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how to build marine artificial reefs

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Figure 1.—Artist's concept of an artificial reef.

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FISHERY FACTS-10

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ABSTRACT

Artificial reefs provide or improve rough bottom habitat and offer fishery scientists and administrators an effective technique to conserve and develop coastal fishery resources. With careful planning and organized efforts, local reef committees can build reefs to improve fishing and contribute to the recreational and financial growth of coastal communities. Advice and procedures are presented for: 1) selecting construction materials, 2) determining a suitable reef site, 3) obtaining permits, 4) buoying the reef, and 5) preparing, transporting, and placing reef-building materials. Included in appendixes are instructions for preparing permits, addresses of Federal and State agencies involved in approving or funding reef construction, and addresses of manufacturers of materials and equipment.

HOW TO BUILD MARINE ARTIFICIAL REEFS

R. O. PARKER, JR., R. B. STONE, C. C. BUCHANAN,[1]

and F. W. STEIMLE, JR.[2]

INTRODUCTION

In 1970, over 9 million saltwater sport fishermen caught nearly 1.6 billion pounds of fish in the United States and commercial fishermen harvested about 4.5 billion pounds from marine waters. With these large and increasing demands on stocks of fishes and the continuing destruction and pollution of marine habitat, new management tools and practices must be devised and implemented to conserve and develop our fishery resources. Artificial reefs have potential as a positive management tool that can be used to: develop quality fishing grounds close to access points, enhance existing rough bottom fisheries, beneficially affect anglers and the economies of local communities (Buchanan 1973) and, if the reef is large enough or not fished, increase stock sizes of reef fishes.

Artificial reefs are man-made or natural objects placed in selected areas of the marine[3] environment to provide or improve rough bottom habitat and thereby increase the productivity and harvestability of certain finfish and shellfish valuable to man (Fig. 1, see cover).

Most exploitable fishes inhabit the continental shelves, but much of the shelf area consists of relatively unproductive sand or mud bottom. Coral reefs and rock outcrops, where desirable recreational fishes abound, are found only in limited areas along most coasts. These

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[2]Middle Atlantic Coastal Fisheries Center, National Marine Fisheries Service, NOAA, Highlands, NJ 07732.

[3]For information on freshwater artificial reefs see "How to build a freshwater artificial reef" by P. Brouha and E. D. Prince, 1974. Virginia Polytechnic Institute and State University, Blacksburg, Va. Sea Grant Extension Publication No. 73-03, 14 p.

rocky areas provide hard substrate needed for attachment of encrusting organisms, such as barnacles, hydroids, corals, mussels, and algae. Such organisms, in turn, provide food for some species and habitat for others. The holes, crevices, and dark corners provided by the irregular substrate and encrusting organisms are used as shelter by many fishes and motile invertebrates. The irregular profiles of reefs are used by many species for orientation to nearby feeding grounds (Randall 1963; Starck and Davis 1966; Hobson 1968). Artificial reefs can provide these rough bottom features on barren bottom and help return habitat that has been impoverished by pollution, dredging, or dumping to productive fishing grounds once pollution ceases and fouling agents dissipate (Stone 1972a).

Artificial reefs have been used in the United States since the 1830's (Holbrook 1860), and since 1935 over 200 permits have been issued by the Corps of Engineers for reef construction. Early reefs were constructed haphazardly and resulted in varying degrees of success. Good reviews of the successes and failures of artificial reefs have been provided by Unger (1966) and Steimle and Stone (1973). Now, as States and other reef-building agencies recognize the potential of artificial reefs in conserving and developing fishery resources, interest in reef construction techniques is growing rapidly. The purpose of this report is to summarize information on reef materials and costs and provide information on how and where to build artificial reefs.

PLANNING

Organization of Effort

Comprehensive planning is essential to a successful reef-building effort. Materials, reef location, buoys, permits, assembly area, labor, financing, transportation, and possible conflicts of interest must be carefully considered at the beginning of the project. Solutions to these considerations are best worked out by a committee representing local and State governments, State and Federal fishery biologists, sport and commercial fishermen, and interested individuals, rather than by an individual.

The construction of a large reef, designed to handle intense fishing pressure, is a major undertaking usually handled by State conservation departments or organizations supported by State funds. Local reef committees also can accomplish this by using and organizing available resources although the coordination of effort is usually more difficult. For example, the committee can organize other community organizations and youth groups, such as the Junior Chamber of

Figure 2.—Reef building can be a rewarding community project for civic organizations, youth groups, and sport fishermen. The operation should be coordinated by representatives of these organizations, local government, and the State fisheries department.

Commerce and Boy Scouts, to help collect and prepare reef material (Fig. 2). Planners should consult State or Federal fishery biologists throughout the effort. With imagination and work the building of artificial reefs can be enjoyable and rewarding for the entire community.

Materials

Almost every type of scrap or discarded object has been used to construct reefs. Some materials, such as old cars and streetcars, are effective for a few years (Carlisle et al. 1964), but are reduced by corrosion to debris in approximately 6 yr (Stone 1972b). Wooden materials collapse even sooner from wave surge and destruction by marine borers. Household appliances such as stoves, refrigerators, and freezers are not recommended because they are buoyant and thus difficult to sink and keep in place. Tires, rock, concrete rubble, and other durable materials are effective types to use. In addition to these materials, artificial reefs have been built of ships, barges, dry docks, culverts, toilet bowls, trees, bricks, prefabricated shelters, and artificial seaweed.

Additional factors to consider when selecting reef materials are their availability, cost of obtaining, assembling, handling, and transporting, and effect on the environment (Table 1). The latter consideration includes: 1) harmful effects on the aquatic environment from gasoline, oil, heavy metals, and other pollutants, and 2) conservation of resources, such as metals. The recent demand for iron and steel has

Table 1.—Cost and longevity of artificial reef materials.

Material	Unit	Cost[1] in dollars (year of construction)	Longevity (years)
Tire-units	each	0.34-12.24 (1972)	[2]1-[3]i
One	each	0.34	
Three (w/concrete)	each	4.68-12.24	
Eight	each	2.87-4.00	
Bale	each	2.00-6.00	
Car	each	10.45-100.00 (1968)	3-6
Vessel	each	0.00-15,000.00 (1972)	[5]1-100+
Rock	ton	5.00 (1960)	[2]6-i
Concrete culvert	ton	2.45-18.90 (1964)	i
Oyster shells	cubic yard	2.00-2.25 (1962)	[2]1-i
Ero-jack (4′)	each	10.00 (1972)	i
Prefabricated shelter	each	140.00 (1960)	[2]1-i

[1]Local cost differences and availability of volunteer help caused the wide ranges of construction costs for a given material.

[2]Sanded over by storm currents.

[3]i = the material will last for an indefinite period of time.

[4]Contracted.

[5]Some wooden vessels may collapse in one year from destruction by marine borers and/or storms.

made it economical, in many instances, to recycle these metals, thus reducing their availability as reef materials.

Reef Location

When selecting the location for a reef, the following factors should be considered: purpose, access, type of bottom, locations of wrecks, or other bottom irregularities that could be used as a nucleus for reef development, current and wave action, bottom depth, clearance above the reef, and interests of other water users.

Different reefs for different species—The types of fisheries desired will greatly influence the design and location of a reef. In areas where the major sport fishery is for demersal species, such as sea basses, groupers, and snappers, low profile reefs can be used effectively. If, however, anglers are more interested in pelagic species, e.g., mackerels, jacksn and bluefish, high profile reefs will be more productive. Floating structures also have been used to attract pelagic species (Klima and Wickham 1971). Although these are not artificial reefs as we define them, they can improve sport fish catches for some pelagic species (Wickham et al. 1973). A combination of high and low profile material is often effective for both demersal and pelagic species.

Depending upon the geographic zone, some of the following species should be attracted to low profile reefs: crabs, lobsters, flounders, sea basses, codfishes, tautog, rockfishes, sheepshead, seatrouts, croaker, black drum, porgies, grunts, groupers, and snappers. High profile reefs also attract some of those species and in addition pelagic fishes, such as spadefishes, mackerels, bluefish, amberjack, tunas, barracudas, and cobia. Since the habits and ranges of fishes vary, it is advisable to consult State fishery biologists about the fishes present in a given area.

Access—Artificial reefs should be within easy and safe access of fishermen. If they are built for small boat fishermen, they should be located in protected waters, or within a few miles of a harbor or inlet. Only fishermen in large boats, such as head or charter boats, can safely use distant reefs. Most boat fishermen use small boats, and therefore fish more over nearshore than distant reefs.

Bottom type—The composition of the ocean bottom is an important factor that could affect the length of time a reef will remain productive. If the material sinks into the sediments or is covered by them, the reef loses its effectiveness. The ideal bottom is bedrock with little sediment cover. Firm bottoms of gravel and compact sand also are good foundations. Soft bottoms of shifting sand, silt, or mud, however, serve as poor foundations and usually result in some or all of the reef material being covered. Information about bottom type and depth can be obtained first hand with bottom sampling equipment, diver inspection, depth recorder, or sounding lead, or it may be obtained from National Ocean Survey charts, State fish and game agencies, local colleges and universities with marine science programs, commercial fishermen, or oil company geologists. If wrecks or other bottom irregularities can be found on firm bottom, these areas should be considered as possible reef sites. The existing material can be used as a nucleus for reef development and the firm bottom will reduce the possibility of sediments covering new reef material.

Effects of current and wave action—Strong currents and wave action can undermine, cover with shifting sediment or scatter materials. Thus, building reefs in areas of strong currents and very shallow depths should be avoided. Local oceanographers or marine geologists should be consulted for information about currents and wave action that might be encountered at a proposed reef site.

Currents can influence the number of boats that fish the reef at one time. Reefs should be constructed across prevailing currents to allow the maximum number of fishermen to anchor and fish the reef.

Depth requirements for reefs—Artificial reefs have been constructed along the coasts of the United States in depths ranging from 18 to 300 feet. They have also been build in shallow estuaries. Depth selection for artificial reefs is dependent upon navigational clearance and material stability.

The highest part of a reef should be of sufficient depth to allow unimpeded navigation. In depths greater than 60 feet (at mean low water), reefs should have a minimum clearance of 50 feet, whereas, in depths less than 60 feet, a general rule of thumb is that the clearance over the reef should be equivalent to the greatest draft of ships using the area plus 10 feet. The Corps of Engineers should be consulted about depth requirements since this guideline may vary in different locations. A natural, hard bottom depression or trough, that is not subject to silting or scouring but remains stable, is a good location for a reef site. The reef then can be constructed so the water depth over the reef is similar to that of the surrounding bottom.

Lightweight reef materials should be used in deep water or in protected estuaries where the effect of waves and currents is not great. Heavy materials that will not move can be used in any depth. Some materials can be assembled into fish houses that are resistant to wave surge and strong currents and can be used on shallow reefs. The size, weight, and stability of various reef materials are explored more fully in the section of this paper dealing with construction techniques and costs.

Conflict of interest—The interests of other individuals or groups that might use the general area of the proposed reef for purposes other than sport fishing must be considered when selecting the exact postion of the reef. The proposed reef must not present a hazard to navigation or interfere with anchoring. The Corps of Engineers and the Coast Guard require that no artificial reefs be placed in navigation channels or anchorages. Commerical fishermen must be allowed free access to historic fishing grounds. A reef placed near a commercial fishing ground must be well marked so that fishing vessels can easily avoid it. A suitable site can usually be selected by consulting the various user groups of that area.

Permits

Federal and many State governments require permits to build artificial reefs. An application must be submitted to the Corps of Engineers to obtain permission to build a reef (Appendix I). The Coast Guard suggests that plans for buoying the reef be included in the

Corps application to eliminate the need for an additional permit to expedite Coast Guard authorization. After the Corps receives an application, a public notice of intent will be posted and local authorities notified. Usually objections to the application must be filed within 30 days. Most objections are the result of misunderstandings and are easily cleared up. Occasionally, however, the Corps will require a public hearing to reach a decision. Refer to Appendix II to determine which Corps district has authority in the area of a proposed reef site and to Appendixes III and IV for the addresses of Corps districts and coastal State agencies that require permits. When a State permit is required, it should be obtained first and included with the application for a Corps permit.

Assembly Area, Labor, and Financing

The assembly area, labor and financing will be dictated by each reef-building situation. An accessible vacant lot, adjacent to a navigable channel, makes an ideal assembly area. Volunteer help, although free, often results in sporadic work schedules and makes the coordination of effort difficult. The cost of building reefs can vary greatly. Among other things, it depends on material preparation costs, land and sea transportation costs, and the size of the reef. Financing can be obtained through donations, fund raising projects, and occasionally local, State, and Federal governments. An ideal situation exists when reef construction is funded and supervised by a State. Arrangements of this type are now taking place in several States.

The U.S. Bureau of Outdoor Recreation considers requests for funds to build artificial reefs. For information regarding their participation a Bureau State Liasion Officer should be contacted (Appendix V).

Marking the Reef Site

A minimum of two buoys should be placed on the reef site prior to construction, so that together they will indicate the reef boundary; one will mark the reef location when the other is being renovated or replaced. Buoys can be bought from manufacturers or built in a small workshop. Manufactured or custom-built buoys suitable for marking marine artificial reefs can be obtained from companies listed in Appendix VI. Most of these buoys are made of tough, hard plastic filled with foam, and cost less than $200.00.

An inexpensive spar buoy, that can be built by a handyman, is shown and described in Appendix VII. This type of buoy is an effective marker for nearshore artificial reefs, will withstand most severe storms, and is a minimal hazard to navigation. It is constructed of styrofoam and coated with fiber glass.

If this buoy is used in water deeper than 50 feet, it does not require ballast other than ¾-inch chain anchor line. In shallower depths or when using wire or rope, a lead counterweight may be necessary. The counterweight can be a separate weight that is shackled to the rod eye with the anchor line.

Buoy anchors are usually made from concrete and should weigh at least 1,000 pounds. It is difficult to define an exact weight for an anchor since buoy sizes vary and anglers are likely to tie their boats to a buoy while fishing. Therefore, the anchor should be heavy enough so the buoy will not drag under any circumstances. If ships or other heavy materials are being used to construct a reef, the buoy can be attached to the material. The length of anchor line will vary with water depth and weight of anchor. When buoys are close or attached to reef material, anchor lines should be short, about 1½ times the water depth, to avoid entanglement. Longer lines, about 3 times the water depth, should be used on buoys with small anchors, and these anchors should be placed farther away from the reef material.

Chain anchor lines usually last longer than wire or rope. A small buoy placed midlength on chain anchor lines, or a piece of fire hose covering the bottom of the chain, will prevent the chain from chafing on the bottom. Zinc rods also can be attached to the chain to retard electrolysis. All fittings should be galvanized to retard corrosion and secured with lock nuts or wired in place. Anchor lines should be inspected at least every 6 mo for wear.

In addition to selecting, handling, transporting, positioning, maintaining, and replacing the buoys, signs on the buoys designating the name of the artificial reef, tie ups for boats, and lighted buoys for night fishing should be considered.

Reef Shape and Size

Theoretically, fishing success increases in proportion to the horizontal and vertical dimensions of a reef. Generally this is true, but several piles of material in an irregular configuration are thought to be better than one pile of the same amount of material. Material should not be scatted over wide areas, but clumped with open spaces between clumps. Turner et al. (1969) recommended that reefs be constructed in a circle or square with a central opening less than 60 feet across. Such an arrangement maximizes the boundary area that is preferred by many fishes. These configurations will be approximated by routine dumping of material in clumps between fixed buoys. Attempts to actually position material on the bottom with divers are expensive, time consuming, and generally impractical. Japanese researchers have found that small, low objects are best for promoting growth of shellfish and seaweed. Structures with many small holes and crevices are best for attracting invertebrates (e.g., shrimp, crab, and lobster) and juvenile fishes, and higher, larger structures with numerous crevices are best for larger fishes (Edmond 1960; Zawacki 1971).

CONSTRUCTION TECHNIQUES AND COSTS

Tires

Tires serve well as reef material. They are readily available, relatively inexpensive to assemble into units, easy to handle, and virtually indestructable. They provide a large surface area for encrusting organisms and suitable habitat for many invertebrates and fishes.

Tires have been incorporated into a variety of designs at costs varying from $0.34 to $4.08 per tire to assemble and place on the bottom (Table 1). They usually need to be ventilated and ballasted to prevent movement off the reef. Several methods have been used in attempts to ventilate tires. Knives, chisels, axes, saws, drills, guns, and blow torches are inefficient; manual and pneumatic punches and a baler with cutting blades have proven successful (Figs. 3, 4).

Following is a list of the most common tire units used, a description of techniques employed in building them and comments on their effectiveness:

One-tire: This unit is constructed by inserting a concrete test cylinder (these cylinders are used to test the hardness of a batch of concrete, then discarded), a number 10 can filled with concrete or equivalent weight in a car tire, and cutting a vent through the thread opposite the weight (Fig. 5). The weight can be banded or tied in place to prevent it from becoming dislodged. Stone and Buchanan (1970) found that this unit stays in place on the bottom, but provides only a low profile habitat and can be easily covered by shifting sand or silt (Fig. 6).

Two-tires: To construct this unit, a folded tire is inserted through the center opening of a one-tire unit (Fig. 7). Holes are cut through both tires to allow trapped air to escape. This unit provides better habitat for fishes than a single tire, but it is awkward to transport and ocasionally comes apart. It may not remain in place in strong currents or storm surge and should be used only on protected reef sites.


FURNITURE

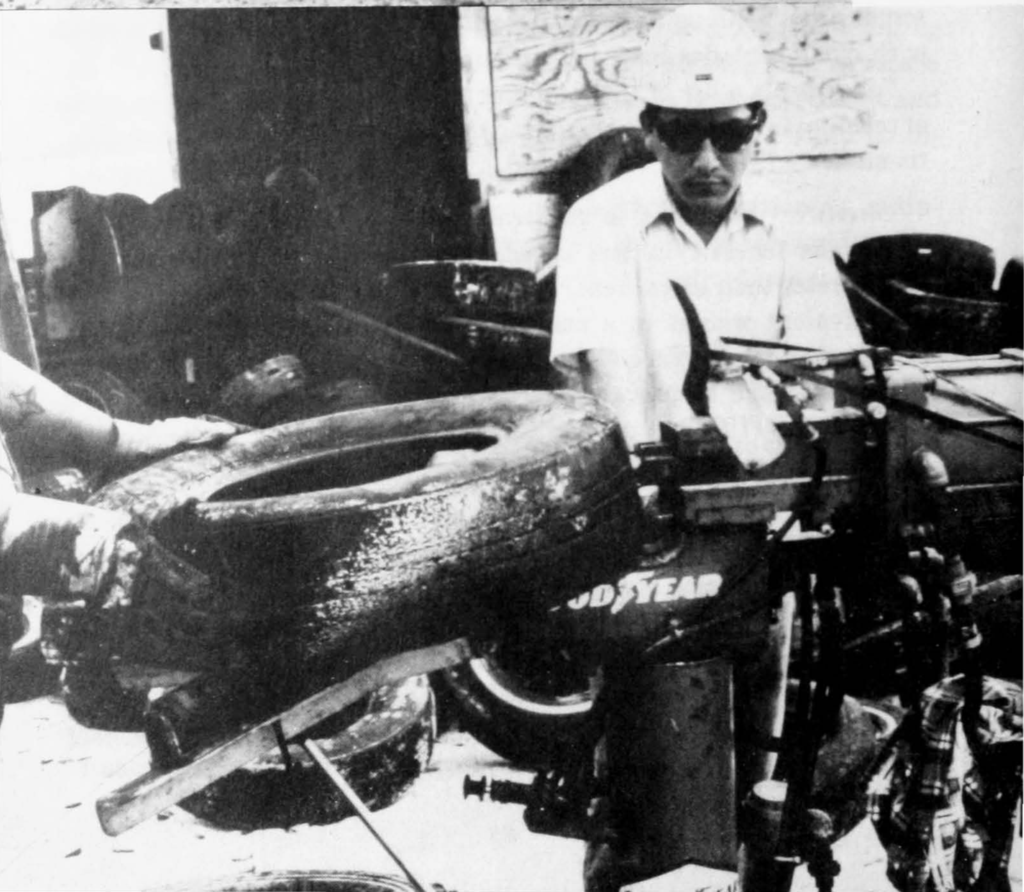


Figure 3.—A manual tire punch made from a 1-inch pipe and scrap lumber.

Figure 4.—A pneumatic punch can be used to facilitate ventilating tires. One tire baler now has built-in cutting blades which completely elminates the labor involved in ventilating tires.

Figure 5.—Single tires, ballasted and vented, can easily be handled by one man.

Figure 6.—Single tires provide good, low profile habitat where fishes, such as black sea bass, can hide and find food.

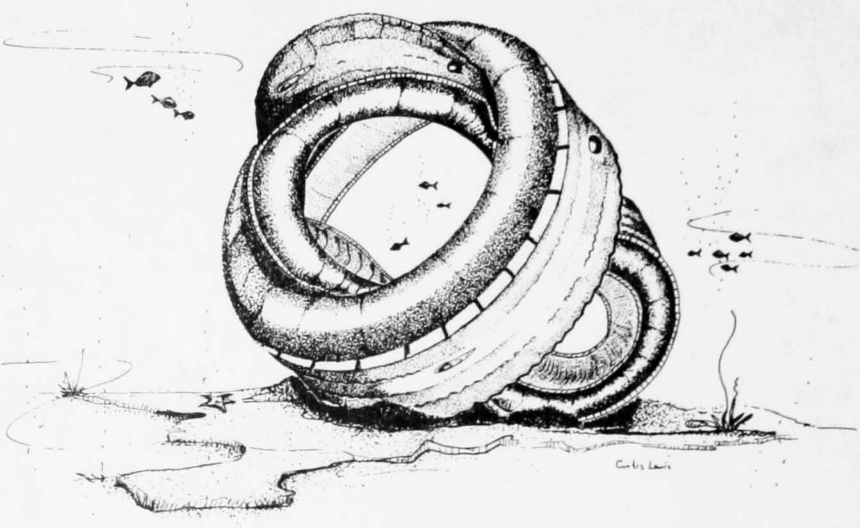


Figure 7.—Two-tire units provide good habitat, but are awkward to transport and occasionally come apart when handled.

Three-tires: This unit is constructed by tying three one-tire units together or by pouring concrete around a metal rod pinning three ventilated tires (Figs. 8, 9). The unit is relatively easy for two men to handle and provides good habitat for fishes and invertebrates. The unit stays in place on the bottom and has been used successfully on a number of shallow-water reefs.

Eight-tires: To construct this unit, three reinforcing rods are hooked through a base tire to form a tripod configuration, and the base tire is then filled with concrete. After the concrete hardens, six to eight ventilated tires are stacked around the tripod, and the rods are bent over the top tire (Fig. 10). The eight-tire unit often attracts large bottom fishes as well as some pelagic species, such as Spanish mackerel, bluefish, Atlantic spadefish, and greater amberjack (Fig. 11). The interior of the unit also provides shelter for many bottom species. The main disadvantages of the unit are the difficulty in transporting, since it weighs over 300 pounds, and the eventual failure of the reinforcing rods through corrosion. This unit should be used only in protected or deep water where wave surge and currents are not great enough to break apart the units and scatter the broken material. A safety line or band of noncorrosive material, e.g., nylon, securing the ventilated tires to the concrete filled base tire, will considerably reduce the chance of this unit breaking apart. The line or

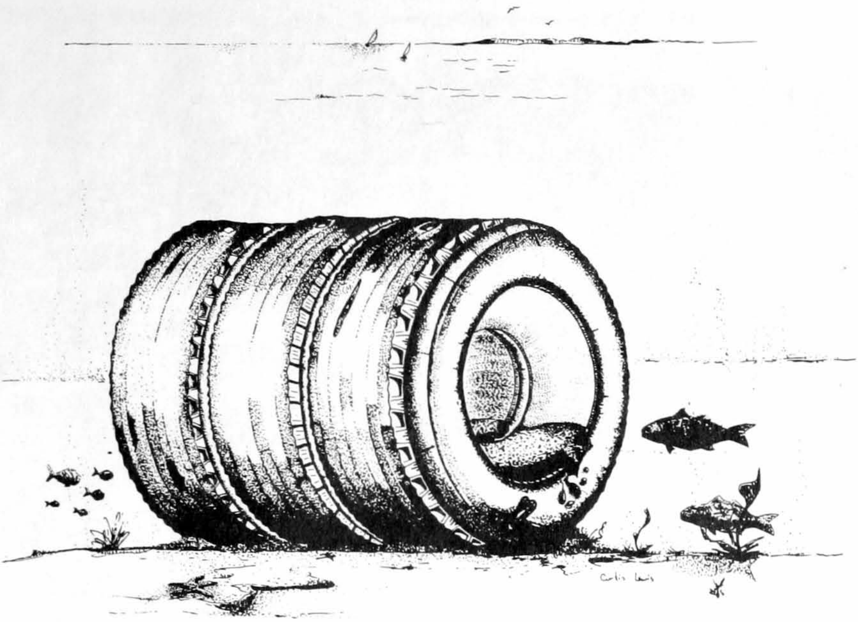


Figure 8.—One method of assembling a three-tire unit is by pouring concrete around a metal rod pinning three vented tires together.

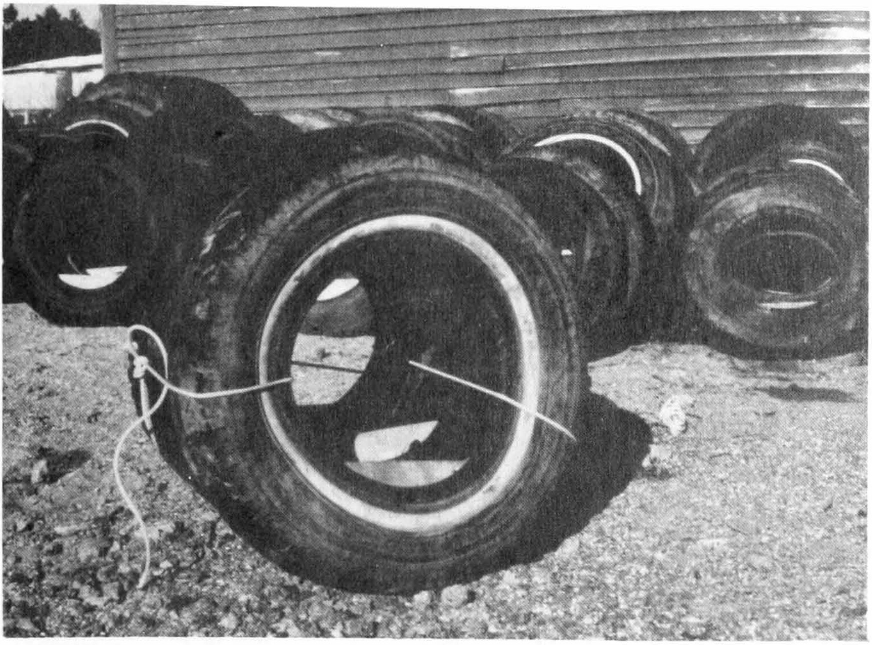
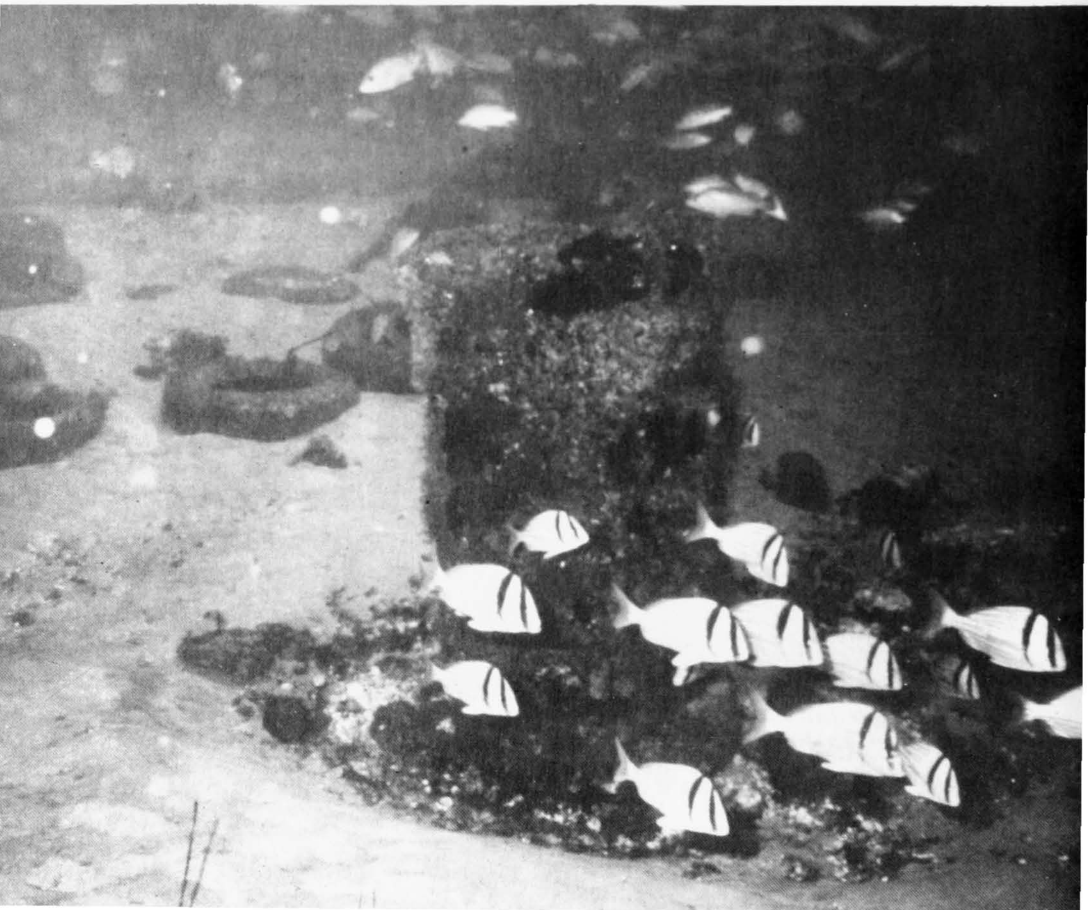


Figure 9.—The three-tire unit can also be assembled by tying three weighted and vented tires together with nylon line.

Figure 10.—Eight-tire units are quickly constructed by assembly-line techniques.

Figure 11.—Eight-tire units provide relief and protected ares required for a successful reef.



band should be inserted through the base tire before the concrete is poured.

Ten-tire bale: This unit is constructed with a tire baler (Fig. 12). The daily output for a two-man crew averages 100 bales. The unit consists of 5 to 12 tires compressed into a bale about 1.5 feet high. It is held together with two or three metal bands and with one plastic band or a ¼-inch polypropylene line. The plastic band or line holds the tires together but also allows them to expand into a fan-shaped array on the bottom once the metal bands corrode and break. The units can be weighted with concrete or they can be held in place on

Figure 12.—The ten-tire bale is assembled by compressing ten tires into a bale, which is held together by steel and plastic bands.

the bottom by stringing them on chain or cable. Stringing the units still permits them to expand when the metal bands break. The units weighted with concrete, however, are normally banded with four plastic bands so they will retain their original shape on the bottom. The expanded unit offers excellent access for fishes to numerous small compartments inside and between the tires. This unit is still being evaluated, but initial tests by South Carolina Wildlife Resources Department indicate that it can be used successfully in many areas. One company offers a baler with cutting blades attached, which eliminates the labor normally required to ventilate the tires. A pneumatic punch also has been developed to facilitate ventilating the tires (Fig. 4). Addresses of those who can supply more information about tire balers and pneumatic punches are listed in Appendix VIII.

Tire bead unit: This unit, developed by Emerson Frost,[4] includes several vented tires, each with the steel reinforced bead cut away from half of the inside ring of one side of the tire (Fig. 13). The loop of bead of one tire is passed through the center of another tire. The cutaway bead of that tire then is passed through the first loop and on through the center of another tire. This technique can be used to develop any length unit desired. The terminus can be half a tire if the unit is placed in protected waters or an anchor weight if the reef site is in open waters. The unit will provide 2 to 3 feet of profile and many small compartments accessible to fishes and invertibrates. The rubber covering on the steel bead will prevent it from corroding and no bands or ropes are needed.

Another easy and effective way to use tires is to chain or cable them to a vessel that is to be sunk as part of an artificial reef. The ship acts as an anchor for the tires while the tires add considerable habitat for fishes in and around the ship.

Cars

Cars do not serve as ideal reef material for several reasons. First, pollutants, such as gasoline, oil, copper, lead, and floatable materials, must be removed. Second, they are bulky to handle, and require a crane and barge for loading, transporting, and offloading (Fig. 14). Third, they must be cabled together in groups of two or more so they will not move during severe storms. Fourth, although car bodies ini-

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[4]Emerson Frost is a member of the Artificial Reef Comittee of New Jersey (P.O. Box 88, Freehold, NJ 07728).

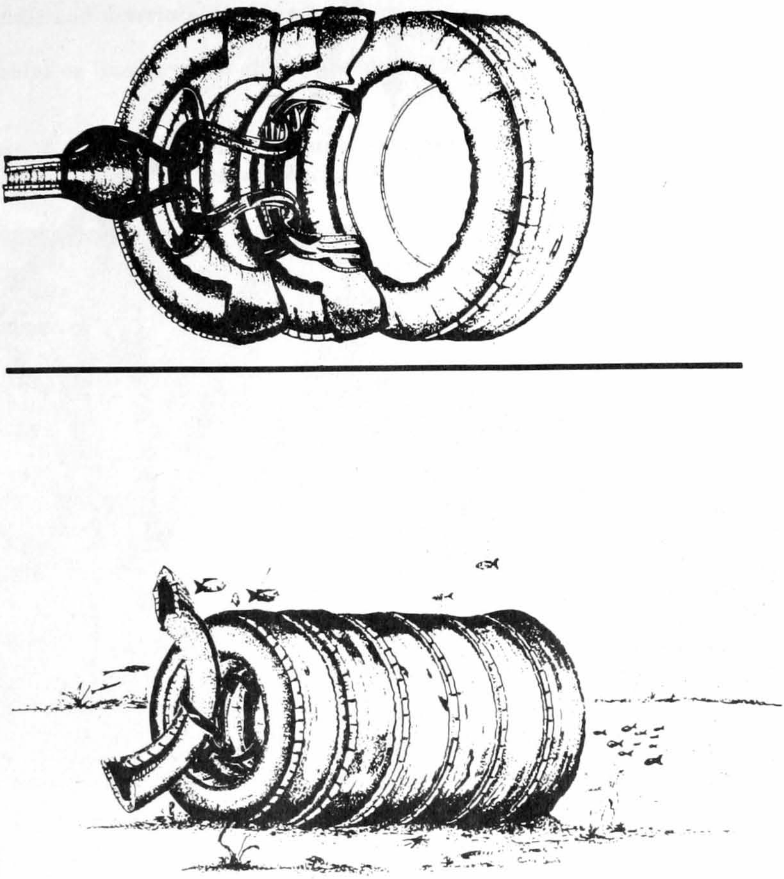


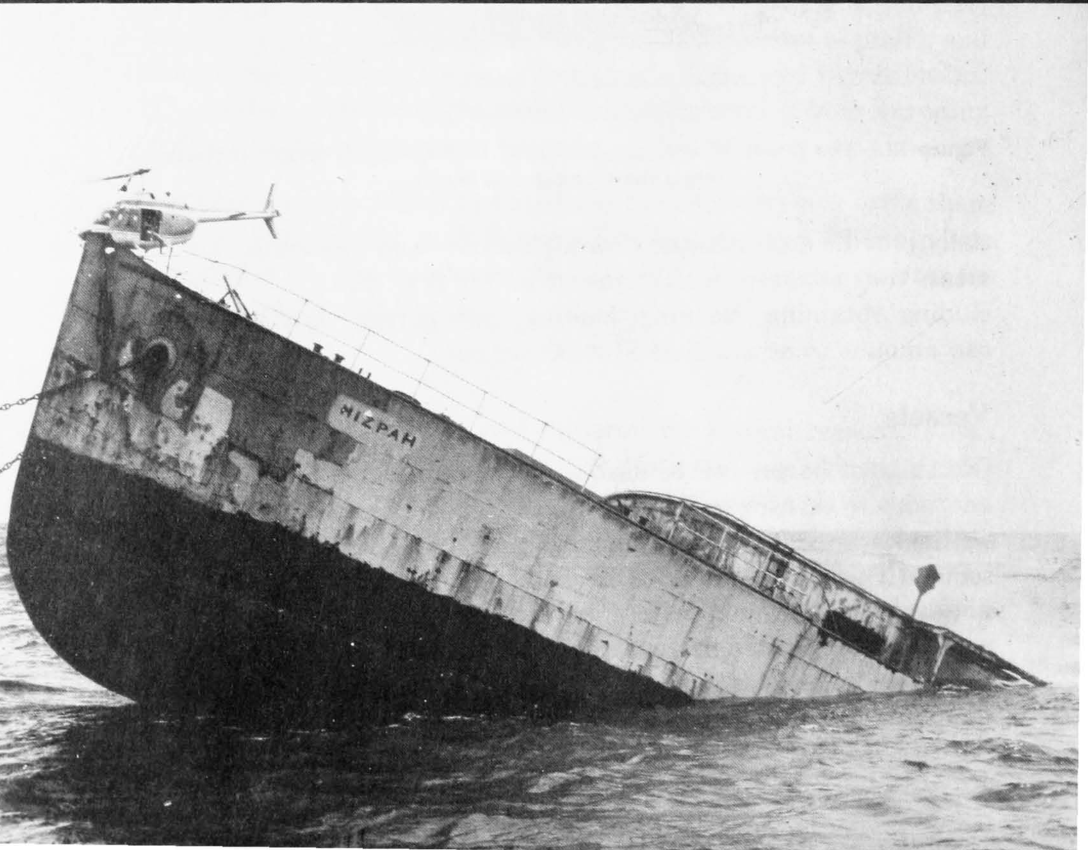
Figure 13.—The tire-bead unit provides good habitat and is simple to assemble when the technique is learned.

tially provide good habitat with high profile and numerous sheltered areas, they collapse from corrosion in 3 to 6 yr. Fifth, total cost, including obtaining, cleaning, loading, transporting, and off-loading, can amount to as much as $100.00 per car.

Vessels

Old ships or barges can be used as new reef material and as effective additions to existing reefs (Figs. 15, 16). The high profile produces upwellings and eddy currents which attract schools of baitfish and subsequently pelagic predators. Old ships that can be towed, however, are not easy to obtain and pollutants, such as gasoline, oil, copper, lead, and floatable materials must be removed. If barges are available, numerous large holes should be cut in the deck and bulkheads to make them more accessible to fishes. Wooden vessels, except well-ballasted,


DIVER


MIZPAH

e 14.—Discarded cars initially provide good habitat, but they are expensive to handle and deteriorate within 3 to 6 yr.

e 15.—Old ships or barges make effective additions to reefs.

Figure 16.—Vessels are used for protection and orientation, and they provide high profile that usually attracts schools of bait and pelagic game fishes.

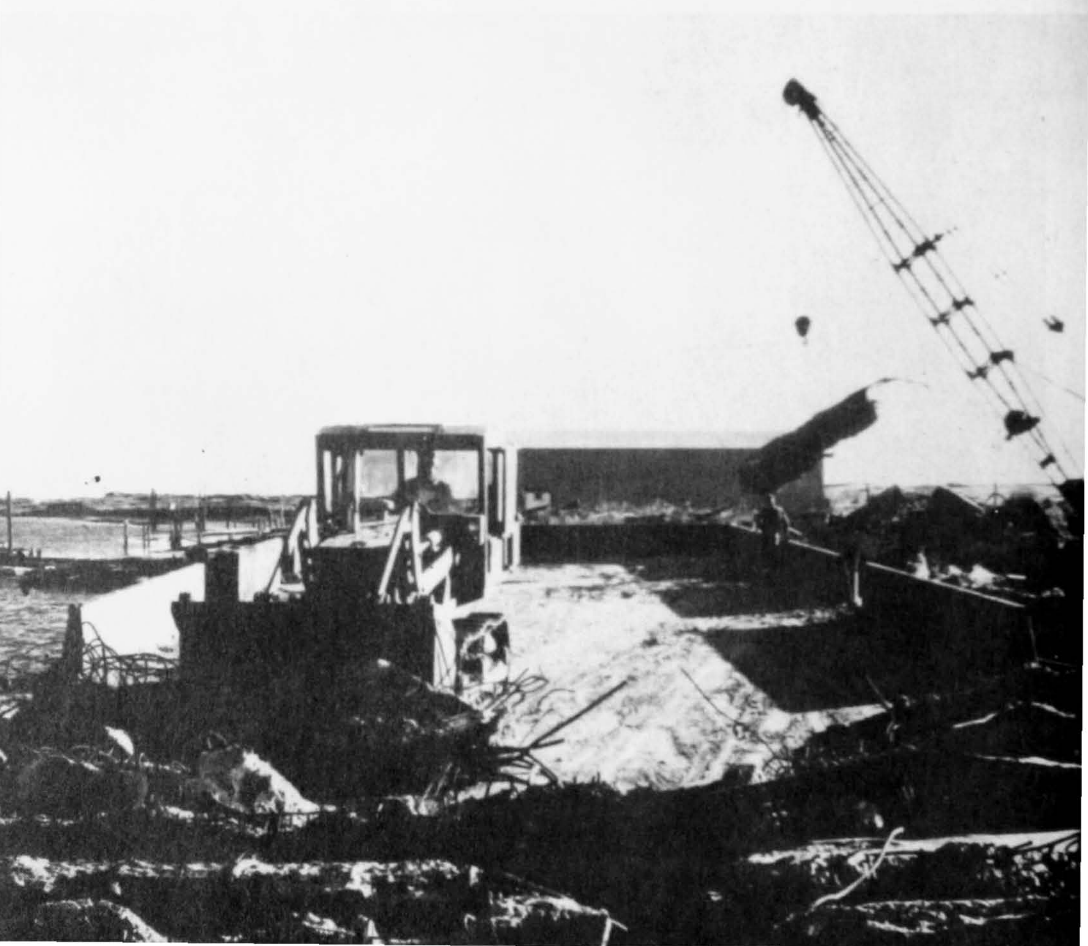
heavy-duty barges, are not good reef material. They are difficult to sink and maintain in place on the bottom, and they collapse rapidly from the effect of wave action and marine borers.

Surplus government vessels become available occasionally. For example, Public Law 92-402, provided Liberty ships to States for artificial reefs. Applications were required from the governor or his designated representative to the Secretary of Commerce (Appendix IX). Although Liberty ships on the East and Gulf coasts have been requested, other surplus government vessels could become available.

Rock, Concrete, Brick, and Tile

Rock, concrete, brick, and tile make excellent habitat and will last indefinitely. These materials, however, are difficult and usually costly to handle and transport (Table 1). Their use requires heavy equipment such as a crane, bulldozer, truck, barge, and tugboat for loading,

Figure 17.—Concrete rubble requires a heavy-duty crane, bulldozer, and barge for handling and transporting.



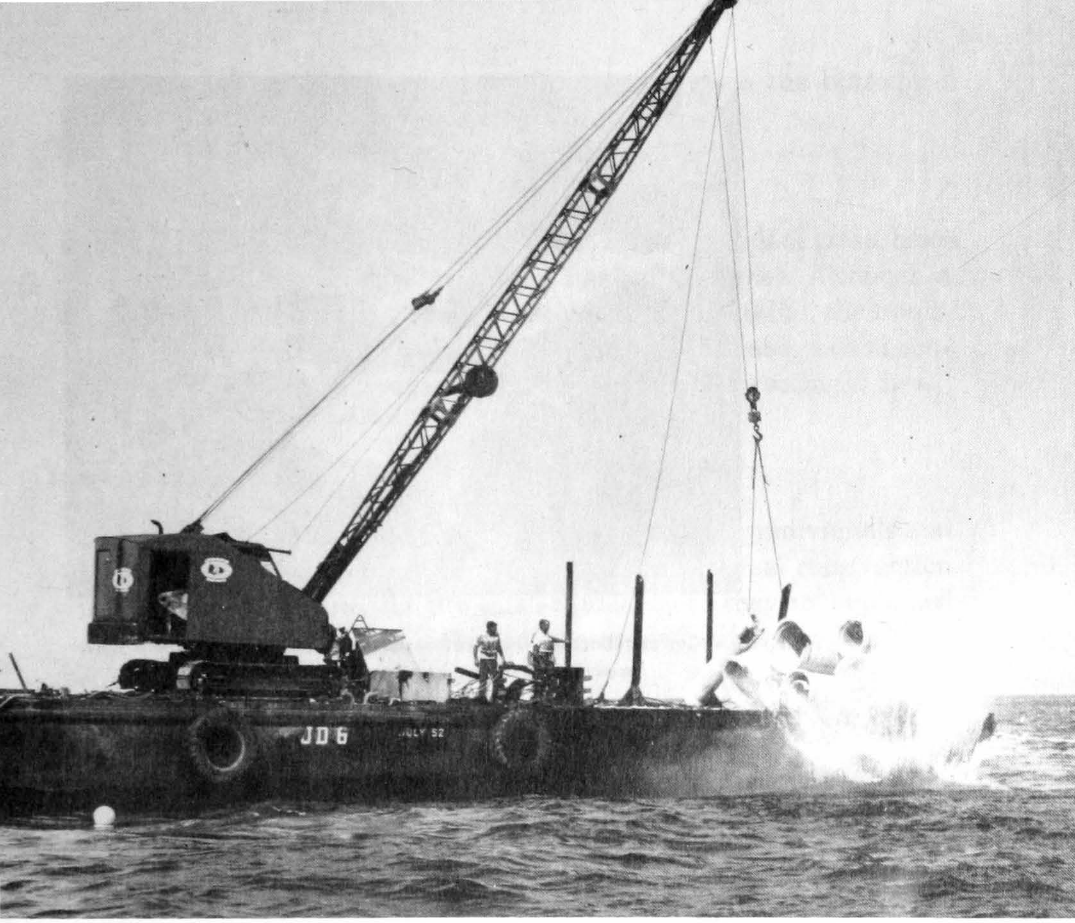


Figure 18.—Concrete culverts are difficult and expensive to handle.

transporting, and unloading (Figs. 17, 18). Occasionally, companies with disposal problems will dump rubble on reef sites without charge. Large pieces of rock or concrete material are more effective in attracting game fishes than small pieces and are less likely to be covered by shifting sediment (Fig. 19).

Prefabricated Shelters

Prefabricted materials, such as Ero-jacks, used for bulkheads and jetties, also make excellent habitat but they too are costly to handle and transport, and they are expensive to make (Fig. 20, Table 1). Concrete shelters, developed by the Japanese and modified by the California Department of Fish and Game, cost $140.00 to put on the bottom in 1960. Each unit is 5 × 8 × 2.5 feet, with walls 2 inches thick and holes 15 inches in diameter, and weighs 1 ton (Fig. 21). There is a partition in the center of the block for strength. To obtain the most

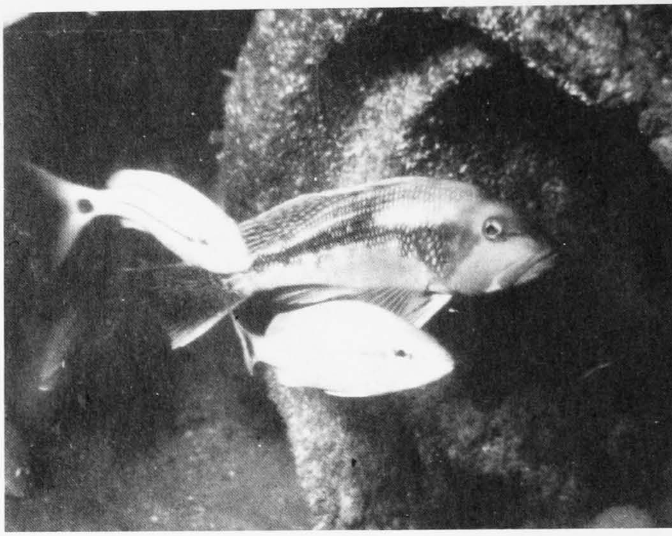


Figure 19.—On the bottom, concrete culverts are stable and provide excellent habitat.

benefit from the blocks, they should be stacked on the bottom, a process that can be directed by divers.

Artificial Seaweed

Mats, with floating plastic streamers that resemble beds of grass, have also been used to provide additional habitat for fishes. Although a variety of organisms are initially attracted to this material, the fronds usually collapse from the weight of the encrusting organisms and considerably reduce effectiveness of the material for attracting fishes.

SUMMARY

Careful planning and the cooperative efforts of many individuals and organizations are the keys to a successful artificial reef construction program. Reef construction projects are ideal when they are organized and funded by States, but if this is not possible local groups can build effective reefs.

Artificial reefs should be located within easy and safe access of

e 20.—Ero-jacks, designed to prevent beach erosion, make good reef materials.

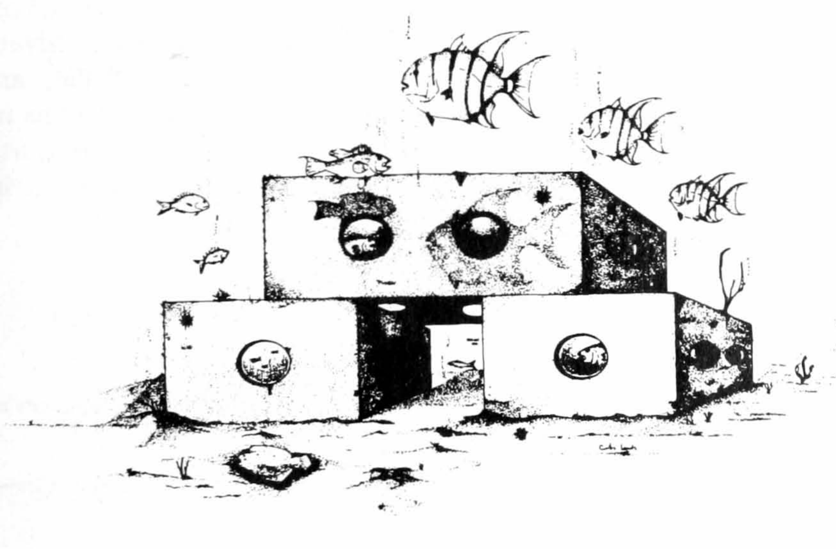


Figure 21.—Although prefabricated concrete shelters make excellent habitat, they are expensive and difficult to handle.

fishermen. They should be placed on firm bottom in areas without strong currents and wave action, allow unimpeded navigation, and not interfere with other user groups. Artificial reefs are accessible to the general boating public, including head and charter boats, spearfishmen, and commercial interests, unless otherwise legislated and enforced. Permits to build reefs are required by the Corps of Engineers and most State governments. At least two buoys should be placed on the reef site prior to construction.

Reef material must be durable, readily available, require minimum preparation costs, and remain in place on the bottom. Consideration also must be given to angler preference for certain fishes. High profile reefs are effective because they attract surface and midwater fishes, as well as bottom-dwelling species. Reefs can be built from rubble, steel vessels, automobile and truck tires, concrete culverts, rock, and concrete fish shelters. Automobiles, streetcars, wooden vessels, and household appliances have been used but are not recommended because they are difficult to prepare and transport, and sometimes drift away from the reef site. Cost of procurement, preparation, transportation, and implacement often determines the material used to build reefs. At most locations, reefs will be composites of different materials as they become available.

ACKNOWLEDGMENTS

We wish to express our appreciation to Chester Zawacki, New York State Department of Environmental Conservation, Dewitt Myatt, South Carolina Wildlife and Marine Resources Department, and Larry Smith, Georgia Department of Naturual Resources, for the information and pictures they provided. We also wish to thank Curtis Lewis, Atlantic Estuarine Fisheries Center, National Marine Fisheries Service, NOAA, for his excellent illustrations.

LITERATURE CITED

Buchanan, C. C.

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

Carlisle, J. G., Jr., C. H. Turner, and E. E. Ebert.

1964. Artificial habitat in the marine environment. Calif. Dep. Fish Game, Fish Bull. 124, 93 p.

Edmond, L.

1960. Marine habitat improvement in Japan. Foreign Service Despatch No. 180 (4 p.). American Embassy, Tokyo, Department of State, Wash., D.C. (Aug. 15).

Hobson, E. S.
1968. Predatory behavior of some shore fishes in the Gulf of California. U.S. Fish Wildl. Serv., Res. Rep. 73, 92 p.
Holbrook, J. E.
1860. Ichthyology of South Carolina. 2nd ed. Charleston, 205 p.
Klima, E. F., and D. A. Wickham.
1971. Attraction of coastal pelagic fishes with artificial structures. Trans. Am. Fish. Soc. 100:86-99.
Randall, J. E.
1963. An analysis of the fish populations of artificial and natural reefs in the Virgin Islands. Caribb. J. Sci. 3:31-47.
Starck, W. A., and W. P. Davis.
1966. Night habits of fishes of Alligator Reef, Florida. Ichthyol. Aquarium J. 38:313-355.
Steimle, F. W., Jr., and R. B. Stone
1973. Bibliography on artificial reefs. Coastal Plains Center for Marine Development Services, Wilmington, N.C., 129 p.
Stone, R. B.
1972a. Artificial reefs of waste material for habitat improvement. Mar. Pollut. Bull. 3:27-28.
1972b. General introduction to artificial reefs. *In* Proceedings of sport fishing seminar, Nov. 18-19, 1971, Jekyll Island, Ga., p. 1-3. Coastal Plains Cent., Semin. Ser. 1.
Stone, R. B., and C. C. Buchanan.
1970. Old tires make new fishing reefs. Underwater Nat. 6(4):23-28.
Turner, C. H., E. E. Ebert, and R. R. Given.
1969. Man-made reef ecology. Calif. Dep. Fish Game, Fish Bull. 146, 221 p.
Unger, I.
1966. Artificial reefs—A review. Am. Littoral Soc., Spec. Publ. 4, 74 p.
Wickham, D. A., J. W. Watson, Jr., and L. H. Ogren.
1973. The efficacy of midwater artificial structures for attracting pelagic sport fish. Trans. Am. Fish. Soc. 102:563-572.
Zawacki, C. S.
1971. An ecological study of the utility of auto tires as an artificial reef substrate. Masters Thesis, Long Island Univ., 75 p.

APPENDIX I

REQUIREMENTS FOR A DEPARTMENT OF THE ARMY PERMIT TO CONSTRUCT ARTIFICIAL REEFS IN THE NAVIGABLE WATERS OF THE UNITED STATES

1. The Application.

a. The application form can be obtained from any local District office. It should be completed and signed by the person responsible for the reef. Where the applicant is a private organization or State or local governmental agency, the proper official of the organization or governmental agency should sign the application.

b. The application, accompanied by plans showing the proposed work, should be forwarded to the District Engineer.

2. The Plans.

a. Five copies of the plans (8 by 10½ inches in size) are required to be submitted with the application.

b. The exact location and size of the proposed reef should be carefully determined and shown on the plans.

c. The center of the reef should be located by distance and bearing from at least two definite well-known points on shore.

d. The plans should contain a typical section showing depth of water at the site and clearance over top of the proposed reef at mean low water.

e. Information as to type of material to be used in construction of the reef should be shown on the plans.

f. Each sheet of plans should contain a simple title, mentioning the proposed work, name of the waterway, general location, name of applicant, date, and number of sheet.

g. In most cases, buoys will be required at the reef site. The location of buoys in relation to the reef should be indicated on the plans. A typical elevation view of the buoys to be used should also be shown. (See typical application drawing attached hereto.)

3. General Criteria.

a. That no artificial reefs will be authorized in natural or improved channels and fairways in general use for navigation.

b. That the depths of water over proposed artificial reefs shall not be less than 50 feet below the plane of mean low water where depths in the vicinity generally exceed this depth.

c. That if deposition of material is authorized in areas limited by large shoals, depth of water over the material below the plane of mean low water shall not be generally less than the least depth of water over such shoal.

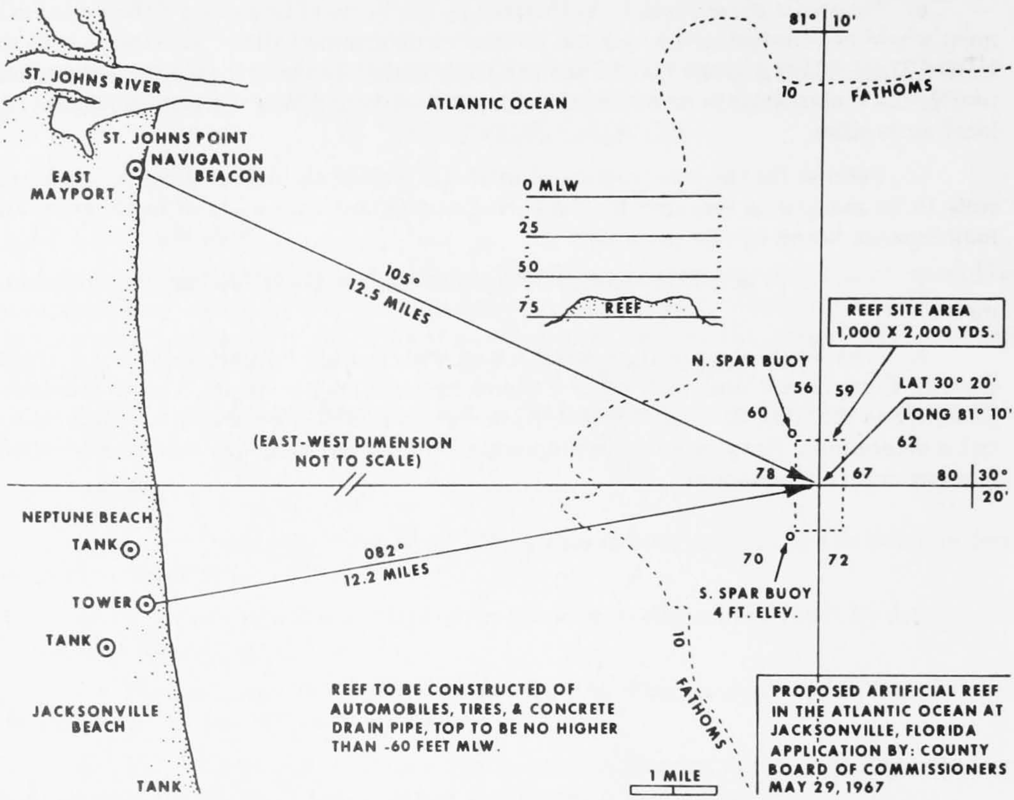
d. That the materials used in constructing artificial reefs shall be restricted to heavy nonfloatable materials.

e. No artificial reefs will be authorized by the Corps of Engineers if their establishment would be inimical to the national interest as determined after consultation with the United States Navy and the United States Coast Guard. Approval for a proposed application for the construction of an artificial reef must be obtained from the pertinent State and local authorities.

f. Permits for the construction of artificial reefs shall include a condition for the reefs to be marked as required by the U.S. Coast Guard with costs of installation and maintenance borne by the permittee.

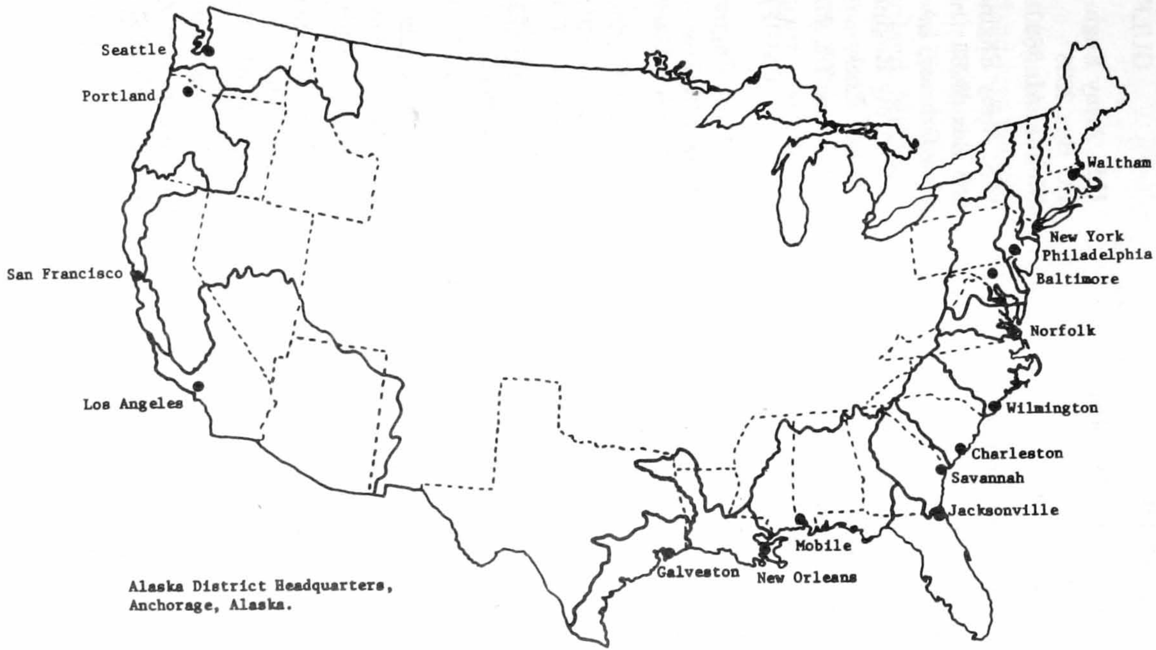
g. The above notwithstanding, all applications will be decided on their individual merit.

h. The application will be coordinated with the appropriate local Coast Guard District Commander and with other Federal agencies as necessary. The Commander, Eastern Sea Frontier, 90 Church Street, New York, NY 14303, has been given responsibility for determining Navy interests in proposed modifications to navigable waters along the Eastern and Gulf seaboard.


ST. JOHNS RIVER
ATLANTIC OCEAN
81° 10'
10 FATHOMS
ST. JOHNS POINT
NAVIGATION
BEACON
EAST
MAYPORT
0 MLW
25
50
75
REEF
105°
12.5 MILES
REEF SITE AREA
1,000 X 2,000 YDS.
N. SPAR BUOY
56
59
60
LAT 30° 20'
LONG 81° 10'
62
(EAST-WEST DIMENSION
NOT TO SCALE)
78
67
80
30°
20'
NEPTUNE BEACH
TANK
082°
12.2 MILES
70
72
TOWER
S. SPAR BUOY
4 FT. ELEV.
TANK
10 FATHOMS
REEF TO BE CONSTRUCTED OF
AUTOMOBILES, TIRES, & CONCRETE
DRAIN PIPE, TOP TO BE NO HIGHER
THAN -60 FEET MLW.
JACKSONVILLE
BEACH
TANK
1 MILE
PROPOSED ARTIFICIAL REEF
IN THE ATLANTIC OCEAN AT
JACKSONVILLE, FLORIDA
APPLICATION BY: COUNTY
BOARD OF COMMISSIONERS
MAY 29, 1967

APPENDIX II

Corps of Engineers districts.



Alaska District Headquarters,
Anchorage, Alaska.

Hawaii District Headquarters,
Honolulu, Hawaii.

The Territory of Puerto Rico
and Adjacent Islands is Included
in Jacksonville District.

Legend
--- state boundaries
—— district boundaries

APPENDIX III

District offices of the Corps of Engineers.

ATLANTIC

U.S. Army Engineer Division
424 Trapelo Road
Waltham, MA 02154

U.S. Army Engineer District
26 Federal Plaza
New York, NY 10007

U.S. Army Engineer District
U.S. Custom House
2nd and Chestnut Street
Philadelphia, PA 19106

U.S. Army Engineer District
PO Box 1715
Baltimore, MD 21203

U.S. Army Engineer District
803 Front Street
Norfolk, VA 23510

U.S. Army Engineer District
PO Box 1890
Wilmington, NC 28401

U.S. Army Engineer District
PO Box 919
Charleston, SC 29402

U.S. Army Engineer District
PO Box 889
Savannah, GA 31402

U.S. Army Engineer District
PO Box 4970
Jacksonville, FL 32201

GULF

U.S. Army Engineer District
PO Box 2288
Mobile, AL 36601

U.S. Army Engineer District
PO Box 60267
New Orleans, LA 70160

U.S. Army Engineer District
PO Box 1229
Galveston, TX 77550

PACIFIC

U.S. Army Engineer District
PO Box 2711
Los Angeles, CA 90053

U.S. Army Engineer District
100 McAllister Street
San Francisco, CA 94102

U.S. Army Engineer District
PO Box 2946
Portland, OR 97208

U.S. Army Engineer District
1519 Alaskan Way South
Seattle, WA 98134

U.S. Army Engineer District
PO Box 7002
Anchorage, AK 99501

U.S. Army Engineer District
Building 96, Fort Armstrong
Honolulu, HI 96813

APPENDIX IV

Addresses of coastal State agencies that require reef permits.

ATLANTIC

Maine

Letter of approval from town counsel.
In Portland area obtain permit from:

Portland Harbor Master
State Pier, Commercial Street
Portland, ME 04101

Department of Environmental Protection
State House
Augusta, ME 04330

Massachusetts

For information regarding State permits contact:
Department of Natural Resources
100 Cambridge Street
Boston, MA 02202

New Hampshire

Fish and Game Department
34 Bridge Street
Concord, NH 03301

Special Board on Dredge and Fill
Room 205, State House Annex
Concord, NH 03301

Water Supply and Pollution Control Commission
PO Box 95, Prescott Park
105 Loudon Road
Concord, NH 03301

Connecticut

Department of Environmental Protection
State Office Building
Hartford, CT 06115

Rhode Island

Division of Coastal Resources
Department of Natural Resources
Veteran's Memorial Building
Providence, RI 02903

New York

Although state permits are not issued, the following agency is responsible for acquiring the Army Corps permits and requests that parties coordinate their activities with them.

Department of Environmental Conservation
Region I Coastal Resource Management
Building 40, State University of New York
Stony Brook, NY 11790

Delaware

State permit is not required, but please notify:
Office of the Director
Division of Fish and Wildlife
Dover, DE 19901

Virginia

Marine Resources Commission
PO Box 756
2401 West Avenue
Newport News, VA 23607

North Carolina

Division of Commercial and Sports Fisheries
Department of Conservation and Development
PO Box 769
Morehead City, NC 28557

South Carolina

Water Resources Commission
2414 Bull Street
Columbia, SC 29201

Georgia

Water Quality Control Unit
Department of Natural Resources
PO Box 1097
Brunswick, GA 31520

Florida

Trustees of the Internal Improvement Fund
Department of Natural Resources
Larson Building
Tallahassee, FL 32304

GULF

Alabama

Water Improvement Commission
State Office Building
Montgomery, AL 36104

Coastal Area Board
Development Office
Montgomery, AL 36104

Mississippi

Marine Resources Council
PO Box 497
Long Beach, MS 39560

Texas

Parks and Wildlife Department
John H. Reagan Building
Austin, TX 78701

PACIFIC

California

Requests for State permits should be coordinated through:

Department of Fish and Game
Marine Resources Region
350 Golden Shore
Long Beach, CA 90802

Oregon

For deposit of motor vehicles and accessories:

Department of Environmental Quality
1234 SW Morrison Street
Portland, OR 97205

Washington

Department of Ecology
Box 829
Olympia, WA 98501

OTHER

Puerto Rico

Department of Natural Resources
Box 5887
San Juan, PR 00906

Virgin Islands

The following agency prepares applications for the Governor of the Virgin Islands to submit to the Department of the Interior. The Department of the Interior issues a Submerged Lands Permit and assists in obtaining the Army Corps of Engineers Permit.

Bureau of Fish and Wildlife
Department of Conservation and Cultural Affairs
PO Box CTC
Charlotte Amalie, St. Thomas, VI

Hawaii

Harbors Division
Department of Transportation
PO Box 397
Honolulu, HI 96809
(Issues permit to perform work in the shore waters of the State.)

Department of Health
PO Box 3378
Honolulu, HI 96801
(Grants zones-of-mixing.)

Board of Land and Natural Resources
Department of Land and Natural Resources
PO Box 621
Honolulu, HI 96809
(Grants approval for use of lands zones "Conservation.")

Office of Environmental Quality Control
State Capitol, Room 436
Honolulu, HI 96813
(Coordinates and evaluates environmental projects and required Environmental Impact Statements.)

APPENDIX V

Addresses of U.S. Bureau of Outdoor Recreation State liaison officers.

Note: When more than one person is listed under a State, copies of all correspondence should be sent to the additional persons.

ATLANTIC

Maine

Lawrence Stuart, Commissioner
Department of Parks and Recreation
Statehouse
Augusta, ME 04301 — 207-289-3821

New Hampshire

George Gilman, Commissioner
Department of Resources and Economic Development
State House Annex
Concord, NH 03301 — 603-271-2411

Massachusetts

Arthur Brownell, Commissioner
Department of Natural Resources
State Office Building, Government Center
100 Cambridge Street
Boston, MA 02202 — 617-727-3163

Rhode Island

Edward C. Hayes, Jr., Acting Director
Department of Natural Resources
Veteran's Memorial Building
83 Park Street
Providence, RI 02903 — 401-277-2771

Connecticut

Dan W. Lufkin, Commissioner
State Department of Environmental Protection
State Office Building, Room 539
Hartford, CT 06115 — 203-566-4667

Ralph Adkins
State Department of Environmental Protection
State Office Building
Hartford, CT 06115 — 203-566-4667

New York

Alexander Aldrich, Commissioner
Office of Parks and Recreation
South Swan Street Building
Albany, NY 12223 — 518-474-0443

New Jersey

David J. Bardin, Commissioner
Department of Environmental Protection
Trenton, NJ 08625 — **609-292-2886**

Delaware

David R. Keifer, Director
State Planning Office
Thomas Collins Building
530 S DuPont Highway
Dover, DE 19901 — **302-736-1216**

Maryland

James B. Coulter, Secretary
Department of Natural Resources
State Office Building
Annapolis, MD 21404 — **301-267-5715**

Louis N. Phipps, Jr., Assistant Secretary
for Natural Resources for Capital Programs
State Office Building
Annapolis, MD 21404

District of Columbia

Joseph H. Cole, Director
DC Recreation Department
3149 Sixteenth Street, NW
Washington, DC 20010 — **202-628-6000**

Virginia

Rob R. Blackmore, Director
Commission of Outdoor Recreation
803 E. Broadstreet
Richmond, VA 23219

North Carolina

W. L. Bondurant
Secretary of Administration
Department of Administration
Raleigh, NC 27602 — **919-829-7232**

Richard Allen, Assistant to the Secretary
Department of Administration
Raleigh, NC 27602 — **919-829-2594**

James S. Stevens
Office of Recreation Resources
Department of Natural and Economic Resources
Raleigh, NC 27602 — **919-829-7701**

South Carolina

John A. May (Colonel), Director
Division of Outdoor Recreation
Department of Parks, Recreation and Tourism
PO Box 1358
Columbia, SC 29202 — **803-758-2111**

Georgia

Joe D. Tanner, Commissioner
State Department of Natural Resources
270 Washington Street, SW
Atlanta, GA 30334 — **404-656-3500**

Mr. Burt Weerts
State Department of Natural Resources
270 Washington Street, SW
Atlanta, GA 30334 — **404-656-3877**

Florida

Ney C. Landrum, Director
Division of Recreation and Parks
Department of Natural Resources
J. Edwin Larson Building
Tallahassee, FL 32304 — **904-488-6131**

GULF

Alabama

Claude D. Kelley, Commissioner
Department of Conservation and Natural Resources
Administrative Building
Montgomery, AL 36104 — **205-269-7221**

Mississippi

Rae Sanders, Outdoor Recreation Director
Mississippi Park System
Robert E. Lee Building
Jackson, MS 39201 — **601-354-6321**

Louisiana

Gilbert Charles Lagasse, Director
State Parks and Recreation Commission
Louisiana National Bank Building
150 N Third Street
Baton Rouge, LA 70801 — **504-389-5761**

Texas

Clayton Garrison, Executive Director
Parks and Wildlife Department
John H. Reagan Building
Austin, TX 78701 — **512-475-3117**

PACIFIC

California

William Penn Mott, Jr., Director
Department of Parks and Recreation
1416 Ninth Street, Room 1311
Sacramento, CA 95814 — **916-445-2358**

Oregon

George M. Baldwin, Administrator of Highways
State Highway Division
Room 300, State Highway Building
Salem, OR 97310 — **503-378-6388**

ATTENTION: David G. Talbot — **503-378-6305**

Kessler R. Cannon
Assistant to the Governor
Natural Resources
State Capitol—Room 109
Salem, OR 97310 — **503-378-3109**

Alaska

Theodore G. Smith, Director
Division of Parks
323 E Fourth Avenue
Anchorage, AK 99501 — **907-279-5577**

Edward J. Kramer
Resource Project Coordinator
Alaska Division of Parks
323 E Fourth Avenue
Anchorage, AK 99501

OTHER

Puerto Rico

Emilio Casellas, Administrator
Public Parks and Recreation Administration
PO Box 3207
San Juan, PR 00904 — **809-725-1966**

Hawaii

Shelly M. Mark (Dr.), Director
Department of Planning and Economic Development
State Capitol
Honolulu, HI 96813

American Samoa

Frank C. Mockler
Lt. Governor of American Samoa
Pago Pago, Tutuila
American Samoa 96920

Guam

Gerald S. A. Perez, Director
of Land Management and Executive Secretary
for the Territorial Planning Commission
Territory of Guam
Agana, GU 96910

Gregorio S. Perez, Deputy Director
of Land Management
Territory of Guam
Agana, GU 96910

APPENDIX VI

Addresses of companies that manufacture and custom build artificial reef buoys.

International Plastics, Inc.
Safety Guide Products Department
PO Box 278
Colwich, KS 67030

Tideland Signal Corporation
PO Box 52430
Houston, TX 77052

Ocean Supply, Inc.
7200 Avenue L.
PO Box 9546
Houston, TX 77011

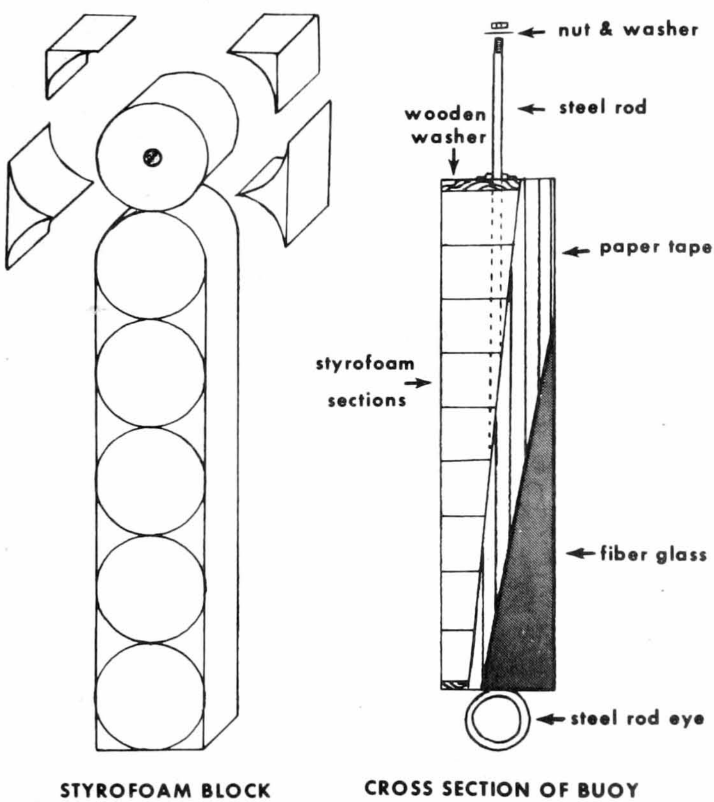
APPENDIX VII

Homemade spar buoy instruction.

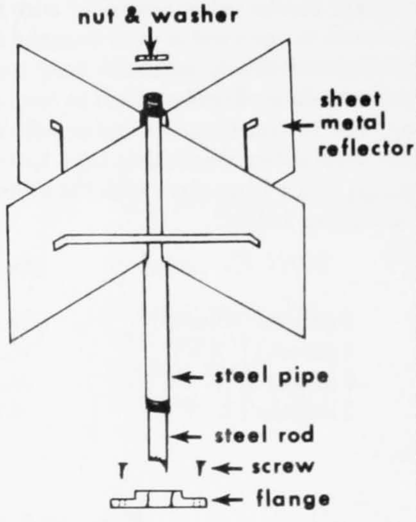
To construct a 6-foot spar buoy, nine cylinders 16 inches in diameter and 8 inches high are cut from styrofoam blocks using a straight wire heating element to melt the styrofoam. A heated ¾-inch rod is used to make center holes in the cylinders for the ¾-inch steel rod which holds the buoy together. One end of the ¾-inch rod is bent into a circle and spot-welded to form an eye. The rod should be about 8 feet long, but 10 feet long if a radar reflector is to be used. The styrofoam is wrapped with brown packaging tape before applying fiber glass. This prevents a reaction of the fiber glass with the styrofoam. Cost estimates for two spar buoys are given below:

		Retail
Fiber glass resin	2 gallons (colored)	$22.00
Fiber glass cloth	4 pieces (1′ × 8′)	16.00
Styrofoam block	3 pieces (8″ × 16″ × 8′)	90.00
Steel rods	2 lengths (¾″ × 8′)	6.00

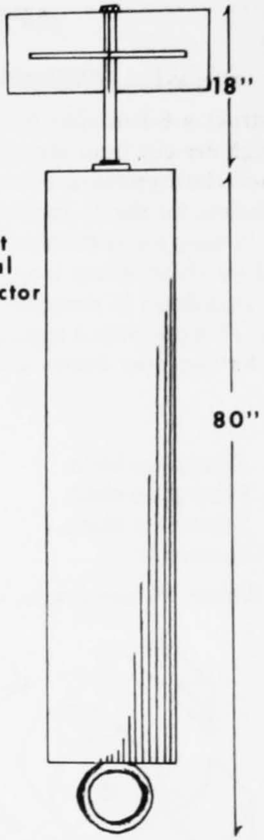
Labor: 16 man-hours.



A simple and durable spar buoy can be easily constructed from styrofoam and fiber glass.



RADAR REFLECTOR
(optional)



BUOY & RADAR REFLECTOR

A radar reflector attached to the buoy will enable vessels with radar to avoid the buoy even in poor visibility.

APPENDIX VIII

Addresses of companies that manufacture tire balers and pneumatic punches.

Bunch Tire Balers, Inc.
4728 SW Macadam
Portland, OR 97201

Goodyear Tire and Rubber Company
142 Goodyear Boulevard
Akron, OH 44316

APPENDIX IX

Letter application to U.S. Secretary of Commerce for transfer of Liberty ships pursuant to Public Law 92-402, approved August 22, 1972.

LETTER APPLICATION TO SECRETARY OF COMMERCE FOR TRANSFER OF LIBERTY SHIPS PURSUANT TO PUBLIC LAW 92-402 APPROVED AUGUST 22, 1972

PART I. *Applicant*

a. Name of applicant State

b. Name, title, address and telephone number (including area code) of Project Manager and/or Coordinator.

PART II. *Number of ships desired* (designate National Defense Reserve Fleet from which you will accept ships)

PART III. *Preparation of ships for sinking*

a. Name and address of party who will perform work.

b. Location where work will be done.

c. Complete description of preparation processes, with particular attention to:

1. Oil removal.
2. Tank cleaning method.
3. Disposal procedure of oil and other hazardous material removed from ship.
4. Intended removals, such as machinery, structural, electrical and pollutants, to prepare ship for sinking.
5. Intended disposal of above removals.
6. Nature, location and quantity of any substances remaining aboard, including tank cleaning compounds.
7. Provisions for inspection of preparation processes, and, by whom.
8. Detoxification process for hazardous materials.

PART IV. *Location where ships will be sunk*

a. Define geographical position by latitude/longitude (degrees, minutes and seconds) or bearing and distance from charted landmark, complete with annotated charts indicating orientation of ships in reef; reef dimentions, relationship of this application to past and future reef construction in general area.

b. Ocean conditions, including depth of water, bottom conditions in immediate and general area of proposed reef, depth of water over reef, current, and tidal conditions. Attention should also be given to the susceptibility of the area to large-scale wave or transport phenomena which might cover the reef structure with sand or otherwise limit its usefulness as a fishery resource. Give weather information as it affects water movements and coastal energy levels seasonally and cyclically.

c. Effects of reef on other uses of area including: navigation considerations, including modifications of existing channels and procedure to States to ensure nautical chart corrections; interference with commercial fishing; and uses of the area which will be curtailed by reef building, including commercial, recreational, and aesthetic uses; any enhancement of the area other than fishing benefits, likely to result from reef building. Locate and identify the following that exist or are contemplated, within a 20-mile radius of proposed reef site:

1. Submerged pipelines.
2. Transmission cables.
3. Coral reefs, recreation beaches, commercial fishing areas, and other sites having historic or cultural value.

PART V. *Describe procedure for sinking* (including in this description whether or not sinking is to be professionally supervised, and if so, by whom)

PART VI. *Method of marking location*

a. Type of buoy.
b. Charting.
c. Depth of water.
d. Buoy maintenance.
e. Minimum depth of water over sunken ship (or hulk) when in place.

PART VII. *Conservation goals*

a. Statement of Conservation Goals, immediate and long range.

b. Fisheries analysis, including a "with and without" reef study of:

1. Sports fishery benefits, including annual catch and worth; and

2. Ecosystem, including productivity, species diversity, and population dynamics.

PART VIII. *Estimated time of completion of reef construction.*

PART IX. Attach a certificate from the Administrator, Environmental Protection Agency that the proposed use of the particular vessels requested will be compatible with water quality standards and other environmental protection requirements.

PART X. Attach an Environmental Impact Statement, discussing fully items (i)-(v) listed in 42 U.S.C. 4332(2) (C) [P.L. 91-190, Title I, section 102(2) (C)].

The attached Certification is a part of and must be attached to the application.

ADDITIONAL INSTRUCTIONS

1. Mail the original and two copies of completed application form to the Maritime Administration, Attention: Code M-743, Washington, D.C. 20235.

2. Mail one copy of the application to the cognizant Environmental Protection Agency Regional Director for his comments, and for forwarding to the Administrator, Environmental Protection Agency, Attention: Mr. Armand Lepage, Office of Federal Activities, Waterside Mall, Room 537, Washington, DC 20460.

3. Mail one copy of the application to each of the addressees listed below:

   Department of Defense
   Attn: Captain William H. Self, USN
   Op 404C—Pentagon
   Washington, DC 20301

   Department of the Interior
   Office of the Assistant Secretary
   Attn: Mr. Richard Waller
   Washington, DC 20240

   Department of Transportation
   U.S. Coast Guard
   Attn: Commander Daniel B. Charter, Jr.
   400 7th Street, S.W.
   Washington, DC 20591

   National Oceanic and Atmospheric Administration
   Department of Commerce
   Attn: Captain John Boyer
   National Ocean Survey
   Rockville, MD 20852

CERTIFICATION

The undersigned, ______________________________

(Name of applicant State)

____

(Mailing address)

hereby applies for the transfer of __________ Liberty ship(s) pursuant to
(Number)
the provisions of Public Law 92-402, approved August 22, 1972, for sinking and use of the ship solely as an offshore artificial reef for the conservation of marine life. Said State Gives its assurance to the Secretary of Commerce that the transferred ship(s) will be properly charted when sunk; and agrees to comply with the terms and conditions as stated in fulfillment of the provisions of Public Law 92-402. Said State further agrees to accept the Liberty ship(s) allocated, fleetside at the National Defense Reserve Fleet in an "as is/where is" condition at no cost to the Federal Government, and to remove such ship(s) on the date to be agreed upon later.

Execution

IN WITNESS WHEREOF this application has been duly executed at __

__________________ *this* __________ *day of* __________ *, 1973.*

____

(Name of State)

By ______________________________

(Signature and title of authorized official)

In addition to information required by the bill, the Department of the Interior suggests that the application also include: 1) within a 20-mile radius of the proposed reef site the locations of a) submerged pipelines and transmission cables, existent or contemplated at the time of application and b) coral reefs, recreation beaches, commercial fishing areas and other sites having historic or cultural value, and 2) a detailed description of the regional physical environment to include data on water current directions and velocities, weather information as it affects water movements and coastal energy levels, seasonally and cyclically.

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