ARTIFICIAL REEFS

What we dump as junk into the sea, fish and other creatures call home. Fishermen reap the immediate benefits of such artificial reefs, but scientists worry about the long-term consequences.

By STEFI WEISBURD

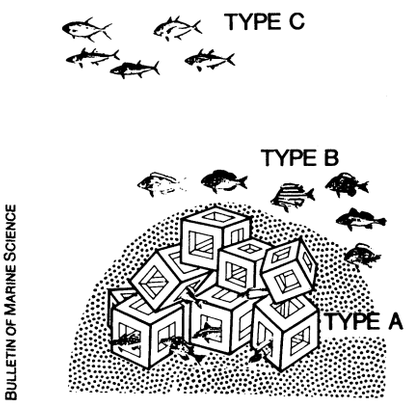
This month, the Sport Fishermen of Broward, in conjunction with Broward County (Fla.) and Boyd's Bait and Tackle Shop, sank a ship in honor of Bill Boyd, one of their deceased members. Bill Boyd's underwater memorial joins more then 500 artificial reefs – constructed of everything from oil rigs and barges to toilets and tires – that have been sunk off U.S. coasts in order to attract fish to places where they can be easily caught. Fishing clubs, local governments and businesses have been eager to build artificial reefs, which bolster local economies by luring sports fishermen as well as fish, while at the same time solving some community waste disposal problems.

But this approach has led to a somewhat haphazard array of often poorly designed and rarely monitored reefs that, some say, provide only short-term increases in fish catch. "We may at first be benefiting everybody because reefs make it easier to catch fish," says James Bohnsack, a fisheries biologist at the National Marine Fisheries Service (NMFS) in Miami, Fla. "But we may also be causing long-term problems by depleting the resource too quickly."

Bohnsack and other scientists and planners would like to see more work in the United States exploring how to use reefs as more effective tools for the long-term management of fisheries. They say there is a great need to answer fundamental questions about the behavior of fish at reefs, such as whether reefs simply attract fish or actually contribute to their production. Studies are also needed, they say, to assess the economics of reefs. Is it more cost-effective, for example, to build one large reef or a series of smaller ones – and out of what materials and what design?

In learning how to design reefs, scientists in the United States and elsewhere have much to learn from the Japanese, who have invested billions of dollars in the development of reefs – all of which are specially designed and built from materials like concrete and fiberglass rather than from conglomerations of abandoned objects – for commercial fishing. "The Japanese are much farther advanced than we are," notes Gregg Stanton, a biologist at Florida State University in Tallahassee. "And unfortunately, because of cultural and translation barriers, their work is not as accessible as it should be. So we are in many ways reinventing the wheel in this country."

Fishermen have known for centuries that fish congregate around sunken ships and other underwater structures, sometimes within hours after these structures have been placed on the sea bottom. The Japanese were building primitive artificial reefs in the 17th century; in the United States, according to Richard Stone at NMFS in Washington, D.C., the first documented artificial reef was constructed off the coast of South Carolina in 1830. Stone cites an 1860 article on Carolina sports, which notes that sheepshead fish ". . . were formerly taken in considerable numbers among our various inlets, into which large trees had fallen to which the barnacles soon became attached; but as the lands have been cleared for the cultivation of sea-island cotton, the trees have disappeared, and with them the fish; and it has been found necessary to renew their feeding grounds by artificial means. Logs of oak or pine are formed into a sort of hut without a roof . . . and sunk in eight feet of water by casting stones or live oak timber within; as soon as the barnacles are formed, which will happen in a few weeks, the fish will begin to resort to the ground."



BULLETIN OF MARINE SCIENCE

Different kinds of fish like reefs for different reasons. While some are attracted to the nooks and crannies that provide hiding places inside a reef, others hover far above, using the reef as a point of reference for navigation.

In the century and a quarter that followed, fishing associations, chambers of commerce and other groups built a variety of saltwater and freshwater reefs. The items used to construct the reefs evolved from logs and cement-filled butter tubs to ships and debris from Manhattan building demolition, and ultimately to concrete-filled Schaefer beer cases and car bodies. In the late 1950s and 1960s, according to Stone, increased interest in sports fishing and a general lack of knowledge of how to construct efficient reefs induced state and federal agencies to begin research on artificial reefs. Stone, for example, conducted a study off Florida that showed that the number of fish in an area doubled when an artificial reef was built near a natural reef.

Interest in artificial reefs has not been limited to the United States. Taiwan, Australia, Korea, France, Italy, Israel, England, China, Cuba, Kuwait and other countries have experimented with artificial reefs and "fish aggregation devices," which are supported by piers or buoys to attract fishes at midlevel depths, according to Stone. But the kingpins of reef development have been the Japanese, who eat more fish per capita than any other people in the world and who, according to Madelon Mottet of the Japanese Scientific Liaison in Friday Harbor, Wash., have plans to place reefs at 2,500 sites along one-fifth of their coastline. According to Makoto Nakamura of

the National Research Institute for Fisheries Engineering in Ibaraki, Japan, about 60 million cubic feet of artificial reefs have been installed in Japanese waters in recent years.

Japan has had more incentive to subsidize artificial reefs than has the United States, partly because Japanese commercial fishing co-ops own the sole rights to their fishing grounds and the reefs placed in them. According to Jeffery Polovina, an NMFS fisheries biologist in Honolulu who has visited Japan, the Japanese government views reefs as public works, such as roads or harbors, which support several different industries at once. In both Japan and southeast Asia, he says, governments have found it politically desirable to reserve for small-scale fishermen fishing grounds that are inaccessible to the larger trawlers.

In the United States, since no one owns parcels of seafloor and anyone can fish off a reef, companies have been less willing to sponsor or depend on reefs, and commercial fishing boats can look for fish farther offshore than recreational boats. "But that's liable to change," observes Stone. "There may very well be a need for reefs for commercial fishing in the future."

The Japanese have put a great deal of effort especially into the engineering of reefs by studying the mechanical and hydrodynamic properties of reef materials and structures. An artificial reef must withstand the fall to the ocean bottom and, once in place, the stresses of currents, burial and storms. The Japanese government sanctions and subsidizes more than 100 different reef designs, which look like modern sculptures of pyramids, terraces, cylinders and other geometric shapes. Japanese researchers have also classified more than 100 fish species according to what kind of reef they prefer – rock cod, for example, like low-standing reefs with lots of holes, crevices and narrow openings, while open-ocean species such as mackerel and tuna are attracted to high-standing, open structures.

"[The Japanese] have an enormous number of types of reef designs and materials and a lot of experience building and deploying them and fishing around them," says Polovina. "Yet even with the enormous money and deployment they haven't really answered the question: What is the value of these reefs from a fisheries production standpoint?"

Mottet concurs, saying that the justification for the money spent on reef projects lies probably not on biological or economic grounds but on political ones. "It seems that Japan is determined to increase its own coastal fisheries production, no matter what the cost, so it will be less susceptible to manipulation by foreign governments," she wrote in a technical report for the State of Washington's Department of Fisheries.

In Japan, as in other countries, there is still a considerable need for more fundamental biological research. For example, while it's clear that fish are attracted to underwater structures, scientists are still uncertain exactly why this happens. Fisheries biologists think that for some fish, the reefs serve as points of reference from which they can forage and navigate on an otherwise featureless seafloor. A few scientists have suggested that reef structures may also divert strong currents, providing more restful refuges for fish. Some fish feed on the abundant plants or other fish living at the reef. And for some species, reefs provide shelter, especially places to hide from predators. Some researchers have also suggested that the force of the currents against a reef creates sound signals and pressure waves that attract the fish from afar.

Depending on the species, fish may stay inside a reef, swim close by or hover far above the reef. Reef builders need to understand the requirements of the species they hope to attract in designing a reef. For fish that like to loiter inside the nooks and crannies of a reef, designers must also take into account the fish's visual ability, since studies have shown that fish tend to be very shortsighted; holes can't be too large or the fish won't notice them. However, says Bohnsack, "it's still wide open as to which features attract certain species and whether certain species can be attracted relative to others."

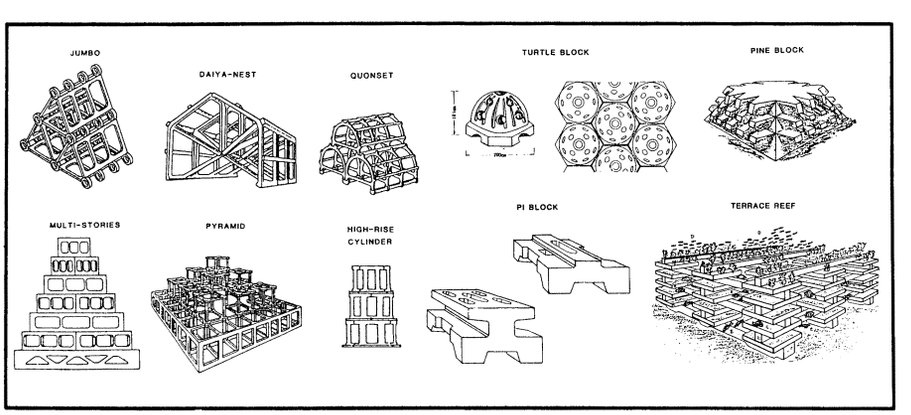
Artificial Reef Development Center/Sport Fishing Institute

This is one type of FAD, or fish-aggregating device, that attracts midwater species.

Beyond the question of why fish are attracted to reefs, the burning issue among reef scientists is whether these structures increase the overall production of fish, rather than just enhance the local population by attracting fish from other areas. According to William Seaman, associate director of the Florida Sea Grant College Program at the University of Florida in Gainesville, evidence has been presented for both sides.

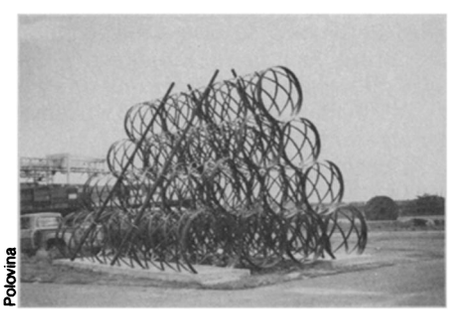
Polovina says that one reason this question has been difficult to resolve is that most field experiments have been performed in continental coastal regions, which are easily accessible to fish from other areas along the coast. Now he and his colleagues are conducting a study on a Molokai (Hawaii) Island bank, an environment they believe is much more isolated than continental coastal regions. The researchers plan to monitor the number of fish and other plants and animals living on the entire bank before and after the reefs are deployed.

"Any change in the production along



BULLETIN OF MARINE SCIENCE

The Japanese have designed a wide variety of artificial reefs. At left are some concrete modules. The Japanese reef below, made of fiberglass-reinforced plastic, is being tested by U.S. researchers in Hawaii.



Polovina

the entire bank, not just at a reef site, will be a measure of whether production around the entire island has been enhanced," says Polovina. His group is now testing a number of reef designs, including a concrete and fiberglass structure from Japan.

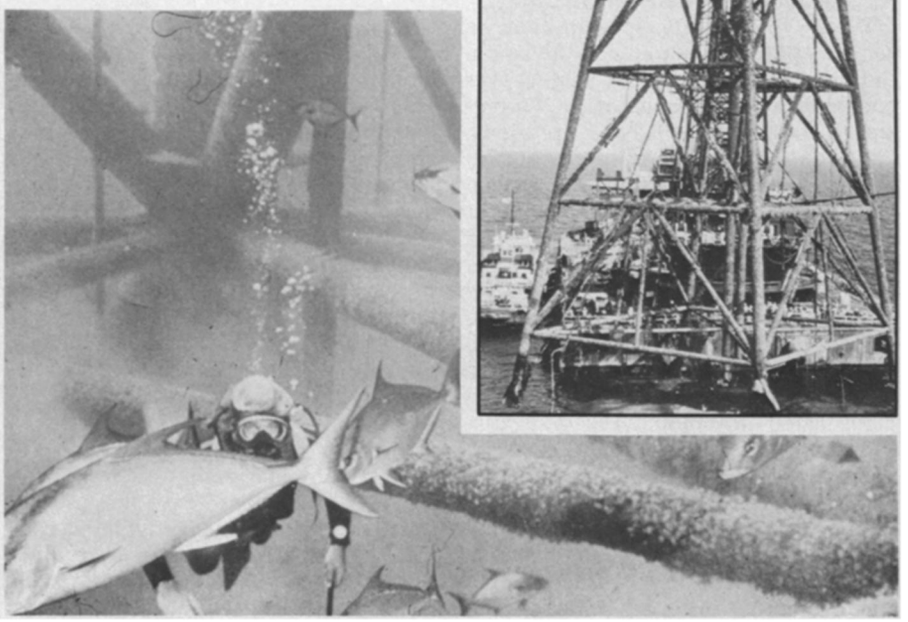
One possible route to ensuring that reefs are contributing to the production of marine life would be to design reefs that enhance the survival of young animals – by providing small holes for hiding, for example. Taking a slightly different approach, Gregg Stanton and his colleagues at Florida State are now working on reef designs that they hope will enhance the mating of stone crabs (whose claws are harvested without killing the animal). They suspect that male crabs gather harems of females, so the researchers are building reefs that contain one hole large enough for two crabs, surrounded by a number of other holes. When crab season arrives this fall, they should know if they have been successful.

Scientists are also exploring the possibility of stocking reefs with fish that have been raised in protected hatcheries. According to Stanton, one Japanese scientist has been working on a sort of Pavlov's fish experiment: Having raised fish in a hatchery where they were always fed just after a bell was rung, he is now studying whether fishermen might be able to harvest them at a reef by drawing them into a catching area with the sound of the bell. Bohnsack says the main uncertainty about stocking studies is whether fish raised in hatcheries would survive in the wild.

In addition to biological questions, U.S. reef scientists say there are many engineering and economic problems to be worked out. It's clear to many scientists that the practice of making reefs out of scrap materials is not a good long-term strategy. Cars and other metal objects usually rust away in a few years, and many structures of junk – even those made out of long-lasting tires – break up and are swept away by tides and currents. Some scientists worry that reefs made from surplus materials might contribute to ocean pollution and destroy natural fish habitats.

U.S. researchers have been designing modules made from durable, nontoxic materials such as concrete and plastics, and some have been testing Japanese-designed structures. There are also some ongoing studies on novel materials for reef structures, such as solid blocks made from the by-products of coal combustion, plastic domes used by drillers to protect wellheads and materials that are built up on underwater structures by electrodeposition – a process in which an electric current causes metallic ions dissolved in seawater to be deposited on a surface.

Oil rigs are not just for drilling. Some types of fish are attracted to a rig's open structure and high stand above the ocean bottom.



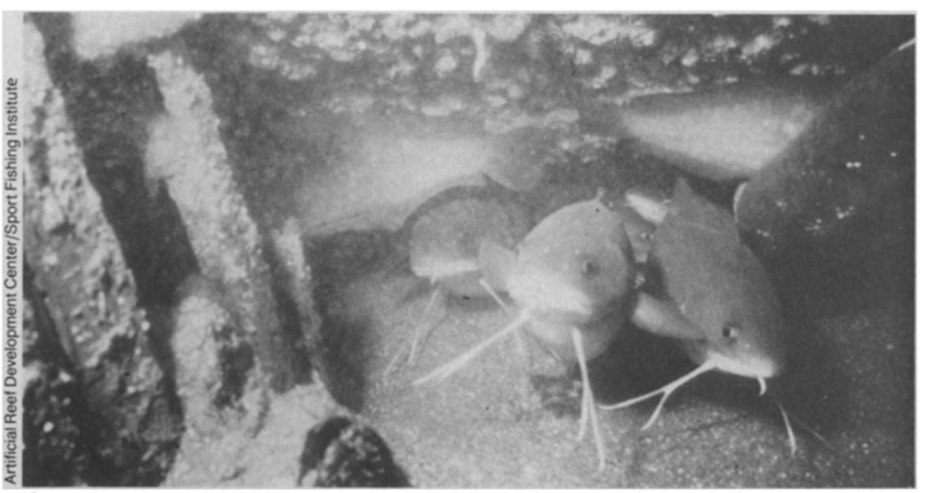
Artificial Reef Development Center/Sport Fishing Institute

Stanton notes that for deep waters, obsolete oil rigs appear to make good reefs for fish that like high-standing, open structures; the federal government has a "Rigs to Reefs" program to encourage oil companies to drop their rigs on community-approved sites rather than scrapping them for the metal. But Stanton also says that little research has been conducted on the biological impact and cost-effectiveness of rigs.

U.S. awareness of the promise and problems of reefs has increased in the last few years. In 1983, for example, the Sport Fishing Institute in Washington, D.C., established the Artificial Reef Development Center as a clearinghouse for information on reefs.

In 1984, Congress passed the National Fishing Enhancement Act, which mandated the National Oceanic and Atmospheric Administration (NOAA) to develop a plan to promote effective artificial reef use based on the best scientific information available. NOAA published this National Artificial Reef Plan last November. Reef scientists are now planning their fourth International Artificial Reef Conference, to be held in November 1987. Seaman also notes that coastal communities are becoming increasingly interested in long-range reef development.

"They are asking farther-reaching questions than perhaps some of the resource management agencies," he says. But in spite of progress that has been made, many of these questions cannot yet be answered. Observes Stone: "By and large, reef building is still much more of an art form than a rigorous science." □



Artificial Reef Development Center/Sport Fishing Institute

Cold-water, bottom-feeding ling fish off the coast of New Jersey make a sunken ship their favorite haunt.