THE OYSTER FISHERY OF THE GULF OF MEXICO, UNITED STATES:
A Regional Management Plan

GULF STATES MARINE FISHERIES COMMISSION

March 1991 No. 24

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by

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Preface

The GSMFC was established by the Gulf States Marine Fisheries Compact under Public Law 81-66 approved May 19, 1949. Its charge was to promote better management and utilization of marine resources in the Gulf of Mexico.

The Commission is composed of three members from each of the five Gulf States. The head of the marine resource agency of each state is an ex officio member. The second is a member of the legislature. The third is a citizen with knowledge of and interest in marine fisheries and is appointed by the governor. The offices of the chairman and vice chairman are rotated annually from state to state.

The Commission is empowered to recommend to the governor and legislature of the respective states action on programs helpful to the management of the fishery. However, the states do not relinquish any of their rights or responsibilities in regulating their own fisheries by being members of the Commission.

One of the most important functions of the GSMFC is to serve as a forum for discussion of various problems and needs of marine management authorities, commercial and recreational industries, researchers and others. The GSMFC also plays a key role in implementation of the Interjurisdictional Fisheries (IJF) Act.

The Interjurisdictional Fisheries Act of 1986 (Title III, Public Law 99-659) was established by Congress to: (1) promote and encourage state activities in support of the management of interjurisdictional fishery resources; and (2) promote and encourage management of interjurisdictional fishery resources throughout their range. Congress also authorized federal funding to support state research and management projects that were consistent with these purposes. Additional funds were authorized to support development of interstate fishery management plans (FMPs) by the GSMFC and other marine fishery commissions.

After passage of the act, the GSMFC initiated development of a FMP planning and approval process. The Commission decided to pattern its plans after those of the Gulf of Mexico Fishery Management Council under the Magnuson Fishery Conservation and Management Act of 1976 (Magnuson Act). This decision ensured compatibility in format and approach to management among states, federal agencies and the council.

The GSMFC established a process whereby each plan was to be developed by a technical task force (TTF) of experts from each state and appointed by the respective state's commission representative of the regulatory agency. The Commission also provided for a member of the TTF from each of the standing committees of the GSMFC (Commercial Fisheries Advisory, Law Enforcement and Recreational Fisheries Advisory) to be appointed by the respective committee. In addition, the Commission provided for members of the TTF from federal agencies, academic institutions and other organizations where such expertise was needed.

Once developed, the Commission established a review and approval process as follows:

TTF → TCC → S-FFMC → GSMFC[1]

↕

Outside Review
(standing committees,
trade associations,
general public)

Once approved by the GSMFC, plans are recommended to the individual states for consideration of adoption and implementation.

[1]TTF = Technical Task Force
TCC = Technical Coordinating Committee
S-FFMC = State-Federal Fisheries Management Committee
GSMFC = Gulf States Marine Fisheries Commission

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3.0 SUMMARY

The Eastern oyster, Crassostrea virginica, is perhaps the most studied marine species in the Gulf of Mexico. Its life history and distribution throughout the gulf are well documented. Factors that affect oyster survival such as pollution, parasitism, disease and predation have been identified.

The habitat of oysters is the most limiting factor controlling oyster abundance both short-term and long-term. Favorable salinity and temperature regimes on reefs are the most important criteria for successful reproduction and spawning. A relatively clean and firm substrate is necessary for oysters to attach, survive and grow to market size.

Because oysters are widely distributed in coastal and estuarine habitats, they fall under the jurisdiction of many federal, state and local government agencies. Although the Gulf of Mexico Fishery Management Council has little authority over management of nearshore oysters, other agencies including the National Park Service, the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, the Office of Ocean and Coastal Resource Management, the Environmental Protection Agency, the U.S. Food and Drug Administration and the National Marine Fisheries Service are actively involved with oyster management. These federal agencies administer a number of federal laws and regulations regarding land and water use, pollution control, wetlands protection and human health and safety.

State agencies that implement their individual laws and policies have the most profound effect on oyster management. In addition to habitat regulation, state agencies are responsible for promulgating and implementing laws and regulations regarding size, harvesting seasons, gear and others. They issue licenses, collect data and enforce regulations and laws.

The oyster fishery in the gulf has a long and diverse history. It is uncertain as to when commercial fishing began but subsistence catches date to the earliest inhabitants of the coastal area. Catch by state and for the entire gulf has varied greatly over the entire time that records have been kept. Habitat changes from year to year, season to season and over long time periods have caused the majority of catch fluctuations.

Gear use is highly traditional. Tongs and dredges are the most commonly employed gear, but their use from reef to reef and state to state is variable.

People often favor consumption of raw, whole oysters. As a result, there is growing concern for public health because oysters can concentrate human pathogens in their tissues and may pass these to humans when oysters are consumed raw or improperly cooked. Through state and federal participation in the National Shellfish Sanitation Program and interaction in the Interstate Shellfish Sanitation Conference, these public health concerns are addressed, and appropriate measures are taken by the states to reduce risks from eating oysters.

The oyster fishery is experiencing many problems. One of the most severe relates to habitat. Habitat deterioration primarily occurs when substrate and cultch are removed or when salinity and freshwater influx to reefs is altered by man or nature. Loss of cultch has occurred as reefs have been harvested and dredged without returning sufficient amounts of shell. Cultch has also been fouled and buried by many natural and man-induced forces.

Another problem is salinity fluctuation. Natural drainage to oyster reefs through rivers, creeks and other tributaries has been altered for flood control, navigation and other purposes. These permanent alterations have eliminated reef areas. Natural, seasonal fluctuations have caused mainly short-term reductions in oyster populations.

Pollution has rendered large areas of productive growing waters unsuitable for harvest of oysters. Although some pollution has killed oysters on reefs, the greatest problem is sewage pollution which renders oysters unsafe for human consumption.

Regulatory problems, enforcement problems and socioeconomic problems have increased through time. The nature and magnitude of these problems are exacerbated by fluctuations in demand and supply coupled with increasing regulations to protect public health.

In order to alleviate problems and increase production, states are considering developing and expanding management efforts. Increasing production and abating or lessening habitat loss are critical issues. Increased shell planting, freshwater diversion and culture techniques are possible management strategies to increase or stabilize production. Also, relaying, depuration and other procedures may increase utilization of presently contaminated oysters. Management programs must also focus on preventing excessive harvest, preventing damage to existing reefs and continuing to monitor pollution.

In order to optimize yield from the oyster industry of the gulf, new and innovative methods to produce and utilize more oysters must be developed. Additional biological, social and economic research is needed to fully understand problems and potential solutions. Fishermen, processors, managers and others must be willing to consider changes to existing ideology regarding oyster ecology and develop cost-effective means of protecting habitat and increasing yield.

4.0 INTRODUCTION

In early 1988, the GSMFC concluded that an interstate fishery management plan for oysters in the U.S. Gulf of Mexico was needed. The Commission determined that the oyster resources of the gulf had been declining in some areas and increasing in others. Some areas were also being affected by pollution and habitat loss. The Commission also received input that there was possible evidence of overfishing (economic and biological) in some areas. Because of the economic importance of this fishery, the large number of participants therein and the lack of any regional plan, it was determined that the oyster fishery should be addressed in a FMP. Consequently, a TTF was appointed in July 1988 and began plan development with an initial meeting in October 1988. The plan focuses on the Eastern oyster, Crassostrea virginica.

4.1 Oyster TTF Members

Mark Berrigan	Florida Department of Natural Resources (state and recreational)
Mark Van Hoose	Alabama Department of Conservation and Natural Resources
John Cirino	Mississippi Department of Wildlife, Fisheries and Parks/Bureau of Marine Resources
Ronald Dugas	Louisiana Department of Wildlife and Fisheries
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Christopher Dyer	University of South Alabama (sociology)
Tom Herrington	U.S. Food and Drug Administration
Walter Keithly	Coastal Fisheries Institute, Louisiana State University (economics)
John Ray Nelson	Bon Secour Fisheries (industry)

4.2 GSMFC Interjurisdictional Fisheries Program Staff

Larry B. Simpson, Executive Director
Richard L. Leard, Program Coordinator
Cynthia B. Dickens, Staff Assistant

4.3 Authorship and Support for Plan Development

Members of the task force contributed by drafting assigned sections. The following is a list of the major sections of the FMP and the authors of each:

Section 5 - Mark Berrigan, Ronald Dugas, Joseph Gray, Richard Leard
Section 6 - Ronald Dugas, Richard Leard
Section 7 - Walter Keithly, Richard Leard
Section 8 - Walter Keithly
Section 9 - Mark Berrigan, Walter Keithly
Section 10 - Christopher Dyer
Section 11 - Tom Herrington
Section 12 - Richard Leard
Section 13 - Richard Leard

Section 14 - Ronald Dugas, Richard Leard
Section 15 - All
Section 16 - All

Authors are listed alphabetically on the title page with no preference for seniority. Each task force member contributed their expertise to discussions that resulted in revisions and led to the final draft of the plan. The GSMFC made all necessary arrangements for task force workshops. Under contract with the NMFS, the GSMFC funded travel for state agency representatives and consultants other than federal employees.

4.4 Objectives

The objectives of the oyster fishery management plan are:

1. To summarize and reference relevant scientific information and studies regarding the management of oysters in such a manner that the reader of the plan is availed of past, present and potential efforts.
2. To describe the biological, social and economic aspects of the oyster fishery.
3. To review state and federal management authorities and their jurisdictions, laws, regulations and policies affecting the oyster fishery.
4. To describe the problems and needs of the oyster fishery and to suggest management strategies.
5. To ascertain and define what constitutes the optimum benefits of the oyster resources of the U.S. Gulf of Mexico and to the region while perpetuating these benefits.

5.0 DESCRIPTION OF STOCKS COMPRISING THE MANAGEMENT UNIT (MU) AND DESCRIPTION OF THE HABITAT

5.1 Biological Description and Geographic Distribution

Oysters are distributed throughout the coastal area of the U.S. Gulf of Mexico. They are most abundant in shallow, semi-enclosed water bodies (<40 feet in depth) with salinities moderated by freshwater outfalls.

Oysters were perhaps first described by Linnaeus (1758) and grouped with other bivalves. Numerous other biological descriptions and taxonomic distinctions of oyster species have followed. Galtsoff (1964) provided an excellent historical account and biological treatise of oysters.

5.1.1 Classification and Morphology

Oysters are members of the Phylum Mollusca, Class Bivalvia and Order Mytoloidea (Barnes 1979). The most commonly observed oysters in the Gulf of Mexico belong to the Family Ostreidae. They differ from other bivalves to the extent that they possess fillibranch gills with interlamellar junctions, a small foot, a reduced anterior adductor muscle and no siphon. Figure 5.1 shows the general anatomy of an adult oyster.

Two species inhabit gulf waters, the Eastern oyster, *Crassostrea virginica* (Gmelin) and the gulf oyster, *Ostrea equestris* (Say 1834). The gulf oyster seldom grows larger than 51 mm (Andrews 1981), thus the Eastern oyster is the only commercially important species. *Crassostrea virginica* may be distinguished from *O. equestris* in that it has a well developed promyal chamber, and it is a nonincubatory spawner (Galtsoff 1964).

5.1.2 Life History

5.1.2.1 Reproduction

Eastern oysters are dioecious, with the sexes separate (Galtsoff 1964, Bahr and Lanier 1981). They are protandrous, and the development of maleness before the female phase is often demonstrated. They are considered alternate hermaphrodites since the sex of individuals can change between spawning (Galtsoff 1961). Andrews (1979) found 3- and 4-year-old populations were 80% female; however, other studies found oyster populations over 4 years of age with approximately equal numbers of males and females (Menzel 1951, Galtsoff 1964). Oyster spat are predominantly male; the sex of an individual oyster may change at least once during its life and can change annually (Galtsoff 1964, Bahr and Lanier 1981). Galtsoff (1964) studied sex changes in 202 individuals for 5 years by examination of spawning products.

The sex ratio of oysters after the second breeding season (18-24 months of age) is influenced by environmental conditions and physiological stress (Coe 1936). Oysters that settle in unfavorable environments, or experience physical injury do not tend to develop as females. Functioning as a female requires more energy for gonad development, and coping with environmental or physiological stress may limit the amount of energy that can be invested in female gonad development (Coe 1936).

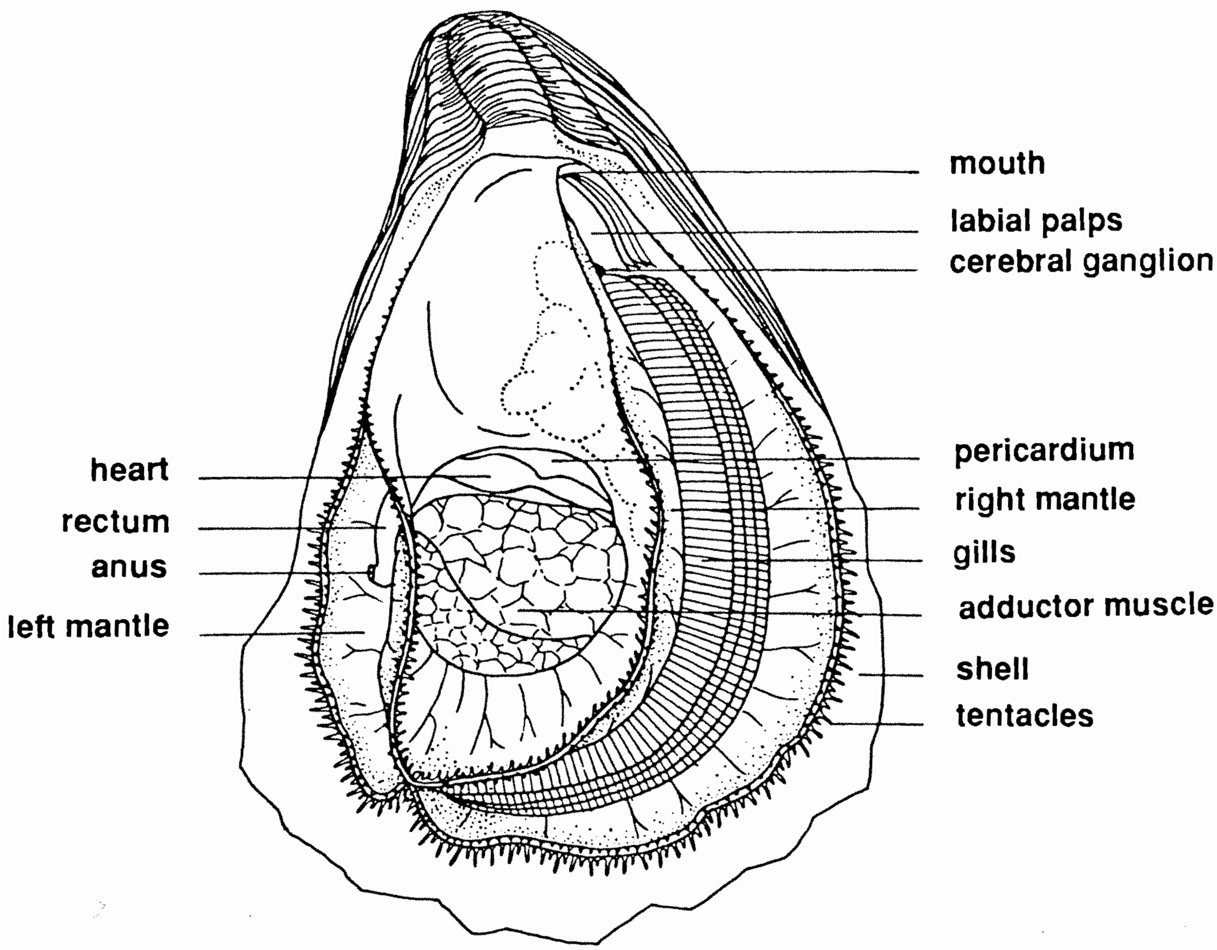

Figure 5.1. General anatomy of the Eastern oyster, Crassostrea virginica (reprinted from Galtsoff 1964).

Under optimal environmental conditions some oysters in gulf bays can become sexually mature and reproductively active 4 weeks after setting (Menzel 1951). Environmental parameters such as temperature, salinity and food availability affect the time required for oysters to mature (Soniat and Ray 1982). Therefore, maturation periods fluctuate with changing environmental conditions (Soniat and Ray 1982).

Oysters that spawn shortly after setting generally do not contribute significantly to the year class because of low gamete production (Hayes and Menzel 1981). After 18 months (76 mm length) oyster growth rate decreases, and the rate of increase in gonad size also decreases (Hofstetter 1977). Consequently, the rate of increase in gamete production decreases after the second spawning season. The number of gametes released during each spawn is directly correlated with oyster size and gonadal development (Davis and Chanley 1955, Galtsoff 1964). Among oysters of the same size, variability of fecundity is due primarily to differences in the physiological condition of the oysters (Galtsoff 1964).

Some females produce more eggs in a single spawn than others do in an entire spawning season (Davis and Chanley 1955). The maximum number of eggs (85.8 million) produced by a single oyster under laboratory conditions during a spawning season (Davis and Chanley 1955) was less than the maximum number of eggs (114.8 million) produced by an individual in a single spawn (Galtsoff 1964). The fecundity of wild populations has not been estimated.

5.1.2.2 <u>Spawning</u>

Oysters may spawn throughout the gulf in all but the coldest months. Spawning peaks are usually clearly defined and typically occur several times throughout the year. Although spawning may be seasonal, regular and of long duration, setting intensity is variable. Spatfall may show peaks in either the spring or fall, depending on environmental conditions.

The release of sex cells from sexually mature oysters requires a stimulus. Numerous observations indicate that under natural conditions, gonad maturation and spawning are associated with rising water temperatures. Gametogenesis usually takes place in the early spring (depending on local climatic conditions). Most spawning is initiated and maintained when water temperature reaches and stays at or above 20°C (Butler 1949a; Loosanoff 1953; Schlesselman 1955; Hofstetter 1977, 1983). Salinity also influences spawning, and most spawning occurs when salinities remain higher than 10 parts per thousand (ppt).

In addition to water temperature and salinity, other factors may influence the onset of spawning. Laboratory studies that examined oyster spawning indicate temperature and salinity manipulations were not always sufficient to induce spawning (Galtsoff 1964, Hopkins 1931). Phytoplankton may stimulate oysters to spawn by chemical induction (Nelson 1955). Additional research is needed to determine the effects of phytoplankton and other substances including hormones, thyroiden, urea, starch and yeast on inducing spawning (Galtsoff 1964).

Under natural conditions, simultaneous release of sperm and eggs into the water is essential for successful reproduction. Females may be less responsive to rising temperature than males (Dupuy et al. 1977) and require stronger stimulation in the form of specific chemical stimulation from male sperm to ensure that eggs are not discharged without the presence of sperm.

Fertilization is external, and its success is dependent on the close proximity of the sexes and their simultaneous response to spawning stimuli. After spawning, the gonad of C. virginica retains bisexual potencies, and its sex may alternate in subsequent spawns. During heavy spawns, the water over shallow reefs may become "milky" with gametes.

The duration and intensity of any spawning event depends on the physiological state of the oysters and the ambient water conditions. The number of spawns per individual is also variable; however, male oysters may spawn more often than females.

The ripe eggs of the American oyster are pear-shaped (55 μ to 75 μ by 35 μ to 55 μ when spawned) but become globular after fertilization (Ray, personal communication). Spawned eggs are heavier than water and quickly sink to the bottom where they are transported by currents and waves. The egg stage is brief, remaining demersal until the first free-swimming larval form develops. Depending on the condition of the egg, salinity, temperature and oxygen content of the water, embryological development begins immediately after fertilization (Figure 5.2).

5.1.2.3 Larval Development

Following fertilization and early larval development, the trochophore stage is attained in 4 to 6 hours. During this stage a powerful ciliated girdle is formed, and larvae begin to swim. The trochophore stage is short, approximately 24-48 hours at 22°-24°C. Development to the veliger stage is accompanied by the development of the velum. During swimming the velum projects between the shell halves. Larger cilia around the margin of the velum are for swimming; smaller cilia covering the base carry food particles to the mouth. As development continues, descriptive names are used that refer to the most conspicuous morphological changes associated with each stage (i.e., umbo larva, eyed larva and pediveliger or "mature" larva). Fully developed larvae in the last stage of development possess a well developed foot which is projected outward while swimming.

The pelagic larvae of oysters act to distribute the species. During this free-swimming stage, larvae are distributed by currents and tidal conditions. Just prior to metamorphosis (settling and attachment), the veliger develops two eye spots (that aid in selecting and acceptable location for attachment) and is termed an eyed-pediveliger. As the eyed-pediveliger larva nears the end of its planktonic development, it passively uses tidal currents, the salt wedge and its ability to migrate vertically to "select" the optimal environment for metamorphosis. Finally, it ceases to swim and creeps over the substrate with its foot until locating a suitable attachment point. Larvae are normally sensitive to strong light and slightly negatively phototactic. They set in an area of reduced light (inside of an empty shell, on the underside of a piece of cultch or low in the water column). Shortly after metamorphosis, the newly attached oyster (the spat) loses its velum, foot and eye spots and begins a sedentary life.

Oyster larvae are filter feeders. Early larvae depend on naked (without rigid cell walls) phytoplankton (e.g., Isochrisis sp. and Monochrisis sp.) as a food source, while older larvae can also feed on phytoplankton that possess cell walls (e.g., Platymonas sp.) (Davis 1953, Davis and Guillard 1958). Laboratory studies indicate that larvae select food by size, and all particles within the size range are ingested (Fritz et al. 1984). Oyster larvae are generally able to ingest phytoplankton ranging from 1 μ to 30 μ (Mackie 1969).

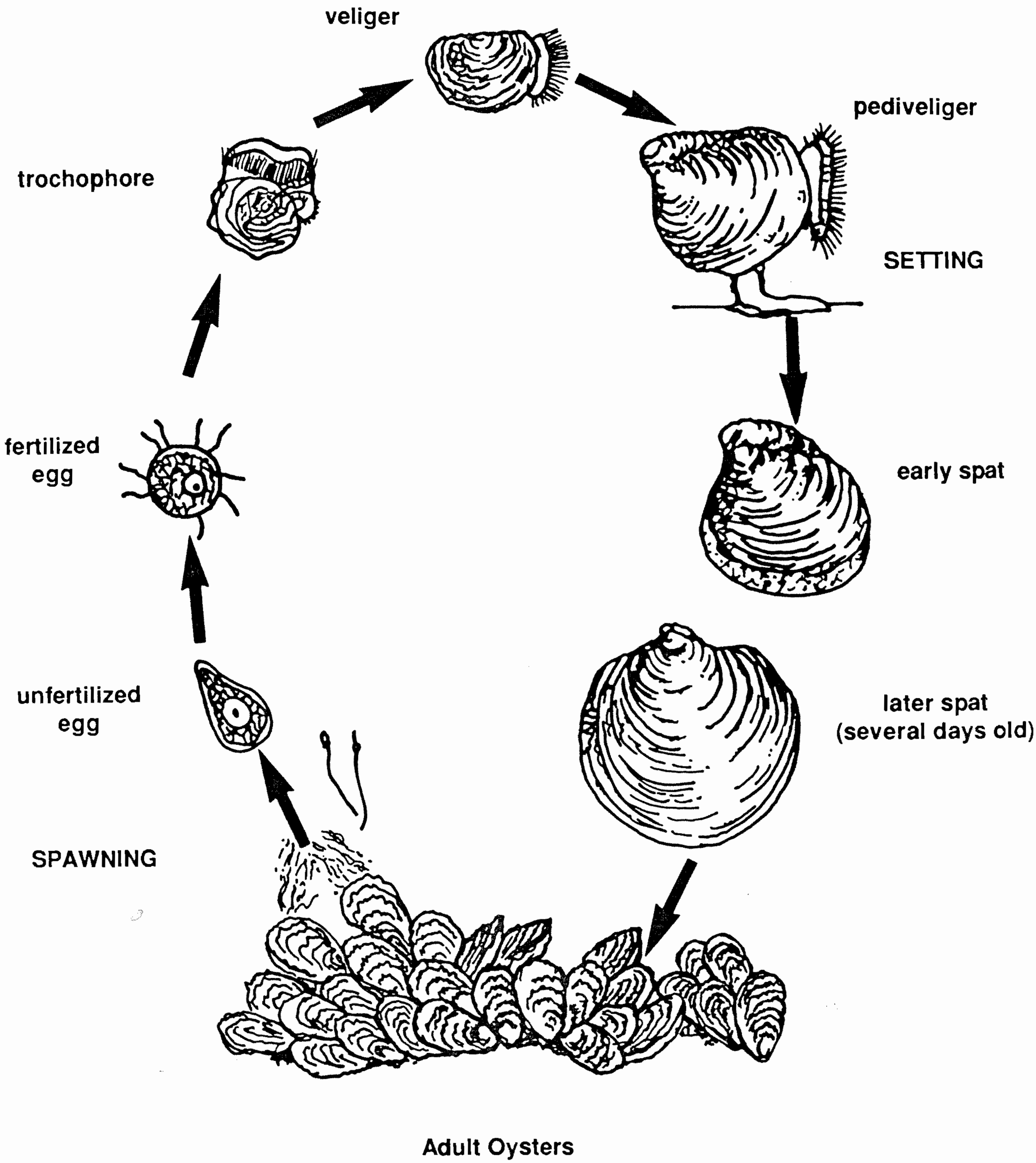

Figure 5.2. Life cycle of the Eastern oyster, *Crassostrea virginica*.

5.1.2.4 Setting and Growth

Successful setting is primarily dependent upon the availability of clean surfaces rather than other factors. Larvae are selective in finding a suitable substrate, preferring a surface that is not covered with film, detritus, soft mud, oil or grease. At metamorphosis the mature larva attaches its left valve (shell) to the cultch with a small amount of cementing fluid (from its pedal byssus gland) that sets in a few minutes. Metamorphosing oyster larvae are gregarious and tend to attach in large groups on common cultch where other larvae have already attached or in the presence of mature oysters. Once attached to the cultch, the tiny (300 μ) oyster is referred to as a spat.

Triggering mechanisms that cause oysters to set are not known; however, salinity (Mackin 1946, Loosanoff 1953, Menzel 1955) and products from live oysters and dead oyster shell (Hidu and Haskin 1971, Keck et al. 1971) may affect setting location. Laboratory experiments showed that the gregarious nature of oyster larvae is mediated by pheromones (a constituent of shell liquor) produced during the larval attachment process (Keck et al. 1971). In salinities of approximately 20 ppt, Eastern oysters tend to attach to substrate in the intertidal zone (Mackin 1946, Menzel 1955). While in salinities below about 20 ppt, most setting occurs subtidally (Loosanoff 1953, Menzel 1955). This conclusion is based on field observations of natural oyster setting under a range of salinities.

During the spat stage, shell growth is usually rapid. Early shell growth generally follows the contour of the surface where spat is attached. The shell is thin, but the mass of the cultch usually supplies some degree of protection from predators. Following the initial rapid growth phase, the shell starts to thicken and the shape of the young oyster begins to resemble that of an adult.

A true juvenile stage, per se, does not really exist in the life cycle of the oyster because gonadal development and gametogenesis begin within a few weeks of metamorphosis and setting. Oysters may become adults within 4 to 12 weeks of settlement thereby permitting spawning by young-of-the-year oysters and production of two generations of oysters per year.

Juvenile and adult oysters are also filter feeders that feed primarily on planktonic organisms and organic detritus. Results of gut content analyses indicate oysters ingest algae, dinoflagellates, ostracods, eggs and larvae of marine invertebrates, pollen grains from terrestrial plants and detritus (Morse 1944, Flint 1956). Laboratory experiments indicate oysters survive and grow when fed various algal species e.g., Isochrisis galbana, Platymonas suecica and Thalassiosira pseudonas (Epifanio 1979, Romberger and Epifanio 1981); Skeletonema sp. and Chaetocerus sp. (Epifanio 1979); and Tetraselmis maculata (Wilkfors et al. 1984).

The growth rate of C. virginica is initially as high as 10 mm/month but decreases with age. It is highest during the first 6 months after setting and gradually declines throughout the life of the oyster (Heffernan 1962; Hofstetter 1962, 1977; Galtsoff 1964, Berrigan 1988). The Eastern oyster can live to a maximum age of 25 to 30 years (Martin 1987).

Oyster growth is influenced by temperature and varies seasonally. Maximum growth usually occurs from fall through the spring. Depending on geographic location, growth slows and may stop during summer. During spring and early summer, growth is slow because most energy is used for gamete production.

Oysters expend as much as 48% of their annual energy budget on reproduction (Dame 1976). In the gulf, oysters typically reach harvest size (76 mm or 3 inches) in 18-24 months from setting (Hofstetter 1977; Berrigan 1988, 1990). They may attain a size of 150 mm (6 inches) in 5 or 6 years (Andrews 1981). The maximum size of Eastern oysters is reported to be approximately 300 mm (Abbott and Alcolado 1978).

Growth is also affected by salinity, food availability, periods of exposure to air and population density. Oysters that are exposed to fluctuating salinities within normal ranges grow faster than those held at a relatively constant salinity (Pierce and Conover 1954). Oysters also grow faster in areas with higher phytoplankton densities (Manzi et al. 1977). Oysters that are exposed to air for short periods may grow as well as continually submerged individuals (Gillmore 1982); however, long exposure periods inhibit growth.

5.1.3 Distribution and Abundance of the Stocks

Three stocks of Eastern oysters have been identified in the continental United States. An Atlantic coast stock (Maine to Key Biscayne, Florida) and two gulf stocks (west coast of Florida to Corpus Christi, Texas, and a lower Laguna Madre stock) have been distinguished based on electrophoretic evidence (Groue and Lester 1982, Buroker 1983, King and Gray 1989).

Oyster stock differentiation based on morphological or physiological differences is not valid (Groue and Lester 1982). Genetic evidence shows that a great deal of morphological and physiological variability identified in the literature occurs naturally within a stock. These differences are probably the result of environmental variation and not genetic variation (Hedgecock and Okanzaki 1984, Rose 1984).

5.1.3.1 Geographic Range

Eastern oysters range from the Gulf of St. Lawrence in Canada through the Gulf of Mexico to the Bay of Campeche, Mexico, and into the West Indies (Stenzel 1971, Abbott and Alcolado 1978, Andrews 1981). Oysters exist in every major bay system along the gulf; however, they are not evenly distributed among or within bays.

5.1.3.2 Spatial Distribution and Movement of Larvae

Oysters are mobile only during planktonic larval stages, and although not well understood, larval movement appears to be primarily dictated by salinity and water currents. Andrews (1983) concluded, based on plankton samples collected during all tidal stages, that larvae swim continuously, and their dispersal and ultimate fates are strongly dependent on current regimes and flushing rates of estuaries. He also found that these forms of hydrographic transport predominate over larval movement in reaction to physical and chemical stimuli. Throughout larval development, veligers are passively transported via water currents within the estuary, and their dispersal is basically controlled by the hydrographic forces of the estuarine system.

Larvae can migrate vertically in the water column. The dispersive effects of currents can be minimized to a certain extent when larvae sink in the water column by closing their valves in response to water movement (Galtsoff 1964). Laboratory experiments led Korringa (1952) to argue that oyster larvae could do very little to escape threatening situations and had little control over the direction of their movement.

The abundance and planktonic dispersal of oyster larvae ensure the species' survival in favorable areas of an estuary, even if traditional reef areas become unacceptable because of adverse environmental conditions or pollution. Planktonic dispersal also ensures oyster survival in the event of adverse climatological conditions such as flooding and drought.

5.1.3.3 Abundance

Oyster abundance may vary drastically from season to season and reef to reef in response to variations in environmental conditions. These conditions may affect both setting and survival of larvae as well as the survival of adults.

5.1.4 Factors Affecting Survival

Oysters suffer from numerous biological sources of stress and mortality throughout their lives. Many competitors, parasites, predators and diseases have been identified, and the manner in which they infect or kill oysters has been described (Butler 1954, Overstreet 1978). However, except for isolated documented cases of very high mortalities due to the parasite *Perkinsus marinus* (Hofstetter 1977) and the predatory southern oyster drill (*Thais haemostoma*) (Schlesselman 1955, Chapman 1959, May 1971), estimates of the total impact of these sources of oyster mortality have not been adequately quantified. Furthermore, the relative impact of these sources of mortality, compared to each other and fishing mortality have not been determined. Information that is available is primarily in the form of identifying species, describing the manner in which they compete with, infect or prey on oysters and other descriptive information.

5.1.4.1 Pollution

Oysters in the Gulf of Mexico suffer mortality from the effects of pollution throughout their lives. Heavy metals, petroleum hydrocarbons, pesticides, chlorine derivatives, sewage, freshwater runoff and other pollutants can negatively affect oyster populations. As the quantity and diversity of chemicals used in industry, agriculture and waste water treatment increase, the quantity of chemical pollutants entering Gulf of Mexico estuaries also increases (Gloyna and Malina 1964; Childress 1963, 1966, 1967).

Increases in sewage generated by coastal populations and excessive freshwater runoff contribute to bacterial contamination of reef areas. There are limited studies of oyster stress and mortality attributed to these types of pollution. Information that is available is primarily in the form of identifying contaminants, describing the manner in which they affect oysters and other descriptive information.

Heavy metals in the environment affect oysters during all stages of their life cycle. These substances can stress or kill oysters by reducing their ability to withstand diseases and parasites (Calabrese et al. 1973, MacInnes 1981, Okazaki and Panietz 1981). The presence of heavy metals in bay waters can lead to the mortality of embryos and larvae, reduce growth of larvae and spat, reduce spat setting and cause shell thinning (Calabrese et al. 1973, Boyden et al. 1975, Cunningham 1976). Results of tests designed to determine contaminant concentrations at which 50% of oyster embryos die (LC_{50}) indicate that of the heavy metals tested, mercury, silver, copper and zinc are the most toxic. Nickel, lead and cadmium have been classified as relatively toxic while arsenic, chromium, manganese and aluminum have been labeled as nontoxic to oyster embryos (Calabrese et al. 1973).

Oil pollution can affect oyster abundance by increasing mortality and reducing reproductive success. Determining the effect of petrochemical pollution on oysters is difficult because oil is composed of a complex mix of hydrocarbons that exhibit different levels of toxicity. Crude oil is generally less toxic than partially refined oils (Anderson and Anderson 1975). Petroleum hydrocarbons cause mortalities or negatively affect oyster physiology by reducing food intake or utilization, interfering with reproduction and lowering resistance to parasites. Chronic exposure to oil contaminated sediment at low concentrations, 0.05-0.15 parts per million (ppm), results in a reduction in food intake or utilization while exposure to higher concentrations of oil in the sediment can cause extensive mortalities (Mahoney and Noyes 1982). Fertilization and developmental success is reduced in proportion to concentrations of water soluble hydrocarbon fractions between 1 and 1,000 ppm (Renzoni 1975). Incidence of parasites is higher in oysters chronically exposed to oil pollution than in unexposed oysters (Barszcz et al. 1978). Pesticides reduce oyster growth, cause pathological tissue damage, interfere with egg development and cause mortalities (Davis and Hidu 1969, Rowe et al. 1971, Lowe et al. 1972, Schimmel et al. 1975). The extent to which pesticides affect oysters depends on the chemical, its concentration and the oyster life stage. Pesticides can become heavily concentrated in oyster tissues (Davis and Hidu 1969, Rowe et al. 1971). Depending on the chemical, oysters can concentrate pesticides at levels 41 to 85,000 times levels found in the surrounding environment. Oysters, however, can purge themselves of pesticides when the pollutants are removed from the environment (Davis and Hidu 1969, Rowe et al. 1971); thus they have been implicated as a possible biological monitor of organochlorine pesticide contamination.

Chlorine and chlorinated compounds affect oyster survival, growth, feeding, reproduction and development. Chlorine may be used to purify municipal water supplies, disinfect sewage waste water and as a biocidal antifouling agent in industrial cooling water. Chlorine and chlorine derivatives (chlorine-produced oxidants) are extremely toxic to oyster larvae at concentrations as low as 0.005 ppm (Haven et al. 1978). Chlorine concentrations as low as 0.05 ppm cause reduced pumping rates, and concentrations greater than 1 ppm cause oysters to close their valves (Galtsoff 1946). Exposure to chlorine concentrations between 0.12 and 0.16 ppm adversely affects adult oyster growth, food intake and reproduction (Scott and Vernberg 1979). Chlorine concentrations greater than 0.16 ppm are toxic to adult oysters (Scott and Vernberg 1979).

5.1.4.2 Competition and Commensalism

Oysters compete with other benthic organisms for space (Galtsoff 1969, Mackenzie 1970) and nutrients (Schlesselman 1955). Competitors include bryozoans (*Conopeum commensale*), barnacles (*Balanus* sp.), hooked mussels (*Ischadium recurvum*), slipper shells (*Crepidula fornicata*), anemones (*Aiptasiomorpha texaensis*), serpulid worms (*Eupomatus dianthus*), tunicates and algae (Ingle 1951, Hedgpeth 1953, Pequegnot 1975, Andrews 1981). The impact of competition for settlement space in the Gulf of Mexico has not been completely determined. In some instances these species have a purely commensal relationship with oysters.

Boring sponges (Cliona sp.), boring clams (Diplothyra smithii), mud worms (Polydora websteri), mussels (I. recurvum) and algae compete with oysters for space and food and/or colonize the oyster's shell matrix (Butler 1954, Galtsoff 1964, Menzel et al. 1966, Overstreet 1978). None of these organisms actually kills oysters, but extensive concentrations of boring sponges and clams may debilitate living populations and limit future generations by destroying valuable cultch. In addition to competing for space and food, extensive populations of mud worms (Polydora websteri) may cause mortalities by smothering juvenile oysters (Galtsoff 1964).

Various commensals that bore into the shell, penetrate the shell lining or irritate the mantle and fouling organisms that simply attach to the shell, may negatively affect the product quality without severely injuring the oyster. Brittle shells, blisters, discoloration and poor condition detract from the quality and presentation of oyster products.

Other filter feeding organisms such as acorn barnacles and mussels compete with oysters for available nutrients. However, information on the impact of this form of competition is incomplete.

5.1.4.3 Parasitism

A variety of parasites are known to infect oysters; the majority are considered only mildly pathogenic to their hosts (Gauthier et al. 1990). Although sporozoans, ciliates, trematodes, cestodes and nematodes are commonly reported from oysters along the gulf, few have been associated with massive oyster mortalities. The protozoan parasite (Perkinus marinus), however, has been identified as a significant pathogen and implicated in mass mortalities throughout its range.

Parasitic infestation can reduce growth, inhibit general development and lead to massive mortalities. Oyster mortality may be increased by physiological stress resulting from parasitic invasions which together may debilitate oyster stocks. Numerous researchers have provided field and histological evidence identifying and elucidating factors affecting oyster parasitism in the gulf (Menzel and Hopkins 1955, Hopkins 1957, Mackin 1962, Hofstetter 1964, Quick 1971, Overstreet 1978, Couch 1985).

The sporozoans (Nematopsis spp.) occur in abundance, but no significant pathogenicity is attributed to them (Sprague and Orr 1952). Similarly, various ciliate-like parasites have been isolated with no significant pathogenicity. Unidentified nematode larvae, metacestodes (Tylocephalum sp.) and the sporocysts and cercaria of Bucephalus spp. have been histologically identified in oysters. The trematode (Bucephalus sp.) has been reported to invade the gonads, displacing gonadal tissue, and severe infestations have effectively sterilized the host (Menzel and Hopkins 1955, Hopkins 1957).

The most serious oyster parasite in gulf waters is the pathogenic protozoan, Perkinsus marinus. It is commonly called "dermo," a previous derivation from Dermocystidium marinum (Labyrinthomyxa marina), and is known to infect oysters throughout the gulf and northward along the Atlantic coast to Delaware. The distribution of P. marinus, its pathogenicity and its relationship to environmental factors have received critical attention because of its association with extensive, warm water mortality of oysters (Mackin et al. 1950, Ray et al. 1953, Ray 1954, Dawson 1955, Ray and Chandler 1955, Quick and Mackin 1971, Beckert et al. 1972, Hofstetter 1977, Soniat and Gauthier 1989, Gauthier et al. 1990). Extensive research, as part of NOAA's Status and Trends Program, has been conducted to determine the extent and severity of P. marinus infections in gulf oyster populations and to identify factors influencing its distribution (Craig et al. 1989, Wilson et al. in press). These studies indicated that P. marinus is widely distributed throughout the oyster producing waters of the gulf, and the prevalence of the parasite is high among oyster populations.

Intensive infections have been associated with massive mortalities. Increased mortality often occurs among larger oysters during the summer months when high water temperatures and salinities exacerbate disease conditions. Low water temperatures and salinities usually lessen the effects of the disease. Oyster mortality may also occur as a result of synergistic actions from physiological and environmental stress, pollution and predation.

Water temperature is an important factor controlling the occurrence and effect of P. marinus infections (Mackin 1962, Quick and Mackin 1971). Reproduction of P. marinus in oysters drastically decreases at temperatures below 20°C (Mackin 1962). Mean water temperatures in gulf bays generally remain above 10°C in the winter and may be as high as 30°C during the summer. Therefore, the prevalence and intensity of P. marinus may not be substantially reduced by low water temperatures during the winter and may be promoted during the warmer and hottest months.

The gastropod, Boonea impressa (Odostomia impressa), is an ectoparasite that infests the Eastern oyster (Robertson and Mau-Lastovicka 1979, Andrews 1981). The actual effect of this gastropod on oyster populations is unknown. Juvenile oyster growth rates can be significantly reduced at a parasite level of ten snails per oyster (White et al. 1984). They found parasite levels of 100 per oyster on the Texas coast and concluded that B. impressa may have a significant impact on oyster populations.

5.1.4.4 Diseases

Bacterial diseases caused by Aeromonas sp., Vibrio sp. and Pseudomonas sp. are known to affect oysters (Mackin 1962, Vanderzant et al. 1970, Vanderzant and Nickelson 1972, Vanderzant et al. 1973). The extent of infection by these bacteria and their effect on Gulf of Mexico oysters has not been determined. Aeromonas sp. can infect and kill oyster larvae and juveniles (Guillard 1959, Tubiash et al. 1965). Vibrio sp. and Pseudomonas sp. infections reportedly kill oysters at all stages (Galtsoff 1964).

5.1.4.5 Predation

Predation represents a serious threat to oyster populations with severe consequences to commercial harvests. Numerous investigations confirm the seriousness of oyster predation by protozoans, anemones, coelenterates, helminths, mollusks, crustaceans and finfish along the gulf. Devastating attacks upon oyster populations by southern oyster drills (Thais haemastoma) stone crabs (Menippe spp.) and black drum (Pogonias cromis) have been documented (Pearson 1929, Butler 1954, Gunter 1955, Menzel and Hopkins 1956, Menzel and Nichy 1958, Menzel et al. 1966, Powell and Gunter 1968, Hofstetter 1977). The feeding behavior of numerous predatory species has also been investigated (Butler 1953, 1954; Schlesselman 1955; Menzel and Hopkins 1956; Menzel and Nichy 1958; Chapman 1959; Loosanoff 1959; McDermott 1960; MacKenzie 1970, 1977; McGraw and

Gunter 1972; Krantz and Chamberlin 1978; Gunter 1979; Steinberg and Kennedy 1979; Cave and Cake 1980; Kennedy and Breisch 1981; Andrews 1983).

Many protozoans, coelenterates, barnacles and mollusks prey on oyster larvae. Laboratory studies indicate that ciliated protozoans can ingest as many as six larvae at a time (Loosanoff 1959). The sea anemone (Diadum leucolena) consumes oyster larvae at a rate of one per minute (MacKenzie 1977). Ctenophores (Pleurobranchia and Mnemiopsis), sea nettles (Chrysaora quinquecirrha) and moon jellyfish (Aurelia aurita) feed upon oyster larvae (Kennedy and Breisch 1981). Steinberg and Kennedy (1979) reported that the acorn barnacle (Balanus improvisus) eliminated numbers of oyster larvae under experimental conditions. Many pelagic larvae including fish fry, coelenterates, ctenophores as well as most benthic organisms with mucous and ciliary feeding mechanisms capture bivalve larvae (Andrews 1983). The most efficient predators might be adult oysters (Andrews 1983).

Numerous species of gastropods, crustaceans and fish prey on spat, juveniles and adult oysters, but the principal predators are most abundant in high salinity waters (Gunter 1955). In most areas where oyster populations flourish, critical fluctuations in daily and seasonal salinity patterns act to deter the establishment of predators with marine affinities. Increased stress that is associated with prolonged high salinity regimes often exacerbates the level and intensity of predation.

Southern oyster drills (Thais haemastoma) are euryhaline, but they are most abundant in higher salinities (Pollard 1973, Cooley 1978). Butler (1954) reported that Thais was the most serious natural predator along the gulf and was distributed wherever oysters were found at salinity levels averaging above 15 ppt. May (1971) also reported that the oyster drill was the most serious oyster predator in Alabama waters and severely restricted oyster distribution in the state. Annual oyster mortality rates due to oyster drills were estimated to range from 50% to 85% in Louisiana (Schlesselman 1955) and from 50% to 100% in Mississippi (Chapman 1959). Numerous researchers have observed the predatory behavior and appetite of oyster drills under experimental conditions (Butler 1953, 1954; Menzel and Hopkins 1956). Butler (1954) reported that losses to Thais were incalculable and concluded that their voracious feeding habits, high reproductive capacity and widely distributed larval stages combined to make this snail the most destructive oyster predator in the gulf environment.

Other investigations along the gulf have identified several additional gastropods that may feed on oysters including whelks (Busycon contrarium and B. perversum), the crown conch (Melongena corona), the moon snail (Polynices duplicatus) and the ectoparasitic snail (Boonea impressa) (Ingle and Dawson 1953, Butler 1954, Menzel and Nichy 1958, Menzel et al. 1966, Quick 1971, White et al. 1984). The levels of predation due to these snails are poorly understood, but they are generally considered to be less devastating than Thais (Butler 1954, Menzel et al. 1966).

Extensive oyster losses have been associated with oyster leeches, Stylochus spp. (Pearse and Wharton 1938, Ingle and Dawson 1953, Menzel et al. 1966, Overstreet 1978). Although these polyclad worms may cause serious damage, evidence indicates that they are secondary predators and generally cause harm in areas where oysters are already in a weakened condition (Pearse and Wharton 1938, Butler 1954, Quick 1971).

Stone crabs (Menippe spp.) have been identified as major oyster predators along the gulf (Menzel and Hopkins 1956, Menzel et al. 1966, Powell and Gunter 1968, Quick 1971). Stone crab densities as high as 8000 crabs per hectare have been reported on reefs in Louisiana (Menzel and Hopkins 1956). Their experiments indicated that each stone crab could kill as many as 219 oysters per year. Such populations could thus destroy over 700,000 oysters per acre, or about 1,000 bushels annually. Annual oyster mortalities resulting from stone crab estimated by Menzel et al. (1958, 1966), Powell and Gunter (1968), and Quick (1971).

The blue crab (Callinectes sapidus) and smaller xanthid "mud" crabs, common in Gulf of Mexico estuaries, also prey on oysters. Blue crabs can consume up to 19 oyster spat per day (Menzel and Hopkins 1956). Krantz and Chamberlin (1978) found blue crabs greater than 100 mm in carapace width could consume single oysters up to 40 mm in length. Panopeus herbstii and Eurypanopeus depressus were reported to destroy young, thin-shelled oysters (McDermott 1960). Neopanope texana has been observed feeding on oyster spat 2.5-10 mm in length (MacKenzie 1970, 1977).

Black drum consume oysters (Pearson 1929). Cave and Cake (1980) found that black drum can crush and ingest oysters that fit within the pharyngeal apparatus. Large drum (over 900 mm TL) can consume oysters up to 112 mm in length while drum less than 900 mm consume oysters less than 75 mm. Mean daily predation rate for individual fish was as high as 48 oysters. Large drum can consume more than two oysters per day for every kilogram of body weight.

Other major fish predators of oysters (at least oyster spat) include toad fish (Opsanus sp.), Atlantic croaker (Micropogonias undulatus), spot (Leiostomus xanthurus), cownosed ray (Rhinoptera bonasus), sheepshead (Archosargus probatocephalus) and striped burrfish (Chilomycterus schoepfi) (Haven et al. 1978, Krantz and Chamberlin 1978, St. John and Cake 1980). The extent to which these fish impact oyster stocks has not been determined.

5.1.4.6 Mortality

The long and short-term effects of mortality on gulf oyster populations are poorly understood. The combined effects of harvesting, fluctuating environmental conditions, man-made perturbations and natural mortality from disease and predation make it difficult to isolate the specific contributions of individual factors on total mortality. Certainly, man has been the most serious threat to the oyster populations. Man-induced perturbations, including habitat destruction (sedimentation), physical disruption (dredging), alteration of hydrologic regimes (freshwater diversion and channelization), pollution burdens and overharvesting have resulted in long-term population losses. To the contrary, oysters have exhibited a remarkable capacity to reestablish thriving populations when mortalities have resulted from natural phenomena, such as floods, drought or hurricanes.

Adverse environmental factors may interfere with the welfare of oyster populations by inhibiting reproductive and recruitment capabilities, increasing vulnerability to disease and predation, and in extreme cases, by direct destruction of all phases in the life cycle. In reality, numerous negative factors may exert their effects in conjunction with all others, and their combined actions may produce a far greater effect than that caused by any single factor. Environmental factors and their relationships to oyster survival and mortality are addressed in detail in later sections.

5.1.4.6.1 Mortality Among Larval Stages

Total mortality and mortality rates for each phase in the life cycle of gulf oysters are not known. Intuitively, mortality is expected to be highest during the planktonic larval stages due to their abundance during peak spawning periods, vulnerability to predation and limited tolerances to changing environmental factors. Numerous investigations have described the effects of environmental factors on larval oysters, particularly salinity and temperature tolerances (Davis 1958, Davis and Calabrese 1964, Hidu et al. 1974, Kennedy and Breisch 1981). At optimum salinities, larvae survive over a wider range of temperatures than at salinities near the lower tolerance limit. Oyster eggs and larvae are also sensitive to suspended silt (Kennedy and Breisch 1981).

5.1.4.6.2 Mortality Among Spat and Juvenile Stages

Finucane and Campbell (1968) reported that oyster mortalities were greatest during the first 2 months after settlement, while other researchers have estimated mortality rates from 15% to 100% among newly set oysters (Loosanoff and Engle 1940, Mackin 1961, Hofstetter 1977). Mortality rates may approach 100% during certain periods or under certain conditions, but overall survival or reestablishment of the population is generally ensured by the dynamic reproductive capabilities of oysters. However, instances of low spatfall or high spat mortality can cause a fishery to fail.

Spat mortality is also higher in dense sets than light sets, due to crowding and increased predation (Webster and Shaw 1968, Hofstetter 1977, Chatry et al. 1983). High mortality may act advantageously when young oysters are concentrated by reducing the survivors to levels where they may grow rapidly. May (1971) reported that 80% to 90% of the oysters less than 50 mm on some reefs in Alabama were killed by oyster drills. The effects of harvesting on spatfall and spat survival are not clear.

5.1.4.6.3 Mortality Among Subadults and Adults

Losses from natural mortality and mortality rates of submarketable and marketable oysters are poorly understood for gulf stocks. Losses from natural mortality are difficult to assess primarily because specific factors that contribute to losses cannot be isolated. Gunter et al. (1956) addressed problems that were associated with determining oyster mortality.

Few investigators have determined the impact of natural mortality on harvestable oyster stocks, except when losses have been of a catastrophic nature resulting from floods, hurricanes, or epizootics. Catastrophic events may result in near depletion of harvestable stocks, making biological and economical assessments relatively straightforward (Galtsoff 1930, May 1972, Little and Quick 1976, Hofstetter 1981, Berrigan 1988). Most often, however, natural mortality from predation, disease or fluctuating environmental conditions occurs at a less rapid and near undetectable rate over an extended period of time. Almost continuous recruitment and rapid growth in many productive areas of the gulf also obfuscate the effects of mortality and adds to the difficulty in determining mortality rates.

Estimates of annual mortality rates exceed 50% to 95% among subadult and adult oysters (Menzel et al. 1966, May 1971, Quick 1971, Little and Quick 1976, Swingle and Hughes 1976, Hofstetter 1977, Quast et al. 1988, Berrigan 1990).

Quast et al. (1988) summarized results from experimental studies to determine mortality rates for oysters in several estuaries in Texas. In these studies, mortality rates for oysters in trays ranged from 1% to 44% per month for oysters between 15 and 100 mm. Berrigan (1990), comparing size frequency distributions on a restored reef over time, estimated average mortality rates of 3.3% per week among oysters larger than 50 mm. Losses attributed to natural mortality accounted for 65% of the population (>50 mm) in 28 weeks.

Natural mortality represents a substantial economic loss to the oyster industry and remains the principle limiting factor for commercial harvesting in many regions. Natural mortality on some reefs, particularly intertidal reefs, is so high as to preclude commercial use. Although these reefs may be highly productive, few oysters live long enough to reach marketable quality. Quast et al. (1988) estimated that 86% of all oysters in Texas waters die before reaching marketable size.

It is unclear what effect fishing and culling activities have on overall mortality rates. Conflicting evidence suggests that harvesting pressure is the primary reason for population losses in some areas while other research indicates that natural mortality has a far greater impact on population depletion. Overfishing is probably most damaging to reefs that are located in waters where environmental conditions are marginal and recruitment is low.

5.2 Habitat Requirements

Wild populations of oysters in the gulf need a proximate location to freshwater discharges such as rivers, creeks and bayous. These discharges provide nourishment while diluting the higher salinity gulf waters. Successful oyster setting and growth are dependent on this median salinity environment where they are generally afforded protection from high salinity predators and disease.

Estuarine areas usually contain large amounts of silt or "mud" deposited when streams empty into bays, sounds and other bodies of water. This material is very soft; consequently, oysters require a hard substrate to which they can attach and grow. Hard, elevated substrates provide increased surface area on the bottom to help support oysters as they grow and prevent them from sinking and smothering. A suitable substrate also helps oysters to aggregate thereby increasing reproductive success.

5.2.1 Salinity, Temperature and Water Flow Requirements

Though oysters can grow and survive over a wide range of environmental conditions, they are most successful when attached to a firm substrate in an area where water circulation provides sufficient food. Oysters are most abundant in water temperatures ranging from 20° to 30°C (Stanley and Sellers 1986), salinity that varies from 10 ppt to 30 ppt (Gunter and Geyer 1955, Copeland and Hoese 1966) and dissolved oxygen levels above 4 ppm.

5.2.1.1 Water Flow and Dissolved Oxygen Requirements

Oysters depend on water currents to provide food and oxygen, dissipate wastes, disperse larvae and prevent burial by siltation. Water flow requirements are poorly understood. For maximum feeding, current velocity must be high enough to exchange the water above a reef three times every hour (Galtsoff 1964).

Oysters are facultative anaerobes and are able to tolerate hypoxic conditions (0-2 ppm) and survive brief exposures to anoxic conditions. Oysters can survive dissolved oxygen levels below 1 ppm for up to 5 days (Sparks et al. 1958). Laboratory experiments indicate the oxygen consumption rate for oysters is 303 ml/kg/hr for wet tissue (Hammen 1969). However, oxygen requirements vary with salinity and temperature. Between water temperatures of 10° and 30°C and salinities of 7 and 28 ppt, oxygen consumption increases with increasing temperature and decreasing salinity (Shumway 1982).

5.2.1.2 Salinity Requirements

Salinity is perhaps the single most important factor influencing the distribution and abundance of estuarine organisms. It is particularly important with respect to oysters.

Oyster populations along the gulf flourish only within a very narrow range of salinities. Salinities less than 10 ppt through the spring and summer inhibit spawning and reduce larval survival thereby resulting in insufficient numbers of mature oyster larvae. When salinities greater than 15 ppt predominate, mature larvae are abundant, but survival of recently set oysters is poor because of increased numbers of fouling organisms and predators.

Oysters normally occur in Gulf of Mexico estuaries in salinities of 10 ppt to 30 ppt but are capable of surviving salinities ranging from 3 ppt to 44 ppt (Gunter and Geyer 1955, Copeland and Hoese 1966). Loosanoff (1953) and Galtsoff (1964) indicated that Atlantic coast oyster populations found at the upper and lower limits of this range exist under marginal conditions with growth and reproduction being inhibited. In the gulf, oysters in South Bay (Texas) tolerate salinities similar to or higher than "sea water." The effects of salinity variation on oyster populations depends largely on the range of the fluctuations and the rate of change.

Salinity also affects the timing and intensity of spat setting. Hopkins (1931) monitored abundance of larvae in plankton samples and spat on suspended oyster shell in Offatts Bayou and West Bay, Texas. He found that even though the water was well populated with oyster larvae, they would not attain setting stage unless salinities reached 20 ppt to 21 ppt. Setting intensity in Louisiana is consistently high when salinities range from 16 ppt to 22 ppt, with a peak occurring between 20 ppt to 22 ppt (Chatry et al. 1983).

Salinities below 3 ppt affect oyster feeding and increase mortality. Laboratory studies using oysters acclimated to 27 ppt showed that no feeding occurred in salinities below 3 ppt (Loosanoff 1953).

Salinities that range from 0 ppt to 15 ppt can benefit oyster stocks by reducing the abundance of some predators. Oyster drills and stone crabs can pose serious threats to oyster populations, but they cannot tolerate salinities lower than 11 ppt and 15 ppt, respectively (Wells 1961, Menzel et al. 1966). A short term decrease in salinity can therefore help control these predators and lead to increased productivity.

Salinity tolerance is inversely correlated with ambient water temperature. Higher water temperatures generally reduce salinity tolerance. Oysters are tolerant of low salinity conditions at temperatures below 5°C but can survive only a few days under the same conditions when the temperature is 15°C (Andrews 1982).

5.2.1.3 Temperature Requirements

Oysters can tolerate ambient water temperatures from 1° to 36°C (Galtsoff 1964). Internal temperatures from 46° to 49.5°C can be tolerated during brief periods of exposure (Galtsoff 1964, Ingle et al. 1971). Optimum water temperatures for growth, reproduction and survival of Eastern oysters range from about 20° to 30°C, and the response of oysters to temperature changes and extremes depends on interaction with other environmental conditions (Stanley and Sellers 1986).

Oyster populations in Redfish Bay and Harbor Island, Texas, have experienced mass mortality when exposed to a water temperature of 37°C (Copeland and Hoese 1966). Atlantic coast stocks tolerate partial freezing of their tissues (Loosanoff 1965); however, gulf stocks do not survive freezing (Cake 1983). Water temperature in combination with salinity determine when gravid oysters spawn (Hopkins 1931, Galtsoff 1964), indirectly influence the mortality rate of developing larvae (Menzel 1951, Hidu et al. 1974, Hayes and Menzel 1981) and determine the success of spat setting (Davis and Calabrese 1964, Hidu et al. 1974).

Water temperature also affects larval development. Under laboratory conditions larvae held at 30°C began setting 10-12 days after fertilization, larvae held at 24°C set after 24-26 days, but few larvae held at 20°C set within 35 days (Loosanoff and Davis 1963).

5.2.2 Substrate and Reef Types

Oyster larvae must settle on a relatively clean, stable surface or they will not survive. Oysters have been known to set on virtually any hard surface including glass, concrete, rock, metal, wood, rubber or other materials. Usually the most suitable cultch material is a clean unencrusted shell on the surface of an established, adequately elevated oyster reef (Truitt 1929; Hopkins 1931; Gunter 1938; Lunz 1958; St. Amant 1961).

Oysters along the gulf are most successful in shallow bays and on mud flats. They can survive on relatively dense mud that is firm enough to support their weight. Soft mud and shifting sand are the only substrates unsuitable for oyster communities (Galtsoff 1964).

Existing reefs generally provide the best and most attractive habitat and receive the greatest spat sets (Truitt 1929). The reef-building proclivity of oysters stems from the fact that oyster larvae attach to the shells of other oysters (Gunter 1972). Live oysters may be found in several layers on a well-elevated reef, with the youngest oysters forming the top layer (Gunter 1972, Hofstetter 1977). This type of growth leads to thick deposits of aggregated shells.

Physiography of oyster reefs varies. Some reefs are long and narrow and oriented with their long axis perpendicular to prevailing water currents or parallel to channels (Price 1954). Other reefs are low mounds (often called "lumps" or "heads") with high centers where the central high point consists of dead shells and a few live oysters. Here, live oysters grow most effectively on the reef shoulders (Hedgpeth 1953).

Two other types of reefs have been described from Texas waters. Scott (1968) described a "pancake" reef with a broad, thin veneer of oysters and shells that seldom exceeded 1 meter in thickness. A "concave reef" is one in which the central portion or the reef is several inches lower than the surrounding mud bottom (Benefield and Hofstetter 1976). The oysters on this type of reef are partially buried in mud with only the upper margins of their bills exposed. This situation is probably not very conducive to oyster growth.

Oyster populations in Florida are found on three principle reef types (fringe, string and patch reefs). Reefs are classified by their configurations and location relative to the nearest shoreline. Fringe reefs are adjacent to shore usually parallel to both the shore and the predominate tidal currents. String (consolidated linear ridges) reefs are usually long and contiguous structures exhibiting distinct elevations. These reefs form across the mouths of rivers and in bays and sounds. They are typically located at right angles to tidal currents. They may also be controlled by tidal amplitude and wind currents. Patch (lumps or tow-head) reefs exist in sounds, bays and lagoons, and they have irregular but fairly compact outlines. Their size and location depend on the availability of suitable substrates. Oyster assemblages may also occur in intertidal locations, on shell out-croppings or other solid substrates (jetties, groins, pilings, seawalls).

Large consolidated reefs over 10 square miles exist in portions of Louisiana and the Mississippi Sound. These reefs are perhaps the oldest type with some having shell deposits to depths greater than 30 feet below the reef surface.

5.3 Habitat Deterioration

The loss of suitable oyster habitat is perhaps the most important factor in the observed decline of oyster populations in the Gulf of Mexico. Reef substrate may be removed during fishing operations and not returned. Also, reefs have been mined for shell material (Gunter 1969, Bouma 1976).

Human populations in coastal areas have steadily increased during the 20th century. Consequently, oyster habitats have been filled and dredged to accommodate human needs. Furthermore, levees, dams, channels and other construction projects have cut off vital freshwater flow and caused saltwater intrusion thereby altering salinity regimes, reducing available nutrients and allowing the influx of predators. Increased human involvement with estuaries has also increased pollution and pollution-related mortality.

5.3.1 Substrate Removal

Substrate or cultch may be removed from reefs by fishery and nonfishery-related activities. Actual oyster harvesting removes substrate that could be available to subsequent generations because of the layering qualities of oysters. Although culling may reduce cultch loss, substrate removal may still be significant if the level of fishing effort is high.

Shrimping activities may also contribute to fishery-related substrate loss. When pulled over oyster reefs, trawls and trawl-related gear may remove or bury cultch thus reducing its availability.

Nonfishery-related shell dredging has occurred in all Gulf States (Bouma 1976). Although most operations today are conducted on buried material, previous operations removed significant amounts of available cultch from productive reefs. This material has been used in road beds, as construction fill, in septic systems, in the manufacture of concrete and for other uses. The amounts of substrate removed and the effects of the removal on reef loss have not been determined.

5.3.2 Salinity Changes

Over the past several decades, there has been a general trend in many gulf estuaries towards decreased freshwater inflow and increased salinities (Van Sickle et al 1976). Activities that affect freshwater inflow include leveeing of rivers (eliminates overflow into surrounding marshes), damming of rivers, channelization and pumping for redistribution.

As a result of increased salinities, many historically-productive reefs have been rendered nonproductive. In some estuarine basins, salinities that are favorable for oyster production now occur in areas that were formerly freshwater habitats.

The "shifting" of favorable salinities away from historically-productive reefs and toward the headwaters of estuarine basins has posed serious problems for the oyster industry. Since the transition has taken place over a relatively short period of time, areas that now have favorable salinities lack extensive reefs for larval settlement. Also, the proximity of the resource to the headwaters of basins has increased the likelihood of massive freshwater-induced oyster mortalities that result from periodic floods. These floods or "freshets" are usually of only a short duration but may cause massive mortalities.

Finally, the oyster resource is now located closer to areas of human habitation and development. This fact increases the likelihood that the sanitary quality of growing waters will be compromised and other pollutant-related disease and mortality will occur.

5.3.3 Effects of Hurricanes, Tropical Storms and Floods

Hurricanes, tropical storms and flooding are an essential part of estuarine ecology along the gulf. The reproductive capabilities, life cycle and broad environmental tolerances make oysters well suited to endure these short-term natural phenomena. If favorable salinities return to subsequent years following a flood, oyster production may even be enhanced as a result of nutrients accompanying the flood, the destruction of high-salinity predators and because more clean shell is available for cultch. Numerous accounts describe the reestablishment of productive oyster reefs after populations were decimated by hydrologic events associated with storms and floods (Hofstetter 1981, 1988; Berrigan 1988, 1990).

Hurricanes have had devastating impacts on oyster production and its dependent economy (Engle 1948, Ford 1970, Berrigan 1988). Turbulent hydrologic conditions that are associated with hurricanes may damage oyster reefs through various mechanism; including (1) destruction of reef integrity, (2) removal of live oysters and shell cultch, (3) sedimentation and burial, (4) scouring and abrasion and (5) freshets (Berrigan 1988). The severity of damage may also be dependent upon local tidal conditions, proximity to the storm, wave surge, rainfall and other climatological factors.

Flooding has also caused extensive damage to oysters throughout the gulf (Galtsoff 1930; Butler 1949b, 1952; May 1972, Hofstetter 1981, Marwitz and Bryan

1990). Extensive flooding may damage oyster reefs by the same mechanisms as hurricanes; often the severity of damage may be greater and recovery slower.

6.0 FISHERY MANAGEMENT JURISDICTION, LAWS AND POLICIES AFFECTING THE STOCKS THROUGHOUT THEIR RANGE OR FISHING FOR SUCH STOCKS

6.1 Management Institutions

Oysters occupy various habitats depending upon the physiological requirements of each particular life history stage; however, the oyster fishery targets predominantly adults within the territorial sea and internal waters of the Gulf States. Numerous state and federal regulations have been promulgated to protect oysters and their habitat.

Various federal agencies through their administration of laws, regulations and policies may affect the oyster fishery, but actual management is accomplished by individual state regulations. The following is a partial list of some of the more important agencies and regulations that affect oysters and their habitat. State agencies should be consulted for specific and current state laws and regulations.

6.1.1 Federal Management Institutions

Since virtually all known oyster populations occur in state waters, federal agencies do not directly manage oysters. However, a variety of federal agencies through their administration of laws, regulations and policies may influence oyster quality and abundance.

6.1.1.1 Regional Fishery Management Councils

With the passage of the Magnuson Fishery Conservation and Management Act (MFCMA), the federal government assumed responsibility for fishery management within the Exclusive Economic Zone (EEZ), a zone contiguous to the territorial sea and whose inner boundary is the outer boundary of each coastal state. The outer boundary of the EEZ is a line 200 miles from the (inner) baseline of the territorial sea. Management of the EEZ is to be based on fishery management plans developed by regional fishery management councils. Each council prepares plans with respect to each fishery requiring management within its geographical area of authority and amends such plans as necessary. Plans are implemented as federal regulation through the Department of Commerce (DOC).

Among the guidelines under which the councils must operate are standards which state that to the extent practicable, an individual stock of fish shall be managed as a unit throughout its range and that management shall, where practicable, promote efficiency, minimize costs and avoid unnecessary duplication (MFCMA Section 301a).

The Gulf of Mexico Fishery Management Council has not developed nor is it considering a management plan for oysters. Furthermore, no significant fishery for oysters is known to exist in the EEZ of the U.S. Gulf of Mexico.

6.1.1.2 National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA)

The Secretary of Commerce, acting through the NMFS, has the ultimate authority to approve or disapprove all fishery management plans prepared by regional fishery management councils. Where a council fails to develop a plan, or to correct an unacceptable plan, the Secretary may do so. The NMFS also collects data and statistics on fisheries and fishermen. It performs research and conducts management authorized by international treaties. The NMFS has the authority to enforce the Magnuson Act and Lacey Act and is the federal trustee for living and nonliving natural resources in coastal and marine areas under United States jurisdictional pursuant to Section 107(f) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or "Superfund"), Section 311(f)(5) of the Clean Water Act (CWA), Executive Order 12580 of January 23, 1987, and Subpart G of the National Oil and Hazardous Substances Pollution Contingency Plan.

The NMFS exercises no management jurisdiction other than enforcement with regard to oysters in the Gulf of Mexico. However, it conducts some research and data collection programs and comments on all projects that affect marine fishery habitat under the Fish and Wildlife Coordination Act and Section 10 of the Rivers and Harbors Act.

6.1.1.3 Office of Ocean and Coastal Resource Management (OCRM, NOAA)

The OCRM asserts authority through the National Marine Sanctuaries Program pursuant to Title III of the Marine Protection, Research, and Sanctuaries Act (MPRSA). The OCRM Estuarine Sanctuary Program has designated Looe Key in Monroe County, Rookery Bay in Collier County, the Apalachicola River and Bay in Franklin County, Florida, and Weeks Bay in Baldwin County, Alabama, as estuarine sanctuaries.

The OCRM may influence fishery management for oysters indirectly through administration of the Coastal Zone Management Program and by setting standards and approving funding for state coastal zone management programs. Some states in the gulf utilize a portion of these monies in their habitat protection and enhancement programs including reef maintenance and enhancement.

6.1.1.4 National Park Service (NPS), Department of the Interior (DOI)

The NPS under the DOI may regulate fishing activities within park boundaries. Such regulations may affect oyster harvest within specific parks. The NPS has authority to manage oysters primarily through the establishment of coastal and nearshore national parks and national monuments. Everglades National Park in Florida and the Mississippi District of Gulf Islands National Seashore are two examples of areas where oyster populations are managed by the NPS.

6.1.1.5 Fish and Wildlife Service (FWS), DOI

The FWS has little direct management authority over oysters. The ability of the FWS to affect the management of oysters is based primarily on the Endangered Species Act and the Fish and Wildlife Coordination Act. Under the Fish and Wildlife Coordination Act, the FWS, in conjunction with the NMFS, reviews and comments on proposals to alter habitat. Dredging, filling and marine construction are examples of projects that can seriously effect oyster populations.

In certain refuge areas such as Breton Sound, Louisiana, the FWS may directly regulate oyster harvest. Here the harvest is usually restricted to recreational limits developed by the respective state. Special use permits are required if commercial harvest of oysters is to be allowed in refuges.

6.1.1.6 Environmental Protection Agency (EPA)

The EPA through its administration of the Clean Water Act, National Pollutant Discharge Elimination System (NPDES) may provide protection to oyster reefs. Applications for permits to discharge pollutants into estuarine waters may be disapproved or conditioned to protect oyster resources.

6.1.1.7 Corps of Engineers (COE), Department of the Army

Oyster production may be influenced by the COE's responsibilities pursuant to the Clean Water Act and Section 10 of the Rivers and Harbors Act. Under these laws, the COE issues or denies permits for proposals to dredge, fill and construct in wetland areas and navigable waters. Such proposals could affect oyster populations and such permits are even required to plant shell as cultch replacement on reefs. The COE is also responsible for planning, construction and maintenance of navigation channels and other projects that may affect oyster populations.

6.1.1.8 The U.S. Food and Drug Administration (FDA)

The FDA may directly regulate the harvest and processing of oysters by its administration of the Food, Drug and Cosmetic Act. Also, the FDA influences the sanitary quality of oysters by assisting states and other entities through the Public Health Services Act and participation in the National Shellfish Sanitation Program (see Section 11).

6.2 Treaties and Other International Agreements

There are no treaties or other international agreements that affect the harvesting of oysters. No foreign fishing applications to harvest oysters have been submitted to the United States Government.

6.3 Federal Laws, Regulations and Policies

The following federal laws, regulations and policies may directly and indirectly influence the quality, abundance and ultimately the management of oysters.

6.3.1 Magnuson Fishery Conservation and Management Act of 1976 (MFCMA)

The MFCMA mandates the preparation of fishery management plans for important fishery resources within the EEZ. It sets national standards to be met by such plans. Each plan attempts to define, establish and maintain the optimum yield for a given fishery.

6.3.2 Marine Protection, Research and Sanctuaries Act of 1972 (MPRSA), Titles I and III and The Shore Protection Act of 1988 (SPA)

The MPRSA provides protection of fish habitat through the establishment and maintenance of marine sanctuaries. The MPRSA and the SPA acts regulate ocean transportation and dumping of dredged materials, sewage sludge and other materials. Criteria for issuing such permits include consideration of effects of dumping on the marine environment, ecological systems and fisheries resources.

6.3.3 Federal Food, Drug and Cosmetic Act of 1938 (FDCA)

The FDCA prohibits the sale, transfer of importation of "adulterated" or "misbranded" products. Adulterated products may be defective, unsafe, filthy or produced under unsanitary conditions. Misbranded products may have false, misleading or inadequate information on their labels. In many instances the FDCA also requires FDA approval for distribution of certain products. The act directly affects the harvest, handling, sale and packaging of oysters

6.3.4 Clean Water Act of 1981 (CWA)

The CWA requires that a National Pollution Discharge Elimination System (NPDES) permit be obtained before any pollutant is discharged from a point source into waters of the United States including waters of the contiguous zone and the adjoining ocean. Discharges of toxic materials into rivers and estuaries that empty into the Gulf of Mexico can cause oyster mortality and/or create health risks to humans eating oysters.

Under Section 404 of the CWA the Corps of Engineers is responsible for administration of a permit and enforcement program regulating alterations of wetlands as defined by the act. Dredging, filling, bulk-heading and other construction projects are examples of activities that require a permit and have potential to affect oyster populations. Such permits may be required for various oyster management program activities, public or private. The NMFS is the federal trustee for living and nonliving natural resources in coastal and marine areas under United States jurisdiction pursuant to the CWA.

6.3.5 Federal Water Pollution Control Act of 1972 (FWPCA) and MARPOL Annexes I and II

Discharge of oil and oily mixtures is governed by the Federal Water Pollution Control Act (FWPCA) and 40 Code of Federal Regulations (CFR), Part 110, in the navigable waters of the U.S. Discharge of oil and oily substances by foreign ships or by U.S. ships operating or capable of operating beyond the U.S. territorial sea is governed by MARPOL Annex I.

MARPOL Annex II governs the discharge at sea of noxious liquid substances primarily derived from tank cleaning and deballasting. Most categorized substances are prohibited from being discharged within 12 nautical miles of land and at depths of less than 25 meters.

These acts protect oyster reefs from oil and other chemical contamination.

6.3.6 Coastal Zone Management Act of 1972 (CZMA), as amended

Under the CZMA, states receive federal assistance grants to maintain federally-approved planning programs for enhancing, protecting and utilizing coastal resources. These are state programs, but the act requires that federal activities must be consistent with the respective states' CZM programs. Depending upon the individual state's program, the act provides the opportunity for considerable protection and enhancement of oyster resources by regulation of activities and by planning for future development in the least environmentally damaging manner.

6.3.7 Endangered Species Act of 1973, as amended

The Endangered Species Act provides for the listing of plant and animal species that are threatened or endangered. Once listed as threatened or endangered a species may not be taken, possessed, harassed or otherwise molested. It also provides for a review process to ensure that projects authorized, funded or carried out by federal agencies do not jeopardize the existence of these species or result in destruction or modification of habitats that are determined by the Secretary of the DOI to be critical.

Oysters in the U.S. Gulf of Mexico are neither endangered nor threatened. Furthermore, present fishing activities for oysters are not known to adversely affect any threatened or endangered species.

6.3.8 National Environmental Policy Act of 1970 (NEPA)

The NEPA requires that all federal agencies recognize and give appropriate consideration to environmental amenities and values in the course of their decision-making. In an effort to create and maintain conditions under which man and nature can exist in productive harmony, the NEPA requires that federal agencies prepare an environmental impact statement (EIS) prior to undertaking major federal actions that significantly affect the quality of the human environment. Within these statements, alternatives to the proposed action that may better safeguard environmental values are to be carefully assessed.

6.3.9 Fish and Wildlife Coordination Act of 1958

Under the Fish and Wildlife Coordination Act, the FWS and NMFS review and comment on fish and wildlife aspects of proposals for work and activities sanctioned, permitted, assisted or conducted by federal agencies that take place in or affect navigable waters, wetlands or other critical fish and wildlife habitat. The review focuses on potential damage to fish and wildlife and their habitat, and therefore, serves to provide some protection to oyster resources from activities that may alter critical oyster habitat in nearshore waters. The act is important because federal agencies must give due consideration to the recommendations of the FWS and NMFS.

6.3.10 Fish Restoration and Management Projects Act of 1950

Under this act, the DOI is authorized to provide funds to state fish and game agencies for fish restoration and management projects. Funds for protection of threatened fish communities that are located within state waters could be made available under the act. This act has little, if any, effect on the oyster fishery or its management.

6.3.11 Lacey Act of 1981, as amended

The Lacey Act prohibits import, export and interstate transport of illegally-taken fish and wildlife. As such, the act provides for federal prosecution for violations of state fish and wildlife laws. The potential for federal convictions under this act with its more stringent penalties has probably reduced interstate transport of illegally-possessed oysters.

16.3.12 Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA or "Superfund")

This CERCLA names the NMFS as the federal trustee for living and nonliving natural resources in coastal and marine areas under United States jurisdiction. It could provide funds for "clean-up" of oyster habitat in the event of an oil spill or other polluting event.

6.3.13 MARPOL Annex V and United States Marine Plastic Research and Control Act of 1987 (MPRCA)

MARPOL Annex V is a product of the International Convention for the Prevention of Pollution from Ships, 1973/78. Regulations under this act prohibit ocean discharge of plastics from ships; restrict discharge of other types of floating ship's garbage (packaging and dunnage) for up to 25 nautical miles from any land; restrict discharge of victual and other recomposable waste up to 12 nautical miles from land; and require ports and terminals to provide garbage reception facilities. The MPRCA of 1987 and 33 CFR, Part 151, Subpart A, implement MARPOL V in the United States.

6.3.14 Fish and Wildlife Act of 1956

This act provides assistance to states in the form of law enforcement training and cooperative law enforcement agreements. It also allows for disposal of abandoned or forfeited property with some equipment being returned to states. The act prohibits airborne hunting and fishing activities.

6.4 State Management Institutions, Laws, Regulations and Policies

State management institutions, laws and regulations for oysters vary among the five Gulf States. All states bordering on the Gulf of Mexico delegate substantial authority to their administrative agencies for establishing substantive management regulations. Conversely, most states still have statutes that contain some specific regulatory measures.

Table 6.1 summarizes the basic characteristics of the state institutions involved in oyster fishery management. Brief narrative descriptions are presented below for each state institution. Important state laws, regulations and policies are also summarized. **To the greatest extent possible, these requirements are current to the date of publication.**

6.4.1 Florida

6.4.1.1 Administrative Organization

Florida Department of Natural Resources
Division of Marine Resources
3900 Commonwealth Boulevard
Tallahassee, Florida 32303
Telephone: (904) 488-6058

Florida Marine Fisheries Commission
2540 Executive Center Circle West, Suite 106
Tallahassee, FL 32301
Telephone: (904) 487-0554

Table 6.1. State management institutions - Gulf of Mexico.

	Administrative body and its responsibilities	Administrative policy-making body and decision rule	Legislative involvement in management regulations
FLORIDA	DEPARTMENT OF NATURAL RESOURCES · administers management programs · enforcement · conducts research · makes recommendations to legislature and Marine Fisheries Commission	MARINE FISHERIES COMMISSION · creates rules that must be approved by the governor and cabinet · seven member commission	· can override any rule of the commission · responsible for licensing, management of fishing in man-made canals and limited entry
ALABAMA	DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES · administers management programs · enforcement · conducts research	· Commissioner of department has authority to establish management regulation · Conservation Advisory Board is a thirteen-member board and advises the commissioner · has authority to amend and promulgate regulations	· authority for detailed management regulations delegated to commissioner · statutes concerned primarily with licensing
MISSISSIPPI	DEPARTMENT OF WILDLIFE, FISHERIES AND PARKS · administers management programs · enforcement · conducts research	COMMISSION ON WILDLIFE, FISHERIES AND PARKS · five-member board · establishes ordinances on recommendation of deputy director (BMR)	· authority for detailed management regulations delegated to commission · statutes concern licenses and taxes with some specific restrictions on oysters
LOUISIANA	DEPARTMENT OF WILDLIFE AND FISHERIES · administers management programs · enforcement · conducts research · makes recommendations to legislature	WILDLIFE AND FISHERIES COMMISSION · seven-member board establishes policies and regulations based on majority vote of a quorum (four members constitute a quorum) consistent with statutes	· detailed regulations contained in statutes · authority for detailed management regulations delegated to commission
TEXAS	PARKS AND WILDLIFE DEPARTMENT · administers management programs · enforcement · conducts research · makes recommendations to Texas Parks & Wildlife Commission (TPWC)	PARKS AND WILDLIFE COMMISSION · nine-member body establishes regulations based on majority vote of quorum (five members constitute a quorum) · granted authority to regulate taking, possession, purchase and sale of oysters (authority expires September 1, 1991 if not extended by the legislature).	· licensing requirements and penalties are set by legislation

The Florida Marine Fisheries Commission, a seven-member board appointed by the governor and confirmed by the senate, was created by the Florida legislature in 1983. This commission was delegated rule-making authority over marine life in the following areas of concern: gear specification; prohibited gear; bag limits; size limits; species that may not be sold; protected species; closed areas; seasons; quality control codes with the exception of specific exemptions for shellfish; and special considerations relating to oyster and clam relaying. All rules passed by the commission require approval by the governor and cabinet. The commission does not have authority over endangered species, license fees, penalty provisions or over regulation of fishing gear in residential saltwater canals.

The agency charged with the administration, supervision, development and conservation of natural resources is the Florida Department of Natural Resources (FDNR) headed by the Governor and Cabinet. The governor and cabinet serve as the seven-member board that approves or disapproves all rules and regulations promulgated by the FDNR. The administrative head of the FDNR is the executive director. Within the FDNR the Division of Marine Resources, through Section 370.02(2), Florida Statutes, is empowered to conduct research directed toward management of marine and anadromous fisheries in the interest of all people of Florida. The Division of Law Enforcement is responsible for enforcement of all marine resource related laws and all rules and regulations of the department.

Florida has habitat protection and permitting programs and a federally-approved CZM program.

6.4.1.2 Legislative Authorization

Chapter 370 of the Florida Statutes Annotated contains law regulating the coastal fisheries. The legislature passes statutes for the management of fisheries resources as well as specific laws which are applicable within individual counties.

6.4.1.3 Reciprocal Agreement and Limited Entry Provisions

6.4.1.3.1 Reciprocal Agreement Provisions

6.4.1.3.1.1 Licenses

Florida statutory authority provides for reciprocal agreements related to fishery access and licenses.

6.4.1.3.1.2 Management

Florida has no statutory authority to enter into reciprocal management agreements.

6.4.1.3.2 Limited Entry

Florida has no statutory provisions for limited entry except as it pertains to the oyster harvesting license in Apalachicola Bay. An educational seminar is mandatory prior to purchase of the license and seminars are only held at certain times of the year. Also, the license must be purchased during a 45-day period; otherwise a late fee of $500 is charged in addition to the license and seminar.

6.4.1.4 Commercial Landings Data Reporting Requirements

Processors are required to report monthly on volume and price of saltwater products. Data are collected and published by the Department of Natural Resources, Marine Fisheries Information System.

6.4.1.5 Penalties for Violations

Penalties for violations of Florida statutes and regulations are prescribed in Section 370.021, Florida Statutes. Upon the arrest and conviction for violation of any of the regulations or laws, the license holder shall show just cause why his saltwater license should not be suspended or revoked.

6.4.1.6 Annual License Fees

Resident wholesale seafood dealer	
• county	$ 300
• state	450
Nonresident wholesale seafood dealer	
• county	500
• state	1000
Alien wholesale seafood dealer	
• county	1000
• state	1500
Resident retail seafood dealer	25
Nonresident retail seafood dealer	200
Alien retail seafood dealer	250
Saltwater products license	
• resident-individual	50
• resident-vessel	100
• nonresident-individual	200
• nonresident-vessel	400
• alien-individual	300
• alien-vessel	600
Oyster harvesting license (Apalachicola Bay only)	
• resident	100
• nonresident	500
Oyster relaying permit	No Charge
Oyster leases (per acre)	20

6.4.1.7 Laws and Regulations

6.4.1.7.1 Minimum Size

Minimum size is three (3) inches, except: (1) a 15% tolerance for undersized attached oysters; and (2) a 5% tolerance for undersized individual oysters.

6.4.1.7.2 Seasons

The oyster harvesting season is closed between July 1 and September 30 of each year, except in Dixie and Levy Counties (June 1 through August 31) and in designated summer harvesting areas.

6.4.1.7.3 Fishing Methods and Gear Restrictions

Bag limits are established in certain areas of the state. Dredges may be used for harvesting oysters or clams on private leases after posting a $3,000 bond and securing a special activity license.

6.4.1.7.4 Leases

Two types of leases currently exist in Florida: shellfish leases and aquaculture leases. Shellfish leases are held under the provisions of Chapter 370, Florida Statutes, but no new leases are issued under this program. Leasing submerged lands for aquaculture purposes is presently authorized under the provisions of Chapter 253, Florida Statutes, and subsections 18-21, Florida Administrative Code.

Authority to lease state-owned lands, within the Department of Natural Resources, rests with the Governor and Cabinet sitting as the Board of Trustees of the Internal Improvement Trust Fund. Specific conditions and terms of aquaculture lease agreements are available from the Division of State Lands, Florida Department of Natural Resources.

6.4.1.7.5 Restrictions

For direct-to-market sales, oysters can only be harvested from approved and conditionally-approved shellfish harvesting areas.

6.4.2 Alabama

6.4.2.1 Administrative Organization

Alabama Department of Conservation and Natural Resources (ADCNR)
Alabama Marine Resources Division (AMRD)
P.O. Box 189
Dauphin Island, Alabama 36528
Telephone: (205) 861-2882

Management authority of fishery resources in Alabama is held by the Commissioner of the Department of Conservation and Natural Resources. The Commissioner may promulgate rules or regulations designed for the protection, propagation and conservation of all seafood. He may prescribe the manner of taking, times when fishing may occur and designate areas where fish may or may not be caught; however, all regulations are to be directed at the best interest of the seafood industry.

Most regulations are promulgated through the Administrative Procedures Act approved by the Alabama Legislature in 1983; however, bag limits and seasons are not subject to this act. The Administrative Procedures Act outlines a series of events that must precede the enactment of any regulations other than those of an emergency nature. Among this series of events are (a) the advertisement of the intent of the regulation, (b) a public hearing for the regulation, (c) a 35-day waiting period following the pubic hearing to address comments from the hearing and (d) a final review of the regulation by a joint house and senate review committee.

Alabama also has the Alabama Conservation Advisory Board (ACAB) that is endowed with the responsibility to provide advice on policies of the ADCNR. The board consists of the governor, the ADCNR commissioner and ten board members.

The AMRD has responsibility for enforcing state laws and regulations, for conducting marine biological research and for serving as the administrative arm of the commissioner with respect to marine resources. The division recommends regulations to the commissioner.

Alabama has a habitat protection and permitting program and a federally approved CZM program.

6.4.2.2 Legislative Authorization

Chapters 2 and 12 of Title 9, Code of Alabama, contain statutes that concern marine fisheries.

6.4.2.3 Reciprocal Agreement and Limited Entry Provisions

6.4.2.3.1 Reciprocal Agreement Provisions

6.4.2.3.1.1 Licenses

Statutory authority provides an arrangement that may permit nonresidents to fish in the coastal waters of Alabama on a reciprocal basis. The reciprocal arrangements are extended to include oystering activities.

6.4.2.3.1.2 Management

Alabama has no statutory authority to enter into reciprocal management agreements.

6.4.2.3.2 Limited Entry

Alabama has no statutory provisions for limited entry.

6.4.2.4 Commercial Landings Data Reporting Requirements

While Alabama law requires that wholesale seafood dealers file monthly reports at quarterly intervals to the department, thorough records were not collected prior to 1982. Records are now compiled by NMFS and ADCNR port agents on sales of fishery products under a cooperative agreement.

6.4.2.5 Penalties for Violations

Violations of the provisions of any statute or regulation are considered a Class C misdemeanor and punishable by fines of $0 to $500 and up to 3 months in jail.

6.4.2.6 Annual License Fees

Commercial oyster catcher	$ 26
Seafood dealer	126
Oyster dredge	26 + $1,000 bond

6.4.2.7 Laws and Regulations

6.4.2.7.1 Minimum Size

Oysters taken for either commercial or personal consumption must be at least 3 inches in length. A 5% tolerance for undersized oysters is allowed.

6.4.2.7.2 Seasons

The Department of Conservation and Natural Resources and the Department of Public Health are authorized to open and close areas during all parts of the year. Taking oysters from a closed area is a misdemeanor. Taking oysters from open areas before sunrise or after 4:00 p.m. is prohibited. All licenses expire on September 30 of each year.

6.4.2.7.3 Fishing Methods and Gear Restrictions

Persons are allowed to take up to 100 oysters for personal consumption without a catcher's license. Oysters may be taken from public reefs and waterbottoms by hand or oyster tongs. Oyster dredges may be used only by owners or lessees of private oyster reefs only after purchasing an oyster dredge license, posting a $1,000 bond and receiving written authorization from the Department of Conservation and Natural Resources. Oysters must be culled on the reef where they are taken.

6.4.2.7.4 Leases

Persons, firms or corporations that desire to lease oyster bottoms shall make application in writing to the commissioner of Conservation and Natural Resources accompanied by such fees as may be prescribed. It is the duty of each such lessee to have established an accurate survey by a registered surveyor of the bottoms, beds or reefs under his control, and each corner shall be clearly marked and defined with the lessee's name clearly attached. Intermediate markers shall be placed and a plat of the area filed with the Division of Marine Resources together with a list of any persons using said lease area.

6.4.2.7.5 Restrictions

It is unlawful to drag any seines over the public reefs or private oyster grounds. Oysters taken commercially must be sacked and each sack tagged before landing. Tags may be purchased for $0.25 each at the Marine Resources Division offices. Commercial tonging limits may be imposed seasonally.

6.4.3 Mississippi

6.4.3.1 Administrative Organization

Mississippi Department of Wildlife, Fisheries and Parks (MDWFP)
Bureau of Marine Resources (BMR)
2620 Beach Boulevard
Biloxi, Mississippi 39531
Telephone: (601) 385-5860

The MDWFP administers coastal fisheries and habitat protection programs through the BMR. Authority to promulgate regulations and policies is vested in the Mississippi Commission on Wildlife, Fisheries and Parks, the controlling body of the MDWFP. The commission consists of five members appointed by the governor. The commission has full power to "manage, control, supervise and direct any matters pertaining to all saltwater aquatic life not otherwise delegated to another agency" (Mississippi Code Annotated 49-15-11).

Mississippi has a habitat protection and permitting program and a federally approved CZM program.

6.4.3.2 Legislative Authority

Chapter 49-15 of the Mississippi Code of 1972 (Annotated) contains provisions for the management of marine fisheries resources.

6.4.3.3 Reciprocal Agreement and Limited Entry Provisions

6.4.3.3.1 Reciprocal Agreement Provisions

6.4.3.3.1.1 Licenses

Mississippi statutory authority allows reciprocal license agreements with other states.

6.4.3.3.1.2 Management

The Commission on Wildlife, Fisheries and Parks is authorized to enter into advantageous interstate or intrastate agreements with proper officials which directly or indirectly result in the protection, propagation and conservation of Mississippi's seafood. The commission may also continue any existing agreements.

6.4.3.3.2 Limited Entry

Mississippi has no statutory provisions for limited entry.

6.4.3.4 Commercial Landings Data Reporting Requirements

Commercial as well as recreational harvests from Mississippi reefs are recorded through a trip ticket system that utilizes check stations. All oysters that are caught in Mississippi territorial waters must be landed in Mississippi (Mississippi Code Annotated 49-15-11). The quantity of oysters that are harvested outside of Mississippi territorial waters and landed in Mississippi is not regularly or accurately obtained. Previously, information on oysters that were harvested from Louisiana and landed in Mississippi was obtained from the Grand Isle, Louisiana, check station by a NMFS port agent in Pascagoula, Mississippi. Since the Grand Isle station closed, Mississippi landings of oysters that were caught outside of its territorial waters are intermittently recorded by a MDWFP statistical agent during interviews with local processors that target shrimp landings.

6.4.3.5 Penalties for Violations

Any person, firm or corporation violating any of the provisions of Chapter 49-15 or any ordinance duly adopted by the commission, unless otherwise specifically provided for herein, shall, on conviction, be fined not less than $100, nor more than $500, for the first offense, unless the first offense is committed during a closed season, in which case the fine shall be not less than $500, nor more than $1,000; and not less than $500, nor more than $1,000, for the second offense when such offense is committed within a period of 3 years from the first offense; and not less than $2,000 nor more than $4,000, or imprisonment in the county jail for a period not exceeding 30 days for any third or subsequent offense when such offense is committed within a period of 3 years from the first offense and also upon conviction of such third or subsequent offense, it shall be the duty of the court to revoke the license of the convicted party and of the boat or vessel used in such offense, and no further license shall issue to such person or for said boat to engage in catching or taking of any seafoods from the waters of the state of Mississippi for a period of 1 year following such conviction. Further, upon conviction of such third or subsequent offense committed within a period of 3 years from the first offense, it shall also be the duty of the court to order the forfeiture of any equipment or nets used in such offense. Provided, however, that equipment as used in this section shall not mean boats or vessels. Any person convicted and sentenced under this section shall not be considered for suspension or other reduction of sentence. Except as provided under subsection 5 of Section 49-15-45, any fines collected under this section shall be paid to the Mississippi Commission on Wildlife, Fisheries and Parks to be paid into the Seafood Fund.

In addition to the above general penalties, specific penalties are provided in separate sections of Chapter 49-15. It is unlawful for any person to fish, catch or take oysters from any of the oyster reefs in the state of Mississippi by the use of any tongs, dredge, rake or other mechanical device, during the hours between sunset and sunrise of each day. Violators shall be punished by a fine not to exceed $10,000 and/or up to 1 year in the county jail.

Any person failing or refusing to deliver shells or shell retention fees to the commission when called for by it, as provided in this section, shall be guilty of a misdemeanor and, upon conviction, shall be fined not more than $100 for each barrel of shells they fail or refuse to deliver, or to tender the shell retention fee; and, in addition thereto, shall pay the reasonable value thereof and shall be ineligible to be licensed for any of the activities set forth in Chapter 49-15.

Any person convicted of taking oysters from leased land or from waters that are not of a safe, sanitary quality without a permit as provided in section 49-15-37 shall, on the first offense, forfeit all equipment used, exclusive of any boat or boats; and be fined not to exceed $2,000 or sentenced not to exceed 1 year in the county jail, or both. Subsequent convictions shall be punishable by forfeiture of all equipment, including any boat or boats; and a fine not to exceed $5,000 or not to exceed 2 years in prison, or both such fine and imprisonment.

6.4.3.6 Annual License Fees

Interstate commerce	
• resident	$ 20
• nonresident	20
Seafood dealer	
• resident	100
• nonresident	100
Seafood processor	
• resident	200
• nonresident	200

Tonging	
• resident	50
• nonresident	100
Dredging	
• resident	100
• nonresident	200
Recreational	
• resident	10

A nonresident will be charged the same fee for a license as is required for a Mississippi resident as a nonresident in that state. This is applicable only if the fees charged exceed the nonresident fees herein listed.

In addition to these fees, 100% of all the oyster shells that are produced from oysters taken from the public reefs of the state of Mississippi are declared nontransferable property of the state. In lieu of demanding a remittance of 100% of the oyster shells, the Commission of Wildlife, Fisheries and Parks levies a shell retention fee in the amount of $0.50 per sack.

6.4.3.7 Laws and Regulations

6.4.3.7.1 Minimum Size

Oysters taken in state waters must be at least three (3) inches long (at greatest length of the shell). At times, however, the BMR may decrease this limit upon public notice to that effect. A 10% tolerance for undersized oysters is allowed.

6.4.3.7.2 Seasons

Season is regulated by legal notice of the Commission on Wildlife, Fisheries and Parks and notice thereof will be duly published in local newspapers and released to both the radio and television media. During open season, oysters may be taken only in daylight hours.

6.4.3.7.3 Fishing Methods, Area and Gear Restrictions

Oysters may be taken by any of the traditional methods of oystering in the state of Mississippi, that is, by hand (cooning), with tongs, or by using a dredge. Dredges for oystering may not exceed 115 pounds in weight nor may they have in excess of 16 teeth. Restrictions on the maximum number of dredges carried will be established seasonally by the Commission of Wildlife, Fisheries and Parks. Oysters for personal consumption may be taken by any legal means.

6.4.3.7.4 Leases

The Mississippi Commission of Wildlife, Fisheries and Parks, Bureau of Marine Resources conducts a program of oyster leasing. Any resident of the state may lease from 5 to 100 acres of state waterbottoms for the purpose of oyster culture provided the areas are not riparian rights areas, natural reefs or public reefs. Applications must describe the area to be leased and include a bid of not less than $1.00 per acre per year as a rental fee for the initial 25-year lease. Other criteria may be established by the MDWFP. Oysters taken from private lease areas must be so designated by tags indicating the official lease number issued by the BMR.

6.4.3.7.5 Restrictions

Commercial dredging and tonging limits are set seasonally. Oysters may be taken only from those waters approved for shellfish harvest by the BMR. The harvesting, shucking, processing and sale of oysters must also conform to shellfish sanitation regulations specified by MDWFP. Following heavy rains, natural reefs and leased areas may be temporarily closed. Such closures are announced in local television and radio media. Oysters that are taken from other than state waters must be accompanied by a bill of lading indicating the point of origin. Oysters that are taken for personal consumption must also be inspected; a tag will be issued for each sack. Such tags will identify that the contents are not to be sold.

6.4.4 Louisiana

6.4.4.1 Administrative Organization

Louisiana Department of Wildlife and Fisheries (LDWF)
P.O. Box 98000
Baton Rouge, Louisiana 70898
Telephone: (504) 765-3617

The LDWF is one of 21 major administrative units of the Louisiana government. A seven-member board, the Louisiana Wildlife and Fisheries Commission (LWFC) is appointed by the Governor. Six of the members serve overlapping terms of 6 years, and one serves a term concurrent with the Governor. The commission is a policy-making and budgetary-control board with no administrative functions. The legislature has sole authority to establish management programs and policies; however, the legislature has delegated certain authority and responsibility to the LDWF. The Secretary of the LDWF is the executive head and chief administrative officer of the department and is responsible for the administration, control and operation of the functions, programs and affairs of the department. The secretary is appointed by the Governor with consent of the Senate.

Within the administrative system, an Assistant Secretary is in charge of the Office of Fisheries. In this office a Marine Fisheries Division, headed by the Division Administrator, performs "the functions of the state relating to the administration and operation of programs, including research relating to oysters, waterbottoms and seafood including, but not limited to, the regulation of oyster, shrimp and marine fishing industries." The Enforcement Division, in the Office of the Secretary, is responsible for enforcing all marine fishery statutes and regulations.

Louisiana has habitat protection and permitting programs and a federally approved CZM program.

6.4.4.2 Legislative Authorization

Title 56 Louisiana Revised Statutes contains rules and regulations that govern marine fisheries in the state. Specific statutes for oysters are included in Sections 421 through 451.

6.4.4.3 Reciprocal Agreement and Limited Entry Provisions

6.4.4.3.1 Reciprocal Agreement Provisions

6.4.4.3.1.1 Licenses

The commission is authorized to enter into reciprocal fishing license agreements with the proper authorities of any other state.

6.4.4.3.1.2 Management

The commission is authorized to enter into reciprocal management agreements with the states of Arkansas, Mississippi and Texas on matters pertaining to aquatic life in bodies of water that form a common boundary.

6.4.4.3.2 Limited Entry

Louisiana law presently does not provide for limited entry.

6.4.4.4 Commercial Landings Data Reporting Requirements

Processors or any other first purchasers must report the previous month's purchases by the tenth of each month. The quantity, vessels, owners and other dealers from whom oysters are purchased must be included in the reports. Wholesalers, processors and first purchasers are also required to report sales of oysters and to whom oysters are sold.

6.4.4.5 Penalties for Violations

Oyster violations vary from Class 1 to Class 6. Penalties depend upon the class of violation and previous offenses. They may range from a $25 to $100 fine to a fine from $1,000 to $5,000; imprisonment from 180 days to 2 years; and forfeiture of anything seized in connection with the violation. Civil penalties may be applied in certain situations.

6.4.4.6 Annual License Fees

Commercial fisherman license	
• resident	$ 55
• nonresident	200
Vessel license	
• resident	15
• nonresident	60
Wholesale/retail dealer	
• resident	105
• nonresident	405
Transport license	
• resident	30
• nonresident	30
Oyster tong (per tong)	
• resident	30
• nonresident	240

Oyster dredge (per dredge)	
• resident	25
• nonresident	200
Oyster harvester's license	
• resident	100
• nonresident	400

6.4.4.7 Laws and Regulations

6.4.4.7.1 Minimum Size

All oysters taken from public grounds must be 3 inches or larger in length from hinge to "mouth." An allowance of 15% of dead shell and/or undersize oysters is accepted. A lessee, when fishing public grounds, may be permitted to take undersize oysters for bedding purposes only and may commercially harvest any size oysters from his private lease.

6.4.4.7.2 Seasons

Designated when open by commission action, public grounds may be fished the first Wednesday following Labor Day through and including April 1st of the following year.

6.4.4.7.3 Fishing Methods, Area and Gear Restrictions

Oysters may be taken from oyster grounds by dredges, scrapers and tongs. Dredges and scrapers shall be no wider than 6 feet as measured along the tooth bar.

6.4.4.7.4 Leases

Any person who qualifies and who desires to lease a part of the bottom or bed of any of the waters shall present to the Secretary (of LDWF) a written application and cash deposit of such amount as is determined by the Department. Lessees, under supervision of the LDWF, shall stake off and mark the leased water bottom in order to locate accurately and fix the limits of the water bottoms embraced in each lease. Areas shall also be prominently marked with signs that state the lease number and initials of the lessee.

6.4.4.7.5 Restrictions

No person shall trawl or seine over any privately leased bedding ground or oyster propagating place that is staked off, marked or posted as required by law or regulation. A 15% tolerance for undersized oysters is allowed from public reefs.

6.4.5 Texas

6.4.5.1 Administrative Organization

Texas Parks and Wildlife Department
Coastal Fisheries Branch
4200 Smith School Road
Austin, Texas 78744
Telephone: (512) 389-4863

The Texas Parks and Wildlife Department is the administrative unit of the state charged with management of the coastal fishery resources and enforcement of legislative and regulatory procedures under the policy direction of the Texas Parks and Wildlife Commission. The commission consists of 9 members appointed by the Governor for 6-year terms. The commission selects an Executive Director who serves as the chief administrative officer of the department. A Director of the Fisheries and Wildlife Division and a Director of the Law Enforcement Division are named by the Executive Director. The Coastal Fisheries Branch, headed by a branch chief, is under the supervision of the Director of Fisheries and Wildlife.

6.4.5.2 Legislative Authorization

Chapter 61, Texas Parks and Wildlife Code (Uniform Wildlife Regulatory Act) provides the Texas Parks and Wildlife Commission with responsibility for management of the state's wildlife resources with the exception that only in designated counties would this authority extend to shrimp or oysters. Of the 18 coastal counties, 8 are under full regulatory authority and 2 are under partial authority established in Chapter 61. In 1985, Chapter 76 was expanded to grant the commission authority to regulate by proclamation the taking, possession, purchase and sale of oysters. All coastal waters are under statutory authority codified in Chapter 76, Parks and Wildlife Code. This authority will expire on September 1, 1991, if not renewed by the Legislature.

As directed by the Texas Legislature, the commission was restricted from making any proclamation under Chapter 76, Parks and Wildlife Code until it had approved and adopted an oyster management plan and economic impact analysis prepared by the department. On November 3, 1988, the commission took the required action and has managed oysters based on provisions of the Texas Oyster Fishery Management Plan (Quast et al. 1988) since that time.

6.4.5.3 Reciprocal Agreement and Limited Entry Provisions

6.4.5.3.1 Reciprocal Agreement Provisions

6.4.5.3.1.1 Licenses

Texas statutory authority allows reciprocal license agreements such as the one that provides for the acceptance of recreational fishing licenses from either state, Texas or Louisiana, in waters that are a common boundary of the 2 states.

6.4.5.3.1.2 Management

Texas has no statutory authority to enter into reciprocal management agreements.

6.4.5.3.2 Limited Entry

While no direct statutory provisions for limited entry exist for the department, provisions within the statutes do limit the time in which licenses may be purchased, and the commission has the authority to increase license fees, and these provisions can serve as an indirect method of access limitation. In addition, the General Land Office, an agency of the state controlling state lands to include submerged lands, has requested that TPWD place a moratorium on leasing of any additional bay bottom for private oyster reefs.

6.4.5.4 Commercial Landings Data Reporting Requirements

All seafood dealers who purchase directly from fishermen are required to file monthly marine products reports with the department. These reports must include species, poundage, price, gear utilized, location of fishing activity and payment of $1.00 for each barrel of oysters handled.

6.4.5.5 Penalties for Violations

Penalties for violation of commission regulations or legislative statutes governing the oyster fishery are found in Section 76.118, Texas Parks and Wildlife Code. These penalties range from a Class C, Texas Parks and Wildlife Code misdemeanor with a fine from $25 to $500 to a Texas Parks and Wildlife Code felony with a fine from $2,000 to $5,000 and confinement from two years to ten years.

6.4.5.6 Annual License Fees

Wholesale fish dealer (each place of business except trucks)	$400
Wholesale fish truck dealer (for each truck used as a place of business)	$250

Required for any person engaged in the business of buying for the purpose of selling, canning, preserving, processing or handling for shipments or sale, fish, oysters, shrimp or other commercial, edible aquatic products to retail fish dealers, hotels, restaurants, cafes or consumers. May purchase for resale, or receive for sale, barter, or exchange fresh or frozen aquatic products only from persons who hold a valid commercial fisherman's license, commercial oyster fisherman's license, commercial oyster boat license, or a wholesale fish dealer's license.

Retail fish dealer (each place of business except trucks)	$30
Retail fish truck dealer (each truck used as a place of business)	$50

Required for any person who buys any fresh or frozen, edible aquatic products for the purpose of sale to consumers. May purchase for resale fresh or frozen aquatic products only from persons or entities in this state who hold a valid commercial fisherman's license, or a wholesale fish dealer's license.

Commercial oyster boat license	
• Resident	$350
• Nonresident	$1,400

Required for each boat used to transport or for taking oysters for pay or for the purpose of sale, barter, or exchange or any other commercial purpose from the public waters of this state by utilizing a dredge, tongs, or other mechanical means. May be purchased only during the month of August and expires August 31 of the following year.

Commercial oyster fisherman's license	
• Resident	$100
• Nonresident	$250

Required of any person who takes oysters from the public waters of this state for pay or for the purpose of sale, barter, or exchange or any other commercial purpose. (Not required of the captain and crew of licensed commercial oyster boats.) May be purchased only during the month of August.

Sports oyster boat license	
• Resident (for boats registered in Texas or having a U.S. Coast Guard documented homeport in Texas)	$10
• Nonresident	$40

Required when using a sports oyster dredge or tongs to take oysters. May be purchased only during the month of August.

Resident combination hunting and fishing license	$15
Sport Fishing License	
• Resident	$8
• Nonresident	$15
Temporary (14 day) resident sport fishing license	$5
Temporary (5 day) Non-resident sport fishing license	$8
Saltwater sport fishing stamp	$5

A person taking oysters is required to have a valid sport fishing license and a saltwater fishing stamp. A person taking oysters with tongs or a dredge must also hold a sports oyster boat license. Sports oyster dredge may not be more than 14 inches in width.

6.4.5.7 Laws and Regulations

6.4.5.7.1 Minimum Size

Minimum size for oysters is 3 inches. Oysters 3/4 to 3 inches are to be culled and returned to the reef from which they were taken. However, each cargo may not contain more than 15% of oysters under the 3 inch minimum.

6.4.5.7.2 Seasons

The open season is from November 1 through April 30 except in that part of the Laguna Madre south of the Port Mansfield Channel where there is no closed season. Private oyster lease holders may take oysters from private leases year round when holding proper permits issued by TPWD. During open season, oysters may be taken from sunrise to sunset. Licenses may be purchased during the month of August only.

6.4.5.7.3 Fishing Methods, Area and Gear Restrictions

Only one oyster dredge not more than 48 inches in width across the mouth and not more than 2-barrel capacity may be used at any given time on board any boat in public waters. Commercial vessels may not have more than two legal dredges on board. Oyster boat and oyster fisherman's licenses may be purchased only during the month of August. Commercial boats are limited to not more than 50 barrels of legal size oysters. Not more than 2 barrels of unculled oysters are permitted on board while fishing on a reef. No more than 1 barrel (3 bushels) of legal-sized oysters may be possessed on board a sports oyster boat.

6.4.5.7.4 Leases

No individual may lease more than 100 acres. Persons interested in acquiring an oyster lease shall be directed to the appropriate regional director for coastal fisheries. The regional director will explain the leasing procedures that include the temporary marking of the proposed lease or leases; a preliminary inspection by a coastal biologist and/or game warden; and the holding of a public hearing to determine if there are objections to the proposed lease site. The applicant will then mark the proposed lease site or sites with temporary poles and/or buoys in such a manner that the outline of the site or sites can be clearly determined. If adjoining leases are proposed the approximate boundaries of each lease must be clearly marked. When the temporary markers have been placed at the proposed lease site, the applicant will make an application to the regional director. Proposed leases are ineligible if 5 or more barrels of oysters are determined to be present on the site prior to leasing. The area must not be a natural reef or have been such at any time during an 8-year period preceding the site inspection.

6.4.5.7.5 Restrictions

Oysters may be taken only from waters approved by the Texas Commissioner of Health. Oysters may not be taken from marked, private leases except by permission of the lessees.

7.0 DESCRIPTION OF FISHING ACTIVITIES AFFECTING STOCKS IN THE MANAGEMENT UNIT (MU)

7.1 History of Utilization

Prehistoric utilization of oysters dates to at least 2,000 B.C. (Wicker 1979). American indians built shell middens predominantly of oyster shell, indicating that oysters made up a substantial portion of their diet (Russell et al. 1936, McIntire 1958, Byrd 1974). Oysters were collected by wading in shallow waters and extracted by hand (Wicker 1979) or by crude tools devised to aid gathering. One such device consisted of rakes made of two strong poles, curved at the ends and interlaced with string vines (Dyer 1917). Speculation infers that oysters were smoked, dried or consumed raw by aboriginal indians (Calver 1920). However, oyster trading was probably not extensive due to trade and transportation difficulties (Wicker 1979).

Du Pratz (1758) recorded that early French settlers harvested oysters; however, consumption was likely one of a last resort when other food supplies had dwindled. By the 19th century, the market for oysters expanded, and they became somewhat of a delicacy. Many tons of oysters were shipped to the east coast and midwest. They also became quite popular in local areas along the gulf coast. They became a staple on many restaurant menus and were prepared in a wide variety of ways. Oysters were even listed on the menus of cross-country railroads.

7.2 Commercial Oyster Fishery

The commercial oyster fishery in the gulf has a long history. Virtually every aspect of this industry can be compared to a roller coaster with many "ups" and "downs." Most noticeable are the fluctuations in catches and landings. These variations indicate the degree of oyster dependence upon and sensitivity to environmental changes.

7.2.1 Development of the Fishery

When the commercial fishery for oysters in the gulf was first developed is uncertain. It is likely that commercial fishing was first developed by aboriginal indians who established trade for smoked oysters in many areas of North America. As the early Europeans began to rely more on native food stuffs and develop local economies, they likely expanded the industry into its modern form. Management efforts with regulatory agencies are recorded back to the late 19th century.

7.2.2 Fishing Methods, Gear, Boats and Vessels

Fishing methods, gear, boats and vessels in the oyster fishery have changed very little over the past century; however, the introduction of motor power to the industry produced many changes, opening new markets, increasing harvests and providing production under most weather conditions. The following is a brief description of the fishery.

The two primary methods of oyster harvest are derived from the gear used, tonging and dredging. Tonging employs the use of hand tongs, sometimes called "rakes" (Figure 7.1). Typically, rakes or heads are attached at the ends of long

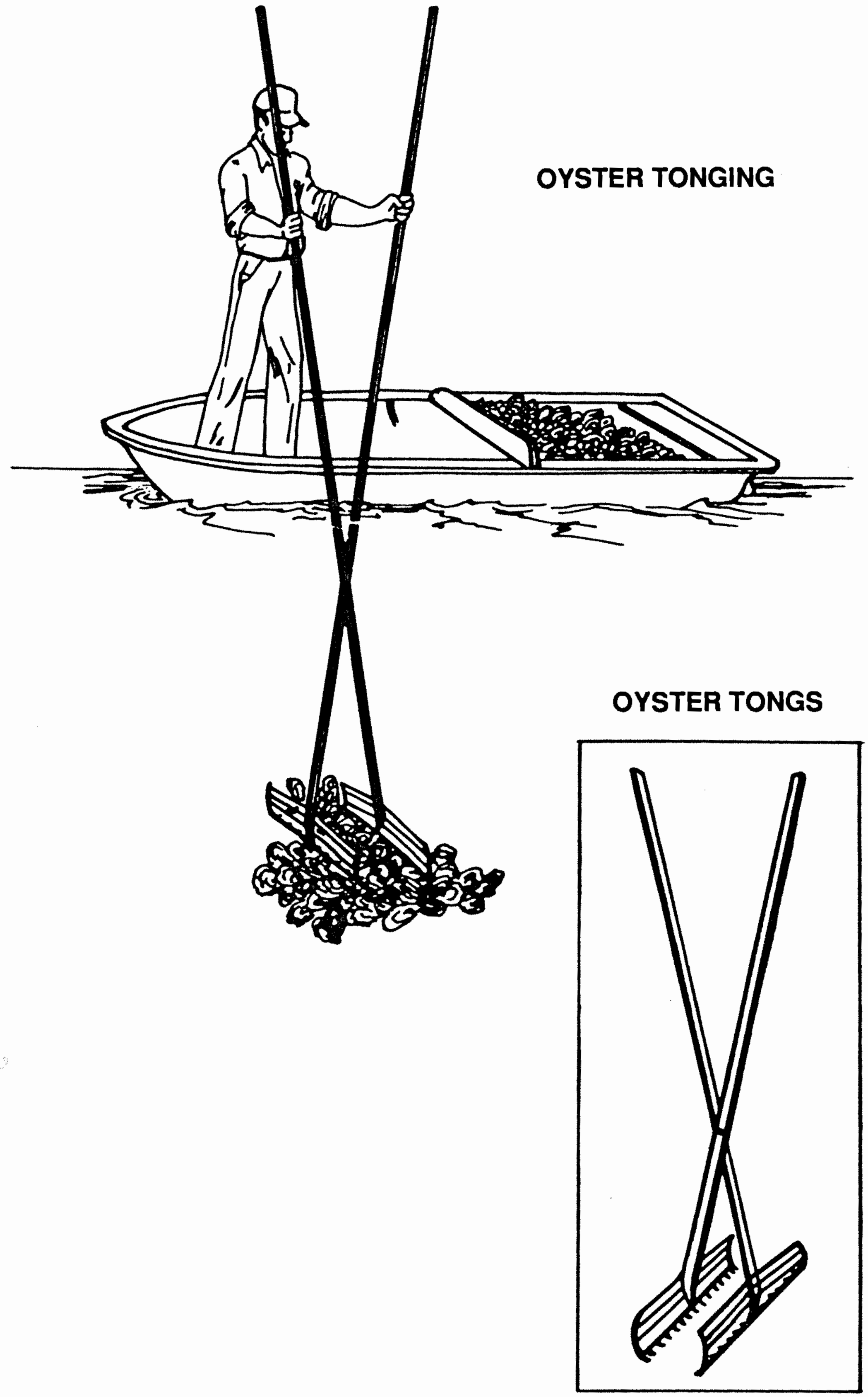

Figure 7.1. Oyster tongs and tonging.

handles or stays. Tongs are 14 to 16 feet long; consequently, tonging is more restricted to shallow bays, bayous and sounds.

With practice, an experienced tonger actually feels the oysters being picked up by the teeth of the rakes as he works the handles back and forth, opening and closing the mouth of the rakes. When the tonger feels that the rake is full or his catch is complete, he closes the handles and lifts the rakes from the water onto a culling deck. He then opens the handles to allow the oysters to fall out.

Tonging is typically conducted from small, wooden skiffs 16-20 feet in length and powered by outboard motors. The skiffs are constructed with wide beams and flat bottoms and may have a large deck and wide railing on which to stand while tonging.

Tonging generally involves one or two people. Usually, two people are involved, and one person tongs while the other culls. Culling involves separating market-size oysters from smaller oysters and dead shell. The small oysters and shells are returned to the reef. Ideally, the procedure would involve tonging for several hours by both people, and when the deck is substantially full, tongers would then move to the edge of the reef area to cull. Later the tongers may return to the reef area and start the process again. Tonging in one area and culling in another reduces labor by precluding repeated pick up of undersized oysters and dead shell. It is also a good management practice because the process redistributes shell and allows the reef to grow from the edges.

Dredging involves the use of one or more oyster dredges (Figure 7.2). The size and weight of a dredge vary from state to state, but typically it measures approximately 3 feet wide and weighs about 120 pounds. See Section 6 for specific dredge requirements by state.

Typically, dredges are attached to a chain and pulled from a winch. The dredge is usually raised and lowered from the side of the vessel slightly forward of midships, or it may also be pulled from the stern. Pipes (approximately 3-4 inches in diameter) are fashioned into vertical and horizontal rollers where the dredge comes onto the deck to facilitate raising, lowering and dumping.

Dredge boats and vessels are generally much larger than tonging boats and range from approximately 25-60 feet in length. The most common dredging methods involve maneuvering a shallow draft boat or vessel in small circular patterns over a reef and employing two dredges, one from each side of the boat. The crew size also varies, but typically ranges from 2-5 persons including the captain. Team work between captain and dredge crew is needed to increase catch efficiency and avoid accidents. Experience and skill are needed to dredge oysters in the most efficient manner to reduce labor and prevent unnecessary damage to reefs. Knowing proper chain length and when the dredge is full are important factors.

Based on the depth of water over a given reef, the dredge is rolled overboard and enough chain is let out from the winch to allow the dredge teeth to scrape and lift oysters from the reef into the bag. Proper chain length must be maintained to allow the dredge to work properly. Too much chain will result in the dredge bogging or simply scraping over oysters without them entering the bag. Not enough chain will cause the dredge to bounce over the reef since the dredge teeth cannot dig under the oysters to lift them from the reef.

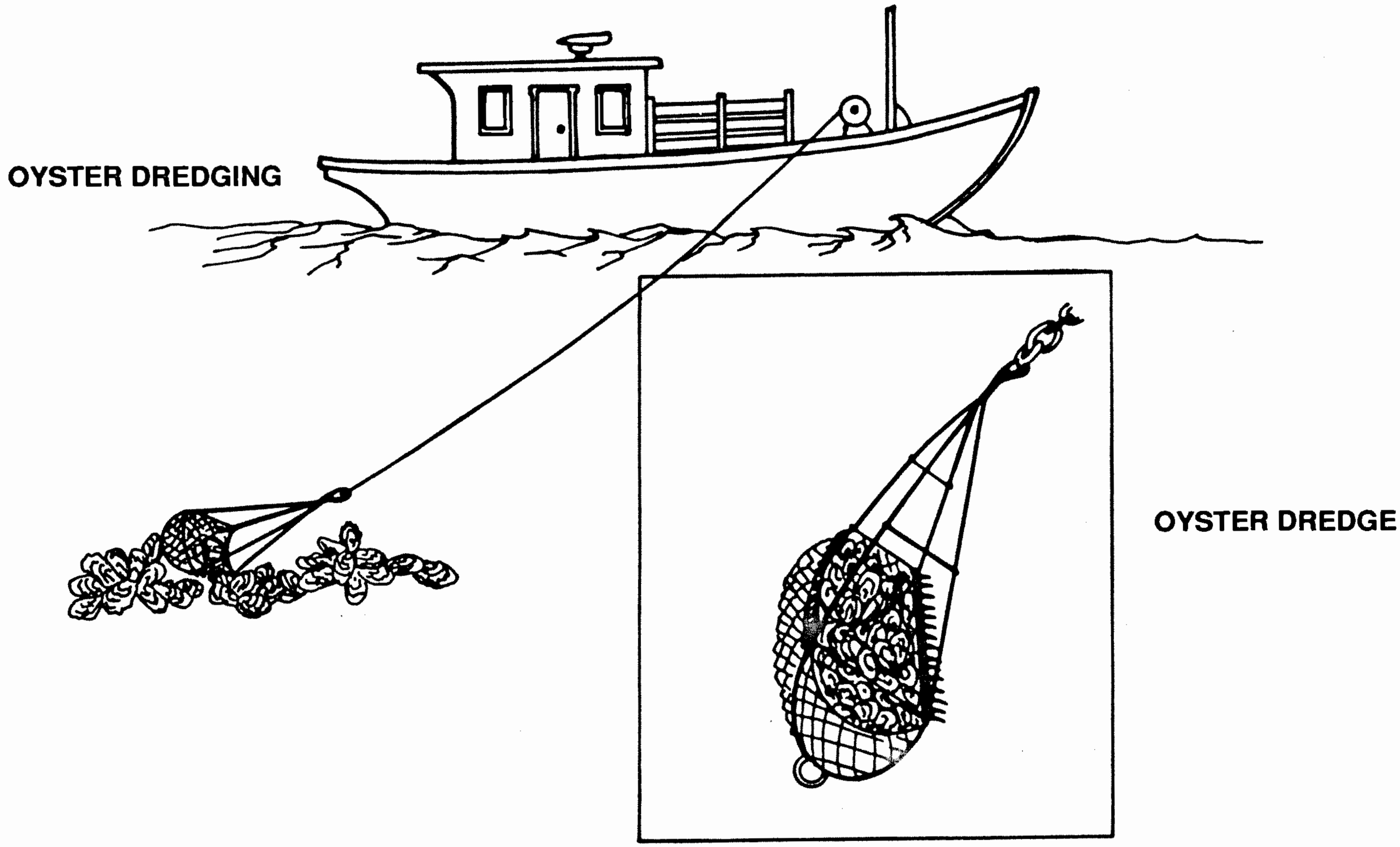

Figure 7.2. Oyster dredge and dredging.

Oysters may be harvested from shallow tidal areas by hand or by using short-handled tongs called nippers. Scuba gear has also been employed for hand picking. These gear and methods have been used on a limited basis in the commercial fishery.

7.2.3 Historical Catch Statistics

This section relies primarily on historical catch data from the NMFS. Catch data from individual states may vary, principally because of timing and methodology of collection.

7.2.3.1 Total U.S. and Gulf of Mexico

U.S. oyster landings have been declining since at least the 1950s. The decline has been especially apparent during the past few years (Table 7.1). The nation's landings during 1961-1965, averaged 58.4 million pounds annually. The 1981-1985 average landings declined by almost 9% to 53.7 million pounds. In 1986-1988 the average annual landings declined by almost 45 percent to 40.2 million pounds. The most recent 3 year production averaged about one-half of the 75 million pound annual harvest during the 1950s (Fisheries of the United States). Record production of 152 million pounds occurred in 1908.

With some exceptions, the Chesapeake Bay area, hereafter referred to as Chesapeake, was the nation's largest producer of oysters during the 1960s and into the mid-1970s (Table 7.1). The gulf generally ranked second in production followed by the Pacific region of the U.S., hereafter referred to as Pacific. The percent contribution to the nation's oyster production by each region for selected time periods is given in Table 7.2 and Figure 7.3.

The gulf has clearly dominated U.S. oyster production since the early 1980s. This is the result of an increase in the gulf oyster production during 1982-1985 and a significant decline in Chesapeake production (Table 7.1). The rapid decline in Chesapeake production since 1982 and especially in the past few years is the cause for much of the recent decline in U.S. production.

The gulf share of U.S. oyster production averaged about 32%-37% during the 1960s and 1970s; it averaged just less than 50% during the 1980s (Table 7.2). By comparison, production from the Chesapeake represented 35%-45% of the nation's total oyster supply during the 1960s and 1970s. The Chesapeake share of the nation's total supply fell sharply in the 1980s and represented less than 30% during 1981-1985 and 23% during 1986-1988.

Production from the Pacific comprised more than 20% of the nation's total domestic supply of oysters during 1986-1988 compared to only about 12%-14% during the 20 year period ending in 1985 (Table 7.2). This recent increase reflects both an increase in oyster production in the Pacific [i.e., annual average landings of 9.2 million pounds during 1986-1988 compared to 7.5 million pounds during 1981-1985 (Table 7.1)] and declining production in the Chesapeake and in other regions of the U.S.

Remaining U.S. oyster production (i.e., combined landings of the South Atlantic, Mid-Atlantic and New England) has historically represented about 7%-11% of the total domestic oyster supply. A sharp decline in recent production, from 5.4 million pounds annually during 1981-1985 to 2.8 million pounds during 1986-1988 (Table 7.1), has led to a concurrent decline in the relative share from

Table 7.1. Historical oyster production in the United States by region, 1961-1988.

Year	Gulf	Pacific	Chesapeake	Other[1]	Total
	Region				
	1,000 lbs				
1961	18,240	10,207	27,500	6,358	62,305
1962	18,838	10,754	19,939	6,506	56,037
1963	24,139	9,791	18,274	6,240	58,444
1964	23,385	9,973	22,098	5,078	60,534
1965	19,156	9,165	21,188	5,179	54,688
1961-1965 average	**20,752**	**9,978**	**21,800**	**5,872**	**58,402**
1966	17,182	7,827	21,231	4,982	51,223
1967	21,747	7,739	25,798	4,673	59,957
1968	26,739	7,770	22,679	4,698	61,886
1969	19,765	6,973	22,157	3,304	52,199
1970	17,714	7,991	24,668	3,229	53,602
1966-1970 average	**20,629**	**7,660**	**23,307**	**4,177**	**55,773**
1971	20,266	8,114	25,557	4,001	57,938
1972	18,260	8,400	24,066	5,332	56,058
1973	14,914	6,599	25,400	5,018	51,931
1974	14,878	5,053	25,021	5,224	50,176
1975	19,295	5,833	22,640	5,459	53,227
1971-1975 average	**17,523**	**6,800**	**24,537**	**5,007**	**53,866**
1976	21,569	6,391	20,964	5,471	54,395
1977	19,670	7,226	18,014	5,178	50,088
1978[2]	18,891	7,103	22,460	5,646	54,100
1979	15,461	7,461	21,686	5,752	50,360
1980	15,517	6,694	22,791	5,823	50,825
1976-1980 average	**18,222**	**6,975**	**21,183**	**5,574**	**51,954**
1981	19,366	6,007	21,606	5,634	52,613
1982	25,150	7,369	17,525	6,146	56,190
1983	29,165	7,342	11,638	5,903	54,048
1984	27,596	8,739	12,364	6,075	54,774
1985	26,509	7,796	13,122	3,454	50,881
1981-1985 average	**25,557**	**7,451**	**15,251**	**5,442**	**53,701**
1986	22,540	9,629	13,742	2,857	48,768
1987	18,380	9,850	8,738	2,839	39,807
1988	16,269	7,976	4,987	2,660	31,892
1986-1988 average	**19,063**	**9,152**	**9,156**	**2,785**	**40,156**

Source: Compiled from data contained in Fisheries Statistics of the United States (1960-1977 issues) and Fisheries of the United States (1978-1988 issues).

[1] Other includes the coastal states in the South Atlantic, Mid Atlantic, and New England regions.

[2] Data from 1978 through 1988 are considered preliminary by the National Marine Fisheries Service.

Table 7.2. Percentage contribution of regional oyster production to the United States total, 1961-1988 selected time periods.

	Region				
Time Period	Gulf	Pacific	Chesapeake	Other	Total
			%		
1961-1965 average	35.5	17.1	37.3	10.1	100.0
1966-1970 average	37.0	13.7	41.8	7.5	100.0
1971-1975 average	32.5	12.6	45.6	9.3	100.0
1976-1980 average	35.1	13.4	40.8	10.7	100.0
1981-1985 average	47.6	13.9	28.4	10.1	100.0
1986-1988 average	47.5	22.8	22.8	6.9	100.0

Source: Compiled from data in Table 7.1.

the eastern U.S., down to 6.9% during 1986-1988 compared to 10.1% during 1981-1985.

The combined harvest of Chesapeake and gulf oysters by poundage represented 70%-80% of the total U.S. domestic supply of oysters from 1960 to 1988. The gulf consistently accounted for about one-third of the total supply during 1960-1980 while the Chesapeake accounted for about 35%-45% of the total. With the sharp decline in the Chesapeake oyster production since 1980, the importance of gulf production as a major source of domestic supply has been highlighted. For example, the average annual production of 19.1 million pounds during 1986-1988 represented just less than one-half (47.5%) of the nation's oyster supply during the period, up substantially from its 35.1% share during 1976-1980.

7.2.3.2 Gulf Landings by State

The production data among Gulf States from 1961 to 1988, are given in terms of landings rather than catch. To the extent that oysters may be harvested in the boundaries of one state and landed in another state, the landings and catch statistics may differ. Catch statistics, however, are presented by water body and are not always unique to a given state.

7.2.3.2.1 Florida

Oyster production in Florida has averaged 4.1 million pounds annually during 1961-1988 (Table 7.3). This represents 20% of the gulf production during 1961-1988 and places Florida second only to Louisiana in long-term average annual production among the Gulf States (Figure 7.4).

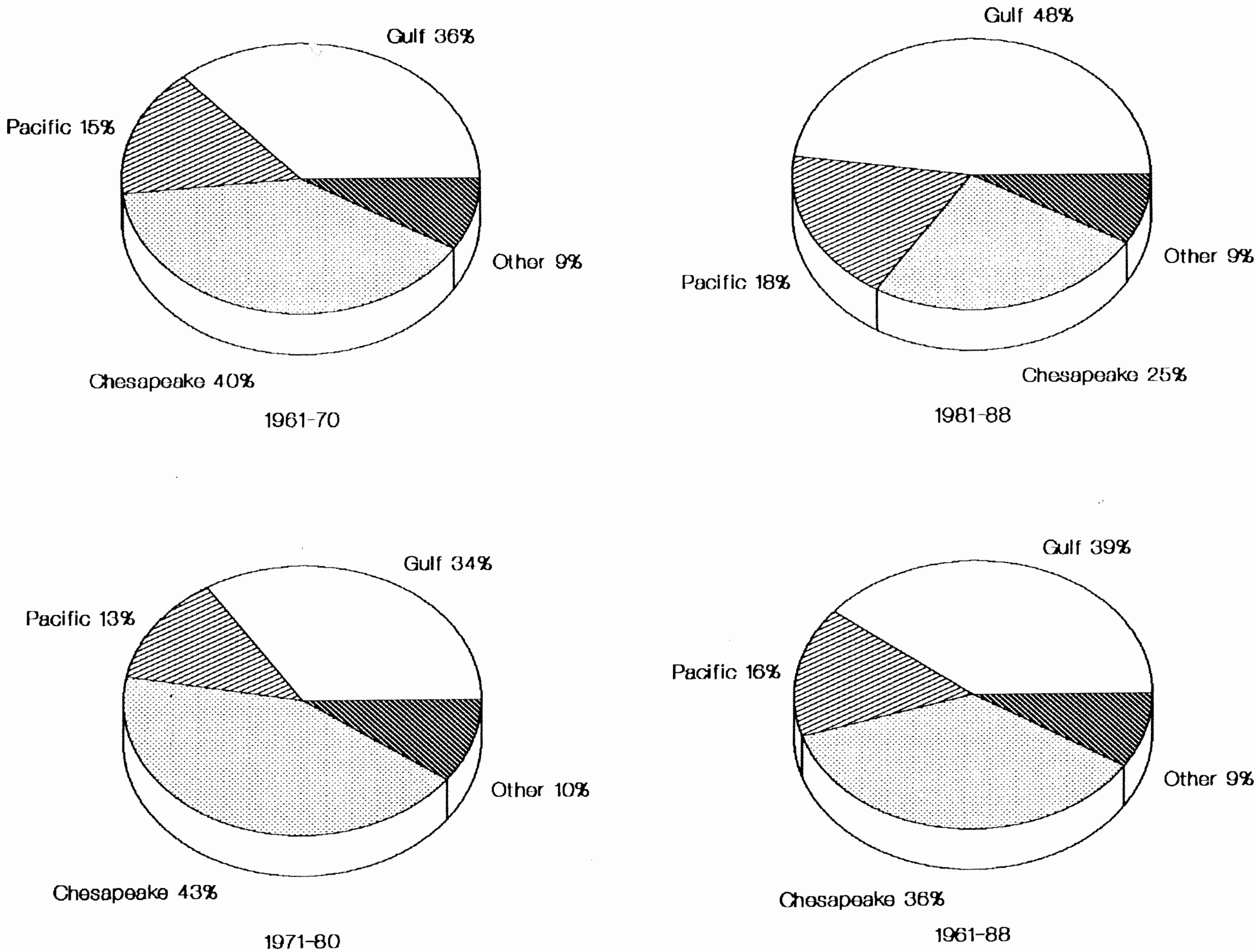

Figure 7.3. Oyster production by region, percent of total U.S. landings.

Table 7.3. Historical oyster production among Gulf States, 1961-1988.

Year	State FL	AL	MS	LA	TX	Total
	1,000 lbs					
1961	3,255	509	3,241	10,139	1,096	18,240
1962	4,952	443	2,073	10,160	1,210	18,838
1963	4,283	995	4,680	11,563	2,618	24,139
1964	2,793	1,005	4,829	11,401	3,357	23,385
1965	2,789	493	2,696	8,343	4,835	19,156
1961-1965 average	**3,614**	**689**	**3,504**	**10,321**	**2,623**	**20,752**
1966	4,157	1,304	2,232	4,764	4,725	17,182
1967	4,578	2,087	3,786	7,743	3,553	21,747
1968	5,318	1,211	3,786	13,122	3,302	26,739
1969	4,912	481	1,430	9,178	3,764	19,765
1970	3,573	279	548	8,639	4,675	17,714
1966-1970 average	**4,508**	**1,072**	**2,356**	**8,689**	**4,004**	**20,629**
1971	3,529	250	1,215	10,528	4,744	20,266
1972	3,231	1,069	1,220	8,805	3,935	18,260
1973	2,409	591	612	8,953	2,349	14,914
1974	2,653	733	276	9,972	1,244	14,878
1975	2,134	638	1,080	13,687	1,756	19,295
1971-1975 average	**2,791**	**656**	**881**	**10,389**	**2,806**	**17,523**
1976	2,602	1,236	1,516	12,334	3,881	21,569
1977	4,072	1,549	1,384	10,065	2,600	19,670
1978[1]	5,882	760	682	9,662	1,097	18,891
1979	6,125	460	272	7,714	889	15,461
1980	6,756	55	21	6,947	1,738	15,517
1976-1980 average	**5,087**	**812**	**775**	**9,344**	**2,203**	**18,222**
1981	7,170	1,330	467	9,093	1,309	19,366
1982	4,782	1,497	2,576	12,621	3,633	25,150
1983	4,307	336	3,333	13,229	7,941	29,165
1984	6,621	477	1,378	13,952	5,168	27,596
1985	4,392	1,442	1,193	14,347	5,134	26,509
1981-1985 average	**5,454**	**1,016**	**1,789**	**12,648**	**4,637**	**25,557**
1986	2,084	946	1,202	12,654	5,607	22,493
1987	3,518	88	132	12,027	2,897	18,662
1988	1,314	103	147	13,254	1,671	16,269
1986-1988 average	**2,305**	**379**	**494**	**12,645**	**3,392**	**19,141**
1961-1988 average	**4,078**	**799**	**1,715**	**10,532**	**3,269**	**20,387**

Source: Compiled from data contained in Fisheries Statistics of the United States (various issues) and unpublished National Marine Fisheries Service data.

[1]Data from 1978 through 1988 are considered preliminary by the National Marine Fisheries Service.

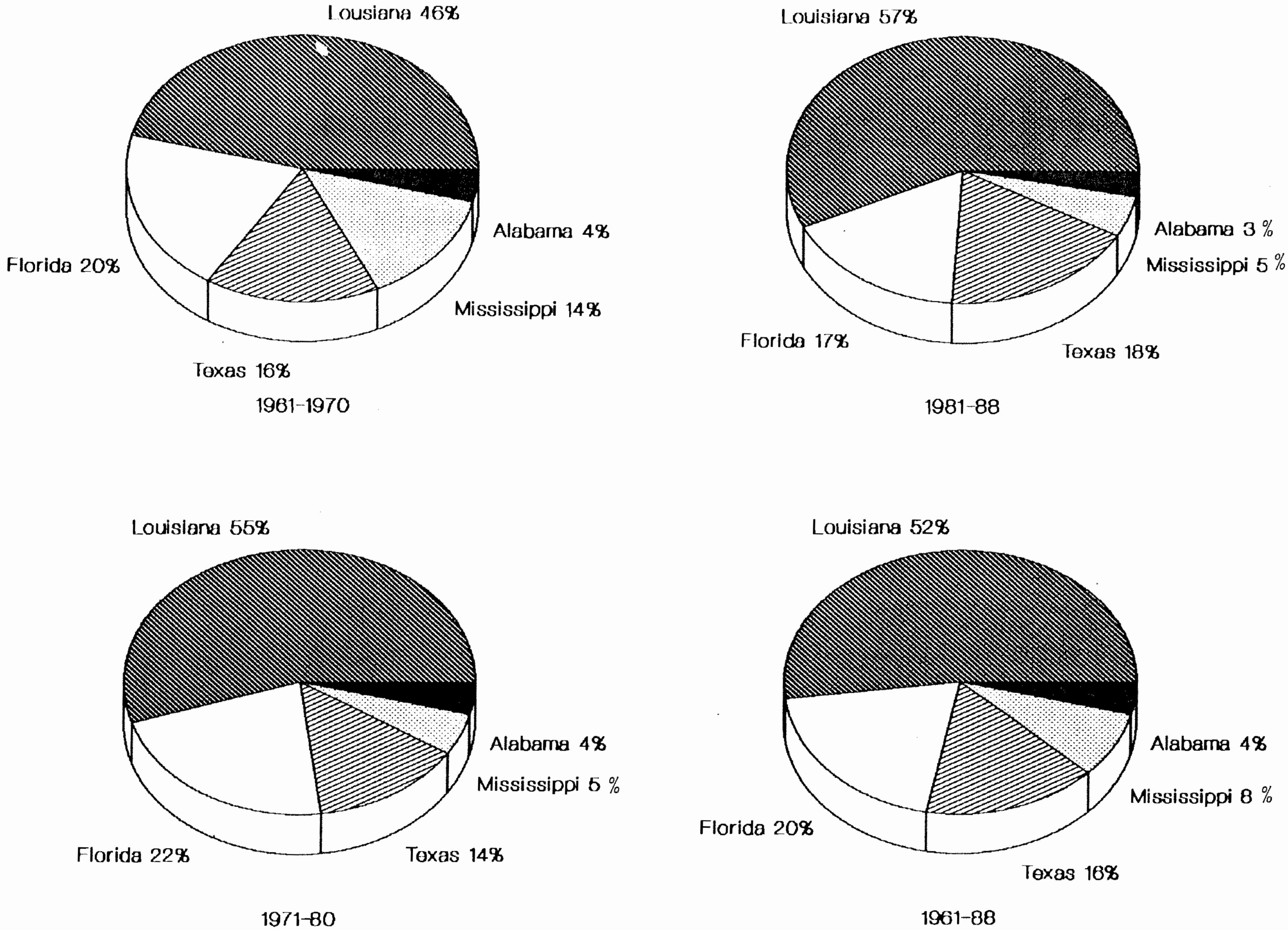

Figure 7.4. Oyster landings by state, percent of total gulf.

Production in Florida tends to be highly variable on a yearly basis, largely the result of environmental fluctuations, and generally falls in the 2- to 6-million pound range (Table 7.3). With the exception of 1971-1975, landings appear to have been gradually rising during the 1960s and 1970s before peaking at 7.2 million pounds in 1981. Since 1985, landings have fallen sharply partially due to the destruction of many productive beds by Hurricane Elena in 1985 and the subsequent periods of prolonged drought from 1987 to 1989.

To help ensure high productivity from its public reefs, the state of Florida has maintained an aggressive shell-planting program since 1949. Details of this program can be found in Whitfield (1973), Futch (1983) and Berrigan (1988, 1990). According to Whitfield, approximately 4.2 million bushels of cultch and oyster shells were planted for cultch purposes between 1949 and 1972. According to Futch, another 1.7 million bushels were added during 1972-1981. Whitfield and Beaumariage (1977) estimated that one-half of the Apalachicola Bay production is derived from constructed reefs. Whitfield (1973) estimated that the potential annual value of shell plants could approximate $3,200 per acre (1973 dollars) based on a potential harvest of 400 bushels per acre. In a later report (Berrigan 1990), benefits from shellplanting were estimated to exceed $8,500 per acre.

7.2.3.2.2 Alabama

Alabama oyster landings averaged just under 800,000 pounds annually during 1961-1988 and represented about 4% of the gulf average (Table 7.3 and Figure 7.4). Annual landings tend to fluctuate widely but generally fall in the 400,000- to 1,500,000-pound range. Annual landings during 1986-1988 averaged less than 400,000 pounds and are well below the average.

7.2.3.2.3 Mississippi

Oyster production in Mississippi averaged 1.7 million pounds annually during 1961-1988 and represented about 8% of the gulf production (Figure 7.4). With the exception of Alabama, this average is the lowest among the Gulf States (Table 7.3). Excluding 1981-1985, oyster landings in the state have clearly been declining with 1986-1988 average annual production at 494,000 pounds which equals about 15% of production during the early 1960s.

7.2.3.2.4 Louisiana

Louisiana is the largest producer of oysters among the Gulf States (Table 7.3 and Figure 7.4). Its average annual production of 10.5 million pounds represents more than one-half of the total annual gulf production during 1961-1988. Though harvest since 1981 is about 2 million pounds above the 10.5-million-pound production, Louisiana's oyster production has remained relatively constant during the past three decades.

Gulf oyster production is derived from both public and private grounds. While production from private grounds has occurred among all Gulf States at one time or another, Louisiana is the only state that produces sizable quantities of oysters from its private grounds. Historical production figures from private and public grounds in Louisiana are provided in Table 7.4.

Table 7.4. Louisiana market oyster production from private and public grounds, 1961-1988.

Year	Private Production	Public Production	Total Production	Priv. Prod. as % Total
	-----------------------1,000 lbs	-----------------------	-----------------------	-----------------------
1961	8,840	1,299	10,139	87.2
1962	8,575	1,585	10,160	84.4
1963	8,766	2,797	11,563	75.8
1964	10,075	1,326	11,401	88.4
1965	7,389	954	8,343	88.6
1961-1965 average	**8,729**	**1,592**	**10,321**	**84.6**
1966	3,741	1,023	4,764	78.5
1967	6,835	908	7,743	88.3
1968	11,541	1,581	13,122	88.0
1969	7,265	1,913	9,178	79.2
1970	7,986	653	8,639	92.4
1966-1970 average	**7,474**	**1,216**	**8,689**	**86.0**
1971	9,716	812	10,528	92.3
1972	7,760	1,045	8,805	88.1
1973	8,598	355	8,953	96.0
1974	8,392	1,580	9,972	84.2
1975	8,952	4,735	13,687	65.4
1971-1975 average	**8,684**	**1,705**	**10,389**	**83.6**
1976	9,121	3,213	12,334	74.0
1977	9,014	1,051	10,065	89.6
1978	8,418	1,243	9,662	87.1
1979	7,061	654	7,714	91.5
1980	6,026	922	6,947	86.7
1976-1980 average	**7,928**	**1,417**	**9,344**	**84.8**
1981	7,006	2,087	9,093	77.0
1982	8,857	3,764	12,621	70.2
1983	10,940	2,290	13,229	82.7
1984	9,872	4,080	13,952	70.8
1985	9,051	5,296	14,347	63.1
1981-1985 average	**9,145**	**3,503**	**12,648**	**72.3**
1986	9,538	3,115	12,654	75.4
1987	9,799	2,227	12,026	81.5
1988	10,969	2,285	13,254	82.8
1986-1988 average	**10,102**	**2,542**	**12,645**	**79.8**

Source: Compiled from data contained in Fisheries Statistics of the United States (1961-1977 issues) and unpublished National Marine Fisheries Service data.

The majority of Louisiana's oyster production (Table 7.4) is harvested from private (i.e., leased) grounds. During the 1960s and 1970s, production from these private grounds consistently averaged about 85% of the state's total production. After declining to an average of 72% during 1981-1985, production from these private grounds increased to an average of 80% of the total during 1986-1988.

While Louisiana's oyster production from private grounds has remained relatively stable during 1961-1988 ranging from 7.5 to 10.1 million pounds, the acreage devoted to the production of these oysters has increased more than 5 times. For example, less than 50,000 acres were leased in 1960 compared to about 130,000 acres in the early 1970s, 230,000 acres in the early 1980s and about 330,000 acres in 1988. The relatively stable production in conjunction with escalating acreage used leads to one or more of the following conclusions: (1) the recently added acreage is not as productive, (2) older leased acreage is losing its productivity and productivity is being replaced by the recently leased acreage or (3) the average productivity of all leased acreage has been declining during the past three decades.

In addition to the 15%-25% of the state's market oyster production attributable to the public grounds, these grounds also provide an essential source of seed oysters. Seed oysters are collected by private lease holders and bedded on the leased acreage until the oysters reach marketable size. Chatry (1987) estimated that from 2-3 boat loads of marketable oysters are recovered for every boat load of seed oysters bedded. To foster the production of seed oysters, the LDWF has scattered cultch material (generally clam shells) over water bottoms to which larval oysters attach. It has been estimated that for every dollar invested in this program, a return of about $20 can be realized suggesting a benefit/cost ratio of 20:1.

7.2.3.2.5 Texas

Oyster production in Texas averaged 3.3 million pounds annually during 1961-1988 and represented 16% of the 20.4-million-pound annual gulf harvest during that period (Figure 7.4). This places Texas third behind Louisiana and Florida among oyster production in the Gulf States (Table 7.3).

Although extremely variable in the short term, oyster production in Texas appears to be relatively stable when examined over the 28 year period ending in 1988, i.e., there is no apparent trend in production. As with Louisiana and Florida, oyster production peaked in Texas during 1981-1985 with annual harvests averaging 4.6 million pounds. Production of 7.9 million pounds in 1983 exceeds any other single year harvest by more than 2 million pounds. By comparison, the 1976-1980 average annual production of 2.2 million pounds is less than one half of the 1981-1985 average annual landings.

7.2.4 Historical Effort and Catch by Gear Type

Fishermen generally use either dredges or tongs in the harvesting of oysters. The extent of use of each gear depends upon state laws, whether harvesting occurs on public or private grounds, and other factors. This section reviews the fishing effort, gear and catch by gear type for each state. The data are taken from NMFS records, and vessels are distinguished from boats because they have a water displacement characteristic of 5 net tons or greater. Catch and effort data from individual states may vary primarily because of timing and methodology of collection.

7.2.4.1 Florida

Virtually all of Florida's production is harvested by hand tongs (Table 7.5a and Figure 7.5a). Florida law prohibits the use of mechanical dredges on public reefs, thus encouraging the dominance of hand tonging activity. Although hand tonging is the preferred gear, oysters are also harvested by hand and by diving. Overall, hand tonging accounts for more than 97% of the oysters landed. The number of tongers, boats and vessels engaged in the fishery varies annually but generally correlates with production trends. Over the last three decades, the number of harvesters has ranged from 400 to 950 per year (Table 7.5b and Figure 7.5b). Five-year averages show some variation from the mean (735) with a decline from 1971-1975 and an increase from 1981-1985. Annual harvests between 1961 and 1987 ranged from 2,700 to 8,300 pounds per tonger (Figure 7.5c).

7.2.4.2 Alabama

Oyster production in Alabama has historically been based on hand tonging (Table 7.6a and Figure 7.6a). All landings have been derived from tonging since 1973.

The number of tongers averaged well over 600 during the 1960s and then decreased to about 370 in the 1980s (Table 7.6b and Figure 7.6b). While some dredging occurred in earlier years, none has been reported since 1972. The number of tongers per boat has consistently averaged between 1.5 and 1.7 with the exception of 1981-1983 when the number of tongers per boat approached 2.

Landings per tonger in Alabama, while fluctuating significantly on an annual basis, have clearly been increasing in the long run (Table 7.6a and Figure 7.6c). The 1,989 pounds harvested per tonger annually since 1981 represents approximately a two-fold increase from the 1961-1965 average annual harvest per tonger of 975 pounds.

7.2.4.3 Mississippi

Dredging activities traditionally yielded from 60% to more than 90% of Mississippi's annual oyster production (Table 7.7a and Figure 7.7a); however, when state production was abnormally low, such as 1978-1981, tonged oysters represented the majority of the state's production. Increases in production are generally related to a larger percentage of the state's production being derived from dredging.

The numbers of vessels and fishermen engaged in oyster dredging have declined relatively steadily during the 1960s and 1970s (Table 7.7b and Figure 7.7b). Increases in oyster dredging vessels and fishermen were observed in the early 1980s, but numbers declined significantly thereafter. Overall, 200 to more than 700 fishermen were typically involved in oyster dredging in Mississippi waters in a given year. Some natural disasters, however, have reduced annual numbers to zero.

Table 7.5a. Florida west coast oyster production by fisherman and gear type, 1961-1987.

Year	Pounds Harvested By:		Pounds Harvested Per:
	Tongs	Other	Tonger
	--------1,000 lbs------		---lbs---
1961	3,218	37	5,655
1962	4,929	11	6,004
1963	4,278	4	5,341
1964	2,768	25	3,517
1965	2,760	28	3,817
1961-1965 average	**3,591**	**21**	**4,853**
1966	4,121	36	6,034
1967	4,528	50	6,177
1968	5,281	36	6,967
1969	4,886	25	7,061
1970	3,560	14	5,290
1966-1970 average	**4,475**	**32**	**6,321**
1971	3,518	11	5,523
1972	3,217	14	5,776
1973	2,404	6	4,659
1974	2,650	3	5,521
1975	2,128	6	2,742
1971-1975 average	**2,783**	**8**	**4,693**
1976	2,579	24	6,448
1977	4,071	[1]	6,796
1978	5,880	2	8,364
1979	6,121	4	7,348
1980	6,753	2	7,301
1976-1980 average	**5,081**	**6**	**7,342**
1981	7,167	4	7,489
1982	4,742	40	5,310
1983	4,216	91	5,205
1984	6,602	18	7,519
1985	4,360	32	5,088
1981-1985 average	**5,417**	**37**	**6,163**
1986	2,057	33	3,070
1987	3,671	10	4,412

Source: Compiled from data contained in Fishery Statistics of the United States (1961-1976 issues) and unpublished data provided by the National Marine Fisheries Service.

[1]Less than 1,000 lbs. or $1,000.

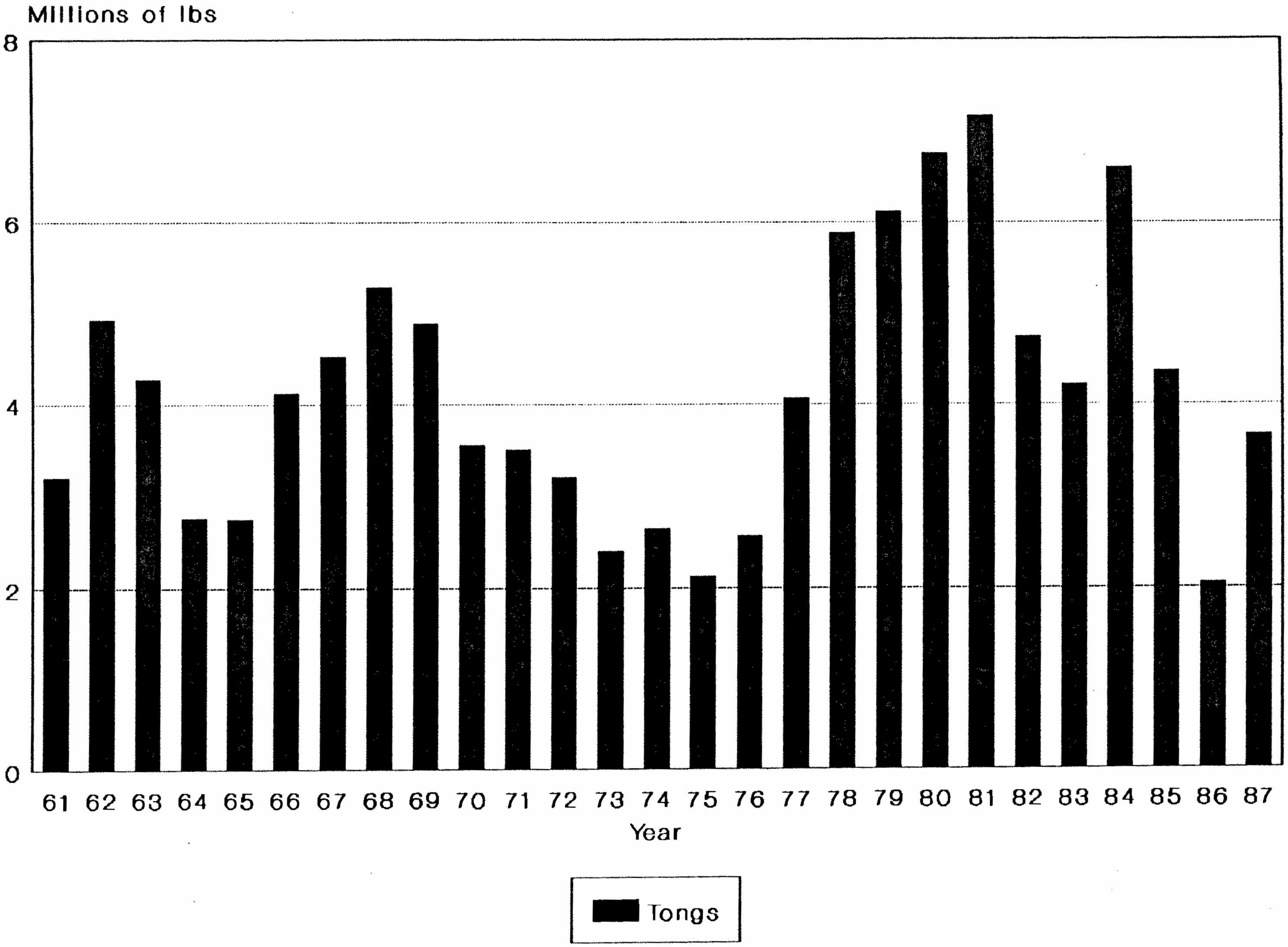

Figure 7.5a. Florida west coast oyster production.

Table 7.5b. Operating units and fishermen in the Florida west coast oyster industry, 1961-1989.

	Florida				
	Tongs			By Hand	
Year	Boats	Vessels	Fishermen	Boats	Fishermen
1961	508	0	569	29	34
1962	632	5	821	29	31
1963	623	8	801	28	33
1964	614	9	787	34	37
1965	565	7	723	45	47
1961-1965 average	**588**	**6**	**740**	**33**	**36**
1966	542	2	683	33	33
1967	576	1	733	40	40
1968	601	7	758	44	44
1969	546	8	692	25	25
1970	513	15	673	34	34
1966-1970 average	**556**	**7**	**708**	**35**	**35**
1971	502	10	637	19	19
1972	470	1	557	22	23
1973	437	1	516	15	15
1974	413	1	480	15	15
1975	624	0	776	22	22
1971-1975 average	**489**	**3**	**593**	**19**	**19**
1976	325	0	400	15	15
1977	479	1	599	12	12
1978	559	1	703	-[1]	-
1979	633	1	833	1	47
1980	683	1	925	-	-
1976-1980 average	**536**	**1**	**692**	**-**	**-**
1981	695	1	957	-	-
1982	677	1	893	-	-
1983	627	1	810	-	-
1984	696	1	878	-	-
1985	637	-	857	-	-
1981-1985 average	**664**	**1**	**879**	**-**	**-**
1986	516	-	668	-	-
1987[2]	790	-	832	-	-
1988[2]	830	-	881	-	-
1989[2]	771	-	816	-	-
1986-1989 average	**727**	**-**	**799**	**-**	**-**

Source: Compiled from data contained in Fishery Statistics of the United States (1961-1977 issues) and unpublished data provided by the National Marine Fisheries Service.
[1]Data are not available.
[2]Preliminary figures.

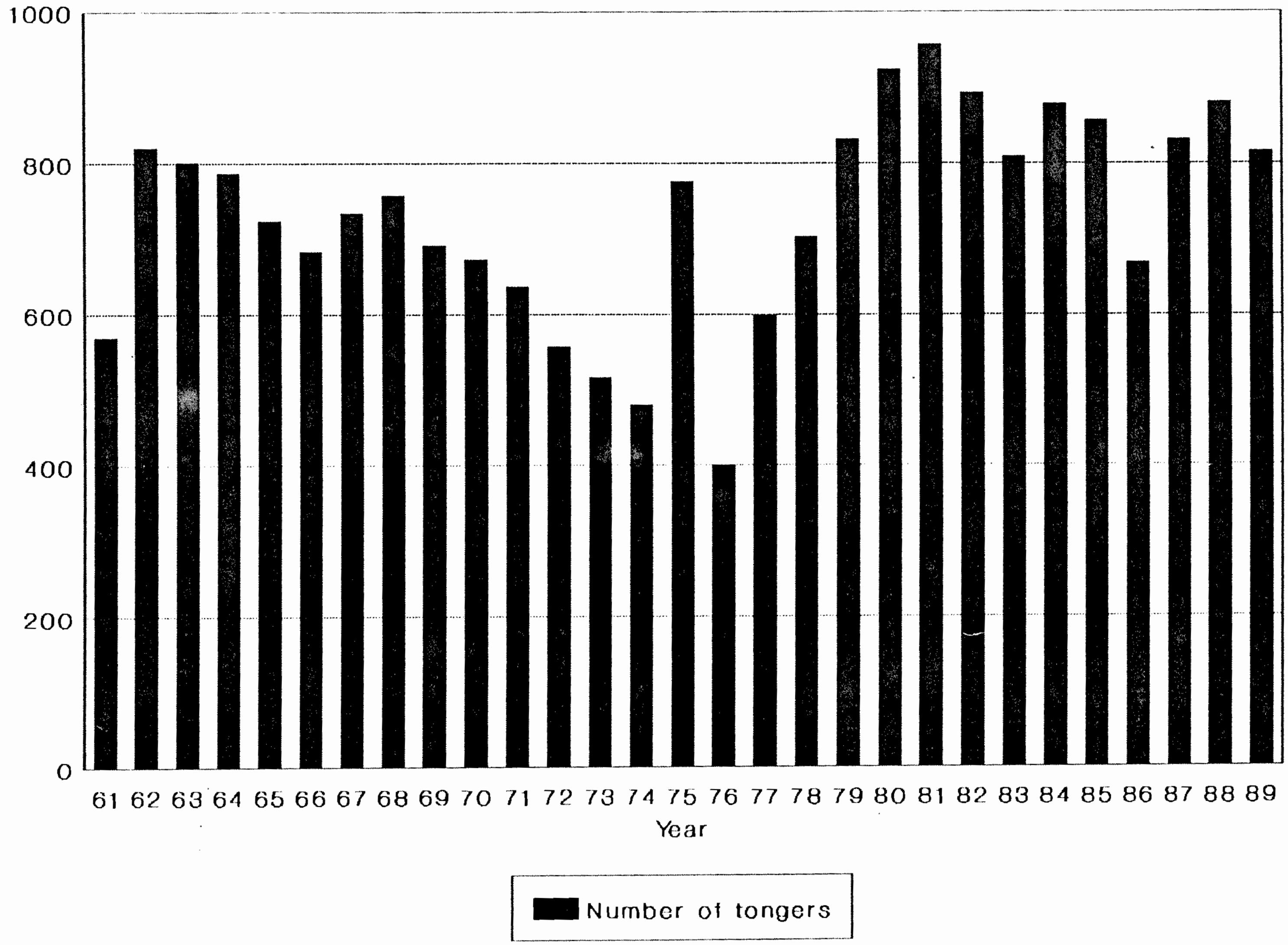

Figure 7.5b. Number of Florida west coast oyster fishermen.

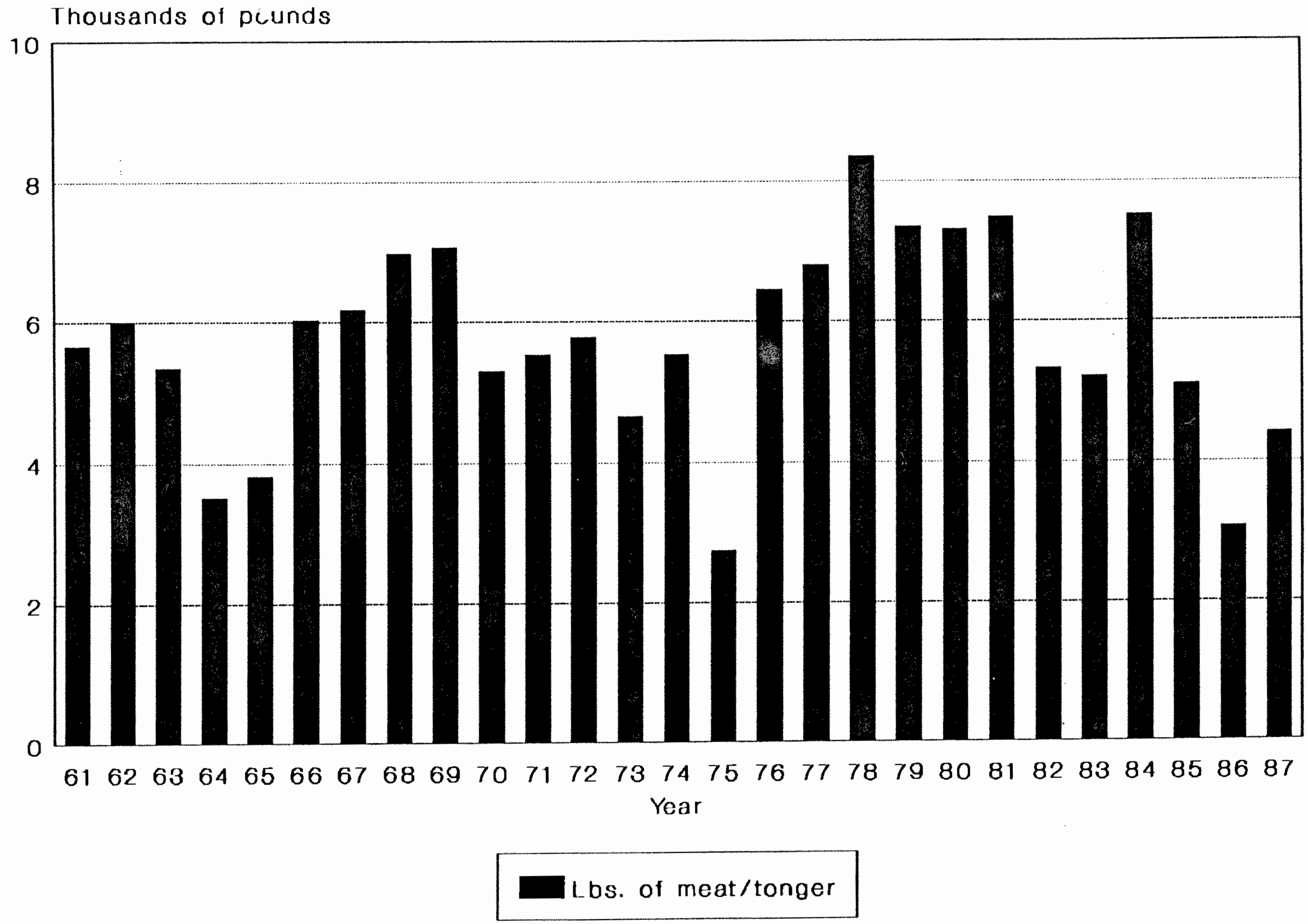

Figure 7.5c. Oyster production per fisherman, Florida west coast.

Table 7.6a. Alabama oyster production by fisherman and gear type, 1961-1988.

Year	Pounds Harvested By: Dredges	Tongs	Pounds Harvested Per Fisherman Tonger
	--------1,000 lbs---------		---lbs---
1961	0	509	677
1962	0	443	756
1963	3	992	1,465
1964	50	956	1,404
1965	27	465	615
1961-1965 average	**16**	**673**	**975**
1966	71	1,233	1,589
1967	94	1,994	2,508
1968	68	1,144	1,782
1969	27	453	709
1970	6	274	511
1966-1970 average	**53**	**1,020**	**1,504**
1971	3	247	538
1972	[1]	1,069	2,274
1973	0	590	1,497
1974	0	733	3,215
1975	0	638	2,562
1971-1975 average	**1**	**655**	**1,819**
1976	0	1,236	4,292
1977	0	1,549	4,376
1978	0	760	1,723
1979	0	460	1,217
1980	0	55	131
1976-1980 average	**0**	**812**	**2,159**
1981	0	1,330	3,970
1982	0	1,497	4,229
1983	0	336[2]	790
1984	0	477	1,340
1985	0	1,442	3,155
1981-1985 average	**0**	**1,016**	**2,697**
1986	0	946	1,739
1987	0	88	320
1988	0	103	368

Source: Compiled from data contained in Fishery Statistics of the United States (1961-1977 issues) and unpublished data provided by the National Marine Fisheries Service.

[1]Less than 1,000 pounds and $1,000.

[2]Includes small amount of oysters landed by other gear.

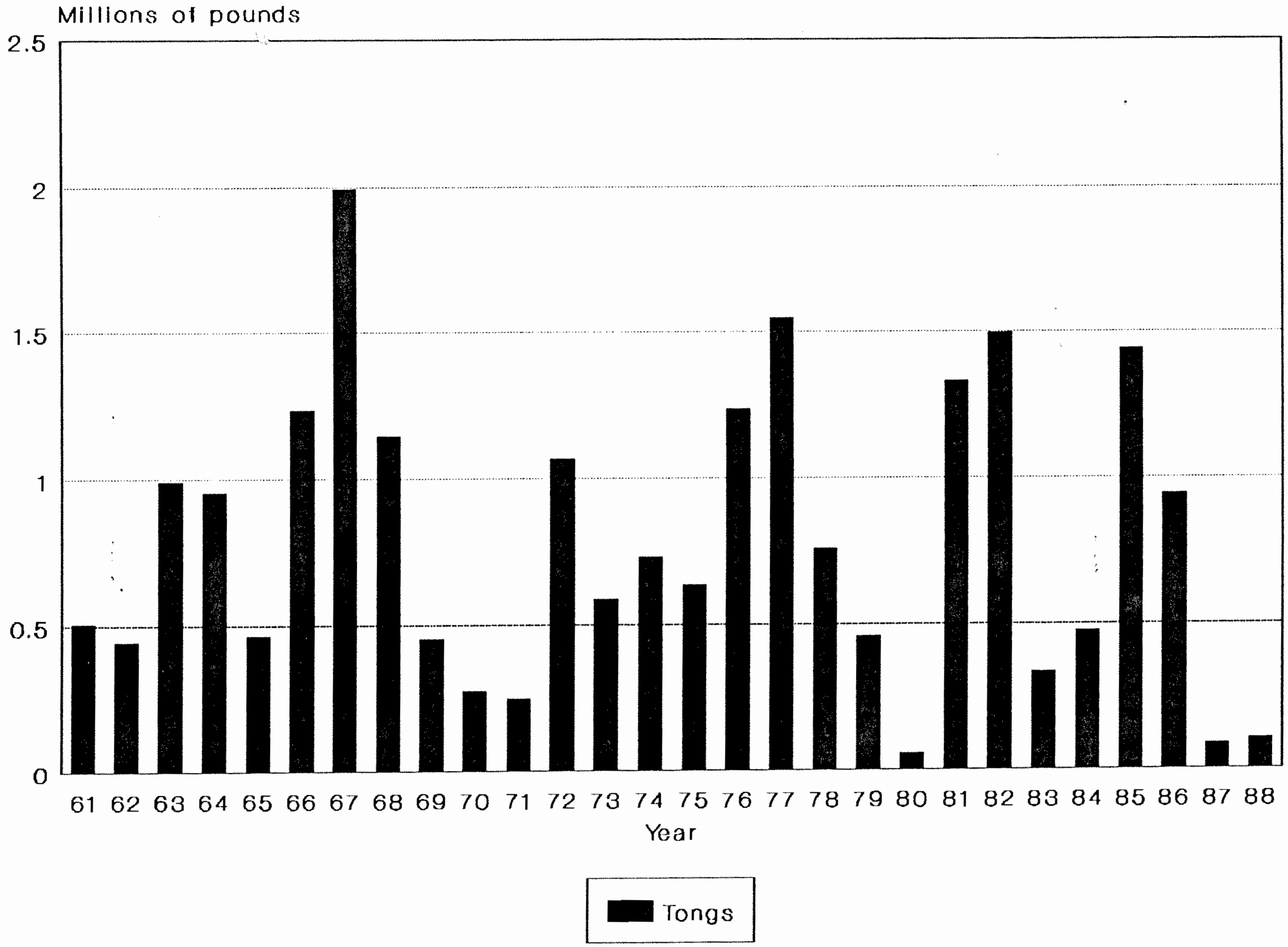

Figure 7.6a. Alabama coast oyster production.

Table 7.6b. Operating units and fishermen in the Alabama oyster industry, 1961-1988.

	Alabama				
	Dredges			Tongs	
Year	Boats	Vessels	Fishermen	Boats	Fishermen
1961	0	0	0	525	752
1962	0	0	0	390	586
1963	2	3	22	444	677
1964	3	0	13	416	681
1965	0	2	7	449	756
1961-1965 average	**1**	**1**	**8**	**445**	**690**
1966	0	3	13	457	776
1967	0	3	13	468	795
1968	0	3	14	395	642
1969	0	3	13	354	639
1970	0	3	13	316	536
1966-1970 average	**0**	**3**	**13**	**398**	**678**
1971	0	3	13	288	459
1972	2	1	4	286	470
1973	0	0	0	237	394
1974	0	0	0	157	228
1975	0	0	0	172	249
1971-1975 average	**0**	**1**	**3**	**228**	**360**
1976	0	0	0	194	288
1977	0	0	0	220	354
1978	0	0	0	226	441
1979	0	0	0	202	378
1980	0	0	0	326	420
1976-1980 average	**0**	**0**	**0**	**234**	**376**
1981	0	0	0	199	335
1982	0	0	0	172	354
1983	0	0	0	208	425
1984	0	0	0	184	356
1985	0	0	0	238	457
1981-1985 average	**0**	**0**	**0**	**200**	**385**
1986	0	0	0	305	544
1987	0	0	0	138	275
1988	0	0	0	143	280

Source: Compiled from data contained in Fishery Statistics of the United States (1961-1977 issues) and unpublished data provided by the National Marine Fisheries Service.

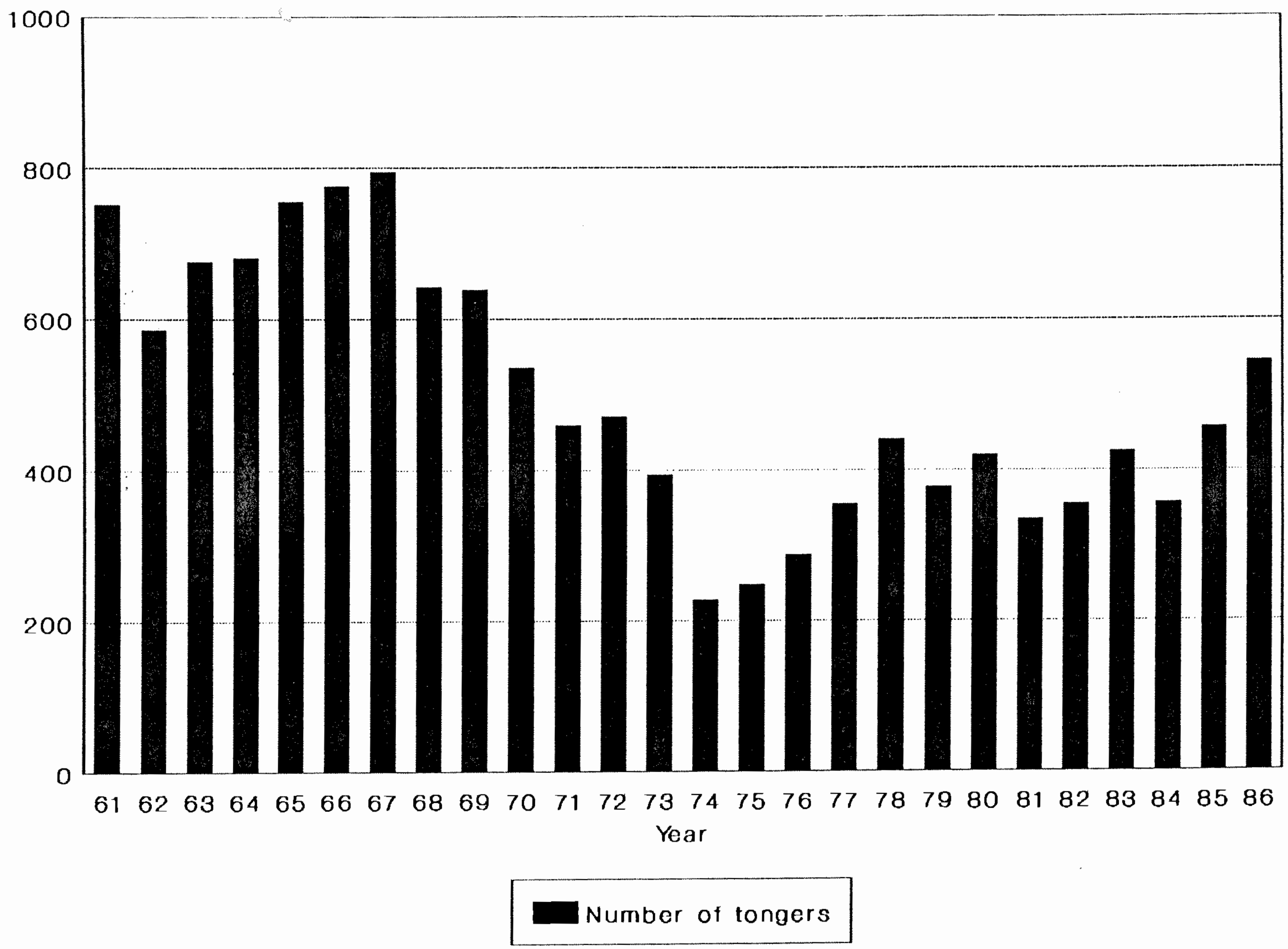

Figure 7.6b. Number of Alabama coast oyster fishermen.

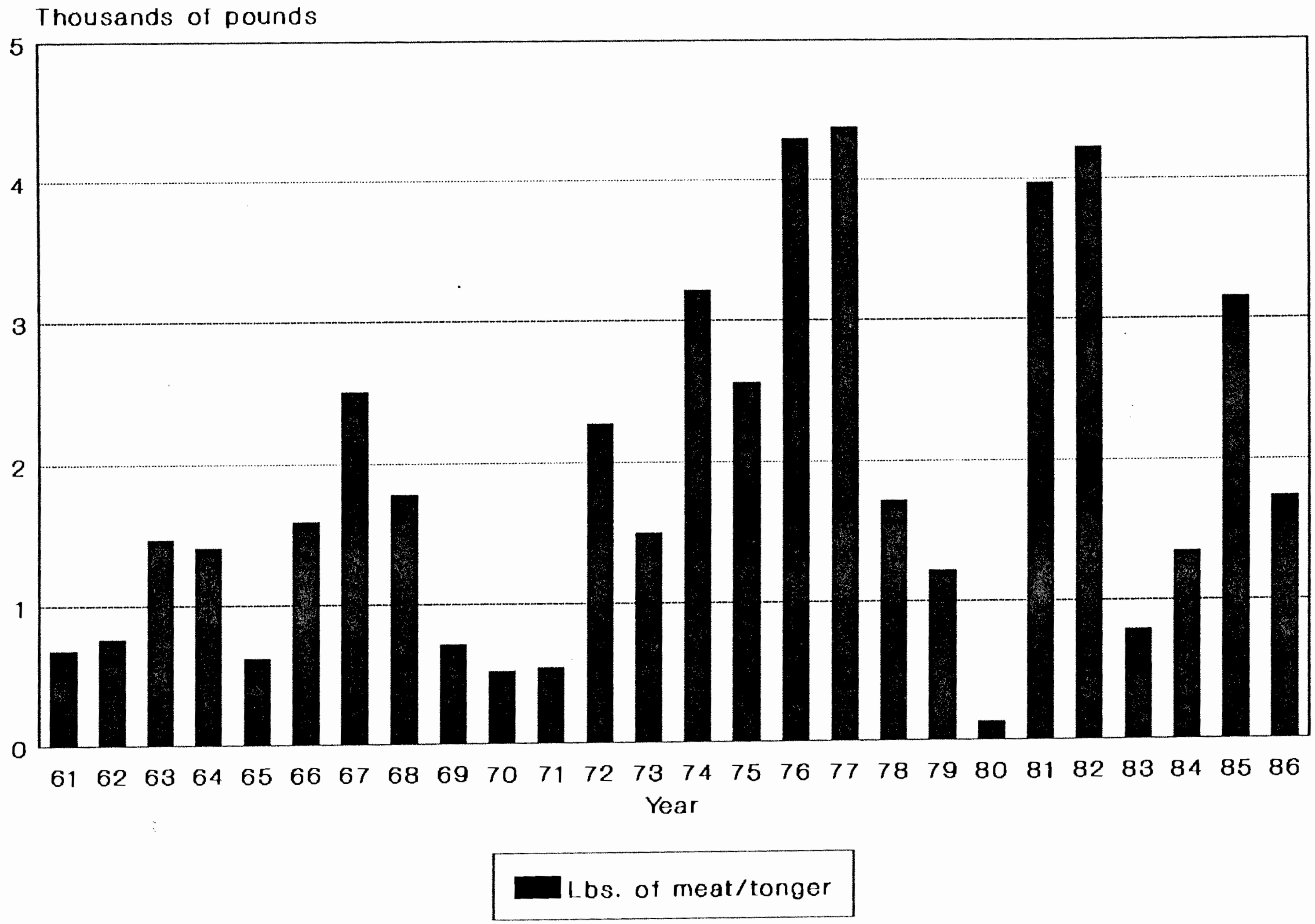

Figure 7.6c. Oyster production per fisherman, Alabama.

Table 7.7a. Mississippi oyster production by fisherman and gear type, 1961-1988.

Year	Pounds Harvested By: Dredges	Tongs	Pounds Harvested Per Fisherman: Dredger	Tonger
	------1,000 lbs-----		--------lbs---------	
1961	2,427	814	4,694	1,190
1962	1,483	591	2,908	845
1963	4,061	619	6,238	955
1964	3,952	877	5,598	1,580
1965	2,332	364	5,170	658
1961-1965 average	**2,851**	**653**	**5,028**	**1,040**
1966	1,226	1,006	2,926	1,685
1967	1,963	1,823	3,091	3,210
1968	3,373	413	5,530	794
1969	841	589	2,597	1,178
1970	508	40	1,511	85
1966-1970 average	**1,582**	**774**	**3,402**	**1,458**
1971	1,126	88	2,858	185
1972	598	622	1,466	1,016
1973	498	114	1,838	222
1974	246	31	1,491	76
1975	1,023	58	4,142	182
1971-1975 average	**698**	**183**	**2,350**	**394**
1976	1,296	221	4,645	429
1977	767	619	2,769	1,279
1978	283	400	[1]	[1]
1979	164	108	659	296
1980	0	21	0	126
1976-1980 average	**502**	**274**	**2,771**	**632**
1981	241	226	913	522
1982	2,053	523	3,540	1,417
1983	3,181	152	4,310	385
1984	1,330	49	1,795	126
1985	1,156	36	1,663	179
1981-1985 average	**1,592**	**197**	**2,444**	**526**
1986	931	271	1,268	797
1987	58	74	360	525
1988	99	48	678	440

Source: Compiled from data contained in Fishery Statistics of the United States (1961-1977 issues) and unpublished data provided by the National Marine Fisheries Service.

[1]Missing value.

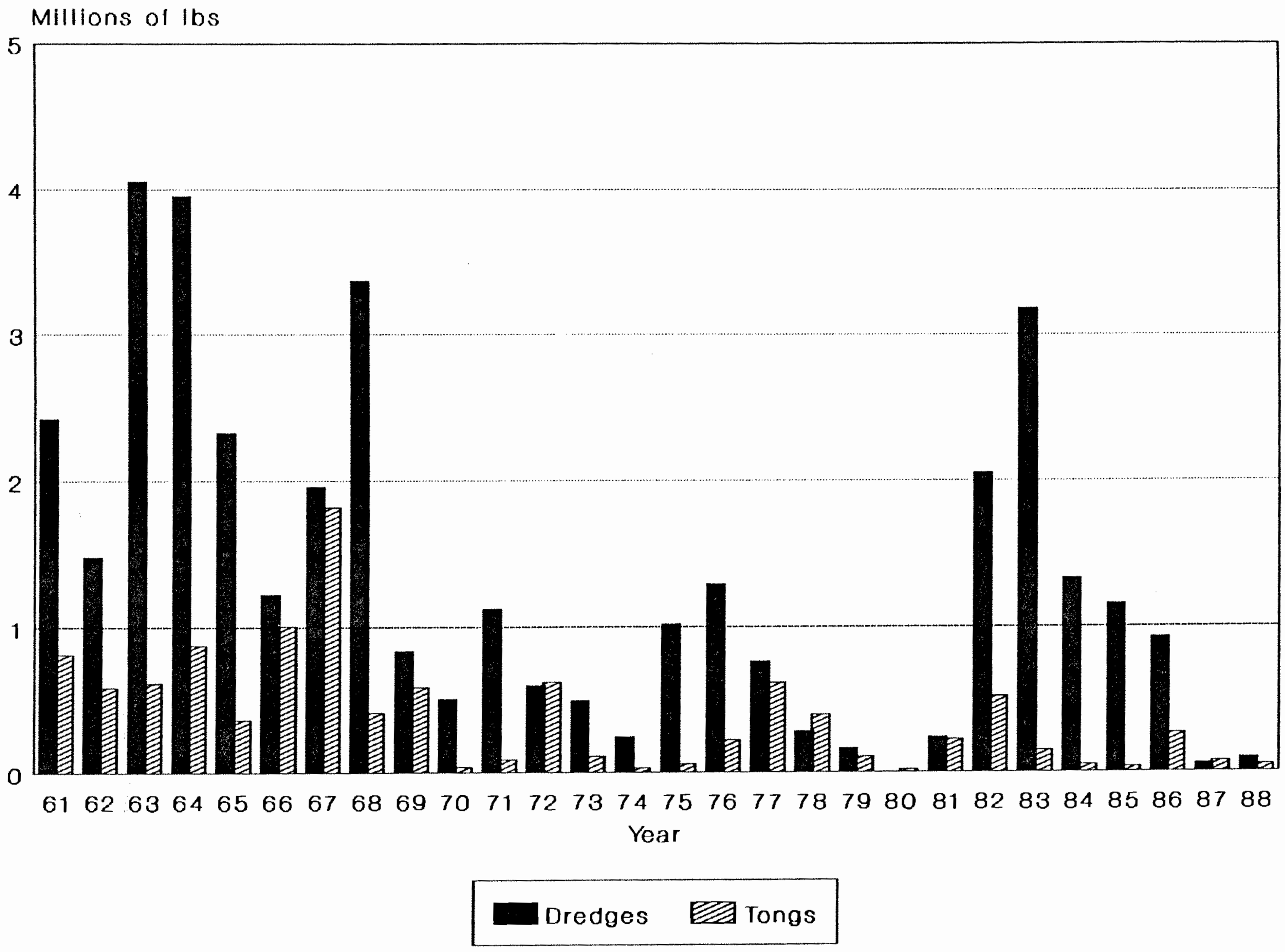

Figure 7.7a. Mississippi coast oyster production.

Table 7.7b. Operating units and fishermen in the Mississippi oyster industry, 1961-1988.

	Mississippi				
	Dredges			Tongs	
Year	Boats	Vessels	Fishermen	Boats	Fishermen
1961	27	162	517	674	684
1962	30	145	510	674	699
1963	30	196	651	633	648
1964	40	192	706	550	555
1965	30	120	451	552	553
1961-1965 average	**31**	**163**	**567**	**617**	**628**
1966	20	124	419	590	597
1967	15	191	635	568	568
1968	22	191	610	510	520
1969	23	81	324	491	500
1970	26	81	336	468	472
1966-1970 average	**21**	**134**	**465**	**525**	**531**
1971	30	88	394	475	475
1972	70	86	408	572	612
1973	36	68	271	483	513
1974	23	38	165	391	406
1975	39	58	247	318	318
1971-1975 average	**40**	**68**	**297**	**448**	**465**
1976	55	54	279	484	515
1977	59	51	277	462	484
1978	[1]	[1]	[1]	[1]	[1]
1979	70	47	249	345	365
1980	0	0	0	165	167
1976-1980 average[2]	46	38	201	364	383
1981	99	40	264	400	433
1982	220	90	580	344	369
1983	241	119	738	385	395
1984	300	115	741	390	390
1985	280	107	695	186	201
1981-1985 average	**228**	**94**	**604**	**341**	**358**
1986	252	107	734	340	340
1987	10	44	161	141	141
1988	42	32	146	109	109[3]

Source: Compiled from data contained in Fishery Statistics of the United States (1961-1977 issues) and unpublished data provided by the National Marine Fisheries Service.
[1]Data for 1978 are not available.
[2]The 1976-1980 average is based on four years of data.
[3]Includes one oysterman and boat harvesting by hand.

The number of tongers in Mississippi followed a similar pattern to that observed for dredgers. In general, the number of tongers declined somewhat steadily during the 1960s and 1970s before increasing slightly during the early 1980s. Though increasing, the 399 tongers harvesting oysters on an annual basis during 1981-1983 represented almost a 40% decline from the 1961-1965 average of 628 tongers (Table 7.7b and Figure 7.7b).

Although highly variable on an annual basis, landings per dredger clearly showed a pattern of decline throughout the 1960s and 1970s (Table 7.7a and Figure 7.7c). An increase in production per dredger during the first three years of the 1980s was probably due to unusually good production following flooding in 1979.

No trend in production per tonger in Mississippi was evident. Harvest per tonger in Mississippi's waters was relatively small, generally falling in the 200- to 1500-pound range (Table 7.7b).

7.2.4.4 Louisiana

Historically, dredging has accounted for more than 90% of Louisiana's annual oyster harvests and often exceeded 95% of annual production (Table 7.8a and Figure 7.8a). Landings from hand tonging activities have declined sharply since the early 1960s in association with a decline in the number of tongers. Oyster production by hand in Louisiana has been minimal, generally representing less than 1% of the state's annual production of oysters.

The Louisiana oyster dredging industry has remained extremely stable during 1961-1988 when evaluated in terms of operating units and fishermen, with the exception of a sharp increase in the number of dredging boats since 1986 (Table 7.8b and Figure 7.8b). With few exceptions, the annual number of boats used to dredge oysters has ranged from about 185 to 215. The number of vessels between 1963 and 1986 has consistently averaged from about 220 to 230 annually, and with an exception of the early 1960s. About 900 to just over 1000 fishermen have participated annually.

As indicated in Table 7.8a, the harvesting of oysters with tongs and by hand has historically occurred in Louisiana. The number of tongers has fallen sharply since 1961-1965 when an average of 400 individuals were employed annually. The number of fishermen harvesting oysters by hand has been minimal since the 1960s, with the exception of a sharp increase in 1987 and 1988 (Table 7.8b and Figure 7.8b).

With some exceptions, oyster harvest per dredger has fluctuated between 8,000 and 12,000 pounds annually (Table 7.8a and Figure 7.8c). Much of this fluctuation was the result of variation in the total state landings rather than annual variation in the number of fishermen. A decline in state landings was generally associated with a decline in pounds harvested per dredger and vice-versa.

Harvest per tonger in Louisiana has historically been less than harvest per dredger and has fluctuated between about 1,000 and 3,000 pounds annually. As with dredgers, there was no clear distinction of either increasing or decreasing annual production per tonger when examined on a pound basis.

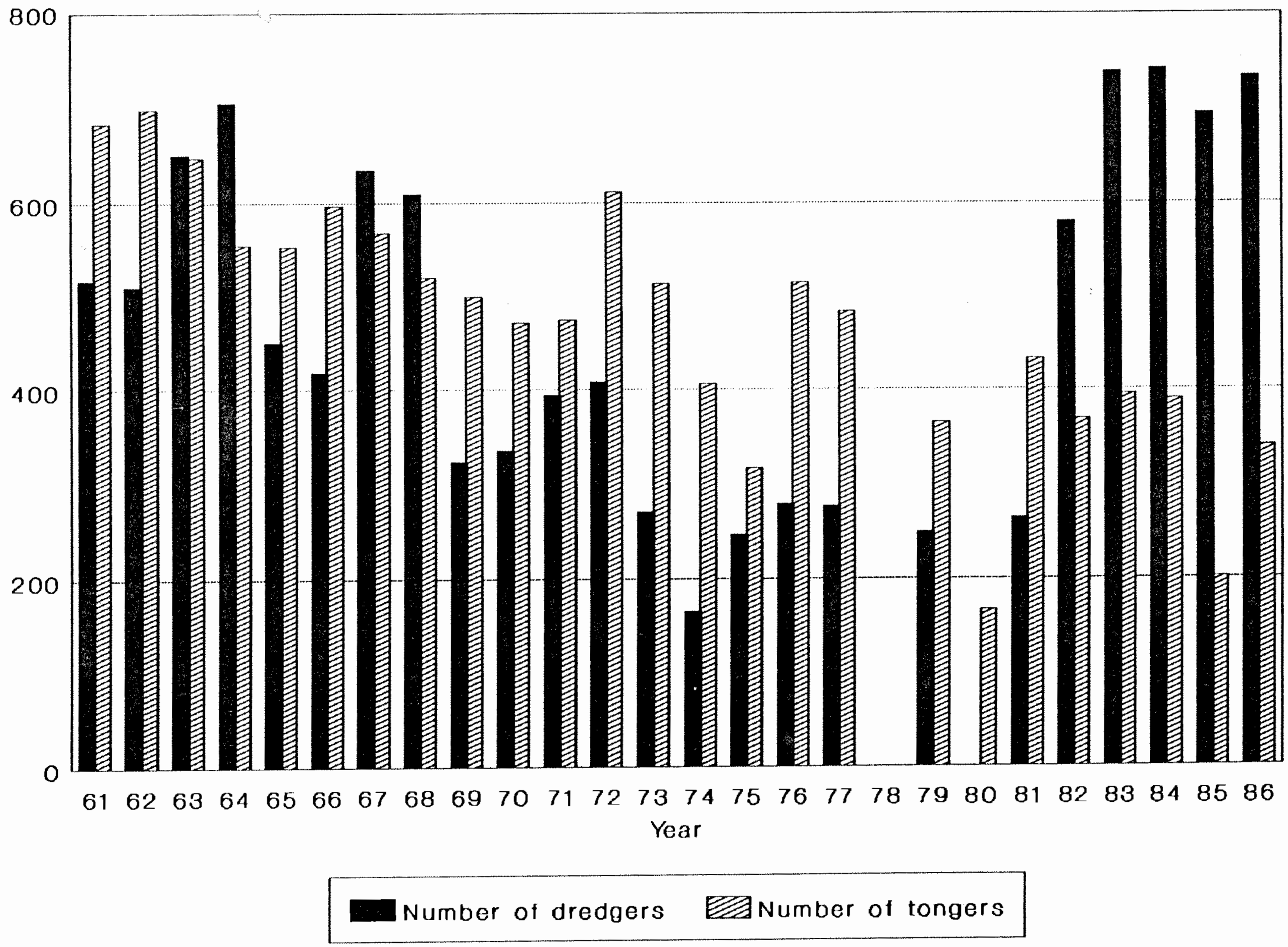

Figure 7.7b. Number of Mississippi coast oyster fishermen.

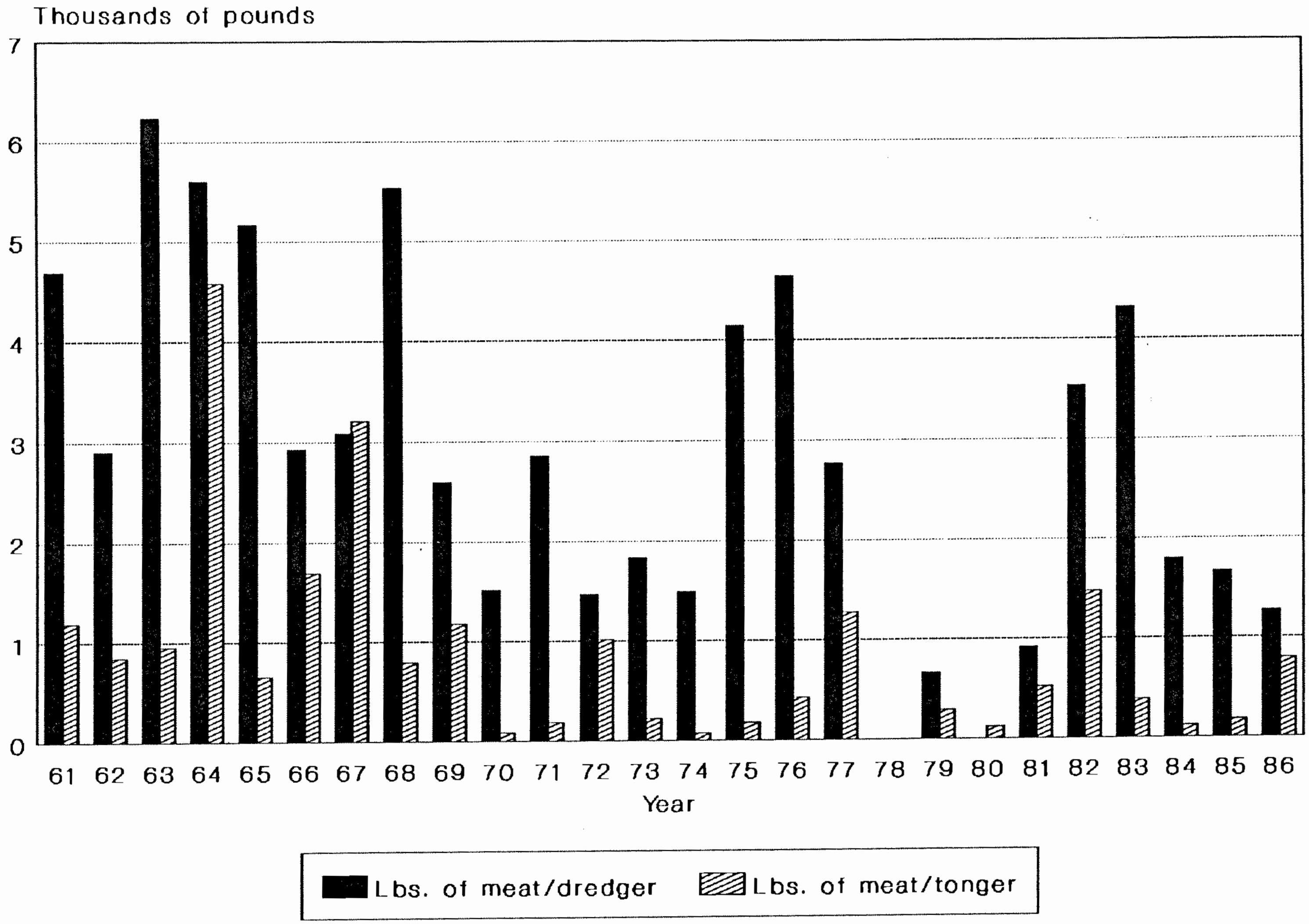

Figure 7.7c. Oyster production per fisherman, Mississippi.

Table 7.8a. Louisiana oyster production by fisherman and gear type, 1961-1988.

Year	Pounds Harvested By:			Pounds Harvested Per Fishermen On:	
	Dredges	Tongs	Other	Dredger	Tonger
	---------1,000 lbs---------			--------lbs-------	
1961	9,708	422	9	13,908	1,722
1962	9,386	763	11	10,789	1,889
1963	10,168	1,369	27	10,992	2,894
1964	10,766	610	26	10,691	1,237
1965	7,930	382	31	7,790	997
1961-1965 average	**9,592**	**709**	**21**	**10,611**	**1,773**
1966	4,581	168	16	4,599	994
1967	7,528	205	10	7,589	2,070
1968	12,874	243	5	12,696	2,455
1969	8,744	363	73	8,779	1,995
1970	8,370	237	32	8,182	1,705
1966-1970 average	**8,419**	**243**	**27**	**8,385**	**1,760**
1971	10,346	165	17	10,035	1,557
1972	8,754	35	16	8,582	376
1973	8,837	96	20	8,638	1,170
1974	9,837	110	25	9,827	1,410
1975	13,525	80	81	13,675	941
1971-1975 average	**10,260**	**97**	**32**	**10,128**	**1,090**
1976	12,151	163	20	11,740	1,552
1977	9,623	441	2	9,537	3,868
1978	9,501	161	0	9,370	2,176
1979	7,423	292	0	7,285	3,476
1980	6,298	649	[1]	6,110	5,643
1976-1980 average	**8,999**	**341**	**4**	**8,814**	**3,480**
1981	8,846	247	0	8,899	2,906
1982	12,501	120	0	12,172	992
1983	13,141	88	[1]	12,999	710
1984	13,517	381	54	13,265	3,256
1985	14,246	100	2	14,022	862
1981-1985 average	**12,450**	**187**	**11**	**12,271**	**1,745**
1986	12,533	114	6	11,042	934
1987	11,760	202	64	8,770	818
1988	13,001	248	4	9,286	1,797

Source: Compiled from data contained in Fishery Statistics of the United States (1961-1977 issues) and unpublished data provided by the National Marine Fisheries Service.

[1] Less than 1,000 lbs

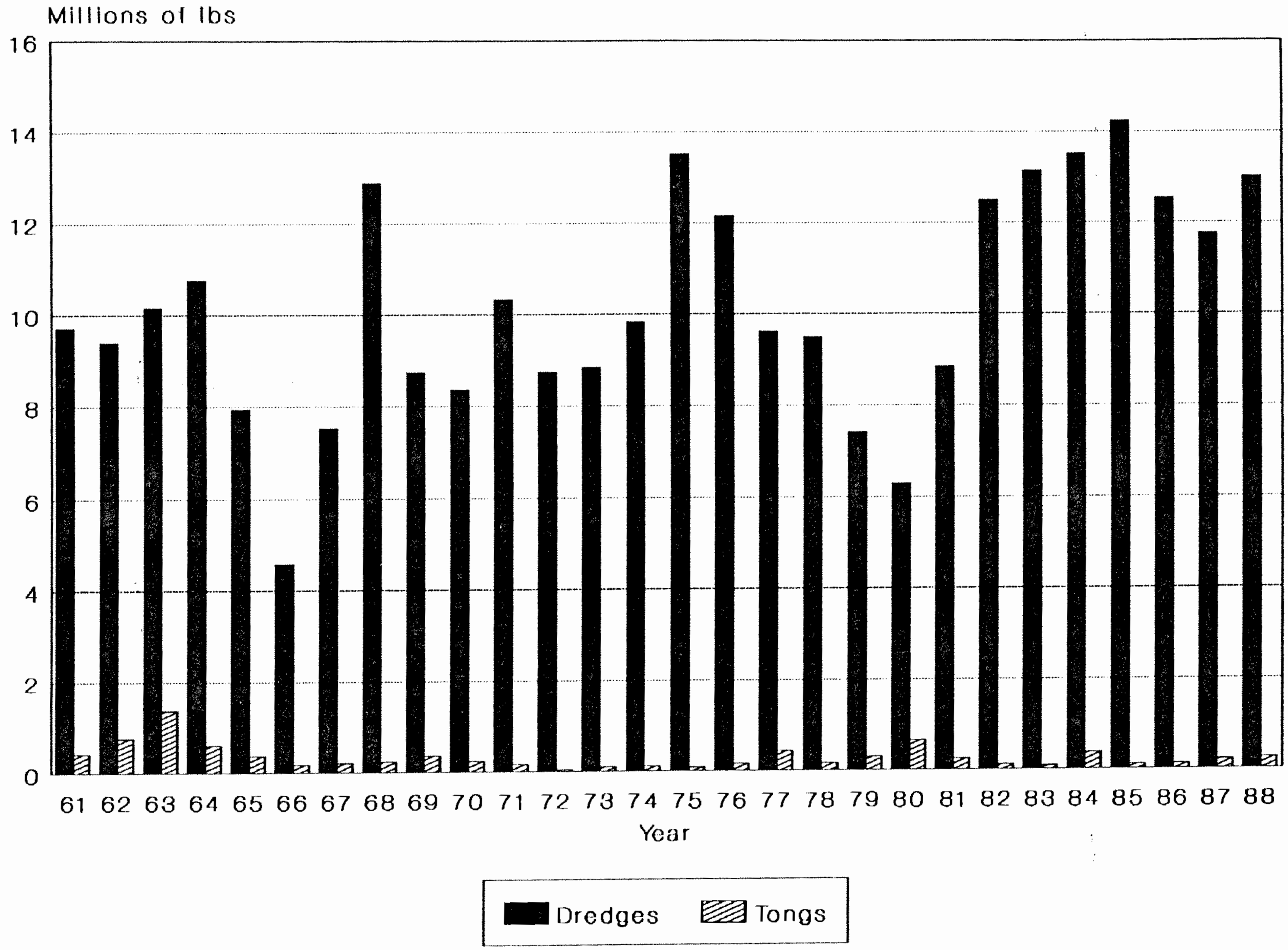

Figure 7.8a. Louisiana coast oyster production.

Table 7.8b. Operating units and fishermen in the Louisiana oyster industry, 1961-1988.

	Louisiana						
	Dredges			Tongs		By Hand & Rake	
Year	Boats	Vessels	Fishermen	Boats	Fishermen	Boats	Fishermen
1961	191	133	698	165	245	43	55
1962	205	171	870	187	404	[1]	[1]
1963	212	202	925	248	473	43	70
1964	199	224	1,007	338	493	40	60
1965	194	233	1,018	350	383	45	45
1961-1965 average	**200**	**193**	**904**	**258**	**400**	**43**	**58**
1966	197	217	996	124	169	20	20
1967	191	225	992	66	99	20	20
1968	199	231	1,014	66	99	20	20
1969	184	233	996	130	182	20	22
1970	212	233	1,023	97	139	10	20
1966-1970 average	**197**	**228**	**1,004**	**97**	**138**	**18**	**20**
1971	214	231	1,031	72	106	13	26
1972	209	232	1,020	59	93	13	26
1973	214	232	1,023	51	82	3	6
1974	213	222	1,001	49	78	3	6
1975	210	220	989	56	85	6	6
1971-1975 average	**212**	**227**	**1,013**	**57**	**89**	**8**	**14**
1976	213	235	1,035	80	105	3	6
1977	215	222	1,009	91	114	3	6
1978	216	221	1,014	61	74	0	0
1979	214	226	1,019	71	84	0	0
1980	192	225	1,030	90	115	1	1
1976-1980 average	**210**	**226**	**1,021**	**79**	**98**	**1**	**3**
1981	185	223	994	75	85	0	0
1982	203	231	1,027	62	121	0	0
1983	191	231	1,011	65	124	0	0
1984	193	231	1,019	59	117	5	5
1985	190	231	1,016	58	116	1	1
1981-1985 average	**192**	**229**	**1,013**	**76**	**113**	**1**	**1**
1986	270	225	1,135	62	122	1	11
1987	441	245	1,341	172[2]	247	39	42
1988	475	248	1,400	71	138	42	52

Source: Compiled from data contained in Fishery Statistics of the United States (1961-1977 issues) and unpublished data provided by the National Marine Fisheries Service.
[1] 1962 data are not included due to an apparent error in published statistics.
[2] Data for 1987 and 1988 include some vessels used in tonging operations.

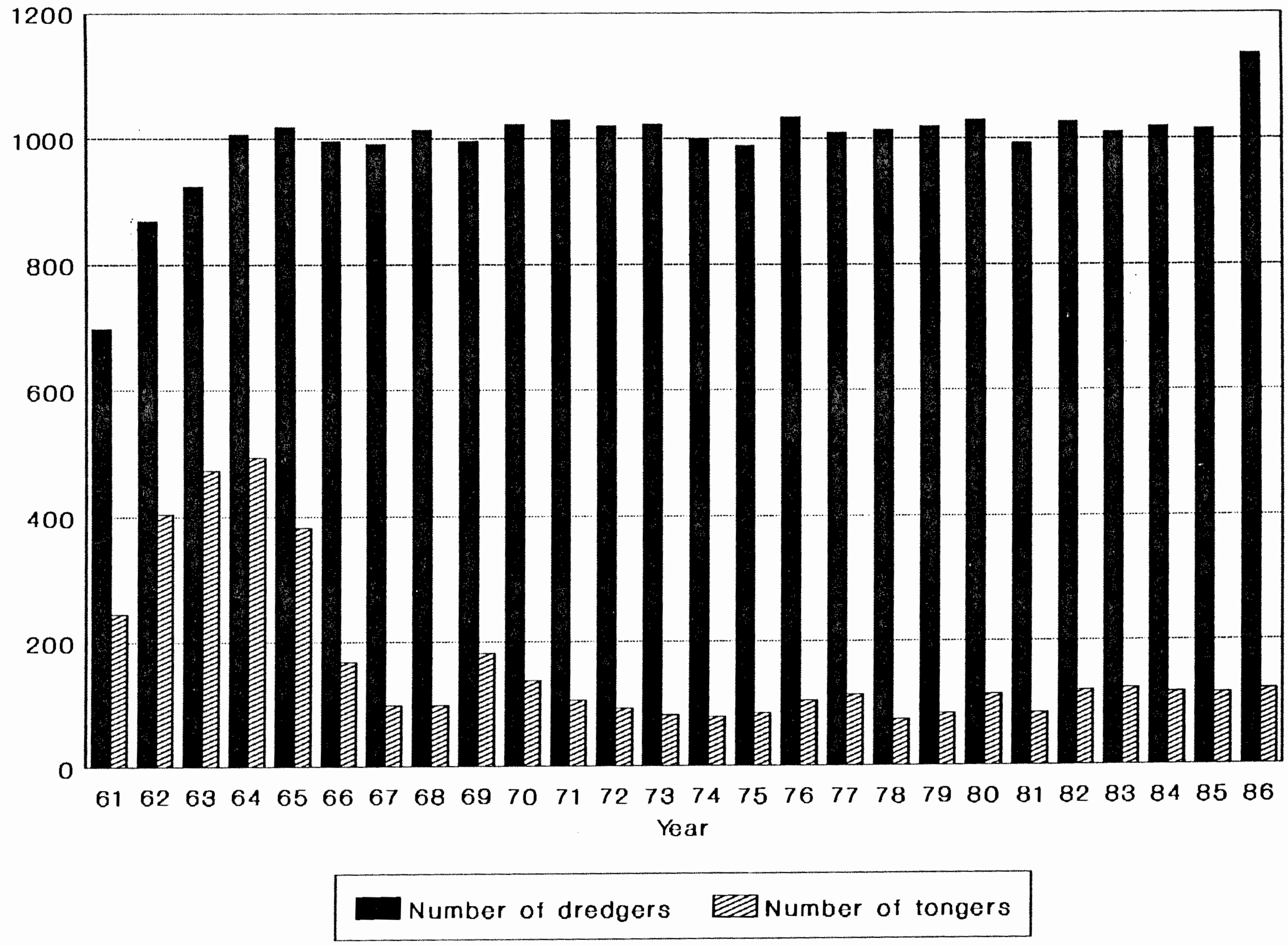

Figure 7.8b. Number of Louisiana coast oyster fishermen.

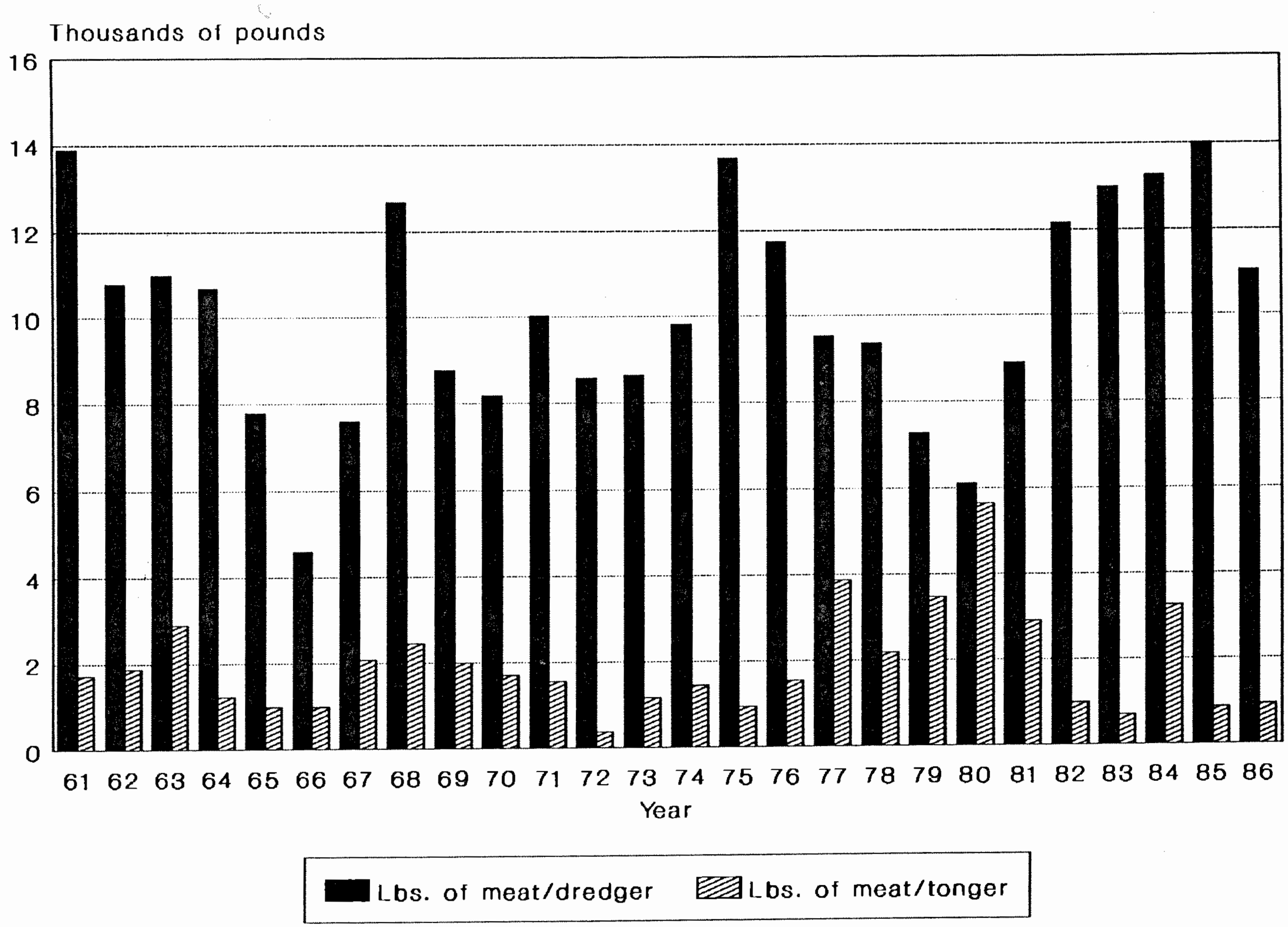

Figure 7.8c. Oyster production per fisherman, Louisiana.

7.2.4.5 Texas

With the exception of 1961, virtually all oyster production in Texas has been derived from dredging (Table 7.9a and Figure 7.9a). Dredgers have constituted the majority of harvesters in the Texas oyster fishery (Table 7.9b and Figure 7.9b). During 1961-1965, an average of 537 oystermen were dredging from 135 boats and 83 vessels. By 1981-1985, the number of oystermen had declined to 349, and the number of boats had declined to an average of 54. The number of vessels increased sharply until the mid-1970s before declining to an average of 106 during 1981-1985.

Tonging has historically been a small component of the Texas oyster harvesting effort (Table 7.9a). Harvesting by hand in the Texas oyster fishery has traditionally been minimal (Table 7.9a).

The annual pounds harvested per dredger has typically fallen in the 3,000 to 8,000 pound range except during 1981-1985 (Table 7.9a and Figure 7.9c). Annual harvest per dredger during 1981-1985 was significantly higher than in other periods, as were total state landings as given in Table 7.3.

7.3 Noncommercial Fishery

7.3.1 Development of the Fishery

It is likely that the earliest inhabitants of the gulf coastal area subsisted at least in part on oysters. Through history and even today, some people enjoy catching oysters for their own consumption and to give to friends and relatives. In recent years, commercial catches have become quite variable and prices have increased. As a result of these factors, it is likely that more people have become involved in noncommercial fishing in the past 10 years. However, statistics are not available to test this hypothesis.

7.3.2 Fishing Methods, Gear, Boats and Vessels

Gear and fishing methods employed by the noncommercial portion of the fishery are basically the same as with the commercial fishermen. Many types and sizes of boats and vessels may be employed.

7.3.3 Historical Catch Statistics

Catch data for the noncommercial fisheries are not available. Mississippi, Louisiana and Texas require licenses for these harvesters, and daily limits are set by all states (see Section 6).

7.4 Description of Fishing Areas

The following subsections show major oyster producing areas by state for each of the five Gulf States. Although many smaller areas have contributed to overall harvests, the following subsections identify the major areas from which catches have been recorded for the period 1961-1985. Within each state these areas are ranked based on the relative amounts of their contribution to the overall state harvest; however, they are not compared with other states. The individual state agencies listed and described in Section 6 herein may be contacted for more specific information concerning reef areas, seasons and other information.

Table 7.9a. Texas oyster production by fisherman and gear type, 1961-1985.

Year	Pounds Harvested By: Dredges	Tongs	Other	Pounds Harvested Per Fisherman On: Dredger
	------------1,000 lbs------------			---lbs---
1961	1,001	90	5	3,024
1962	1,139	55	17	3,571
1963	2,558	37	23	3,997
1964	3,266	48	44	4,824
1965	4,811	14	10	6,701
1961-1965 average	**2,555**	**49**	**20**	**4,758**
1966	4,666	57	2	6,852
1967	3,467	58	28	5,906
1968	3,251	48	3	5,615
1969	3,731	33	0	6,871
1970	4,654	21	[1]	7,446
1966-1970 average	**3,954**	**43**	**7**	**6,557**
1971	4,719	24	2	8,596
1972	3,906	29	0	6,362
1973	2,347	[1]	0	3,684
1974	1,240	3	0	2,988
1975	1,748	8	0	6,177
1971-1975 average	**2,792**	**13**	[1]	**5,584**
1976	3,876	5	0	6,971
1977	2,591	9	0	5,466
1978	1,907	[2]	[2]	4,530
1979	889	-	-	8,156
1980	1,739	-	-	6,984
1976-1980 average	**2,200**			**6,077**
1981	1,309	-	-	4,642
1982	3,633	-	-	10,440
1983	7,941	-	-	24,661
1984	5,168	-	-	13,745
1985	5,134	-	-	12,312
1981-1985 average	**4,637**			**13,287**

[1] Less than 1,000 lbs

[2] All landings have been attributed to dredges since 1978 due to unavailability of data by gear type. Harvest by tongs and "other" has historically been less than one percent of the total.

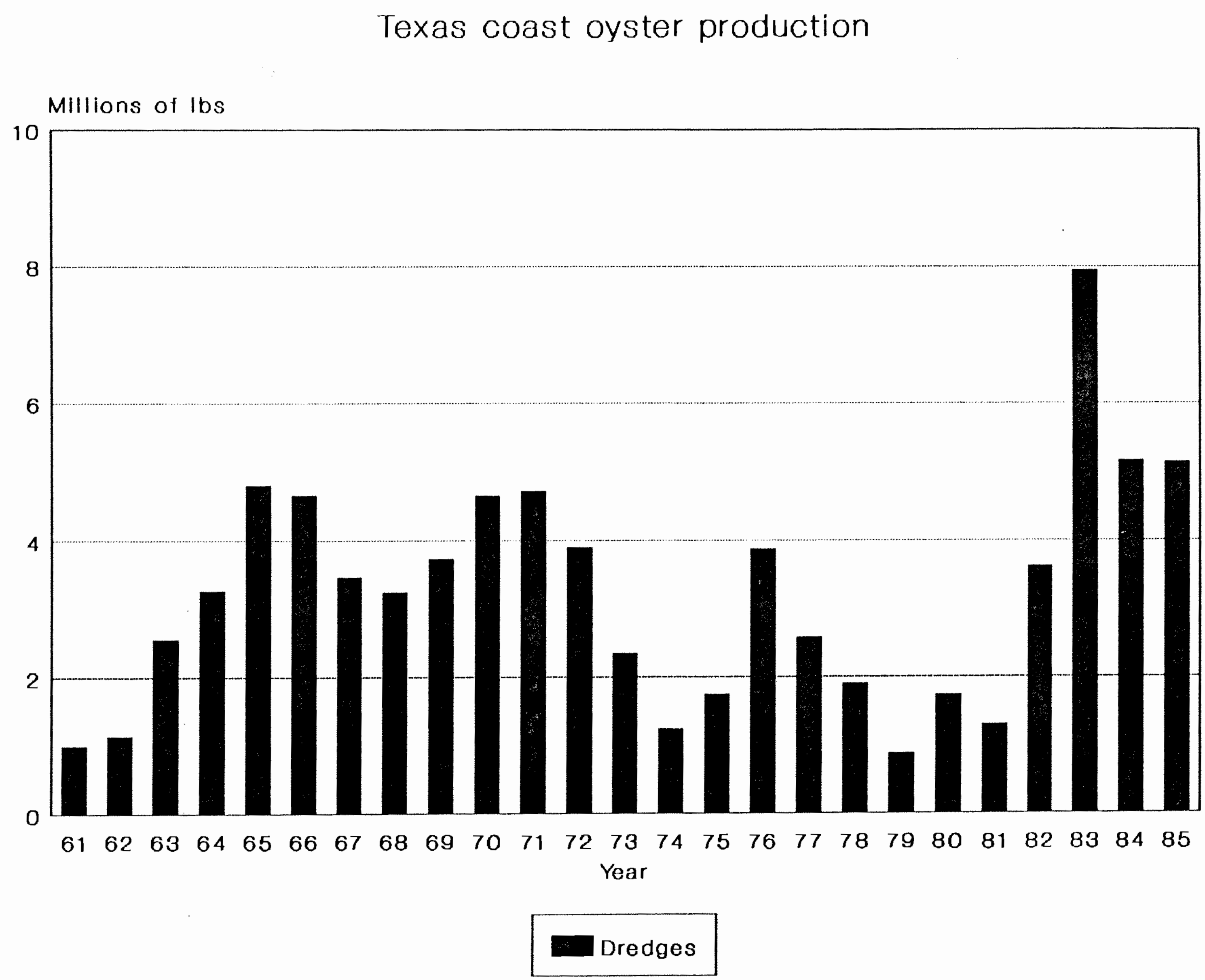

Figure 7.9a. Texas coast oyster production.

Table 7.9b. Operating units and fishermen in the Texas oyster industry, 1961-1985.

	Texas						
	Dredges			Tongs		By Hand	
Year	Boats	Vessels	Fishermen	Boats	Fishermen	Boats	Fishermen
1961	124	35	331	31	36	3	3
1962	108	32	319	37	38	10	10
1963	176	65	640	45[1]	46	21	21
1964	153	122	677	32	32	34	34
1965	116	159	718	10	15	19	19
1961-1965 average	**135**	**83**	**537**	**31**	**33**	**17**	**17**
1966	141	157	681	25	30	2	2
1967	117	129	587	37	37	[2]	[2]
1968	121	145	579	43	43	2	2
1969	88	169	543	35	35	0	0
1970	140	165	625	33	33	1	1
1966-1970 average	**121**	**153**	**603**	**35**	**36**	**1**	**1**
1971	73	176	549	29	50	0	2
1972	68	206	614	32	62	0	0
1973	85	204	637	2	2	0	0
1974	76	122	415	2	2	0	0
1975	31	101	283	2	2	0	0
1971-1975 average	**67**	**162**	**500**	**13**	**24**	**0**	[3]
1976	72	184	556	2	2	0	0
1977	61	170	474	2	2	0	0
1978	44	163	421	2	2	0	0
1979	17	42	109	2	2	0	0
1980	19	101	249	3	3	0	0
1976-1980 average	**43**	**132**	**362**	**2**	**2**	**0**	**0**
1981	36	88	282	4	12	0	0
1982	58	110	348	2	2	0	0
1983	37	110	322	1	1	0	0
1984	61	110	376	1	2	0	0
1985	76	110	417	0	0	0	0
1981-1985 average	**54**	**106**	**349**	**2**	**3**	**0**	**0**

Source: Compiled from data contained in Fishery Statistics of the United States (1961-1977 issues) and unpublished data provided by the National Marine Fisheries Service.

[1]Includes one vessel.

[2]Data for 1967 excluded due to apparent error in published statistics.

[3]Less than 1,000 lbs.

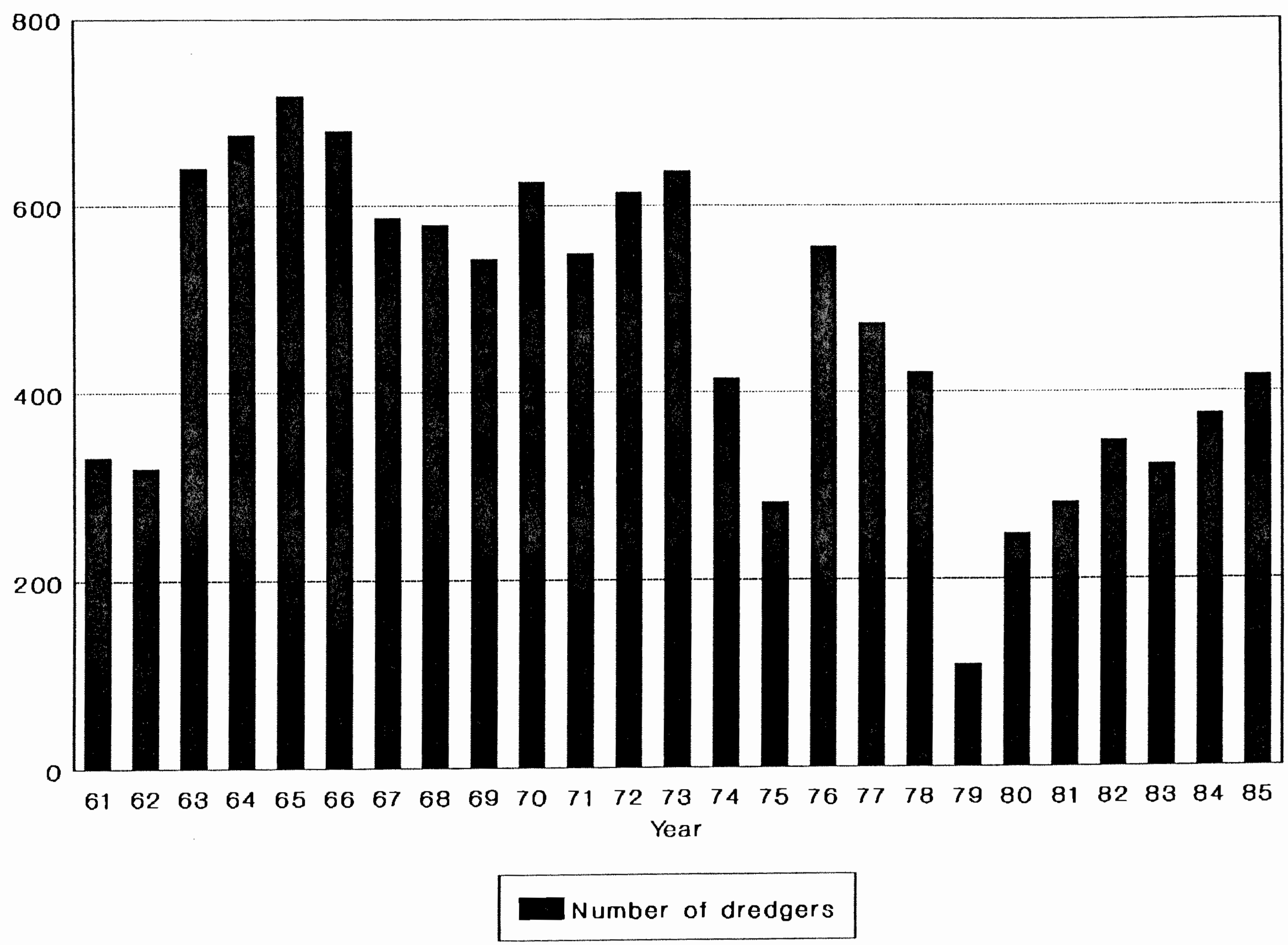

Figure 7.9b. Number of Texas coast oyster fishermen.

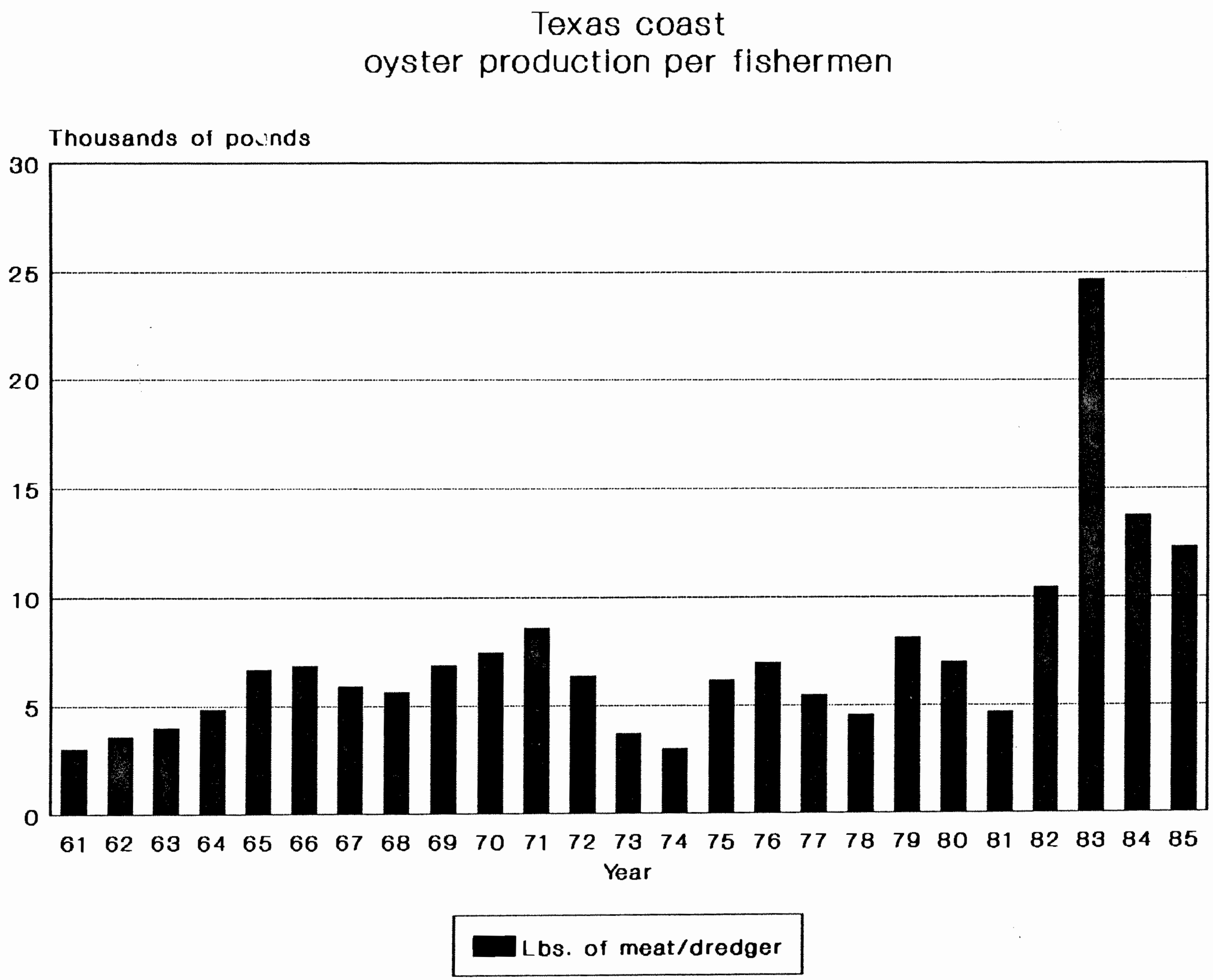

Figure 7.9c. Oyster production per fisherman, Texas.

7.4.1 Florida

The major public oyster producing areas in Florida are shown in Figure 7.10. They are numbered in order of importance to the overall oyster harvest from the Florida west coast.

By far, the most productive area is Apalachicola Bay which contributes approximately 80%-95% of the average annual harvest for Florida. The Suwanee Sound area is the second largest supplier, followed by Apalachee Bay, the estuarine areas of Bay County and smaller contributions from Walton, Okaloosa and Santa Rosa counties.

7.4.2 Alabama

Figure 7.11 shows the major public oyster producing areas of Alabama. The Cedar Point Reef has produced the greatest amount of oysters on an annual basis for the past 10 years in Alabama. The Kings Bayou and Buoy reefs have been the second largest producing areas for the state followed by Portersville Bay and Whitehouse Reef, respectively. Recently, Portersville Bay production has been confined to private leases.

7.4.3 Mississippi

In Mississippi, a large expanse of very old reefs in the western portion of Mississippi Sound has traditionally produced the greatest amount of oysters for the state. This area, termed "Square Handkerchief," is composed of Henderson Point, Pass Christian and Pass Marrianne oyster reefs (Figure 7.12).

The St. Joe Dredging Reef is the second most important producer, followed by the small tonging reefs of St. Stanislaus/Waveland, Graveline Bayou and Bayou Cumbest, respectively.

7.4.4 Louisiana

Louisiana has by far the largest amount of oyster producing area in the Gulf States with approximately 4 million water acres within its estuarine zone. Within this acreage, the state has been divided into two areas: (1) those areas from which a citizen can lease waterbottom and (2) those waterbottoms set aside for public seed production and commercial harvest. An estimated 340,000 acres are currently under lease.

The majority of public oyster grounds are located east of the Mississippi River in Plaquemines and St. Bernard parishes (Figure 7.13); however, because of increasing salinities in recent years, production in this area is presently limited primarily to the reef areas of Plaquemines Parish. Another major public area is located in the central portion of the state in the Vermilion/Atchafalaya Bay complex. This area is highly influenced by freshets from the Atchafalaya River system, and production is sporadic. The other major public access area is the Calcasieu/Sabine Lake tonging reef. This area is limited in reef acreage and has been subjected to numerous closures due to public health concerns. There are three remaining areas referred to as "oyster seed reservations." These are small in size but contribute to overall production from the public grounds.

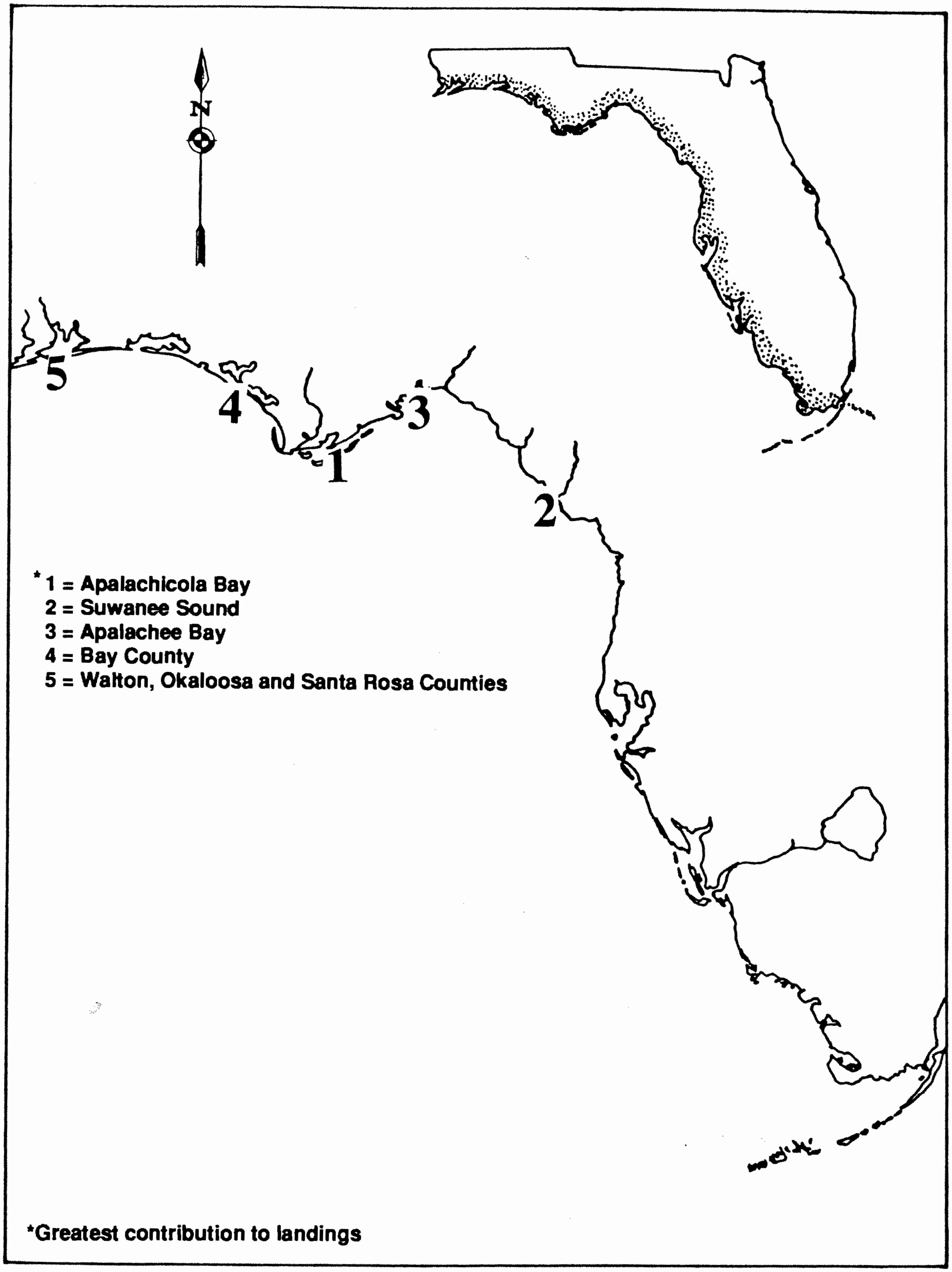

Figure 7.10. Major oyster producing areas in order of contribution to total landings, Florida west coast.

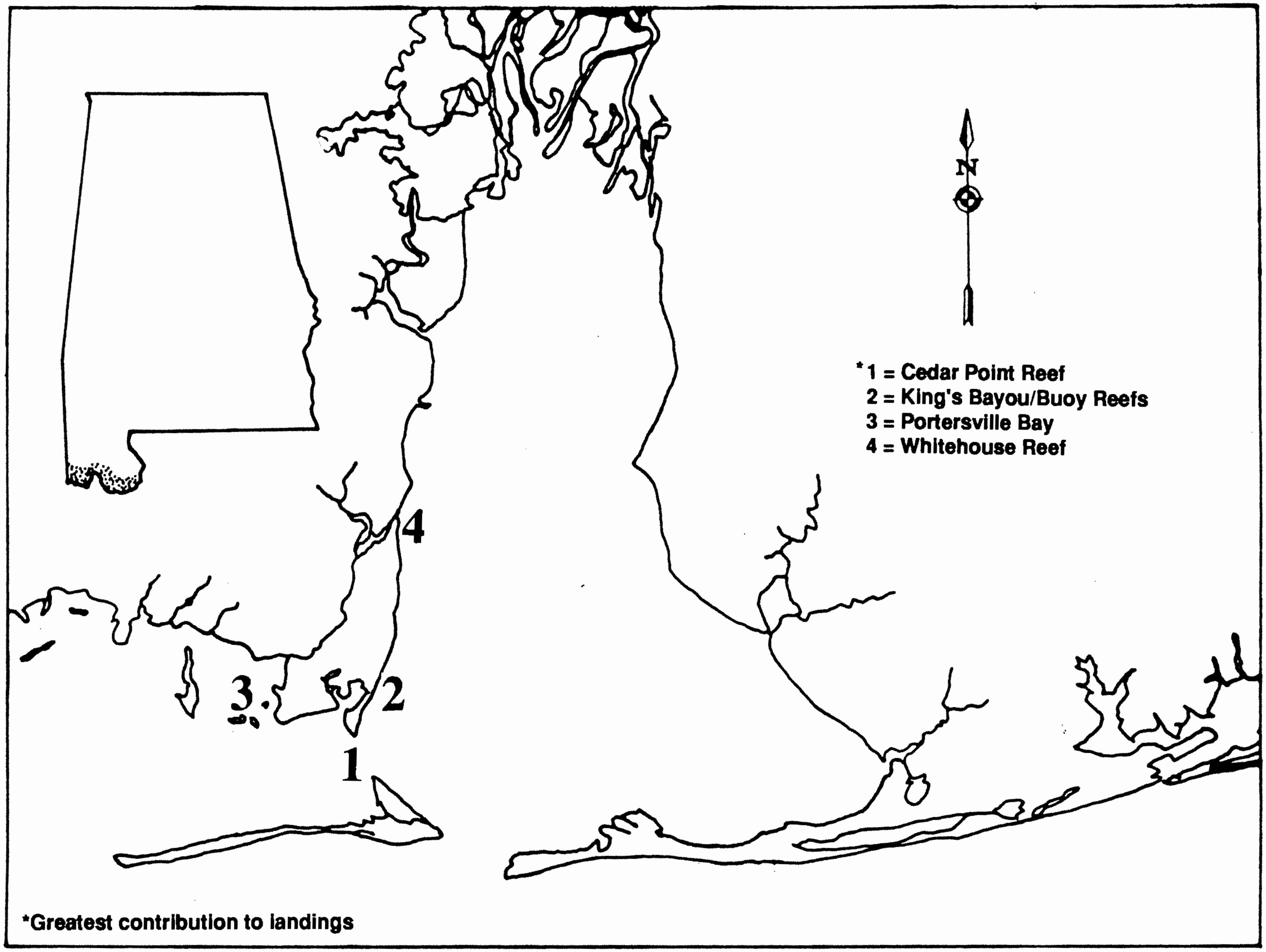

Figure 7.11. Major oyster producing areas in order of contribution to total landings, Alabama.

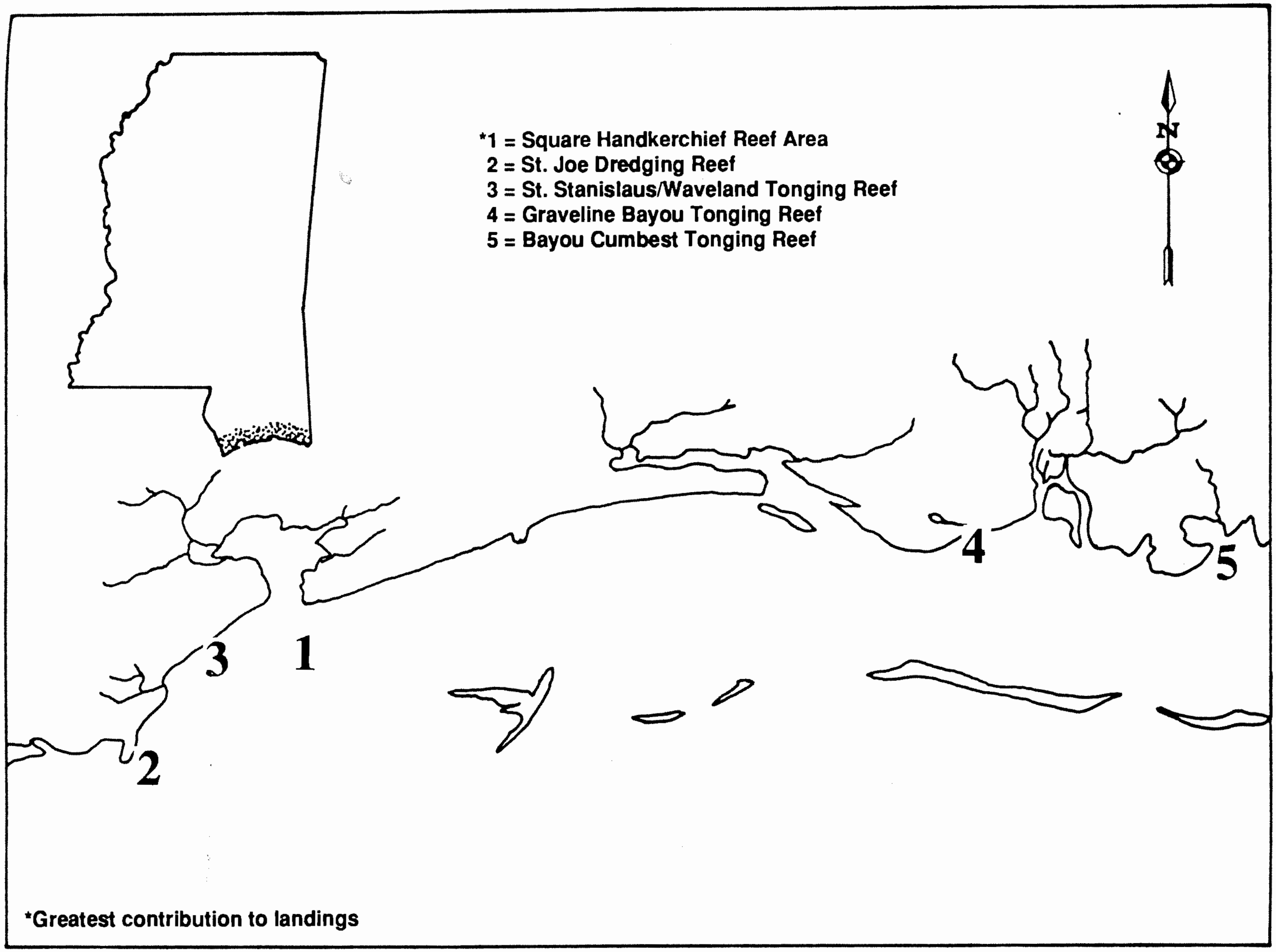

Figure 7.12. Major oyster producing areas in order of contribution to total landings, Mississippi.

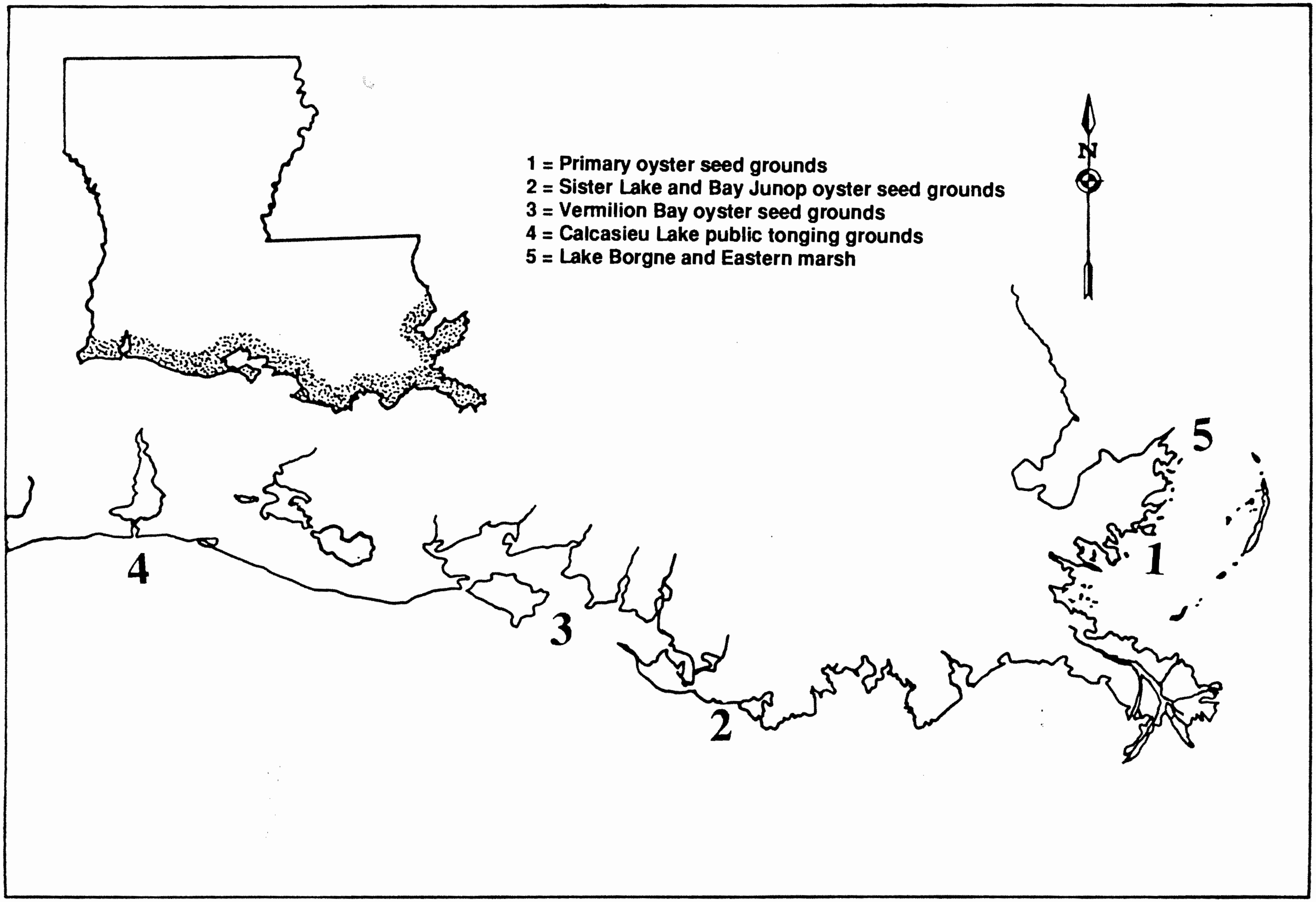

Figure 7.13. Major oyster producing areas in order of contribution to total landings, Louisiana.

7.4.5 Texas

Since 1972, Galveston Bay has accounted for approximately 70% of the coastwide Eastern oyster landings in Texas (Figure 7.14). The San Antonio, Matagorda and Aransas bay systems combined have produced approximately 25%. The only commercially harvestable reefs below Nueces Bay occur in South Bay; however, these reefs account for less than 1% of the total commercial landings. Within Galveston Bay, four areas account for most of the commercial landings. Redfish Bar produces about 75%, Todd's Reef about 10%, East and West bays about 5%-10%, respectively (Hofstetter 1988).

7.5 Description of Leases

7.5.1 Florida

Granting sovereignty lands for the production of oysters has a rather long history in Florida; laws permitting oyster grants were passed by the Florida Legislature in 1881. A comprehensive leasing program was initiated in 1913 when the Florida Shellfish Commission was organized (Whitfield and Beaumariage 1977). Since 1933, the power to grant leases has been held by the FDNR and its predecessor, the Board of Conservation. Currently, authority to lease state-owned lands from the FDNR rests with the Governor and Cabinet sitting as the Board of Trustees of the Internal Improvement Trust Fund.

Two types of leases currently exist in Florida: (1) shellfish leases; and (2) aquaculture leases. Shellfish leases are held under the provisions of Chapter 370, Florida Statutes, but no new leases have been issued under this program since 1985. Leasing submerged lands for aquacultural purposes is presently authorized under the provisions of Chapter 253, Florida Statutes, and subsections 18-21, Florida Administrative Code.

In 1989, there were 156 shellfish leases and 6 aquaculture leases totalling approximately 2,100 acres. Leasing activity is concentrated on Florida's east coast; only 20 shellfish leases totalling 800 acres are located on the gulf coast (Figure 7.15). Among these, 10 active shellfish leases (656 acres) are located in the Apalachicola Bay system. Oysters harvested from leases during 1988 and 1989 accounted for less than 5% of Florida's reported landings.

The FDNR has entered into management agreements providing submerged state lands for oyster aquaculture demonstration programs. These programs, located in Suwannee Sound, Cedar Keys and Apalachicola Bay, provide comprehensive aquacultural training and a progressive step toward expanded aquaculture leasing in the state.

7.5.2 Alabama

At present in Alabama there are no oyster leases on state regulated bottom. There are some 25 oyster leases in existence on riparian bottoms along the northern shore of the Mississippi Sound (Figure 7.16). Most of these leases are recent, and few have reached the production stage. Two lease areas produced oysters in 1989, and their harvest exceeded that reported from the public reefs.

The size of these riparian leases varies according to the amount of waterfront property an individual owns. The riparian rights extend 600 yards from the shoreline.

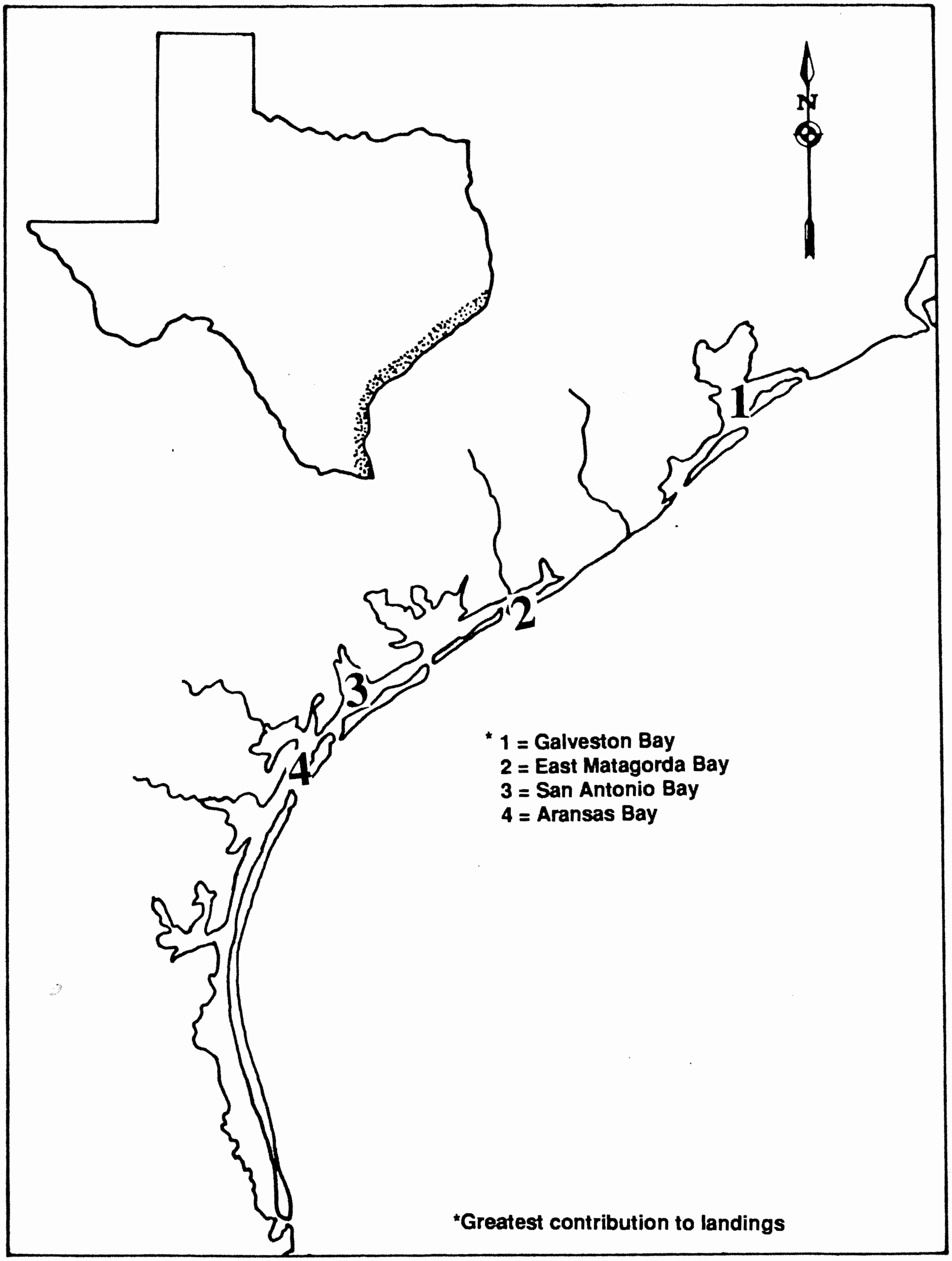

Figure 7.14. Major oyster producing areas in order of contribution to total landings, Texas.

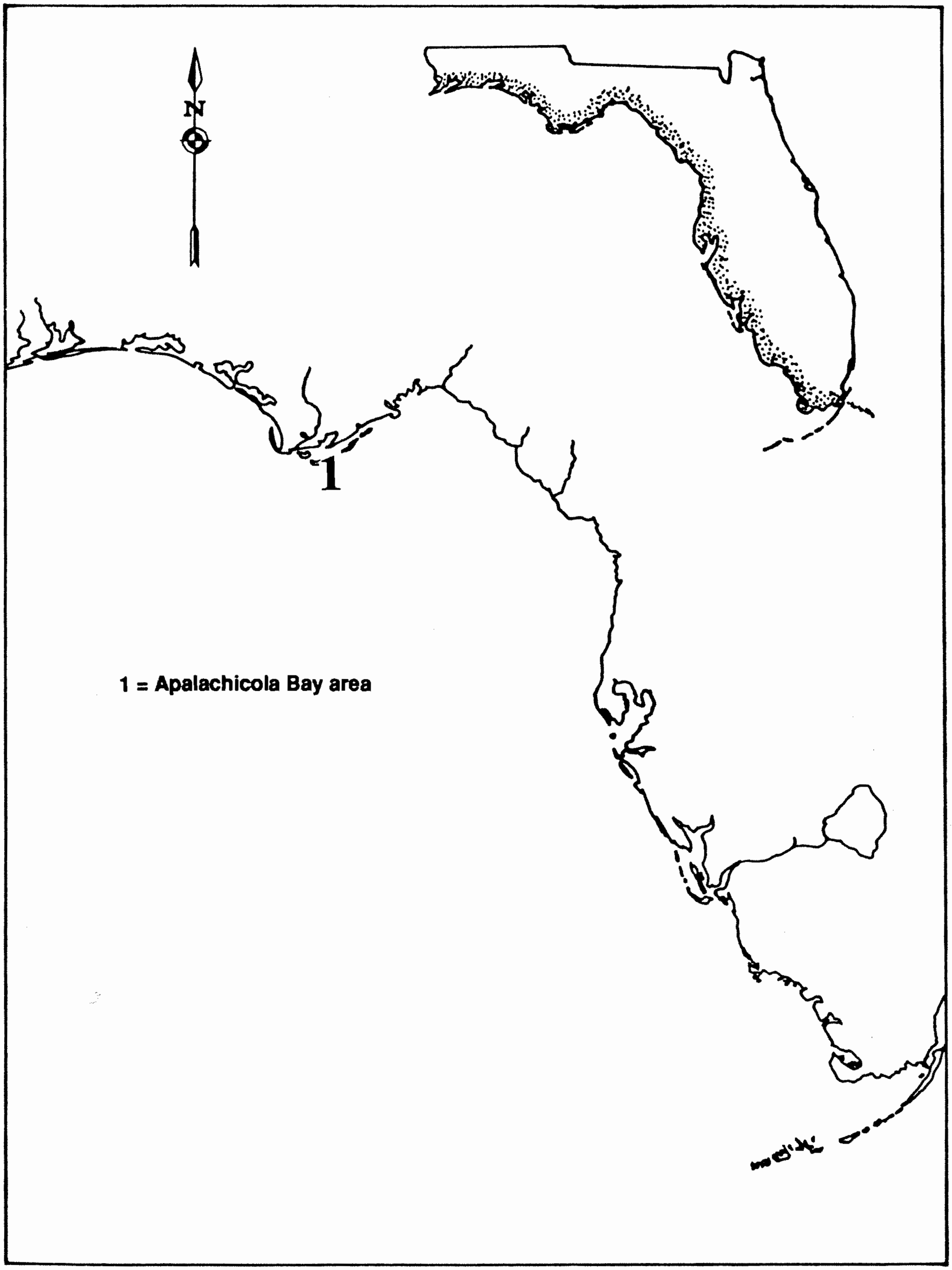

Figure 7.15. Major oyster lease areas, Florida.

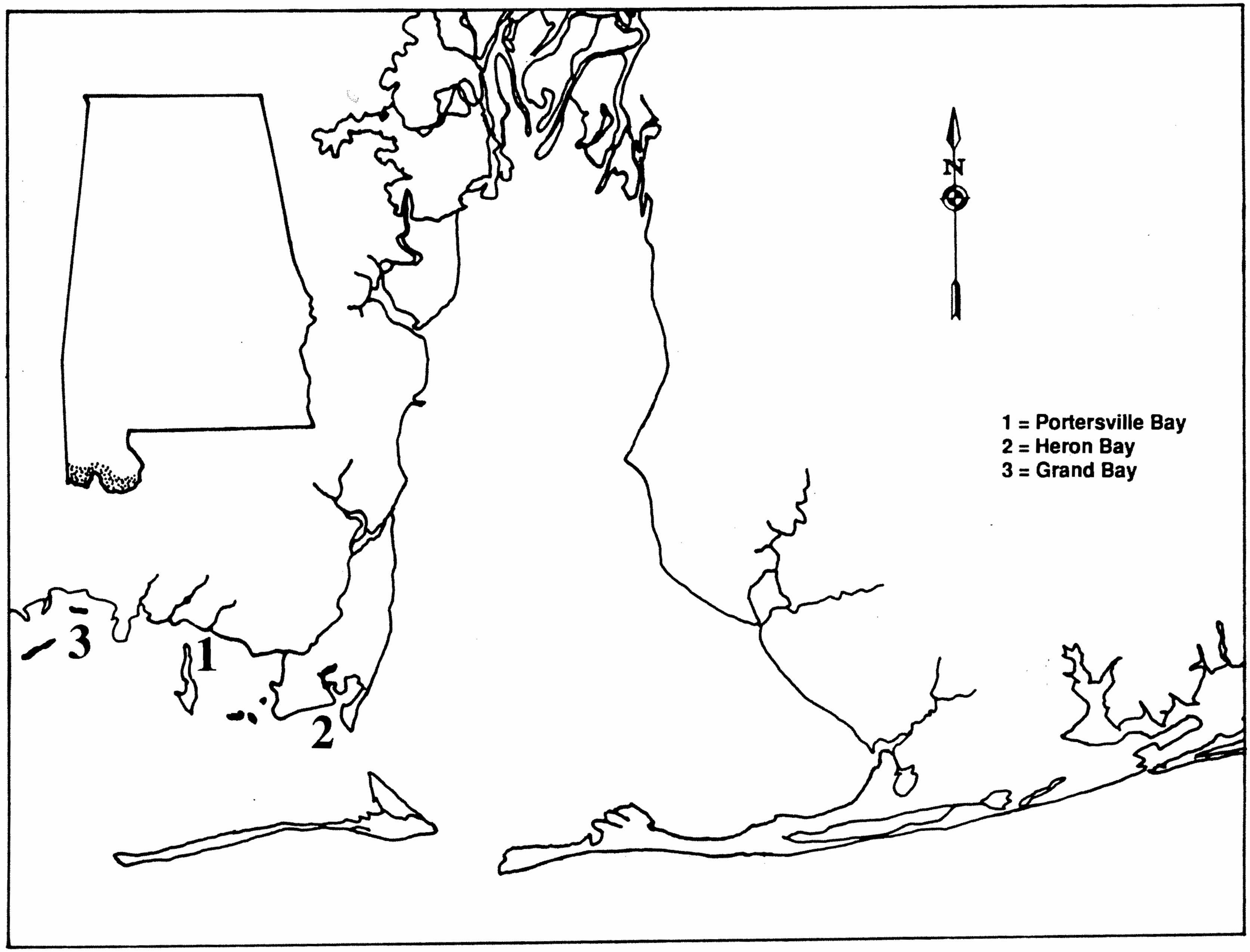

Figure 7.16. Major oyster lease areas, Alabama.

7.5.3 Mississippi

There was very little interest in leasing in Mississippi prior to 1977. At that time, the Mississippi Legislature enacted laws to allow lessees under bond to relay oysters from public reefs that had been permanently closed due to sewage contamination. This action sparked interest in leasing, and by 1979 over fifty leases were approved.

Relaying efforts began in mid-1977, and by 1980 most of these closed areas had been virtually depleted of marketable oysters. The amount of relaying continued to decline throughout the 1980s, and no relaying by lessees was conducted in 1989 or 1990.

The number of active leases has also declined. The majority of active leases are currently located in the western portion of Mississippi Sound where some growth is occurring without the reliance on relayed oysters (Figure 7.17)

7.5.4 Louisiana

In Louisiana, over 2,000 people hold more than 9,000 individual, active leases encompassing approximately 340,000 acres of state waterbottoms. These leases are issued for 15 year periods. The average size of a lease is approximately 36 acres. The majority of the leases are located in the eastern half of the state (Figure 7.18); while others are located in the central parishes of Terrebonne, Iberia and St. Mary. No leases are located west of the Vermilion Bay complex; however, one lease is located south of Vermilion Bay, 7 miles offshore.

The LDWF has a survey crew to perform lease surveys, and the department is compensated for services in the form of survey fees or application fees. However, a lease applicant has the prerogative to obtain his own surveyor, and the department only charges an administrative fee. Additionally, an annual rental fee of $2.00 per acre must be paid to the LDWF.

In addition to surveying and resurveying leases, an ongoing project is nearly completed that will establish geographic markers in the marshes of Louisiana adjacent to oyster producing waterbottoms. As a result, future survey work will be more accurate and accomplished in a shorter time span. Up-to-date maps of the coast that indicate the location of all leases and lease applications are maintained for the use of the department, lessees and other interested parties.

7.5.5 Texas

In Texas, approximately 10% of the commercially landed oysters are harvested from private leases, all of which occur in the Galveston Bay system (Figure 7.19). Transplantation from public reefs accounts for most of the private lease landings; however, a small percentage is located in restricted waters due to natural setting (Quast et al. 1988). Currently there are 43 private leases in Galveston and East Galveston bays accounting for approximately 2,356 acres of bay bottoms. The average size of each lease is about 54 acres. None of the leases granted in other bay systems has been successful, and thus have been returned to the state. The amount of suitable bay bottom and transplantable oysters is limited, mostly occurring in the Galveston Bay system.

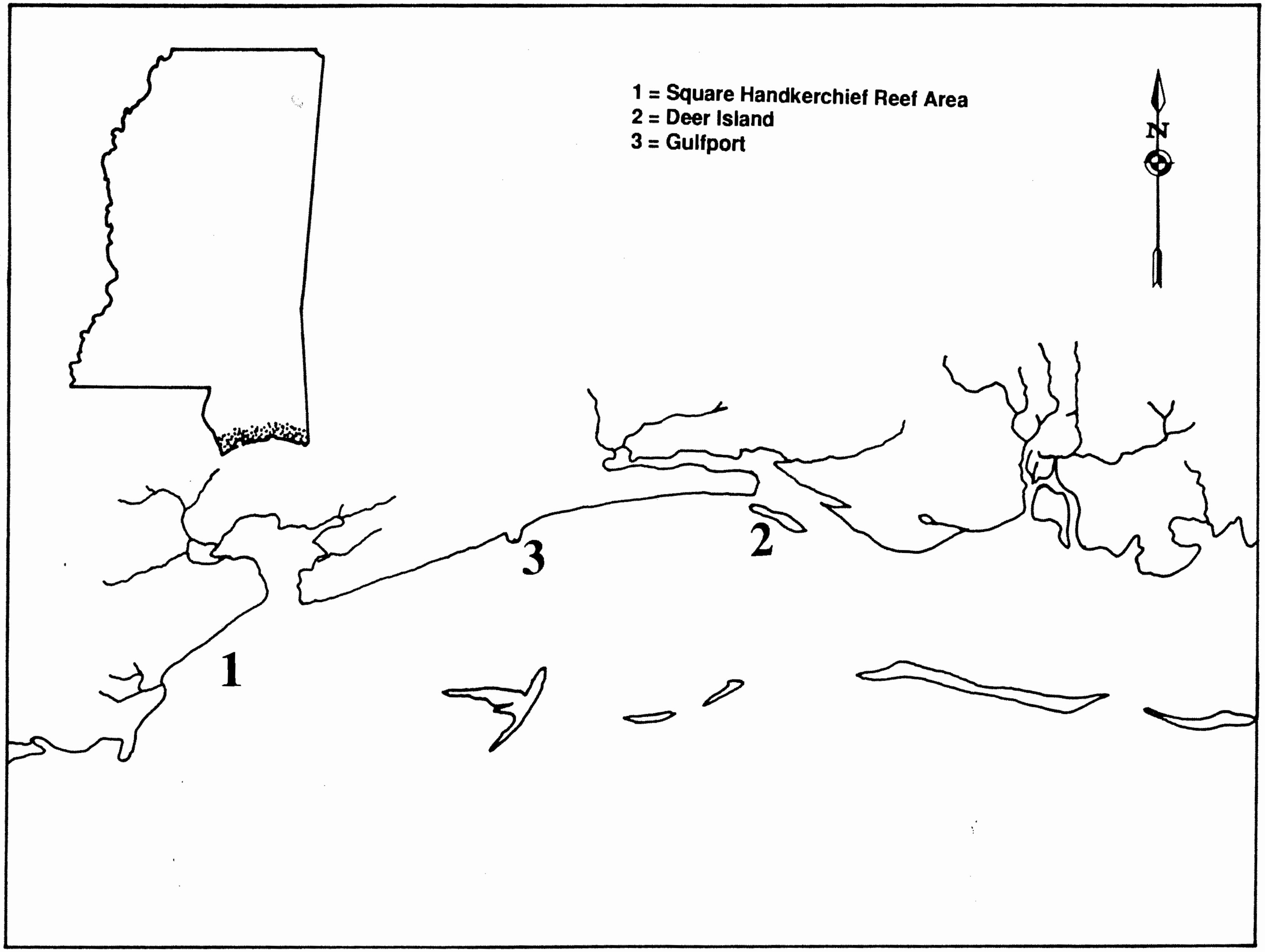

Figure 7.17. Major oyster lease areas, Mississippi.

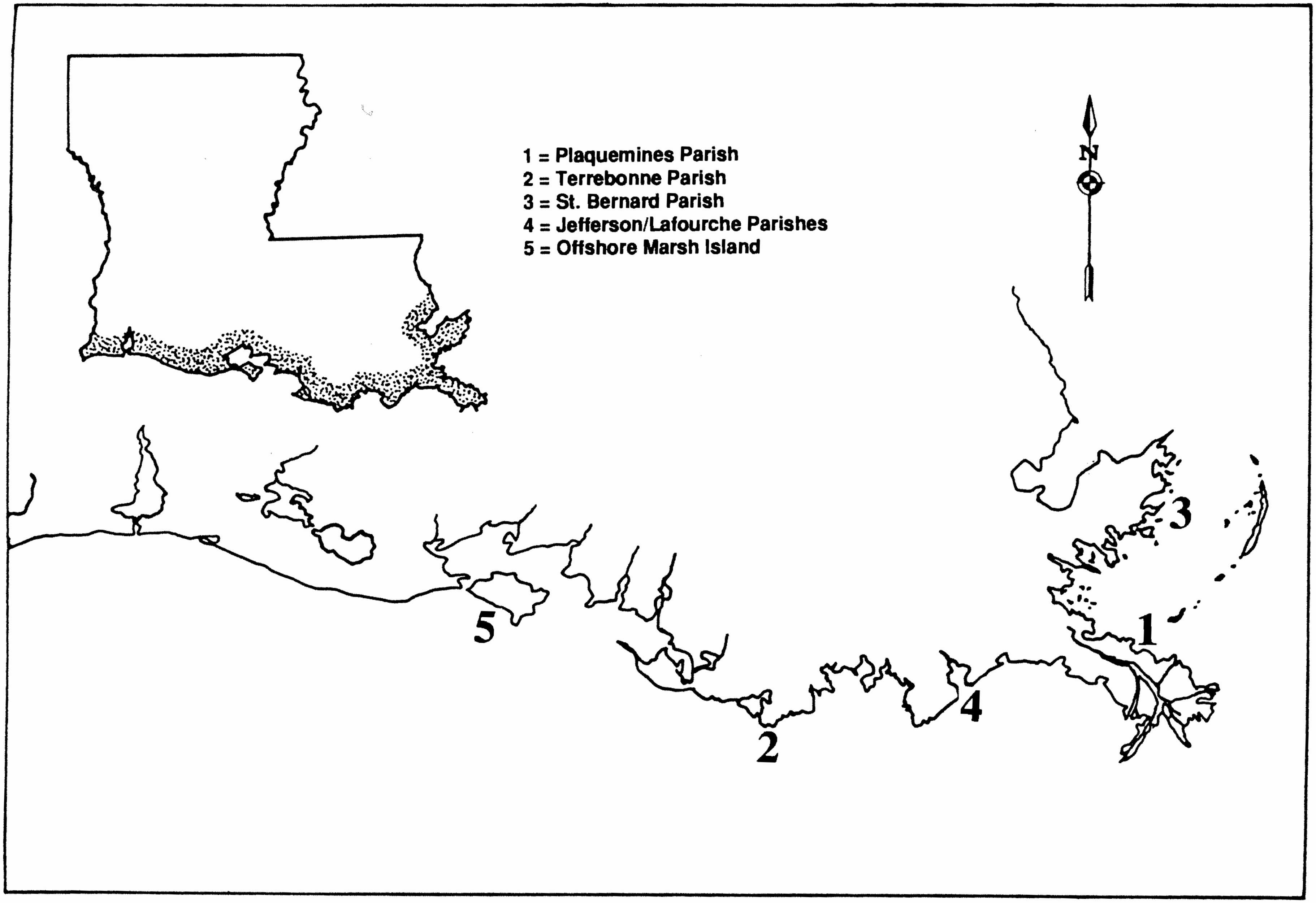

Figure 7.18. Major oyster lease areas, Louisiana.

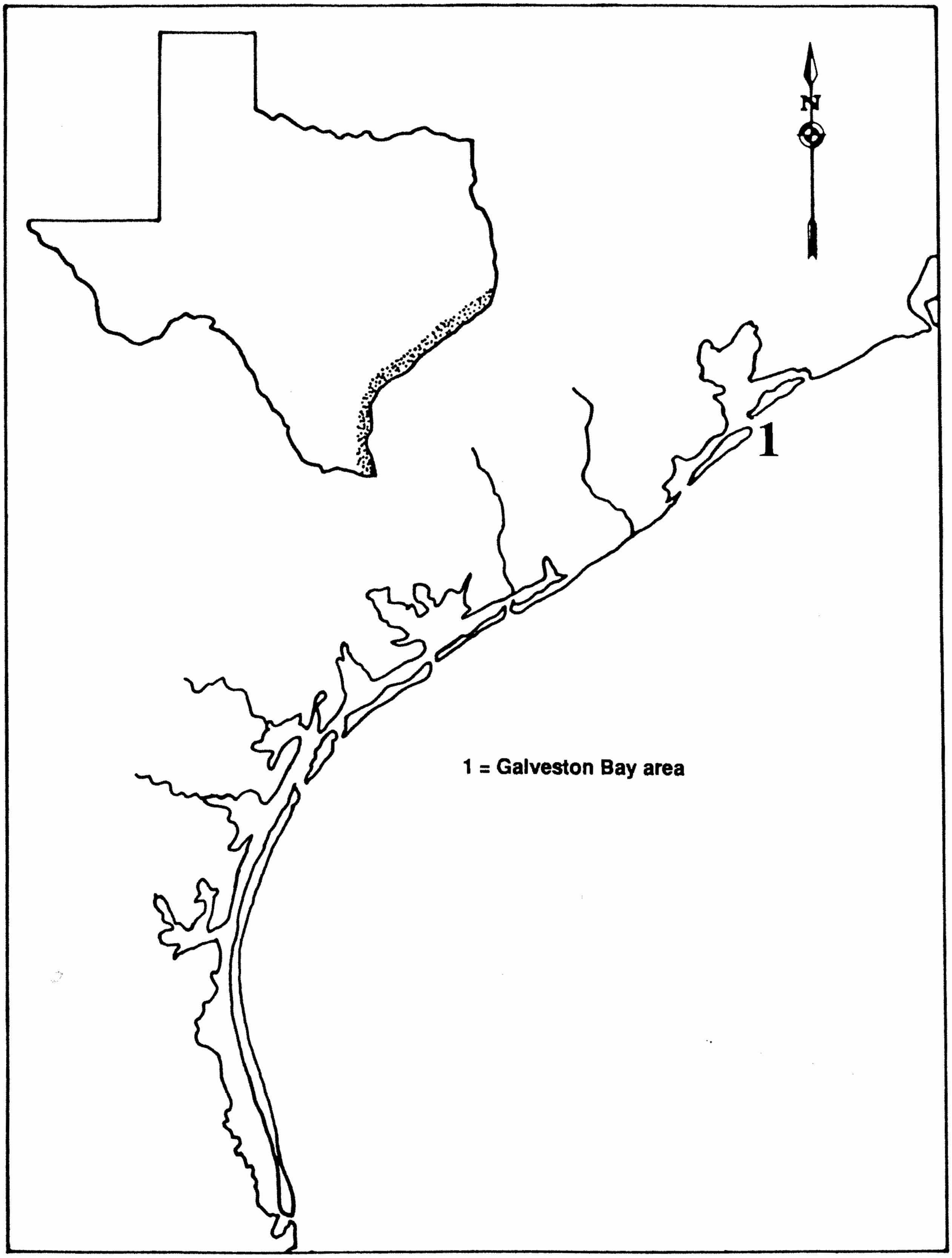

Figure 7.19. Major oyster lease areas, Texas.

8.0 DESCRIPTION OF ECONOMIC CHARACTERISTICS

8.1 Commercial Oyster Fishery

The oyster fishery is one of the largest components of the nation's seafood industry and involves 18 of the 21 coastal states (Dressel et al. 1983). It is also one of the most valuable fisheries in the U.S. The nation's 1988 oyster production was valued at $78.5 million, which represents about 2.3% of the $3.36 billion U.S. commercial edible seafood industry. On a per pound basis, the 1988 dockside price of oysters, almost $2.50, was exceeded by fewer than ten species.

8.1.1 Historical Production/Value of Oysters by Region and for the Entire United States

The dockside value of the U.S. oyster production increased significantly during 1960-1988 (Table 8.1). The 1986-1988 average annual value of $88.9 million, for instance, exceeded the 1976-1980 average value, $60.3 million, by almost 50% and was more than triple the 1961-1965 average value of $29.0 million. After peaking at $95.8 million in 1986, the value of U.S. oyster landings fell sharply in the past few years. Much of this recent decline, as indicated in Table 7.1, was related to the decline in production.

The increase in dockside value of U.S. oysters is primarily based on inflation. The annual values of oyster production during 1960-1988, after removing the effects of inflation, are given in Table 8.1. These values are referred to as real or deflated values and are indexed to the base year of 1967, i.e., 1967=100. The deflated values can be viewed as those that would be observed if consumer purchasing power had remained constant at the 1967 level.

When evaluated on a deflated basis, the dockside value of the U.S. oyster fishery exhibited little change during 1960-1988, other than a moderate decline during the 1980s which is in sharp contrast to the current increasing value of U.S. oyster production (Table 8.1). Overall, the deflated dockside value of U.S. oyster landings averaged about $26 million (1967 dollars) during 1986-1988 compared to about $30 million during 1976-1980 and almost $32 million during 1961-1965.

As with pounds landed, the Chesapeake Bay area ("Chesapeake") generally accounted for the largest portion of the total value of U.S. oyster production during the 1960s and 1970s. Its annual average 1961-1965 dockside value of $18.3 million (Table 8.1), for instance, represented almost 58% of the total value of U.S. oyster production during that period (Table 8.2). By comparison, the gulf contributed 20.8% to the nation's oyster supply by value during 1961-1965, while the Pacific contributed another 8.3% (Table 8.2) based on annual average landings valued at $2.4 million.

Similarly, the Chesapeake accounted for 51.3% of the nation's annual oyster supply by value during 1966-1970 (Table 8.2) with average annual landings valued at $15.2 million (Table 8.1). The gulf contributed another 27.5% of the nation's oyster supply by value with landings valued at $8.2 million, while the Pacific contributed 10.3% of the nation's oyster production based on average annual landings of $3.05 million.

Table 8.1. Historical value of oyster production in the United States by region, 1961-1988.

	Region									
	Gulf		Pacific		Chesapeake		Other[1]		Total	
Year	Current	Deflated[2]	Current	Deflated	Current	Deflated	Current	Deflated	Current	Deflated
1961	5,125	5,720	2,020	2,254	21,734	24,257	4,325	4,827	33,204	37,058
1962	5,898	6,510	2,628	2,901	15,956	17,611	4,657	5,140	29,139	32,162
1963	7,186	7,836	2,483	2,708	13,728	14,970	3,708	4,043	27,105	29,558
1964	6,273	6,752	2,645	2,847	15,806	17,014	3,202	3,447	27,926	30,060
1965	5,712	6,044	2,230	2,360	16,697	17,669	3,229	3,417	27,868	29,490
1961-1965 average	**6,039**	**6,572**	**2,401**	**2,614**	**16,784**	**18,304**	**3,824**	**4,175**	**29,048**	**31,666**
1966	6,493	6,680	2,745	2,824	14,543	14,962	3,592	3,695	27,373	28,161
1967	8,486	8,486	3,171	3,171	17,322	17,322	3,262	3,262	32,241	32,241
1968	10,274	9,860	3,001	2,880	15,260	14,645	3,475	3,335	32,010	30,720
1969	8,148	7,421	2,612	2,379	13,995	12,746	2,784	2,536	27,539	25,081
1970	7,542	6,485	3,722	3,200	15,080	12,966	3,141	2,701	29,485	25,352
1966-1970 average	**8,189**	**7,786**	**3,050**	**2,891**	**15,240**	**14,528**	**3,251**	**3,106**	**29,730**	**28,311**
1971	9,208	7,591	4,758	3,923	16,044	13,227	4,018	3,312	34,028	28,053
1972	9,756	7,786	6,345	5,064	15,317	12,224	5,648	4,508	37,066	29,582
1973	9,713	7,298	6,066	4,557	16,766	12,597	6,442	4,840	38,987	29,292
1974	9,797	6,633	6,048	4,095	17,552	11,884	7,448	5,043	40,845	27,654
1975	10,860	6,737	7,454	4,624	18,126	11,244	8,545	5,301	44,985	27,906
1971-1975 average	**9,867**	**7,209**	**6,134**	**4,453**	**16,761**	**12,235**	**6,420**	**4,601**	**39,182**	**28,497**
1976	16,127	9,459	8,362	4,904	21,748	12,755	8,126	4,766	54,363	31,884
1977	19,027	10,483	10,648	5,867	19,934	10,983	7,859	4,330	57,468	31,663
1978[3]	20,450	10,471	5,869	3,005	24,865	12,732	9,503	4,866	60,687	31,074
1979	17,838	8,205	6,879	3,164	26,983	12,412	10,042	4,619	61,742	28,400
1980	20,139	8,160	5,608	2,272	29,323	11,881	11,956	8,844	67,027	27,158
1976-1980 average	**18,716**	**9,356**	**7,473**	**3,842**	**24,571**	**12,153**	**9,497**	**4,685**	**60,257**	**30,036**
1981	27,846	10,222	4,540	1,667	29,297	10,755	13,138	4,823	74,821	27,467
1982	31,509	10,899	6,177	2,137	25,768	8,913	15,366	5,315	78,820	27,264
1983	37,554	12,582	6,018	2,017	19,833	6,646	13,104	4,391	76,509	25,640
1984	43,319	13,924	8,562	2,752	26,201	8,422	16,798	5,400	94,879	30,498
1985	40,892	12,839	8,820	2,769	22,797	7,157	9,646	3,028	82,155	25,794
1981-1985 average	**36,224**	**12,093**	**6,823**	**2,268**	**24,779**	**8,379**	**13,610**	**4,591**	**81,437**	**27,333**
1986	42,059	12,807	13,058	3,976	29,123	8,868	11,598	3,532	95,838	29,183
1987	46,035	13,524	14,098	4,142	22,630	6,648	9,660	2,838	92,423	27,151
1988	39,911	11,265	14,553	4,107	14,161	3,997	9,873	2,786	78,498	22,156
1986-1988 average	**42,668**	**12,532**	**13,903**	**4,075**	**21,971**	**6,504**	**10,377**	**3,052**	**88,920**	**26,163**

[1] Other includes the coastal states in the South Atlantic, Mid Atlantic and New England regions.

[2] The deflated value is derived by dividing the current value by the Consumer Price Index (1967 is the base year and equals 100).

[3] Data from 1978 through 1988 are considered preliminary by the National Marine Fisheries Service.

Source: Compiled from data contained in Fisheries Statistics of the United States (1961-1977 issues) and Fisheries of the United States (1978-1988 issues).

Table 8.2. Percentage contribution of the value of oyster production by region to the U.S. total, 1961-1988 selected time periods.

Time Period	Region: Gulf	Pacific	Chesapeake	Other	Total[1]
	%				
1961-1965 average	20.8	8.3	57.8	13.2	100.0
1966-1970 average	27.5	10.3	51.3	10.9	100.0
1971-1975 average	25.2	15.7	42.8	16.4	100.0
1976-1980 average	31.1	12.4	40.8	15.8	100.0
1981-1985 average	44.5	8.4	30.4	16.7	100.0
1986-1988 average	48.0	15.6	24.7	11.7	100.0

Source: Compiled from data in Table 8.3
[1] Summation across regions may not equal 100.0 due to rounding.

As indicated in Tables 8.1 and 8.2, the Chesapeake contribution to the U.S. dockside oyster value has been shrinking since the 1960s, while the gulf's contribution has been expanding. By the early 1980s, the gulf had surpassed the Chesapeake in terms of relative shares of the U.S. oyster production by value. Furthermore, the gulf's share of the total continued to expand throughout the decade of the 1980s (Table 8.1).

The increasing contribution of the gulf to the total dockside value of the U.S. oyster industry is the result of two factors: (1) the gulf's share of the total U.S. oyster poundage has expanded, especially during the 1980s (Tables 7.1 and 7.2); and (2) the average price per pound for gulf-produced oysters has increased relative to the prices observed in the Chesapeake and for the nation, especially during the 1960s and 1970s.

Historical Chesapeake oyster prices and relative movements have differed significantly from those observed in the gulf. For example, Chesapeake oyster prices during 1961-1965 averaged more than twice those observed for the gulf and were more than 50% higher during 1966-1970. Unlike gulf oyster prices, oyster prices in the Chesapeake have exhibited downward movement during much of the historical data base. For instance, the deflated oyster price per pound in the Chesapeake during 1981-1985 (averaging \$0.54 per pound) was one third lower than that observed during 1961-1965 (\$0.84). By contrast, the deflated price in the gulf during 1981-1985 (averaging \$0.47 per pound) was significantly higher than that observed during 1961-1965 (\$0.32).

Changes in relative dockside prices are indicated in Table 8.3. The 1961-1965 average gulf price equalled only 58% of that for the national average and only about 40% of the Chesapeake average. The gulf price as a percent of the U.S. average increased throughout 1961-1988; however, the Chesapeake price fell sharply until the mid-1970s after which it increased slightly. By 1986-1988, the gulf average dockside price equalled that observed for the nation and was only about 8% less than that observed for the Chesapeake.

An increasing relative price per pound in conjunction with increasing relative production has resulted in the gulf contributing an ever increasing share of the nation's oyster production by value. Equalling almost 50% of the nation's oyster supply by value during 1986-1988, there is little indication that the gulf's share will decline in the foreseeable future.

8.1.2 Historical Production/Value of Oysters for the Gulf of Mexico

With some exceptions, the current value of oyster harvest in the gulf increased steadily from 1960 to 1988 (Table 8.1). The 1986-1988 average annual value of harvest, $42.7 million, was more than twice the 1976-1980 average annual value of harvest, $18.7 million, and more than seven times the 1961-1965 average annual harvest of $6.0 million. Exceptionally large dockside value increases were observed between 1971-1975 and 1976-1980 and also between 1976-1980 and 1981-1985 wherein value approximately doubled during each successive 5 year period.

Table 8.3. Regional dockside oyster prices as a percentage of the U.S. average price, 1961-1988 selected time periods.

	Region				
Time Period	Gulf	Pacific	Chesapeake	Other	U.S. average
	---% of U.S. average---				
1961-1965 average	58%	48%	154%	130%	100%
1966-1970 average	75%	75%	123%	147%	100%
1971-1975 average	77%	123%	93%	175%	100%
1976-1980 average	89%	92%	99%	147%	100%
1981-1985 average	93%	60%	107%	165%	100%
1986-1988 average	101%	69%	109%	168%	100%

Source: Compiled from data in Table 8.5.

In contrast to that observed for the U.S., the gulf (in total) has experienced a significant increase in the real, or deflated, dockside value of its oyster landings (Table 8.1). The annual 1986-1988 gulf, deflated dockside value ($12.5 million) exceeded figures for 1976-1980 ($9.4 million) by 35% and figures for 1961-1965 ($6.6 million) by about 90%.

As indicated in Table 8.4, the gulf oyster price per pound has exhibited an upward trend when evaluated on either a current or deflated basis. In current terms, the gulf price increased from an average of $0.29 per pound during 1961-1965 to $2.24 per pound during 1986-1988. Expressed in constant 1967 dollars, the gulf price per pound doubled between 1961-1965 and 1986-1988, from $0.32 to $0.66. Though the deflated gulf price during 1981-1985 was slightly below that observed during the previous 5 year period, much of this decline was probably in response to the sharp increase in production during 1981-1985 as indicated by the data contained in Table 7.1.

Economic oyster statistics for the Gulf of Mexico are presented by state in Tables 8.5 and 8.6. Specifically, value of production and price statistics are provided.

8.1.2.1 <u>Florida</u>

The current value of Florida's oyster landings, averaging $3.05 million annually during 1961-1988, has generally increased (Table 8.5). The 1981-1985 average annual value of $5.8 million was almost four times the 1971-1975 average annual value of $1.46 million and almost six times the 1961-1965 average annual value of $1.08 million. Much of the increased value during 1981-1985 represented increased landings as indicated in Table 7.3.

The deflated or real value of Florida's oyster landings has exhibited relatively little long-term growth (Table 8.5). For example, the 1986-1988 average annual deflated value of $1.47 million was almost identical to the 1961-1988 average annual deflated value of $1.52 million and about 25% above the $1.17 million annual deflated value reported during the early 1960s. The real value of Florida's oyster landings peaked in the late 1970s and early 1980s in conjunction with maximum landings.

The increasing price per pound for Florida oysters has largely been based on inflation (Table 8.6). Except for abnormally low landings in 1986-1988, only a moderate increase in the price of Florida oysters has been exhibited when the effects of inflation have been removed, i.e., price has been put on a deflated basis. The average deflated price per pound during the 1970s (about $0.38) exceeded the average price per pound during the 1960s ($0.33) by about 15%. In response to increased production in Florida and throughout the gulf, the deflated price fell significantly in the early 1980s before rising to a high of $0.67 during 1986-1988. This most recent increase probably reflected the sharp decline in production.

8.1.2.2 <u>Alabama</u>

With the exception of a sharp decline during the most recent 3 year period, the current value of Alabama's oyster production generally increased (Table 8.6). On a deflated basis, however, no increase in the value of Alabama oyster landings was evident during 1961-1988.

Table 8.4. Current and deflated dockside oyster prices by region, 1961-1988.

	Region									
	Gulf		Pacific		Chesapeake		Other		Total	
Year	Current	Deflated[1]	Current	Deflated	Current	Deflated	Current	Deflated	Current	Deflated
1961	0.28	0.31	0.20	0.22	0.79	0.88	0.68	0.76	0.53	0.59
1961	0.31	0.35	0.24	0.27	0.80	0.88	0.72	0.79	0.52	0.57
1963	0.30	0.33	0.25	0.28	0.75	0.82	0.59	0.65	0.46	0.51
1964	0.27	0.29	0.27	0.29	0.72	0.77	0.63	0.68	0.46	0.50
1965	0.30	0.32	0.27	0.26	0.79	0.83	0.62	0.66	0.51	0.54
1961-1965 average	**0.29**	**0.32**	**0.24**	**0.26**	**0.77**	**0.84**	**0.65**	**0.71**	**0.50**	**0.54**
1966	0.38	0.39	0.35	0.36	0.68	0.70	0.72	0.74	0.53	0.55
1967	0.39	0.39	0.41	0.41	0.67	0.67	0.70	0.70	0.54	0.54
1968	0.38	0.36	0.39	0.37	0.67	0.64	0.74	0.71	0.52	0.50
1969	0.41	0.37	0.37	0.34	0.63	0.57	0.84	0.77	0.53	0.48
1970	0.43	0.37	0.47	0.40	0.61	0.52	0.97	0.83	0.55	0.47
1966-1979 average	**0.40**	**0.38**	**0.40**	**0.38**	**0.65**	**0.62**	**0.78**	**0.74**	**0.53**	**0.51**
1971	0.45	0.37	0.59	0.48	0.63	0.52	1.00	0.83	0.59	0.48
1972	0.53	0.43	0.76	0.60	0.64	0.51	1.06	0.85	0.66	0.53
1973	0.65	0.49	0.92	0.69	0.66	0.50	1.28	0.96	0.75	0.56
1974	0.66	0.45	1.20	0.81	0.70	0.47	1.43	0.97	0.81	0.55
1975	0.56	0.35	1.28	0.79	0.80	0.50	1.57	0.97	0.85	0.52
1971-1975 average	**0.56**	**0.41**	**0.90**	**0.65**	**0.68**	**0.50**	**1.28**	**0.92**	**0.73**	**0.53**
1976	0.75	0.44	1.31	0.77	1.04	0.61	1.49	0.87	1.00	0.59
1977	0.97	0.53	1.47	0.81	1.11	0.61	1.52	0.84	1.15	0.63
1978[2]	1.08	0.55	0.83	0.43	1.11	0.57	1.68	0.86	1.12	0.57
1979	1.15	0.53	0.92	0.42	1.24	0.57	1.75	0.80	1.23	0.56
1980	1.30	0.53	0.84	0.34	1.29	0.52	2.05	0.83	1.32	0.53
1976-1980 average	**1.03**	**0.51**	**1.07**	**0.55**	**1.16**	**0.57**	**1.70**	**0.84**	**1.16**	**0.58**
1981	1.44	0.53	0.76	0.28	1.36	0.50	2.33	0.86	1.42	0.52
1982	1.25	0.43	0.84	0.29	1.47	0.51	2.50	0.86	1.40	0.49
1983	1.29	0.43	0.82	0.27	1.70	0.57	2.22	0.74	1.42	0.47
1984	1.57	0.50	0.98	0.31	2.12	0.68	2.77	0.89	1.73	0.56
1985	1.54	0.48	1.13	0.36	1.74	0.55	2.79	0.88	1.61	0.51
1981-1985 average	**1.42**	**0.47**	**0.92**	**0.30**	**1.62**	**0.55**	**2.50**	**0.84**	**1.52**	**0.51**
1986	1.87	0.57	1.36	0.41	2.12	0.65	4.06	1.24	1.97	0.60
1987	2.50	0.74	1.43	0.42	2.59	0.76	3.40	1.00	2.32	0.68
1988	2.45	0.69	1.82	0.51	2.84	0.80	3.71	1.05	2.46	0.69
1986-1988 average	**2.24**	**0.66**	**1.52**	**0.45**	**2.40**	**0.71**	**3.73**	**1.10**	**2.21**	**0.65**

[1]The deflated value is derived by dividing the current value by the Consumer Price Index (1967 is the base year and equals 100).
[2]Data from 1978 through 1988 are considered preliminary by the National Marine Fisheries Service.
Source: Compiled from data in Tables 8.1 and 8.3.

Table 8.5. Historical value of oyster production among Gulf States, 1961-1988.

	State											
	Florida		Alabama		Mississippi		Louisiana		Texas		Total	
Year	Current	Deflated[1]	Current	Deflated	Current	Deflated	Current	Deflated	Current	Delfated	Current	Deflated
	$1,000s											
1961	1,032	1,152	162	181	753	840	2,849	3,180	329	367	5,125	5,720
1962	1,407	1,553	164	181	537	593	3,317	3,661	473	522	5,898	6,510
1963	1,225	1,336	352	384	975	1,063	3,721	4,058	913	996	7,186	7,836
1964	781	841	324	349	1,099	1,183	2,976	3,203	1,093	1,177	6,273	6,752
1965	938	993	207	219	627	663	2,402	2,542	1,538	1,628	5,712	6,044
1961-1965 average	**1,077**	**1,175**	**242**	**263**	**798**	**868**	**3,053**	**3,329**	**869**	**938**	**6,039**	**6,572**
1966	1,296	1,333	607	624	597	614	2,156	2,218	1,837	1,890	6,493	6,680
1967	1,427	1,427	1,008	1,008	1,066	1,066	3,414	3,414	1,571	1,571	8,486	8,486
1968	1,745	1,683	608	583	1,163	1,116	5,305	5,091	1,444	1,386	10,274	9,860
1969	1,851	1,686	251	229	552	503	3,969	3,615	1,525	1,389	8,148	7,421
1970	1,475	1,268	158	136	238	205	3,631	3,122	2,040	1,754	7,542	6,485
1966-1970 average	**1,561**	**1,479**	**526**	**516**	**711**	**701**	**3,695**	**3,492**	**1,683**	**1,598**	**8,189**	**7,786**
1971	1,568	1,293	151	124	473	390	4,638	3,824	2,378	1,960	9,208	7,591
1972	1,510	1,205	701	559	581	464	4,457	3,557	2,507	2,001	9,756	7,786
1973	1,494	1,122	496	373	366	275	5,544	4,165	1,813	1,326	9,713	7,298
1974	1,524	1,032	641	434	158	107	6,348	4,298	1,126	762	9,797	6,633
1975	1,183	734	576	357	535	332	7,174	4,450	1,392	864	10,860	6,737
1971-1975 average	**1,456**	**1,077**	**513**	**369**	**423**	**314**	**5,632**	**4,059**	**1,834**	**1,390**	**9,867**	**7,209**
1976	1,664	976	1,155	677	1,015	595	9,092	5,333	3,201	1,877	16,127	9,459
1977	2,967	1,635	1,549	853	1,156	637	10,363	5,710	2,992	1,648	19,027	10,483
1978[2]	4,499	2,304	847	434	735	376	12,164	6,228	2,206	1,130	20,450	10,471
1979	5,152	2,370	479	220	275	126	10,883	5,006	1,049	482	17,838	8,205
1980	6,054	2,453	72	29	22	9	11,299	4,478	2,692	1,091	20,139	8,160
1976-1980 average	**4,067**	**1,948**	**820**	**443**	**641**	**347**	**10,760**	**5,371**	**2,428**	**1,246**	**18,716**	**9,356**
1981	7,057	2,591	2,002	735	473	174	16,163	5,934	2,151	790	27,846	10,222
1982	4,795	1,659	2,151	744	2,238	774	17,011	5,884	5,314	1,838	31,509	10,899
1983	4,568	1,531	417	140	3,601	1,207	17,621	5,905	11,337	3,799	37,544	12,582
1984	7,299	2,346	681	219	1,734	557	25,296	8,131	8,309	2,671	43,319	13,924
1985	5,066	1,591	1,811	569	1,499	471	23,758	7,459	8,755	2,749	40,892	12,839
1981-1985 average	**5,757**	**1,944**	**1,412**	**481**	**1,909**	**637**	**19,970**	**6,663**	**7,173**	**2,369**	**36,222**	**12,093**
1986	3,897	1,187	1,564	476	1,800	548	24,385	7,425	10,413	3,171	42,059	12,804
1987	7,389	2,171	294	86	427	125	31,034	9,117	6,891	2,024	46,035	13,524
1988	3,720	1,050	276	78	464	131	31,209	8,809	4,242	1,197	39,911	11,265
1986-1988 average	**5,002**	**1,469**	**711**	**213**	**897**	**268**	**28,876**	**8,450**	**7,182**	**2,131**	**42,668**	**12,531**

[1]The deflated value is derived by dividing the current value by the Consumer Price Index (1967 is the base year and equals 100).
[2]Data from 1978 through 1988 is considered preliminary by the National Marine Fisheries Service.
Source: Compiled from data contained in Fisheries Statistics of the United States and unpublished National Marine Fisheries Service data.

Table 8.6. Current and deflated oyster prices by state, 1961-1988.

Year	Florida Current	Florida Deflated[1]	Alabama Current	Alabama Deflated	Mississippi Current	Mississippi Deflated	Louisiana Current	Louisiana Deflated	Texas Current	Texas Deflated	Gulf Average Current	Gulf Average Deflated
	$/lb											
1961	0.32	0.36	0.32	0.36	0.23	0.26	0.28	0.31	0.30	0.33	0.28	0.31
1962	0.28	0.31	0.37	0.41	0.26	0.29	0.33	0.36	0.39	0.43	0.31	0.34
1963	0.29	0.32	0.35	0.38	0.21	0.23	0.32	0.35	0.35	0.38	0.30	0.33
1964	0.28	0.30	0.32	0.34	0.23	0.25	0.26	0.28	0.33	0.36	0.27	0.29
1965	0.34	0.36	0.42	0.44	0.23	0.24	0.29	0.31	0.32	0.34	0.30	0.32
1961-1965 average	**0.30**	**0.33**	**0.36**	**0.38**	**0.23**	**0.25**	**0.30**	**0.32**	**0.33**	**0.36**	**0.29**	**0.32**
1966	0.31	0.32	0.47	0.48	0.27	0.28	0.45	0.46	0.39	0.40	0.38	0.39
1967	0.31	0.31	0.48	0.48	0.28	0.28	0.44	0.44	0.44	0.44	0.40	0.40
1968	0.33	0.32	0.50	0.48	0.31	0.30	0.40	0.39	0.44	0.42	0.38	0.36
1969	0.38	0.35	0.52	0.47	0.39	0.36	0.43	0.39	0.41	0.37	0.41	0.37
1970	0.41	0.35	0.57	0.49	0.43	0.37	0.42	0.36	0.44	0.38	0.43	0.37
1966-1970 average	**0.35**	**0.33**	**0.49**	**0.48**	**0.30**	**0.30**	**0.43**	**0.40**	**0.42**	**0.40**	**0.40**	**0.38**
1971	0.44	0.36	0.60	0.49	0.39	0.32	0.44	0.36	0.50	0.41	0.45	0.37
1972	0.47	0.38	0.66	0.53	0.48	0.38	0.51	0.41	0.64	0.51	0.53	0.42
1973	0.62	0.47	0.84	0.63	0.60	0.45	0.62	0.47	0.77	0.58	0.65	0.49
1974	0.57	0.39	0.87	0.59	0.57	0.39	0.64	0.43	0.91	0.62	0.66	0.45
1975	0.55	0.34	0.90	0.56	0.50	0.31	0.52	0.32	0.79	0.49	0.56	0.35
1971-1975 average	**0.52**	**0.39**	**0.78**	**0.56**	**0.48**	**0.36**	**0.54**	**0.39**	**0.66**	**0.50**	**0.56**	**0.41**
1976	0.64	0.38	0.93	0.55	0.67	0.39	0.74	0.43	0.82	0.48	0.75	0.44
1977	0.73	0.40	1.00	0.55	0.84	0.46	1.03	0.57	1.15	0.63	0.97	0.53
1978[2]	0.76	0.39	1.11	0.57	1.08	0.55	1.26	0.65	1.16	0.59	1.08	0.55
1979	0.84	0.39	1.04	0.48	1.01	0.47	1.41	0.65	1.18	0.54	1.15	0.53
1980	0.90	0.36	1.31	0.53	1.05	0.43	1.63	0.66	1.55	0.63	1.30	0.53
1976-1980 average	**0.80**	**0.38**	**1.00**	**0.55**	**0.83**	**0.45**	**1.15**	**0.58**	**1.10**	**0.57**	**1.03**	**0.51**
1981	0.98	0.36	1.50	0.55	1.01	0.37	1.78	0.65	1.64	0.60	1.44	0.53
1982	1.00	0.35	1.44	0.50	0.87	0.30	1.35	0.47	1.46	0.51	1.25	0.43
1983	1.06	0.36	1.24	0.42	1.08	0.36	1.33	0.45	1.43	0.48	1.29	0.43
1984	1.10	0.35	1.42	0.46	1.26	0.41	1.81	0.58	1.61	0.52	1.57	0.50
1985	1.15	0.36	1.26	0.40	1.26	0.40	1.66	0.52	1.71	0.54	1.54	0.48
1981-1985 average	**1.06**	**0.37**	**1.39**	**0.47**	**1.07**	**0.36**	**1.58**	**0.53**	**1.55**	**0.51**	**1.42**	**0.47**
1986	1.87	0.57	1.65	0.50	1.50	0.46	1.93	0.59	1.86	0.57	1.87	0.57
1987	2.10	0.62	3.34	0.98	3.23	0.95	2.58	0.76	2.38	0.70	2.47	0.73
1988	2.83	0.80	2.68	0.76	3.16	0.89	2.35	0.66	2.54	0.72	2.45	0.69
1986-1988 average	**2.17**	**0.64**	**1.88**	**0.56**	**1.82**	**0.54**	**2.28**	**0.67**	**2.12**	**0.65**	**2.23**	**0.65**

[1] The deflated value is derived by dividing the current value by the Consumer Price Index (1967 is the base year and equals 100).
[2] Data from 1978 through 1988 are considered preliminary by the National Marine Fisheries Service.
Source: Compiled from data in Tables 8.7 and 8.8.

In contrast to Florida, the deflated price of Alabama-produced oysters increased steadily throughout the 1960s and into the mid-1970s. Like that observed for Florida, real prices fell during the 1981-1985 period (Table 8.6). Overall, the price of oysters produced in Alabama generally exceeded comparable prices among other Gulf States during the 1960s and into the mid-1970s (Table 8.6). This trend may have resulted from the large number of processing activities in the state relative to its landings, as will be examined later in more detail. This price advantage, however, has eroded since the mid-1970s.

8.1.2.3 Mississippi

The current value of Mississippi's oyster production averaged about $900 thousand annually during 1961-1988. Because of the sharp decline in historical production in the state, there was little trend towards an increasing value of Mississippi's oyster resources (Table 8.5). On a deflated basis, the value of Mississippi's annual oyster harvest has declined, 1981-1985 being an exception.

The dockside oyster price in Mississippi has generally been well below the gulf average and often has been the lowest among Gulf States. The deflated price in the state, however, has generally increased with an exception during 1981-1985.

8.1.2.4 Louisiana

The current value of Louisiana's oyster harvest increased almost ten times during 1961-1988, from $3.05 million annually during 1961-1965 to $28.69 million annually during 1986-1988. On a deflated or real basis, the annual value of Louisiana's oyster harvest increased from an average of $3.3 million during 1961-1965 to $8.5 million during 1986-1988, or about 150%. Overall, Louisiana has exhibited the most consistent and largest growth in the value of oyster landings among Gulf States, expressed in either current or deflated dollars.

Because of its large contribution, the annual dockside price of oysters in Louisiana closely mirrored the gulf average with differences in excess of $0.05 per pound being uncommon during the 1960s and into the mid-1970s (Table 8.6). During the 1977-1985 period, the dockside oyster price in Louisiana generally exceeded the gulf average with observed differences from $0.10 to $0.30 per pound being common. Since 1985, Louisiana's dockside oyster prices have closely resembled the gulf average.

8.1.2.5 Texas

Averaging $3.26 million annually during 1961-1988, the dockside value of the annual oyster production in Texas contributed approximately 17% to the gulf totals during the 28 year period ending in 1988. The current value of landings during 1981-1985 averaged $7.14 million annually. The 1981-1985 average annual value was almost three times as large as the observed value during the previous 5 year period ($2.4 million) and more than four times the value observed during 1966-1970. The 1986-1988 average annual value of $7.1 million was slightly below the 1981-1985 average annual value; however, because of a significant decline in landings, it was well above the comparable statistics observed during the 1960s and 1970s.

After removing the effects of inflation (i.e., deflating) the dockside value of oyster landings in Texas increased moderately and averaged $1.57 million annually during 1961-1988. Based on the purchasing power in 1967, the deflated value of Texas oyster landings peaked in conjunction with maximum landings during 1981-1985 at $2.36 million. The deflated value of the Texas oyster landings has fallen sharply since 1986, largely in response to a decline in annual harvest.

Dockside oyster prices in Texas have generally been in line with those observed among the other Gulf States (Table 8.6). With the exception of 1981-1985 when landings in both Texas and the gulf were abnormally high, the deflated dockside oyster price in Texas has consistently increased with the 1986-1988 average deflated price per pound ($0.63) exceeding the 1961-1965 average deflated price per pound ($0.36) by almost 75%.

8.2 Noncommercial Fishery

The contribution of the noncommercial oyster catch to overall landings and local economies is poorly understood. Few states collect data on such harvests, although they do set regulatory limits.

The capital investment needed for gear, boats and vessels in this fishery is quite low; however, the fishing techniques are quite laborious. Consequently, it is unlikely that there is a high degree of participation. Work-like fishing, restricted catch (approximately one sack per day in most states) and low investment capital indicate that the noncommercial component is a minimal economic contributor in the oyster fishery.

8.3 Production/Value of Oysters by Gear Type

The oyster harvesting sector is an important source of income in many coastal areas of the gulf with annual employment in the thousands. These fishermen generally use either dredges or tongs to harvest oysters; the extent of use of each gear depends upon state laws, whether harvesting occurs on public or private grounds and other factors.

8.3.1 Florida

Annual harvest per tonger averaged almost $6,500 annually during 1981-1985 or almost five times the $1,446 grossed per tonger during 1961-1965 (Table 8.7). Much of this increase was inflationary based. After removing the effects of inflation, catch per tonger has remained relatively stable, though there has appeared to be some upward movement. This upward movement, to the extent that it exists, has reflected an increase in the real dockside price of oysters in Florida since the early 1970s (Table 8.6).

8.3.2 Alabama

As depicted in Table 8.8, both value and pounds landed per tonger increased over the long term. After removing the effects of inflation, the value of harvest per tonger increased approximately three-fold from an average of $375 per year during 1961-1965 to $1,297 during 1981-1985 (expressed in 1967 dollars), or more than three times. Although the long-term increase was consistent, annual fluctuations of several fold were common.

Table 8.7. Florida oyster value by gear type and by fisherman, 1961-1988.

Year	Value		Dollars Per Tonger	
	Tongs	Other	Current	Deflated[1]
	-------$1,000------		---------$---------	
1961	1,020	12	1,793	2,001
1962	1,400	4	1,705	1,881
1963	1,224	1	1,528	1,666
1964	774	7	983	1,058
1965	928	9	1,284	1,359
1961-1965 average	**1,069**	**7**	**1,446**	**1,593**
1966	1,285	11	1,881	1,935
1967	1,406	21	1,918	1,918
1968	1,738	16	2,293	2,200
1969	1,841	9	2,660	2,423
1970	1,469	6	2,183	1,877
1966-1970 average	**1,548**	**13**	**2,186**	**2,071**
1971	1,563	5	2,454	2,023
1972	1,501	9	2,695	2,151
1973	1,491	4	2,890	2,171
1974	1,522	2	3,171	2,147
1975	1,178	5	1,518	942
1971-1975 average	**1,451**	**5**	**2,447**	**1,887**
1976	1,639	25	4,098	2,404
1977	2,966	[2]	4,952	2,728
1978	4,496	2	6,395	3,274
1979	5,148	4	6,180	2,843
1980	6,051	2	6,542	2,651
1976-1980 average	**4,060**	**7**	**5,867**	**2,780**
1981	7,053	4	7,370	2,706
1982	4,750	45	5,319	1,840
1983	4,466	101	5,514	1,848
1984	7,277	22	8,288	2,664
1985	5,021	45	5,858	1,839
1981-1985 average	**5,713**	**43**	**6,470**	**2,179**
1986	3,897	-	5,834	1,777
1987	7,389	-	8,881	2,609
1988	3,720	-	4,222	1,192

[1] Deflated dollars per tonger are computed by dividing the current dollar per tonger by the Consumer Price Index, 1967=100.

[2] Less than $1,000.

Table 8.8. Alabama oyster value by gear type and by fisherman, 1961-1988.

Year	Value		Dollars Per Tonger	
	Dredges	Tongs	Current	Deflated[1]
	-------$1,000------		----------$---------	
1961	0	162	215	240
1962	0	165	282	311
1963	1	351	518	565
1964	17	307	451	485
1965	10	197	261	276
1961-1965 average[2]	**5**	**236**	**342**	**375**
1966	28	579	746	767
1967	48	960	1,208	1,208
1968	33	575	896	860
1969	14	236	369	336
1970	3	154	287	247
1966-1970 average	**25**	**501**	**739**	**684**
1971	2	150	327	270
1972	[3]	700	1,489	1,188
1973	0	496	1,259	946
1974	0	641	2,811	1,903
1975	0	576	2,313	1,435
1971-1975 average	**[3]**	**513**	**1,425**	**1,148**
1976	0	1,155	4,010	2,352
1977	0	1,548	4,373	2,409
1978	0	847	1,921	984
1979	0	479	1,267	583
1980	0	72	171	69
1976-1980 average	**0**	**820**	**2,181**	**1,279**
1981	0	2,002	5,976	2,194
1982	0	2,151	6,076	2,102
1983	0	417[2]	981	329
1984	0	682	1,916	616
1985	0	1,811	3,963	1,244
1981-1985 average	**0**	**1,413**	**3,782**	**1,297**
1986	0	1,564	2,875	875
1987	0	294	1,069	314
1988	0	276	986	278

[1] Deflated dollars per tonger are computed by dividing the current dollar per tonger by the Consumer Price Index, 1967=100.
[2] Includes a small amount of oysters caught by other gear.
[3] Less than $1,000.

8.3.3 Mississippi

Because of the decline in production per dredger during the 1960s and 1970s, the current value of production per dredger showed little or no increasing trend during the period. The deflated or real value of production per dredger declined (Table 8.9). Increases in both the current and deflated value of production per dredger have been witnessed during the early 1980s.

8.3.4 Louisiana

The annual value of catch per dredger increased steadily when evaluated in current dollars (Table 8.10). The average annual harvest per dredger of $19,403 during 1981-1985 represented an increase more than six times that since 1961-1965 when average annual harvest per dredger was only $3,094.

When evaluated on a deflated basis, the annual value of harvest per dredger in Louisiana increased significantly since the mid-1970s. This increase largely reflected an increase in Louisiana's deflated oyster price during the period (Table 8.6).

8.3.5 Texas

Texas has experienced substantial increases in landings and value of dredged oysters since 1982 when compared to the previous 10 years (Table 8.11). With a corresponding decrease in the number of fishermen over the same comparative time period, individual catches and income have significantly increased (Tables 7.9b and 8.11). The average dollars per dredger from 1981 through 1985 were almost three times greater than the 1976-1980 average and nearly six times greater than the 1971-1975 average (Table 8.11).

Table 8.9. Mississippi oyster value by gear type and by fisherman, 1961-1988.

Year	Value Dredges	$ Per Dredger		Value Tongs	$ Per Tonger	
		Current	Deflated[1]		Current	Deflated
	$1,000	---$---		$1,000	---$---	
1961	545	1,054	1,176	208	304	339
1962	368	722	797	170	243	268
1963	829	1,273	1,388	146	225	245
1964	864	1,224	1,318	235	423	455
1965	544	1,206	1,276	83	150	159
1961-1965 average	**630**	**1,111**	**1,191**	**168**	**268**	**293**
1966	332	792	815	265	444	457
1967	579	912	912	487	857	857
1968	1,003	1,644	1,578	160	308	296
1969	305	941	857	246	492	448
1970	219	652	561	19	40	35
1966-1970 average	**488**	**1,049**	**945**	**235**	**443**	**419**
1971	426	1,081	891	46	97	80
1972	318	779	622	262	428	342
1973	287	1,059	796	78	152	114
1974	134	812	550	23	57	39
1975	495	2,004	1,243	39	123	76
1971-1975 average	**332**	**1,118**	**820**	**90**	**194**	**130**
1976	841	3,014	1,768	174	338	198
1977	626	2,260	1,245	530	1,095	603
1978	299	[2]	[2]	436	[2]	[2]
1979	165	663	305	111	304	140
1980	0	0	0	22	132	53
1976-1980 average[3]	**386**	**2,030**	**830**	**255**	**546**	**249**
1981	243	920	338	230	531	195
1982	1,770	3,052	1,056	468	1,268	439
1983	3,475	4,709	1,578	126	319	107
1984	1,672	2,256	725	62	159	51
1985	1,451	2,088	656	48	239	75
1981-1985 average	**1,722**	**2,605**	**871**	**187**	**503**	**173**
1986	1,386	1,888	575	414	1,218	382
1987	188	1,168	343	239	1,695	498
1988	314	2,151	607	149	1,367	386

[1] Deflated dollars per dredger are computed by dividing the current dollar per dredger by the Consumer Price Index, 1967=100.

[2] Data not available to compute values.

[3] Averages for 1976-1980 are adjusted for missing data in 1978.

Table 8.10. Louisiana oyster value by gear type and by fisherman, 1961-1988.

Year	Value Dredges	$ Per Dredger Current	$ Per Dredger Deflated[1]	Value Tongs	$ Per Tonger Current	$ Per Tonger Deflated
	$1,000	---$---		$1,000	---$---	
1961	2,688	3,851	4,298	158	645	720
1962	3,029	3,482	3,843	284	703	776
1963	3,270	3,535	3,855	442	934	1,019
1964	2,766	2,747	2,957	201	408	439
1965	2,232	2,193	2,321	156	407	431
1961-1965 average	**2,797**	**3,094**	**3,455**	**248**	**620**	**677**
1966	2,054	2,062	2,121	94	556	572
1967	3,301	3,328	3,328	108	1,091	1,091
1968	5,190	5,118	4,912	114	1,152	1,106
1969	3,778	3,793	3,454	160	879	800
1970	3,516	3,437	2,955	102	734	631
1966-1970 average	**3,568**	**3,554**	**3,354**	**116**	**841**	**840**
1971	4,571	4,434	3,655	59	557	459
1972	4,433	4,346	3,468	17	183	146
1973	5,461	5,338	4,011	72	878	660
1974	6,247	6,241	4,225	84	1,077	729
1975	7,079	7,158	4,440	48	565	350
1971-1975 average	**5,558**	**5,487**	**3,960**	**56**	**629**	**469**
1976	8,947	8,644	5,070	132	1,257	737
1977	9,953	9,864	5,435	409	3,588	1,977
1978	11,968	11,802	6,043	196	2,649	1,356
1979	10,468	10,273	4,725	415	4,940	2,272
1980	10,415	10,112	4,097	883	7,678	3,111
1976-1980 average	**10,350**	**10,137**	**5,074**	**407**	**4,153**	**1,891**
1981	15,786	15,881	5,830	377	4,435	1,628
1982	16,853	16,410	5,676	158	1,306	451
1983	17,480	17,290	5,794	141	1,137	381
1984	24,656	24,196	7,778	566	4,838	1,555
1985	23,611	23,239	7,296	147	1,267	398
1981-1985 average	**19,677**	**19,403**	**6,475**	**278**	**2,597**	**883**
1986	24,161	21,287	6,482	216	1,770	539
1987	30,378	22,653	6,655	516	2,089	614
1988	30,571	21,836	6,163	628	4,550	1,284

[1]Deflated dollars per tonger are computed by dividing the current dollar per tonger by the Consumer Price Index, 1967=100.

Table 8.11. Texas oyster value by gear type and by fisherman, 1961-1985.

Year	Value		Dollars Per Dredger	
	Dredges	Tongs	Current	Deflated[1]
	-------$1,000------		---------$---------	
1961	301	26	909	1,015
1962	445	21	1,395	1,540
1963	893	12	1,395	1,521
1964	1,059	17	1,564	1,684
1965	1,529	4	2,130	2,254
1961-1965 average	**845**	**16**	**1,574**	**1,603**
1966	1,814	22	2,664	2,741
1967	1,530	27	2,606	2,606
1968	1,423	21	2,458	2,359
1969	1,511	14	2,783	2,535
1970	2,031	9	3,250	2,794
1966-1970 average	**1,662**	**19**	**2,756**	**2,607**
1971	2,356	12	4,291	3,538
1972	2,489	18	4,054	3,235
1973	1,812	[2]	2,845	2,137
1974	1,122	4	2,704	1,831
1975	1,383	9	4,887	3,032
1971-1975 average	**1,832**	**9**	**3,664**	**2,755**
1976	3,195	5	5,746	3,370
1977	2,983	9	6,293	3,467
1978	2,206	-	5,240	2,683
1979	1,049	-	9,624	4,427
1980	2,692	-	10,811	4,380
1976-1980 average	**2,425**	**-**	**6,699**	**3,665**
1981	2,151	-	7,628	2,800
1982	5,314	-	15,270	5,282
1983	11,337	-	35,208	11,799
1984	8,309	-	22,098	7,103
1985	8,755	-	20,995	6,592
1981-1985 average	**7,173**	**-**	**20,553**	**6,715**

[1] Deflated dollars per tonger are computed by dividing the current dollar per tonger by the Consumer Price Index, 1967=100.

[2] Data not available.

9.0 DESCRIPTION OF OYSTER PROCESSING, MARKETING/DISTRIBUTION AND TRADE ORGANIZATIONS

9.1 Processing

In many ways, oyster production is unique from other seafood production and processing operations. Fresh oyster products comprise the majority of sales in local and national markets. The fresh or "raw" product is highly perishable. In many local markets, demand for raw product is sustained throughout the year, and peak marketing intervals for processed oyster meats occur around major holiday periods. Satisfying demands for fresh, wholesome products requires the expeditious flow of oysters from harvesting through processing and distribution channels to the consumer. Figure 9.1 illustrates the flow of oyster products through processing channels.

Processing begins as soon as oysters are harvested. Separating live oysters from dead shell, culling, washing and transporting are all processing operations. Additional processing of shellstock may include washing, grading, storage, refrigeration, distribution and controlled purification in special cases.

9.1.1 History

9.1.2 Shucking and Washing

Shellstock, live oysters in the shell, are delivered to certified shellstock dealers for processing, storage and distribution. Shellstock must be tagged or labeled to facilitate identification of the original source and growing area in case of a shellfish-associated disease outbreak.

Processing oysters for fresh and frozen trade is a high-cost, labor-intensive operation. Processing is exclusively by hand shucking in the Gulf States, although limited heat-shock shucking occurs on Florida's east coast where gulf oysters may be processed. Attempts to mechanize oyster shucking operations have not received wide acceptance. Three methods are used by hand shuckers to remove oyster meats from the shell and include stabbing, chipping and grinding. Hand shucking operations have focused on select, single oysters that have good meat yield, bring higher prices and require lower shucking costs per volume.

Skimming, washing and blowing of shucked oyster meats are additional processing steps. These operations remove dirt and shell fragments from oyster meats and help to lower the temperature of oyster meats, thus extending shelf life. "Blowing" refers to the washing process when air is forced through the washing water. Aeration in the washing tank stirs and agitates oyster meats to facilitate removal of undesirable materials. Blowing and washing also improve the appearance and yield of oyster meats.

It is generally recognized that for sanitary and aesthetic reasons meats must be washed after shucking and before packing. During these procedures a certain amount of osmotic uptake of the wash water is inevitable, especially when meats have a high salt content. However, shucked oyster meats can absorb substantial quantities of fresh water which diminishes quality and product identity. In the absence of an objective test for measuring oyster composition (identity), current standards are based on processing practices. It is permissible to wash oyster meats in freshwater for as long as 30 minutes with each minute of "blow" time

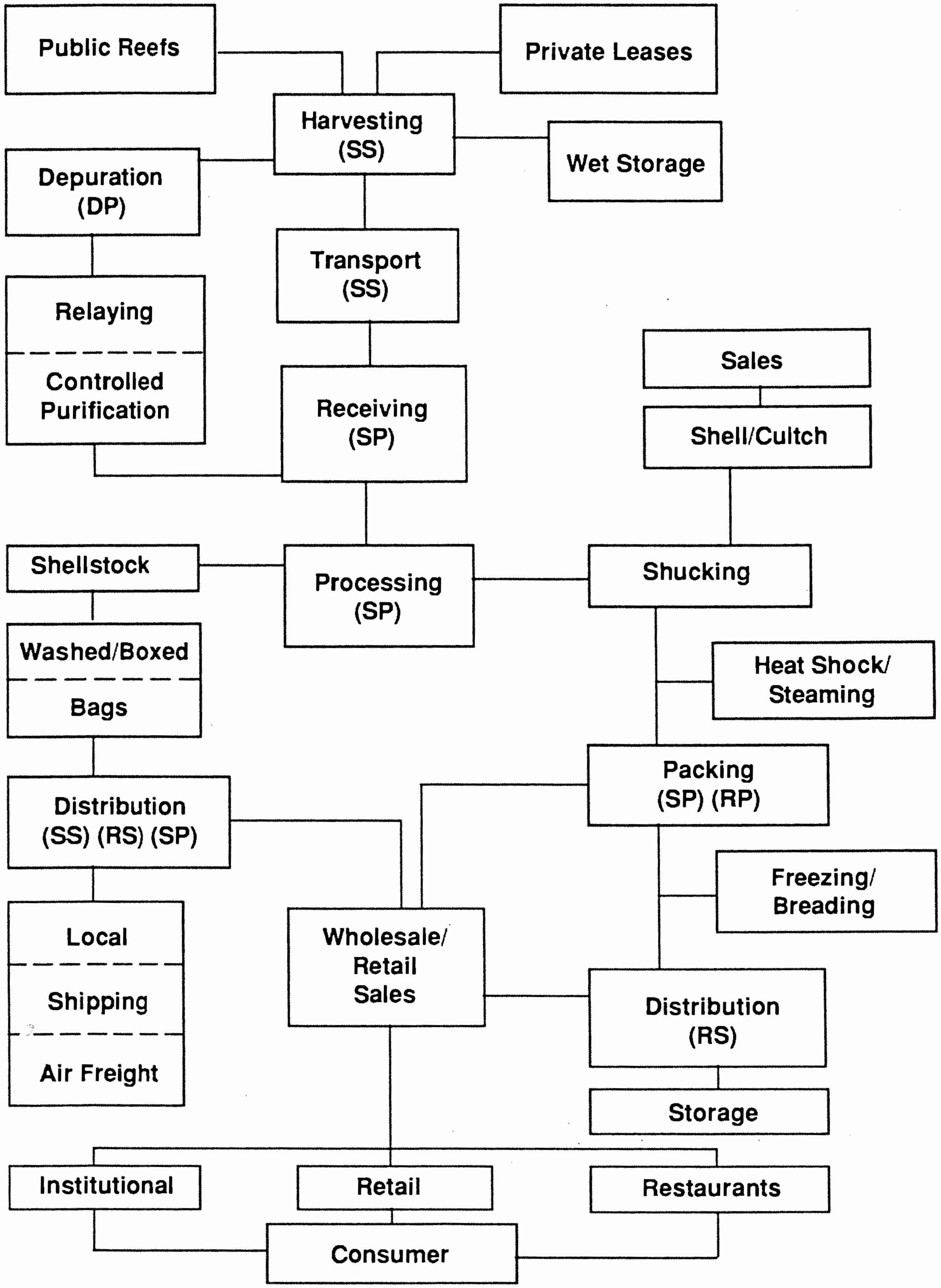

Figure 9.1. Harvesting, processing and distributional channels for oysters from the Gulf States.

equivalent to 2 minutes of soak time. Draining is controlled by specifying that meats must be drained for 5 minutes on a specified draining surface or skimmer. If they are drained within 15 minutes of the time that they are packed, the drained liquid is not to exceed 5% of the net weight of the package (Dressel et al. 1983).

While there appears to be no enforceable free-liquor standard, the net drained weight of 7 pounds of oyster meats per gallon, or 85% net drained weight for frozen oyster meats are commonly practiced. These requirements are equivalent to 15% free-liquor content at the point of delivery (Dressel et al. 1983).

Oysters also "bleed" liquids prior to, during and after shucking. Free-liquor content can reflect the oysters' ability to retain or absorb water. Variations in conditions prior to and during processing can have significant effects on the weight and yields of the final product form and, thus, affect profitability of the processing operation. There is a potential to increase profits by adding water to packed oysters.

9.1.3 Storage

Fresh, live shellstock should be stored at or below temperatures of 45°F. Raw shucked oyster meats should be stored below 45°F for maximum shelf life. Frozen oysters should be stored at or below 0°F; it is illegal to thaw frozen oysters for sale as fresh oysters. Shellstock and processed oyster meats should be shipped in refrigerated units with temperatures at or below 40°F.

9.1.3.1 Fresh Storage

Repacking oysters is an important function in the processing and marketing system. Repackers pack shucked oyster meats in containers or repack from larger containers to smaller containers for distribution to the final customer. Repacking is common in large processing operations and in operations that are supplied by several smaller shucking plants. Repackers generally have established markets but may depend on production from smaller suppliers who do not have ready market entries.

9.1.3.2 Frozen Storage

Specialty processors that supply frozen breaded products and specialty items for soups and stews account for additional processing activities and value-added products.

9.1.4 Processing Guidelines and Regulations

The five Gulf States have varying regulations regarding processing of oysters. Variations result in part from differences in organizational structures within separate states. All state programs must be in compliance with the National Shellfish Sanitation Program Manual of Operations in order for oysters to be shipped out of state. The NSSP manual and the separate state regulations should be reviewed for specific details of processing guidelines and regulations.

9.1.5 Product Forms

Raw oyster products are marketed as shellstock, fresh shucked or frozen. The descriptions of product forms are from the Southeastern Fisheries Association Seafood Product Quality Code. Shellstock are live oysters in the shell. "Culled" shellstock implies single oysters and may be marketed as "graded" and "washed." Shellstock is sold by shell size (count) and/or weight. Thus shellstock can be purchased by count and/or weight per bag or box. Shell size and meat yield vary greatly per location and season (Table 9.1), thus there is no standard box or bag size, count or weight.

No statistics are routinely collected by NMFS for the annual production of culled oysters; however, Prochaska and Keithly (1985) reported that about 46% of the oysters handled by Florida's (Franklin County) first dealers/processors during the 1983-1984 season were shipped in a washed and boxed form. Keithly and Roberts (1988) found that 7% of Louisiana's processor/wholesalers' supply was sold in boxed trade during the 1985-1986 season. Production of culled oysters in the other Gulf States likely falls within the ranges reported for Louisiana and Florida.

The gulf's annual production of shucked oysters as reported by NMFS is given in Table 9.2 for 1971-1988. These shucked oysters are packed wet and may be graded as "standards," "selects," "extra selects," or "counts." The largest meat size, "counts," should not be confused with the common grading term.

Annual production of shucked oysters in the gulf generally ranged from 1.5 to 2.5 million gallons and averaged about 1.8 million gallons annually during 1971-1988, almost 16 million pounds of meat (based on the NMFS conversion figure of 8.75 pounds of meat per gallon). Production of shucked oysters fell sharply after the 1985 peak of 2.6 million gallons, apparently in response to a decline in the gulf harvest (Table 9.2).

Additional processing of the raw shucked product can occur through breading activities. As indicated in Table 9.2, these activities tend to be limited in the gulf. Output of breaded products is generally less than 2.0 million pounds annually and averaged about 1.1 million pounds annually during the 11 year period ending in 1988.

Canning of oysters has historically represented the bulk of cooked oyster production in the gulf. Canned oysters, once an important component of the gulf oyster processing sector, have not been produced in the gulf since 1984.

9.1.6 Depuration

Depuration is discussed in Section 14 of this document as a potential management consideration that could increase production by cleansing oysters from certain areas that are presently classified as restricted. Depuration may also be a form of processing. By placing oysters in depuration systems, oysters are being stored alive; thus the highest quality is maintained. Depuration also reduces bacterial content; therefore there is potentially a greater assurance of product wholesomeness and consumer acceptance. Consequently, depurated oysters may command higher prices and be in greater demand.

9.1.7 Processing Establishments and Sales

Estimates of oyster processing activities in the gulf by state are provided in Table 9.3. These activities are measured only in terms of value. Estimates of processing activities are not given in terms of poundage because the wide variety of oyster products processed on an annual basis could lead to aggregation inconsistencies if summation across different product forms was attempted. Also given in Table 9.3 are annual estimates of the number of oyster processing

Table 9.1. Average annual weight per U.S. standard bushel[1] among Gulf States, 1960-1987.

Year	State				
	Florida	Alabama	Mississippi	Louisiana	Texas
	------------------ Pounds/U.S. Bushel ------------------				
1960	4.22	4.17	3.86	4.54	5.07
1961	4.07	4.85	4.02	4.57	4.86
1962	3.97	4.25	4.01	4.61	4.36
1963	3.61	4.12	3.96	4.65	4.01
1964	3.74	4.22	4.04	4.74	4.46
1965	3.64	4.43	4.21	4.93	5.36
1966	3.81	4.59	4.02	4.43	5.02
1967	3.78	4.20	4.09	4.58	4.44
1968	4.19	5.15	4.00	4.88	4.82
1969	4.21	5.53	4.48	5.00	5.47
1970	3.93	5.40	4.31	5.16	4.87
1971	4.11	5.38	4.11	4.90	5.15
1972	3.99	5.37	4.30	5.13	5.47
1973	4.08	5.49	4.37	5.08	5.58
1974	4.01	6.06	4.35	5.04	4.77
1975	3.97	6.03	4.20	5.42	4.91
1976	4.54	6.12	6.50	4.82	5.29
1977	3.56	7.54	6.28	4.51	5.42
1978	5.29	6.77	7.56	4.33	5.27
1979	3.72	7.08	7.89	4.43	5.09
1980	3.76	6.65	7.55	4.55	5.01
1981	N/A[2]	7.10	N/A	4.10	4.90
1982	N/A	4.19	5.66	4.61	4.97
1983	N/A	4.00	5.24	4.64	5.32
1984	N/A	3.88	5.07	4.33	5.02
1985	N/A	4.40	4.90	4.60	5.04
1986	N/A	4.56	4.91	4.29	5.21
1987	N/A	4.14	4.90	4.05	4.87

Source: Compiled from data contained in Fisheries Statistics of the United States and unpublished data provided by the National Marine Fisheries Service.

[1]The capacity of a U.S. standard bushel is 2,150.4 cubic inches.

[2]Data not available.

Table 9.2. Gulf processed oyster production by product year, 1971-1988.

Year	Raw Shucked	Breading	Canned
		Product Type	
	Gallons (1,000s)	Pounds[1] (1,000s)	Cases (1,000s)
1971	1,543	1,914	364
1972	1,509	1,898	303
1973	1,273	2,302	225
1974	1,186	1,340	242
1975	1,517	1,279	309
1971-1975 average	**1,406**	**1,747**	**289**
1976	1,867	1,661	116
1977	1,813	1,338	N/D[2]
1978	1,968	1,488	N/D
1979	1,522	1,194	N/D
1980	1,443	946	N/D
1976-1980 average	**1,723**	**1,325**	**--**
1981	1,814	1,656	N/D
1982	2,182	1,423	N/D
1983	2,071	1,275	N/D
1984	2,428	1,327	N/D
1985	2,579	1,728	0
1981-1985 average	**2,215**	**1,482**	**--**
1986	2,004	1,031	0
1987	1,677	1,073	0
1988	1,596	912	0
1986-1988 average	**1,759**	**1,005**	**0**

Source: Unpublished data provided by the National Marine Fisheries Service, Fisheries Statistics Division. These data may differ slightly from published statistics.

[1] Includes the weight of breading materials.

[2] Canned oyster production during the 1977-1984 period is not disclosed (N/D) because of the confidentially (i.e., there was an insufficient number of oyster canners in the gulf to release data). No production of canned oysters has been reported in the gulf since 1984.

Table 9.3. Historical oyster processing activities in the gulf by state, 1971-1987.[1]

	Florida			Alabama			Mississippi		
	Number of	Value		Number of	Value		Number of	Value	
Year	Establishments	Current	Deflated[2]	Establishments	Current	Deflated	Establishments	Current	Deflated
		---------$1,000--------			-------$1,000---------			-------$1,000-------	
1971	61	3,306	2,725	31	4,027	3,320	24	2,353	1,940
1972	52	4,269	3,407	31	4,987	3,980	25	2,648	2,113
1973	59	4,636	3,483	27	4,493	3,376	25	2,254	1,693
1974	56	3,783	2,561	23	4,433	3,001	24	2,543	1,722
1975	55	5,283	3,277	23	5,955	3,694	21	3,599	2,233
1971-1975 average	**57**	**4,255**	**3,091**	**27**	**4,779**	**3,474**	**24**	**2,679**	**1,940**
1976	54	6,748	3,958	24	6,276	3,681	22	5,105	2,994
1977	58	7,850	4,325	25	8,544	4,707	19	5,032	2,772
1978	82	10,780	5,520	26	5,169	2,647	19	4,253	2,178
1979	86	10,595	4,874	24	8,267	3,803	20	3,276	1,507
1980	83	10,313	4,179	20	10,068	4,079	19	3,937	1,595
1976-1980 average	**73**	**9,257**	**4,571**	**24**	**7,665**	**3,783**	**20**	**4,321**	**2,209**
1981	81	12,949	4,754	26	9,146	3,358	19	4,535	1,665
1982	73	12,773	4,418	29	11,591	4,009	19	6,841	2,366
1983	70	14,925	5,002	36	10,686	3,581	20	6,002	2,011
1984	72	15,607	5,017	41	20,101	6,461	21	7,778	2,500
1985	62	15,895	4,991	39	17,934	5,631	21	7,751	2,434
1981-1985 average	**72**	**14,430**	**4,836**	**34**	**13,892**	**4,608**	**20**	**6,581**	**2,195**
1986	42	13,736	4,183	37	18,274	5,565	18	6,421	1,955
1987	45	13,328	3,915	34	15,290	4,492	16	6,468	1,900
1988	41	12,358	3,488	35	12,566	3,547	16	6,778	1,913
1986-1988 average	**43**	**13,141**	**3,862**	**35**	**15,357**	**4,535**	**17**	**6,556**	**1,923**

	Louisiana			Texas			Gulf		
		---------$1,000--------			--------$1,000--------			-------$1,000------	
1971	41	8,760	7,222	30	3,230	2,663	187	21,676	17,870
1972	46	8,535	6,812	34	2,808	2,241	188	23,247	18,553
1973	42	9,177	6,895	37	3,308	2,485	190	23,868	17,932
1974	42	9,003	6,095	32	2,800	1,896	177	22,562	15,276
1975	40	11,214	6,957	33	3,959	2,456	172	30,010	18,617
1971-1975 average	**42**	**9,338**	**6,796**	**33**	**3,221**	**2,348**	**183**	**24,273**	**17,650**
1976	40	10,912	6,400	27	6,147	3,605	167	35,188	20,638
1977	46	12,027	6,626	29	4,910	2,705	177	38,363	21,137
1978	41	15,764	8,072	37	5,070	2,596	205	41,036	21,012
1979	38	11,189	5,147	34	2,892	1,330	202	36,219	16,660
1980	32	10,094	4,090	30	2,887	1,170	184	37,299	15,113
1976-1980 average	**39**	**11,997**	**6,067**	**31**	**4,381**	**2,281**	**187**	**37,621**	**18,912**
1981	45	12,590	4,622	29	5,556	2,040	200	44,776	16,438
1982	49	16,600	5,742	25	5,767	1,995	195	53,572	18,531
1983	48	15,859	5,315	23	5,536	1,855	197	53,008	17,764
1984	44	16,852	5,417	24	4,721	1,518	202	65,059	20,913
1985	41	18,216	5,719	22	7,774	2,441	185	67,570	21,215
1981-1985 average	**45**	**16,023**	**5,363**	**25**	**5,871**	**1,970**	**196**	**56,797**	**18,972**
1986	43	17,264	5,257	19	1,739	529	159	57,434	17,489
1987	39	18,369	5,396	16	2,461	723	150	55,916	16,427
1988	40	20,623	5,821	15	3,545	1,000	147	55,870	15,769
1986-1988 average	**41**	**18,752**	**5,491**	**17**	**2,582**	**751**	**152**	**56,407**	**16,562**

[1]These figures may include small amounts of nonedible oyster processing activities such as production of shell grit.

[2]Deflated values are based on the 1967 Consumer Price Index.

Source: Compiled from unpublished data provided by the National Marine Fisheries Service, Fisheries Statistics Division.

establishments by state and for the total gulf. The two terms, "establishments" and "companies," are used interchangeably in this section; however, a company may operate more than one establishment. The extent of this activity in the gulf is not known but is thought to be small.

The number of gulf establishments that processed oysters on an annual basis generally fluctuated in the 175-200 range during 1971-1985 before falling sharply in each of the successive 3 years. The 147 processors in 1988 represented the smallest number observed during the 18 year period beginning in 1971.

The value of oyster processing activities in the gulf has increased during the 18 year period ending in 1988 (Table 9.3). Overall, the annual value of these activities peaked in 1985 at $67.6 million before declining more than $10 million dollars during the following three years.

After adjustment for inflation, oyster processing activities in the gulf have increased only minimally in the long run. For instance, deflated processing activities during 1981-1985 averaged about $18.9 million annually (expressed in 1967 dollars), and were less than 10% above processing activities valued at $17.7 million annually during 1971-1975. Processing activities in 1986, 1987 and 1988 were below those generally observed during 1976-1985 when evaluated on a deflated basis.

Gulf oyster landings and deflated values of processing activities appear to be positively related, albeit a weak relation. For example, there were relatively large annual harvests of oysters in the gulf during 1975-1978 and 1982-1985. There were also relatively substantial processing activities, as measured in terms of real value, during those same time periods. With the decline in landings during 1986, 1987 and 1988 processing activities, as measured in constant dollars, also declined.

Oyster processing activities among the five Gulf States often mirror harvest activities. For instance, Louisiana generally ranks first among Gulf States in both oyster landings and the value of processing activities. By comparison, only a small share of the gulf's total oyster production is Mississippi based, and its processing activities tend to be relatively limited.

While there are relationships between state landings and processing activities, these relationships are limited. Although Louisiana's annual oyster harvest has generally represented more than 50% of the gulf's total in recent years, its processing activities represent less than a third of the total. Conversely, Alabama's oyster landings have represented less than 5% of the gulf's annual production in recent years, while its processing activities generally represent more than 20% of the total and can approach a third in selected years. Similarly, processing activities in Florida as a percent of the gulf's total generally exceed that which might be expected based on state landings.

The relatively substantial oyster processing activities in Florida, Alabama and to a lesser extent Mississippi are the result of shipments of shellstock originating in Louisiana and Texas to processors/dealers in these states. Prochaska and Keithly (1985) reported that 68% of the total oyster shellstock handled by Florida's (Franklin County) first processors/dealers during 1983-1984 originated from out-of-state sources, primarily Louisiana and Texas. Similarly, Keithly and Roberts (1988) reported that 30%-35% of Louisiana's 1985-1986 oyster harvest was processed by out-of-state dealers, largely in Alabama and Florida; however, Louisiana dealers used some Texas production in their own processing activities.

by out-of-state dealers, largely in Alabama and Florida; however, Louisiana dealers used some Texas production in their own processing activities.

Long-term growth in the real value of oyster processing activities can be most clearly identified in Florida and Alabama. Declines in processing are most readily apparent in the states of Louisiana and Texas. In Florida, the deflated value of oyster processing activities increased from an average of $3.1 million annually during 1971-1975, to $4.8 million (1967 dollars) during 1981-1985, or about 56%. The average number of establishments processing oysters increased from 57 to 72 during the same period. Processing activities in the state fell somewhat during the subsequent 3 years in relation to a sharp decline in annual oyster harvest in both the state and gulf and from the direct impact of Hurricane Elena on the processing houses.

The deflated value of oyster processing activities among establishments in Alabama increased from an annual average of $3.5 million during 1971-1975, to $4.6 million during 1981-1985, or approximately one-third. The number of establishments that processed oysters increased from an average of 27 during 1971-1975, to 34 during 1981-1985. The value of processing activities, as measured in 1967 dollars, peaked in 1984 at about $6.5 million and declined during each of the following 4 years, possibly in response to a decline in oyster production among Gulf States.

Louisiana generally ranked second to Florida in number of oyster processors (Table 9.3). On an annual basis, an average of 42 establishments processed oysters in the state during 1971-1975 and declined to 39 during 1976-1980 before increasing to an average of 45 during 1981-1985. While the current value of Louisiana's oyster processing activities increased during the 8 year period ending in 1988, the deflated value of processing activities declined significantly; although significant growth occurred in 1988. The 1981-1985 average annual processing activities, valued at $5.4 million in 1967 dollars, were less than 90% of annual activities during 1976-1980, valued at $6.1 million on average, and less than 80% of activities witnessed during 1971-1975, averaging approximately $6.8 million annually. One probable explanation for declining processing activities reflects the demise in the Louisiana oyster canning operations that probably resulted from increased competition in the form of imports.

The number of oyster processing establishments in Texas has gradually declined since the early 1970s. An average of 33 companies were processing oysters in the state on an annual basis during 1971-1975, compared to 31 during 1976-1980 and 25 during 1981-1985. By 1988, the number had declined to 15. With the exception of 1986 and 1987 when the decline in processing activities was extreme, the deflated value of oyster processing activities in Texas has also gradually decreased.

9.1.8 Sales Per Establishment

Annual estimates of processed oyster sales per establishment are provided by state in Table 9.4. These estimates are derived from information provided in Table 9.3 and are given on both a current and deflated basis.

Table 9.4. Averaged processed value of oyster products per oyster processing establishment by state, 1971-1987.

	Florida		Alabama		Mississippi		Louisiana		Texas		Gulf	
Year	Current	Deflated	Current	Deflated	Current	Deflated	Current	Deflated	Current	Deflated	Current	Deflated
	$1,000											
1971	54.2	44.7	129.9	107.1	98.0	80.8	213.7	176.1	107.7	88.8	115.9	95.6
1972	82.1	65.6	160.9	128.4	105.9	84.5	185.5	148.1	82.6	65.9	123.7	98.7
1973	78.6	59.0	166.4	125.0	90.2	67.7	218.5	164.2	89.4	67.2	125.6	94.4
1974	67.6	45.7	192.7	130.5	106.0	71.8	214.4	145.1	87.5	59.3	127.5	86.3
1975	96.1	59.6	258.9	160.6	171.4	106.3	280.4	173.9	120.0	74.4	174.5	108.2
1971-1975 average	**75.2**	**54.6**	**177.0**	**128.7**	**112.6**	**81.5**	**221.3**	**161.0**	**97.4**	**71.1**	**132.8**	**96.6**
1976	125.0	73.3	261.5	153.4	232.0	136.1	272.8	160.0	227.7	133.5	210.7	123.6
1977	135.3	74.6	341.8	188.3	264.8	145.9	261.5	144.0	169.3	93.3	216.7	119.4
1978	131.5	63.3	198.8	101.8	223.8	114.6	384.5	196.9	137.0	70.2	200.2	102.6
1979	123.2	56.7	344.5	158.5	163.8	75.4	294.4	135.4	85.1	39.1	179.3	82.5
1980	124.3	50.3	503.4	204.0	270.2	83.9	315.4	127.8	96.2	39.0	202.7	82.1
1976-1980 average	**127.5**	**63.0**	**322.1**	**158.9**	**218.2**	**111.6**	**304.5**	**154.0**	**139.5**	**72.6**	**201.2**	**101.1**
1981	159.9	58.7	351.8	129.2	238.7	87.6	279.8	102.7	191.6	70.3	223.9	82.2
1982	175.0	60.5	399.7	138.2	360.1	124.5	338.8	117.2	230.7	79.8	274.7	95.0
1983	213.2	61.5	296.8	99.5	300.1	100.6	330.4	110.7	240.7	80.7	269.1	90.2
1984	216.8	69.7	490.3	157.6	370.4	119.0	383.0	123.1	196.7	63.3	322.1	103.5
1985	256.4	80.5	459.8	144.4	369.1	115.9	444.3	139.5	353.4	111.0	365.2	114.7
1981-1985 average	**201.5**	**67.5**	**406.2**	**135.5**	**329.1**	**109.8**	**352.9**	**118.1**	**238.7**	**80.1**	**290.1**	**96.9**
1986	327.0	99.6	493.9	150.4	356.7	108.6	401.5	122.3	91.5	27.8	361.2	110.0
1987	296.2	87.0	449.7	132.1	404.3	118.8	471.0	138.4	153.8	45.2	372.8	109.5
1988	301.4	85.1	359.0	101.3	423.6	119.6	515.6	145.5	236.3	66.7	380.0	107.3
1986-1988 average	**308.2**	**90.6**	**434.2**	**127.9**	**394.9**	**115.7**	**462.7**	**135.4**	**160.5**	**46.6**	**371.3**	**108.9**

Source: Compiled from data presented in Table 9.1.

The current value of processed oyster sales per company in the gulf has increased. Sales during 1981-1985 ($290.1 thousand) exceeded processed sales per establishment during 1976-1980 ($201.2 thousand) by almost 45% and the 1971-1975 annual processed sales per establishment ($132.8 thousand) by almost 120%. Average processed oyster sales per establishment in 1988 ($380.0 thousand) exceeded the 1971-1975 average sales per establishment by almost 200%.

Much of the increased, company-processed oyster sales during 1971-1987 was inflationary based. Little growth in average processed oyster sales per establishment was evident when these sales were evaluated on a real, or deflated, basis. For instance, 1981-1985 average, annual, deflated processed sales of $96.9 thousand were slightly below comparable numbers of $101.1 thousand during 1976-1980. Deflated sales per company after 1985 were, however, well above the long-term average.

On a state-by-state basis, increasing sales of processed oyster per establishment, as measured in constant 1967 dollars, were most evident in Florida (Table 9.4). Sales per company, in real terms, increased to an average of $67.5 thousand annually during 1981-1985 (up from $54.6 thousand during 1971-1975). These sales averaged more than $90 thousand since 1983. Increased sales per establishment occurred after 1985 even though the total deflated value of processed sales declined somewhat reflecting a concurrent decline in the number of establishments processing oysters.

Declining processed oyster sales per company, as measured in constant 1967 dollars, were most readily identified in Louisiana (Table 9.3). Deflated sales per establishment fell from $161.0 thousand annually during 1971-1975, to $154.0 thousand annually during 1976-1980 and declined again to $118.1 thousand during 1981-1985. On average, deflated sales per company during 1981-1985 were only about three-fourths of those observed during 1971-1975; however, significant increases in sales per establishment were identified after 1984.

Deflated processed oyster sales per company in Alabama appeared to have peaked during 1976-1980 and declined thereafter. There was, however, considerable year-to-year variation in processing activities within the state. In more favorable years during the 1980s, the deflated processed oyster sales per establishment were approximately the same as the average experienced in the state during 1976-1980.

As was the situation in Alabama, deflated processed oyster sales among Mississippi establishments appeared to have peaked during 1976-1980. When expressed in 1967 dollars, deflated sales per company during this period averaged almost $112 thousand annually. Unlike that witnessed among Alabama companies since 1976-1980 (i.e., a large decline in deflated sales per company), deflated sales per oyster processor in Mississippi remained relatively constant equalling $110 thousand annually during 1981-1985, $109 thousand in 1986 and $119 thousand in 1987.

In general, deflated processing activities per company in Texas increased during 1971-1985. Concurrent with the extreme decline in the state's oyster processing activities in 1986 and 1987, processing activities per establishment fell sharply in these 2 years; however, they showed significant recovery in 1988.

9.1.9 Establishments and Sales Industry Concentration and Stability

Keithly et al. (1988) analyzed industry concentration in the gulf oyster processing sector and found that the largest 5 oyster processing establishments accounted for 22.5% of processed oyster sales in 1985. Similarly, the largest 10, 20 and 50 establishments accounted for 35.8%, 52.4% and 78.3%, respectively, of total gulf processed oyster sales in 1985.

Keithly et al. (1988) also examined stability in the gulf oyster processing sector and reported rather high annual turnover of establishments. For example, 184 establishments were processing oysters in the gulf in 1980, and 185 establishments were processing oysters in 1985 (a net increase of only one). During the 5 year interval, however, 158 establishments ceased oyster processing operations while 159 establishments either started or renewed oyster processing activities. Many of the establishments that ceased oyster processing operations during the period probably resumed operations later in the same period, possibly more than once.

Keithly et al. (1988) reported that the rate of movement among gulf oyster processing establishments during 1970-1985 averaged about 75% on a 5 year basis. The rate of entry (77.6%) slightly exceeded the 5 year rate of exit (75.5%). This rate of movement, significantly higher than that found for shrimp processing activities, was hypothesized to be related to: (1) the relatively low capital-intensive nature of the oyster processing sector; and (2) the high annual variation in gulf oyster landings that, in the absence of imports, results in annual instability within the processing sector.

9.2 Marketing and Distribution

Relatively little is known of the marketing and distribution of gulf oysters. Markets for various product forms and the origin of the shellstock on any given market vary from year to year within a given state and also between states. Prochaska and Keithly (1985) described oyster markets and distribution in Florida during 1983-1984, but they have probably changed since that time.

9.3 Trade Organizations

9.3.1 Purpose and Need

Oyster resources provide many benefits in terms of employment and revenue at local, state and national levels. Oystermen, processors, distributors and dealers are economically dependent upon these resources and have a vested interest in the conservation and perpetuation of the resource. All sectors of the oyster industry should strive to promote judicious management of oyster resources by participation in the development of fisheries management policies. Oyster industry members should work together and cooperate with agencies regulating the industry to promote industry needs.

Many industry members, particularly in the harvesting segment, feel they lack significant input into resource management decisions. The oyster industry is often represented by local associations or cooperatives, but these associations are fragmented and represent specific industry segments. As an example, local associations may be comprised exclusively of oyster harvesters or oyster dealers who approach specific issues as antagonists. This diversity of opinion makes it difficult to develop policies that will satisfy each segment's industry-wide problems. In general, industry associations do not possess the capital or the expertise to promote their image or views.

9.3.2 Organizations, Associations and Other Groups

9.3.2.1 National

National Fisheries Institute (NFI)
National Shellfisheries Association (NSA)
Interstate Shellfish Sanitation Conference (ISSC)
Shellfish Institute of North America (SINA)
World Aquaculture Society (WAS)

9.3.2.2 Regional

Southeastern Fisheries Association, Inc. (SFA)
Gulf and South Atlantic States Shellfish Conference
Gulf and South Atlantic Fisheries Development Foundation (GSAFDF)

9.3.2.3 State and Local

9.3.2.3.1 Florida

Organized Fisherman of Florida (OFF)
Florida Aquaculture Association
Shellfish Farmers Association
Panhandle Oystermen's Association
Bay Oystermen's Association
Franklin County Seafood Workers' Association
Franklin County Seafood Dealers' Association
Horseshoe Oystermen's Association
Suwanee Oystermen's Association
Cedar Key Oystermen's Association

9.3.2.3.2 Alabama

Alabama Oyster Farmers Association
Save Our Shells (SOS)
South Alabama Seafood Association
Waterfront Property Owner's Association

9.3.2.3.3 Mississippi

Mississippi Coastal Fishermen's Organization
Mississippi Shellfish Dealers Association
Southern Aquaculture Association

9.3.2.3.4 Louisiana

Louisiana Oyster Growers and Dealers Association
Plaquemines Oyster Association
Terrebonne Parish Oyster Leaseholders Association
Concerned Citizens & Fishermen Association
East Plaquemines Fishermen & Dealers Association
Southwest Pass Oyster Leaseholders Association

9.3.2.3.5 Texas

Coastal Oyster Leaseholders Association
PISCES
Texas Aquaculture Association
Texas Oyster Association

9.4 Imports

Imports have constituted a large and expanding share of the total U.S. oyster supply. This expanding share has resulted from a combination of dwindling domestic harvest and increasing imports. Imports have represented an average of 31% of the total U.S. oyster supply during 1971-1975, and increased their relative share to 34%, 38% and 55% during the 1976-1980, 1981-1985 and 1986-1988 periods, respectively (Table 9.5).

Imports averaged 49.3 million pounds annually during 1986-1988 compared to 23.8 million pounds annually during 1971-1975. In 1988, imports of fresh and frozen oysters equalled between 5 and 6 million pounds. In 1975, imports of these oyster products were 3.6 million pounds (derived from U.S. General Imports: Schedule A Commodity by Country of Origin and Fisheries of the United States 1988).

U.S. oyster imports are dominated by imports from the Republic of Korean and Hong Kong. In 1987, U.S. oyster imports from Korea totaled more than two-thirds of U.S. imports of oysters on a meat-weight basis while Hong Kong provided more than one-fifth. Japan, once a major U.S. supplier of canned oysters, shipped only about 1.3 million pounds of canned product to the U.S. in 1987.

Table 9.5. U.S. supply of oysters, meat weight, 1970-1988.

	Domestic Landings	Imports[1]	Total Supply	Imports as % of Total Supply
	-------------------	1,000 lbs	-------------------	
1971	57,938	17,519	75,457	23%
1972	56,058	30,893	86,951	36%
1973	51,931	26,351	78,282	34%
1974	50,176	23,634	73,810	32%
1975	53,227	20,542	73,769	28%
1971-1975 average	**53,866**	**23,788**	**77,654**	**31%**
1976	54,395	23,682	78,077	30%
1977	50,088	29,774	79,862	37%
1978	54,100	33,843	87,943	38%
1979	50,362	27,131	77,493	35%
1980	50,826	21,732	72,558	30%
1976-1980 average	**51,954**	**27,232**	**79,187**	**34%**
1981	52,612	25,769	78,381	33%
1982	56,189	27,529	83,718	33%
1983	54,048	30,775	84,823	36%
1984	54,774	36,086	90,860	40%
1985	50,881	45,926	96,807	47%
1981-1985 average	**53,701**	**33,217**	**86,918**	**38%**
1986	48,769	50,038	98,807	51%
1987	39,807	52,085	91,892	57%
1988	31,892	46,414	78,306	59%
1986-1988 average	**40,156**	**49,512**	**89,669**	**55%**

[1] Imports were converted to meat weight by using these conversion factors: canned, 0.93; canned smoked, 3.12; and other, 0.75.

Source: Fisheries of the United States.

10.0 SOCIAL AND CULTURAL CHARACTERISTICS OF OYSTER FISHERMEN AND THEIR COMMUNITIES

The management of natural resources is integrally linked to the management of users of those resources. To develop sustainable, human management policies, it is crucial to understand the social and cultural characteristics that guide traditional use patterns. With regard to the gulf oyster fishery, it is important to understand the interaction among oyster fishermen, their families, other families, other groups and regulatory agencies. The characterization of oyster fishermen, their families and their communities is necessary in order to adequately define their problems and to develop acceptable solutions.

10.1 Gulf Oyster Fishermen

For convenience, oyster fishermen in the gulf may be divided into two groups: lease fishermen and nonlease fishermen. The social and cultural characteristics, problems and relationships with management are quite different for each group. Problems and management considerations are discussed in Sections 13 and 14, respectively.

Nonlease fishermen constitute the vast majority of oyster fishermen in the gulf. Only in Louisiana is the fishery predominated by lease fishermen or lessees. However, Louisiana also has a significant population of nonlease fishermen.

10.1.1 Nonlease Oyster Fishermen

Nonlease fishermen work the public oyster grounds and compete with other fishermen for the common property resource. Unlike finfishermen or shrimp fishermen, these oyster fishermen do not actively "hunt" their target species over a wide area. Oysters grow in specific localities that become known to them. They may be termed a "capture stock" and become the focus of seasonal harvesting.

10.1.1.1 Description of the Fishermen

Oyster fishermen and their families may be characterized by independence and individualism. The need for independence is not uncommon in other fisheries of the world. A number of researchers have indicated that fishermen can be characterized in terms of behavior and thinking that reflects a strong orientation towards independence. For example, Poggie and Gersuny (1974) emphasize the salience of "independence" in the thinking and behavior of the southern New England fishermen they studied. Further, Price (1964), Pollnac and Ruiz-Stout (1977) and Peterson and Smith (1981) note that Caribbean, United States and Panamanian fishermen, respectively, often cite independence as a important characteristic of the work fishermen do. According to Aronoff (1967), fishermen from Saint Kitts in the West Indies emphasized independence and self-reliance in statements concerning reasons why they chose fishing in contrast to other occupations. Kottak (1966) reported that successful marine fishing at Arembepe, Brazil, requires individualistic behavior. Similar observations have been made in Southeast Asia (Fraser 1966, Harrison 1970). Finally, Pollnac (1988) presented an analysis of a world-wide sample of 186 societies that indicates that fishing societies place greater emphasis on self-reliance training for males in late boyhood than other social types.

The tendency toward relative independence in fishing has been theoretically and empirically related to environmental and technological aspects of the occupation. For example, Poggie (1980) in his analysis of data from southern New England, argued that independence helps marine capture fishermen (fishermen who target common property fishery stocks) to psychologically adapt to their occupation. The decisions that they have to make in the face of uncertainty have immediate effects with respect to the safety of the vessel and its crew as well as the success of the fishing trip. These decisions have to be made independently, with little or no time for consultation and deliberation due to the rapidly changing nature of the sea (Pollnac 1976). Poggie (1980) further suggested that an independent personality characteristic is related to and selected by the fact that most capture fishermen are physically removed from the help and support of land-based society.

The independent nature of oyster fishermen is, therefore, not uncommon among human populations seeking common "capture" stocks. This independence is an adaptive trait, given the nature of the fishery. Since there is no advantage to sharing information about where and when to oyster, outside of already established kin networks, it cannot be considered an irrational attitude born of ignorance. Rockwood (1973) commented in reference to Apalachicola, that "It seems evident that there are jealousies between families and factions which represent long-standing antagonisms. The oyster fishermen will have to be convinced that common good (or peril) is at stake if these are to be set aside."

In some areas, fishermen become somewhat territorial and identify particular oyster beds as communal property. These beds may also be viewed as a "territory" in which those having traditional harvester rights will resist or discourage outside harvesting (Rockwood 1973). Beds can be utilized year after year, and the availability of that resource is anticipated as part of a livelihood cycle.

Along with territoriality (Sack 1986) may come an active degree of stewardship. Oyster fishermen are members of communities and families that have a historical investment in their livelihood. Here oystering becomes a way of life with social as well as economic rewards constantly reinforced by transmission of associated traditions through families.

10.1.1.2 Structure of the Community

The structure of all coastal communities which rely on natural resources taken from the public domain can be based on a cyclic model (Figure 10.1). This model diagrams the interaction between cultural and natural cycles, with the cultural cycle divided into the four phases of (1) preparation, (2) harvesting, (3) utilization and (4) anticipation. Preparation (1) includes all activities involving the readying of gear, identification of target areas, crew selection and (if needed) training. Harvesting (2) is the actual event of, in this case, oystering. Utilization (3) involves conversion of catch to usable resources. Anticipation (4) is an interim "resting" phase in which predictions about the upcoming season and assessment of the previous harvest season guide the decision to remain active in the fishery.

Fishing communities characterized by the model, at least in their traditional fishing origins, can be termed natural resource communities (NRCs). A natural resource community is a population of individuals living within a bounded area whose existence is primarily based on the utilization of renewable natural resources. The direct reliance of NRCs on the environment makes understanding such communities important to the management of the resources (Dyer et al 1990).

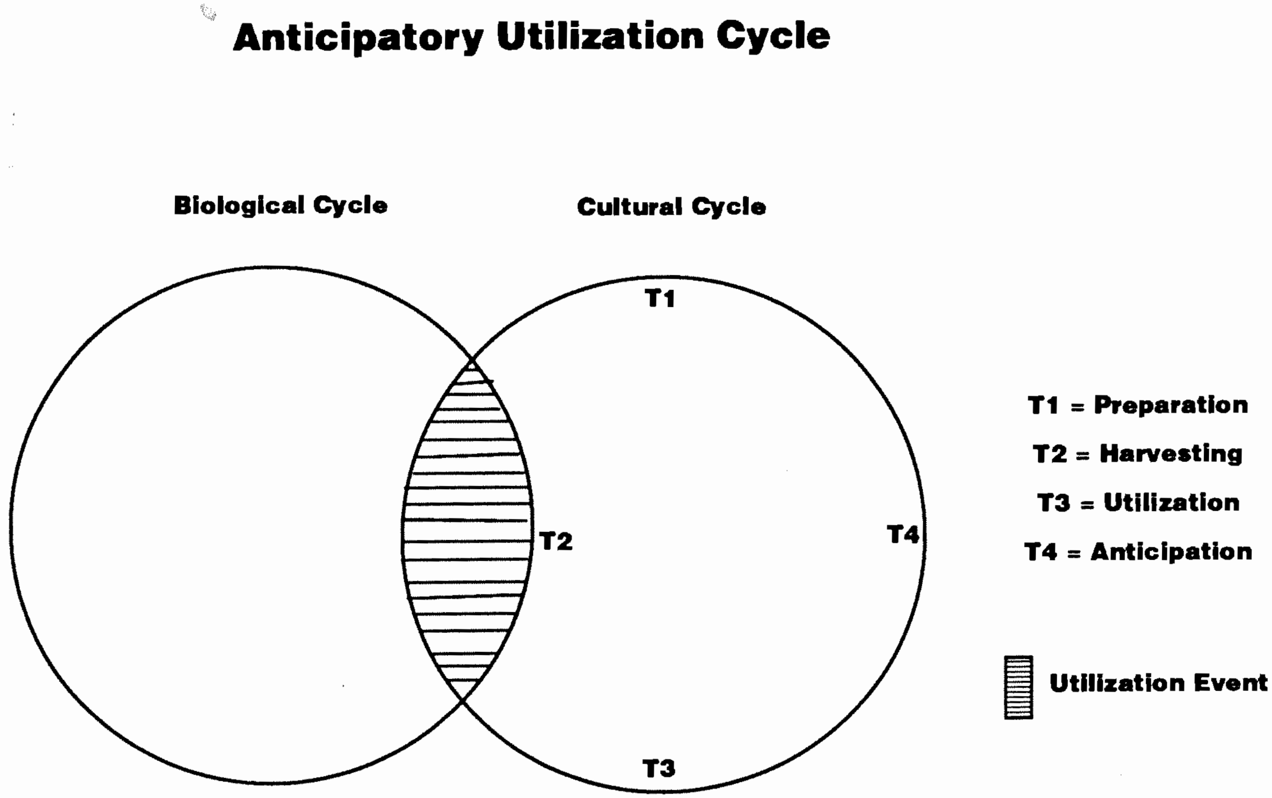

Figure 10.1. The interrelation of cyclic biological and cultural events in a natural resource community.

The organization of NRCs is most often traditional; thus it determines the options available for the large majority of residents who have lived in the community for several generations or more. Oyster fishermen families are NRC linked and identification as "insiders" may take several generations to establish. An important part of identification as a legitimate user of any oyster resource can also be kinship. As Rockwood (1973) noted, kinship ties are used to establish legitimacy of individuals as community members.

NRCs may be open or closed. Closed NRCs are geographically and traditionally isolated from outside influence, and kinship ties are more important to gain knowledge and access to the oyster fishery. Tonging is the principle means of harvest. An example of a closed NRC would be Apalachicola, Florida.

Open NRCs do not have the same emphasis on historical legitimacy. An example of an open oystering community would be Biloxi, Mississippi. In an open NRC, it is easier to gain access to the fishery, and establishing relationships with buyers and sellers does not require being linked to long-established social networks or kinship. Dredging is more likely to be promoted and practiced in an open NRC where the territorial claims on public reefs more typically associated with tonging are not as strong.

10.1.1.3 Relationships with Management and Others

The level of cooperation attainable among oyster fishermen is probably low and may arise from the independence of the activity of oystering, as well as an independence of family units. Competition is also a major obstacle to cooperative management. When common property resources become limited, competition can lead to periodic overharvesting (McCay and Acheson 1987). If such overharvesting is coupled with an increase in other impacts to oyster stocks (e.g., pollution, habitat loss), it can lead to a cyclic collapse of the fishery. This is because the perception that stocks are severely declining, even if temporary, can accelerate competition and subsequent overharvesting.

Paradoxically, oyster fishing is predicated on sustainability, and traditional NRC families can trace back conservation measures four generations (respondent, Bayou La Batre, Alabama). Increased competition in the fishery decreases responsibility for management of common oyster stocks by oyster fishermen NRCs. They blame other factions for the problems and give up traditional responsibilities for oyster bed management to regulators. An outcome of this is continued individual overfishing of public beds and increased resistance to cooperative management with other fishermen and with regulators.

With the exception of Louisiana, leasing of oyster beds is often viewed as another outcome of loss of individual control and responsibility for management, and it has been resisted by some independent oyster fishermen. Resistance to lease options stems from the traditional values of open access, and may be seen by some traditional oyster fishermen as giving up on reseeding and conservation of public oyster beds (respondent, Dauphin Island, Alabama).

Within closed NRCs, oyster fishermen are more likely to resist restrictive regulation on themselves but support restrictions on outsiders. An outcome may be the underutilization of local fishermen ethnobiology in devising management strategies. In establishing a successful oyster management plan for either open or closed NRCs, it is crucial to take into account the unique ethnobiological knowledge, also known as natural history, which links the user and the fishery resource. Vecchio (1988) has noted that user/regulator interaction as a basis of management, must involve communication and respect for natural history information. Communication becomes most difficult if fishery managers perceive the relationship between themselves and oyster fishermen as antagonistic. Additionally, communication is hampered in closed oyster NRCs because the people are suspicious of all outsiders, including regulators.

Because of an emphasis on inside-outside categorization in closed NRCs, the ability to form a sustainable cooperative entity is limited. Respondents from Alabama and Florida report that it is difficult to get different families and factions together to cooperate on any joint effort. This makes the prospect of cooperative management at least a two-step proposition. Since some oyster fishermen are unlikely to initiate their own cooperative organizations, it is difficult to get them to accept a cooperative management relationship with regulators. Even in the face of perceived political threats from the outside, cooperative organizations of oyster fishermen have failed (McCay 1989). Adaptive independence may preclude cooperative organization with traditional management structures, altogether.

The only way that these oyster fishermen can be organized into a cooperating, interdependent group is through actions aimed at increasing the social solidarity of cooperative members. Sustainable cooperative relationships must be maintained between kin networks and between oyster fishermen and regulators to achieve solidarity. However, the question of initiating and devising strategies to achieve that solidarity must come from the regulators, not the users. The problem is to develop such strategies in a manner compatible with existing traditions and social networks. Blanket policies are unlikely to be successful, particularly given the complex variability in the community size, history and fishery traditions of both closed and open NRCs spanning the Gulf of Mexico.

10.1.1.4 Family Interactions

In dealing with a population of non-lease oyster fishermen, it is important to note that the production activity of individual fishermen is embedded in a social network of kin-based responsibilities and actions. The core of this network is the oyster family. The nature of family structure is reflective of many fisheries around the world (Firestone 1966; Acheson 1981, 1988; Dyer et al. 1990). It is highly cohesive, production-oriented and tradition-limited. Tradition-limited means that perceived options of family members are tightly linked to the expectations and perceptions of fishing as a profession. Even though young individuals may be encouraged to leave the community, their socialization teaches them a value set that brings them back to the community. The occupational roles available to such individuals will be related to fishing and supporting roles (e.g., shucking, trucking, marketing). Thus, despite parental expectations for "something better" for offspring, the learned traditions of fishing tend to override outside aspirations. The result is that many return to, or remain in, their native communities (Rockwood 1973).

Rockwood (1973) described the nature of oyster families as informal social organizations that are highly competitive with each other. Competition among families, as with individuals, is a major obstacle to forming a cooperative organization in the communities. Kinship ties define the boundaries of cooperation. The family is a production unit, and values of work and family cooperation in the fishery may even be an important factor in overriding individual options, i.e., other occupations, education and leaving the community.

A low educational level may also limit opportunities for traditional oyster fishermen. Although recent data are not available, the education level attained by many oyster fishermen is relatively low, and opportunities for other occupations are limited (Forbus et al. 1989).

Oystering as an occupation is usually not a choice of those who are members of traditional oyster families. Likewise, in other fisheries in the world, sons and daughters of fishermen are often discouraged from following the occupation of their elders (Pollnac 1976; Dyer 1988). Fishing is often a last choice occupation which is followed when other options are not available or when the educational opportunity to get out of fishing is too costly or unattainable due to poor academic achievement. Offspring are seemingly held by the learned traditions of the oyster family.

Unfortunately, those who become oyster fishermen in gulf coast communities are faced with a problem of uncertainty and variability in income. This is due to the "capture" nature of the fishery. Income gained from one oystering season to the next is unpredictable. This variability is made worse by the fact that oyster fishermen may be underemployed if they have no other source of income.

10.1.2 Lease Fishermen and Lease Holders (Lessees)

The cultural and historical context of oystering in Louisiana is distinct from oystering in other states (Bordelon 1986). The oyster fishery of Louisiana is based on a state lease system that, in effect, limits access to the resource. Oyster fishermen pay for the privilege of working geographically defined oyster bedding grounds, that produced an average of 80% of the oyster harvest from 1962 to 1984 (Pawlyk and Roberts 1986). Those who work oyster beds are, in effect, following a tradition of oyster mariculture through reseeding of privately controlled areas. This tradition has made the Louisiana oyster fishery by far the most productive in the gulf.

10.1.2.1 Description of the Fishermen

Oyster fishermen and their families in Louisiana follow an independent lifestyle as do oyster fishermen elsewhere in the gulf; however, they are more intricately linked to the management of the resource. This is because those who lease beds invest time and resources into maintaining them. If they do not do so, they loose the resource. Many of the oyster fishermen in Louisiana are descendants of Dalmatian fishermen from Yugoslavia (Vujnovich 1974). They arrived in Louisiana between 1840-1850 and can be given credit for initiating cultivation of oysters. This cultivation knowledge was part of a fishing heritage common to the Adriatic region of Yugoslavia. Their efforts were very successful and can be attributed in part to an ethic of hard work and sincerity (Vujnovich 1974):

> "They developed the art of cultivating oysters to a science. Their reputation for good business practices, quality of the oysters, and truthfulness in dealing with the oyster dealers and consumers is beyond reproach."

Beside being honest and hard working, these Louisiana oystermen were also inventive. They are credited with inventing oyster tongs and introducing oyster dredging technology to the Gulf of Mexico (Vujnovich 1974).

10.1.2.2 Structure of the Community

Traditionally, Louisiana oystermen composed transient NRCs based on oyster camps. These camps were working sites in the bayous and originally were inhabited by oystermen only. Oystermen prospered, and camps eventually included families. Many of these camps grew into permanent communities. Early camps experienced rotation and back-and-forth migration of laborers between Dalmatia and Louisiana (Vujnovich 1974). Traveling back and forth allowed oystermen to work in vineyards and olive groves in the summer months and participate in oystering the rest of the year.

Such travel still continues but less frequently. Individuals may stay 2 or 3 years in Yugoslavia for every 6 or 7 years in Louisiana. Migration to New Orleans and other urban areas has dispersed the once concentrated oyster family populations. Migration of younger fishermen and sons of fishermen has been an ongoing trend (Bordelon 1986). Urbanization has made it more difficult for some lease oystermen to actively manage and patrol their leases. Some have lost leases held for decades while others suffer losses from poaching. In 1986, a group of Louisiana oyster fishermen requested that the LDWF establish special patrols to halt the stealing of oysters and destruction of leased oyster beds (Bordelon 1986). Because of threats to the viability of the fishery, oyster fishing communities are under stress.

10.1.2.3 Relationships with Management and Others

Oyster fishermen who own private leases are more active in the conservation and management of the resource. As with lobster fishermen in Maine (Acheson 1988), oyster lease fishermen must invest in management as part of their production strategy. Cooperation between lease owners can help reduce poaching, and sharing information on stock condition can also help lease holders make appropriate decisions on seeding and harvesting activities. Relationships between fishery managers, oystermen and the state date back to 1902 with the enactment of the state lease law and coincided with the establishment of the Louisiana Oyster Commission. From its inception, this commission was actively supported by oyster lease fishermen.

In contrast, non-lease oyster fishermen must still actively compete for a limited (public) resource in Louisiana. They do not often have the extensive cooperative networks common in oyster lease communities (key respondent, New Orleans).

10.1.2.4 Family Interactions

Traditional oyster camp families encouraged trans-generational participation in the fishery. In some cases, children were encouraged to pursue their education. This encouragement included housing the family in New Orleans away from oystering camps. Many oystermen would make weekly trips to the city to bring oysters and visit with their families (Vujnovich 1974). Those who fished public reefs from New Orleans were more likely to diversify into restaurants, wholesale oyster houses, or related endeavors. Children would be set up in these businesses with the seed money coming from the fishing activities of fathers (Bordelon 1986). Extended family ties were and are still maintained within camp communities between recent immigrants and relatives back in Dalmatia and between diffused households in urban areas.

10.2 Production and Marketing Relations

Production is here defined as "the utilization of resources to achieve a socioeconomic goal." This definition puts social as well as economic values on the production process. It implies that the livelihood itself has value, not merely in economic terms, but in the social benefits it provides. Marketing is the distribution of products for the purpose of achieving socioeconomic goals. Marketing of oysters and other seafood products also has social value and is linked to production through social and kin networks (Rockwood 1973).

The production of oysters is realized through the utilization of both public oyster reefs and leases. Production is initiated by harvest. In most states, technological advances in the fishery have been resisted. A form of institutionalized obsolescence (sail power only) was used to maintain the Chesapeake Bay fishery. Along the gulf, dredging as a form of harvesting has been resisted in Florida and Alabama.

Most often, self-employed, nonlease oyster fisherman sell their oysters to "raw-house" dealers/processors. Some of these marketers still provide rigs (e.g., fishing boats or vessels "rigged" for oyster dredging) to oyster fishermen on a contractual basis. Shares are deducted from the oysters gathered depending on the value of the rig, the debt-load of the operator with his patron and whether or not the rig is being rented (Rockwood 1973). Patron-client relationships between marketers and fishermen restrict to whom fishermen can sell oysters. The majority of independent oystermen can theoretically sell to anyone, but will usually establish socioeconomic ties to one or two buyers. These ties are based upon kinship and/or friendship between marketers and fishermen. Control of supply and price is maintained to a degree by informal agreement between marketers and may restrict from whom they buy. Such agreements may be ignored because of competition for buying oysters during the peak of the season (November through December).

Lease fishermen/lessees provide all needed equipment and capital for harvest. Markets may sometimes be traditional and kinship oriented; however, production is much more business-like. There is little sociological resistance to change marketers when prices fluctuate or when other problems arise.

In some nonlease oyster communities, adult males in a household are socialized as oyster fishermen, and supporting family members are involved in shucking and marketing of oysters. Marketing is also controlled within family networks. This nuclear family is the basis of the fishery. Older boys work with their fathers in tonging oysters. The wives and daughters work in oyster houses as shuckers. In the case of the shucking houses, wives of owner-operators work with their husbands in managing the business. This includes all operations from buying oysters to bookkeeping.

Although kinship ties are evident with oyster lease fishermen and lessees, business operations often involve specialized jobs that are sometimes conducted by persons unfamiliar with fishing itself. Many of these operations are quite large employing not only fishermen, but also biologists, bookkeepers, sales personnel and other persons.

In summary, the social and cultural characteristics of the gulf oyster fishery present a dichotomy. One branch is very independent and tradition oriented. It resists change even that which increases efficiency, such as gear use. It is sometimes communal and clan-like with family units participating in all aspects of production, processing and marketing, and success is often determined by competition.

The other branch is shielded from competition at the harvest level and success is mostly determined by available capital and environmental factors. It is also tradition oriented but with distinctly different values and precepts. Kinship ties exist, but business involves many persons and groups outside of the family or community.

11.0 PUBLIC HEALTH CONCERNS OF THE OYSTER FISHERY

11.1 Introduction and History

Virtually every food product that is consumed by humans has some ability to transmit disease-causing microorganisms. Oysters are of particular concern in the transmission of human diseases because of their feeding biology. They are sessile, filter feeders that concentrate disease causing bacteria, viruses and chemicals to many times the ambient water concentrations. Another important factor in the transmission of disease to humans is the propensity for consumption of raw, whole oysters.

Although the history of oyster consumption is quite long, the public health concerns from eating contaminated shellfish in the United States are relatively new. In the early 1900s shellfish-related diseases escalated and became epidemic by the early 1920s. At that time the states, federal government, industry, local government and others came together and developed the National Shellfish Sanitation Program (NSSP).

11.2 State, Federal and Other Authorities

Shellfish sanitation is basically regulated by the individual states in the Gulf of Mexico. Minimum standards are, however, promulgated and recommended to the states for adoption through the cooperative efforts of the states, the federal government and the industry. Enforcement of regulations is primarily a state function with the possible exception of the use of the Lacey Act and the Food, Drug and Cosmetic Act.

11.2.1 National Shellfish Sanitation Program (NSSP)

The NSSP, for the certification of interstate shellfish shippers, was established by a conference of federal, state and municipal authorities and representatives of the shellfish industry in February 1925. The conference was held in response to a major outbreak of typhoid fever in 1924 in the United States that was attributed to sewage-polluted oysters.

The NSSP is designed to prevent human illnesses that are associated with the consumption of fresh and fresh-frozen oysters, clams and mussels through sanitary control over all phases of growing, harvesting, shucking, packing and interstate transportation. Its purpose is to develop strict guidelines covering the quality of growing waters, harvesting techniques, record keeping, tagging, processing and shipping. These guidelines and criteria for the program are contained in the NSSP, Manual of Operations, Parts I and II, 1990.

The NSSP is a voluntary, tripartite program composed of shellfish producing and receiving states, the shellfish industry, and federal agencies. The Food and Drug Administration coordinates and administers the NSSP. In each participating state, one or more regulatory agencies manage the local shellfish sanitation program. The criteria of the NSSP are applied to both domestic and imported fresh and fresh-frozen shellfish. The NSSP defines shellfish as: "all edible species of oysters, clams, mussels and scallops;[1] either shucked or in the shell; fresh and frozen; whole or in part."

A principal objective of the NSSP is to provide a mechanism for certifying that shellfish that are shipped in interstate commerce meet agreed-upon, specific sanitation and quality criteria. The NSSP has procedures that allow a participating state to certify firms that handle shellfish products that have passed state inspection. This inspection and certification assures public health officials in a receiving state that shellfish products from a certified dealer have been grown, harvested, transported, processed and shipped in accordance with NSSP criteria.

Simply stated, the NSSP certification system requires all fresh and fresh-frozen oysters, clams and mussels in interstate commerce be tagged by a certified dealer. Certified dealers must also maintain files identifying the source of each lot of shellfish shipped in interstate commerce. This certification and record-keeping provides sanitary controls and product traceability from the moment of shellfish harvest to its final sale. For the certification process to be effective, certified dealers must fully comply with these requirements.

The minimum plant sanitation requirements for interstate shippers are described in Part II of the NSSP Manual of Operations. Only those shellfish firms that meet the guidelines are eligible for certification and listing in FDA's monthly publication, the "Interstate Certified Shellfish Shippers List (ICSSL)." Over 5,000 copies of the ICSSL are distributed monthly. The circulation of the ICSSL is an important NSSP function because shellfish that are sold in retail establishments and restaurants are required to originate from an approved source. Listing in the ICSSL provides this assurance. The ICSSL lists both domestic and foreign certified sources of shellfish.

Some of the activities that require certification under the NSSP are:

- Harvesting of shellfish that originate in estuarine and marine waters (Part I of the Manual of Operations) or the culture and subsequent harvest of shellfish from artificial environments (Parts I and II).

- Purchasing shellstock directly from licensed harvesters, tagging and packing the shellstock and shipping this product in interstate commerce (Part II, Section E).

- Depuration. This is the process of controlled purification where shellfish that originate in restricted (i.e., moderately-polluted) waters are cleansed in tanks in accordance with NSSP guidelines (Part II, Section I).

- Shucking and packing of shellfish where one or both shells are removed in accordance with NSSP guidelines (Part II, Sections D and H).

[1] Scallops are to be excluded where the final product is the shucked adductor muscle only.

- Wet storage of shellstock either in nearshore floats or in tanks (Part II, Section C).

- Repacking. This is the practice of purchasing shellfish, either shucked or as shellstock, and repacking the shellfish into different containers (Part II, Section F).

- Reshipping. This means the purchase of shucked shellfish or shellstock from another certified dealer and selling the product without repacking or relabeling to other certified dealers, wholesalers, or retailers (Part II, Section G). The use of the reshipper classification is, however, left to the option of the state.

Record-keeping is an important part of the NSSP. State programs require that records on location of catch, date, etc., be maintained by the reshipper. Such records could be invaluable in locating the source of the contaminated shellfish in the event of a local outbreak of suspected shellfish-related illness.

11.2.2 Interstate Shellfish Sanitation Conference (ISSC)

In September 1982, the ISSC was established in Annapolis, Maryland, by state regulatory officials (state officials from 22 states including Texas, Louisiana, Mississippi, Alabama and Florida). Other participants at the conference included the FDA, the NMFS, the DOC and members of the shellfish industry. The state officials established a constitution, by-laws and procedures for the operation of the ISSC.

The purpose of the ISSC is to promote conformity within the NSSP by providing for formal structure wherein regulatory authorities can establish updated guidelines, procedures for the uniform application of those guidelines and for sanitary control of the shellfish industry.

A memorandum of understanding (MOU) between the FDA and the ISSC was signed in 1984 and published in the Federal Register, Volume 49, Number 63. The MOU established a basis upon which the FDA and the states can work cooperatively to foster and improve the sanitary quality of shellfish in the U.S.

The ISSC formally identifies as uniform guidelines for state shellfish control programs, the NSSP Manual of Operations, Parts I and II, 1990. The manual consists of the following sections:

Part I - Growing Areas
- Section A: General Administrative Procedures
- Section B: Laboratory Procedures
- Section C: Growing Area Survey and Classification
- Section D: Controlled Relaying
- Section E: Control of Harvesting

Part II - Harvesting, Processing and Distribution
- Section A: General Administrative Procedures
- Section B: Shellstock
- Section C: Wet Storage

Section D: Shucking and Packing
Section E: Shellstock Shipping
Section F: Repacking
Section G: Reshipping
Section H: Heat Shock
Section I: Controlled Purification

The ISSC is an organization of state shellfish control agencies, the shellfish industry and federal agencies. The primary goal of the ISSC is to promote the adoption of uniform standards, rules, regulations and procedures for use by state shellfish control agencies. All coastal shellfish producing states, shellfish receiving states, shellfish industry, FDA, NMFS and EPA participate in or support the ISSC.

The FDA regional shellfish specialist is the focal point for answering questions on shellfish sanitation and the NSSP requirements. The shellfish specialists evaluate state shellfish programs each year to assure conformity with the NSSP criteria. Specific areas for evaluation include: (1) administrative and legal authority, (2) laboratory facilities, (3) plant sanitation and processing and (if applicable) (4) growing area classification and (5) enforcement of harvesting restrictions. The points covered in the state evaluation are summarized and explained in Table 11.1.

11.2.3 State Agencies

State agencies and their respective responsibilities with regard to oyster sanitation management are listed in Table 11.2.

11.2.4 National Marine Fisheries Service (NMFS)

The NMFS is currently involved with a number of projects regarding shellfish and oyster sanitation. Studies regarding methods to depurate and eliminate pathogens are underway, and an indicator study is proposed. Also, it has completed and tested a model for hazard area critical control point (HACCP) inspection. The Mussel Watch Program to assess chemical contamination and various cooperative enforcement efforts with FDA and states are ongoing programs.

11.2.5 U.S. Food and Drug Administration (FDA)

The FDA provides assistance to states and advises the states on matters pertaining to the preservation and improvement of public health as they relate to shellfish in the Public Health Services Act, as amended (Public Law 410). Additionally, the Code of Federal Regulation (21 CFR 1240.610) prohibits the interstate shipment of shellfish that are likely to spread disease.

The FDA Northeast Technical Service Unit (NETSU) provides technical assistance, consultation, training and research services for NSSP participants. These support services (subject to prior commitments) are available at no cost if requested in writing. The NETSU engineers and microbiologists have developed training courses and materials for all aspects of the NSSP. In addition, the FDA maintains fishery research laboratories at Dauphin Island, Alabama, and Seattle, Washington, that complement the research capabilities of the NETSU.

Table 11.1. National Shellfish Sanitation Program (NSSP) state program evaluations.

Administrative & Legal Authority	Laboratory	Plant Sanitation	Growing Water Classification	Patrol
Effective state laws and regulations Seizure/embargo powers	Follows APHA* procedures or other established procedures Bacteriological/ toxicological proficiency Participates in FDA quality control programs Qualified state laboratory evaluation officer	Certify and inspect interstate shippers Participates in joint FDA/state inspections Regulates shipping and labelling Provides effective supervision of depuration and wet storage facilities	Water sampling and classification program Necessary measures are taken to make classifications available to the public	Prevention of shellfish harvest from closed areas Enforcement of harvesting restrictions

*American Public Health Association

Table 11.2. State authorities responsible for NSSP evaluation segments.

State	Administrative Legal Authority	Laboratory	Plant Sanitation	Growing Water Classification	Patrol
FLORIDA	Florida Department of Natural Resources	Division of Marine Resources, Bureau of Marine Resource Regulation and Development, FDNR	Division of Marine Resources, Bureau of Marine Resource Regulation and Development, FDNR	Division of Marine Resources, Bureau of Marine Resource Regulation and Development, FDNR	Florida Marine Patrol, Division of Law Enforcement, FDNR
ALABAMA	Alabama Department of Public Health	Alabama Department of Public Health	Alabama Department of Public Health	Alabama Department of Public Health	Alabama Department of Conservation and Natural Resources, Division of Marine Resources
MISSISSIPPI	Department of Wildlife, Fisheries & Parks; Bureau of Marine Resources	Bureau of Marine Resources, Gulf Coast Research Laboratory	Bureau of Marine Resources	Bureau of Marine Resources	Bureau of Marine Resources
LOUISIANA	Louisiana Department of Health and Human Resources, Office of Health and Environmental Quality	Louisiana Department of Health and Human Resources, Office of Health and Environmental Quality	Louisiana Department of Health and Hospitals	Louisiana Department of Health and Human Resources, Office of Health and Environmental Quality	Louisiana Department of Wildlife and Fisheries
TEXAS	Fisheries and Wildlife Division - Coastal Branch; Texas Parks and Wildlife Department	Seabrook Marine Laboratory	Texas Department of Health	Texas Department of Health	Law Enforcement Division, Texas Parks and Wildlife Department

The FDA regional office is the appropriate location to initiate inquiries about participation in the NSSP. The FDA regional shellfish specialists can answer questions pertaining to all aspects of the program, from administrative to field topics. The regional specialist aids a prospective NSSP participant by acquainting him/her with the appropriate NSSP guidelines and will facilitate the development of state regulations and procedures. Also, the regional specialist is the first line contact for state technical/training requests.

Upon confirmation that the newly developed state shellfish sanitation program is ready to be evaluated, a regional shellfish specialist and NETSU microbiologist will be scheduled to appraise the program. The FDA must evaluate a state's administrative and technical capabilities before that state may participate in the NSSP. Also, program expansion into new areas such as depuration and wet storage require FDA evaluation prior to becoming operational.

Upon successful completion of this evaluation, the FDA Shellfish Sanitation Branch will accept state recommendations for firms to be included on the ICSSL. The time frame for completion of the process will vary according to the complexity of the state program and availability of FDA staffers.

11.3 Classification of Oyster Growing Waters

Each state growing area shall be correctly designated by the state shellfish control authority with one of the following classifications described in Part I, Section C, of the NSSP Manual of Operations.

Approved Area - A growing area that has been approved for growing or harvesting shellfish for direct marketing. An approved shellfish growing area may be temporarily closed when a public health emergency is declared (e.g., hurricane or flooding).

Conditionally Approved Area - A growing area determined to meet approved area criteria intermittently. The area is closed when approved area criteria are not met, and the conditions affecting this degradation of the water quality must be predictable and specified in a management plan.

Restricted Area - An area from which shellfish may be harvested only if permitted and subsequently subject to a suitable and effective purification process.

Conditionally Restricted - An area that meets restricted area criteria intermittently. The area is closed when restricted criteria are not met, and the conditions affecting this degradation of water quality must be predictable and specified in a management plan.

Prohibited Area - An area prohibited for the harvesting of shellfish for any purpose except depletion thereby eliminating the potential for illegal harvest.

Growing areas shall be classified on the basis of sanitary and marine biotoxin survey information. All state coastal and estuarine shellfish growing areas that have not been surveyed shall be designated as prohibited. All closures and classifications are the primary responsibility of the state shellfish control authority.

11.4 Shellfish Processors, Shippers and Packers

The state shellfish sanitation control agency (SSCA) shall conduct inspections and maintain records of those inspections, with such frequency as to ensure that sanitary conditions of operations are maintained. Dealers that do not meet and maintain the minimal sanitation requirements shall not be eligible for listing in the ICSSL.

11.5 Imports/Exports

Sanitation control of imported oysters from other countries is accomplished in a similar fashion as with state shellfish sanitation programs. The FDA evaluates a particular country's shellfish sanitation program, and if approved the FDA enters into a memorandum of understanding (MOU) with the country. The country then operates its own program and certifies dealers/processors for approval to export oysters to the U.S.

Only certified dealers from countries with approved MOUs may export oysters to the U.S. The FDA publishes a list of certified dealers with MOU approved countries in the same manner as the "State Certified Shellfish Shippers List" is produced.

11.6 Illnesses and Intoxications

Historically, illnesses and intoxications (resulting from ingestion of toxins) have been associated with consumption of molluscan shellfish from waters that do not meet approved criteria. The harvest from these waters was usually illegal and done by unscrupulous persons. These pirates of shellfish from closed waters have been commonly referred to as "bootleggers." Occasionally, a state has misclassified growing waters and this has also resulted in illness outbreaks associated with consumption of shellfish. A list of these illnesses and intoxications are as follows:

INFECTIOUS DISEASES	MEDICAL CONSEQUENCES
Bacterial	
Typhoid fever (*Salmonella typhi*)	Characterized by continued fever, constipation, slow pulse, involvement of lymphoid tissues. Fatality rate may be 10% but can reduce to 2% to 3% with antibiotics. Shellfish associated typhoid has not been reported in the U.S. since 1954.
Cholera (*Vibrio cholera*)	A serious, acute intestinal disease characterized by sudden onset, vomiting, profuse watery stools, rapid dehydration and collapse. Death may occur within a few hours after onset. Case fatalities may run from 5% to 75% in explosive epidemics. Serological types 0-1 and non 0-1 are responsible for recent outbreaks.

Salmonellosis (Salmonella spp.)	Three clinically-distinguishable forms occur in man: enteric fever, septicemia and acute gastroenteritis. Diseases vary in severity but are generally milder than that of typhoid. There are many pathogenic Salmonella species.
Shigellosis (Shigella spp.)	Gastrointestinal illness characterized by nausea, vomiting, diarrhea (can be severe) and dehydration. Onset ranges from 12 to 50 hours.
Other bacterial pathogens	Certain genera and species have been reported that cause gastroenteritis of varying severity. These include Escherichia coli, Bacillus cereus, Staphylococcus, Campylobacter, Plesiomonas shigelloides, Aeromonas hydrophila.
Viral	
Hepatitis A	An acute infectious disease that ranges from subclinical infection to severe jaundice, liver degeneration and death. Onset ranges from 15 to 50 days. Convalescence may be prolonged (several weeks to months).
Other viral agents	Many different viruses are known to cause diseases of varying nature and severity. Their role in shellfish-borne disease is poorly described.
Unknown	
Acute gastroenteritis	Acute gastroenteritis is a relatively benign and self-limiting disease, more a cause of acute discomfort than of serious morbidity. Onset is typically within 2 days and the duration is as short as 1 to 2 days but may be considerably longer. Because of the nature of this illness, it often goes unreported to medical authorities although it is being reported with increasing frequency. In most cases no infectious agent is demonstrated. Recent reports have implicated viruses (notably Norwalk virus) as the etiological agent.

MARINE BIOTOXINS

Paralytic shellfish poison (PSP)

This shellfish-associated neurotoxin causes paralysis that may progress from numbness and slight tingling about the lips, mouth and face to death by respiratory failure. There is no known antidote and the only therapy is supportive, artificial respiration. The toxin-producing agents are marine dinoflagellates of the Gonyaulax genus.

Neurotoxic shellfish poison (NSP)

Symptoms of poisoning are associated with numbness and tingling around the mouth and face progressing to involvement of the hands and feet and sometimes accompanied by difficulty walking. Deaths from this type of poisoning have not been reported. The causative agent is Gymnodinium breve, a marine dinoflagellate.

Diarrhetic shellfish poison (DSP)

A toxin first isolated from mussels and scallops in 1976 in Japan. The toxin is fat-soluble and was extracted from the hepatopancreas of shellfish. Epidemiological data indicate that 12 mouse units (MU) will induce a mild form of poisoning in humans. The dominant symptoms are diarrhea, nausea, vomiting and abdominal pain occurring within 30 minutes to a few hours after ingestion. The agent responsible for the production of this toxin is a marine dinoflagellate, Dinophysis fortii. Other Dinophysis species, as well as certain Prorocentrum species, have been implicated as DSP producers.

Venerupin poison

This poisoning has been reported only from local areas around Japan. Persons who have eaten toxic clams and oysters develop hemorrhagic spots on the skin with bleeding from the mucous membranes and acute yellow atrophy of the liver.

CHEMICAL POISONING

Minamata disease (mercury poisoning)

Chronic intoxication from organic mercury begins with paresthesia in extremities leading to total nervous system involvement.

OTHER

VIBRIOS

Other illnesses associated with consumption of oysters from the gulf that are not associated with the classification of the growing area are those caused by naturally occurring marine vibrios. These marine bacteria may cause illnesses by invading wounds or cause illness in oyster consuming persons whose immune system has been compromised. This immunosuppression has been associated with underlying diseases such as diabetes, cirrhosis, alcoholism, hemochromatosis, etc. The more important vibrios are as follows:

Vibrio vulnificus

A particularly virulent marine pathogen for patients with certain underlying chronic illness. Primary sepsis may be associated with fever, chills, hypotension, nausea, vomiting, diarrhea, abdominal pain and skin lesions. Case fatality rate generally exceeds 60%.

Vibrio parahaemolyticus

A gastrointestinal pathogen whose clinical manifestations include diarrhea, cramps, nausea, vomiting and fever. Incubation ranges from 4-96 hours. Illness is self-limiting and the median duration is about 3 days.

Other *vibrios*

Several species have been identified as causative agents of gastroenteritis of varying severity. These include *V. fluvialis*, *V. mimicus*, *V. hollisae* and *V. furnissii*.

12.0 MAXIMUM SUSTAINABLE YIELD (MSY) AND OPTIMUM YIELD (OY)

The MSY and OY are common and traditional concepts used to establish measurable management goals for harvest in a given fishery. The purposes for these calculations are to describe the biological limits of fishery production (MSY) and to determine the catch level that provides the greatest social and economic benefits to users (OY).

12.1 MSY

The MSY for a fishery can be defined as the largest amount of fish or shellfish that may be harvested from a given population on a sustained basis for its carrying capacity. Calculations of MSY rely on and are only as good as the data input to the estimation. There are basically two methods or methodologies that are employed to calculate MSY.

The first requires a long-term data base of catch and effort within the fishery. The data base must also contain production levels at or near maximum. When tabulated in a graph, catch continues to increase as effort increases to a point. Thereafter, catch levels decrease as effort increases thus establishing a point where fishing pressure begins to reduce the biological ability of the species to perpetuate its numbers. In essence, MSY will be a harvest level near the highest point on the graph. At that point increasing effort will no longer produce increased harvest, but sustaining that level of effort will continue to produce the maximum harvest, thus MSY. Such catch/effort data are not available for meaningful calculations of MSY for oysters in the gulf.

Where adequate data are missing estimations must be made regarding growth, mortality, migration and recruitment. These factors and perhaps others define the carrying capacity for a given population.

With regard to the oyster fishery of the gulf, environmental fluctuations, both natural and man-induced, cause extreme variations in populations. Within the boundaries of a given state, these factors may positively affect oyster populations on one reef and negatively affect those on another. Thus, estimations of carrying capacity must be reef or area specific.

Populations of oysters also fluctuate greatly over time, both long-term and short-term. For example, all oysters on a given reef may be killed as the result of floods, hurricanes or other natural disasters. In subsequent years, near record levels of production may be observed on the same reef. Conversely, relatively large populations may produce few additional oysters in subsequent years when environmental conditions are unfavorable for spawning, setting and maturation. Although growth rates have been calculated (McGraw 1980), they are quite variable by area and environmental conditions.

Because oysters become sessile soon after a planktonic larval period, estimates of migration can only be attempted for the larval stages. Calculations are thus nonapplicable to harvestable adult populations. Recruitment to a population also occurs at the time of metamorphosis from larvae to juveniles. Recruitment to the adult spawning stock is quite rapid and usually occurs prior to growth to fishable size. Since fishing effort does not affect larvae and would only affect juveniles and adults through incidental mortality by gear and handling, it is not a significant factor influencing MSY calculations for oysters.

There are wide variations in nonfishery-related mortality for a given population and a lack of applicability or significance of other factors used in traditional MSY calculations. Variability in environmental influences on a given population over time makes estimation of natural mortality impractical, if not impossible. An adequate, long-term data base of catch and effort for a given population is also lacking. Without such information, attempts at MSY calculations would be futile and of no practical value to management.

Oyster abundance and range appear to be more limited by salinity/temperature regimes and available substrate for setting than fishing pressure. Pollution and environmental stresses play a greater role in available harvest than previous years' fishing. Hence, MSY is not established for the gulf oyster fishery.

12.2 OY

Because of a paucity of existing data with which to calculate MSY, and the extreme environmental dependence of gulf oyster stocks, OY is defined as follows:

> All the adult oysters of practical value and use that can be harvested from a given reef area provided:
>
> 1. The shell (or an equal or greater amount of other cultch material proven to be as effective as the whole oyster shells in catching and retaining spat) are returned to the reef in the same area that harvest occurred; and
>
> 2. Freshwater from natural stream sources and runoff to the reef are maintained or restored in a manner that
>   a) eliminates contamination from harmful substances to the oyster or man (as a result of consumption) and
>   b) optimizes salinity, temperature, water flow and nutrient conditions for oyster setting, growth and survival.

13.0 PROBLEMS IN THE GULF OF MEXICO OYSTER FISHERY

Numerous factors contribute to the problematic nature of the oyster fishery in the gulf. The oyster fishery is perhaps the most labor intensive fishery in the gulf. Many people are involved with the fishery, fishery support functions and other activities that directly affect the fishery. Because of increased involvement of people in the industry and the inability of oysters to retreat from potentially mortal conditions, it is expected that this fishery has the highest incidence and diversity of problems.

Problems that have most severely affected gulf oyster abundance are habitat loss and pollution, including pollution that has rendered otherwise healthy oysters unsafe for human consumption. Other problems including user conflicts have resulted in more regulation and enforcement. Regulatory and enforcement problems coupled with associated socioeconomic and public perception problems have consumed the greatest portion of management attention. The combination of environmental problems and user related problems has created one of the most complicated and diverse management challenges.

13.1 Habitat Problems

Loss of habitat is perhaps the most serious problem facing the gulf oyster industry. It was a past problem; it is a present problem; and seemingly, it will be a future problem. Habitat losses are natural and man-made, temporary and permanent. Most natural losses are temporary. Permanent natural losses in one area may result in reestablishment of oyster populations in another area over time. Man-induced losses are usually permanent and have had the most profound negative effect on gulf oyster abundance particularly since the 1940s and 1950s. The most serious and long-lasting losses have resulted from habitat alterations to provide for human habitation and other needs in rapidly developing coastal areas. Habitat degradation has also occurred as a result of cultch loss and fluctuations in salinity on reefs. In some cases, reefs have been destroyed.

13.1.1 Loss of Cultch

The loss or lack of available cultch has significantly reduced oyster abundance in many areas of the gulf. Cultch has been removed by fishing and shell dredging without adequate replacement. Cultch has also been lost as a result of natural processes such as burying and fouling.

13.1.1.1 Oyster Shells Not Returned to Reefs

Oyster shells have proven to be very effective in setting and retaining spat. It has been perhaps the most widely used cultch material. However, oyster shells have other practical values that create competition for their use in resource management programs.

13.1.1.1.1 Oyster Shells Used for Other Purposes

Although oyster shells make excellent cultch, they are also quite valuable for other purposes. Their shape and compaction qualities make them a highly desirable material for road-bed construction, particularly in low-lying or swampy areas. Since this type of construction activity occurs largely in the same general area where oysters are harvested and processed, the construction industry competes with the oyster industry for shells. The construction industry is usually able to pay a higher price for shells and is better physically equipped to transport shells from process locations to use locations. Shells are thus irreclaimable to the oyster industry.

Oyster shells are primarily composed of calcium carbonate which has value in other industries. They have been ground to various consistencies and used in the manufacture of many products from chicken feed (Galtsoff 1964) to cement (Arndt 1976). The increased surface area to volume ratio of piles or partially compacted shells has also created a demand for oyster shells in septic systems and water filtration systems.

13.1.1.1.2 Lack of Recovery Methods and High Costs

Many oysters harvested from gulf coastal waters are sold as shellstock and may be shipped to other states precluding recovery of the shells. Oyster shells are usually recovered from local shucking operations and raw oyster bars within states. These operations are usually scattered, and the amount of shell generated by any individual operation is quite small when compared to overall cultch needs.

State agencies and private lessees are the primary users of oyster shells as cultch. These entities are less able to pay a premium price for shells and are usually poorly equipped to collect, handle and store shells prior to optimum planting seasons. The nature of recovery operations requires periodic collection of small amounts of shells over a wide area. This method of oyster-shell recovery for replanting becomes quite labor intensive and expensive.

13.1.1.1.3 Legal Questions of Ownership and Fees

In an effort to purchase replacement cultch in a competitive manner with other users, some Gulf States have enacted laws/regulations providing for state ownership of the shells. Some states have mandated that the shells be replanted or a fee commensurate with the shell value be collected in lieu of replanting the shells when it is not economically feasible.

Legal questions remain unresolved regarding the right of a licensed harvester to the entire oyster (shells included), and whether or not a fee can be charged for recovered shells. Resolution of this problem is important to states that wish to recover shells for replacement cultch.

13.1.1.1.4 Lack of Funding Support to Cultch Planting Programs

The success of shell planting is most often limited by the amount, not the type of cultch used, and funding is the main factor controlling availability. Most cultch planting programs in the Gulf States are underfunded and cannot replace cultch at the same rate it is being lost. In some cases shell planting may be viewed as a subsidy program rather than environmental maintenance. In other cases, social, political and economic structures are not in place to assess financial responsibility for return of shells/shell value to reefs.

13.1.1.2 Lack of Alternative Cultch Materials and Other Replacement Practices

Cultch loss from reefs is exacerbated by the lack of alternatives to the recovery and replanting of oyster shells. In the north central gulf, clam shells (*Rangia cuneata*) have been dredged for many years and used as a low cost cultch. However, environmental concerns about dredging operations have severely restricted or eliminated these industries. Scallop shells, broken concrete and other materials have also been used on a limited basis because they are not available in sufficient quantities, or they are less effective than oyster shells in spat collection and retention.

Past harvesting practices included both culling and shucking on reefs, thus replacing shells in the same area as harvest. Health considerations now prohibit shucking on reefs; consequently, shells are removed from the harvest area.

13.1.1.3 Burying

Cultch is sometimes lost on a reef as a result of burying. This process may occur naturally as a result of storms, subsidence or increased sedimentation. Man-induced burying may occur during normal harvest operations, particularly on reefs where dredging is allowed. It may also occur when shrimp trawls or other such gear are dragged over reefs. Burying of cultch may also occur as a result of new channel dredging, maintenance dredging or other silt-dispersing operations in close proximity to reefs.

13.1.1.4 Fouling of Cultch

The ability of cultch to set and retain oyster spat may be reduced as a result of fouling. Fouling may occur as a result of biological competitors or abiotic factors such as sedimentation. Biological fouling is usually temporary or seasonal and may not entirely preclude larval attachment. Abiotic factors may deter attachment for longer periods.

13.1.1.4.1 Fouling by Competitors

Competitors foul oyster reefs by occupying surface area where oysters would also attach. As competition increases, the availability of suitable attachment sites for oysters decreases. Some competitors such as boring sponges and boring clams may actually destroy oyster shells and render them unsuitable for attachment of spat and growth to adult size.

13.1.1.4.2 Sedimentation Fouling and Other Physical or Chemical Fouling

Sedimentation reduces the availability of cultch, especially in shallow areas where fine silt covers oyster reefs. It may occur whenever the silt is resuspended. Other physical and chemical fouling may occur whenever substances (oil or other chemicals) are in contact with reef material and preclude successful larval attachment.

13.1.2 Salinity Fluctuations

Because oysters are sessile, changes in salinity regimes on reefs can have a profound effect on oyster populations. Total mortality of oyster populations and losses of reef complexes can occur as a result of flooding or "freshets" that reduce or eliminate salinity. On the contrary, high salinity periods may allow marine predators to move into estuarine reef areas and decimate oyster populations.

These changes may be seasonal or long-term, and they may be natural or man-induced.

13.1.2.1 Natural Fluctuations

Salinities in any given estuary where oysters are present may fluctuate seasonally depending on rainfall and stream flow. Oyster abundance fluctuates from season to season based in part on these salinity changes. Peak oyster production generally occurs when salinities are in the median range for the area. Oyster abundance decreases as salinities are depressed or elevated beyond optimal ranges.

Although depressed production periods caused by wide, natural fluctuations in salinity are severe at times, they are usually complemented by high production periods with optimum conditions. An exception may occur when a coastal stream changes course and diverts to a new channel. Major and permanent impacts will then occur at the outfalls of both the old and new channels. Little can be done to avert these natural changes.

13.1.2.2 Man-Induced Fluctuations

Salinity changes that have had the greatest long-term, negative impact on oyster populations are man-induced. Channelization and other deepening projects in shallow estuaries have allowed high salinity saltwater wedges to infiltrate reef areas bringing with them increased numbers of oyster predators. Other activities such as construction of levees, dams, locks and freshwater diversion structures, as well as, freshwater withdrawal from streams and shallow aquifers have reduced the natural supply of freshwater to reefs.

Such habitat changes have permanently changed salinity regimes on numerous reefs, thereby reducing or even precluding continued production. These changes have had the greatest effect on reducing oyster production in the gulf, and they will be extremely difficult to reverse or ameliorate.

13.1.3 Reef Destruction

In some instances oyster reefs may be physically destroyed. Natural destruction has occurred as a result of hurricanes. The strong tidal surges of such storms have scoured and buried reefs. Also, storms have eliminated portions of coastal barriers and barrier islands that provide protection to inshore reefs.

Reefs have also been destroyed by dredging and filling activities. Past incidences of this type of destruction were most numerous in high growth coastal areas when few habitat protection laws were in effect.

13.1.4 Disease

The impacts of disease on production levels are poorly understood and resource managers have had minimal success in eliminating the threat. The incidence and severity of disease outbreaks within oyster populations may be likened to similar situations with agriculture. Once epizootics occur, they may totally devastate an entire population. As such, these outbreaks affect the overall abundance of oysters and are a problem for managing the fishery. Although prevention and treatment of disease outbreaks may not be practicable from a management perspective, a greater understanding of the causative factors could reduce both the biological and economic impacts.

In the gulf, Perkinsus marinus is the most important protozoan pathogen and has been implicated in numerous epizootics resulting in massive oyster mortalities. The distribution and abundance of P. marinus appear to be limited by salinity and to a lesser degree by temperature. The incidence and intensity of this disease may also be exacerbated by environmental stress and pollutional burden (Ray et al. 1953, Quick and Mackin 1971, Craig et al. 1989, Soniat and Gauthier 1989). A more thorough discussion of P. marinus is presented in Section 5.

The protozoan, Haplosporidium nelsoni, popularly called MSX disease, is responsible for massive oyster mortality from Massachusetts to the Chesapeake Bay. An organism similar to MSX was recently reported as far south as Biscayne Bay, Florida. The potential for this organism to be introduced into gulf waters represents a serious problem to shellfish managers. The introduction of this disease to gulf stocks may be facilitated by accidental or purposeful introductions of oysters, natural range extension or coincidental transport.

13.1.5 Pollution

Pollution is a major problem for the oyster industry. Oysters are particularly susceptible to pollution in most forms because they are sessile, filter-feeders that pump large amounts of water through their systems to extract food. In the course of feeding, oysters concentrate pollutants to many times the ambient levels in the surrounding water.

Pollutants vary from biological forms such as bacteria and viruses to chemical substances (pesticides, herbicides, petrochemicals and heavy metals). Concentration of these substances in oysters can cause stress and ultimately death, either directly or in combination with other factors, particularly disease. Also, relatively large amounts of these substances may be passed on to predators and even man when polluted oysters are consumed. Other forms of pollution may reduce oxygen levels and change temperatures thus affecting oyster survival and reproduction.

13.2 Public Health Problems

The public health concerns that are associated with the handling and consumption of oysters by humans are discussed in Section 11. Those concerns are reiterated in this section because they constitute a major problem for the oyster industry. Concerns for public health also create many regulatory and enforcement problems that are discussed later in this section.

Categorically, public health concerns involve disease and toxin (poison) transmission to humans. Pathogens from human and other animal feces entering oyster growing areas are taken up by the filter-feeding oysters. These wastes may contain human pathogens that when present are concentrated by the oysters. When oysters from these waters are consumed even in relatively small quantities, disease may result. Toxins and other substances may likewise be concentrated by oysters. Ingestion of contaminated oysters can cause disease, poisoning or death.

Public health problems are aggravated because many of the best growing waters are located in close proximity to discharges of sewage and other wastes.

This phenomenon is increasingly evident in highly developed coastal areas and is exacerbated by the fact that oysters flourish in low salinity nearshore waters.

13.3 Regulatory Problems

The oyster fishery is one of the most regulated fisheries in the gulf. The limited supply and high value of oysters coupled with large numbers of participants and handlers contribute to the need for extensive regulations. However, the majority of regulations deal with protecting public health. Very explicit regulations are needed to govern harvesting, processing, shipping and storage in order to ensure that a safe product reaches the consumer.

More regulations usually mean more regulatory problems. Regulatory problems are present in many aspects of industry and management interaction.

13.3.1 Inadequate Tagging and Product Identification

Because of the potential for humans to contract diseases or poisons from oysters and the relatively rapid spoilage of the product, it is important to know the areas from which oysters are harvested and the date of harvest. Most states use a tagging system to gain this information. Under these systems, tags or labels are attached to sacks or other containers into which oysters are placed following harvest, and facts such as the harvester, date, harvest location, dealer/processor receiving the oysters and perhaps other facts are recorded on the tags. This information allows enforcement officers and health officials to follow oysters through processing channels and to ensure that an acceptable product reaches the consumer.

Problems with tagging and identification of shucked products result from inconsistencies in the information required and the method of issuance among Gulf States. Some states allow fishermen to purchase large numbers of blank tags and fill in the required information as harvest occurs during the season. This procedure may result in incorrect or incomplete information being placed on tags. Also, it provides a means for irreputable persons to tag and disguise illegally harvested (i.e., taken from closed reefs) oysters as legally harvested. Similar problems occur due to the lack of standardized information requirements for labels and shipping receipts for shucked oyster products.

13.3.2 Inconsistent Size Regulations and Measures

Variations in size limits and measures among states may cause enforcement and perhaps processing, marketing and pricing problems. Products may be lost as a result of shuckers culling small oysters during processing. Also, the value of a given measure may change depending on the size of oysters.

In the past, variable size limits were allowed within a state for different processes (e.g., one size for "steam oysters" and another size for "raw stock"). States also have differing tolerances for undersized oysters within a given measure.

13.3.3 Inconsistent Gear Regulations and Catch Quotas

A wide variation in allowable gear exists among the five Gulf States. The exclusion of certain gear by certain states is perhaps more a traditional measure than a resource management need. Some gear restrictions are needed to prevent damage to reefs (especially soft-bottom reefs). Other gear restrictions may only reduce efficiency, and most of the Gulf States have daily catch quotas to limit harvest.

Problems with variation in allowances for gear and quotas result primarily when fishermen harvest in two or more states. First, the harvester may be required to invest in two or more types of the same or related gear thereby increasing production costs or reducing efficiency. Second, enforcement problems such as the potential possession of both illegal and legal gear arise. Variable quotas invariably cause problems when enforcement attempts to determine from where oysters are harvested.

13.3.4 Lack of Recreational Harvest Information

Very little information on recreational harvests exists. Some states do not require licenses for recreational harvesters, but most limit their daily catch. Information on the numbers of recreational harvesters and the amount of harvest by gear type is needed.

13.3.5 Lack of Standardized Criteria for Opening and Closing Conditionally Approved Areas

Because of the increasing incidence of pollution, many reefs that were previously approved for harvest are now conditionally approved. Individual states establish the criteria for closing of conditionally approved reefs under guidelines established by the ISSC and published in the NSSP Manual of Operations. Problems occur primarily with reefs and reef complexes that exist in two states. These problems become acute when each state follows the guidelines but establishes different closing criteria that result in adjacent reefs having differential openings. Coordinated efforts are needed to solve these problems, especially in reef areas that cross state lines.

13.3.6 Inconsistent Classification of Oyster Growing Waters

Problems associated with classifications of growing waters (approved, conditionally approved, restricted, prohibited, etc.) are similar to those outlined in 13.3.5 above. They occur primarily between states and are most serious when similar areas are classified differently. For example, growing waters on the western side of a state may be classified as "approved," while the same waters across the state line in the eastern end of the adjoining state are "conditionally approved," thus subject to closure.

13.3.7 Lack of Financial Support for Resource Development Programs

Whether oyster development programs are conducted by private lease holders or the respective state, there is an overall lack of funding commitment to these efforts. As previously discussed, the amounts of money and effort that are expended for cultch replacement are inadequate and have declined in some states. Additionally, little support has been garnered for new programs such as aquaculture, depuration and genetic research. Additional development efforts are needed to combat losses of approved oystering areas to pollution and habitat destruction if a viable industry is to be maintained.

13.4 Enforcement Problems

Enforcement problems that are related to management of the gulf oyster fishery are quite unique. The majority of enforcement effort is spent enforcing public health safeguards rather than resource protection regulations as with most other fisheries. For example, it is almost impossible for an officer in the field to distinguish "polluted" oysters from "nonpolluted" ones. Officers cannot determine the reef of origin for oysters once they have been sacked and are in shipment if oysters are not properly identified.

Many enforcement problems are closely associated with regulatory problems discussed in Section 13.3. Descriptions of harvest areas may be vague and accurate descriptions may include imaginary lines. The timing of closures as the result of pollution events or other factors may be short and may cause the removal of fishermen from reefs and the loss of their catch. These regulatory problems coupled with problems of actual observance of a crime may increase the difficulty in making arrests and obtaining convictions.

13.4.1 Insufficient and Inconsistent Penalties

Because of the tremendous health risk involved with consumption of contaminated oysters, penalties for convictions of harvesting and selling polluted oysters should be extreme. In some states these penalties are scarcely more severe than other seafood related misdemeanors. No illegal oyster fishing offenses are considered felonies except in Texas. Other state's statutes may provide for high penalties but also allow judicial discretion to sentence in accordance with other seafood misdemeanors.

13.4.2 Inability to Mark or Accurately Define Closed Areas

Definitions of closed areas and criteria for closing (especially for conditionally approved areas) are quite complicated in most states. Imaginary lines forming some of the boundaries are difficult to mark and keep marked. These problems create difficulties for fishermen and enforcement officers in determining actual areas of harvest. They also provide excuses for illegal harvesters which are often accepted by courts (e.g., "The reef wasn't marked"; "I wasn't aware of the closure"; or "My radar showed I was legal.")

13.4.3 Lack of Coordination with Public Health Agencies

In some states the agency responsible for promulgation of regulations regarding oyster sanitation and the agency responsible for enforcing such regulations are different. Some sanitation agencies lack sufficient enforcement authority and must rely on other agencies for assistance. There are also jurisdictional questions between agencies with regard to various aspects of oyster management.

Inadequate interaction between these agencies results in regulations with reduced enforceability. It may also create management overlap and duplication of authority. There is a need for greater cooperation and understanding of the separate needs and responsibilities of the agencies involved in order to implement management regulations in the most enforceable manner.

13.4.4 Inadequacies and Ignorance of the Justice Court System

In most states, oyster violations are prosecuted as misdemeanors in the justice court system. In many cases there is a lack of judicial understanding of the seriousness of crimes involving illegal harvest of contaminated oysters. Consequently, these cases are treated much like traffic offenses and other wildlife offenses. This problem is compounded because the court system is usually quite overburdened by a large number of similar cases.

13.4.5 Lack of Personnel and Equipment

Enforcement of oyster regulations is hampered by the same problems as most other aspects of marine law enforcement, namely, a large patrol area, insufficient equipment and too few personnel. Marine enforcement requires expensive equipment and maintenance costs are very high. Because state management institutions are often budget driven, these high costs may negatively affect the numbers of officers and amounts of equipment.

Enforcement of oyster regulations requires a strong commitment of equipment and personnel. Fast, shallow draft boats, long patrol periods, night observation devices, etc., are needed to detect illegal oyster harvesters. Also, there is the need for inspection of dealers and processors requiring enforcement 24 hours a day.

13.5 Social and Economic Problems

13.5.1 Sociological Problems

13.5.1.1 Open Access and Closed Access Problems

Problems are associated with both the open access and leasing aspects of the oyster fishery. Problems with the lease fishery primarily involve the "taking" of perceived common-property bottoms and limiting access to only a few fishermen. Questions concerning appropriate fees, qualifying criteria and proper marking of leases are common. Additionally, it is sometimes argued that lease areas are not sufficiently worked and could perhaps produce more.

Problems with open access fisheries occur among user groups and between users and regulators. Fishermen often squabble over preferred areas and harvest practices. Also, conflicts occur between fishermen and dealers/processors regarding culling and adequate measures. Other problems are also evident; however, the primary problem with the open access fishery centers on overfishing, whether in fact or perception.

13.5.1.2 Tonger-Dredger Conflicts

Conflicts between tongers and dredgers primarily occur when reefs reserved for the separate gear are located in close proximity to one another. Problems primarily result from perceptions by tongers of illegal dredging on tonging reefs. Enforcement efforts to resolve conflicts are hampered by inadequate definition of the areas.

13.5.1.3 Lack of Sociological Considerations in Management Programs

Along the northern Gulf of Mexico, the oyster fishery has faced a variety of problems of human origin. These problems have led to decreasing stocks in some areas and threaten what has been a viable occupation for many users (Stimpson 1990). In recent years, conflicts between users and regulators stem from debate over how to best manage oyster resources. In this debate, it is difficult to evaluate the impacts of fishing when compared to habitat destruction, pollution and changing hydrographic regimes.

In order to adequately manage the oyster fishery, baseline data on three parameters are needed. These parameters are (1) ecological, (2) economic and (3) sociocultural. Excessive emphasis on ecological data can bias conclusions based on the impact of utilization behaviors in the fishery.

The MFCMA mandates the collection of ecological, economic and sociocultural data when determining OY (Section 620.ii). Also, the GMFMC has recently recognized the need for "socioeconomic" data in formulation of regulations (GMFMC 1989). However, no specific plans exist for the collection, evaluation and utilization of social science information by the GMFMC (Gregory, personal communication).

Social science information, collected using valid methodologies of the discipline, can be invaluable to managers. It will allow managers to develop fair and equitable policies based on the best possible information. In some instances, managers may be reluctant to solicit input from user groups. This is due, in part, because many diverse factions vie for a greater share of the oyster resource and management attention. Consequently, management programs are structured primarily on the basis of biological considerations but become skewed by political involvement that is initiated by controlling factions. Managers may even feel that increased solicitation of input can only lead to increased political involvement and confuse program goals. These difficulties can be avoided if managers work cooperatively with social scientists in gathering valid data on user groups. This can lead to greater communication between users and regulators, higher success levels for management policy and ultimately cooperative management in all aspects of fishery regulation.

13.5.1.4 Confusion of Oyster Ethnobiology

The "ethnobiology" of oyster harvesting and oyster processing includes natural history information as well as folk myths. Natural history knowledge acquired through years of fishing may be a valuable source of habitat information. Natural history information can supplement data gathered through scientific fieldwork and laboratory research. However, folk myths are perhaps more numerous and may impede rather than help the management process. Myths are perpetuated within a social context and are meant to influence people to behave in certain ways. Two of the best examples of "oyster myths" are: (1) "oysters are an aphrodisiac," and (2) "oysters are only safe to eat in months containing a 'r.'" These folk myths are directed at users and can be analyzed as to how they affect human behavior.

13.5.1.4.1 Oysters Are an Aphrodisiac

No scientific data exist to support this claim. It is similar to claims made by Chinese apothecaries concerning rhinoceros horn. Using this myth may be a good sales strategy to aid the marketing of oysters as people can be influenced to respond to this information. The regional marketing of oysters may be enhanced, but there is no proof of increased sexuality or libido as a result of oyster consumption.

13.5.1.4.2 Oysters Are Safe to Eat During Months Containing a "R" Only

Although this belief is completely myth, it could have an origin in natural history. Due to spawning behavior, oysters are in poor condition, and their palatability (especially when consumed raw) is reduced during summer months, May, June, July and August. Poor taste, poor quality and associated illness could have initiated the myth.

13.5.2 Economic Problems

13.5.2.1 Lack of Stable Oyster Supply

The major economic problem facing the oyster industry is the highly variable supply of oysters. Many factors are involved with these fluctuations, but they are primarily environmental and biological in origin. The wide range of the variation and the lack of predictability cause prices and values to fluctuate greatly from year to year and during the season; thus, profits and other economic measures are difficult to determine.

14.0 OYSTER FISHERY MANAGEMENT PROGRAM

14.1 Management Unit

For the purposes of this management plan, the management unit is all of the natural and artificially propagated oysters within the boundaries of each of the five Gulf States. This description does not preclude different management strategies for reefs within a given state's jurisdiction, nor does it limit or diminish states' efforts to jointly manage adjacent reefs where such management is beneficial and warranted.

14.2 Management Objectives

1. To ameliorate and reverse oyster habitat losses caused by human alterations and natural erosion, including but not limited to: (1) destruction of reefs, (2) removal and fouling of cultch, (3) changes to salinity and waterflow on reefs and (4) pollution of shellfish growing areas.

2. To establish and maintain public health standards for the harvest and handling of oysters to ensure that consumers receive a safe and wholesome product.

3. To develop easily understandable regulatory and management strategies for oyster populations within the management unit that provide for optimum benefits from the resource while: (1) promoting harvest efficiency, (2) reducing conflict, (3) encouraging compatibility and standardization, (4) ensuring enforceability and (5) supporting management and culture techniques with the highest benefit/cost relationship.

4. To implement research and development programs to increase production, increase utilization and expand the overall knowledge base for oysters.

14.3 Specific Management Measures to Attain Management Objectives

The following is a listing and brief discussion of management measures and strategies that if implemented could help solve management problems and achieve management goals. For various reasons, some of these strategies may be inappropriate or impossible to accomplish at one time or another; therefore, this program does not preclude different management strategies for reefs within a given state's jurisdiction, nor does it limit or diminish states' efforts to jointly manage adjacent reefs where such management is beneficial and warranted. They are listed here for future reference, and specific recommendations are discussed in Section 15. Also, potential disadvantages with the implementation of each management measure or strategy are discussed.

14.3.1 Measures to Increase Production and Abate Habitat Loss

14.3.1.1 Shell/Cultch Planting

Cultch planting is perhaps the most commonly used management strategy to maintain or increase production. A clean, hard substrate is necessary for oyster setting and growth. Also, when environmental factors are conducive to oyster spawning and setting, more available cultch equals more oyster production.

Optimum cultch planting is a complex operation that requires knowledge of water temperature, salinity and density of oyster larvae in plankton samples. Timing of cultch plants is critical. If planted too early, shells may become fouled by other marine organisms, and if planted too late, peak larval production may have passed. In either case, setting densities and ultimate production will be reduced.

Site selection for cultch planting projects is also critical. Usually sites are chosen on or near existing reefs where oysters are usually present. Bottom conditions, water depth, sediment types, turbidity, current patterns, salinity, temperature and historical catch data are important factors to be considered.

Techniques that are employed during actual planting operations are also important to future production. A relatively thin, even application of cultch produces best on established reefs while "piling" cultch may be optimum on softer substrates where high current velocity can further disperse material.

The type of cultch material is perhaps the least important factor in planting. Oyster shells are the most widely used, primarily because of their availability, low cost, ease to plant and good setting history. Clam shells (Rangia cuneata) have been used extensively and in large volumes, as well as other bivalve mollusk shells.

States could review cultch planting programs and expand efforts where appropriate. States could also increase efforts to find affordable, alternative cultch materials.

Disadvantage:

1. Conflicts may occur with other uses of submerged lands (e.g., shrimping, trawling, oil and gas drilling, dredge material disposal, etc.).

14.3.1.2 Freshwater Diversion Projects

The importance of freshwater to oyster setting, growth and survival is well known and has been discussed in this document. Controlling and maintaining optimum salinity and water quality is equally important to increasing oyster yield. Production from many reefs, both large and small, throughout the gulf could be increased if freshwater influx to such reefs was likewise increased and controlled. Some major diversion efforts are underway in Louisiana, and others are planned. States could review water-use plans and other data concerning river basins that are associated with present and historical reef areas and determine areas where increased, controlled freshwater diversion could increase oyster production. A thorough knowledge of the biological and engineering feasibility of such projects is needed prior to pursuing detailed plans, designs and actual construction.

Disadvantages:

1. Freshwater diversion projects may have a low benefit cost ratio not only from the standpoint of construction costs but also from the impacts to valuable coastal real estate.

2. Freshwater diversion may biologically change both the area from which water is diverted and the area receiving diverted freshwater. Production of some species (e.g., oysters) may be enhanced at the expense of other

species (e.g., shrimp). Thus, biological, social and economic value disputes are possible, and the total environmental impacts and benefits are difficult to measure.

3. Depending on the freshwater source, diversion projects may decrease water quality and increase sedimentation in a given oyster area. Any increased production, in such a case, may be negated if harvesting is restricted as a result of increased contamination or short-term losses of oystering areas.

14.3.1.3 Aquaculture

Because oysters are sessile from a very early age, they can be easily cultivated in aquaculture operations. Numerous techniques are used in many areas of the U.S. These operations have been shown to produce wholesome, high quality oysters.

Potential exists for increased oyster production in the gulf as a result of aquaculture development. Also, such operations could help offset production declines caused by habitat losses. The following is a brief discussion of some aquaculture techniques that could be used in combination or separately to increase oyster production.

14.3.1.3.1 Pond Culture

Pond culture has potential in areas outside natural oyster environments. In essence, new growing areas can be created in uplands.

Pond culture, like most aquaculture operations, would require systems to control and monitor salinity, temperature, dissolved oxygen and other water quality parameters in order to maintain optimum growing conditions and to detect contamination and disease.

Disadvantages:

1. Pond culture expense will likely be higher than cultivation in existing growing areas.

2. Spawning by young can cause water quality and system/design problems by fouling and clogging equipment if not controlled by reducing temperature or sterilizing techniques. Such controls may be costly or not 100% effective.

3. Difficulties related to monitoring water quality for public health purposes would likely occur.

14.3.1.3.2 Full Water-Column Planting

This technique has potential to increase production both from an aquaculture prospective and from relaying oysters harvested in restricted areas. Previous studies have also shown that oysters grow faster when suspended above the bottom (May 1969).

Disadvantages:

1. This operation would be more labor intensive than wild harvesting, and the production costs would likely be greater.

2. This operation would remove the water column from use by other public interests.

14.3.1.3.3 Genetic Alteration and Selection

Genetic selection is a technique that has been used in agriculture and aquaculture to produce faster-growing species or other desired traits. Studies have shown variations of growth rate from different populations of oysters. Additionally, sterilization (i.e., the production of triploids) may increase growth rates and oyster quality.

Further studies are needed to assess the potential of genetic selection to increase oyster production, particularly in aquaculture environments. These genetic alterations could also be combined with other aquaculture techniques previously discussed.

Disadvantages:

1. Scientific studies will likely be long-term and receive low priority for funding.

2. Sterilization techniques would be more labor intensive and result in increased costs.

3. Sterilization techniques cannot assure 100% effectiveness.

4. Discharges for such aquaculture operations would have to be controlled and not allowed to enter natural oyster environments.

14.3.1.4 Remote Setting and Replanting

Because young oysters are most vulnerable to environmental variations and predation, production can be increased by providing a controlled environment during this initial development. Near-shore estuarine areas provide a more suitable environment for setting and growth, and they have been used extensively in Louisiana for "seed" production. Aquaculture techniques are also capable of producing these "seed" oysters by remote setting. Later, natural and cultured seed can be transported to reefs for further growth to harvest size.

Disadvantages:

1. These operations would be more labor intensive than wild harvesting and production costs would probably be higher.

2. Mortalities and loss from transfer are not known.

14.3.2 Measures to Increase Utilization

Throughout the gulf numerous populations of oysters exist in areas where harvest is restricted due to pollution. A wide variety of contaminants and their effect on oysters has previously been discussed. Methods to purge these oysters of pathogens or render the pathogens harmless would increase oyster production by increasing utilization.

14.3.2.1 Allow Utilization from Restricted Areas

Regulations presently allow very limited harvest of oysters from waters classified as "restricted." In most cases these waters are classified "restricted" because of the high potential of pathogen contamination and resultant disease to humans when these oysters are consumed raw or improperly prepared. Additional harvests from restricted oyster areas are possible provided that managers, harvesters, processors and consumers understand the risks and are aware of methods to adequately reduce them. Also, such harvests must be carefully controlled.

14.3.2.1.1 Relaying

This technique involves removal of oysters from restricted areas and transfer to "approved" areas. It may be accomplished by simply respreading the oysters on new bottom or suspending the oysters in various types of containers. The oysters must remain in the area until tests show that pathogens have been purged, approximately 15 days. Increased use of this technique could increase utilization and production.

Disadvantages:

1. Relaying is more costly and labor intensive than wild harvest.

2. Testing for viruses and *Vibrio* spp. may be inadequate to ensure against public health problems.

3. Increased regulatory controls and manpower are needed.

4. Removes submerged lands from other public use.

14.3.2.1.2 Harvest for Cooking, Canning and Other Heat Processing

Potential exists to increase utilization of restricted oysters by controlled harvesting and heat processing. Changes to existing laws and regulations, as well as development of processing standards, are needed.

Disadvantage:

1. Increased regulatory controls and manpower would be needed.

14.3.2.1.3 Harvest with Analysis for Pathogens

Classification of growing waters is based principally on fecal coliform contamination, not actual pathogens. Potentially, some oysters could contain high levels of fecal coliform and no pathogens. Analysis for pathogens would allow a accurate determination of disease potential at any given time or reef area. If pathogens were not present, such areas could be opened for harvest, thus increasing oyster production.

Disadvantage:

1. Comprehensive analyses for many pathogens are expensive, time-consuming and in some cases inconclusive; thus safety for consumption could not be completely assured.

14.3.2.1.4 Harvest with Hazardous Food Declaration

Some "restricted" oyster areas may be considered borderline, and the tendency of management with regard to harvest and consumption of potentially hazardous foods is to be conservative and more restrictive. Where such areas exist, special allowances for and monitoring of harvest could increase utilization. Once harvested these oysters and products would be appropriately labeled for consumption with thorough cooking and separated from other products.

Disadvantages:

1. Management costs would likely increase to inspect and monitor catch and processing.

2. Health risks could increase as a result of ignorance regarding proper preparation, "bootlegging" and accidental mixing of oysters.

3. Enforcement costs would probably increase.

14.3.2.2 Depuration

Depuration of contaminated oysters involves removal from contaminated areas and cleansing the oysters by removing harmful substances. This process is most often accomplished by a controlled purification process. Here, oysters purge pathogens into clean water where they are killed by irradiation, oxidation and even chemical treatment. This technique has been employed in other shellfish industries for many years, but it has received little attention in the gulf for oysters. Techniques and operations could be developed to increase depuration efforts in the region and thus increase utilization.

Disadvantages:

1. Depuration is much more costly and labor intensive than wild harvest.

2. The success of the treatment process in removing viruses and *Vibrio* spp. is poorly understood and may be inadequate to ensure safety from disease following consumption.

3. Lack of standards and lack of knowledge of the process for removing heavy metals is uncertain.

4.3.3 Measures to Prevent Overharvest

In most cases where overharvest occurs, it is a socioeconomic overharvest or a reduction in yield below optimum. In such cases too many market-size (approximately 3-inch) oysters are removed during a typical harvest season thereby precluding the availability of adequate amounts of harvestable oysters in the following season.

As previously discussed environmental fluctuations are more devastating to annual populations than fishing pressure. Depletion, however, can occur when reef cultch is removed and insufficient reef building material is replaced.

Although much of this subsection is concerned with measures to prevent overharvest, conditions may exist when overharvest is desirable. Examples are when threats of flooding or disease are imminent or when an impending development project will destroy a given reef area.

The following is a discussion of management measures that may be implemented to prevent or lessen impacts of overharvesting.

14.3.3.1 Size Restrictions

Size restrictions are desirable measures and are commonly used to stabilize harvests and to provide the most desirable economic-sized oysters for processing. They are least important for maintaining spawning stock because oysters mature at a very early age. Size limits are effectively implemented because oysters are minimally damaged by handling and culling.

A typical size limit would be 3-inch minimum with a 10% allowance for undersized oysters. Smaller oysters (2 to 2.5 inches) may be desirable for raw consumption at oyster bars.

Disadvantage:

1. Size limits may conflict with economic and biological factors.

14.3.3.2 Gear Restrictions

Gear restrictions may be used to prevent excessive damage to reefs during harvesting. They may also be used to reduce harvest. In some instances gear use may be established based on socioeconomic issues (e.g., tonging only).

Disadvantage:

1. Harvest efficiency may be reduced.

14.3.3.3 Season and Area Closures

Season and area closures may be used to reduce harvest pressure. Warm weather closures may increase spawning success because fragile spats and juveniles are not disturbed by fishing. They may also significantly reduce total mortality because highest natural mortality also occurs at this time (Melancon 1990). Oyster quality may also be enhanced by warm weather closures because the more desirable appearance and overall condition of oyster meats occurs during winter months when oysters are not as actively spawning.

Area closures may be used to restrict harvest from areas that were re-shelled with cultch until the number and percentage of market sized oysters reach acceptable levels for fishing. Area closures may also be used to halt harvest from a given reef when data indicate declines in availability of market-sized oysters, reef destruction, pollution or other problems.

Disadvantages:

1. Stocks that could have been harvested may be lost due to environmental factors (hurricanes, floods, etc.), disease and predators.

2. Season and area closures necessitate increased enforcement responsibility.

14.3.3.4 Limited Access Considerations

Limited access measures are most often used to reduce effort in fisheries that are subject to overharvesting. Oyster leasing of submerged lands in Louisiana is perhaps the best example of limited access in the oyster fishery. In excess of 80% of Louisiana's production comes from these leases.

Whether open access causes or contributes to overfishing in the gulf oyster fishery is uncertain. Evidence does indicate that limited access, lease fisheries are more stable and result in higher production per fisherman.

Conceptually, limited access considerations could be applied within the gulf oyster fishery to reduce effort and increase individual profits at both the fishing and processing levels. Limited access might also ameliorate some product quality and public health problems by focusing responsibility, inspection and enforcement on fewer participants.

Limited access strategies could take many forms. Implementation of these measures would likely be more complicated. The following is a listing and brief description of potential measures applicable to the gulf oyster fishery:

1. Leasing - This method of oyster production is widely used in Louisiana. In fact, most of the favorable bottom not under public usage is currently leased, and few, if any, new leases are given. Consequently, leasing may be considered as a form of limiting access. Further leasing of public grounds and expanded privatization of the industry by leases could reduce effort, reduce management costs and increase production. Criteria, qualifications, size and location are just some of the factors to be considered in a limited access leasing program.

2. Restriction of license sales - Limiting the number of participants (fishermen and processors) by limiting license sales could effectively reduce effort and may increase profits. Many different methods exist to issue permits and qualify participants.

Disadvantage:

1. Limited access criteria would be difficult to establish and implement in an acceptable manner. Also, disruption of traditional fishing and processing practices, as well as other public uses of leased areas would likely occur.

14.3.3.5 Quotas and Bag Limits

Establishing seasonal and daily catch restrictions for individual reefs is an effective means of preventing overharvest. Such restrictions are also used to extend harvest and income over a longer seasonal period.

Disadvantages:

1. Potential exists for conflicts regarding actual limits, and data used for establishing such limits are poor. Consequently, limits are often based on social acceptance rather than biological stock parameters.

2. Efficient oyster harvesters may be penalized.

14.3.3.6 Reef Monitoring

Reef monitoring is a desirable management strategy to determine ongoing status in oyster production. Knowledge of oyster size, abundance by size, cultch availability and other factors are important to prevent overharvest. Such data may also be used to direct cultch planting and to predict future harvest.

14.3.3.6.1 Fishery Independent Monitoring Programs

Fishery independent monitoring involves random sampling of oyster reefs and reef areas. They may involve samples of larvae, juveniles and all sizes of adults.

Larval sampling is very important to timing and location of cultch planting. Samples of juveniles and adults provide data on reef status, harvest availability and predictions for future harvest by assessing numbers of "spat," "seed," "market" and perhaps other categories of adults. Additionally, such data may be used to prevent overharvest through closures when samples indicate depletion or damage is occurring.

Disadvantage:

1. Because the size and shape of oyster reefs are quite variable and relatively small areas may be quite productive, random sampling without an adequate sample size may not provide adequate data of oyster abundance for some reefs.

14.3.3.6.2 Fishery Dependent Monitoring Programs

Fishery dependent monitoring involves reviewing catch data from reef areas and comparing catch with effort expended. This strategy may be effective in analyzing trends in catch and effort. If effort, either individual or total, on a given reef remains the same or increases over a time period and catch decreases while natural mortality remains relatively stable, overharvesting is likely to be occurring, and closures or further restrictions may be needed.

Disadvantage:

1. Variation in fishermen's skills and their ability to locate oysters on reefs may cause incorrect conclusions from data received.

14.3.4 Measures to Reduce Health Risks

All of the management strategies discussed under increasing utilization (Section 14.3.2) herein could also be considered measures to reduce health risks. The increased utilization discussed herein relates to oysters that are potentially contaminated with human pathogens. Greater public knowledge of the risks and hazards, as well as ways to eliminate them, are primary factors in reducing health risks.

14.3.4.1 Coordinated Season and Area Closures

Health risks could be reduced when states coordinate season and area closures. Coordinated season and area closures could reduce health risks by assisting enforcement efforts to identify harvest origins. Timely, coordinated closures of adjacent reef areas with conditionally approved status could reduce health risks when polluting conditions threaten. Seasonal closures in warmer months could reduce the risk of disease especially related to *Vibrio* contamination of oysters.

Disadvantage:

1. Some economic losses could occur when harvesting areas are closed.

14.3.4.2 Coordinated Tagging and Container Identification Program

A coordinated system among all Gulf States to accurately identify the date and location of oyster harvest could help reduce health risks and increase consumer confidence in eating oysters. The most desirable system would require compatible tagging and labeling information and incorporate usage of the same forms to identify oysters and oyster products from harvest to consumption.

Disadvantages:

1. Regulatory and statutory changes may be needed.
2. Some increased management costs could occur to develop and implement such a program.

14.3.4.3 Enhanced Enforcement

As with most laws or regulations, increasing enforcement capabilities could help reduce violations which would translate into reduced health risks from consumption of illegally harvested and improperly handled oysters. Any part or combination of increased funding, personnel or equipment would likely result in increased protection.

Disadvantage:

1. Higher costs would be incurred.

14.3.5 Measures to Support Management

The following is a brief discussion of management strategies that could strengthen management and make it more efficient.

14.3.5.1 Licenses

Establishing uniformity of licenses and license fees for all Gulf States could eliminate confusion and provide for greater public acceptance. These fees should also be sufficient to fund the states' management programs.

Disadvantage:

1. Social and political conflicts may result.

14.3.5.2 Shell Retention Fees

States should investigate the establishment of shell retention fees commensurate with shell value and handling costs for oyster shells removed from an individual state's reefs and not returned. Ideally, states should assess fees to the user segment which ultimately benefits from unreturned shell.

Disadvantages:

1. Increased monitoring and enforcement costs may offset benefits.

2. Shell retention fees may lead to higher costs to consumers.

14.3.5.3 Other Fees and Taxes

States should investigate the feasibility and appropriateness of establishing or maintaining user fees and other taxes to support state management programs. Such assessments should be as fair as possible to all users.

Disadvantage:

1. Fees and taxes may lead to higher costs to consumers.

14.3.6 Cooperative Management Program

Managing fishery resources by sharing responsibility over the use of such resources is an effective means of integrating social concerns into management strategies. As problems in the oyster fishery intensify, human related effects on fishery stocks may best be dealt with through the cooperative interaction of users and regulators (Pinkerton 1989). The dynamics of user/regulator interaction is becoming a major focus in devising management techniques that provide realistic assessment of acceptable and optimal yield of limited fishery resources (Acheson 1988). This interaction may ultimately build mutual trust and respect, which are crucial to the acceptance of management needs and recognition of common interests between users and regulators.

Cooperative management has potential: (1) to promote conservation and enhancement of fish stocks; (2) to improve the quality of data and data analysis; (3) to reduce excessive investments by fishermen in competitive gear; (4) to make allocation of fishing opportunities more equitable; (5) to promote community economic development; (6) to increase product quality and reduce health risks and (7) to reduce government versus fishermen and fishermen versus fishermen conflicts.

To design and implement cooperative management strategies, two fundamental requirements are: (1) to develop baseline data on the status of user populations including perceived needs, use patterns and attitudes towards conservation (see Section 19.1) and (2) to provide a means to communicate management concerns and goals to fishermen and their communities.

14.3.6.1 General Prerequisites of Cooperative Management

Management councils and state and federal agencies could be linked with user groups through direct representation by those groups, as well as through special extension offices. General prerequisites of cooperative management become more concrete when considered in association with one or more of three secondary prerequisites. These are: (1) cooperative management as a route to community-based development; (2) cooperative management as a route to decentralizing decisions that address problems effectively and (3) cooperative management as a mechanism for gaining the support of local fishermen and reducing conflict through a process of participating democracy.

14.3.6.2 Specific Prerequisites of Cooperative Management

Specific prerequisites of cooperative management are outlined as preconditions, support mechanisms and conditions, and scale of effort.

14.3.6.2.1 Preconditions

1. Cooperative management is most likely to develop out of a real or imagined crisis in stock depletion or a problem of compatible magnitude.

2. Cooperative management is most likely to develop when fishermen show a willingness to contribute financially (or recruit other sources of support) to the rehabilitation of the resource and/or contribute to other management functions.

3. Cooperative management is most likely to develop when there is an opportunity for a negotiation process and/or experimental cooperative management of one simple function that may later be expanded to other functions.

14.3.6.2.2 Support Mechanisms and Conditions

1. Cooperative management operates most favorably when there is a mechanism for recirculating back into communities some of the wealth generated by management programs.

2. Cooperative management operates most favorably where agreements are formalized, legal and multi-year.

3. Cooperative management operates most favorably where the mechanisms for conserving and enhancing a fishery can, at the same time, conserve and enhance the operation of a cultural system.

4. Cooperative management operates best where external support can be recruited (university, nongovernment scientists, credible organizations) and where external forums of discussion (e.g., technical committees) including more than fishermen and government members can be involved in the cooperative management process.

14.3.6.2.3 Scale of Effort

1. Cooperative management operates most favorably where the area is not too large, that is, where benefits may be linked to watersheds or local waters.

2. Cooperative management operates most favorably where the number of fishermen or communities is not too large for effective communication, or where there are well-organized subgroupings (villages, kin groups, organizations) that communicate well with each other or have effective umbrella organizations.

3. Cooperative management operates most favorably where the size of the government bureaucracy is small and its mandate is fairly regional or local.

14.3.6.3 Cooperative Management Program Summary

Cooperative management can be considered as an option to traditional management techniques particularly when a fishery is under stress. The capability of utilizing fishermen and their knowledge as a resource for successful management can facilitate the development of regulations and can decrease the amount of funding expended on enforcement. The complexity and variability in oyster communities and oyster reefs along the gulf must be taken into account in devising effective cooperative management strategies. Management on a local level is not only more effective but more sustainable. It is up to local and state officials and regulators to devise such plans in a manner that brings users and regulators together in productive and ongoing cooperative relationships. Cooperative management is only possible when significant segments agree to cooperate.

Disadvantages:

1. The process is slow.

2. Increased costs would be encountered.

15.0 SPECIFIC MANAGEMENT RECOMMENDATIONS

15.1 Increase Cultch Planting

States should implement programs to increase cultch planting on public reefs and encourage other efforts to increase planting on private lease areas. Such programs should have a minimum goal of returning an amount of material equal to that removed.

In developing such programs states should:

1. evaluate the potential for reef enhancement by cultch planting;

2. develop site-selection criteria;

3. develop reef monitoring programs to determine when, where and how much cultch to plant;

4. determine legal obligations of industry factions to return oyster shells or shell worth to the program and pursue the proper authority to implement return; and

5. determine the most cost effective procedures for physically relocating cultch to reef sites and appropriately scattering the material to achieve optimum results.

15.2 Restore Freshwater Flows to Reefs

States should assess reef areas that have been impacted by reduced freshwater discharge. The causes for the reductions should be carefully evaluated. Efforts should also be instituted to determine if all or part of the freshwater flow can be restored.

In order to implement successful freshwater diversion programs, states must first study the biological, social and economic impacts that are likely to result. They must also determine costs and benefits.

Surface water diversion is the most logical choice for restoring flows. However, groundwater sources, particularly shallow, "quick-charge" aquifers should also be evaluated.

15.3 Study and Evaluate Aquaculture Programs and Replanting

States should increase efforts to support aquaculture studies. Such efforts are needed in the gulf to refine techniques and to evaluate cost effectiveness.

States should encourage private investment into oyster aquaculture. They should evaluate the use of incentives to offset initial capital outlay by industry.

States should also review legal barriers to aquaculture operations (i.e., leasing) in certain submerged land areas and the full water column.

States should also study the feasibility of setting oysters in a controlled or otherwise highly-favorable estuarine environment and replanting "seed" oysters for grow out. Such efforts could be conducted by the states, by industry or some combination. Programs should be implemented if they are determined to be economically feasible and compatible with state management programs.

15.4 Evaluate Depuration and Relaying Opportunities

Because many oyster reefs are now classified as restricted for direct-to-market harvest, states should assess the possibilities for relaying and depuration. These programs could be conducted by industry, by the state or in some cooperative manner.

In developing such programs, states must carefully monitor water quality conditions in areas from which oysters are taken as well as the relay areas or depuration facilities. States must also develop a supervisory program to ensure that only "cleansed" oysters reach markets. Liabilities and other legal constraints should also be evaluated.

15.5 Size Restrictions

States should develop size restrictions to best ensure a continuing supply of oysters in the desired economic and social size range. Where reef areas cross state lines, states should develop a uniform size limit via cooperative agreements. Uniform size limits enhance enforcement and reduce regulatory burden on fishermen.

15.6 Gear Restrictions

States should develop gear restrictions to prevent excessive damage to reefs. States should also pursue cooperative agreements on gear usage (type and size) on reefs that are harvested by fishermen from two (2) or more states. Uniform gear allowances enhance enforcement and reduce regulatory burden on fishermen.

15.7 Season and Area Closures

States should evaluate using closed seasons and areas to prevent overfishing and enhance the market quality of oysters. Where such closures are not in effect, states should determine potential economic losses and compare them with expected future gains to determine feasibility. States should close areas that have been reshelled with cultch until sufficient populations of market oysters are present.

15.8 Limited Access Strategies

States should evaluate the feasibility of limiting participants in the oyster fishery. In particular, increased privatization through leasing should be carefully studied to ascertain social acceptance, potential for increased profits and potential for increased production. License limitations are another alternative for limiting access to the fishery. States should also consider the impacts of leasing on public uses of the resource.

15.9 Quotas and Bag Limits

States should evaluate the use of quotas and bag limits to reduce fishing pressure and extend harvest over a longer period. Quotas and bag limits, if needed, should be determined in conjunction with reef monitoring programs and should be reef- or region-specific, depending on enforcement needs and the condition of harvestable stocks.

15.10 Reef Monitoring Programs

States should develop and/or evaluate reef monitoring programs of two (2) basic types. First, a fishery independent sampling program is needed to assess the status of reefs and spawning conditions in order to properly time cultch planting. Second, a fishery dependent sampling program is needed to understand fishing pressure and to prevent overfishing. These programs are complementary and are needed to properly manage oyster resources on a reef-specific basis.

15.11 Public Health Considerations

States should develop cooperative interstate agreements for opening and closing conditionally approved reef areas that are in close proximity to state boundaries. States should also pursue cooperative management through the development of coordinated-tagging and container-identification programs. Additional and cooperative enforcement efforts are also needed to reduce health risks.

15.12 Law Enforcement Penalties

States should provide more stringent penalties for violations of laws and regulations regarding harvest and possession of oysters taken from "polluted" areas and increase penalties where appropriate. States should also pursue cooperative education programs and other agreements with the courts and other enforcement agencies to apprehend and more aggressively prosecute such violators.

15.13. Cooperative Management Program

States should develop a social science data base and incorporate its use into a cooperative oyster resource management program. This program should include: (1) regional identification of user populations, utilization strategies and commercial/personal permit numbers; (2) specification of demographics, traditions and attitudes of oyster fishermen through social science surveys and industry-oriented advisory committees; (3) development of management infrastructures/options for cooperative management of oyster resources; (4) coordinated exchange of social science information between regions; (5) classification of communities as open or closed NRCs and (6) testing of the NRC paradigm in resource management and development.

15.14 Management Program Support

States should pursue efforts to increase financial support for management and enforcement programs to ensure that they are adequately financed to accomplish their objectives. License fees, shell retention fees and other user fees should be evaluated for appropriateness and fairness. Where feasible, states should develop cooperative license and fee programs with other states. States should also seek other sources of funding including, but not limited to, general revenue and habitat enhancement funds. States should pursue cooperative agreements with fishermen, dealers, processors and other governmental entities to help recover shells, plant cultch and monitor harvest.

16.0 RESEARCH AND DATA NEEDS

Research and data needs of the gulf oyster fishery include a wide range of biological, social, economic, environmental and health related studies. Biologically, the Eastern oyster has been one of the most studied marine species in the gulf; however, many such factors involving spawning, setting, growth and survival, particularly in regard to environmental influences on these factors, are only partially understood.

The high degree of human involvement in the fishery creates many opportunities to better understand the social and economic problems of the fishery. Information is also needed from harvesters regarding catch and effort in order to properly manage reefs.

Because habitat deterioration results from substrate loss and pollution, important research efforts are needed to address these problems and more importantly, to develop ways to lessen them. In this regard studies to determine potentials for aquaculture, depuration and genetic alteration are needed. Also assessment of oyster contamination from chemicals/pathogens and disease potential is necessary to protect public health.

The following is a list of some of the more important research and data collection needs. These are not listed in order of priority, and there are perhaps others that are not listed.

16.1 Biological

1. Genetics
   a. identify and select for possible strains of fast-growing and disease-resistent oysters
   b. determine the benefits of triploid production
2. Determine factors contributing to MSX and dermo infection
3. Assess impacts of predators and determine methods of predator control

16.2 Environmental

1. Examine causes and effects of oyster habitat degradation
2. Predict future habitat losses and pollution

16.3 Industrial/Technological

1. Develop shucking procedures and practices to reduce contamination
2. Identify practical and cost effective alternatives to "burlap sacks" for holding shellstock
3. Develop time and temperature standards for holding shellstock and shucked raw oysters
4. Develop uniform packaging and labeling standards
5. Establish uniform criteria for water content in oyster meats

16.4 Economic

1. Study economic feasibility of all aspects of aquaculture, depuration and relaying

2. Determine costs and benefits of cultch planting programs including stocking of oyster shells for cultch
3. Evaluate the effects of various measures of shellstock and container size for shucked product on pricing and marketing
4. Assess economic effects of mandatory seafood inspection

16.5 Social

1. Evaluate consumer attitude toward health risks from oyster consumption
2. Determine size preference and propensity for eating cooked and uncooked oysters
3. Determine attitudes of fishermen toward dredges versus tongs

16.6 Aquaculture

1. Evaluate feasibility of pond culture, off-bottom and other grow-out techniques
2. Evaluate remote setting and cultchless seed production

16.7 Public Health

1. Study the feasibility of *Vibrio* depuration
2. Develop criteria for assessing health risks from eating oysters
3. Evaluate indicators of pathogen contamination

16.8 Resource Management

1. Cultch
   a. Evaluate feasibility of stock piling and replanting oyster shells
   b. Assess alternative cultch use and availability
   c. Determine ability to tax or set fees for unreturned shells
2. Evaluate feasibility for freshwater diversion to reefs that have become more saline
3. Assess pollution sources to reefs
   a. Nature of pollution and severity
   b. Point sources
   c. Feasibility for elimination and/or clean-up
4. Evaluate feasibility for leasing prime oyster production areas (public and natural reefs) and other privatization in the industry
5. Evaluate feasibility of reclassifying some restricted areas for production of cooked products
6. Study feasibility of uniform enforcement procedures
7. Develop compatible opening and closing regulations for reefs contiguous to two states' boundaries
8. Establish uniform measures for oyster shellstock

17.0 REVIEW AND MONITORING OF THE PLAN

17.1 Review

The State-Federal Fisheries Management Committee (S-FFMC) of the Gulf States Marine Fisheries Commission (GSMFC) will review, as needed, the status of the stocks, condition of the fishery and habitat, the effectiveness of management regulations and research efforts. Results of this review will be presented to the GSMFC for approval and recommendation to the management authorities in the Gulf States.

17.2 Monitoring

The GSMFC, NMFS, states and universities should document their efforts toward plan implementation and research. They should provide information to the GSMFC and review such efforts with the S-FFMC, as appropriate.

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19.0 APPENDIX

19.1 Alabama Oyster Survey

Dear Sir:

I am an anthropologist at the University of South Alabama. This is a survey of oystermen having resident licenses in the state of Alabama. The purpose of this survey is to provide oystermen with information on the state of their industry. By participating in this survey, you will have the opportunity to influence future management of oystering in Alabama. Recommendations based upon your experiences and problems are important to the development of oystering policy. If you do participate in this survey, you will receive a complete report on the outcome and how it will be used to improve oystering conditions in state waters.

All information gathered on this survey is confidential, and you may decline responding to any question you feel is too personal. You may contact me directly if you have any questions concerning the survey or want to communicate information you feel is not covered.

Thank you for your support and attention, and I look forward to hearing from you.

Sincerely,

Christopher L. Dyer
Phone: (205) 460-6347

OYSTER FISHERMAN SURVEY

PART I

First, I would like to ask you a few questions about your experience and how you got into the industry.

1. How many years have you been oystering? ____ years

2. How did you get started in oyster fishing?

3. Do you consider yourself a member of an oystering family? ____ yes ____ no

4. In reference to question #3, was your father or any other male relatives in oyster fishing?

Father: ____ yes ____ no
Relatives (relation to you):

________________________________ ________________________________

________________________________ ________________________________

5. Do you consider oyster fishing a good occupation? Why or why not?

   ____ yes ____no

6. What is the name of your oyster boat?

7. If you do not own an oyster boat, who do you oyster with?

8. What is the federal vessel documentation number of your boat?

9. Is your boat (or the boat you work on) used to fish other species (e.g., shrimp, croaker)?

10. In your opinion, what is the single most important piece of equipment on your boat?

11. What type of oystering gear do you use?

    tongs ________
    dredge ________
    other ________

12. a. Do you go oystering alone or with someone? If with someone who do you oyster with?

    b. Where do you usually go oystering?

    c. Is this a public reef or is it leased?

13. What is your estimate of the current value of your rig (boat and gear) or the rig you oyster with?

14. How much does it cost you to go out on an oystering trip?

    food ________
    fuel ________
    other ________

15. How many months out of the year do you oyster?

16. About how many trips do you make in a month?

17. About how many trips do you make in a year?

18. What months do you spend oyster fishing?

19. Do you consider oyster fishing a full or part-time job?
   a. _____ full time (more than 50%)
   b. _____ part time (50% or less)

20. If part time, what else do you do?

21. a. What is your approximate total income from all sources?
   b. What was your personal income from oystering last year?
   c. Do you think this was the same, more than or less than the average for oyster fishers in Alabama?

22. How many months do you consider yourself to be unemployed?

23. Where do you normally go during the off season?

24. a. Do you hold oystering licenses in other states?
   b. If yes, which states?

PART II

25. The following questions deal with the oyster fishery and its problems. The following questions don't necessarily have a correct answer; all that is being requested is an honest opinion. Based on your experience, circle the number that most accurately reflects your opinion/experiences.

   1 - Strongly Agree (SA)
   2 - Agree (A)
   3 - Neutral (N)
   4 - Disagree (D)
   5 - Strongly Disagree (SD)

	SA	A	N	D	SD
a. Government understands the environment.	1	2	3	4	5
b. The earth's resources (air, water, oysters) are limited.	1	2	3	4	5
c. Overall, government regulation of industry to protect the environment has done more harm than good.	1	2	3	4	5
d. The balance of nature is very delicate and easily upset.	1	2	3	4	5
e. Oyster reefs in Alabama waters are well protected.	1	2	3	4	5
f. There are too many oystermen fishing Alabama waters.	1	2	3	4	5
g. Private leasing of oyster reefs is a good idea.	1	2	3	4	5

		SA	A	N	D	SD
h.	The states should help support families of oyster fishers directly.	1	2	3	4	5
i.	Plants and animals exist primarily to be used by humans.	1	2	3	4	5
j.	The oyster reefs are overfished.	1	2	3	4	5
k.	Pollution is more of a threat to oyster reefs than overfishing.	1	2	3	4	5
l.	I make a good living oyster fishing.	1	2	3	4	5
m.	Humans have a responsibility to conserve natural resources.	1	2	3	4	5

26. If you were in charge of oyster management in Alabama, what would you recommend?

27. In your opinion, who is responsible for the decline of the oyster fishery? (circle two)

    a. oyster fishers
    b. state government
    c. federal government
    d. local industry
    e. nature/weather

28. What is your age?

29. What is the highest level of education you have completed?

30. How many people live in your household?

31. Are you ____ married, ____ single, ____ divorced, ____ widowed?

THANK YOU FOR TAKING THE TIME TO FILL OUT THIS QUESTIONNAIRE. I look forward to receiving it and will send you a copy of the completed report when it is finished.