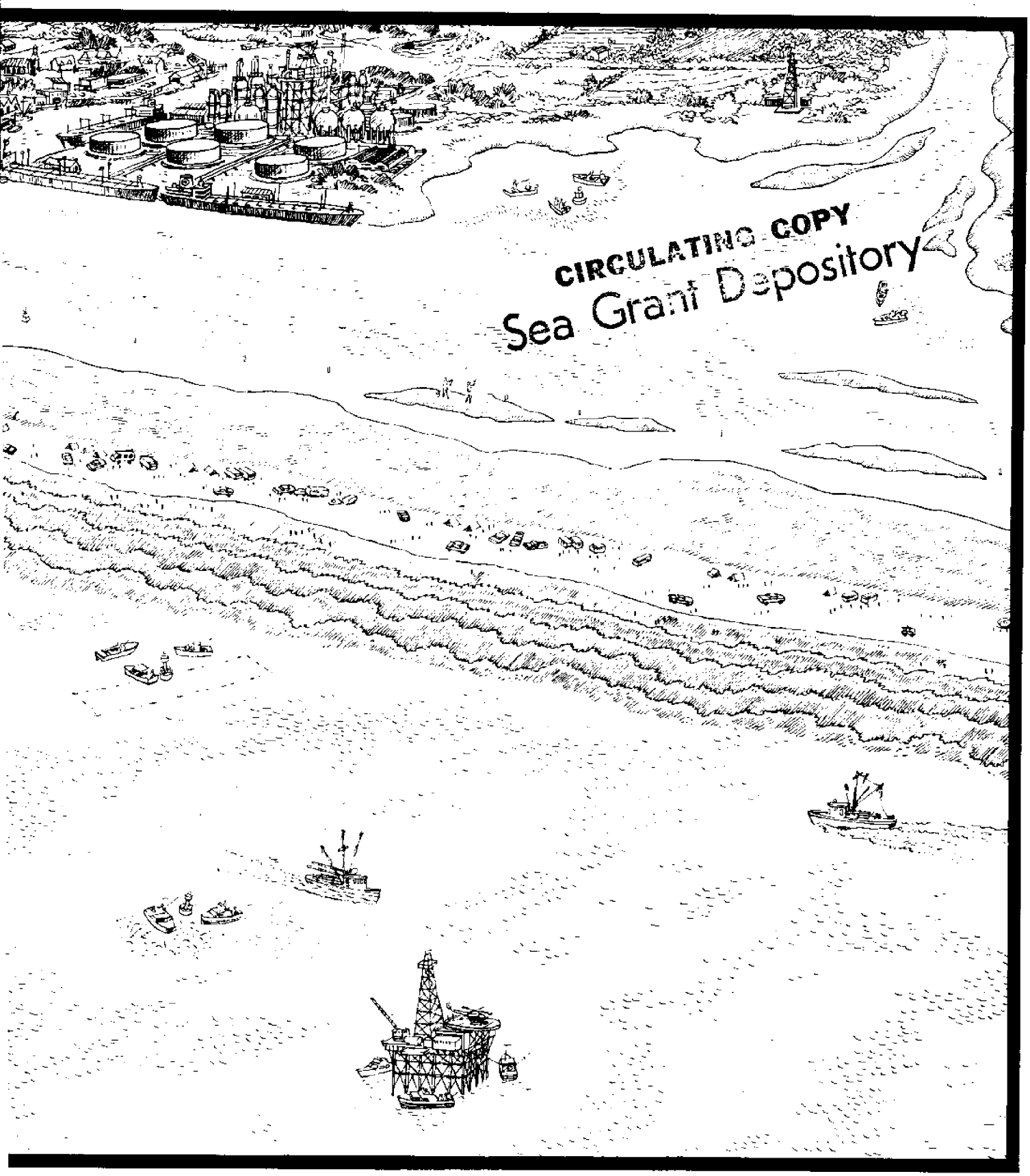
Artificial Reefs for Texas



The Texas Coastal and Marine Council and Texas A&M University wish to thank all who have been of assistance in this project. Special appreciation is due the task force who formulated the study effort. Task force members were Howard Lee of the Marine Council, E.D. McGehee of the U.S. Corps of Engineers, Gene Shinn of Shell Oil Co., Dr. Al Sparks of National Marine Fisheries Service, and Jim Stevens of the Texas Parks and Wildlife Department. Special thanks also goes to Dick Stone of the National Marine Fisheries Service and Dana Larson of Exxon who reviewed the manuscript.

This project's technical report was prepared by Norman Whitehorn of the Texas A&M Industrial Economics Division. Information from that report was extracted and developed into this publication by Linda Johnston of the Marine Council.

Artificial Reefs for Texas

Prepared by
the Industrial Economics Division
at Texas A&M University and
the Texas Coastal and Marine Council

Sea Grant Program
TAMU-SG-73-214
IAC (72-73)-1225

March 1974

TEXAS A&M UNIVERSITY
INDUSTRIAL ECONOMICS RESEARCH DIVISION
COLLEGE STATION, TEXAS 77843

November 1973

The Honorable A. R. Schwartz
State Senator
State Capitol
Austin, Texas

Dear Senator Schwartz:

We are most pleased to have been of service to the Texas Coastal and Marine Council and the State of Texas in the execution of the study which led to this report, "Artificial Reefs for Texas." It was a most interesting project. Many people made valuable contributions to this effort and I would like to collectively thank all of them.

Sincerely,

James R. Bradley

James R. Bradley
Head of Division

TEXAS ENGINEERING EXPERIMENT STATION · RESEARCH AND DEVELOPMENT FOR MANKIND

TEXAS COASTAL AND MARINE COUNCIL

December 1973

Dear Fellow Texans:

This report summarizes the current state of the art in the construction of artificial reefs. The Council was designated by Governor Briscoe to lead Texas' effort in the acquisition of the Liberty Ship Reefs. As a result of that effort, many persons asked about how they might build nearshore and bay reefs. To satisfy these multiple needs, the Texas Coastal and Marine Council contracted with the Industrial Economics Research Division for this study, and the Texas A & M University Sea Grant program provided matching funds. Its principle purposes are:

(1) Illustrate the many alternative approaches, methods and materials available for reef construction.

(2) Provide positive ideas for local groups desiring to undertake reef development ventures.

(3) Point out possible constraints/limitations associated with certain materials and methods.

(4) Lay the groundwork for a comprehensive artificial reef program for Texas.

If the Council can be of any further assistance, please do not hesitate to call on us.

Sincerely,

A. R. Schwartz

Senator A. R. Schwartz
Chairman

POST OFFICE BOX 13407 / AUSTIN, TEXAS 78711 / PHONE (512) 476-3561

Fishing is a favorite sport among Texans – for the comradeship it affords, the mouthwatering taste of the catch, and the ancient pleasure of stalking the prey.

Many fish are found concentrated near irregularities such as bottom obstructions, passes, channels and structures which break up the generally smooth bottom of the Gulf and its bays and estuaries. In other areas fish tend to inhabit rocky coastlines, jagged banks, and the rough terrain of natural reefs. These types of habitats provide protection for young and smaller fish from predators as well as food from both animal and plant life which are able to prosper under these conditions. What ultimately results is a marine food chain culminating in the commercial and sport species sought by man. Accident-created reefs, such as shipwrecks, provide much the same type habitat as natural reefs. But in Texas today there are not enough natural or accident-created reefs to satisfy the increasing demand for sport and commercial fishing, whether the desire be for food or for recreation.

One possible solution to this problem is the construction of artificial reefs from materials such as building rubble, used tires, and obsolete vessels. Artificial reefs also provide a means to reuse these materials in another beneficial manner.

This report will discuss some of the factors and criteria which must be taken into account in the development of artificial saltwater reefs for the Texas coast. Topics covered include:

- Materials – What materials have been used in the past and which others might effectively be used in the future for reef construction? What are the limitations of the materials? What are the possible sources for materials and what do they cost, if anything?

- Site Location – What criteria must be applied in locating reef sites in order to prevent interference with other uses, minimize user risks, and enhance accessibility and usability?

- Project Financing – What are the possible alternative arrangements that could be developed between fishermen and divers, government, industry, and civic organizations to finance reef construction and maintenance?

- Legal and Institutional – What are the principle legal issues involved, such as liability, and what kinds of approval and permits are required from governmental authorities?

Broward Artificial Reef, Inc.

Background

Attempts to enhance fishing with artificial reefs began in the thirties.

Interest in artificial reef building has proliferated within the last 12 to 15 years, but the first deliberate artificial reef effort was engineered by a party fishing boat skipper in the mid-30s. Capt. Robert G. Pierpoint was responsible for the construction of a reef composed of auto bodies, cement filled drums, barges, boat hulls, and concrete rubble off the New Jersey coast at Cape May – Wildwood in 1935.

The reef was enlarged in 1936, and a second reef was built off the Atlantic City coastal area. Well-patronized 10-14 car excursion trains labeled "Fishermen's Specials" ran for some time from Philadelphia to the South Jersey coast. The reefs, known as "fishing preserves," were highly productive with anglers' catches sometimes tripling earlier catches in the area.

World War II halted the excursion trains, and little or no fishing was done on the reefs until after V-J day in 1945. By then the auto bodies and cement filled drums had disintegrated, the barges and boat hulls deteriorated, and the broken concrete rubble sunk in bottom sands.

Since this initial experiment many reef building projects have been undertaken by many groups in the coastal states utilizing a wide variety of materials and a wide range of locations.

California Reef Building

A study of artificial reefs was undertaken by the California Department of Fish and Game in the late 50s. Their research efforts tested reefs of streetcars, junk cars, rubber tires, quarry rocks, offshore oil drilling installations, and special concrete for "fish apartments."

In 1958 the California agency placed a reef consisting of old car bodies in 50 feet of water at Paradise Cove near Malibu. In the same year they also placed a reef constructed of six wooden streetcars approximately one mile offshore from the Redondo Beach – Palos Verdes area. The streetcars (each 50 feet long, 10 feet wide and 11 feet high) were placed 10 feet apart, covering approximately 7,700 square feet of bottom. The top of one car was carried down-current 16 feet during a storm and its sides collapsed into rubble, effectively increasing the reef size to about 8,100 square feet. The total water mass taken up by the reef was approximately 160,000 cubic feet.

The California Department of Game and Fish built a production model reef of 1,000 tons of class B quarry rock (each stone weighs about 1,000 pounds) and deposited it in four 80-foot diameter piles in 75-80 feet of water 2,200 yards offshore Redondo Beach in 1963. The reef was built at a cost of $6,000 and financed by the Los Angeles County Fish and Game Commission.

The agency also studied the effects of offshore oil drilling, including the effects on marine life of man-made structures and of depositing washed drill cuttings on the ocean floor. Four offshore oil drilling installations near Santa Barbara and one near Seal Beach were visited between May 1958 and December 1960.

Other reef building efforts include one which was constructed of 800 concrete blocks (each 16x18x8 inches) on a seagrass bottom in about 29 feet of water in Lesser Lameshur Bay, St. John, Virgin Islands. Concrete was also used in the "McAllister Grounds" reef built near Long Island in 1950.

The Sand Sharks Skin Diving Club of Newport News, Virginia joined forces with the Tidewater Artificial Reef Development Association in 1961 to build a reef. They sank a load of car bodies in 15 feet of water, 1¼ miles northwest of Thimble Shoal Light in the Chesapeake Bay. The reef site had been surveyed in advance and found to be an area of barren sand practically devoid of marine life. A few months later a report was made that the reef had "absolutely the largest concentration of fish variety for an area of this size ever observed."

In 1960 skin divers working with the Jacksonville Outboard Sport Fishing Club helped build Montgomery Reef, about five miles off the St. Johns River entrance in northeast Florida. The reef included hundreds of old cars, 5,000 old tires, and numerous junk appliances. The reef quickly attracted fish and provided excellent fishing for five years. By 1970 the cars and appliances had long disappeared, while the tires were still attracting fish.

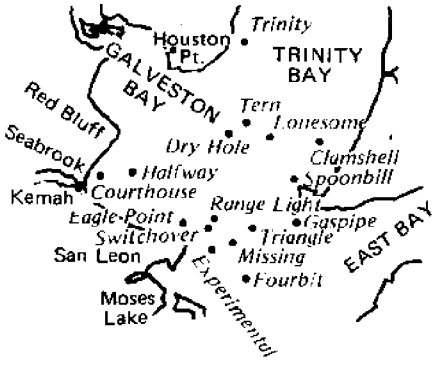
The Sandy Hook Marine Laboratory of the National Marine Fisheries Service, located in New Jersey, has made quite extensive studies in artificial reef programs and has actually constructed several reefs off the coasts of New Jersey, Virginia, North Carolina, South Carolina, Georgia and Florida. In addition, considerable expertise has been extended to other groups in building reefs. Their initial study reef was built with car bodies off Monmouth Beach, New Jersey in 1966. The sunken autos rapidly became covered with encrusting organisms and attracted many fish.

During the period 1953-1966, 27 artificial reefs were built

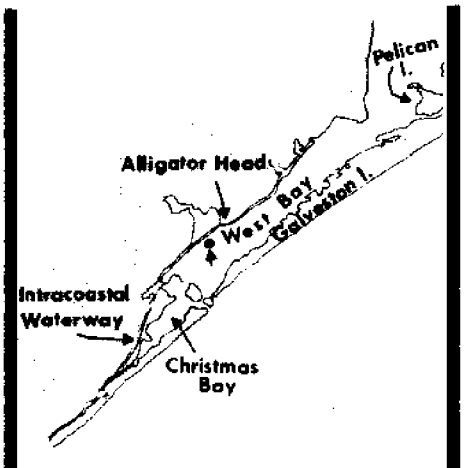
off Florida's coast. Distances offshore ranged from one-half mile to 13 miles, and depths ranged from 13 feet to 120 feet. Materials in the reefs included metal junk, concrete rubble, automobile bodies, aircraft bodies, refrigerators, stoves, tires filled with concrete, limestone rock, concrete pipe, barges, and Japanese – style hollow concrete blocks. By 1966 reefs had been built adjacent to 21 of Florida's 35 coastal counties. Since then many other reefs have been constructed in various Florida locations.

The first attempt to build an artificial reef from scrap tires on the West Coast was initiated by the Eureka Kiwanis Club and the California Department of Fish and Game. A reef was placed in South Humboldt Bay in 1968 consisting of 800 scrap truck tires set in an upright position, singly and in groups of three or four. The multiple groups of tires were banded together by plastic strips, and all tires were held together by a long piece of polypropylene line. In 1971 a different tire configuration was designed to withstand the tidal action in the bay and to attract more fish. It stood eight feet high, doubling the vertical profile of the original configuration.

One of the first substantial efforts to construct an artificial reef in the Gulf of Mexico was initiated in Alabama waters in 1953. The Orange Beach Deep-Sea Fishing Association (an organization of party-boat interests) began construction of the first of a series of artificial "snapper banks," utilizing junked auto bodies. For the next decade the Alabama Conservation Department created additional snapper banks at various locations in Gulf waters. Altogether, several thousand auto bodies were dumped on the Gulf floor off Alabama. The auto bodies lasted for only about four or five years before disintegrating. The largest of Alabama's artificial reefs – "Fisherman's Paradise" – consisted of a sunken drydock lying 14 miles off



Oyster shell and concrete and clay pipe reefs are abundant in the Galveston Bay area.



Sportsmen's Clubs of Texas has constructed a reef composed of 2,000 tires in Galveston's West Bay.

Twenty-seven artificial reefs were built off Florida's coast between 1953-1966.

Mobile in 70 feet of water. The 300-foot long, 150-foot wide reef was sunk in July 1959.

Construction in Texas

Artificial reef building in Texas bays and offshore has been in progress for about the past 15 years. While some oyster reefs had been created in Galveston Bay prior to this time, the first three offshore reefs, constructed of old automobile bodies, were built in 1958 by the Texas Parks and Wildlife Department. They were located in 60 feet of water offshore from Freeport, Port Aransas and Port Isabel, as near shore as federal rules regulating navigational obstructions would permit. The Port Aransas reef consisted of 200 cars costing $20 each.

In 1962 and 1963 artificial fish havens of concrete and clay pipe were built off Galveston and Port Aransas. This material produced nearly permanent reefs of sufficient bulk to attract fish, yet prevent easy shifting by water currents. Several steel barges were later added to the reef off Port Aransas. The Galveston reef was placed approximately 10 miles offshore in 60 feet of water and has a 50-foot clearance from water surface level.

Several reefs have been built inside Texas bays. Although most of these reefs are built of oyster shell, they attract fish in the same manner as the reefs built of other materials. Most of them have a low profile of one to two feet and are in eight to ten feet of water. They are constructed of shell, and some are marked with permanently lighted structures. Some of these reefs were built by dredging companies in compliance with the terms of dredging permits issued by the Texas Parks and Wildlife Department.

Fishing and diving groups are responsible for building some nearshore and bay reefs. Sportsmen's Clubs of Texas, Inc., in cooperation with the Boating Trade Association of Metropolitan Houston, recently built a reef in Galveston West Bay. The reef is composed of tires put together with three steel rods running through each tire and the bottom tire weighted with concrete.

The Sportsmen's Club reef contains 2,000 tires, 600 of which were placed the first year and 1,400 of which were placed a year later. The tires were obtained at no cost, but reef maintenance to haul tires by barge to the location runs $2,000 per year. The reef measures 600 feet x 600 feet in very shallow water and is marked by creosoted piling rising above the water at each corner and in the center.

No set pattern for financing artificial reef projects has been established in Texas. The Galveston reef was financed completely by the Texas Parks and Wildlife Department with the

exception of one enlargement when scrap pipe was donated by a Houston firm. The second Port Aransas reef was a cooperative effort between the Texas Parks and Wildlife Department and the Port Aransas Boatman's Association, which provided the construction material. Some bay reefs were built by dredging companies, and others were financed by the Parks and Wildlife Department.

Scientists, Divers Interested

Fishermen are not the only group interested in artificial reefs. Divers also use artificial reefs for recreation. Other groups are involved with the scientific and technical aspects of such structures. Biologists are interested in the growth and development of marine life. What kinds of algae and other plant life will the reef support? What types of encrustations will appear on the reef and how soon? What species of fish will inhabit the reef, how many will inhabit the reef, and how soon will they arrive? Which fish will take up permanent residence in contrast to those just passing through? The artificial reef provides an additional area of concentration for biologists to study these and other habits and characteristics of marine life.

With support from the National Oceanic and Atmospheric Administration scientists recently began an experiment on Pacific Reef off the upper Florida Keys. A one-month old tire reef showed signs of becoming a brand new marine community. The 500-square foot reef was full of one-to-three inch specimens of reef fish — grunts, parrotfish, damselfish, wrasses, drums, hogfish, tomtates and hamlets. They had set up permanent residence in the algae covered tires. Fishery biologists will make periodic examinations to determine whether a permanent population of larger fish has been established.

Florida State University biologists conducted a study in 1964 and 1965 on a reef near Panama City using a modification of the "light and dark bottle" technique. Entire sections of experimental reefs were placed inside water-tight light and dark boxes for measurement of dissolved oxygen. These measurements were compared with measurements of plankton production in conventional light and dark bottles made in nearby waters. Findings indicated that the productivity of the artificial reef was greater throughout the year than the productivity of the adjacent water.

In addition to studies conducted by biologists, engineers are interested in changes in materials submerged in sea water over prolonged periods of time as well as settling conditions of the seabed. Oceanographers are interested in fish movements, water current changes and characteristics, and general ocean conditions.

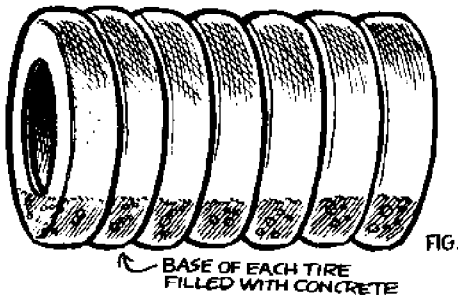


FIG. 1

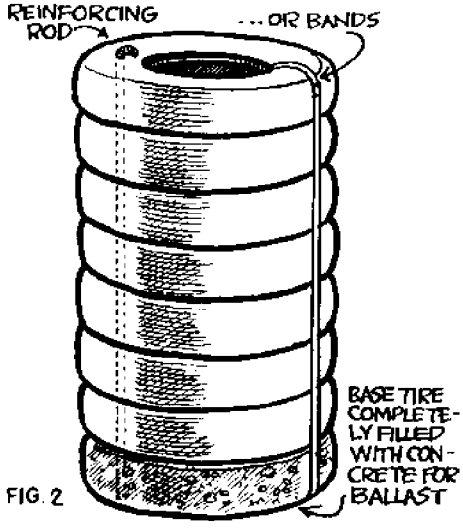
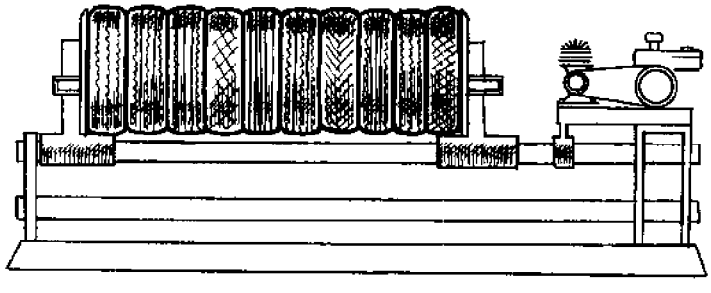
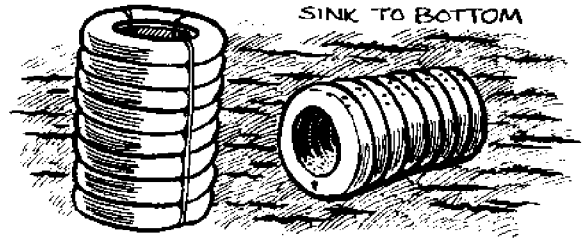


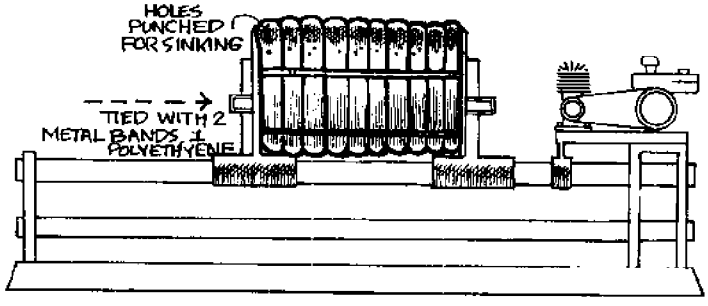
FIG. 2

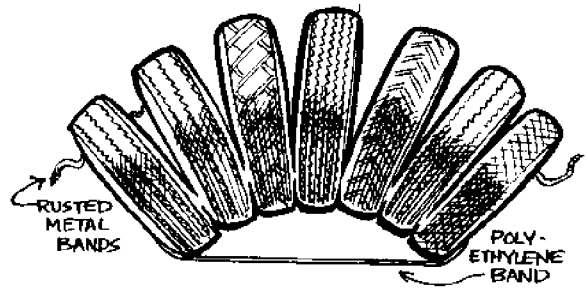
Tires, an inexpensive, abundant commodity for artificial reef building, can be assembled and manipulated in a variety of ways. The first figure represents a 3-7 tire configuration where the base of each tire is filled with concrete. Figure 2 shows a 6-8 tire design where only the base tire is ballasted with concrete and the tires are bound together with reinforcing rods or bands. Tires can be combined in this fashion to provide reefs of varying profile depending on the number of tires used. Figure 3 demonstrates probably the most feasible and inexpensive way to use tires for artificial reefs. The process, developed by Goodyear Tire and Rubber Co., is called compacting and requires the use of a compactor to compress the tires. The tires are also punched to facilitate sinking and bound with wire cable and polyethelene bands.

FIG. 3









Materials

Fish havens can be constructed from a variety of materials.

An artificial reef should be constructed of firm and inert, long-lasting material. In selecting suitable material it must be remembered that the function of an artificial reef is to provide shelter for fish and to allow marine organisms such as algae, barnacles, mussels, corals and hydroids to attach themselves, thus providing food for larger fish and establishing a food chain. For an artificial reef to be successful, it must provide surface area for the encrustation of small marine organisms as well as cracks, crevices, and other hiding places for shelter and protection of the smaller fish that will inhabit the area.

Several types of materials have been used with varying degrees of success to construct artificial reefs. Factors such as suitability and availability of materials, costs, durability in salt water, and environmental impact must be considered before an artificial reef is constructed. Site location is also a primary factor in determining what type material will work best.

Artificial reefs have been constructed from rubber tires, building rubble such as concrete pipes and blocks, automobile bodies, ships and barges, offshore oil platforms, and other materials. A quarter century's experience in artificial reef building has demonstrated that a combination of materials provides a better reef site than one utilizing only one material because it provides a variety of habitat.

Rubber Tires

Soon after tires of synthetic rubber began to be manufactured they began to accumulate and spot the landscape across the nation. Because of their durability, tires present a major disposal problem. But, this same durability also makes them excellent artificial reef material. Their abundant availability also makes them desirable. In fact, many artificial reefs currently being constructed are at least partially composed of automobile tires.

Tires must be stabilized in some way to keep them from moving away from the reef site and becoming a trawling hazard. A typical design consists of seven or eight tires, held together with two lengths of reinforcing rod and ballasted by completely filling the base tire with concrete. The ballast tire weighs 240 pounds when dry. The unit can be rolled onto a barge for the trip to the reef site.

This process is slow and expensive, however, so a press and punch method has been devised by Goodyear Tire and Rubber Co. In this method tires are compressed into tight small bundles and bound together with wire cable and polyethylene bands. This helps keep them in position after being placed on the reef site and provides more area for encrusting organisms to attach themselves.

The cost of binding several tires together and weighting with concrete varies with different configurations and processes. The seven or eight noncompressed tire configuration cost $2.87 per unit or about 35 to 40 cents per tire in 1969. Current cost for constructing a 12-tire configuration using a compactor and some concrete, as was built at Marco Applied Marine Ecology Station at Marco Island, Florida, is about $6 or about 50 cents per tire. The cost includes the use of a punch and press machine and a compacting machine to compress the tires, tying with nylon tape, and transporting by barge about three miles offshore. Initial cost of the press and punch machine was approximately $3,200, and initial cost of the compactor was about $5,500.

Used tires are in great abundance along the Texas Gulf Coast, and disposal has become a problem. A check with the City of Houston and Harris County authorities indicated no specific policy with regard to tire disposal except that they cannot be burned within the city or county nor can they be carried to the city or county solid waste disposal areas.

Most tire dealers, dispose of their used tires by paying someone to haul them off. This action has necessitated the creation of service companies which do nothing but haul away used tires from service stations and tire stores. The service companies usually charge 10 to 15 cents each to haul the tires away.

Concrete Pipe, Concrete Blocks and Rubble

The "McAllister Grounds" reef was built near Long Island in 1950, following a proposal by marine fishery biologists as a possibly beneficial use of broken masonary building materials. Since then broken concrete pipe, concrete blocks, and concrete rubble have been used with great success as artificial reef material in the Gulf and Pacific, as well as in the Atlantic.

In their research with artificial reef materials, the scientists at the Sandy Hook Marine Laboratory of the National Marine Fisheries Service concluded that concrete pipe and building rubble reefs will last indefinitely. Granite, quarry stone, or other hard rocks are as effective as the concrete blocks except where

concrete is specially built with hollow interiors.

Damaged concrete pipe is available in large quantities in most of the larger cities along the coast. In most instances the pipe can be obtained for the cost of transportation alone. However, the transportation may be quite expensive.

Limitations in using concrete rubble include the necessity of using handling equipment to load the heavy material on barge at the the dock and unloading it at the reef site. Costs of transportation from plant to construction site to reef location may prohibit the use of these materials if they are not available near waterfront areas. Equipment, such as hopper barges or front loaders, necessary to handle the concrete runs from $1,000 to $10,000 a day for leasing.

But, concrete rubble does make excellent reef material and is used on many reefs in all sections of the country. In preparing concrete pipe for reefs it is often desirable to cement or to tie together with cable several pieces of the pipe. This helps to secure the pipe after it is placed on the ocean floor and prevents scattering by water movements.

If concrete pipe and rubble are not readily available, a substitute structure has proven quite adequate, but costly and difficult to work with. The Japanese have developed "fish apartments" of hollow reinforced concrete blocks about 3¼ feet square with walls four inches thick and a large hole in each side. The California Department of Fish and Game adopted this structure but modified the blocks to 8x5x2½ feet with walls two inches thick, 15-inch holes in each side, and a partition in the center for strength. By using a crane the blocks are stacked on the ocean floor in such a way so as to provide greater surface area for encrustation of marine life as well as a very desirable habitat for fish.

This construction cost the California Department of Fish and Game about $75 for each block in 1966. Including transportation, a 1,000-ton barge load of quarry rock (2-to 3-ton chunks) cost $4,800 unloaded by crane in three locations off the California coast.

An estimate given by one Houston firm for transportating a barge load (378 pieces of 36-inch x 6-foot pipe on a barge 120x40 feet) of concrete pipe and unloading in Galveston or West Bay area was about $3,200. For offshore sites this cost would increase by several fold, partially because of added haul, but mostly because larger, more expensive equipment is required for Gulf operations. Cost would be approximately the same for transporting similar materials. It is possible, however, that a portion of this cost might be eliminated by a company donating a barge and tug for use in a project of this kind.

Estimated Number of Scrap Tires Available Annually in Coastal Zone Counties

Harris	1,588,000
Jefferson	228,000
Nueces	223,000
Galveston	135,000
Hidalgo	135,000
Brazoria	100,000
Cameron	100,000
Orange	62,000
Victoria	51,000
Fort Bend	40,000
Montgomery	40,000
San Patricio	40,000
Liberty	38,000
Wharton	37,000
Jim Wells	31,000
Matagorda	27,000
Kleberg	24,000
Lavaca	24,000
Colorado	21,000
Bee	19,000
Walker	18,000
Austin	17,000
Calhoun	16,000
Dewitt	16,000
Chambers	13,000
Jackson	13,000
Willacy	13,000
Waller	12,000
Refugio	10,000
Duval	9,000
Aransas	7,000
Brooks	7,000
Live Oak	7,000
Goliad	5,000
McMullen	1,000
Kenedy	less than 1,000

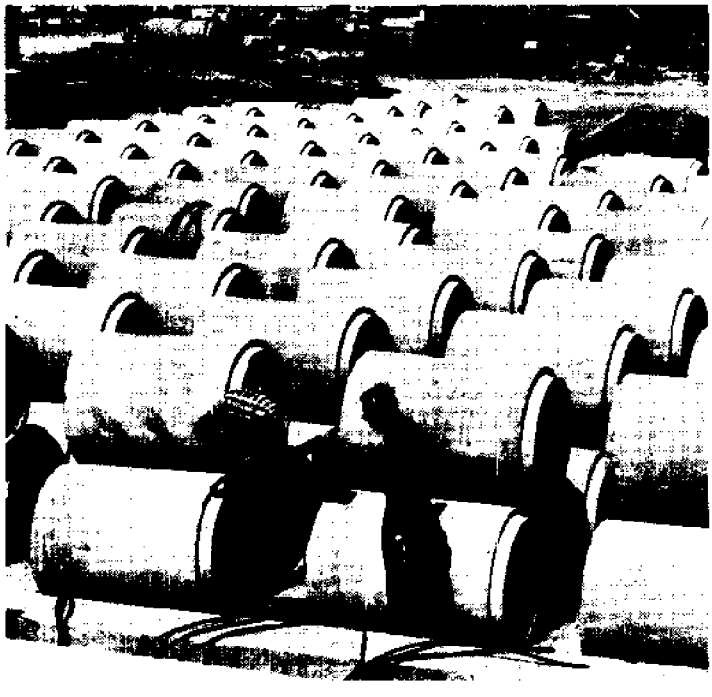
Automobile Bodies

The first artificial reefs built in Texas were constructed of old automobile bodies by the Texas Parks and Wildlife Department (then the Game and Fish Commission) in 1958.

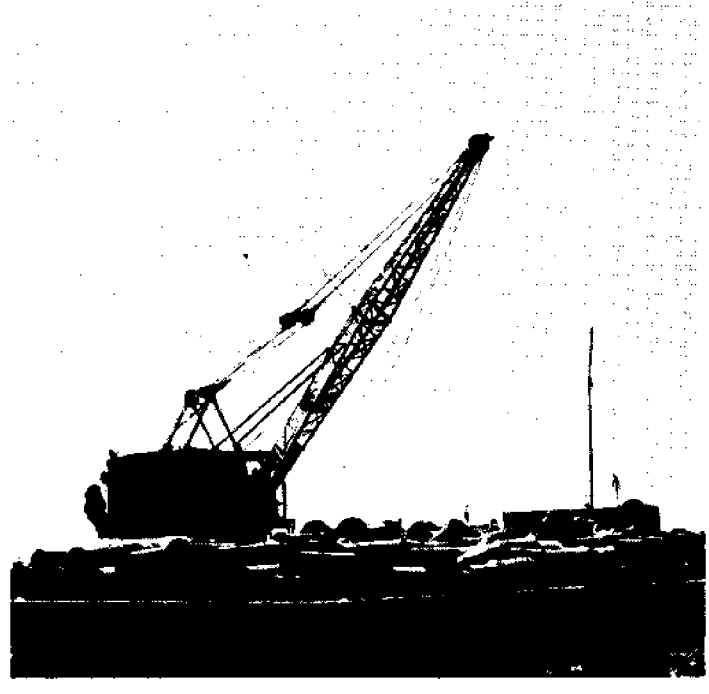
Several problems were associated with the maintenance and usage of these reefs. Temporary buoys marking the sites were either lost or destroyed and relocation for replacement was either difficult or impossible. The car bodies were prepared by burning all the nonmetallic material, and three to five were bound together in bundles with a steel cable. The bundles were pulled off the barge by a second tug, rather than lifted with a crane, and dropped on the seabed. Evidently in this operation some of the cables either broke or pulled loose from the car bodies. High winds and rough waves moved some of the single car bodies away from the marked area. Some were caught in shrimpers nets, while others washed to shore presenting a safety hazard in the surf and an ugly nuisance. Due to saltwater corrosion the light metal reefs degenerated rather rapidly. They did, however, provide excellent fishing during their short life.

The experiment proved that automobile bodies make productive artificial reef material, but have their limitations. They must be tied together for stability against rough waves, especially in shallow water and hurricane-prone areas. They do not last long in sea water and must be replaced after three to five years. They are easily scattered if the tying cable pulls loose or when it rusts away. The scattered car bodies can get caught

Texas Parks and Wildlife Department



Though concrete pipe is cheap and easily accessible for artificial reef construction, it is bulky to store and expensive to transport often requiring the use of a crane.



in shrimpers' nets causing considerable damage and loss to the shrimper. Because of these problems plus the difficulty of transporting the car bodies to the reef site, automobile bodies should generally be disregarded as potential artificial reef material.

The old car bodies used for reefs by the Parks and Wildlife Department during the late 1950s cost about $20 each. Additional expenses were incurred for cleanup and assembly.

Ships and Barges

The federal government has recently made surplus World War II Liberty Ships available to the states for use as offshore artificial reefs. Eighteen of these ships are currently mothballed in the Defense Reserve Fleet at Beaumont, 12 of which Governor Dolph Briscoe has requested for use in an artificial reef program for Texas. North and South Carolina, Georgia, Florida and Alabama are also pursuing Liberty reef projects using ships from other reserve fleets.

The value of ships as artificial reef material has been demonstrated in Texas by the V.A. Fogg which sank off Freeport in 1972 and has already proven itself a productive fish haven even though it has been blown apart to eliminate possible hazards to shipping.

The governor has designated the Texas Coastal and Marine Council to represent him in securing the Liberty Ships for use as artificial reefs, and the 63rd Legislature passed a resolution directing the Marine Council and the Parks and Wildlife Department to handle all arrangements for securing, preparing and sinking the ships.

Preparation of ships for use as artificial reefs, towing and sinking must comply with all federal and state regulations governing ocean dumping and proper marking by buoys to insure navigation safety and easy location. According to the Marine Council proposal, the ships will be stripped of the superstructure and cut to above the second deck, cleaned of fuel oil from tanks and lines, divested of all floatable materials such as wood, and stripped of all hatches and doors. In addition, large holes will be cut into all compartments and holds to insure that adequate light will enter and ample circulation will occur to promote biological activity.

A marine salvage company in Freeport has initially estimated this cost of preparation to be between $65,000 and $70,000 per ship. The salvage value of structural materials above the second deck and all internal machinery, including the oil, is estimated to be about $50,000, leaving a net cost of $15,000 to $20,000. The estimated cost for towing and sinking is

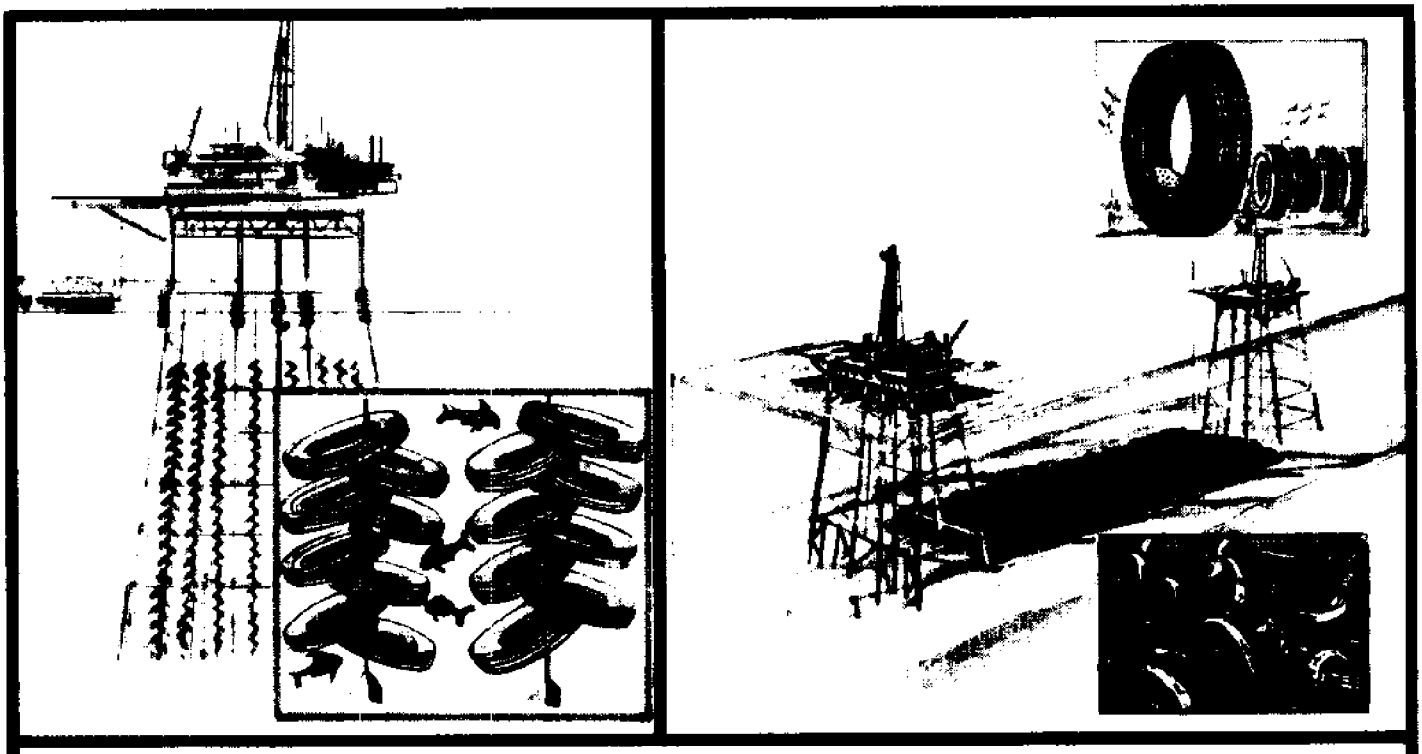
approximately $10,000 to $15,000. This amounts to a total cost of about $30,000 to prepare, tow and sink a Liberty Ship for use as an artificial reef.

However, consultations by state officials with private firms indicate the costs listed above may not be applicable. At least one salvage firm has said it would be willing to provide all towing, preparation and sinking in exchange for salvage value of the metal and internal machinery. The arrangement would be contingent upon the company being able to prepare several of the ships simultaneously so as to achieve significant economies of scale and operational efficiency.

In public hearings held by the Marine Council concerning the Liberty reefs, some have questioned whether a better use of the ship would be to recycle all of the metal. Others have questioned whether the ship might be a pollutant in the ocean. However, the Environmental Protection Agency is satisfied both that the ships can be sufficiently cleaned so as not to pollute and that their use as reefs constitutes "the highest and best use of ships." The amount of scrap iron that will be left on the ships is less than one percent of the steel in all the reserve fleets of the United States. About 1,700 of the 3,400 tons of scrap iron will be removed in the stripping and preparation process.

Broward Artificial Reef, Inc.

Goodyear had developed a method for preparing tires for use in artificial reef construction which utilizes a compacting machine.



Shell Oil Co. has devised several possibilities for enhancing offshore oil platforms as artificial reefs by the addition of tires. The first illustration shows tires strung alternately on cables beneath a production platform. The second illustration shows a tire mat placed on the bottom of the ocean between two adjacent production platforms.

A Texas firm has offered the Marine Council several shallow barges for use as artificial reef material. The Council is attempting to determine if the barges are usable. A possible way to use a barge as an artificial fish haven is to fill it with tires before sinking.

Offshore Oil Platforms

Offshore oil platforms have proven to be very good fish havens. More than 1,700 offshore platforms are scattered throughout the Gulf along the Texas and Louisiana coasts.

Generally, oil companies are very cooperative with fishermen using the area around the platforms as fishing grounds even while oil wells are in production. It is a common sight on any fair weather day to find fishing boats of all types tied to an offshore platform. On one such occasion 32 moderately sized boats, 12 yachts, 2 shrimp trawlers, and 3 party boats were observed at Buccaneer Field, located approximately 30 miles south of Galveston.

When production ceases, removal of platforms, as required by federal regulations, is an expensive operation, often running from $250,000 to $1,500,000 a platform. After the platform

legs are cut off approximately 15 feet beneath the mud line, the platform must be hauled to shore and dismantled. The cost of transportation and labor involved in dismantling the platform in dry dock is substantially greater than the salvage value of the material. Thus, some of the major oil companies have expressed a willingness to explore the possibilities of removing abandoned platforms, hauling them to a reef site, and dumping them near existing reef materials at no cost to the state.

Oil platforms can be enhanced as artificial reefs with tire configurations running below an individual platform or between two platforms to increase the surface area and provide additional habitat for fish.

It has been suggested by some that a conservation or recreational government agency could assume ownership of some offshore platforms and maintain them solely for fisheries purposes. Such a venture would require research into some major international legal issues and liability considerations, but may be a viable possibility.

Other Materials

There are other less desirable materials that can possibly be used for artificial reef construction. Some solid by-product materials such as slag, dredge spoil and gypsum are available in abundance at little or no cost, but are generally unsuitable for use alone due to their nature. Dredge spoil, in particular, would be a worthwhile material to explore for artificial reef construction due to the desirability of its use in innovative manners such as the creation of shallows, grassflats, and artificial marshes, and its potential use to enhance estuarine circulation.

Combination Reefs

The most successful artificial reef attempts seem to be those that have utilized more than one material. A reef can be considered "low profile" or "high profile" with regard to the height of the column of material. The most productive reefs are those having both characteristics, a quality which is usually achieved by combining materials.

For instance, where a sunken barge or ship is used as a reef, low profile material such as tire bundle units of one to three tires, concrete pipe, or concrete rubble should also be used. Even if only tires are used, experience indicates that for best results "highrise" bundles should be used with low profile ones. Different types and sizes of fish are attracted to small areas and larger ones to more open spaces. The small areas give the smaller fish a better place to hide from predators.

Site Location

Where to place the reef is a determination based on many factors.

In constructing an artificial reef few, if any, considerations are more important than the location of the reef. Many factors must be considered in determining the best location.

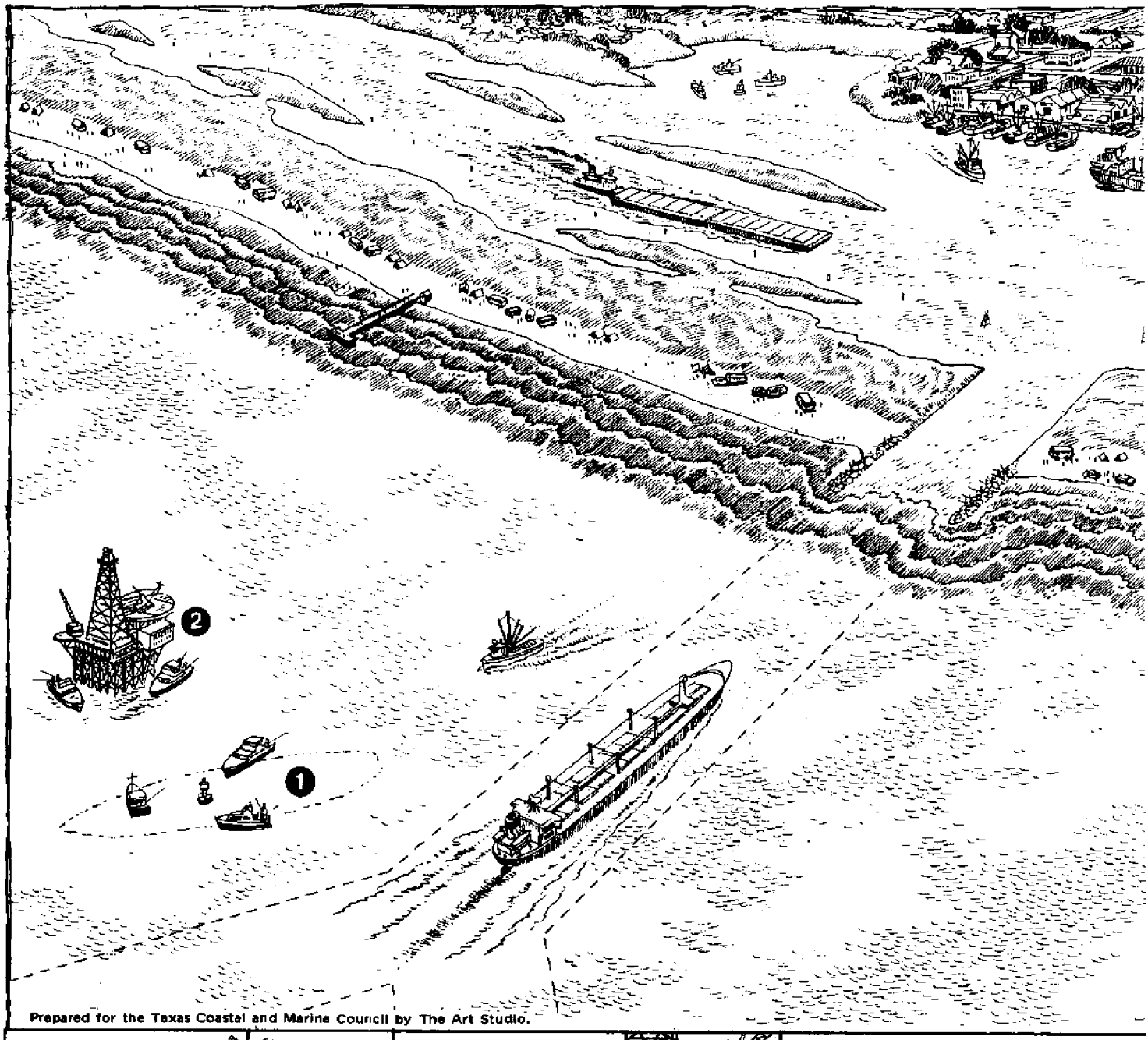
Determining site locations includes an understanding of where reefs should not be placed. The Gulf is used for a multitude of purposes including transportation, commercial shrimp trawling, and mineral production as well as recreation and sport fishing. But there is plenty of room in the Gulf for all of these activities if they are coordinated so as not to interfere with each other. Shipping fairways to all Gulf ports and across the Gulf are well established, and nothing may be dumped or constructed in or near them so as to interfere with traffic. Reefs must be kept at a safe distance from the fairways to protect large ships as well as fishermen. In addition to existing shipping fairways, tentative sites proposed for offshore terminal ports for supertankers are also off limits for artificial reefs.

Knowledge of existing bottom obstructions is also important in the selection of artificial reef sites. Areas with snags or rocks already have some reef activity going on and can probably be enhanced with the addition of artificial materials. At the same time, an area that is already an obstruction can be marked for a beneficial use. These areas are considered "bad bottom" by shrimpers, so there is little chance for conflict between shrimpers and reef fishermen.

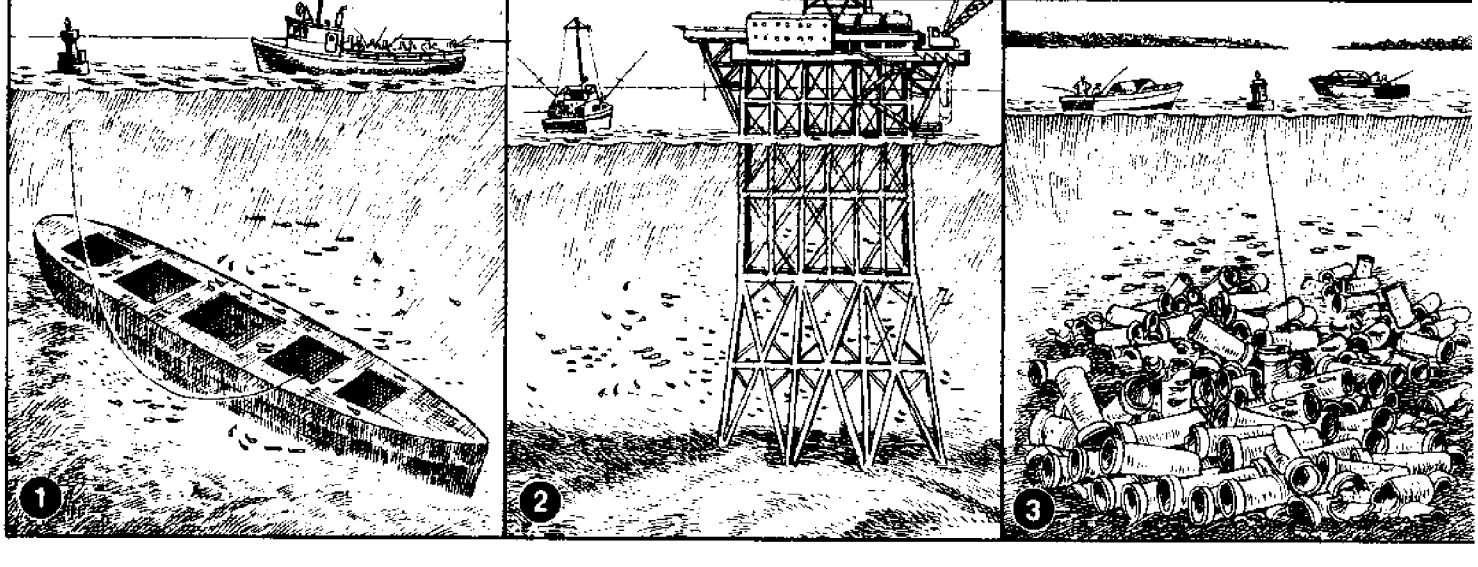
Existing snags have been mapped by Gary Graham of the Texas Agricultural Extension Service. These maps are available through the Texas A&M Sea Grant office.

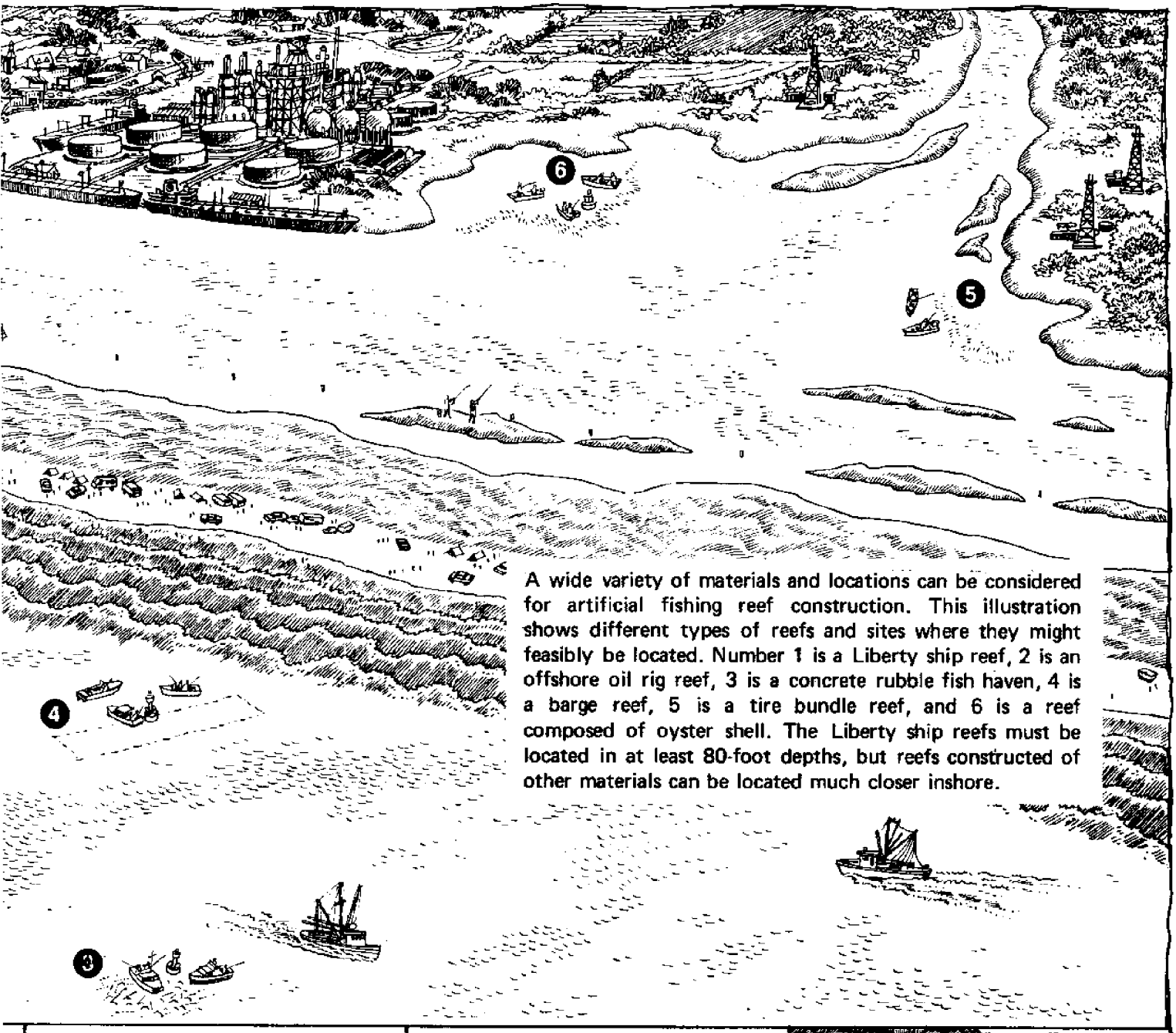
Depth of water must be considered for all types of artificial reefs. The U.S. Corps of Engineers has indicated that 50 feet would be a reasonable clearance for artificial reefs located in deep water since no Texas port has channels more than 45 feet deep. The 50-foot depth would therefore insure that the reef is not a navigational hazard. This much clearance for nearshore reefs is not necessary, however. When the obsolete Liberty Ships now berthed at Beaumont are used as reef material, they will need to be sunk in at least 80 feet of water. Even with the superstructure removed and the hull partially cut down, the height of the ship is still about 30 feet.

Distance offshore is also a factor to be considered in the

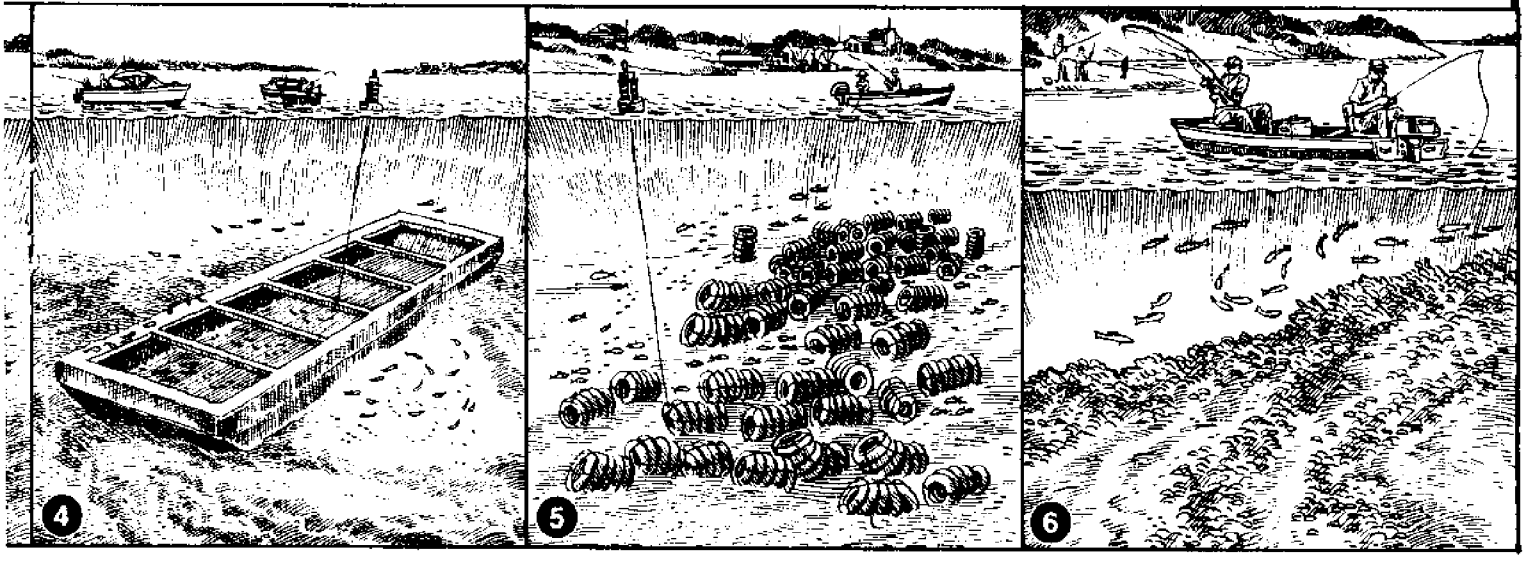


Prepared for the Texas Coastal and Marine Council by The Art Studio.





A wide variety of materials and locations can be considered for artificial fishing reef construction. This illustration shows different types of reefs and sites where they might feasibly be located. Number 1 is a Liberty ship reef, 2 is an offshore oil rig reef, 3 is a concrete rubble fish haven, 4 is a barge reef, 5 is a tire bundle reef, and 6 is a reef composed of oyster shell. The Liberty ship reefs must be located in at least 80-foot depths, but reefs constructed of other materials can be located much closer inshore.



location of an artificial reef. The maximum safe range for a moderately sized privately owned boat, which is 30 miles, and the maximum depth for amateur divers, which is 100-110 feet, should be taken into account when locating an artificial reef.

Reef sites need not be limited to the minimum 80-foot depth required for Liberty Ship reefs. Other materials such as tires, concrete pipe, concrete rubble and car bodies can be used on sites closer to shore. Reef sites closer inland in water depths less than 20-30 feet would probably be highly popular with many fishermen and scientists who use smaller boats.

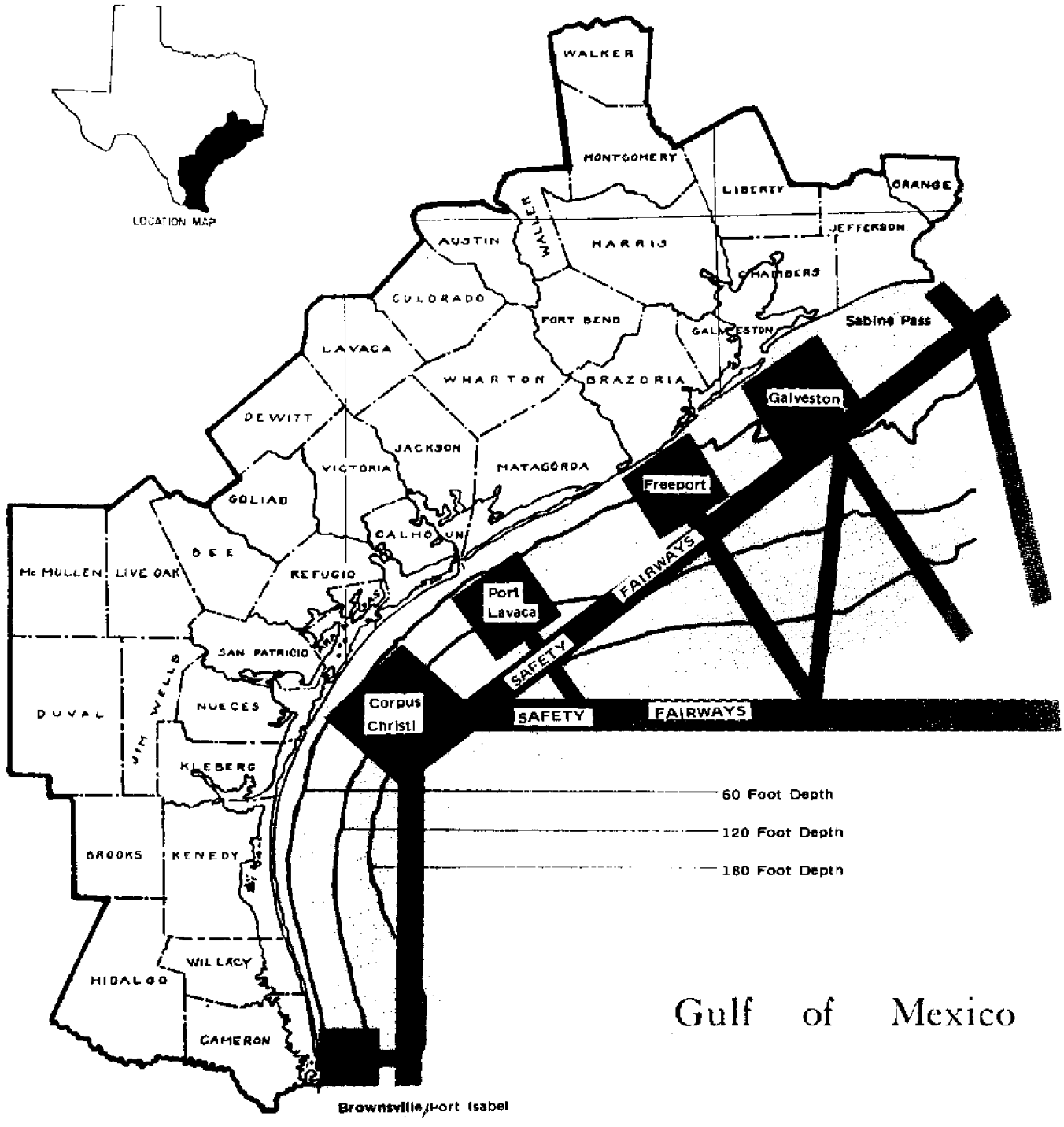
A thorough investigation of the seabed and its environment is important in determining an artificial reef site. A firm ocean floor is necessary to keep the reef from sinking into sediments. A hard, rocky shoal or high sand-content (if clay is shallow) bottom is the most desirable. Mud substrates are not desirable because the reef would sink and the water would be turbid. If such bottoms are the only ones available, it may be necessary to build a foundation pad of slag, shell or gravel on which to place the other reef materials.

Low-turbidity water provides the best location for artificial reefs because underwater visibility is better. Clear water on the surface does not necessarily mean clear water down to the seabed. The clearest waters are found over mud-free bottoms. Bottom conditions vary greatly in the Gulf, but less muddy, clearer bottoms are found along the nearshore reaches of the southern end of the coastline. However, the heterogenous nature of the seabed in both the Gulf and the bays necessitates on-site sampling before a reef is placed.

Prior to a final decision for site locations, detailed observations and core samples must be taken at potential sites to determine the mud content and the load bearing capacity. Before the reef material is placed on the ocean floor, the weight of the material together with sediment analysis must be calculated to determine how much settling will take place. A bottom profile must be made on potential sites showing sediment conditions, snag areas, rock and similar structures, and rough elevations.

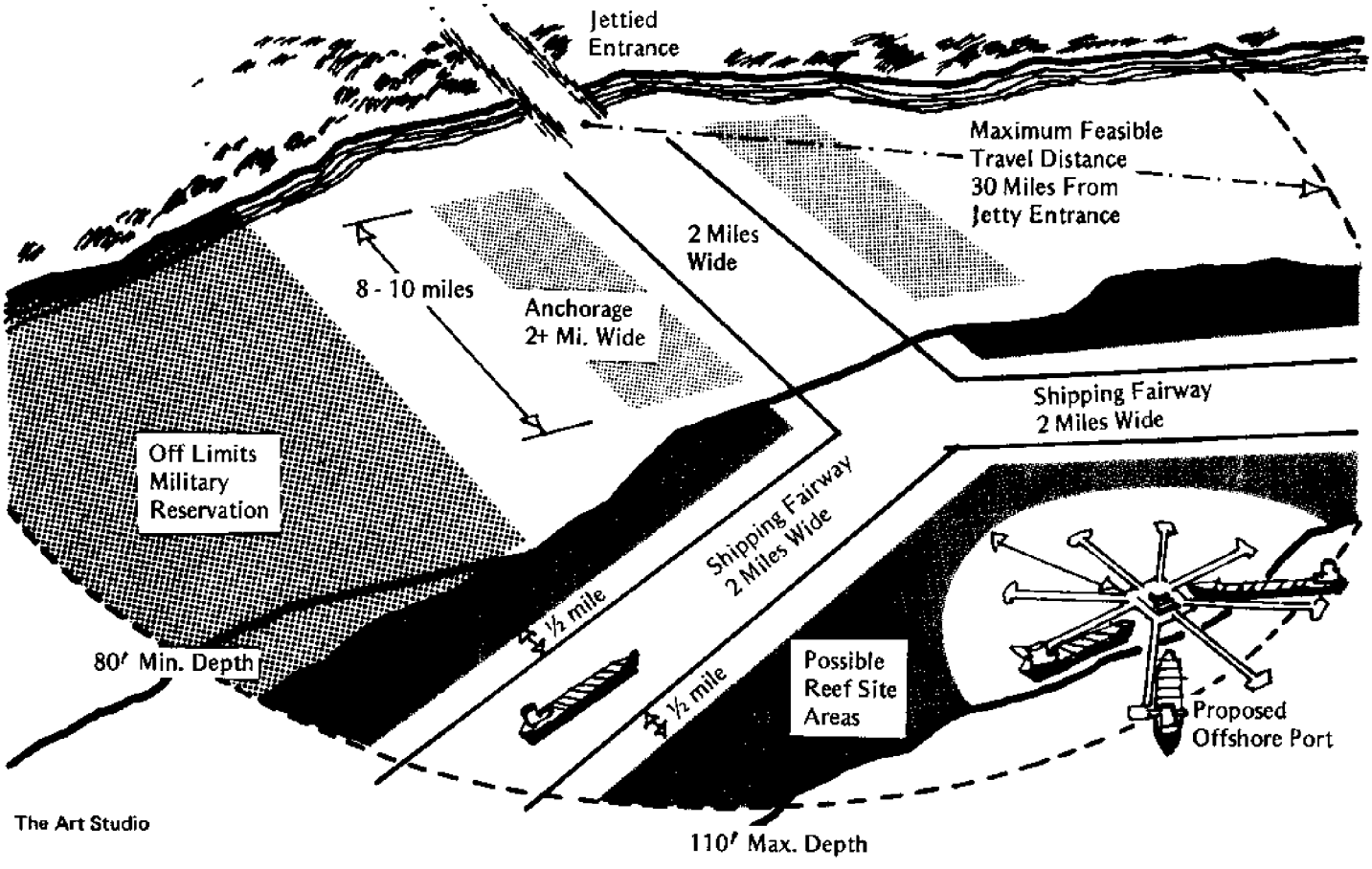
Before a reef is sunk the site should be examined by biologists to determine the existing marine life in the area so that the beneficial influence of the reef can later be ascertained. It should also be determined if any extraordinary or unusual ocean currents or wave actions due to hurricanes or other phenomena exist that might cause the site to be unsuitable.

In addition to the accessibility from shore to reef, the availability of onshore facilities and the number of people likely



Knowledge of shipping fairways and water depths is essential in making prudent decisions for artificial reef site locations. Reefs must not obstruct navigation. Water depth becomes a factor when locating a large structure such as a Liberty ship reef and in locating so as to be within safe ranges for fishermen and divers.

to use the reef should also be considered in site location. Along the Texas coast the Golden Triangle, the Houston-Galveston area, Freeport, the Corpus Christi-Aransas Pass area, and the Brownsville-Port Isabel area are the current primary population and business centers. These areas also contain most of the existing tourist accommodations and all weather roads. Boating facilities and boat launching facilities are adequate in these locations. In addition, it is in these areas where most private boats are located, according to Texas Parks and Wildlife Department registration records. These areas, therefore, should be given consideration when determining sites for artificial reefs. The popular fishing sites of the mouth of the Colorado River, Matagorda Bay and Port Mansfield would also be excellent locations for artificial reef construction.



Sites for Liberty ship reefs must be within a feasible travel distance of 30 miles and in at least an 80-foot depth. They must be located so as not to obstruct shipping fairways, the proposed offshore port site, mineral production or shrimping.

Financing a reef project can be a cooperative effort.

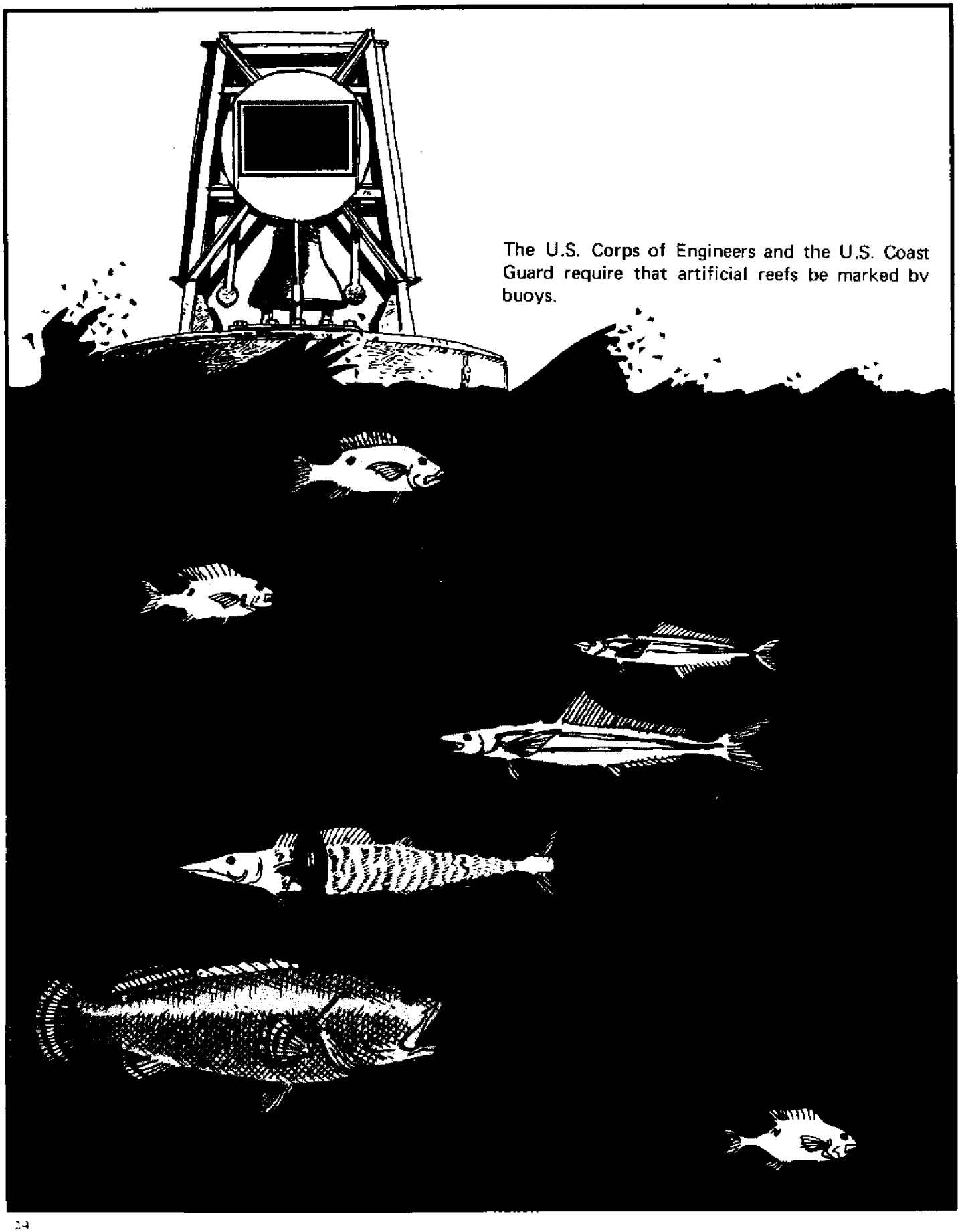
Costs for materials, preparation, handling and transporting, sinking, marking, and policing and maintenance must all be taken into account when considering the creation of an artificial reef.

There are numerous possibilities for financing artificial reef projects. In many instances, materials are donated to the reef builder. In other cases, transportation services are donated by firms or organizations having barge or trucking facilities. State, federal and local agencies have made funds available for reef projects in some cases. Special interest groups such as sport fishing clubs, diving clubs, chambers of commerce, civic clubs, and similar organizations often lend their support in time and funds. Some industries also have the potential for getting interested in artificial reef building. Shell dredging companies have built some oyster shell reefs in the Galveston Bay area. It is possible that a combination of groups might enter into a joint artificial reef building effort.

Governmental agencies could possibly make funds available for artificial fish havens through general revenue or through dedicated funds from direct or indirect taxes such as taxes on party boats or saltwater fishing licenses. In South Carolina, funds for reef construction have been appropriated by the state and several federal agencies, including the U.S. Bureau of Sport Fisheries and Wildlife and the U.S. Bureau of Outdoor Recreation. In 1967 the South Carolina General Appropriations Act made the sum of $30,000 available for the construction of "offshore fishing drops" along the South Carolina coast.

Although it is difficult to get nongovernmental interests to enter into long term financial agreements to maintain reefs, local interest groups such as chambers of commerce could possibly undertake reef building projects as an enhancement to the community's tourism industry. At least one Texas coastal county is exploring the possibility of establishing a tire reef project to help solve the problem of their disposal as well as to improve recreational opportunities in the area.

Certain industries such as petroleum companies and shell dredging companies could benefit from artificial reef projects by using them as a tax write-off and, in some cases, as a "least cost" disposal alternative. In addition, artificial reef building could be used by certain industries as an effective public relations project.



The U.S. Corps of Engineers and the U.S. Coast Guard require that artificial reefs be marked by buoys.

The Art Studio

Artificial reefs present an uncommon legal situation

Legal Aspects

The concept of artificial reefs is relatively new, and in some instances the legal questions associated with artificially created underwater marine reefs will require a novel construction of existing legal principles. The majority of questions of a legal nature that will arise regarding the placement and operation of artificial reefs, however, will be similiar to those concerning construction and maintenance of many facilities on land.

Before an artificial reef is constructed permission must be obtained from the State of Texas, if the reef is less than 10.35 miles offshore, and from the federal government, including the U.S. Corps of Engineers. Reefs must meet all Coast Guard and Corps of Engineers marking regulations.

The questions of who is involved in developing the artificial reef and who is to decide the methods, rules and regulations of operation need to be determined before a definitive legal assessment can be made on a particular project. Whether regulatory decisions are to be made at the local level, the state level, the federal level, or merely by the private sector, must be ascertained.

Territorial jurisdiction over the reefs will vary with where a reef is placed. Legal considerations will also vary with the type of material used to construct the reef.

The purposes for which the reef is to be used must be known to determine the legal consequences. If the reef and the aquatic area around it are to be considered a state or federal wildlife preserve, considerably different consequences will result than if they are to be used in conjunction with a private recreational or resort development project.

If the facility is within a state's boundaries, then the state may apply its criminal and civil jurisdiction over it. If it is within county or city jurisdiction limits, they can, of course, exercise their police powers as those powers relate to events associated with the reefs.

Common Law

Common law will probably be applied to activities resulting from the reefs. The general principle that public interests or the interests of the community will have preference over private uses

Navigation is one use that must be permitted in any artificial reef zone.

will be fairly significant where the reefs are to be placed over public lands. Because these reefs are to be in an area presently held in trust, either by the state or the federal government, the public trust doctrine will be available to require recognition of the public's rights. This is not to say that private uses for private reefs could not be authorized by the state or the federal government, but the public must be compensated adequately for any leasing by private investors of submerged lands, and the reefs would have to serve a purpose that does not violate the public interest.

Where conflicting uses exist, there must be some accommodation of these uses. In determining a priority to accommodate these conflicts, it should be noted that there are essentially no existing regulatory provisions. The only Texas provision (Section 5.023 Texas Water Code) that tends to establish priorities is that state waters may be appropriated for domestic and municipal uses, industrial uses, irrigation, mining, hydro-electric power, navigation, recreation and pleasure, stock raising, public parks, and game preserves.

Where the construction and operation of an artificial reef materially would affect navigation, present fishing grounds, oyster beds, mineral extraction sites, and other current uses, a new use for the reef would be subservient to the existing uses. Although artificial reefs generally will result in an exclusive use of the seabed area, they will not necessarily result in exclusive use of the water area above the seabed.

Certainly, the Corps of Engineers would not permit the artificial reefs to be placed beneath recognized shipping lanes because of the increased number of fishing or recreational vessels that would be attracted to the area. It may be that some special purpose district or other authority could be created by the state to outline fairways or safety zones around the artificial reef to prohibit all but certain classes of vessels in the area. This would have to be done while not violating the navigation servitude which exists in all navigable waters of the United States.

The state or the local government might want to make special provisions for management of the fishery resources associated with these artificial reefs that would be different from existing commercial and sport fishing regulations. Otherwise, the current regulations will apply.

If the reefs are designed with sport fishing in mind, perhaps commercial fishing should be excluded by regulation in the area. If the reef is designed to be a large area to provide commercial fishing opportunities, then perhaps the state should lease the area for commercial fishing purposes and prohibit sport fishing.

Public Access

There is considerable legal question as to whether or not the state could restrict public access to the waters above an artificial reef. The state, however, may restrict access to the area for limited purposes. Under current Texas laws if the state should lease the submerged lands for the construction of an artificial reef to a private firm, access to the waters above the reef could not be denied to the general public. Perhaps the state could enact legislation that would allow the private firm to restrict access to the reef if it is located such that there are relatively few significant competing uses of the water column. Simple navigation may be one use that must be permitted in any such zone.

Reef construction on submerged lands beneath internal waters comes under the auspices of the School Land Board and the General Land Office of the State of Texas and would require the leasing or granting of an easement of the submerged lands from the state as provided under the Texas Coastal Public Lands Management Act of 1973. The easement would apply even if the Texas Parks and Wildlife Department, another state agency, built an artificial reef inside the state's territorial limits.

Environmental Protection

Construction, maintenance and use of artificial reefs for any purpose will require observance of all environmental protection and enhancement acts, including the federal Water Pollution Control Act and the Texas Water Quality Act. The building of an artificial reef would be characterized as construction, in all probability, as opposed to mere dumping.

An environmental impact assessment should be prepared at the beginning of the project. In the case of the Liberty Ship reef it is probable that the Maritime Administration might prepare it since they would be initiating the action by releasing the ships to the state. To permit such construction under the Rivers and Harbors Act of 1899, many factors regarding artificial reefs should be examined. As an example, artificial reefs built near the shore would require an assessment of the reef's impact on the shoreline, including possible accretion or erosion of the coastal land.

Liability

The law of admiralty will apply for any navigational accidents occurring as a result of the reef's placement. Reefs will be required to be charted as underwater obstruction by the Coast Guard. Depending on the type and location of the reef, Coast Guard regulations may or may not require that buoys be

An environmental impact assessment should be prepared at the beginning of the project.

The common law of torts would apply for negligent actions.

placed to designate their location. An admiralty question which might arise is whether the intentional sinking of a Liberty Ship would make the ship recoverable under the laws of salvage – probably not.

The questions of tort which might arise from the construction and operation of an artificial reef would be similar to ordinary tort liability located on land, except where the rules of admiralty apply. If the state constructs the facility for a preserve or marine park to be used by citizens, the state will possess its usual sovereign immunity where tort actions are brought resulting from mishaps on the reef. Under the Texas Coastal Public Lands Management Act of 1973 private enterprise which has leased a portion of the submerged lands of Texas for the construction of an artificial reef would be subject to the normal legal provisions which apply in relation to torts occurring in these locations. This is exclusive of those which would come under the admiralty rules. The common law of torts would apply to harms resulting from intentional and negligence actions and perhaps especially in case of strict liability or liability without fault.

If the private reef builder rented skin diving equipment for use around a reef, or if he encouraged, advertised, or otherwise supported the idea of skin diving in the vicinity, he might be operating an ultra-hazardous activity. Under the law, this would make the operator liable without the need to prove negligence or fault on his part. Some question exists in cases of this type whether liability is removed even when the utmost care is given to the maintenance and operation of the facility. Defenses which normally would be available in an action for negligence such as contributory negligence and assumption of the risk would probably not be available in cases resulting from the operation of an ultra-hazardous activity, although assumption of the risk may prove to be a defense. It probably would be wise for the operator of such an underwater artificial reef to obtain written releases from liability from skin divers. This would need to be a full, complete, and knowing release on the part of skin divers and not merely a perfunctory signing of a paper without the full disclosure that it is in fact a release from liability.

Jurisdiction

The previous arguments generally have pertained to situations that would exist if a facility were being constructed within the three-mile territorial limit. Within this area, the State of Texas has full jurisdiction over the activities occurring on the submerged lands and in the water and area above those lands. The state, in fact, owns these submerged lands out to 10.35 miles.

As one moves away from shore, the legal rules relating to ownership, jurisdiction, and authority change. The United States presently claims and recognizes only a three-mile territorial sea. However, the U.S. does respect territorial sea claims of 12 miles and has recommended this limit in a draft proposal to the United Nations Sea Bed Committee, which is beginning the process of re-codifying the law of the sea in convention or treaty form. In its "Draft Articles on the Breadth of the Territorial Sea, Straits, and Fisheries," the U.S. also calls for "free transit" (something which would be more than the present right of innocent passage) and a system of preferential fishing rights for coastal states. If the 12-mile limit is adopted by the international community through the upcoming conventions relating to the law of the sea, then the international law problems would essentially disappear out to this new 12-mile limit.

As one moves away from shore the legal rules relating to ownership, jurisdiction and authority change.

The coastal national state exercises sovereignty in this territorial sea with the provision being made that the ships of foreign nations have the right of "innocent passage" through these territorial seas. Obstructions (such as artificial reefs) which would hinder these rights of innocent passage must be made known on charts prepared by the coastal states. An initial question to ask here is whether or not the construction of artificial reefs will be consistent with the rights which pertain to coastal states. These rights may be the result of customary international law or international agreement.

Customary international law recognizes the rights of coastal nations to utilize the continental shelf, and construction of an artificial reef may be considered such a use.

An artificial reef is submerged and covers in some cases a considerable area of the shelf, making the seabed's surface now the surface of the artificial reef. Essentially, the 1958 Geneva Convention on the Continental Shelf confers exclusive rights on the coastal nations to explore for and exploit the natural resources which "consist of the mineral and other nonliving resources of the seabed and subsoil together with living organisms belonging to sedentary species".

Before the Geneva Convention even an insignificant interference which was unrelated to the "reasonable conceived requirements of exploration and exploitation of the natural resources of the continental shelf" would not be justified. The question arises whether an artificial reef designed to "attract free swimming fish" will be considered unrelated to the seabed beneath the reef and therefore not involved with the legal concept of the continental shelf. If so, then an artificial reef could be associated with the high seas as merely an incident to fishing, therefore requiring only "reasonable use" that would be compatible with other nations' use of the high seas area.

Beyond the territorial sea, the international legal regimes relating to the high seas and the shelf have to be considered.

The North Seas Continental Shelf Case suggests that construction on the continental shelf for purposes other than the exploration and exploitation of the natural resources associated with the seabed and subsoil does not come under the jurisdiction of the coastal nation under the present regime relating to the continental shelf.

The question of structures and artificial islands to be placed on the continental shelf will be discussed at the upcoming Law of the Sea Conference. A broad interpretation of "natural resources" possibly could include the concept that the bed itself is a natural resource to support artificially constructed installations.

State's Rights

It is important to determine what rights exist in what area to ascertain the extent to which Texas would have the power to regulate activities such as construction and maintenance of artificial reefs off its coast. Obviously, within the internal waters of the nation, the state will have complete jurisdiction. For instance, the State of Texas would have regulatory jurisdiction over artificial reefs constructed in its rivers, bays, and cut canals on the internal waters side of the baseline, which is used to determine the width of the territorial sea.

However, the U.S. does "retain all its navigational servitude rights and powers of regulation and control of said lands and navigable waters for the constitutional purposes of commerce, navigation, national defense, and international affairs. Navigational rules and procedures of the federal government such as the Coast Guard regulations must be complied with by all those using territorial sea waters. The Corps of Engineers regulations which require a permit to be obtained before a structure or facility is erected in the navigable waters of the United States are derived from the Rivers and Harbors Act of 1899. The Corps of Engineers under the Outer—Continental Shelf Lands Act has the same powers to regulate construction and issue permits for construction on the outer—continental shelf lands.

International Law

Beyond the territorial sea, the international legal regimes relating to the high seas and the continental shelf have to be considered. Under present international law, there is some question as to whether a coastal nation has the jurisdiction to construct an artificial reef beyond its territorial sea.

Assuming that such reefs are constructed, there would also be the question of whether the nation could apply its civil and criminal laws (including special regulation) to activities in this

area. Does the coastal nation have the jurisdiction to regulate activities associated with the operation of an artificial reef?

Under the International Regime for the high seas that calls for freedom of the seas, the 1958 Geneva Convention on the High Seas states that "no state can validly purport to subject any part of the high seas to its sovereignty." There is considerable question as to whether an artificial reef would come within the scope of the high seas convention since the convention does specifically grant nations the right to use the ocean for navigation, fishing, laying of pipelines and cables, and overflight. It also recognizes the use of the high seas for other activities that are recognized by the general principles of international law. Obviously artificial reefs lack a great deal of precedent to establish them under international law since their concept and introduction has been a recent matter. Other recognized uses have been for such activities as ocean dumping and scientific research.

'No state can validly purport to subject any part of the high seas to its sovereignty.'

All uses of the high seas are to be predicated with the idea that they shall "be exercised by all states with reasonable regard to the interests of other states and their exercise of the freedom of the high seas." For instance, it would be assumed that the construction of an artificial reef in a shallow portion of the high seas where heavy navigation or intensive bottom fishing occurs would be considered an unreasonable interference of other nations.

The construction of an artificial reef will necessarily be an exclusive use, as opposed to inclusive uses (such as navigation), of part of the high seas. Artificial reef construction beyond the territorial sea would constitute a new use of the high seas but probably would not be an objectionable use as long as it remains consistent with other uses of the high seas.

Nations constructing such reefs would be engaged initially in unilateral action since international law does not exist regarding this use of the ocean. After construction, it would need to be determined whether or not the activity will be protested by other nations. If there are no protests, the activity may result in international customary law. With the negotiations to determine the international law of the sea soon to begin, there are some questions as to whether or not any unilateral action on the part of the United States such as construction of artificial reefs in high seas would have an effect on our position in these negotiations.

The construction of artificial reefs may be characterized, however, as an incident to fishing, which is a recognized use of the high seas. The construction of an artificial reef could be considered in the nature of sophisticated equipment that increases fishing productivity. In other words, it is a different

In other words, it is a different type of 'fishing hole.'

type of "fishing hole." Such reefs increase the fishing efficiency much the same as the utilization of a factory ship is used to increase fishing ability.

The State of Texas as well as the Gulf Coast of Florida have unique jurisdiction regarding their seabeds. Under the Submerged Lands Act, their jurisdiction extends beyond the territorial sea of the United States out to a total distance of nine nautical miles from the baseline. The resulting question is whether Texas' rights in this area are only for extractive purposes or whether those rights include the rights to minerals and free-swimming fish in the waters above the continental shelf in this area.

As is clearly the case within the territorial sea, the Submerged Lands Act specifically mentioned these minerals and fish in the superjacent waters as belonging to the coastal state. If this is the case, then an artificial reef facility to attract fish between the three geographical mile limit and the nine nautical mile limit would certainly be under the jurisdiction of Texas.

If, however, the Submerged Lands Act is controlled and restrained by subsequent international treaty (which is probably the case), then the State of Texas will be limited to jurisdiction over extractive uses of the continental shelf and will have no claim to the fish and minerals in the waters above. This question is further complicated by the fact that the United States since 1966 has claimed a 12-mile exclusive fishing zone. Whether the Submerged Lands Act gives the State of Texas jurisdiction over the free-swimming fish between three geographical miles and nine nautical miles is really the question of whether Texas could be granted something that the U.S. did not have to give.

What about the problems of jurisdiction regarding the regulation of the facility once constructed? There would be no difficulty of jurisdiction over United States citizens since this is merely nationality jurisdiction. What basis of jurisdiction then could be shown over non-U.S. citizens who are to be excluded from the area? Perhaps the area would not be regulated regarding nonnationals but merely would be left open to the freedom of the high seas so that everyone could fish there. In other words, the United States may be able to license and regulate her own citizens concerning the reefs but be completely helpless from possible abuse from noncitizens. The situation establishes a need for study in this unexplored area of law.

Conclusions

Sport fishing is by far the major reason for the accelerated interest in artificial reefs. Diving enthusiasts and scientists also have an avid interest in these structures. Where rocky coasts, coral reefs, jagged banks, and bottom snags are not found, artificial structures have been placed in many areas to increase the fish population.

Kinds of materials, site locations, financing possibilities, and legal aspects must all be considered before a reef project is undertaken. Current information concerning artificial reefs reveals these major conclusions:

- Different types of reefs can be constructed in different locations in order to satisfy various conditions and local characteristics such as water depth, accessibility and availability of material.
- Many different materials are available and should be utilized, but they must be dealt with on an individual basis to insure maximum beneficial use.
- Reefs can be constructed and located so as not to interfere with other uses such as navigation, trawling, or mineral production.
- A variety of funding possibilities exists and should be explored including state government financing by dedicated revenue or general funds, local government financing, or funding by local interest groups, or private industry.
- A number of legal issues must be taken into account, some of which could conceivably present complex liability and jurisdictional problems, but should present no obstacles under the current regulatory framework and climate. (The major possible exception would be tort liabilities arising from privately financed and owned reefs.)

A comprehensive reef project would include a variety of individual artificial reefs. For instance, an area that contains a ship reef should also contain some tire or concrete rubble reefs for fishermen with boats too small to reach the ship reef.

Some scientists maintain that artificial reefs increase productivity in a large area while others maintain that productivity is not necessarily increased but that the reefs cause the existing fish population to concentrate in that area. Whichever opinion is correct, artificial reefs have created fishing grounds and provided pleasure and recreation to many more fishermen than could possibly crowd onto the natural reefs in our bays and estuaries and nearshore in the Gulf.

Appendix

Buoys

United States Corps of Engineers and United States Coast Guard regulations dictate that artificial reefs be marked with buoys. The Maritime Administration requires that reefs built of Liberty Ships be buoyed.

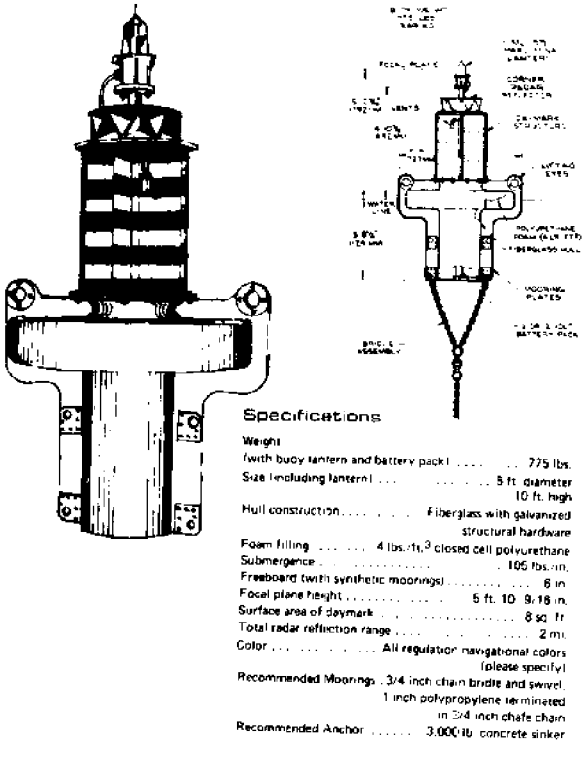
Coast Guard regulations state that any owner or operator, excluding an agency of the United States, of a structure who violates any of the rules and regulations prescribed for marking navigational obstructions, commits a misdemeanor and shall be fined $100 each day the violation continues. The Coast Guard is not responsible for checking and maintaining signaling devices. If, however, such a device is noticed to be missing or malfunctioning, the owner or operator will be notified and given an appropriate time to correct the situation.

Prescribed lights and signals are installed, maintained and operated by and at the expense of the owner or operator. After obtaining a Corps of Engineers' permit authorizing construction of a reef, the builder should apply to the Commander of the Eighth Coast Guard District, New Orleans, Louisiana, for an application form. The applicant completes all parts of the form relevant to the reef and forwards the application in quadruplicate to the district commander. The following information is required:

(1) The proposed position of the aid to navigation by two or more horizontal angles, or bearings, and distance from charted landmarks. A section of chart showing the proposed location of the aid to navigation should be included.
(2) The name and address of the person at whose expense the aid will be maintained.
(3) The name and address of the person who will have direct charge of the aid to navigation.
(4) The time and dates during which it is proposed to operate the aid.
(5) The necessity of the buoy.
(6) For lights: the color, characteristic, height above water and description of illuminating apparatus.
(7) For fog signals: type such as whistle, horn or bell and characteristic.
(8) For buoys and daybeacons: shape, color, number or letter, depth of water in which located or height above water.

Buoys, as any other structure in the ocean, can fall prey to the elements. They may be carried away, shifted, capsized or sunk. Lighted buoys may be extinguished or sound buoys may not function as the result of storm, the accumulation of ice, running ice, or other natural causes or collision. For these reasons mariners should not rely completely upon the position or operation of floating aids to navigation, but should also utilize bearings from fixed objects and navigational aids on shore.

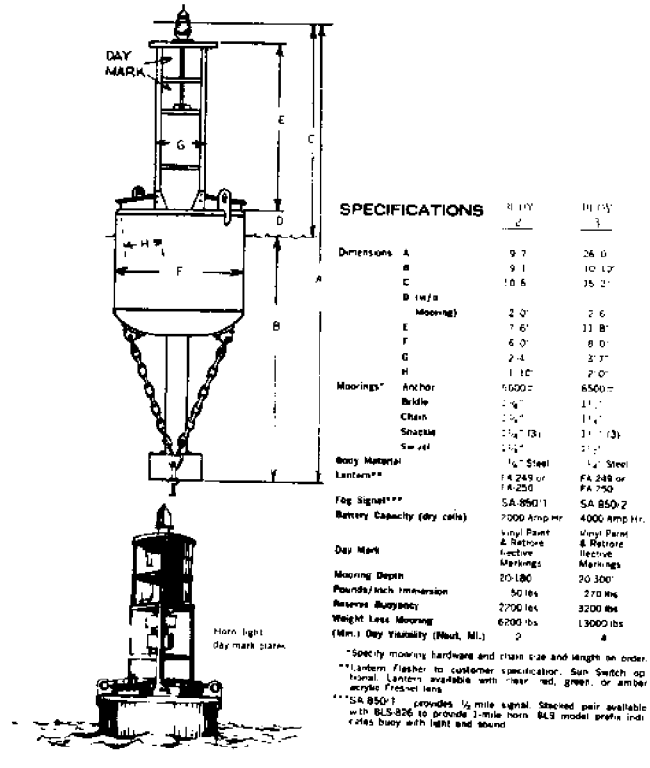
Whenever an artificial reef is erected in a position on or adjacent to the edges of navigable channels and fairways or to lines of demarcation, the district commander is authorized to require that the structure be marked by lights. Required lights are powered from a reliable power source including auxiliary power sources as necessary. They should display a flash characteristic prescribed in the permit issued by the district commander.



Specifications

Weight (with buoy lantern and battery pack)	775 lbs.
Size (including lantern)	5 ft. diameter 10 ft. high
Hull construction	Fiberglass with galvanized structural hardware
Foam filling	4 lbs./ft.^{3} closed cell polyurethane
Submergence	105 lbs./in.
Freeboard (with synthetic moorings)	6 in.
Focal plane height	5 ft. 10 9/16 in.
Surface area of daymark	8 sq. ft.
Total radar reflection range	2 mi.
Color	All regulation navigational colors (please specify)
Recommended Moorings	3/4 inch chain bridle and swivel, 1 inch polypropylene terminated in 3/4 inch chafe chain
Recommended Anchor	3,000 lb. concrete sinker

Courtesy of Tidelands Signal Corporation, Houston, Texas

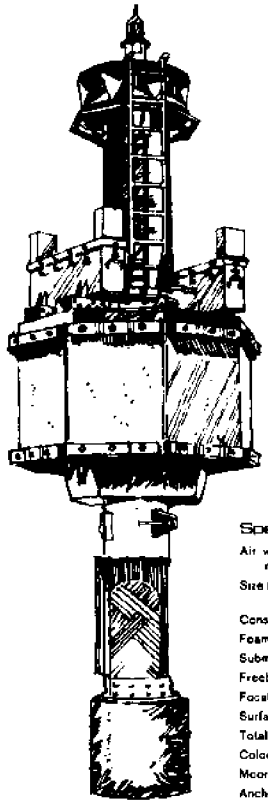


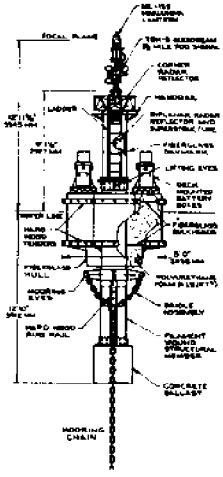
SPECIFICATIONS

Dimensions	A	9.7	26.0
	B	9.1	10.13'
	C	10.6	35.2'
	D (w/o Mooring)	2.0'	2.6
	E	7.6'	11.8'
	F	6.0'	8.0'
	G	2.4	3.7'
	H	1.10'	2.0'
Moorings*	Anchor	5600 lbs.	6500 lbs.
	Bridle	1 1/8"	1 1/4"
	Chain	1 1/4"	1 1/4"
	Shackle	1 1/4" (3)	1 1/4" (3)
	Swivel	1 1/4"	1 1/4"
Buoy Material		1/4" Steel	1/4" Steel
Lantern**		FA 249 or FA 250	FA 249 or FA 250
Fog Signal***		SA 850-1	SA 850-2
Battery Capacity (dry cells)		2000 Amp Hr	4000 Amp Hr.
Day Mark		Vinyl Paint & Retrore flective Markings	Vinyl Paint & Retrore flective Markings
Mooring Depth		20-180	20-300'
Pounds/inch Immersion		50 lbs	270 lbs
Reserve Buoyancy		2700 lbs	3200 lbs
Weight Less Mooring		6200 lbs	13000 lbs
(Min.) Day Visibility (Naut. Mi.)		9	9

*Specify mooring hardware and chain size and length on order.
**Lantern Flasher to customer specification. Sun Switch optional. Lantern available with clear red, green, or amber acrylic Fresnel lens.
***SA 850-1 provides ½ mile signal. Stacked pair available with BLS-856 to provide 1-mile horn. 84.9 model prefix indicates buoy with light and sound.

Courtesy of Pennwalt-Automatic Power, Houston, Texas



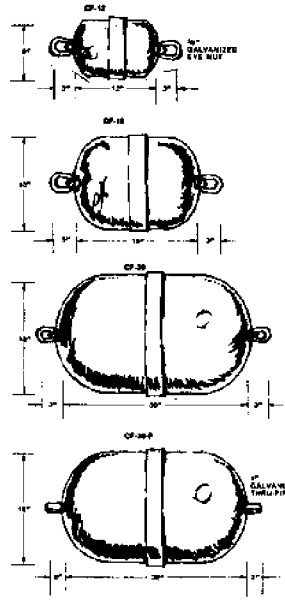


Specifications

Air weight (less batteries, bridle, moorings, fog signal)	7,360 lbs.
Size (approximate, less associated equipment)	8 ft. wide 22 ft. tall
Construction	Fiberglass with metal hardware
Foam filling	4 lbs./ft.³ closed-cell polyurethane
Submergence	188 lbs./in.
Freeboard (approximate for 40' water depth)	14 inches
Focal plane height (less fog signal)	11 feet
Surface visibility of daymark	16 sq. ft.
Total daymark radar reflection range	8 mi. max.
Color	international orange (or as specified)
Moorings (recommended)	1" open link chain
Anchor (recommended)	10,000 lb. concrete sinker

Courtesy of Tidelands Signal Corporation, Houston, Texas

Capsule Buoys



	CF-12	CF-16	CF-30	CF-30-P
Weight	5 lbs.	13 lbs.	33 lbs.	45 lbs.
Total Buoyancy (weight of water displaced by buoy)	20 lbs.	65 lbs.	220 lbs.	220 lbs.

COLOR International Orange. Other colors available upon request.

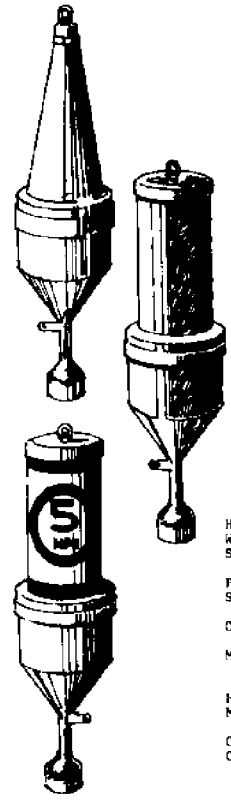
HULL: ¼" fiberglass reinforced polyester resin with 1-mil resin thickness color impregnated gel coat exterior.

FLOTATION: 2 lbs./ft.³ density non-absorbent 02% closed cell polyurethane foam, machine mixed and dispensed to assure uniform cell structure.

HARDWARE: ½" galvanized eye nuts (except 1" galvanized thru-pipe for CF-30-P).

Courtesy of Tidelands Signal Corporation, Houston, Texas

P-2ST Buoy



The high visibility, vertical stability and non-rotating characteristics of Tideland's P-2ST buoys enable them to perform as superior aids to navigation and regulatory markers.

In the can and nun configurations, colors and markings for the Cardinal Navigation System, they properly direct marine traffic. As regulatory (information) markers, they zone and control areas of surface activities for safer boating, skiing, swimming and fishing. They provide general information to the boater and locate and warn of hazardous conditions.

Long life with little or no maintenance is assured by the fiberglass hull with color impregnated gel coat exterior, polyurethane foam flotation, and corrosion-resistant hardware. Approved by U.S. and state regulatory agencies for private aids to navigation installations.

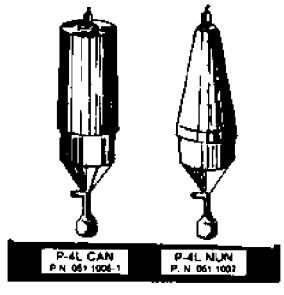
	CAN	NUN
Height	5' 6½"	5' 10½"
Weight	84 lbs.	80 lbs.
Submergence	8.68 lbs./in.	8.68 lbs./in.
Freeboard	33"-37"	36"-40"
Surface Visibility	3.20-3.76 sq. ft.	2.50-3.00 sq. ft.
Color	Black or White	Red
Maximum Mooring Line Weight	40 lbs.	40 lbs.

Hull: 1/8" fiberglass reinforced polyester resin.
Minimum Anchor Weight:

	Soft Bottom	Hard Bottom
Cast Iron Sinker	350 lbs.	700 lbs.
Concrete Sinker	500 lbs.	1,000 lbs.

Courtesy of Tidelands Signal Corporation, Houston, Texas

P-4L Wink Lite Buoy



The P-4L Wink Lite buoy is a minimal size lighted navigational aid weighing less than 100 pounds which is easily deployed. Designed for marking channels through bays and sounds, it is ideal for defining entrance channels to marinas, marking underwater obstructions, and controlling small craft marine traffic.

The buoy body is filled with closed cell polyurethane foam providing positive flotation in the event the buoy is damaged. Flashing light signal range is approximately one mile; dry cell battery pack duration is twelve months.

Specifications

	Can	Nun
Weight	97 lbs. (43.6 kg)	87 lbs. (39.1 kg)
Submergence	9.2 lbs./in (1.6 kg/cm)	9.2 lbs./in (1.6 kg/cm)
Surface visibility	3.15 sq. ft. (.29 sq. meter)	2.13 sq. ft. (.20 sq. meter)
Maximum mooring line weight	18 lbs. (8.1 kg)	18 lbs. (8.1 kg)
Color (as specified)	Black or white	Red
Hull construction	¼"(3mm) Fiberglass reinforced polyester resin with alloy steel thru-rod and mooring eye and gray cast iron keel weight	
Foam filling	4 lbs./ft.³ (.064 gms/cc) closed cell polyurethane	
Radar reflector	Bipleaner internal, to fit buoy configuration	
Color of lens	Clear, red or green (insert)	
Flasher code	Quick flash	
Visibility range of flashed light, clear lens	Approx. 1 mile (for red or green lens range is approx. ½ mile)	

Minimum Anchor Weight	Soft Bottom	Hard Bottom
Cast iron sinker	500 lbs. (225 kg)	1000 lbs. (450 kg)
Concrete sinker	750 lbs. (337.5 kg)	1500 lbs. (675 kg)
Mushroom anchor	150 lbs. (67.5 kg)	—

Courtesy of Tidelands Signal Corporation, Houston, Texas

If you're really interested...

People

Persons knowledgeable concerning artificial reef construction include:

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Local chambers of commerce and newspaper sportswriters may also be able to offer assistance.

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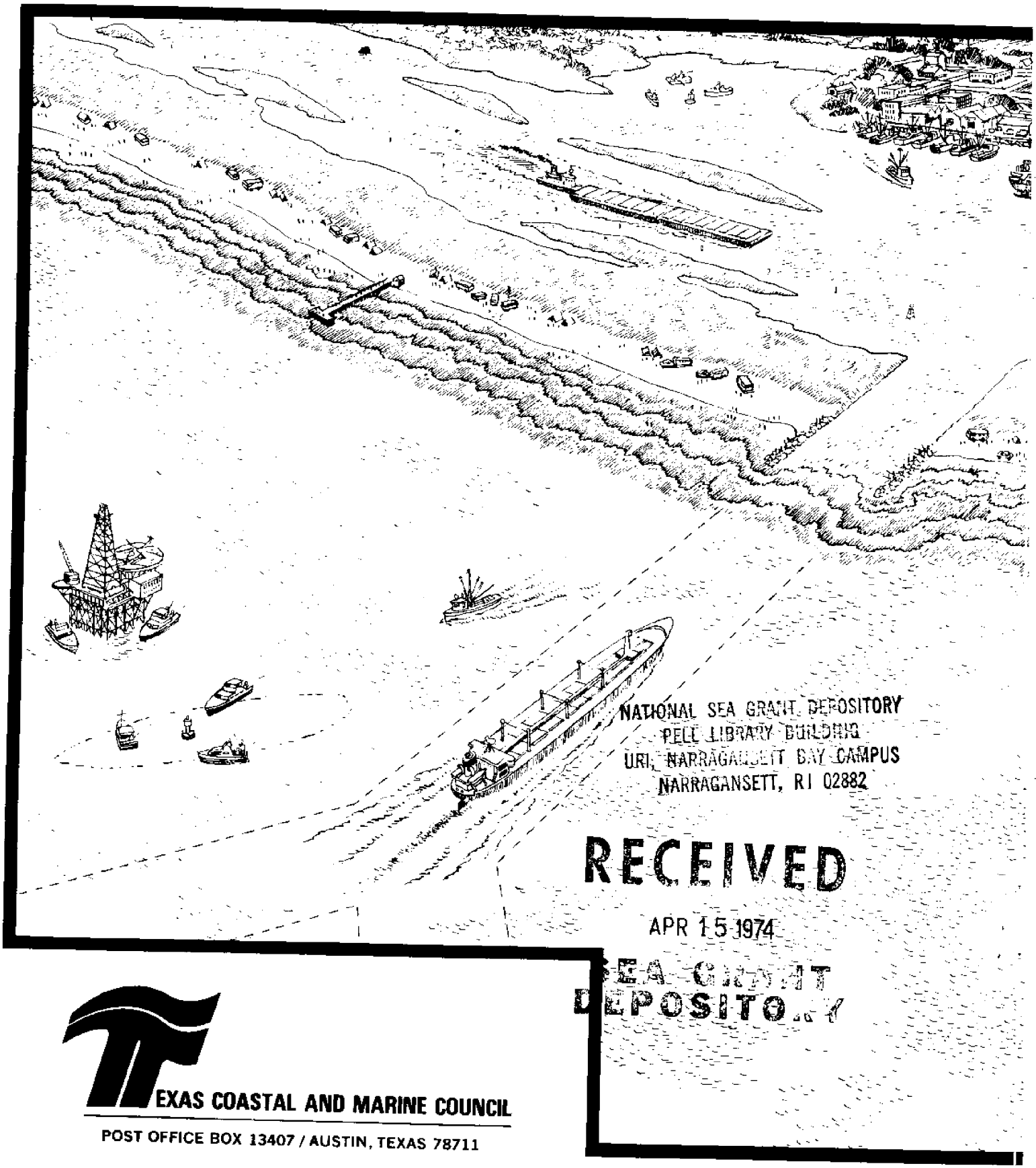
The Texas Coastal and Marine Council is a state agency charged to assist the state in the comprehensive assessment and planning of coastal and marine-related affairs in this state and their relationship to national and international marine-related affairs. The Industrial Economics Division at Texas A&M University is an applied research group. Sea Grant at Texas A&M University is a multi-disciplinary program of advisory services, education, and applied research administered by the Center for Marine Resources. Texas A&M is one of seven Sea Grant Colleges in the nation.



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