# ARTIFICIAL REEFS AND FISH AGGREGATING DEVICES IN SOUTHEAST ASIAN FISHERIES: MANAGEMENT ISSUES

BY

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## 1. INTRODUCTION

**State of resources in SE Asia:** The total marine catch of the ASEAN region is about 6 million tons and accounts for 90% of the production of the Central Western Pacific. The catches of the demersal resources is either stagnating or declining in a context of global overfishing (with important exceptions in Indonesia due to drastic management measures (total trawl ban) or to underdevelopment in difficult remote areas. The situation of the shrimp resources is particularly serious. The total catches stagnate or even decrease. The stocks of the region are considered overfished with some rare exceptions (e.g. the Arafura Sea). In addition, the progressive concentration of trawlers searching for valuable shrimp resources in coastal zones has led to violent conflicts with artisanal fisheries and to landings with a large proportion (70−80%) of "trash fish" in a global context of ecosystem overfishing.

The pelagic resources offer a different picture with large increases in catches of mackerel, scads and anchovies although trends have been different in different countries. Catches of large coastal or oceanic pelagic fish have increased as well with trends depending on countries and species. There is, therefore, no concern regarding the state of these stocks although some words of caution are expressed regarding the stocks of yellowfin tuna.

In many countries which had developed large long-distance fleets (e.g. Thailand) the establishment of EEZs has led to a forced repatriation of the vessels and to a considerable increase of pressure in the coastal zone. In other words, the establishment of property rights at international level has exacerbated the effects of the absence of property rights at national level. As a consequence, artificial reefs appear to fisheries managers as a way to reduce conflicts by impeding trawling in the inshore waters while FADs appear as a means to increase catchability of pelagic resources and divert effort from demersal fisheries. In both cases they are aimed essentially at small-scale fisheries, except for oceanic FADs used by industrial tuna vessels.

**The environmental context:** In Southeast Asia the coastal environment is seriously threatened through various human activities such as: mangrove clearing for domestic use or for aquaculture space, degradation of nurseries by trawling and pollution, siltation due to mountain forest clearing, coral reef destruction by pollution, illegal fishing and direct exploitation by the construction industry, coastal dumping of a wide diversity of effluents and discharges, dredging, filling and reclamation of inshore areas for coastal development. Unless drastic changes are implemented rapidly (and this is unlikely), this is the environmental context within which artificial reefs and FADs will develop and will have to be managed.

**The management context:** The last IPFC Symposium (FAO, 1987) described a quasi-general situation of poor economic returns, social unrest and permanent conflicts. It recommended that funding and development agencies give priority to projects which facilitate management by effort controls and exert caution with regard to projects which would increase fishing pressure directly or indirectly.

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## 2. OBJECTIVES

A programme for deployment of artificial structures requires time and large amount of financial resources. In addition, artificial reefs may have large impacts (positive or negative) for a long time indeed. The problem is much less crucial for FADs whose lifespan is much shorter but in all cases a set of clearly stated development and management objectives is required if any assessment of the effectiveness of the programme is to be made.

Artificial structures are not a panacea. They have different effects depending on location, material, structure, physical as well as socioeconomic environment, management etc. The efficiency of artificial reefs and FADs could be assessed by their potential or measured contribution to resolve the two overwhelming problems of coastal overfishing and environmental degradation. In this regard, the various froms of overfishing (growth, recruitment, ecosystem and economic), underlined at the IPFC Symposium on the Exploitation and Management of Marine Fishery Resources in Southeast Asia, need to be considered.

A major general objective is to increase economic and social returns through reduction of direct fishing costs, better enforcement, reduction of conflict, protection of coastal resources, biological enhancement (by improving spawning, recruitment and habitat), coastal economic enhancement (e.g. in Japan, through increase in nearby real estate value, promotion of tourism, diving, angling, boat sales), optimal solid waste disposal (if harmless and cheaper than alternative methods), or even recreation and education (especially reefs)).

In theory at least, artificial structures can be used to solve man-made problems or to compensate or correct for natural deficiencies. In some developed countries, e.g., the USA, south eastern France or Singapore (Hsu et. al., 1988) the pressure to create them originates essentially from the land and they are seen as a way to recreate slightly more offshore the productivity that has been destroyed in the coastal area by reclamation, littoral "development", and pollution. In Asia, Italy and south western France, however, the present pressure seems to originate essentially from the sea and more specifically as a protection from the pressure exerted by trawlers.

A reef deployment programme raises two types of issues related respectively to the administration of the programme (planning, deployment, maintenance etc.) and to the management of the fisheries on and around the artificial structures. These will be examined successively in the following sections.

## 3. ADMINISTRATION

Implementing a reef deployment programme involves various activities related to site selection, delivery of permits for site exploitation, monitoring of structure integrity (safety), maintenance and other interventions of a technical nature. A good example of the activities involved can be found in Ditton and Burke (1988). They concern:

– the evaluation of the demand for reefs and FADs. In many areas of the world artificial structures seem to have become the potential solution for all the problems encountered in the fisheries. This is certainly not a reasonable expectation and it is important that the demand for reefs and FADs be properly evaluated with regard to their potential contribution to the solution of the existing problems.

– the site selection. This is a crucial step and involves considering factors such as location, building material, structure, appropriate technology, oceanographic conditions, expected user groups, historical background, social cohesion etc... A particular difficulty arises from the need to avoid locational conflict with existing gears, particularly for permanent structures like reefs.

– the granting of permits which are given or not after consideration of factors such as the position relative to navigation channels, maximum elevation and water clearance, material duration and expected lifespan, resistance to storms etc...Usually this step involves the identification of potential conflicts and public hearings are organised before the permit is granted or denied.

– the baseline studies: these are required as a basis to assess the impact of the structure, and (pre-reef) surveys of the bottom and fish communities may be required. The determination of the optimal structure size is important because the impact of artificial structures depends also on their size. Tests are necessary, but undoubtedly difficult ot conduct, to decide on the best compromise between costs and production per unit of reef volume.

– the construction and deployment of the artifacts which may have to be supervised, especially for reefs, by an administration which will control the nature of the material used as well as the dumping site. When the construction is undertaken by the villagers themselves, it is necessary to provide them with storage space for the material necessary for construction and maintenance (tyres, cement, iron bars, ropes, etc.). The proper marking of the artifact location is necessary, with buoys, radar reflectors etc... and reef areas should be indicated on maps. The location must be easily accessible to the target group and should not interfere with navigation or major tidal currents (erosion in highly dynamic areas may cause reefs to sink !).

– the monitoring and maintenance. These are particularly necessary for FAD moorings and buoys, but also for the artificial reefs (depending on the technique, material and structure used) and the system of buoys marking their location. Reefs can disaggregate and become hazards for fisheries in neighbouring grounds. They can sink and lose productivity. They can be colonized by undesirable hosts and require correction (cf. biomanipulations).

– the intersectoral coordination. As the establishment of artificial structures interferes with tourism, navigation, fisheries, national parks, public works etc... there is a need for coordination both prior to and after their installation. In addition, there are usually four different national competencies involved in the deployment and management of artificial structures. Marine engineering competence is needed for ensuring the protection of the public interest and navigation safety. The competent authority generally organizes the public hearings required before the utility of the structure is recognised officially and its construction allowed. Enforcement competence is needed for security and navigation safety as well as of fisheries regulation enforcement. Fisheries administration is required for the design of the sanctuaries, the allocation of fishing zones, the regulation of gears and, in general, to deal with coastal fisheries management. It must integrate artificial structures within the overall management plans. Finally, competence in environmental conservation is required to ensure the overall conservation of the integrity of the coastal environment, to control the location of the structures, their material, and to check on the long-term environmental impact.

– the search for funding. The funding required for the construction of artifacts and also for research prior to and after their installation is not trival and requires constant efforts from a dedicated authority. If properly managed, through allocation against payment of user fees, artificial structure could be used to generate at least part of the required funding.

– the project evaluation: Projects for artificial structures must be evaluated in order to learn from documented successes and failures, to obtain facts from which further financial support can be more successfully obtained, to ascertain the attainment of the original objectives and change future projects or objectives accordingly. Proper monitoring of key variables during the colonization and exploitation phase of a reef is essential for an adequate evaluation. This is particularly important now, because after three decades of seemingly unconditional support to the deployment of artificial structures despite the quasi-total absence of usable scientific evaluation (Thierry, 1988), doubts are being expressed on their real cost-effectiveness (Polovina, 1989).

## 4. FISHERIES MANAGEMENT ISSUES

The techniques relevant to the management of fisheries on artificial structure are not very different from the general fisheries management tools. But artificial structures raise particular issues related to the availability of data, the alleged effects on resource concentration and generation, their potential role in conflict resolution, resource allocation, coastal protection and development and their cost-effectiveness.

### 4.1 Information requirements

Proper management of reefs and FADs implies some availability of biological, economic and sociological data and most reviews on this issue recognize that the situation is presently grossly inadequate when considering the investments involved (Bohnsack and Sutherland, 1985; ASEAN/UNDP/FAO/,1988).

The biological problems are numerous (cf. Polovina, this issue). They are related to several issues, including the evaluation of the biomass and of the annual production; the optimization of energy transfers from primary production to fishable biomass; the separation between new (additional) and attracted production; and the issue of interactions between adjacent reefs (competition, synergies). A major difficulty lies in the forecasting and assessment of the biological impact, in relation to site, reef type and fishing methods. Huntsman (1981) indicates, for instance, that most reef fish are herbivores and small carnivores while consumers prefer large carnivores (with low natural mortality and slow growth) implying fisheries with high age at first capture and low fishing mortality. This, in turn, would imply that reefs are useful for sport or recreation (or small scale) non-intensive fisheries rather than for commercial-fisheries.

The research problems arising in marine fisheries because of multispecies interactions and the determinism of recruitment need to be urgently addressed, no matter how difficult they are to resolve; closer attention needs also to be given to the link between local environment, primary production and fishable resources if any understanding and forecasting ability has to be developed. With the present knowledge on multispecies resources and fisheries community dynamics, the modelling and forcasting of short and long-term impacts of the development of artifacts is at best a risky exercise (cf.Polovina and Willmann, this issue). A large body of research and experience will be needed to reduce substantially the present uncertainty and for the time being, while such research should be actively promoted, the empirical (experimental) approach will have to play a primary role.

The social and economic considerations are also far from trivial (cf. socio-economic issues). They are related to the identification of the fishery constituency; the understanding and forecasting of the benefits and their distribution; the understanding of the rate of use of the reef; the identification and collection of appropriate sociological, demographic and attitudinal data. A major difficulty lies in the undertaking of baseline studies and in the clarification of the fisheries "relation" between the reef fishery and the ambient fishery (transfers of employment and effort, market price effects etc...).

The legal implications are still largely undebated but the issue of user or property rights, the conflicts between competing uses and the responsibility for long-term impacts as well as liability in case of accident involving an artifact, are certtainly worth considering (cf. legal issues).

### 4.2 Concentration of resources

Both types of articial structures operate as attracting devices, increasing catchability of otherwise more dispersed resources. The consequence is to increase fishing efficiency and economic returns and there is therefore a risk of aggravating overfishing if effort is not regulated. In the short term fishermen profitability may increase because of reduced operating costs through more efficient localisation of fish concentrations and reduction of searching time relative to fishing time. An example is given by

Cillauren and David (1989) in Vanuatu. This may provide incentives for more fishermen to enter the fishery if the effort in the area is not controlled, thereby aggravating the overfishing problem. The increase in catchability and in effort will lead to a general increase in fishing mortality and a corresponding reduction of stock size, catch rates and possibly total catches. It is therefore evident that artificial structures are not a solution to the growth overfishing problem (Polovina, 1989). This was also observed by Aprieto (1988 and this meeting) who noted that large quantities of juvenile yellowfin and skipjack of 16–20 cm total length are captured on the payaos in the Phillippines and although the impact on the surrounding tuna fisheries is not yet clear, some reactions from industry are already apparent.

Another effect of resources concentration is that, by reducing the costs of fishing, especially when construction and deployment costs are subsidized, the artificial structure may alleviate the economic overfishing problem only temporarily, if there is no control on effort.

### 4.3 Resources enhancement

It is significant that, in the reef-related bibliography, management is often taken in its broad sense including resource enhancement as well. Artificial reefs may, and most probably do produce, at least locally, some additional biomass by (i) trapping biological productivity which would otherwise be transported elsewhere (like in the Adriatic Sea), (ii) by accelerating natural reefs regeneration and (iii) by improving pre-recruitment survival through the range of shelters offered to larvae and juveniles. If installed in non-reef areas, they may also allow the growth of non-traditional species leading to biological diversification. Good scientific assessments are rare but a convincing example is given by Polovina (1989a). This seems, in the short term, to lead to higher catches, species and better returns. If effort is not properly controlled, however, this will provide incentives for more fishermen to enter the fishery, resulting in an aggravation of growth overfishing and in the dissipation of the additional rent created by the reef. As a consequence, the catches might be higher as well as employment, but catch rates and profitability would return to original and low "equilibrium" levels.

The problem of artificial reefs installed in the vicinity of natural reefs areas is different. Polovina (1989) argues that, if the decrease in resources is due to recruitment overfishing, artificial reefs are a costly and inadequate response because there cannot be a shortage of adequate habitat when the spawner stock has been reduced by fishing to less than 50% of its virgin size.

In some cases artificial reefs have been established as protected marine enhancement areas where fishing is prohibited as in Malaysia (Wong, this issue) and Singapore (Hsu et al., 1988). It is obvious that in overfished coastal zones this approach requires costly surveillance and, with reference to Polovina's argument, might be justified only when the decrease in resources is due to habitat destruction. Stopping habitat degradation should in that case become a priority.

In the case of FADs, however, fears have been expressed that the concentration of juveniles, together with large predators, might lead to increased natural mortality by predation and cannibalism and therefore to reduced stock potential (Aprieto, 1988).

### 4.4 Conflicts for space and resources

Paradoxically, reefs and FADs are also a limited resource (if only for the limitation of space available to place them) and they may generate an allocation problem, rather than serving as a means to reduce conflict. The inevitable consequence of the concentration of fish is the concentration of fishermen around fewer fishing spots. This can lead to gear saturation and competition, to lower returns and to enhanced conflict. Aprieto (1988), for instance, shows that payao fishermen in the Philippines had to agree to a minimum distance of 7 miles between FADs. Reefs and FADs may also generate conflicts between divers, anglers and commercial fishermen, between commercial or recreational fishermen, between fishing and navigation , between sportfishing and photography. As these conflicts may be difficult to resolve, it might be desirable to create different reefs to dilute conflicts between incompatible types of uses rather than to try to reconcile these conflicting uses within a single large artificial reef.

Artificial structures may be used to occupy the coastal space effectively to impede the intrusion of trawlers into coastal areas as observed, for example, in Thailand (Sungthong, 1988). This could be an effective way to reduce conflicts between artisanal and trawl fisheries. Partial or total protection of the reefs resources can also be aimed at and artificial reefs can be used to create sanctuaries like in Malaysia (Wong, 1988) and Singapore (Hsu et. al.,1988).

**4.5 Allocation of user-rights**

Artificial structures may be used to explicitly allocate marine space and resources to identified social strata of the fishery sector for their exclusive use. This might be even the main purpose of artificial reefs installed in a natural reef area. If the occupation of space by reefs and FADs is effective enough to drive fishing effort of trawlers out of the coastal nursery area, there should be a general increase in biomass due to reduced mortality and increase in age at first capture. Although the real effect needs to be carefully assessed in each case, the example of such total or temporary trawl bans in coastal tropical areas under severe overfishing have already proved to result in significantly larger biomasses (Garcia, 1986; Dwiponggo, 1990). The example in Cyprus shows that the recovery can be extremely rapid (+ 100% in about two years) but also that the response of the small-scale fishery can be just as rapid in expanding effort and dissipating rent if effort is not controlled.

When the coastal area is overfished and fishing spots are crowded, artificial reefs and coastal FADs can provide alterneative fishing grounds. In the USA, for instance, anglers and sport fishermen require reefs for their own use. Here, artificial structures may help reduce, (at least temporarily), conflicts for space by creating more fishing space. The long term effect, however, will depend on the overall trend in fishing effort.

In general it may be advisable to consider explicitly the conflict and allocation issue at an early stage of reef deployment planning in order to avoid it becoming only an additional subject for conflict.

The issue of property rights is more crucial for artificial reefs that are practically permanent structures, than for FADs which can be easily removed. In general, property rights would provide security (tenures), reduce uncertainty, increase present value of future yields, improve local support for data collection, research and resources management.

The artificial reef may be privately or publicly owned. In the latter case its use can be allowed by anyone (Res nullius) or restricted to an identified group, or community (Res communae). In the Philippines private ownership of reefs is not accepted by the administration which favours communal property or tenure and artificial reefs are exploited by fishermen organizations on the basis of Territorial Use Rights (Ferrer, 1988). It is evident that the form of property adopted has drastic consequences on the management of the optimisation of economic returns, the way the proceeds will be shared, and the nature and extent of the conflicts. It is also evident that the most appropriate form for reef property depends on management objectives and there could be conflict between private and state interests as well as between different types of private interests. In attributing property or user rights in the marine coastal area one may note that customary territorial rights are often an extension of terrestrial territoriality. In many instances, property rights in the marine environment are still legally undefined and require immediate attention from lawyers. As a matter of fact the massive introduction of artifacts in the coastal zone and their necessary control by the coastal communities may leal to new coastal tropical areas under severe overfishing have already proved to result in significantly larger fishing rights on permanent artificial reefs together with their free exchange could lead to progressively concentrated ownership of the coastal space. While some stable user rights are probably necessary to reduce overfishing, the process would have to be carefully monitored and controlled to avoid undesirable effects (e.g., creation of a caste of "Lords of the Sea").

In the Philippines, the FADs are usually owned by boat owners, fishing companies or concessionaires and anyone can build one (Aprieto, 1988). In that case competition for space and conflict occurs as for any other gear and some sort of agreement on the limitation of numbers and spacing of FADs must be reached. In fact, Aprieto suggests government intervention to fix and enforce the fishing regime including a licensing scheme. A major problem exists with the payaos system (e.g. in the Philippines), sometimes considered as equivalent to a turf approach. Although the gear can be fixed, the resources are highly migratory and although the payaos may lead to some apparent space allocation scheme they do not lead to a real allocation of a resource which remains shared by everybody. The implication is that without a global limitation on the FADs and, above all, on effort and catches, FADs have no obvious management properties in an overfished fishery.

The social organization needed for resources allocation, decision making, information and communication and enforcement at the local level should be promoted. A solution is to establish private or community ownership, to organize fishermen around Turfs or cooperatives or communes. This would help them acquire from the state the necessary loans or subsidies for artificial reef construction, with the assistance possibly of NGO's which could be very instrumental in that respect. In order to develop local support for community-based management, efforts are necessary to develop the appropriate institutions and mechanisms at the village, community, or regional level, to improve the communications, and to provide technical assistance. In addition, support to the reef programme must be strengthened through research, training, and manpower development.

**4.6 Habitat protection and rehabilitation**

Artificial reefs may contribute to environmental mitigation by reducing the effect of trawling on fragile coastal habitats and nurseries. They are used also to compensate for destroyed coastal habitat or for natural reef regeneration (e.g. in the Philippines and Indonesia). Artificial reefs may also help improve environment on land by offering an opportunity to dump a large number of tyres, car wrecks, etc. This opportunity should obviously not hide the danger of using reefs as a pretext to dumping unqualified material that may irremediably damage the marine environment. Artificial reefs may also serve to protect coastlines from erosion and from the impact of storms (e.g., Japan).

**4.7 Development**

These structures may be used to create new fishing spots close to villages for commercial, subsistence or recereational purposes. For example, the payao system in the Philippines has led to the development of a major tuna fishery shared between an artisanal fishery for mid-water resources and industrial purse seining for surface resources (Aprieto, 1988). The attraction, enhancement and diversification of resources resulting from artificial structures could, in many cases, lead to economic gains and improved performance of the fishery sector. Whether these effects are really obtainable depends on how carefully the structures have been planned. Whether the improvement will be sustainable depends on proper reef and fisheries management because unresolved allocation issues and the resulting conflicts will definitely lower economic performance.

The development of rural areas and the conservation of socio-economic activity in remote littoral areas are always a major concern especially, but not exclusively, in developing countries (e.g. Japan). The massive and sustained introduction of reefs tends to generate a significant economic activity in the coastal zone, resulting from the construction of the reef, its maintenance and exploitation. This effect, and the political support it generates is apparently sufficient to justify the large subsidized investments in countries like Japan, in spite of the apparent absence of proper economic analysis.

### 4.8 Cost-effectiveness

As discussed in section 2, artificial structures may increase economic gains, but a number of conditions have to be fulfilled to ensure net ecónomic and social benefits. Net gains will be realized only if the artificial structures are the most cost-effective method of achieving the intended purpose. It is a matter of concern that in practice there has been very little effort made to try to estimate the real cost-effectivencss of these devices. The cost of the inital investment is a relevant parameter in this respect and has been generally supported by the state through subsidies. Decisions could therefore be made on the allocation of the rent eventually created through improved catch-rates, between the state (by payment of a fishing right) and the users.

It is far from obvious that artificial structures can be cost effective when dealing with growth or recruitment overfishing, particularly if the problems of excess fishing capacity and open access are not faced. It should, however, be noted that any comparison would have to take into account the political costs attached to traditional management techniques. In addition, artificial structures may generate hidden or unforeseen costs obstruction of sea transports, foregone opportunities for the use of space, pollution from wastes, damage to coast resulting from modification of currents, etc.

To optimize the use of the structures and enhance the motivation of the fishermen, it is essential that poaching and use of deleterious methods (poison, dynamite) be kept to a minimum or eradicated. The cost of enforcement may be reduced drastically by inducing the exclusive users to practice self-management and the explicit transfer of responsibility from the central to the local level is probably advisable in most cases. Miclat (1988) notes for the Philippines that the mechanics for reef management and the responsibilities within the municipalities are not yet clear.

This issue is dealt with in more detail in Willmann's contribution to this Symposium.

## 5. FISHERIES MANAGEMENT TECHNIQUES

Artificial structures must be an integral part of the local fisheries. This means that all the traditional management measures can be used and their relevance and efficiency will be largely influenced by the history of the fisheries and their management around the reefs or FADs and prior to their installation. Aprieto (1988) mentions that "where fishermen use poison and dynamite the granting of rights might be premature" that statement might be challenged. The opportunity offered by artifacts to correct difficult situations be neglected (Bojos and Vande Vusse, 1988).

Effort controls are absolutely necessary, as in any other fishery, to avoid overfishing of the artificial structures and the surrounding resources. Rotational harvesting of artificial reefs to avoid depletion and to conserve minimum reproductive biomass could be introduced in some cases. If reduction of fishing effort appears socially and economically too costly in the short term, freezing of present fishing effort is a possible minimal measure.

Resources allocation is necessary to avoid or reduce damages due to "common property" (in the sense of *res nullius*). The concept of Territorial Use Rights (Christy, 1982) can be applied to artificial structures to generate long-term conservation awareness and promote self-regulation and enforcement. Care must be taken to avoid creating a class of "Sea Lords". Even if property rights are not considered immediately applicable, some form of allocation of stable user rights must be developed.

The deployment of artificial reefs may introduce severe spatial constraints into the coastal zone, potentially leading to formal space allocation and tenures. It is, therefore, important that careful consideration be given to the introduction or reinforcement of zoning and to the development of an areal management planning (similar to land use planning) whereby all the interacting, and probably competing, fishing techniques are considered.

Provided overall effort can be controlled, traditional technical measures can be applied to try to avoid suboptimal fishing regimes. Gear characteristics (mesh or hook sizes, gear length and type etc...) can be controlled to optimize yield per recruit or reduce undesirable interactions with neighbouring fisheries. Protected areas can be defined around artificial reefs where fishing is restricted to the artificial reef owners. When they are entirely protected (i.e., reefs used as marine parks) areas permanently closed to fishing can be designed in the immediate vicinity. In this last case, if is obvious that in a context of severe coastal overfishing an important and costly surveillance will be needed.

.Biomanipulations may be possible. The process of colonization of the reefs is not well known and the results of a reef programme are usually empirical and difficult to forecast although the reef structure, composition, extension and elevation can be designed in theory to obtain certain results. Depending on local environments, biomanipulations might be needed to modify species composition in the reef by species introduction or removal, in an atempt to fix predator-prey densities, to develop appropriate algal habitat or to optimize the trophic chain. The principles involved are close to those of extensive aquaculture and husbandry and although documented examples are still scarce the potentials may be large. Modifications or "decisions" on species composition are also possible, in theory, through the adaptation of the size, the structure, the depth and the vertical elevation of the reef.

## 6. CONCLUSION

In discussing the issues related to the management of artificial reefs and fish aggregating devices it has been implicitly assumed that these artificial structures are used in order to promote the sustainable development of fisheries.

Coastal areas represent a domain where natural resources are available (water, space. fish etc...) that can be used for industrial development, tourism, capture fisheries and aquaculture, recreation, waste dumping, mineral extraction, navigaion etc... Artificial reefs and FADs are just one additional way of using the coastal zone resources and they interact with the others. They can be beneficial for or in conflict with other uses of the coastal space. Their deployment must therefore be considered within the framework of integrated coastal management.

In addition, it is clear that artificial reefs and FADs are not a panacea. They have advantages and limitations just as any other option available to managers. The problems they raise are compounded by problems related to environment and fishery management. Artificial structures may offer opportunities. They may be a useful way of raising the awareness of coastal communities and support for community-based fisheries management but they are not an alternative to the necessary, albeit difficult, effort regulation and resources allocation decisions.

On the one hand, it is argued that artificial reefs, whose intensive development has been undertaken largely on political arguments. with possibly some short term and non-fishery economic considerations may not be cost effective fishery management measures. On the other hand, artificial reefs may have some value as environmental rehabilitation devices. The main problem is that studies are lacking to demonstrate these points convincingly in the absence of scientific quantitative investigations.

Fish attracting devices are clearly fishery development tools with little or no management properties. Their introduction should therefore be extremely careful in overfished areas and avoided on overexploited species. Their effect should be taken into consideration in effort limitation or reduction programmes. Inasmuch as they divert effort from demersal fisheries they may reduce overfishing. Their overall impact on management however remains doubtful in the absence of an effective effort control policy.

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