

# THE POTENTIAL OF ARTIFICIAL REEFS AS FISHERIES MANAGEMENT TOOLS IN DEVELOPING COUNTRIES

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## ABSTRACT

There is a growing need for international cooperation among developing countries in order to increase the contribution of artificial reefs to reverse the trend of fisheries resource depletion. To establish desirable directions for future cooperation in this field, we analyzed three recent artificial reef projects in the Philippines and Senegal. Past experience has begun to teach us that artificial reef deployment alone does not produce clear, positive effects in enhancing fisheries resources, but rather leads to the opposite effect of attracting fishing activities in protected areas. As poverty among fishermen lies behind this problem, it is imperative to include economic activities, such as commercialization of highly valued fish in artificial reef projects. Income from such activities can be used to compensate for the decline of income due to reduction of catch and to raise funds for sustainable surveillance of undesirable fishing practices on the artificial reefs. Furthermore, artificial reef projects must be integrated in a broader fisheries management plan in order to be effective. Unless the positive impacts of artificial reefs are clearly established, they should not be overestimated. While a participatory approach is desirable for an artificial reef project, the ideal outcome should be co-management by fishing communities and the government.

There have been an increasing number of cases of international cooperation to introduce artificial reefs to developing countries, which are facing worsening conditions of their fisheries resources (IC Net, 2002; PRIMEX-OAFIC, 2003; OFCA, 2004; OAFIC, 2005). Behind such cooperation lies the need for developing countries to revive the fisheries sector by increasing fisheries resources through the use of artificial reefs and the intention of developed countries to utilize their technical expertise regarding artificial reefs.

Prior to such international cooperation, artificial reefs were used by many developing countries for various purposes, including improvement of fishing efficiency, increase of fisheries resources, deterrent to access by trawlers, shore protection from wave action, protection of coral reefs, and promotion of SCUBA diving and recreational fishing (von Brandt, 1984; National Research Council, 1988; Polovina, 1991; Chou, 1997; Kakimoto, 1998a). While technologies to introduce structures and devices in the sea to create good fishing grounds have a long history in Africa, Asia, and the Pacific Region, the contribution of artificial reefs to coastal area management as a resource enhancement tool has long been recognized in Southeast Asia (White et al., 1990).

It is frequently noted that although artificial reefs can be a tool for “fisheries development,” their functioning as a tool for “fisheries management” is difficult (Meier et al., 1989; Polovina, 1991; Grossman et al., 1997; Pickering and Whitmarsh, 1997; Babaran, 2004). Although the introduction of artificial reefs creates fishing grounds by attracting fish, there is a corresponding concentration of fishing efforts, resulting in further decline of the resources. It is anticipated that this problem with artificial reefs will be particularly manifested in developing countries, where the livelihoods of many poor people depend on fisheries (National Research Council, 1988; Munro

and Balgos, 1995). Developing countries also face other problems, including: 1) an increase in the number of fishing boats with free access to fisheries resources, 2) lack of a legal and institutional basis for fisheries management, and 3) an absolute shortage of funds, technologies, and human resources to solve problems in the fisheries sector. In order to enhance the positive effects of artificial reef projects under these circumstances, the implementation of a comprehensive policy that corresponds to the development stage of each country is necessary. The implementation of a win-win approach, which aims at simultaneously achieving fisheries management and poverty reduction is particularly important.

We have participated in international cooperation projects for fisheries management in the Philippines as well as in Senegal and have directly witnessed the problems associated with artificial reefs in developing countries. It is becoming clear that projects solely aimed at introducing artificial reefs achieve the opposite effect than that anticipated. Instead of improving, the fisheries resources become prone to heavy exploitation, as local fishermen continue to invade the no-fishing zone around the newly introduced artificial reefs. In contrast, projects that further aim to improve the standard of living provides an economic incentive for local fishermen and a tendency for them to actively adopt fisheries management practices.

Here, we outline three projects and examine these case studies to identify problems. Based on these observations we make several recommendations for future projects involving artificial reefs in developing countries. Although generalization is difficult due to the diversity of developing countries in terms of the income level, social system, fishing characteristics, etc., we can make some arguments by considering the similarities of developing countries.

### THE PHILIPPINES

The Philippines is a leading country in terms of fisheries and aquaculture in Southeast Asia, with a production volume of 2.5 million t in 2002 (FAO, 2004). The fisheries sector accounts for 4.3% of the GDP and 5% of the employed population and the annual per capita consumption of marine products of 28.5 kg far exceeds that of meat, making the stable supply of marine products for the public an important issue for the country. A number of problems have emerged, including the depletion of fisheries resources in important habitats in the coastal areas due to over-fishing, illegal fishing, and development of aquaculture, constituting major causes of the poor performance of fisheries activities (Barut et al., 2004).

As part of the overall efforts to revive fisheries in the Philippines, particular attention has been paid to artificial structures as creative fish resource management schemes. In the mid-seventies, the *payao* (a floating device attracting valuable pelagic species as skipjack and tuna) technology emerged as an effective fish aggregating device. At about the same period, the use of anchored-type bottom structures to attract and concentrate demersal fishes also became popular. Since the use of old tyres at Negros Island in 1977 by the Siliman University, numerous experiments have been conducted using various materials, such as wood, bamboo, rocks, concrete, out-of-service fishing boats, and cars (Munro and Balgos, 1995). However, the virtual biological and socioeconomic effects of artificial reefs remained unclear.

There are few deployed artificial reefs in the Philippines known to have institutional arrangements for management. These artificial reefs are supported by resolu-

tions of the adjacent communities or ordinances from municipalities, declaring such areas as protected areas. However, documents on sustainable enforcement of these laws, including monitoring and evaluation of these reefs are still wanting. Nevertheless, community involvement in artificial reef management could be tried as an instrument to institutionalize and sustain the aspirations of the artificial reef in the Philippines.

**FISHERIES RESOURCE MANAGEMENT PROJECT.**—The Government of the Philippines has implemented the Fisheries Resource Management Project at 18 bays nationwide from 1999 to 2005 by using loans provided by the Asian Development Bank (ADB) and the Japan Bank for International Cooperation (JBIC). The Bureau of Fisheries and Aquatic Resources (BFAR), the implementation body for the project, has been implementing wide-ranging sub-projects in tandem with local public bodies, fishermen, and NGOs to proceed with the decentralization of fisheries management and to create a participatory management system. These sub-projects include the profile development of fisheries resources and the related environment, organizing of fishermen, introduction of marine protected areas (MPAs), rehabilitation of mangroves, provision of alternative means of livelihood, improvement of fisheries statistics and the fisheries licensing system, development of fisheries and geographic information systems, and development of a fisheries management model in the pilot area.

There is increasing interest in MPAs (including areas with either spatially restricted or no fishing) in the Philippines as a fisheries management tool. Various MPAs have been established across the 18 bays selected for the project. These MPAs are set up to protect the reef areas from degradation and to allow resources therein to regenerate without or with minimal disturbance from the human population. The size of a typical MPA is approximately  $600 \times 500$  m (30 ha). Fishing is often totally prohibited within a core zone of each MPA, including the coral reef area. The surrounding area of the core zone in these cases is called a buffer zone, where only hand-line fishing is permitted.

At Sapan Bay of Panay Island, there has been a debate concerning the planned introduction of artificial reefs in the buffer zone of the MPA. The supporting arguments were that artificial reefs: 1) recover demersal fish resources, and 2) prevent the invasion of trawlers in the coastal area. Meanwhile, the opposing arguments were that: 1) there is no precedence of the proper management of artificial reefs in the Philippines, even though such management is a precondition to recover demersal fish resources; 2) artificial reefs constitute an incentive and opportunity for fishermen to use resources inside the MPA, possibly facilitating the destruction of coral reefs by means of fishing using dynamite, etc.; 3) fishing should also be prohibited in the buffer zone as permission would lead to further fishing without effective control; and 4) no additional money should be invested in a project of which the positive effects were doubtful. In the end, the side in favor of artificial reef deployment won the debate and 64 cubic concrete artificial reefs (1 m each side) were introduced in the buffer zone of Sapan Bay MPA.

The municipal government is responsible for the management of the MPA, including the artificial reefs, while the Fish Sanctuary Management Committee formed by the residents of the municipality is supposed to conduct daily patrols to prevent illegal fishing. However, as this committee consists entirely of volunteers, it is now facing a situation where it can no longer sufficiently provide the necessary manpower

or funding to continue to conduct patrols. Because of the reduction of the frequency of patrols, a sizable number of fishing boats are conducting gill-net fishing and spear fishing in the MPA.

The Philippines case presents a problem in the community-based form of artificial reef management. Although the community is willing to manage the artificial reefs, it lacks the financial capability to implement its operations. Another issue is whether the artificial reefs have been effective in preventing trawl fishing and whether demersal fish resources have recovered as stated in the objectives. Thus, deployment of artificial reefs must be cautiously done in terms of purpose and financial capability.

## SENEGAL

The fisheries sector in Senegal accounted for 11% of the GDP produced by primary industries from 1990 to 2000. Some 600,000 people, or 17% of the working population, are estimated to work in this sector. The annual per capita consumption of marine products is 27 kg (Ministry of Fisheries, 2003).

Even though Senegal is a leading fisheries country in West Africa, the landed quantity of fishes by artisanal and industrial fisheries has been stagnant in recent years at ~350,000 and ~50,000 t, respectively (Ministry of Economy and Finance, 2003). A decline in the demersal fish resources due to over-fishing is evident, which is seriously impacting the national economy and household economy of fishermen. In many fishing villages, the income of fishermen is low, and fishing activities are increasing, resulting in the decline in fisheries resources, further exacerbating poverty. Efforts of the Senegal government to establish sustainable use of fisheries resources have not been successful due to funding and manpower shortages. To improve the situation, the World Bank, EU, FAO, European countries, and NGOs have implemented various aid projects to achieve fisheries management, but tangible achievements have yet to be made.

**COASTAL FISHERIES RESOURCES MANAGEMENT AND ENHANCEMENT PROJECT.**—The Overseas Fisheries Consultants Association (OFCA) of Japan implemented an artificial reef project from 2001 to 2003 to increase demersal fish resources. This project materialized following the government of Senegal's request to the government of Japan, a country with a long history and much experience of using artificial reefs. At that time, hardly any technologies or knowledge concerning artificial reefs existed in Senegal except for one case of the Leisure Fishing League sinking several out-of-service buses and boats into the sea off the coast of Goree Island at a water depth of 30–50 m in the 1990s (OFCA, 2004).

Under this project, a site with a water depth of 20 m off the coast of Bargny was selected as the site for the deployment of artificial reefs because of 1) its proximity to the capital of Dakar, which would allow easy monitoring of the project, and 2) the calm sea and few natural reefs at the site, which would make it easier for artificial reefs to have their intended effect. The specifications of the artificial reefs were determined in Japan and a local construction company fabricated and installed the artificial reefs based on the provided specifications. Six concrete blocks of 3 m each side (weighing 9 t each) were placed along the circumference of a circle with a diameter of 30 m. Rocks (totaling 130 m<sup>3</sup>) were then sunk inside the circle.

After the deployment of the artificial reefs, educational activities were organized for fishermen and a management committee made up of fishermen representing five

nearby coastal villages was formed. On the advice of the Dakar-Thiaroye Oceanographic Research Center (CRODT), this committee designated the entire artificial reef area as a no fishing zone to protect the demersal fish resources, and rules prohibiting fishing in this zone were given legal status under an ordinance of the competent province. To ensure the enforcement of this ordinance, the committee members in turn patrolled the area in and around the zone three times a week in principle. Meanwhile, the CRODT regularly gathered landing data and conducted tests on the available resources for fishing to evaluate the scientific and economic effects of the artificial reefs. Moreover, a local NGO was subcontracted to observe and take photographs of fish gathering around the artificial reefs. The entire cost of these activities was approximately US\$100,000 and was paid by the OFCA. In December 2003, 1.5 yrs after the installation of the artificial reefs, a seminar to summarize the findings and outcomes of the project was held. This seminar marked the end of the project as well as the Japanese financial assistance (OFCA, 2004).

The Senegal artificial reef project was aimed at increasing the demersal fish resources not only through the deployment of artificial reefs to attract fish, but also through such measures as legal restrictions and monitoring to prevent illegal fishing. The positive effect of the reef deployment was suggested by underwater images showing the gathering of such high-valued fishes as grouper and snapper around the reef, though this does not necessarily mean that the fishes were raised in the artificial reefs. The positive effect of reef deployment was indicated by the testimony of many fishermen from nearby fishing villages stating that new types of fish are now caught locally. An increase in small canoes not equipped with outboard motors is likely due to the shorter distance to the fishing grounds created by the artificial reefs (OAFIC, 2005).

However, once funding was terminated for the project, expenses-related problems arose such as the inability to purchase fuel for the patrol boat to monitor illegal fishing and the lack of budget to reinstall lost buoys defining the boundary of the no-fishing zone. The sense of dependence on outsiders, which developed among local fishermen because of the project mechanism whereby all of the necessary funds were supplied from outside, lies at the root of these problems.

**STUDY ON FISHERIES RESOURCES ASSESSMENT AND MANAGEMENT.**—The Japan International Cooperation Agency (JICA) is conducting a study on fisheries resources assessment and management in Senegal for a period of 3 yrs from 2003. This project does not solely focus on artificial reefs, but aims at establishing a community-based fisheries management model by means of solving the problems faced by Senegalese fishermen engaged in artisanal fishing in a comprehensive manner. Nianing and Yenne have been selected as the pilot project sites (only the pilot project at Nianing is described here). As a fishing village, Nianing has such characteristics as a high level of awareness of the need for fisheries management, strong bonds of fishermen's organization, high proportion of local fishermen, high number of immobile fisheries resources, compactness of the village (population of approximately 6000), adjacency to fishing villages with similar fishing conditions, no overlapping of donor projects, convenient access from government offices, proximity to a market, and absence of fisheries infrastructure. One hundred and seventy-seven fishing boats operate from Nianing and the local fishing methods include bottom gillnet targeting *Cymbium* sp. and *Murex* sp. (gastropods), trammel net and traps targeting cuttlefish, hand-lines

targeting octopus and beach seines. The total catch in 2002 was 1479 t with the top three consisting of *Cymbium* sp. (65%), octopus (21%), and cuttlefish (7%).

A workshop to define the pilot project was held with the participation of local resources users and proceeded from understanding of the existing situation (Step 1), analysis of the problems (Step 2), planning of the pilot project (Step 3), establishment of a local body responsible for fisheries management (Step 4), and determination of the role of the government of Senegal (Step 5). The issues emphasized at the workshop were situations specific to the area, traditional knowledge possessed by fishermen, findings of a socioeconomic survey, and biological information on important fisheries resources. The perception that fishermen can handle fisheries management once the financial problems of fishing households are solved was shared. It was decided that the first activity under the pilot project would be the introduction of a closed season for octopus from 15 September to 15 October 2004 and the commercialization of marine products for export to supplement the income of fishermen. The fact that commercialization conducted prior to the introduction of the closed season produced much profit enhanced the motivation of fishermen to introduce a closed season and almost all of the fishermen observed the rules. Common responses to a questionnaire survey on evaluation of the pilot project were: "income increased after the project despite the introduction of the closed season" (72% of the respondents) and "the closed season for octopus fishing should be implemented every year" (91%). These responses indicate that the efforts to simultaneously achieve fisheries management and poverty reduction have been making progress with the implementation of the pilot project.

Among the fishermen who successfully introduced the closed season for octopus fishing, voices called for the introduction of artificial reefs as the next step. Aside from over-fishing, the habitats of octopus might have been disturbed by excessive trawling. After some discussion, it was decided to create a spawning bed of which multiplication effects with the closed season could be expected. The introduction of octopus spawning structures in the sea as an initiative of fishermen to protect and increase octopus resources was believed to be very important, not only because of its contribution to promoting local fisheries, but also because of the possible extension of the practice to other areas experiencing the same problem.

The stakeholders preferred unglazed pots to serve as spawning beds for octopus because they could be locally made, cost less, and have a relatively short life on the seabed. Octopus pots (20 × 30 cm) of smaller sizes attract octopus, but not necessarily fishes, thus areas with octopus pots do not attract fishermen as large artificial reefs do, as such it is not necessary to exercise strict surveillance in octopus pot areas.

Instead of simply unilaterally deploying spawning pots, a joint survey on octopus spawning was conducted with the fishermen in an attempt to foster their awareness of the need to protect fisheries resources. The stable finances of fishing households due to commercialization created no economic hindrance of this activity. In fact, willingness to participate in this activity has spread to nearby fishing villages.

## DISCUSSION

The problems associated with the use of artificial reefs as a tool for fisheries management as experienced in the Philippines and Senegal include: 1) the difficulty in practice to conduct surveillance designed to prevent illegal fishing near artificial

reefs; 2) people involved in international aid operations have the excessive expectation that the establishment of artificial reefs is sure to contribute to an increase of fisheries resources; 3) there are limited efforts to evaluate the effects of artificial reefs apart from the biological and socioeconomic aspects; 4) the level of awareness among fishermen of their responsibility for the management of artificial reefs is low in the absence of appropriate integrated coastal management and training programs. Additionally, governmental bodies show a strong tendency to depend on external aid and thus do not plan appropriately for maintenance and enforcement costs; and 5) the response of the governments of developing countries to fisheries management in general is insufficient in terms of implementing adequate policies, administration, and financial support.

The problem of illegal fishing is not specific to the Philippines or to Senegal and can be found in any developing country. Fishermen in developing countries where the information as well as education on artificial reefs is inadequate tend to regard artificial reefs as a tool for gathering fish. Even if they understand that the area of artificial reefs is closed for fishing, it may be the case that their illegal fishing is inevitable because of the dependence of poor fishermen on fishing for their own survival. Moreover, the severity of the living conditions is the same for those fishermen who have the responsibility to monitor illegal fishing. In Senegal where the GDP per capita is US\$1580 and the Human Development Index (HDI) is 0.437 (UNDP, 2004), it is impossible for both government and fishermen to bear the surveillance cost (approximately US\$20 per day). Realization of the effective management of artificial reefs in a country such as Senegal requires a secured self-funding source. Unless an aid project is prepared to provide assistance for the creation of such a source, it is practically impossible to achieve the essential objective of fisheries management.

One way of creating a self-funding source is to classify the artificial reef area as partially accessible fishing grounds instead of introducing a total ban on fishing in this area while restricting fishing efforts to access the available resources. The management body then collects a fee for the use of resources and conducts joint fishing. Some of the fishing fees and income from the joint fishing can be used to finance the necessary management cost. In the case of Senegal, the trial calculation results indicate that the management of artificial reefs is feasible if joint fishing is conducted twice a month (OAFIC, 2005). However, the reality is that the income falls short of the management cost due to the poor catches, resulting in the continued lack of surveillance.

If the use of artificial reefs alone is insufficient to generate funding, one alternative is to earn income from other activities to divert some of the said income to the management of artificial reefs. Improvement of the freshness of the catch and the commercialization conducted at Nianing in Senegal resulted in a stable income, enabling the introduction of a closed season for octopus fishing and the management of spawning reefs.

The second problem is the tendency for developing countries to over-emphasize the positive aspect of artificial reefs; i.e., increase of fisheries resources. This typically occurs through manipulation of information by the donor side, which has traditionally recommended the use of artificial reefs. It is essential for both donors and recipients to properly understand that the incorrect use of artificial reefs has the opposite effect (decline of fisheries resources) and to carefully examine the pros and cons of their introduction (Fig. 1). Elementary fisheries management measures, which

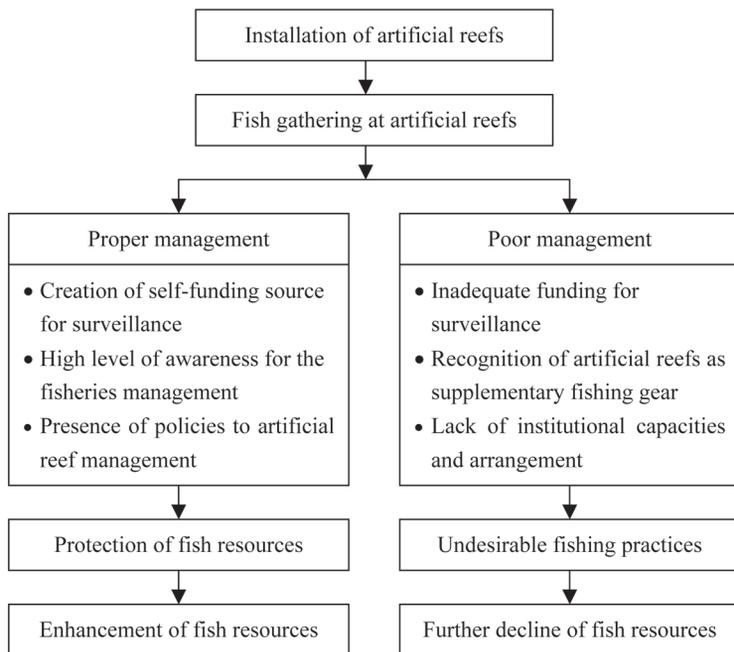


Figure 1. The expected positive and negative effects associated with installation of artificial reefs in developing countries.

should be implemented by developing countries, must not be overlooked because too much attention is paid to artificial reefs. Presently, fisheries management in developing countries is at the initial stage and there is no accurate data on the volume of the available resources, catch quantity, numbers of fishing boats, etc. The introduction of artificial reefs without basic information for fisheries management is not a fundamental solution. In many developing countries, the number of fishermen is steadily increasing. Artificial reefs cannot support an ever-increasing number of fishermen and, by themselves, cannot prevent a decline of fisheries resources. If it is necessary to focus on artificial reefs due to various constraints or an aid policy, it is important for the donor to provide as much knowledge and information as possible so that the government and fishermen of the recipient developing countries can consider integrated fisheries management.

With regard to the third problem, as artificial reefs are submerged structures, evaluation of their effects is difficult. As such, many artificial reefs are currently used as "trials" and there have been many studies on the effects of artificial reefs from the viewpoint of the fish-gathering and catching effects (Kitamado, 1984; Sato, 1984; Polovina and Sakai, 1989; Polovina, 1991; Kakimoto, 1998b; SEAFDEC, 2004). However, their effect on the resource enhancement has not yet been fully analyzed. Projects lasting for several years in developing countries cannot possibly provide the scientific information required for analysis of the effects of artificial reefs. Nevertheless, it is natural for any project to be expected to have some positive effects worthy of funding. Taking such expectation into consideration, the establishment of an analytical method for evaluating the resource enhancement effect of artificial reefs

is essential with examination of the necessary project period and cooperation for biological research on target resources.

Artificial reefs can produce several socioeconomic impacts such as: 1) increasing production value (due to fishing activities in the area around artificial reefs), 2) creating nearby fishing grounds (shortening the distance to the fishing grounds by artificial reefs, including a reducing fuel costs, lengthening operating hours, and reduction of labor intensity due to shortening of the fishers transit period), and 3) organizing fishermen (i.e., creating a fishermen's organization based on common interests arising from the sense of the common ownership of artificial reefs among fishermen; OAFIC, 2005). Among these effects, increasing the production value is the most common. If the spillover effect (i.e., spilling out of regenerated resources from the no fishing zone) of the artificial reefs results in an increase of fishermen's income, few problems arise. Illegal fishermen may benefit from this situation too, thus careful analysis is required.

Dependency tends to occur when the government or donor takes the technological and financial initiative with regard to the planning, fabrication, installation, and monitoring of artificial reefs without placing fishermen at the heart of the project. There have been numerous cases where the leading role in fisheries management has been assumed by the government or donor, resulting in the passivity of fishermen with the project coming to a halt when the involvement of the government or donor ceases (Watanuki, 2002, 2004). To solve this problem, assistance as well as encouragement should be provided for the active involvement of fishermen in fisheries management. In other words, the practice of community-based fisheries management in which fishermen are the leading participants should be introduced. In the case of an artificial reef project, the important points in this context are: 1) promotion of the strong willingness of fishermen to act and generate ideas through a series of discussions with the residents of fishing villages; 2) maximum utilization of local resources (rock from locality, surplus labor, etc.) for the fabrication and installation of artificial reefs; 3) encouragement of the use of economic activities of fishing communities to earn income to cover the management cost; 4) entrusting fishermen to conduct the surveillance of illegal fishing and assist with a study to evaluate the effects of artificial reefs. These actions will generate a sense of artificial reef ownership among fishermen, leading to the establishment of fisheries management led by fishermen.

In many developing countries, there is a general rule that anyone can freely catch fish and the uncontrolled number of fishermen and fishing boats has been steadily increasing. As long as people are allowed to freely enter the fisheries sector to catch limited fish, over-fishing or "tragedy of the commons" cannot be prevented. It appears that fisheries management cannot work well unless fishermen utilize management tools such as the artificial reefs and acquire the monopolistic idea of "protecting our resources by ourselves" instead of allowing free access by all to fisheries resources.

One concern relating to the problem of policy is that even if the effectiveness of artificial reefs is recognized, the continuation of a project may become difficult without the development of a support system by the government. Without such a system, extension of the experience and technical expertise accumulated under a project to a wider area is difficult.

There are many cases in developing countries where such problems as manpower and government fund shortages, lack of technological development, lack of a legal system and inefficiency of the administration persist even though the government

has adopted a policy of advancing fisheries management. These problems cannot be solved without international cooperation. It is, therefore, essential to adopt a strategy to implement capacity-building for fisheries management, not only at the local level, but also at the level at which national policy is decided.

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