ARTIFICIAL REEF TECHNOLOGY IN JAPAN

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INTRODUCTION

This report highlights artificial reef technology in Japan emphasizing ideas which were expressed in meetings with about a dozen artificial reef researchers and obtained from a number of reports and publications which were acquired during the author's ten-day visit to Japan in August 1985.

Japan has a long history of developing fishing reefs. Historically, piles of rocks were placed in shallow waters to create fish habitat. In 1952, the government began a subsidy program to support the construction of artificial reefs. In 1976, concerned over the declaration of the 200-mile exclusive economic zones by a number of countries of the world which threatened to reduce the fish catches of Japan's far seas fleet, the government made a major commitment to increase fish production in her coastal waters. The government saw artificial reefs as one way to increase fish catches in their local waters and in 1976 initiated the a six-year program with about $40 million a year to be spent on construction and deployment of artificial reefs. In 1982, a second six-year program continued the first six-year program with annual funding for artificial reef construction and deployment at about $50 million.

Much of this funding in recent years has been directed toward large-scale artificial reef projects, those which have an enclosed volume of more than 50,000 m^3 and which are installed in areas where there is no existing fishery with the objective of creating new fishing grounds. The national government funds about 50% of the costs of the smaller projects, those which are used to enhance existing fishing grounds, and about 70% of the costs of the larger projects. The remainder of the funding comes from prefectural governments with a small contribution from fishing villages and cooperatives.

CURRENT STATUS

While the design of an artificial reef is still largely an empirical art, the Japanese feel strongly that the construction of an artificial reef at a specific site must take into account oceanographic and bottom conditions and the biological requirements of the target species. Dr. Yoshinori Ogawa of the Nansei Regional Fisheries Research Laboratory indicated that the behavior around artificial reefs of about 150 marine species has been examined and five patterns of reef usage have been identified. There are those species such as lobsters and moray eels which prefer strong physical contact with the reef structure. Then there are those species such as the rockfish which prefer close contact with a fin or belly to the reef. The third type of behavior is found with many reef fish such as the red snapper which is close proximity to the reef without actually touching it. The fourth pattern of behavior is exhibited by fishes such as mackerel and yellowtail which do not necessarily require a hard structure but use it for orientation when one is found. Finally, there are those fishes which appear to use the internal wave generated by the current over the reef structure; these fishes tend to be more pelagic in nature such as the tunas and swordfish. Artificial reefs can be used in a number of ways by fishes. Larval fishes may settle out on the reef and use it for shelter. Some fishes will use the reef for habitat and actually reside in the artificial reef while others will stay some distance from the reef and just use it for orientation. For some fishes the reef will be a foraging site while for others it will be used as a spawning site.

Prior to the construction of a large-scale artificial reef, oceanographic and fishing surveys are conducted to evaluate a potential site. Typically the artificial reef should be separated from an existing natural reef to avoid competiton for the same fish stocks. In Japan it is recommended that artificial reefs be separated by at least 1 km from natural reefs. The artificial reef should be sited on a hard bottom where subsidence will be minimal and in an area which is flat or gently sloping where the bottom contours are parallel to each other. In this type of monotonous environment, the reef will be conspicuous to fish looking for food, shelter, or a feature to provide orientation.

The artificial reef is composed of a number of modules. These modules are most frequently constructed with concrete, steel, or fiberglass. Their designs range from simple open cubes to large and intricate steel or fiberglass structures (Figure 1). The type of reef module used and the depth at which it is placed must be tailored to the behavior of the target species. For example, species such as lobsters and abalone require reefs with small intricate spaces and a rough surface while adult sea bream use reefs with large openings and vertical height.

Typically the size of an artificial reef is measured as the volume it encloses since the volume appears to be the single most important factor in influencing the abundance of fish found at the reef. Thus, a reef composed of 1000 concrete cubes 1 m on a side would have a volume of 1000 m^3. In the Japanese artificial reef design there are four levels of construction. The reef unit or module is the individual block. The size of the individual module can range from 1 m^3 to several hundred m^3. The reef set is composed of a number of reef units. It is recommended that the reef units be piled together to form a reef set to increase the spatial complexity and the vertical relief, and that the total size of the reef set be at least 1000 m^3. A reef group consists of 10 to 20 reef groups with a separation of about 400 m between each reef set in the group. The size of the reef group should be at least 50,000 m^3. In some instances, for a particularly large-scale artificial reef a number of reef, groups will be used to form a reef complex.

EFFECTIVENESS OF ARTIFICIAL REEFS

I was particularly interested in learning what the Japanese have discovered concerning the effect that artificial reefs have on the marine ecosystem and the role they play in their coastal fishery. Two of Japan's foremost experts on artificial reefs, Dr. Yoshinori Ogawa of the Nansei Regional Fisheries Research Laboratory and Dr. Hiroshi Kakimoto of the Niigata Prefectural Fisheries Laboratory, both indicated that artificial reefs in Japan generally impinge in a number of ways. They aggregate fish and thus increase the catchability of fishing vessels. This role is particularly useful for the more migratory demersal and pelagic fishes, and artificial reefs are frequently sited in migration paths where they interrupt the migration for a period of time which allows fishermen time to fish the stocks. A time series of acoustic surveys conducted along the coast of Niigata Prefecture covering both an area with and without and artificial reef indicated that usually the greatest concentrations of both demersal and pelagic fishes were found at or near the artificial reef rather than over the open bottom with similar oceanographic conditions but without an artificial reef. However, large concentrations of fishes were not always at the artificial reef site and at times the acoustic survey did not detect any fish at the artificial reef site.

A second function of the artificial reef in Japan, in areas where there are conflicts between large trawlers and small vessels which use hook and line and trammel net gear, is to use the artificial reefs which would damage a trawl net to close an area to trawling and

create a fishing ground for the small vessels with more traditional gear.

A number of studies in Japan indicate that a different composition of species are caught at artificial reefs than on nearby open bottoms with the same oceanographic conditions. Thus, artificial reefs appear to produce a change in the species composition from flat bottom associated fishes to reef associated fishes and this change in species composition in many cases is beneficial because the fishes which are found associated with artificial reefs such as rockfish and red snappers often command a higher market price than the fishes caught on the flat bottoms.

One question which has yet to be resolved is the extent that artificial reefs actually increase production rather than simply aggregate fishes. Surprisingly the Japanese, even with their large expenditures on the construction of artificial reefs, have not rigorously addressed this question. In general, there were no baseline studies of catch rates in areas which received artificial reefs prior to the placement of these reefs to compare with the catch rates after the creation of the artificial reef. Even this data would not adequately address the question unless data were available on catch rates along the coast on both sides of the artificial reef to determine the extent that the artificial reef drew fishes from the adjacent areas rather than actually increased production.

The work that has been done to evaluate the extent that artificial reefs increase production has not been conclusive. Frequently a value of the increase in annual production of about 5 kg of fish biomass per cubic meter of artificial reef volume is cited, particularly in feasibility studies but this value has not been rigorously documented. Other studies such as one conducted in Makimura, Hokkaido, which compared the value of fish catches in a area prior to the placement of an artificial reef with the value of the catches after an artificial reef, found that there was no significant economic benefit from the reef.

However, relative to the other functions the artificial reef plays such as aggregating, and excluding trawlers, the increased production offered by the reef may in many cases be secondary. For example, in the Niigata area about 350,000 m^3 of artificial reefs have been installed since 1955 along about 250 km of coastline. The average annual fish landings from that area is about 100,000 metric tons. Even if the artificial reef increases production by 5 kg per cubic meter of reef volume, the increase in production from the artificial reefs will only be 1750 metric tons or less than 2% of the total annual landings from the area and not even enough to be measurable relative to the annual variation in total landings. However, the benefits from effectively aggregating migratory fishes to vessels can increase their catches and reduce their travel time and benefits to maintaining employment in coastal fisheries by providing fishing grounds for smaller vessels with more traditional gear which cannot compete with larger trawlers can make artificial reefs an effective management tool. They are popular politically because they benefit the numerous fishing villages and cooperatives which have political influence. Further, the government subsidies directly benefit large concrete, steel, and fiberglass companies which produce the reef modules as well as other industries involved in the deployment of the modules.

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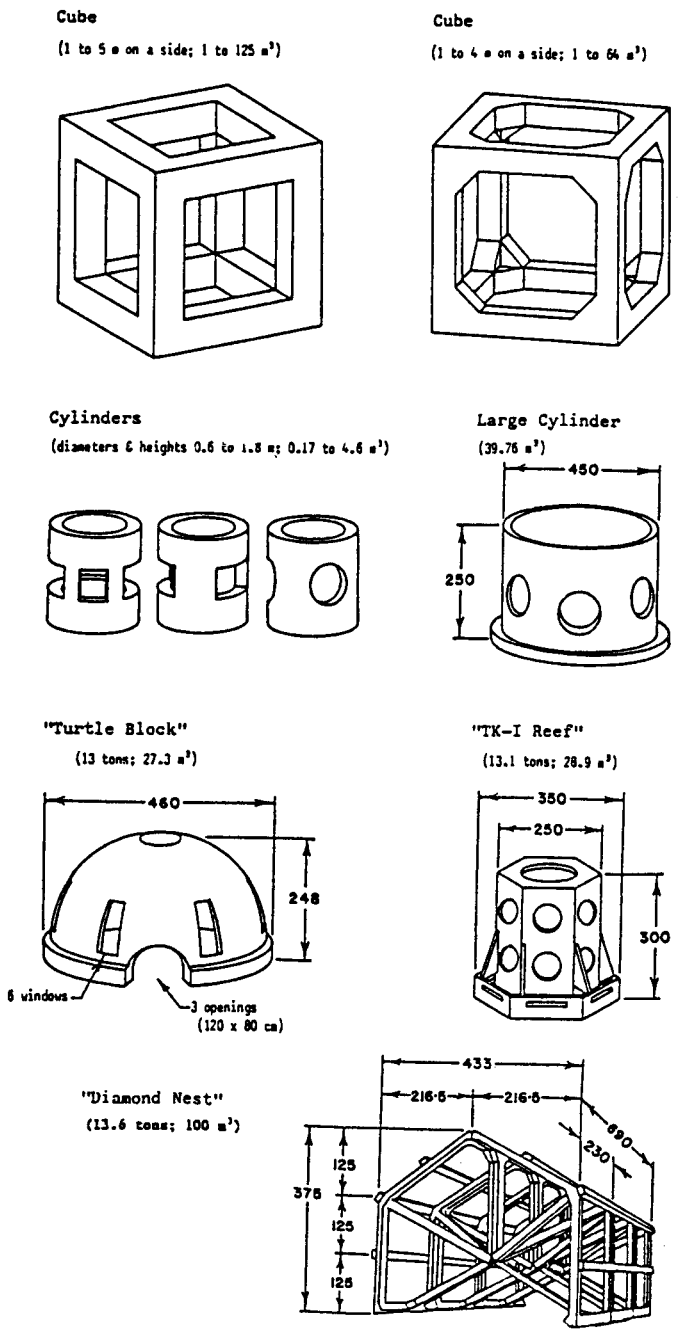

Figure 1. Selected artificial reef modules (sizes in cm)

Note: These figures are from "Enhancement of the Marine Environment for Fisheries and Aquaculture in Japan," Mottet, M. G. State of Washington, Department of Fisheries, TR No. *69* (1981).

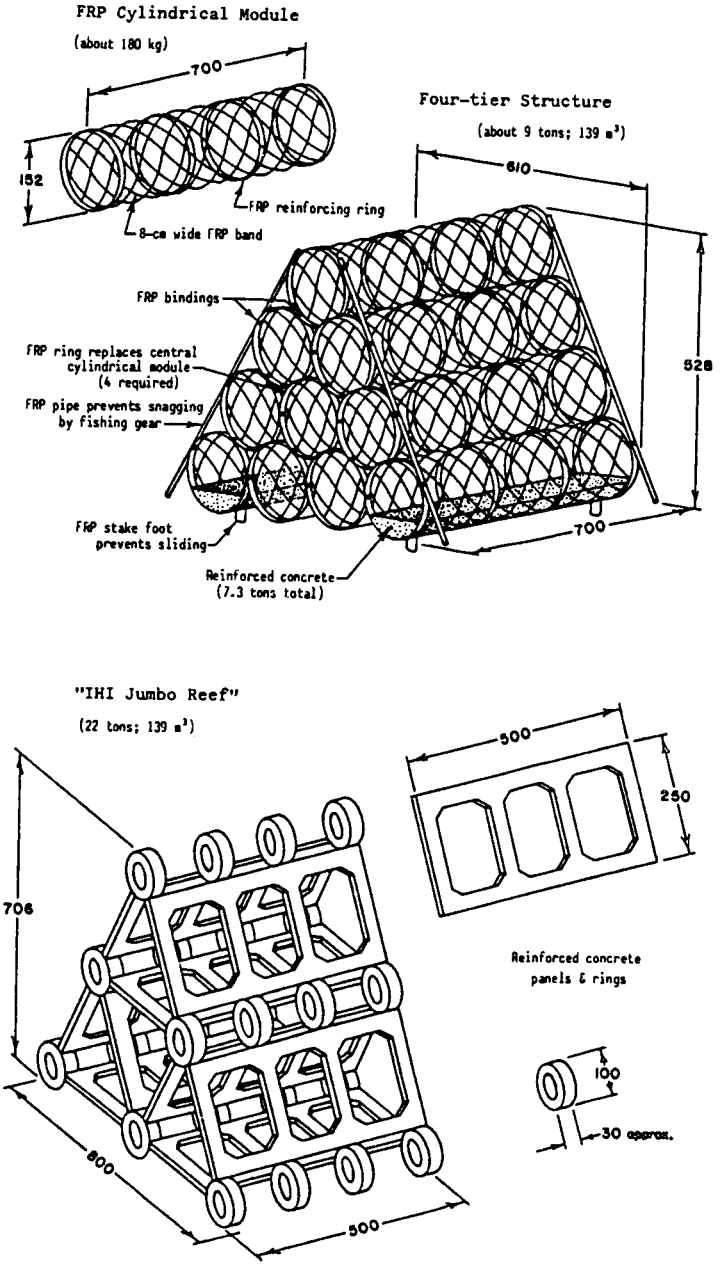

Figure 1 continued.