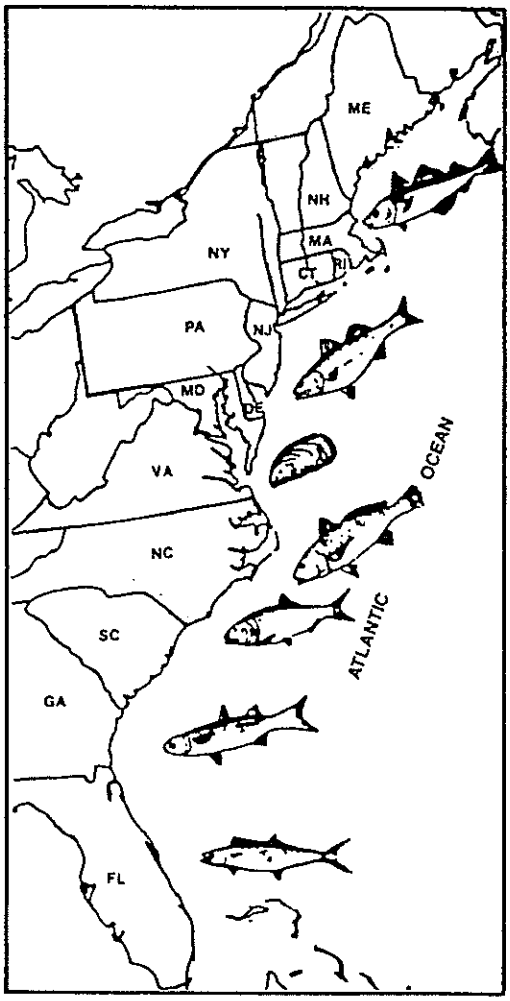
Special Report No. 14
of the
ATLANTIC STATES MARINE FISHERIES COMMISSION



A PROFILE OF ATLANTIC ARTIFICIAL REEF DEVELOPMENT

AUGUST 1988

THIS PROJECT WAS CONDUCTED IN COOPERATION WITH THE U.S. FISH AND WILDLIFE SERVICE, AND FUNDED BY FEDERAL AID IN SPORT FISH RESTORATION ADMINISTRATION FUNDS.

A PROFILE OF ATLANTIC ARTIFICIAL REEF DEVELOPMENT

By
Joseph McGurrin (ASMFC)
and the
ASMFC Artificial Reef Committee

August 1988

Special Report Number 14 of the Atlantic States Marine Fisheries Commission

ACKNOWLEDGMENTS

"A Profile of Atlantic Artificial Reef Development" was developed by the Atlantic States Marine Fisheries Commission (ASMFC) Artificial Reef Committee in cooperation with the U.S. Fish and Wildlife Service, National Marine Fisheries Service,, and the Artificial Reef Development Center. Preparation of individual state artificial reef descriptions were by the authors noted at the beginning of each state chapter. Florida Sea Grant was instrumental in compiling and processing the large number of Florida reef sites. Information on general artificial reef development issues was provided by the ASMFC Reef Committee.

This publication is dedicated to the memory of
James R. Martin (1958-1987),
student and builder of artificial reefs,
valued colleague...trusted friend.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Although artificial reefs have been in use for over a century in the United States, national concern with the planning and management of these dynamic systems has been a recent development. The National Fishing Enhancement Act (PL 98-623) of 1984 placed a new emphasis on the role of artificial reefs in fishery development and management. Subsequently, increasing public support and a growth of Federal Aid in Sport Fish Restoration funds (Wallop-Breaux) have led to a dramatic expansion of Atlantic coast artificial reef development. The Atlantic states have acknowledged that artificial reefs can offer increased fishing opportunities for the fishing industry, boost the economies of coastal communities, and still be compatible with other marine activities. As a result of these events, the Advisory Committee of the Atlantic States Marine Fisheries Commission (ASMFC) created an Artificial Reef Committee and initiated an interstate artificial reef program. The goal of the program is to promote effective use of artificial reefs in fishery development and management. In order to provide baseline information to satisfy present and upcoming artificial reef management needs, "A Profile of Atlantic Artificial Reef Development" (Profile) has been constructed.

The Profile is the first effort to systematically examine the artificial reef programs and projects along the Atlantic coast of the United States and includes information on both artificial reef programs (14 states and the District of Columbia) and permitted artificial reef sites. The present document was developed from a survey of coastal states and the information stored on a computerized database similar to that created by the Artificial Reef Development Center. The use of a computerized catalog of Atlantic reef information will allow for periodic Profile updates in the future.

Atlantic coast artificial reef development involves a wide diversity of activities. Of the 14 coastal states (plus the District of Columbia) surveyed for this Atlantic profile, 12 had some documented record of reef development activity. Of those 12 jurisdictions, 9 had government sponsored reef programs. Four states (New Jersey, North Carolina, Maryland, Virginia) are writing formal statewide artificial reef plans.

There are 273 permitted reef sites along the entire coast, with 26 of these still waiting for deployment of reef structures. This reef activity can be further characterized according to regions (divided according to Regional Fishery Management Council jurisdiction). The South Atlantic region is by far the most active along the coast, with development activity declining as one moves north through the Mid-Atlantic and New England areas. Florida is the most active reef building state (112 permitted sites) followed by North Carolina (66 permitted sites).

Together, these two states account for 65 percent of the total Atlantic sites. Most notably, there are no government sponsored programs in New England and virtually no artificial reef activities being conducted by any state north of New York at present.

Types and locations of Atlantic reefs also can be summarized. In terms of types of reefs, 92 percent are purely benthic reefs (251 of 273 sites). Only 6 sites consist solely of midwater Fish Aggregating Devices (FADs) and these midwater reefs were deployed in linear patterns as "trolling alleys." The combination reef (ie. attachment of midwater FADs to a benthic reef) was found on 16 permitted sites. More than half (56 %) of all Atlantic reef sites are located in federal waters (153 of 273 permitted sites). Of the remaining 120 reef sites found in state waters, 65 sites were found in inland waters (tidal rivers and estuaries) and 55 were within the Territorial Sea (within 3 miles of the coast). The fact that the majority of reefs are found in federal waters (3-200 miles offshore in the ocean) is important from a fishery management viewpoint as regulations for harvest of reef resources are set by the Regional Fishery Management Councils in these areas; not the individual states that might construct the reefs.

When types and locations of reef activity are viewed according to Council regions, a number of patterns are apparent The South Atlantic area is the dominant region using midwater FADs. Of the 22 Atlantic sites with FADs (either midwater or combination reefs), 18 are found in the South Atlantic. While well established in the south, the use of midwater devices to the north (4 sites) is strictly experimental. In the South Atlantic, the majority (62 %) of sites are oriented to offshore fisheries found in Federal waters. One outgrowth of this trend is that the states of Georgia and South Carolina are presently managing gear use on all of their offshore sites through the use of Special Management Zones under the South Atlantic Council Fishery Management Plan for Snapper and Grouper. In contrast to the South Atlantic, the majority (64 %) of Mid-Atlantic sites lie in state waters (Territorial Sea and/or Inland Waters). The bulk of these state water sites (25 of 35 sites) are in the estuaries, with the majority located in the Chesapeake and Long Island areas. Most of these reefs are new deployments and the dynamics of estuarine reefs remains one of the least studied areas of reef development.

A final area to consider in Atlantic artificial reef activity is the rate of growth. In the last 10 years, the number of new reef sites has approximately doubled, with the majority of this increase coming in the last five years. Since 1983, there has been a 67 % increase in South Atlantic sites and a 52 % percent increase in the Mid-Atlantic area. The impacts of this artificial reef growth on Atlantic fish stocks and fisheries remain hard to quantify.

"A Profile of Atlantic Artificial Reef Development" is a first step in evaluating the limitations and benefits of the artificial reef as a tool for fisheries enhancement. It provides a coastwide review of artificial reef programs and projects, fulfills the public mandate for greater knowledge about reef activities, and establishes a framework for improving artificial reefs in the future. Based on the information in this report, a number of new initiatives addressing reef management, technology, and research have been recommended by the ASMFC Artificial Reef Committee. The results of this upcoming work should lead to more cost effective fishery development, better artificial reef management, and benefits for fisheries resources and their users.

AN INTRODUCTION TO ATLANTIC ARTIFICIAL REEFS

prepared by

Joseph McGurrin
Atlantic States Marine Fisheries Commission

An artificial reef is a man-made structure which is constructed or placed in the water for the purpose of enhancing fishery resources and creating opportunities for resource use. Artificial reefs serve as architecture for marine resources. Like architecture, the construction of fish habitat is the art and science of building. Successful reef projects exhibit a blending of technical expertise, knowledge of the marine environment, and an understanding of coastal communities and natural resource management.

Although artificial reefs have been used in the United States for over a century, they have only recently become a well-known resource enhancement technique. The National Fishing Enhancement Act (NFEA) of 1984 (P.L.98-623) "promotes and facilitates responsible and effective efforts to establish artificial reefs in U.S. waters." It acknowledges 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." These benefits have led to increased public support for artificial reef programs. With the the growing public interest in artificial reefs, there is an increasing need to define the basics of reef technology and its role in marine resource development and management.

The Basics of Artificial Reef Technology

Artificial reef technology today is a blend of traditional methods and new innovations. A great range of structures and situations may be considered. Reefs may be as small as a ten cubic yard rock pile or as large as a 500 ton obsolete oil production platform. They may be constructed from recycled items, such as old tires and concrete culverts, or from specially tested and fabricated materials. Reefs have been deployed throughout the U.S., in a variety of climates, and in fresh and saltwater. They are used by a wide range of aquatic resources including fish, mollusks, and crustaceans and are employed for a number of purposes such as recreational and commercial fishing, sport diving, and aquaculture.

Given this wide array of reef systems, an organized approach to defining artificial reef technology was advanced under the National Fishing Enhancement Act through the development of the National Artificial Reef Plan (Department of Commerce 1985). By treating reefs as a valuable fishery management tool, the Plan is a first step in bringing artificial reefs into the mainstream of aquatic resource management.

Artificial reef technology may be defined as the systematic approach to creating effective reef structures. A wide variation exists in the various possibilities for using reef technologies, but certain aspects of creating artificial reefs remain constant. These aspects form the basic components of reef technology, and include reef types, materials, designs, and deployment.

Types of Artificial Reefs

There are three basic types of reef structures (benthic, mid-water, and floating). The position of the reef in the water column defines its type and greatly influences the kind of fish species that use the structure (Figure 1). Benthic reefs are structures based on the bottom. They can be divided into two categories according to their vertical relief or height from the bottom: low profile reefs have a height to water depth ratio of less than one-third, while high relief reefs have a height greater than one-third of the water depth.

The other two reef types are very similar. Mid-water Fish Aggregating Devices (FADs) are structures suspended in the water column between the surface and the bottom. They may be deployed in a linear series to create a "trolling alley" which provides fishermen with the opportunity to troll for certain gamefish (Figure 2). Surface FADs are structures which float on the water. Structures of this type are are typically surface mats and rafts. Like mid-water devices, these structures often attract pelagic fish which either feed on forage attracted to the area, or use it for orientation. Floating and mid-water reefs are secured to the bottom by an anchor. The operative principle of the mid-water and floating design is that they are fish "attractors". Some argue that because of this, they are not technically reefs. However, as reefs have been defined by law "as structures ... for the purpose of enhancing fishery resources and fishing opportunities," they remain part of reef technology (NFEA 1984).

Artificial Reef Materials

Artificial reefs have been constructed of almost every material imaginable. Over the years, much has been learned about the importance of material selection in constructing a successful reef. There are two general classes of materials that are commonly used to develop artificial reefs: materials of opportunity and fabricated materials.

Materials of opportunity are construction materials that have outlived their original purpose, are environmentally safe, are of suitable size and shape for the target site, can be transported if necessary to a permitted reef site, and are both durable and stable. They may take many forms; from small derelict boat hulls, to larger vessels like liberty ships. Old tires and damaged concrete culvert also have been used extensively and may be obtained at little or no cost. One of the largest materials

Figure 1. Basic Types of Artificial Reefs

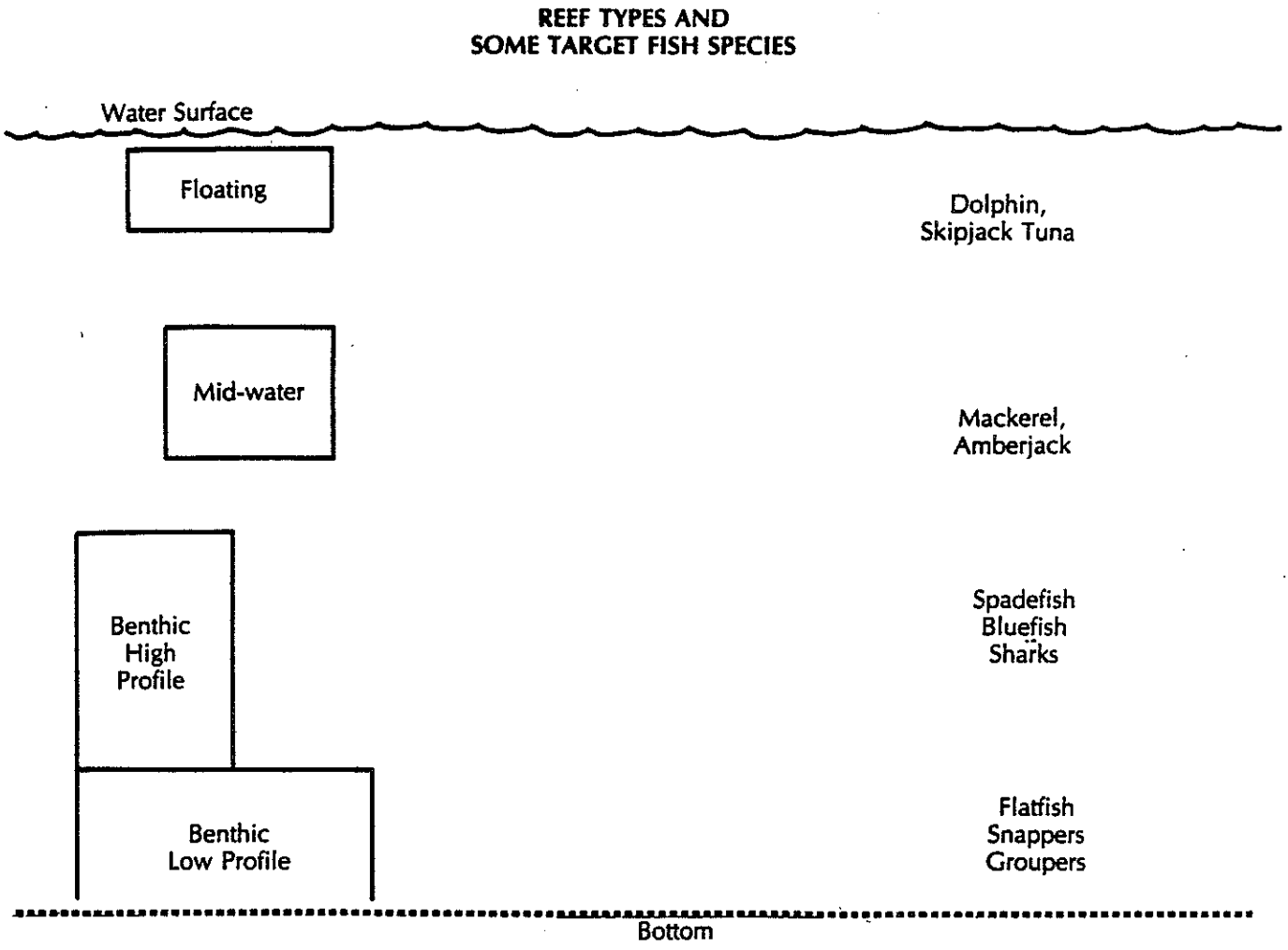


Figure 1. *The three basic reef types are defined by the position of the structure in the water column. The kinds of fish that use artificial reefs vary according to the type of reef deployed.*

Figure 2. Fish Aggregating Devices (FADs) deployed in a linear series to form a trolling alley (from Myatt, 1978)

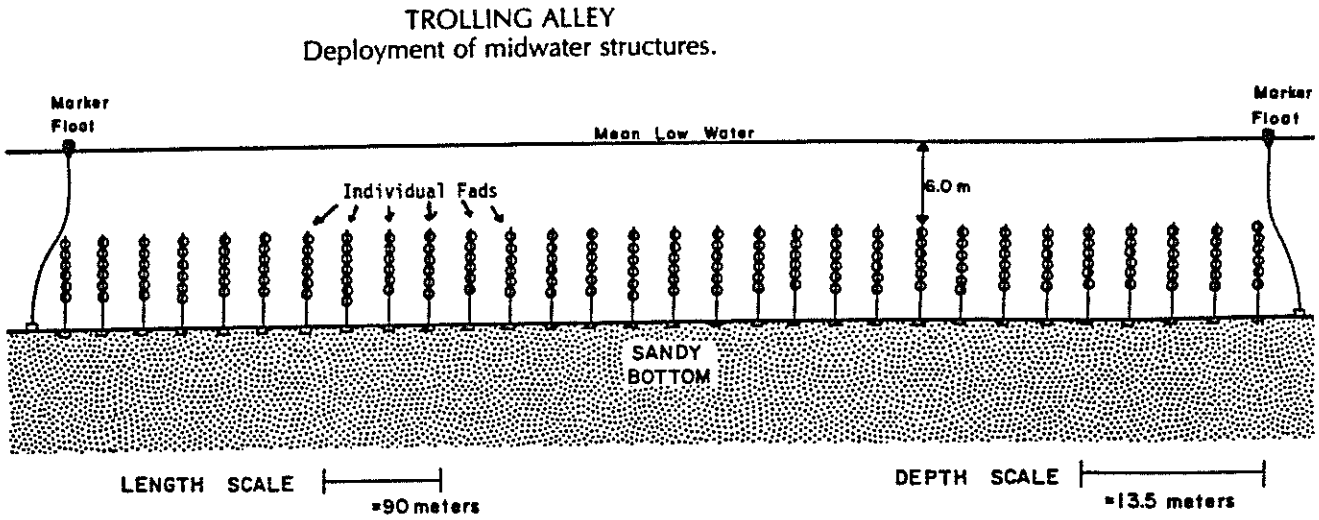


Figure 2. *Some of the earliest midwater Fish Aggregating Devices (FADs) were deployed in South Carolina and made of recycled automobile tires. They can be deployed in a linear series to form trolling alleys.*

of opportunity are obsolete oil platforms which have demonstrated outstanding fish habitat attributes.

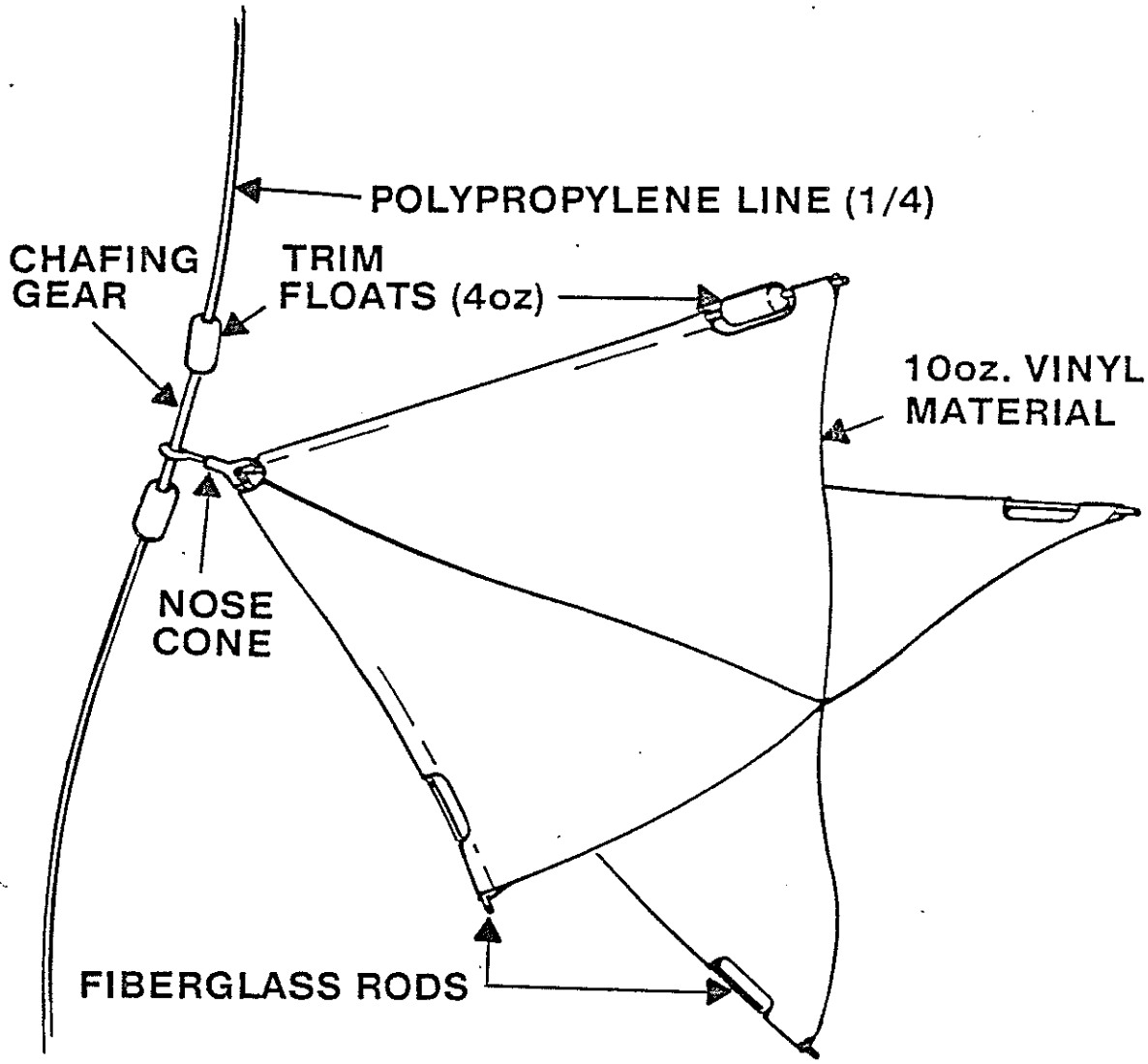
Thus, materials of opportunity not only include recycled items, but also surplus substances which were not originally constructed with artificial reef use in mind. While artificial reefs may offer the option of recycling some solid waste, it is not one of their prime functions. The use of materials of opportunity should not lead to the erroneous conception of reef programs as elaborate forms of ocean dumping.

In contrast to the United States, where materials of opportunity predominate, Japan has developed some of the most advanced fabricated materials in the world. Fabricated materials are specifically designed and constructed for use in artificial reefs and can be chosen for specific sites and species. Fabricated reef production in the United States has been mainly limited to metal and nylon mid-water FADs (Figure 3); and more recently, benthic fish domes shaped like igloos.

As part of its review of reef materials, the National Artificial Reef Plan addresses important characteristics of materials in reef construction. Four characteristics or standards are listed: functional capability, environmental compatibility, availability, and durability and stability.

Durability and stability of materials are particularly notable. The durability of a material is a major factor in maintaining reef structural integrity. Reefs must be able to withstand the effects of waves and currents, as well as the corrosive nature of sea water. Car bodies were originally deployed as reef material, but their use has been discontinued due to high preparation costs and a short lifespan in salt water. Stability of reef material refers to its ability to stay on its site. Reef units such as tires or pipes have sometimes rolled great distances on the bottom and ended up in fishermen's nets, on public beaches, or damaging natural areas. Despite these problems, developers may overcome some of the difficulties inherent to certain materials through proper unit design and deployment.

Figure 3. Fabricated U.S. Reef Production - A Fish Aggregating Device manufactured by McIntosh Marine Inc.



Artificial Reef Design

Regardless of the material used, design is a major consideration both in terms of the biological success and stability of the reef structure. Biological success can be considered in terms of both the amount and in the kind of resources that will use the reef structure. The amount of reef life or biomass has been related to the number and type of internal open spaces and crevices in reef structures. The relative height or profile of a structure also influences the amount and type of species present. Beyond the design of the unit itself, the configuration of a reef on the ocean bottom can be arranged in different ways to create currents and eddies which can enhance reef effectiveness. Thus, even rubble material which can not be easily incorporated into a single unit, can be size sorted and layered in different bottom configurations. Finally, such characteristics as reef orientation, openness, color and contrast, and surface area are properties related to design and also may influence reef function. These characteristics are especially useful for planning and evaluating artificial reef designs, and are reviewed in more detail in the National Artificial Reef Plan.

Given the influence of these various design features on reef function, structures may be designed and targeted to a particular species. While this aspect of reef development is still not precise, reef units have been successfully designed for different species groups (lobsters, tuna, etc.) and for different uses (commercial harvest, recreational fishing, sport diving, aquaculture).

Reef Deployment

A final technological aspect of reef development is reef deployment which also involves the final preparation and siting of a structure on the ocean floor. Deployment concerns vary with reef type, water depth, transportation distance, and other such factors.

Deployment of an old ship as a reef may include processing (removal of residual oil, toxic materials, etc.) to maintain safe environmental standards, and involve correctly locating a permitted reef site which may lie twenty miles offshore. Other structures may require transportation from a construction site to a loading and staging area and then out to the reef site. In the case of lightweight structures such as midwater FADs, units may be transported on a small boat and deployed by a few individuals. In contrast, the removal of an obsolete oil platform and deployment as a reef involves hundreds of trained individuals, large cranes, barges, and tugboats, with associated costs running into millions of dollars. A final step in the deployment process often will be meeting Coast Guard requirements for the marking of the structure with a buoy. Installing and maintaining a buoy is often overlooked by prospective developers and requires additional money and vigilance long after the actual reef is

deployed.

Deploying the artificial reef is a final consideration in the technological aspects of the reef development process, but is no less important than other aspects of reef technology. Improper siting of the reef could create a hazard to navigation, and even be potentially dangerous to divers and other users.

Atlantic Artificial Reef Development

While recent events point to an increasing national and regional emphasis on artificial reef development, reef advances have evolved from a tradition of enthusiasm and ingenuity in the local community. Reef activities in the states along the Atlantic seaboard reflect this trend and play an important role in tracing the history of reef development in this nation.

A Brief History of Atlantic Reef Development

Although the first recorded effort of U.S. reef development (some small log huts) occurred in the 1830's in South Carolina, large-scale ocean artificial reef construction began in earnest in 1935 with the placement of four vessels and tons of other materials off the New Jersey coast by the Cape May-Wildwood Party Boat Association. Fishing on the reef became so popular that the Pennsylvania-Reading Railroad offered a "fisherman's special": a one day round trip fare from Philadelphia to Cape May of $1.25. Within two years, the publicity and increased business that centered about the reef prompted other New Jersey communities to develop more reefs (Stone 1985).

The 1940's saw the outbreak of World War II, and consequently, little reef construction occurred at that time. In the 1950's, the resurgence in reef development was typified by the "Beer-Case Reef" off the New York coast. The F&M Schaefer Brewing Company donated 14,000 wooden beer cases to a group of charter boat captains who filled them with concrete and sank them off Fire Island (Stone 1985).

From the mid-1950's into the 1960's, as successful reef building efforts were more widely publicized, numerous organizations tried building small reefs to improve fishing conditions in their areas. Many of these efforts, attempted without technical assistance from state or local agencies, were poorly organized and, because of their dependence on volunteer labor and donations, often ended abruptly. Other projects were developed in a haphazard manner due to inadequate management and planning, insufficient funding, and an unreliable supply of reef materials. Another persistent problem was the lack of communication and exchange of information between the states and organizations involved in artificial reef programs. Artificial reef builders in one area sometimes repeated the mistakes made by those constructing artificial reefs in another part of the country, and new innovations and ideas in the technology of reef construction and placement were not widely circulated. It became

obvious that while many of these problems affecting artificial reef development had been identified, few practical solutions had emerged.

In response to some of these difficulties, a national artificial reef program was begun. From 1966 to 1974, the federal government operated an artificial reef research program. Much of the research was conducted in the states of New Jersey, South Carolina, and Florida. The focus of the work was to determine how reefs could best be used to help develop and conserve recreational fishery resources. The program developed information on construction, costs, and management of artificial reefs for state agencies and private organizations. Some years later, funding was eliminated and the effort was greatly reduced. By 1974, the federal government had ended its formal artificial reef program.

In the mid 1970's, most Atlantic states were conducting artificial reef activities, particularly in the South and Mid-Atlantic areas. Florida was the most active reef building state in the country, and Georgia and Virginia were leaders in the deployment of large obsolete government vessels through the federal Liberty Ship Law.

As reef development came into the 1980's, increased public awareness about the decline of certain ocean resources heightened interest in artificial reef development. This new momentum led to the passage of the National Fishing Enhancement Act, the development of the National Artificial Reef Plan, and the revitalization of a national and regional focus for reef activities.

A centerpiece of this renewed national focus was the National Artificial Reef Plan of 1985. Compiled by Richard Stone of the National Marine Fisheries Service, the Plan represents a team effort by a wide variety of reef interests including fishermen, divers, researchers, conservation groups, fishery managers, and government agencies. Although the Plan is a comprehensive presentation of national concerns on reef development, it should be considered as a "working document" that serves as a starting point for developing the science of artificial reef development. The Plan serves three major functions. First, it provides guidance to individuals, organizations, and agencies on technical aspects of artificial reef development and management. Second, the Plan is a technical reference for federal and state agencies involved in meeting standards for reef permitting and management. Third, the Plan encourages the development of systematic regional, state, and local artificial reef plans that focus on criteria for specific conditions and uses.

By emphasizing reef guidelines, standards, and uses, the Plan stresses the improvement of fishery resources and fishing opportunities, while minimizing user conflicts and risks to people and the environment.

Beyond the National Artificial Reef Plan, a number of other national and regional efforts have been continued. Through the cooperative efforts of the National Marine Fisheries Service (NMFS) and the Sport Fishing Institute, the Artificial Reef Development Center was created in 1983 to fill the need for communication and coordination among different reef programs. The ARDC is a national center that assists reef developers through information services, publications on the practical problems of project development, and public education about reef benefits and limitations. In 1986, with the help of the U.S. Fish and Wildlife Service, Atlantic States Marine Fisheries Commission (ASMFC) formed the first regional artificial reef program. Under the auspices of its Interstate Fishery Management Program, an ASMFC Artificial Reef Committee was created with representatives from the federal, state, and private sectors.

An Atlantic Artificial Reef Program

With the need for planning and management as an impetus, an ASMFC interstate program on artificial reefs was formed to facilitate the exchange of information among fishery managers and address specific management and research issues which will enhance state artificial reef programs. Program objectives include:

- To encourage proper planning of state artificial reef programs
- To share information on siting, construction, research, and management of artificial reefs
- To encourage evaluation of artificial reef costs and benefits
- To define the appropriate role of artificial reefs in an overall fisheries management program

In order to accomplish these program objectives, baseline information on Atlantic reefs needed to be compiled and resulted in the development of the present report.

PROFILES OF STATE ARTIFICIAL REEF PROGRAMS AND PROJECTS

Prepared By:

ASMFC Artificial Reef Committee

The following descriptions of state (plus the District of Columbia) artificial reef activities exhibit the great diversity in Atlantic coast artificial reef development. They will be useful both in educating the public about artificial reef programs, and also in assisting resource professionals in effectively constructing and managing individual reef structures. In addition to the narratives and tables, the individual state reef profiles contain citations that provide the reader with references to obtain further information.

Reef Profiles Data Base

Data on artificial reef activities was collected through a survey of state artificial reef developers. The survey focused on two areas: state programs and individual reef projects. The survey information was entered into an Atlantic coast data base similar to the "Reef Profiles" data base developed by the Artificial Reef Development Center (ARDC).

The ARDC Reef Profiles was designed as a computerized catalog of information on coastal state artificial reef programs and all permitted reef sites in U.S. waters (McGurrin and Reeff 1986). The system is IBM/DOS compatible with a software program written in dBase III that allows for the review, analysis, and categorization of existing reef programs and projects. A detailed explanation of system variables, the search function, and applications has been previously published (Reeff 1986). Using a similar computer format and by modifying some of the ARDC Reef Profiles data variables, the ASMFC Reef Committee constructed a data base for coastwide and regional analysis of reef characteristics.

Keys to Atlantic Reef Data Tables

Narratives on state programs and projects were developed by Committee members using the survey results. Except where specifically noted in the text, the narratives include the best available data as of January 1, 1988. Highlights of individual state reef activities are summarized in tables of program and project characteristics. Reef program tables include all states that have a documented record of reef development activity. Reef project tables include only those artificial reef sites which have received an Army Corps of Engineers construction permit. Permitted reef sites, rather than actual reef structures or reef names, were the basic unit of study for this review. Multiple deployments on the same permitted site - either material placed on the exact location of the original reef structure or in a new location within the permitted area - are also included in the tables. Keys to the variables in the state program and project tables are listed on the following page.

Key - Tables of State Program Activities

REEF FISHERY MANAGEMENT AUTHORITIES (Federal and State):
Names and addresses of federal and state authorities responsible for artificial reef management

NUMBER OF PERMITTED REEF SITES: Total number
Number In Federal Waters:
(3-200 miles offshore)
Number in Territorial Sea:
(0-3 miles offshore)
Number in Inshore Waters:
(estuarine, riverine)

TYPES OF REEFS: Three basic reef types are listed
Benthic - number of sites with structures resting on the bottom
Midwater - number of sites with structures suspended in the water column
Combination - number of sites that contain both benthic and midwater structures

REEF COORDINATOR: Name and address of Artificial Reef Coordinator

STATE REEF PUBLICATIONS: Documents that provide descriptive overview of state reef activities

STATE ARTIFICIAL REEF PLAN: Document citation

Key - Tables of Artificial Reef Projects

REEF SITE: Local or Common Name

LOCATION: Approximate site reference points (measured from reef buoys, center of sites, or from reef boundaries such as site corners, etc.).
Distance - Distance in nautical miles from nearest point of shore
Latitude - Degrees, minutes, seconds
Longitude - Degrees, minutes, seconds

REEF CHARACTERISTICS: Basic descriptions of sites and structures
Permit date - Year of site permit approval
Type\Environment - Benthic, midwater, or combination of both types\ placed in either ocean or estuarine environment
Depth - Average depth of reef site in feet at mean low water
Composition - Materials used for construction of reef structures

Data on all the above variables is provided where possible. If the information for a particular reef characteristic was unavailable, the table entry was left blank.

Only states with a documented record of individual reef projects have been included in this publication. Thus, profiles of the artificial reef activities of Delaware, District of Columbia, Florida, Georgia, Maryland, Massachusetts, New Jersey, New York, North Carolina, Rhode Island, South Carolina, and Virginia are detailed in the ensuing sections.

For further information on those coastal states without any record of artificial reef activity, but that conduct other types of habitat enhancement activities, consult the ASMFC Report on Marine Recreational Fisheries Programs of the Atlantic Coast (Halgren et al. 1988).

ARTIFICIAL REEF DEVELOPMENT

IN

DELAWARE

Prepared By:

Anne-Marie Eklund, University of Delaware

Although Delaware does not have a formal artificial reef program or well established reef history, it possesses some unique artificial reef projects. The construction of prefabricated artificial reefs for mitigation purposes in Delaware Bay and an ongoing coal ash artificial reef research project in the ocean highlight the state's reef activities.

Delaware Reef Programs

Delaware has no artificial reef coordinator, plan, or program (Table 1). Delaware Sea Grant investigated program possibilities in the past (Jensen et. al 1980), but no program is in operation at present. Based on the results of the artificial reef mitigation effort in Delaware Bay over the next few years, state officials will reconsider future program alternatives.

Table 1. Delaware Program Activities

REEF FISHERY MANAGEMENT AUTHORITIES (Federal and State):
Mid-Atlantic Fishery Management Council
Delaware Division of Fish and Wildlife

NUMBER OF PERMITTED REEF SITES: 1
Number In Federal Waters: 0
(3-200 miles offshore)
Number in Territorial Sea: 1
(0-3 miles offshore)
Number in Inshore Waters: 0
(estuarine, riverine)

TYPES OF REEFS:
Benthic - 1
Midwater - 0
Combination - 0

REEF COORDINATOR: None

STATE REEF PUBLICATIONS: Artificial Reefs for Delaware? by Paul A. Jensen, et. al, 1980. University of Delaware Sea Grant College Report #DEL-SG-06-80

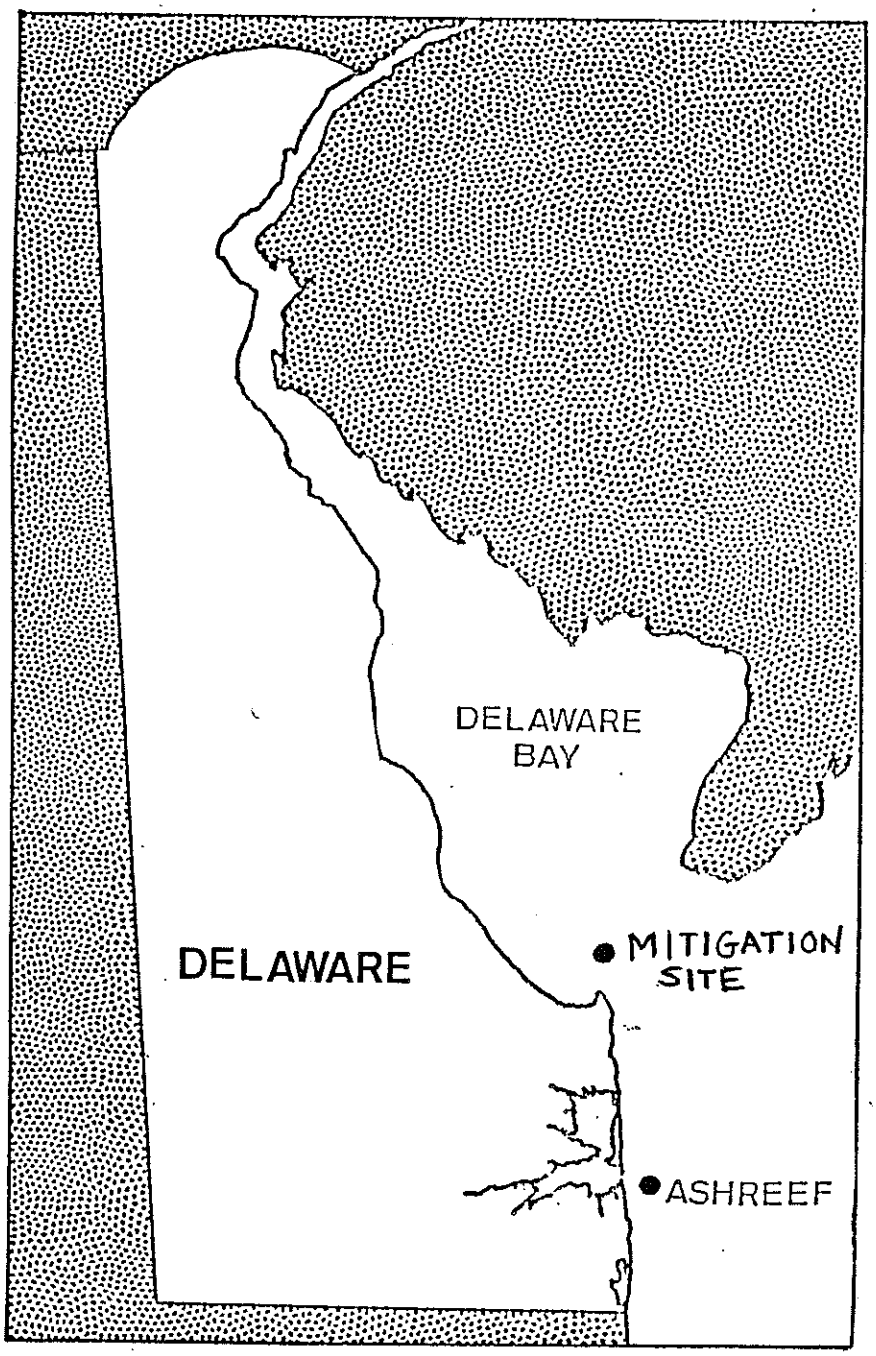
STATE ARTIFICIAL REEF PLAN: None

Delaware Reef Projects

Project Ashreef

In the spring of 1985, Project Ashreef was conceived by the University of Delaware's Electric Power Partners Program and funded by Atlantic City Electric Company, Delmarva Power and Light Company, and Jersey Central Power and Light (Figure 4).

Figure 4. Locations of Delaware Artificial Reefs



This project is intended to verify that coal waste materials, stabilized with concrete and hardened to cinder block consistency, are acceptable as marine structural materials, particularly for fish and oyster reefs. Several issues have been addressed to ensure maximum reef use by marine life and, thereby, the enhancement of commercial and recreational fisheries. (Price, 1987).

Preliminary studies were undertaken before the coal waste blocks were deposited in the marine environment. It was necessary to determine whether the reef materials release biocidal or inhibitory substances that could slow colonization rates and cause bio-accumulation of toxins in the reef food web.

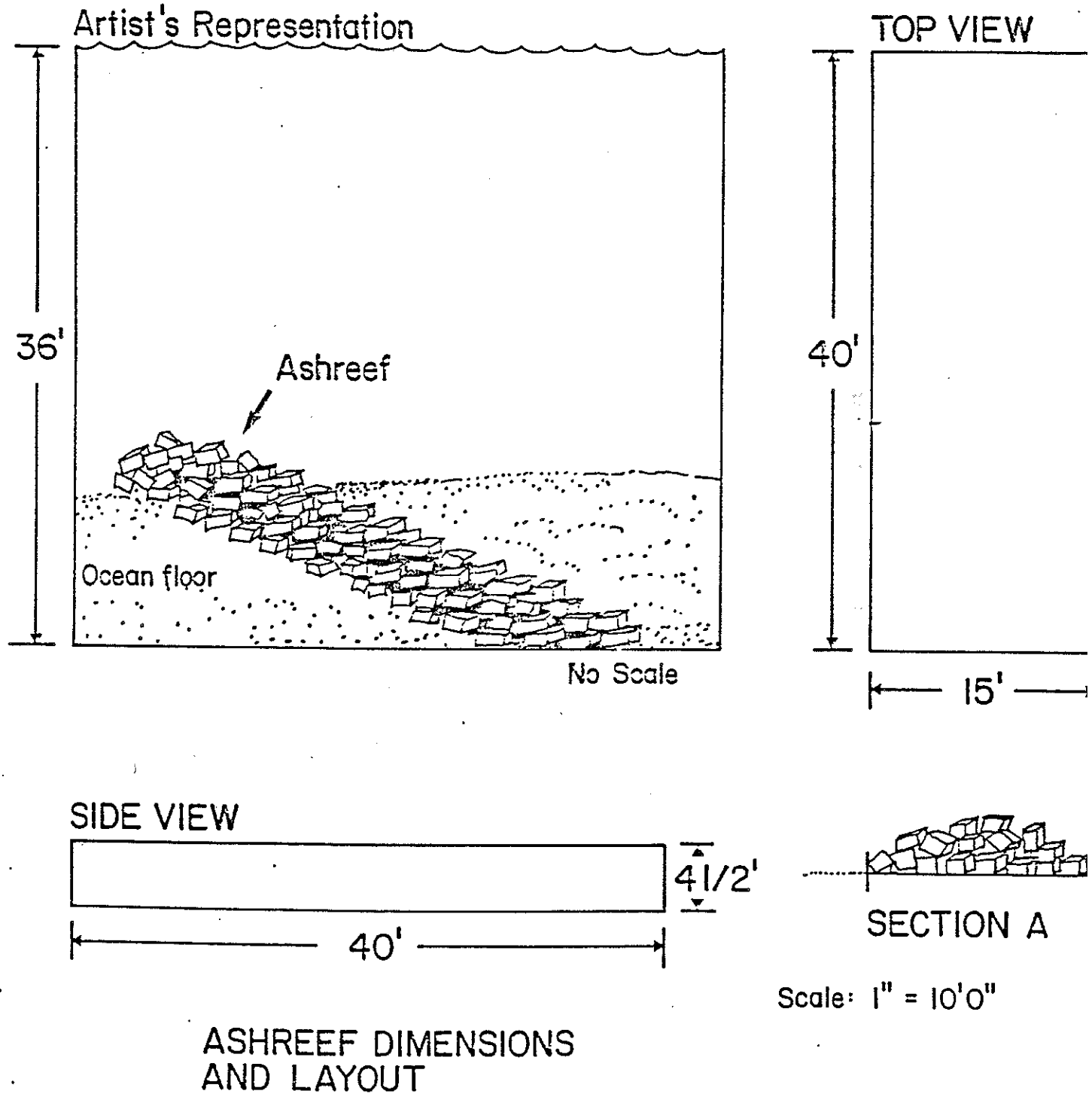
First of all, the degree of leaching of heavy metals from the reef blocks was measured by grinding the ash material and placing it in a seawater system. Most of the metals remained in the ash and did not leach into the seawater, so that the concentrations of metals were minimal and well within the EPA standards. Secondly, biological colonization of sample reef material placed in the marine environment was found to be substantial and not different from colonization of concrete blocks. The suitability of the reef material as a substratum for the setting and growth of the American oyster was also deemed successful, with no evidence that the oysters were uptaking any toxins. Oyster feeding and growth was not significantly different from those oysters growing on control oyster shell substratum.

In addition to the biological studies, strength tests were also performed on the blocks, so that the reef material would be a stable, durable mixture of coal ash and concrete. After these studies determined that the coal waste blocks were indeed stable and would not cause any negative effects on the animals associated with them, the construction of the Ashreef began.

The artificial reef was formed in May, 1986 with 250 tons of stabilized coal waste blocks (including fly ash, bottom ash, and flue-gas desulfurization scrubber sludge), along with 90 tons of concrete control blocks. The blocks were made into a variety of shapes and sizes, ranging from one to two square meters, to maximize the complexity of the shelter provided. The material formed a small experimental reef, 60 feet long and 20 feet wide with a height of four to five feet (Figure 5). The reef structure is located 1.25 nautical miles offshore (Latitude 38 36′ and Longitude 75 02′) at a depth of 36 feet and is a benthic ocean reef.

A multi-gear approach has been used to determine the community structure of the reef, so that the biases and limitations of each method would be minimized. Diving, angling and trapping have been used in order to obtain the greatest amount of accurate data. Diver observations, only 7 weeks

Figure 5. Reef Design and Layout of Delaware Coal Ash Reef



after reef placement, revealed reef blocks completely covered with epibenthic growth. Literally hundreds of juvenile black sea bass were observed, as well as a few large summer flounder and conger eels. Six months after reef placement, reef blocks were collected to identify the animals growing on the blocks, and no differences between the epifauna on the coal ash blocks and on the concrete control blocks were found. Strength and erosion tests performed on the sample blocks determined that no strength deterioration had occurred.

Angling on the reef has demonstrated that commercially and recreationally desirable fish species are attracted to the reef structure. In addition to demersal species such as black sea bass, scup, gray triggerfish, summer flounder, and Atlantic croaker being caught on the reef, more pelagic species like bluefish and weakfish were also caught in the "enhanced fishing zone" around the reef.

A string of wooden traps was set on the Ashreef to sample the reef fish community on a more regular basis. The catch was compared to several natural hard bottom areas off the Delaware coast. The fish species composition of the Ashreef was very similar to the other areas sampled, exhibiting the same seasonality patterns.

The final step in the Ashreef Project will be an economic analysis by the Electric Power Partners to determine the feasibility of building a larger artificial reef form stabilized coal waste. Considering the growing expense for deposition the waste in landfills, as well as the extremely positive results from the biological studies, it is probable that future "ashreefs" may be deployed. These reefs will help alleviate a serious waste problem and will provide stable and productive fish habitats at the same time.

Mitigation in Delaware Bay

In another project of great interest to the artificial reef community, the Philadelphia District corps of Engineers proposes to deploy prefabricated artificial reefs for fishes in Delaware Bay as a mitigation project (Figure 4). The mitigation is out-of-kind and off-site, and has been brought about by the dredging (and subsequent destruction) of nursery areas important to fish species such as the spot (leiostomus zanthurus) and weakfish (Cynoscion regalis). A preliminary siting study has already been completed for the project (Aquabio, 1984).

In step one of the mitigation process, the Corps requested technical proposals for prefabricated artificial reefs (U.S. Department of the Army, 1987). Price or cost elements are not to be revealed during the first step. The second step (to begin in late March 1988) will consist of a formally advertised procurement and sealed bidding process, which will be confined to proposers who submitted acceptable proposals under step one.

Under step one, the following criteria will be used for review and screening of the submitted proposals:

1) Materials most be encourage growth of encrusting organisms;

2) Durability and stability, functional: life must be a minimum of 30 yrs.;

3) Profile must have a minimum height 4 ft. and maximum height of 9 ft.;

4) Configuration must have a structurally complex design;

5) Performance must be supported by inferences based on empirical or theoretical data.

The artificial reef community will be watching the progress of the Delaware Bay mitigation project. Money generated from mitigation projects may allow for more private sector involvement in development of artificial reef technology.

ARTIFICIAL REEF DEVELOPMENT

IN THE

DISTRICT OF COLUMBIA

Prepared By:
Stephen M. Smith, District of Columbia
Fisheries Management Program

The District of Columbia of Columbia's Fisheries Management program was established in 1985 and is the most recent program of its kind in the nation. The exclusion of the District from past D-J eligibility was corrected by the 1984 Wallop-Breaux legislation prompting the city government to create the first solely urban fisheries program.

Accomplishments to date include the implementation of regulation and licensing of recreational anglers, initiation of a creel survey of recreational fishing trends and the formation of an Aquatic Resource Education Program for school age children. A resident and anadromous fish survey is regularly conducted and a study of contaminants in fish tissue is currently underway. The D.C. Fisheries Program is committed to developing a comprehensive fisheries research and management facility to address present and future needs.

District of Columbia Reef Program

The Artificial Reef Program was established by the Fisheries Management Program in 1987 to enhance recreational fishing and investigate artificial reef potential in a strictly urban environment (Table 2). As an outgrowth of a city sponsored management organization, the primary duty of the Artificial Reef Program is to provide tangible benefit to the municipal population, and secondarily to conduct research that applies to the protection and enhancement of fishery resources (Smith and Buckley, 1988).

Table 2. District of Columbia Program Activities

REEF FISHERY MANAGEMENT AUTHORITIES (Federal and State):
District of Columbia Fisheries Management Program

NUMBER OF PERMITTED REEF SITES: 1
Number In Federal Waters: 0
(3-200 miles offshore)
Number in Territorial Sea: 0
(0-3 miles offshore)
Number in Inshore Waters: 1
(estuarine, riverine)

TYPES OF REEFS: Benthic

REEF COORDINATOR: Stephen M. Smith, District of Columbia Fisheries Management Program

DISTRICT REEF PUBLICATIONS: None

DISTRICT ARTIFICIAL REEF PLAN: None

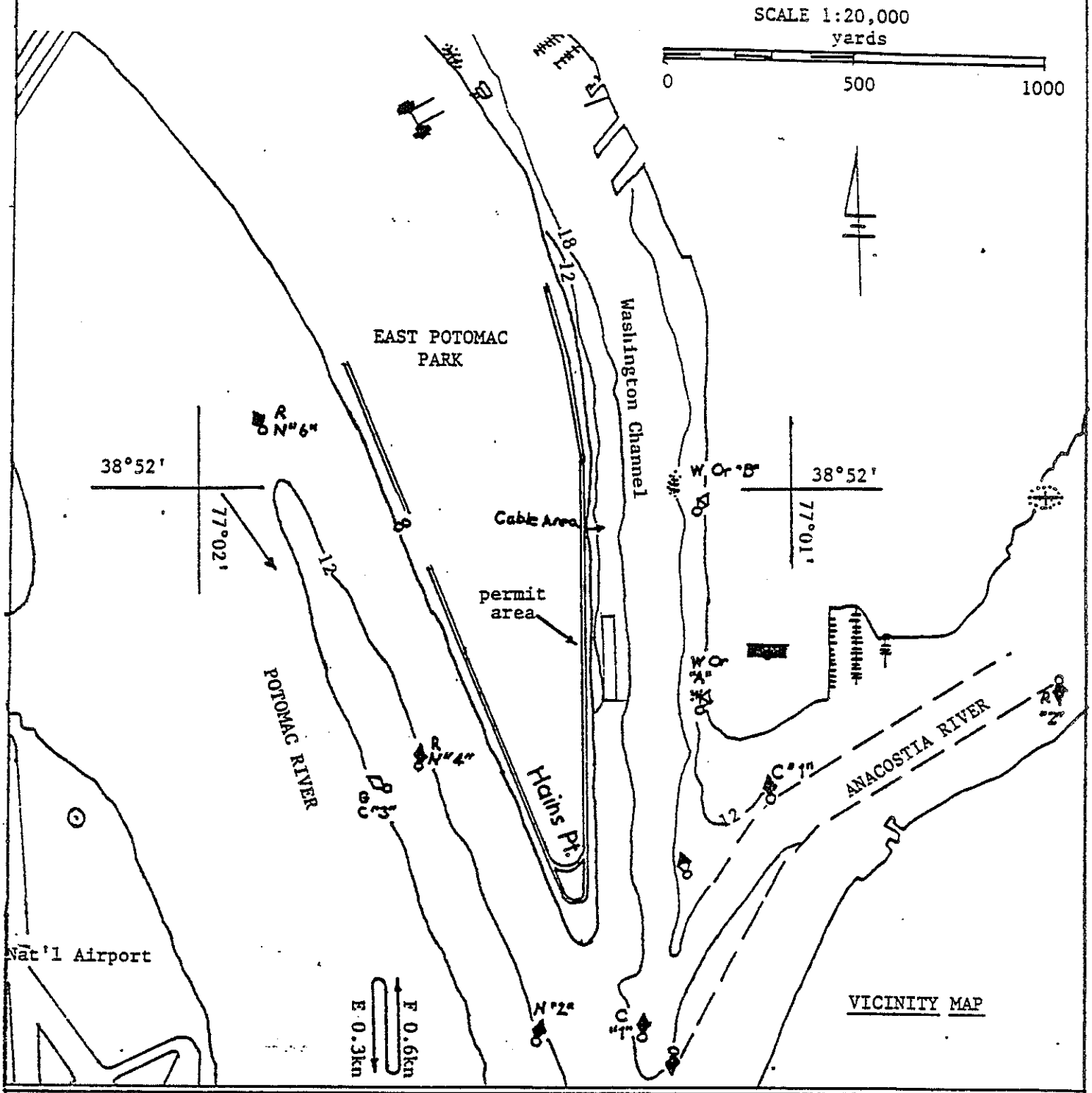
The Reef Program has identified the following objectives and guidelines for reef development projects:

- Establish artificial fishing reefs in the District of Columbia
- Utilize artificial reef for enhancement of resident and anadromous fish species
- Develop artificial reef structures suited to urban environment
- Investigate potential use of artificial reefs for fisheries assessment and management decision making
- Create increased angling opportunity and interest in sport fishing
- Provide access to productive fishing areas for special requirement and handicapped groups
- Conduct research on topics related to artificial reefs development and structural refinements

District of Columbia Reef Projects

Initial District of Columbia project activities have centered upon site selection of regions for reef development by analysis of recreational requirements and preferences and establishing baseline biological and hydrographic monitoring of potential reef sites (Figure 6). In addition, artificial reef structures have been designed and selected through evaluation of compatibility with proposed reef sites and appropriateness to targeted fish species (Smith and Buckley 1988). The structures have been designed and selected for stability in a riverine system and ease of deployment, as well as a combination of attraction and production attributes. A hexagonal "concrete slab" reef design will provide generous habitat and complexity with high profile. This particular structure is designed to be surface built on rebar guide poles obviating the need for costly deployment equipment (Phillips, 1987). Artificial submerged aquatic vegetation grids (benthic SAV grids) and cone reefs (dome-shaped polyolefin cones) are also going to be sited in the reef system (Figure 7).

Figure 6. Location of District of Columbia Reef



NOTES: - Depths at MLLW
- From NOAA chart 12285, 27 ed., 8/31/85
- Proposed project would require three reef structures in the permit area.
- Total Area 410 m²

Fisheries Management
Dept. of Consumer and Regulatory Affairs
5010 Overlook Avenue, S.W.
Washington, D.C. 20032

(202) 767-7370

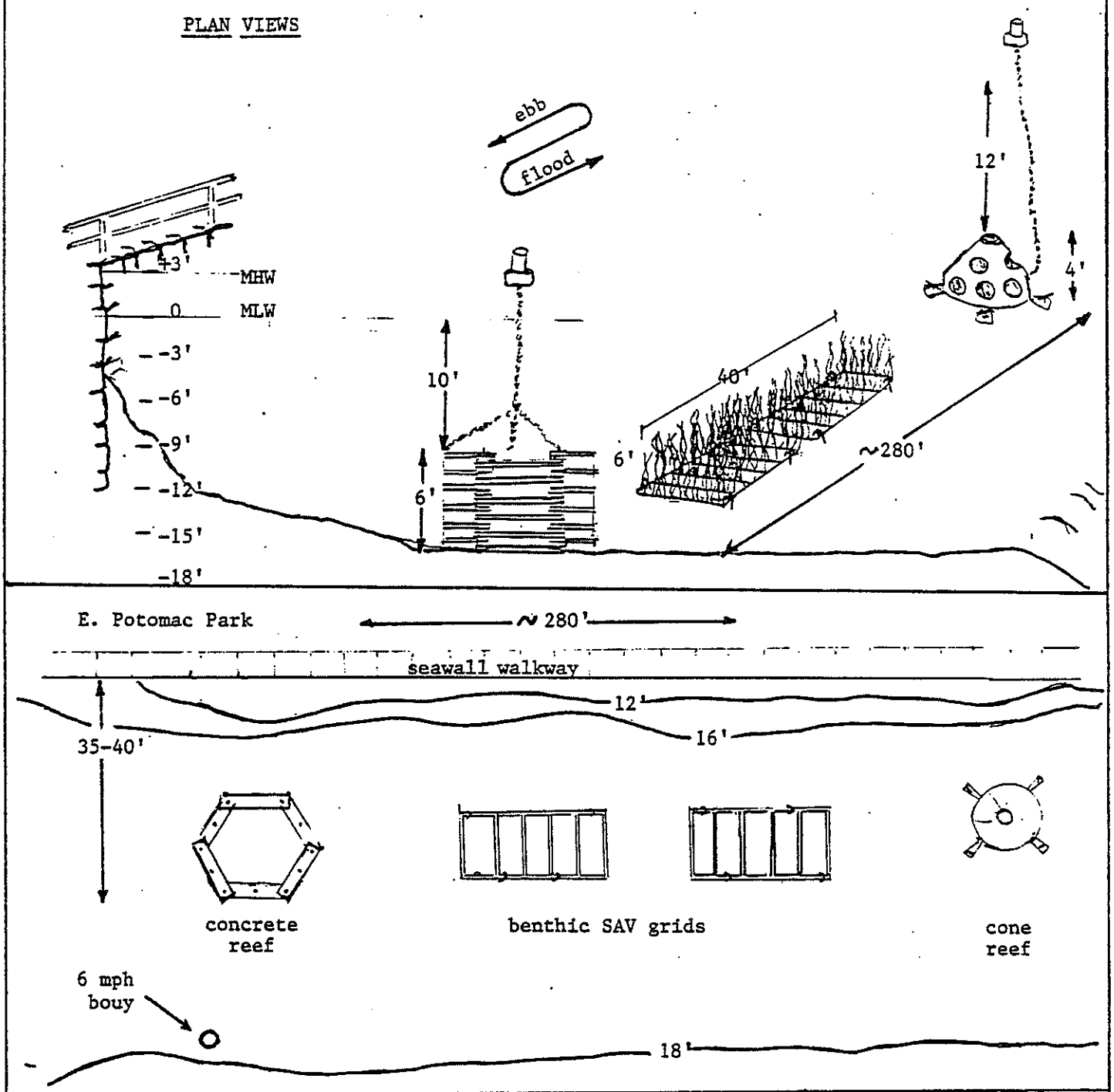
Proposed Artificial Reef Project

IN: Washington Channel, adj. East Potomac Park

AT: Washington, District of Columbia

sheet 1 of 6 7/24/87

Figure 7. Designs of District of Columbia Reefs



NOTES: - Depths and contours at MLW.
- Scale as shown.
- Adjacent property under jurisdiction of U.S. Nat'l Park Service Capital Region.
- Filter cloth may be used to stabilize reef.

Fisheries Management
Dept. of Consumer and Regulatory Affairs
5010 Overlook Avenue, S.W.
Washington, D.C. 20032

(202) 767-7370

Proposed Artificial Reef Project

IN: Washington Channel, adj. East Potomac Park

AT: Washington, District of Columbia

sheet 2 of 5 7/27/87

Plans for an initial fishing reef system and permit application have been submitted to the Corps of Engineers Baltimore Permitting Section for review. The reef will be located off the Washington Channel in the Potomac River (Latitude 38 51′ 46" Longitude 77 01′ 16") at a depth of 18 feet. The timetable for deployment of the initial reef system is scheduled for early spring 1988 to coincide with optimal water clarity and allow monitoring of recruitment over the summer and fall months.

ARTIFICIAL REEF DEVELOPMENT

IN

FLORIDA

Prepared By:

Virginia Vail, Florida Department of Natural Resources

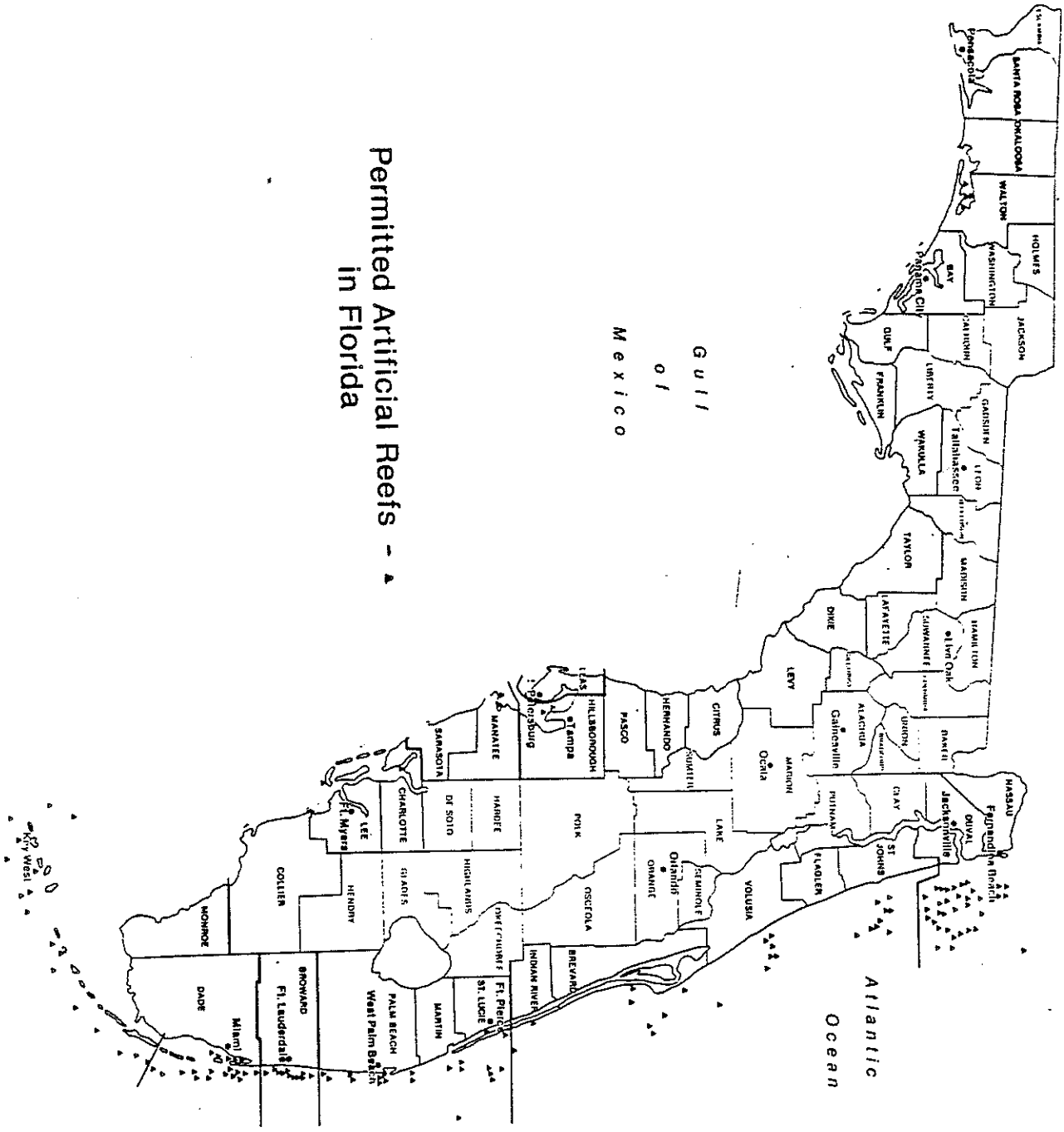
Florida leads the nation in both the total number and annual development/replenishment rate of marine artificial fishing reefs. According to available data, development of artificial fishing reefs in Florida has been occurring for at least seventy years. The oldest known reef was developed around 1918. After a slow beginning, spanning several decades, the rate of artificial reef development has increased dramatically during recent years. In a 1966 report, Woodburn identified 35 artificial reef sites, seven of which were in the Atlantic Ocean. In 1983 Aska and Pybas, conducting a survey of artificial reefs for Florida Sea Grant, reported a total of 173 reef sites, 87 of which were in the Atlantic Ocean. In a 1987 update of this survey, Pybas lists a total of 228 reef sites, 112 of which are in the Atlantic Ocean. These recent surveys (Aska and Pybas 1983; Pybas 1987) along with other information provided by Florida Sea Grant form the basis of much of the present report. For further information on Florida reef activities, particularly in regard to Gulf Coast developments, the reader should consult these references which are cited at the end of this report.

Florida Reef Programs

In Florida anyone may apply for and receive the necessary permits for constructing an artificial fishing reef. For reef projects proposed in federal waters, only a U.S. Army Corps of Engineers (Corps) dredge and fill permit is required. At this time the State does not comment on such projects. For reef sites proposed in state waters, dredge and fill permits are required from the Corps and the Florida Department of Environmental Regulation (DER) plus the Florida Department of Natural Resources Division of State Lands (DNR/DSL) must consent to the use of state owned submerged lands as an artificial reef site. From 1952 to April 1987 at least 387 permits were issued for artificial reef construction. In 1982, to facilitate permitting, the Corps and DER developed a joint permit application form, which is also accepted by the DNR/DSL. Both agencies have also developed, separately, general artificial reef permitting criteria. Projects not qualifying for a general permit from either agency may still be permitted after a more extensive evaluation. As projects are reviewed and permitted separately by each agency, it is the applicants' responsibility to obtain all necessary permits.

Florida reef sites are highly variable in size and may accommodate one artificial reef or a system of artificial reefs. Most reef sites have been permitted specifically for construction of artificial fishing reefs. However, in a few cases permitted construction was for a different purpose (e.g., navigation aid, erosion control) and it secondarily functions as an artificial reef. In other cases, a reef and reef site were created by accident, i.e., the unintentional sinking of a barge or vessel without benefit of proper permits. An artificial reef is herein considered to be materials placed at a specific location within a reef site. Reef sites are permitted areas designated by an Army Corps of Engineers permit (Figure 8).

Figure 8. Distribution of Florida's Atlantic Reef Sites



As of April 1987, 112 active reef sites and 245 active reefs have been documented in waters off Florida's Atlantic coast (Table 3). Approximately one third of the reefs are in state territorial waters, and all but ten of these are in the state waters off Palm Beach, Broward and Dade Counties.

Table 3. Florida Program Activities

REEF FISHERY MANAGEMENT AUTHORITIES (Federal and State):
South Atlantic Fishery Management Council
Florida Department of Natural Resources

NUMBER OF PERMITTED REEF SITES: 112 on the Atlantic Coast
Number In Federal Waters: 75
(3-200 miles offshore)
Number in Territorial Sea: 30
(0-3 miles offshore)
Number in Inshore Waters: 7 (estuarine)
(estuarine, riverine)

TYPES OF REEFS:
Benthic - 101
Midwater - 4
Combination - 7

REEF COORDINATOR: Virginia Vail (For Florida DNR Funding Program Only) All other reef administration is on county level. Florida Sea Grant also is active with their own statewide artificial reef program which includes training for reef diver performance, extension services for reef design and placement, information transfer and publications, and research for reef planning and improvement (Contact Florida Sea Grant College Program, Bldg. 803, University of Florida, Gainesville, FL 32611).

STATE REEF PUBLICATIONS:
Atlas of Artificial Reefs in Florida by Donald W. Pybas 1987 (published by Florida Sea Grant)

STATE ARTIFICIAL REEF PLAN: None

Many artificial reefs in Florida have been and are being developed through the efforts of private citizens or fishing/diving/artificial reef clubs. For example, the Jacksonville Offshore Sports Fishing Club has been building artificial reefs off Duval County for nearly 30 years; the Florida Keys Artificial Reef Association was incorporated in 1980, and the Tallahassee based organization for artificial reefs has been active in the Big Bend coastal area.

Local coastal governments are also involved in artificial reef development. In the thirteen counties on Florida's Atlantic coast, there are eleven active government sponsored reef programs. Responsibility for the reef program differs from county to county, with the departments of Parks and Recreation, Environmental Services, Waste Management, and Resource Management and Port Authorities likely recipients of that responsibility. Often government staff receive assistance and technical advice from local fishing clubs. Such cooperation facilitates achieving the reef building goals of both parties.

Local governments and sport fishing organizations also receive considerable advice and technical assistance in site selection and placement of materials from Florida Sea Grant, which established a statewide Artificial Reef Advisory Group in 1977. In addition to working directly with local reef programs, Sea Grant hosts conferences (local, regional, statewide, international) to facilitate discussions and sharing of information on key artificial reef issues, trains recreation divers to monitor artificial reefs using standard scientific techniques, and produces a series of educational and advisory publications on artificial reefs to increase public awareness and assist reef program managers. One publication, an atlas of artificial reefs in Florida, is the only comprehensive assessment of statewide reef development and distribution. Sea Grant has also provided significant support and assistance to the State artificial reef program.

The State's involvement in actual construction of artificial reefs dates back to the mid-1960's when the Florida Board of Conservation awarded a limited number of grants to local governments to fund reef development projects. In 1971 a Florida Recreational Development Assistance grant was awarded to a local government by the DNR Division of Recreation and Parks for reef construction. Between 1976 and 1980 the DNR Division of Marine Resources received, prepared (using funds from the sale of scrap iron to the salvager) and placed five Liberty ships. In 1978 the Division of Marine Resources received a large grant from the Coastal Plains Regional Commission for artificial reef development. Receipt of this grant signaled the beginning of a state artificial reef program. Rules for dispersing these funds were developed, defining a grants-in-aid program with projects selected through a competitive evaluation of local government proposals. In 1979 the State Legislature appropriated general revenue funds for reef construction, beginning the annual appropriation of funds for reef projects which, with the exception of one year, has continued to present. In 1982, in addition to receiving general revenue funds, the program was officially established as a grants-in-aid program by state statute (s.370.25, Florida Statutes). One staff position was assigned responsibility for program administration. In 1986 the reef program was expanded using "Wallop-Breaux" funds from the U.S. Fish and Wildlife Service, and now sponsors approximately 20 reef projects each year.

In addition to funding local government reef projects, the State obtained and placed three oil rigs, a Coast Guard vessel and three Japanese style reef modules in the early 1980's. In 1987, the State received three surplus federal vessels, and efforts to obtain additional surplus ships and coordinate donations of materials are continuing.

Limited funding for artificial reef construction is also available to local governments through two other programs in DNR: The Division of Law Enforcement's Derelict Vessel Removal Program and the Division of Recreation and Parks' Florida Boating Improvement program. In addition, the Florida Department of Transportation assists local reef programs by disposing of suitable highway construction debris (e.g., concrete slabs, bridges) on permitted reef sites when it is a cost effective disposal alternative.

In general, artificial reef development in Florida is not guided by any policies other than those defining permitting criteria. Responsibility for and authority over reef related issues (e.g., placement, construction, fisheries management, maintenance, enforcement, monitoring, etc.) is assigned to separate federal, state and local government bodies which function independently from the state reef program.

Artificial Reef Projects

While it exists, descriptive information on the status of artificial reef projects in Florida is not readily accessible or, once obtained, not easily analyzed. The large number of reefs constructed by the wide variety of Florida development entities make detailed descriptions of each site beyond the scope of this report. For the purposes of this regional description of Atlantic reef sites, artificial reef distribution along Florida's Atlantic coast is summarized below county by county, beginning with the northern most (Nassau County) and progressing south to the Florida Keys (Monroe County). The first reference to the number of reef sites and reefs in each county identifies sites permitted for artificial reefs. Undeveloped, unpermitted or otherwise permitted sites are specifically noted if present. Beyond the specific information in this review (Tables 4 to 7), other details (Loran C coordinates, etc.) on each reef and reef site may be obtained from the updated "Atlas of Artificial Reefs in Florida" (Pybas, 1987), published by Florida Sea Grant.

NASSAU COUNTY: (Table 4)

Three reef sites, five reefs, located 10.3 to 15.1 nautical miles (NM) offshore in 55-70 feet of water. Predominant reef material: barges. Reef placements date from 1973 to present.

DUVAL COUNTY: (Table 4)

Twenty five reef sites, 78 reefs, located 8-28 NM offshore in 48-106 feet of water. Predominant reef materials: barges and tugs. Two reef sites lie within approximately 10 NM of shore, eight sites are within approximately 10-15 NM of shore, five sites are approximately 15-20 NM offshore and nine sites are more than 20 NM offshore. Most reefs lie in 60 to 80 feet of water. Reef placements date from 1941 to present.

REEF SITE		LOCATION		REEF CHARACTERISTICS			
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
NASSAU COUNTY							
Sahlmans Gulley	15.1	304007	810934	1973	Benthic/Ocean	70	Steel barge
Whitakers Snapper Hole	12.7	303813	811322	1973	Benthic/Ocean	55	Steel barge
(Replenishment)	13.0	303813	811322	1984	Benthic/Ocean	60	Steel barge
(Replenishment)	10.3	303813	811322	1986	Benthic/Ocean	70	Steel hull
Fernandina Snapper Banks	14.4	303635	811039	1975	Benthic/Ocean	70	Wood vessel
DUVAL COUNTY							
Amberjack Hole	16.8	303249	810310		Benthic/Ocean	83	Barge, two tugs
(Replenishment)	18.5	303249	810310		Benthic/Ocean	76	Barge
(Replenishment)	19.3	303249	810310		Benthic/Ocean	67	Culverts
Rabbit's Lair	13.1	303135	811009		Benthic/Ocean	68	Wooden tug
Tournament Reef	22.4	302148	805601		Benthic/Ocean	90	
Tunzlers Waters	17.0	302937	805730	1976	Benthic/Ocean	102	Tugs
(Replenishment)	23.5	302937	805730		Benthic/Ocean	86	Barge
(Replenishment)	22.2	302937	805730		Benthic/Ocean	86	Tug
Montgomery Reef	5.5	302647	811312	1959	Benthic/Ocean	76	Autos, metal junk, concrete rubble
(Replenishment)	8.4	302647	811312		Benthic/Ocean		Barge
(Replenishment)	8.5	302647	811312		Benthic/Ocean	68	Tug
(Replenishment)	8.5	302647	811312		Benthic/Ocean	66	Tug
(Replenishment)	8.0	302647	811312		Benthic/Ocean	65	Culverts
(Replenishment)	8.5	302647	811312		Benthic/Ocean	61	Barge
(Replenishment)	9.6	302647	811312		Benthic/Ocean	63	North wreck
(Replenishment)	8.4	302647	811312		Benthic/Ocean	65	Steel barge

Table 4. FLORIDA Artificial Reef Projects (cont'd.) - **(Nassau & Duval Counties)**

REEF SITE	LOCATION			REEF CHARACTERISTICS			
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
Busey's Bonanza	12.5	302559"	810810"		Benthic/Ocean	52	Drydock, barge, tug vessel
(Replenishment)	12.5	302559	810810		Benthic/Ocean	52	Tires
(Replenishment)	12.5	302559	810810		Benthic/Ocean	54	Drydock
(Replenishment)	12.5	302559	810810		Benthic/Ocean	54	Tug
(Replenishment)	10.6	302559	810810		Benthic/Ocean	48	Two wrecks (drydock)
Harm's Ledge North	24.5	302459	805407		Benthic/Ocean	92	
Harm's Ledge	24.0	302220	805352		Benthic/Ocean	100	Tug
(Replenishment)	22.7	302220	805352		Benthic/Ocean	90	
Jacksonville 9 Mi. Reef	11.0	302332	811011		Benthic/Ocean	72	Barge, steel tanks, culverts
(Replenishment)	10.4	302332	811011		Benthic/Ocean	72	Barge, steel tanks, culverts
(Replenishment)	10.5	302332	811011		Benthic/Ocean	72	Barge
(Replenishment)	10.5	302332	811011		Benthic/Ocean	58	Barge
(Replenishment)	10.4	302332	811011		Benthic/Ocean	56	Culverts, pillboxes
(Replenishment)	10.5	302332	811011		Benthic/Ocean	58	Barge
(Replenishment)	10.5	302332	811011		Benthic/Ocean	58	Barge
(Replenishment)	10.4	302332	811011		Benthic/Ocean	70	Tug
(Replenishment)	10.4	302332	811011		Benthic/Ocean	68	Nine Mile Barge
(Replenishment)	10.2	302332	811011		Benthic/Ocean	63	Tanks
(Replenishment)	10.4	302332	811011		Benthic/Ocean	63	Tug
East 14 & 15	15.0	302324	810455			65	Stadium demolition material

Table 4. FLORIDA Artificial Reef Projects (cont'd.) - (Nassau & Duval Counties)

REEF SITE	LOCATION			REEF CHARACTERISTICS			
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
(Replenishment)	16.4	302324"	810455"		Benthic/Ocean	68	Press box sections
(Replenishment)	16.4	302324	810455		Benthic/Ocean	68	Culverts
(Replenishment)	17.4	302324	810455		Benthic/Ocean	71	Tug, barge, culverts
(Replenishment)	16.3	302324	810455		Benthic/Ocean	67	Press box sections
East of EF	21.6	302234	805713		Benthic/Ocean	90	
Pablo Grounds	73.0	302018	811241	1982	Benthic/Ocean	73	Culverts, rubble, steel tanks, tires
(Replenishment)	10.1	302018	811141		Benthic/Ocean	67	Maddox culverts
(Replenishment)	10.0	302018	811141		Benthic/Ocean	67	Culverts
(Replenishment)	10.0	302018	811141		Benthic/Ocean	63	Pillboxes, culverts
(Replenishment)	10.0	302018	811141		Benthic/Ocean	68	Barge
(Replenishment)	9.0	302018	811141		Benthic/Ocean	65	Steel tanks, culvert
Blackmars Reef	65.0	302148	804650	1971	Benthic/Ocean	10	Ferryboat, barges, tugs
(Replenishment)	28.2	302155	805005		Benthic/Ocean	106	Ferry
(Replenishment)	27.8	302155	805005		Benthic/Ocean	104	Barge
(Replenishment)	27.8	302155	805005		Benthic/Ocean	104	Tug
(Replenishment)	28.7	302155	805005		Benthic/Ocean	106	Airplane wreck
(Replenishment)	27.8	302155	805005		Benthic/Ocean	104	North barge
(Replenishment)	27.6	302155	805005		Benthic/Ocean	103	Tug
Paul Mains Reef	68-75.0	301952	811101	1967	Benthic/Ocean	63	Culverts, tugs, barge
(Replenishment)	10.6	301952	811101		Benthic/Ocean	63	North barge
(Replenishment)	10.6	301952	811101		Benthic/Ocean	63	Banana boat, pogey boat
(Replenishment)	10.6	301952	811101		Benthic/Ocean	63	Tug

Table 4. FLORIDA Artificial Reef Projects (cont'd.) - (Nassau & Duval Counties)

REEF SITE		LOCATION		REEF CHARACTERISTICS			
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
(Replenishment)	10.6	301962	811101		Benthic/Ocean	63	Navy barge
(Replenishment)	10.6	301952	811101		Benthic/Ocean	63	Linden's msyts, culverts
Claytons Holler	14.0	301841	810407		Benthic/Ocean	80	Steel tugs
(Replenishment)	16.7	301841	810407		Benthic/Ocean	82	Tug
(Replenishment)	16.5	301841	810407		Benthic/Ocean	82	Tug
Middle Grounds	13.6	301920	810837	1982	Benthic/Ocean	85	Japaneses FRP Reef
(Replenishment)	14.7	301920	810837		Benthic/Ocean	75	Steel tug
Casa Blanca	28.3	301735	804917		Benthic/Ocean	105	LST, cables
Dunn's Run	13.0	301856	810859		Benthic/Ocean	72	
Jacksonville Beach Wreck	10.5	301619	811334	1941	Benthic/Ocean	60	Steel tanker, dredge pipe
Main 14 & 15	14.9	301735	810451		Benthic/Ocean	76	
North of SS	21.2	301718	805746		Benthic/Ocean	72	
Southeast 16 & 17	22.4	301445	805919		Benthic/Ocean	90	
Hospital Grounds	22.1	301310	810008		Benthic/Ocean	90	
East of PV	13.0	301241	810452		Benthic/Ocean	85	
Ponte Vedra Grounds	16.1	301211	810936	1977	Benthic/Ocean	75	Tires, steel scaffolding
(Replenishment)	16.1	301211	810936		Benthic/Ocean	75	Steel plates
(Replenishment)	16.1	301211	810936		Benthic/Ocean	75	Navy scaffolding
(Replenishment)	16.1	301211	810936		Benthic/Ocean	75	Steel plates, tires
(Replenishment)	16.1	301211	810936		Benthic/Ocean	75	Tires

ST. JOHNS COUNTY: (Table 5)

Ten reef sites, ten reefs, located 2-19.3 NM offshore in 56-72 feet of water. Predominant reef materials: concrete and vessels. All reefs were originally placed in the early to mid - 1970's.

FLAGLER COUNTY:

No documented reef sites.

VOLUSIA COUNTY: (Table 5)

Six reef sites, six reefs, located 4.4 -11.0 NM offshore in 60-85 feet of water. An unpermitted barge wreck lies 29 NM offshore in 73 feet of water. Predominant reef materials: concrete beams and rubble; the Liberty ship MINDANAO. Reef placements date from 1970 to present.

BREVARD COUNTY:(Table 5)

Six sites, six reefs (one of which is a trolling alley of FADs), located 2-10 NM offshore in 25-120 feet of water. The reef sites nearest the furthest from shore are in the shallowest and deepest water, respectively. Predominant reef materials: concrete culverts and blocks. Reef placements date from 1964 to present.

INDIAN RIVER COUNTY: (Table 5)

One reef site; an experimental reef constructed in 1987 of oil ash and cement blocks, 1.2 NM offshore in 38 feet of water.

ST. LUCIE COUNTY: (Table 5)

Six reef sites, eight reefs, located 1.0 - 13.0 NM offshore in 29-192 feet of water with predominant reef materials: tugs. Reef placements date from 1961 to present with the oldest reefs consisting of autos and concrete placed on the same site in 1961.

Table 5. FLORIDA Artificial Reef Projects - (St. Johns, Volusia, Brevard, Indian River, and St. Lucie Counties)

REEF SITE	LOCATION			REEF CHARACTERISTICS		
Name	Distance (Naut. mi.)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
ST. JOHNS COUNTY							
Four Mile Reef	2.1	295626"	811027"	1974	Benthic/Ocean	60	Tires (on natural reef)
Dorothy Louise	19.5	295610	805712	1973	Benthic/Ocean	70	Concrete, old vessel
Pop Warner Reef	7.6	205603	810532	1976	Benthic/Ocean	65	Tires
Nine Mile North Reef	8.9	295514	810520	1974	Benthic/Ocean	65-70	Tires (on natural reef)
Nine Mile South Reef	7.3	295320	810622	1974	Benthic/Ocean	60	Tires (on natural reef)
Desco Boat	12.8	295316	810031	1973	Benthic/Ocean	70	Concrete, old vessel
Inner Plane	15.1	295112	805814	1974	Benthic/Ocean	72	Small plane
Outer Plane	16.4	295011	805711	1974	Benthic/Ocean	80	Pieces of plane
Leon Roddy Boat	7.0	295525	810736		Benthic/Ocean	63	Vessel
Shipwreck - not necessarily permitted as artificial reef, but listed by Florida Sea Grant.							
VOLUSIA COUNTY							
The Wreck	10.0	291230	804600	1982	Benthic/Ocean	75	WWII ship, concrete beams, culverts
Liberty Reef	10.6	291158	804445	1981	Benthic/Ocean	85	Liberty ship, Mindinoa
County Reef	4.4	290904	805320	1971	Benthic/Ocean	60	Tires, autos, rubble
Nine Mile	6.5	290900	804900	1972	Benthic/Ocean	70	Barge, autos, concrete rubble
Wharton Tire Reef	7.4	290854	804926	1970	Benthic/Ocean	70	Concrete beams, culverts, rubble
Cracker Ridge	11.0	290847	804127	1982	Benthic/Ocean	70	Concrete beams, rubble
BREVARD COUNTY							
Unnamed	10.0	283000	802118	1970	Benthic/Ocean	80	Concrete rubble, tires
Unnamed	2.0	281935	803325	1964	Benthic/Ocean	25	Concrete blocks
Brevard Reef Site #1	17.0	282530	801730	1985	Benthic/Ocean	85	Vessel, concrete culverts

Table 5. FLORIDA Artificial Reef Projects (cont'd.) - (St. Johns, Volusia, Brevard, Indian River, and St. Lucie Counties)

REEF SITE	LOCATION			REEF CHARACTERISTICS		
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
Brevard Reef Site #2	10.0	282530"	801730"		Benthic/Ocean	45	Concrete culvert
Brevard Deep Site	20.0	282530	801730	1987	Benthic/Ocean	115-120	
FAD Alley	9.1	281825	802717	1987	Midwater/Ocean	60	Trolling Alley of FADs
INDIAN RIVER COUNTY							
FPL/FIT Experimental Reef	1.2	274000	802000	1987	Benthic/Ocean	38	Oil ash and cement blocks
ST. LUCIE COUNTY							
North Beach Reefs	1.0	273021	801655	1961	Benthic/Ocean	36	Autos, concrete rubble
(2 Replenishments) - in the same year, but no other data available.							
Outer Reef Site		272648	801024	1987	Benthic/Ocean	125	
Inner Reef Site	1.5	272348	800200	1987	Benthic/Ocean	55-60	Tug, barge
Unnamed		272329	800200	1987	Benthic/Ocean		
Stan's Reef #2	11.5			1986	Combination/Ocean	150	Tug, FADs
Stan's Reef #1	13.0			1985	Combination/Ocean	192	Tug, FADs

MARTIN COUNTY: (Table 6)

Four reef sites, seven reefs (one of which is a FAD trolling alley), located 3.5 - 8.0 NM offshore in 58-85 feet of water. Predominant reef materials: Barges, bus bodies. Reef placements date from 1971 to present.

PALM BEACH COUNTY: (Table 6)

Ten reef sites, ten reefs, located 0.7 - 2.1 NM offshore in 35-240 feet of water. Two additional sites, 3.1 and 4.5 NM offshore, have been permitted but not yet developed. Predominant reef materials: ships, concrete and a Rolls Royce auto deployed for publicity purposes. Reef placements date back to 1965.

BROWARD COUNTY: (Table 6)

Seven large reef sites, 40 reefs, located 0.1 - 2.1 NM offshore in 12 - 388 feet of water. One recently permitted site, 2.0 NM offshore in 90 - 400 feet of water, has not been developed yet. The 40 reefs have individual names and not all could be correlated with the seven permitted areas. Predominant reefs materials: ships and vessels (13, including the MERCEDES I), Tenneco II oil rig platform decks and jackets. Reef placement date from 1967, but 31 of the reefs have been developed since 1982. Two sites function as artificial reefs but also include erosion control as one of the reasons for permitting.

Table 6. FLORIDA Artificinl Reef Projects - (Martin, Palm Beach, and Broward Counties)

REEF SITE		LOCATION			REEF CHARACTERISTICS		
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
MARTIN COUNTY							
Capt. Al Sirotkin Reef	8.0	271217"	800218"	1970	Benthic/Ocean	85	Landing craft, tires
(Replenishment)	3.25	271210	800620	1982	Benthic/Ocean	58	Barges, concrete barrels, tubs, bowls, toilets
Bill Donaldson Reef	3.25	271210	800620	1980	Benthic/Ocean	58	Barges, concrete barrels, tubs, bowls, toilets
FAD Trolling Alley		271348	795918	1984	Midwater/Ocean	150-250	FADs
Dr. Edgar Ernst Reef	4.7	270930	800330	1971	Benthic/Ocean	60	Barges, tires, bus bodies
(Replenishment)	4.7	270930	800330		Benthic/Ocean	60	Barges, tires, bus bodies
(Replenishment)	4.7	270930	800330		Benthic/Ocean	60	Barges, tires, bus bodies
PALM BEACH COUNTY							
Palm Beach Artificial Reef	1.0	264537	800100	1965	Benthic/Ocean	65-95	Vessels Amarylis and Mizpah, tires, metal, PC boat
Palm Beach Reef #1	2.1	264740	795934	1985	Benthic/Ocean	125	Concrete culverts, metal pipes
Palm Beach Reef #2	0.7	264507	800122		Benthic/Ocean	55-65	
Palm Beach Reef #3	1.2	264550	800015	1985	Benthic/Ocean	87	Car, barge, vessel
Jupiter Reef Site #1	3.1	265801	800105	1986	No materials		
Jupiter Reef Site #2	4.5	265758	795922	1986	No materials		
Boynton Beach Reef #2	1.2	263320	800111	1986	Benthic/Ocean	150-200	
Boynton Beach Reef #1	0.7	263154	800201	1986	Benthic/Ocean	35-70	
Boca Raton Reef #1	0.8	262141	800207		Benthic/Ocean	68	
Boca Raton Reef #2	1.3	263154	800336		Benthic/Ocean	160-240	

Table 6. FLORIDA Artificial Reef Projects (cont'd.) - (Martin, Palm Beach, and Broward Counties)

REEF SITE	LOCATION			REEF CHARACTERISTICS		
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
BROWARD COUNTY							
Deerfield Beach Reef	2.0	261857"	800258"	1986	No materials	90-400	
Rodeo Divers Reef	1.1	261317	800343	1985	Benthic/Ocean	78	Tugs, barge cement vessel, small vessels
Corey & Chris' (Rodeo)	1.7	261310	800307	1986	Benthic/Ocean	244	Steel barge
Renegade (Rodeo)	1.5	260747	800314	1985	Benthic/Ocean	190	Steel ship
Lowrance (Rodeo)	1.5	261231	800319	1984	Benthic/Ocean	180-210	Steel ship
Mako Reef (Rodeo)	1.6	261203	800330	1986	Benthic/Ocean	240	Numerous Mako hull molds
Caicos Express (Rodeo)	1.6	261155	800319	1985	Benthic/Ocean	237	Steel ship
Tote Machines	1.5	261149	800319	1986	Benthic/Ocean	200	Steel equipment
Chevron Tanks (Rodeo)	1.5	261136	800327	1983	Benthic/Ocean	170	Service station fuel tanks
FL League of Anglers	2.2	261010	800304	1986	Benthic/Ocean	388	Minesweeper
Rebel	1.2	260937	800400	1985	Benthic/Ocean	110	Steel ship
Jay Scutti	1.0	260849	800427	1986	Benthic/Ocean	67	Steel tug
Mercedes I	1.2	260837	800412	1985	Benthic/Ocean	97	Steel ship
Bill Boyd Reef	1.9	260833	800336	1986	Benthic/Ocean	265	Steel ship
Qualmann Barge	1.4	260813	800357	1983	Benthic/Ocean	145	Barge
Trio Bravo	1.4	260756	800354	1982	Benthic/Ocean	145	Steel tug
Houseboat	1.2	260748	800218	1974	Benthic/Ocean	95	Steel houseboat, small vessels
Riverbend	1.2	260743	800408	1983	Benthic/Ocean	98	small vessels
Grouper Grotto	1.4	260746	800413	1983	Combination/Ocean	150	Fuel tanks, concrete culvert, FADs
Spaghetti Barge	1.2	260746	800413	1972	Benthic/Ocean	105	Barge, LCVP, small vessels

Table 6. FLORIDA Artificial Reef Projects (cont'd.) - (Martin, Palm Beach, and Broward Counties)

REEF SITE	LOCATION			REEF CHARACTERISTICS		
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
Great Lakes	1.4	260741"	800355"	1984	Benthic/Ocean	170	Dredge pontoons and equipment
Monomy	1.0	260731	800421	1970	Benthic/Ocean	60	Yacht
Osborne	1.0	260735	800427	1972	Benthic/Ocean	73	Barge, erojacks, tires
Chevron I	1.0	260724	800433	1982	Benthic/Ocean	73	Fuel storage tanks, concrete culvert
Hog Heaven	1.0	260723	800435	1986	Benthic/Ocean	70	Barge
Powell Barge, DB 24	2.1	260715	800341	1986	Benthic/Ocean	314	Barge, concrete mixer drums
Rueben Reef	1.0	260715	800436	1986	Benthic/Ocean	70	PVC structure
U.S. Concrete Pipe	1.0	260717	800430	1983	Benthic/Ocean	70	Concrete culvert
DNR Barges	1.0	260714	800430	1982	Benthic/Ocean	70	Two barges
Trolling Alley	1.2	260706	800418	1984	Midwater/Ocean	110	Fish aggregating devices
Powell Barges	1.8	260700	800354	1982	Benthic/Ocean	270	Two barges
Fish Aggregating Device	1.3	260640	800407	1982	Midwater/Ocean	135	Subsurface buoy with 40' parasols
Erojacks Ft. Lauderdale	0.3	260637	800554	1967	Benthic/Ocean	14	Concrete Erojacks
Marriott Reef	1.0	260637	800432	1985	Benthic/Ocean	71	DC-4 airplane
TE AMO	1.5	260620	800352	1985	Benthic/Ocean	215	Sailing vessel
Chris Craft Molds	1.6	260609	800356	1978	Benthic/Ocean	210-240	Hull molds, small vessels and airplanes
Tracor/Navy Drydock	1.6	260601	800353	1982	Benthic/Ocean	220	Steel drydock
Erojacks Dania	0.1	260346	800624	1967	Benthic/Ocean	12	Concrete Erojacks
Tenneco II, Decks	1.6	255811	800441	1985	Benthic/Ocean	105	Three oil production platform decks
Tenneco II, Jackets	2.1	255810	800427	1985	Benthic/Ocean	190	Two oil production platform jackets

DADE COUNTY: (Table 7)

Seventeen permitted reef sites, 54 reefs, located 0.1 - 4.0 NM offshore in 10-372 feet of water. Similar to Broward County, individual reef names could not always be correlated with the permitted reef sites. Predominant reef materials: ships and barges (40), concrete. Reef placements date from 1947 with most (56) occurring during the 1980's.

MONROE COUNTY: (Table 7)

Seventeen reef sites, 28 reefs, located 4.0 - 25.0 NM offshore in 26-300 feet of water. Predominant reef materials: bridge rubble and vessels. One deep water (250 feet) site has been permitted but not developed. Reef placements date from 1961 but most reefs have been developed since 1982.

Table 7. FLORIDA Artificial Reef Projects – (Dade and Monroe Counties)

REEF SITE	LOCATION			REEF CHARACTERISTICS		
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
DADE COUNTY							
Fireboat	2.25	255031"	800402"	1973	Benthic/Ocean	222	Steel tug
Mine Sweeper	2.0	255001	800414	1971	Benthic/Ocean	180	Minesweeper
Lotus	2.25	254954	800450	1971	Benthic/Ocean	216	C.G. tender
Wolka Q	2.5	254922	800350	1980	Benthic/Ocean	282	Steel freighter
Pimellons	1.75	254906	800411	1971	Benthic/Ocean	135	Steel ferry
West End	2.25	254905	800401	1973	Benthic/Ocean	228	LCI
Julia Tuttle		254848	801012	1982	Benthic/Estuarine	28	Autos, boats, rubble
LCT	2.0	254842	800403	1969	Benthic/Ocean	202	Landing craft
Pipes	2.0	254833	800402	1978	Benthic/Ocean	204	Scrap steel, rubble
Deep Freeze	1.75	254821	800423	1976	Benthic/Ocean	120	Transport vessel
Dry Dock	2.5	254819	800343	1978	Benthic/Ocean	330	Pontoon dock
Hopper Barge	2.25	254718	800354	1970	Benthic/Ocean	234	Metal barge
Shrimp Drift-Boats	4.0	254209	800510	1981	Benthic/Ocean	85-100	Vessels
Biscayne Wreck	3.5	254208	800517	1976	Benthic/Ocean	55	Freighter
Dade County Reef	5.0	254200	800406	1977	Benthic/Ocean	220	Concrete rubble
Arida	4.0	254143	800424	1982	Benthic/Ocean	90	Steel LCT
Lakeland	4.25	254129	800423	1982	Combination/Ocean	126-140	Steel ship, midwater reefs
Star Trek	4.75	254128	800401	1982	Combination/Ocean	210	Steel ship, midwater reefs
Orion	4.0	254126	800503	1981	Benthic/Ocean	95-100	Steel tug
Cement Mixer	4.0	254105	800447	1982	Benthic/Ocean	75-92	Twenty cement mixer bowls
Hopper Barge	5.25	253643	800437	1981	Benthic/Ocean	160-166	Steel hopper barge

Table 7. FLORIDA Artificial Reef Projects (cont'd.) - (Dade and Monroe Counties)

REEF SITE	LOCATION			REEF CHARACTERISTICS			
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
Railroad Barge	6.5	253448"	800449"	1980	Benthic/Ocean	163	Steel barge
Santa Rita	5.0	252436	800550	1976	Benthic/Ocean	240-247	Steel ship
Almirante	4.75	252416	800626	1975	Benthic/Ocean	122-132	Refrig. vessel
Belcher Barge	4.75	252357	800629	1973	Benthic/Ocean	117-122	Fuel barge
San Rafael	2.5	*	*	1980	Benthic/Ocean	330	Steel freighter 200 ft.
Dumfoundling Bay Reef	0.1	255654	800746	1985	Benthic/Estuarine	35	Steel tanks, drums, concrete
Cruz Del Sur	2.3			1986	Benthic/Ocean	230	Steel freighter
Greynolds Park Reef	0.1			1987	Benthic/Estuarine	12	Limerock boulders
North Bayshore Park Reef	0.1	255315	800904	1982	Benthic/Estuarine	5-7	Concrete rubble, pipe
Liberty Ship	2.5	255259	800339	1976	Benthic/Ocean	372	Liberty Ship
Crane Boom	2.75	255200	800500	1947	Benthic/Ocean	70-85	Crane boom
Narwal	2.1			1986	Benthic/Ocean	115	Steel freighter
Rossmerry	2.25			1985	Benthic/Ocean	240	Steel freighter
Andro	2.0			1985	Benthic/Ocean	103	Steel freighter
Anchorage Area Reef	1.5			1984	Benthic/Ocean	46	Vessels
Shamrock	1.5			1985	Benthic/Ocean	44	Steel LCT
John Koppin Memorial Reef	1.5			1986	Benthic/Ocean	45	Steel barge, concrete pipes
Rickenbacker Cswy Reef	.25	254451	801054	1986	Benthic/Estuarine	10	Concrete pilings, bridge rubble
Mercy Hospital Reef	.10	254418	801240	1984	Benthic/Estuarine	10	Concrete bridge rails, bicycle racks
Proteus	3.75			1985	Benthic/Ocean	72	Steel freighter
Steane D'Auray	4.0			1986	Benthic/Ocean	68	Steel trawler
Moby One	5.0			1983	Benthic/Ocean	97	Wood shrimper

Table 7. FLORIDA Artificial Reef Projects (cont'd.) - (Dade and Monroe Counties)

REEF SITE		LOCATION		REEF CHARACTERISTICS			
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
Ultra Freeze	5.0			1984	Benthic/Ocean	120	Steel freighter
Hopper Barge	5.25	253643"	800437"	1981	Benthic/Ocean	163	Steel hopper barge
Railroad Barge	6.5	253448	800449	1980	Benthic/Ocean	163	Steel barge
Pioneer I	7.0			1983	Benthic/Ocean	215	Steel freighter fuel tanks
Blue Fire	6.5			1983	Benthic/Ocean	110	Steel freighter
Sir Scott	4.75			1985	Combination/Ocean	220	Steel freighter, FAD
FPL Stacks North	4.5			1983	Benthic/Ocean	185-195	Steel exhaust stacks
FPL Stacks South	4.5			1983	Benthic/Ocean	185-195	Steel exhaust stacks
Doc De Milly	5.0			1986	Combination/Ocean	140	Steel freighter, FADs
MONROE COUNTY							
Alva Chapman Reef	8.0	251236	801136	1978	Benthic/Ocean	220	Two concrete hulls, dredge pipe
Islamorada Art. Reef	5.0	245142	803406	1981	Benthic/Ocean	110	Concrete rubble
(3 Replenishments)	5.5	245105	803345	1984	Benthic/Ocean	210	Vessels
American Shoal Reef	1.7	243400	812000	1982	Benthic/Ocean	40-45	Concrete, bridge rubble
Big Pine Shoal Reef	4.0	243300	812800	1982	Benthic/Ocean	123	Concrete, bridge rubble
Wilkes Barre	9.0	242848	813300	1961	Benthic/Ocean	200-300	Cruiser, destroyer
Conzelman Reef	5.75	252000	800700	1985	No materials	200-300	
Key Largo Art. Reef		250100	802310	1987	Benthic/Ocean		
Long Key Art. Reef	2.5			1986	Benthic/Ocean	26	Concrete bridge rubble
E. Turtle Shoal Art. Reef					Benthic/Ocean	31	
Marathon Reef	5.0	243930	805830	1982	Benthic/Ocean	115	Concrete bridge rubble
(Replenishment)	5.0	243930	805830	1986	Benthic/Ocean	115	Freighter

Table 7. FLORIDA Artificial Reef Projects (cont'd.) - (Dade and Monroe Counties)

REEF SITE	LOCATION		REEF CHARACTERISTICS			
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
Seven Mile Bridge Reef	2.0	24°36'20"	80°10'00"	1982	Benthic/Ocean	115	Concrete and steel bridge rubble
(Replenishment)	2.0	243620	811000	1984	Benthic/Ocean	115	Numerous sections of steel barge
Bahia Honda Art. Reef	2.6			1985	Benthic/Ocean	30	Concrete rubble and bridge decks, pipe, steel
Big Pine Art. Reef	4.0	243300	812800	1982	Benthic/Ocean	123	Shrimp boat
Labriola Reef	4.2	243020	813754	1984	Benthic/Ocean	13	Unconfirmed construction
Cayman Salv. Master Reef	5.2			1985	Benthic/Ocean	86	Steel freighter
Key West Tournament Reef	7.0	242747	814615	1983	Benthic/Ocean	180	Ship curb
(Replenishment)	7.3	242747	814615	1983	Benthic/Ocean	184	Steel barge
(Replenishment)	7.5	242747	814615	1983	Benthic/Ocean	180	Ship L.S.M.R.
Key West Gulfside	8.1			1983	Benthic/Ocean	32	Steel I-beams
(3 Replenishments)	8.1			1983/1986	Benthic/Ocean	32	Rubble, barge, vessels
Gunbor Reef	25.0			1985	Benthic/Ocean	523	Steel ship

ARTIFICIAL REEF DEVELOPMENT

IN

GEORGIA

Prepared By:

Henry Ansley, Georgia Department of Natural Resources

Georgia is bordered by a flat and generally featureless continental shelf characterized by sand and clay (Harris, 1978). This shelf is sporadically interspersed with "islands of broken relief" commonly referred to as "live bottom relief" or simply as "live bottoms" (Struhsaker, 1969). Hunt (1974) defined these live bottoms as "an outcrop of a body of rock on an otherwise sandy bottom which expresses relief above the surrounding bottom and supports an accumulation of sessile benthos". Further, these areas provide habitat for a diverse ichthyological assemblage represented by snappers, groupers, porgies, and jacks (Struhsaker, 1969).

Some scientists feel that the occurrence of natural live bottom reefs off Georgia may be less than 5% overall, the lowest percentage among the southeastern states (Parker, 1983). Inside the scattered "snapper banks" found 35-40nm offshore and outside of the Gray's Reef National Marine Sanctuary, 17nm east of Sapelo Island, this small percentage of natural reefs decreases even further, offering few opportunities for gamefish and anglers alike. Because of this lack of natural reef areas close to shore, Georgia has been active in artificial reef development.

Georgia Reef Programs

Much of the history of Georgia's early artificial reef efforts is found in a review of "The Fisheries Resources on Selected Artificial and Live Bottom Reefs on Georgia's Continental Shelf" by Harris, 1978. During the mid 1930's Malcolm McKinnon, then Chairman of the Glynn County Commission and the State Game and Fish Commission, organized the first artificial reef construction efforts in Georgia. With the assistance of the U.S. Bureau of Commercial Fisheries, he and his sportfishing associates acquired a 60-foot wooden vessel and towed it offshore of Jekyll Island, where they sank it to provide offshore fish habitat. Fishing was outstanding around Georgia's first artificial reef, which still provides some fishing today.

On April 9, 1942, artificial reef construction in Georgia received an unexpected boost when the 3365 gross ton Freighter ESPARTA was torpedoed by a German submarine and sank 16nm offshore of Cumberland Island. During the next few years several operations were conducted to salvage the ESPARTA. Explosives used during these efforts reduced the vessel to jagged sheets of metal which now rise up to 25' above the ocean floor. The wreck was eventually buoyed by the U.S. Coast Guard and designated Brunswick Coastal Wreck Lighted Bell Buoy WR2. Recently designated Georgia Artificial Reef C, WR2 became an outstanding fishing location for anglers for Georgia and Florida and remains so today.

Excellent SCUBA diving provided by the ESPARTA was impetus for the Golden Isles Skin Divers to also initiate artificial reef construction efforts. During mid 1960's the Golden Isles Skin Divers sank a 70-foot wooden vessel and placed two bargeloads of scrap material consisting of bus and automobile bodies,

refrigerators, stoves, sinks, sewer pipe, etc., southwest of U.S. Coast Guard Buoy R2B, located 13nm east of Jekyll Island. They also constructed another artificial reef using similar scrap material midway between Buyos R2B and WR2.

Several problems with these early reefs, however, essentially eliminated any further private efforts. As elsewhere, automobile and bus bodies quickly deteriorated, while some of the more buoyant material found its way into the commercial fishing grounds and fishermen's nets. Errant buoys and untested buoy system compounded the problems, resulting in the loss of the reef sites entirely. These problems, along with chronic labor and funding shortages, convinced many that a successful artificial reef construction program would best be conducted by a governmental agency. The government agency that eventually assumed this role was the state of Georgia's Game & Fish Commission, later becoming the Georgia Department of Natural Resources (Table 8).

Table 8. Georgia Program Activities

REEF FISHERY MANAGEMENT AUTHORITIES (Federal and State):
Coastal Resources Division, Georgia Dept. of Natural Resources
South Atlantic Fishery Management Council

NUMBER OF PERMITTED REEF SITES: 16
Number In Federal Waters: 10
(3-200 miles offshore)
Number in Territorial Sea: 0
(0-3 miles offshore)
Number in Inshore Waters: 6
(estuarine, riverine)

TYPES OF REEFS:
Benthic - 16
Midwater - 0
Combination - 0

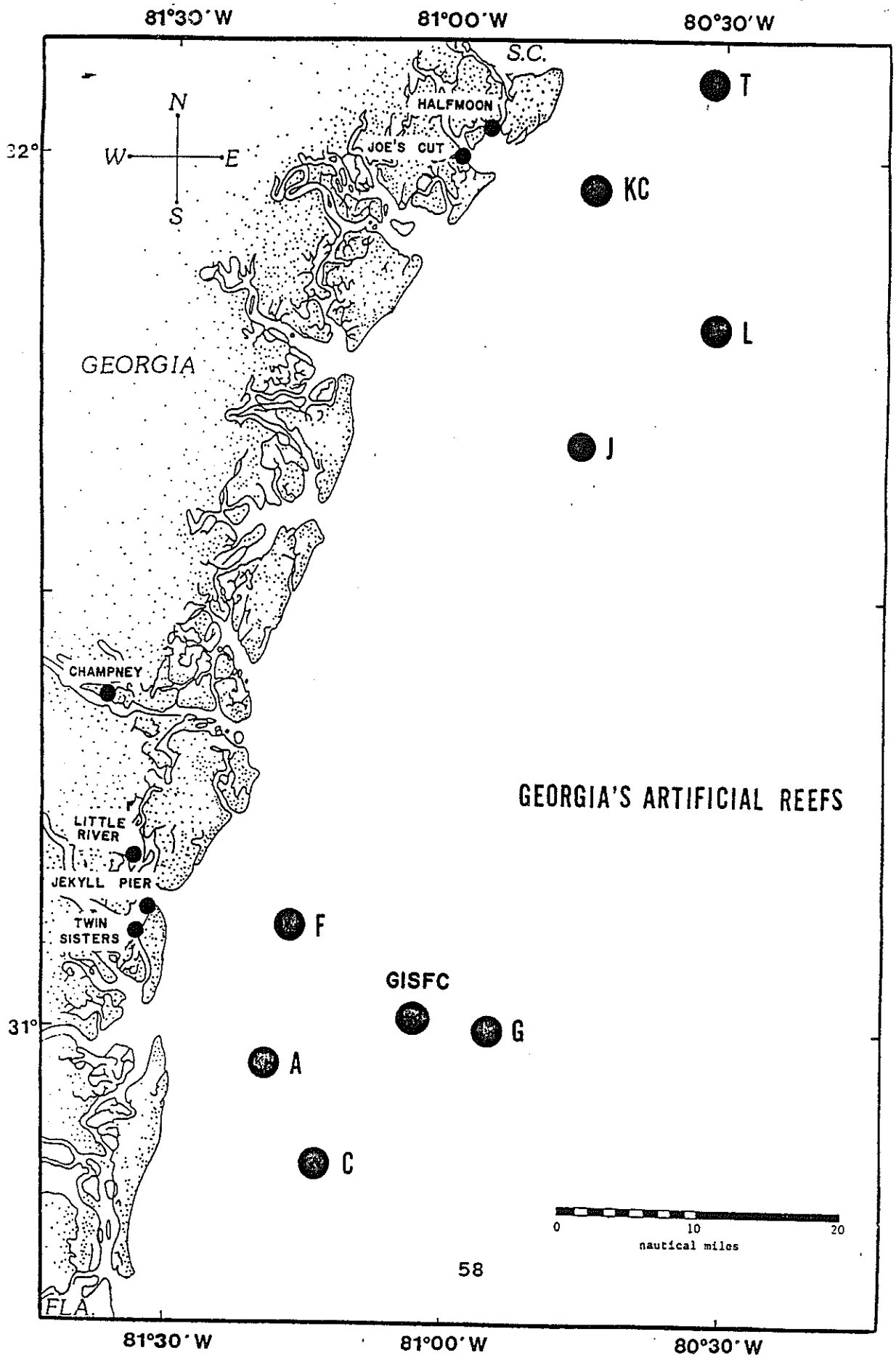
REEF COORDINATOR:
Henry Ansley, Georgia Department of Natural Resources
Outer Continental Shelf Program
Coastal Resources Division
Georgia Dept. of Natural Resources

STATE REEF PUBLICATIONS:
Georgia's Offshore Artificial Reefs, by Georgia Department of Natural Resources.

STATE ARTIFICIAL REEF PLAN: None

The state run program has 16 permitted reef sites that includes both inshore and offshore locations (Figure 9). Thus, state program endeavors can be divided according to inshore and offshore activities.

Figure 9. Distribution of Georgia Artificial Reef Sites



Offshore Program

State involvement in a directed fisheries enhancement program offshore began with preliminary research in the late 1960's and followed with construction in the early 1970's. Although experimental inshore reefs proved ineffective, small offshore pilot reefs composed of scrap tires bound into units showed promise (Smith, 1972). Additional investigations by Game and Fish Commission biologists and National Marine Fisheries Service artificial reef staff also indicated that durable, stable and inexpensive reef material could be constructed with tires (Smith, 1976), long considered a major disposal problem ashore.

With increased federal support from the Coastal Plains Regional Commission, the Georgia Department of Natural Resources began major offshore reef construction in 1971. Directed at improving and creating more accessible offshore recreational fishing opportunities, newest undertaking was able to utilize a growing volume of artificial reef research findings and the experiences of other programs to address many potential managerial problems prior to actual construction offshore. Construction sites, for instance, were chosen on the basis of water depth, substrate, material type, non-reef user conflicts, proximity of population centers, and local recommendations. Reef configurations were aimed at providing hatitat for those demersal and pelagic fish targeted by Georgia anglers (Smith, 1972). Large, highly-visible buoys were also placed and maintained to assist fishermen navigate safely to the reefs (Smith, 1974), most of which were finally necessary water depths and to avoid conflicts with commercial trawling interests (Harrington, 1972).

In 1978, CPRC and matching state funds earmarked for reef construction and buoy maintenance ended. Reef development came to rely on available state funds and on the efforts of coastal sportfishing clubs. Buoy maintenance was fortunately able to continue on almost uninterrupted with Dingell-Johnson support.

Offshore research on the artificial reefs similarly continued relatively unbroken until 1978. Discontinuance of offshore artificial reef investigations that year, however, only represented a shift in emphasis by the state to broader research objectives across the entire shelf, rather than loss of funding. During the previous ten-year period, Dingell-Johnson investigations had attempted to address problems and questions concerning the management of the offshore artificial reefs. In addition to the earlier studies concentrating on material design and durability, later studies concentrated on the biological aspects of the reefs (Harris, 1978: Ansley and Harris, 1981), canvassed user groups to evaluate angling pressure and success (Harris and Ansley, 1981), and published a brochure to help anglers locate reefs (DNR, 1987).

With the Wallop-Breaux amendment, Federal Aid in Sportfish Restoration funds increased substantially, providing greater support for Georgia's offshore artificial reef program.

Currently administered by the Outer Continental Shelf Program of the Coastal Resources Division, Georgia Department of Natural Resources, the state reef program has resulted in eight reefs from 7-23nm offshore, including a jointly constructed reef with South Carolina.

As did other states, the Georgia program utilized scrap automobile tires as material in its earlier years. Following some initial failures, an eight-tire unit compressed and held together by iron rods anchored in a concrete-filled base tire was developed and eventually constituted the program's primary bottom material. Scrap vessels, ranging from a 33' utility boat to two 440' liberty ships, have also been placed at the offshore reefs, as has concrete culvert and rubble.

Today, almost 173,000 tires, 21,000 tons of concrete, a WWII wreck, and 17 vessels make up the state's offshore artificial reef system. In addition, another offshore reef composed of two vessels has been successfully constructed east of Brunswick, Georgia, by the Golden Isles Sport Fishing Club.

Georgia's reef program has also established an all-yellow buoy with a tower and radar reflector at each of the state's offshore artificial reefs (except Reef T, which is marked by South Carolina). Maintained regularly, the buoys are intended to help fishermen and divers to not only locate the reefs (which are typically out-of-sight of landmarks), but also assist them in finding the various structures at each site. Each marker similarly provides important backup should electronics fail.

In other areas, concerns over the impact of seasonal fish trapping (primarily for black sea bass) and the harvest of jewfish led Georgia to follow South Carolina's lead in designating its offshore artificial reefs as "Special Management Zones", or SMZ's. In 1987 the South Atlantic Fishery Management Council approved the state's request and established the artificial reefs as SMZ's (Federal Register, 1987). As SMZ's 1) fishing gear was limited to hand-held hook-and line or spearfishing gear; and 2) the possession of jewfish was prohibited, regardless of the gear used.

Two user groups utilize the offshore artificial reefs - recreational fishermen and divers. Some conflicts have arisen between these interests, primarily over wrecks and similar structures that are attractive to both groups.

Recreational fishing on Georgia,s reef occurs year-round, but is most concentrated from mid-spring through late fall. During these warmer months, bluefish, cobia and little tunny show up earliest, followed by amberjack, king and Spanish mackerel, sharks, barracuda, crevalle jack, and an occasional dolphin, sailfish or tuna. Popular bottom fish include black sea bass, red and vermilion snapper, grouper, sheepshead, spadefish, triggerfish and others. Weakfish and large red drum also are caught on the reefs in late fall, winter and spring.

In recent years, interest in SCUBA diving off Georgia's coast has increased. Most of this activity, including spearfishing and underwater photography, takes place in the warmer months and at the deeper reefs, which feature better visibilities. Overall, however, visibilities can vary daily, depending on tides, seas, water depth, and distance offshore. Currents can also be very strong. Finally, since the offshore artificial reefs were built primarily to provide structures for fish and not divers, entanglement and entrapment are dangers unavoidably associated with the reef materials. Divers are cautioned to judge each situation carefully.

Presently, Georgia's artificial reef program relies on Federal Aid in Sportfish Restoration Funds matched primarily by state in-kind services and salaries. Since the Wallop-Breaux amendment, funding for Georgia's offshore reef construction and buoy maintenance has increased, ranging from $36,000 annually (including the 25% state in-kind match). Project personnel include a part-time biologist and technician.

Depending on funding and available permitting, the Division's offshore artificial reef program hopes to increase the size and number of its offshore reefs. Several more Georgians possessing small boats (averaging 16'-19') and who may not have the navigational skills or equipment to venture further offshore.

With the development of inexpensive, highly accurate LORAN C electronics and improved buoy systems, it is felt that specifically designed units or very heavy materials may be in more accessible locations near traditional fishing grounds. In an attempt to minimize conflicts with trawling interests, these nearshore structures will be located, if possible, around existing "hangs" or on unproductive bottoms. By working closely with the commercial fishing industry throughout the permitting stages, it is felt that appropriate areas can be identified and reefs sited with minimal impacts.

Further offshore, existing reefs will be expanded primarily with materials-of-opportunity that require greater water depths and clearances. The creation of more artificial reefs in these depth zones (40'-80') is not anticipated, although additional reefs may be needed in the future near to the state's growing population centers.

Inshore Program

Georgia's inshore artificial reef construction program began officially in the late 1960's with the placement of some small estuarine reefs composed primarily of tires. Placed by the Georgia Game and Fish Commission in cooperation with other state agencies, the reefs, however, were quickly lost and further inshore efforts were discontinued as program efforts moved offshore.

Construction of inshore reefs did not occur again until the eighties. Coordinated by the Georgia Department of Natural Resources, concrete bridge rubble was placed sub-tidally to enhance angling adjacent to a bridge catwalk and park in McIntosh County as part of a bridge reconstruction project. In the mid-eighties these limited efforts were followed by similar construction activities in neighboring Glynn County. Coordinated by DNR's Coastal Resources Division, bridge rubble was again placed near a fishing catwalk and a public pier on Jekyll Island state park.

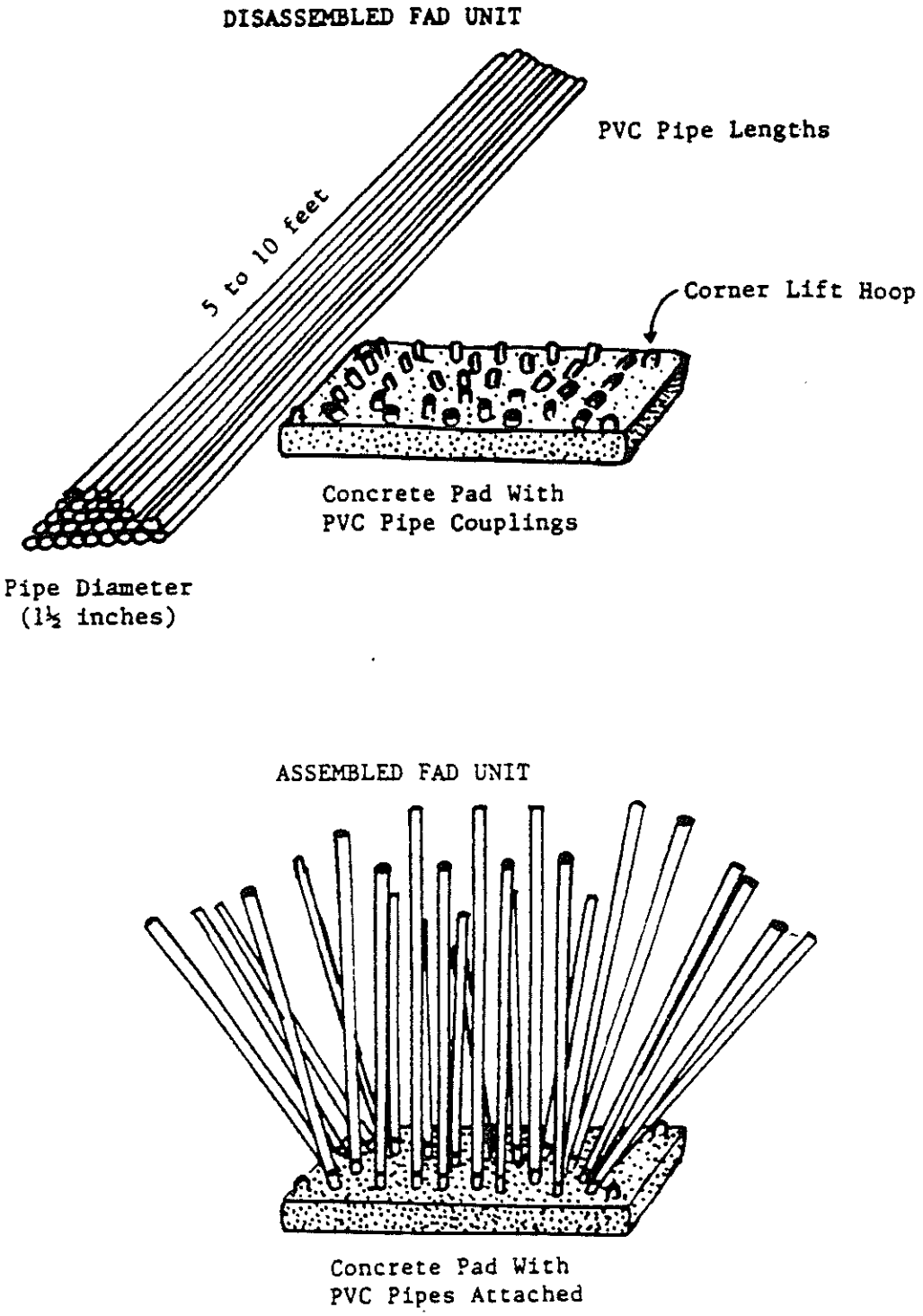
With increased Wallop-Breaux funds, Coastal Resources Division's Recreational Fisheries Program expanded its inshore reef construction activities. To date, all of the reefs sited inshore were subtidal, providing excellent opportunities for sheepshead and black drum. Program biologists, however, recognized that more popular recreational species, such as spotted seatrout and red drum, would require different habitat more similar to naturally occurring oyster reefs. For this reason, the program launched its efforts to create intertidal artificial reefs that would provide the hard substrate needed for oyster growth. Composed of PVC pipes anchored in concrete and weighing 300 to 350 pounds apiece, an experimental FAD was developed, tested and deployed (Figure 10).

To date, over 120 of these units have been placed at the Twin Sisters reef site in Glynn County. Placement of additional FAD's at two recently approved sites in Chatham County will likely occur in 1988-1989. Deployment, however, will be restricted until the FAD's are evaluated fully over a long-term period to determine their effectiveness. Other future activities of the inshore artificial reef construction program include the development of additional units, equipment acquisition, and possible enhancement of public fishing areas near piers and parks.

As with the offshore program, inshore reef construction relies on Federal Aid in Sportfish Restoration funds matched by state in-kind services, primarily salaries. Again, Wallop-Breaux increases created the support needed to initiate a Georgia inshore reef construction effort. This funding also provides the needed maintenance associated with the marking of the inshore reef sites. Typically, one to four pilings with warning signs are used, depending on the reef's size and location.

Total funding for the inshore reef development and maintenance program was $19,900 and $35,000 for FY 87 and FY 88, respectively (including the state's 25% match). No full-time personnel are assigned to this one program; instead, these duties are shared among three biologists, a project technician, and project laborers.

Figure 10. Georgia Inshore Fish Aggregating Device



Drawing of experimental inshore fish aggregating device (FAD). Top drawing shows FAD unit disassembled for transportation to artificial reef site and lower drawing shows unit assembled and ready for placement. On-site FAD unit assembly allows transportation of more units to the reef construction site.

Georgia Reef Projects

Of the 16 permitted artificial reef projects in Georgia (Table 9), 10 are located in federal waters (3-200 miles offshore) and 6 are in inshore locations (estuarine and intertidal riverine areas). None are located in the Territorial Sea (0-3 miles offshore).

REEF A

Located seven nautical miles east of Little Cumberland Island, bottom material at this site consists of 1,700 tire units and concrete wharf rubble from the Kings Bay Naval Submarine Base. While tire units are scattered throughout, major concentrations are located approximately 250 yards northeast of the buoy. Concrete rubble is found 400 yards to the east and south, with vertical relief up to 10 feet.

REEF C (WR2)

Located 13.5 nautical miles east of Cumberland Island, this site was formerly buoyed by the U.S. Coast Guard to mark a freighter sunk during World War II. Repeatedly salvaged, the wreckage now bears little resemblance to a ship and consists primarily of large, encrusted boiler sections. Placed in the early 1970's, scattered tire units with heavy marine growth are found approximately 600 yards southeast of the buoy, but have settled and are difficult to find. More easily marked are the 12-15 foot stacks of concrete wharf rubble, 400 yards to the north, south and east-southeast of the buoy.

REEF F

Two 55-foot landing vessels and 6,000 tire units make up this reef, located nine miles east of Jekyll Island. The vessels are approximately 670 and 1300 yards east of the buoy and most tire units are concentrated 75 to 400 yards north and northwest of the buoy. The vessels exhibit up to 12 feet of relief and the tire units three to four feet of relief.

REEF G

The largest of Georgia's artificial reefs, Reef G is located 23 nautical miles east of Little Cumberland Island. The reef consists of 3,000 tire units located 100-250 yards to the north, northeast, south, and west of the buoy, as well as several wrecks, including the 441-foot liberty ship, **E.S. Nettleton**; a 33-foot utility boat; and the 100 and 108-foot tugboats, **Tampa-A and Recife**. Often conspicuously marked by schools of baitfish, the **Nettleton** and **Recife** are well away from the buoy to take advantage of deeper waters and to ensure permitted depth clearances are maintained. Vertical profiles at Reef G range from 5 feet over the tires to almost 40 feet over the liberty ship.

Table 7. GEORGIA Artificial Reef Projects

REEF SITE		LOCATION		REEF CHARACTERISTICS			
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
Reef A	7.0	305509"	811509"	1976	Benthic/Ocean	35	Tires, concrete, rubble
Reef F	9.0	310509	811205	1971	Benthic/Ocean	38	Vessels, tires
Reef C (WR 2)	13.5	305008	810907	1969	Benthic/Ocean	47	Vessels, rubble, tires concrete
Reef G	23.0	305804	805807	1971	Benthic/Ocean	70	Vessels, tires
Reef J	17.4	313600	804702	1973	Benthic/Ocean	65	Vessels, tires
Reef KC	9.0	315007	804606	1972	Benthic/Ocean	42	Vessels, tires
Reef L	23.0	314508	803605	1976	Benthic/Ocean	60	Vessels, tires, culvert, concrete
Reef T	11.7	320007	803604	1976	Benthic/Ocean	45	Tires
Reef R2B	13.0	310445	810905	1976	Benthic/Ocean	45	Rubble
Golden Isles	18.0	305909	810201	1983	Benthic/Ocean	55	Vessels
Champney River Fishing Reef	0.1			1981	Benthic/Estuarine	12	Concrete, rubble
Little River Fishing Reef	0.1	311013	812653	1984	Benthic/Estuarine	20	Concrete, rubble
Jekyll Pier Fishing Reef	0.1	310700	812540	1984	Benthic/Estuarine	20	Concrete, rubble
Twin Sisters Fishing Reef	4.0	310600	812500	1987	Benthic/Estuarine	5	FADs
Halfmoon River Fishing Reef	4.0	315700	805600	1987	Benthic/Estuarine	4	None
Joe's Cut A Fishing Reef	2.0	315400	805900	1987	Benthic/Estuarine	3	None

REEF J

Located 17.4 miles east of St. Catherine's Island, three vessels have been placed at Reef J including the 55-foot ferry **Janet**, the 105-foot tugboat **Elmira**, and the 444-foot **A.B. Daniels**, the second of the liberty ships obtained by the state reef program. Sunk in 1975, the **Daniels** is in two pieces as a result of 1979's Hurricane David which moved the ship's stern almost 200 yards south of the main wreck. Other materials include 1,000 tire units scattered between the buoy and the **Daniels**. Relief ranges from five feet over the tires to 35 feet at the ship. Small and scattered pieces of live bottom are found to the south and east of the buoy.

REEF KC

Nine nautical miles southeast of Tybee Island, this artificial reef is largely composed of tires, with 5,700 units scattered throughout the area. Major concentrations are found 75-400 yards southeast, southwest, west and northwest of the buoy. One vessel, the 95-foot LCU **Motherlode**, lies south of the buoy. Relief exhibited by the tires and vessel ranges from 3-7 feet.

REEF L

Located 23 nautical miles east of Ossabaw Island, Reef L was started in 1977 and has become one of the state's largest offshore reefs. It is composed of two 90-foot barges; a 150-foot dredge, the Henry Bacon; and the 100-foot tugboat, Senasqua. Almost 2,000 tire units also are scattered between the two steel barges. Concrete culvert placed by the Savannah Sport Fishing Club also can be found scattered southeast of the buoy. Exhibiting 4-5 feet of relief, both the tire units and culverts may at times be difficult to locate, but the wrecks with 10-30 foot profiles, are easily detected on depth finders.

REEF T (HILTON HEAD REEF)

Representing a joint construction effort by Georgia and South Carolina, Reef T is located 11.7 nautical miles east of Tybee Island. South Carolina presently maintains three primary markers to help anglers locate three wrecks and a midwater trolling alley deployed between the northern and southern buoys. Concentrated to the north and south of the northernmost wreck, 1,000 tire units can also be found, exhibiting 4-5 feet of relief. Vessel profiles range from 5-10 feet. Scattered, low-relief live bottom is present on and near the reef.

REEF R2B

Although the state obtained the permit, the reef itself was constructed by the Golden Isles Sport Fishing Club. Located a few hundred yards north of USCG Buoy R2B, only very limited amounts of tires, concrete and ceramic pipes were off loaded at the site. Since then, the low relief material has not been relocated, causing speculation that the reef may have entirely or partially silted in.

GOLDEN ISLES SPORT FISHING CLUB (GISFC) REEF

Unbuoyed, the GISFC reef consists of two 55' landing crafts, the **Optimist** and the **Scalper.** The wrecks are located approximately one hundred yards apart. Bottomfish on the wrecks include black sea bass, porgies, and grouper. Good catches of king mackerel, barracuda, amberjack, and even an occasional blackfin tuna or sailfish have been made in this area. Its permit recently renewed, the club anticipates furter construction.

CHAMPNEY RIVER FISHING REEF

Rubble resulting from the replacement of the Champney River bridge was used to construct a subtidal artificial reef parallel to a new fishing catwalk and adjacent to a newly built park/recreation area. Striped bass and large black drum are frequently landed at this site.

LITTLE RIVER FISHING REEF

Approximately 480 cubic yards of bridge rubble resulting from the expansion of the F.J. Torras causeway in Glynn County was used to construct the Little River bridge fishing reef. Located south of a newly established fishing catwalk, the material was placed in a lattice type configuration parallel to the river banks. The center portion of the channel remained clear and a minimum 8' water clearance was maintained over the structures (MLW). Intended to provide maximum surface area and free passage for fish, the crisscross design provides excellent fishing for sheepshead and black drum; spotted seatrout are also taken. Pilings with signs are situated on the southern end of each structure.

JEKYLL PIER FISHING REEF

Also utilizing F.J. Torras causeway rubble, almost 160 cubic yards of concrete was placed between the western arm of the Jekyll Island fishing pier and the adjacent shoreline. Latticed construction was again employed at this site, where it was hoped that the material would not only enhance fishing, but also reduce current velocities. Located at the south end of Jekyll Island state park, the reef is marked by a single piling and maintains a MLW clearance of six feet. Although it is still too early to ascertain any improvements over these subtidal structures, anglers report good catches of black drum and occasionally spotted seatrout and flounder.

TWIN SISTERS FISHING REEF

The first of Georgia's inshore artificial reefs program designed FAD's constructed from concrete and PVC, the Twin Sisters reef is located on the western shore o Jekyll Island and is accessible only by boat. Over 120 of the FAD's have been deployed in rows perpendicular to the shore, extending from the low tide line to a depth of 10 feet (MLW). Partially exposed at low tide, it is anticipated that the units will provide the needed foundation for oyster growth and provide fishing for spotted seatrout, red drum, sheepshead, black drum, and flounder. The site is marked by four corner pilings.

HALFMOON RIVER FISHING REEF

Recently permitted, the Halfmoon River fishing reef will be constructed with program FAD's. Slated to be deployed in "quad" design rather than parallel rows, the number of units will similarly be limited initially until the FAD and its placement configurations can be fully evaluated. Program staff hope to determine whether the grouping of the units ("quad" design) or placement in rows are equally effective and accessible to the boating fisherman. This Chatham County site will also be marked by corner pilings.

JOE'S CUT FISHING REEF

The second of two fishing reefs approved for the Wassaw Sound system in Chatham County, Joe's Cut fishing reef will also employ FAD's as the primary reef material. Also experimental in nature, the area will be marked by a single piling.

ARTIFICIAL REEF DEVELOPMENT

IN

MARYLAND

Prepared By:

John Foster and Jim Martin
Maryland Department of Natural Resources

Maryland has been involved with artificial reef construction for over 20 years. Efforts from as early as 1960 are documented. The state has initiated a major reef building program which started in 1986. This program is due largely to the advent of the Chesapeake Bay Sport Fishing License. Reefs have been constructed in both the Chesapeake Bay and the Atlantic Ocean adjacent to the Maryland coast and have been constructed of both materials of opportunity and specifically designed reef modules. In addition to these marine units, the Department of Natural Resources' Tidewater Administration plans for species designed reefs for all the haline regimes of the Chesapeake estuary.

Maryland Reef Program

Maryland's artificial reef program is responsible for habitat restoration and creation in the tidal waters of the state (Table 10). Funding for the Chesapeake Bay activities comes from the Chesapeake Bay Sport Fishing License. Oceanside reefs have been funded through user donations and local government contributions. The program is operated by one staff person who is responsible for overseeing planning and development, construction contracting, inspection, and evaluation. Seasonal assistance has occasionally been available.

Table 10. Maryland Program Activities

REEF FISHERY MANAGEMENT AUTHORITIES (Federal and State):
Mid-Atlantic Fishery Management Council
Maryland Department of Natural Resources, Tidewater Administration

NUMBER OF PERMITTED REEF SITES: 21
Number In Federal Waters: 2
(3-200 miles offshore)
Number in Territorial Sea: 4
(0-3 miles offshore)
Number in Inshore Waters: 15
(estuarine, riverine)

TYPES OF REEFS:
Benthic - 19
Midwater - 2
Combination - 0

REEF COORDINATOR:
John Foster, Maryland Department of Natural Resources, Tidewater Administration

STATE REEF PUBLICATIONS: None

STATE ARTIFICIAL REEF PLAN: None at present; Plan to be completed in 1989.

As of the summer of 1988, the Maryland Recreational Fisheries Program has constructed seven new reefs in the Chesapeake Bay and one offshore near Ocean City. Permits for two additional sites (one bay, one ocean) have been applied for. Work has begun on the Maryland Artificial Reef Development Plan (MARDP).

Maryland Artificial Reef Plan

Program personnel have developed the goal and objectives for an artificial reef development and and management plan, MARDP, and establishing a salinity based classification scheme for the tidal waters of Maryland. The classification system was based upon the distribution of important sport fishing target species. The goal of the program calls for the use of specific reefs designed, sited, and constructed for important recreational fish species. The objectives of MARDP are: 1. increasing available hard substrate in tidal waters; 2. spreading out recreational fishing pressure; and 3. increasing overall sport fishing success.

Under the classification scheme, five separate regions were established for artificial reef development. Each region has various target species important to sport fishing in that zone. These fish species include large mouth bass and channel catfish in the tidal freshwater zone, striped bass and bluefish in the middle mesohaline zones, and weakfish, bluefish, and black seabass in the lower Bay zone. In the Atlantic Ocean, black seabass and tautog were targeted. In all, about 15 species are represented as target species in the various zones.

Maryland Reef Projects

There are 21 reef sites on record in the Maryland reef program with 8 of those activated in the last two years (Table 11). The selection of these new reef sites was based upon numerous criteria. These reefs were designed so to facilitate evaluation of estuarine reefs. The need for information was due to the fact that existing literature contains few papers on estuarine reefs, especially those in the headwaters of an estuary similar to the Chesapeake Bay. Six sites were selected for development, with an additional site if time and funding permitted.

Initial siting criteria addressed location, substrate, salinity, species availability, depth, water quality, other fisheries, and shipping lanes. Although no precise distances were available for this review, the vast majority of Bay reefs were located within two miles of shore. One particularly notable site is the Cedar Point Reef which beyond its use by fishermen, serves as an experiment by the state using 3 different reef systems including quarry rock, Japanese Fiberglas Reinforced Plastic (FRP) units, and U.S. Beach Prisms.

Table 7. MARYLAND Artificial Reef Projects

REEF SITE		LOCATION		REEF CHARACTERISTICS			
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
CHESAPEAKE BAY							
Cedarhurst Reef		385024"	762743"	1966/1983	Benthic/Estuarine	30	Concrete rubble
Kent Point		385031	762040	1967/1983	Benthic/Estuarine	28	Concrete rubble
Little Cove Point		382032	762248	1967	Benthic/Estuarine	20	Tires (reef disappeared)
Miller Island		391436	762112	1967	Benthic/Estuarine	15	Tires (reef disappeared)
Hacketts Bar		385924	762410	1967	Benthic/Estuarine	15	Concrete pipe (reef disapeared)
Love Point		390405	761727	1967	Benthic/Estuarine	26	Tires (reef disapeared)
Chesapeake Beach		384257	763011	1967	Benthic/Estuarine	30	Tires (reef disappeared)
Jane's Island		375700	765500	1967	Benthic/Estuarine	17	Tires (reef disappeared)
Tolchester		391429	761608	1986	Benthic/Estuarine	18	Concrete rubble
Holland Point		384442	762907	1986	Midwater/Estuarine	25	McIntosh FADs
Sharps Island		383357	762425	1987	Midwater/Estuarine	30	McIntosh FADs
Choptank River Pier		383448	760320	1986	Benthic/Estuarine	15	Concrete rubble, rock
Tilghman Island		384136	762243	1988	Benthic/Estuarine	24	Rock
Cedar Point		381843	762243	1986	Benthic/Estuarine	24	Rock, concrete modules, FRP modules
Great Fox Island		375513	765640	1988	Benthic/Estuarine	28	Rock
ATLANTIC OCEAN							
Bass Grounds West	11.0	381748	745352	1968	Benthic/Marine	27-50	Wooden fishing boats
Bass Grounds East	13.0	381714	745305		Benthic/Marine	30	Wooden fishing boats
Great Gull Bank	3.5	381602	750135		Benthic/Marine	21	Tires (washed ashore)
Purnell's	1.0	382100	750331	1974	Benthic/Marine	28	Tires (washed ashore)
Kelley's	1.5	381630	750433	1974	Benthic/Marine	25	Tires (washed ashore)
African Queen	15.0	380905	745712	1986	Benthic/Marine	70	Barge, vessels, concrete rubble

The FRP and Beach Prism units are some of the most advanced fabricated reef systems available and along with designed quarry rock reefs will be compared on the reef site. Comparisons will be based on such factors as fishing success, overall attractiveness of the reefs to various fish species, and economic factors, i.e. costs and benefits. A remotely operated video camera will provide direct observations on the evolution of the estuarine communities on the structures.

In the future, the formulation of an artificial reef development plan and the development of a reef monitoring program will take priority. The reef plan is expected to be completed by spring 1989.

ARTIFICIAL REEF DEVELOPMENT

IN

MASSACHUSETTS

Prepared By:

Tom Morrissey
National Marine Fisheries Service

Massachusetts has a record of artificial reef activity. Like most of the states in the New Engalnd area, there are numerous defacto reefs in terms of shipwreck fishing sites. There are state sponsored marine recreational fishing activities, but no formal artificial reef program.

Massachusetts Reef Programs

Although there has never been a formal artificial reef program in Massachusetts (Table 12) the state has a recreational program that is organizationally discrete and housed in the Department of Fisheries, Bureau of Wildlife and Environmental Law Enforcement, Bureau of Recreational Fisheries, Bureau of Shell fisheries. All shellfish and crustacean program, where commercial or recreational, are under the Bureau of Commercial Fisheries.

Table 12. Massachusetts Program Activities

REEF FISHERY MANAGEMENT AUTHORITIES (Federal and State):
New England Fishery Management Council
Massachusetts Marine Fisheries Advisory Commission
Massachusetts Division of Marine Fisheries

NUMBER OF PERMITTED REEF SITES:1
Number In Federal Waters:0
(3-200 miles offshore)
Number in Territorial Sea: 1
(0-3 miles offshore)
Number in Inshore Waters:0
(estuarine, riverine)

TYPES OF REEFS:
Benthic: 1
Midwater: 0
Combination: 0

REEF COORDINATOR: None

STATE REEF PUBLICATIONS: None

STATE ARTIFICIAL REEF PLAN: None

Eleven people are assigned to MRF programs. These regional biologists are part of a system of district biologists who conduct surveys, investigations, and studies necessary to assist management planning, protect habitat, resolve use conflicts and to interact and communicate with the sport fishing public.

Massachusetts Artificial Reef Projects

There is only one site on record that indicates artificial reef activity in Massachusetts. The Yarmouth, Massachusetts Tire Reef off Barnstable County at a Latitude of 41 36.5'N and Longitude of 70 11.8'W (Loran:13943-43942) was permitted in the mid 1970's at a distance of approximately 2 nautical miles from shore. There are no other formally constructed reefs in Massachussets ; however, there are a number of old wrecks that are used as fishing sites. There are two wrecks of old fishing boats in Buzzards Bay used by a small group of anglers and divers, principally for blackfish fishing. In Vineyard South, there is a freighter and a schooner used by local charter and party boat operators. In Nantucket Sound, there are two schooners and a barge with a crane; and in the area around Pollock Rip, there are three old shipwrecks, all of which are used by charter boats and knowledgeable local residents. In Cape Cod Bay, the wreck of the F/V Longstreet is used by divers and local lobstermen. Arnie Carr, Massachussetts Division of Marine Fisheries, is an expert on the location of wrecks in the Southern New England area, and would be helpful in any future effort to pinpoint the location of such wreck sites. In addition to the wreck information, a publication by Carr and Amaral (1981) on the "Review of the Potential for Artificial Reefs along Coastal Massachusetts" can be found in the Proceedings of Oceans 81 published by the Marine Technology Society in Washington, DC.

ARTIFICIAL REEF DEVELOPMENT

IN

NEW JERSEY

Prepared By:

William Figley
New Jersey Bureau of Marine Fisheries

New Jersey's sea floor consists almost entirely of a mixture of gravel, sand, mud and clay. Hard substances are limited to a few rock outcroppings, located primarily along the shore of Sandy Hook, and the remains of some 500 shipwrecks scattered along the coast. There is heavy competition for the use of these underwater structures from sport and commercial fishermen and scuba divers. In an attempt to reduce this competition and increase fish productivity, private groups, usually charter boat association, have tried off and on for over the past 50 years to build artificial reefs off New Jersey.

New Jersey Program Activities

The earliest artificial reef effort in New Jersey was in 1935 on Five Fathom Bank off Cape Cape May, where fishermen constructed a reef out of old commercial fishing boats and cedar poles ballasted with concrete. Similar reefs were started off Atlantic City, Mantoloking, Sea Bright, and the most successful off Sea Girt, where a half dozen vessels and 60,000 tires were placed on the sea floor. During the 1970's, the National Marine Fisheries Services' Sandy Hook Laboratory constructed experimental reefs out of car bodies, tire units and barges.

The New Jersey Marine Fisheries Administration (Department of Environmental Protection, Division of Fish, Game and Wildlife) did not get actively involved in artificial reef construction until 1983. The objectives of the state's new reef program (Table 13) are as follows:

1. To create a network of artificial reefs easily accessible from all ocean inlets.

2. To provide reef habitat for fish, crustaceans and encrusting organisms.

3. To increase populations of certain fish and shellfish.

4. To create new fishing grounds for sport and commercial fishermen and structures for scuba divers.

The policies and guidelines for siting, constructing and managing the artificial reef sites are presented in detail in the New Jersey Artificial Reef Plan, which was prepared in 1987.

Table 13. New Jersey Program Activities

REEF FISHERY MANAGEMENT AUTHORITIES (Federal and State):
Mid-Atlantic Fishery Management Council
New Jersey Marine Fisheries Administration (Department of Environmental Protection, Division of Fish, Game and Wildlife)

NUMBER OF PERMITTED REEF SITES: 8
Number In Federal Waters: 7
(3-200 miles offshore)
Number in Territorial Sea: 1
(0-3 miles offshore)
Number in Inshore Waters: 0
(estuarine, riverine)

TYPES OF REEFS:
Benthic - 8
Midwater - 0
Combination - 0

REEF COORDINATOR:
William Figley, New Jersey Marine Fisheries Administration

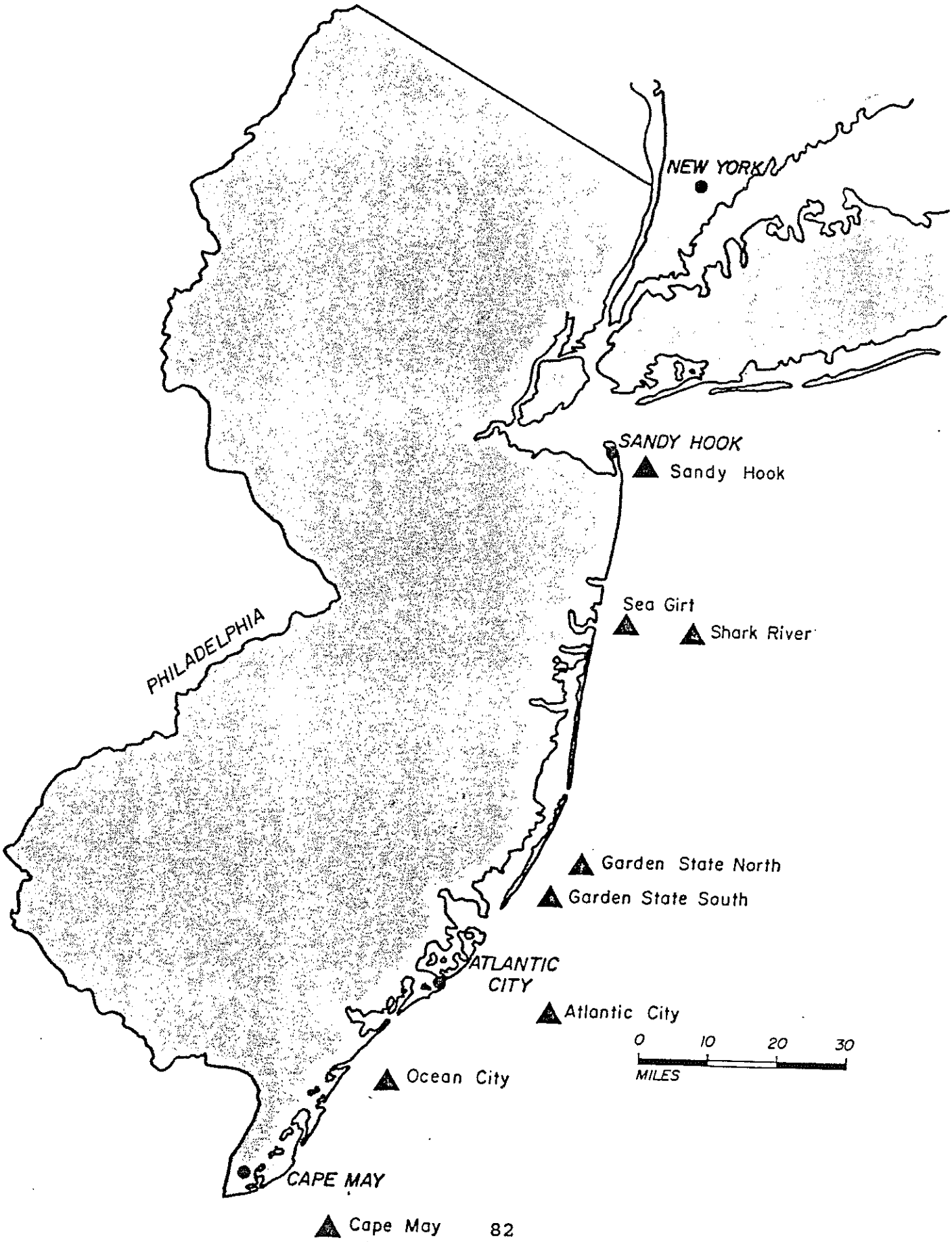
STATE REEF PUBLICATIONS:
(1) New Jersey's Artificial Reefs by Evelyn Myatt, DeWitt Myatt, and William Figley.
(2) New Jersey Tire Reef Unit Stability Studies by D.O. Myatt and William Figley.
(3) Old Ships Make New Homes for Fish by William Figley.
(4) New Jersey's Artificial Reefs - 42-minute film

STATE ARTIFICIAL REEF PLAN: Yes - New Jersey Artificial Reef Plan (1987)

New Jersey Reef Projects

To provide access to fishermen from every ocean inlet, a network of artificial reef sites has been established along the New Jersey coastline (Figure 11). At present, there are eight reef sites permitted by the U.S. Army Corps of Engineers, ranging in sizes from 0.5 to 4.5 square nautical miles, in the network The Marine Fisheries Administration holds all of these permits. To provide for safe navigation, a clearance requirement of 50 feet over the top of reef structures must be maintained for all reef sites, except the Cape May and Sandy Hook Reef Sites, where clearance requirements are 30 and 40 feet, respectively.

Figure 11. Distribution of New Jersey Artificial Reef Sites



At this time, the reef network (Table 14) consists of six inshore, shallow water sites (40' to 80' depth) and two offshore, deepwater sites (80' to 135' depth). The inshore sites are suited for low profile reef material, such as building rubble, tire units, small boats and barges, while the offshore sites are reserved for high profile structures, such as ships and storage tanks.

The Sandy Hook, Sea Grit, Atlantic City and Cape May Reef sites are located on former reef sites. New sites were selected based on the following criteria:

1. Distance Offshore -- sites are chosen as close to inlets as possible to increase accessibility to recreational users.

2. Depth -- the height and density of the reef material and clearance requirements dictate the depth selected.

3. Substrate Type -- hard sand or gravel is preferred; soft mud is avoided because of the rapid subsidence of reef structures.

4. Biological factors -- areas near fish-producing wrecks are selected.

5. Conflict with Commercial Fisheries-traditionally important trawling and dredging grounds are avoided.

6. Sea Lanes, Cable and Pipeline Crossings -- reef sites cannot be located within one mile of these routes to reduce navigation hazards and damage to sea floor structures.

7. Water Quality -- areas exhibiting chronic anoxia or near waste dump sites are avoided.

Details on all eight New Jersey reef sites (listed north to south) are given below.

SANDY HOOK REEF

The Sandy Hook reef site was first permitted by the Artificial Reef Committee and the National Marine Fisheries Service in 19. The Department of Environmental Protection reactivated the site in 1988. The site will receive massive quantities of concrete and steel building rubble from New York Harbor.

SEA GIRT REEF

The Sea Girt Reef was established in the 1960s by the Artificial Reef Committee, which was composed of the National Marine Fisheries Services, charter captains and local citizens. Initial reef building efforts consisted of sinking a half dozen

Table 11. NEW JERSEY Artificial Reef Projects

REEF SITE		LOCATION		REEF CHARACTERISTICS			
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
Sandy Hook	1.4	402318	735553	1988	Benthic/Ocean	32-60	Rubble
Sea Grit	3.5	400815	735530	1978	Benthic/Ocean	60-75	Vessels/tires
Shark River	5.1	400720	734105	1984	Benthic/Ocean	57-63	Ships
Garden State South	14.8	393349	740545	1981	Benthic/Ocean	120-135	Tires, rubble
Garden State North	6.5	393803	740042	1981	Benthic/Ocean	66-78	Tires, vessels
Atlantic City	12.5	391356	741148	1984	Benthic/Ocean	75-95	Ships, tires
Ocean City	4.5	391045	743227	1983	Benthic/Ocean	58-64	Tires
Cape May	8.5	385327	743826	1986	Benthic/Ocean	50-73	Vessels, tires

vessels and 60,000 ballasted single tires. The permit was transferred to the Department of Environmental Protection in 1985. This is the most developed reef off New Jersey and is located offshore of Manasquan Inlet, one of the busiest inlets for sportfishing activities in the world. Reef materials for this site will include barges, vessels under 100' in length, tire units and concrete rubble.

SHARK RIVER REEF

The Shark River reef site is New Jersey's deepest and most distant reef site, located at the southern edge of the Mud Hole. This site was located close to New York Harbor to sink large ships that are too high to deploy on shallower inshore reefs. In additional to demersal fish species, this site may also attract pelagic species such as bluefin and yellowfin tuna and sharks.

GARDEN STATE NORTH

The Garden State North reef site was permitted in 1984 by the Garden State Reef Committee, a group of local fishermen. In 1988, the permit was transferred to the State of New Jersey. This site is located between Barnegat and Little Egg Inlets and about 5 miles north of the Garden State South reef site. This site is being used as a research reef by the Department of Environmental Protection to test the stability of tire units and study biological parameters. This mid-depth reef site is capable of receiving large vessels, by cutting down the superstructure, as well as low profile material, consisting primarily of tire units.

GARDEN STATE SOUTH

The Garden State South reef site was permitted in 1981 by the Garden State Reef Committee, a group of local fishermen. The permit was transferred to the State of New Jersey in 1988. The reef is located in a narrow slough in an area know locally as "the fingers." This site is being used as a research reef by the Department of Environmental Protection to test stability of tire units and study biological parameters. This shallow water reef site will be used for placement of low profile reef material, consisting primarily of tire units and concrete building rubble.

ATLANTIC CITY REEF

The Atlantic City Reef site was first permitted by a private reef committee. The permit was reactivated by the Department of Environmental Protection in 1984. Located in the Lobster Hole, this is New Jersey's second deepest reef site. It has been used primarily for the placement of large vessels.

OCEAN CITY REEF

The Ocean City Reef was first permitted i 1983 by the Ocean City Artificial Reef Committee. In 1985, the permit was transferred to the Department of Environmental Protection. Reef materials that will be deployed on this site will include tire units, barges and small vessels.

CAPE MAY REEF

The Cape May reef site is the oldest permitted ocean reef site along the New Jersey coast. It was established in 1935 by a charter boat association Initial reef building efforts included the sinking of several commercial fishing boats and the development of cedar poles and christmas trees ballasted with concrete. The permit for the site was reactivated by the Department of Environmental Protection in 1986. The site is located just inshore of Five Fathom Bank. The primarily reef materials slated to be placed on this site include vessels under 150' in length, tire units and concrete building rubble.

NEW JERSEY REEF PERFORMANCE

New Jersey's experiences with the individual reefs listed above have led to a number of conclusions about basic reef performance including such factors as reef materials, reef construction, biological effects, and commercial and recreational use.

Reef Materials

Due to severe budgetary constraints, materials used to construct reefs in New Jersey must be donated and delivered to reef sites at the donor's expense. This limits the program to materials slated to be discarded, such as building rubble, used tires and derelict vessels. In some cases, private donations have subsidized some of the costs involved in acquiring structures. From a biological perspective, almost any material that provides surface area for organism attachment and crevices for hiding and is non-toxic will support a thriving marine community. In addition to biological concerns, the density and durability of the reef material is of equal importance to the reef builder. Reef structures must resist movement and destruction under the constant and powerful forces of the sea. Debris, scattered and moving off reef sites. poses a threat to navigation, commercial fishing and the state's beaches. To meet the biological and stability demands, the Administration has developed policies regarding the types of materials that can be used and the procedures for preparing them for deployment of reefs.

Building rubble -- concrete and steel rubble from the demolition of buildings, piers and bridges is acceptable providing there are not floatable materials, toxic residues or large volumes of fine sediments.

Vessels -- derelict steel or concrete ballasted fiberglas boats, ships, barges and dry docks are acceptable; wooden vessels are unacceptable. Before sinking, vessels must be thoroughly cleaned to pass a U.S. Coast Guard pollution inspection. Floatable debris -- wood, mattresses, containers, compressed air cylinders, etc. -- must be removed. Cargo and fuel tanks, engines, hydraulic lines and the bilge must be drained and cleaned of oil and grease. All watertight compartments must be cut open to vent air during sinking. Superstructures that may protrude above the required clearance depth must be trimmed down.

Tire units -- Although tires are durable and provide an excellent attachment surface, their low density in seawater must be overcome before they can be used as reef material (Figure 12). Over a four year period, the Administration tested the stability and durability of 11 different tire unit designs, ranging in size from 7 to 45 tires in the ocean. Concrete was used to both bind the tires together and ballast them. Results of the study indicate that 50 pounds of concrete are needed per car tire to maintain unit stability in a depth of 60 feet under storm conditions generating 15-foot high waves. All tire units now constructed for the reef program must meet this minimum ballast requirement.

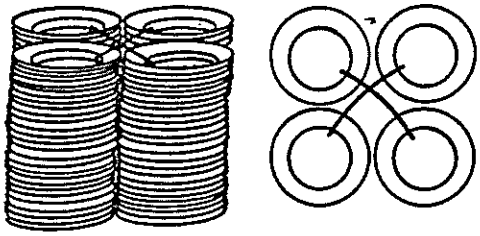
Reef Construction

As materials become available, specific sites are assigned for deployment. Vessels are towed to the site, while other materials are transported on dock barges. Vessels are anchored in position. To minimize structural damage and thus increase their life span on the sea floor, vessels are sunk either by blasting small holes in the hull with minimal explosive charges, or by simply opening the sea cocks to allow flooding. Tire units are dropped off barges with a crane in a scattered configuration to maintain a mixture of units and open bottom. Concrete building rubble is either pushed off flat deck barges with front end loaders, or is dropped in bulk by hopper barges. The objective with rubble is to create 5 to 10-foot high mounds. Administration personnel accompany each shipment of material to make certain that it reaches the proper location and depth on the site.

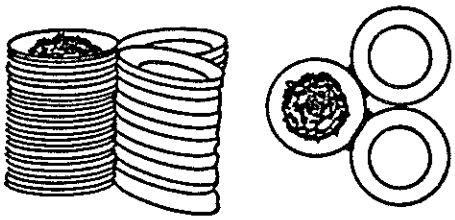
Since October, 1984, over 75,000 cubic yards of materials have been placed on seven reef sites, including:

vessels	55,949 cu. yds.
tire units	7,113 cu. yds.
concrete rubble	12,400 cu. yds.
steel towers	416 cu. yds.

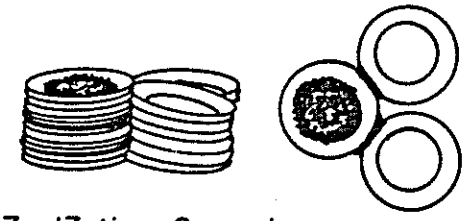
Figure 12. New Jersey Tire Unit Designs - Experimental Modules



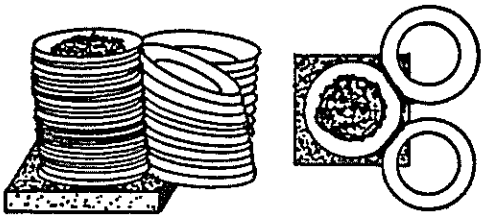
1. 60 tire unballasted Quad



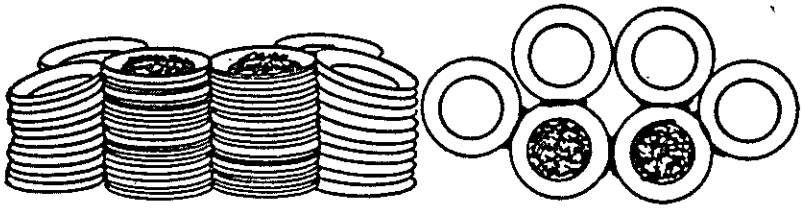
2. 25 tire Cascade



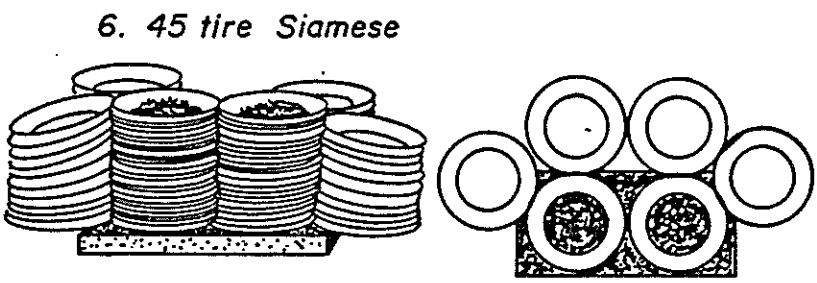
3. 13 tire Cascade



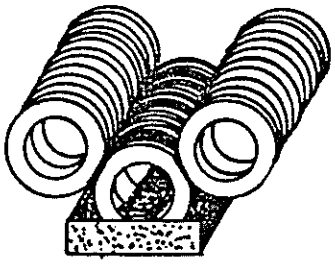
4., 5. 25 tire Cascade with base



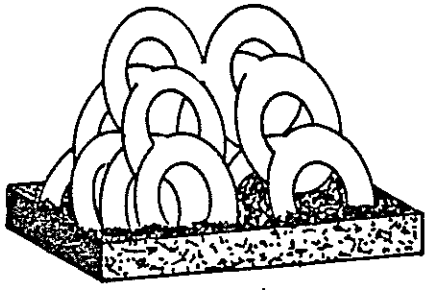
6. 45 tire Siamese



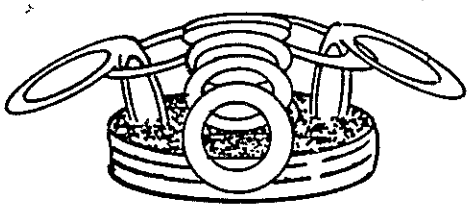
7. 45 tire Siamese with base



8. 25 tire Mickey Tic



7 tire Mini Tic



10. LEM truck-car combination

The 24 vessels sunk on reefs included seven small boats (31'to 56'), four barges (85' to 270'), three tugboats (85'to 110'), a schooner (125'), seven tankers and freighters (165' to 265'), and two commercial fishing boats (90' to 110'). Tire reef units have been fabricated from over 160,000 car and truck tires in two tire reef pilot projects by the Ocean County Road Department and the Southern State Correctional Facility.

On each artificial reef site, the objective is to construct dozens of small patch reefs, one to two acres in size, separated from each other by expanses of open, sand bottom. Rather than a single massive reef in the center of each site, the patch reef concept affords several advantages. Patch reefs would increase biological productivity and diversity by providing increased exposed surface area, edge effect and juxtaposition of hard substrate, natural sand bottom, and pelagic habitats. Furthermore, patch reefs help spread out fishermen and divers and allow for greater use with reduced friction between users.

The type and height of reef material influences the species inhabiting the reef. Low profile structures, such as building debris and tire units, are particularly attractive to demersal species, such as black sea bass, tautog, summer flounder, scup, red hake, lobster and rock crab. Ships and other high profile structures, on the other hand, attract many species of baitfish and pelagic predators, such as bluefish, tuna and sharks. By intermixing different types and heights of structures on the reef sites, a greater diversity of species can be attained.

Biological Observations

With the first years of the reef program dedicated to establishing guidelines and standards for reef construction, biological investigations were limited to the general observations of scuba divers while studying the stability and placement of reef materials.

Epibenthic organisms were visible on all structures within one month of deployment. The first groups to appear included hydroids and barnacles, followed by tube worms and blue mussels. The barnacles appeared to be sustaining predation by grazers as evidenced by the presence of a large number of basal scars among the living barnacles. Complete coverage of many surfaces by a living carpet occurred within three or four months. The following fish species were observed while scuba diving on the two Garden State reefs:

black sea bass	red hake
tautog	butterfish
cunner	spiny dogfish
scup	anglerfish
summer flounder	sea raven
banded rudderfish	spiny dogfish

The primary beneficiaries of new reef habitat are sea bass, tautog and cunner, using structures for feeding and hiding. Sea bass and tautog darted in and out of tire units, using them effectively to hide from approaching divers. Sea bass also used tire units as protected resting areas, perhaps cutting down on energy expenditures. By lifting the loose flaps of the tire units, divers exposed groups of sea bass huddled calmly together. Species such as summer flounder and anglerfish hide in the sand along the edges of the reefs, probably feeding on smaller residents.

Fish diversity and abundance on the reefs fluctuated with the season. During spring and fall when fish were moving, colonization of reefs occurred rapidly. For example, fishable quantities of sea bass and porgy colonized a reef made in October of two small boats and 50 tire units within 24 hours of deployment. Sea bass appeared to be more abundant on the reefs during spring and fall than summer. Summer flounder were most abundant in the fall during their offshore migration.

As mentioned previously, pelagic species, such as bluefish, bluefin tuna and sharks, are also attracted to artificial reefs, particularly those with high profile structures, because of the concentration of smaller, forage fishes. Fathometer graph recording that we took of sunken ships on artificial reefs showed marks of fish on top of, and alongside the hull, 20' to 40' off the bottom. These readings suggest the presence of schools of baitfish and predators.

Beginning in the summer of 1988, detailed biological investigations of the population dynamics of major demersal reef fishes will be initiated. These studies will include food habits, seasonal abundance, mortality rates, population, age class, structure, and migratory patterns. Investigations of the colonization, species diversity and abundance of epibenthos will also be started.

Recreational and Commercial Use

Most reefs in the artificial reef network are relatively new and limited in size. Sport fishermen are just beginning to use the new reef sites. However, catches have been very good and each year the number of anglers using the reefs has increased. Sport diving, particularly on the sunken ships, is also on the rise, with some dive shops using the reefs for check-out dives.

Commercial fishermen have also looked to the reefs for sea bass and lobster. In addition to the traditional lath lobster and fish pots, commercial harvests have also been taken with wire crab traps and rod and reel.

One of our chief concerns as the reefs develop is the possibility of overfishing and depletion of reef populations. Baseline catch per effort and size frequency data are being collected to monitor future trends in abundance. Since all but

one reef site are in federal waters beyond the state's jurisdiction, the state currently has no management or regulatory powers over the sites. Once the needed baseline information has been collected, the state will petition the Mid-Atlantic Fisheries Management Council to adopt management measures to protect artificial reefs from over-exploitation.

ARTIFICIAL REEF DEVELOPMENT

IN

NEW YORK

Prepared By:

Chester Zawacki
and
William McGroarty
New York State Department of Environmental Conservation

New York has a wide diversity of artificial reef development. Recent materials added to the New York reefs range from a "pirate ship" from the 1967 Jones Beach Marine Theatre production of "Arabian Nights," to specially designed and constructed units consisting of 3 to 12 discarded auto tire casings. The use of materials of opportunity such as old tires, derelict barges, and masonry rubble offers potential for recycling certain solid wastes found around large cities while providing excellent fishing opportunities for the ever increasing angling public. It has been estimated that there will be 1,618,000 saltwater anglers fishing in New York waters by the end of 1990; artificial reefs will play an important role in providing them with additional areas for recreational fishing.

New York Reef Programs

Artificial reef development is not a new activity in New York State (Table 15).

Table 15. New York Program Activities

REEF FISHERY MANAGEMENT AUTHORITIES (Federal and State):
Mid-Atlantic Fishery Management Council
New York State Department of Environmental Conservation

NUMBER OF PERMITTED REEF SITES: 12
Number In Federal Waters: 5
(3-200 miles offshore)
Number in Territorial Sea: 3
(0-3 miles offshore)
Number in Inshore Waters: 4
(estuarine, riverine)

TYPES OF REEFS:
Benthic - 12
Midwater - 0
Combination - 0

REEF COORDINATOR:
Chester Zawacki - New York State Department of Environ. Conservation
William McGroarty - New York State Department of Environ. Conservation

STATE REEF PUBLICATIONS: None

STATE ARTIFICIAL REEF PLAN: None

The first artificial reef on record in New York waters was built in the Great South Bay in the mid-1920's when a number of wooden butter tubs half-filled with concrete were sunk in several locations by the Boatmen's Association of Great South Bay. Wooden boxes, also half-filled with concrete were sunk in the

same bay in 1946 and 1947 in a program carried out by the Bay Shore Tuna Club. Steimle (1982) provides a thorough historical review of these and other early reef building efforts in his article on reefs in the New York Bight.

In other instances man's activities have created unplanned artificial reefs. The fishing grounds known as the Subway Rocks, offshore of the Rockaways resulted from ocean disposal of Manhattan bedrock from subway excavations.

Artificial reef planning and development continues today under the direction and supervision of the New York State Department of Environmental Conservation, Division of Marine Resources. The goal of New York's artificial reef program is to enhance recreational and commercial fishing access and opportunity; while at the same time enriching fishery habitat and protecting our finite marine resources. With pressure on marine resources in New York State at an all time high, balancing the needs of the resource consumer with those of the resource itself is a sizable challenge. New York is considering the development of a state artificial reef plan. This plan is expected to become and integral part of the overall fisheries management program for New York State.

New York Artificial Reef Projects

The following narrative is a discussion of the status of New York's artificial reefs as of June 1, 1987. It provides a brief history and site description, the materials used, successes, failures and problems encountered, research results and fisheries present in each area. The order presented is from west to east (numbered 1 to 12 in Figure 13) along the south shore of Long Island and concludes with the single site in Long Island Sound (Table 16).

ROCKAWAY BEACH ARTIFICIAL REEF

The Rockaway Beach Artificial Reef site (1) was authorized under a Department of the Army Corps of Engineers (COE) permit originally issued to the New York State Conservation Department, Division of Fish and Game on September 14, 1965. The site is located about 5 miles (8.1 km) east-southeast of Rockaway Inlet in 35-38 feet (11.0-11.6 m) of water. This area was chosen through the efforts of David H. Wallace, Chief of the N.Y.S. Bureau of Marine Fisheries and Captains Laddie Martin and Howard Berlin of the Sheepshead Bay Boat owners Association. The proposed reef site was authorized at a length of 2,000 yds. (1,828.8 m) with a width of 1,000 yds. (914.4 m). A wreck, presumed to be "The Mistletoe" lies just south of the southwest corner of the reef site with a clearance of 24' at mean low water (MLW). The proximity of this wreak allowed for a permitted clearance for the reef site of only 23'@ MLW. Most other New York ocean sites require 40 or more feet of clearance.

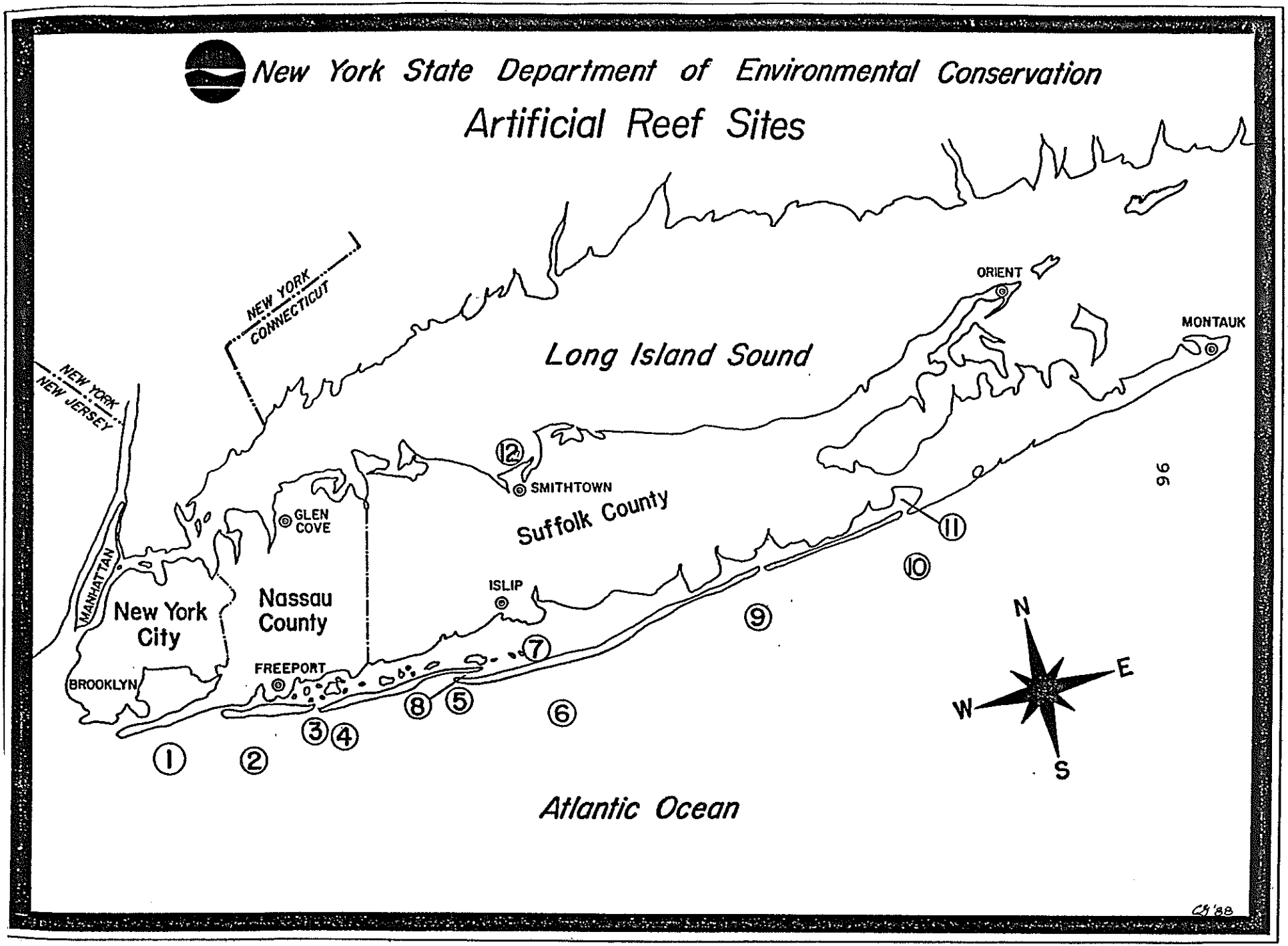


Figure 13. Distribution of New York Artificial Reef Sites

Table 16. NEW YORK Artificial Reef Projects

REEF SITE	LOCATION			REEF CHARACTERISTICS		
Name	Distance (Naut. mi)	Latitude (o ' ")	Longitude (o ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
Rockaway Beach	4.5	403230	735052	1965	Benthic/Ocean	35	Tires, Concrete, culvert, rock, rubble
Atlantic Beach	3.5	403130	734300	1967	Benthic/Ocean	63	Car bodies, tires, wood/steel barges, concrete culvert, rubble
McAllister	4.3	403212	733927	1949	Benthic/Ocean	52	Rock, rubble, brick
Jones Inlet (Hempstead)	3.8	403554	731400	1967	Benthic/Ocean	70	Concrete culvert, wood barges
Schaeffer	1.8	403536	731324	≈1953	Benthic/Ocean	56	Wood boxes with concrete ballast
Captree (Fire Island)	4.5	404410	724510	1962	Benthic/Ocean		Rock, rubble, tires, wooden steel barges, coal ash
Kismet	0.5	403554	731499	1964	Benthic/Estuarine	25	Wood barge, concrete blocks, tires, culverts
Moriches Reef	2.4	404410	724510	1968	Benthic/Ocean	72	Wooden boats
Oak Beach	0.3	403812	731800		Benthic/Estuarine	20	Wood barge
Shinnecock	2.6	404718	722812	1968	Benthic/Ocean	80	Tires, wood barge, steel bridge, wood/steel boats
Shinnecock Bay	1.2	405128	732845	1972	Benthic/Estuarine	10	Tires
Smithtown Bay	1.0	405604	731103	1976	Benthic/Estuarine	40	Wood barges, tires

The United States Coast Guard (U.S.C.G.), New York District, originally required the State Conservation Department of mark the site with tow lighted private-aids-to navigation. This requirement was amended at our request to allow use of unlighted buoys. Spar buoys were maintained by the Department with some success for several years, often on only a seasonal basis. Repeated cuts in budget requests for buoy maintenance funds required the Department with some success for several years, often on only a seasonal basis. Repeated cuts in budget requests for buoy maintenance funds required the Department to advise the U.S.C.G. in 1974 of our inability to maintain buoys at the site. The Rockaway Beach Artificial Reef is presently unbuoyed. The reef site was visually surveyed by divers in 1966. The bottom was found to be composed of hard compacted san and shells. Surf clams (Spisula solidissima) and tube worms (unidentified sp.) were observed during the survey. The Conservation Department initiated work in 1967 by contracting for the placement of 6,000 auto tires (3 tires per unit) at the site. In 1968 and 1969, 420 tons of concrete culvert pipe were added. In 1970, the concrete rubble from the demolition of the South Channel Bridge (Cross Bay Boulevard) was placed at the site. This addition consisted of 8 bargeloads of material (approximately 9,900 cu. yds.). The U.S.C.G., Aids to Navigation Branch from Governor;s Island also donated, transported and sank 60 steel buoys in 1970 at the site. No LORAN positioning is available for these early efforts. The proximity of the Rockaway reef site to the New York metropolitan area has prompted many requests from demolition and ocean transportation contractors to use the Rockaway Beach Artificial Reef site rather than seek their own ocean disposal permits. The DEC has offered the site in good faith to all contractors who have expressed a sincere interest in using this area for its intended purpose, i.e. improving habitat for bottom feeding fish.

The DEC is not interested in any and all materials but has been selective of the size and composition of any material destined for this site. In cases where we find the material to be suitable, the contractor is required to assume all responsibility for accurate location of material within the boundaries of the permitted site and for compliance with he minimum clearance requirement. The contractor is also required to allow a DEC observer to accompany the dumping although in reality, staffing and scheduling have allowed few field observations. The contractor using the site is required to provide the DEC with a complete description of the work performed including a description of all materials, the amount (volume and weight), the time and date of the deployment, the location in Loran C Time Differences (TD's), Latitude, Longitude (LAT/LON) and the depth before and after the deployment.

Under this arrangement, the site has been utilized by several contractors under our direction and authorization. They include the following:

Moran Towing Corporation - 25 bargeloads during 1972-1973 as part of disposal of select rock material excavated from Water Tunnel Contractors aqueduct project.

New York State Department of Transportation - 8 bargeloads (approximately 4,000 cu. yds, total) in 1982 as part of disposal of reinforced concrete slabs in connection with West Side Highway Demolition project.

Weeks Stevedoring Company, Inc. - 5 bargeloads @ 2,000 ton/barge in 1983 as part of demolition and removal of Pier No. 3 Exxon Co., Bayonne, NJ. Material consisted of concrete deck slabs, concrete piles.

Week Stevedoring Company, Inc. - 22 bargeloads @ 2,000 ton/barge in 1984 as part of New York Harbor Collection and Removal of Drift Project, Stapleton Reach, Staten Island. Material consisted of concrete.

Schiavone-Chase Corp. - 1 bargeload of concrete slabs. NYSDOT contract.

Don Jon Marine Company, Inc. - 1 bargeload of 2,000 ton in 1984 of select concrete rubble as part of Industrial Wrecking and Demolition project.

Wittle Heavy Lift, Inc. - 2,000 tons concrete slabs on 11/3/1984. 2,000 tons concrete pile caps on 5/20/1985.

Weeks Stevedoring Company, Inc. - 12 bargeloads @ 2,000 ton/barge in 1986 select concrete rubble from NYSDOT contract Oak Link Point, Harlem River, Bronx.

Week Stevedoring Company, Inc. - 2 bargeloads @ 2,000 ton/barge in 1987. Brooklyn Reach One - Army Corps Contract.

The construction of the Rockaway Beach Artificial Reef is considered by the DEC to be a long term project. The project is approximately 50% completed in its 20+ years of existence. It is anticipated that the reef will be completed utilizing only materials of opportunity, preferably rock or select concrete rubble. As of May, 1987 the DEC has temporarily halted additional deployments pending a survey of the existing profiles at the site. This action is expected to direct some materials of opportunity to the Atlantic Beach Artificial Reef. The COE permit for the site has been periodically renewed. The most recent extension of time was granted on September 13, 1985 for an expiration date of June 20, 1990.

The Rockaway Beach Artificial Reef is utilized by recreational fishermen and divers and by some commercial (pot and hook and line) fishermen. Party, charter and private boats from Sheepshead Bay, Jamaica Bay, East Rockaway and Island Part

utilize the reef throughout the year. The rough bottom habitat offers protection from commercial trawl gear and provides excellent hook and line fishing for summer flounder. Tautog, scup, black sea bass and red hake are also seasonally pursued. Recreational divers take American lobster from the rubble piles. No estimates of the economic activity associated with the reef are available. It is suspected that occasional low oxygen levels limit productivity of the area. No research has been conducted at the site.

ATLANTIC BEACH ARTIFICIAL REEF

The Atlantic Beach Artificial Reef (2) site was authorized under a Department of Army (COE) permit originally issued to the New York State Conservation Department, Division of Fish and Game on April 20, 1967. The site is located about 4 miles (6.4 km) south of East Rockaway Inlet in 58-65 feet (17.7 to 19.8 m) of water. This areas was chosen as the site of an experimental auto body reef by the State of New York and the U.S. Department of Interior, Fish and Wildlife Service, Sandy Hook Marine Laboratory, Highlands, New Jersey. The proposed reef site was authorized at a length of 2,000 yds. (1,828.8 m) with a width of 1,000 yds. (914.4 m). The original permit authorized a minimum clearance of 50 feet at mean low water (MLW). The site was chosen to incorporate the R-4 Whistle Buoy as a U.S. Coast Guard maintained buoy at the southwest corner of the reef.

Work was initiated on the site on June 24, 1967 with the placement of the first barge load of automobile bodies cabled together in groups of 3-4. A total of seven barge loads (404 cars) was placed during 1967. The Sandy Hook Marine Lab, under the direction of Richard Stone added 15,000 tires in 1968 and 15,000 tires in 1969. An approximate breakdown of the number and type of tire units is 15,000 single-tire units and 2,400 multi-tire units. The Department of Environmental Conservation contracted for the placement of 5 wood barges, 4 steel barges and 200 tons of concrete culvert. Loran positioning of this material was unavailable.

In 1971 the DEC became aware that many of the 8 tire units deployed in 1968 and 1969 were being washed up on the beaches of Long Beach and Atlantic Beach approximately 3-4 miles to the north of the reef site. Commercial surf clam dredges were reported to be encountering others between the reef and the beach. The ballasted base tire of this particular unit was breaking free from the unit allowing the remaining unballasted tires to roll off location. Cleanup was handled each spring for 2 years by DEC personnel.

1975, the DEC requested a COE permit modification to allow a minimum depth of 30′ below MLW at the Atlantic Beach site. This request was not considered favorably. A second request by the DEC to modify minimum clearance to 40′ was approved in a letter from COE dated August 1, 1975. This action allowed the placing in 1975 of a 65′ steel tugboat which had capsized in

Jones Inlet at the site. This tug, the Fran S, which is located at Loran C TD's 26873.1-6, 43733.6-8 has become a favorite attraction for sport divers. Recent additions include the sinking in 1986 of a wood barge, a steel crane, and a steel lifeboat. The Weeks Stevedoring Company, Inc. also provided 2 bargeloads of concrete bridge abutments and decking in 1986 as part of NYSDOT contract - Meadowbrook and Loop Parkway Bridges. The COE permit for the site was extended in 1978 for an expiration date of September 8, 1988.

The Atlantic Beach Artificial Reef provides excellent nearly year-round fishing for tautog. Peak seasons are usually May and November. Cunner, black sea bass, and red hake are also taken by bottom fishermen. Trollers often report bluefish from the area of Bell Buoy R-4 t the southwest corner of the reef. No estimates of the economic activity associated with the reef are available. Research attempted at the reef by diver-biologists from the Mid-Atlantic Coastal Fisheries Center was often hindered by poor underwater visibility.

"Mc ALLISTER GROUNDS" ARTIFICIAL REEF

The "Mc Allister Grounds" Artificial Reef (3) was created by the planned dumping of at least two barge loads of rock, rubble and brick (commonly referred to as "cellar dirt") offshore of Long Beach, N.Y. The project was developed by James R. Westman, Senior Biologist of the Bureau of Marine Fisheries, N.Y.S. Conservation Department and Captain Jefferson D. Beard, U.S.N., Supervisor of New York Harbor. The first loads were recorded dumped by the Mc Allister Lighterage Line of New York City on December 6, 1949. Captain Chris Specht of the partyboat "Margaret" out of East Rockaway Inlet is credited with being among the first to exploit the population of black sea bass that were congregated on the site. The profiles created were estimated at only 1-2 feet! The spot, although poorly defined, remains on the latest Coast and Geodetic charts.

HEMPSTEAD TOWN ARTIFICIAL REEF

The Hempstead Town Artificial Reef (4) was authorized under a Department of the Army (COE) permit issued to the Department of Conservation and Waterways, Town of Hempstead on June 22, 1967. The site is located approximately 3 miles south of Jones Inlet in 70 feet (21 m.) of water and had a minimum clearance requirement of 50 feet at MLW. The reef was constructed in July and August of 1967 with the sinking of 7 wood barges ballasted with concrete culvert pipe and ready-mix concrete. The reef is fished by fares aboard open and charter boats from Pt. Lookout and Freeport. Black sea bass, tautog, red hake and scup have been reported as taken from the site. Recent reports (1986) indicate the reef has been greatly reduced in profile. The permit for the site expired on December 31, 1970.

SCHAEFER GROUNDS ARTIFICIAL REEF

The "Schaefer Grounds" Artificial Reef (5) was created in 1953 approximately 3 miles south of Fire Island Inlet. Approximately 14,000 wood beer cases (Schaefer Beer donation) partially filed with concrete were manually off-loaded from a wood barge to create the reef. It is reported that the site produced fish (black sea bass) for 2 years before being scattered and sand-covered. There was little communication with conservation agencies on this reef and few results were recorded.

FIRE ISLAND ARTIFICIAL REEF

The Fire Island Artificial Reef (6) site was authorized under a Department of the Army (CORPS) permit originally issued to the Captree Boatmen of Captree State Park, Babylon, N.Y. on May 18, 1962. The area was originally chosen by Captain William Joseph, then Chairman of the Captree Boatmen's Association. The site is located approximately 5 miles southeast of Fire Island Inlet in 65-70 feet (20-21m.) of water. The original permit authorized the use of rock and concrete building rubble to be at a minimum depth of 50' at mean low water (MLW). The proposed site was authorized at a length of 1760 yds. (1,609.3m) with a width of 176 yds. (160.9m).

Inspection of the site in July, 1962, by American Littoral Society divers showed the bottom to be hard packed sand with few marine organisms present. In 1962 and 1963, 13 barge loads of (29,000 cu. yds.) concrete building rubble and rock were dropped on the site. By May and June of 1963, good catches of red hake and black sea bass were being reported. In 1965 the permit for the site was renewed in the name of the N.Y.S. Dept. of Conservation. During 1965 the Department contracted for the manufacture and deployment of 40 reinforced concrete structures to be placed on the site. No Loran positioning was available on these deployments and they are presumed "lost".

During the early 1970's the Dept. of Environmental Conservation constructed auto-tire-in-concrete units (TIC's) and contracted for their placement (1972) at the site. Many wood and steel barges were also added as they became available and as limited state limited state general fund budgets allowed. The Conservation Department seasonally maintained private aids to +navigation (buoys) at the site. In 1974 budget reductions prevented further buoy maintenance and since that time the site remains unbuoyed.

In 1969 the Department conducted research on the fish and invertebrates inhabiting the Fire Island Reef. The results were reported in Philip Briggs in "An Evaluation of Artificial Reef in New York's Marine Water", New York Fish and Game Jour., Vol. 22, No.1, January 1975 and by Briggs and Chester Zawacki in "American Lobsters at Artificial Reefs in New York, N.Y. Fish and Game Jour., Vol. 21, No.1. Jan. 1974. In 1978 the permit for the site was modified to allow for the placement of 700 cubic yards of

stabilized coal wastes (fly ash and scrubber sludge stabilized with quicklime). The results of this study were published by Peter Woodhead, J. Parker and I. Duedall in the The Coal Waste Artificial Reef Program (C-WARP) in Marine Fisheries Rev. 44 (6-7 - 16-23). In 1986 the Department of Environmental Conservation received authorization from the Department of Environmental Conservation received authorization from the Department of the Army (COE) to allow a decrease in the minimum depth over the Fire Island Reef from 50 feet to 40 feet thereby permitting the placement of larger derelict vessels at the site. This permit expires on June 24, 1989. On November 29, 1986, the DEC arranged and supervised the delivery and sinking of a 200'Lx85'Wx32 wood drydock at Loran C TD's 26625.5, 43731.2. This is the largest single object deployed to date at any of the New York Artificial reef sites.

GREAT SOUTH BAY (KISMET) ARTIFICIAL REEF

The Great South Bay (KISMET) Artificial Reef (7) site was authorized under a Department of the Army (COE) permit originally issued to the New York State Conservation Dept., Bureau of Marine Fisheries on April 22, 1964. The site is located approximately 1 mile east of the Fire Island Lighthouse in 25 feet (7.6m) of water. The reef site was authorized at 1,000 yards long and 50 yards in width to be at a minimum depth of 16 feet at MLW. The reef is approximately 75 yards from the Fire Island shore and is in an area of heavy tidal current (maximum flows may exceed 2.5 knots).

The reef was built of 24,000 (8"x8"x16") concrete blocks (1965), two 30' X 90' wood barges (1965), and 940 tons of concrete culvert pipe 1974. Approximately 4,000 auto tires (in units of 3-4 tires each added in 1967) are also located on the reef site. In its early development the reef was buoyed by the D.E.C. on a seasonal basis. Since 1975 the reef site has been unbuoyed. The COE permit for the site lapsed in 1977 after a determination by the D.E.C. that the reef site was completed.

The Great South Bay reef at Kismet is a seasonal producer of fish. Tautog become available in April and May although best fishing occurs in the fall from mid-September through October. The size composition, population numbers, movement and survival of tautog from this reef were studied from 1969 to 1972. The results were reported by Philip Briggs in "Status of Tautog Populations at Artificial Reefs in New York Waters and Effect of Fishing", New York Fish and Gam Jour., Vol. 24, No. 2, July 1977. Black sea bass are available from June through September. This reef occasionally harbors quantities of pelagic fish, such as weakfish and bluefish, and striped bass are often taken in good numbers at night. An 18 lbs. 3 oz. summer flounder (IGFA #6 line class record) was taken from this reef in 1974. The good fishing often found on this reef make it one of New York's most popular, occasionally overcrowded, artificial reefs.

OAK BEACH ARTIFICIAL REEF

The Oak Beach Artificial Reef (8) was authorized under a Department of the Army (COE) permit issued to the NYSDEC on March 21, 1977. The site is located 100 yds. from the Oak Beach shore in 20 feet of water. The center of the site is 295 degrees east at 3,767 yds. from Robert Moses State Park Tower. The site was authorized at a length of 500 yds (457.2m) with a width of 100 yds. (91.4m) to be at a minimum depth of 10 feet at MLW.

Work was initiated at the site with the sinking of a wood barge ballasted with concrete on November 1, 1980. The barge was donated by a local ferry company and was sunk under Dec supervision. In October of 1981, the DEC was notified of an unauthorized attempted sinking of 2 derelict vessels at the site. Requests were received from the Town of Babylon and the Oak Beach Civic Association to discontinue building of the reef. On November 20, 1981 the D.E.C. voluntarily requested that the Corps of Engineers revoke the authority to build a fishing reef at this site.

The single barge at this site is fished by open and charter boats from Captree State Park. The species of fish attracted to the site are similar to those of the Great South Bay reef at Kismet.

MORICHES ARTIFICIAL REEF

The Moriches Artificial Reef (9) site was authorized under a Department of the Army COE permit issued to the N.Y.S. Department of Conservation, Bureau of Marine Fisheries on August 23, 1968. The site is located approximately 2.4 miles (3.9 km) south-southwest of Moriches Inlet in 72 feet (21.9 m) of water. The reef site was authorized at a length of 450 yds. (411.5 m) with a width of 150 yds. (137.2 m) with a minimum clearance of 50 feet at MLW. The reef was a result of the Moriches Anglers Club requesting a reef site convenient to Moriches Inlet. The success of the Shinnecock Anglers in making progress at the Shinnecock site also prompted interest in the Moriches area.

Work on the reef began with the sinking of two small wooden boats and approximately 600 auto tires in 1970. The Department of Environmental Conservation was not offered the opportunity to direct and supervise the commencement of the work, despite specific requests to the fishing club to do so. Complaints of materials off location were soon received by the DEC from irate commercial trawler fishermen. The Secretary of the Long Island Fishermen's Association requested that the COE urge the State to more closely supervise the operation. The Moriches Anglers Club was cautioned about the need for supervision in location and placement of materials. Interest in the project waned and the permit lapsed on May 14, 1985. No research has been conducted and no reports of angling success have been reported at this site.

SHINNECOCK OCEAN ARTIFICIAL REEF

The Shinnecock Ocean Artificial Reef (10) site was authorized under a Department of the Army COE permit issued to the N.Y.S. Department of Conservation, Division of Fish and Game on September 16, 1968. The site is located about 2.6 miles (4.2 km) south of Shinnecock Inlet in 80 feet (24.4 m). The reef site was authorized at a length of 450 yds. (411.5 m) with a width of 150 yds. (137.2 m) with a minimum clearance of 50 feet at MLW. The reef was a direct result of the interests of the Shinnecock Anglers Club and the Long Island Fishing Reef Foundation, Inc. The beginning efforts on the reef were funded by money raised from entry fees collected from swordfish tournaments conducted by the Shinnecock Anglers.

Work was initiated at the site in January of 1969 with the concrete. A wood barge laden with the steel framework of the Shinnecock Canal bridge was placed at the site in 1973. The reef is fished commercially by at least 1 lobster/black sea bass pot fisherman. Hook and line catches of black sea bass, tautog and cod have been reported from the reef. The profile of the reef was reported in 1986 to be greatly reduced. Unconfirmed Loran C TD's for the highest profiles are reported at 26287.5-7 and 43787.2-.5-.7. The COE permit for this site expires on October 8, 1995.

SHINNECOCK BAY ARTIFICIAL REEF

The Shinnecock Bay Artificial Reef (11) was constructed as part of a study by the N.Y.S. Conservation Department to evaluate the utility and effectiveness of auto tire structures as reef substrate. The reef site is located in Shinnecock Bay (90 degrees east at 2465 yds. from the Ponquogue Tank). The reef site was designated as 420 feet long and 210 feet wide in 10 feet of water. Minimum clearance of 6 feet @ MLW was provided.

On July 10 and 11, 1970, 1000 auto tires in 4 different configurations (250 each) were placed on the corners of the reef site. The location and construction details were not announced since the reef was installed for research purposes and it was felt that fishing and boating activities would jeopardize the results. The reef was studied visually by diver observation and by the use of traps and fish pots. The results were described by Chester Zawacki in an unpublished M.S. thesis entitled "The Utility o Auto Tires As An Artificial Reef Substrate in Shinnecock Bay." Long Island University, 1971. A Department of the Army approval of the plans was granted May 23, 1972. An attempt was made by the DEC to re-examine the site in 1976 and the location could not be found.

SMITHTOWN BAY ARTIFICIAL REEF

The Smithtown Artificial Reef (12) site was authorized under a Department of the Army (COE) permit issued to the N.Y.S. Department of Environmental Conservation on June 8, 1976. The

site is located in Long Island Sound approximately 1 mile west of the Stony Brook entrance buoy in 38-40 feet of water. The reef site was authorized at 150 yards long and 100 yards wide to be at a minimum depth of 23 feet at MLW. The idea for a reef at this site came from Mr. Steve Resler of the Town of Smithtown Conservation Advisory Council.

The reef was originally built in 1976 of 22,000 auto tires in units of 3 each. In 1979, the first wood barge was sunk at this site. Additional barges were added as follows: 1981 (1), 1982 (1), 1984 (2). Six steel cement cylinders were added in 1980. The reef was used in 1981 by the Marine Sciences Research Center of SUNY Stony Brook as a site for algal research. No additions have been made since 1984.

Tautog is the number one species to be found on the reef site with small sea bass, scup, summer flounder, winter flounder and cunner also seasonally available. The barges often harbor large schools of juvenile (YOY) bluefish in September. Commercial and recreational lobster traps are often found on the area. Fishermen aboard open and charter boats from Port Jefferson and areas of western Long Island Sound occasionally fish on the site. The area has been seasonally buoyed by the Town of Smithtown. The COE permit for the site expires on June 8, 1989.

ARTIFICIAL REEF DEVELOPMENT

IN

NORTH CAROLINA

Prepared By:

Liz Noble
North Carolina Division of Marine Fisheries

With the advent of the National Fishing Enhancement Act (1984), the National Artificial Reef Plan (Stone 1985), Wallop-Breaux funding and more stringent US Army Corps Engineers artificial reef regulations, the state-sponsored artificial reef program in North Carolina has undergone a resurgence and reorganization. In 1985, the North Carolina General Assembly passed legislation giving the Marine Fisheries Commission the power and duty to establish standards and adopt rules and regulations governing the location and utilization of artificial reefs in North Carolina's coastal waters. By this legislation, for the benefit of the resource and user groups, the artificial reef program is integrated into the overall marine fisheries management policies of the state.

North Carolina Reef Programs

To assist the North Carolina Marine Fisheries Commission in its artificial reef efforts, the North Carolina Division of Marine Fisheries (DMF) has prepared an artificial reef management plan for the state. The goals, objectives and policies of North Carolina's artificial reef program are stated in the plan. Guidelines are given for reef siting, design and construction, maintenance and enhancement. The plan also addresses liability, coordination, funding and research needs. The purpose of the plan is to guide artificial reef development in North Carolina in a responsible and productive manner for the long term.

The Division of Marine Fisheries is also coordinating all past, present, and future artificial reef development in the state's ocean and estuaries. This coordination involves placement and maintenance of artificial reef buoys, initiation of a general permitting process with the US Army Corps of Engineers, and cataloging of existing sites.

The general artificial reef permit developed by DMF and US Army Corps of Engineers (USACE) allows for multiple planned reef sites to be applied for under one permit. The process is more efficient and the procedures clearly delineated. Artificial reef sites are proposed by interested individuals, organizations or DMF. Preliminary site investigations with respect to bottom sediments, current regimes, proximity to natural hardbottom or traditional commercial fishing grounds, and risk of navigational hazard are made. These initial requirements satisfied, public notice is issued listing the sites, and also announcing the dates and places of mandatory public meetings. DMF also prepares a Pre-Constitution report on each artificial reef site to fulfill USACE permit requirements. Included in the report are site locations, water depths and clearances, proximity to shipping lanes, construction materials, biological and physical site descriptions, and anchoring methods. The public meetings and site investigations ensure that a proposed reef will not endanger naturally productive areas, interfere with commercial fishing, or

pose as a navigational hazard or liability. Sites must also be accessible, providing maximum benefits to the greatest number of fishermen.

As of December 1987, there were a total of 66 permitted North Carolina reef sites. Of these, 42 are ocean sites, of which 35 are developed. North Carolina also has 24 permitted estuarine sites, of which 9 are developed. Eight new artificial reef sites were requested by sport fishing clubs and local governments in 1987. A database containing reef location, material, permit numbers, construction dates and other important facts on each artificial reef has been developed by DMF. This information is continually updated. The purpose of this compilation is not only to have accurate data of all existing artificial reefs, but also to provide essential base line data from which management decisions and future reef program development can be based (Table 17).

Table 17. North Carolina Program Activities

REEF FISHERY MANAGEMENT AUTHORITIES (Federal and State):
South Atlantic Fishery Management Council
North Carolina Division of Marine Fisheries

NUMBER OF PERMITTED REEF SITES: 66
Number In Federal Waters: 32
(3-200 miles offshore)
Number in Territorial Sea: 10
(0-3 miles offshore)
Number in Inshore Waters: 24
(estuarine, riverine)

TYPES OF REEFS:
Benthic - 44
Midwater - 0
Combination - 0

(The remaining 22 permitted sites are undeveloped.)

REEF COORDINATOR: Steve Murphey

STATE REEF PUBLICATIONS:
Beyond the present work on the state reef plans, there have been a number of publications developed by the Division of Marine Fisheries in the past; most notably 3 pamphlets, all titled "North Carolina Artificial Reefs" dated 1974, 1975, 1976 which may be of historical interest only.

STATE ARTIFICIAL REEF PLAN:
The North Carolina Artificial Reef Management Plan is presently being developed. There are two parts to this plan:
1) The North Carolina Artificial Reef Master Plan; and
2) The North Carolina Artificial Reef Implementation Plan.

Research on North Carolina's artificial reefs has been conducted by several universities, the National Marine Fisheries Service, UNC Sea Grant, and the DMF. In the mid-seventies, in conjunction with an active state-sponsored reef program, DMF conducted a recreational creel census and underwater biological survey on several artificial reefs (North Carolina Division of Marine Fisheries 1975, 1976, 1977). Visual surveys gave a good indication of the abundance and diversity of smaller fish (tomtate, pinfish, spottail, and long spine porgy), whereas the creel survey was a better indicator of the presence of larger fish species (king mackerel, amberjack, barracuda). McDonald (1978) researched the standing crop, distribution, and production of the macrobenthic epifauna on the Atlantic Beach reef. 84 species of macrobenthic epifauna were identified. Total macrofaunal biomass on the liberty ship was approx. 10,000 kg. Ostrea equestris, the horse oyster, was the major epifaunal organism on a weight basis (54% of dry weight biomass). These studies showed that artificial reefs off North Carolina's coast are colonized by diverse benthic communities, attract a variety and abundance of fish, and enhance recreational fishing opportunities.

The National Marine Fisheries Service (NMFS) has conducted investigations of North Carolina's natural hardbottom community ecology and reef fish abundance and biology (Grimes et al. 1982, Parker and Ross 1986, Manooch 1977). Data are also available on the offshore headboat fishery (Huntsman 1976). The Division of Marine Fisheries (West et al. 1986) and NMFS (Chester et al. 1984) have collected statistics on the commercial reef fish fishery.

Murray et al. (1985) studied the use of midwater FADs to attract marine fish at two North Carolina fishing piers. Results did showed that FADs are successful in aggregating baitfish in the nearshore environment. Further UNC Sea Grant research is proposed to study the effectiveness of FADs off North Carolina's coast.

The University of North Carolina at Wilmington has been actively involved with artificial reef research off the southern coast of North Carolina since the mid 1970s. To compare noncryptic fish species populations on two jetties at Wrightsville Beach, quantitative visual surveys were conducted by Lindquist et al. (1985). Dietary analysis was also done on resident reef fish to assess their dependence on reef-associated prey. A comparative analysis of fish assemblages associated with old and new shipwrecks and also FADs in Onslow Bay was done by Stephan and Lindquist (1987). Lindquist and Pietrafesa (1987) are studying the effects of the fluid dynamics and current fields around a tugboat reef on fish aggregations and populations. Future studies by researchers at the University of North Carolina at Wilmington (Lindquist et al. 1987) will focus on quantifying the food resources available to key reef fish from the water column, the reef itself, and also the surrounding soft substrate.

The North Carolina Artificial Reef Management Plan addresses future research needs of artificial reefs in North Carolina. Recommendations focus primarily on the study of relative productivity of various reef locations and materials, and also biological monitoring for management decisions.

Artificial Reef Projects

The general distribution of North Carolina's artificial reefs covers the entire coast and most of the estuaries (Figure 14). The first reefs sunk off the coast were within three miles of the shoreline and were in close proximity to major inlets. These reefs are easily assessable to recreational fishermen and divers. In the early 1980s, strong public interest was expressed for estuarine reefs. Tire units were placed on eight estuarine sites during this period. Recently, requests have been made for reefs to be placed in deeper water, with a higher profile, farther off shore to attract species such as king mackerel and tuna.

State program directors and administrators encourage cooperation between the public and private sectors when developing artificial reefs. Many of North Carolina's reefs have been built due to the combined efforts of several state and federal agencies, sport fishing clubs, university researchers, and local communities. Materials for the first artificial reefs in North Carolina were procured and deployed by saltwater sportfishing clubs. Local effort continues today to be instrumental in artificial reef development. In the 1970's, US Marine Corps demolition teams assisted in the sinking of Liberty Ships for artificial reefs. As a training exercise, Marine helicopters transported and deployed materials to ocean reef sites. More recently, Seaboard System Railroad donated 209 train cars for use in the state's artificial fishing reef program. Funding appropriated by the North Carolina General Assembly allowed the cars to be prepared and deployed on 20 reef sites off the northern, central, and southern coasts. With this recent surge in artificial reef development, the state now uses a numbering system to keep track of its artificial reef permits (Table 18).

All benthic reef materials used to date in North Carolina have been materials of opportunity. Aside from train cars, more conventional materials used have been liberty ships, tug boats, trawlers, barges and boat hulls. In the past, tires and tire units were used extensively in artificial reef construction. Due to movement of the tires off reef sites and on to beaches and commercial fishing grounds, the state at this time no longer uses tires as artificial reef material. Recently several older drawbridges over North Carolina's sounds and estuaries have been replaced by more modern high-rise structures. Concrete from the replaced bridges is being used as artificial reef material. Because of the durability and stability of this material, it is hoped that more will be made available in the future for artificial reefs.

Figure 14. Distribution of North Carolina Ocean and Estuarine Artificial Reef Sites

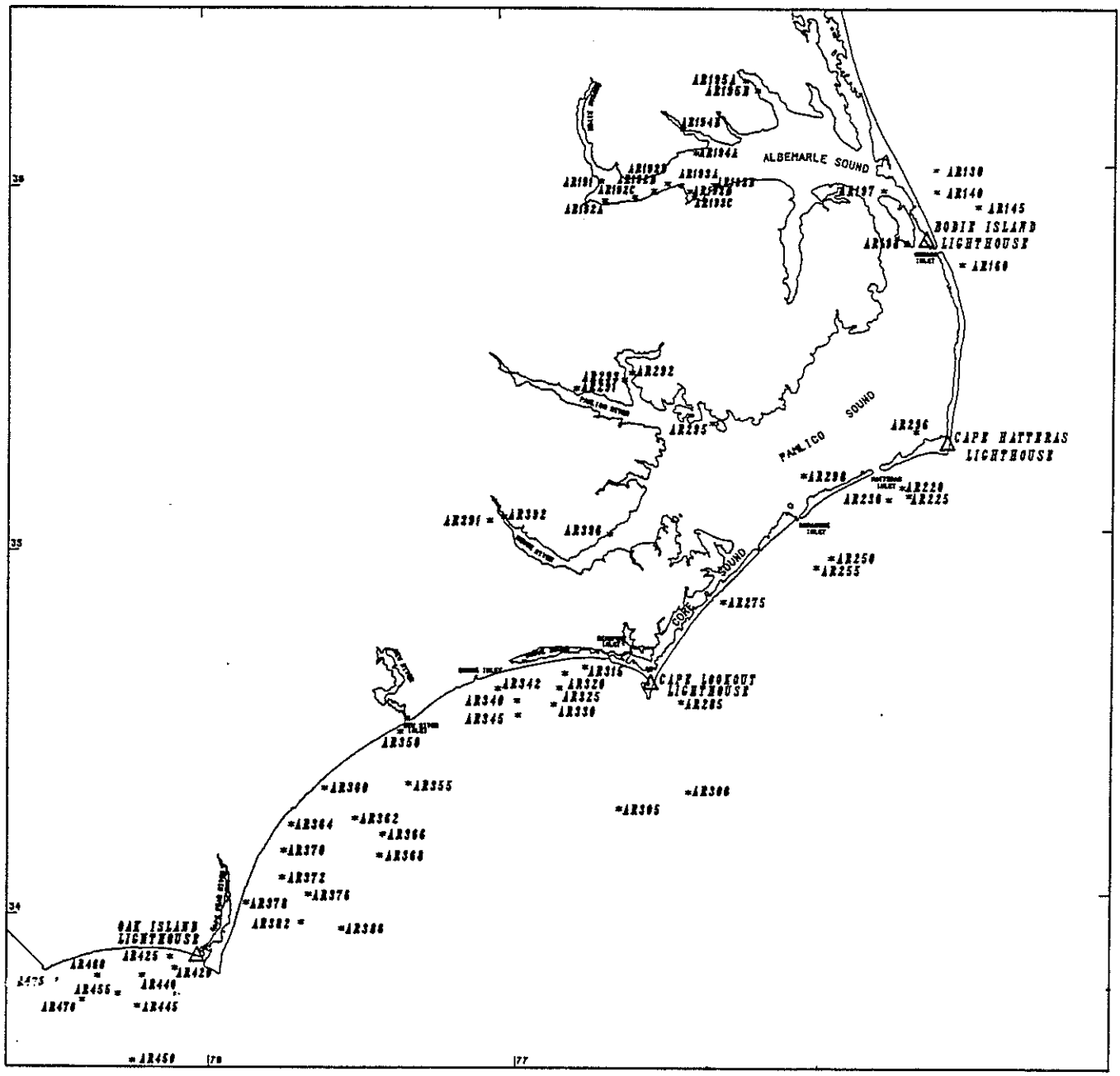


Table 18 North Carolina Artificial Reef Projects

REEF SITE		LOCATION		REEF CHARACTERISTICS			
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
AR-130	5.2	360018	753200	1986	Benthic/Ocean	54	Steel train cars
AR-140	3.7	355645	753200	1986	Benthic/Ocean	54	Steel train cars
AR-145	8.7	355401	752348	1986	Benthic/Ocean	70	Steel hull vessel
AR-160	2.2	354440	752720	1973/77/87	Benthic/Ocean	70	Steel hull vessel
AR-191	0.9	360000	764000	1983	Benthic/Estuarine	18	Tires, steel scrap
AR-192A	0.7	355645	763915	1985	/Estuarine	14	
AR-192B	0.7	353815	762900	1985	/Estuarine	20	
AR-192C	0.5	355715	763300	1985	/Estuarine	20	
AR-192D	0.9	355920	762615	1985	/Estuarine	14	
AR-193A	0.2	355900	762330	1985	/Estuarine	14	
AR-193B	0.9	355800	762140	1985	/Estuarine	14	
AR-193C	0.5	355700	762050	1985	/Estuarine	14	
AR-193D	0.8	355900	761654	1985	/Estuarine	18	
AR-194A	0.9	360415	762020	1985	/Estuarine	17	
AR-194B	0.3	360815	762245	1985	/Estuarine	12	
AR-195A	0.2	361557	760955	1986	/Estuarine	10	
AR-195B	0.4	361417	760725	1986	/Estuarine	10	
AR-197	0.9	355715	754236	1972/87	Benthic/Estuarine	10	Tires
AR-198	1.0	354820	753825	1973/77/87	/Estuarine	11	
AR 220	4.4	350811	754033	1986	Benthic/Ocean	54	Steel train cars, concrete, rubble
AR-225	5.9	350648	753918	1986	Benthic/Ocean	60	Steel train cars, concrete, rubble
AR-230	5.1	350619	754322	1986	Benthic/Ocean	66	Steel hull vessel

Table 18 North Carolina Artificial Reef Projects (cont'd.)

REEF SITE		LOCATION		REEF CHARACTERISTICS			
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
AR-250	8.3	345700	755500	1987	Benthic/Ocean	78	Steel train cars
AR-255	8.8	345530	755800	1987	Benthic/Ocean	84	Steel train cars
AR-275	1.9	345013	761642	1974/87	/Ocean	54	
AR-285	5.5	343351	762532	1986	/Ocean	60	
AR-291	0.4	352555	764542	1984	Benthic/Estuarine	15	Tires
AR-292	0.4	352815	763415	1984	Benthic/Estuarine	13	Tires
AR-293	0.6	352710	763550	1973/77/87	/Estuarine	10	
AR-295	1.1	351940	761810	1973/77/87	/Estuarine	11	
AR-296	2.3	351720	753730	1984	Benthic/Estuarine	11	Tires
AR-298	3.7	351042	755959	1985	Benthic/Estuarine	19	Steel hull vessel
AR-300	18.0	341900	762430	1985	/Ocean	78	
AR-305	19.5	341630	763830	1985	/Ocean	104	
AR-315	1.8	343900	764500	1978/87	Benthic/Ocean	50	Steel hull vessel tires
AR-320	2.2	343900	764900	1986	Benthic/Ocean	49	Steel hull vessel concrete, rubble
AR-325	4.8	343635	765010	1986	/Ocean	50	
AR-330	7.9	343355	765120	1986	Benthic/Ocean	60	Steel train cars
AR-340	5.5	343438	765835	1986	Benthic/Ocean	58	Steel train cars
AR-342	3.0	343642	770218	1974/78/87	Benthic/Ocean	49	Tire units, tires scrap steel
AR-345	7.9	343215	765830	1986	Benthic/Ocean	60	Steel train cars
AR-350	1.5	342949	772124	1987	Benthic/Ocean	31	Steel hull vessel scrap steel
AR-355	9.3	342118	771954	1986	Benthic/Ocean	60	Steel train cars

Table 18 North Carolina Artificial Reef Projects (cont'd.)

REEF SITE		LOCATION		REEF CHARACTERISTICS			
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
AR-360	1.7	342042	773612	1973/78/87	Benthic/Ocean	44	Tires
AR-362	8.7	341540	773024	1986	Benthic/Ocean	54	Steel train cars
AR-364	1.9	341448	774254	1973/78/87	Benthic/Ocean	49	Concrete rubble tires
AR-366	13.6	341300	772506	1986	Benthic/Ocean	66	Steel train cars
AR-368	15.8	340930	772548	1986	Benthic/Ocean	66	Steel train cars
AR-370	3.2	341030	774430	1973/78/87	Benthic/Ocean	52	Steel hull vessel tires
AR-372	5.3	340605	774405	1987	Benthic/Ocean	48	Steel train cars
AR-376	10.2	340314	773940	1987	Benthic/Ocean	60	Steel train cars
AR-378	1.2	340200	775200	1974/78/87	Benthic/Ocean	40	Steel hull vessel tires
AR-382	10.8	335836	774112	1987	Benthic/Ocean	58	Steel hull vessel
AR-386	17.2	335730	773318	1987	Benthic/Ocean	78	Steel hull vessel steel train cars
AR-391	0.1	350425	770325	1983	Benthic/Estuarine	20	Tire units
AR-392	0.5	350500	770037	1983	Benthic/Estuarine	12	Tire units
AR-396	0.5	350150	763930	1972/78/87	Benthic/Estuarine	10	Tire units
AR-420	3.2	335115	780630	1987	Benthic/Ocean	30	Steel hull vessel concrete, steel scrap
AR 425	1.2	335306	780724	1973/78/87	Benthic/Ocean	30	Concrete rubble tires
AR-440	4.9	335000	781300	1987	Benthic/Ocean	42	Steel train cars concrete rubble, tires
AR-445	9.8	334500	781400	1987	Benthic/Ocean	53	Steel train cars
AR-450	18.8	333600	781500	1987	/Ocean	65	

Table 18 North Carolina Artificial Reef Projects (cont'd.)

REEF SITE		LOCATION		REEF CHARACTERISTICS			
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
AR-455	7.6	334700"	781800"	1987	Benthic/Ocean	46	Steel train cars
AR-460	4.0	335000	782200	1987	Benthic/Ocean	38	Steel train cars
AR-470	7.2	334600	782500	1987	/Ocean	48	
AR-485	2.8	334912	782948	1987	Benthic/Ocean	32	Tires TICs, steel scrap

At present, no fish aggregating devices (FAD's), are being deployed by the state. Sport fishing clubs and researchers have used FAD's in the past and are at present requesting permits for their use in the ocean to attract pelagic game fish.

In the future, it is the intention of the North Carolina Division of Marine Fisheries to develop, with the support and interest of local sport fishing clubs, researchers, and county governments, an integrated system of artificial reefs, well managed with respect to both the resource and the user groups. The reefs must be easily accessible, well marked and maintained, and built with stable, durable, environmentally safe materials. With the recommendations of the artificial reef management plan on proper siting, enhancement, and biological monitoring, maximum benefits will be realized and user conflicts minimized. The state will continue to encourage the exchange of information and extensive cooperation with local effort and other state artificial reef programs.

ARTIFICIAL REEF DEVELOPMENT

IN

RHODE ISLAND

Prepared By:

Tom Morrissey
National Marine Fisheries Service

There is no artificial reef development in Rhode Island at present, although the state university conducted significant research programs in the early 1970's. A state sponsored program is being considered, but no definitive actions have been taken.

Rhode Island Reef Programs

Although there are no government sponsored programs or projects now underway (Table 19), several types of designed artificial shelters for lobsters were fabricated from pumice concrete as part of a series of studies begun in Rhode Island during 1971. The results of these studies were published in Marine Fisheries Review (Sheehy [1982] Vol 44. No 6-7, pp 4-15) and excerpts are quoted below.

Table 19. Rhode Island Program Activities

REEF FISHERY MANAGEMENT AUTHORITIES (Federal and State):
New England Fishery Management Council
Rhode Island Division of Fish and Wildlife

NUMBER OF PERMITTED REEF SITES:1
Number In Federal Waters:0
(3-200 miles offshore)
Number in Territorial Sea:1
(0-3 miles offshore)
Number in Inshore Waters:0
(estuarine, riverine)

TYPES OF REEFS:
Benthic: 1
Midwater: 0
Combination: 0

REEF COORDINATOR: None

STATE REEF PUBLICATIONS: None

STATE ARTIFICIAL REEF PLAN: None

Rhode Island Reef Projects

"Preliminary studies with a small single chamber unit (concrete huts) were conducted at several shallow sites off Point Judith, R.I., to determine if the carrying capacity for lobster in sand bottom areas could be increased. Results indicated that the addition of lobster shelters significantly increased resident lobster populations. Observed lobster abundances were equal to or greater than those observed on good natural grounds. In addition, results indicated that shelter spacing had a significant effect on occupancy by lobsters and that shelter orientation, with respect to predominant wave and current directions, affected the stability of the shelters on the bottom.

Interactions between lobster size and shelter spacing intervals were also suggested (Sheehy, 1976).

Two-piece shelters used in the initial study proved to be unstable during severe wave conditions and current velocities. Shelter loss was due both to subsidence resulting form scour and to overturning and separation of sections by wave action. Shelter orientation had some influence on the rate of loss; however, the design was considered unsuitable for all but experimental purposes (Sheehy, 1976).

A second pilot study which compared single-and triple-chamber shelter units affording approximately the same available shelter volume demonstrated that triple-chamber units had greater overall use and supported larger populations due to the compartmentalization. During this study, all benthic life stages of the lobster were observed on and within the reefs. Significant seasonal variations in both lobster and other populations occupying the reefs were also observed (Sheehy, 1976). Although triple-chamber shelters were more stable due to increase weight and bottom surface area, they proved more difficult for divers to handle and space. Both laboratory and field studies were conducted by Jones (1974) to develop a more stable design and a basic computer simulation program to evaluate these units under various combinations of substrate and oceanographic conditions. This information, as well as fabrication costs and logistic considerations, was to design a new and smaller single-chamber unit to conduct larger scale controlled tests at six sites in Rhode Island.

Each of these six reefs was monitored bimonthly by divers for a year. The three most stable reefs were monitored for a second year as part of a second year as part of a tagging program. During each survey, divers carefully monitored the position, size, sex, molt condition, and claw number and size of each lobster. Multidimensional contingency table analysis was used to examine the interaction of variables in the lobster abundance and distribution within the reef (Sheehy, 1977).

Results from this study confirmed and expanded on the prior studies by again demonstrating that the addition of artificial shelters in areas devoid of natural shelter or substrate suitable for burrowing can significantly increase the abundance of lobsters. However, the results also confirmed earlier statements by Scarratt (1973) and others that suitable sites for lobster reefs are limited. A careful examination of all relevant site factors, particularly maximum wave and current conditions substrate and available food resources, should be made prior to future construction. Unit artificial shelters may offer a viable alternative to the use of natural rock or scrap material in the construction of large-scale reefs for lobsters. Although such designed shelters can be used to create new habitat for lobster, a careful analysis of all cost factors should be made before commercial scale reefs are constructed. If some of the legal restraints to "extensive aquaculture" are removed, additional uses for such reefs may soon develop."

ARTIFICIAL REEF DEVELOPMENT

IN

SOUTH CAROLINA

Prepared By:

Mel Bell
South Carolina Wildlife and Marine Resources Department

South Carolina's involvement with artificial reefs dates backs to the late 1830's (Elliott, 1846). This is also the first recorded effort of artificial reef development in the United States. At that time, fishermen commonly caught large numbers of sheepshead (Archosargus probatocephalus) around trees which had fallen into the estuaries and become encrusted with barnacles (a favorite food item of sheepshead). Clearing of the land to permit the cultivation of sea-island cotton began taking away the natural supply of newly fallen trees along the waters edge, and with the disappearance of these trees sheepshead fishing soon began to decline. Realizing the important link between the trees, barnacles and fish, fishermen set about building South Carolina's first artificial reefs. These reefs consisted of hut-like structures 5 or 6 feet high, constructed from oak or pine logs and floated to a desired location in about 8 feet of water. The huts were sunk in place by filling each structure with stones and live oak timbers. After a few weeks barnacles began to grow on the logs, and sheepshead returned once again in abundance.

Despite South Carolina's early history of artificial reef utilization to enhance coastal fishing, it was not until over one hundred years later that further documented construction efforts took place. In the early 1960's, following the success of artificial fishing reefs in other coastal states such as Alabama, Florida and California, a great deal of interest and enthusiasm was sparked among South Carolina's marine recreational anglers (Moore, et al., 1980). Offshore angling groups were formed as early as 1961. As in other parts of the country, many of these organizations were developed specifically for the purpose of building artificial fishing reefs along a particular section of the coast. Today, South Carolina's activities center around a state-sponsored program that constructs and maintains reefs on a coastwide basis.

South Carolina Reef Programs

The first modern reefs constructed off South Carolina were placed three to twelve miles offshore and were made up of a conglomeration of automobile bodies, school buses, large appliances and automobile tires. Most reefs were buoyed in some fashion, but frequent loss of markers due to storms or vandalism made finding reefs often difficult. By 1967, six artificial reefs had been established along South Carolina's coast, providing easy access to one or more reefs from each major coastal population area.

In 1967, the South Carolina state legislature appropriated $30,000 for the construction of offshore artificial fishing reefs. Efforts were directed mainly towards adding material to existing reefs. State funding at this level continued for several years, and in some cases additional matching federal funds were received to further reef construction activities. Reef additions were primarily in the form of single and baled auto and truck tires and a wide assortment of stripped down steel and wooden hulled vessels. During several years, when state

funds were not made available, money was obtained to expand existing reefs from the federal government through the Coastal Plains Regional Commission.

With the reorganization of the South Carolina Wildlife and Marine Resources Department (SCWMRD) in 1973, a state maintained Artificial Reef Program was established under the Saltwater Sportfishing Section of the South Carolina Marine Resources Division (Table 20). This program enabled the state to better manage its efforts in the area of establishing and maintaining artificial fishing reefs along the entire coast. Existing reefs were re-permitted by the U.S. Army Corps of Engineers, listing SCWMRD as permittee. Additionally, SCWMRD accepted responsibility for marking reefs with properly maintained Private Aids to Navigation. Since 1973, all reef construction activities in South Carolina have been carried out by, or have been under the supervision of the state reef program.

Table 20. South Carolina Program Activities

REEF FISHERY MANAGEMENT AUTHORITIES (Federal and State):
South Atlantic Fishery Management Council
S.C. Carolina Wildlife and Marine Resources Department (Marine Resources Division)

NUMBER OF PERMITTED REEF SITES: 22
Number In Federal Waters: 16
(3-200 miles offshore)
Number in Territorial Sea: 3
(0-3 miles offshore)
Number in Inshore Waters: 3
(estuarine, riverine)

TYPES OF REEFS:
Benthic - 9
Midwater - 0
Combination - 11
Two benthic sites are planned for summer of 1988.

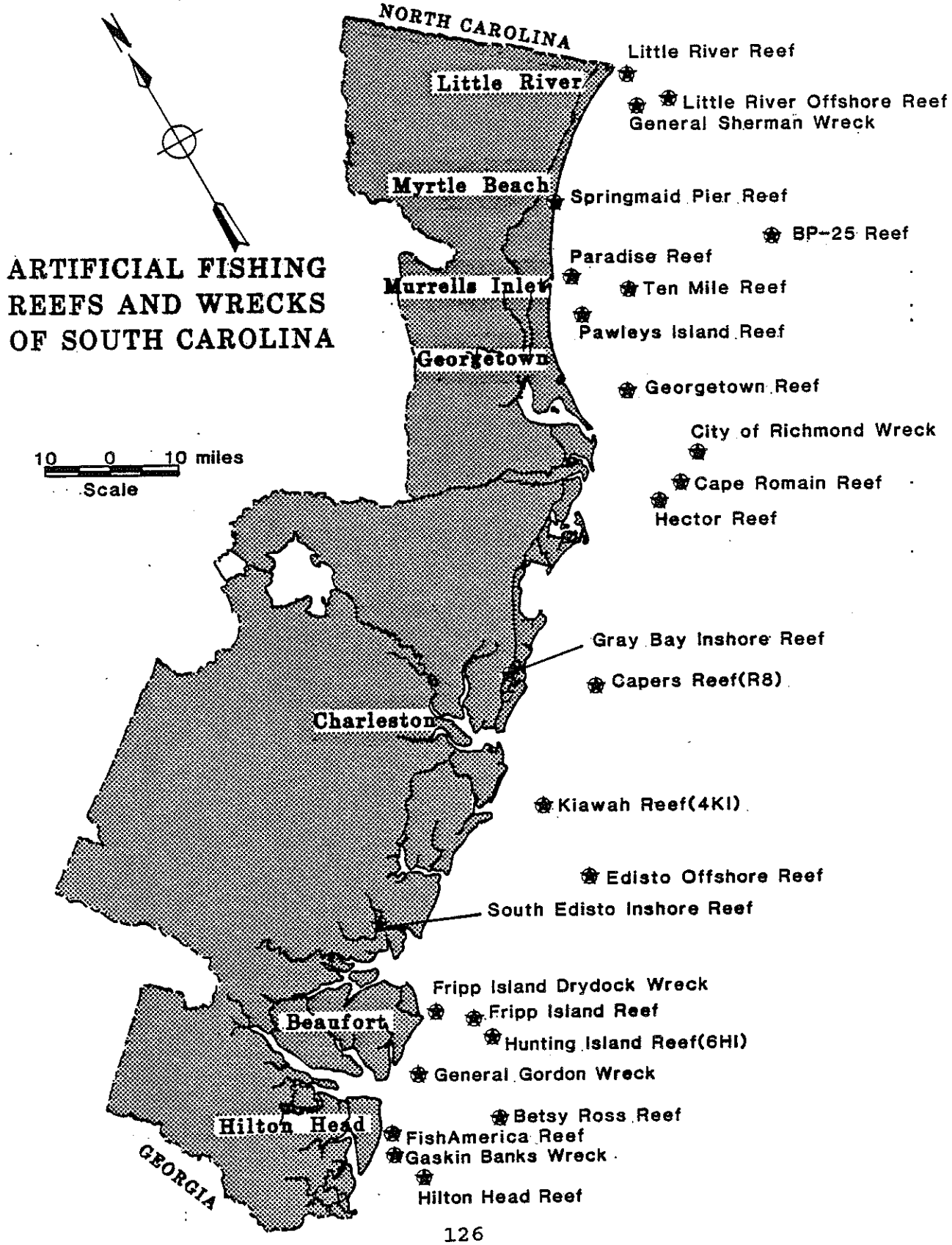
REEF COORDINATOR: Melvin Bell, S.C. Marine Resources Division

STATE REEF PUBLICATIONS:
Saltwater Conversation - Artificial Reef News
A Guide to Saltwater Recreational Fisheries, SCMRD Monthly Publication

STATE ARTIFICIAL REEF PLAN: None

From 1973 to 1987, fifteen additional artificial reefs were established along South Carolina's coast. Today South Carolina's 22 established artificial reef sites can be categorized as follows: 15 offshore (3-32 miles out), 3 nearshore (0-3 miles out), and 3 estuarine (Figure 15). Permits have recently been

Figure 15. Distribution of Artificial Fishing Reefs and Wrecks of South Carolina



obtained for the establishment of two new offshore reefs (vessels) in 1988, and plans are being made for the creation of one or two additional nearshore reefs. Further work is also being considered in the area of estuarine reefs. Most of South Carolina's artificial reefs are typical benthic reefs with both high and low profile bottom structures. In addition to these materials, twelve of the offshore reefs and one nearshore reef now contain trolling alleys, consisting of one to two hundred midwater fish aggregation devices (FAD's) deployed in rows up to a half mile long.

Since its establishment in 1973, SCWMRD's Artificial Reef Program has maintained responsibility for all permitting, design, marking and construction activities for marine artificial reefs off South Carolina. This program has operated on an annual state appropriated budget, excluding salaries, which has ranged from no funds at all to as high as $46,500. Recent public support and awareness to the benefits of artificial reefs are felt to have helped assure, at least to some degree, funding over the past several years. Support from Wallop-Breaux funding has also been received for two years to carry out a project to design, deploy and evaluate manufactured artificial reef materials for the reef program. The Artificial Reef Program is currently staffed by one full-time biologist and one full-time technician. Support in the form of additional personnel, equipment and vessel time is also provided by the Marine Resources Division as needed.

Artificial Reef Program personnel often work with recreational fishing clubs or other interested groups in accomplishing artificial reef projects in a particular area. SCWMRD is currently working with the U.S. Army Corps of Engineers to obtain a general permit for all future artificial reef construction projects. As funding is limited, much of the reef construction activity in South Carolina is still dependent upon donations of materials, funds or services from private companies, supportive groups or individuals. The high price of suitable marine transportation for offshore construction remains the primary prohibitive factor in constructing new, or expanding existing reefs.

The Artificial Reef Program uses a substantial portion of its annual budget in maintaining an effective system of buoys. Currently, there are 38 of these federally permitted Private Aids to Navigation marking South Carolina's artificial reefs. Since the majority of artificial reefs off South Carolina's coast are out of sight of land, the accurate placement of these markers is essential in allowing the average recreational fishermen access to these reefs. Even for those fishermen who have the ability to navigate offshore by Loran C, buoys are effective in allowing them to more readily utilize the reef.

Providing accurate information which will allow fishermen to locate and enjoy these reefs is an important function of SCWMRD's reef program. This is effectively accomplished through recreational fisheries publications, newsletters, special brochures and news releases. A great deal of information is also relayed to the public through speaking engagements, attendance at fishing club meetings and providing displays and handouts during special activities such as recreational fishing fairs and outdoor recreational expositions. In addition to such direct contact with the public, hundreds of individual requests for information concerning reefs are responded to through the mail each year.

The future of artificial reef construction in South Carolina depends greatly upon funding. The current level of funding provided through state appropriations is inadequate for broadened construction activity, and the likelihood of significantly expanded support through state revenues is doubtful. However, in the near future additional operating funds will be obtained as a result of the passing of Federal Public Law 98-369 (Wallop-Breaux Funds). There is also the possibility of future funding for artificial reef construction activities becoming available within the next few years through the adoption of a statewide saltwater fishing license. Such a license, if put into place, would be a logical source of funding for increased recreational fisheries enhancement projects, of which artificial reefs would play a major role. For this reason the future for artificial reef construction in South Carolina looks bright.

Whatever future level of funding is realized, the South Carolina Artificial Reef Program will continue to work towards continued reef expansion. The intense recreational fishing pressure currently being exerted on individual reefs dictates that construction of new reefs and expansion of existing ones be carried out as much as possible to prevent over-exploitation of associated fish populations. Over-fishing these smaller reefs would greatly affect the quality of fishing available, and subsequently detract from their usefulness and long-term cost-effectiveness. Construction activities will continue to be carried out utilizing good quality scrap materials when available, and by incorporating the use of specifically designed prefabricated reef materials when possible.

At present, South Carolina's artificial reef system is geared only toward recreational fisheries enhancement. Twelve offshore artificial reefs were recently designated as special management zones (SMZ's) by the South Atlantic Fisheries Management Council. This action was requested by SCWMRD to protect these artificial reefs from over-fishing, especially throughout the use of fish traps. The SMZ status resulted in the restriction of fishing activities on these reefs to hand-held hook-and-line fishing, and spear fishing by SCUBA divers only. If warranted, SMZ status may be sought for additional offshore reefs in the future. Due to their small size, South Carolina's existing artificial reefs are over-fished too easily under heavy

fishing pressure and cannot support intensive commercial activities. The establishment of artificial reefs with commercial applicability needs to be considered as a future possibility, based on what has been learned from smaller scale reefs. At present, it is most likely that such reefs would be located in offshore areas to enhance fisheries for commercially valuable finfish such as snapper and grouper.

South Carolina Reef Projects

South Carolina has constructed a variety of artificial reefs (Table 21). As is the case with most artificial reef construction in the United States, South Carolina's program has depended almost entirely upon the utilization of scrap materials to carry out construction efforts.

Over 60 unserviceable watercraft of all shapes and sizes have been sunk, providing the bulk of the existing benthic substrate in the reef system. The majority of these vessels are steel hulled barges, boats and ships acquired from the U.S. Government Property Disposal Office or through donations from private companies. South Carolina also has one liberty ship reef which was sunk in 1978, the Artificial Reef Program is currently preparing to create a new offshore reef from a 460 foot vessel obtained from the U.S. Maritime Administration's research fleet.

Used automobile and truck tires which were once placed on South Carolina's reefs by the tens of thousands are currently only used when embedded in concrete slabs. Unballasted tires in single or baled configurations lacked long-term stability and therefore proved to be less cost effective over time as other more stable materials. The concrete slab units are stable and useful in certain situations when complex low profile (2-4 ft.) reef structure is required.

In 1974, the South Carolina Artificial Reef Program began experimenting with the concept of using mid-water FAD's in a long line to enhance recreational fishing for pelagic species. This configuration of FAD's became known as a trolling alley (Hammond et al., 1977). The first experimental scale trolling alley was built adjacent to an existing artificial reef off Charleston, S.C. in 1974. Thirty FAD's made from automobile tires, suspended 20 feet below the surface, were set out in a single row near the reef in 45 feet of water. This trolling alley was evaluated and found to significantly improve angler success over fishing in a nearby control area.

In 1980, a one mile long trolling alley, consisting of 120 tire FAD's was constructed 21 miles off Charleston in 72 feet of water. This reef provided favorable results for recreational anglers, and also received attention from commercial king mackerel fishermen working in the area, (Myatt and Myatt, 1982). Since 1980 eleven additional trolling alleys have been constructed using a FAD designed from monofilament fishing line and plastic strapping. These new FAD's which have proven to be

Table 21. SOUTH CAROLINA Artificial Reef Projects

REEF SITE	LOCATION			REEF CHARACTERISTICS			
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
Betsy Ross	15.8	320302	800500	1978	Benthic/Ocean	85	Vessels
BP-25	30.0	332112	782512	1985	Combination/Ocean	90	Vessels, FADS
Cape Romain	12.5	325945	790221	1986	Combination/Ocean	68	Vessel, Scrap metal FADS
Capers	7.9	324450	793440	1968	Combination/Ocean	45	Vessels, tires, FADS scrap concrete & metal
Edisto	23.5	321510	795050	1981	Combination/Ocean	70	Vessels, FADS
South Edisto	1.0	323203	802330	1980	Benthic/Estuarine	25	Tires, concrete rubble
FishAmerica	2.0	320810	804066	1984	Benthic/Ocean	90	Concrete
Fripp Island	5.5	321570	802190	1968	Benthic/Ocean	36	Tires, concrete and metal rubble
Georgetown	8.2	331468	785975	1975	Combination/Ocean	41	Tires, vessels, scrap metal, FADS
Gray Bar	1.0	325040	794600	1982	Benthic/ Estuarine	15	Tires, scrap concrete
Hector	11.0	330002	790600	1985	Benthic/Ocean	23	Vessel, scrap metal
Hilton Head Reef	11.5	320040	803550	1976	Combination/Ocean	50	Tires, vessel FADS
Hunting Island	8.1	321350	801950	1971	Combination/Ocean	50	Tires, vessel, scrap metal, FADS

Table 21 SOUTH CAROLINA Artificial Reef Projects (cont'd.)

REEF SITE		LOCATION			REEF CHARACTERISTICS		
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
Kiawah	7.0	322900"	800030"	1967	Combination/Ocean	45	Tires, vessels, scrap metal, FADS
Little River	2.5	334920	783000	1975	Combination/Ocean	32	Tires, scrap metal FADS
Little River Offshore	10.5	334110	782640	1985	Combination/Ocean	55	Vessels, scrap metal FADS
Paradise	2.8	333100	785800	1969	Combination/Ocean	31	Tires, vessels, scrap
Pawley's Island	5.0	332630	790055	1973	Combination/Ocean	38	Tires, vessel, metals
Springmaid Pier	0.1	334000	785500	1984	Benthic/Ocean	18	Fabricated concrete scrape concrete, rock, tires
Ten Mile Reef	10	332650	785140	1975	Combination/Ocean	42	Tires, vessels, metals, FADS
Vermilion	28	325750	783970	1988	Benthic/Ocean	110	Vessel
Y-73	25	323250	791950	1988	Benthic/Ocean	95	Vessel

equal to or better than the tire FAD's in improving fishing, are much lighter and easier to transport and deploy. Utilization of the light-weight design has made trolling alleys much more affordable, and its simplicity has also permitted various fishing clubs and other organizations to assist in the construction of trolling alley units.

In 1984, South Carolina's Artificial Reef Program, working in conjunction with the owners of a well established fishing pier at Myrtle Beach, S.C., helped establish the states' first fishing pier/artificial reef combination in the Atlantic Ocean. The reef was established on a small scale to allow careful consideration prior to future expansion. One hundred tire/concrete slab reef units were placed adjacent to one side of the pier in groups of ten. To date, the reef has remained extremely stable (despite three hurricanes), and has provided the owner of the pier with increased revenues and improved catch rates. In a similar project in 1987, an artificial reef was constructed adjacent to a pier inside one of the coastal inlets. This reef was made from scrap concrete pipe and beds of oyster shell as well as live oysters. Continued observations at both of these reefs will dictate whether or not additional construction is carried out at other South Carolina coastal piers in the future.

In an effort to evaluate modern artificial reef technology for future long-term construction efforts on South Carolina's reefs, the Artificial Reef Program recently began a research project to design, manufacture and test specifically constructed artificial reef units. Thus far, nine different designs of reef habitat units have been deployed on test reefs off the coast. Materials used in these designs include plastics, steel, concrete and scrap truck tires. At this point several of the designs seem to hold a great deal of promise for continued use on a larger scale in future reef construction efforts. The primary purpose of using designs such as these in building reefs, is to provide reef managers with a low cost, readily available source of sufficient quantities of material from which to construct broader scaled artificial reefs. Utilization of such materials is planned to coincide with adequate funding levels becoming available in the near future.

With a reliable design, or designs, of manufactured reef materials available, South Carolina's artificial reef program could lessen its dependence on the uncertain availability of suitable scrap materials to complete reef construction projects. That is not to say that quality scrap materials such as steel barges, boats and ships would no longer be utilized, but reef development could be planned and carried out in a logical more timely manner using the designed materials as a primary source with suitable scrap materials taking on a secondary role as they become available.

In addition to the above studies on reef designs, several of South Carolina's artificial reefs have been the subject of scientific studies involving various aspects of artificial reef

ecology (Parker, et al., 1979; Steimle and Ogren, 1982; and SCWMRD, 1984). The economic significance of artificial reefs and their importance to the well-being of the recreational sportfishing industry has also been addressed (Buchanan, 1973; Buchanan et al., 1974; Liao and Cupka, 1979). Development and utilization of fish aggregation devices and the concept of multiple FAD configurations in trolling alleys have also been documented (Hammond et al, 1977, Myatt and Myatt, 1982).

ARTIFICIAL REEF DEVELOPMENT

IN

VIRGINIA

Prepared By:

Michael Meier
Virginia Marine Resources Commission

Virginia's interest in saltwater sport fishing is evidenced by 1985 estimates which place the number of recreational anglers fishing in Virginia's Chesapeake Bay and coastal waters at 909,000. 86.7% of these anglers fished from boats, taking 2,912,000 fish, 62.6% of which were caught in the Chesapeake Bay system (Virginia Marine Resources Commission, 1987). This level of participation has resulted in the growth of the recreational fishing industry in general and placed an increasing demand upon the resource which supports it.

Virginia's Artificial Reef Program is attempting to address this pressure with controlled artificial reef development in Virginia's Chesapeake Bay and coastal waters to approximately 30 nautical miles offshore. The program's long range objectives are to provide increased recreational opportunity, while spreading the resource as well as the harvesting pressure upon it, through the introduction of habitat providing structure/substrate. The expected benefits of this program are:

To provide enhanced recreation;

To develop an increased resource awareness in the general public; and,

To augment, from a fisheries management standpoint, the understanding of the Commonwealth's recreational fishery, as well as the habitat utilization and biological characteristics of reef, or structure, associated fishes.

Virginia Reef Programs

The state was not Virginia's first reef builder. Organized interest in building artificial reefs (permitted sites referenced on navigation charts) can be traced back approximately forty years. As has been the case elsewhere, these early efforts were undertaken as a "labor of love" by dedicated sport fishermen. As is often the case now, volunteerism and donated "materials of opportunity" were the order of the day. Junked autos, old fishing vessels, discarded tires, and military surplus, consisting of primarily of landing craft and pontoon sections, were all pressed into service for artificial reef duty.

Somewhat limited documentation indicates that, in 1950, a total of 90 automobile bodies were deployed in Virginia's coastal waters at two reef sites off of Chincoteague. The development of these reefs, at Blackfish Bank and Winter Quarter Shoal, was a cooperative effort involving local townspeople and the Coast Guard Auxiliary (Lucy, personal communication). The first permitted reef in Chesapeake Bay was constructed off Thimble Shoal Light in 1961, also using auto bodies, by the Tidewater Artificial Reef Development Association (TARDA). Virginia's first recorded tire reef was placed in the Bay off the mouth of Onancock Creek in 1970 by the Eastern Shore of Virginia Angler's Club. The first Liberty Ship was sunk in the Atlantic Ocean at Triangle Reef, 30 miles off the Virginia Capes, as a

cooperative effort between the Tidewater Artificial Reef Association of Virginia (TARAV) and the state. The first use of structures specifically designed for use as artificial reefs occurred in 1983 during a three-year research project in the Atlantic at Wachapreague Reef off of Wachapreague Inlet. Some of the early reefs are still fished today, although most of the sponsoring organizations have long since disbanded.

Virginia's current state-supported artificial reef program (Table 22) is a product of private sector efforts which began in 1970 with the formation of TARAV. Working in concert with Richard Stone of the National Marine Fisheries Service and Virginia Congressman Tom Downing, TARAV was instrumental in the passage of Public Law 92-402. This act enabled the U.S. Maritime Administration to "make available to the states" surplus World War II Liberty Ships for use as artificial reefs. In addition to obtaining permits for two offshore reef sites, one of which was chosen for the placement of four of the ships, TARAV's further efforts resulted in state legislation that reappropriated unrefunded motorboat fuel taxes to support an ongoing reef program. The state became formally involved in reef building when the Virginia Marine Resources Commission (VMRC) was named the authorized recipient for the preparation and deployment of six Liberty Ships.

Table 22. Virginia Program Activities

REEF FISHERY MANAGEMENT AUTHORITIES (Federal and State):
Mid-Atlantic Fishery Management Council
Virginia Marine Resources Commission

NUMBER OF PERMITTED REEF SITES: 12
Number In Federal Waters: 6
(3-200 miles offshore)
Number in Territorial Sea: 1
(0-3 miles offshore)
Number in Inshore Waters: 5
(estuarine, riverine)

TYPES OF REEFS:
Benthic - 10
Midwater - 0
Combination - 2

REEF COORDINATOR: Michael Meier, VA Marine Resources Commission

STATE REEF PUBLICATIONS: LORAN Coordinate Handout, Reef and Wreck Chart available from Marine Resources Commission

STATE ARTIFICIAL REEF PLAN: Preliminary stages of development

---

The first project facing Virginia's state reef program was to coordinate the preparation and sinking of each of the six ships acquired under P.L. 92-402. This consisted primarily of monitoring the partial scrapping and cleaning operations so as to comply with U.S. Army Corps of Engineers and U.S. E.P.A. permit requirements. Due to the anticipated development at that time of new generations of super tankers, permitting agencies required that each vessel be cut down to the second deck level, which limited maximum profile to approximately 28'. Propulsion machinery and internal compartments were removed. Only primary transverse bulkheads and some decking over and around the main cargo hatches was left in place. All fuel and other petroleum based residues were flushed out with cleaning agents which were, in turn, flushed out with water. Using the opportunity as a training exercise, all six vessels were sunk by the U.S. Navy's Harbor Clearance Unit II from Little Creek Amphibious Base at two offshore sites.

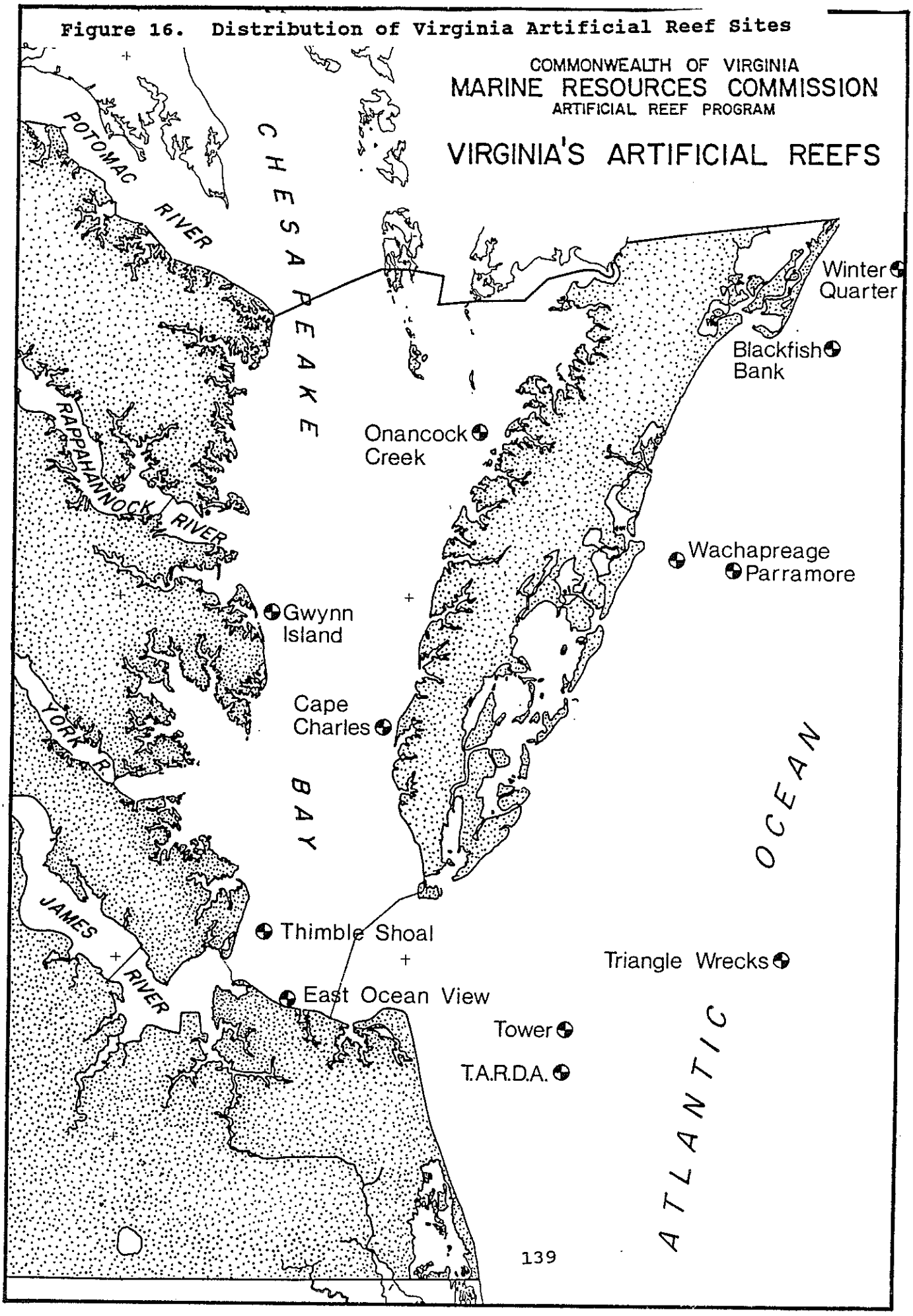
The next task to be undertaken was the development of an ongoing tire reef program. A deck barge was acquired as a donation from Lone Star Industries and a berthing and loading facility was established at a slip provided by the N.O.A.A. Atlantic Marine Center in downtown Norfolk. A tire collection and staging operation was set up on property owned by the City of Norfolk.

The first tire configuration used consisted of bundles of compacted and baled automobile tires strung on steel cable. The bales were loaded onto a cargo barge arranged in beam-to-beam rows three layers deep. A continuous steel cable was then run through the bales. Once over the reef site, the bales of tires were then towed off the deck by the cable length using a pull boat. Similar configurations were being used successfully at that time by the North Carolina reef program (Meier, et. al., 1985).

In an effort to gain more profile, a tire "module" was developed consisting of four stacks of split tires fastened together in the form of a 31/2 to four foot cube. Split tires were used to increase the density of the module. Short term observations indicated the individual "splits" sanded in with little movement. The units were loaded and deployed from barges using front end loaders. From a fishing standpoint, the modules were successful in that they could be stacked on the bottom two to three high, making them easy to locate on a fathometer and extremely effective in attracting fish (Feigenbaum and Blair, 1983); however, further observation of a test deployment confirmed the instability of the unballasted design, leading to the discontinuation of their use by the program.

Virginia's reef program is currently developing sites in the Chesapeake Bay and coastal waters to approximately 30 NM offshore (Figure 16). Along with consideration of the usual siting criteria (i.e., target species, appropriate environmental conditions, accessibility, etc.), obstruction areas currently

Figure 16. Distribution of Virginia Artificial Reef Sites



avoided by commercial fishing vessels are being given priority for development. A variety of structures and materials are utilized, depending upon application and reef location. The program operates under a quota system requiring the annual deployment of 217,000 sq. ft. of substrate.

Virginia Artificial Reef Projects

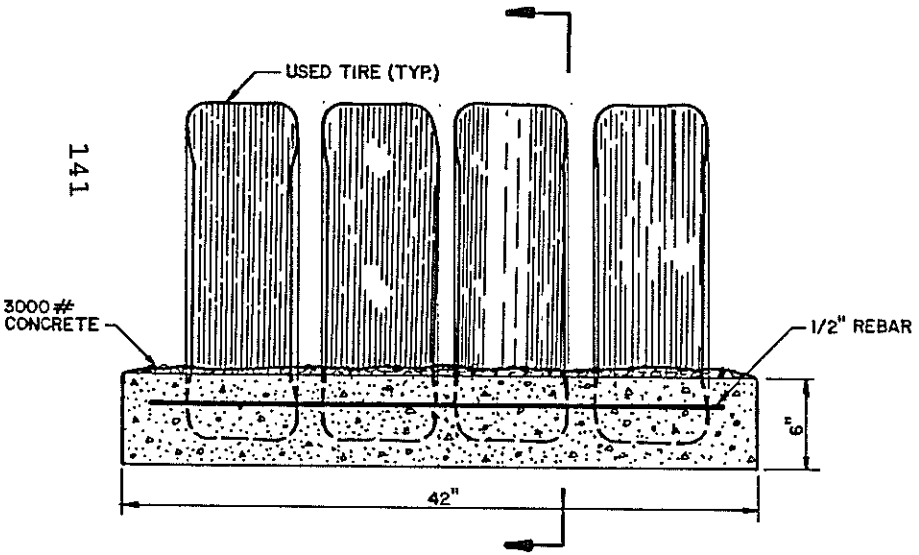
All of Virginia's reef sites with the exception of Triangle Reef, the NE corner of which is delineated by a permanent USCG aid, are normally marked by a network of buoys. The program is currently evaluating a number of different buoy and semi-taut mooring system designs. Reef buoys are established and maintained on an in-house basis as part of normal program operations.

The program maintains an active liaison with the public by sponsoring and participating in seminars and programs involving sport fishing organizations and other interested groups. Descriptive information on reef sites in the form of handouts giving reef locations and LORAN bearings and reef/wreck charts is prepared and distributed.

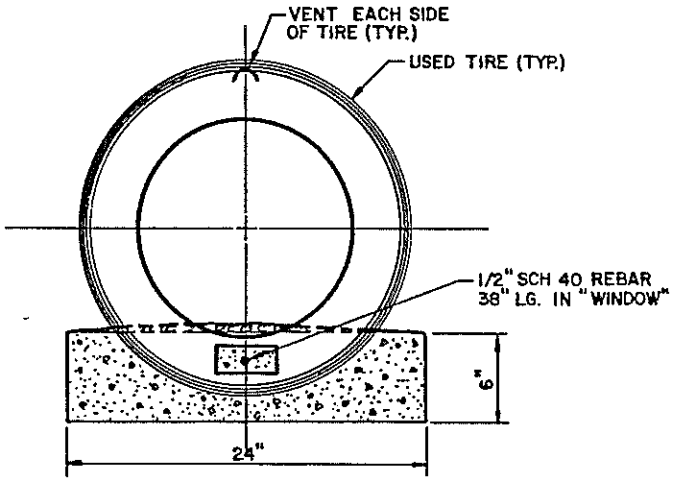
Structures and Materials Utilized

A Tire-In-Concrete, or "TIC" unit is produced "in house" by the program and is used to develop low-profile forage habitat. The unit consists of a 27"x42"x6" reinforced concrete slab, into which four tires are inserted upright (Figure 17). The TIC has proven to be durable and stable and an effective structure in terms of fouling characteristics and fish attraction. These units are currently being deployed on offshore sites around vessels, such as barges, landing craft and drydocks which have been sunk to provide medium to high profile.

In the Bay, the current fabricated structure of choice is the concrete "Igloo" (Figure 18). Developed during a three-year study conducted for the artificial reef program by Old Dominion University (ODU), the structures have been deployed and monitored in both the Chesapeake Bay and Atlantic Ocean. The present version is fabricated of 4,000 PSI reinforced concrete, weighs approximately 6 tons in air and provides 7 1/2 feet of profile. An 18" wide flange at the base of the structure drops the bottom loading factor to approximately 130 lbs. per sq. ft. As with the TICs, monitoring has confirmed the stability, durability (which is conservatively estimated to exceed 50 years) and biological effectiveness of these units. The current application of the Igloo is to provide medium to high profile habitat on Chesapeake Bay reefs. At this writing, one reef in the lower Bay (East Ocean view) has been redeveloped with 40 Igloos. Following guidelines developed during the referenced study, the structures are deployed in a staggered grid pattern in groups consisting of three to four units each. At a later date, lower profile materials, such as rock or concrete rubble, will be placed around the clusters to increase habitat complexity.



ELEVATION



SECTION

COMMONWEALTH OF VIRGINIA
MARINE RESOURCES COMMISSION
ARTIFICIAL REEF PROGRAM

TIRES IN CONCRETE (TIC)

NOT TO SCALE MARCH 1987

Figure 17. Virginia Tire Reef Units

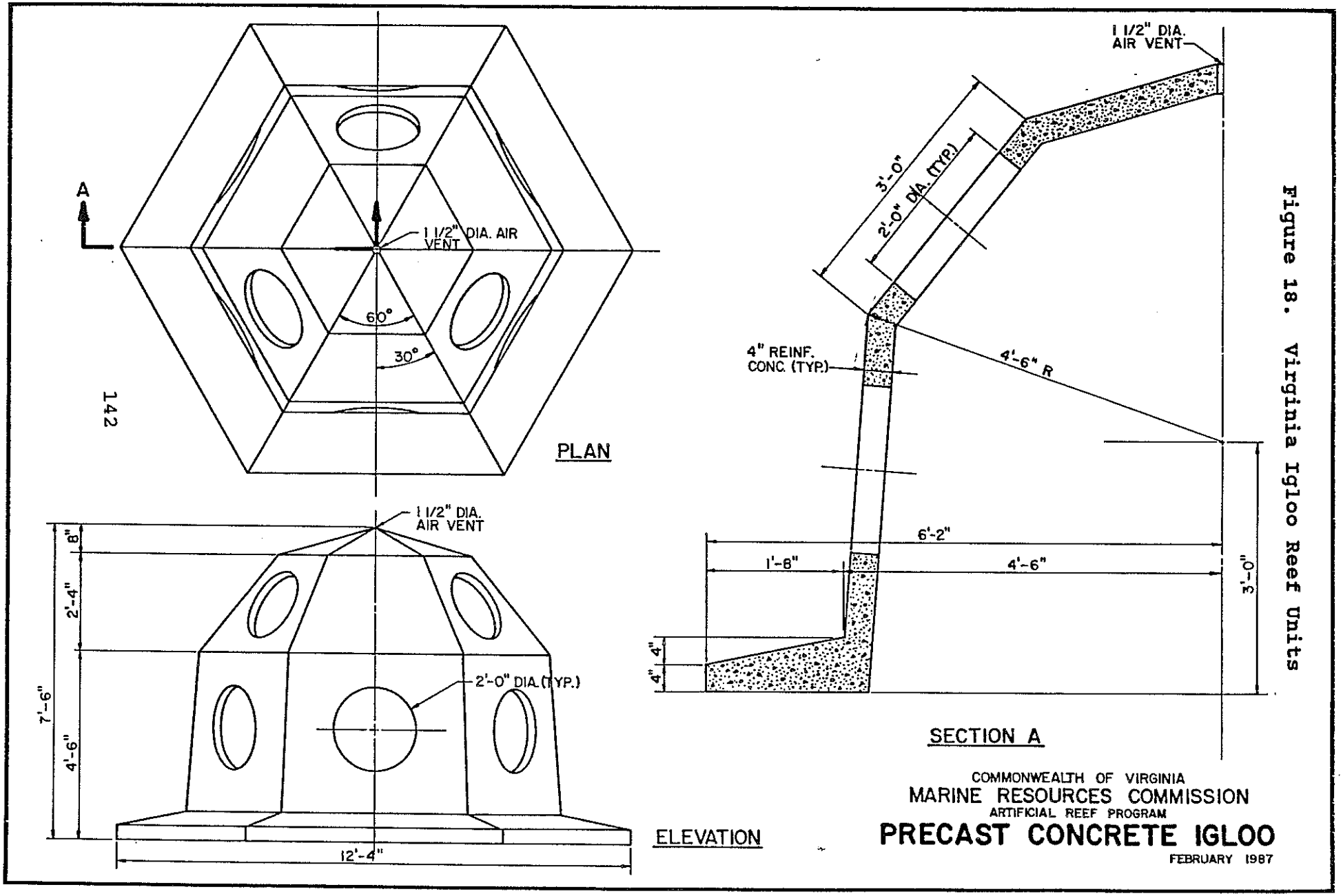


Figure 18. Virginia Igloo Reef Units

Along with TICs and Igloos, Virginia's program has and will continue to utilize metal "vessels of opportunity" to provide medium to high profile on offshore reefs. On Chesapeake Bay sites, concrete rubble and rock will be utilized to augment higher profile structures as well as develop sites in depths too shallow for other materials (Table 23). The further enhancement of existing sites as well as the establishment of additional Bay and oceanic reefs is planned.

Site Monitoring and Research

As mentioned previously, ODU was contracted to perform a three-year artificial reef study for the program. This was the program's first opportunity to conduct any type of research and monitoring activity. The study consisted of the development of three test reefs, one Bay and two offshore sites, with a combination of recycled materials and specifically designed structures. After the various units were deployed, they were diver-monitored to assess structural stability and durability as well as fouling characteristics. All three reefs were fished using standardized hook and line methods to develop CPUE and species composition data. The results included the development of the concrete Igloo, a changeover in the "in house" produced tire units and a series of recommendations for future direction, many of which are being used in the development of a state plan. For a detailed description and summary, see Feigenbaum and Blair, 1986.

The baseline CPUE and species composition data generated during the study have been augmented by further monitoring of the Gwynns Island test reef, one of the Bay sites (Feigenbaum, et. al., 1988), and a two-year catch and effort survey of the Chesapeake Bay and offshore reefs by systematic interview (Lucy, et. al., 1988).

In the future, Virginia's Artificial Reef Program will comply with the intent of the National Artificial Reef Plan by continuing to conduct compliance and productivity monitoring as follows:

Compliance monitoring will include pre- and post deployment surveys to develop detailed baseline and update data in determining bottom conditions as well as structure and buoy status. Data will be obtained by diver inspection and analysis of printouts generated by side-scan SONAR and electronic digital surveys.

Productivity monitoring will include continued catch and effort surveys, diver observation, and studies to obtain information concerning population estimates and characteristics.

Table 23. VIRGINIA Artificial Reef Projects

REEF SITE	LOCATION			REEF CHARACTERISTICS			
Name	Distance (Naut. mi)	Latitude (° ' ")	Longitude (° ' ")	Permit Date	Type\Environment	Depth (ft.)	Composition
Blackfish Bank	4.0	375112"	751600"	1950	Benthic/Ocean	10-30	Autos
Cape Charles	1.3	371936	760248	1983-1986	Benthic/Estuarine	29-38	Igloos, concrete pipes, tire units
East Ocean View	.4	365632	761211	1967-1987	Benthic/Estuarine	28	Vessels, autos, igloos
Gwynns Island	1.6	372854	761420	1984-86	Benthic/Estuarine	22	Tire units, igloos
Onancock Creek	2.2	374400	755245	1969-1970	Benthic/Estuarine	19-31	Tires
Parramore	7.1	373236	752618	1972-1988	Benthic/Ocean	50-75	Liberty ships, tire units
TARDA (Tidewater Art. Reef Dev. Assn.)	11.0	365036	754400	1959	Benthic/Ocean	64	Auto bodies
Thimble Shoal	2.0	370155	171454	1961	Benthic/Estuarine	14	Auto bodies
Tower	13.6	365404	754330	1971-1988	Combination/Ocean	45-80	Vessels, barges, drydocks, tire units FADs
Triangle Wrecks	28.0	370000	752124	1971-1988	Benthic/Ocean	100	Liberty ships, vessels
Wachapreague	1.4	373506	753112	1983-1986	Combination/Ocean	28-45	FADs, concrete pipes, tire units, igloos
Winter Quarter	5.4	375800	750918	1950	Benthic/Ocean	10-30	Auto bodies

AN ASSESSMENT OF ATLANTIC REEF DEVELOPMENT: PRESENT STATUS AND FUTURE TRENDS

Prepared By:

Joseph McGurrin
Atlantic States Marine Fisheries Commission

Atlantic coast artificial reef development involves a wide diversity of activities. Given the existing information on individual state reef activities, a basic assessment of the present status of Atlantic reef development can be developed along with projections about future reef development trends.

Present Status of Atlantic Artificial Reef Development

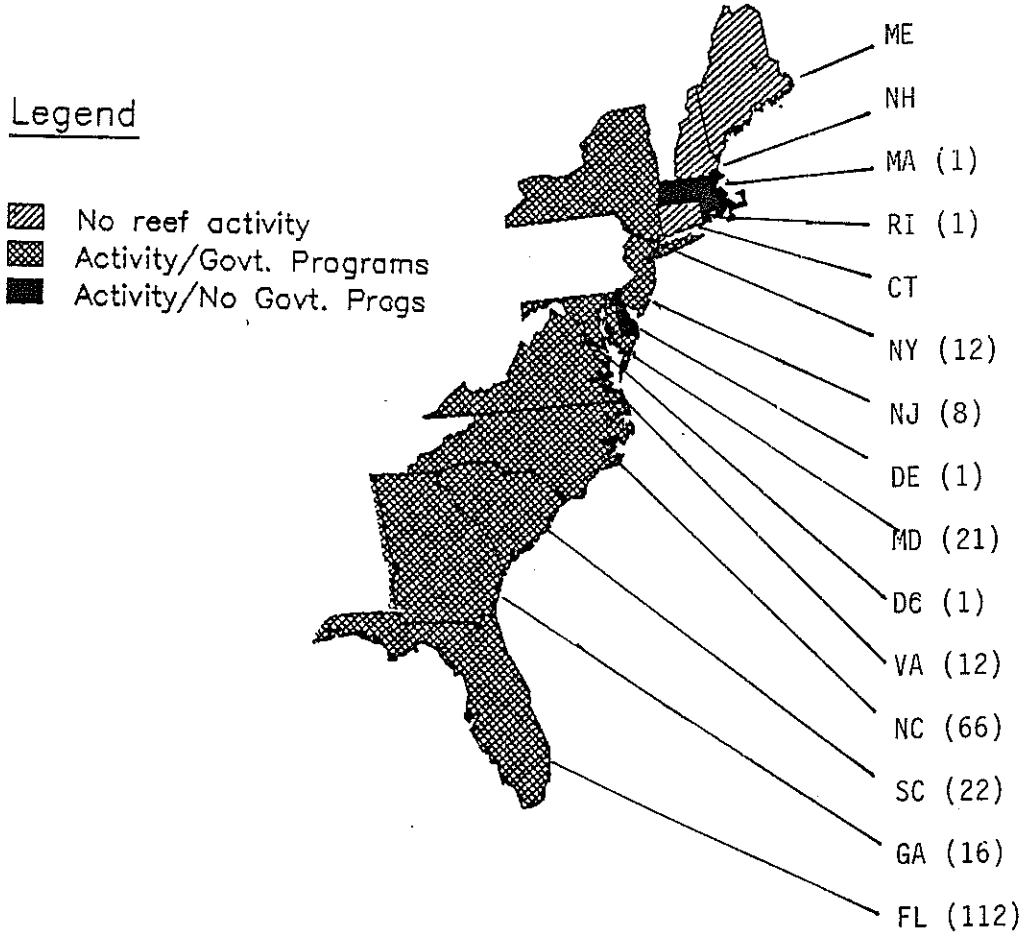
Of the 14 coastal states (plus the District of Columbia) surveyed for this Atlantic profile, 12 had some documented record of reef development activity (Figure 19). Of those 12 jurisdictions, 9 had government sponsored reef programs. Four states (New Jersey, North Carolina, Maryland, Virginia) are writing formal statewide artificial reef plans.

There are 273 permitted reef sites along the entire coast, with 26 of these still waiting for deployment of reef structures. This reef activity can be further characterized according to regions (divided according to Regional Fishery Management Council jurisdiction). The South Atlantic region is by far the most active along the coast, with development activity declining as one moves north through the Mid-Atlantic and New England areas (Table 24). Florida is the most active reef building state (112 permitted sites) followed by North Carolina (66 permitted sites). Together, these two states account for 65 percent of the total permitted Atlantic sites. Most notably, there are no government sponsored programs in New England and virtually no artificial reef activities being conducted by any New England state at present.

Table 24: Number of Permitted Artificial Reef Sites by Council Region

Artificial Reef Regions	Number of Artificial Reefs	Percentage of Atlantic Total
New England (ME, NH, MA, RI, CT)	2	1 %
Mid-Atlantic (NY, NJ, DE, MD, VA plus DC)	55	20 %
South Atlantic (FL, GA, SC, NC)	216	79 %
TOTAL	273	100 %

Figure 19. An Overview of Atlantic State Reef Activities including Government Sponsored Programs and Number of Reefs



Types and locations of Atlantic reefs also can be summarized (Table 25). In terms of types of reefs, 92 percent are purely benthic reefs (251 of 273 sites). Only 6 sites consist solely of midwater Fish Aggregating Devices (FADs) and these midwater reefs were deployed in linear patterns as "trolling alleys." While trolling alleys are an effective means of attracting pelagic fish, the anchoring of individual units is a problem. With storm surge and high currents, individual FADs are sometimes moved off site and lost. The combination reef (ie. attachment of a midwater FADs to a benthic reef) was found on 16 permitted sites. These combination reefs are a popular way to use FADs as the benthic reef acts as an anchoring device and overcomes some of the problems with keeping midwater units on site.

The locations of Atlantic reefs are notable (Table 25). More than half (56 %) of all reef sites are located in federal waters (153 of 273 permitted sites). Of the remaining 120 reef sites found in state waters, 65 sites were found in inland waters (tidal rivers and estuaries) and 55 were within the Territorial Sea (within 3 miles of the coast). The fact that the majority of reefs are found in federal waters (3-200 miles offshore in the ocean) is important from a fishery management viewpoint as regulations for the harvest of reef resources are set by the Fishery Management Councils in these areas; not the individual states that might construct the reefs.

Table 25: Types and Locations of Atlantic Artificial Reefs

Artificial Reef Types and Locations	Number of Permitted Sites	Percentage of Total (273 Sites)
Types		
Benthic	251	92 %
Midwater	6	2 %
Combination	16	6 %
Locations		
Federal Waters	153	56 %
Territorial Sea	55	20 %
Inland Waters	65	24 %

When types and locations of reef activity are viewed according to Council regions, a number of patterns are apparent (Table 26). The South Atlantic area is the dominant region using midwater FADs. Of the 22 Atlantic sites with FADs (either midwater or combination reefs), 18 are found in the South Atlantic. With the preponderance of southern "bluewater" fisheries, FADs are popular fish attractors for pelagic species. While well established in the south, the use of midwater devices to the north (4 sites) is experimental and being tested for bluefish among other species.

Different regions also vary according to locations of reef sites. In the South Atlantic, the majority (62 %) of sites are oriented to offshore fisheries found in Federal waters. One outgrowth of this trend is that the states of Georgia and South Carolina are presently managing gear use on all of their offshore sites through the use of Special Management Zones under the South Atlantic Council Fishery Management Plan for Snapper and Grouper. In contrast to the South Atlantic, the majority (64 %) of Mid-Atlantic sites lie in state waters (Territorial Sea and/or Inland Waters). The bulk of these state water sites (25 of 35 sites) are in the estuaries, with the majority located in the Chesapeake and Long Island areas. Most of these reefs are new deployments and the dynamics of estuarine reefs remains one of the least studied areas of reef development.

Table 26: Types and Locations of Permitted Artificial Reef Sites by Council Region

Artificial Reef Regions	Types of Artificial Reefs	Locations of Artificial Reefs
New England (ME, NH, MA, RI, CT)	Benthic - 2 Midwater - 0 Combination - 0	Federal Waters - 0 Territorial Sea - 2 Inland Waters - 0
Mid-Atlantic (NY, NJ, DE, MD, VA plus DC)	Benthic - 51 Midwater - 2 Combination - 2	Federal Waters - 20 Territorial Sea - 10 Inland Waters - 25
South Atlantic (FL, GA, SC, NC)	Benthic - 198 Midwater - 4 Combination - 14	Federal Waters - 133 Territorial Sea - 43 Inland Waters - 40
TOTALS	Benthic - 251 Midwater - 6 Combination - 16	Federal Waters - 153 Territorial Sea - 55 Inland Waters - 65

A final area to consider is the rate of growth of Atlantic artificial reef activity. Although there are some limitations in using permit information (ie. not all permits necessarily indicate actual reef construction), dates of original permit application can be used to track the general growth of artificial reef development over time (Table 27).

Table 27. Artificial Reef Permit Dates by Council Region

Artificial Reef Regions	Total Number of Permitted Artificial Sites - Year 1978	1983	1988
New England (ME, NH, MA, RI, CT)	1	2	2
Mid-Atlantic (NY, NJ, DE, MD, VA plus DC)	31	36	55
South Atlantic (FL, GA, SC, NC)	103	129	216
TOTAL	135	167	273

(Note: Although 22 sites in the database had no exact permit date, they were classified as pre-1978 reefs by looking at other information on the original Army Corps permits.)

The record shows an increase in the amount of new Atlantic reef sites over time. In the last 10 years, the number of sites has approximately doubled, with the majority of this increase coming in the last five years. Since 1983, there has been a 67 % increase in South Atlantic sites and a 52 % percent increase in the Mid-Atlantic area. The impacts of this artificial reef growth on Atlantic fish stocks and fisheries remain hard to quantify.

Future Trends in Programs and Projects

The previous discussion highlights the regional differences along the Atlantic coast in terms of reef numbers, types, locations and rate of growth. Such differences are a reflection of the variation in goals and strategies within artificial reef programs. Based on the existing patterns of reef development, some future trends in reef development are apparent.

New Reef Technologies and Applications

Although most reef programs still depend on materials of opportunity for use in artificial reef construction, the application of fabricated reef technology to east coast fisheries is presently occurring and will likely continue. The use of specially designed and manufactured reef units, such as Japanese Fiberglas Reinforced Plastic structures, are being employed in the oceans and estuaries of Florida and Maryland. In addition, state programs have begun to develop their own fabricated reef units, such as the various concrete and steel structures designed in South Carolina, Georgia, and Virginia. Fish Aggregating Devices have also undergone a number of recent changes in materials and design and at least one U.S. company is involved in manufacturing and marketing these units.

Other future technological changes relate to the recycling of materials of opportunity. One technology relates to by-products from power plants. There are a number of projects now underway to create reef building materials from fly-ash and scrubber residues. The process involves mixing waste materials with special additives to create a substance similar to concrete. New York and Delaware have pilot reefs using coal ash, and a Florida utility is testing an oil ash reef. Similar efforts using other waste incineration materials will probably be proposed.

Another material of opportunity that has a long history of use in artificial reefs are auto and truck tires. While this material has been attractive as fish habitat, durability and stability of tire units has been a problem in the past. Recent efforts in New Jersey and Virginia have led to new tire reef designs that focus on durable well ballasted units that will remain stable on the ocean floor.

The use of reef technologies centered on recycling various materials promises to be a major issue in the future of artificial reef development. The topics of waste disposal, recycling, and marine habitat are presently in the forefront of the management of marine fisheries. The question of whether reefs should, or can be a way to deal with waste issues remains to be resolved.

Overall, efforts are moving toward both recycled and fabricated reef technologies that emphasize the optimal design, size, and placement of artificial reefs that can maximize and sustain fisheries production.

Trends in Reef Program Activities

Recent events in the legislative arena have impacted the nature and extent of Atlantic artificial reef programs. Besides the National Fishing Enhancement Act which mandated the development of the National Artificial Reef Plan, the newly expanded Sport Fish Restoration Act (Wallop - Breaux Amendments) earmarks a specific percentage of funds to be used for marine fisheries projects including reef construction. In addition to these federal activities, state legislatures also have become more active. The District of Columbia and North Carolina have passed legislation establishing new artificial reef programs. Florida has appropriated funds to establish artificial reefs, and Maryland's Chesapeake Bay Sportfishing License provides the money for a new Chesapeake artificial reef program. The private sector is also becoming more active in sponsoring reef projects and research. Local communities, fishing clubs, and fishery conservation groups have provided funds for a variety of reef development activities. These trends in reef legislation and funding point to more sophisticated reef programs and deployments in the future.

With the likelihood of a continuing increase in new reef projects, the question of monitoring and managing existing reef sites comes to the forefront. The advent of Special Management Zones for artificial reefs highlights the need for more state/Federal cooperation in regulating the use of reef sites and in improving knowledge of reef fishery resources. As noted by Bohnsack and Sutherland (1985) in their comprehensive review of artificial reef literature, scientific studies of the biology, ecology, and economics of artificial reefs are sorely needed. Although general agreement exists that artificial reefs can be effective fish habitats, most published papers deal with qualitative descriptive studies detailing successional changes and species diversity. Few studies used quantitative experimental methods and many lacked scientifically valid controls. The importance of fish attraction versus fish production and the relationship between standing crop and fish catch have not been adequately addressed. The economics and social impact of artificial reefs also have not been carefully examined. Thus, as reef programs move forward, there needs to be increased attention on the questions regarding the effectiveness of artificial reefs; not just development of more reef sites.

Finally, the new emphasis placed on planning, information exchange, and management by both the private and public sectors will help solve some of the past difficulties which hindered reef projects. State artificial reef plans are being drafted by New Jersey, North Carolina, and Maryland. Other state agencies will likely develop similar plans in the future. A key element in planning will be the availability of databases like the one used for the present report. These can provide baseline information for evaluating past projects and improving future efforts.

Recommendations

The Atlantic States Marine Fisheries Commission (ASMFC), the U.S. Fish and Wildlife Service, the National Marine Fisheries Service (NMFS), the Artificial Reef Development Center (ARDC), and the fisheries programs of the Atlantic states will continue to work together through the ASMFC Interstate Artificial Reef Program.

The immediate priority for the ASMFC Reef Committee will be to expand and conduct further analyses with the database used to develop this report. Because the database is computerized, updates of the system can be accomplished by member states and maintained in the offices of ASMFC, NMFS and the ARDC. Specific recommendations for activities that will use this database are listed below:

1. Given the emergence of Special Management Zones for artificial reefs and the public demand for better management of all reef sites, the need for coordination of state and federal reef policies has come to the forefront. As part of this process, the Committee is planning a cooperative effort with North Carolina Sea Grant on "A Policy Assessment of Southeast and Mid-Atlantic Artificial Reef Programs."

2. The improvement of reef technology remains a coastwide concern. To address this issue, an ASMFC Reef Subcommittee will be constructing a guidebook to reef materials and designs.

3. Biological, social, engineering, and economic research that is directly applicable to present reef management issues remains a top priority. To promote more practical reef research for the Atlantic coast, the Committee is developing a list of artificial reef research priorities to be distributed to public and private funding sources.

By addressing the above recommendations from a regional perspective, the ASMFC Reef Committee will continue to improve artificial reef development as a tool for enhancing fisheries and creating habitat in the marine environments.

REFERENCES FOR ATLANTIC COAST ARTIFICIAL REEF DEVELOPMENT

The following references are cited in the text of "A Profile of Atlantic Artificial Reef Development." In addition to a section of general reference sources for artificial reefs, state specific citations have been listed (if available).

General References

Aska, D.Y. (ed.). 1981 Artificial Reefs: Conference Proceedings. Report No. 41, Florida Sea Grant College. 229 p.

Atlantic States Marine Fisheries Commission. 1986. Memorandum Number S/F 86-20, Formation of ASMFC Artificial Reef Committee June 30, 1986, Attachment #4, Washington DC 20036

Bohnsack, J.A. and D. L. Sutherland, 1985. Artificial reef research: A review with recommendations for future priorities. Bull Mar. Sci. 37(1): 11-39

Buchanan, C. C. 1973. Effects of an artificial habitat on the marine sport fishery and economy of Murrells Inlet, South Carolina. Mar. Fish. Rev. 36(9):15-22.

Colunga, Laura and Richard Stone (eds.). 1974. Proceedings of an International Artificial Reef Conference.TAMU-SG-74-103. Texas A&M University Sea Grant College Program. 152 p.

D'Itri, Frank M. (Ed.). 1985. Artificial Reefs: Marine and Freshwater Applications. Lewis Publishers, Inc., Chelsea, Michigan. 589 p.

Grove, and C. J. Sonu. 1983. Review of Japanese Fishing Reef Technology. Southern California Edison Company, P.O. Box 800, Rosemead, CA 91770, Tech. Rep. 83-RD-137. 112 p.

Halgren, B., J. M. McGurrin and ASMFC Marine Recreational Fisheries Committee. 1988. Marine recreational fisheries programs of the Atlantic coast. Recreational Fisheries Report No. 2 of the Atlantic States Marine Fisheries Commission. Washington, D.C. 22pp.

McGurrin, J. and M. Reef. 1986. Artificial reef profiles: a national database of artificial reef programs and projects. Artificial Reef Development Center, Washington, D.C. 480 pp. (unpublished manuscript).

Mottet, M. G. 192. Enhancement of the Marine Environment for Fisheries and Aquaculture in Japan. Washington Dept. Fish., Tech. Rep. 69 p.

Murray, James D. (Ed.). Mid-Atlantic Artificial Reef Conference: A Collection of Abstracts. NJSG-82-78, Marine Sciences Consortium, The State University of New Jersey, Rutgers Campus at New Brunswick.

Myatt, D. O. 1978. The "trolling alley" fishing system. Pages 35-36 in D. Y. Aska, ed. Artificial Reefs in Florida. Florida Sea Grant Report 24.

Parker, R. O., R. B. Stone, C. C. Buchanan and F. W. Steimle. 1974. How To Build Marine Artificial Reefs. Fishery Facts #10. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Washington, D. C.

Reef, M. 1986. Reef profiles: technology evaluation for resource development. Pages 538-541 in Oceans 86. Marine Technology Society 887 pp.

Reeff, Mark J. and Joseph McGurrin. 1986. The Artificial Reef Source: An Annotated Bibliography of Scientific, Technical, and Popular Literature. Artificial Reef Development Center, Sport Fishing Institute, Washington, D.C. 3 vol. 528 p. (unpublished manuscript)

Stanton, G., D. Wilber and A. Murray. 1985. Annotated bibliography of artificial reef research and management. Florida Sea Grant College Report no. 74. pp. 275

Steimle, F. and Stone, R. B. 1973. Bibliography on artificial reefs. Publ. 73-2, Wilmington, N.C. Coastal Plains Center for Marine Development. 129pp.

Stone, R. B. 1985. History of artificial reef use in the U.S. In Frank M. D'Itri (ed.) Artificial Reefs: Marine and Freshwater Applications Lewis Publishers, Chelsea, MI.pp. 3-9.

Stone, R.B., H.L. Pratt, R.O. Parker, Jr., and G.E. Davis. 1979. A comparison of fish populations on an artificial reef and natural reef in the Florida Keys. Marine Fisheries Review 41 (9):1-11.

Stone, R. B. 1985 National Artificial Reef Plan. NOAA Technical Memorandum NMFS of - 6. National Marine Fisheries Service, Washington, D.C. 39pp.

Delaware References

Aquabio, Inc. 1984. Artificial reef siting and design development plan for delaware bay and adjoining coastal waters. Delaware Division of Fish and Wildlife, Department of Natural Resources and Environmental Control Document No. 40-05-84-10-7.

Jensen, Paul A., I. Walker, M. Falk, and R. Hall, Jr., Artificial Reefs for Delaware? University of Delaware Sea Grant College Report No. DEL-SG-06-80.

Price, Kent S. (ed.) 1987. Project Ashreef - A Report on a Stabilized Coal Waste Fish Reef on Delaware Subaqueous Lands. Electric Power Partners Project Interim Report.

United States Department of the Army, Philadelphia District, Corps of Engineers. 1987. Request for Technical Proposals No. DACA61-88-R-0

District of Columbia References

Artificial Reefs in the District of Columbia: An Overview. Reef Briefs, Stephen Phillips (ed.) No. 12, Fall 1987.

Smith, S.M. and J.L. Buckley. 1988. Urban artificial reefs development the District of Columbia. Abstract from Fourth International Confe on Artificial Habitats. Bull. Mar. Sci. in Prep.

Smith, S.M. and J.L. Buckley. Proposal to build artificial reefs to enhance recreational fishing in the District of Columbia. Proposal submitted to the FishAmerica Foundation, August 1987.

Florida References

Artificial Reefs in Florida. 1978. D.Y. Aska ed. Florida Sea Grant Report No. 24. 69pp.

Bortone, S.A. and D.V. Orman. 1985a. Biological survey and analysis of florida's artificial reefs. Florida Sea Grant Technical Paper No. 3 University of Florida, Gainesville, Florida. 11pp.

Bortone, S.A. and D.V. Orman. 1985b. Data base formation and assessmen of biotic and abiotic parameters associated with artificial reefs. Florida Sea Grant Technical Paper No. 35. University of Florida, Gainesville, Florida. 26pp.

Milon, J.W. 1987. The Economic benefits of artificial reefs: an analys of the dade county, florida reef system. Florida Sea Grant Report N 90. University of Florida, Gainesville, Florida.

Milon, J.W. Economic evaluation of artificial habitat for fisheries: progress and challenges. Bull. Mar. Sci.; In Press.

Pybas, D.W. 1987. Atlas of artificial reefs in florida. Florida Sea Grant Extension Bulletin no. 13. University of Florida, Gainesville Florida. 26pp.

Pybas, D.W. and W. Seaman. Artificial reefs in florida. Florida Sea Grant, In Press.

Sheehy, D.J. 1983. Evaluation of japanese designed and american scrap material artificial reefs. Aquabio, Inc. Research and Development Report No. 83-RD-607. 73pp.

Smith, G.B., D.A. Hensley, and H.H. Mathews. 1979. Comparative efficac of artificial and natural gulf of mexico reefs as fish attractants. Florida Marine Research Publications No. 35, Florida Department of Natural Resources. 7pp.

Seaman, W. and D. Aska. 1985. The Florida Artificial reef network: strategies to enhance user benefits. Pages 545-561 in F. Ditri, Freshwater ed. Artificial reefs Marine and freshwarter applications. Lewis publishers Inc., Chelsea, Michigan 589pp.

Georgia References

Ansley, Henry L.H. and C.D. Harris 1981. Migration and standing stock of fishes associated with artificial and natural reefs on Georgia's outer continental shelf. (Final report, Dingell-Johnson Project F-31, Georgia). Ga. Dept. of Natural Resources, Coastal Resources Division, Brunswick, Georgia, 38 p.

Georgia Department of Natural Resources. 1987. Georgia's Offshore Artificial Reefs. Georgia Department of Natural Resources, Coastal Resources Division, Brunswick, Georgia, 8 p.

Harrington, D.L. 1972. The viewpoints of commercial fishermen on artificial reefs. In Proceedings of a sport fishing seminar, November 18-19, 1971, Jekyll Island, Georgia. Seminar Series No. 1. Coastal Plains Center for Marine Development Services, Wilmington, North Carolina, pp 115-16.

Harris, C.D. 1978. The fisheries resoures on selected artificial and live bottom reefs on Georgia's continental shelf. (Final report, Dingell-Johnson Project F-31, Georgia), Georgia Department of Natural Resources, Coastal Resources Division, Brunswick, Georgia, 55 p.

Harris, C.D. and H.L.H. Ansley. 1981. Fishing pressure and success in Georgia's offshore waters. (Final report Dingell-Johnson Project F-31, Georgia). Georgia Department of Natural Resources, Coastal Resources Division, Brunswick, Georgia, 29 p.

Hunt, J.L., Jr. 1974. The geology and origin of Gray's Reef, Georgia continental shelf. M.S. Thesis. UGA, Athens, Georgia, 83

Parker, R.O., D.R. Cobly, and T.D. Willis. 1983. "Estimated amount of reef habitat on a portion of the U.S. South Atlantic and Gulf of Mexico continental shelf". Bulletin of Marine Science, 33(4) :935-940.

Smith, L. 1972. Construction and studies of an artificial reef off Brunswick, Georgia. In Proceedings of a Sport Fishing Seminar, November 18-19, 1971, Jekyll Island, Georgia. Seminar Series No.1. Coastal Plains Center for Marine Development Services, Wilmington, North Carolina, pp 5-6.

Smith, L.D. 1974. Habitat improvement on the Continental Shelf of Georgia. (reprint), In: L. Colunga and R. Stone, eds. Proceedings of an international conference on artificial reefs, March 1974. Center for Marine Resources, Texas A & M University, College Station, Texas, 3 p.

Smith, L.D. 1976. Feasibility analysis of selected artificial reef materials. (Final report, Dingell-Johnson Project F-31, Georgia). Ga. Dept, of Nat. Res., Game & Fish Div., Atlanta, Georgia, 11 p.

Struksaker, P. 1969. Demersal fish resources; composition, distribution, and commercial potential of the continental shelf stocks off the southeastern United States. Fis. Ind. Res. 4(7):261-300.

United States Department of Commerce, National Oceanic and Atmospheric Administration. 1987. "Snapper-Grouper Fishery of the South Atlantic" In Federal Register, 52(59).

New Jersey References

Long, D. and W. Figley. 1982. New Jersey's recreational and commercial ocean fishing grounds. New Jersey Division of Fish, Game and Wildlife, Technical Series 82-1. 38pp.

Myatt, D., E. Myatt and B. Figley. 1988. New Jersey tire reef unit stability studies. New Jersey Department of Environmental Protection Technical Report 87-2. 40pp.

Myatt, D., E. Myatt and B. Figley. 1986. New Jerseys artificial reefs. Information Series 86-1, Marine Fisheries Administration, CN-400, Trenton, N.J. 8pp.

New Jersey Department of Environmental Protection. 1987. Draft artificial reef management plan for New Jersey. 70pp.

New York References

Briggs, P. T. 1978. Black sea bass in New York waters. N.Y. Fish and Game Jour. 25(1): 45-58.

Briggs, P. T. 1977. Status of tautog at artificial reefs. N.Y. Fish and Game Jour. 24(2): 154-167.

Briggs, P. T. 1975. An evaluation of artificial reefs in New York's marine waters. N.Y. Fish and Game Jour. 22(1): 51-56.

Briggs, P. T., and C. S. Zawacki. 1974. American lobsters at artificial reefs in New York. N.Y. Fish and Game Jour. 21(1): 73-77.

Jensen, A. C. 1975. Artificial fishing reefs. MESA New York Bight Atlas Monograph, 18: 1-23.

Steimle, F. 1982. Artificial reefs in the New York Bight: 50 years of experience. International Council for the Exploration of the sea. United States Department of Commerce.

Zawacki, C. S. 1969. Long Island's Artificial Fishing Reefs. N.Y.S. Conservationist, 24(1): 18-21.

North Carolina References

Chester, A.J., G.R. Huntsman, P.A. Tester, and C.S. Manooch III. 1984. South ATlantic Bight reef fish communities as represented in hook and line catches. Bull. of Mar. Sci. 34(2):267-279.

Grimes, C.B., Manooch, D.J. and G.R. Huntsman.1982. Reef and rock outcropping fishes of the outer Continental Shelf of NC and SC, and ecological notes on the red porgy and the vermilion snapper. Bull. of Mar. Sci. 32(1):277-289.

Huntsman, G.R. 1976. Offshore headboat fishing in N. and S. Carolina. NOAA Mar. Fish. Rev. 38(3):13-23.

Lindquist, D.G. and L.J. Pietrafesa. 1987. Current vortices, artificial reef configurations, and fish aggregations: An analysis of the current field and associated fishes around a tugboat wreck, Onslow Bay, NC. Paper to be presented at the 4th Int'l Conference on Artificial Reef Habits for Fisheries. November, 1987, Miami, FL.

Lindquist, D.G., L.B. Cahoon and I.E. Clavijo. 1987. Sources of primary productivity supporting NC's inshore reef fish communities. UNC Sea Grant proposal. 10p.

Liao, D. S. and D. M. Cupka. 1979. Economic impacts and fishing success of offshore sport fishing over artificial reefs and natural habitats in South Carolina. South Carolina Marine Resources Center Technical Report Number 15. pp. 27.

Moore, C. J., D. L. Hammond and D. O. Myatt, III. 1980. A Guide to Saltwater Recreational Fisheries in South Carolina. Office of Conservation, Management and Marketing, South Carolina Marine Resources Division. pp. 88.

Myatt, D. O. and E. Myatt. 1982. "Midwater Fish Attractors," pp. 54-71 In: World Record Game Fishes 1982. Published by International Game Fish Association.

Parker, R. O., Jr., R. B. Stone and C. L. Buchanan. 1979. Artificial reefs off Murrells Inlet, South Carolina. Mar. Fish. Rev. 41(9): 12-24.

SCWMRD, 1984. South Atlantic OCS Area Living Marine Resources Study Phase III, Vol. I, SCWMRD Marine REsources Research Institute Report prepared for M.M.S. Washington, D.C. August, 1984. pp. 223.

Steimle, F. W., Jr., and L. Ogren. 1982. Food of fish collected on artificial reefs in the New York Bight and off Charleston, South Carolina. Mar. Fish.Rev. 44(6-7): 49-52.

Virginia References

Feigenbaum, D. 1984. Artificial Reef Study - Year 1 Report. Progress Report for the period Jan. 2 to December 31, 1983. Prepared for the Virginia Marine Resources Commission. 29 p.

Feigenbaum, D., C. Blair, M. Bushing, L. Parker, D. Deveraux and A. Friedlander. 1986. Artificial Reef Study - Final Report. Prepared for the Virginia Marine Resources Commission. Old Dominion University, Department of Oceanography Tech. Rep. No. 86-2, 93 p.

Feigenbaum, D. 1988. Monitoring of the Gwynn's Island Test Reef. Prepared for the Virginia Marine Resources Commission. Old Dominion University, Department of Oceanography Tech. Rep. No. 88-1, 30 p.

Lucy, Jon. 1988. Development and Implementation of a Catch and Effort Data Collection System for Monitoring Trends in Fishing Success on Virginia's Artificial Fishing Reefs. Contract report, Wallop-Breaux Project No. F-63-R. Prepared for the Virginia Marine Resources Commission, Newport News, Virginia, 68 p.

Linquist, D.G., M.V. Ogburn, W. B. Stanley, H.L. Troutman, and S. M. Pereira. 1985. Fish utilization patterns on temperate rubble-mound jetties in NC. Bull. of Mar. Sci. 37(1):244-251.

Manooch, C.S. 1977. foods of red porgy. Pagrus pagrus, from N. & S. Carolina. Bull.of Mar. Science 27:776-787.

McDonald, M.E. 1978. The standing crop, distribution, and production of the macrobenthic epifauna on an artificial reef off the coast of NC. Masters thesis. NC State Univ., Raleigh, NC.

Murray, J.D..D.G. Lindquist, D.C. Griffith, and J.C. Howe. 1985. the use of midwater fish aggregating devices: to attract marine fish at 2 NC fishing piers. UNC Sea Grant Publication UNC-SG-WP-85-1. 54p.

Parker, R.O., Jr. and S.W. Ross. 1986. Observing reef fishes from submersibles off NC. Northeast Gulf Science. Vol. 8(1):31-49.

Stephan, C.D. and D.G. Lindquist. 1987. 'A comparative analysis of the fish assemblages associated with old and new shipwrecks and FADs in Onslow Bay, NC. Paper to be presented at 4th Int'l Conference on Artificial Habitats for Fisheries, Nov. 1987, Miami, FL

West, K.H., L.P. Mercer, F.C.Rhode, and S.P.Epperly. 1986. NC/Nat'l Marine Fisheries Service Regional Cooperative Statistical Program: 6/83 to 3/86. NC Nat. Res. and Community Develop, Div. Mar. Fish. 192p.

South Carolina References

Buchanan, C. C. 1973. Effects of an artificial habitat on the marine sport fishery and economy of Murrells Inlet, South Carolina. Mar. Fish. Rev. 35(9): 15-22.

Buchanan, C. C., R. B. Stone and R. O. Parker, Jr. 1974. Effects of artificial reefs on a marine sport fishery off South Carolina. Mar. Fish. Rev. 36(11): 32-38.

Elliott, W. 1846. Carolina sports by land and water, including incidents of devil fishing, wildcat, deer and bear hunting. Published in Charleston, S.C. pp. 27.

Hammond D. L., D. O. Myatt and D. M. Cupka. 1977. Evaluation of midwater structures as a potential tool in the management of the fisheries resources on South Carolina's artificial fishing reefs. South Carolina Marine Resources Center Technical Report Number 15. pp. 19.

Meier, M., J. Martin, D. Feigenbaum and M. Bell. 1985. Artificial Reefs in Virginia - Old Beginnings and New Directions. Ch. 12 in Artificial Reefs, Marine and Freshwater Applications. F.M. D'Itri (ed.), Lewis Publ., Chelsea, Michigan, 589 p.

Virginia Marine Resources Commission. 1987. Marine Recreational Fishing in Virginia, 1985. VMRC Tech. Rep. NO. 87-01, 91 p.

LIST OF ASMFC ARTIFICIAL REEF COMMITTEE MEMBERS

ASMFC ARTIFICIAL REEF COMMITTEE

Virginia Vail
Marine Resources Advisor
FL Dept. of Natural Resources
3900 Commonwealth Blvd.
Tallahasse, FL 32303

Henry Ansley
GA Dept. of Natural Resources
1200 Glynn Ave.
Brunswick, GA 31523-9990

Mel Bell
SC Wildlife & Mar.Resources
PO Box 12559
Charleston, SC 29412

Steve Murphey
NC Div. Marine Fisheries
P.O Box 769
Morehead City, NC 28557-0769

Mike Meier (Chairman)
VA Marine Resources Commission
PO Box 756
Newport News, VA 23607

John Foster
MD Dept. of Natural Resources
Tawes State Office Bldg.
Annapolis, MD 21401

Charles A. Lesser
DE Div. Fish and Wildlife
PO Box 1401
Dover, DE 19903

Bill Figley
NJ Bureau of Marine Fisheries
Nacote Research Station
Star Route
Absecon, NJ 08201

Chester Zawacki
NY Dept. of Env. Cons.
Bldg. 40, SUNY
Stony Brook, NY 11794-3090

Roderick MacLeod
CT Bureau of Fisheries
Marine Fisheries Office
PO Box 248
Waterford, CT 06385

Dick Satchwill
RI Div. Fish and Wildlife
150 Fowler St.
N. Wickford, RI 02852

Steve Phillips (Secretary)
ARDC
1010 Massachusetts Ave., NW #10C
Washington, DC 20001

Richard B. Stone
NMFS
1825 Connecticut Ave., NW
Washington, DC 20235

Charles Wooley
U.S. Fish & Wildlife Service
Tawes State Office Bldg.
Annapolis, MD 21401

Ron Schmied
NMFS, SE Region
9450 Koger Blvd.
St. Petersburg, FL 33702

Frank Steimle
NMFS
Sandy Hook Marine Lab
PO Box 428
Highlands, NJ 07732

Stephen Smith
DC Fisheries Management
5010 Overlook Ave., SW
Washington, DC 20001

Advisory Members

Joseph McGurrin-ex officio
ASMFC
1400 Sixteenth St., NW #310
Washington, DC 20036

Jon A. Lucy
Marine Recreation Specialist
VIMS - Advisory Services
Gloucester Pt., VA 23062
(804)

Bill Muir
Regional Oceanographer
USEPA 3PM70
6th & Walnut
Philadelphia, PA 19106

Tom Morrissey
NMFS
Northeast Fisheries Center
Water Street
Woods Hole, MA 02543

Jim Murray
MAS Director
NC Sea Grant
105 1911 Building
North Carolina State University
Raleigh, North Carolina 27650

Mark Reeff
IAFWA
444 N. Capitol St., NW #534
Washington, DC 20001

Anne Marie Eklund
15405 Biscayne Drive #12
Leisure City, FL 33033

Liz Noble
NC Div. of Marine Fisheries
PO Box 769
Morehead City, NC 28557-0769

Donald W. Pybas
FL Sea Grant Ext. Agent
RSMAS
4600 Rickenbacker Causeway
Miami, FL 33149