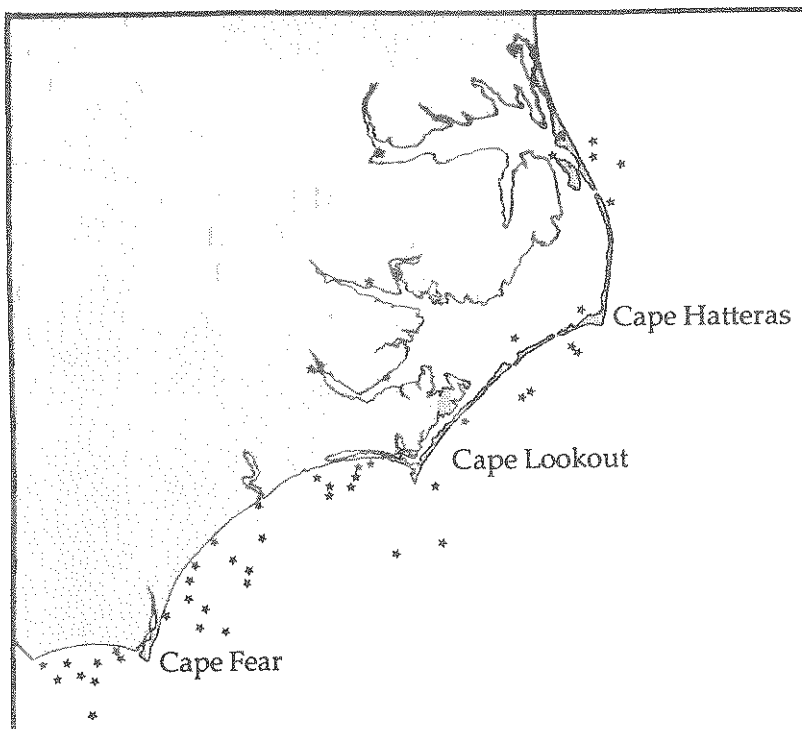


North Carolina Artificial Reef Master Plan

October 1988

North Carolina
Department of
Natural Resources &
Community Development

Division of Marine Fisheries

This report was conducted under the Federal Aid in Sport Fish Restoration Act (Dingell- Johnson Act) through the Wallop-Breaux Amendment, and funded, in part, by the U.S. Department of the Interior, U.S. Fish and Wildlife Service, under Project No. F-25.

NORTH CAROLINA ARTIFICIAL REEF MASTER PLAN

APPROVED

S. Thomas Rhodes

S. Thomas Rhodes, Secretary
Department of Natural Resources and
Community Development

11/8/88
Date

APPROVED

Thomas S. Bennett

Thomas S. Bennett, Chairman
N.C. Marine Fisheries Commission

11/4/88
Date

APPROVED

William T. Hogarth

William T. Hogarth, Director
Division of Marine Fisheries

11/1/88
Date

TABLE OF CONTENTS

EXECUTIVE SUMMARY iv

INTRODUCTION 1

North Carolina Reef Activities 1

Target Fish Species 4

GOALS AND OBJECTIVES 8

ADMINISTRATION AND EVALUATION 9

Public Involvement 9

Coordination 11

Funding 12

Liability 15

Research 17

Program Review 24

DEVELOPMENT AND OPERATIONS 25

Materials 25

Design 29

Siting 31

Permitting 34

Buoys 38

MANAGEMENT 40

Monitoring and Maintenance 40

Enhancement 41

Special Management Zones 42

Federal Waters 42

Coastal and Estuarine Waters 45

Mitigation 48

PLAN REVIEW 49

ACKNOWLEDGMENTS 51

LITERATURE CITED 52

APPENDICES 58

A. Program History

B. North Carolina Statutes and Regulations

C. Information Sources

D. Artificial Reef Inventory

EXECUTIVE SUMMARY

Significant advancements in the field of artificial reef development and management have occurred on the national, regional, and state levels in the last five years. Artificial reef programs are developing policies which recognize that artificial reefs should benefit the public and the resource. It has become evident that this will not occur in the long term without sound management strategies. Federal and state legislation and regulations point to the fact that the ocean cannot be a dumping ground for unwanted garbage disguised as artificial reefs. Researchers and resource managers agree that the fisheries stocks attracted to the artificial reef structures are not unlimited.

Two major risks associated with artificial reef development are user conflicts and over-exploitation of fisheries stocks. Accessibility of artificial reefs to the public is also a concern. Problems can also occur if reef materials move off-site damaging naturally productive bottom or interfering with navigation and commercial fishing activities. Without monitoring efforts, reef programs have no gauge as to the cost-effectiveness or production capabilities of their artificial reef structures.

North Carolina's artificial reef program is committed to providing enhanced opportunities for the fishing and diving public, but not at the expense of the state's marine resources. The North Carolina Artificial Reef Management Plan was prepared to assist the program in this commitment. The Management Plan consists of two parts--a Master Plan and an Implementation Plan.

The Master Plan provides a single focus for policy, siting guidelines, construction standards, maintenance and monitoring requirements, research needs, designation of responsibility, and long term management of North Carolina's artificial reefs and their associated uses. By stating the goals, objectives, and priorities of the artificial reef program, this plan provides a framework on which the Implementation Plan is directly based. The Implementation Plan is a five year plan to be used by the artificial reef program staff as their work plan. The Implementation Plan provides specific strategies, time frames, and funding requirements necessary to accomplish the proposed recommendations found in the Master Plan.

This planning process is particularly evident when addressing the issue of allocation of reef sites. The Master Plan states, in general terms, where and where not to site artificial reefs. It recommends a moratorium on permitting any new reef sites, emphasizes enhancement of existing sites, and suggests a study of utilization patterns to determine which reef sites along the coast are overcrowded. If, in the next five years, the program decides there is need for a new reef site, it will be selected from those sites proposed in the Implementation Plan.

The North Carolina Division of Marine Fisheries artificial reef program recognizes that each aspect of artificial reef development

addressed in the Master Plan is important. However, the program will give the following activities top priority in the next five years:

1. Monitoring the effects of artificial reef development on reef-associated fisheries stocks and the implementation of any necessary management measures to protect them from over-exploitation.

2. Coordination of all artificial reef construction activities in the state's estuarine and ocean waters.

3. Maintenance and enhancement of existing reef sites.

4. Education of and cooperation with the public on artificial reef activities.

Summarized below are the Master Plan recommendations:

Public Involvement

- Hold public meetings prior to requesting all artificial reef permits and maintain records of all public comments.

- The Marine Fisheries Director should approve or deny all artificial reef sites.

- Efforts to involve and educate the public in artificial reef development should be an integral part of the reef program, and could include:

  - An artificial reef guide for fishermen and divers.

  - An artificial reef newsletter for general distribution.

  - Artificial reef location charts at boating access ramps.

  - Announcements of the availability of the artificial reef program video.

  - Talks by artificial reef program staff to interested clubs and organizations.

Coordination

- The Division of Marine Fisheries should coordinate all marine artificial reef construction in the State.

- An agreement should be developed between DOT and DMF regarding the use of replaced bridge materials for artificial reefs.

- An Artificial Reef Steering Committee should be reinstated to advise DMF on proper management of North Carolina's artificial reefs.

Funding

- Secure a continuing state appropriated budget to provide the artificial reef program with basic general operating funds.

- Request special legislative appropriations to be used for special reef project funding.

- Utilize Wallop-Breaux funds where appropriate.

- Cooperate with sport fishing clubs in their efforts to raise funds for local artificial reef development.

- Funding priorities:

  - Maintenance of buoy and mooring systems.

  - Monitoring condition of reef materials after deployment.

  - Enhancement of present permitted sites with suitable reef materials.

  - Distribution to the public of a North Carolina artificial reef guide with information on material locations and fish species availability.

  - Feasibility studies in design research of pre-fabricated artificial reef materials.

  - Utilization studies of present artificial reef sites by recreational fishermen to determine adequacy of number available and accessibility in terms of potential user conflicts and overfishing.

Liability

- The State should make a commitment to a reef monitoring and maintenance program to ensure the safety of fishermen, their vessels and gear.

- The State will accept legal responsibility for its artificial reef construction to the extent provided under existing state law.

Research

- Collect and analyze baseline ecological data on the abundance and biomass of economically important reef-associated finfish over time.

- Maintain database on status of reef-associated fish stocks.

- Conduct material and design studies of artificial reef structures with respect to stability, durability, cost effectiveness, and safety.

- Collect and analyze socioeconomic data pertaining to user satisfaction, expectations, and utilization patterns.

Artificial Reef Program Review

- Annual artificial reef program review by the Fisheries Development Section Chief with the Artificial Reef Construction Coordinator should be conducted.

- The Division of Marine Fisheries Director should be informed of program developments and concerns.

- An annual report of artificial reef activities and program status should be made available to the public.

Materials

- North Carolina's artificial reef program should NOT use materials that:

  - Are toxic to the environment.

  - Are not stable and may move off-site, such as tires or any other highly buoyant low density material. Extensive stability tests and stringent ballasting requirments should be followed if these types of materials are considered.

  - Are not durable and will have a short lifespan in the ocean, such as automobiles or appliances, aluminum or wood structures.

- All materials must be inspected and approved by the Artificial Reef Construction Coordinator, EPA, USCG, and any other appropriate state or federal agency. An International Load Line Exemption Certificate (USCG) must also be obtained for all vessels prior to deployment.

- North Carolina should continue using obsolete vessels for artificial reef construction provided that:

  - Structural integrity of the vessel is intact.

  - Preparation and deployment will not cost more than the expected economic benefits.

  - Minimal amounts of explosives are used in deployment.

- North Carolina should incorporate pre-fabricated materials into its artificial reef construction program. Utilizing available technology, this should be done only after stability and design studies are conducted.

- Materials used should provide the degree of habitat complexity and profile appropriate to fish species the reef is intended to attract.

- Extreme caution and planning should be employed when using explosives in deployment to insure the safety of personnel and that minimal structural damage of the material will occur.

Design

- Increase surface area and interstitial space by the addition of rock, concrete or other suitable materials to barges and stripped vessels. U .S. Coast Guard load line requirements must be followed when towing vessels with these additional materials.

- Increase profile by the addition of mid-water FADs to low profile benthic reefs.

- The use of surface FADs in deep water to attract pelagic species such as tuna is not recommended.

- Trolling alleys, reef clusters, and reef sanctuaries should be incorporated into reef complex designs.

Siting

Artificial reefs should NOT be sited where:

- A natural live bottom exists. This includes, but is not limited to, sea grass beds, scallop grounds, and natural reef communities.

- The sea floor would not support proposed reef structures. This includes deep and frequently shifting sandy bottom, or mud bottom.

- High energy environments exist. This includes strong currents, heavy wave action or storm surge that would damage or remove reef materials, or be unsafe to fishermen and divers. Such environments include shoals, banks, and inlets.

- Traditional commercial fishing activities occur. This includes trawling and potting for finfish and crustaceans, seining, gill netting, pound netting, long lining, raking and dredging. If there is ambiguity as to whether a particular reef site will interfere with commercial fishing, the Marine Fisheries Director should make the final determination. This decision should be made only after meetings with the commercial fishing community directly involved. Their concerns and the Director's justification should be on record and available to the public.

- They would be a navigation or liability hazard. This includes areas too shallow to provide adequate vertical clearance, areas with heavy boat traffic, or areas used by the U.S. Navy for surface and submarine operations.

Artificial reef sites should be chosen:

- Only after public input has been obtained.

- Only after biological and physical investigations are made to determine if the proposed site is suitable for reef construction.

- That are easily accessible to a majority of recreational fishermen and divers.

Permitting

- The present DMF general permitting procedure should be continued, with appropriate up-dating and review as necessary.

- Good communication with all permitting agencies, especially the USACE and USCG must be maintained.

- The DMF artificial reef program must take responsible action pursuant to any new legislation (state or federal) affecting artificial reef permitting.

- The Artificial Reef Construction Coordinator should maintain accurate records of all artificial reef permits, including periodic permit reviews.

- Automatic renewal for all reef sites is not recommended. If sites have no materials on them and there are no specific plans for future development, the permit should not be renewed.

- The North Carolina Division of Marine Fisheries should be the single permit holder for all of North Carolina's estuarine and marine artificial reefs to ensure acceptance of long term legal, financial and maintenance responsibilities involved in artificial reef development.

- Artificial reefs proposed by individuals, organizations, or local government bodies should be eligible for DMF sponsorship only after they meet the criteria set forth in the general permit and this plan.

Buoys

- Buoys should identify the site as an artificial reef, including reef number, DMF's telephone number (in case of removal off-site), and warning not to damage or injure the buoy in any way.

- Buoys should have internal or external radar reflectors and reflective tape on them for protection at times of poor visibility.

- Buoys and anchoring systems should be constructed of the most durable materials reasonably available.

- A routine semi-annual maintenance schedule should be followed for all of North Carolina's coastal artificial reef buoys.

- Buoy bottoms should be protected with antifouling paint.

- Buoys should conform to all USCG standards.

Monitoring and Maintenance

- Develop a diver inspection schedule to monitor condition of reef structures.

- Develop emergency procedures to replace missing buoys or retrieve reef materials that have moved off-site endangering commercial fishing operations or vessel navigation.

- Utilize Marine Fisheries Division aircraft for monitoring buoy systems in estuarine and nearshore ocean waters.

- Monitor effectiveness of an artificial reef(s) in attracting desired fish species.

- Utilize the efforts of volunteer sport diver surveys in artificial reef monitoring.

Enhancement

- A program of enhancing existing artificial reefs and reef sites should be conducted.

- Enhancement activities should be given a higher priority than the permitting and construction of new artificial reef sites.

- Enhancement activities should be conducted only after biological and user evaluations studies are conducted.

Special Management Zones

- Prior to requesting SMZ designation for any artificial reef in federal waters, the Division of Marine Fisheries should meet all criteria and follow all procedures set forth by the South Atlantic Fisheries Management Council and this plan.

- The same considerations that are taken with respect to requesting SMZ designation for an artificial reef in federal waters should also be taken prior to any restriction placed

in or around an artificial reef in the Territorial Sea or estuarine waters by the Division of Marine Fisheries.

- With regards to regulation NCAC 3B .0111, the following should be considered and amended as appropriate:

  - The area of jurisdiction, i.e. the state's Territorial Sea and estuarine waters, should be clarified.

  - Whether or not the state will require a buoy on all artificial reef sites should be determined. It is recommended that all artificial reef sites be buoyed, except those that are in water too deep to allow the buoy to remain on-site, and then only after USCG approval.

  - Required buoy location, i.e. the middle of the site, should be stated. Any future restrictions or closures can then be measured from the buoy.

  - The concern of damage to artificial reefs and their biological communities by salvage operations, explosives, and also oil and gas seismic testing should be addressed.

  - The maximum area around ocean and estuarine artificial reefs that can be closed or restricted should be reconsidered. In some cases, the permitted area may be sufficient.

- Guidelines should be developed on how to provide adequate enforcement for any future closures or restrictions that may be enacted to protect the state's artificial reefs and their resources.

- The state's system of estuarine artificial reefs should be evaluated to determine if existing reefs are productive and if additional reefs are warranted. No new estuarine reefs should be constructed until this issue is resolved.

Mitigation

- Artificial reefs should not be used in mitigation, unless they are to replace natural reef habitat that has been damaged or destroyed.

- If artificial reefs are used to replace natural reef habitat that has been damaged or destroyed, they should be designed and constructed to provide proven biologically productive habitat.

Plan Review

- The Fisheries Development Section Chief and the Artificial Reef Construction Coordinator should review the plan annually.

- They should assess the program's accomplishments and discuss new program developments as they relate to the plan.

- Any changes necessary should be incorporated into the plan upon approval by the Marine Fisheries Director.

INTRODUCTION

In 1984 the United States Congress passed The National Fishing Enhancement Act (P.L. 98-623). The purpose of this act was to establish a national policy to promote and facilitate responsible and effective efforts to establish artificial reefs in U.S. waters. The Act also mandated preparation of the National Artificial Reef Plan (Stone 1985). The purpose of the National Artificial Reef Plan was to provide artificial reef technical guidance, to inform artificial reef builders of the national standards and objectives of the National Fishing Enhancement Act, and to encourage more detailed and site-specific plan preparation by individual states or other regional agencies.

In 1985 the North Carolina General Assembly gave the North Carolina Marine Fisheries Commission (MFC) the authority and responsibility to establish standards and adopt regulations governing the siting, management, and utilization of North Carolina's marine artificial reefs. This statute is now part of the North Carolina Marine Fisheries Act of 1987, Section 143B-289.4 (2) (j) (Appendix B). This plan and future iterations will assist the MFC with this duty.

North Carolina Reef Activities

North Carolina has one of the most active artificial reef programs in the country. As of December 1987, North Carolina had 66 permitted artificial reef sites. Forty-two of these are ocean sites, of which 35 have artificial reef materials on them. The remaining 24 permitted sites are in North Carolina's estuaries. Nine of these estuarine sites have artificial reef materials on them. Figure 1 shows the locations of the state's 66 permitted artificial reef sites. Figure 2 gives the distance from shore and the depth of the 42 ocean sites. Seventy-four percent of North Carolina's ocean artificial reef sites are beyond three nautical miles. The depth range of these ocean sites is between 30 and 104 ft., with 67% between 44 and 66 ft.

At this time, there is strong public interest in accelerated reef development. Local governments and saltwater sport fishing clubs are providing materials and limited funds for reef construction. An aggressive coastal bridge replacement program by the North Carolina Department of Transportation could make excellent reef material available to the artificial reef program over the next several years if a cooperative agreement could be developed between the two agencies.

Studies have shown that artificial reefs do enhance fishing opportunities (Briggs and Zawacki 1974, Buchanan 1975, Myatt 1978, Parker et al. 1979, Feigenbaum et al. 1986). However, proper planning and good management are needed to ensure desired results. Improperly deployed or maintained artificial reefs may be ineffectual, interfere with commercial and sport fishing, or damage natural habitat.

Since the early 1970s the North Carolina Division of Marine Fisheries (DMF) has been involved in construction, permitting and

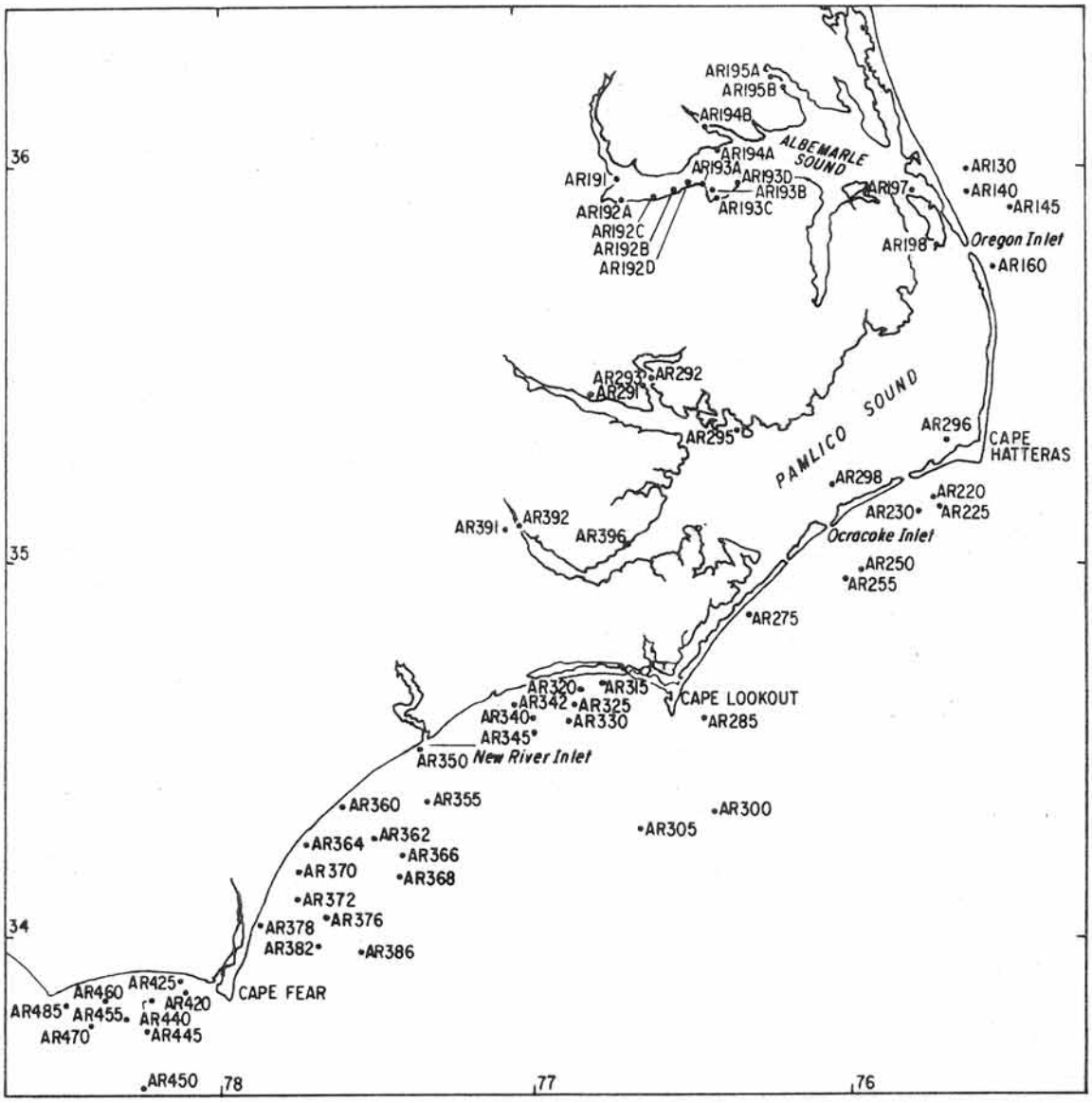
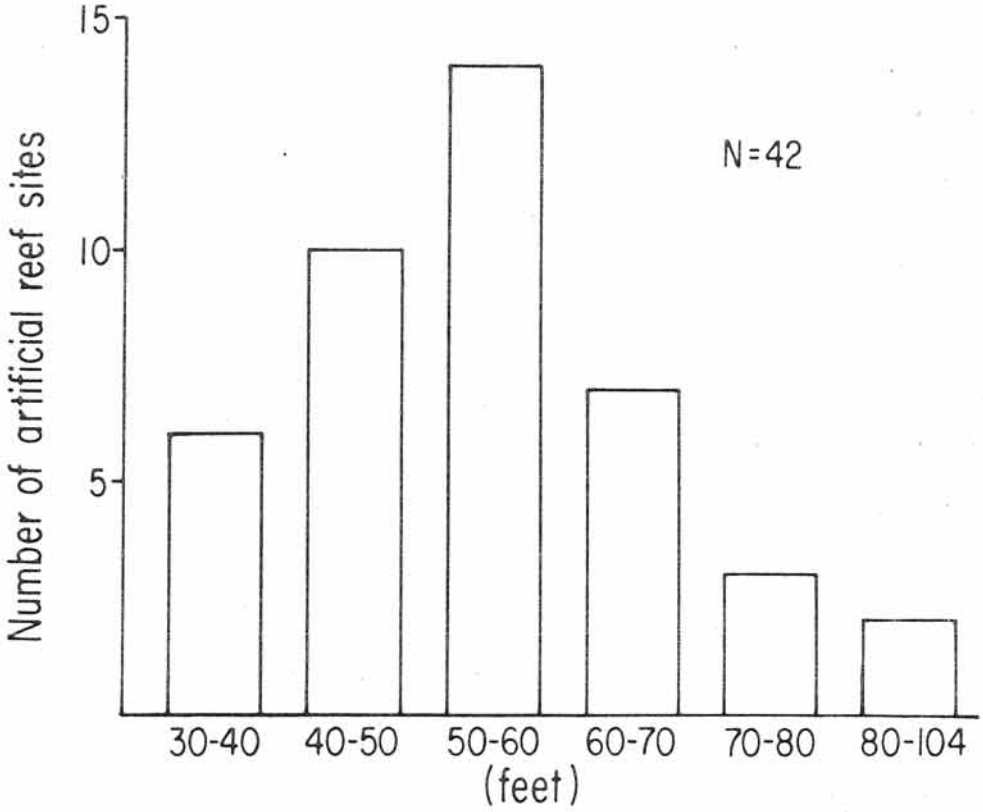


Figure 1. North Carolina's ocean and estuarine artificial reef sites as of December, 1987.



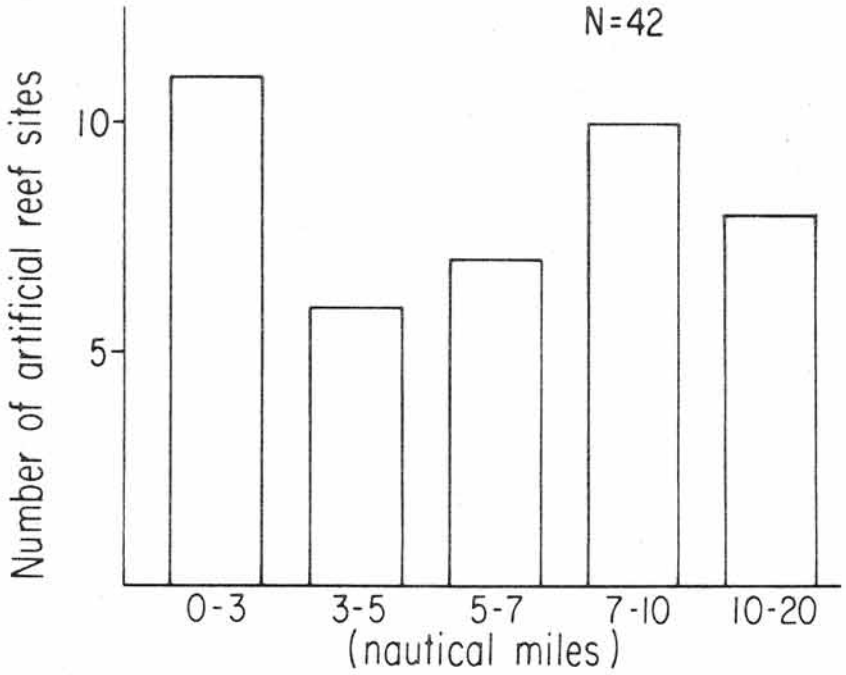


Figure 2. The depth and distance from shore of North Carolina's ocean artificial reef sites as of December, 1987.

buoying of estuarine and ocean reefs. Biological monitoring was also conducted by DMF in 1974, 1975, and 1976 (North Carolina Division of Marine Fisheries 1976, 1977, 1978). More recently, DMF's activities have concentrated on the construction of twenty new train car artificial reefs, the development of a general permit for artificial reefs, and coordination of all marine artificial reef activities in North Carolina.

Target Fish Species

Maintenance and enhancement of North Carolina's marine fisheries resources is a goal of the artificial reef program. Different reef designs in different locations attract different species. Also, different fishermen fish for different species. Knowledge of North Carolina's reef-associated fish communities and which fish are preferred by fishermen is an important component of artificial reef development.

Numerous fish species inhabit North Carolina's artificial and natural reefs depending upon the season, distance offshore, latitude, water depth, and temperature. Many species are present throughout the entire range, with more temperate fish species found north of Cape Hatteras and more tropical species present south of Cape Lookout. Chester et al. (1984) presented a zoogeographic description of South Atlantic Bight reef communities occurring on hard bottom in water deeper than 20 m based on hook-and-line catches. They found an inner-shelf community (<30 m) dominated by sea bass (*Centropristis* spp.) and porgies (*Calamus* spp. and *Stenotomus* spp.). The mid-shelf region (30-100 m) was populated by red porgy (*Pagrus pagrus*), vermilion snapper (*Rhomboplites aurorubens*) and gray triggerfish (*Balistes capriscus*). At the continental shelf edge (>100 meters), *Epinephelus* groupers (*E. niveatus*, *E. nigritus*, *E. flavolimbatus*) were present. Two other major groups of fish that are associated with North Carolina's artificial and natural reefs are the open-water pelagic species and the estuarine-dependent species.

Table 1 gives a general breakdown of those reef associated species important to North Carolina's recreational fishermen. Table 2 provides estimated catches of some of these species by marine anglers in North Carolina. Species such as black sea bass, snappers, groupers, porgies, grunts, king mackerel, and flounder are also important to North Carolina's commercial fisheries. Many other fish species found on North Carolina's artificial reefs are not economically important, but are part of the reef's ecosystem. This group includes the bait fish, which are a major food source for many piscivorous fish pursued by fishermen.

Utilization patterns of these reef associated species vary. Some species utilize artificial reefs for spawning and/or nursery grounds (Feigenbaum et al. 1986). Species, such as the black sea bass, are more or less permanent residents only moving offshore to warmer water in the winter. Other species, such as Spanish and king mackerel, and bluefish are seasonal residents, undergoing extensive north-south or east-west migrations. Many of the snapper/grouper complex of reef fishes are permanent reef residents and are very territorial. These long lived, slow growing species are susceptible to over-exploitation, particularly,

Table 1. Recreationally important fish species associated with North Carolina's artificial (and natural) reefs. Inshore species are more commonly caught in water depths of less than 30 meters, with offshore species more common in water depths greater than 30 meters. Various shark species are found in all categories.

Pelagic fishes		Bottom fishes	
		INSHORE	
amberjacks	*Seriola* sp.	Atlantic spadefish	*Chaetodipterus faber*
barracuda	*Sphyraena barracuda*	black sea bass	*Centropristis striata*
bluefish	*Pomatomus saltatrix*	Atlantic croaker	*Micropogonias undulatus*
bonito	*Sarda sarda*	flounder	*Paralichthys* spp.
cobia	*Rachycentron canadum*	kingfish	*Menticirrhus* spp.
king mackerel	*Scomberomorus cavalla*	longspine porgy	*Stenotomus caprinus*
little tunny	*Euthynnus alletteratus*	pigfish	*Orthopristis chysoptera*
Spanish mackerel	*Scomberomorus maculatus*	pinfish	*Lagodon rhomboides*
		sheepshead	*Archosargus probatocephalus*
		spot	*Leiostomus xanthurus*
		spottail pinfish	*Diplodus holbrooki*
		tautog	*Tautoga onitis*
		tomtate	*Haemulon aurolineatum*
		weakfish	*Cynoscion nebulosus*
		white grunt	*Haemulon plumieri*
		whitebone porgy	*Calamus leucosteus*
		OFFSHORE	
albacore	*Thunnus alalunga*	gag	*Mycteroperca microlepis*
dolphin	*Coryphaena hippurus*	gray triggerfish	*Balistes capriscus*
sailfish	*Istiophorus platypterus*	groupers	*Epinephelus* spp.
wahoo	*Acanthocybium solanderi*	porgies	*Calamus* spp. and *Pagrus pagrus*
yellowfin tuna	*Thunnus albacares*	scamp	*Mycteroperca phenax*
		snappers	*Lutjanus* spp. and *Rhomboplites aurorubens*
		white grunt	*Haemulon plumieri*

Table 2. Estimated total number of some of the more popular finfish caught by marine anglers in North Carolina for 1980-1986. Numbers are in thousands and "-" denotes less than thirty thousand. (Source: NMFS Marine Recreational Fishery Statistics Survey).

Species	1980	1981	1982	1983	1984	1985	1986
sharks	88	217	-	200	304	116	53
black sea bass	507	2,698	316	2,772	2,547	3,336	217
bluefish	5,640	2,641	4,593	8,227	2,973	3,402	1,861
dolphins	-	172	62	132	-	37	34
gray snapper	-					116	-
red snapper					102	532	
vermillion snapper	52	-		328			
white grunt	-	303	-	31	1,223		
pinfish	400	297	612	481	972	1,553	1,646
sheepshead	-	41	60	-	-	-	45
red porgy		190	-	68	1,143		-
porgies	-	40	-	59	117	44	-
weakfish	186	263	199	293	587	245	980
spot	8,841	5,402	4,569	6,998	3,764	9,149	3,638
kingfishes	353	583	701	730	461	805	1,108
Atlantic croaker	2,404	1,563	1,255	2,693	6,875	2,446	487
little tunny	-	-	-	87	-	160	-
king mackerel	115	1,523	169	469	479	430	141
Spanish mackerel	219	237	1,222	-	661	532	660
tunas	77	83	-	299	-	392	37
summer flounder	615	976	2,733	1,702	2,414	2,400	1,472
Gulf flounder				41			
southern flounder	-	-	-	54	-	-	62
triggerfishes/filefishes		-	-		-	-	-
pigfish		565	398	1,080	520	1,364	294
tautog		-	-	42		-	-
groupers				172	189	49	51

growth overfishing. When fishing mortality is greater than natural mortality, growth overfishing occurs, and smaller and smaller fish are caught.

It is difficult to manage such a complex and diversified resource. Policies and regulations implemented to protect this resource, such as bag limits, size limits, and quotas are difficult to enforce in the open ocean. The aggregating capabilities of artificial reefs may cause problems by concentrating certain species even as their total population declines, thus creating the need for more limits. To simply increase the habitat available to these species is not enough. Stock assessment of target species is a critical element in artificial reef development and to the success of the artificial reef program.

GOALS AND OBJECTIVES

The goal of North Carolina's artificial reef program is to develop, maintain, evaluate and administer a successful system of artificial reefs as an integral part of North Carolina's marine fisheries management program, so as to enhance marine fisheries habitat and public fishing and diving opportunities. The program will do this in conformance with applicable state and federal statutes and regulations.

In its efforts to accomplish this goal, the Division of Marine Fisheries' artificial reef program intends to:

Coordinate all marine artificial reef planning and construction activities in the state by becoming the permittee for all marine artificial reefs;

Follow proper procedures and obtain all necessary permits and authorizations from the U.S. Army Corps of Engineers, U.S. Coast Guard, Environmental Protection Agency, National Marine Fisheries Service, the North Carolina Division of Coastal Management, and all other appropriate permit agencies, without creating delays or time extensions;

Comply with all legal and financial responsibilities as artificial reef permittee as set forth by U.S. Army Corps of Engineers regulations, North Carolina Coastal Resources Commission regulations, and other applicable government agency regulations;

Require artificial reef materials that are environmentally safe, durable, and stable, and which provide suitable habitat for productive epifaunal and reef fish communities;

Site artificial reefs to provide productive reef habitat without harming existing natural habitat, and appropriately distribute reefs along the coast with respect to major inlets and user needs;

Site artificial reefs so as not to interfere with commercial fishing, navigation, or create safety hazards;

Construct a manageable number of artificial reefs that provide public benefits without endangering fisheries stocks;

Construct, whenever and wherever possible, large artificial reef complexes designed to accommodate more diverse fishing activities and associated fishing pressure;

Identify North Carolina's artificial reefs by well designed, easily recognizable, and properly maintained buoy systems;

Coordinate and encourage research and monitoring activities to determine appropriate artificial reef designs, locations for optimum yield, and maximum cost effectiveness;

Evaluate all state marine artificial reefs in terms of their biological, social, and economic success and issue an annual report to the Marine Fisheries Director;

Emphasize monitoring, maintenance, and enhancement of existing artificial reefs rather than developing new sites;

Maintain an accurate, up-to-date record on all artificial reefs: permits, authorizations, specifications, and status;

Increase public awareness of North Carolina's artificial reef system by making reef inventories, maps, and related information readily available;

Hold public meetings for the purpose of soliciting comments on the siting and management of artificial reefs;

Participate in interstate coordination activities to obtain and share information on artificial reef management and technology;

Work with Regional Fishery Management Councils to develop coastwide management policies and regulations for reef associated species;

Develop procedures for immediate action when emergency situations arise; and

Review and update the artificial reef plan annually.

ADMINISTRATION AND EVALUATION

Public Involvement

Making public participation and public education an integral part of the artificial reef program can facilitate effective management. In North Carolina, the majority of artificial reefs have been built and are maintained with public funds. Some artificial reefs have been developed through the support of area sport fishing clubs and local governments. Public concerns and interests should be considered in the planning stage of an artificial reef. Input from the public on where they want the reef located and what species they would like to catch can ensure that the reef program is responsive to the needs of user groups.

Jones et al. (1986) found the public meeting to be a successful vehicle for obtaining this type of information. As required by the Division of Marine Fisheries' general permit from the U.S. Army Corps of Engineers, public meetings must be held prior to the official request for each artificial reef permit. Since 1986, public meetings have been held by DMF prior to the permitting of all new artificial reef sites. All support and opposition to proposed reef sites should be documented and every attempt made to overcome concerns. Final decisions on reef sites with significant unresolved public opposition should be made by the Division of Marine Fisheries Director.

Two examples of public participation that could be part of the artificial reef program are the reef sponsor concept (Gordon and Ditton 1986) and sport diver volunteer artificial reef assessments. As a sponsor of an artificial reef, sport fishing clubs, local governments, and civic organizations could provide financial support for materials, deployment and enhancement. Good communication between DMF and sponsoring organizations would result in public needs and priorities reaching the state's artificial reef program on a regular basis. Such "adopt-a-reef" programs could benefit both the state and the reef users.

Volunteer sport diver artificial reef assessment projects also have benefits. Florida Sea Grant Extension personnel trained sport divers to observe, collect, document, and permanently store data on local artificial reefs in northeast Florida (Halusky and Tipping 1987). These reef research teams surveyed reef sites, documenting changes in material positions and fish communities over time. They also established local public archives for reef data. By photographing and recording artificial reef communities over time they provided fishery data to the scientific community and also increased community awareness about the results of reef building. The volunteer divers in Florida now recruit and train others in a self-perpetuating program. Information about a reef site is obtained at minimal expense to the State. For a similar program to be successful in North Carolina, the diving community would have to express their interest and commitment to the project for the long term.

Education efforts on the functions of an artificial reef and the benefits it can have will help enlighten the public and dissipate public concerns. There are several aspects of North Carolina's artificial reef development that would be of interest to the public. First is an inventory of the specific locations of all artificial reefs in the state and the materials used in their construction. Users need buoy locations and also reef material locations. Information about what fish are found on North Carolina's artificial reefs and when they are there would also be helpful. General information about the reef program and reef ecology would also increase public awareness about artificial reef development in North Carolina. Recommended methods of disseminating this information include:

1. An artificial reef guide for fishermen and divers which would provide reef locations and fish species lists.

2. An artificial reef newsletter for general distribution which would notify the public of the artificial reef program's current events.

3. Artificial reef location charts at boat access ramps.

4. Announcements of the availability of the artificial reef program video from the Division of Marine Fisheries to sport fishing clubs, aquariums, museums, and civic organizations.

5. Artificial reef talks by reef program staff to interested clubs and organizations.

Recommendations

- Hold public meetings prior to requesting all artificial reef permits and maintain records of all public comments.

- The Marine Fisheries Director should approve or deny all artificial reef sites.

- Efforts to involve and educate the public in artificial reef development should be an integral part of the reef program.

Coordination

It is the objective of North Carolina's artificial reef program to construct a system of strategically located reefs, to properly buoy the reefs, to maintain and improve the reefs by the addition of suitable construction material, and to manage them for optimum public benefit. The State of North Carolina, through the Division of Marine Fisheries, can gather public input, construct reefs, assume liability, and install and maintain buoy systems for all marine artificial reefs in the state more readily than local governments or local organizations. As coordinator of all artificial reef development, the Division should continue to encourage public support. Reef development can be carried out in close coordination with existing or planned fishing programs, private sector fishing tournaments, charter boat services, fishing piers, and the sport diving community. Integrating this kind of information into artificial reef development can help create multiple fishing opportunities (Gordon and Ditton 1986). Sponsorship of artificial reefs by interested groups is beneficial. However, coordination of all marine artificial reef management activities in North Carolina should be a specific responsibility of DMF. An effective way to accomplish this objective is for DMF to be the single permittee for all existing and future estuarine and ocean artificial reefs.

Formal and/or informal interagency coordination is important to a successful reef program. Much information exchange has occurred with DMF's participation in the Atlantic States Marine Fisheries Commission (ASMFC) Artificial Reef Committee. The DMF should continue to be an active member of this committee and work closely with the Mid- and South Atlantic Fishery Management Councils, Atlantic States Marine Fisheries Commission, University of North Carolina Sea Grant Program, NC Division of Coastal Management, and the National Marine Fisheries Service. Artificial reef research is presently being conducted at the University of North Carolina at Wilmington. Coordination between DMF and the university when research projects are in the proposal stage could mean investigation of questions which DMF needs answered to best manage its reefs.

Another agency DMF must work closely with is the North Carolina Department of Transportation (DOT). As discussed in other sections, bridge rubble is effective and durable reef construction material. Coordination between DOT and DMF on bridge replacement schedules would benefit both agencies and the public. In 1985, the North Carolina

General Assembly passed a resolution concerning coordination between these two state agencies. Specific action should now be taken in the form of a cooperative agreement between the Department of Transportation, Highway Division, and the Marine Fisheries Division regarding the use of replaced bridge materials as artificial reefs. By knowing when and where coastal bridges are to be replaced, permit and transportation arrangements can be made in advance with bridge rubble going directly to appropriate reef sites. In 1987-88, the state spent $975,000 removing the Atlantic Beach drawbridge. Through the efforts of the Carteret County Sportfishing Association, in cooperation with DOT and DMF, this bridge rubble was used as artificial reef material on-site AR320 (Figure 1).

Another good example of interagency coordination was the Artificial Reef Steering Committee. This informal committee, appointed by the Marine Fisheries Division Director, met in April 1986 to develop initial artificial reef siting parameters and guidelines, to conduct quantitative evaluations of potential artificial reef sites, and to assist in the development of an artificial reef management plan. Committee members included representatives from the North Carolina Division of Coastal Management, Attorney General's Office, and the House of Representatives. Other participants included the University of North Carolina at Wilmington, University of North Carolina Sea Grant, U.S. Army Corps of Engineers, Carteret County Watermen's Association, Carteret County Sportfishing Association, and MFC Advisory Committees. This committee should be reinstated. The agenda and meeting dates should be designated by the Artificial Reef Construction Coordinator. A copy of the minutes should be sent to the U.S. Coast Guard and the U.S. Army Corps of Engineers for their information.

Recommendations

- The Division of Marine Fisheries should be the sole permit holder for all estuarine and ocean reefs.

- An agreement should be developed between DOT and DMF regarding the use of replaced bridge materials for artificial reefs.

- An Artificial Reef Steering Committee should be reinstated to advise DMF on proper management of North Carolina's artificial reefs.

Funding

Funding is a critical part of the artificial reef program. Responsible program development and long-term management are not possible without dependable funding. In the past, funds for the artificial reef program have come from unrebated motor fuel taxes, special legislative appropriations, private donations and DMF's general operating budget. Special appropriations and private donations have been used almost exclusively for special projects such as North Carolina's train car reefs. Local fund raising events, such as the Atlantic Beach and Wrightsville Beach King Mackerel tournaments, have also donated money for reef construction. After materials are deployed, however, buoy and maintenance costs remain.

With the advent of the Wallop-Breaux Amendment (1984) to the Federal Aid in Sport Fish Restoration Act (Dingell-Johnson Act, 1950), a potential source of funding was made available to the artificial reef program. The state, however, must provide matching funds which may or may not be available. To date, Wallop-Breaux funds (administered by the U.S. Fish and Wildlife Service) have been used to improve public access to artificial reefs (marker buoys and location maps), to coordinate construction of artificial reefs, and to prepare this artificial reef plan.

Private donations of time and money to artificial reef development in North Carolina over the past 15 years has been significant, but very difficult to document. Towing companies have provided free docking and have cleaned vessels free of charge in exchange for salvageable materials found on these vessels. The U.S. Marine Corps has donated their expertise, equipment, and men for deployment of numerous reef structures. Free labor has been provided by the public through volunteer efforts. Also, public interest and political lobbying for artificial reef development in the state has provided the reef program with funding it would not have received otherwise.

Securing a long term budget for the artificial reef program is challenging. With the use of materials of opportunity for artificial reef construction, determination of funding needs is even more complex. It is difficult to know when these materials will become available, and how much it will cost to prepare them for deployment. A 439 foot cable laying vessel will cost approximately $104,000 to prepare, tow, and sink on a site off Beaufort Inlet in 1988. With the use of pre-fabricated reef materials funding needs can be more easily determined. Maintenance costs of artificial reef buoys and mooring systems also vary from year to year. Buoys drift off-site and, by U.S. Coast Guard regulations, must be replaced as quickly as possible. Buoy system maintenance in 1987 cost $58,000. These uncontrollable costs make budget determinations difficult. The artificial reef program budget is developed annually. Total expenditures for fiscal year 1986-1987 were $517,064. Total expenditures for fiscal year 1987-1988 were $495,099. Table 3 gives expenditures for North Carolina's artificial reef program from 1973 through June 1988.

Presently, the artificial reef program is administered and operated by the Fisheries Development Section of the Division of Marine Fisheries. Full time staff, under the Section Chief, include a construction coordinator, technician, and two maintenance mechanics. A biologist is also assigned to the program for 40% of his time. Manpower and equipment from other Fisheries Development programs can be used for reef activities when available. This flexibility allows for efficient use of the Section's resources.

Determining a finite future budget for the reef program is difficult, in part because of the sporadic availability of funding and materials of opportunity. However, below are priorities for where and how monies should be spent when they become available. More detailed funding requests are included in the Implementation Plan.

Table 3. Expenditures for North Carolina's artificial reef program.

Fiscal year	State	Federal	Total
1973-74	$ 88,983	$ 0	$ 88,983
1974-75	232,854	0	232,854
1975-76	258,299	0	258,299
1976-77*	272,000	0	272,000
1977-78*	80,000	0	80,000
1978-79	110,777	0	110,777
1979-80	160,277	0	160,277
1980-81	98,309	30,136	128,445
1981-82	145,772	14,910	160,682
1982-83	247,539	0	247,539
1983-84	271,657	0	271,657
1984-85	302,493	0	302,493
1985-86	151,609	24,420	176,029
1986-87	405,196	111,868	517,064
1987-88	345,334	149,765	495,099

* Estimated

1. Maintenance of buoy and mooring systems.

2. Monitoring condition of reef materials after deployment.

3. Enhancement of present permitted sites with suitable reef materials.

4. Distribution to the public of a North Carolina artificial reef guide with information on material locations and fish species availability.

5. Feasibility studies in design research of pre-fabricated artificial reef materials.

6. Utilization studies of present artificial reef sites by recreational fishermen to determine adequacy of number available and accessibility in terms of potential user conflicts and overfishing.

Recommendations

- Secure a continuing state appropriated budget to provide the artificial reef program with basic general operating funds.

- Request special legislative appropriations to be used for special reef project funding.

- Utilize Wallop-Breaux funds where appropriate.

- Cooperate with sport fishing clubs in their efforts to raise funds for local artificial reef development.

Liability

Title II of the National Fishing Enhancement Act (1984) addresses the issue of liability by the federal government, the donor of reef materials, the permittee, and the permittee's insurer. Nothing in Title II creates any liability on the part of the federal government. Any person who transfers title to artificial reef construction materials to a permittee is not liable for damages arising from the use of these materials as an artificial reef if those materials met the requirements of the National Plan and were not otherwise defective at the time the title was transferred. Nor is the permittee liable under the Act for damages caused by activities required to be undertaken by the permit's terms and conditions, but only to the extent that the permittee remains in compliance with those terms and conditions. The permittee, however, shall be liable to the extent determined by applicable law for damages which are not within the scope of activities required by the permit's terms. This also applies to the insurer of the permittee. A permit may not be issued unless the applicant can demonstrate the financial ability to assume liability for all damages that may arise with respect to an artificial reef.

Concern has been raised by various North Carolina commercial fishing organizations over the threat of injury to individuals, damage to vessels and/or gear, and the loss of catches due to artificial reef materials that have moved off-site. One suggestion was that a contingency fund be made available to commercial fishermen for such losses. Care should be taken to avoid siting artificial reefs near navigation channels, in order to minimize the danger of reef materials becoming hazards to navigation if shifted by storms, or other events.

If reef materials move off-site and become a hazard to navigation or commercial fishing activities, costs to the Division could be substantial. The National Fishing Enhancement Act (Title II, Section 205 (e)) authorizes the Secretary of the Army to assess civil penalties for violations of issued permits under the Act. The maximum civil penalty is $10,000 per violation. Besides paying up to $10,000 for each violation, the permittee or insurer may be liable for the cost of correcting the violation.

The State's liability for its artificial reef construction is defined by existing state law. The State of North Carolina has waived its sovereign immunity for tort liability by enactment of the State Tort Claims Act, G.S. 143-291 et seq. This Act authorizes the North Carolina Industrial Commission to hear and determine claims against departments, agencies or institutions of the State arising as the result of negligence of any officer, employee, involuntary servant or agent of the State while acting within the scope of his office, employment, service, agency or authority. The maximum recovery allowed is $100,000 per claim. If any of the employees or agents of the Department of Natural Resources and Community Development or Division of Marine Fisheries are negligent in the management or maintenance of artificial reefs and that negligence is the proximate cause of damages, then the Division can be held liable pursuant to the State Tort Claims Act. This liability exists regardless of whether the artificial reefs are sited within or outside of the state's territorial waters. Liability is limited to $100,000 per claim, but the number of claims per incident is not restricted. Therefore, the State, as permittee, could be liable for damages caused by an artificial reef project if the project is not built and maintained in compliance with the conditions of any permit, but then only to the extent provided by law.

Apart from its liability for damages arising from the negligent acts of its employees or agents, the State could incur substantial expense from removing artificial reef materials which wash up on beaches or become hazards to navigation when shifted off-site by storms or other events. To the extent that such artificial reef materials actually cause damage to vessels or injury to seamen, under the Eleventh Amendment to the Federal Constitution, the State is immune from federal court suits brought in admiralty or under the Jones Act (Title 46 U.S. Code 688). However, the State may nonetheless be liable for such damages under the State Torts Claims Act, where the negligence of a State employee or agent is the proximate cause of the injury.

Recommendations

- The State should make a commitment to a reef monitoring and maintenance program to ensure the safety of fishermen, their vessels and gear.

- The State will accept legal responsibility for its artificial reef construction to the extent provided under existing state law.

- The State should avoid siting artificial reefs near navigation channels to minimize the danger of reef materials becoming hazards to navigation if shifted by storms or other events.

- The State should avoid siting artificial reefs near commercial fishing areas to minimize the potential for reef materials to interfere with commercial fishing activities.

Research

A goal of North Carolina's artificial reef program is to provide an enhanced marine fisheries habitat and enhanced opportunities for the fishing and diving public. Therefore, successful reef development efforts should result in effective, viable, and productive artificial reefs. Research has an important role in deciding whether or not these goals are being met. Research provides information that can be used to improve upon present reef development practices. Ecological studies help determine if an artificial reef is providing enhanced marine fisheries habitat, and socioeconomic surveys can determine if the reef program is providing sufficiently enhanced opportunities to the fishing and diving public.

Not all artificial reefs are effective. Bohnsack and Sutherland (1985) reviewed artificial reef research and found numerous cases of reef failures. They cited investigations showing reefs that were destroyed by storms or corrosion or sank into the substrate; artificial reefs that did not improve total population numbers, biomass, or fishing success for certain species; and that artificial reefs could potentially lead to overfishing. They also suspected that additional reef failures have occurred due to failure to monitor the reef after its construction. Information from biological investigations of proposed and existing reef sites can direct reef deployment to areas where optimum conditions exist for fish attraction and/or production. Marine recreational fishing surveys and assessments produce indices of user participation and satisfaction as well as future needs and demands.

Besides ecological and socioeconomic investigations, technical and engineering research should be a part of the artificial reef program. Stability studies and design research will improve upon existing reef construction materials and deployment techniques. A shift from total dependence on "materials of opportunity" to a mix of these materials and specifically designed pre-fabricated structures may be possible, based on such investigations.

Sound management strategies which protect reef-dwelling fishes from over-harvesting are crucial to the future of artificial reef development. Sound data are necessary in the development of these management strategies.

Prior research on North Carolina's artificial reefs has been conducted by the NMFS, DMF, and university researchers. As part of its active reef program (1974-1977), DMF conducted a recreational creel census and underwater biological survey on artificial reefs built during this period. Creel census results are shown in Tables 4 and 5. Some results of the biological visual census are shown in Table 6. Results from visual surveys were a good indication of the abundance and diversity of smaller fish (tomtate, pinfish, spottail and scup). Whereas the creel survey was a better indicator of the presence of larger fish species (king mackerel, amberjack, barracuda).

McDonald (1978) examined the standing crop, distribution, and production of the macrobenthic epifauna on the Atlantic Beach reef, identifying 84 species. Total macrofaunal biomass on the Liberty Ship was calculated to be 10,000 kg. Ostrea equestris, the horse oyster, was the major epifaunal organism on a weight basis (54% of dry weight biomass).

By providing food and shelter, artificial reefs can attract large numbers of many different fish species. Concentrating these fish in a known location makes them relatively easy prey for fishermen. Fisheries managers must pay serious attention to the condition of these various stocks of reef-associated fishes. Artificial reefs can attract species whose stocks are down, contributing to their decline. This is not an intention of North Carolina's artificial reef program.

Stock assessments of those reef-associated fishes found off North Carolina are conducted by federal and state agencies and university researchers. Results from these studies, when applicable, should be incorporated into artificial reef development decisions. The DMF is presently involved in a cooperative study with NMFS of the king and Spanish mackerel stocks off North Carolina. These species are very popular with North Carolina's fishermen and are very common on the state's artificial reefs. At present there is a recreational bag limit in federal waters of three king mackerel per person per trip. Both state and federal regulations limit the catch of Spanish mackerel to 10 fish per person per trip. These regulations were enacted to help protect these stocks which many researchers believe are threatened. This situation is an example of the kind of problems artificial reef developers face when trying to enhance fisheries habitat and fishing opportunities, while not endangering the health of the fisheries resources.

The National Marine Fisheries Service 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 reef

Table 4. North Carolina Division of Marine Fisheries Artificial Reef Recreational Creel Census - 1974 to 1977.

		HOURS FISHED		FISH PER HOUR		POUNDS PER HOUR	
		Wrightsville Beach Reef	Atlantic Beach Reef	Wrightsville Beach Reef	Atlantic Beach Reef	Wrightsville Beach Reef	Atlantic Beach Reef
1974							
	Summer		1,968		1.0		0.7
	Fall		1,397		3.5		3.0
1975							
	Spring	1621	1,155	2.6	3.6	5.4	5.5
	Summer	5390	1,830	3.8	2.6	4.5	1.8
	Fall	4697	2,366	1.6	2.6	5.7	2.4
1976							
	Spring	3767	877	1.3	1.4	3.9	1.5
	Summer	4449	1,796	2.7	1.9	3.6	3.5
	Fall	3926	2,802	4.0	4.2	4.8	3.1
1977							
	Spring	2577	1,550	1.3	2.7	4.7	4.9
	Summer	6839	2,745	2.9	1.9	3.4	1.7

Table 5. Major fish species caught by recreational fishermen at the Wrightsville Beach and Atlantic Beach Reefs in the spring and summer of 1977. Information obtained from North Carolina Division of Marine Fisheries artificial reef recreational creel survey.

Species	Pounds	%	Species	Pounds	%
WRIGHTSVILLE BEACH: 1977					
Spring			Summer		
king mackerel	7,644	64.0	king mackerel	5,282	25.0
shark	2,782	23.0	shark	4,261	18.0
black sea bass	653	5.0	black sea bass	2,893	12.0
bluefish	159	1.0	amerjack	2,400	10.0
red drum	141	1.0	grunt	1,444	6.0
Spanish mackerel	122	1.0	cobia	1,351	6.0
grouper	79	0.7	pigfish	1,213	5.0
sheepshead	79	0.7	Spanish mackerel	699	3.0
pigfish	56	0.5	flounder	284	2.0
grunt	54	0.4	sheepshead	263	1.0
flounder	51	0.4	croaker	176	0.8
spot	27	0.2	bluefish	173	0.7
king fish	15	0.1	snapper	150	0.6
other	275	2.0	spot	147	0.6
			king fish	80	0.3
			other	2,042	9.0
Total pounds	12,137			22,858	
Total hours	2,577			6,839	
ATLANTIC BEACH: 1977					
Spring			Summer		
king mackerel	2,443	40.0	king mackerel	1,267	31.0
shark	804	13.0	Spanish mackerel	1,202	22.0
weakfish	722	12.0	amberjack	416	8.0
amberjack	415	7.0	Pigfish	384	7.0
bluefish	399	7.0	black sea bass	384	7.0
black sea bass	337	6.0	cobia	149	3.0
pigfish	267	4.0	grunt	137	2.0
croaker	182	3.0	spot	81	1.0
spot	103	2.0	bluefish	58	1.0
flounder	69	1.0	croaker	45	1.0
other	314	5.0	sheepshead	30	1.0
			flounder	24	0.5
			shark	9	0.5
			other	815	15.0
Total pounds	6,055			5,001	
Total hours	1,550			2,745	

Table 6. Predominate fish species seen by divers during biological visual surveys on two North Carolina artificial reefs.

Dates	Artificial reef	Number visual samples	Most abundant species in order of abundance
Jul-Nov 1974 Apr-Jun 1975	Atlantic Beach	26	*Index species tomtate Spanish mackerel pigfish round scad sheepshead
Sep-Nov 1974 Feb-Jun 1974	Wrightsville Beach	20	Index species tomtate blueback herring round scad and tomtate

*Index species: black sea bass, spottail porgy, long spine porgy, pinfish.

fish fisheries. The North Carolina artificial reef program should encourage and assist in any way possible with reef related research. Using this knowledge, informed decisions can be made with respect to artificial reef development and management in North Carolina.

Murray et al. (1985) studied the use of midwater FADs to attract marine fish at two North Carolina fishing piers. Results of the study were mixed. Hurricane Diana interrupted the study during the peak fishing season, and pier owners demanded the units be placed 750 feet away from the piers. However, results did show that FADs are successful in aggregating baitfish in the nearshore environment. Stephan (1988) has also conducted research 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). They also conducted dietary analyses 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 FADs in Onslow Bay was done by Stephan and Lindquist (in press). Lindquist and Pietrafesa (1987) examined the effects of the fluid dynamics and current fields around a tugboat reef on fish aggregations and populations. Future studies proposed 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 forage fishes from the water column, the reef itself, and also the surrounding soft substrate.

Addressing research questions, such as aggregation -vs- production is beyond the scope of state artificial reef programs. The New Jersey Marine Fisheries artificial reef program has initiated a process by which research needs critical to their program can be addressed. Working through the New Jersey Sea Grant Extension Service, a list of artificial reef research needs as identified by New Jersey's reef program coordinator was distributed to appropriate state university researchers. A summary of these identified needs include food habits of reef fishes, reef colonization studies, artificial reef fishing success, effects of reef populations on surrounding bethos, estimates of adult fish populations, and reef productivity (W.K. Figley, personal communication).

Recommendations

The recommended research topics discussed below are those that would be most helpful to North Carolina's reef program; research that asks questions whose answers will contribute directly to management of the state's artificial reefs. Any research agenda developed should involve the Artificial Reef Construction Coordinator and also collaborate with other Atlantic Coast states under the ASMFC-developed research program.

Baseline Ecological Data

As of December 1987, 35 artificial reef sites in North Carolina's ocean had materials on them. A subsample of reefs is suggested based on latitude, distance from shore, depth, and construction material. Stratified random sampling is recommended. Preliminary site investigations should be conducted prior to construction and relatively intensive sampling should occur (depending upon the season) during the reef's initial colonization. After this stage, sampling frequency could be decreased substantially. Collection of abundance and biomass data is recommended only for those reef-associated finfish that are economically important. Recruitment and colonization rates would document a measure of the reef's aggregation capability. Data would be available for comparative analyses of different sites and materials and their suitability to different species.

Sampling methods used in the collection of ecological data should be both statistically sound and also appropriate for targeted species. Certain pelagic reef-associated fishes such as king mackerel are rarely seen during diver surveys. Trolling or drift CPUE sampling are more appropriate for these species (D.G. Lindquist, personal communication). When diver surveys are used for benthic reef-associated fishes, the methods must be carefully specified so that data can be treated statistically and meaningful intra- and inter-reef comparisons can be done (D.G. Lindquist, personal communication). Bohnsack and Bannerot (1986) have developed a stationary visual census technique for quantitatively assessing reef fish community structure. Their technique could be applied to monitoring and research on North Carolina's artificial reef communities.

Status of Reef-Associated Fish Stocks

Information on the status of reef-associated fish stocks provides the basis on which management policies and regulations are based. NMFS and DMF have been and continue to be involved in stock assessment of these fish. They also collect data from the commercial reef fish fishery. The plan recommends continuing these assessments.

It is critical that monitoring studies be conducted to measure productivity and harvest rates. Data from monitoring studies could be used to establish some sort of trigger mechanism to invoke management measures if overharvesting is detected, i.e. if CPUE falls to "X" level for a specified period (W.M. Groarty, personal communication).

Material and Design Studies

Material and design studies would help move the artificial reef program away from dependence on materials of opportunity and towards a sound designed reef construction capability. Design research should be conducted at inshore locations. This would mean significant operational benefits over an offshore site. Such studies should be conducted under the direction of the Artificial Reef Construction Coordinator to improve the quality and effectiveness of North Carolina's artificial reefs.

Socioeconomic Data

Socioeconomic studies are necessary to document success of the program and to provide guidance for future artificial reef development. There is an optimum number of reef sites, with optimal amounts of material on them, at optimal locations for the number of recreational fishermen and the number of fishing trips that are made in a given area. Too many reefs mean a waste in money and effort. Too few reefs mean heavy fishing pressure, user dissatisfaction, and potential user conflicts. Data needed include the numbers of boats and fishermen at a reef over time, how long they fish, and how far offshore they fish. Much of this and similar information is available from recreational and creel surveys conducted by DMF, NMFS, and also from boat registration information. Analyses of expectations and satisfaction are needed.

Artificial Reef Program Review

Periodic assessment and evaluation of North Carolina's system of artificial reefs in terms of the established goals and objectives is needed. The Fisheries Development Section Chief, working closely with the Artificial Reef Construction Coordinator, should consider the following during program review:

- Is there a manageable number of artificial reefs, considering maintenance, buoys, enforcement logistics, and long term funding requirements?

- Are the artificial reefs strategically located in terms of accessibility to the public and proximity to major inlets?

- Are user conflicts occurring as a result of heavy utilization of an artificial reef(s) or for other reasons?

- Is there a depletion of a fisheries stock associated with an artificial reef(s) due to overfishing? If so, what regulations are needed to prevent further declines?

- What is the availability of materials of opportunity and the possibility of utilizing pre-fabricated artificial reef structures?

With respect to these issues, the Section Chief should keep the Marine Fisheries Division Director abreast of developments and concerns.

The program should also comply with appropriate state and federal documentation and reporting requirements. This includes the Marine Fisheries Division's program documentation process and also the research proposal and review process.

Recommendations

- An annual artificial reef program review by the Fisheries Development Section Chief with the Artificial Reef Construc-

tion Coordinator should be conducted in terms of the program's goals and objectives.

- An annual report of artificial reef activities and program status should be made available to the public.

- Documentation, reporting, and review procedures should be met in a timely manner.

- The Division of Marine Fisheries Director should be informed of program developments and concerns.

DEVELOPMENT AND OPERATIONS

Materials

Factors to consider when choosing artificial reef materials are absence of toxins harmful to the environment, durability, stability, cost, availability, desired function, ease of deployment, and the amount of habitat complexity they provide. Japanese researchers believe that fish recognize the shape and size of a structure, not the material. For the Japanese, material considerations are mainly affected by structural, economical, and handling requirements (Grove and Sonu 1985). Proper choice of materials will enhance the lifespan of a reef. Safety during construction, preparation, transportation and deployment should always be a major consideration. Material strength is an important factor which can affect possible structural failure or damage during handling.

Obsolete federal and military vessels have proven to be effective in artificial reef construction. Their large size (often over 400 ft.) and solid construction usually mean they are durable, stable, and provide good profile and habitat complexity. North Carolina has used Liberty ships, a Navy cable laying vessel, barges, and dredges for artificial reef construction. These vessels are often made available by the federal government at no cost.

Not all structures offered as a donation to the State may be effective as reef material or inexpensive to utilize. Preparation, transportation and deployment costs may outweigh the benefits of donated material. Only those materials that will, after sufficient investigation, make a suitable artificial reef and will not cost inappropriate amounts of time and money should be accepted. The State should also not accept "unknown" materials until the toxic and stability factors are determined.

Another consideration in selecting obsolete vessels for artificial reef materials are the deployment methods. Explosives are often used to sink these ships. Extreme caution and planning is recommended with this type of deployment. A high degree of technical expertise is necessary for two reasons: (1) safety of the deployment crew, and (2) maintaining structural integrity of the vessel. The use of explosives in deployment often damages the structure more than necessary to facilitate sinking. This extensive structural damage decreases the

reef's lifespan by accelerating decomposition and corrosion. An alternative deployment method, although not as dramatic as explosives, is simply flooding the vessel with water pumped from the surrounding ocean. A benefit of many prefabricated structures is that they can be designed for ease of deployment.

Another option in artificial reef construction, aside from materials of opportunity, is the use of pre-fabricated materials. Pre-fabricated materials can be durable, stable, and environmentally safe. The flexibility inherent in a designed structure permits the fabrication of units which are effective for the target species and reef objective (Sheehy 1985). Initial costs may be high, but not significant when applied over the extended use of the reef. They can be used as benthic, mid-water or surface reefs. Many mid- and south Atlantic states with reef associated fishes common to North Carolina and similar oceanographic and bottom conditions have used these materials in their reef construction.

The New Jersey Marine Fisheries personnel (Myatt et al. 1987) have developed TICs (tires-in-concrete) that not only provide an excellent habitat for benthic species, but have proven to be stable units as well. Artificial reef programs in Virginia (Meier et al. 1985) and South Carolina (Bell et al. 1987) have been investigating a variety of concrete structures. Fiberglass-reinforced plastic units have been deployed off the Atlantic and Gulf Coasts of Florida (Sheehy 1985).

Fish aggregating devices (FADs) are another type of pre-fabricated structure. FADs are deployed in mid-water or at the surface and come in a variety of designs (Myatt 1985, Workman et al. 1985). They are primarily used to attract bait fish and pelagic species. Their cost is variable and lifespan relatively short (1-2 yrs). In some areas, extensive fouling can render the unit inoperable. Feigenbaum et al. (1986) also reported that subsurface FADs without buoys were more difficult to locate than those with buoys. South Carolina (Myatt 1983) has done extensive design research on FADs and presently uses a light weight, simple, low-cost unit that is easy to deploy. Feigenbaum et al. (1986) have also done comparative studies on several types of FADs presently available. Using FADs in combination with benthic reefs has been shown to be effective (Hammond et al. 1977, Chandler et al. 1985, McIntosh 1985).

Two new developments in artificial reef construction materials are petroleum platforms and the use of coal and oil waste materials. The Gulf of Mexico states and Florida are presently utilizing derelict offshore petroleum platforms as artificial reefs. A "Rigs to Reefs" program has been developed by the Minerals Management Service for the Gulf of Mexico. This agency has published a report (Reggio 1987) stressing the value of these oil and gas structures as artificial reef development material. High transportation costs may make the use of these structures as artificial reefs unrealistic in North Carolina.

Other new materials for construction of artificial reefs in the ocean are by-products from coal and oil combustion. Experimental reefs in New York (Woodhead et al. 1985) and Delaware (Price 1987) have been built using coal-waste materials. Reef construction in Florida

(Kalajian et al. 1987) has utilized stabilized oil ash. Investigations (Parker 1985, Savercool 1988) have shown that reefs built from these materials are colonized by marine organisms and support fish communities comparable to other artificial reefs. Studies continue, however, to monitor possible harmful effects on organisms from the leaching of toxins found in these materials.

Various studies have been conducted on the typical properties of the different materials used in artificial reef construction. One study by Ueda (1978) tested tensile strength (kg/mm^3) of wood, aluminum, steel, reinforced concrete, unfortified plastic, fiber-reinforced plastic (FRP), and filament-wound FRP. He found filament-wound FRP structures to have the greatest tensile strength, with steel second and unwound FRPs third. Unfortified plastic and reinforced concrete had the least tensile strength.

Table 7 gives an overview of possible materials that North Carolina's artificial reef program could utilize. It should be noted that material properties may vary and can change the degree of effectiveness (i.e., steel thickness, size of concrete structure, type of fasteners). Also, those materials that provide only low profile can have a higher profile if combined with FADs. Low profile materials such as rock, can also be used to enhance high profile structures that have minimal complexity.

General Criteria

- North Carolina's artificial reef program should NOT use materials that:

    1. Are toxic to the environment.

    2. Are not stable and may move off-site, such as tires or any other highly buoyant low density material. Extensive stability tests and stringent ballasting requirements should be followed if these types of materials are considered.

    3. Are not durable and will have a short lifespan in the ocean, such as automobiles or appliances, aluminum or wood structures.

- Minimum standards should be developed for recycled materials used in reef construction. This will reduce environmental hazards from unwanted or nonfunctional materials that may be "dumped" on the artificial reef program.

- North Carolina should continue using obsolete vessels for artificial reef construction provided that:

    1. Structural integrity of the vessel is intact.

    2. Preparation and deployment will not cost more than the expected economic benefits.

    3. Minimal amounts of explosives are used in deployment.

Table 7. Overview of artificial reef materials that could be used by North Carolina's artificial reef program. Availability, preparation costs, and deployment factors were not rated due to their variability. (E=excellent, G=good, P=poor, H=high, L=low, V=variable)

	Durability	Stability	Habitat complexity	Profile
MATERIALS OF OPPORTUNITY				
Steel vessels	E	E	V	H
Oil and gas platforms	E	E	G	H
Bridge rubble	E	E	E	L
Concrete culvert	G	V	G	V
Rock	E	E	E	L
PREFABRICATED MATERIALS				
Tires-in-concrete	G	G	E	L
Concrete structures (igloos, pyramids, modules, slabs)	V	G	E	M-L
Ballasted FRPs	E	G	E	M-L
FADs	P	G	P	H

- North Carolina should incorporate pre-fabricated materials into its artificial reef construction program. Utilizing available technology, this should be done only after stability and design studies are conducted.

Recommendations

- North Carolina's artificial reef program should use only those materials in its construction of artificial reefs that meet the general criteria specified in this plan.

- All materials to be used in artificial reef construction must be inspected and approved by the Artificial Reef Construction Coordinator and any other appropriate state or federal agency.

- As specified in the general permit, all vessels must be inspected by the EPA or their designated representative (USCG) to certify that the vessel is substantially free of all pollutants (oil, gas, etc.) and is ready for sinking as an artificial reef.

- An International Loadline Exemption Certificate must be obtained from the USCG for all vessels prior to deployment.

- Materials used should provide the degree of habitat complexity and profile appropriate to fish species the reef is intended to attract.

- Materials of opportunity should be used only after sufficient investigation to ensure they will make a suitable reef and will not cost inappropriate amounts of time and money to prepare and deploy.

- Extreme caution and planning should be employed when using explosives in deployment to insure the safety of personnel and that minimal structural damage of the material will occur.

Design

Proper design of artificial reefs and reef sites can decrease costs and improve effectiveness. The National Artificial Reef Plan (Stone 1985) recommends that the following criteria be considered when designing artificial reefs: surface area, profile, horizontal area, interstitial space, configuration, contrast, fishability, structural integrity, stability, durability, and flexibility. Some of these factors apply more to FADs (flexibility) and others more to benthic reefs (profile, orientation, stability). The function of a reef may be different for migratory and demersal fishes. Grove and Sonu (1985) found the height, rather than horizontal spread, to be more important for migratory fish, while the horizontal spread rather than the height was more important for demersal fish. Chandler et al. (1985) suggested that midwater structures attract greater numbers of pelagic species to existing reefs but, once present, these fish may associate more with bottom than suspended structures. Even though initial costs of complex structures, utilizing both benthic and midwater materials,

may be high, long term benefits are realized when they attract both pelagic and benthic species. Depending upon the type of material used, the desired target species, and the location of the reef, as many of these factors as feasible should be incorporated into the reef design.

Another criteria to consider in reef design is the orientation of benthic reefs on the ocean floor. Studies have shown (Baynes 1987, Lindquist and Pietrafesa 1987) that the orientation of reef materials to prevailing currents can affect densities of sessile macrofaunal communities and fish aggregations on the reef. Further investigations need to be conducted on the effects of water flow. However, deployment logistics often preclude placement of reef materials in a certain direction relative to the currents.

Reef Structure Design Recommendations:

- Increase surface area and interstitial space by the addition of rock, concrete or other suitable materials to barges and stripped vessels. Addition of these enhancers will increase complexity, providing substrate for encrusting organisms, and enhancing food supply and protection to finfish. U.S. Coast Guard load line requirements must be followed when towing vessels with these additional materials.

- Increase profile by the addition of mid-water FADs to low profile benthic reefs. Pelagic species will be attracted by the floating structure. However, potential conflicts could arise between recreational fishermen anchored for demersal species versus those fishermen trolling for pelagics.

- When at all possible, subsurface FADs should be buoyed. In efforts to keep the program's buoy system at a manageable number, FADs should be incorporated at reef sites with existing buoys whenever possible.

- The use of surface FADs in deep water to attract pelagic species such as tuna is not recommended until extensive research is done on cost, maintenance requirements, required mooring systems, and how they affect fish stocks.

- The use of predesigned prefabricated structures is recommended after evaluation studies have been conducted.

Determining how reef materials are to be distributed on each reef site can be just as critical to effectiveness and fishability as the design of the reef structure itself. This is especially true when the reef site is large. Many of North Carolina's recently permitted sites are 162 acres. Some advantages to designing a reef fishing complex on a reef site is the dispersion of fishing pressure, increased fishability, and the possibility for a reef sanctuary. According to Grove and Sonu (1985), the threshold distance over which a fish is known to perceive the presence of a reef structure is 1.5 km. The following recommendations are for individual permitted reef sites. Their goal is to properly enhance reef sites presently permitted, and minimize the need to permit additional sites.

Reef Complex Design Recommendations:

- Trolling Alleys — Multiple benthic reefs and/or FADs should be deployed in a corridor. This would provide a "fishing lane" to recreational fishermen and increased habitat for the resource. Trolling alleys should be designed to minimize conflicts between anchored and trolling fishermen.

- Reef Clusters — Deploy different types of reef structures dispersed over the entire reef site. Each structure should stand alone as an artificial reef, and could be designed for different species. Sufficient distance between the structures will allow for optimum fishing opportunities and the dispersion of fishing pressure. When all materials are deposited directly below the buoy, user conflicts arise. Loran coordinates of each reef structure's location must be readily available.

- Reef Sanctuaries — Use one or more reef structures in a reef complex to provide a haven, spawning and/or nursery ground for fish species. Fishing on these reefs could be prohibited or seasonally restricted. With enforcement very difficult in the ocean, South Carolina has deployed its reef sanctuaries away from the buoy and not made their location public knowledge (S.W. Murphey, personal communication).

Siting

Before choosing an artificial reef site, oceanographic investigations of the biological, chemical, physical, and geological environment should be conducted. Sites should be located a significant distance from natural reef communities. A study by Grove and Sonu (1985) found 600 meters to be the maximum range that two fish groups, one residing in a natural reef and the other in an artificial reef, could engage in mutual interactions. They recommended that the distance between a natural and artificial reef range between 600 and 1,000 meters to avoid competition. A favorable bottom topography is gently sloping, with a relatively flat profile. In this environment, an artificial reef will be easiest to find by fish and fishermen.

A good understanding of user needs in each area should also be considered. Demographic data of the recreational fishing community, including their numbers, growth and distribution along the coast, can be obtained, in part, from the boat registration system (Gordon and Ditton 1986). Data on distances traveled offshore by boat size and type of fishing, general access points and frequency of their use, and shore-based infrastructure (facilities and services for the recreational fishermen) should be utilized for site determinations (Gordon and Ditton 1986). They found that boats of 19 ft. or less normally do not fish

beyond ten miles. Reefs should be placed near good access points, major population centers, and in areas where recreational fishing demand is high. However, if the bottom will not support the reef structure or the current regime is too strong, sinking, severe scouring, and/or sanding over can occur.

Sites should not be selected in navigation channels, traditional commercial fishing locations, or where there is already a live, productive bottom. Neither should reef sites be located in registered natural areas within the State's natural heritage program. It is important to realize that a particular site may meet user qualifications, but not meet those criteria that ensure safety, longevity and productivity.

With such extensive requirements for the siting of artificial reefs, advanced planning is essential in order to realize optimum benefits. As discussed earlier, public input is extremely important to the site selection process. Good information can come from the local level, with coordination of these local level activities through state level planning. Therefore, an important part of the planning process is public meetings and agency workshops.

The Louisiana artificial reef program used a process developed by the Sport Fishing Institute's Artificial Reef Development Center to select potential artificial reef sites called exclusion mapping (Myatt and Ditton 1985, Wilson et al. 1987). First, all areas that are commercial fishing grounds, navigational channels or highways, established hard bottom reef communities, unsuitable bottom substrate or topography, or whose current regimes will cause significant scouring or sand disposition were identified and mapped out. Essentially what remained were whole areas where no commercial fishing or navigational interference would occur, that had suitable hydrographic and topographic conditions, and where no damage would occur to natural hard bottom. Out of these remaining areas, whole sections were charted based on easy accessibility to recreational fishermen. It is from these sections, and only these sections, that future reef sites can be chosen.

In 1985 and 1986, members of the Artificial Reef Steering Committee and DMF District Managers met with commercial fishermen to delineate traditional commercial fishing grounds along North Carolina's coast. These areas were blocked off on navigational charts. Artificial reef construction was unofficially restricted from these areas. This process could be expanded to include all areas unsuitable for reef construction. These areas could then be given an official designation through the regulation process as locations closed to artificial reef construction.

North Carolina already has over sixty permitted reef sites. The need for many more is debateable. However, if more sites are chosen, the following criteria should be followed.

Siting Criteria for Artificial Reefs in North Carolina:

Artificial reefs should NOT be sited where:

- A natural live bottom exists. This includes, but is not limited to, sea grass beds, scallop grounds, and natural reef communities.

- The sea floor would not support proposed reef structures. This includes deep and frequently shifting sandy bottom, or mud bottom.

- High energy environments exist. This includes strong currents, heavy wave action or storm surge that would damage or remove reef materials, or be unsafe to fishermen and divers. Such environments include shoals, banks, and inlets.

- Traditional commercial fishing activities occur. This includes trawling and potting for finfish and crustaceans, seining, gill netting, pound netting, long lining, raking and dredging. If there is ambiguity as to whether a particular reef site will interfere with commercial fishing, the Marine Fisheries Director should make the final determination. This decision should be made only after meetings with the commercial fishing community directly involved. Their concerns and the Director's justification should be on record and available to the public.

- They would be a navigation or liability hazard. This includes areas too shallow to provide adequate vertical clearance, areas with heavy boat traffic, or areas used by the U.S. Navy for surface and submarine operations.

Artificial reef sites should be chosen:

- Only after public input has been obtained. Public meetings should be held at appropriate coastal and inland sites. Information made available at these meetings should include exact locations and area of proposed site on maps and charts, and also proposed construction plans. These meetings should be held prior to the USACE permit request. Public notice should be made, written comments accepted and all input received kept on file.

- Only after biological and physical investigations are made to determine if the proposed site is suitable for reef construction. These should include cores and seismic surveys of bottom sediment and topography, visual biological census of fish, macroinvertebrate and plant communities, and current meter determinations of velocity and direction of the predominant currents. All of these data should be recorded and kept on file for each reef site.

- That are easily accessible to a majority of recreational fishermen and divers. This includes proximity to major inlets, launching and docking facilities, and other reefs. Safety and cost to users in traveling to and from the site should be important considerations.

Permitting

Permitting of an artificial reef in North Carolina involves numerous State and Federal agencies. These agencies include the U.S. Army Corps of Engineers-Wilmington District (USACE), the U.S. Coast Guard-Fifth District (USCG), the Environmental Protection Agency (EPA), the North Carolina Division of Coastal Management (DCM), and the North Carolina Division of Environmental Management (DEM). The National Oceanic and Atmospheric Administration (NOAA) and its National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (FWS) are also involved in the permitting process. The principal coordinating permitting agency for artificial reefs in North Carolina is the USACE. A USACE permit is required for all artificial reefs in the state's estuaries and coastal waters to the seaward limit of the outer continental shelf. A major permit from the North Carolina Division of Coastal Management is required for all marine reefs inside 3 miles and is a matter of consistency for reefs outside of 3 miles. An environmental impact statement is not required by either agency. However, an environmental assessment is part of DMF's siting criteria as required by their artificial reef program and the general permit.

Federal legislation that addresses the permitting of artificial reefs include sections of the Marine Protection, Research, and Sanctuaries Act (1972), Coastal Zone Management Act (1972), Federal Water Pollution Control Act (1972), Clean Water Act (1977), and the Consolidated National Pollutant Discharge Elimination System Regulations. Environmental assessments are advised for projects of this type by the National Environmental Policy Act (1969). The most recent and pertinent regulations affecting the construction of artificial reefs are found in Vol. 51, No. 219, Section 322.5 of the November 13, 1986 Federal Register. These regulations were in direct response to recommendations in the National Artificial Reef Plan.

As stated in section 322.5, when considering an artificial reef application, the USACE district engineer will review the applicant's provisions for siting, constructing, monitoring, operating, maintaining, and managing the proposed reef. These provisions must be consistent with the enhancement of fishery resources, the facilitation of access and utilization by recreational and commercial fishermen, the minimization of conflicts among competing uses of navigable waters, the minimization of environmental risks and risks to personal health and property, and the prevention of any unreasonable obstruction to navigation. The District Engineer will issue a permit for the proposed artificial reef only if the applicant demonstrates that the responsibility for maintenance of the reef is clearly established, and that he has the financial ability to assume liability for all damages that may arise with respect to the proposed artificial reef. It is important to note that a civil penalty can be levied by the USACE against the permittee if an infraction occurs.

The U.S. Coast Guard's role in the permitting process is primarily with regard to information and criteria that will be used to ensure navigational safety and the prevention of obstructions to navigation. This involves compliance with aids to the navigation system by proper

identification and marking of the artificial reef by the permittee. In North Carolina, a private aid to navigation application must be submitted to the Fifth District of the U. S. Coast Guard for buoys established to mark artificial reefs in inland, as well as, offshore waters. After approval, the permittee is required to advise the Coast Guard when the work authorized is accomplished, and to report any discrepancy, change in location, transfer of ownership, and interference or tampering with navigational aids by others.

The North Carolina Wildlife Resources Commission may also have buoy or marking requirements for artificial reefs in the vicinity of inland waters over which they have jurisdiction.

The General Permit

In October, 1985, the USACE, Wilmington District, issued a general permit (No. SAWC085-N-000-0194) to the North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries. This general permit obviates the need to process individual artificial reef permit applications through a full public review process. Included in the general permit requirements are a pre-construction report, public meeting locations and dates, accessibility report, environmental assessment, reef site investigation report, reef location chart, reef construction schematic, and also a section stating that the artificial reef will not interfere with commercial fishing activities. When all requirements are met, the general permit authorizes the construction, repair, and maintenance of artificial reefs and fish attractors in coastal and offshore waters within the regulatory jurisdiction of the Wilmington District. The permit provides for DMF to efficiently manage and operate an artificial reef program for the benefit of the people of North Carolina.

Special conditions of the permit require specific information to be provided by DMF to the District Engineer on the following:

(1) The location of the structure expressed in both latitude/longitude and Loran C coordinates.

(2) Water depths and clearances measured in ft. from mean sea level (msl) or ordinary high water (ohw), as appropriate.

(3) Proximity to shipping lanes and general navigation channels.

(4) Types, quantities and on-site orientation and boundaries of materials to be used for construction.

(5) Description of site conditions as evidenced by marine survey or inspection performed by a qualified party.

(6) Anchoring methods to be used.

This information is then provided by the District Engineer to the following agencies:

Director
Defense Mapping Agency
Hydrographic Center
Washington, D.C.

Assistant Secretary of Defense
Manpower, Reserve Affairs and Logistics
ASD(MRA&L)
Washington, D.C.

Regional Fisheries
Officer
Office of Fisheries
Management/FCM3
National Marine
Fisheries Service
Washington, DC

Director
National Ocean Survey
NOAA, Department of Commerce
Rockville, MD

Director
Southeast Region
National Marine
Fisheries Service
St.Petersburg, FL

Director
Atlantic Marine Center
National Ocean Service
Norfolk, VA

Other conditions of the general permit include, but are not limited to:

1. Reef materials must be placed so as to avoid movement due to sea conditions or currents. The permittee will be responsible for materials which move off-site and any damage caused by the materials.

2. Reef materials must be environmentally safe, as specified in the EPA's Ocean Dumping Act (1977 Sections 227.5, 227.6), any loose, free-floating material, and other deleterious substances. The DMF must notify the EPA prior to each reef placement activity so that inspections can be performed. This applies especially to any enclosed structure, container or items that may be contaminated.

3. The use of tires to form artificial reefs or FADs is not authorized by the general permit.

4. Artificial reefs shall not be located within significant submerged beds of sea grasses, freshwater grasses, coral reefs, oyster reefs, scallop beds, clam beds or live bottoms supporting communities of sponges, seafans, soft corals and other sessile macroinvertebrates.

5. Artificial reefs shall not be located within marine sanctuaries established pursuant to the Marine Protection, Research, and Sanctuaries Act, or within mineral areas leased by the Bureau of Land Management.

6. This permit does not provide authorization for the construction of artificial reefs or FADS in shrimp, fish or shellfish trawling areas as designated by DMF, unless, in the opinion of the District Engineer, such construction would not constitute a hazard to trawling activities.

7. This permit is not applicable to proposed construction that would adversely affect historic, cultural, scenic, conservation or recreational areas as designated by the Wild and Scenic Rivers Act, National Historic Preservation Act (1966, 1980), Endangered Species Act, and the National Registry of Natural Landmarks.

Copies of authorizations for reef construction to DMF from appropriate State and Federal agencies, including a Dredge and Fill Permit (DCM), a Coastal Area Management Act Major Permit (DCM), a Water Quality Certification (DEM), and a Private Aids to Navigation Permit (USCG) must be sent to the District Engineer. Work may commence when all conditions of the general permit are met, and written notice to proceed has been received from the District Engineer. This notice may include appropriate conditions or restrictions. Authorized work must be performed in a manner so as to minimize any degradation of water quality (increased turbidity), or any adverse impact on fish, wildlife and natural environmental values. A USACE representative may make periodic inspections at any time to assure activity is performed in strict accordance with all conditions of the permit. If, for any reason, the Wilmington District Engineer determines the general permit process is not applicable to a specific construction proposal, then an individual permit is required. Authorization provided by either permit may be modified, suspended, or revoked in whole or in part by the District Engineer. If DMF should fail to comply with the terms and conditions of the permit, it has 60 days after written notification from the District Engineer to comply with the terms and conditions or return the work site to a prework condition. Unless subject to modification, suspension, or revocation, placement of material within a reef site is authorized for a period of no more than five years from the effective date of the permit for construction, maintenance and/or repair.

It must be emphasized that the permittee's legal and financial responsibilities are now more clearly delineated, a situation that did not previously exist. These responsibilities continue beyond initial deployment of an artificial reef.

Recommendations

- The present DMF general permitting procedure should be continued, with appropriate up-dating and review as necessary.

- Good communication with all permitting agencies, especially the USACE and USCG must be maintained.

- The DMF artificial reef program must take responsible action pursuant to any new legislation (state or federal) affecting artificial reef permitting.

- The Artificial Reef Construction Coordinator should maintain accurate records of all artificial reef permits, including periodic permit reviews.

- Automatic renewal for all reef sites is not recommended. If sites have no materials on them and there are no specific plans for future development, the permit should not be renewed.

- The North Carolina Division of Marine Fisheries should be the single permit holder for all of North Carolina's estuarine and marine artificial reefs to ensure acceptance of long term legal, financial and maintenance responsibilities involved in artificial reef development.

- Artificial reefs proposed by individuals, organizations, or local government bodies should be eligible for DMF sponsorship only after they meet the criteria set forth in the general permit and this plan.

Buoys

Artificial reef sites should be properly marked, and the marker conscientiously maintained. Marking is required by the United States Coast Guard in almost all situations. The permittee complies with the aids to navigation system with proper identification and marking of an artificial reef site. One exception to this is offshore sites where water depth and Gulf Stream current make buoying practically impossible. Benthic or mid-water artificial reefs placed and maintained by state and/or federal funds must be accessible to their users. Even if reef materials were financed with private funds, if the state holds the artificial reef permit, it is a public reef. Reef material locations represent public investment and must be public knowledge. When at all possible, artificial reef sites should be buoyed. This marking ensures accessibility of artificial reefs to all users. Upon approval of the USCG and the USACE, when deep water and strong currents prohibit buoying, LORAN coordinates of the reef materials must be made available to the public. In terms of accessibility, this should not present a problem, with most offshore fishermen having LORAN capabilities.

Oceanographic and meterologic conditions present off North Carolina's coast can be extremely severe. Storm surge, wave action, and strong currents make continuous buoying of artificial reefs difficult. DMF's artificial reef program has and will continue to experiment with various buoy designs. The goal is to mark North Carolina's artificial reefs with the most durable, stable, cost efficient, and easily identified buoy system available. On each buoy is the following information: reef number and "N.C. ARTIFICIAL REEF, (919) 726-7021, DO NOT TIE TO BUOY."

Maintenance of this buoy system is time-consuming and expensive. Buoys can be damaged or totally removed from their site by storms, ships or vandals. Article 20, Section 113-266, "Interference with artificial reef marking devices," of the North Carolina General Statutes states:

> "It shall be a general misdemeanor, punishable in the discretion of the court pursuant to G.S. 14-3, for any person to destroy, injure, relocate, or remove any navigational aids, buoys, markers, or other

devices lawfully set out by the Division of Marine Fisheries in connection with the marking of any artificial reef in the coastal waters of the State and in the Atlantic Ocean to the seaward extent of the State's jurisdiction as now or hereafter defined." (1985 (Reg. Sess., 1986), c. 996, s. 1.)

As an authorized private aid to navigation, the artificial reef buoys are entitled to the same protection against interference or destruction as is offered by law to Coast Guard Aids to Navigation (33 CFR 66, 01-50).

The buoy anchoring system must be prepared and deployed by the best methods available. Estimated cost of placing a buoy on-site by North Carolina's artificial reef program in 1988, including cost of the buoy, mooring system, ship time, and man hours was $3,000 (S.W. Murphey, personal communication). Myatt (1984) stated that inspection, repair, and placement can cost up to $10,000 per buoy annually, depending upon the sophistication of the buoys and location of the reef. Even when precautionary steps are taken, buoys are damaged or lost.

In compliance with USCG regulations, missing buoys must be promptly reported to the nearest Marine Inspection officer and promptly replaced. Failure to do so could result in a $500 fine for every day the buoy is off-site.

One limiting factor to the number of artificial reef sites developed off North Carolina's coast is the manpower, boats, equipment, time and money necessary to maintain an adequate buoy system.

Recommendations

- Buoys should identify the site as an artificial reef, including reef number, DMF's telephone number (in case of removal off-site), and warning not to damage or injure the buoy in any way.

- Buoys should have internal or external radar reflectors and reflective tape on them for protection at times of poor visibility.

- Buoys and anchoring systems should be constructed of the most durable materials reasonably available.

- A routine semi-annual maintenance schedule should be followed for all of North Carolina's coastal artificial reef buoys, to prevent loss of buoys due to weakened structures.

- Buoy bottoms should be protected with antifouling paint.

- Buoys should conform to all USGS standards.

MANAGEMENT

Monitoring and Maintenance

Monitoring and maintenance programs are essential to sound artificial reef management. Bohnsack and Sutherland (1985) believed that, because of inadequate long-term monitoring, critical knowledge of why artificial reefs work or do not work is lacking. As stated in the National Artificial Reef Plan (Stone 1985), one of the primary reasons for establishing a monitoring program as part of reef management is to provide an assessment of the predicted performance of reefs and assure that the reefs meet the general standards established in Section 203 of the National Fishing Enhancement Act of 1984. Stone (1985) classified this as "performance monitoring" and stated that information gained from such a program will improve future planning and design of reefs and also provide support for management actions. For example, a monitoring program, by documenting the deterioration of an artificial reef community, might help identify the cause and provide quantitative data on which management actions or reef enhancement could be based to protect and improve the resource. Performance monitoring could also alert the reef program to impending user conflicts. Socioeconomic data collected could be used in benefit-cost analyses. Such work should help maintain public and administrative support for reef programs and define the most efficient methodology (Stone 1985).

Another aspect of a monitoring program is the maintenance of reef structures and their buoy systems. The primary reason for such activities is to assure compliance with the conditions defined in authorizing permits or other applicable laws and regulations (Stone 1985). "Compliance monitoring," as defined in the National Artificial Reef Plan, involves regularly scheduled inspections of reef buoys, mooring chains, anchors, and materials. Necessary maintenance would include replacement of all worn, damaged, lost or outdated materials. Also, buoys might need to be repainted or repositioned; entangled fishing gear and anchors can be removed; reef structures can be examined to see if they have moved, or become buried.

Reef permittees are required by federal law to immediately respond to any reported problems (missing buoys, displaced reef materials). When considering that DMF is responsible for an extensive system of artificial reefs, proper maintenance is no small task. A dedicated commitment to a maintenance program is required.

Compliance Monitoring Recommendations

- Develop a diver inspection schedule to monitor condition of the reef structures.

- Utilize Marine Fisheries Division aircraft for monitoring the buoy systems in estuarine and nearshore ocean waters.

- Develop emergency procedures to replace missing buoys or retrieve reef materials that have moved off-site endangering commercial fishing operations or vessel navigation.

Performance Monitoring Recommendations

- Evaluate various reef materials and designs for stability, durability, cost effectiveness and safety.

- Quantitatively document biological enhancement created by artificial reefs over time.

- Monitor user utilization patterns to evaluate benefits and costs and to document the effectiveness of the reef's intended purpose.

- Monitor effectiveness of an artificial reef(s) in attracting desired fish species.

- Utilize the efforts of volunteer sport diver surveys in artificial reef monitoring.

Enhancement

North Carolina has over 60 permitted estuarine and ocean reef sites. Forty-four have materials on them. As discussed throughout the plan, responsible artificial reef planning, design, maintenance, and monitoring should direct the reef program to concentrate on reef improvements and enhancements rather than on new development. Artificial reef enhancement should be considered a core responsibility of North Carolina's artificial reef program in the future. With an enhancement program in place, long term productivity and reef effectiveness have a greater chance of being realized. These improvements and additions can be categorized as either reef enhancements, reef site enhancements, or reef system enhancements.

Artificial reef enhancements include the addition of materials to existing artificial reefs to improve the reef's production and/or aggregating capabilities. This would include increasing habitat complexity and/or profile. The following are questions that should be answered prior to artificial reef enhancements: What is the condition of existing materials? Is the artificial reef attracting/producing the intended target fish species? Are the stocks of any of these species threatened? If so, would the addition of materials contribute to their over-exploitation? Are there already too many boats fishing the reef? Would the addition of materials be better utilized as a separate reef to disperse fishing pressure?

Artificial reef site enhancements include the addition of new artificial reefs to existing sites. Developing reef complexes on existing sites would disperse fishing pressure and help avoid user conflicts. Reef sanctuaries can be incorporated into the reef complex design. When placing more than one artificial reef on a reef site, it is important that all reef material locations are readily available to the public. Careful planning and design considerations should be incorporated into reef site enhancements.

Artificial reef system enhancements would be done to improve upon the existing network of North Carolina's artificial reefs. Prior to any reef system enhancements, an evaluation of the distribution and density of reef sites off our coast would be needed. Based on utilization patterns and user surveys, do some areas have too many reefs and other areas not enough reefs? What reef sites are overcrowded? What reef sites are under-utilized? What are the reasons some reef sites are under-utilized? Is it inadequate access or material location information? As these questions are answered, steps can be taken by the reef program to improve and expand the opportunities associated with artificial reefs available to the public.

Recommendations

- A program of enhancing existing artificial reefs and reef sites should be conducted.

- Enhancement activities should be given a higher priority than the permitting and construction of new artificial reef sites.

- Enhancement activities should be conducted only after biological and user evaluation studies are conducted.

Special Management Zones

Federal Waters

A Special Management Zone (SMZ) is a designated area surrounding an artificial reef in which certain restrictions and regulations apply. In waters from three miles offshore out to 200 miles (the Exclusive Economic Zone or EEZ), the South Atlantic Fishery Management Council in cooperation with the National Marine Fisheries Service can designate such an area, based on authority found in Section 12.1.2 of the "Fishery Management Plan, Regulatory Impact Review, and Environmental Impact Statement for the Snapper-Grouper Complex of the South Atlantic Region" (FMP) (South Atlantic Fishery Management Council 1982).

To date, 21 Special Management Zones exist in the South Atlantic's EEZ. Seven are off Georgia's coast, eleven are off South Carolina's coast, and one SMZ is shared by these two states. In all cases, the permittee is the respective state natural resources agency. A different set of circumstances exists off Florida's Atlantic coast, where to date, six formal SMZ requests and numerous informal inquires have been made, with only two being approved. Requests for the Florida areas have been made by local governments, sport fishing clubs or other recreational fishing interest groups. To date, there have been no SMZ requests from North Carolina.

Various rationales given for the establishment of SMZs around artificial reefs include:

1. To ensure that the intended uses (designated by the permittee) and the socioeconomic values associated with these artificial reefs will be maintained.

2. To promote orderly utilization of the resource.

3. To reduce user group conflicts.

4. To optimize use of biological production.

5. To create fishing opportunities that would not otherwise exist, thereby maintaining and promoting conservation.

6. To create incentives to maintain artificial reefs and establish other artificial reefs and fish attracting devices.

7. To maintain fish stocks.

8. To protect recreational fishing.

A common impetus for SMZ requests is the concern from the recreational fishing community that commercial fishing (traps, hydraulic/electric reels, long lines) could reduce fish populations on a reef to the point where the reef was no longer useful to recreational fishermen. SMZ designation is not meant to ban anyone from artificial reefs, but to prevent extremely efficient gear from being used on those sites. Restrictions on gear type vary. Usually hand-held hook and line and spear fishing are the only gears allowed. Although SMZ regulations restrict gear type and not commercial fishing, requests for SMZs can clearly become a user conflict issue.

Management measure #17 of the Snapper-Grouper FMP provides for the designation of modified habitats or artificial reefs as Special Management Zones in federal waters (South Atlantic Fishery Management Council 1983). This measure states:

<u>Prohibition or Restraint of Specific Fishing Gear From Artificial Reefs</u>

Upon request to the Council from the permittee (possessor of a Corps of Engineers permit) for any artificial reef or fish attraction device (or other modification of habitat for the purpose of fishing) the modified area and an appropriate surrounding area may be designated as a Special Management Zone (SMZ) that prohibits or restrains the use of specific types of fishing gear that are not compatible with the intent of the permittee for the artificial reef or fish attraction device. This will be done by regulatory amendment similar to adding or changing minimum sizes (Section 10.2.3):

1. A monitoring team composed of members of council staff, and NMFS Southeast Fishery Operations Branch and Fisheries Center, will evaluate the request in the form of a written report considering the following criteria:

a. fairness and equity
b. promote conservation
c. excessive shares

2. At the request of the Steering Committee, the Council Chairman may schedule meetings of the Advisory Panel (AP) and/or Scientific and Statistical Committee (SSC) to review the report and associated documents and to advise the Council. The Council Chairman may also schedule public hearings.

3. The Council, following review of the Team's report, supporting data, public comments, and other relevant information, may recommend to the Southeast Regional Director of the National Marine Fisheries Service (RD) that a SMZ be approved. Such a recommendation would be accompanied by all relevant background data.

4. The RD will review the Council's recommendation, and if he concurs in the recommendation, will propose regulations in accordance with the recommendations. He may also reject the recommendation, providing written reasons for rejection.

5. If the RD concurs in the Council's recommendations, he shall publish proposed regulations in the Federal Register and shall afford a reasonable period for public comment which is consistent with the urgency of the need to implement the management measure(s).

The Council must ensure that SMZs are consistent with the objectives of the FMP, the Magnuson Act and other applicable law. They consider the natural bottom in and surrounding potential SMZs, impacts on historical uses, and cumulative and future impacts.

It should be remembered that the opportunity to request the Council to designate a SMZ is open to all permit holders and can focus on gear restrictions applicable to any or all user groups. Benthic artificial reefs and fish aggregating devices are both eligible for SMZ designation. If a request is denied by the Council, the permit holder can re-petition.

If the Division of Marine Fisheries should consider requesting SMZ status for an artificial reef in the EEZ, it must follow procedures and comply with requirements set forth by the South Atlantic Fishery Management Council and the Snapper-Grouper FMP. Prior to presenting a formal request to the South Atlantic Fishery Management Council, the following criteria should be met:

1. Background data on the area in and surrounding the artificial reef should be compiled and reviewed. These data must include historical use of area, natural bottom present, and commercial and recreational fishery data. Fishery statistics should include number of fishermen; quantity, size

and species composition of catch from the area by various gear types; and information on the respective fishing sectors utilizing the area.

2. The initial intended uses of the artificial reef should be documented, including the primary species the reef was established to attract/produce.

3. Careful consideration of specific proposed gear restrictions should be made. A detailed rationale/justification for restrictions should be prepared. If more than one artificial reef is being considered for SMZ designation, gear restrictions must be appropriate to all proposed sites.

4. Public meetings should be held prior to requests to the Council. These meetings should be well publicized, all forementioned data and rationale should be available at the meeting, and the exact locations of all artificial reefs under consideration must be clearly stated. Documentation of conflict or competition, and the public perception of potential problems brought forth at the meeting should be made.

Special Management Zones should not be created to appease any particular special interest group. They should be considered as a management tool, and only when biological production or the health of a fisheries stock is seriously threatened by overfishing on that particular reef. Before restricting any type of gear on an artificial reef built and maintained with state or federal funds, statistically sound data must be available to substantiate the overfishing concern. The designation of a Special Management Zone should not have a significant economic impact on a substantial number of small entities. The anticipated benefits must exceed the compliance cost to the public.

Coastal and Estuarine Waters

"North Carolina Fisheries Regulations for Coastal Waters 1988" authorizes the Director of DMF to close or restrict by proclamation the waters around artificial reefs, "with respect to taking or attempting to take any or all kinds of marine or estuarine resources and with respect to using any kind of equipment" (NCAC 3B .0111(a)). The closure or restriction "shall be based on overall public interest and prudent fisheries management and research" (NCAC 3B .0111(a)). The economic effect of the closure or restriction must be considered before the restriction is put into effect. The proclamation must also be approved by the MFC at their next official meeting or else it is automatically void. The closure can be for no more than one year and is subject to renewal at the discretion of the MFC.

The regulation also states that the waters can be closed and/or restricted up to 1,000 yards from the reef buoy in the Atlantic Ocean and up to 500 yards from the reef buoy in estuarine waters. A copy of the regulation can be found in Appendix B of this report.

These state regulations were written prior to the development and adoption of Special Management Zones in federal waters. Federal rules now preclude any action by the MFC or Fisheries Director dealing with restrictions on fishing activities in or around artificial reefs beyond the Territorial Sea (E.G. McCoy, personal communication). The waters over which the Division of Marine Fisheries has authority should be stated in Regulation NCAC 3B .0111. By clearly delineating the state's authority in its Territorial Sea and estuarine waters, any requests for restrictions on artificial reefs in federal waters can be directed to the SAFMC.

Another consideration with respect to present state regulations is the maximum area that can be closed or restricted. With the 1,000 yard designation in the ocean and the 500 yard designation in the estuaries, up to 649 acres and 162 acres, respectively, could be restricted at each ocean and estuarine reef site. Commercial fishermen have expressed concern over the total area that could possibly be closed or restricted to commercial fishing if the Marine Fisheries Director would, by proclamation, implement this regulation on all artificial reefs in the state's estuaries and Territorial Sea.

Recent ocean artificial reef sites permitted in North Carolina are circular sites measuring 1,000 yards in diameter. With reef sites this large, there may be no need to close or restrict waters outside the permitted area. This permitted area has already gone through the public and agency review process. Reef complexes could be designed so as to leave a buffer zone between them and the site's perimeter.

Regulation NCAC 3B .0111 also states that artificial reefs shall be marked by one readily identifiable official buoy by the Department and any distances called for in the regulation shall be measured from such buoy. Two concerns need to be noted relevant to this section of the regulation. The first is that all reef sites may not have a buoy. The USCG does not require a buoy if all procedures for the aids to navigation application have been followed and approved, and if structure is in deep enough water so that it is no threat to navigation. Buoying an artificial reef in deep water (25 fathoms) is virtually impossible with the buoy systems currently available to the reef program.

The other concern is position of the buoy on the reef site. The present artificial reef program places one buoy in the center of the site. This has not always been the case. Other programs have placed buoys at site perimeters. If the regulated area is to be marked from the buoy, then where the buoy is to be located should also be specified in the regulation. Buoy location could make a significant difference in the total amount of restricted area.

A threat to artificial reefs and another concern expressed by fishermen is the extensive damage that marine salvage operations and offshore oil and gas explorations can cause to the artificial reef biota, materials, and structures. Although the Marine Fisheries Commission has no authority over salvage operations or oil and gas explorations, every effort should be made to coordinate with those agencies that do so that artificial reefs may be protected from these damaging activities.

Key Largo National Marine Sanctuary designated a buffer zone to protect its natural resources from oil and gas seismic surveys. Relevant to the issue of protecting artificial reefs from marine salvage operations is the Abandoned Shipwreck Act of 1987 passed by U.S. Congress (P.L. 100-298 - April 28, 1988). This act protects certain historic shipwrecks by requiring that a permit be obtained prior to any disturbance or removal of materials.

The above discussion of managing North Carolina's artificial reefs has focused principally on the state's ocean artificial reefs. However, as of December, 1987, there were 24 permitted estuarine artificial reef sites. Fifteen of these sites have no materials on them. The majority of the remaining sites are tire-reefs built prior to 1980. Because of high turbidity, siltation, and the presence of adequate existing substrate (shellfish plantings, natural oyster beds) estuarine artificial reef development in North Carolina's inshore waters may not be cost-effective. A report on the condition and effectiveness of the older estuarine tire reefs is needed. No future estuarine sites should be developed in North Carolina without investigations into the productivity and cost-effectiveness of existing estuarine reefs.

Enforcement of any management option (size limits, gear restrictions, salvage operation prohibitions) in the ocean is difficult. However, action will be needed if a reef-associated fisheries stock or the reef structure itself is threatened. The Division of Marine Fisheries must be prepared to monitor the waters around the state's artificial reefs and to enforce any restrictions or closures that may be implemented to protect these marine resources.

Recommendations

- Prior to requesting SMZ designation for any artificial reef in federal waters, the Division of Marine Fisheries should meet all criteria and follow all procedures set forth by the South Atlantic Fisheries Management Council and this plan.

- The same considerations that are taken with respect to requesting SMZ designation for an artificial reef in federal waters should also be taken prior to any restriction placed in or around an artificial reef in the Territorial Sea or estuarine waters by the Division of Marine Fisheries.

- With regards to regulation NCAC 3B .0111 the following should be considered and amended as appropriate:

    1. The area of jurisdiction, i.e. the state's Territorial Sea and estuarine waters, should be clarified.

    2. Whether or not the state will require a buoy on all artificial reef sites should be determined. It is recommended that all artificial reef sites be buoyed, except those that are in water too deep to allow the buoy to remain on-site, and then only after USCG approval.

3. Required buoy location, i.e. the middle of the site, should be stated. Any future restrictions or closures can then be measured from the buoy.

4. The concern of damage to artificial reefs and their biological communities by salvage operations, explosives, and also oil and gas seismic testing should be addressed.

5. The maximum area around ocean and estuarine artificial reefs that can be closed or restricted should be reconsidered. In some cases, the permitted area may be sufficient.

- Procedures should be developed regarding how DMF will provide adequate enforcement for any future closures or restrictions that may be enacted to protect the state's artificial reefs and their resources.

- The state's system of estuarine artificial reefs should be evaluated to determine if existing reefs are productive and if additional reefs are warranted. No new estuarine reefs should be constructed until this issue is resolved.

Mitigation

Artificial reefs can be used to mitigate habitat loss. Reef projects in several states have been funded by private companies and government agencies to replace marine habitat damaged by their operations (Phillips in press). California's reef program was one of these (Grant 1987). Their program was revitalized when a major power company funded the construction of an artificial reef to replace kelp habitat that was damaged by their plant. Grant (1987) reported that the reef design focused on mitigative requirements, particularly the development of a kelp community on the reef. A kelp transplant project was also initiated in the Los Angeles Harbor to offset losses to marine habitat by the placement of fill in the inner harbor by the city (Rice 1987). In Biscayne Bay, Florida, a study was conducted to determine if artificial reefs could provide a temporary habitat for juvenile spiny lobsters during a marina rehabilitation project (Davis 1985). Davis reported that a population of juvenile lobsters did move into the reefs before construction began and remained there during construction. The structures did not increase the lobster population in the bay, but did provide a haven for them during the marina's rehabilitation. In New York, artificial reef concepts were incorporated into a dredge and fill application for a project in the Hudson River to maximize aquatic habitat and to mitigate, in part, for the loss of overwintering striped bass habitat (Alveras and Edwards 1985).

There are four types of mitigation. The most desireable form is to replace with the same kind of habitat in the same location. Next desireable would be to replace the same habitat, but off-site. A less acceptable method is to replace with a different habitat on-site. The last type of mitigation, and one that is unacceptable to the reef program, is to replace habitat lost or damaged with a different habitat on a different site.

The National Artificial Reef Plan (Stone 1985) recommends that when using artificial reefs to help mitigate development-related habitat loss, they should not be construed as an appropriate replacement for dissimilar habitat types such as shallow-water estuarine habitat, submerged grass beds, or mud flats. The state of Washington has incorporated this philosophy into their artificial reef mitigation policy (Hueckel et al. 1987). Artificial reefs constructed in Puget Sound have developed into biological replicates of the natural rocky reef communities which were degraded in Elliott Bay.

The Sport Fishing Institute Artificial Reef Development Center does not endorse the use of artificial reefs for mitigation (Phillips in press). They recommend that if and when mitigation occurs, the artificial reef habitat used should be required to be a proven biologically productive habitat, and not just a fish attracting device. Reefs designed and constructed as nursery area habitat for juvenile fish would be acceptable.

One type of habitat lost to development in coastal North Carolina is estuarine marsh. Artificial reef construction in North Carolina has concentrated on ocean reefs built with steel and concrete. The ecological systems and community structures found in North Carolina's estuarine marshes will not benefit from habitat provided by a derelict vessel 5 miles offshore.

The mitigation policy of North Carolina's Coastal Resource Commission states that a preferred form of mitigation is the "enhancement of coastal resources with created or restored systems determined to be potentially more productive of the resources characteristic of unaltered North Carolina ecosystems than those destroyed" (NCAC 15 7m.0704 (a) (1)). The policy also gives a higher priority to the "creation or restoration of an area of similar ecological utility and potential biological value than that destroyed or altered" than an area of "different ecological function or potential" [NCAC 15 7M.0704(a) (2-3)].

Recommendations

- Artificial reefs should not be used in mitigation, unless they are to replace natural reef habitat that has been damaged or destroyed.

- If artificial reefs are used to replace natural reef habitat that has been damaged or destroyed, they should be designed and constructed to provide proven biologically productive habitat.

PLAN REVIEW

Planning is a continuing process. The objectives, issues, and strategies stated in this plan must be adjusted to reflect new developments in the legal responsibilities of the MFC and DMF, progress in meeting stated objectives of the artificial reef program, and availability of new information.

Recommendations

- The Fisheries Development Section Chief and the Artificial Reef Construction Coordinator should review the plan annually.

- They should assess the program's accomplishments and discuss new program developments as they relate to the plan.

- Any changes necessary should be incorporated into the plan upon approval by the Marine Fisheries Director.

ACKNOWLEDGMENTS

This plan could not have been possible without the prior efforts of numerous people. Marine Fisheries Division staff who greatly contributed to this plan were M.W. Street, W.T. Hogarth, F.H. Munden, M.D. Marshall, S.W. Murphey, and others. The guidance and encouragement given to me by the Atlantic States Marine Fisheries Commission Artificial Reef Committee during the plan's preparation was invaluable.

Much information was obtained from The National Artificial Reef Plan by R.B.Stone (1985). Other useful documents referred to were the New Jersey Department of Environmental Protection's artificial reef management plan and the Sport Fishing Institute Artificial Reef Development Center's artificial reef development planning guide.

During the plan's initial preparation, an artificial reef plan survey was sent to over 100 individuals, including resource managers, fisheries biologists, and commercial and sport fishermen. The author would like to thank the 53 respondents for their insightful and contributory remarks.

For their in-depth and most helpful review of the plan, I would especially like to thank:

C. Moss	Carteret County Sport Fishing Association
R.B. Stone	National Marine Fisheries Service
D. Franklin	U.S. Army Corps of Engineers
C.S. Park	U.S. Coast Guard
R.L. Schmied	National Marine Fisheries Service
G. Huntsman	National Marine Fisheries Serice
M. Harriss	Carolina Marine Research Foundation
W. Cole	U.S. Fish and Wildlife Service
W.K. Figley	New Jersey Marine Fisheries Administration
V.A. Vail	Florida Department of Natural Resources
H. Ansley	Georgia Department of Natural Resources
W.M. McGroarty	New York State Department of Environmental Conservation
D.G. Lindquist	University of North Carolina at Wilmington
J.D. Murray	University of North Carolina Sea Grant Program
J.D. Costlow	Duke University Marine Laboratory
J.M. McGurrin	Atlantic States Marine Fisheries Commission
S.H. Phillips	Sport Fishing Institute's Artificial Reef Development Center
J.A. Jernigan	North Carolina Attorney General's Office
T.W. Jones	North Carolina Wildlife Resources Commission

Many thanks to D. Willis and D. Tootle for typing the manuscript and V. and H. Page for preparing the figures.

LITERATURE CITED

Alevras, R.A. and S.J. Edwards.
1985. Use of reef-like structures to mitigate habitat loss in an estuarine environment. Bull. Mar. Sci. 37(1):396.

Baynes, T.W.
1987. The effect of current on the sessile benthic community structure of an artificial reef. Paper presented at the Fourth International Conference on Artificial Reef Habitats for Fisheries, Miami, FL, Nov. 1987.

Bell, M., C.J. Moore, and S.W. Murphey.
1987. Utilization of manufactured artificial reef structures in South Carolina's marine artificial reef program. Paper presented at the Fourth International Conference on Artificial Reef Habitats for Fisheries, Miami, FL, Nov. 1987.

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.

_____, and S.P. Bannerot.
1986. A stationary visual census technique for quantitatively assessing community structure for coral reef fishes. NOAA Technical Report NMFS 41, 15 p.

Briggs, P.T. and C.S. Zawacki.
1974. American lobsters at artificial reefs in New York. NY Fish Game Journal: 21:73-77.

Buchanan, C.C.
1975. Effects of an artificial habitat on the marine sport fishery and economy of Murrells Inlet, South Carolina. Mar. Fish. Rev. 36(9):15-22.

Chandler, C.R., R.M. Sanders, Jr., and A.M. Landry, Jr.
1985. Effects of three substrate variables on two artificial reef fish communities. Bull. Mar. Sci. 37(1):129-142.

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. Mar. Sci. 34(2):267-279.

Davis, G.E.
1985. Artificial structures to mitigate marina construction impacts on spiny lobster, Panulirus argus. Bull. Mar. Sci. 37(1):151-156.

Feigenbaum, D., C. Blair, M. Bushing, L. Parker, D. Devereaux, and A. Friedlander.
1986. Artificial reef study-final report. Old Dominion University Tech. Rep. No. 86-2, 93 p.

Figley, W.K.
1988. Personal communication. Artificial Reef Coordinator, New Jersey State Department of Environmental Protection, Nacote Creek Research Station, Abesecon, NJ.

Gordon, W.R., Jr. and R.B. Ditton.
1986. A user-resource planning framework for offshore recreational artificial reefs. Coast. Zone Mgmt. J. 13(3/4):369-395.

Grant, J.J.
1987. Mitigation policy -vs- artificial reef design (or, the marine biologist's impact wrench). Paper presented at the Fourth International Conference on Artificial Reef Habitats for Fisheries, Miami, FL, Nov. 1987.

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

Grove, R. S., and C. J. Sonu.
1985. Fishing reef planning in Japan. p. 187-251 In D'Itri, F.M. Artificial Reefs: Marine and Freshwater Applications. Lewis Publishers, Inc. Chelsea, Michigan.

Halusky, J. G., and Tipping, J. L.
1987. Training volunteer sport divers to document artificial reefs for their community. Paper presented at the Fourth International Conference on Artificial Reef Habitats for Fisheries, Miami, FL, Nov. 1987.

Hammond, D.L., Myatt, D.O., and D.N. Cupka.
1977. Evaluation of midwater structures as a potential tool in the management of the fisheries resources on South Carolina's artificial fishing reefs. SC Mar. Resour. Ctr. Tech. Rep. Ser. No. 15, 19 p.

Hueckel, G.J., R.M. Buckley and B.L. Benson.
1987. Rocky habitat mitigation using artificial reefs. Paper presented at the Fourth International Conference on Artificial Reef Habitats for Fisheries, Miami, FL, Nov. 1987.

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

Jones, J.I., S. Chang, A. Crosby, M. Flandorfer, K. Fucik, A. Sage, and R. Shaul.
1986. A plan for siting artificial reefs in the northern Gulf of Mexico. Mississippi-Alabama Sea Grant Contsortium and Continental Shelf Associates, Inc. MASGP-86-021, 840 p.

Kalajian, E. H., I.W. Duedall, C.S. Shieh, and J.R. Wilcox.
1987. Reef construction using stabilized oil ash. Paper presented at the Fourth International Conference on Artificial Reef Habitats for Fisheries, Miami, FL, Nov. 1987

Lindquist, 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 North Carolina. Bull. Mar. Sci. 37(1):244-251.

_____, 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, North Carolina. Paper presented at the Fourth International Conference on Artificial Reef Habitats for Fisheries, Miami, FL, Nov. 1987.

_____, L.B. Cahoon, and I.E. Clavijo.
1987. Sources of primary productivity supporting North Carolina's inshore reef fish communities. UNC Sea Grant proposal. 10 p.

_____.
1988. Personal communication. Professor Marine Biology, University of North Carolina at Wilmington, Wilmington, NC.

Manooch, C.S.
1977. Foods of red porgy, Pagrus pagrus, from North Carolina and South Carolina. Bull. Mar. Sci. 27:776-787.

McCoy, E.G.
1988. Personal communication. North Carolina Division of Marine Fisheries, Morehead City, NC.

McDonald, M.E.
1978. The standing crop, distribution, and production of the macrobenthic epifauna on an artificial reef off the coast of North Carolina. M.S. Thesis, N.C. State Univ., Raleigh, 59 p.

McGroarty, W.M.
1988. Personal communication. Marine Resources Specialist, New York State Department of Environmental Conservation, Stony Brook, NY.

McIntosh, G.S., Jr.
1985. Enhanced enhancement: The use of fish aggregating devices (FADs) to improve existing artificial reefs. Bull. Mar. Sci. 37(1):398.

Meier, M.H., J.R. Martin, D.L. Feigenbaum, and M. Bell.
1985. Artificial reefs in Virginia old beginnings and new directions. p. 337-347. In D'Itri, F.M. Artificial Reefs: Marine and Freshwater Applications. Lewis Publishers, Inc. Chelsea, Michigan.

Murphey, S.W.
1988. Personal communication. Artificial Reef Construction Coordinator, North Carolina Division of Marine Fisheries, Morehead City, 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 two North Carolina fishing piers. UNC Sea Grant Publ. UNC-SG-WP-85-1, 54 p.

Myatt, D.O.
1978. The "trolling alley" fishing system. In Aska, D.Y. Artificial reefs in Florida. FL Sea Grant Rep. 24, 73 p..

_____.
1983. Midwater trolling alleys. Paper presented at the Third International Artificial Reef Conference, Newport Beach, CA, Nov. 1983. Unubl. MS

_____.
1984. Artificial reef maintenance. Sport Fishing Institute, Artificial Reef Development Center, 30 p. + Append.

_____.
1985. Midwater fish attractors. p. 303-315 In D'Itri, F.M. Artificial Reefs: Marine and Freshwater Applications. Lewis Publishers, Inc. Chelsea, Michigan.

_____, and R.B. Ditton.
1985. Exclusion mapping for artificial reef site selection to maximize recreational fishing benefits in the Gulf of Mexico. The Sport Fishing Institute, Artificial Reef Development Center, 157 p.

_____, E.N. Myatt, and W.K. Figley
1987. New Jersey tire reef unit stability studies. Paper presented at the Fourth International Conference on Artificial Reef Habitats for Fisheries, Miami, FL, Nov. 1987.

North Carolina Division of Marine Fisheries.
1976. North Carolina artificial reefs monitor: Ann. Rep. 1 July, 1974 - 30 June, 1975. NC Dept. Nat. and Econ. Resour., Div. Mar. Fish., 40 p.

_____.
1977. North Carolina artificial reefs monitor: Ann. Rep. 1 July 1975 - 30 June 1976. NC Dept. Nat. and Econ. Resour., Div. Mar. Fish., 60 p.

_____.
1978. North Carolina artificial reefs monitor: Ann. Rep. 1 July 1976 - 31 December 1977. NC Dept. Nat. Resour. and Community Develop., Div. Mar. Fish., 40 p.

Parker, J. H.
1985. Documenting a five-year study of building an artificial reef with coal waste blocks. Bull. Mar. Sci. 37(1):399.

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

_____, and S.W. Ross.
1986. Observing reef fishes from submersibles off North Carolina. Northeast Gulf Science 8(1):31-49.

Phillips, S.H.
in press. Artificial reefs and fishery conflicts: problems and opportunities for the sportfishing industry. Sport Fishing Institute Artificial Reef Development Center, Washington, DC.

Price, K.S.
1987. Project ASHREEF: a report on a stabilized coal waste fish reef on Delaware subaqueous lands. University of Delaware. College of Marine Science. Lewes, Delaware. 20 p. + Append.

Reggio, V.C. Jr.
1987. Rigs-to-Reefs: The use of obsolete petroleum structures as artificial reefs. OCS Rep. MMS 87-0015, 17 p.

Rice, D.W.
1987. Los Angeles Harbor kelp transplant project. Paper presented at the Fourth International Conference on Artificial Reef Habitats for Fisheries, Miami, FL, Nov. 1987.

Savercool, D.M.
1988. Fouling communities on oil ash reefs off of Vero Beach, Florida. Paper presented at the SE Resour. Soc. Meet., Folly Beach, SC., Mar. 1988.

Sheehy, D.J.
1985. New approaches in artificial reef design and applications. p. 253-263. In D'Itri, F.M. Artificial Reefs: Marine and Freshwater Applications. Lewis Publishers, Inc., Chelsea, Michigan.

South Atlantic Fishery Management Council.
1982. Fishery management plan, regulatory impact review, and environmental impact statement for the snapper-grouper complex of the South Atlantic region, 47 p.

_____.
1983. Fishery management plan, regulatory impact review, and final environmental impact statement for the snapper-grouper fishery of the South Atlantic region, 89 p. + App.

Stephan, C.D.
1988. A comparative analysis of the fish assemblages associated with old and new shipwrecks and FADs in Onslow Bay, North Carolina. M.S. Thesis, UNC-W., Wilmington, NC.

_____, and D.G. Lindquist.
(in press). A comparative analysis of the fish assemblages associated with old and new shipwrecks and FADs in Onslow Bay, North Carolina. Bull. Mar. Sci.

Stone, R.B.
1985. National Artificial Reef Plan. NOAA Technical Memorandum NMFS OF-6, 39 p.

Ueda, I.
1978. Characteristics and application of FRP. Ocean Age 10(11):56-59.

West, K.H., L.P. Mercer, F.C. Rohde, and S.P. Epperly.
1986. North Carolina/National Marine Fisheries Service regional cooperative statistical program: Compl. Rep. Proj. SF-20, NC Dept. Nat. Resour. and Community Develop., Div. Mar. Fish., 192 p.

Wilson, C.A., V. Van Sickle, and D. Pope.
1987. The Louisiana artificial reef plan executive summary. Prepared by the Louisiana Artificial Reef Initiative for the Louisiana Artificial Reef Council, 17 p.

Woodhead, P.M.J., J.H. Parker, and I.W. Duedall.
1985. The use of by-products from coal combustion for artificial reef construction. p.265-292. In D'Itri, F.M. Artificial Reefs: Marine and Freshwater Applications. Lewis Publishers, Inc. Chelsea, Michigan.

Workman, I.K., A.M. Landry, Jr., J.W. Watson, Jr., and J.W. Blackwell.
1985. A midwater fish attraction device study conducted from Hydrolab. Bull. Mar. Sci. 37(1):377-386.

APPENDICES

APPENDIX A: HISTORY OF ARTIFICIAL REEF DEVELOPMENT IN NORTH CAROLINA

ARTIFICIAL REEF DEVELOPMENT - 1973 to 1977

From 1973 to 1977, the state-sponsored artificial reef program in North Carolina was very active. Funds were provided by the North Carolina Legislature from an estimate of the unrebated motor fuel tax paid by North Carolina boaters. One-eighth of one percent of this tax was allocated for reef construction, approximately $275,000 per year. Tire-units, three Liberty ships and four other vessels were placed on nine ocean reef sites and two estuarine reef sites. All sites had U. S. Army Corps of Engineers permits and approved Environmental Impact Statements. Areas were also checked for commercial fishing activities by Division of Marine Fisheries law enforcement officers, for bottom suitability by divers, and advice was given on local currents by NOAA scientists.

The ocean sites were in close proximity to major inlets, and 1 to 3 miles from shore, making them easily accessible to smaller boats (Table 1). The ocean reefs were located in water depths between 33 and 72 ft., providing habitat for bottom dwelling fish and attracting pelagic species. Estuarine reefs were in 10-12 ft. of water.

Procurement and deployment of reef materials were only part of the artificial reef project. During this period a creel census was conducted, the ecology and structural stability of the reefs were monitored by SCUBA divers, and a series of educational pamphlets were distributed. These pamphlets contained information about the newly established artificial reefs and their fishing potential.

Reef Construction

Liberty ships were sunk at Oregon Inlet, Atlantic Beach and Wrightsville Beach. The ships were stripped and cleaned before sinking. Additional tire units were clustered around Liberty ships at the Wrightsville and Atlantic Beach sites. A tremendous number of tires where processed as reef material for these and other sites. These tire reefs were made of cabled strands of tire units. Tire units were constructed of five or six tires compressed to approximately 16 inches and banded with metal and plastic straps. After deterioration of the metal straps, the plastic strap held the units together, but allowed them to expand, creating more surface area for the reef community. A list of the total number of tires placed on the ten reef sites is shown in Table 2.

All reefs had at lease two marker buoys. Radar reflectors were attached to some of the larger buoys, which were placed in the center of reef sites. Smaller white boundary buoys marked reef perimeters. These buoys were to be moved as reef areas increased.

Table 1. Water depth and distance offshore of North Carolina's ocean artificial reefs constructed in 1974-1975.

Reef site	Water depth (ft)	Distance from shore (mi)
Oregon Inlet	72	2
Atlantic Beach	50	2.5
New River	33	1.5
Topsail Beach	43	2.0
Rich's Inlet	42	2.0
Wrightsville Beach	50	3.0
Long Beach	30	1.2

Table 2. Total number of auto and truck tires placed on reef sites from April 1974 to December 1977. It was calculated that an average truck or tractor tire had 3.4 times the surface area of an average auto tire.

Reef site	Total number of auto tires	Total number of truck tires
Wrightsville Beach	145,840	8,022
Atlantic Beach	124,184	4,442
Long Beach	102,798	6,376
Lockwood Folly	41,806	978
Figure Eight	33,567	1,203
Little River	14,307	899
Oriental	9,624	
N. Roanoke Sound	5,172	
Topsail	4,800	
New River	3,766	268
Total	485,864	22,188

Monitoring Efforts

Creel Census

In conjunction with reef construction, a creel census was taken of recreational fishing at the Wrightsville and Atlantic Beach artificial reefs. The survey consisted of a stratified random sampling design with non-uniform probability, with the majority of sampling during the months and days with the greatest fishing activity. Interviews were mailed to boat owners observed on reef sites during sample hours. The sampling schedule consisted of up to four samples per week per reef during June through November, and only two samples per week per reef March through May. Sampling was discontinued during the winter months due to bad weather and minimal fishing effort. A reef site had up to 135 sample periods in one year.

Results gave hours fished, major fish species caught, and number of fish and pounds per fisherman hour at the Wrightsville and Atlantic Beach reefs. Other interesting information gathered by the creel census was type of fishing method and bait used, and the fisherman's target species.

The creel census showed that, with 147,000 pounds of fish caught in 38,000 hours on the Atlantic and Wrightsville Beach artificial reefs, fishing success was good. From the creel census and other fishing reports, the following trends were seen on the artificial reefs off the coast. Bottom fishing was good all year on most reefs. Off the northern coast, at the Oregon Inlet, artificial reef large king mackerel were caught in October and November and large bluefish November through May. Smaller kings and blues were found there from May to November. Further south at the Atlantic Beach artificial reef, which is west of Cape Lookout, big flounder and king mackerel were caught during September through November. Pigfish and black sea bass were also plentiful in the fall. During the spring and summer, recreational fishermen caught spot, croaker, pigfish, Spanish mackerel and smaller bluefish. The large blues were caught in the fall. About 100 miles south of the Atlantic Beach reef, at the Wrightsville Beach reef, fishing opportunities were very similar. Flounder, amberjack and large kings were caught in the fall. Black sea bass, bluefish, Spanish mackerel and small kings were caught during the spring and summer.

Visual Samples

Monthly dives were made on four artificial reefs to observe fish species, size and quantity, and also condition of reef materials. Visual samples of fish species, number, total length and activity were taken on four reef sites between 1974 and 1977. Two divers independently recorded fish seen in a 20-ft. circle for ten minutes. Recordings were discussed and quantities averaged after each dive.

There were sample stations at the Wrightsville and Atlantic Beach reef sites. These were on the deck and near the stern of the Liberty ships, and on the tire portion of the reef. There were no Liberty ships

placed on the Topsail Beach and Figure Eight reefs, so these sites only had a tire sample station. Each station was observed once a month at all four reef sites. A total of 78 fish species were observed on the reefs. Most common species were black sea bass, spottail porgy, scup, pinfish, and tomtate. To assess the quality of data obtained from the underwater surveys, one small mesh and one large mesh pot were set for 30 minutes at three stations on the Wrightsville Beach reef--inside the hold, adjacent to the ship, and along the tires. Results showed diver observations were accurate, and pot sampling was discontinued. During the summer of 1977, funds were terminated and the program came to a halt.

Summary

North Carolina's artificial reef program from 1973 through most of 1977 can be divided into an organizational phase, a growth phase, and finally, a production phase. During the organizational phase over one-fifth of the total amount of funding spent on the project was used to hire and pay staff, and to purchase necessary equipment such as boats, dump trucks, and tractors. With the lack of new technology and expertise in a reef development program of this magnitude, reef construction was slow and expensive during the growth phase. Despite difficulties, several hundred thousand tires and three Liberty ships were sunk. During the production phase construction methods were refined and more tires were sunk. A new low-cost method of banding tires was developed.

ARTIFICIAL REEF DEVELOPMENT - 1977 to 1985

In the summer of 1977, funds for the artificial reef program were stopped. Activities, like the creel survey and diver biological observations, begun in 1974, and scheduled through the fall of 1977, were not completed. Remaining funds were used to break down and clean up stagging areas in Morehead City and Wilmington.

In the summer of 1978, due to interest by local organizations to build their own artificial reefs, new funds were appropriated by the General Assembly to the Division of Marine Fisheries for artificial reef activities. The total amount of money was less than one third of the former budget. County governments and local sportfishing clubs had the interest, resources and USACE permits to put artificial reef material on specific sites. Counties had unwanted tires they wanted to donate as reef material. The role of DMF was to give technical assistance to local efforts by helping to procure, prepare, and deploy materials for these various groups.

In the 1980's, the amount of funding was increased. However, funding was not at the level available to the reef program during the 1974 - 1977 period. Recreational fishermen and local governments were requesting artificial reefs in North Carolina's sounds, which would be easily accessible by small boats. These requests prompted more funds to be allocated for the reef program. In 1982, the amount of money appropriated for the program was increased from $100,000 to approximately

$190,000. A construction and tire stagging site was built in New Bern. From this production site, tires received from five counties were taken to estuarine reef sites. Salaries were available for a full time supervisor and several temporary helpers at these tire processing sites. During the 1983 session of the N.C. General Assembly, Representatives Tyndall, Fulcher, and Ethridge sponsored House Bill 1533, which appropriated $100,000 for fiscal year 1984-1985 to establish and maintain an artificial reef in the waters off Carteret County. DMF's 1984 budget for artificial reef construction and maintenance was approximately $120,000.

Reef Materials and Siting

Materials used as artificial reefs during this period were tire units, tug boats, boat molds, steel waste containers, and one Liberty ship. Artificial reefs were located at ocean sites already shown to be productive fishing areas and also on several estuarine sites.

The ten metal trash containers were transported and sunk on-site by US Marine Corps helicopters in a training exercise. These units measured 22 x 8 x 10 ft., providing over forty cubic yards of artificial reef.

Program staff knew that ships and barges made excellent material for artificial reef construction. However, these materials were difficult to obtain during this period. Most of the reef materials during this period were tire units.

Tires

As previously mentioned, an abundance of tires was available and county governments were looking for alternative uses to keep the tires out of local landfills. Tires were processed and deployed by DMF. In an attempt to be more cost-effective, efforts were made to change the size and shape of the tire units. Tires were brought to the processing areas where tire units were made. Many of them were placed on reef sites chosen by local organizations. Seventy-five percent of the tires used in the reef project were rejects from a North Carolina tire manufacturing plant. Many of the tires were new steel belted tires which made processing difficult.

Reef Tire Processing Area/Tire Staging Areas

These were sites where tires were collected and processed. During the entire reef program history, three sites were used. The Wilmington staging area was opened in 1974, closed in 1977 and reopened in 1978, finally to be closed in 1986. The New Bern area was used during the construction of the state's estuarine reefs. It closed 1 May 1985. Morehead City also had a stagging area which, like the Wilmington site, opened in 1974 and closed in 1977 when funds were ended. It did not

reopen as the Wilmington site did. Construction methods and techniques varied.

Estuarine Reefs

A need was expressed by the public for estuarine reefs. Recreational fishermen wanted reef sites which small boats could easily and safely reach. There were already two estuarine reefs, one at Roanoke Island and one at Oriental. The reef at Oriental had been designed as an experimental reef in 1973. Several more estuarine reefs were built during this period. Approximately 7 tire units were placed on each new reef site. Visibility at most sound reefs was often very limited. However, when divers were able to see, observations on the Oriental and Frisco reefs showed good oyster abundance and growth.

Permits during this period were applied for and obtained by local fishing clubs and county governments. Several counties around Albemarle Sound, planning to use rubble from demolition of a bridge across the Sound (N.C. Highway 32), applied for permits in 1985. Thirteen permits were given to Tyrrell, Washington and Chowan counties. Table 3 lists estuarine reefs constructed or enhanced during this period.

Ocean Reefs

WRIGHTSVILLE BEACH REEF SITE: The Wrightsville Beach King Mackerel Tournament was responsible for sinking two tugs in February 1985. Tires were placed on this reef between 1975 and 1981. A 135 ft. barge was also sunk on the Wrightsville Beach site in November 1980.

CAROLINA BEACH REEF: The Division of Marine Fisheries had previously obtained a permit for this site, but no materials were placed on it between 1974 and 1977. Beginning in 1980 materials were sunk on this site, including three 98 ft. barges in late 1981 and the spring 1982.

BOGUE INLET REEF: In 1980, Onslow County obtained a permit for this reef site. The Division placed tire-units on this site and also cooperated with the U.S. Marine Corps to sink 40 cubic yards of metal containers here. Reports said for its relatively small size, more fish were seen from visual observations and caught by recreational fishermen than any other reef during this period.

OREGON INLET REEF: Another Liberty ship was sunk at the end of November, 1978, on a reef site previously permitted by DMF. The vessel was 440 ft. long and was sunk by a US Marine Corps demolition team. Salvage of the ship paid for the sinking, which cost approximately $27,000. The reef already had a 440 ft. Liberty ship and an 83 ft. trawler on-site.

NEW RIVER INLET REEF: Onslow County commissioners obtained permits for this reef site. The same Marine Corps helicopters that dropped metal containers on the Bogue Inlet site, also dropped them on this site. Another reef material used here was a fiberglass boat hull.

Table 3. Estuarine artificial reefs constructed or enhanced between 1983 and 1986.

Reef	Original permit holder	Material	epth (ft)
New Bern	Craven County	tire units	12
Brices Creek	Craven County	tire units	20
Oriental	DMF	tire units, scrap metal	12
Bayview	Beaufort County	tire units	16
Pungo River	Beaufort County	tire units	15
Hatteras Island	Hatteras Island Business Association	tire units	14
Ocracoke	Hyde County	110' barge	19
Black Walnut Point	Chowan County	tire units, 13 fiber-glass boat molds, 10 metal boxes (10 cubic yards each)	16

Cooperative Efforts

Cooperation with the Marine Corps occurred on several occasions during this period of the reef program. In 1979, the demolition team from the Marines sank the Liberty ship off Oregon Inlet. Also, the trash containers were transported and deposited on-site by Marine helicopters.

Another cooperative effort was undertaken by the Raleigh Salt Water Sport Fishing Club, the North Carolina Saltwater Fishing Federation and the Carteret County Chamber of Commerce. The recreational fishing organizations sold raffle tickets and promoted other fund raising events, with proceeds designated to help obtain a Liberty ship for the Cape Lookout area.

Monitoring Efforts

There was no formal biological monitoring during this period. No research was funded or conducted by the Division. The policy was to assist in putting reefs on-site and not to monitor how productive they may or may not be. The research that had been done between 1974 and the summer of 1977 showed fish present on the reefs. They had produced fish for recreational fishermen. This was believed to be enough evidence, and efforts were directed towards sinking reef materials.

Maintenance dives were made on the artificial reefs to check buoys. During those dives casual observations were made of fish observed by divers.

Summary

Several recommendations from this period were:

1. Produce quality tire units instead of quantity. Putting concrete in more units would have meant less tires placed on-site, but better results could have been achieved.

2. Coordination among various local, state, and federal agencies was highly recommended.

3. The importance of adequate supplies, functioning equipment and an enthusiastic crew was emphasized.

With the change in policy and much less money appropriated for the reef program, this was a very different period for the state's artificial reef program from the earlier years and also from the period to follow. At this stage it was a program designed to assist interested local agencies and organizations.

ARTIFICIAL REEF DEVELOPMENT - 1985 to PRESENT

During the 1985 North Carolina General Assembly, Representative Howard Chapin introduced a bill which provided $300,000 for additional artificial reef construction, entirely with railroad cars. The railroad cars were donated by Seaboard System Railroad. The bill (Senate Bill 182) also gave the Marine Fisheries Commission the authority to control siting and use of artificial reefs. With this bill the Division of Marine Fisheries became committed to coordinating all marine artificial reef activities.

House resolution 1038, sponsored by Representatives Tyndall, Chapin, and Gardner also ratified in the 1985 legislative session, encouraged the Department of Transportation and the Department of Natural Resources and Community Development to cooperate in using structures and scrap materials from replaced coastal bridges for artificial reef construction.

With the advent of Wallop-Breaux funding for marine recreational fishing programs, a new phase in North Carolina's artificial reef program began. The Wallop-Breaux funds were appropriated to mark, maintain and provide access to artificial reefs. Money was also approved for preparation of this plan. However, no Wallop-Breaux funds were to be used to build artificial reefs.

Reef Materials

In 1985, The Cape Lookout Artificial Reef Fund was established as a joint venture of the Carteret County Chamber of Commerce and the North Carolina Marine Education and Resource Foundation. The purpose of the fund was "to improve and enhance marine fisheries habitat by raising monies to prepare, tow, and sink the Liberty ship PROTECTOR as an artificial reef off Carteret County". Additional funds were to be used in the maintenance of existing reefs and to establish new reefs in the Carteret County area. The PROTECTOR was 441 ft. long and the last Liberty ship available for use as an artificial reef. The estimated cost was between $100,000 and $140,000. The Legislature allocated $100,000 and money was donated by the Raleigh and Carteret County sport fishing clubs and local businesses. Because of it's status as the last Liberty ship of the "mothball" fleet, the PROTECTOR could not be obtained. The Navy then offered the state the AEOLUS, a 439 ft. cable-laying vessel. The funds and reef site designated for the PROTECTOR were re-designated for the AEOLUS. The ship was sunk 25 miles south of Beaufort Inlet in 104 ft. of water in July 1988. Minimal explosives were used to sink the AEOLUS to keep the vessel as intact as possible.

Another reef material used during this period has been bridge rubble. The Atlantic Beach draw bridge was replaced by a highrise bridge. The 3,900 ft. draw bridge was sunk on a 100 acre permitted reef site 1-1½ miles off Atlantic Beach. The site already had a 149 ft.

menhaden fishing boat. The total cost of removing the bridge and placing it on-site was approximately $975,000. Working in cooperation with the state, the Carteret County Sport Fishing Club was responsible for the bridge becoming an artificial reef. As the bridge system in North Carolina is improved, with proper planning and cooperation, more bridges can be used as artificial reefs.

The Train Car Reefs

In July 1985, Seaboard System Railroad donated 200 railroad cars to the state for artificial reef material. Public meetings were held and an Artificial Reef Steering Committee was established to determine the best reef sites. Twenty ocean sites were chosen based on access to major inlets, lack of commercial fishing interference or navigational hazard, and avoidance of already productive naturally occurring hardbottom. These twenty sites were located 3 to 25 miles offshore between Dare and Brunswick counties.

Preparation of the train cars included a thorough cleaning, removal of the wheels and doors, and windows cut in each side. The box cars were then taken to the site on a large barge, lifted by crane into the ocean and released. Large yellow buoys with the reef number on them were placed on-site prior to sinking. Initial SCUBA dives made on several sites found train cars to be in an upright position. However, later investigations showed many of the train cars have collapsed, providing minimal profile.

Summary

During the train car reef project many policies and practices were improved. One of the more significant ones was the preparation of a general USACE permit, making the Division the primary permittee for the state. This streamlined the permitting process significantly. Public participation and local effort were still encouraged by the Division. The Division is willing to work with any club or organization interested in artificial reefs. The Division's policy at this time is to conduct a comprehensive reef program for the state, coordinated and managed by DMF.

LOCAL EFFORT

Local effort was responsible for artificial reefs off North Carolina's coast from the very beginning. Prior to 1973, when the Division of Marine Fisheries became involved, various groups in the Atlantic Beach and Wilmington areas had built several artificial reefs. In some areas, local groups continue to have a major influence on the state's artificial reef development.

The Brunswick County area has been very involved with artificial reef programs. Three sportfishing clubs joined together to establish the Long Bay Artificial Reef Association, Inc. The function of this

association was to obtain funds and coordinate efforts and subsequent construction of offshore reefs. By September 1985, six new reef permits (up to 18 miles offshore) had been obtained by the Brunswick County Sport Fishing Club. Various reef materials acquired by the Association and the Fishing Club include two 60-ton steam boilers, a 140 ft. barge, and a 140 ft. Army Corps of Engineers vessel. A total of $35,000 was pledged by County Commissioners. The DMF was heavily involved in these efforts and now holds the permits for all of the Brunswick County reefs.

Another active area is New Hanover County. County Commissioners contributed $30,000 to $50,000 a year for reef efforts over several years. Organizations that have been especially involved are the Carolina Marine Research Foundation and The Wrightsville Beach King Mackerel Tournament. The Foundation promotes reef efforts by obtaining funding and reef materials for artificial reefs offshore, and the Tournament obtained reef permits and funds for reef construction. Reef materials acquired included two 100 ft. tug boats and the HYDE, a 240 ft. surplus vessel. Heading up research on North Carolina's artificial reefs is the University of North Carolina at Wilmington. Research topics include fish attracting devices (FADs), fish utilization patterns and comparative analysis of fish assemblages on North Carolina's reefs.

Carteret County has a very active salt water sportfishing club. The club was involved in attempts to obtain a Liberty ship, and then in efforts to sink it's replacement the AEOLUS. It also holds an annual king mackerel tournament to raise money for reef construction. They initiated the Atlantic Beach draw bridge reef project and are continually involved in improving the reef network off Carteret County.

Dare County Commissioners established the Dare County Artificial Reef Committee in 1985. This committee was responsible for selecting several reef sites off the Outer Banks, obtaining permits for these sites, and working with the state to have materials placed on them.

Inland, the Raleigh Salt Water Sport Fishing Club historically has been very involved in reef development on the coast, from raising funds to promotion of artificial reefs off North Carolina's coast.

APPENDIX B: NORTH CAROLINA STATUTES AND REGULATIONS

North Carolina Marine Fisheries Act of 1987.

¶143B-289.4. Marine Fisheries Commission--powers and duties.

The Marine Fisheries Commission shall have the power and duty to adopt rules and regulations to be followed in the management, protection, preservation, and enhancement of the marine and estuarine resources of the State including commercial and sport fisheries resources.

(2) The Marine Fisheries Commission shall have the power and duty to establish standards and adopt rules and regulations:

(j) Governing the location and utilization of artificial reefs in coastal waters;

North Carolina Fisheries Regulations for Coastal Waters 1988

3B .0111 Artificial Reefs and Research Sanctuaries

(a) The Fisheries Director may close or restrict by proclamation any coastal fishing waters with respect to taking or attempting to take any or all kinds of marine or estuarine resources and with respect to using any kind of equipment. Such closing or restriction shall be in the discretion of the Fisheries Director and shall be based on overall public interest and prudent fisheries management and research.

(b) Any closing or restriction proclaimed by the Fisheries Director under Subsection (a) of this Rule is subject is the following conditions:

(1) Artificial reefs in the Atlantic Ocean shall not be closed or restricted under this Regulation beyond 1000 yards and artificial reefs in the inside coastal fishing waters shall not be closed or restricted under this Regulation beyond 500 yards. Artificial reefs shall be marked by one readily identifiable official buoy by the department and any distances called for in the Regulation shall be measured from such buoy.

(2) Any closure or restriction shall be for no more than one year, subject to renewal in the discretion of the commission.

(3) The economic effect of the closure or restriction on fishing interests with respect to the size and location of the area and the nature of the equipment affected

shall be considered before such closure is made and findings shall be made in writing which findings shall be available for public inspection at the office of Division of Marine Fisheries in Morehead City.

(4) The proclamation must be approved by the Marine Fisheries Commission at their next official meeting or else it is automatically void.

(c) It shall be unlawful to engage in any fishing activity or to use any equipment, or to conduct any other operation which has been prohibited by any proclamation issued under the authority of this Regulation.

History Note: Statutory Authority G.S. 113-134; 113-181; 113-182; 143B-289.4: Eff. February 1, 1976; Amended Eff. December 1, 1987; January 1, 1979.

APPENDIX C: INFORMATION SOURCES

North Carolina Division of Marine Fisheries
P.O. Box 769
Morehead City, NC 28557
(919) 726-7021

Michael D. Marshall, Fisheries Development Section Chief
Stephen W. Murphey, Artificial Reef Construction Coordinator

U.S. Department of Transportation, United States Coast Guard-Fifth Coast Guard District

John R. Walters
Chief Operations, Planning and Hydrographic Section
Aids to Navigation Branch
Federal Building
431 Crawford Street
Portsmouth, VA 23705-5004
(804) 398-6229

Department of Defense, United States Army Corps of Engineers-U.S. Army Engineer District, Wilmington

Colonel Paul W. Woodbury
District Engineer
U.S. Army Engineer District, Wilmington
P.O. Box 1890
Wilmington, NC 28402

APPENDIX D: REEF INVENTORY OF NORTH CAROLINA'S MARINE ARTIFICIAL REEFS AS OF DECEMBER 1987

Name	Distance (Naut. mi.)	Latitude	Longitude	Type/Environment	Depth (ft)	Composition
AR-130	5.2	36°00'18"N	75°32'00"W	Benthic/Ocean	54	Steel train cars
AR-140	3.7	35°56'45"N	75°32'00"W	Benthic/Ocean	54	Steel train cars
AR-145	8.7	35°54'01"N	75°23'48"W	Benthic/Ocean	70	Steel hull vessel
AR-160	2.2	35°44'40"N	75°27'20"W	Benthic/Ocean	70	Steel hull vessel
AR-191	0.9	36°00'00"N	76°40'00"W	Benthic/Estuarine	18	Tires, steel scrap
AR-192A	0.7	35°56'45"N	76°39'15"W	/Estuarine	14	
AR-192B	0.7	35°58'15"N	76°29'00"W	/Estuarine	20	
AR-192C	0.5	35°57'15"N	76°33'00"W	/Estuarine	20	
AR-192D	0.9	35°59'20"N	76°26'15"W	/Estuarine	14	
AR-193A	0.2	35°59'00"N	76°23'30"W	/Estuarine	14	
AR-193B	0.9	35°58'00"N	76°21'40"W	/Estuarine	14	
AR-193C	0.5	35°57'00"N	76°20'50"W	/Estuarine	14	
AR-193D	0.8	35°59'00"N	76°16'54"W	/Estuarine	18	
AR-194A	0.9	36°04'15"N	76°20'20"W	/Estuarine	17	
AR-194B	0.3	36°08'15"N	76°22'45"W	/Estuarine	12	
AR-195A	0.2	36°15'57"N	76°09'55"W	/Estuarine	10	
AR-195B	0.4	36°14'17"N	76°07'25"W	/Estuarine	10	
AR-197	0.9	35°57'15"N	75°42'36"W	Benthic/Estuarine	10	Tires
AR-198	1.0	35°48'20"N	75°38'25"W	/Estuarine	11	
AR-220	4.4	35°08'11"N	75°40'33"W	Benthic/Ocean	54	Steel train cars Concrete rubble
AR-225	5.9	35°06'48"N	75°39'18"W	Benthic/Ocean	60	Steel train cars Concrete rubble
AR-230	5.1	35°06'19"N	75°43'22"W	Benthic/Ocean	66	Steel hull vessel
AR-250	8.3	34°57'00"N	75°55'00"W	Benthic/Ocean	78	Steel train cars
AR-255	8.8	34°55'30"N	75°58'00"W	Benthic/Ocean	84	Steel train cars
AR-275	1.9	34°50'13"N	76°16'42"W	/Ocean	54	

REEF INVENTORY (continued).

Name	Distance (Naut. mi.)	Latitude	Longitude	Type/Environment	Depth (ft)	Composition
AR-285	5.5	34°33'51"N	76°25'32"W	/Ocean	60	
AR-291	0.4	35°25'55"N	76°45'42"W	Benthic/Estuarine	15	Tires
AR-292	0.4	35°28'15"N	76°34'15"W	Benthic/Estuarine	13	Tires
AR-293	0.6	35°27'10"N	76°35'50"W	/Estuarine	10	
AR-295	1.1	35°19'40"N	76°18'10"W	/Estuarine	11	
AR-296	2.3	35°17'20"N	75°37'30"W	Benthic/Estuarine	11	Tires
AR-298	3.7	35°10'42"N	75°59'59"W	Benthic/Estuarine	19	Steel hull vessel
AR-300	18.0	34°19'00"N	76°24'30"W	/Ocean	78	
AR-305	19.5	34°16'30"N	76°38'30"W	/Ocean	104	
AR-315	1.8	34°39'00"N	76°45'00"W	Benthic/Ocean	50	Steel hull vessel Tires
AR-320	2.2	34°39'00"N	76°49'00"W	Benthic/Ocean	49	Steel hull vessel Concrete rubble
AR-325	4.8	34°36'35"N	76°50'10"W	/Ocean	50	
AR-330	7.9	34°33'55"N	76°51'20"W	Benthic/Ocean	60	Steel train cars
AR-340	5.5	34°34'38"N	76°58'35"W	Benthic/Ocean	58	Steel train cars
AR-342	3.0	34°36'42"N	77°02'18"W	Benthic/Ocean	49	Tire units, tires Scrap steel
AR-345	7.9	34°32'15"N	76°58'30"W	Benthic/Ocean	60	Steel train cars
AR-350	1.5	34°29'48"N	77°21'24"W	Benthic/Ocean	31	Steel hull vessel Scrap steel
AR-355	9.3	34°21'18"N	77°19'54"W	Benthic/Ocean	60	Steel train cars
AR-360	1.7	34°20'42"N	77°36'12"W	Benthic/Ocean	44	Tires
AR-362	8.7	34°15'40"N	77°30'24"W	Benthic/Ocean	54	Steel train cars
AR-364	1.9	34°14'48"N	77°42'54"W	Benthic/Ocean	49	Concrete rubble, tires

REEF INVENTORY (continued).

Name	Distance (Naut. mi.)	Latitude	Longitude	Type/Environment	Depth (ft)	Composition
AR-366	13.6	34°13'00"N	77°25'06"W	Benthic/Ocean	66	Steel train cars
AR-368	15.8	34°09'30"N	77°25'48"W	Benthic/Ocean	66	Steel train cars
AR-370	3.2	34°10'30"N	77°44'30"W	Benthic/Ocean	52	Steel hull vessels Tires
AR-372	5.3	34°06'05"N	77°44'48"W	Benthic/Ocean	48	Steel trail cars
AR-376	10.2	34°03'14"N	77°39'40"W	Benthic/Ocean	60	Steel train cars
AR-378	1.2	34°02'00"N	77°52'00"W	Benthic/Ocean	40	Steel hull vessels, Tires
AR-382	10.8	33°58'36"N	77°41'12"W	Benthic/Ocean	58	Steel hull vessels
AR-386	17.2	33°57'30"N	77°33'18"W	Benthic/Ocean	78	Steel hull vessels Steel train cars
AR-391	0.1	35°04'25"N	77°03'25"W	Benthic/Estuarine	20	Tire units
AR-392	0.5	35°05'00"N	77°00'37"W	Benthic/Estuarine	12	Tire units
AR-396	0.5	35°01'50"N	76°39'30"W	Benthic/Estuarine	10	Tire units
AR-420	3.2	33°51'15"N	78°06'30"W	Benthic/Ocean	30	Steel hull vessels Concrete, steel scrap
AR-425	1.2	33°53'06"N	78°07'24"W	Benthic/Ocean	30	Concrete rubble, tires
AR-440	4.9	33°50'00"N	78°13'00"W	Benthic/Ocean	42	Steel train cars Concrete rubble, tires
AR-445	9.8	33°45'00"N	78°14'00"W	Benthic/Ocean	53	Steel train cars
AR-450	18.8	33°36'00"N	78°15'00"W	/Ocean	65	
AR-455	7.6	33°47'00"N	78°18'00"W	Benthic/Ocean	46	Steel train cars
AR-460	4.0	33°50'00"N	78°22'00"W	Benthic/Ocean	38	Steel train cars
AR-470	7.2	33°46'00"N	78°25'00"W	/Ocean	48	
AR-485	2.8	33°49'12"N	78°29'48"W	Benthic/Ocean	32	Tires, steel scrap