Artificial Reefs Feasibility Study

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Prepared for

The Marine Institute

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EXECUTIVE SUMMARY

The Marine Institute commissioned this study to review the current status of artificial reefs world-wide with a view to determining the feasibility of the development of a sea angling initiative based on the deployment and exploitation of artificial reefs. The study, conducted by the Coastal Resources Centre, National University of Ireland, Cork, includes a review of the current status of artificial reefs globally with a focus on site selection, reef design, construction material and reef use. The Beara Tourism Development Association has expressed an interest in developing a sustainable sea angling initiative based on the construction of a series of artificial reef sites. In response to this interest, the Beara Peninsula was used as a case study area for the purpose of determining feasible artificial reef site locations. Consultations with relevant regulatory bodies, local tourism development groups and the sea angling sector in the Beara Peninsula were an essential element of this study.

The use and benefits of artificial reefs have been widely accepted with both ongoing research and national development programmes in place in over forty countries worldwide. In Japan for example, national programmes have been in operation for over twenty years. The Japanese have been at the forefront of reef design, construction and deployment since their inception. However, little research has ever been undertaken on artificial reefs in Ireland, to date one application for the creation of an artificial reef has been submitted to the Department of the Marine & Natural Resources. This initial application was rejected.

From an Irish perspective, artificial reefs could potentially be utilised as a:
- soft engineering approach to coastal erosion;
- tool for the protection of sensitive habitats, biota and nursery grounds;
- possible tool in the removal of nutrients from waste discharge;
- means of increasing biodiversity and biomass;
- means of boosting inshore fisheries within our 12 mile waters;
- tool for the enhancement of crustacean and Molluscan fisheries (e.g. lobster) and
- for the algo culture sector.

From a recreational perspective, reefs could be deployed in Irish waters to:
- enhance prospects for sea angling;
- enhance shore angling sites and
- be used as locations for diving and snorkeling.

A wide range of materials and designs have been used in the construction and deployment of artificial reefs. Variations in the designs and materials used occur as a result of different goals and objectives for the creation of the reef (e.g., from coastal protection to SCUBA diving) in addition to the local availability of materials. Availability of materials accounts frequently for the choice of materials used in reef construction.

In Ireland there is indicative support from the marine sector for the development and deployment of artificial reefs. Aquaculture, inshore fisheries, tourism and the environment could all potentially benefit from the deployment of such structures. The

coming years are likely to see a significant increase in the development and deployment of reefs in Irish coastal waters. Artificial reefs are perceived as a potential solution to a number of problems currently experienced in Irish waters. Their use as a tool in coastal management may become relevant in the future and consequently further research needs to be conducted in this area. The development of marine-based wind power generating units is likely to act as a catalyst in this process.

Preliminary research indicates that a sea-angling enterprise based around the construction of several artificial reefs placed strategically around the Beara Peninsula is feasible. Factors favouring such a development include the:

- recognised need to develop the sea angling sector in the Beara area;
- active support for such a venture from local tourism and inshore fishing groups;
- large variety of angling species and the number of potentially suitable artificial reefs in the area;
- artificial reef research undertaken to date in the area.

However, a number of other factors are required to ensure the success of such a venture. These include the continued support of the inshore fishermen, sufficient financial resources to undertake research and development and the support of relevant state agencies.

This study has identified a number of sites, which offer potential in terms of site suitability. These sites will have to be assessed on the basis of the final goal of the deployment, the finances available, and the type of reef units to be deployed. Only then can the final decisions be made as to the sites that best suit the task. In principle, however, both the Beara Tourism & Development Association and the Coastal Resources Centre, University College Cork are committed to the goal of developing a sustainable sea-angling sector that will incorporate artificial reef sites deployed around the Peninsula.

1 INTRODUCTION

1.1 Principal Aims and Objectives

The principal aims of the study were to review the current status of artificial reefs worldwide, and to then attempt to identify potential sites for the location of artificial reefs within the vicinity of the Beara Peninsula. With these aims in mind, a number of important objectives were specified:

1. To complete a literature review on the current status of artificial reefs globally. This report would specifically focus on site selection, reef design, materials, construction, reef success, etc.

2. To undertake a review of the species most relevant to sea angling in the context of potential developments off the Beara Peninsula, West Cork.

3. To conduct meetings with local and national groups to ascertain information on the views on the use of artificial reefs and on information on potential sites for the location of reefs around the Beara Peninsula.

4. To carry out an assessment of potential sites around the Beara Peninsula on the basis of the physical, biological, oceanographic and socio-economic features of the sites.

1.2 Scope of the Study

While the practical aspects of the study are confined to a body of water around the Beara Peninsula, West Cork, many aspects of this research work are of national relevance. This is particularly the case in terms of both the review of artificial reefs and the regulatory body consultations.

1.3 Justification

Like most rural coastal locations in Ireland, the natural resources of the Beara Peninsula have strongly influenced its socio-economic development. This has resulted in activities based on the following primary sectors: fishing, aquaculture and agriculture. Despite this, the economic status of the Beara Peninsula is exemplified by:

- lower than average national income levels;
- higher than average national unemployment levels;
- subsistence agriculture on poor soils with very small farming units;
- high labour dependency ratios;
- inshore fishing from small boats;
- limited industrial development.

While there has been significant effort in promoting this region for industrial development purposes, there are extreme difficulties in attracting sustainable industries to the area. The drawbacks such as location and poor infrastructure have made it unlikely that industrial development will create the necessary stable and long-term activity needed. For these reasons, the development of natural and marine resources in particular has been identified as offering a significant advantage in developing stable and acceptable long-term economic activity, offering work for which many of the skills required are available locally.

The development of a sea-angling sector incorporating the construction of a series of artificial reefs could help to realise the following opportunities:

- An increase in the range of tourism products on offer in the Beara Peninsula, increasing the attractiveness of the Peninsula as a tourist destination.
- Socio-economic benefits from increased tourist throughput (both direct and indirectly).
- The benefit of aiding other fisheries, such as the lobster fishery.
- Enhanced habitat protection.
- Improvement of nature conservation and bio-diversity.
- Increased opportunities for diversification of the fishing fleet.

2 THE ARTIFICIAL REEFS REVIEW

The following is a summary of an extensive review of the literature on artificial reefs, undertaken as part of this study.

2.1 Introduction

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).

From a geographical perspective, research into the use and deployment of artificial reefs is currently taking place in over forty countries on six continents (CARAH 1999). 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).

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[1]). 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).

[1] http://www.soc.soton.ac.uk/SOES/RES/groups/EARRN/

In an Irish context there has only ever been one application for a Foreshore Licence for the development of an artificial reef in Irish waters. This application, to sink a decommissioned trawler for the purposes of developing a reef, was refused by the Department of Marine and Natural Resources. Currently, two Marine Institute funded studies are looking at researching artificial reefs and their potential deployment in Irish Coastal waters[2].

2.2 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[3]) 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.

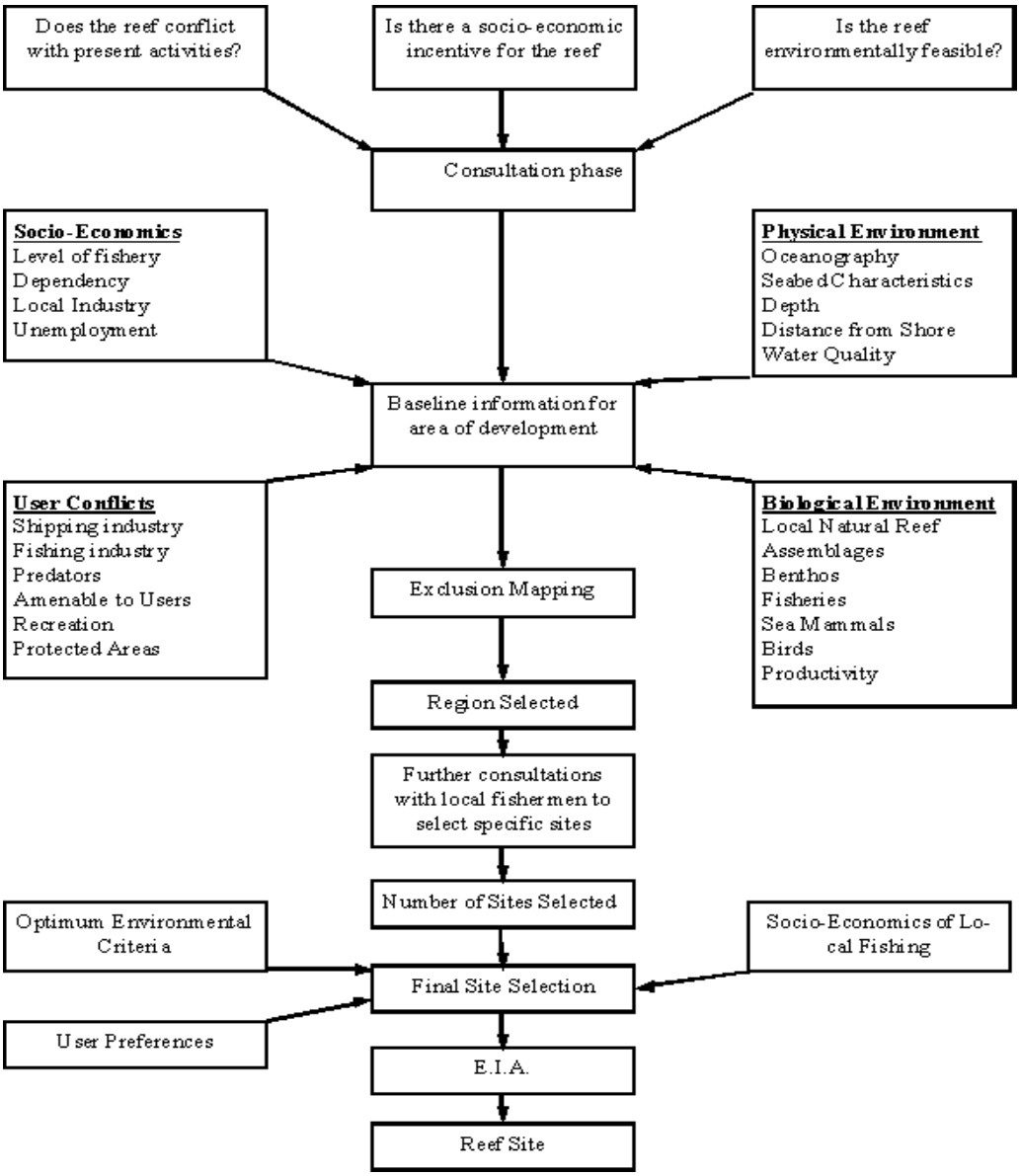
As artificial reefs are a relatively new phenomenon in Europe, it is only in recent years, particularly through the action of EARRN, that various studies throughout Europe have been examined comparatively, and that collaboration on a wider scale is

[2] (i) Artificial Reef Feasibility Study (Coastal Resources Centre, Beara Tourism and Development Association and the South West regional Fisheries Board) - Funded by the Marine Institute.
(ii) Assessment of the Impact of Offshore Wind Energy Structures on the Marine Environment (Byrne O' Cleirigh, EcoServe and Southampton Oceanography Centre) - Funded by the Marine Institute.

[3] In the strictest sense, a GIS is a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information , i.e. data identified according to their locations.

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 Figure 1.

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



2.3 Design & Materials

Seaman (1996) defined the design of artificial reefs as: "*The part of the planning process that determines the composition, arrangement and location of materials used as or in artificial reefs, in order to achieve the stated purpose of the reef, and which is in accord with technically valid concepts and methods related to construction, financial and environmental considerations.*" 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. The following outlines briefly the materials and designs utilised in artificial reef construction.

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. Table 2 lists 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 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.

Table 1. Principal Types of Natural and Man-made Materials Used in Artificial Habitats in the Aquatic Environment.

Material and structure	Ocean	Estuary	Freshwater
Natural Materials			
Bamboo	C	-	-
Brush	A	-	-
Coconut	A	-	-
Oyster Shell	-	H	-
Quarry Rock	R,H,M,E	R	R
Rope	A	-	-
Stone (piled or in gabions)	H	H	R
Trees, logs	H	-	R
Wooden frames	R	R	-
Manufactured or scrap products			
Concrete			
Poured Structures	R,C,H,E	R,H,E	E
Rubble	R,H	R	R
Fibreglass/plastic			
Benthic reef modules	R,C	-	-
Midwater buoys, streamers	R,C,A,E	R,H	-
Seaweed	H	-	R
Incineration ash	E	-	E
Rubber			
Automobile Tyres	R,C,H,A,E	R,H	R
Steel			
Automobile bodies	R,C,H	R,H	-
Benthic reef modules	C	-	-
Fuel storage tanks	R	-	-
Petroleum production			
Platforms	R	-	-
Street cars (trolleys)	R	-	-
Vessels	R,H	R	-
Wood			
Vessels	C	-	-

Abbreviations in columns indicate, in descending order of relative importance, principal use of structure: A, artisinal (small-scale) fishing; C, commercial fishing; E, experimental; H, habitat enhancement; M, mitigation; R, recreational fishing (Seaman & Sprague, 1991)

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.

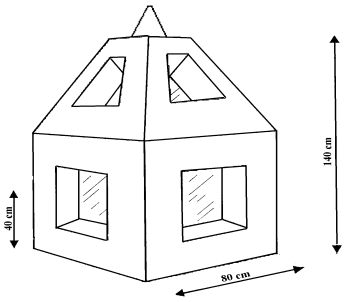


Figure 2. Simple Hollow concrete module (Lok *et al*., 1999)

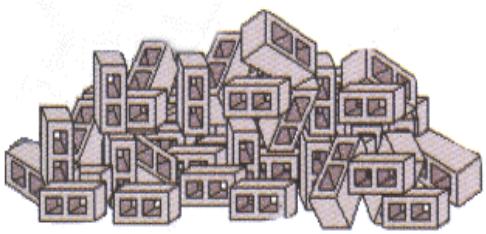


Figure 3. Concrete blocks used as a reef complex. © CCMS, Dunstaffnage Marine Institute Resources Laboratory.

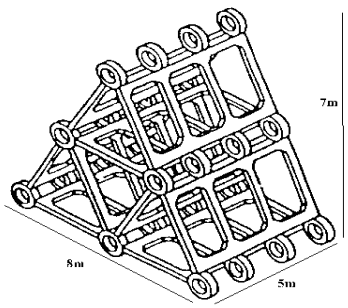


Figure 4. Japanese reef module "JUMBO" (Mottet, 1981)

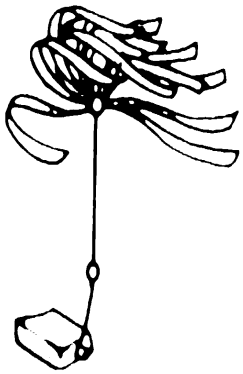


Figure 5. Plastic Kelp (Ishikawa, 1976)

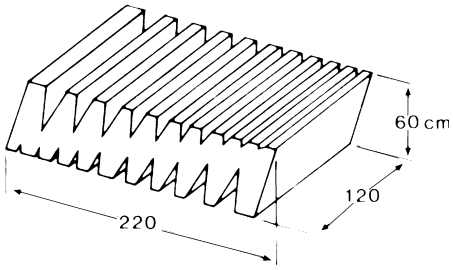


Figure 6. Abalone Nursey Block (Seaman, 1996)

Figure 7. Reefball
© Reefball International

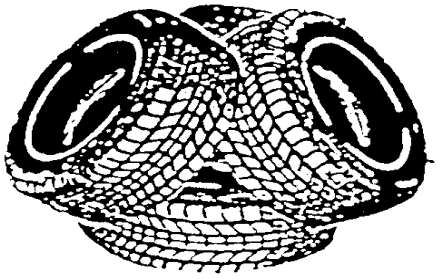


Figure 8. American tyre reef modules (Collins *et al.*, 1999)

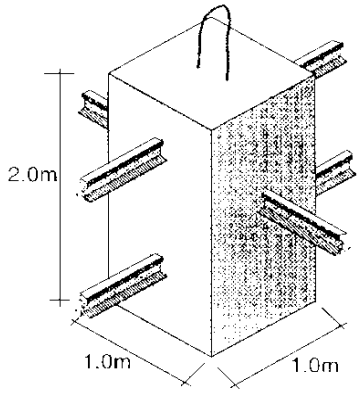


Figure 9. Spanish Reef module used for habitat protection (Revenga *et al.*, 1996)

2.4 Legislation[4]

Over the past decade there has been a rapid growth in interest in artificial reefs, so much so that in Europe it has outpaced the development of law applicable to such structures. This has been attributed to the "lack of firm scientific evaluation of the devices, leaving fisheries administrators and law-makers uncertain what sort of property and use rights, incentives, controls and other legal measures would be appropriate" (Christy 1991, as in Pickering 1997). This general lack of explicit legal provision is prevalent throughout almost all EU countries. In many countries the small-scale nature of reef projects and the scope of existing legal provisions have been such that specific legislation to regulate reefs has not been deemed necessary. Consequently, the law in many European countries fails to recognise the need to establish the necessary institutions to fully exploit the potential of artificial reefs.

Artificial reefs fall under such regulations as the provisions of the *London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter* (London Dumping Convention) 1975. The scope of this regulation has been extended by the implementation of the *United Nations Laws of the Sea Convention 1982 in 1994*. This convention which obliges those who had not signed the *London Dumping Convention* to abide by its standards and requires states to protect the marine environment from all sources of pollution, including dumping (Pickering 1996). Other regulations that apply to the seas around Europe include the *Oslo Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft 1972*, and its replacement the *Convention for the Protection of the Marine Environment of the North East Atlantic*, the declarations made at the Second and Third Conferences on the Protection of the North Sea in 1987 and 1990, the *Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention)*, the *Convention for the Protection of the Mediterranean Sea against Pollution 1977 (Barcelona Convention)* and most importantly the *OSPAR Convention*, to which Ireland is a signatory.

Ireland's signatory to the OSPAR convention for the protection of the marine environment of the North-East Atlantic has a number of implications for any Irish artificial reef project. One such implication is that it precludes the use of a wide range of materials previously utilised in artificial reef construction. 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.

[4] For various national, European and International legislation impacting on the Irish coastal zone please refer to Appendices I, II & III for more information.

- 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.

The principle national legislation in this area would be the Foreshore Acts (1933 to 1998). Other national legislation of importance would include:

- The Wildlife Act, 1976
- Fisheries Act, 1933 & Fisheries Consolidation Act, 1963
- Harbours Act, 1946 & 1995
- Fisheries Harbour Centres Act, 1968
- Coast Protection Act, 1963
- Water Pollution Act, 1977 & Amendment 1990
- Dumping at Sea Act, 1996
- Oil Pollution at Sea Acts, 1956-1977
- Sea Pollution Act, 1991
- Environmental Protection Agency Act, 1992
- Fisheries Amendment Act, 1997 (No. 23)

Areas of particular interest with respect to legislative issues include:

- Ownership and commercial exploitation rights.
- Allocation of property rights for artificial reef construction.
- Construction and installation of artificial reefs.
- Operating artificial reefs.
- Decommissioning.

(Pickering 1994, 1996 & 1997).

The allocation of property rights for artificial reef construction internationally is quite varied. In the US for example, state and local governments, with only general guidance and minimal funding carry out most marine artificial reef projects. These reef developments are incorporated into a common-property allocation system. In Japan on the other hand, through a political system, user rights are given to those who construct and deploy reefs. These rights convey the sole control of the harvest and use of the fishery resources around their structures. The Irish situation falls between the Japanese and US systems. In Ireland, a successful foreshore license application would result in exclusive rights to the use of the deployed artificial reef being granted to the applicant. However, there is uncertainty about the ownership of fishing rights around the reef and on how any such rights would be enforced.

2.5 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.

2.5.1 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). The benefits of using such material are twofold in that they are a cheap and readily available raw material and secondly that they would reduce the pressure on landfill sites. The materials mentioned previously are controversial since there are concerns that pollutants may leach into the marine environment, and may subsequently enter marine food chains. In an Irish context it is considered unlikely that the use of such materials would be sanctioned without significant pre-deployment testing of such substances.

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).

2.5.2 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.

2.5.3 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.

2.6 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.

3 CONSULTATIONS

3.1 Introduction

This section of the report describes the consultation process.

- Section 3.2, determines the role of the various state authorities in the regulation of artificial reefs.
- Section 3.3, attempts to harness local knowledge to help identify potentially suitable sites and to ascertain local perception with regard to the use of artificial reefs around the Peninsula.

3.2 Consultation with Regulatory Authority

3.2.1 Methodology

A list of government bodies, departments and representatives who were likely to be involved in any area of reef building, deployment and the regulation process was established. An inclusive approach was adopted which ensured that any group, even with only a tentative involvement in the process, was given the opportunity to make their opinions known.

A copy of the draft "Artificial Reefs Review" document was circulated to some 20 individuals, representing a significant cross section of groups considered likely to have any involvement in the regulation and control of artificial reefs. Those contacted were asked to make submissions on the basis of the content of the report and on their regulatory role in this area. Groups represented in this process included:

- Department of the Marine and Natural Resources (DOMNR)
- Department of the Environment and Local Government (DOELG)
- The Office of Public Works (OPW)
- Central Fisheries Board (CFB)
- South West Regional Fisheries Board (SWRFB)
- The Environmental Protection Agency (EPA)
- Fisheries Research Centre (FRC)
- Marine Institute (MI)
- Taigh de Mara Teo (TMT)
- Bord Iascaigh Mhara (BIM)
- The Nautical Studies Department, Cork Institute of Technology (CIT)

In addition, a number of phone conversations were held with representatives of the above organisations and with other subsequently identified interest groups, including Dúchas (The National Heritage Agency).

While the response rate was not high, the responses that were received were informative and went a significant way towards identifying how various organisations might be involved in the regulation of any artificial reef developments. The following is a summary of the current situation.

3.2.2 The current situation

The Foreshore Acts (1933 to 1998) control the construction and deployment of artificial reefs in Ireland. These Acts require that, before any work can commence on State owned foreshore, an appropriate license or lease must be obtained from the Minister for the Marine & Natural Resources. Foreshore is defined as "the land and seabed between the high water of ordinary or medium tides (shown HWM on Ordnance Survey maps) and the twelve mile limit (twelve nautical miles is approximately 22.24 kilometers). For an application to be considered, copies of the following documents must first be sent to the Department of the Marine and Natural Resources:

1. Ordnance Survey map of 25" scale (latest edition) with the exact site of the area concerned in so far as it is situated below the line of high water of medium tides clearly marked on the map in distinctive colour. The area of the site should be stated on the map.

2. Plan, elevation and sectional drawing showing clearly the nature of the proposed works and lines and levels of high and low water of spring tides.

3. Longitudinal section showing clearly how such works will be laid in relation to the surface of the shore and having delineated on it the lines and levels of Spring tides.

The applicant will be required to publish notice of the proposal in newspapers circulating in the area. The Department will prepare the notice and specify the newspapers in which it should be published. A three-week period is allowed for representations and objections to be made to the Minister. The applicant is allowed an opportunity to comment on these before the final report is made to the Minister. That report will detail the proposal, the process for development, the objections and the decision on whether or not to grant a lease or licence and, if so, under what conditions.

3.2.3 Pre-considerations

- Pre-consultation with the Department of the Marine and Natural Resources would be an important factor in helping to ensure that such a foreshore licence application was successful.
- Letters stating the support of local groups/bodies as well as local marine interests (fishing, aquaculture, tourism etc.) in any such reef development project would be highly regarded.
- The biggest obstacles in getting a foreshore licensing application approved for the development of an artificial reef would be to prove:
  - that the structure does not impinge upon navigation or existing fisheries;
  - that it would not be a source of pollution;
  - whilst also proving that the structure is permanent[5].

[5] The term permanent in this context means that the reef will not disintegrate over time, rather than that it cannot be removed. In fact, the ability to remove the reef is a pre-requisite of United Nations

Certain developments are subject to the European Communities (Environmental Impact Assessment) Regulations, 1989 [SI N° 349 of 1989]. An application for any development above the threshold set in these regulations must include an Environmental Impact Statement (EIS). An appraisal of the environmental effects of a development below the threshold must be submitted in the application to allow the Minister to decide whether it is likely to have significant effects on the environment. Whilst artificial reefs are not listed as a development type for which there is a prerequisite for the production of an EIS, discussions with the DOMNR would suggest that an EIS would be required for such developments under all but the most exceptional cases (e.g. very small scale research studies). The EIS should contain the applicant's analysis of the possible negative and positive effects of the development on the environment. It would also set out any measures to be taken to avoid or moderate any adverse environmental effects and may identify decisions already taken by the proposer for this purpose. The public consultation period for an application requiring an EIS is one month and a copy of the EIS must also be provided by the applicant to the consultative bodies named in the Foreshore (Environmental Impact Assessment) Regulations, 1990 [SI N° 220 of 1990].

The consultative bodies named in Section 19(A) (3) of the Act of 1933 include:

- The Commissioners of Public Works in Ireland, if the development is to take place on an area of archaeological, scientific or ecological interest or both;
- The Local Authority, within whose functional area or contiguous to whose functional area the proposed development is to take place;
- An Taisce, the National Trust for Ireland, if the development is to take place on an area of special amenity value or special interest;
- Bord Failte Eireann.

Discussions with representatives of the Department of the Marine and Natural Resources indicated that both An Taisce and Bord Failte Eireann would only play a minor role in the processing of an EIS based on the submission of a foreshore license for an artificial reef. Local Authorities, under the Local Government (Planning Development) Acts and Regulations made under them would take a much more active role. The Acts and Regulations under Local Authorities provide that permission must be sought and obtained from the local planning authorities, e.g., County Council, Corporation, etc., before any development which is not exempted from planning control may be undertaken. Any permission that might be given under the Foreshore Acts would be without prejudice to the powers of the local planning authority. Foreshore license applicants should, therefore, consult with the local planning authority regarding the proposed reef development. Areas of particular concern would include for example where the local authority has a regulatory role in the administration of the sea area in question, as is the case in inner Bantry Bay (Cork County Council). In these situations the Local Authority would have a direct and immediate involvement in the decision process. Compliance with local development regulations should be adhered to particularly where reef modules are being

legislation which necessitates that all artificial reefs should be removable and that costings for their initial development should include removal expenditures.

manufactured locally. In addition, the Local Authority would have an involvement if pier facilities/slip-ways under its jurisdiction are being utilised.

Other government bodies likely to have significant inputs in the assessment of the EIS and foreshore license applications for artificial reefs would include the Department of Arts, Heritage, Gaeltacht and the Islands who have two constituent services which have direct responsibility in the coastal zone. The National Parks and Wildlife Service (NPWS) has responsibility for nature conservation and habitat protection, while Dúchas, the Heritage Service, has responsibility for the natural and built heritage.

Under the Wildlife Act, 1976, the NPWS has responsibility for nature conservation. Under this act the service can make the following designations:

- Areas of Scientific Interest
- Statutory Nature Reserves
- National Parks
- Refuges for Fauna
- Wildflower Sanctuaries
- Flora Protection Sites
- Special Protection Area
- Special Areas of Conservation
- Natural Heritage Areas

The statutory instruments and EU regulations used to underpin these designations and to safeguard designated sites include:

- Wildlife Act 1976
- Directives on the Conservation of Wild Birds (79/409/EEC)
- Conservation of Wild Bird Regulations (S.I. 291 of 1985)
- Habitats Directives (92/43/EEC) - Special Area of Conservation
- Natural Habitats Regulation 1996

Bearing the above in mind, the NPWS would assess the foreshore license application and EIS produced for any artificial reef development on the basis of the impact of any such development on any sites or species covered under the above regulations. Their recommendations would be based on that assessment.

Dúchas on the other hand proposes policies and priorities for the identification, protection, preservation and enhancement of the natural heritage, including flora, fauna, wildlife habitats and seascapes. It is likely that Dúchas would require an assessment of the archaeological value of any sites in question and at that stage the underwater unit of the Office of Public Works archaeology section would have some input.

As a signatory to the *OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic,* Ireland would be required to enforce certain regulations, which could effect artificial reef projects in Irish waters. One such implication is that it precludes the use of a wide range of materials previously utilised in artificial reef construction elsewhere.

Whilst the above summarises the potential obstacles to be overcome in obtaining a foreshore application for an artificial reef through the licensing processes, discussions held with representatives from many of the organisations and agencies mentioned above were very positive about the potential opportunities that artificial reefs may afford.

3.3 Consultation with Local Stakeholders

3.3.1 Methodology

Following discussions with the Beara Tourism & Development Association, a list of local stakeholders was drawn up. These individuals were identified as key stakeholders with an interest in the use of artificial reefs or with a direct involvement in the fishing, tourism and or sea angling sectors. Meetings were arranged with a cross section of these individuals and perceptions regarding the use of artificial reefs around the Beara Peninsula for the purposes of developing a sea angling sector were documented. In addition, the maritime knowledge and experiences of many of these consultants was utilised to aid in the determination of potential sites for reefs and in determining general conditions (biological, physical, etc) at these locations. Maps were used extensively during the consultation process.

3.3.2 Site Selection

As mentioned in Section 2.2 (Site Selection), reef site selection is one of the most critical decisions in the entire reef building process; unsuitable site selection is the most frequent cause of artificial reef failures (Mathews, 1985). The optimum site conditions required for artificial reef deployment depend greatly on the intended purpose and design of the reef. Thus, it was necessary to invoke the first generic rule of reef planning i.e. to identify the goals for the artificial reef deployment exercise.

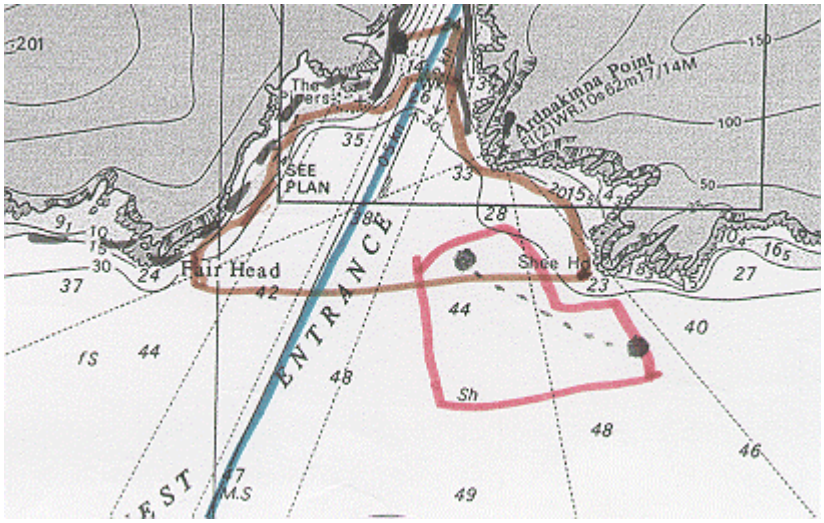
The Goal of the Beara Tourism Development Group

"To determine whether it is feasible to develop artificial reef sites around the Beara Peninsula so as to maximise the use of these site by species of particular relevance and in sufficient quantities to help sustainably support a sea angling sector, and to locate these sites so as to maximise their availability during poor weather periods and close to support facilities."

3.3.3 Constraint Mapping

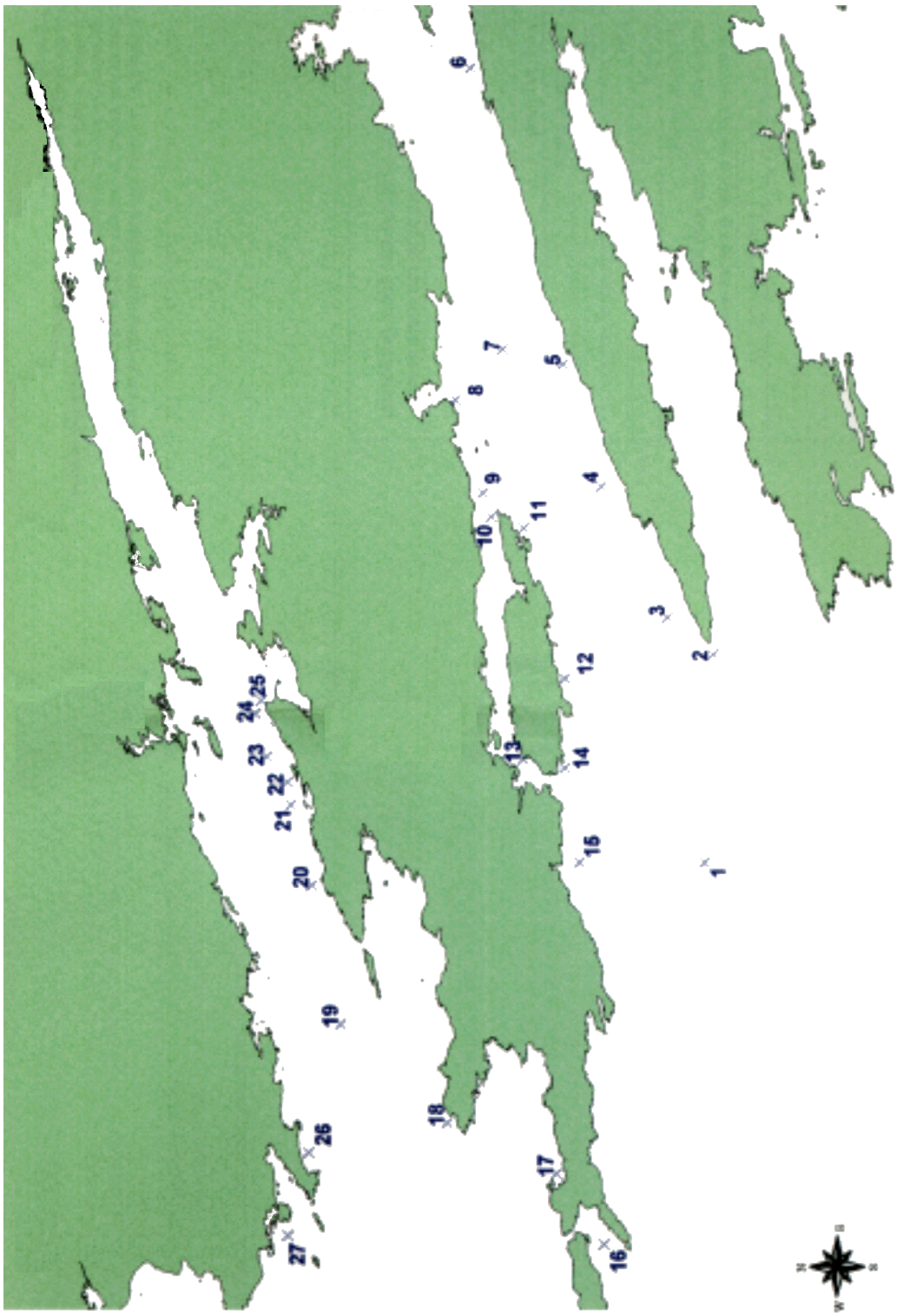
Figure 10 below shows a scanned section of a map used during the consultation meetings. The maps were used to identify current resource usage and to aid in the identification of potentially suitable sites.

Figure 10. A section of map used in the constraint mapping process



A very simple constraint mapping method was adopted, following, where possible, techniques used from other more established studies. In our study, time did not allow for the use of a GIS system to any great extent, the constraint mapping exercise was carried out on conventional maps of the area. This approach, combined with consultations with local stakeholders, focused initially on areas where reefs could be safely located and where limited conflicts were likely to arise. The sites were typically chosen to be as far as possible away from existing activities that could be considered to be incompatible with a reef development. This condition is often difficult to fulfil within any coastal zone where marine activity is high. As a result of this process some twenty-seven sites were identified around the Beara Peninsula. These sites are illustrated on Figure11.

Figure 11. Potential locations of twenty-seven suitable artificial reef sites as identified by local stakeholders.



3.3.4 Data Capture

For each of the twenty-seven sites around the Beara Peninsula identified by local stakeholders, a variety of physical and biological data was collated. Information was gathered from a variety of sources, which included BioMar, Admiralty charts, the Quality Status Report, the South West Coast of Ireland Environmental Appraisal, as well as a number of local sources. Factors taken into consideration, when determining the suitability of these sites and those known to be important in the site selection process included:

- Physical Environment
- Biological Environment
- Uses and Users of the Area.

It was possible only to develop limited information regarding the potential sites identified by local interests within the timeframe of this study. Further and more detailed site specific technical studies will need to be undertaken to determine the full suitability of these sites. These studies should include a diving survey and wave, current and tidal dynamics studies.

Factors such as funding availability will significantly impact on the types and numbers of reef modules that can be deployed. The type of modules to be used would have a significant role in determining the locations that could be used as sites to deploy such structures, the impacts of currents, depths and wave action also playing a critical role.

Following discussions with local stakeholders, preliminary physical and biological research, and from information on current use, the twenty-seven sites have been evaluated for sea angling, diving and lobster enhancement (see Table 3). Lobster enhancement was considered following consultations with local inshore fishermen who expressed an interest in undertaking a joint venture whereby sites identified as being suitable locations for artificial reefs for sea angling would also be developed in terms of lobster stock enhancement. The involvement of inshore fishermen in this way could help safeguard the artificial reefs from potential inshore fishing pressure. Sites were also assessed on the basis of their potential suitability for recreational SCUBA diving.

Table 3. Suitability of potential sites for various uses (* suitable)

No.	Site Name	Suitability for		
		Sea Angling	**Diving**	**Lobster Enhancement**
1	The Three Wrecks	*		
2	Sheeps Head	*		
3	Foilnadeal	*		
4	Coosbrack	*	*	*
5	Trasloosh	*	*	*
6	Leagre Point to Cooskeen	*	*	
7	Middle of Channel	*		
8	Bulliga Ledge	*	*	*
9	Lonehort Point - Aughabeg Point	*	*	*
10	Middle of East Entrance to Bearhaven	*	*	*
11	Leahern's Point	*	*	*
12	Doonbeg Head	*		*
13	Foilnaboe Rock	*	*	*
14	Shee Head	*		*
15	Foilcoora	*	*	*
16	South Dursey Sound	*	*	*
17	Garnish Bay	*	*	*
18	Cod's Head	*		*
19	Rocky Patch	*		*
20	Doonagh	*		
21	Illaunbweeheen	*		*
22	Foilaluggig	*		*
23	North of Kidney Rock	*		*
24	Dog's Point North	*		*
25	Dog's Point	*		*
26	Lamb's Head	*		*
27	South of Bulligmore Rock	*		*

4 SEA ANGLING SPECIES REVIEW

An extensive list of the species relevant to the sea angling sector in the south west area was developed as part of the study. A review on each of the species was undertaken resulting in a profile of each species habitat requirements, life history, reproductive patterns etc. The species review, where appropriate, also included basic procedures through which artificial reefs could be adapted to enhance the utilisation of these structures by the species in question.

The Japanese have adopted several classification schemes to describe how fish use artificial reefs, including horizontal and vertical use, length of occupancy, fidelity to a reef, and the part of the life cycle that uses an artificial reef (Grove and Sonu 1983; Ogawa 1968). Ogawa provided one of the most useful classifications for describing behavioural patterns of fish attraction and use of artificial reefs. For the purposes of this study the classifications used by Ogawa were adopted with slight amendments. Ogawa's approach grouped the species on the basis of their habitat requirements with respects to artificial reefs, the species were categorised as follows:

A. Reef Dwelling Species
B. Occasional Reef Dwelling Species
C. Rare Species

Various fishery publications were accessed to obtain the relevant information. On completion of the first draft of the categorised species report a number of local sea anglers and fishermen were approached to review the document. These individuals felt that the list was representative of the vast majority of species likely to occur in the area and that the categorisation adopted seemed to compare with their own fishing experiences.

A number of key species have been identified by local fishermen (pollack, blue shark, ling, spur dogfish, spotted dogfish, haddock, whiting, cod and conger) as being crucial to developing a commercially successful sea angling industry. One of the central goals in the development of artificial reef sites will be to endeavour to enhance the colonisation and increase the numbers of sea angling species at these sites. This should provide the basis upon which a sustainable sea angling sector can be developed. Decisions such as reef location, depths and module types will be made with the goal of maximising the uptake of these sites by key species.

From discussions held with the Beara Tourism Development Association it has been agreed that any sea angling undertaken on artificial reefs deployed by them will adopt a catch-and-release policy. This policy will only allow specimen fish to be taken, all others would be returned. There are a number of reasons for adopting this policy including to ensure the sustainability of sea angling on the reefs and to ensure the continued support of the inshore fishermen. Inshore fishermen perceive these sites as being important nursery/conservation zones, acting in a restocking capacity. Gaining the support of the inshore fishermen in this way should help to ensure that the site receives some protection from targeted fishing.

Table 4. The following lists the species examined in the review

A Reef Dwelling Species	B Occasional Reef Dwelling Species	C Rare Species
Atlantic Cod (*Gadus morhua*)	**Coalfish** *(Pollachius virens)*	**Anglerfish** (*Lophius piscatorius*)
Conger Eel (*Conger conger*)	**Picked Dogfish** (*Squalus acanthias)*	**Brill** (*Scophthalmus rhombus*)
John Dory (*Zeus faber)*	**Greater Spotted Dogfish** (*Scyliorhinus stellaris*)	**Dab** (*Limanda limanda*)
Ling (*Molva molva)*	**Lesser Spotted Dogfish** (*Scyliorhinus canicula*)	**Flounder** (*Platichthys flesus*)
Pollack (*Pollachius pollachius)*	**Red Gurnard** (*Aspitrigla cuculus*)	**Garpike** (*Belone belone belone*)
Pouting (*Trisopterus luscus)*	**Haddock** (*Melanogrammus aeglefinus)*	**Grey Gurnard** (*Chelidonichthys gurnardus)*
Triggerfish (*Balistes capriscus*)	**Atlantic Halibut** (*Hippoglossus hippoglossus)*	**Tub Gurnard** *(Chelidonichthys lucerna)*
Red Sea Bream *(Pagellus bogaraveo)*	**Porbeagle** *(Lamna nasus*)	**European Hake** (*Merluccius merluccius)*
Ballan Wrasse (*Labrus bergylta*)	**Cuckoo Ray** (*Raja naevus)*	**Flathead Mullet** (*Mugil cephalus)*
Cuckoo Wrasse *(Labrus mixtus / L. bimaculatus*)	**Electric Ray** (*Torpedo nobiliana*)	**Atlantic Herring** (*Clupea harengus)*
	Spotted Ray (*Raja montagui)*	**Atlantic Mackerel** (*Scomber scombrus)*
	Common Stingray *(Dasyatis pastinaca)*	**Megrim** (*Lepidorhombus whiffiagonis)*
	Thornback Ray *(Raja clavata)*	**Monkfish** (*Squatina squatina*)
	European Seabass *(Dicentrarchus labrax*)	**Grey Mullet** (*Chelon/Mugil Labrosus)*
	Blue Shark (*Prionace glauca*)	**European Plaice** (*Pleuronectes platessus*)
	Six Gilled Shark (*Hexanchus griseus)*	**Atlantic Pomfret** (*Brama brama)*
	Tope Shark (*Galeorhinus galeus)*	**Blonde Ray** (*Raja brachyura*)
	Three-bearded Rockling *(Gaidropsarus vulgaris)*	**Small-Eyed Ray** (*Raja microocellata)*
	Torsk (*Brosme brosme)*	**Sole** (*Solea solea*)
	Whiting (*Merlangius merlangus)*	**Undulate Ray** *(Raja undulata)*
	Wreckfish *(Polyprion americanus)*	**Twaite Shad** (*Alosa fallax)*
		Common Skate (*Raja batis)*
		White Skate (*Rostroraja alba)*
		Scad (*Trachurus tachurus*)
		Common Smooth-hound (*Mustelus mustelus)*
		Sea Trout (*Salmo trutta)*
		Turbot *(Psetta maxima)*

Table 5. A sample of one of the completed sheets used for the species review

Species Name: Conger Eel (*Conger conger*)
Family: CONGRIDAE **Order:** ANGUILLIFORMES
Class: ACTINOPTERYGII **Common Name(s):** European conger
Identification: A large marine eel with a rounded cylindrical body, prominent pointed pectoral fins, and moderately large gill openings. The dorsal fin origin is placed well forward, vertically above the tip of the pectoral fin. The upper jaw is longer than the lower. Body scaleless. **Colouration**: Dull brown above sharply set off from the light golden brown or cream on the underside. Deep-water specimens are light grey-brown, lighter ventrally but with the margins of the dorsal and anal fins black.
Distribution: Eastern Atlantic: Norway and Iceland to Sénégal. Also in the Mediterranean and Black Seas. English Channel, North Sea, Irish Sea and occasionally into the Baltic.
Habitat: Conger eels favour very rough ground and inhabit deepwater wrecks, reefs and broken ground. In shallow waters Conger are mostly nocturnal feeders, but in depths of 20m or more they feed at any time. They may be found from a depth of a few metres to at least 1,000 m.
Food: Congers are bottom feeders more than capable of catching live food. They will hole up in a wreck or rough ground and ambush lesser species. They feed on fishes such as herrings, rocklings and flatfish, cephalopods and also on large crustaceans like lobsters and crabs.
Breeding: The breeding cycle of the Conger is still something of a mystery due to the enormous distances that they will travel to spawn. It is thought that the Conger migrate to the Sargasso Sea in the sub-tropical Atlantic to breed, spawning at depths of 3,000 to 4,000m. The larvae are transparent and flattened, and drift at the surface for up to 2 years before reaching the shoreline where they become cylindrical. At this stage they are still transparent and about 8cm long. The full colouring appears by the time that the eel is 30cm long. The Conger, in the aquarium, at least spawns only once and the teeth are shed and calcium is lost from the bones so that they become soft and gelatinous. There is one spawning area between Gibraltar and the Azores and this probably serves the northern European Conger population. There are also spawning areas in the Mediterranean.
Max. Size: 300.0 cm TL; max. weight: 65 Kg
Environment: Bathydemersal, marine
Climate Zone: Subtropical
Commercial Importance: The commercial importance of the species has increased in recent years and it has the potential in become progressively more significant.
Status of Threat: Not on IUCN Red List
Dangerous: Can be dangerous to handle.
Notes: Considerable numbers caught by anglers.
Enhancement: ▪ Highly complex chamber structures ▪ Integration of piping ▪ 2m - 1000m, depth limited by fishing gear ▪ possible enhancement of man made sites including piers, jetties etc

5 CONCLUSIONS

Conclusions are drawn and examined on both a national and local level.

5.1 Conclusions with a national relevance

- Artificial reefs have been widely used all around the world for a considerable period of time, for such diverse uses as tools in fisheries management, coastal protection and marine recreation.

- Considerable ranges of design types have been utilised to date. Reef designs have varied from rubble scattered on the seabed to the large scale deployment of highly technical prefabricated structures.

- Materials used in the construction of reefs can vary from materials of convenience to specially developed marine products.

- The Japanese are at the forefront of artificial reef design and deployment; lessons can and should be learnt from their experiences. However much of the Japanese literature has not been translated into English.

- The European Artificial Reef Research Network (EARRN) is an important group, which should be contacted with respect to any future artificial reef developments in Ireland.

- Little or no official artificial reef research and development has been undertaken in Ireland to date. There has only ever been one application for a foreshore license for the deployment of an artificial reef. This application, to sink a decommissioned vessel, was refused by the Department of the Marine and Natural Resources.

- Appropriate project planning and site selection for the construction of an artificial reef will be critical to its success. The determination of success or failure of the deployment of an artificial reef can thus be measured against the initial goal set for its construction.

- Techniques such as constraint mapping and stakeholder consultation should be employed to ensure that potentially suitable sites are selected and that the local community has accepted them through consensus.

- Constraint mapping should investigate physical and biological environmental conditions in the region, as well as considering current and future potential uses by stakeholders of the area.

- The allocation of property rights for artificial reef construction is quite varied. In the US for example, state and local governments, with only general guidance and

minimal funding, carry out most marine artificial reef projects. These reef developments are incorporated into a common-property allocation system. In Japan, on the other hand, through a political system, user rights are given to those who construct and deploy reefs. These rights convey the sole control of the harvest and use of the fishery resources around their structures.

- In terms of the Irish situation with respect to the allocation of property rights, this lies somewhere between the Japanese and US systems. A successful foreshore license application would result in exclusive rights to the use of the deployed artificial reef being granted to the applicant. However, a difficulty arises in terms of fishing rights around the reef as to who would own them and how any such rights would be enforced. Clarification on this issue needs to be sought.

- In Europe, the rapid growth in interest in artificial reefs has outpaced the evolution of legislation applicable to such structures. This general lack of explicit legal provision is prevalent throughout almost all EU countries.

- Any artificial reef developments would require the application of a foreshore license to the Department of the Marine and Natural Resources. Dúchas and the relevant Local Authority would also review this application.

- Conditional for an approved foreshore license for the development of an artificial reef would be proof that the structure does not impinge upon navigation, or existing fisheries and that it would not be a source of pollution; in addition to proving that the structure is permanent. The term *permanent* in this context means that the reef will not disintegrate over time, rather than that it cannot be removed.

- United Nations legislation necessitates that all artificial reefs should be removable and that costing for their initial development should include removal expenditure.

- The use of cost benefit analysis techniques is important in determining whether any artificial reef development is likely to succeed or fail. A cost benefit analysis should be used for any proposed artificial reef development in Irish waters.

In an Irish context, the potential uses of artificial reefs could include a:

- soft engineering approach to coastal erosion;
- tool for the protection of sensitive habitats, biota and nursery grounds;
- possible tool in the removal of nutrients from waste discharge;
- means of increasing biodiversity and biomass;
- means of boosting inshore fisheries within our 12 mile waters;
- tool for the enhancement of Crustacean fisheries (e.g. Lobster);
- tool in the enhancement of Molluscan fisheries (e.g. Mussels);
- tool in the development of an algo culture sector in Ireland.

From a recreational perspective reefs could:
- be deployed to enhance prospects for sea angling;
- be utilised to enhance shore angling sites;
- be utilised as locations for diving and snorkeling.

5.2 Conclusions with relevance to the Beara area

- Consultations with a cross section of local stakeholders around the Beara Peninsula indicate that there is popular support for the deployment of artificial reef structures to enhance opportunities for sea angling, crustacean fisheries and diving.

- There is also the perception locally that such reefs would benefit the environment through stock enhancement, and their potential as conservation zones.

- Preliminary consultations have resulted in the identification of twenty-seven potential locations for the possible siting of artificial reef structures around the Beara Peninsula.

- In addition to an expressed interest in the use of artificial reef structures as a tool in the development of a recreational fishing sector, based around the Beara Peninsula, many individuals also expressed a keen interest in the use of these structures in the development and enhancement of lobster fisheries.

- It may be possible and beneficial to link any future artificial reef projects based on sea angling with local lobster stock enhancement programmes. The support of inshore fishermen on this basis should help to ensure that reef sites would be given some protection from inshore fishing pressure.

- Preliminary investigations of recently deployed reef type structures and discussions with the diving and sea angling communities would indicate that there is significant colonisation of these sites by desirable sea angling species such as pollack, ling, dogfish and conger.

- From a marketing perspective, the promotion of sea angling through the activity of wreck fishing is one deemed to be of significant commercial value. The development of artificial reefs from a promotional perspective would also be viewed in a positive light by the sea angling community and could be used as a marketing tool for the Beara Tourism and Development Association.

- The Beara Peninsula has been identified in a number of previous studies as a location with considerable potential for the development of a sea angling sector. Several individuals, interviewed during the local consultation process, expressed an interest in developing such commercial activities.

- The findings of the study suggest that the deployment of a series of artificial reefs in the Beara Peninsula presents a feasible option for the development of a local sea angling initiative. The Beara Tourism Development Group have responded

positively to the study findings and are committed to advancing to the next phase of development, which would include the development of artificial reefs sites around the Beara Peninsula.

- From discussions with local stakeholders, it appears that there is potential for the development of recreational diving around the Beara Peninsula. Such developments could be carried out in tandem with the development of artificial reefs for sea angling. However, careful consideration would have to be given to how the two activities could safely interact. The possibility of allowing recreational diving on reef sites during fallowing periods should be explored. Another area of possible concern would be the interaction between recreational divers and inshore lobster fishermen. It will be important to insure that the use of artificial reefs by different groups (such as sea anglers, lobster fishermen and divers) will require the development of agreed operational protocols to be observed by each group. This is potentially an area where conflict may arise.

- If artificial reef sites are developed around the Beara Peninsula for the purposes of sea angling, lobster enhancement, as conservation zones and as recreational diving sites, there would be the possibility of utilising such sites and activities as the basis for a tourist attraction.

- The potential also exists to utilise these artificial reef sites as a basis for a centre of European artificial reef education, with students from all over Europe coming to the Beara to undertake research projects in the area.

6 RECOMMENDATIONS

Drawing from the data and conclusions of the reports produced over the duration of the study, the following recommendations are made.

- A strategy for artificial reef development needs to be formulated for Ireland. 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.

- Any reef developments undertaken in Irish waters should ensure that ongoing monitoring is at its core. Monitoring should also 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.

- A request for further information should be made to Japanese government agencies, as leaders in the field. The possibility of a fact-finding mission should be explored. 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.

- Much of the Japanese literature has not been translated into English; this is an issue, which should be addressed.

- The Marine Sea Fisheries and Marine Environment and Health Services Divisions of the Marine Institute should be consulted in relation to any potential artificial reef developments particularly with respect to Ireland's signatory of the OSPAR convention.

- Previous studies have shown that the long term viability of sea angling ventures can prove difficult. Analyses indicate that sea angling initiatives based around the Beara Peninsula should be undertaken in tandem with existing businesses such as guesthouses, hotels and/ or local co-operative ventures. This type of initiative should be encouraged to offer a range of other services, which would also help to ensure the long term sustainability of the enterprise. Examples of such services could include diving trips, bird watching, whale watching, historical trips and ferry services.

- Further research is recommended in the following areas:

    - The impacts of new artificial reef structures on natural reefs and nursery grounds.
    - The possibility of developing large scale commercial fisheries around artificial reef structures within Ireland's 12 mile limit.
    - The application of reef technology to the development and enhancement of lobster fisheries.
    - The potential for the development of commercial/recreational deep sea fishing opportunities based around prefabricated structures placed at deep water locations.
    - Detailed hydrographic and oceanographic studies on the changes caused by the construction and deployment of artificial reefs on a micro and meso spatial scale.
    - The potential for the design and manufacture of prefabricated artificial reef modules in Ireland applicable to the environmental conditions of the North Eastern Atlantic should be further explored. The capabilities of Irish companies in this regard need to be assessed. This study should also look at the materials which may be available for use in constructing such units, and possible markets which may exist for such products.
    - The necessity to quantify the colonisation of artificial reef structures. This work should also look at the biomass of each of the key sea angling species on such sites.

- A final recommendation would be that the Beara Peninsula should be utilised as a site for research into the application of artificial reefs for sea angling, and lobster and crustacean fisheries development. A number of factors support this recommendation and these include:

    - The recognised need for the development of a sea angling sector in the community.
    - The current support which exists from a very active tourism group (Beara Tourism and Development Association) and from local inshore fishermen.
    - The research already undertaken in the Beara Peninsula.

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APPENDICES

Appendix I: National Legislation of Relevance to the Coastal Zone

Legislation	Purpose of Legislation	Responsibility
Foreshore Act, 1933 & Amendment 1992	To provide for the granting of leases and licenses on the foreshore	Department of the Marine and Natural Resources
Local Government Planning & Development Act, 1963	The compulsory making of development plans for all local authority areas	Local authorities
Wildlife Act, 1976	To protect and conserve habitats, wild flora and fauna - limited powers under this Act (amendment pending)	National Parks & Wildlife Service of the Department of Arts, Heritage, Gaeltacht and the Islands
Fisheries Act, 1933 & Fisheries Consolidation Act, 1959	To control the pollution of inland and marine waters through the issue of discharge licenses	Department of the Marine and Natural Resources
Harbours Act, 1946 and 1995	To establish Harbour Authorities responsible for the administration of harbours legislation in their area	Department of the Marine and Natural Resources
Fishery Harbour Centres Act, 1968	To facilitate in the creation of new harbours for the purposes of fishery development	Department of the Marine and Natural Resources
Coast Protection Act, 1963	To provide for the making and execution of coastal protection schemes	Department of the Marine and Natural Resources
Water Pollution Act, 1977 & Amendment 1990	To preserve, protect and improve water quality	Local authorities – have primary, but not exclusive control
Dumping at Sea Act, 1996	Prohibits the dumping or incineration of any material in tidal waters. The Amendment, *inter alia:* • extends the limit of Ireland's control form 12 miles up to 200 miles off the Irish coast • bans the dumping at sea of sewage sludge from 31/12/98 • bans incineration at sea, dumping of radioactive wastes and dumping of offshore installations	Department of the Marine and Natural Resources

Oil Pollution at Sea Acts, 1956-77	Prohibits the discharge of oil by ships	Department of the Marine and Natural Resources
Sea Pollution Act, 1991	To reduce to a minimum, and in certain instances prohibit, the operational discharge of marine pollutants from ships	Department of the Marine and Natural Resources
Waste Management Act, 1996	To establish a centralised licensing system in relation to waste disposal facilities. Under this Act a license is required from the EPA in respect of all landfills, disposal facilities for hazardous waste and other facilities which have an annual intake exceeding 25,000 tonnes per annum	Environmental Protection Agency
Environmental Protection Agency Act, 1992	The establishment of the Environmental Protection Agency as a statutory body responsible for the promotion of improved environmental protection in Ireland	Environmental Protection Agency (EPA)
Fisheries Amendment Act, 1997 (No.23) (May, 1997).	To provide a transparent licensing process for aquaculture, both offshore and inland.	Department of the Marine and Natural Resources

Appendix II: European Legislation of Relevance to the Irish Coastal Zone

Directive	Aim of Directive	Implementation Measures in Ireland	Responsibility in Ireland
76/160/EEC Quality of Bathing Waters	To set and maintain quality standards for bathing waters throughout the EU	EC (Quality of Bathing Waters Regulations) 1992-96	Local authority *via* Department of Environment and Local Government
76/464/EEC Directive on pollution caused by certain dangerous substances discharged to the aquatic environment	To prevent the discharge of certain dangerous substances to the aquatic environment	Local Government (Water Pollution) Acts 1977 and 1990	Local authority *via* Department of Environment and Local Government
Directive 86/280/EEC on limit values and quality objectives for discharge of certain dangerous substances included in list 1 of Annex of Directive 76/464/EEC	Sets down the limits for discharge of a number of potentially dangerous substances to coastal waters.	Local Government (Water Pollution) Acts 1977 and 1990	Local authority *via* Department of Environment and Local Government
79/409/EEC Conservation of Wild Birds	To designate Special Protection Areas (SPA) for protection of the natural habitats of certain wild bird species.	Partly implemented by orders declaring nature reserves under the Wildlife Act	NPWS of the Department of Arts, Heritage, Gaeltacht and the Islands.
79/923/EEC Quality of Shellfish Waters	To set the quality of water required for growing shellfish for human consumption	Local Government (Water Pollution) Acts 1977-90. Fisheries Acts 1979-90. Quality of Shellfish Waters Regulations, 1994	Local authorities and Fisheries Boards
85/337/EEC Environmental Impact Assessment	To assess the impact of certain public and private projects on the environment	EC (Environmental Impact Assessment) Regulations, 1989. Local government (Planning and Development) Regulations, 1990	Local authority *via* Department of Environment and Local Government

91/271/EEC Urban Waste Water Directive	To protect the environment from the adverse effects of urban waste water discharges	EPA Act 1992 (Urban Waste Water Treatment Regulations) 1994	Environmental Protection Agency and Local authority Via Department of Environment and Local Government
93/75/EEC Directive on minimum requirements for vessels bound for or leaving EC ports carrying dangerous or polluting goods.	Sets the minimum requirements for vessels bound for leaving EC ports carrying dangerous or polluting goods	Implemented on 13th September 1995 under the regulations of the Harbour's Act	Department of the Marine and Natural Resources
92/43/EEC Habitats Directive - to protect natural & semi-natural habitats of wild flora and fauna.	To establish a network of Special Areas of Conservation (SAC) of European significance for rare, endangered, and vulnerable species and habitats across the community	SACs to be designated by 2004	NPWS of the Department of Arts, Heritage, Gaeltacht and the Islands
96/82/EC Directive on the control of major-accident hazards involving dangerous substances (COMAH)	The EU Directive is concerned with "the prevention of major accidents which might result from certain industrial activities and with the limitation of their consequences for man and the environment"	Not yet implemented	Department of Enterprise, Transport and Employment

Appendix III: International Conventions of Relevance to the Irish Coastal Zone

Convention	Aim of Convention	Situation in Ireland	Responsibility in Ireland
Ramsar Convention, 1971	To recognise and conserve any internationally important wetlands, especially waterfowl	Ratified in 1984; 21 sites designated covering 12,500 hectares or circa 0.02% of national territory	NPWS of the Department of Arts, Heritage, Gaeltacht and the Islands
Bern Convention on the conservation of European Wildlife and Natural Habitats 1979	To declare Biogenetic Reserves as a contribution to the Convention's aims	To date 14 reserves have been designated in Ireland but these are all covered by other national designations – statutory nature reserve orders under the Wildlife Act, 1976	NPWS of the Department of Arts, Heritage, Gaeltacht and the Islands
Bonn Convention on the Conservation of Migratory Species of Wild Animals 1979	To provide a framework for the conservation of migratory species and their habitats by means of, as appropriate, strict protection and the conclusion of international agreements		NPWS of the Department of Arts, Heritage, Gaeltacht and the Islands
UNESCO Biosphere Reserve	To recognise sites of international importance for scientific and educational purposes	Only two sites have been designated in Ireland; Bull Island, Co Dublin & Killarney Valley, Co. Kerry	NPWS of the Department of Arts, Heritage, Gaeltacht and the Islands
OSPAR Convention	To protect the marine environment of the North-East Atlantic (also known as the Oslo and Paris Conventions)	Ratified in Ireland in 1997 under the regulations of the Dumping at Sea Act, 1996. Came into force in March 1998	Department of Marine and Natural Resources.
International Convention for the Prevention of Pollution from Ships, 1973; and Protocol modifying it, 1978. MARPOL 73/78	To prevent the pollution of the seas by discharges from ships	Ratified in Ireland under the regulations of the Sea Pollution Act, 1991	Department of the Marine and Natural Resources