Getting Increase of the Aquaculture Population and Varieties with the Artificial Habitats

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Abstract: The significance and protection of the biological diversity in the continental waters of countries in the world has become one of the concerns which should be addressed as a matter of urgency. The scientists consistently underline the fact that several species are endangered to extinct and that the number and population of such species are gradually decreasing. There observed many causes of the extinction of the species. The heavily increase of the human population is the most important reason for this. Such a heavy increase leads to establishment of new settlement areas and constriction of the wild life. In this case, the number of wild species extinct rapidly. Several scientists and members of the nature protection organizations are aware of this particular case and conduct studies to protect the natural environment of the wild life. In this context, the wild life should be given the chance to reproduce through formation of the national parks and natural protection zones. Such parks and zones should function as a shelter for some of the wild species. However, the measures always include the inland environments. As a matter of fact, sea and lake ecosystems should also be protected. It is a well known fact that one of the most important reasons of the species leading their lives in the inland waters is the excessive fishing. When the environmental pollution is taken into account, the descendance of several species is left to chance. In addition global warming and climatic changes may have an impact on this particular matter. In this case, it can be argued that various fisheries in the continental waters may extinct. It is an inevitable fact that the scientific studies to be conducted to increase the population of the fisheries and water products in the lakes and rivers of the country through promoting the survival of miscellaneous fishes and aqua Formation of artificial habitats in the lakes and rivers and such other appropriate locations may be of importance in the future. In this context, our study will bear a torch on the researches to be conducted for the ecological and sustainable water resources.

Keywords: ecology, inland waters, artificial habitats.

1. Introduction

The creation of artificial reef habitat has been employed by many coastal states as an effective method of increasing fisheries productivity, providing additional recreational and commercial fishing opportunities for hard substrate dependent fisheries, and enhancing the forage base (Ambrose 1994; Ditton et al. 2002; Figley 2004; Myatt & Myatt 1992; Stevens & Pondella 2002). The creation of artificial reefs on flat, featureless, sandy seabeds has been a form of enhancement for subsistence, commercial and sport fishing practiced in certain countries for centuries. It is only in more recent years that advanced engineering and design principles have been incorporated into this field, along with quantitative ecological and socio-economic assessment of habitat structure and function (Seaman, 1995). Artificial reefs have been used most prominently for fisheries harvest enhancement though they have been employed globally in a variety of other coastal management schemes including aquaculture in the Adriatic Sea (Fabi et al., 1989), enhancement of recreational diving and tourism opportunities throughout the United States (Milon, 1991; Ditton et al. 1999), habitat rehabilitation in the Maldives (Clark & Edwards 1994), and prevention of trawling in Europe (Reilini, 2000).

In the restoration of ecosystems after some damage (storms, exposure to toxic phytoplankton blooms, destructive fishing practices, construction and dredging projects and chemical pollutant contamination) especially where physical structure provides added benefits (e.g., habitat or shelter) to the ecosystem, artificial reefs represent one potentially useful restoration tool (Pickering et al. 1998). Physical structure in an ecosystem can be achieved in a number of ways, and definitive progress has been made since the early 1900s when artificial reefs were built as a hit-or-miss dumping operation of unsightly scrap material (Dean, 1983) such as tires and car bodies.

Japan and the United States have by far been the two most active nations in the evolution of artificial reef habitats. Although the early histories of reef building in both countries show many similarities, current designs, deployment strategies and use of materials exhibit sharply contrasting approaches. In Japan the government is actively involved in reef construction activities through its fishery agency subsidy programme. This agency is involved in planning and guidance and provides substantial funding for those projects that use government-certified reef products. An important aspect of the Japanese system is a political approach that provides rights of use to those who construct and deploy reefs. These rights convey the sole control of the harvest and use of the fishery resources around these structures. By contrast, in the United States, state and local governments, with only general guidance and minimal funding, carry out most marine and freshwater habitat construction activities. In the US these reef developments are incorporated into a common-property allocation system (Stone et al. 1991).In general, European artificial reefs are in the developmental stage (e.g. Italy, Portugal, Spain, United Kingdom and Germany). Research programmes are currently in operation in a number of European countries. One of the most significant events in recent times, with regards to the whole area of reef development in Europe was the establishment in May 1995 of the European Artificial Reef Research Network (EARRN). The Network, involving 51 members, active in various aspects of artificial reef research, has over the last number of years helped to focus and drive active research in this area (Jensen 1998).

The goal of the article is to discuss the pertinent information of an artificial reef study including details on artificial reef's objectives, reef site, environmental conditions, design, monitoring, results and performance evaluation.

2. Definition/Purpose of an Artificial Reef

MarineFisheries defines an artificial reef as:

An area within the marine waters/Inland waters of the Commonwealth in which approved structures have intentionally been placed or constructed for the purpose of enhancing benthic relief. Structures may be designed to provide and/or improve opportunities for recreational and commercial fishing, aid in the management or enrichment of fishery resources and ecosystem services, or to achieve a combination of these objectives.

Artificial reefs have been used in fishery management to

- provide new habitats that increase number and biomass of depleted fishery resources,
- restore habitats,
- prevent trawlers from using areas,
- reduce fishing pressure,
- and possibly, mitigate deterioration of habitats (Bohnsack & Sutherland 1985; Chang, 1985; Polovina,1989, Seaman & Sprague 1991).

İn most cases, investigations suggest that artificial reefs are effective in naturel conservation and habitat reconstruction. They are also beneficial to small-scale fisheries (Fujisawa et al.1991; Supongpan & Sintothong, 1992).

3. Biological Productivity and Aggregation

Artificial reefs are used as tools by resource managers to enhance desired species, attract fish to more suitable areas, restrict certain gear types, and to partition activity among competing user groups (Sheehy 1985).

The fundamental question in artificial reef science today examines whether artificial structures have the ability to produce new fish biomass or whether reefs merely concentrate existing fish populations (Bohnsack 1989). Several studies demonstrate the attractive properties of artificial reefs by documenting the ability of artificial reefs to yield higher catch rates of targeted fish species when compared to similar fishing over natural reef areas (Turner et al. 1969; Candle 1985). Other studies outline the production properties of artificial reefs by documenting higher densities of mature fish on artificial reefs when compared to nearby natural reefs (Love et al. 2005).The consensus of the 8th Conference on Artificial Reefs and Artificial Habitats (CARAH) was that artificial reefs "are now believed to be more of a continuum, both attracting and enhancing fish populations. Properly constructed, and strategically sited artificial reefs can enhance fish habitat, provide more access to quality fishing grounds, benefit fishermen, divers and the economies of shore communities, increase total biomass in a given area and provide managers with yet another option for conserving, managing and developing fishery resources."

The degree of attraction or production of an artificial reef may be the direct result of many complex variables, including location of the reef, type of reef materials, life history, behavior of fish species, proximity of natural reefs, age of the reef, and numerous environmental factors. Since the majority of artificial reefs have the ability to serve in each capacity, fisheries managers and other reef builders must consider the consequences of production and aggregation of reef fish populations when planning new reefs or establishing management policies for future and existing reefs. The wise use of artificial reefs as a potential tool for fisheries management requires the implementation of sound standards and practices regarding construction, maintenance, and exploitation of all artificial reefs established.

4. Site Selection

Reef site selection is one of the most critical decisions in the entire reef building process, and the most frequent cause of artificial reef failures. The construction of artificial reefs began before the scientific community started to develop sound guidelines for site selection. This has lead to artificial reefs being built in locations and at depths that were not suitable for construction. Consequently, many reefs ended up on a shoreline after a storm, disappeared totally, or sank down into the bottom to the point where much, if not all, of their effectiveness was lost (Matthews 1985). The optimum site conditions required for artificial reef deployment depends greatly on their intended purpose and design. Thus it is necessary to invoke the first generic rule of reef planning, i.e. "to identify the goals for the artificial reef deployment exercise" (Kennish et al. 1999). There are a range of factors that should be taken into account when selecting a site for an artificial reef, these include taking into consideration the physical environment, the biological environment and local users of the area (Heaps et al. 1997).

Constraint mapping techniques are commonly used in site selection studies to bring together social, economic and environmental considerations in an overall context (Gordon 1994; Heaps et al. 1997; Kennish et al. 1999). Once the physical and biological characteristics of potential sites have been deemed suitable for artificial reef construction, the process of site selection can then encompass stakeholders, including public agencies, businesses, private non-profit organisations, scientists, engineers, managers, users of the resource, as well as the general public. Constraint mapping involves the building up of layers of information concerning areas where some form of constraint exists, for example, user conflict, and environmental or engineering constraints. Computer assisted Geographical Information Systems (GIS) are usually employed to provide a powerful tool enabling these areas of constraint to be represented in a "user friendly" way. The resulting maps then show unconstrained areas in which further investigations can be focused.

As artificial reefs are a relatively new phenomenon in Europe, it is only in recent years, particularly through the action of EARRN, that various studies throughout Europe have been examined comparatively, and that collaboration on a wider scale is beginning to take place. One of the main problems in setting out a European framework for site selection is that each potential site for the construction of an artificial reef may be subjected to very different physical and biological factors, and constructed for very different uses. Because of these various factors, and due to the limited knowledge of the impact and biological production of artificial reefs in Europe to date, it is best to consider each location using the selection matrix shown in (Fig. 1).

5. Design & Materials

The three main aspects to reef design: the location of the artificial reef, the materials used in it, and the way in which they are arranged are all factors that can be planned and controlled. When any of these factors are neglected, the probability of failure of the reef increases. In the past, and to some extent at present, materials of opportunity account for a large part of materials used in reef construction, the most basic and common materials being rocks. Artisanal fisheries use natural materials that not only include rock but also brush piles and log cribs on the bottom, floating rafts of bamboo, coconut fronds, and cork. A wide variety of materials currently used in the development and construction of artificial reefs globally. Among the oldest habitat enhancement practices is the use of floating structures made of natural materials to attract finfish. In Japan, rocks have been placed either singly, as a pile, in wooden cribs, or in scuttled boats. The traditional Japanese word for an artificial fishing reef "Tsuki Iso" means "constructed shore rock". Surplus and scrap materials, including derelict ships, automobile bodies, automobile tyres, debris from demolition projects, and even discarded off-shore oil platforms, make up the majority of materials of opportunity. These can usually be obtained at no cost and deployed without assembly or significant

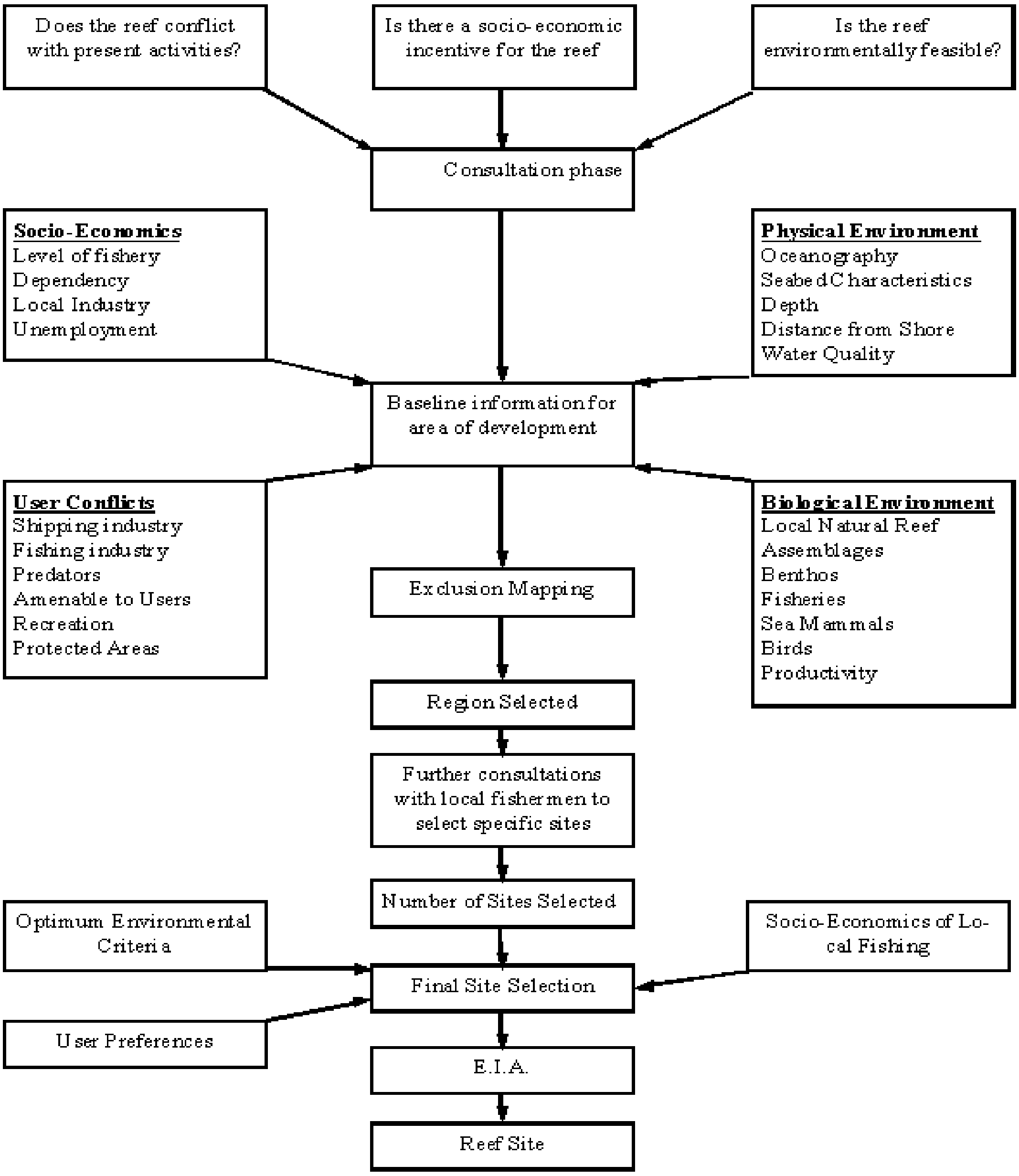


Figure 1: Artificial Reef Site Selection Process (Heaps et al. 1997)

modification, except for cleaning to eliminate environmental hazards. More recently, waste combustion by-products from fossil fuel-fired electricity generating plants (i.e. mixes of fly ash with flue-gas sulphurisation scrubber sludge) have been experimentally tested (Grove et al. 1991).

There has been an increase in man-made materials in the construction of artificial reefs. These include concrete, iron and steel, reinforced concrete (concrete and steel), ceramic, plastic, plastic concrete (concrete mixed with polyethylene, polypropylene, sand, and iron), fibre-reinforced plastic (FRP), and asbestos fibre, among others. Structures made from these materials are usually fabricated on land according to particular design specifications. While available in all shapes and sizes, virtually all reefs have been built with some form of tangible benefit in mind. In doing so, reef builders incorporate one or more principles from relevant disciplines such as biology, economics or physical sciences and engineering (Seaman 1996). Biological principles include habitat limitation, habitat complexity, refuge from predators and environmental stress to name but a few. Physical principles deal with strength and stability of reef materials and construction, involving factors such as material science, civil engineering and physical oceanography. Psychological, social and economic aspects of human behaviour also are important when considering reef design, taking into account the requirements of possible end user groups, such as commercial fishermen, sea anglers and SCUBA divers. Throughout the world, there have been huge variations in the shape, size and complexity of blocks used in artificial reefs. Over the course of this research, it has been shown that even though scrap materials and rock can function effectively as artificial reefs when properly handled and sited, the shapes, size, and long-term physical stability and biological productivity afforded by such materials are less then ideal. Most of the new reef units, particularly in Japan, are fabricated from reinforced or pre-stressed concrete, steel, fibreglass, or a variety of composite materials. Prefabricated sections are either produced individually at shore staging areas or mass-produced at a central location and transported to the staging area. Here they can be combined and built in a variety of configurations thus allowing adjustment to local conditions and needs. While variations may be considerable, most of the large-scale units for fish are designed to provide substantial open space, permit good circulation within the unit, promote current deflections, and project high enough in the water column to attract both reef and mid-water species. Figures 2 to 9 show the variation in designs and materials, which have been utilised in global reef developments.

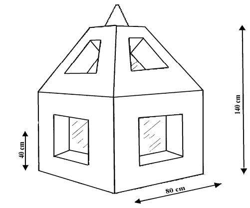
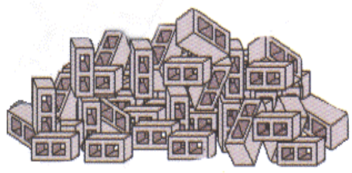


Figure 2.Simple Hollow concrete module
(Lok et al., 1999)

Figure 3. Concrete blocks used as a reef complex. © CCMS, Dunstaffnage Marine Institute Resources Laboratory.



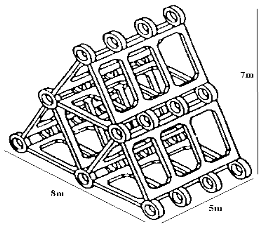


Figure 4. Japanese reef module "JUMBO" (Mottet, 1981)

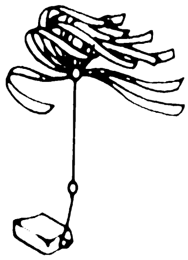


Figure 5. Plastic Kelp (Ishikawa, 1976)

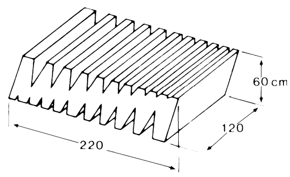


Figure 6. Abalone Nursey Block
(Seaman, 1996)

Figure 7. Reefball
© Reefball International

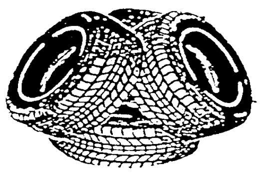


Figure 8. American tyre reef modules (Collins et al. 1999)

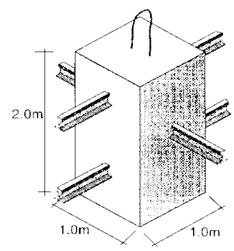


Figure 9. Spanish Reef module used for habitat protection (Revenga et al.1996)

The OSPAR guidelines on artificial reefs in relation to living marine resources, state with respect to materials used in reef building that: Materials used should be inert. Inert materials being those which do not cause pollution through leaching, physical or chemical weathering and/or biological activity. Physical or chemical weathering of structures may result in increased exposures for sensitive organisms to contaminants and lead to adverse environmental effects. Materials used for the construction of permanent artificial reefs will of necessity be bulky in nature, for example geological material, concrete or steel. No materials should be used for the construction of artificial reefs, which constitute wastes, or other matter whose disposal at sea is otherwise prohibited.

6. Utilisation

The uses of artificial reefs can be grouped into three major categories: physical, biological, and recreational. Artificial reefs have in the past exploited various combinations of these categories.

6.1. Physical

From a physical point of view the utilisation of abandoned structures such as shipwrecks, platforms and stabilised recycled waste materials, could provide a good opportunity for the construction of artificial reefs (Collins & Jensen 1997). Modern coastal defence philosophy has been turning away from the "hard" defences typified by concrete seawalls towards a "soft engineering" approach, absorbing wave energy before it impacts easily erodible beaches and cliffs. For example, reefs designed for coastal protection may be composed of breakwater blocks. These are typically massive structures with low centres of gravity for high strength and stability, designed to form void spaces when stacked close together to dissipate the energy of waves and currents. Artificial reefs may also be specifically designed to physically protect sensitive biotopes and nursery areas. In areas where small trawling boats violate the law and enter the coastal area where fishing is prohibited, artificial reefs can be used as simple mechanical obstacles. This will enable more fish to develop and thereby increase the biomass of the stocks in the open sea (Bombace 1997). For example, artificial reef projects were implemented between 1988 and 1993 off the Spanish coasts of the Mediterranean Sea, Cantabric Sea (northern Spain) and around the Canary Islands. At depths of less then 50m, these shallow reefs were placed in areas where trawling was already prohibited. However, the subsequent discovery of nets, traps and other fishing gear entangled on the reefs proved that fishing bans were often ignored (See Fig 9, Revenga et al. 1997).

6.2. Biological

From a biological perspective the enhancement of biomass and biodiversity, particularly in the form of harvestable resources, is one of the main goals in artificial reef construction programmes. As many studies have focused on specific groups or subjects, it can often be difficult to decide if artificial habitats act only as attractors or contribute to biomass production. While there is no doubt that most reefs can enhance benthic biomass by providing new surfaces for settlement, the main problem is the effective and quantitative measurement of fish biomass and the question of biomass enhancement. Similarly, little attention has been given to understanding the role of artificial reefs in preserving and implementing biodiversity. There is an urgent requirement to standardise research protocols for studying artificial reefs, so that these issues may be clarified. It must also be remembered that while an increase in biomass of harvestable resources is one of the main goals of most artificial reef constructions, protection and restoration of littoral communities and bio-diversity must also be considered (Relini & Relini 1997).

Commercially fished crustacea are generally dependent on a hard substratum in which to live. Therefore the role of artificial reefs in lobster stock enhancement is primarily one of either providing habitat where none had existed before, or the modification of a natural habitat. At least four countries, Canada, Israel, the USA and the UK have focused attention on artificial reefs as a specific lobster habitat (Spanier 1991; Jensen & Collins 1992). Although artificial reefs have been shown to effectively support several commercially important lobster species, the economics of these reefs in lobster stock enhancement are still being investigated.

The best examples of the use of artificial reefs for Molluscan culture comes from Japan, where habitat construction for bivalves has been applied for both soft and hard bottom species enhancement. The aim of these artificial reefs has been to cause stagnation and local accumulation of drifting larvae and eggs, thereby preventing attrition and dispersal of juveniles and thus enhancing their settling opportunity on local grounds. The introduction of such artificial reefs can not only help to improve productivity for molluscs, but also that of other organisms, especially fish (Fabi & Fiorentini 1997). For example, the cubic concrete blocks used frequently in Italian reef construction have also proved to be suitable for benthic and nekto-benthic reef dwelling fish. Conversely, concrete cages and floating structures for shellfish culture are mainly effective for pelagic and nekto- benthic species that live inside and around the reef but do not require shelter or physical contact with the structures. Research indicates that in the future, creation of artificial habitats for molluscs may play an important role in both the enhancement of wild populations and in the establishment of new marine farming grounds on exposed sandy beaches, rocky shores and in estuaries (Fabi et al.1989).

Another potential area for the use of artificial reefs is in the seaweed culture sector.There have been a number of cases where artificial reefs have been specifically deployed to encourage the development of seaweeds on a commercial basis (Falace & Bressan 1997). In Japan, there are currently many projects in operation that are designed to improve the environment for seaweeds, typically Laminaria. These artificial reefs involve placing substrate blocks or rocks at depths suitable for the growth of the most desirable local seaweeds, and are often planned to include sea urchin or abalone culture (Mottet 1981).

Artificial reefs are even now being used as a tool in nutrient removal by increasing the amount of hard substrata that can be colonised. Aquatic plants and filter- feeding sessile animals such as mussels and barnacles are among the groups capable of effectively absorbing nutrients (Jensen 1998). The removal of absorbed nutrients is then accomplished through harvesting the biomass. In order to increase the limited knowledge about the economic realism of artificial reefs in nutrient removal, the use of reefs needs to be compared with the solutions used in normal community wastewater treatment. While artificial reefs will always represent a low-efficiency solution for nutrient removal, it may also be possible to achieve a low-cost solution as well. It is mainly for this reason that the concept of nutrient removal with artificial reefs is considered to be worth developing.

6.3. Recreational

In addition to their physical and biological uses artificial reefs have been used in more direct and functional roles. Artificial reefs have been utilised to provide more reliable access to fish for recreational fishermen, while also reducing both vessel and automotive fuel consumption.

Recreational diving has become an increasingly important source of income to the tourist industry, particularly in countries such as North America, Australia, and some islands of the South Pacific. Artificial reefs are popular with divers as they provide convenient sites with a concentration of fishes and other organisms (Reggio 1989).Ships, concrete, tyres and stone rubble are among the most common materials used for reef construction for divers. Artificial reefs used as dive tour sites are subject to less fishing pressure from the public, as the high use patterns by dive tour firms preclude much of the fishing activity. When used as part of a non-destructive “eco-tourism” dive package, such reefs provide significantly greater economic return than when used for commercial fishery purposes (Brock 1994).

In more recent years, surfing has increased in popularity worldwide and there is significant potential for income generated from this activity. The growth rate in the UK is now about 20% per year. One of the biggest constraints to this growth is the lack of reasonable surf sites, and severe overcrowding of beaches with the better break waters. However, surfing reefs are now being constructed in Australia and the United States. These reefs also help provide coastal protection as research suggests a tendency for sand to build up on the shoreward side of the reef.

7-Monitoring

Upon maturation, colonisation of artificial reefs leads to the establishment of an ecosystem comparable to that of rocky sea bed with high structural complexity. In order to understand the functioning of a reef as a system, all living components, their relationship with the surrounding environment, and all parameters controlling them within a system need to be taken into account (Harmelin & Bellan-Santinin 1997). In recent years the planning and construction of artificial habitats has been directed towards more specific objectives, resulting in a need for the biological sciences to use more specialised methods to quantitatively assess and monitor habitats when determining if objectives are being met. Any reef developments undertaken in Irish waters should ensure that ongoing monitoring is at its core; this should also include predeployment monitoring which is critical for providing baseline data. It is only on the basis of such systematic analysis that a determination as to the success or failure of an artificial reef can be made.

8. Applications of Artificial Reefs

The purposes of artificial reefs around the world can be categorised into habitat creation, enhancement, restoration or protection. Additionally, structures that are designed for other functions (such as piers and pontoons) can incidentally serve as artificial reefs. The motivations of different user groups to create artificial reefs include:

• Fishing enhancement – commercial, recreational or artisanal fishing (Baqueiro & Mendez 1994.);

• Tourism / recreational opportunity enhancement – diving, submarine tours (Rhodes et all.1994);

• Science – experimentation and research (experimental tool e.g. patch reefs, translocation experiments, techniques for management/restoration) (Ortiz-Prosper et al. 2001);

• Mariculture (Bombace 1989.);

• Mitigation / compensation (for habitat loss elsewhere) (Muir et al. 1995; Foster et al. 1994);

• Conservation of biodiversity (e.g. by providing or enhancing habitat for the re- establishment or enhancement or depleted organisms (e.g. red coral, Corallium rubrum, in Sardinia, Italy (Chessa et al.1993);

• Restoration of damaged habitat (e.g. following ship groundings in the USA (Hudson 2004) or coastal development in Singapore (Loh & Chou 2004)

• Protection of habitat or control of fishing mortality by using artificial reefs as physical barriers (e.g. to protect seagrass from trawling and exclude fishing operations from designated areas in the Mediterranean Sea (Lok et al. 2002; Guillen et al. 1994; Gomezbuckley & Haroun 1994)

• Protected (no-take) artificial reefs for fisheries restoration purposes, particularly in severely over-fished areas such as Hong Kong (Pitcher & Seaman 2000; Wilson et al. 2002).

There are three principal sectors involved in the development, deployment and utilisation of reefs globally. These include artisanal fisheries typically centred in coastal Asia, commercial fishing, located in coastal Asia, the eastern Indian Ocean, the Caribbean and northern Mediterranean basins, and the islands of the South Pacific and recreational fisheries typically found in North America, Australia, and some South Pacific Islands (Seamen & Sprague, 1991).

Populations of urban coastal communities include economically disadvantaged individuals that rely on subsistence fishing as a means of nourishment. Shore-based infrastructure such as bridges, jetties, and pilings provide structural benthic relief utilized by commercially and recreationally important shellfish and finfish species. The strategic placement of artificial reefs near waterfront infrastructure has the potential to enhance shore-based fishing opportunities (Buckley 1982).

The enhancement of commercial fishing activities is a primary function of artificial reefs in the Western Pacific (Sheehy & Vic 1982). Italy and France have experimented with a number of reef designs used in support of commercial harvesting of finfish and shellfish species (Bombace 1989). In the United States, most utilization of artificial reefs by commercial fishermen is restricted to benthic artificial reefs constructed primarily for use by recreational fishermen and sport divers. Artificial reef technology has been applied to the creation of kelp beds, mariculture of shellfish such as oysters and mussels, enhancement of lobster survival, and harvest of pelagic species (Stone 1985).The concept of artificial reefs as a potential method to enhancing commercial fishing activity may be appropriate for species of shellfish, lobster, and finfish, but more research is necessary before commercial reefs can be implemented on a larger scale.

Marine recreational fishing activities are extremely popular in both inshore and offshore waters. The types and degree of saltwater fishing activities that take place are linked to the quality of the marine resources, and to the physical resources available to marine anglers in pursuit of these activities. Steinback and Gentner (2001) estimate the total direct and indirect economic activity generated by marine recreational fisheries in Massachusetts was $880 million in 1998. They found that about 800,000 anglers participate in marine recreational fishing, and this number continues to grow. Over 70 different species are landed recreationally in Massachusetts' waters. Striped bass, tautog, black sea bass, scup, summer and winter flounder, cod, haddock, bluefish and tuna are common recreationally targeted finfish species, as well as American lobster and several shellfish species. Any future artificial reef development efforts must focus on understanding the degree of fishing effort exerted in different regions, by different user groups, and on different marine resource populations.

9- Conclusions

A strategy for artificial reef development needs to be formulated for different area. Such plans exist in other countries: Israel, Italy, Japan, South Korea, Monaco, Spain, Turkey and the USA.The strategy would need to be developed by an inter- departmental body with representation from a range of government departments, state agencies, NGOs, maritime organisations and academic institutions.

Monitoring should include pre-deployment monitoring which is critical for providing baseline data. It is only on the basis of such systematic analysis that a determination as to the success or failure of an artificial reef can be made. Areas to be examined would include: cost benefit analysis, predeployment site analysis, government certified reef products, design of prefabricated structures, deployment of structures and the fisheries developed around such structures. A final recommendation would be that artificial reefs area should be utilised as a site for research into the application of artificial reefs for sea angling, and lobster and crustacean fisheries development.

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