oyster depuration facility: environmental, legal and management aspects

FINAL REPORT

DR. EDWIN W. CAKE, JR.
Gulf Coast Research Laboratory
Ocean Springs, MS 39564

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Mississippi-Alabama Sea Grant Consortium
Ocean Springs, MS 39564

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proposed

SUPPLEMENT TO

1976 MISSISSIPPI-ALABAMA COHERENT SEA GRANT PROGRAM

JANUARY 1976 SUPPLEMENT DATE: APRIL 1977

Title: Environmental, Legal, and Management Aspects of Proposed Oyster Depuration Facility

Applicants:

Edwin W. Cake, Jr., Ph. D.
Social Security Number: 267-62-6891
Head, Oyster Biology Section
Gulf Coast Research Laboratory
Ocean Springs, Mississippi 39564
Telephone: (601) 875-2244

William J. Demoran
Social Security Number: 428-20-6052
Head, Fisheries Management Section
Gulf Coast Research Laboratory
Ocean Springs, Mississippi 39564
Telephone: (601) 875-2244

David W. Cook, Ph. D.
Social Security Number: 425-64-0895
Head, Microbiology Section
Gulf Coast Research Laboratory
Ocean Springs, Mississippi 39564
Telephone: (601) 875-2244

Duration of Project: One year (April 1, 1977 through March 31, 1978)

Total Project Budget: $19,626 (Sea Grant - $ 5,000
Matching - $14,626)

Background and Need:

Oyster production in Mississippi since 1970 has averaged only 33,000 barrels per year, but oyster biologists have estimated that there are approximately 100,000 barrels of oysters, representing an approximate sustainable yield, which could be harvested on state reefs. These reefs are presently closed because of domestic pollution. At the present average value of $25.00 per barrel, these oysters represent $2,500,000 worth of a renewable resource which is being lost by Mississippi each year. A similar situation exists in the State of Alabama although the value of oysters in closed waters is significantly less ($16,000.00 in 1968).

Large population increases in the Alabama and Mississippi coastal zone over the past two decades have caused a significant reduction in estuarine water quality primarily because of domestic pollution. As a result, thousands of acres of productive oyster harvesting areas have been closed. If this trend continues, and projected population increases indicate that it will, we may lose all oyster harvesting areas to pollution.

Oysters from domestically polluted waters must be cleansed before they can be utilized, and the U.S. Food and Drug Administration recognizes two cleansing methods. One method, relaying, involves harvesting oysters from closed waters and transplanting them to approved waters for a period of fourteen days or more. This method involves a duplication of effort, because the oysters must be harvested twice. The second harvest is usually incomplete and results in a loss of oysters. The second method, depuration, involves a process of self-cleansing in an onshore facility, a depuration plant, where ozoniation or ultraviolet irradiation purified water flows through tanks containing the oysters. The depuration process in such a facility requires 48 to 72 hours with bacteriological testing to confirm that depuration has been completed. Each method has certain disadvantages related to economic, engineering, environmental, and operating characteristics that must be considered before the selection of either method in a particular locality.

Relaying appears to be the most economically feasible method at the present time. However, if populations and pollution increase, additional oyster producing grounds and relaying areas now available may be closed. Thus, the future of the oyster industry appears to lie in depuration.

Depuration is a technologically feasible process as indicated by the attached literature review. Clam depuration facilities are currently operating in this country, and many oyster depuration plants are operating in Europe. Since no oyster depuration plants are presently operating in the United States, data are not available upon which a firm decision can be based concerning establishment of a plant in this area.

During the past year, representatives of the Mississippi Marine Conservation Commission, Mississippi Research and Development Center, Mississippi State Board of Health, and Gulf Coast Research Laboratory have met on several occasions to discuss the problems of the oyster industry and to formulate plans for utilizing oysters from the closed areas. Further, the Gulf Coast Research Laboratory has developed a program which hopefully will culminate in the establishment of a commercial oyster depuration facility. This program is divided into the three steps outlined below, and the results derived at each step will indicate whether the program should proceed to the next.

Step One : Feasibility study of oyster depuration including an assessment of the following factors:

a. economic aspects,

b. plant design and construction costs,

c. environmental aspects,

d. legal aspects, and

e. management aspects.

Step Two : Construction, operation and monitoring of a pilot-scale depuration facility to demonstrate and prove the process and to test the economic and management aspects of operating such a plant.

Step Three: Construction and operation of a commercial-scale depuration facility to serve the needs of Mississippi's oyster industry.

The research outlined in this proposal is intended to acquire data relevant to Step One. We realize that the economic aspect is probably the dominant factor to be considered in Step One. However, information on plant design and construction costs must be available to adequately determine this factor. Since funds are limited at present and the cost of obtaining economic and engineering data is high, efforts have been limited in the proposed project to the examination of other aspects associated with Step One. Funds are being sought from other sources which will be used to obtain the other information necessary for the completion of this step of the larger project.

Approach:

The research proposed in this project is designed to assess the environmental, legal, and management factors involved with the establishment of a depuration facility in Alabama or Mississippi. The procedures for data collection and analysis will be documented so that other states that wish to establish depuration facilities can apply the same procedures.

Task I - Environmental Aspects: Since waste water will be discharged from a depuration plant, some type of discharge permit must be obtained. Contacts will be made with all local, state, and federal agencies to determine what discharge permits are required, their discharge limitations, and if environmental impact statements are required before discharge points can be established. Agencies which will be contacted include, but are not limited to, the following: Alabama Department of Public Health, Alabama Coastal Area Board, Alabama Marine Resources Division of the Department of Conservation and Natural Resources, Alabama Water Improvement Commission, Mississippi Air and Water Pollution Control Commission, Mississippi State Health Department, Mississippi Marine Conservation Commission, Mississippi Marine Resources Council, U.S. Army Corps of Engineers, U.S. Coast Guard, U.S. Environmental Protection Agency, and U.S. Food and Drug Administration.

Task II - Analysis of Legal Aspects: Two legal areas are known to merit consideration, and additional areas may be uncovered as other aspects of the project develop. First, consideration must be given to legislation which can adequately control the harvesting of oysters for depuration. Second, the legality and liability of a state operated facility must be considered if an analysis of the management factors indicates that the plant should be operated by the state. With the help of a legal consultant, we propose to examine the legal considerations with states presently operating depuration plants and review present Alabama and Mississippi laws pertaining to or affecting depuration and relaying. We shall also determine if new statutes must be promulgated before plant operation can begin. We will prepare draft legislation for oyster depuration operations in both Mississippi and Alabama.

Task III - Analysis of Management Aspects: The success of any depuration operation depends on interagency cooperation among the many agencies concerned with the shellfishing industry. We propose to contact controlling agencies to determine the management procedures in states which have existing depuration plants or which have operated plants in the past. These management data will be compiled and utilized to develop a management plan for submission to those state and federal agencies which must approve or cooperate with such an operation. Considerable input to this plan is expected from both the state and federal levels. It is expected that the resulting management plan will detail the procedures governing harvesting of oysters from polluted waters and transportation of these oysters to the depuration plant. The plan will also detail procedures for operations within the plant to insure that oysters released from the plant for sale are safe for human consumption.

Literature Review:

The principal investigators reviewed the extensive depuration literature available when this proposal was developed. A synoptic review of some of the important publications and reports follows this introduction, and a complete bibliographic listing of all available literature follows the synoptic review. The principal investigators are aware of several other depuration investigations presently under way where final reports or publications are pending (U.S. Food and Drug Administration contract to Dr. Dexter Havens, Virginia Institute of Marine Science), and they have communicated with these other investigators and shall draw upon their findings during this proposed research.

Most depuration reports published to date are concerned with the biological purification of molluscan shellfish that were removed from sewage polluted estuaries. The need for depuration facilities is based upon the necessity to protect those who consume raw or partially cooked shellfish which may have concentrated pathogenic micro-organisms from their polluted habitat. These biological contaminants may be removed from polluted mollusks in onshore depuration facilities or by transplanting (relaying) these mollusks to approved shellfish growing waters (Cook and Childers, 1968; Etzold, 1975).

Huntley and Hammerstram (1971) discussed the operation and evaluation of an experimental depuration plant used for the bacteriological cleansing of oysters under prevailing Gulf Coast environmental conditions. This report indicates that the maximum level of fecal coliform bacteria allowed by the FDA in the depurated oyster was established with a 72 hour period. The effects of physical parameters of sea water, including salinity, turbidity, temperature, pH, and dissolved oxygen, on the depuration process were reported. Ultraviolet light was used to control the bacterial quality of the water in the depuration tank. Their report indicates that engineering studies are needed to determine the design of the depuration tanks and the sea water feed system.

MacMillan and Redman (1971) reported that there are approximately 52,000 acres of underwater marine lands in New York suitable for the harvesting of shellfish that are closed due to microbial pollution. They report that there may be advantages in depuration plants that use wells as a system to supply sea water to the depuration tanks. Data presented for depuration trials conducted during the summer and winter seasons indicated that the depuration process may be used to cleanse hard clams taken from restricted waters.

Oscar C. Liu et al. (1967) performed a critical evaluation of the feasibility of using the self-cleansing mechanism as a practical means to obtain virus-free shellfish. In this study, it was determined that the efficiency of viral depuration was roughly a function of the water temperature within the range of 5^{o} to 20^{o} C. A reduction of salinity to 50 or 60 percent of the original level completely stopped the depuration process.

Holmsen and Stanislo (1966) reported on the technical and economic aspects of hard clam depuration, including the design of a processing plant, equipment, and economic analysis of the depuration process. This study used ultraviolet light for bacterial decontamination during the depuration process.

Devlin (1973) demonstrated the economic and biological feasibility of the depuration process in Canada. A satisfactory process was established by careful monitoring and control of rate of flow, temperature, turbidity, and dissolved oxygen. Ultraviolet light was used to control bacteria levels in the sea water.

Design criteria (Furfari, 1966) are available to insure proper environmental control of the depuration process for the marketing of oysters. Control of the biological activity in sea water used for depuration may be accomplished by proper utilization of ultraviolet light having a wave length of 2,537 Angstrom units.

On the other hand, Furfari (1976) noted that depuration plants which used ozone to control the bacterial quality of water for depuration have been constructed and operated in other countries.

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A. General Environmental Factors that Affect or Are Affected by the Depuration Process along the Gulf Coast of Mississippi and Alabama.

1. Physical Factors

a. Meterological Phenomena

i. Excessive Rainfall: The Gulf coasts of Mississippi and Alabama receive approximately 67 inches (190 cm) of rain/year (range, 37 to 90 inches, 95 to 227 cm) (Mobile, Alabama, Climatological Data, 1977, National Weather Service). Unless abnormal, and excessive rates occur during a short time span (one week or less), rainfall should not affect the depuration process, especially in a facility that utilizes a closed, covered water system. If an open, flow-through (or uncovered, closed) water system is utilized, extended periods of heavy rainfall and the resulting "freshets" may restrict or prohibit the use of surface water resources. Although the American oyster is a euryhaline species, i.e., able to withstand salinities of 5 to 40°/oo (Galtsoff, 1964), Furfari (1966) recommends that depuration process water should be within ±20% of the harvest area salinity. Neilson et al. (1976a) found that oysters would depurate at any salinity between 10 and 32°/oo. They found that oysters required a maximum of 12 hours of acclimation from harvest salinity to process salinity.

Seasonal freshets should be anticipated at least during the winter cold front phenomena that occur along the Gulf coast. Rainfall rates of one inch/hour (2.5 cm/hour) are not uncommon during some frontal passages and should such a weather front stall along the Coast, several days of heavy rainfall may cause flash flooding and the resulting freshets may reduce salinity of the bays and bayous to less than the acceptable, lower salinity limit for depurating oysters (10°/₀₀, Neilson, et al., 1976a). Mobile recorded a rainfall of 13.36 inches (33.9 cm) during one 24-hour period in April of 1955.

The siting of future depuration facilities should take these phenomena into account. Facilities that are located on Mississippi Sound or open the Gulf of Mexico would least likely be affected. Facilities that utilize saltwater wells, subterranean brines, or closed, covered seawater systems would negate the affects of excessive rainfall.

ii. Tropical Storm Activities: The northern Gulf coast is moderately susceptible to the effects of tropical cyclones (tropical storms, hurricanes, etc.). Between 1886 and 1970, 21 and 13 tropical cyclones occurred within 50 statute miles (80 km) of Mobile, Alabama, and Biloxi, Mississippi, respectively. Of those, 13 and 6 respectively, were hurricanes (Simpson and Lawrence, 1971). Mobile has 21 and 13% probabilities of receiving tropical storms and hurricanes, respectively, during any year, and Biloxi has 13 and 9% probabilities of receiving tropical storms and hurricanes, respectively (within 50 miles) (Simpson and Lawrence, 1971).

The official hurricane season extends from June 1 to November 30, but most storm activity generally occurs between August and September (U.S. National Weather Service, personal communication). According to Weather Service records and statistics, the Mississippi-Alabama Gulf coast should experience the direct effects of less than one tropical storm (wind speed less than 75 mph [120 kmph]), and less than one minimal hurricane (wind speed: 75+ mph [120+ kmph]) each season. Great hurricanes such as Hurricane Camille which hit the Mississippi Gulf coast in August of 1969, should be expected approximately once every 175 years according to the U.S. Geological Survey. Storms such as Betsy (September 1965) and Frederick (September 1979) should be expected once every 50 years. Storms which raise the water level to 4, 6, 8, and 10 feet (1.2, 1.8, 2.4, and 3.0 m) above mean sea level can be expected in the Biloxi area once every 4, 10, 25, and 50 years, respectively (U.S. Geological Survey Hydrologic Atlas HA-405).

The potential effects of a tropical storm on depuration operations depend on several factors including the storm's size and severity, its position (if approaching), and whether or not it makes landfall in the vicinity of the facility. Should a hurricane make landfall or pass within 50 miles (80 km), especially if the facility is within the storm's northeastern quadrant, the following factors must be taken into account:

(a) Excessive rainfall: The previous section detailed the potential affects of excessive rainfall on the natural seawater resources of a depuration facility. According to the National Weather Service and the Geological Society, rainfall amounts of up to 10 inches can be expected if a tropical cyclone approaches or makes landfall along the northern Gulf coast.

(b) Storm surge and excessive high tides: As a tropical cyclone approaches or makes landfall, it is accompanied by a storm surge (wave). The surge pushes vast quantities of water onto lowlying, coastal areas and if it occurs concurrently with a high tide, especially a spring high tide, major flooding will occur in the coastal zone. The Hurricane Camille surges at Pass Christian and Biloxi (Point Cadet), Mississippi, were 24.2 and 15.6 feet (7.4 and 4.8 m), respectively (U.S. Geological Survey). Such a storm surge would completely inundate a depuration facility built along the waterfront in Mississippi and Alabama unless certain precautions were taken.

Prior to the construction of any depuration facilities in the coastal zone, the operators must determine the probably extent of storm surge flooding at the proposed stie. Flood charts (Hydrologic Atlases) are available from the U.S. Geological Survey (Washington, DC) and should be utilized in the planning process. If an adequate, natural elevation is not available at the proposed site, then pile-construction, site filling, etc., should be considered. Increased elevations will increase plumbing and pumping costs, but may prolong the useful life of such a facility. A two-story facility that contains tanks, rapid-disconnect pumps, and cold storage facilities at or above the predicted height of minimal, stormsurge flooding level and all remaining facilities (laboratories, offices, etc.) on the second level should be seriously considered.

(c) High winds and tornadoes: The potentially destructive effects of the high winds and tornadoes that accompany tropical storms along the Gulf coast cannot be negated without great expense. The facility should be built according to "code" (Southern Standard Building Code published by the Southern Building Code Congress, 3617 8th Avenue South, Birmingham, Alabama 35222) to minimize the destructive effects and the structure should be sufficiently insured in the event all or part of it is damaged or destroyed.

iii. Frontal Passage ("Northers"): The effects of the passage of winter weather fronts through the coastal zones are minimal unless the strong northerly wind coincide with a series of spring low tides. In such an event, the resulting low tides may be several feet below the lowest low spring tide and may expose the intake lines for those depuration facilities that utilize baywater in an open system or for make-up water in a closed system. Those low water periods may last for 24 to 48 hours depending on the wind strength and duration, and should be taken into account when planning the facility water system.

b. The Tides and Other Current Phenomena

i. Spring Tides: (For the purpose of this discussion, spring tides are defined as the bimonthly highest high tides and lowest low tides that occur when the combined gravitational effects of the moon and sun are most pronounced).

Mean diurnal tidal amplitudes range from 1.8 foot and 1.6 foot (55 and 49 cm) at Biloxi, Mississippi, and Bon Secour, Alabama, respectively, to 1.5 foot and 1.2 foot (46 and 37 cm) at Pascagoula, Mississippi, and Mobile Point, Alabama, respectively. Those amplitudes may vary by a foot (30 cm) or more during spring tides, especially in the winter. Those tidal amplitudes should have little influence on the siting of future depuration facilities, except with regard to the location of water intake pipes. Such intake pipes should be located well below the lowest, anticipated or recorded spring low tide level for a particular locality, unless pumping can be interrupted for extended periods especially during the passages of weather fronts (see previous section). Any permanent terrestrial structures that are associated with such a facility should be located well above the highest, anticipated or recorded spring high tide.

ii. Tropical Cyclone Surges: When coupled with spring high tides, storm surges may render low-lying coastal sites unsuitable for permanent, depuration facilities. (See previous section.)

iii. Localized Currents: The effects that other localized currents may have on potential depuration sites and their characteristics should be examined. Those currents, which include longshore or littoral drifts, river discharges, and tidal currents, will influence the quality of depuration water sources with regard to salinity and turbidity, but more importantly, water-borne domestic and industrial pollutants.

c. Atmospheric and Hydrospheric Temperature (Extremes)

i. Seasonal Extremes: The montly temperature means and ranges for several Mississippi-Alabama-Gulf coast localities are presented in Table __. The air temperature extremes should not influence the depuration process unless they cause the temperature in exposed reservoirs and depuration tanks to fall below that which would significantly reduce or stop the depuration process in oysters. (The minimum depuration temperature has not been determined for Gulf coast oysters, but was established for Atlantic coast oysters in general as 10°C [Furfari, 1966; Neilson et al., 1976].) If extreme air temperatures have a potential effect, the facility should stop production or utilize some type of temperature maintenance device. (Immersion heaters and heat exchangers are utilized in some soft clam facilities in New Jersey.) Protective insulation may be necessary or desirable.

If the facility uses a flow-through system and depends on water from an adjacent water body, the same water-temperature maintenance capability will be required. Since depuration is not anticipated during the summer months when normal oyster harvesting operations cease, water chillers or heat exchangers would not be required. In the event that oysters are imported for depuration from adjacent states that permit year-round harvesting (e.g., Louisiana), however, some type of chilling device may be required to maintain depuration water temperature below 29°C (Neilson et al., 1976a).

ii. Waste Heat (or Thermal Enrichment): Although power generating facilities are now being restricted with regard to the amount and extent of their thermal effluent, such a condition should be considered when siting a potential depuration facility. The problems of discussing waste heat are evident, especially if the temperature of the depuration process water is elevated to or above the recommended maximum of 29°C (Neilson et al., 1976a); however, under the right winter water temperature conditions, thermal enrichment might be beneficial if properly controlled.

Most power generating facilities now utilize cooling ponds and/or towers, and are located far enough from the coast so as not to cause problems for potential depurators in the foreseeable future.

iii. Maintenance of Static Water Temperatures: Furfari (1966) recommends that the temperature of the depuration process water "should be carefully monitored and controlled during the process, because of the lack of knowledge of its effect on <u>depuration rates</u>... In any area where seawater temperatures at depuration plants...markedly exceed the water temperatures of harvest areas, cooling...may be required." Neilson et al. (1976a) recommended that temperatures be measured at least daily and more often when lower or upper extremes are approached.

2. Chemical Factors

a. Salinity: Because oyster activities (osmoregulation, feeding, etc.) are affected by salinity, this factor must be considered (and controlled) during the depuration process. Furfari (1966) reviewed depuration requirements and suggested that salinities be maintained within 100± 20% of the harvest area value (Appendix I). He also indicated that those facilities that utilized flow-through seawater systems would experience significant salinity variations over each tidal cycle, especially if they were dependent on estuarine water sources. Neilson et al. (1976) found, however, that if oysters were given sufficient time to acclimate (up to 12 hours) they would depurate at any salinity between 10 and $32^{o}/_{oo}$.

i. Extremes and Variability: Salinity extremes along the Mississippi-Alabama coast are dependent on several factors including excessive rainfall, tropical storms, drought conditions, river discharge rates and locations, etc. Several of these factors are discussed in previous sections of this report. According to Christmas (1973) and Eleuterius (1977) salinity extremes of 0 to $26^{o}/_{oo}$ can be expected along the mainland shores of Mississippi Sound. (The mainland shore is typified by Bellefontaine Point, between Biloxi and Pascagoula. During June 1973 and July 1974, the bottom water salinities along Bellefontaine Beach ranged from approximately 4 to $26^{o}/_{oo}$. Salinities at that location were below the minimum depuration salinity of $10^{o}/_{oo}$ only during brief periods in January, April, and May.) Low salinity problems would be significantly reduced by locating depuration facilities away from the months of large-drainage river systems (e.g., Alabama, Pearl, Pascagoula). Unless the facility utilizes a closed seawater system, this requirement reduces the potential depuration localities to the areas depicted on the accompanying chart (Fig. 1). The most important sites are the southeastern part of Mobile Bay, that area between Bayou La Batre, Alabama, and Point aux Chenes Bay, Mississippi, between Biloxi and Pass Christian, Mississippi, the vicinity of Deer Island (south shore), Bellefontaine Point, and the barrier islands not now under the control of the U.S. National Park Service: Dauphin Island, Alabama, and Cat Island, Mississippi.

Short-term salinity variations that are associated with tidal cycles, especially at locations adjacent to river discharge areas, should have little effect on the euryhaline oysters. If extremes are determined to be detrimental, some form of salinity maintenance should be available. Salinity control mechanisms will be discussed in the following section.

ii. Maintenance to Static Salinity Conditions: Depuration salinities can be adjusted up or down with the addition of artificial seasalts or freshwater, respectively. Furfari (1966) does not recommend the former, and chlorinated freshwater may cause problems in the latter.

Although Furfari (1966) recommended routine salinity measurements, Neilson et al. (1976a) suggested that salinity should be measured at least daily and more frequently when it is suspected of being $>10^{\circ}/_{\circ\circ}$ of the ambient salinity. If it is more than $\pm 10^{\circ}/_{\circ\circ}$ of ambient, the oysters should be checked routinely to insure that they were pumping.

Two potential sources of high salinity water exist along the Mississippi-Alabama Gulf coast that might be tapped for depuration water. The first source, shallow saltwater wells (ca. 90 foot; 27.4 m) is available at certain localities including Pascagoula, Mississippi (Wickham, 1971). Water from such wells usually has a constant salinity and temperature; it is free of (pathogenic) bacteria; but its high ferrous iron content requires oxidation and filtration (Wickham, 1971). Other investigators have suggested the same saltwater source for hard clam depuration (MacMillan and Redman, 1971). "Electric logs" are available from the U.S. Geological Service for coastal wells and they should be examined when selecting a potential facility site. (See Section A.3.b.).

The second source, deep-well brine, is available in those coastal areas (e.g., Hancock County, Mississippi) where dry gas and oil wells penetrate strata with "clean" brines. Brines should be considered as an important potential source considering that the wells already exist, the resource is vast and unutilized, and the cost of artificial (dry) seasalts is often prohibitive. Should subsequent experiments demonstrate the practicality, feasibility, and acceptability of "brine water" in the depuration process, overland transportation of the brines would negate the requirement for locating near a well site.

b. Dissolved Oxygen (DO): Dissolved oxygen, like salinity, is an important chemical factor that determines oyster activities such as respiration, filter-feeding, etc. At saturation levels, dissolved oxygen is salinity- and temperature-dependent. Super saturation may cause gas bubble disease (air embouli which are ultra-small bubbles that adhere to gill filaments), and extremely low oxygen concentrations will cause the depurating oyster to reduce its filtering activities and eventually close its shell entirely and respire anerobically. In both extremes the depuration process is negated.

i. Minimum Concentrations: Furfari (1966) recommends a minimum DO level of 5 μg/l. (That value was calculated on the basis of an oxygen consumption rate of 2.4 mg/oyster/hr and a flow rate maintained at 4 l/min/bushel. Refer to Furfari, 1966, p. 55.) Neilson et al. (1976) found that oysters depurated in 48 hr at a DO range of 0.8 to 8.8 μg/l and in 72 at 0.6 μg/l. They recommend minimum DO levels of 72 μg/l and the maximum levels given in the following table:

S(°/oo)	T(°C)		
10	10.7	10.1	9.4
20	8.6	8.1	7.6
30	7.2	6.7	6.4

(Supersaturation and gas bubble disease occur above these DO levels.)

ii. Monitoring Devices and Schedule: Dissolved oxygen should be monitored regularly to insure a proper operating range, especially if static recirculation, depuration tanks are utilized. Dissolved O_2 meters are available from such companies as Yellow Springs Instruments for that purpose. Monitoring schedules will depend on water salinity and temperature and a tank loading capacity, but should include at least one check every 12 hours during the 48- to 72-hour depuration run. Neilson et al. (1976a) suggested that DO be monitored several times each day, especially during the summer when temperature and salinity conditions foster super saturation.

iii. Control Procedures and Apparatuses: Some form of aeration apparatus should be utilized in each depuration tank. Among those devices that have been used successfully in other depuration facilities are simple spurgers (bubblers) and cascading or spraying systems that allow O_2 uptake from atmospheric sources. Such aeration devices should not be designed and utilized in such a manner that depurating oysters are physically disturbed by rising bubbles or splashing water.

In recirculating systems, such as that to be investigated in year two (1978) of this study, aeration will take place outside of the depuration tank, thereby reducing physical disturbance and super saturation.

iv. Environmental Factors that May Affect Dissolved Oxygen (DO) Levels: Besides those factors mentioned previously (salinity, temperature, capacity, etc.), DO may be influenced by several environmental problems. The most significant problem would be elevated biochemical oxygen demand (BOD) levels that would result from excretory activities of the depurating oysters. Each oyster produces an enormous amount of feces and pseudofeces that must be removed from the depuration system. Our 1978 project will determine the average amount of those feces that can be expected from each bushel of depurating oysters and will propose methods for eliminating at least part of those waste products from the system on a continuous basis, thereby reducing the time and efforts required for daily wash-downs of the depuration tanks. (Refer to Wastewater Treatment Section.)

Putrefying oyster meats and decaying plant and animal materials that are not removed from the shells during normal predepuration washings will also increase the BOD. Daily wash-downs of the oysters themselves may reduce this potential problem.

c. Chemical Pollutants: Although this is a broad topic, we shall attempt to identify those pollutants that would affect the depurating oyster, their sources, and concentrations in the coastal waters of Mississippi and Alabama.

i. Agriculture Wastes including Pesticides: If the depuration water (or the oyster supply) is derived from a source which receives agriculture (land) runoff, pesticide levels may be a potential problem. According to Furfari (1966, p. 57) the amount of pesticide allowed in the depuration water is predicated on the maximum amount allowed in the shellfish tissue to be depurated. In the case of DDT that concentration cannot exceed ___ ppm. Because the oyster is a very efficient biological filter, it may concentrate low pesticide levels in the depuration water to final levels that are unacceptable to the U.S. Food and Drug Administration.

Elevated pesticide levels, especially from agricultural sources, would be associated with the river systems flowing into Mobile Bay, the Pascagoula River and its tributaries, and the Pearl River. The pesticide levels of oysters from those areas should be determined routinely before approving them for depuration. Potential depuration-facility sites on those same river/estuary systems should be considered thoroughly with regard to past, present, and future (anticipated) pesticide levels in the water. Primary consideration should be given to those sites that do not receive agriculture wastewater and runoff such as the following coastal systems: Grand Bay, Biloxi Bay, St. Louis Bay, and the barrier islands.

Any estuarine systems that receives wastewater from livestock feedlot operations may exhibit elevated fecal coliform (bacteria) levels. Oysters and/or depuration process water from those systems may be unacceptable for use under FDA regulations.

ii. Domestic Wastes: These are the most serious concern of the depurator and are the primary reason for oyster depuration in the first place. Domestic sewage pollution has resulted in the closure of vast oyster growing areas in Mississippi and Alabama in the past and unless sewage treatment along the coast is upgraded in those estuarine systems that affect major growing areas (Mobile, Pascagoula, Biloxi, and St. Louis bays), "closed" areas will continue to expand. The coastal area is now in the process of developing a 201-208 Regional Wastewater Management plans that may reverse the recent trend in closures. According to FDA officials and regulations, however, oyster growing areas within one tidal cycle of effluent discharge point sources must remain permanently closed to harvesting in the event of plant failure and bypass.

Depuration facilities that depend on process water from estuarine sources must be prepared to upgrade that water to acceptable FDA standards or be located on water bodies that do not receive extremely large amounts of treated effluents. Those depuration facilities that utilize saltwater wells or diluted brines for process water would not have to contend with domestic sewage problems except with regard to the influence of those problems on actual and potential sources of oysters for depuration.

iii. Industrial Wastes: The Mississippi-Alabama Gulf coast is undergoing rapid industrialization, especially in the following areas: Mobile Bay-Theodore, Alabama, and Pascagoula River-Bayou Casotte, Biloxi Bay Industrial Seaway, St. Louis Bay, and Port Bienville, Mississippi. Continued discharge of industrial wastes in the form of toxic heavy metals, hydrocarbon residues, and effluents with high biochemical and chemical oxygen demands (BOD and COD) will render oyster growing areas down stream from those locations unfit for oysters harvesting and the waters unfit for depuration purposes, if they have not reached that state already. Industrial expansion is presently underway in all of those areas, thereby threatening oyster resources near the mouth of Mobile Bay, in the vicinity of Pascagoula and in Biloxi Bay. Industrial and residential expansion in the Hancock County, Mississippi coastal region may detrimentally affect oysters and water quality in the major oyster growing areas of the western Mississippi Sound (Pass Christian, Pass Marianne, Waveland).

Furfari (1966) reviewed the effects of heavy metals on depurating oysters and concluded that water that contained heavy metal concentrations above those usually found in seawater should not be used for depuration. Summer (1962) noted that iron in low concentrations (1 ppm as $FeCl_3$) reduced the transmissivity of ultraviolet light from 90 to 5%. Depuration water that is derived from saltwater wells (and diluted brines) along the Gulf coast of Mississippi have high concentrations of iron which must be chemically floculated and removed prior to utilization (Wickham, 1971). Even with that minor chemical problem, saltwater wells appear to be potential sources of depuration water. Water from such sources is free of bacterial contaminants and has a stable salinity and temperature profile (MacMillan and Redman, 1971).

iv. Navigation Pollutants: Depending on the location of proposed depuration facilities (with regard to navigable waterways), several other pollution sources should be seriously considered including hydrocarbon (oil) spills, bilge residues, dredge and fill residues, etc.

Mississippi Sound, Mobile Bay, and adjacent waters serve as transportation corridors for large volumes of crude oil and refined hydrocarbons. Oil barges regularly traverse the Sound along the Gulf Intracoastal Waterway and/or enter the major bays to service oil refineries, power generation facilities, etc. In addition, oil tanks and submerged oil pipe lines service refineries in Mobile Bay and Bayou Casotte. The Sound and adjacent waters will eventually be opened for oil and gas exploration as the nation's energy reserves continue to be depleted. These oil-related activities will eventually result in a major pollution problem. When a spill does occur, prevailing hydrographic and meterologic conditions may result in the degradation and closure of areas from which oysters are harvested for depuration. That water quality degradation may also affect any depuration facilities that utilize bay water for depuration purposes.

Although of minor importance, bilge water, human waste, and other pollutants that are discharged by commercial, recreational, and sportsfishing boats in Mississippi Sound, Mobile Bay, and adjacent waters may affect oyster growing waters and potential depuration facilities unless properly controlled. Federal regulations (Federal Water Pollution Control Act of 1972 as amended by the Clear Water Act of 1977) specifically prohibit such boating discharges, but they still pose a definite threat.

Dredge and fill activities occasionally take place in and adjacent to oyster growing areas. Although those necessary activities can be accomplished so as to minimize their physical effect on oyster growing areas, they may result in the addition of chemical pollutants into the surrounding water (from the sediments). This may be an important factor if heavy metals and pesticide residues in the sediments exceed background and/or permissible levels.

3. Geological and Geochemical Factors Affecting Depuration

   a. Sediment Load and Turbidity (of depuration water): Excessive turbidity can reduce the feeding activity of oysters as well as ultraviolet light penetration (if the latter is used for water sterilization) and may affect the palatability of the oysters (Furfari, 1966). Furfari recommends that turbidity of the depuration water not exceed 20 Jackson Turbidity Units (JTU). Neilson et al. (1976) found that turbidities at or below 77 μg/l did not affect depuration. They also found that higher turbidities resulted in the production of greater amounts of pseudofeces, higher bacterial levels, higher BOD levels, and increased oyster deaths during no- or low-flow conditions. Neilson et al. (1976a) recommends that turbidities be monitored if excessive levels are experienced or predicted because of local meterological phenomena. Furfari (1966) simply recommended that turbidity tests be "routine."

Turbidity is controlled by many factors including the sediment load and water turbulence. Both of these factors are quite variable in coastal waters of Mississippi and Alabama and depend on the location (with respect to river discharge) and the ambient meterological conditions. Flooding rivers and/or rivers that drain large agricultural areas bring large sediment loads into the coastal waters; stormy conditions over the coastal waters resuspend those sediments (especially the clay and silt fractions). When either condition prevails turbidities will exceed the maximum recommended value of 20 JTU (or 77 mg/l).

Excessive turbidity can be reduced via several methods including filtration, centrifugation, and settling. The first may remove necessary food particles and the second may be too costly or time consuming (for large volumes). Settling is the desired method at present, but requires several hours per batch of depuration process water and large settling tanks. This would be no problem or added expense for a depuration facility that utilizes a closed water system and large reservoir tanks. The reservoir tanks would, in fact, promote algal growth for increased food supplies, especially, if they are maintained in a greenhouse situation or under light-transmitting panels. Covering devices are required by FDA to keep out animal feces, vermin, etc. (Furfari, 1966). Excessive turbidity would also not be a factor if salty well water or diluted brines are used as process water. If saltwater wells or brines are not available and the depurator desires to reduce the turbidity associated with makeup or process water, the facility location can be of prime importance. If adjacent substrates are predominantly sand, wellheads can be located several meters below the water/sand interface to take advantage of natural percolation and filtering. Barrier island or beach locations may provide this substrate/ filtration process. If sand fractions predominate in substrates that are adjacent to proposed facility sites, the potential threat of increased turbidities from meterological phenomenon will be reduced.

In-tank turbidities may be elevated by oyster biodeposition (of feces and pseudofeces) and subsequent water turbulence. That problem can be controlled by daily tank-cleaning. Engineering studies will be conducted during the second year of this project with an experimental, closed-system depuration process. That system will include a device for continuous removal of water-brine biodeposits that will hopefully reduce in-tank turbidities (and elevated BOD) and eliminate the requirements for extensive daily tank cleansing.

b. Subsurface, Ground (Salt) Water Resources: Saline wells are a potential source of depuration water in coastal Mississippi and Alabama. Subsurface salt water has been used in mariculture applications including depuration (MacMillan and Redman, 1971) and fish maintenance (Wickham, 1971). MacMillan and Redman (1971) reported the use of a shallow (ca. 45-ft. x 4-in. diameter) saltwater well in conjunction with a pilot, hard clam (*Mercenaria mercenaria* [Linné]) depuration plant at West Sayville, Long Island, N.Y. Their well proved extremely effective and offered the following advantages over ambient bay water:

(1) Constant salinity (24.0 to 25.5°/oo);

(2) Constant year-round temperature (54.5 to 55.5°F; 12.5 to 13.0°C);

(3) Elimination of water heating requirements;

(4) Minimization of ultra-violet sterilization because of lack of detectable bacteria;

(5) Elimination of fouling organisms and growth within seawater distribution lines; and,

(6) Elimination or reduction of sediment-settling requirements because of a lack of suspended matter.

Wickham (1971) utilized a shallow (90-ft, 27.4-m), saltwater well to supply a recirculating system at the

Pascagoula, Mississippi, National Marine Fisheries Service Laboratory. Elevated concentrations of iron in the form of soluble ferrous hydroxide, $Fe(OH)_2$ (up to 15 ppm) were a potential problem but were reduced to less than 1 ppm when the water was continuously aerated, and the oxidized and insoluble ferric hydroxide, $Fe(OH)_3$, was removed via a commercial, swimming-pool, diatomaceous-earth filter. Salinities of approximately 23°/oo were obtained after removal of the ferric hydroxide. That salinity is within the salinity ranges perferred by oysters (Galtsoff, 1964) and recommended for oyster depuration (Furfari, 1966) considering the normal salinities encountered in oyster growing areas in Mississippi Sound.

The availability and reliability of subsurface salt water for depuration purposes in the Mississippi-Alabama coastal zone must be ascertained for each potential locality. The Water Resources Division of the U.S. Geological Survey (430 Bonds Street, Jackson, Mississippi 39206) will provide "electric logs" for wells nearest the potential locations. Potentially subsurface resources are present at 90 ft (27.4 m) in Pascagoula and at 110 ft (33.5 m) in eastern Biloxi (Pt. Cadet). As indicated previously the utilization of depuration water from such wells may reduce the need for water quality control apparatuses and eliminate the problems associated with undependable, ambient water conditions. We, therefore, strongly recommend that serous consideration be given to this potential saltwater resource as well as to diluted brines from nonproductive gas wells.

Depending on the location or potential location of proposed depuration plants, salt water may be derived from very shallow salt wells (subsand abstraction). These subsand wells can only be utilized in localities where clean, sandy substrates predominate. Such conditions exist around the Mississippi-Alabama barrier islands and along some stretches of the mainland. In such a system shallow wellheads are placed in the sand at a depth below which the sediment is not disturbed by storm activities (ca. 3.3 ft, 1 m). Sea water percolates through the overlying sand and enters the well heads where it can be pumped ashore. Cansdale (1975) listed the advantages of such wells as follows:

(1) Efficient removal of suspended particles including sediments, fouling organisms, and surface debris and pollutant such as oil;

(2) Damping of diurnal and longer-term temperature fluctuations;

(3) Damping of salinity extremes caused by heavy run-off from rain; and,

(4) Low maintenance and operation costs compared to deep wells.

Subsand abstraction should be preferred over ambient water utilization, but may not be as dependable as deeper well sources, depending on the location.

c. Soil and Subsurface Characteristics: Coastal soils and the subsurface features may have a significant effect on potential depuration plant locations. Alluvial soils and marsh sediments that are prime locations (adjacent to productive oyster grounds) may not support such a facility or its allied systems (e.g., settling and holding tanks and/or ponds). Supportive pilings and/or fill materials may be required. These are civil engineering problems and will not be considered further herein.

Soil porosity and/or drainage, however, may affect the design and siting of earthen ponds. In the event that such minimum wastewater treatment as settling and drying (of tank washings) is required, sandy, porous soils would be advantageous. If, however, widely varying ambient water conditions require the storage of large volumes of water in earthen reservoirs (during favorable hydrographic conditions), soil porosity must be reduced or eliminated. Again, that is a civil engineering matter if soil porosity is to be altered. Proper drainage must be engineered and maintained for ease of water treatment and effluent handling, and for maintenance and protection of all structures associated with a depuration facility.

Subsurface porosity, as mentioned in the previous section, is an important factor in the subsand abstraction of process water from nearshore resources.

4. Biological Factors.

a. Microbiological Characteristics of Incoming (Process) Water: Depending on the source of incoming water, some treatment (sterilization) may be required prior to its use in the depuration process. According to FDA regulations (Furfari, 1966; National Shellfish Program Manual, Part I, 1962), median coliform bacteria levels in untreated makeup water must be "equal to or less than 700 MPN/100 ml." (Not more than 10% of the samples may exceed 2,300 MPN/100 ml for a 5-tube, 3-dilution test; and 3,000 for a 3-tube, 3-dilution test.) Following treatment, that coliform level cannot exceed 1.0 MPN/100 ml.

i. Seawater Resource Areas: The accompanying chart (Fig. 2) deliniates those areas where median coliform levels exceed or are suspected of exceeding the 700-MPN/100-ml limit. Coastal zone areas that do not now meet that criterion include:

(a) The Mississippi shoreline and nearshore area between Bayou Cassotte and Graveline Bayou including the East and West Pascagoula River discharges and Pascagoula Bay);

(b) The Back Bay of Biloxi, Mississippi (upbay from the Louisville and Nashville Railroad Bridge);

(c) The vicinity of Bayou La Batre, Alabama;

(d) That part of Mississippi Sound that receives Mobile Bay discharge during flood conditions (including the vicinity of Dauphin Island, Alabama); and,

(e) Those coliform "hotspots" that often occur in the vicinity of storm-drain discharge points in Mississippi Sound between Ocean Springs and Waveland, Mississippi, especially after periods of heavy rainfall.

ii. Bacteriological and Virological Control Measures: The Mississippi and Alabama State Health Departments have responsibility under the National Shellfish Sanitation Program to monitor and enforce FDA regulations pertaining to the depuration of oysters. Operational permits will be required from those state agencies and periodic federal and state health inspections will no doubt occur. In-house testing and accurate record maintenance of all depuration operations will be required. Plant operators will be required to have qualified personnel for said testing or have the tests conducted or certified by private microbiology laboratories.

b. Resource Availability and Utilization.

i. Oyster Availability: Oyster management personnel in Mississippi and Alabama estimate that a sustainable yield in excess of 100,000 barrels (328,100 bu; 11,562 m^3) of oyster can be harvested annually from reefs that are closed because of domestic pollution (i.e., they occur in "restricted" waters). At present market values those oysters represent an estimated $2.5 - 3.0 million renewable resource. (Figure 2 depicts the location of those oyster resources in restricted waters of Mississippi and

Alabama.) Median coliform levels in restricted waters may not exceed 700 MPN/100 ml and since they seldom drop below the minimum median level of 70 MPN/100 ml (for approved shellfish waters), they can only serve as a source of oysters for depuration or relaying.

According to Part I, Section D, of the National Shellfish Sanitation Program Manual of Operations (p. 22), oysters from "prohibited" waters (where median coliform levels exceed 700 MPN/100 ml) cannot be utilized for depuration ("contolled purification") "unless relaying is not practical for biological reasons, and no public-health hazard will result from the use of such shellfish." Since present biological factors do not negate the applicability of relaying in "approved" waters of Mississippi and Alabama, oysters from "prohibited" areas cannot serve as a depuration resource. There is a definite danger, however, that if present domestic pollution trends continue, some "restricted" areas may be designated as "prohibited" thereby reducing the resource.

The majority of depuratable oysters occur in Biloxi Bay (down bay from the L&N R/R bridge) and in the vicinity of the West Pascagoula River mouth (Pascagoula Bay). Those areas are readily accessible to harvesting craft (dredge boats) and potentially acceptable sites are available on adjacent shorelines for depuration facilities. (Those potential sites will be discussed in later sections of this report.) The close proximity of those oyster reefs to potential depuration sites should minimize the environmental impact of present and future fuel shortages. Since those areas are classified by the FDA as "restricted" shellfish growing waters, the predischarge treatment of "depuration wastes," especially filtered and/or settled process water, into those same waters may not be required.

iii. Oyster Resource Management: (The management aspects of oyster depuration will be reviewed and discussed in detail in a separate section of this report.) Management responsibility for resource (depuratable) oysters lies with the following agencies:

(a) The Alabama Department of Conservation and Natural Resources (Marine Research Laboratory);

(b) The Mississippi Department of Wildlife Conservation (Bureau of Marine Resources); and,

(c) The Mississippi and Alabama State Boards of Health (under the auspices of the FDA National Shellfish Sanitation Program; depuration/harvesting management.

c. Bio-Fouling Problems and Controls.

i. Fouling Organisms: Sessile estuarine invertebrates and protochordates whose planktonic larval stages attach to water intake pipes, settling and filter systems, as well as depuration tanks and accessories must be controlled and/or removed from most depuration systems. In Mississippi Sound and adjacent waters the important foulers include, but are not restricted to, the following:

(a) Sea Anemones (Aiptasiomorpha texanensis);

(b) Bryzoans - moss animals (Membranipora tennis and Bowerbankia gracilis);

(c) Bivalve Mollusks - oysters (Crassostrea virginica, and mussels (Ischadium recurvum and Mytolopsis leucophaeta);

(d) Gastropod Mollusks - slipper shells (Credidula spp.);

(e) Crustaceans - barnacles (Balanus spp.);

(f) Echinoderms - holothurians or sea cucumbers, (Thyone mexicana); and,

(g) Ascidians - tunicates or sea squirts (Molgula manhattensis)

Those fouling organisms are most numerous and of greatest importance during the warmer months when they reproduce and their planktonic larvae permeate the estuarine waters.

ii. Fouling Problems: When fouling organisms attach in large number within the seawater system of the depuration facility, they will severely restrict volume flow unless removed periodically or controlled. When they settle on tank, tray, and other surfaces within the depuration system, they may interfere with laminar flow thereby interrupting downstream oysters, or their metabolic, reproductive, or degradative (postmortem) products may interfere with normal oyster depuration.

Those same fouling organisms and a few burrowing forms that infest oyster shells (e.g., burrowing sponges, *Cliona* spp.; clams, *Diplothyra smithii*; and polychaete worms, *Polydora* spp.) may cause secondary problems during the actual depuration process. Relatively few individuals will be removed during predepuration cleansing, and many of those that remain will die as a result of dessication during out-of-water storage. It is these moribund and dead fouling organisms that may cause additional water quality problems for the depurators.

iii. Control and Removal Procedures: Fouling organisms that enter the seawater system can be controlled by several methods. The simplest is to prevent the attachment by using fouler-free process water. Salt well and subsand abstraction waters will be free of planktonic larvae and the primary fouling problems will not exist. If raw bay water must be utilized, it should be sand-filtered (commercial swimming pool sand filters may be adapted for this purpose) or redundant water supply systems (pipes and pumps) should be installed in the facility. In a redundant system one intake/discharge line can be back-filled with fresh water to kill attached larval or juvenile fouling organisms while the other line is being utilized. Freshwater back flooding should be cycled on a one- or two-week schedule so that newly attached foulers are killed before growing to an appreciable size.

Fouling organisms that attach to other, open surfaces, should be scrapped off and flushed from the depuration tanks. Those that come in with the oysters to be depurated will be the most difficult to handle. Unless some form of cleansing is developed to physically remove the external shell foulers, and burrowing forms, the depurator will have to constantly monitor water quality and be ready to replace the process water if moribund or dead foulers reduce the water quality with their degradative products.

5. General Environmental Factors

a. Energy Conservation and Efficiency: In the 1980's the Mississippi and Alabama coastal zone will experience a significant reduction in energy (fuel resources). The seafood industry, which is already beset by rapidly escalating operating expenses, will experience drastic production and profit declines. Any plans for future depuration facilities must take into consideration the predicted, future fuel shortages. Every effort must be made to reduce the amount of energy required to operate such a facility and to reduce the needless waste of energy. New sources of energy, especially solar and/or wind energy should be examined.

i. Energy Requirements: Oyster depuration will require low levels of energy throughout the process from harvest through depuration to distribution of the final, cleansed product. If we consider that the harvest and product distribution requirements approximate those of oysters from "approved" water, then we have only that utilized during in-plant operations to consider. During depuration electrical energy will be required for the following:

(a) Predepuration cold storage;

(b) Predepuration cleansing (exterior of shells);

(c) Depuration (which includes):

(1) water pumping,

(2) UV or ozone sterilization,

(3) product movement, and

(4) waste removal and treatment;

(e) Postdepuration cold storage;

(f) Postdepuration bacteriological testing; and

(g) Support requirements (lights, heat, hot water heater, etc.).

(Building and process-water heating requirements may be minimized or eliminated because of generally mild Gulf coast winters.)

Energy cost estimates are available for hard clam depuration (in Rhode Island) where building and process-water heating is required. Holmsen and Stanislas (1966) reported that energy costs (for UV lights, electricity, natural gas, and freshwater) amounted to approximately 7¢/ bushel of depurated hard clams or about 16% of the depuration cost. In the 15 to 20 years since that feasibility study was conducted inflation and increased fuel costs have probably tripled or quadrupled and the energy cost should now approximate 25% of the depuration cost per bushel. (The economics of oyster depuration in the Mississippi Sound will be examined during Year III of this Sea Grant project.)

ii. Energy Conservation: The conservation or reduction of depuration energy requirements must be considered during the planning and construction phases of such a facility. Energy conservation can be accomplished by the following methods.

(a) Solar Energy Utilization: As indicated previously, facility and process-water heating requirements should be minimal along the Mississippi-Alabama Gulf coast and those requirements could easily be met with inexpensive solar collectors and storage tanks. Process-water that is stored in large tanks or small ponds could be insulated and covered with translucent material for solar heating.

(b) Insulation: Proper insulation of all cold storage facilities and solar energy storage facilities would reduce energy loss. New and more efficient types of insulation are available and should be utilized and maintained in good condition.

(c) Electricity Utilization: Although the largest amount of electricity will be required for water pumping, some conservation may be accomplished by optimizing pump efficiencies and utilizing gravity flow where possible, especially for filtering and settling purposes. Translucent, overhead skylights will reduce the amount of artificial lighting required to operate the facility in a safe, sanitary, and efficient manner.

These are but a few solutions to the energy problems that a depuration plant operator will face. They are by no means exclusive or inclusive. This research team is not aware of all of the latest engineering aspects of energy conservation and defer to those professionals that are. By the time such a facility is constructed, however, additional energy-saving devices and processes should be commercially available including, but not limited to:

(d) Wind Power: for process-water pumping, espcially in gravity-flow reservoirs. (According to Wells [1978], windmill-pumping of depuration process water is pratical and should be economically feasible in the immediate future along the Gulf coast of Mississippi.) (Electrical pumps would then be utilized only when necessary.)

(e) Bio-processing of wastes (land or water application and composting of depuration wastes) to reduce cost of expensive, waste treatment systems.

(f) Optimization of sterilization equipment (Which sterilization process requires the least energy input - UV, ozoniation, or some other alternative?)

(g) Product-flow optimization to increase efficiency and production while reducing energy utilization.

b. Land Management.

i. Coastal Zone Management: CZM plans for Mississippi and Alabama have not been approved or implemented as provided by the US Coastal Zone Management Act of 1972 (16 U.S.C. 1451, et seq; PL 92-583; as amended by PL 93-612 and 94-370). That management which does exist is under the direction of the Mississippi Bureau of Marine Resources (MBMR) and the Alabama Coastal Area Board (ACAB), respectively. Those agencies are presently restricted in their jurisdiction by the upper limits of the mean high tide line. Mississippi's Coastal Wetlands Act of 1973 established the MBMR as the coastal zone management authority in that state. Should pending legislation ever pass that state's legislature, the CZM boundary would be set at one of the following:

(a) The 13-ft contour line,
(b) The Interstate Highway (I-10), or
(c) The northern boundary of Jackson, Harrison, and Hancock Counties.

Regardless of the northern boundary, the CZM agencies will have management control over all activities in the coastal zone or that affect the coastal zone including depuration. That authority would cover the location of any proposed depuration activity (facility) and permits would have to be acquired in order to construct and operate such a facility within said coastal zone. The MBMR and the ACAB should be contacted during the planning phases of any proposed depuration facilities to ascertain their role, if any, what permits are needed, and what zoning restrictions are applicable. The addresses of those agencies along with those of other county and municipal zoning authorities are provided in Appendix B along with other pertinent zoning information.

ii. County and Municipal Zoning Agencies: Local zoning agencies presently control to some extent most activities along the shores of Mississippi Sound and adjacent waters. As is the case with other seafood processing operations, depuration will come under the jurisdiction of those agencies. Zoning ordinances vary somewhat from county-to-county and from municipality-to-municipality; two typical ordinances shall be compared herein.

(a) Title, date, and administrative agency:

(1) Jackson County, Mississippi, Zoning Ordinance of 1977; Jackson County Planning Commission (under the authority of the Jackson County Board of Supervisors).

(2) Biloxi, Mississippi, Code of Zoning Ordinances of 1974; Biloxi Planning Commission (under the authority of the Mayor and City Council of Biloxi).

(b) Zoning District Designations (that would include depuration):

(1) Jackson County should permit depuration as a light industry and thereby restrict it to a light industry district (LID) (I-2) in accordance with Article II, Section 10. No I-2 zones are located adjacent to productive and "restricted" oyster growing areas that would be suitable for depuration plants. Most of the county's coastal land is zoned for either residential development (in which case an exemption or variance would be required) or as a flood plain district (FPD) (in which case planning commission approval would be required; Art. II, Sec. 12). Depuration plants should be approved in the FPD provided that the plants are "located on a landfill or on pilings, or pillars of not less than a mean sea level elevation of 12.5 feet; provided such fill, pilings, or pillars do not restrict or impede the flow of waters in the floodway" (Art. II, Sec. 12.3).

(2) The City of Biloxi should also permit depuration as a Light Industry and thereby restrict is to a LID (I-1) in accordance with Art. 5, Sec. 19. The majority of the potential plant locations (and I-1 districts) lie along the western shore of Biloxi Bay and along the southern shore of the Back Bay of Biloxi. Since the latter body

of water is classified as "closed" for shellfish purposes by the State Board of Health, process-water and oysters from it cannot be utilized for depuration; the plant should, therefore, be located elsewhere. The majority of the LID zone in eastern Biloxi is utilized by marine-related industries including seafood harvesters and processors. The Biloxi zoning code does not designate a FPD as did the Jackson County ordinance. It does, however, provide for a sand beach district (Art. 5, Sec. 21), but unless special exemptions are granted, no light industries such as depuration would be approved for that district.

(c) Critical Exposure Zones (CEZ): Both Jackson County and the City of Biloxi designate a CEZ to include: "All land lying within 1,000 feet of the shoreline of the Mississippi Sound...and all land north of the after said area less than 12.5 feet above mean sea level (MSL), and all lands, waters and bottoms within jurisdictional limits lying south of and within one mile of the shoreline of the Mississippi Sound" (Jackson County Ordinance, Art. II, Sec. 13; Biloxi Code, Art. 5, Sec. 21.7). Both ordinances require that structures built within that CEZ must conform to the addition provisions of Sections 116 and 117 of the Southern Standard Building Code (SSBC) as adopted by the respective agencies. (The shoreline referred to in both ordinances is defined as "the mean high tide line of the Mississippi Sound, together with straight lines across the mouths of bays, estuaries, and rivers flowing into or connecting with said Sound."

Most potential depuration sites, because of water pumping and shipboard off-loading requirements, should be located within that CEZ and must therefore comply with Sections 116 and 117 of the SSBC.

(d) Permits and Certificates: County and/or city building permits and occupancy certificates will be required of the depurator by the respective planning commissisions.

Depending on the location of proposed depuration facilities, planning and/or zoning agencies in the following coastal counties and municipalities should be consulted well in advance of land acquisition and construction planning:

(1) Mississippi: Hancock County, cities of Waveland and Bay St. Louis; Harrison County, cities of Pass Christian, Long Beach, Gulfport, and Biloxi; Jackson County, cities of Ocean Springs, Gautier, and Pascagoula.

(2) Alabama: (The South Alabama Regional Planning Commission has zoning responsibility for all coastal lands in Alabama including Dauphin Island.)

Names and addresses of those county, municipal, and regional commissions are provided in Appendix B of this report, along with a coastal map depicting their zones of authority.

c. Water-front and Water-bottom Management: The use of water-front property for depuration facilities and/or the use of riparian properties for those facilities or allied systems will be subject to management by several state, county, or municipal agencies depending on the proposed location. The requirements and restrictions governing waterfront properties are in general the same as those outlined and discussed in the preceeding section (part b); however, when the use of that waterfront extends into or involves the immediate, nearshore waters and bottoms, two additional factors must be taken into account.

i. Riparian Rights: Any activities in the nearshore coastal zone that involve the water column and/or the water bottom may be subject to the riparian rights of adjacent property owners. Those activities may include, but are not restricted to, the construction of any structures in or on the bottom (piers, intake or discharge lines, etc.), retaining devices (bulkheads, dikes, jetties, etc.), or the like. Specific approval for the placement of such devices, if they infringe on the riparian rights of an adjacent property owner, will have to be approved by the holder of those rights.

The specifics of the Mississippi Riparian Right Code will be described and discussed in the legal part of this report.

ii. State Rights: Most coastal states including Mississippi and Alabama have laws which control to some extent the use of the water column and bottom for various activities including those listed in Section i above. In Mississippi, the Bureau of Marine Resources has statutory authority over all such activities in state waters according to the 1973 Wetlands Protection Act. In Alabama, similar statutory authority is vested in the Alabama Coastal Area Board. Any activity that shall make use of the water column or bottom other than normal commercial fishing, must meet with their approval. That approval generally requires a permit. (See Part II, for a discussion of the Mississippi Wetland Protection Act.)

iii. Federal Rights: Any depuration activities in or involving the use of navigable waterways may require additional permits and/or approval from the US Army Corps of Engineers, the US Coast Guard, and the US Environmental Protection Agency (if pollutants are to be discharged). Any activities that involve the construction of permanent facilities systems, structures, etc., in, on, or over navigable waterways or which result in the discharge of pollutants into those waterways, must have the approval of one or more of those agencies. In Mississippi, potential depurators may refer their requests for such permits to the State Clearinghouse for Federal Programs, 510 George Street, Jackson, Mississippi 39201. Requests for permits in Alabama should be referred to Alabama Coastal Area Board (see Appendix B for address). Potential depurators who are unsure of the impact of their facilitiy or operation on the adjacent marine or estuarine environment are advised to contact the proper agency in their respective state during the planning and development stages to insure the acceptance of such a facility or its systems in a specific location. (See Section C of this part for additional information on those permit requirements.)

B. "Environmental" Permits (Required for:)

1. In-plant Depuration Operations

a. FDA: The FDA does not require any environmental permits, *per se*; however, that agency does suggest that conditions within the depuration facility be maintained in accordance with environmental guidelines set forth by Furfari (1966). Those environmental criteria are discussed in detail elsewhere in this report.

2. Ex-plant Depuration Operations

a. Seawater Intake System:

i. US Army Corps of Engineers: Depending on the type of intake water system, its supportive structures, and its location relative to "navigable" waterways, a COE permit may be required prior to installation. Most estuarine systems (bays, bayous, river mouths, etc.) are considered "navigable" by the COE for permit purposes (Dept. of Army Pamphlet No. 1145-2-1, 1 October 1974). All persons and agencies that anticipate the placement of structures in coastal waters of Mississippi or Alabama are urged to consult the US Army Engineers District Office, P. O. Box 2288, Mobile, Alabama 36628. (Appropriate sections of the aforementioned pamphlet are duplicated in Appendix C.)

ii. Mississippi Bureau of Marine Resources (MBMR): Seawater intake systems may also require permits from the MBMR which operates under the authority of the Mississippi Wetlands Protection Act of 1973. Potential depurators should review the appropriate MBMR guidelines (see Appendix C) and/or consult directly with the MBMC (see Appendix B for that address).

b. Wastewater Discharge System:

i. US Army Corps of Engineers: Under the Rivers and Harbors Act of 1899 (33 U.S.C. 403) ("Refuse Act") and Section 404 of the Federal Water Pollution Control Act, as amended by the Clean Water Act of 1977 (33 U.S.C. 1251, et seq., PL 92-500; as amended by PL 93-207, 93-243, 93-592, 94-238, 94-558 and 95-217), the discharge of any material including wastewater into a "navigable" waterway or a tributary thereof is illegal unless permitted by the COE. That permit will be granted only if the discharged material will meet the "applicable water quality standards," which are set by state and federal agencies. (See following sections). An additional COE permit will be required if the discharge system or its supportive structures extend into "navigable" waterways. (In the latter case a permit would also be required from the Mississippi Bureau of Marine Resources or the Alabama Coastal Area Board.)

ii. US Environmental Protection Agency (EPA), Mississippi Bureau of Pollution Control (MBPC), Alabama Water Improvement Commission (AWIC): The EPA and/or appropriate state pollution control agencies will require permits for any material discharged into state waters, navigable or otherwise. The EPA operates under the auspices of the National Environmental Policy Act of 1969 (42 U.S.C. 4341; amended by PL 94-52, July 3, 1975; PL 94-83, August 9, 1975) and the Federal Water Pollution Control Act, as amended by the Clean Water Act of 1977 (33 U.S.C. 1251, et seq., PL 92-500; as amended by PL 93-207, 93-243, 93-592, 94-238, and 95-217). The intent of that legislation is to clean up the waters of the US and maintain acceptable water quality standards.

Prior to 1975 no standards had been established for the discharge of oyster fecal wastes into the US waterways; however, under present standards that are applicable to BOD loads and suspended solids, no discharges, including oyster wastes, can be discharged without treatment if those factors exceed a daily average of 30 mg/l (BOD) or 60 mg/l (suspended solids) or a daily maximum of 60 mg/l (BOD) or 120 mg/l (suspended solids) (Jerry Bank, MBPC, Jackson, Mississippi, personal communication). The state pollution control agencies of Mississippi and Alabama are responsible for the issuance of discharge permits for such activities under the National Pollutant Discharge Elimination System (NPDES). Potential depurators should consult with the appropriate pollution control agencies (see Appendix B) and/or regulations (or parts thereof - see Appendix C).

If process water is to be discharged into shellfish growing waters (e.g., if process water is circulated from and returned to Biloxi Bay) it must meet the minimum standards set forth in EPA Technical Bulletin 430/9-74-010, "Protection of Shellfish Waters" (see Appendix C). In the case of oyster fecal wastes, the coliform median MPN values cannot exceed 70/100 ml, and not more than 10% of the samples can ordinarily exceed an MPN of 230/100 ml for a 5-tube decimal dilution test (or 330/100 ml, where the 3-tube decimal dilution test is used). If these wastewater criteria cannot be maintained, some form of in-plant or municipal waste treatment system will be required. Coliform levels can be controlled via chlorination, ozoniation, etc., and suspended solids (including those that result in elevated BOD levels) can be removed via settling or centrifugation.

(The wastewater treatment requirements for an experimental depuration system will be determined during a 1978 Sea Grant awarded to the Gulf Coast Research Laboratory and the Mississippi State University [Project #R/SP-2]. The results of that investigation will help state and federal officials assess the waste treatment requirements for commercial depuration facilities along the northern coast of the Gulf of Mexico.)

C. Sample Environmental Impact Statement (EIS)

The sample EIS proposed herein is based on the guidelines provided by the Mississippi Bureau of Marine Resources and is intended to provide potential depurators with a "model" EIS. Its use is recommended with caution since each facility will differ based on size, location, capacity, etc. Consult with the appropriate state and federal agencies (COE, MBMR, or Alabama Coastal Area Board) that are responsible for issuing permits prior to final submission of an EIS for the appropriate format.

The EIS is an assessment of the impact of the proposed action (depuration) or projects (depuration facilities) upon a number of existing environmental elements and factors. That environmental assessment is multidisciplinary and may involve any number of scientific, economic, and social disciplines, all of which are employed in discussing the following seven (7) main points that should comprise the environmental impact statement. (The scope and depth of information included within the EIS will usually be related to the magnitude of the project and the potential environmental impact.)

1. Description of the proposed project (including adequate technical data to permit careful assessment of impact):

The applicant will construct and operate a _____ (size) -bushel, oyster depuration facility adjacent to ______________________ (name of waterway). The facility will be located at or above the level expected of minimal tropical storms. (If appropriate:) Bulkheading will be installed along _______ (length) feet of the applicants property; _______ (length) feet of piling and piers will be constructed to permit direct off-loading of oysters for processing (storage and depuration); _______ (length) feet of roadway and ramps will be constructed using shells/clay substrates; unlimited quantities of process water will be removed from ______________________ (name of waterway) and either sterilized and used or stored for future use. The intake line will be supported on a ______________________ (type of construction; wood, etc.), _______ (length) foot pier that extends _______ (distance) foot into ______________ (name of waterway); approximately _______ (amount) gpm of treated (settled and/or chlorinated) or untreated wastewater (containing less than _______ (amount) mg/l of suspended solids, and with a BOD value of _____ mg O_2/l) will be discharged through a _______ (length) ft _____ (size) in diameter, PVC discharge line that extends _______ (distance) ft into ______________________ (name of waterway).

2. Probable impact of the proposed project on the environment:

During construction of the facility and until roadbed and upland fill materials have stabilized some erosion and siltation in the immediate vicinity may occur. Seeding and containment (with bales of hay or straw) will be utilized wherever and whenever appropriate to prevent an impact on adjacent wetlands (salt marshes or water bottoms). Pier and piling construction will have a very minimal effect on the water bottoms and the bulkheading will prevent deterioration of adjacent water bottoms from eroding shore materials. All shore and marsh vegetation will be protected and encouraged to grow and retain its normal productivity and stabilizing characteristics.

During the operation of the facility the discharge of waste process-water is not expected to have any measurable effect on the estuarine environment outside of the immediate vicinity of the discharge terminus. Coastal waters of Mississippi and Alabama abound with productive oyster reefs. The oysters' natural digestive processes do not affect those environments and the small release of oyster fecal waste should not effect other oysters or benthic invertebrates in the area. The additional nutrients may be beneficial to those organisms that utilize oyster wastes and thereby increase the productivity in that area. Sufficient tidal currents exist in the area to insure movement of high DO (dissolved oxygen) water into the area and/or suspended wastes out of the area (except on slack tides). The transportation of oysters to and from the facility may result in insignificant quantities of hydrocarbon residues in the water (from boats) and on the shore (from trucks). Wherever and whenever practical, the facility will utilize solar energy to illuminate the facility, heat process water and the building interior, and treat process wastes (drying). Sufficient insulation will be utilized to reduce energy requirements for cold storage facilities. State-of-the-art, energy-efficient equipment will be installed and utilized wherever practical to reduce energy requirements. Energy utilization by this depuration facility is expected to offset that needed for double-harvesting and transportation required in the presently utilized oyster cleansing method (relaying).

3. Probably adverse environmental effects that cannot be avoided include:
   a. Minimal, short-term erosion and sedimentation in the immediate vicinity of the depuration facility;
   b. Minimal, short-term reduction of water quality (increased BOD and suspended solids levels) in the immediate vicinity of the waste water discharge point.
   c. Minimal loss of benthic organisms that inhabit the substrate where bulkhead and piling structures will exist.
   d. Minimal, short-term effects may be experienced from wood-preservative leachate in the water column immediately adjacent to any bulkhead, pier, or piling structures.

4. Alternatives to the proposed project include:
   a. No action; rely on oyster transplantation (with its increased energy and time requirements and decreased, reharvest efficiencies) rather than onshore depuration.
   b. Limit discharge effluent to federal standards via pretreatment (via settling, chlorination, etc.)
   c. Pretreat process water effluent and discharge into municipal treatment facility if available.

d. Pretreat process waste water and discharge into onsite "septic" tank system if local conditions and zoning restrictions permit such action.

e. Insist on returning water quality to a status that permits a reclassification of "restricted and prohibited" shellfish waters to "approved" (201/208 Regional Sewage Treatment Facilities).

f. Off-bottom, raft or suspension cleansing (form of relaying). (That process is presently being investigated by GCRL personnel.)

5. The relationship(s) between local short-term uses of man's environment and the maintenance of an enhancement of long-term productivity include:

   a. Short-term productivity in the adjacent ecosystem may be reduced initially by construction activities, but that productivity should rapidly return to its original levels.

   b. Long-term productivity may be increased in the vicinity of the discharge point of the treatment of process wastewater is not required.

   c. Long-term productivity of the oyster industry should increase if depuration facilities are available and oyster resources are properly managed.

6. Irreversible and irretrievable commitments of resources which would be involved if the proposed project is implemented include:

   a. None anticipated.

7. Problems and objectives expressed by other federal, state, and local agencies and by private individuals and organizations (may) include:

   a. Zoning variances to permit facility;

b. Reparian right infringements;

c. Objections by adjacent property owners;

d. Health certification by federal and state agencies under the auspices of the National Shellfish Sanitation Program

e. Legal certification by local and state agencies with regulatory authority; and,

f. Economic feasibility (or cost of facility and process to industry and eventually to the consumer.

D. Environmental Monitoring and Assessment.

State and federal regulatory agencies that are responsible for insuring that the depurator complies with the requirements of a National Pollution Discharge Elimination System (NPDES) discharge permit and with the public health aspects of product safety will require certain monitoring and assessment of the depuration operation. Those agencies and their requirements are discussed below.

1. Wastewater Discharge Permit (NPDES)

The Mississippi Bureau of Pollution Control (MBPC) and the Alabama Water Improvement Commission (AWIC) which operate in conjunction with and under the auspices of the US Environmental Protection Agency are responsible for insuring compliance with the terms of the NPDES discharge permit. Paragraphs 35 (page 11) and 36 (page 12) of the MBPC Wastewater Permit Regulation prescribe the monitoring by the regulatory agency and the permittee (depurator).

[35.] Monitoring of Discharges Authorized by Permits: Requirements

[a.] The Permit Board of MBPC may prescribe monitoring requirements of any discharge authorized by a State [Mississippi], UIC, [Underground Injection Control], or NPDES permit issued by it pursuant to this regulation. A State, UIC, or NPDES permit issued pursuant to this regulation may be subject to such monitoring requirements as may be reasonably required by the Permit Board, including the installation, use, and maintenance of monitoring equipment or methods including, were appropriate, biological monitoring methods.

[b.] A discharge authorized by an NPDES permit which the Regional [EPA] Administrator [see Appendix B for address] by written request to the Executive Director [of the MBPC;

see Appendix B for address], requires to be monitored or which contains toxic waste constituents for which an effluent standard or limitation has been established by the Administrator of EPA pursuant to Section 307(a) of the Federal [Water Pollution Control] Act [PL 92-500, U.S.C. 1344], shall be monitored by the permittee for any or all of the following:

(1) The measurement of the discharge in gallons per day or other units required by the Permit Board.

(2) Waste constitutents subject to reduction or elimination under the terms and conditions of the permit.

(3) Specific waste constituents which are determined by the Permit Board to have a significant effect on the quality of the waters of the State.

(4) Waste or wastewater constituents specified as subject to monitoring by the Administrator of the EPA in regulations promulgated pursuant to the Federal Act.

(5) Any other specific waste constituents which the Regional Administrator may request in writing to be monitored.

[c.] The frequency of monitoring of a wast discharge required to be monitored pursuant to the regulation shall be specified in a State, UIC, or NPDES permit when issued, except that the Permit Board at any time may require additional monitoring for purposes of determining compliance by so notifying the permittee in writing.

[36.] Monitoring of Discharges Authorized by Permits: Recording and Reporting

[a.] A permittee required to monitor a waste discharge pursuant to Paragraph 35 shall maintain records of all information obtained from such monitoring, including the date, place and time of sampling; the date analyses were performed; the person performing the analyses; the analytical techniques, procedures or methods used; and the results of such analyses. All records and results of monitoring activities, including calibration and maintenance records, shall be retained by the permittee a minimum of three (3) years unless otherwise required or extended by the Permit Board, copies of which shall be furnished to the Director [of the MBPC] upon request.

[b.] The Permit Board may require a permittee to report periodically the results of all required monitoring activities undertaken by him on an appropriate reporting form supplied by the Permit Board. The Permit Board shall notify the permittee of the frequency of reporting, but in no case shall the reporting frequency be less than once in a period of one (1) year.

[c.] Upon written request of the Regional [EPA] Administrator, the Executive Director [of the Mississippi Department of Natural Resources] shall transmit thereto any reporting form or other monitoring information required by the regulation.

[d.] Any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or methods required by the Permit Board to be maintained as a condition in a permit, or who alters or falsifies the results obtained by such devices or methods, shall be deemed to have violated a permit condition and shall be subject to the penalities provided for a violation of a permit condition to Section 49-17-43 of the [Mississippi] Code [of 1972].

[e.] The permittee shall report any instances of noncompliance orally to the Director [of the MBPC], or his representative, within 24 hours of becoming aware of the circumstances. A written report shall also be provided within five (5) days of such time, and shall contain the following information: 1) a description of the noncompliance and its cause, if known, and 2) the period of noncompliance, including exact dates and times; or if not corrected, the anticipated time the noncompliance is expected to continue, and steps being taken to reduce, eliminate, and prevent recurrence of the noncomplying discharge. [Requirements for monitoring wastewater discharges in Alabama would be essentially the same since the AWIC operates under the same EPA statutory authority as does the MBPC.]

2. National Shellfish Sanitation Program (NSSP)

The Alabama and Mississippi State Boards of Health, which operate cooperatively with the US Food and Drug Administration, are responsible for implementing the State/Federal National Shellfish Sanitation Program. Under that program the State Boards of Health are responsible for monitoring depuration plant operations and/or assessing the records of said plants. Section D(2) [Controlled Purification] of Public Health Service Publication No. 33, Part I: Sanitation of Shellfish Growing Areas stipulates that the following environmental factors shall be monitored to insure compliance with said regulations:

a. Bacteriological, chemical, and physical quality of

(1) Depuration process water, and

(2) Harvest area water; and,

b. Bacteriological quality of each lot of shellfish

(1) after depuration.

Furfari (1966) expanded those regulations in his depuration guidelines. He recommended the following minimum sampling procedures to insure effective depuration:

c. Sea Water Sampling

(1) Raw process water (test/frequency)

(a) Temperature, turbidity, and salinity (daily),

(b) Total and fecal coliform (weekly).

(2) Treated process water (from UV units)

(a) Coliform (2/day with one UV unit; 1/day/UV unit if multiple units utilized).

(3) Process water in or from depuration tanks (effluent)

(a) Dissolved oxygen and coliform (daily/tank).

(4) Harvest area waters

(a) Temperature, salinity, pH, and coliform counts (at least 15 samples during course of harvest season).

d. Shellfish Sampling

Shellfish from each harvest area should be sampled from randomized harvestor's lots as follows:

(1) Sampling Time

(a) As delivered to plant,

(b) At beginning of process (depuration) if storage exceeds 24 hours,

(c) At 24 hours of depuration,

(d) At 48 hours of depuration,

(e) At 72 hours, if necessitated by choice of 3-day depuration, and,

(f) In storage, if storage time after depuration exceeds 24 hours (recommended).

(2) Tests

(a) Fecal coliform MPN/100 ml

3. Provisional Oyster Depuration Regulations (Mississippi-Alabama)

The operation of all depuration plants are under the administrative control of the state shellfish control agency (e.g., Mississippi State Board of Health; Alabama State Board of Health). Depuration plants may be operated by private and commercial enterprises; however, insofar as the National Shellfish Sanitation Program is concerned, the State Board of Health is responsible for satisfactory operation (Section D, 2, g, PHS Publ. 33 Part I Revised 1965 [Paraphrased]).

Neither the Mississippi nor Alabama State Boards of Health presently have (in house) regulations that govern depuration since no purification operations were anticipated prior to this time. Now that those operations may become necessary or economically feasible in the future, some regulations may be desirable or required under the auspices of the NSSP. Although the author of this report was not required to formulate those regulations, he would be remiss in his duty as an interested shellfish biologist if he failed to suggest appropriate guidelines that should be included in future regulations.

To that end, oyster depuration quality and monitoring guidelines are proposed in Appendix D (based in part on Furfari, 1966).

4. Miscellaneous Agency Participation

In addition to the state shellfish control agencies (State Boards of Health), other agencies within a given state may wish to monitor all or certain aspects of the depuration process for research and development purposes. In Mississippi and Alabama, those agencies include, but should not be limited to the following:

a. Research Laboratories (with shellfish research programs)
   - (1) Mississippi
     - (a) Gulf Coast Research Laboratory, Ocean Springs
     - (b) National Marine Fisheries Service Laboratory, Pascagoula.
   - (2) Alabama
     - (a) Department of Conservation and Natural Resources, Dauphin Island
     - (b) USFDA Shellfish Laboratory, Dauphin Island
     - (c) Dauphin Island Sea Lab.

b. Shellfish Regulatory Management Agencies
   - (1) Mississippi
     - (a) Department of Wildlife Conservation, Bureau of Marine Resources, Long Beach
   - (2) Alabama
     - (a) Department of Conservation and Natural Resources, Dauphin Island.

c. Research and Development Agencies
   - (1) Mississippi
     - (a) R & D Center, Jackson.

Those agencies should be advised of any potential depuration operations in their respective states. They should be invited to inspect the facilities and/or participate in preliminary planning in order to prevent unnecessary modifications after the facility is built and in operation. All of those agencies are required to assist public and private shellfish interests with regulatory and management problems and as such should be consulted by the potential depurator.

APPENDIX D

Provisional Oyster Depuration Regulations

A. Bacteriological Quality and Monitoring

1. Source Process Water Quality

a. Coliform (MPN/100 ml): Median of samples shall be equal to or less than 700. (Not more than 10% of the samples shall exceed 2,300 for a 5-tube, 3-dilution test; and 3,300 for a 3-tube, 3-dilution test.)

b. Monitoring (frequency): Coliform and fecal coliform MPN tests shall be conducted once a week unless local meterological phenomena (precipitation and flooding) or malfunction of nearby domestic waste disposal facilities occur.

c. Records: Results of bacteriological tests shall be recorded and transmitted to the appropriate state shellfish control agency upon request or at 30-day intervals throughout the depuration season.

2. Treated Process Water (from sterilizer device)

a. Quality: The maximum allowable coliform content of process water contacting system shall be 1 MPN/100 ml.

b. Monitoring (frequency): Coliform tests shall be conducted once each day for each sterilizing device (UV or ozone) if multiple devices are utilized and twice each day if only one sterilizing device is utilized.

c. Records: Results of bacteriological analyses shall be recorded and transmitted to the appropriate state shellfish control agency upon request or at 30-day intervals throughout the depuration season. Records shall be available for in-plant inspection at all times.

3. Depurated Oysters

a. Quality: The bacteriological quality of depurated oysters shall be less than 50 MPN (fecal coliforms) per 100-g sample of oyster tissue. Three 200-g samples shall be analyzed from each group of depurated oysters.

b. Monitoring (frequency): Tissues from oysters undergoing depuration shall be tested for fecal coliforms MPN/100 g and E.C. gas-positive MPN/100 g (in accordance with APHA standards) at the following intervals:

(1) as delivered to depuration plant,

(2) at begining of depuration if storage exceeds 24 hours,

(3) at 24 hours of depuration,

(4) at 48 hours of depuration,

(5) at 72 hours (if necessitated by choice of allowing 3-day depuration), and

(6) in storage, if storage time after depuration exceeds 24 hours (recommended).

c. Records: Results of bacteriological analyses shall be recorded and transmitted to the appropriate state shellfish control agency upon request or at 30-day intervals throughout the depuration season. Tests results shall be recorded on the identification tag affixed to each container of depurated oysters.

B. Chemical Quality and Monitoring of Depuration Water

1. pH: The hydrogen ion concentration of the incoming process water shall be determined and recorded once each day and shall not exceed a range of 7.0 to 8.4.

2. Salinity: The salinity of the incoming process water shall be determined and recorded once each day and shall not exceed 100±20% of the salinity in the harvest area.

3. Oxygen: The amount of dissolved O_2 in the process water shall be determined and recorded once each day and shall not exceed a range of 5.0 mg/l to saturation at the ambient temperature.

4. Metallic Ions and Compounds: Potentially toxic metals shall not be in concentrations above that found in natural sea water. Appropriate analyses shall be conducted prior to the beginning of each depuration season and at 30-day intervals thereafter unless flooding and/or industrial spills in tributaries or adjacent water bodies warrant immediate action. In such an event, analyses shall be conducted daily until the pollution or threat thereof abates.

5. Organics and Radioisotopes: Pesticides, detergents, dye stuffs, radioisotopes, and marine toxins shall not be in concentrations in water above that which can cause concentrations in oysters which are unacceptable by the regulations of the US Food and Drug Adminstration. Appropriate analyses shall be conducted prior to the beginning of each depuration season and at 30-day intervals thereafter unless flooding and/or industrial spills in tributaries or adjacent water bodies warrent immediate action. In such an event, analyses shall be conducted daily until the pollution or threat thereof abates.

6. Records: Results of chemical analyses shall be recorded, maintained for inspection, or transmitted to the appropriate state shellfish control agency upon request.