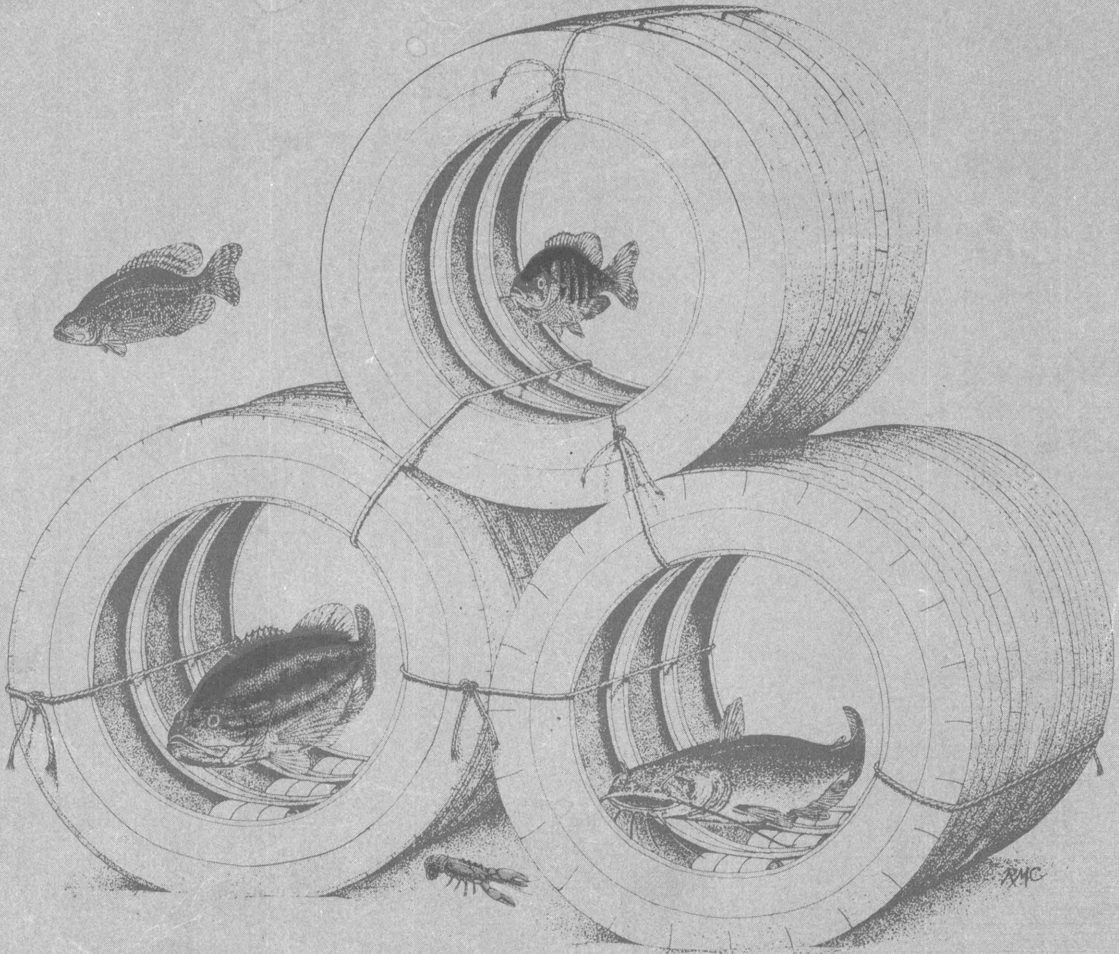
how to build a freshwater artificial reef



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FOREWORD

Construction of artificial reefs in marine waters is a popular method of improving saltwater sport fishing. Much has been published about artificial reefs and reef-building (Frank Steimle and Richard B. Stone (1) have compiled a voluminous bibliography concerning the subject). Parker, Stone, Buchanan, and Steimle of the National Marine Fisheries Service have recently completed *How to Build a Marine Artificial Reef* (2), as an aid in planning and constructing artificial reefs in marine environments.

Fishing in lakes, reservoirs, and ponds could possibly be improved, as well, by proper use of artificial reefs. However, the freshwater reef builder is confronted with somewhat different problems than those encountered in marine water. The purpose of this publication is to offer guidelines for planning and constructing artificial reefs in freshwater environments.

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Paul Brouha* and Eric D. Prince*

HISTORY OF ARTIFICIAL REEFS

An artificial reef may be described as any collection of rigid structures placed close together in an aquatic environment to improve fish habitat. Some authors, Wilbur (3) and Davis (4), refer to freshwater artificial reefs as fish attractors or fish hides. Artificial reef is a more descriptive term, since reefs may serve as spawning habitat, shelter, and a source of food, as well as simply fish attractors.

Because the amount of favorable habitat may be a limiting factor in some freshwater fisheries, the addition of artificial reefs is becoming a potentially useful tool in fisheries management. The idea of improving fish habitat by building artificial reefs is not new. For centuries Japanese commercial fishermen have successfully used various types of structures to concentrate fish in marine waters. Unger (5) gives a historical review of saltwater reef projects that traces their increase in popularity. Most coastal states and territories in the United States have constructed artificial reefs in marine waters.

Many of the lakes, reservoirs, and ponds that lack favorable habitat for fishes could also possibly benefit from installation of artificial reefs. For instance, lack of fish cover in reservoirs is frequently a result of one or two factors; 1) where clearcutting of shallow water areas prior to impoundment of waters has reduced navigational hazards, or 2) in older reservoirs where brush has deteriorated past the point of providing sufficient shelter for fish.

Although the need for increased shelter has long been recognized, handling and maintenance costs of the classical construction material (brush) have restricted its use. Brush shelters, while not as durable as some of the other building materials, are good fish concentrators. Rodeheffer (6) found that brush shelters placed in Douglas Lake, Michigan, increased the average number of fish taken in seine hauls from 12 to 579. More recently, personnel from North Carolina (7) and Florida (8) conservation agencies obtained encouraging results with more durable reef materials (concrete blocks, clay pipe, and scrap tires).

The North Carolina study compared fishing success rates associated with tire shelters to fishing success rates from brush and control (open) areas. Tire shelters were found to provide significantly better fishing than the other areas. The Florida investigations showed that fishing success was significantly higher on brush structure than clay pipes, and both were significantly higher than control (open) areas. In Florida, the clay pipe and brush units were not heavily fished at first even though fishing success was high. Gradually, usage has increased, and at one point, even professional fishing guides used the shelters to provide good fishing for their clients. However, recent increases in water levels have provided additional habitat and use of these artificial structures has declined.

Although reefs have gained widespread acceptance as part of marine sport fisheries management and have been shown to be effective fish concentrators in freshwater, more detailed research is needed to adapt this potentially valuable tool for general use in freshwater fisheries management. The freshwater reef builder is confronted with somewhat different problems than those encountered in marine waters. Our purpose is to identify likely construction problems, consolidate available information on freshwater reefs, and offer guidelines for construction in freshwater.

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REEF-BUILDING GUIDELINES

Reef-building guidelines vary depending on habitat type (i.e., lakes, ponds, reservoirs). Artificial reefs have not often been used in rivers and our guidelines will be more appropriate for non-flowing waters. Since each body of water has its own unique characteristics and problems, the reef builder must use flexibility in adapting these guidelines to his particular situation.

Most of the inland waters that are accessible to the general public are state or municipally owned, and, as a result, we address ourselves mainly to problems in these waters. The owner of private waters (i.e., ponds) is not obligated to follow the procedures recommended for public areas; however, the same management principles apply and it would be to his advantage to seek the professional advice of his state conservation agency.

Biological and Physical Considerations

1. The need for reefs must be established. Reefs should be installed only after physical and biological surveys of the proposed area have been conducted by trained personnel. These surveys should determine whether cover and bottom relief are limiting factors to the desired fish species, and that habitat improvement using artificial reefs is appropriate.

Providing additional spawning sites, more shelter, and increasing food supplies may increase fish survival. However, in freshwater the use of reefs to increase size of fish populations may be unwarranted. In warm-water fisheries, differential survival rates, in conjunction with high reproductive potentials, often result in population imbalances. Such imbalances cause increased numbers of small stunted fish that are usually detrimental to the fishery. Artificial reefs must be planned to avoid aggravating potential or existing imbalances in fish populations.

2. Reef structures should be bulky, possess many cavities, and have several entrances. Reef structures that rise well above the bottom provide more shelter and surface area than do low-profile structures. Low-profile structures, however, may be better for shallow water and can be used to increase spawning area.

3. Selecting reef size and number of component structures is difficult. The reef should be large enough to attract a substantial number of fish, but as Wilbur (3) states, "how big is big enough". Marine studies have shown that intensive fishing pressure on reefs can deplete fish populations (C. C. Buchanan, personal communication, NMFS, Beauford, N.C.). Reefs should be large enough to support anticipated fishing pressure. Wilbur (3) recommends conservative installation practices and suggests a rule of thumb, "total reef acreage should not exceed .25% of the surface acreage (0.25 acres of reefs per 100 acres of lake)". He also suggests a maximum of three separate reef locations for waters 100 to 1000 acres in size. In waters larger than 1000 acres, Wilbur recommends no more than one location per 500 acres. We advocate simply building a reef in stages until the size is satisfactory to support the realized fishing pressure.

4. To be of greatest value, reefs should generally be located on hard substrate in barren littoral areas, away from other reefs and natural cover. In some instances, however, it may be advantageous to use reefs to increase the amount of favorable habitat already present, or to take advantage of a potential food source such as locating reefs near weed beds.

5. Where reefs must be built on soft mud bottoms or in places subject to siltation, component structures should rise high enough off the bottom to insure prolonged effectiveness.

6. Large water level changes may expose reef structures, thus creating boating hazards and detracting from the aesthetics of an area. Lakes or ponds with large fluctuations in water levels may therefore not be ideally suited for artificial reefs.

Legal Considerations

1. A permit to construct artificial reefs in navigable waters must be obtained from the U.S. Army Corps of Engineers. A letter of application signed by the person responsible for the reef should be submitted to the District Engineer, Corps of Engineers. The letter of application must be accompanied by a complete plan including exact location and size of the proposed reef. Clearance over the top of the reef at mean low water level must also be stated.

2. In navigable waters, reefs should be clearly marked with permanent buoys, as required by the U.S. Coast Guard. Buoys also assist sportsmen in locating the reef and aide its effective use.

3. Reefs should be constructed away from navigational channels. State, county, and municipal authorities should be consulted to insure complete compliance with laws.

4. Reefs should not be installed near hydroelectric turbine intakes.

5. Lake front property owners should be consulted before reefs are installed near their properties.

6. The owners of private waters are responsible for the safety of their premises and should mark any structures that present a hazard to swimmers or boaters.

Other Considerations

1. Potential benefits should be determined. Establish that the reef will provide enough hours of recreation to justify the time, effort, and cost of installation. In addition to providing recreation, Iverson (9) suggests that artificial reefs may have a future in fish farming or biomass production, but this has not yet been established.

2. Durable construction materials should be used. Artificial reefs with prolonged utility lower prorated costs.

3. Since a reef project requires a great amount of work, the planner should organize his labor force to get active participation over an extended time period. In a longlived project some people tend to lose interest more quickly than others. For this reason, a dynamic overseer is desirable to organize and maintain participation by the work force. Work incentives such as prizes, parties, or refreshments should be considered to keep participation high until the project is complete.

INTEREST GROUPS

The owners of fee-fishing areas must provide good fishing for their clients. Fishing dock operators and retail stores catering to fishermen should all be able to acquaint fishermen with good fishing spots to sell goods and services. Professional fishing guides must be able to provide clients with good fishing. Sportsman's clubs (fishing, scuba diving, etc.) may want to create fishing or diving hotspots for their members. Service clubs (Scouts, Kiwanis, Elks, Rotary) often get involved in projects to improve the environment. Federal and state fish and game agencies attempt to maintain and improve fishing. Municipal governments encourage and participate in many projects to improve recreational facilities. Because artificial reefs have the potential to concentrate fish, their construction in freshwater should be of special interest for all groups concerned and could provide substantial economic incentives for some.

COMMON MATERIALS AND DESIGNS OF ARTIFICIAL REEFS

Materials that have been used in freshwater include tires, brush, trees, concrete and clay pipes, cement blocks, stake beds, and car bodies. The decision regarding the selection of construction material and design depends on the cost of labor, availability of material and equipment (barges, cranes, etc.), and the amount of money allocated for the project. The cost of several reef structures has been estimated where it was possible to do so. No labor costs or transportation of material costs have been included because of the variation in these costs among different reef construction projects. If the reef becomes a community action project, sufficient manpower and materials may be donated to successfully complete the project with a small budget.

Tires

Scrap tires are available in large quantities and can be acquired at no cost. In some cases, artificial reef committees have been paid by the dealers to collect tires; this method costs some businesses less than other means of tire disposal. Scrap tires can be readily assembled into many different configurations. Tires are easy to ship to the construction site and to install. Since tires are inert, they will not rust, corrode, leach harmful toxicants, or decompose (Stone, Coston, Hoss and Cross; 10).

The construction of five types of tire units will be discussed. These units may be joined together with synthetic rope and anchored to the bottom. Many more configurations can be developed by imaginative reef builders.

1. Single tire unit as described by Stone and Buchanan (11).

Materials	*Costs*
Old tires (1 per unit)	Free (tire dealers)
No. 10 can	Free (restaurants)
Concrete	$0.07 per No. 10 can

Total estimated cost = $0.07 per unit

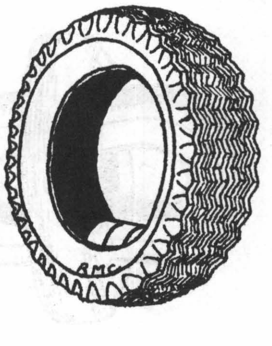

Figure 1. Single tire unit.

A No. 10 can filled with concrete is pushed between the sidewalls into the body of the tire as ballast. Two large air holes are drilled or cut in the tread portion opposite the can to allow escapement of trapped air. (Use of a 3/4" auger mounted in an electric drill is advised; frequent sharpening is necessary). The unit is then ready to be added to the reef.

2. Triangle unit as described by Prince and Brouha (12).

Materials	*Costs*
Old tires (3 per unit)	Free (tire dealers)
No. 10 can	Free (restaurants)
Concrete	\$0.07 per No. 10 can
1/4" polypropylene line	\$0.02 per foot
Total estimated cost = \$0.37 per unit	

Three tires are tightly lashed together to form a triangle of tires whose tread portions are in contact with the ground. One No. 10 can filled with concrete is forced between the sidewalls of one of the tires (two or three may be necessary if there is any current). To assure sinking, large holes are drilled through the tops of all three tires to allow escapement of air.

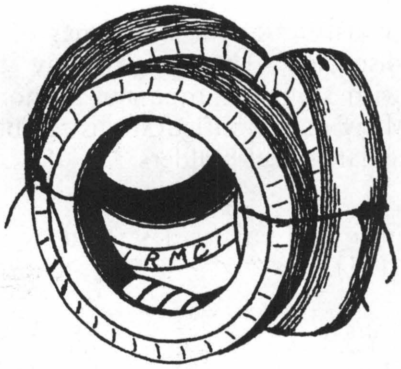

Figure 2. Triangle unit.

3. The tire chain unit after the method described by Davis (4)

Materials	*Costs*
Old tires (6 per unit)	Free (tire dealers)
Concrete	\$0.11 per gallon
1/4" polypropylene line	\$0.02 per foot
Total estimated cost = \$0.60 per unit	

After being drilled or slashed to allow escapement of air, six tires are connected to form a single unit. Five units are joined together by a polypropylene line to form a pyramid-shaped structure. Three concrete-filled tires are attached to one end of the line to serve as an anchor.

4. Pyramid Tire Unit after the method described by Prince and Brouha (12).

Materials	*Costs*
Old tires (9 per unit)	Free (tire dealers)
No. 10 can (6 per unit)	Free (restaurants)
Concrete	\$0.07 per No. 10 can
1/4" polypropylene line	\$0.02 per foot
Total estimated cost = \$1.22 per unit	

Three tires are put together to form a cylindrical assembly. Two of these three tire assemblies are then roped together to form a base of six tires. A third assembly is lashed on top of the middle of the base to form a pyramid. Six No. 10 cans filled with concrete are then forced between the side walls of the base tires to anchor the unit. The upper tread portions of all but the middle tire of the top assembly are drilled to allow escapement of air. The air trapped in the undrilled tire assures that the unit will sink to an upright position on the bottom.

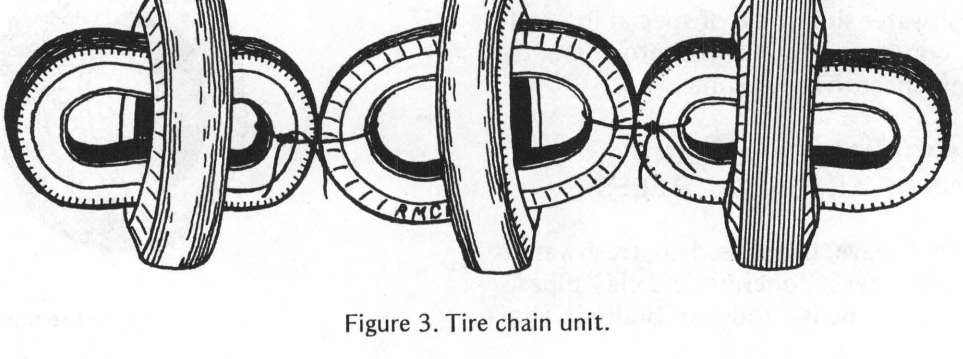

Figure 3. Tire chain unit.

5. A modification of the high-profile tire unit described by Prince and Lambert (13) was used by Prince and Brouha (12).

Materials	*Costs*
Old tires (13 per unit)	Free (tire dealers)
Concrete	$0.11 per gallon
1/2" Reinforcing bar (40 ft. per unit)	$0.10 per foot

Total estimated cost = $8.40 per 8-foot-high unit

A large truck tire is placed horizontally on flat ground. Four holes are drilled in the upper sidewall dividing the tire into quarters. The holes are then enlarged by cutting out a wedge toward the center of the tire with a saber saw (use knife blade insert). Four 10-foot pieces of reinforcing bar are each bent perpendicular 2 feet from their ends. These bent ends are pushed down through the holes, and opposite bars are welded together in center of the tire. The tire is then filled with concrete. The resulting base tire has four vertical rods rising from it (see drawing). Two tires are then drilled and slashed further with a saber saw to allow two rods to be driven through each. These tires are then threaded down the reinforcing rod parallel to each other above the base tire. Parallel tires are successively forced down the rods to form right angles with the tires below. A horizontal tire threaded over the ends of the rods is used to cap the structure (see drawing). The tips of the rods are bent to hold the tires in place. The completed unit weighs several hundred pounds and must be handled with the aid of heavy equipment. Units may be delivered to the reef site by floating platform or barge. (This unit differs from Prince and Lambert's in that no stabilizing tires are used. They are not necessary where the unit is not subjected to strong currents.)

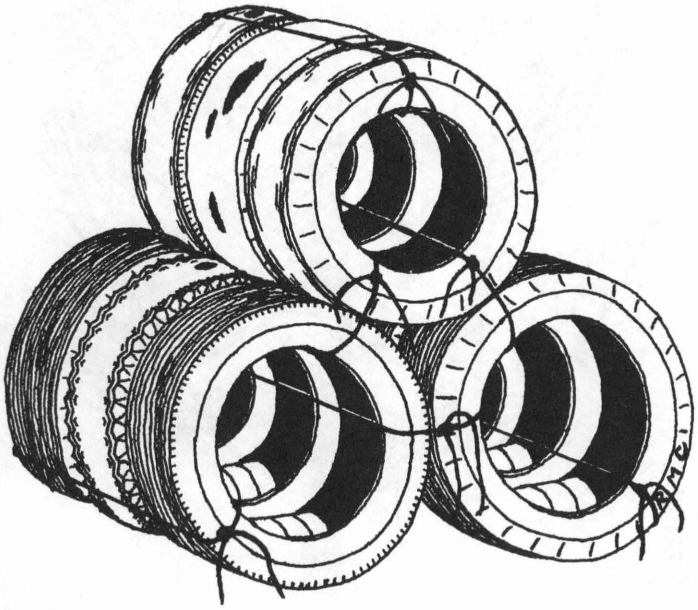

Figure 4. Pyramid tire unit.

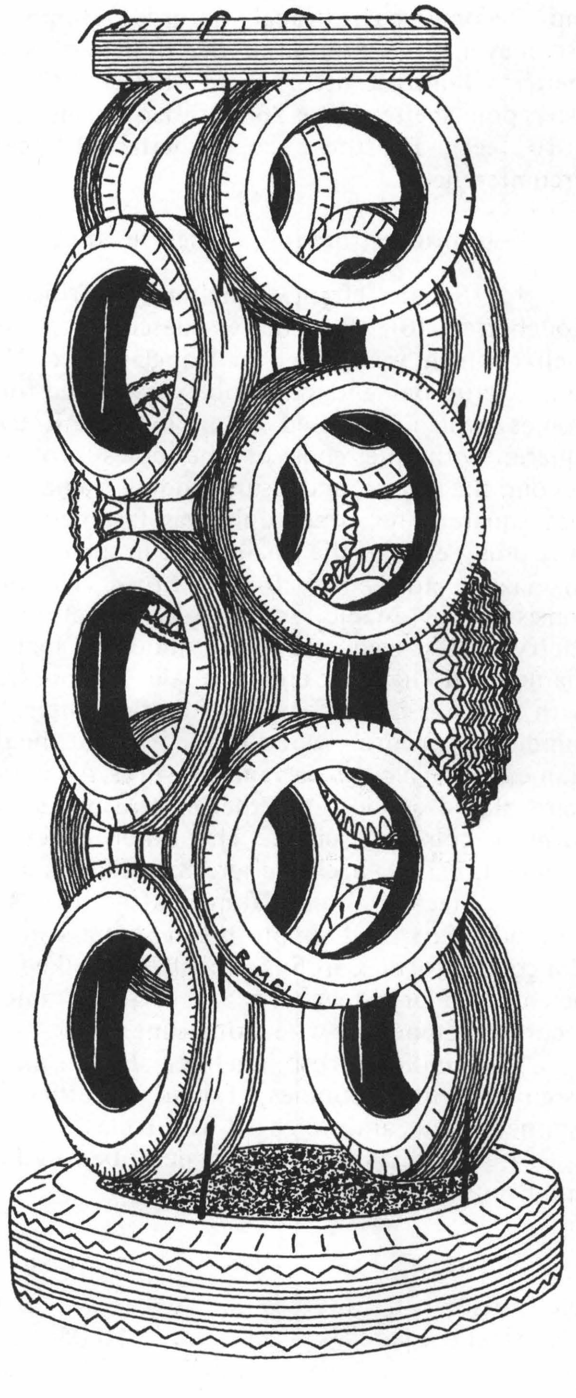

Figure 5. Modified high-profile tire unit.

Brush

As previously mentioned, brush, while usually available, is difficult to handle, and reef maintenance costs are high because brush is likely to deteriorate faster than more durable building materials. A design problem results from the nature of the material. The brush must be firmly attached to a frame or carefully bundled and well anchored. Unless such care is taken, pieces may float away and become navigational hazards. Hubbs and Eschmeyer (14) pioneered the design of several shelters: hollow-center square shelter (22 x 22 feet), pole shelter (18 x 26 feet), ladder shelter (14 x 16 feet), and the circular shelter (12 feet in circumference).

Four brush structures are described in detail.

1. Square frame shelter described by Rodeheffer (6). Rodeheffer describes a frame shelter which was placed in Douglas Lake, Michigan: "Scrub oak and maple poles were used for the frames, which consisted of an inner unit 9 feet square, with the ends of the poles protruding beyond the square, and a surrounding frame 11-1/2 feet square. The larger unit was fastened to the protruding ends of the smaller one in such a way as to make a sturdy base for the brush. The brush, consisting of maple, scrub oak, tag alder, and cherry, was placed in bundles about 18 inches in diameter at the butt end and laid on this frame, with the tops pointing away from the center. Each bundle was securely wired to the poles of the inner frame, with No. 9 galvanized wire. All bundles were placed as close together as possible, so as to form a complete circle. The outer edges were trimmed, making each shelter 18 feet in diameter."

2. Stacked brush frame after May's (7) method. May used simple brush shelters in Lake Concord, North Carolina. Brush is stacked to a height of 5 or 6 feet on a 5 x 10 foot frame and securely fastened by wire clothesline.

3. Bundled brush shelters. Brush may be assembled into bundles, bound together with synthetic rope, and weighted with ballast.

4. Christmas tree shelters described by Prince and Brouha (12).

Materials	*Costs*
Old Christmas trees	Free
1/4" steel bar stock	$0.05 per foot
Concrete	$0.11 per gallon
5-gallon can	Free (bakery)

Total estimated cost = $0.50 per unit

A 3/8-inch hole is drilled at the base of the trunk of each Christmas tree and a piece of steel bar stock forced into the hole. The butt of the trunk is then put into a 5-gallon can and the can is filled with concrete to three quarters of its capacity. These single tree units may be connected with polypropylene line at the time of installation.

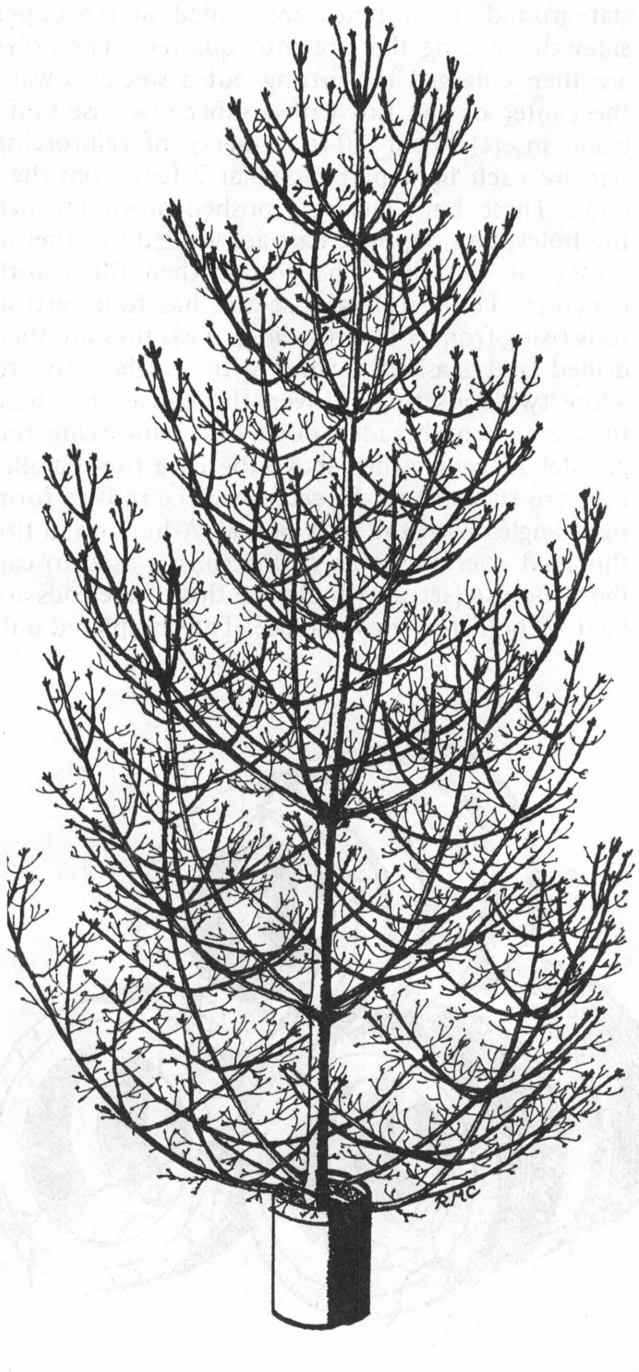

Figure 6. Tree unit.

Vitrified Clay Pipe and Concrete Blocks

Damaged clay sewer pipe and concrete blocks may often be obtained from manufacturers at little or no cost. Crumpton (8) and Wilbur (3) describe the use of these materials for artificial shelters in Lake Tohopekaliga near Kissimee, Florida.

1. Clay pipe structure. Clay pipes are bundled together with plastic banding material to form a pyramid. Twenty bundles (of 6 pipes per bundle) are used in each fish attractor. Half the bundles are of 6-inch diameter pipes and half are of 4-inch diameter pipes. Other larger diameter pipes up to 3-feet long are randomly distributed around the reef site.

2. Block-brush structures. The concrete block attractors used in Lake Tohopekaliga are combined with brush. Brush bundles weighted with cement blocks are distributed around the perimeter of each 15 yard square site. Seven hundred concrete blocks are then distributed in the center of each site to create a pyramid which has a base fringed with brush.

Stake beds

Stake beds have been used by the Tennessee Game and Fish Commission to concentrate crappies. In order for these structures to be economically feasible, lumber to make the stakes would have to be free or obtainable at very little cost. Petit (15) describes several methods of construction:

1. Driven stake bed. Stakes can be driven into the lake bottom during winter drawdown to create a bed 4 x 8 feet with about 150 stakes, 4 to 7 feet long.

2. Prefabricated bed. The stakes described above can be nailed to a 4 x 8 foot wooden frame. The portable prefabricated bed can then be floated to the desired spot and sunk with concrete blocks attached to the frame.

Car bodies

Charles (16) describes the use of car bodies to create artificial reefs, but such material is difficult to use for freshwater structures. Even if the car bodies are available free, they must be stripped of upholstery, steam cleaned to rid them of grease or oil, and transported to the site. Transportation costs are usually high because of the size and weight of each unit. Handling is difficult; usually a crane is required to install the car bodies at the reef site.

Others

Plastics have been used to create artificial aquatic plants and other types of fish shelters. Concrete houses have also been built specifically for fish. A complete bibliography (1) on artificial reefs containing references for these and many other structures is available from the Coastal Plains Center for Marine Development Services, 1518 Harbour Drive, Wilmington, N.C. 28401.

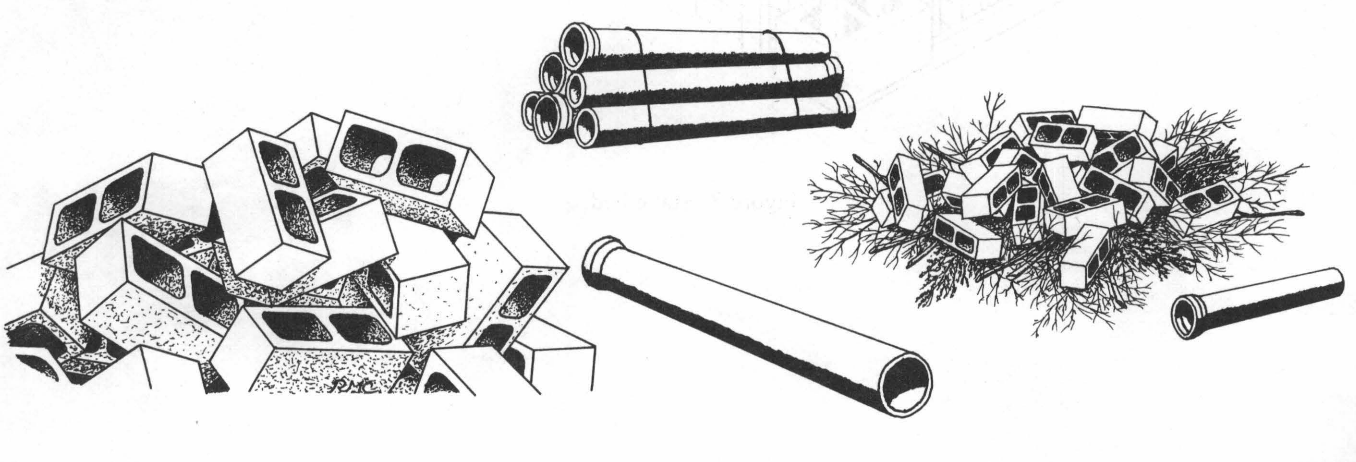

Figure 7. Clay pipe bundle and brush-ringed pyramid.

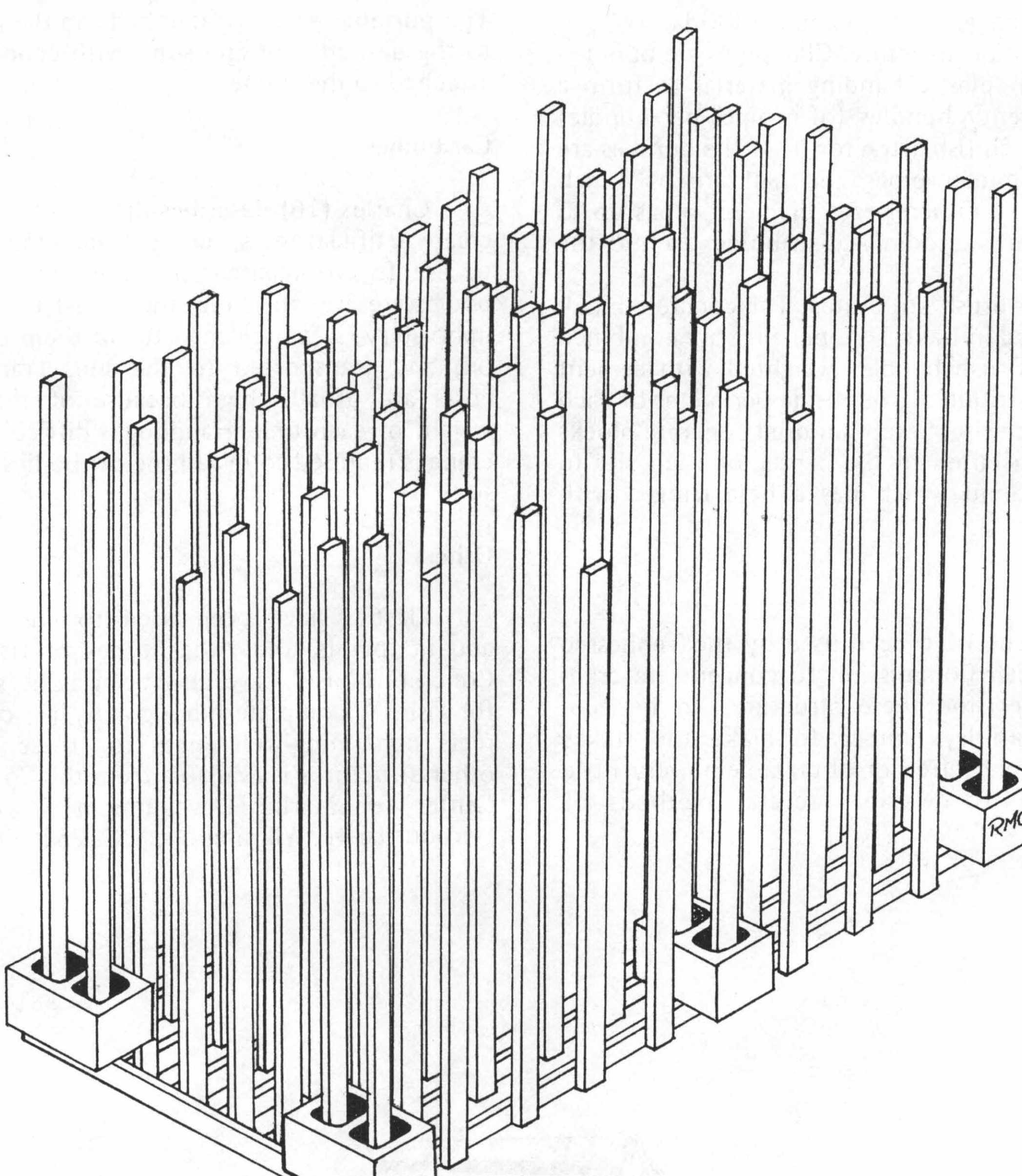

Figure 8. Stake bed.

SUMMARY

Any reef project must be carefully thought out before action is taken because there are many items to be considered before the final decision is made. From a logistical viewpoint, while the materials may be acquired free, a plan must be made to move them to the construction area and space provided to store the materials for extended periods. After the reef units have been constructed, a way must be found to deploy them at the chosen site. If there is sufficient winter ice on the lake or reservoir the units may be hauled out on the ice by truck and allowed to sink during the spring thaw. Reefs may also be planned directly in conjunction with reservoir construction, and the units trucked to the installation site prior to initial flooding of the reservoir basin. (If certain areas of the reservoir are left uncleared during reservoir construction, artificial reefs may be unnecessary.) If the reservoir is designed primarily for flood control, the reef might be installed on the exposed bottom during winter drawdown.

All construction projects will cost money, but costs of materials and equipment can be drastically reduced by making the project a community action program and by actively soliciting support from different sectors of business or from municipal, state, or federal agencies.

In the late 1930's and 1940's, habitat improvement by means of artificial structures was actively investigated. Structures were found to attract large numbers of fish, but prohibitively high costs prevented the general utilization of artificial reefs as a freshwater fisheries management technique.

Recently, the public has become increasingly aware of the environment. Public interest groups are now willing to actively participate in projects to improve and restore the environment. This heightened interest in the environment has now made possible the widespread use of habitat restoration in fisheries management that was not possible earlier. As a community sponsored project, volunteer manpower can be found to reduce labor costs to practically nothing.

It must be reiterated that an artificial reef is not a panacea; it is simply one of the potentially valuable tools available to the fisheries manager in his continuing attempt to provide quality angling for the public. Decisions regarding management of inland waters must be made on an individual basis by trained personnel. We have tried to emphasize that our guidelines are general in nature and will be subject to modification as new information becomes available. Some of the problems we have considered may not have hard and fast answers because each body of water with its resident fish population is unique, but perhaps a consensus can eventually be obtained by continued investigation.

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