



**Mississippi
Department of
Marine Resources**

**Artificial Reef Development Plan
For The
State Of Mississippi**

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Artificial Reef Development Zones



- Zone 1
- Zone 2
- Zone 3



Zone 4 --Federal water not illustrated.
Please refer to Chapter 6 for
Reef development criteria
For Planning Purposes Only
Based on USGS 1:100,000
topographic map.

Artificial Reef Development Plan

This document is an authorized release of The Department of Marine Resources, and was prepared by Mr. Ron Lukens of LUCON Company through Tidelands Trust Fund Project FY97-37.

This document has been prepared in accordance with State Laws 49-15-15, Jurisdiction and Authority, and 49-15-17 Seafood Fund and Artificial Reef Program Account.

The effective date of this Plan is 1 November 1999. It will be reviewed and updated annually or as significant changes occur in the scope and management of the Artificial Reef Development Plan.



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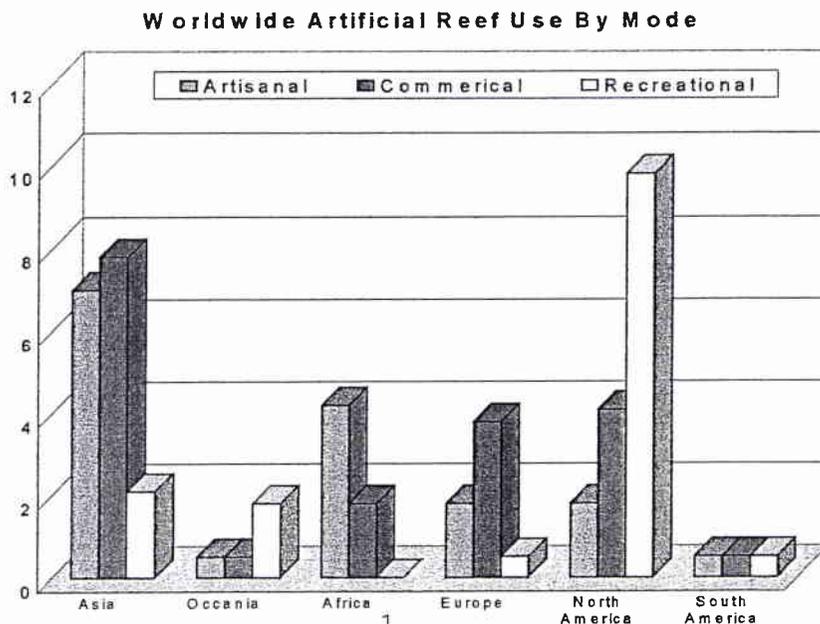
CHAPTER 1

INTRODUCTION

Worldwide Use of Artificial Reefs

The use of artificial reefs to enhance the capability to harvest fish is not unique to the United States. Artificial reefs have been used for centuries by many countries of the world. Very early efforts at harvesting fish using artificial reefs relied upon the use of natural substances such as palm fronds and other branches and brush material. These materials were used as fish attraction devices (FADs), which are materials floating at the surface or suspended in the water column. FADs are still used today in many parts of the world. The success of using artificial materials in the water to attract fish and enhance harvest capability has been widely acknowledged, and has resulted in major government programs designed to assist in the efforts to improve the technology and application of artificial reefs. Perhaps the most aggressive national program was begun by Japan over sixty years ago, spending billions of yen annually (Yamane 1989).

Worldwide there are three broad applications of artificial reefs used to harvest fisheries species. Perhaps the oldest is artisanal use. Artisanal use of artificial reefs is characterized by low cost, easily deployed structures of natural material, the harvest from which is used for family and local community (village) subsistence. Many countries, Japan in great measure, have developed artificial reef programs aimed at producing fish for the commercial market. Finally, artificial reefs are developed in many areas for recreational purposes such as angling and diving. Figure 1 shows the relative uses, based on the above three categories, of artificial reefs worldwide. The figure is an adaptation of data provided by Seaman and Sprague (1991) which is the result of a review of world literature on artificial habitats for fisheries and reliance upon the observations of knowledgeable persons.



A quick glance at Figure 1 reveals that, worldwide, the United States has the greatest recreational emphasis on artificial reef development. The overwhelming emphasis in other areas of the world is on artisanal and commercial applications.

Use of Artificial Reefs in the United States

Artificial reefs have been used to enhance fishing success in the United States for over a century. The first documented artificial reef in the United States was off South Carolina in the 1830s using log huts (McGurrin et al. 1989). From that time to the present, the vast majority of artificial reefs developed (over 80%) has utilized materials of opportunity. Materials of opportunity include such natural materials as rock, shell, or trees, and such man-made materials as concrete, ships, barges, and mineral producing structures, among others. Most early artificial reef development efforts were accomplished by volunteer groups interested in increasing fishing success. It was widely held that artificial reefs were successful; consequently, deployment of materials took a higher priority to other activities such as planning, research, and experimentation with various materials, including designed structures (Bohnsack 1987).

Summarizing from McGurrin et al. (1989), artificial reef development in the United States began in earnest in the early 1900s. New Jersey, in 1935, established a rather large-scale artificial reef using four ships and tons of concrete. This artificial reef was considered to be a success, providing economic benefits to the state and spawning artificial reef development in other locations. In the 1950s, artificial reef development continued; however, during the mid 1950s through the 1960s, increased publicity of the success of artificial reef development activities increased the visibility of such activities. This increased focus on artificial reef building brought about increased scrutiny of those activities, and revealed that many efforts to build artificial reefs were poorly planned and poorly executed. Communication among reef builders was sporadic, resulting in repetition of mistakes. Also during this period, research on artificial reefs began to appear. From late 1960 through the mid 1970s, an artificial reef research program was conducted by the federal government through the National Marine Fisheries Service (NMFS). As the decade of the 1980s began, a heightened awareness of the status of our natural resources brought an increased interest in artificial reef technology, both from a concern over negative impacts to those resources and the potential to enhance those resources through habitat development.

The National Fishing Enhancement Act of 1984 (Act) called for the development of a national plan to provide guidance to those individuals and agencies interested in artificial reef development and management. The NMFS was charged with developing the National Artificial Reef Plan (National Plan), which was a combined effort of fishermen, divers, conservation groups, scientists, and state and federal fishery agencies (Stone 1985). The National Plan states that "... properly designed, constructed, and located artificial reefs ... can enhance the habitat and diversity of fishery resources; enhance United States recreational and commercial fishing opportunities; increase the production of fishery products in the United States; increase the energy efficiency of recreational and commercial fisheries; and contribute to the United States and coastal economies." With this emphasis on the need for a more

comprehensive approach to artificial reef development and use, the need for increased planning became evident. The National Plan provides a template for planning in a broad sense; however, the unique nature of the various geographic and political boundaries requires planning at a more local level. Currently in the Gulf of Mexico region, the States of Texas, Louisiana, and Florida have comprehensive state artificial reef plans, while the State of Alabama has well-developed plans for permitting and inspection for deployment of materials. Additionally, many states along the Atlantic and Pacific coasts have now adopted state artificial reef plans.

Gulf of Mexico Artificial Reef Development

This section generously summarizes the text of the Gulf States Marine Fisheries Commission publication entitled "A profile of artificial reef development in the Gulf of Mexico (GSMFC 1993)." The contributing authors are as follows: Alabama, Mr. Walter Tatum; Florida, Virginia Vail; Louisiana, Rick Kasprzak; and Texas, Hal Osburn and Jan Culbertson.

Alabama

The Marine Resources Division of the Alabama Department of Conservation and Natural Resources has been involved in artificial reef construction since 1953, and was the first state agency in the Nation to establish an artificial reef program. The first project was conducted at the request of the Orange Beach Charter Boat Association, resulting in the placement of 250 automobile bodies in water depths of 60 to 90 feet off Baldwin County. This is reported to represent the first intentionally constructed artificial reef in the Gulf of Mexico. Following this first successful effort, the Department, in 1957, constructed a series of artificial reefs throughout the waters off Baldwin and Mobile Counties. The State of Alabama was integrally involved in establishing the federal legislation that made retired Liberty ships available to coastal states for artificial reef development. Other materials used offshore Alabama include an old dry dock and concrete rubble.

The State of Alabama was the first to establish general permit sites in its offshore waters. The general permits are held by the Alabama Department of Conservation and Natural Resources and are available to anyone who would like to place artificial reef materials on the bottom. There is a comprehensive permitting and materials inspection program that oversees who puts materials out and the kind and condition of materials deployed. The Alabama General Permit Areas represent an action that was forced into effect by enforcement of existing laws. It also required that competing resource interests work together for mutual benefit, and made the Association and other reef builders recognize the common property nature of artificial reefs when built in public waters. During 1994 and 1995, the State of Alabama participated in a military operation known as REEF-EX, which is a program to make obsolete military hardware, primarily M48 and M60 battle tanks, available as artificial reef material. As of this writing, over 100 tanks have been deployed in Alabama's General Permit Areas.

Florida

Florida leads the nation in both the total number and annual development/replenishment rate of marine artificial fishing reefs. According to available data, development of artificial fishing reefs in Florida has been occurring for at least 70 years. After a slow beginning, spanning several decades, the rate of artificial reef development has increased dramatically during recent years. Permitted reef sites vary in size from a quarter mile diameter to well over one square mile.

The prolific development of artificial reefs in Florida has been highly decentralized, typically built through the coordinated efforts of a county or city governmental unit (as the permit holder and project manager) and private citizens. Materials deployed are typically "materials of opportunity," especially concrete rubble (e.g., culverts, junction boxes, slabs, bridges), scrap steel, and vessels/barges. During 1994 and 1995, the State of Florida participated in a military operation known as REEF-EX, which is a program to make obsolete military hardware, primarily M48 and M60 battle tanks, available as artificial reef material. As of this writing, nearly 100 tanks have been deployed in various areas offshore Florida in the Gulf of Mexico.

Communications among local program managers, volunteer groups, state program officials, state and federal regulatory agency staff are enhanced through periodic conferences and workshops hosted by Florida Sea Grant, volunteer groups, or the Florida Department of Environmental Protection. Such gatherings, which address specific current reef issues or management needs, are eagerly anticipated and well attended.

Louisiana

The development of the mineral producing industry in the Gulf of Mexico resulted in the creation of this country's most extensive artificial reef system. Currently, over 75% of all recreational fishing trips originating in Louisiana are destined for one or more of these structures. Approximately 470 of these structures are estimated to have been removed from coastal Louisiana, and by the year 2000, over 40% of the remaining mineral producing structures in the Gulf of Mexico could be removed. This would represent a major loss to Louisiana fishermen. Louisiana recognized the potential loss of habitat and developed a plan to offset it by either creating new artificial reefs or preserving existing structures.

The Louisiana Fishing Enhancement Act (Act 100) became law during the 1986 regular legislative session. The Louisiana Artificial Reef Plan contains the rationale and guidelines for implementation and maintenance of a state artificial reef program, and established the Louisiana Artificial Reef Council (LARC). The LARC consists of the Secretary of Wildlife and Fisheries, who is responsible for administration of the program, along with the Dean of the Center for Wetlands Resources, and the Director of the Louisiana Geological Survey at Louisiana State University, which provides technical support. Louisiana has also developed an inshore program, or Phase II, of the Louisiana Artificial Reef Plan.

Texas

The Texas Parks and Wildlife Department has been involved in artificial reef development since the 1940s. Major programs have included the development of oyster reefs and transplanting oyster spat in Texas Bays from 1947-1989. Tire reefs were also placed in bay systems between 1966-1977 without success. Cars and concrete structures (culverts and pre-fabricated forms) were placed offshore at several near shore locations between 1950-1970s. However, it was not until the Texas Coastal and Marine Council was able to take advantage of Public Law 92-402, that 12 Liberty Ships were transferred to the state and placed at five strategic offshore locations. These ships represented the first successful offshore artificial reef off the coast of Texas.

In response to the National Fishing Enhancement Act of 1984, the Texas Legislature passed the Artificial Reef Act of 1989. This Act directed the Texas Parks and Wildlife Department to promote, develop, maintain, monitor and enhance the artificial reef potential in state waters and federal waters adjacent to Texas. To fulfill these purposes the Department was directed to develop a State Artificial Reef Plan with the goals of enhancing fishery resources and increasing fishing and diving opportunities in such a manner as to minimize conflicts among competing user groups and also reduce environmental risks.

The Department adopted the "Texas Artificial Reef Plan" (Texas Plan) in 1990, which was modeled after the guidelines established in the National Plan. The Department also created a program within the Coastal Fisheries Branch to administer the goals of the Texas Plan. Under the auspices of the Plan, an Artificial Reef Advisory Committee was also established. This Committee is composed of 10 citizens representing every user group in the Gulf of Mexico to advise and make recommendations to the Department on details and specifications of the Texas Plan.

Since 1989, to fulfill their goals of preserving or enhancing the artificial reef habitat potential off the coast of Texas, the Department has accepted the donation of mineral producing platforms either toppled in place, mechanically cut in place or towed to existing reef sites. In 1992, the Department obtained a General Permit to develop a 2500 square mile area offshore of High Island. In 1995, with cooperation from other federal agencies including the Minerals Management Service, the Department accepted the first partially mechanically removed platform in the Gulf of Mexico. The top 85-ft. of structure was severed and placed on the bottom next to the standing remains of the platform base, still attached to the sea floor. This type of placement operation allows for the maximum biological profile in the water column at deep water reef sites and still maintains safe navigational clearance over the reef profile. Another benefit of this type of donation is that it has the least impact to the existing reef habitat and the fishery resource.

Artificial Reef Development in Mississippi

The first known efforts at artificial reef construction off Mississippi took place in the 1960s, with the deployment of automobile bodies in offshore waters. It was not until 1972 that

concerted efforts were again undertaken to construct artificial reefs offshore Mississippi. These efforts were in response to Public Law 92-402 which made World War II Liberty ships available from the National Defense Reserve Fleet for the creation of artificial reefs in coastal environments. The State of Mississippi received five of the derelict vessels and, through a coordinated effort between the then-Mississippi Marine Conservation Commission and the Mississippi Gulf Fishing Banks, Inc. (MGFB), a local, non-profit fishermen's organization, sunk the scrapped hulls on two permitted sites offshore Horn Island. Following completion of the sinking of the five Liberty ship hulls in 1978, the permits for the two artificial reef sites were transferred to the MGFB. Since that time, the MGFB has acquired eight (8) additional permits on which materials have been deployed, ranging from clamshell to derelict barges to concrete housing units to an old tugboat. In addition to those eleven (11) sites, the Mississippi Department of Marine Resources (MDMR) holds permits for twenty-one (21) nearshore, low profile sites on which clam or oyster shells have been placed, primarily in conjunction with fishing piers or bridges.

From 1975 through 1978, Lukens (1980) conducted a series of fish observations on one of the Liberty ship artificial reefs in conjunction with research for a Master of Science degree, constituting the first attempt at monitoring and evaluation of the artificial reefs offshore Mississippi. That work was accomplished through a cooperative project involving the Mississippi-Alabama Sea Grant Consortium, the Dauphin Island Sea Lab, and the Gulf Coast Research Laboratory. In 1985, the Mississippi Sea Grant Advisory Service (Lukens and Cirino 1985 and 1986) entered into a cooperative program with the MGFB to establish a monitoring program to be implemented by the MGFB which focused on the physical aspects of the artificial reef material. Since that time the MGFB has continued to monitor the physical parameters of Mississippi's artificial reefs. In 1988, the Gulf States Marine Fisheries Commission established a working subcommittee to address significant recreational fisheries issues. Their first action was to implement a project to compare in situ physical monitoring of artificial reef materials with the use of side-scan sonar technology. The investigations were conducted on the artificial reefs off Mississippi (Lukens et al. 1989).

There are a total of 2100 acres of permitted artificial reef area off Mississippi's coast. The permits and responsibility for maintenance of those sites rests with the MGFB. While a number of investigative efforts have been conducted and are ongoing, there has never been a comprehensive plan developed to provide guidance for such issues as monitoring for effectiveness, siting, materials criteria, assessment of need, enhancement of existing sites, among other issues.

Federal Involvement In Artificial Reef Activities

National Marine Fisheries Service

Federal involvement in artificial reef research and development began in earnest around 1966 with the initiation of a formal research program at the U.S. Bureau of Sport Fisheries and Wildlife's Sandy Hook, New Jersey Laboratory. Original research objectives included evaluations of existing reefs to determine their efficacy, construction of a series of new reefs to

evaluate building materials, development of engineering techniques, assessment of biomass impacts, and general evaluation of artificial reefs as fishery management tools. A series of ten reefs was built and studied along the Atlantic coast, but the most successful study sites were in South Carolina and Florida offshore waters. When the U.S. Department of the Interior's Bureau of Commercial Fisheries and Marine Game Fish Program was combined in 1970 to form the National Marine Fisheries Service (NMFS) within the U.S. Department of Commerce's National Oceanic and Atmospheric Administration, this research program was continued by the NMFS to its completion around 1973.

From the mid-1970s forward, the NMFS took on more of a supporting role, assisting the states, counties, and private interests in their artificial reef activities. Many contributions were made in the form of technical and financial assistance regarding artificial reef planning, design, permitting, construction, monitoring, and evaluation. Specific examples include:

- funding and sponsorship of numerous local, regional, and international artificial reef conferences,
- securing and improving access to surplus federal properties for reef construction, such as Liberty ships and other vessels,
- funding and technical support of artificial reef research involving:
 - translation, transfer, and application of Japanese artificial reef research findings
 - deployment and evaluation of Japanese and other prefabricated reef construction modules, including fish attraction devices
 - development of artificial reef planning protocols and siting plans
 - development and testing of research and monitoring methodologies
 - development of a National Artificial Reef Development Center and data base (housed by the Sport Fishing Institute)
 - development of strategies, tactics, and methods for overcoming artificial reef development constraints involving permitting, maintenance, liability concerns, transportation costs, and economic assessment methods
- development and implementation of streamlined federal and state permitting procedures (joint applications and general permits).

Perhaps one of the more significant contributions of the NMFS has been the development and publication of the National Plan (Stone 1985). This plan was produced pursuant to the National Fishing Enhancement Act of 1984 (P.L. 98-623, Title II) to promote and facilitate responsible and effective artificial reef use based on the best available scientific information. Notably, the National Plan describes the roles of government and private organizations in artificial reef development and provides guidelines regarding artificial reef siting, construction materials and methods, reef design, regulatory requirements, reef management, and liability.

Most importantly, the National Plan encourages and promotes the development of more specific state and local reef siting and management plans.

Since 1985, the NMFS has continued to actively support regional, state, and local artificial reef development programs through technical consultations, research funding assistance, and participation as members of regional artificial reef management committees established and supported by interstate marine fisheries commissions.

U.S. Fish and Wildlife Service

The primary involvement of the U.S. Fish and Wildlife Service (Service) in artificial reef work is through the Federal Aid in Sport Fish Restoration (Federal Aid) Program which provides funding to the states for important recreational fisheries work. Each coastal state in Region 4 of the Service (NC, SC, GA, FL, AL, MS, and LA), and Texas from Region 2 use Federal Aid funding to develop and maintain artificial reefs and provide access to them according to the relative configuration of its respective portion of the continental shelf. These artificial reefs have been historically used to attract, concentrate, and exploit desirable fisheries species. Under U.S. Army Corps of Engineers and/or U.S. Coast Guard permits, the states perform planning and development activities including assessment of appropriate development materials and locations, and transportation and deployment practices. Maintenance activities include monitoring reef effectiveness and stability as well as informing the public about artificial reef locations through buoy systems, reference charts, and information booklets. Some states have used Federal Aid funds to develop strategic plans and policies for using artificial reefs as fishery management tools. Through the establishment of standards and guidelines for use of Federal Aid funds for artificial reef work, the Service plays an important role in the quality and direction of current and future activities.

U.S. Army Corps of Engineers

The Corps of Engineers (COE) Permits and Evaluation Branch regulates all construction operations in U.S. waters, including artificial reef construction. The COE receives its regulatory authority from several congressional directives including the Rivers and Harbors Act of 1899, the Outer Continental Shelf Lands Act of 1953, the National Environmental Policy Act of 1969, the Clean Water Act of 1972, and the Marine Protection Research and Sanctuaries Act of 1972 (Ocean Dumping Act).

Section 10 of the Rivers and Harbors Act (33 U.S.C. 403) empowers the COE to prohibit the alteration or obstruction of navigable waters of the United States. This authority was extended to include construction of artificial reefs and fixed structures located on the continental shelf (beyond territorial seas) by Section 4 of the Outer Continental Shelf Lands Act (43 U.S.C. 1333). Under the authority of these two Acts, the COE is required to evaluate any navigational issues which may impact the navigable waters of the United States within the territorial seas and beyond the territorial seas on the outer continental shelf before issuing a permit. Under the provisions set forth by the National Environmental Policy Act, the COE is also required to assess the potential environmental impact of artificial reef projects before issuing a permit.

The COE is also empowered by Section 404 of the Clean Water Act (33 U.S. C. 1344) to prohibit the discharge of dredged or fill material into the waters of the United States without first obtaining a permit. In addition, Section 103 of the Marine Protection Research and Dumping Act prohibits the transportation of dredged materials for the purposes of oceanic dumping, unless authorized by a COE permit. However, construction of fishing reefs are specifically excluded from these regulations provided the nature of the materials used to construct the reef are regulated by an appropriate state or federal agency. An important function of the COE under the jurisdiction of these two Acts is to require an inspection of the materials prior to placement to certify them free of toxic materials and pollutants. Comprehensive discussions of permit requirements for artificial reef development in Mississippi and adjacent federal waters is found later in this document.

Minerals Management Service

In January 1983, the Minerals Management Service (MMS) of the U.S. Department of the Interior (USDO I) announced its support for the concept of the conversion of selected obsolete mineral producing structures to artificial reefs (Rigs-to-Reefs) to enhance recreational and fishing opportunities. Subsequently, actions were undertaken within the USDO I and MMS to promote the development of artificial reefs. The USDO I, for example, formed the Recreational and Environmental Enhancement for Fishing in the Seas Task Force composed of representatives from the federal, state, and private sectors to promote an artificial reef program at the national level. This Task Force motivated agencies and organizations to begin planned and organized development of artificial reefs. Such actions were instrumental in the enactment of the National Fishing Enhancement Act of 1984 (P.L. 98-623, Title II) which established national standards for construction of artificial reefs. Formally adopted as federal policy by the MMS in 1985, Rigs-to-Reefs has become an important component and integral part of state artificial reef programs. Working in cooperation with the Gulf of Mexico Program of the U.S. Environmental Protection Agency, the COE, and the petroleum industry operating in the Gulf of Mexico, the MMS has and continues to support the conversion of offshore petroleum structures and other feasible and environmentally compatible materials into artificial reefs in state artificial reef planning areas.

U.S. Coast Guard

The U.S. Coast Guard (USCG) is responsible for ensuring aids to navigation are established and maintained for all navigable waters of the United States. Aids to navigation include any device external to a vessel or aircraft intended to assist a navigator in determining his/her position or safe course, or designed to warn him/her of dangers or obstructions to navigation. The USCG's authority is provided in Title 14 U.S.C. Section 81-87 and 43 U.C. C. Section 1333 for regulation of the proper marking of obstructions to protect maritime navigation, commerce and the armed forces (Burgess 1974, Christian 1984, Ditton and Burke 1985). By law, the permit holder, lease holder or owner of an obstruction is held liable for the cost of marking the obstruction with an appropriate aid to navigation (Stone 1985).

Environmental Protection Agency

The Environmental Protection Agency (EPA), as mandated under Section 1412 of the Marine Protection, Research, and Sanctuaries Act (MPRSA), is responsible for regulation of the dumping of materials in the waters of the United States. In addition, the EPA must ensure compliance with Sections 402 and 404 of the Clean Water Act (Stone 1985).

Although the regional ocean dumping coordinator for the EPA has the authority to require a permit for artificial reef construction, the general policy has been to act as a review agency for the U.S. Army Corps of Engineers artificial reef permits, provided the project is intended for fishery enhancement, and the construction materials are not in violation of water quality standards. Since the COE permit applications are routinely reviewed by the EPA (Christian, 1984), it is assumed that any negative comments generated by the EPA would be forwarded to the applicant.

Coastal Zone Management (CZM) Act Programs

Under the Coastal Zone Management (CZM) Act, states receive federal assistance grants to maintain federally approved planning programs for enhancing, protecting and utilizing coastal resources. These are state programs, but the act requires that federal activities must be consistent with the respective states' CZM programs. Depending upon the individual state's program, the Act provides the opportunity for considerable input into artificial reef development within state jurisdictional waters.

Under the CZM program, states are encouraged to develop coastal zone management programs that establish unified policies, criteria, and standards for dealing with land and water use issues in their coastal zone, an area that includes the states' territorial sea. Approved CZM programs are thus capable of directing activities away from areas possessing particularly sensitive resources. Thus, criteria for CZM programs can, in part, be used to establish requirements for permitting artificial reef activities.

CHAPTER 2

GUIDING PRINCIPLES, GOAL, AND OBJECTIVES

Guiding Principles

The National Plan has provided broad guidance regarding concerns and issues to be addressed during planning, either at large geographical levels or for an individual artificial reef construction project. The following items are incorporated as broad guiding principles regarding artificial reef development and management activities for the State of Mississippi.

- 1) Enhance fishery resources to the maximum extent practicable;
- 2) Facilitate access and utilization by Mississippi recreational and commercial fishermen;
- 3) Minimize conflicts among competing uses of waters covered under the Mississippi Artificial Reef Plan and the resources in such waters;
- 4) Minimize environmental risks and risks to personal health and property; and
- 5) Be consistent with the generally accepted principles of international law and not create any unreasonable obstruction to navigation.

Specific planning, research, and data collection items and activities that should be considered in planning for artificial reef activities are listed below, and are a subset of the guiding principles above.

- 1) Geographic, hydrographic, geologic, biological, ecological, social, economic, and other criteria for siting artificial reefs;
- 2) Design, material, and other criteria for constructing artificial reefs;
- 3) Mechanisms and methodologies for monitoring the compliance of artificial reefs with the requirements of permits;
- 4) Mechanisms and methodologies for managing the use of artificial reefs;
- 5) A synopsis of existing information on artificial reefs and needs for further research on artificial reef technology and management strategies.

Goal

Virtually all early efforts at development of artificial reefs, through the mid 1980s and to some extent currently, focused on increasing and enhancing access to fish by creating known locations where fish would likely be found. While this is certainly an expected benefit of a successful artificial reef program, it should not be the driving force. Therefore, the goal of this artificial reef plan is to:

Establish guidelines and recommendations for planning, siting, constructing, and evaluating artificial reefs in all waters under the jurisdiction of the State of Mississippi and adjacent federal waters for the purpose of creating and enhancing habitat for fish and invertebrate species to assist in their overall conservation and management.

Objectives

The objectives of this artificial reef plan, under the overall goal of habitat creation and enhancement are as follows:

- **To support and enhance populations of important fish and invertebrate species associated with artificial reefs that are typically exploited by recreational and commercial fishing activities**
- **To enhance recreational and commercial fishing opportunities and success**
- **To enhance recreational diving opportunities**
- **To prohibit illegal ocean dumping under the guise of artificial reef development**
- **To reduce or eliminate user conflicts**
- **To promote the use of artificial reefs as fishery management tools**
- **To avoid risks to the environment and personal health**
- **To adhere to existing international, federal, state, and local laws affecting maritime activities**

Discussion of Objectives

1. *To support and enhance populations of important fish and invertebrate species associated with artificial reefs that are typically exploited by recreational and commercial fishing activities*

Fish and invertebrate species associate themselves with different habitats for a variety of reasons. Principals among these reasons are shelter and food. Some species are highly specialized, and require coral reef or reef-like habitats for survival. These reef dependent species, such as snappers, groupers, triggerfish, grunts, pinfish, and others, exhibit thigmotaxis, which is defined as the association with objects in water for the purpose of feel or touch. In other words, these species are genetically or otherwise predisposed to associate with irregular features in the water, whether they are naturally occurring coral reefs, geologic structures, or man-made artificial reefs. Further, in the absence of these reef or reef-like habitats, reef dependent species will not regularly occur. The establishment of artificial reefs in areas offshore Mississippi, where natural reefs or bottom irregularities do not occur, provides essential habitat for reef associated species, and establishes populations of species that would not normally occur in those waters. The coastal waters offshore Mississippi constitute a large area that is typically devoid of bottom irregularities or reef-like habitats. The addition of artificial reefs in this area has created populations of fish species that would not normally be present, and in doing so, has created a reef fish fishery.

Other species use artificial reefs as one of many habitat types that are important to their survival. For example, red drum, spotted seatrout, white trout, flounder, among other estuarine associated species, use a variety of habitat types during their life cycle. These include oyster reefs, emergent and submerged grass beds, mud flats, and natural and man-made depth breaks (such as a shipping channel). The addition of artificial reefs in nearshore and estuarine areas provides the benefits of one or more of the naturally occurring habitats; however, the species described will occur in the area whether or not artificial reefs are established. Such reefs do not constitute a requirement for occurrence or survival. In the event of loss of one or more of the above-described estuarine habitat components, artificial reefs could be used to mitigate that loss and provide the needed habitat parameters for enhancement of estuarine species.

The following is an excerpt from a document developed by the Gulf States Marine Fisheries Commission (in preparation) describing the relationship of various species of fish with artificial reefs in estuarine and offshore waters. This discussion is provided in an effort to clarify expectations regarding artificial reef development in a variety of locations and environmental conditions.

"The occurrence of certain species of fish in a given area is largely attributable to the existence of factors on which the species depends for survival. Among factors of importance for estuarine and marine species are the presence or absence of topographic relief, temperature, salinity, food availability, and tidal or current movement. It is important to know the species of fish that normally inhabit an area, and the prevailing environmental factors of an area, prior to developing artificial reefs, because these will to a large extent dictate the species of fish that will likely be attracted to or found associated with an artificial reef. Also, it is important, in attempting to enhance the occurrence or abundance of fish species in any given area, to know the limiting factors. Those factors will also dictate to great extent what species of fish will be attracted to and flourish on an artificial reef.

Generally, artificial reef development has been greatest in areas that are largely devoid of irregular bottom topography. A large portion of the continental shelf of the northern Gulf of Mexico is gently sloping with a seemingly barren mud or sand bottom (Stone et al. 1974). These vast expanses of flat, featureless bottoms provide an excellent backdrop for the application of artificial reefs to alter/enhance the environment, thereby providing habitat for a variety of species. If, however, the area in question is an estuary, probably the most limiting factors for the occurrence or lack of occurrence of particular species are temperature and salinity. Typical species which inhabit low salinity, relatively shallow estuarine areas include spotted seatrout, red drum, flounder, Atlantic croaker, among others. These species utilize a variety of habitat components including mud flats, submerged and emergent grass beds, and oyster reefs, to name a few. The addition of artificial habitat will, in all likelihood, attract these species of fish at various times, but will not likely be the sole, or even primary, factor in their occurrence. In other words, in the absence of artificial reefs, those species will still be available to fishermen.

In deeper offshore areas where salinity is generally higher, an additional suite of species may occur if habitat components preferred or required by those species are present; however, those species may not occur in the absence of those preferred or required habitat components. For example, Franks et al. (1972) documented that fish occurrence offshore Mississippi was dominated by the family *Sciaenidae*, species that are typically not dependent upon irregular bottom topography for survival. The addition of Liberty ship artificial reefs in this area altered the species composition significantly, with the addition of such fish as red snapper, other snapper species, several grouper species, triggerfish, and several species of tropical or subtropical origin (Lukens 1980). An index of similarity comparing the species composition of the flat, featureless bottom with the artificial reef resulted in a value of 0.32, which indicates little similarity (Lukens 1980).

It is important to understand the limiting environmental factors related to the occurrence or lack of occurrence of target species of fish or invertebrates prior to developing an artificial reef, so that there will be some understanding regarding the potential performance of that artificial reef. For instance, if someone were to build an artificial reef in the middle of Mississippi Sound with the intent of attracting snapper and grouper species, the effort would most likely result in a failure. If, however, the purpose of the artificial reef was to provide a known location where anglers would have the likelihood of catching spotted seatrout or red drum, the effort would likely be a success."

2. *To enhance recreational and commercial fishing opportunities and success*

The beginnings of artificial reef development were predicated on the knowledge that fish could be found around natural or man-made objects in the water. Early recognition of this phenomenon was undoubtedly related to ship wrecks or the placement of structures in the

water for other purposes, such as breakwaters, piers, and bridge spans. As mentioned earlier, the use of artificial reefs to improve fishing success is still a driving force behind many development efforts. The primary focus in the United States, as evidenced by Figure 1., is the enhancement of recreational fishing opportunities. The development of artificial reefs in Mississippi and adjacent federal waters has enhanced recreational fishing opportunities; although, quantification of that enhancement is not available. While a much smaller component of artificial reef users, some commercial fishing activities have been enhanced through artificial reef development. On the Atlantic coast, for instance, fish traps are used around artificial reefs to catch black seabass. The use of powerheads on spear guns has become commonplace in areas that harbor such species as amberjack, lemonfish, and grouper. In the Gulf of Mexico, commercial reef fish fishermen have reportedly used artificial reefs to harvest red snapper, vermilion snapper, and several species of grouper, using hook-and-line gear with multiple hooks, known as bandit rigs. The degree to which commercial fishermen use artificial reefs in Mississippi and adjacent federal waters is unknown. All of the above stated uses of artificial reefs are legitimate within an overall management structure that ensures responsible harvest of fish, avoids over-fishing of our valuable fish stocks, and avoids to the extent possible spatial conflicts.

3. To enhance recreational diving opportunities

Diving, either free or using SCUBA (self-contained underwater breathing apparatus), can be placed into two categories, consumptive and non-consumptive. Consumptive diving involves the harvest of fish or invertebrates for recreational or commercial use. Typically, spear guns and other spear apparatus, are used to harvest fish. A less prevalent consumptive diving activity in Mississippi and adjacent federal waters, is the recreational and commercial collection of aquarium organisms. Non-consumptive diving typically involves underwater photography and general observations.

The establishment of artificial reefs within a reasonable distance from shore and in safe diving depths has encouraged the growth of the diving industry nation-wide. While marine waters offshore Mississippi lack the consistent clarity or visibility of other waters that traditionally attract diving tourism, the opportunity to see and harvest a variety of reef associated fish species offshore Mississippi has created an avid corps of local divers. The continued development and rational management of artificial reefs offshore Mississippi will contribute to the viability of the diving industry in this area. Harvest of fish species by divers must be conducted within an overall regulatory regime that insures the long-term reproductive viability of the associated fish populations.

4. To prohibit illegal ocean dumping under the guise of artificial reef development

While some artificial reef programs, such as the government-supported Japanese program, almost exclusively use designed structures as artificial reef material, in the United States, designed structures have played a relatively insignificant role in artificial reef development, being overshadowed by the use of "materials of opportunity," loosely defined as anything that is available. Some materials of opportunity are compatible with the marine environment, while others are not. Over the history of artificial reef development, a number of materials have

been promoted for artificial reef use based upon the goal of disposal of the material, which is considered to be a waste disposal problem. A primary example is automobile tires, which were the subject of much research and promotion. Today, most artificial reef programs avoid the use of automobile tires except under strict design requirements. Other examples of materials that are not well suited as artificial reef material but constitute waste disposal problems include automobile bodies, white goods (refrigerators, washing machines, dryers, etc.), and coal and municipal waste combustion byproducts. There are undoubtedly others.

This is not to say that some materials of opportunity that are waste disposal problems are not appropriate artificial reef materials. For example, used under strict chemical and engineering guidelines, coal combustion fly ash may make a suitable artificial material. Concrete rubble, derelict ships and other vessels when properly prepared and deployed can make effective artificial reef material. The principle in this case is to select artificial reef materials to achieve the goals and objectives of the artificial reef plan and program. The disposal of waste material should not be among those goals and objectives. In a later section, criteria for selection, preparation, and deployment of materials for artificial reef development in Mississippi and adjacent federal waters will be discussed.

5. To reduce or eliminate user conflicts

One of the overriding principles which guides management of public lands and waters is the "multiple use principle." This means that a given plan or regulatory action recognizes that any given resource, living or non-living, can be used for a variety of legitimate and sometimes competing purposes. It is important to recognize that creating or providing recreational and commercial opportunities for the general public automatically creates the potential for user conflict. In the context of artificial reefs, there are several levels of conflict, including but not necessarily limited to 1) recreational versus commercial, 2) recreational versus recreational, 3) commercial versus commercial, 4) fishing versus diving, 5) fishing and diving versus recreational and commercial boating and vessel traffic, 6) others. By carefully monitoring the use of existing artificial reefs, a management plan to address ongoing uses and existing or potential user conflicts can be established. It may be possible to establish reefs exclusively for diving, recreational fishing, commercial fishing, use as a sanctuary, or some combination of uses.

Many of the above mentioned potential conflicts are spatial conflicts that have nothing to do with access to fish at an artificial reef. The placement of artificial reefs in areas that historically have high shrimp trawling activity will, without question, cause conflict, because shrimp trawlers will hang their nets on materials deployed to enhance fish habitat. Another example is placing an artificial reef in areas of high jet-ski use, where jet skiers will interfere with fishing, and fishermen will interfere with jet-ski use. Proper siting of artificial reefs to avoid areas already used for other competing purposes will minimize the potential for spatial conflict.

6. *To promote the use of artificial reefs as fishery management tools*

In the overall context of this artificial reef plan, artificial reefs developed under this auspice will automatically function as fishery management tools, insofar as they are developed in order to create or enhance fishery habitat. But further, there are a variety of planning and regulatory activities that can use artificial reefs as their basis. For example, the above reference to establishing artificial reefs for specific user groups constitutes management action. Likewise, the establishment of artificial reefs as sanctuaries, establishing regulatory regimes for specific artificial reefs, and zoning of activities, all constitute management uses of artificial reefs. In recent years, the concept of special management zones (SMZ) has gained considerable attention within the federal fishery management council arena. While currently limited in use and scope in the Gulf of Mexico, this concept will likely gain in support and application.

7. *To avoid risks to the environment and personal health*

A program for pre-deployment preparation of materials and proper and responsible monitoring and inspection of artificial reef materials prior to deployment will ensure that materials that are hazardous to the environment or public health are not placed into the aquatic environment. Artificial reef site selection to avoid potential hazards to navigational is vital to saving lives and property. Siting artificial reefs in known high traffic areas for commercial and recreational boats and vessels, including jet skis and other personal watercraft, will guarantee conflict and increase the potential for damage to watercraft and human life. While significantly more difficult to address, loss of life while diving on artificial reefs can be minimized through responsible site selection and careful selection, preparation, and deployment of materials. Continual monitoring of the condition of materials provides data that will alert responsible parties of developing or potential hazards to divers.

8. *To adhere to existing international, federal, state, and local laws affecting maritime activities*

All laws related to navigation, regulations related to harvest of fish and invertebrates, laws regulating materials that are placed in aquatic environments, among a long list of other laws and regulations, should be adhered to in the process of planning, developing, and deploying artificial reefs. Establishment of artificial reefs within strict governmental guidelines and requirements will minimize possible negative impacts to the environment and public health, and will increase the probability that any reef building activities will result in success. Examples of such laws include all state and federal fisheries regulations, the State of Mississippi Marine Debris Law, the Mississippi and federal Coastal Zone Management Acts, the Mississippi Wetlands Act, the Mississippi Derelict Vessel Act, relevant sections of the Mississippi Code of 1972, Marpol Annex V (related to disposal of plastics at sea), the Rivers and Harbors Act, the Marine Protection Research and Sanctuaries Act, the National Environmental Policy Act, the Outer Continental Shelf Lands Act, and the Clean Water Act, among a long list of others.

CHAPTER 3

SITING OF ARTIFICIAL REEFS

General

The siting of artificial reefs will be discussed in two different contexts within this plan. The first discussion will provide general guidelines and recommendations regarding how to properly site an artificial reef. These are factors that should be considered by an artificial reef developer in order to expect the greatest potential for success. The second discussion, which will appear later in this plan, will provide mandatory criteria for zoning of artificial reef development activities.

It is of primary importance to identify the purpose for which an artificial reef is being developed prior to its development. For instance, if the artificial reef is intended to enhance small-boat recreational fishing opportunities, a site within easy, safe access of small boats is of paramount importance. If enhancement of habitat for a particular species is the purpose, then environmental/biological factors play a larger role than proximity to access. These and other considerations will require a statement of purpose in order to properly site an artificial reef. The discussion of general guidelines for siting of artificial reefs will be divided into two sections, including 1) environmental/biological and 2) social/economic. By combining the evaluations of the biological, environmental, social, and economic factors, areas which should be excluded (known as exclusion mapping, developed by Myatt and Ditton in 1986 for the Sport Fishing Institute's Artificial Reef Development Center) from artificial reef development can be readily identified. The remaining areas can then be considered to have potential for artificial reef development.

Environmental/Biological Factors

Environmental and biological criteria are inter-related, such that both factors affect the species likely to be present on an artificial reef. In some cases, environmental factors are purely physical in nature, and only affect the long-term viability of an artificial reef structure as a habitat enhancement tool.

Biologically Sensitive Areas

Areas with existing significant biotic activity should be considered very carefully. Since most areas in the marine environment harbor biological life, it must be understood that the addition of artificial reef materials will, in all likelihood, alter and/or displace the existing biota. For example, many species of invertebrates, including shrimp, inhabit the flat muddy bottoms offshore Mississippi. The bottom covered by artificial reef materials will render that area unavailable to the invertebrate fauna. Such trade-offs must be considered when siting an artificial reef.

Of particular importance are areas such as oyster beds, grass beds, existing live bottom, and existing coral reef areas. Live bottom is characterized by hard, rocky substrate inhabited by hard and soft corals (non-reef-building corals), a variety of invertebrate species, and reef associated fish fauna. Off Mississippi, the most prevalent, and thus the most critical, are oyster beds and emergent and submerged grass beds, since there are no coral reefs in the area, and live bottom is scarce. It is recommended that artificial reefs should not be sited on existing areas of live bottom, oyster reefs, emergent or submerged grass beds.

Bottom Type

The type of bottom on which an artificial reef is deployed is important primarily because of the potential for subsidence. In areas, such as offshore Mississippi, the bottom composition is dominated by silty mud with sand and shell mixed at varying proportions. Past experience (Lukens 1995) has proven that large items, such as a scrapped Liberty ship hull will sink, either partly or completely, into soft, muddy substrates. While some settling is acceptable, significant subsidence diminishes the effectiveness of the material. For example, a site located approximately 14 nautical miles south of the east end of Horn Island (FH-6) is comprised of three Liberty ship hulls. As a result of Hurricane Fredrick in 1979, one of those hulls has nearly completely subsided into the bottom, rendering it ineffective. Other hulls have subsided to varying degrees, with varying loss of effectiveness. It is recommended that a pre-deployment survey be conducted to evaluate bottom suitability for the size and/or

There are other considerations regarding bottom type, such as the sand blasting effect of sand and other suspended sediments that bombard artificial reef material, cleaning the material of epiphytic growth. Loss of invertebrate growth can negatively affect the entire biota. In some cases, the prevailing bottom type may determine the species available for recruitment due to species preference for such substrates as mud, hard-packed sand, shell hash, coral, among others.

Wave and Current Activity

Artificial reefs should not be developed in areas of continuous wave activity. While water associated with waves does not move in the direction of the wave, energy is passed along through the water; consequently, any obstruction in the path of a wave will be subject to the wave energy as it passes. This constant exposure to energy transference can cause structural damage to artificial reef materials and/or render materials ineffective due to subsidence.

Regardless of the type of bottom on which an artificial reef is deployed, excessive currents can create problems, such as the sand blasting effect mentioned above. Excessive currents may also impede the settlement of larval forms of vertebrate and invertebrate species, and may prolong or prevent an artificial reef from reaching a mature community stage. Also, if the direction of prevailing currents does not provide a supply of larvae and juveniles, colonization of an artificial reef may be delayed, thus impeding its full effectiveness. It is recommended that areas of strong tidal currents be avoided (Mathews 1981).

Salinity

Salinity is an environmental factor that primarily affects the species likely to be recruited to an artificial reef. Artificial reefs located in areas where salinity is at full seawater levels and remains relatively stable, the species that will successfully recruit there will be significantly different than a site in an estuary where salinity fluctuates widely as a result of freshwater introduction. Salinity may also affect the function of an artificial reef due to the associated species. For example, an estuarine artificial reef may be used only occasionally by species such as spotted seatrout, red drum, black drum, and others. These species are present in an estuary regardless of the presence or absence of an artificial reef. That site may only serve to concentrate fish and enhance their availability to fishermen. This is a question that should be further investigated. However, an offshore artificial reef in relatively stable salinity will provide habitat for a number of species that are dependent on such habitat, and may actually serve to increase the production of biomass. This issue is still the subject of much debate, but most artificial reef researchers agree that it is probable.

Temperature

Just as in the discussion of salinity above, temperature is of primary concern related to the species likely to be recruited to an artificial reef. This factor can be closely related to water depth and distance from shore for Mississippi waters, since the farther offshore and the deeper the water, the more likely that temperature will be more stable than in nearshore, shallow water. Nearshore, where temperatures fluctuate widely, species likely to be found in association with an artificial reef will vary significantly from a site where the temperature is more stable. Some species may only be found at an artificial reef during the summer months when water temperatures are warmer, either migrating or dying during the colder winter months. Some species may only be able to withstand the cold winter months as adults, thus precluding reproduction and requiring constant recruitment of adults from other areas.

General Habitat Quality

It is important that the habitat factors associated with a potential artificial reef site be of a quality that will support the organisms that are likely to be recruited. For example, it would be unproductive to place an artificial reef in a location where there is the likelihood for continued exposure to waterborne pollutants. If, in the past, pollutants have become embedded in the substrate at a given site, the addition of artificial reef material may re-suspend those pollutants and negatively affect the success of the endeavor. A thorough assessment of all habitat components associated with a prospective site is important, in order to avoid placing an artificial reef in an area where failure is likely.

Species Life History

As discussed immediately above, life history requirements of target species, related to bottom types, salinity, and temperature, are of significant importance in determining where to locate

an artificial reef. Water depth is another physical habitat factor that can affect the species that are likely to be associated with an artificial reef, since many species are distributed according to depth preferences. However, there are other considerations in this regard. For example, if the grey snapper (*Lutjanus griseus*) is an important target species, and it has been determined that additional habitat will enhance the production, and thus the harvest, of that species, an offshore artificial reef could be deployed for that purpose. It should be understood, however, that the juveniles of the species require estuarine grassbed habitats in the northern Gulf of Mexico. Consequently, if the nearshore habitat for the species has been diminished or degraded, increased production, and thus harvest, of the species will not be enhanced by the deployment of an offshore artificial reef. A full understanding of this, and other life history requirements, is vital to an effective evaluation of the success of any artificial reef development.

Social and Economic Factors

Social and economic factors are primarily those factors related to the use of artificial reefs. As stated above, before these factors can be evaluated properly, a well-defined purpose for development of a specific artificial reef must be established. For example, if an artificial reef is being proposed as a sanctuary, small-boat access to the site will be of lesser importance than other factors. If, however, the development of an artificial reef is intended to stimulate small-boat, recreational fishing in an area, the most important factors will be population size and existing infrastructure, such as marinas and boat ramps.

Social Factors

Spatial Conflict

As mentioned in Objective 5, the **multiple use concept** of managing land and water use must be paramount in siting considerations. Areas where other activities have a demonstrated historical use should be avoided. Examples include, but are not limited to, water skiing, jet-ski use, sailing and other recreational boating activities, shrimp fishing, and shipping traffic. A comprehensive evaluation of the historical use of areas must be conducted during siting consideration.

Access

Many artificial reefs are developed to enhance the potential for commercial or recreational harvest of fishery resources. In this regard, artificial reef siting considerations must include proximity to population centers, which are coastal communities with likelihood of high boat ownership. Along the Mississippi coast, this criterion will likely include the entire offshore area under the jurisdiction of the State of Mississippi and the adjacent federal waters. For artificial reefs developed as sanctuaries or research purposes, sites located away from major population centers and high boat access are more desirable. Another consideration regarding access is to use artificial reef development, in conjunction with other activities such as marina and boat ramp development, to enhance areas for fishing that are currently not well developed.

Of additional importance is the distance offshore for which safe boating can be conducted. Artificial reefs should be developed within safe boating distances. Typically, the nearer to shore that a reef is built, the greater its use. Distances in excess of 40 to 50 nautical miles offshore require larger boats for safe artificial reef access. Considering the purpose for which an artificial reef is developed, sites long distances offshore could be designated for commercial fishing activities, which typically can operate safely farther offshore. For a comprehensive discussion regarding the sociological aspects of artificial reef use refer to Jones (1986).

Economic Factors

Economic factors can be viewed in two primary ways, the economics related to all aspects of development (cost factors) and the economics generated from the use of artificial reefs (benefit factors). While few economics studies have been conducted related to the development and use of artificial reefs, it is generally believed that spending generated by the use of artificial reefs, by anglers and divers, exceeds the costs. A study conducted in South Carolina (Rhodes et al. 1994) estimates the total economic impact in South Carolina associated with fishing on artificial reefs to be slightly over \$17 million. Clearly, the economics related to artificial reef development should be investigated on a program-by-program basis, since various areas of the nation exhibit different economic conditions. It should also be noted that from a recreational fishing perspective, if a fisherman does not fish on an artificial reef, he/she is likely to fish in another mode, such as trolling or beach/bank fishing. Even if individuals did not fish if artificial reefs were not present, the money that would have been spent fishing would likely be spent in pursuit of another recreational activity. In the case of commercial fishing use of artificial reefs, which is uncommon and undocumented in the United States, the value of the fish harvested from a reef represents a real economic benefit, since the dollars generated from that harvest would not exist otherwise.

Cost Factors

All operational aspects of artificial reef development and management must be considered regarding cost evaluation. The type of material to be used will determine much of the costs involved in preparation and deployment. For instance, if a scrapped ship hull is to be used, costs involved in cleaning the ship to environmental specifications, towing the ship hull to the location and sinking it, and long-term maintenance of buoys must be considered. If concrete rubble is to be used, barge and towboat services must be secured, along with a front-end loader or other equipment to move the material off the barge. Artificial reef programs or developers must take into account the various costs related to the use of a material prior to selecting that material for deployment.

Benefit Factors

On the benefits side of the equation, for recreational fishing such items as boats, electronic equipment, fishing or diving gear, gasoline, ice, food, lodging, and other expenditures related to a fishing trip should be quantified. For commercial fishing, the above listed items must be

quantified, along with the ex-vessel value of the harvest and attendant multipliers as the product moves through the various value-added stages.

It is not always necessary for artificial reef programs to operate on a strictly positive cost/benefit basis. This is particularly true when artificial reef development is incorporated into an overall program of fisheries management. The selected application of artificial reefs to enhance marine resource habitats can produce intangible benefits to the overall health and sustainability of the marine environment, and should be considered apart from the costs/benefit factors discussed above. It is, however, important to quantify the value of artificial reefs in economic terms as a means of justifying the continuation of the activity. For a detailed discussion regarding economic evaluation of artificial reef activities, refer to Jones (1986).

CHAPTER 4

MATERIALS

General

Artificial reef development in the United States is typified by the phrase "materials of opportunity." Its origin is unknown; however, it accurately describes the kinds of materials that have typically been used in the United States to develop artificial reefs, including trees and other plant parts, rocks, automobiles and other vehicle bodies, garbage dumpsters, refrigerators, washing machines, bed frames, aircraft, boats, ships, concrete rubble, and mineral producing structures. This list is by no means all-inclusive; however, it is exemplary of what is meant by materials of opportunity. Obviously, not all of these materials are ideal for use as artificial reef material; however, some are.

In recent years, there has been a nation-wide trend to examine the feasibility of using designed structures made from fiberglass, concrete, metal, and plastics, among others. South Carolina, for instance, has conducted a number of projects to evaluate the use of manufactured materials including a number of steel and concrete designs. Virginia has experimented with a concrete "igloo", which appears to have promise, while a number of Atlantic coast states have experimented with designed units using automobile tires ballasted with concrete. There are also a growing number of commercial enterprises that are manufacturing artificial reef materials for the commercial market. This may be a benefit to some programs that may have funds to purchase materials, but not have sufficient infrastructure to handle and prepare materials of opportunity for deployment. These and other issues will be discussed in this section.

General Criteria

As set forth in the National Plan, there are five general criteria for materials that are proposed to be used as artificial reefs. The first four criteria are related generally to the performance of materials, while the fifth is less critical and related only to the availability of materials. As discussed above, it is equally important to establish the purpose for which artificial reefs are being built, because to a great extent that purpose will help determine the type of material that will be used.

Function

This criterion is related to how well a particular material performs as artificial habitat for the species of fishes or invertebrates desired. After decades of artificial reef development, a body of knowledge exists to assist in determining, to some degree, how well selected materials function as artificial fisheries habitat. Important factors related to this criterion include, but

are not limited to, interstitial spaces, surface area, vertical elevation, and stimulation of epiphytic growth.

Compatibility

This criterion is related to whether or not a proposed material is both chemically and physically compatible with the marine environment in order to minimize environmental risks. For example, the use of coal combustion ash, without adhering to strict guidelines, could result in a number of heavy metals and other toxic materials becoming available and possibly leaching into the environment. Using tires as an example, past use of unballasted automobile tires has resulted in them washing onto beaches following major storm events. This deposition of tires on beaches may have resulted in some environmental damage from tires washing over grass beds, oyster reefs, natural live bottoms, or other environmentally sensitive areas, not to mention the social and economic consequences of unsightly tires present on public beaches. Another example is the use of materials that contain plastics that could become free in the environment. The disposal of plastics at sea is regulated by MARPOL Annex V, discussed elsewhere in this plan, and can have detrimental environmental results. Sea turtles are known to ingest plastic sheeting; plastic foam materials can be ingested by a number of marine organisms. These phenomena typically result in the death of the organisms in question. These materials, among others, would be considered incompatible with the marine environment.

Stability

This criterion is related to how stable a specific material is in the marine environment. If a material is not sufficiently dense, or has broad, flat projections that can make it unstable in heavy currents, the material can move from the site on which it was originally deployed, thus rendering the artificial reef site ineffective and causing a potential hazard to navigation and such fishing activities as shrimp trawling. Again using tires as an example, the deposition of tires on beaches has resulted in a complete loss of effectiveness of the subject artificial reefs, leading to the conclusion that unballasted automobile tires are unstable in the marine environment and do not function well as artificial reef material. Artificial reefs should be developed with the expectation that they will be subjected to exceptional storm events with significant currents and storm surge.

Durability

Durability is the characteristic related to how long a material will last in the marine environment and maintain its function as artificial habitat. For instance, automobile bodies, once widely used, are known to deteriorate rapidly in the marine environment, with a useful life as habitat lasting only three to five years. While parts of automobile bodies may remain after that length of time, the function of the material as habitat for desired fish or invertebrate species is minimized or eliminated. Storm events and human activities, such as dredging, trawling, and anchoring, may negatively impact the durability of some materials of opportunity. Artificial reefs should be developed with these eventualities in mind.

Availability

While this criterion has no practical applicability regarding the effectiveness of an artificial reef, it can be a significant factor related to economics and program infrastructure. The availability of materials will dictate the kind, amount, and cost of material that can be used by specific programs. Regardless if a material is readily available, its use should be predicated primarily on satisfying the above listed criteria. Secondly, its availability becomes important.

Specific Requirements

While not every material of opportunity or designed material can be listed here, this section is an attempt to identify those materials that are specifically allowed for use and those that are prohibited from use under the auspices of the Mississippi Artificial Reef Plan. For general information and application, this plan will rely on the guidelines and recommendations established in "Guidelines for Marine Artificial Reef Materials" developed by a coordinated state-federal technical committee of the Gulf States Marine Fisheries Commission (in preparation).

Based on the above referenced document and past experiences, the following are lists of materials that are approved and not approved for use in artificial reef development in Mississippi's jurisdictional and adjacent federal waters. These lists are not inclusive, and the Mississippi Department of Marine Resources reserves the authority to disallow any material for use in artificial reef development on a case-by-case review and based on new information as it becomes available.

Approved Materials

Shell - Shell materials, such as clam and oyster shell, are naturally occurring in the marine environment and pose no threat to the environment or associated living resources. The State of Mississippi has a long and productive history of using shell materials as cultch for enhancing commercial oyster production. Secondly, that activity may have enhanced recreational fishing opportunities and success.

Rock - Like shell materials, rock is a naturally occurring, stable material that poses no threat to the marine environment or associated living resources. Much of the rock used in the past has been quarried limestone, which is the same rock that forms the shelves and ledges that are the basis for natural reefs on the continental shelf in the northern Gulf of Mexico.

Concrete - Concrete is a dense, stable material that is environmentally compatible. Concrete can be used in designed structures, such as the Virginia "igloo" and other forms, or as rubble from razed buildings, parking lots, road beds, bridges, and other sources. Concrete is often readily available.

Railroad Boxcars - Four railroad boxcars were deployed offshore Mississippi in 1989. As of 1995, they were still intact; however, it is important to note that deployments in other states have resulted in failure due to collapse of the sidewalls. If railroad boxcars are used, they should be stacked, if there is sufficient water depth, or they should be clustered, to minimize the effects of currents on the sidewalls.

Steel-hulled Ships, Boats, and Barges - Steel-hulled vessels have been used offshore Mississippi for a number of years and have proven to be stable and long lasting in the marine environment. All vessels to be deployed as artificial reefs must be cleaned of all contaminants and toxicants to Environmental Protection Agency and Mississippi Coastal Program specifications.

Mineral Producing Platforms - Mineral producing platforms have been used as artificial reefs extensively by the States of Louisiana and Texas, and have proven to be effective, stable, and durable. The primary constraint is the requirement for deep water in which to deploy the structures to assure sufficient navigable clearance.

Manufactured Materials Using Coal Fly Ash - Extensive experimental work has been done on the use of coal fly ash in hardened, aggregate form, usually blocks, as artificial reef material. Coal fly ash can be used to create artificial reef units for deployment offshore Mississippi only if the guidelines for such use, developed and adopted by the Gulf States Marine Fisheries Commission (unpublished report 1995), are followed. Protocols for proposed use of coal fly ash as artificial reef material must be submitted to the Department of Marine Resources for review and approval.

Designed Materials - The use of designed materials, for artificial reef development offshore Mississippi, is encouraged. However, such materials must be deemed compatible with the marine environment and pose no threat to living marine resources. Such designed materials must adhere to the other basic criteria of function, stability, and durability.

Military Hardware - In recent years, the U.S. military has expressed an interest in making military battle hardware, primarily main battle tanks, available for use as artificial reefs. As such, several U.S. coastal states have deployed tanks in their offshore waters. Once cleaned to environmental specifications of the Environmental Protection Agency and the Mississippi Coastal Program, military hardware is durable and stable, and will provide effective habitat for marine resources.

Disapproved Materials

Vehicle Tires - Throughout the 1950s and 1960s, vehicle tires were used to develop artificial reefs. It was later found that vehicle tires are not stable in salt water, and are easily displaced from the permitted artificial reef site by shrimp trawls, strong currents, and storms. In addition, the cost of preparation and ballasting of the tires is a prohibitive factor in using this material for artificial reefs.

Wood - While wooden materials have been used effectively in freshwater environments, they are not durable in the marine environment, degrading rapidly and reducing effectiveness as artificial habitat. Ship worms are known to increase the rate of wood deterioration, even though initially the ship worm holes provide small interstices for habitation of small organisms. There is also a tendency for wood materials to be neutrally or positively buoyant in salt water, creating a hazard to navigation and a potential conflict with trawl and other fishing activities. Manufactured wood, such as lumber, is frequently treated with toxic substances that can leach into the marine environment and negatively affect living marine resources.

Automobiles and Other Vehicles - In the 1950s and 1960s, automobile bodies were deployed offshore Alabama and Mississippi to create artificial reefs. It was quickly noted that they rapidly deteriorated, lasting only three to five years. At present, the practice of deploying vehicle bodies as artificial reefs has been largely discontinued. Modern automobile bodies are significantly comprised of plastics, fiberglass, and rubber. As the metal bodies corrode and disintegrate, the associated materials are left free in the water column. There is some concern that this could result in a violation of MARPOL Annex V, an international treaty that regulates the disposal of plastics at sea. Vehicle bodies also tend to be unstable in the marine environment. For example, following Hurricane Opal in 1995, a large number of automobile bodies was displaced offshore Alabama, later being found approximately 900 feet from their original site.

Aircraft - Various aircraft have been deployed as artificial reefs, ranging from passenger jetliners, to fighter craft, to helicopters. Aircraft are not allowed as artificial reef material because they are typically constructed of light gauge metal that quickly corrodes in the marine environment. Fixed wing aircraft, aerodynamically designed and lightweight, have the potential to be displaced when exposed to significant current velocities associated with storms. Sunken aircraft pose a danger to divers who are typically attracted to them and will frequently attempt to enter the unit.

Fiberglass Boat Hulls and Molds - In recent years, a significant number of fiberglass boat hulls and molds have been deployed as artificial reefs. These hulls and molds tend to be unstable in the marine environment and can easily be displaced by storm currents, unless heavily ballasted. Fiberglass boat hulls frequently contain foam flotation, which caused further instability on the bottom.

All Coal, Oil, and Municipal Combustion Byproducts Except Coal Fly Ash - Currently, coal fly ash is the only combustion byproducts that has received enough research and protocol development to be approved for use as artificial reef material. If sufficient research is completed and other combustion byproducts are found to be acceptable, they will be considered for approval when protocols for their use are developed and adopted.

White Goods - White goods are comprised of such items as refrigerators, washing machines, clothes dryers, dishwashers, and other appliances. These materials are made from extremely light gauge metals that rapidly deteriorate in salt water, making associated plastics and other substances free in the marine environment. They are light in weight and are not stable on the bottom, causing a potential threat to navigation and fishing activities.

CHAPTER 5

PERMITTING

General

In Chapter 1, the respective roles of the various federal agencies are discussed. In particular, the roles of the COE and the U.S. Coast Guard in the permitting process are outlined. This chapter will provide a description of how to obtain the necessary permits for artificial reef development.

Federal

Site Permits

Applications from the COE can be obtained from the appropriate district office, which for Mississippi is located in Mobile, Alabama. Along with a permit application, the COE typically includes instructions for filling out the application. Upon receiving a completed application form, the COE automatically sends out public notices to state, federal, and private interests. For an application for artificial reef development within the state's jurisdiction, state authorization of the application precedes federal approval. States can veto any permit approved by the COE through Section 401 of the Clean Water Act (33 U.S.C. 1251g). The requestor is also required to obtain a determination of consistency from the state's Coastal Zone Management Program under the authority of that act [PL 92-583; 16 U.S.C.; 1463; Section 307 (c)(3)].

The COE has the authority to establish General Permits, which set forth requirements to regulate the development of artificial reefs. If an application meets the requirements contained in the General Permit, the application can be processed much faster than when subjected to the individual permitting review and approval process.

Buoy Permits

The U.S. Coast Guard has the responsibility of issuing private aids to navigation for artificial reef application. Their general authority for making rules pertinent to navigational obstructions and their marking is found in 33 Code of Federal Regulations, Part 64. Applications for private aids to navigation for artificial reefs must be submitted prior to its construction. The Eighth Coast Guard District in New Orleans, Louisiana is responsible for issuing private aids to navigation for artificial reefs developed offshore Mississippi and in adjacent federal waters. Application forms (CG-2554) are available from:

Commander (oan)
Eighth Coast Guard District
Hale Boggs Federal Building
501 Magazine Street
New Orleans, Louisiana 70130-3396
Attention: Private Aids to Navigation Section

Permit Information Required - In addition to the basic information required on the form, the following additional information regarding the proposed artificial reef project is required:

- general locality or area
- COE permit or letter
- OCS lease number
- latitude and longitude (degrees, minutes, and seconds) of each buoy
- plot plan showing proposed location of each buoy relative to the artificial reef
- profile drawing of the proposed mooring system
- manufacturer and model number of buoys and mooring systems proposed

Buoy Requirements and Water Depth - Due to issues related to navigational clearance above an obstruction, different types of buoys are required for different depths of water. The following are the general rules:

- In water less than 85 feet in depth, a yellow, special-purpose buoy(s) with a flashing yellow light is required. The light must be visible for three nautical miles on a clear night.
- In water from 85 to 200 feet in depth, a yellow, unlighted, special-purpose buoy(s) is required.
- In water exceeding 200 feet in depth, marking is not required.

Buoy Requirements and Reef Size - As stated above, water depth determines the type of buoy required. The size of the proposed artificial reef will determine the number of those buoys that will be required. The following are the size criteria:

- For an artificial reef site that is less than one-half nautical mile on a side, one buoy, positioned in the center of the site, is required.
- For an artificial reef site that is one-half to one nautical mile on a side, buoys positioned in each corner of the site are required.
- For an artificial reef site that is more than one nautical mile on a side, buoys positioned in each corner of the site, and additional buoys positioned on the site perimeter at one nautical mile intervals or as directed by the Coast Guard Commander, are required.

Additional Requirements - If a proposed artificial reef site is located within 500 yards of a fairway, channel, or anchorage area, there are additional lighting requirements. Each buoy that is permitted by the Coast Guard will be assigned a number. That number must be displayed on each buoy in three-inch block letters in a color that contrasts the color of the buoys.

Waivers - The above information represents the general rules and guidelines for marking artificial reefs. Waivers may be obtained based on a number of criteria, as follows:

- Lighting requirements can be waived for artificial reefs with over 50 feet of navigable clearance. The buoy must be collision resistant and non-metallic, and the site must have the following criteria:
 - over two nautical miles from any fairway, channel, or anchorage area,
 - there is no history of deep draft vessel traffic in the area in which the site is located, and
 - the entire reef complex is adequately marked.
- Requirements for buoys for artificial reefs with over 85 feet of navigable clearance may be waived under the following conditions:
 - the site is included on updated NOS navigational charts,
 - the site is over two nautical miles from any fairway, channel, or anchorage area, and
 - there is no history of deep draft vessel traffic in the area in which the site is located

These rules and guidelines are subject to change by the Coast Guard Private Aids to Navigation Section based on updated information on vessel traffic and potential obstructions to navigation. In addition, the state reserves the right to require any additional marking deemed necessary.

Mississippi

The State of Mississippi has entered into a joint General Permitting agreement with the COE, such that any application for artificial reef development can be submitted to either the COE or the Mississippi Department of Marine Resources (MDMR). Specific authority for a General Permit to develop artificial reefs is found in MSG1395/MDG1395, entitled "Fish Havens, Fish Reefs, Fishery Enhancement, Mariculture, and Aquaculture Activities." **Authority under this provision does not include activities related to development of commercial oyster reefs and farms.**

The General Permit process involves three main steps, including initial actions, data access and site inspection, and data review and recommendations. In Step One, the requestor submits a completed application. That application is evaluated to determine if it is applicable to the General Permit. If not, the application is deferred to the Individual Permit process. If the application falls within the General Permit requirements, it is then assigned a Project Manager, and a file is established. During Step Two, the data relative to the application are obtained and a site inspection is planned. Typically, if artificial reef development is in relatively open water, which they usually are, site inspections are not necessary. Step Three involves a review of pertinent data, and an evaluation regarding habitat gain/loss is made. After consultation

with the Secretary of State (where applicable), the COE, and the Mississippi Department of Environmental Quality (MDEQ) to determine final compliance with the General Permit requirements, the permit is issued.

If, in the early stages of the General Permit process, it is determined that the application is not in compliance with the General Permit requirements, the application is deferred to the Individual Permit process. Again, there are three primary steps in this process, including initial actions; review, comment, and hearing; and appeal procedure. Step One is primarily the receipt of the completed application from the requestor and the assignment of a project manager. If the application passes this step, a file is established. If not, a waiver or a finding of exclusion will be issued. Step Two is complex, and begins with a full review to assure that the application is complete. The application is then distributed to the COE, the Secretary of State (if applicable), the MDEQ, the Mississippi Department of Archives and History, the Office of the Governor, and local government agencies. A reevaluation of the application is conducted and a site visit planned (if applicable). Following these steps, a public notice is issued. If no objections are raised during the public comment period, the MDMR issues its recommendations. If objections are raised, a notice of public hearing is issued, and appropriate public hearings are held. Following the hearing(s), the MDMR then issues its recommendations. The Mississippi Commission on Marine Resources (MCMR) considers recommendations. If the MCMR approves, a permit is issued. If the MCMR disapproves, the permittee may petition the MCMR for reconsideration. If the applicant's permit request is again denied on petition for reconsideration, the applicant may file an appeal in Chancery Court.

Permitting of artificial reef sites should be carefully reviewed by the MDMR because it is the agency responsible for managing the marine fisheries resources. Artificial reef permits should only be issued to the state or an entity identified by the state that can show responsibility for long term accountability of liability.

CHAPTER 6

ZONING AND CRITERIA

General

This section will provide a detailed description of the four artificial reef development zones and the criteria affecting artificial reef development in each zone. See Appendix A for zone map.

Zones

Zone 1

Description - Zone 1 is comprised of internal waters of the State of Mississippi that are within the jurisdiction of the Mississippi Department of Marine Resources, and includes all waters north of the beach along the coastline. Regarding rivers and embayments, a line across the river or bay mouth at the location of the CSX railroad bridges will form the southern boundary of Zone 1. The northern boundary of Zone 1 will be the northern boundary of jurisdiction of the Mississippi Department of Marine Resources.

Criteria - Zone 1 is an area of high use, including commercial and recreational boat traffic, water skiing, use of personal watercraft, recreational fishing, bait shrimp fishing, among others. Such high use increases the potential for spatial and use conflicts, rendering any in-water development activity potentially hazardous.

Within Zone 1, permits for artificial reef development will not be available to the public. The Mississippi Department of Marine Resources will be the only entity eligible to receive a permit for artificial reef development within Zone 1. Because of safety and marking consideration only the following materials will be approved. Shell materials will be allowed for use as artificial reef development. Other approved materials in Zone 1 are small rock or concrete material no greater than 2 inches in diameter. Any other material proposed for such use will be reviewed on a case-by-case basis, with the assurance that artificial reef development will not affect navigation or other traditional activities in Zone 1.

Zone 2

Description - Zone 2 is described as all waters in Mississippi Sound that lie between the southern boundary of Zone 1, as described above, and an east/west line drawn one half mile to the south of the southern boundary of Zone 1. There is a one-half mile buffer zone around all navigation channels, boat dock, and marinas. Artificial reef development activity will not be allowed in that buffer zone.

Criteria - Zone 2 is an area of high use, including recreational fishing, jet skiing, swimming, sailing, paddle boating, among others. As indicated by the Harrison/Hancock County Sand

Beach Master Plan, there are areas within Zone 2 in which public use is significantly higher than other Zone 2 areas. These are clearly identified by the Sand Beach Master Plan. Proposed artificial reef development in any Zone 2 area will be reviewed on a case-by-case basis. All areas designated as high use by the Harrison/Hancock County Sand Beach Master Plan will be unavailable for artificial reef development. Because of safety and marking considerations only the following materials will be approved. Proposed artificial reef development within approved Zone 2 areas must use shell material. Other approved materials in Zone 2 are small rock or concrete material no larger than 2 inches in diameter.

Water depth within Zone 2 rarely exceeds six (6) feet. Artificial reefs constructed within Zone 2 will not be allowed to have a vertical profile which reduces water clearance above the reef materials to less than four feet at mean low tide. This provision is intended to reduce the potential for conflict with occasional jet-ski use, sailing, and small boat navigation. All artificial reefs developed within Zone 2 will be appropriately marked.

Zone 3

Description - Zone 3 extends from the southern boundary of Zone 2, as described above, to the southern extent of jurisdiction of the Mississippi Department of Marine Resources. The legal buffer zone of one mile around the Gulf Islands National Seashore, a part of the National Park Service, is excluded from Zone 3, however, proposed artificial reef development within that one mile buffer zone may be considered on a case-by-case basis in conjunction with the full authority of the National Park Service to regulate activities within that one mile area. There will be a one-half mile buffer zone around all navigation channels. Artificial reef material will not be placed within 5 times the distance of the water depth away from a pipeline.

Criteria - The waters of Mississippi Sound have historically and traditionally been an area of heavy shrimp fishing activity using otter trawls, crab fishing using trawls and traps, recreational boating, and recreational and commercial fishing other than for shrimp and crabs. The development of artificial reefs within Zone 3 has a high potential to create hazards to navigation and conflicts with historical and traditional uses. All proposals for artificial reef development within Zone 3 will be considered on a case-by-case basis. Since the average water depth within Zone 3 is six (6) to eight (8) feet, materials proposed for artificial reef development within Zone 3 are limited to shell and concrete rubble and rock. In waters of eight (8) feet or less, a navigable clearance of four (4) feet must be maintained. In waters of greater than eight (8) feet, vertical height of artificial reef materials must not exceed 4 feet. All artificial reefs developed within Zone 3 will be appropriately marked.

Zone 4

Description - Zone 4 includes all waters south of the southern boundary of Zone 3. These waters are designated federal waters, and under the Magnuson/Stevens Fishery Conservation and Management Act of 1976, as amended, are designated the Exclusive Economic Zone (EEZ). The southern boundary of Zone 4 is delineated by the southern boundary of the EEZ, which is 200 nautical miles from the southern line of jurisdiction of the Mississippi Department of Marine Resources. There will be a one-half mile buffer zone around all navigation

channels. Artificial reef material will not be placed within 5 times the distance of the water depth away from a pipeline. Any proposals for artificial reef development within one mile of an operational mineral producing structure will be considered only in conjunction with and approval of the appropriate mineral producing company and the U.S. Minerals Management Service.

Criteria - Extensive artificial reef development has occurred in Zone 4 over the past 30 years. This zone also used extensively for recreational and commercial vessel navigation, recreational and commercial fishing, military activities, among others. While water depths are more conducive to artificial reef development than in Zones 1 through 3, the potential for conflict does exist. Proposals for artificial reef development within Zone 4 will be considered on a case-by-case basis. Materials listed in this plan as approved will be eligible for use in Zone 4. Any material not listed as approved will be considered on a case-by-case basis. Navigable clearance above any proposed artificial reef will follow the guidelines set forth by the U.S. Army Corps of Engineers. All artificial reefs developed within Zone 4 will be marked using U.S. Coast Guard approved buoys and guidelines.

CHAPTER 7

REEF CONSTRUCTION

Artificial reef construction in the U.S. has largely been relatively low budget utilizing materials of opportunity. Reef construction in other areas of the world, particularly Japan, have utilized designed materials placed in scientifically selected sites (Bohnsack & Southerland 1985). It is unclear if the specific construction techniques on design, placement vertical relief, spatial arrangement, and orientation by Japanese artificial reef builders will work in reef development in Mississippi and adjacent waters. However, because little information exists on different aspects of reef construction within the Gulf of Mexico it is suggested that the following recommendations be followed and researched.

1. It is recommended that artificial reefs be built along a hierarchical design that Japanese researchers have found to be most productive. This design consists of sets of material, and groups of sets which are then clustered together to make a reef complex. Recommendations on the amount of material and spacing for each set, group, and reef complex are reviewed by Bohnsack and Sutherland (1985).
2. It is recommended that artificial reefs incorporate a combination of high and low profile material to attract demersal and migratory fishes. For example, to increase complexity around FH-3, concrete rubble should be added to the site to compliment the higher profile Liberty ships already onsite.
3. Artificial reefs may be oriented perpendicular to prevailing currents in order to produce small upwelling effects that are utilized by some species. In addition this orientation creates a condition of slack current on the lee side of the structure which is also utilized by certain species of fish.
4. To try and improve juvenile recruitment and survival, it is recommended that FH-3 be expanded and a new site south of Petit Bois Island be developed with scattered concrete rubble.
5. To spread out pressure on currently existing artificial reef sites, it is recommended that a site be developed southeast of FH-12.
6. The use of artificial reefs as sanctuary areas is a relatively new concept within the artificial reef community. These are areas set aside where no fishing is allowed. They reefs would typically serve to enhance spawning stock biomass and diversity within an area. It is recommended that the sanctuary reef concept be investigated and possibly incorporated into artificial reef development plans.

CHAPTER 8

MONITORING

General

The National Artificial Reef Plan established two primary categories of monitoring, including compliance monitoring and performance monitoring. Compliance monitoring is related to assuring that specific provisions of the permits under which artificial reefs are developed are met, while performance monitoring is related to evaluating the relative success in achieving the goals for which artificial reefs are developed.

Compliance Monitoring

Any time an artificial reef is developed, whether under a general or individual permit, there is a requirement to meet specific provisions of the permit. Examples of permit provisions include geographic location (latitude and longitude), water depth, navigable clearance above materials, type of material, among others. While specific monitoring practices are not outlined in the National Artificial Reef Plan, it is clear that the only way in which to assure that artificial reef sites that have been developed initially and continually meet permit requirements is to conduct periodic monitoring surveys.

Whether developed under a federal permit or a state permit, any individual or group that is authorized to develop an artificial reef will be required to conduct periodic monitoring surveys to document compliance with permit requirements.

Material Inspection - Any material to be deployed will be inspected by a representative of the Mississippi Department of Marine Resources or its designated official prior to deployment to ensure the material is environmentally safe and free of toxic contaminants or pollutants and meets the terms and conditions in the permit under which the artificial reef is developed.

Pre-deployment Monitoring Surveys - Prior to actual deployment of artificial reef materials, the permit holder must conduct a survey of the site to determine 1) if there is any existing live bottom within the permitted area, 2) if there are any existing obstructions such as a sunken vessel, mineral producing industry debris, pipelines, or others, and 3) to determine bottom sediment suitability for the size and/or type of material deployed. This survey can be accomplished with a boat equipped with a Differential Global Positioning (DGPS) unit and a depth recorder or with side-scan sonar. Assessing bottom sediment suitability may be accomplished by sediment coring or other methods which would be determined by cost and/or feasibility. It is vital that the pre-deployment survey be conducted to avoid any conflicts with existing activities or obstructions.

Initial Monitoring Surveys - Upon deployment, the permit holder is required to have a representative on site to mark the location of deployment and to document that the appropriate

materials were deployed on the location required by the permit. This survey can be accomplished with a boat equipped with a DGPS unit.

Post-deployment Monitoring Surveys - At least once per calendar year, the permit holder is required to conduct a survey of artificial reef sites that have been developed to determine if the site continues to be in compliance with permit requirements. The primary permit requirements that must be evaluated during these surveys are 1) location and 2) navigable clearance above the materials. While such surveys could be quite detailed, for instance using SCUBA divers, for the purpose of documenting compliance, the minimum requirement is the use of a DGPS unit and depth recorder to verify the location of the materials in relation to the location required by the permit. Side-scan sonar can also be used in this application.

Additionally, it has been well documented that artificial reef materials have been moved significant distances and damaged or destroyed by large storms, such as tropical storms and hurricanes. All permit holders with developed artificial reef sites are required to conduct a compliance monitoring survey immediately following a major storm, which is defined as any storm that meets or exceeds the criteria for designation as a tropical storm.

Finally, most artificial reef permits require some kind of marking, either posts or signs or buoys. Holders of artificial reef permits for sites that have been developed and require marking are required to conduct buoy inspection activities four times during the calendar year, once during each quarter. Replacement of lost or damaged buoys must be accomplished according to U.S. Coast Guard requirements. The permit holder immediately following all storms that meet or exceed the criteria for designation as a tropical storm must conduct buoy inspection activities.

Performance Monitoring

Above and beyond compliance monitoring is performance monitoring, which addresses the physical, biological, economic, and social aspects of artificial reef development. While most permits do not require performance monitoring, such an activity is extremely important in determining if a reef is accomplishing the purposes for which it was built. At the discretion of the Mississippi Department of Marine Resources, performance monitoring requirements can be included in the permit language, which will categorize such monitoring as compliance monitoring.

Physical monitoring allows for assessment of how well the materials withstand the environment, how stable the materials are, and materials longevity. Biological monitoring provides data on how the artificial reef is affecting the biological community of the reef area. It can also provide information as to the effectiveness of materials in attracting and holding fish and other organisms. Economic and social aspects of artificial reefs are related to use of reefs by anglers and divers. Depending on the source of funding for artificial reef activities, economic and social issues can be very important, and associated data can be useful, in justifying that artificial reefs are of benefit to a community.

Physical Monitoring - Physical monitoring requires either remote sensing equipment, such as a side-scan sonar or a depth recorder, or SCUBA divers to acquire data to determine if the artificial reef material is still on location and still sufficiently below the required navigable clearance. Another important aspect of physical monitoring is to determine if the material being used is durable enough to provide effective fish and invertebrate habitat for a reasonably long period of time. Periodic monitoring will provide data and information to determine if a material used to develop an artificial reef is deteriorating. This is not only important from a program management standpoint, but it can also be important regarding potential liability. For instance, if an artificial reef becomes degraded to the point that it would be unsafe for divers, the program could post warnings in dive shops, newspaper articles, and other public information media to minimize the possibility that individuals would use that location for sport diving. Physical monitoring should be a routine function of any artificial reef program, and should be the responsibility of the permit holder.

Biological Monitoring - Under any circumstances, the development of artificial reefs will have biological consequences. The first consequence is to affect existing vertebrate and invertebrate fauna at the development location. Secondly, a new community will be anticipated, likely different from the community that existed at the location prior to deployment of artificial reef materials. It is important to the understanding of the effects of artificial reef development that artificial reef programs conduct biological monitoring to determine if artificial reefs are achieving the purpose for which they were built and to assess the ecological effects of artificial reefs on the overall environment.

Biological monitoring can be accomplished in a number of different ways, including

- underwater video sampling,
- use of nets and traps,
- hook-and-line angling,
- *in situ* diver observations (SCUBA),
- remote sensing (LIDAR, Sonar, etc.), and
- others.

The methods used to monitor the biota of an artificial reef will depend on the kind of data required for decision-making. Biological monitoring should not be conducted without first establishing a purpose for which the data will be used.

Economic Monitoring - Economic monitoring is important in gathering data to determine the economic impact of artificial reef development on the local economies, and to conduct cost/benefit analyses. Such data can be used to justify expenditures related to managing the program, as well as to assess the relative importance of artificial reefs to the fishing public.

Sociological Monitoring - Sociological monitoring is primarily used to gather data regarding potential user conflicts. For instance, conflicts can arise over multiple uses of artificial reefs or multiple uses of the space, which an artificial reef occupies. Periodic assessments of the use of artificial reefs and the surrounding area can provide the data and information needed to address such conflicts.

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APPENDIX A

Artificial Reef Development Zone Map