY CATCH	HARVESTING DAYS[b]	HOURS OPERATED	HOURLY CATCH[c]
1/1-1/4								
1/5-1/11	566	4	24	23.6	470	4	28	16.8
1/12-1/18	364	3	23	15.8	206	2	9	22.9
1/19-1/25	91	1	7	13.0	473	4	27	17.5
1/26-2/1	434	4	30	14.5	282	3	19	14.8
2/2-2/8	136	2	14	9.7	98	1	6	16.3
2/9-2/15	167	3	16	10.4	226	4	25	9.0
2/16-2/22	269	4	25	10.8	205	3	16	12.8
2/23-3/1	140	4	21	6.7	65	2	11	5.9
3/2-3/8	104	4	20	5.2				
3/9-3/15	14	1	5	2.8				
3/16-3/22								
3/23-3/29								
3/30-4/5								
Total Catch	2,285				2,025			
Total Days	30				23			
Total Hours	185				141			
Mean Daily Catch	76.2				88.0			
Mean Hourly Catch	12.4				14.4			

[a]Clam quantities expressed in "bags" containing approximately 250 clams regardless of commercial size grading.
[b]The number of days spent harvesting during the week indicated in this table.
[c]The average quantity of clams harvested per harvesting hour (excluding repair, lunch time, etc.).

	Permit Number 307				Permit Number 308			
OPERATING WEEK	WEEKLY CATCH	HARVESTING DAYS[b]	HOURS OPERATED	HOURLY CATCH[c]	WEEKLY CATCH	HARVESTING DAYS[b]	HOURS OPERATED	HOURLY CATCH[c]
1/1-1/4								
1/5-1/11	370	3	19	19.5	403	5	24	16.8
1/12-1/18	417	4	26	16.0	311	3	13	23.9
1/19-1/25	276	3	20	13.8	224	2	12	18.7
1/26-2/1	175	3	15	11.9	247	3	23	10.7
2/2-2/8	207	3	20	10.4	32	1	4	8.0
2/9-2/15	237	4	28	8.5	127	3	11	11.6
2/16-2/22	242	4	28	8.6	171	3	18	9.5
2/23-3/1	145	3	22	6.6				
3/2-3/8	156	4	30	5.2	65	2	11	6.0
3/9-3/15	153	4	30	5.1	101	3	20	4.6
3/16-3/22	114	4	28	4.1	44	1	6	7.3
3/23-3/29								
3/30-4/5								
Total Catch	2,492				1,715			
Total Days	39				26			
Total Hours	266				142			
Mean Daily Catch	63.9				66.4			
Mean Hourly Catch	9.4				12.2			

[a]Clam quantities expressed in "bags" containing approximately 250 clams regardless of commercial size grading.
[b]The number of days spent harvesting during the week indicated in this table.
[c]The average quantity of clams harvested per harvesting hour (excluding repair, lunch time, etc.).

APPENDIX III. Clam catch[a] and effort (hours and days) in North Santee River from January, 1975 thru March 1975 using Maryland-type escalator harvesters.

Permit Number 309								
OPERATING WEEK	WEEKLY CATCH	HARVESTING[b] DAYS	HOURS OPERATED	HOURLY CATCH	WEEKLY CATCH	HARVESTING[b] DAYS	HOURS OPERATED	HOURLY[c] CATCH
1/1-1/4								
1/5-1/11	263	4	14	18.8				
1/12-1/18	102	1	3	34.0				
1/19-1/25	301	4	16	18.9				
1/26-2/1	206	3	20	10.3				
2/2-2/8	131	2	14	9.4				
2/9-2/15	155	3	19	8.2				
2/16-2/22	141	3	19	7.4				
2/23-3/1	37	2	8	4.6				
3/2-3/8	29	1	9	3.2				
3/9-3/15								
3/16-3/22								
3/23-3/29								
3/30-4/5								

Total Catch	1,364
Total Days	23
Total Hours	122
Mean Daily Catch	59.4
Mean Hourly Catch	11.2

[a]Clam quantities expressed in "bags" containing approximately 250 clams regardless of commercial size grading.

[b]The number of days spent harvesting during the week indicated in this table.

[c]The average quantity of clams harvested per harvesting hour (excluding repair, lunch time, etc.).

APPENDIX IV. Clam Catch[a] and effort (hours and days) in South Santee River from September, 1974 thru December, 1974 using Maryland-type escalator harvesters.

	Permit Number 301				Permit Number 302			
OPERATING WEEK	WEEKLY CATCH	HARVESTING[b] DAYS	HOURS OPERATED	HOURLY[c] CATCH	WEEKLY CATCH	HARVESTING[b] DAYS	HOURS OPERATED	HOURLY[c] CATCH
9/1-9/7	731	7	45	16.2				
9/8-9/14	651	7	49	13.3				
9/15-9/21	457	5	29	15.8				
9/22-9/28	486	5	33	14.7				
9/29-10/5	197	4	20	9.9				
10/6-10/12	524	6	38	13.8				
10/13-10/19	208	3	18	11.6				
10/20-10/26	247	2	20	12.4	12	1	2	
10/27-11/2	60	1	9	6.7	35	2	3	6.0
11/3-11/9	58	1	7	8.3				11.7
11/10-11/16	241	4	28	8.6				
11/17-11/23	209	5	29	7.2				
11/24-11/30	80	2	14	5.7				
12/1-12/7	464	7	49	9.5				
12/8-12/14	198	3	19	10.4				
Total Catch	4,811				47			
Total Days	62				3			
Total Hours	407				5			
Mean Daily Catch	77.6				15.7			
Mean Hourly Catch	11.8				9.4			

[a]Clam quantities expressed in "bags" containing approximately 250 clams regardless of commercial size grading.
[b]The number of days spent harvesting during the week indicated in this table.
[c]The average quantity of clams harvested per harvesting hour (excluding repair and lunch time, etc).

	Permit Number 304				Permit Number 305			
OPERATING WEEK	WEEKLY CATCH	HARVESTING[b] DAYS	HOURS OPERATED	HOURLY[c] CATCH	WEEKLY CATCH	HARVESTING[b] DAYS	HOURS OPERATED	HOURLY[c] CATCH
9/1-9/7	353	5	30	11.8	396	4	18	22.0
9/8-9/14	418	6	35	11.9	40	1	2	20.0
9/15-9/21	241	4	19	12.7	323	4	18	17.9
9/22-9/28	150	3	15	10.0	221	4	11	20.1
9/29-10/5	147	3	13	11.3				
10/6-10/12					61	2	14	4.4
10/13-10/19					87	2	13	6.7
10/20-10/26					209	3	14	14.9
10/27-11/2	9	2	2	4.5				
11/3-11/9					79	2	10	7.9
11/10-11/16					154	4	19	8.1
11/17-11/23					125	5	24	5.2
11/24-11/30					15	1	3	5.0
12/1-12/7					174	4	10	17.4
12/8-12/14								
Total Catch	1,318				1,844			
Total Days	23				36			
Total Hours	114				156			
Mean Daily Catch	57.3				52.3			
Mean Hourly Catch	11.6				12.1			

[a]Clam quantities expressed in "bags" containing approximately 250 clams regardless of commercial size grading.
[b]The number of days spent harvesting during the week indicated in this table.
[c]The average number of clams harvested per harvesting hour (excluding repair and lunch time, etc.).

APPENDIX IV. Clam Catch[a] and effort (hours and days) in South Santee River from September, 1974 thru December, 1974 using Maryland-type escalator harvesters.

	Permit Number 306				Permit Number 307			
OPERATING WEEK	WEEKLY CATCH	HARVESTING[b] DAYS	HOURS OPERATED	HOURLY[c] CATCH	WEEKLY CATCH	HARVESTING[b] DAYS	HOURS OPEARTED	HOURLY[c] CATCH
9/1-9/7	112	2	13	8.6	98	1	7	14.0
9/8-9/14	190	3	14	13.6	347	6	31	11.2
9/15-9/21	153	3	17	9.6	222	4	21	10.6
9/22-9/28	927	4	30	30.9	295	6	33	8.9
9/29-10/5	251	5	42	6.0	284	5	31	8.2
10/6-10/12					217	4	25	8.7
10/13-10/19	392	5	40	9.8	101	1	6	16.8
10/20-10/26	62	2	14	4.4	58	1	7	8.3
10/27-11/2	69	2	17	4.1				
11/3-11/9	71	2	17	4.2	189	4	25	7.6
11/10-11/16	139	4	26	5.4	195	5	28	7.0
11/17-11/23	184	4	29	6.4	168	6	35	4.8
11/24-11/30	126	2	16	7.9	241	5	40	6.8
12/1-12/7					98	3	16	6.1
12/8-12/14								
Total Catch	2,676				2,513			
Total Days	38				51			
Total Hours	274				305			
Mean Daily Catch	70.4				49.3			
Mean Hourly Catch	9.8				8.2			

[a]Clam quantities expressed in "bags" containing approximately 250 clams regardless of commercial size grading.
[b]The number of days spent harvesting during the week indicated in this table.
[c]The average quantity of clams harvested per harvesting hour (excluding repair and lunch time, etc.).

	Permit Number 308				Permit Number 309			
OPERATING WEEK	WEEKLY CATCH	HARVESTING[b] DAYS	HOURS OPERATED	HOURLY[c] CATCH	WEEKLY CATCH	HARVESTING[b] DAYS	HOURS OPERATED	HOURLY[c] CATCH
9/1-9/7								
9/8-9/14								
9/15-9/21								
9/22-9/28	179	3	19	9.4				
9/29-10/5	165	4	19	8.7	7	1	6	1.2
10/6-10/12	210	3	18	11.7				
10/13-10/19								
10/20-10/26	383	5	31	12.4				
10/27-11/2	81	2	15	5.4				
11/3-11/9	102	2	14	7.3				
11/10-11/16	182	4	27	6.7	26	1	9	2.9
11/17-11/23	167	4	25	6.7	138	3	20	6.9
11/24-11/30	82	3	15	5.5	106	3	23	4.6
12/1-12/7	108	3	21	5.1	72	2	16	4.5
12/8-12/14								
Total Catch	1,659				349			
Total Days	33				10			
Total Hours	204				74			
Mean Daily Catch	50.3				34.9			
Mean Hourly Catch	8.1				4.7			

[a]Clam quantities expressed in "bags" containing approximately 250 clams regardless of commercial size grading.
[b]The number of days spent harvesting during the week indicated in this table.
[c]The average quantity of clams harvested per harvesting hour (excluding repair and lunch time, etc.).

APPENDIX V. Commercial Molluscan Fishery User Data.

Commercial Harvesting Data

This is a voluntary system depending upon the normal sale transaction between the licensed shellfish buyer and commercial fishermen. It is similar to the "ticket system" developed for the shrimp trawler fishery (See Rhodes, 1974). It is suggested that the following information be obtained:

1. Quantity of shellfish (e.g., oysters, clams, etc.) harvested by commercial grade (e.g., little neck clams, select oysters, etc.).
2. Harvesting location (e.g., lease, creek, etc.).
3. Harvesting method (e.g., patent tongs, hand rakes, etc.).
4. Number of operating units responsible for harvesting quantity given.

Optional information might include crew size, fishing hours and ex-vessel prices.

Leasing System Planting Data

This could be a mandatory system requiring more specific information on shell and seed oyster planting activities. The following information should be obtained:

1. Quantity of shell and seed (clam or oyster) planted by size and/or commercial grade.
2. Location of planting.
3. Method of planting (e.g., gear, etc.)
4. Source (e.g., location, etc.) of shell and seed.

Optional information could include: hours associated with planting activities, number and size of vessels employed, and estimated total cost per unit planted.

APPENDIX VI. Selected characteristics for major hydraulic escalator harvesters operating in the Santee estuary, South Carolina during 1975.

	HULL TYPE			
	BARGE (3)		STANDARD (4)	
	$\bar{X}$	RANGE	$\bar{X}$	RANGE
Vessel LOA, Ft.	47.3	43-56	34.0	32-40
Escalator Head Width, In.	34.7	32-36	32.0	24-36
Crew Size*	---	4 - 6	---	3- 4

*The Captain of the vessel is included as a crew member.