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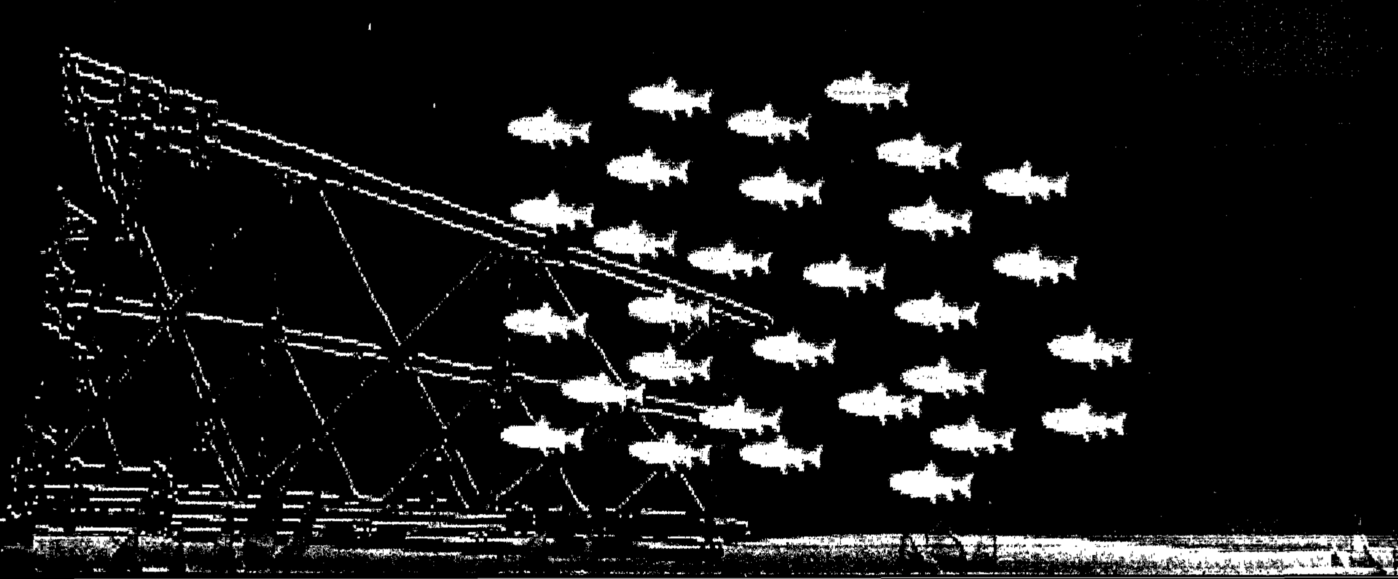
Creating Artificial Reefs from Decommissioned Platforms in the North Sea:

review of knowledge and proposed programme of research

Volume 1 of a 2 volume report

Summary of the main report, with an executive overview



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Creating artificial reefs from decommissioned platforms in the North Sea:

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Summary of the main report, with an executive overview

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Executive Overview

Basis for the report

1. A report has been prepared for the Offshore Decommissioning Communications Project (ODCP), a project team sponsored by The Oil Industry International Exploration and Production Forum (E & P Forum), The UK Offshore Operators Association (UKOOA) and The Norwegian Oil Industry Association (OLF) to:- •review the use and effectiveness of artificial reefs •summarise existing knowledge of the reef effect of North Sea platforms •outline possible scenarios for the creation and exploitation of platform reefs in the North Sea •highlight gaps in knowledge •propose programmes of work to study the reef effect at an inshore and an offshore site in the North Sea.

The nature of Artificial Reefs

2. Artificial reefs are "submerged structures which have been deliberately placed on the seabed to mimic some of the characteristics of a natural reef". By altering the existing natural habitat, they can be used by humans to derive direct or indirect benefits.

3. Artificial reefs can have four primary effects: they can •provide a new hard surface on which fixed animals and plants can grow •provide a new habitat for animals that require a solid structure as a resting place, "home", or nesting place •cause mobile marine life, including shellfish and fish, to aggregate around them, with individuals living either temporarily or permanently on or close to the structure, and •attract new species, not previously found at the site.

4. Artificial reefs have been used for centuries by coastal communities and are well-established fisheries management tools world-wide. Traditionally, they have been constructed for fishery enhancement, to attract and concentrate fish to make them easier to catch, but they are now also built to serve a wide variety of purposes including: •to improve the size or quality of catches of finfish or shellfish •to provide spawning areas, or protected habitats for juveniles •to permit shellfish and finfish to be "ranched" •to reduce fishing pressure on particular stocks •to help to mitigate damage, or to restore degraded habitats.

5. Artificial reefs have been constructed from many types of material, both natural and man-made. Two main types of reef may be classified: •Those that are purposefully built from "new" or unused materials. They range from simple structures made out of wood or by dumping stones or rocks, through concrete or steel cubes, to large, complex steel and concrete structures. •Those that are created from the deployment of "materials of opportunity", such as worn-out, obsolete, waste or redundant materials or structures including tyres, cars, or ships.

6. Artificial reefs are generally fixed, immobile structures placed totally submerged on the seabed. They may comprise a single reef unit, a group of units, or an arrangement of several groups of reef units to form a large reef complex

7. "Low profile" reefs are generally less than 2m high, and are constructed from rocks, blocks or concrete cubes for the purposes of creating individual habitats for shellfish or small fish. "High profile" reefs are constructed from large concrete blocks or steel lattice-type structures, and extend several metres from the seabed into the water column. Their main purpose is to attract shoaling or migratory fish.

The application of artificial reefs throughout the world

8. The USA, Japan, most European Union countries, and many other maritime nations around the world have built artificial reefs. Japan has long history of reef building, for the purposes of sustaining and expanding its nearshore fisheries for finfish and shellfish. The USA has several well-established State programmes to build reefs to support commercial shrimp fisheries and valuable sports fisheries. European programmes have started in the last 20 years, mainly to protect nearshore habitats and promote shell fisheries.

9. Only Japan and the USA have National Programmes for the establishment, building, studying and exploitation of artificial reefs.

Use of decommissioned platforms as artificial reefs

10. Decommissioned offshore oil and gas structures have and are being deployed as artificial reefs in the Gulf of Mexico, primarily to support a valuable sports fishing industry. This programme is part of the National Artificial Reef Plan, and follows specified procedures for:- •the setting up of reef areas •the identification, preparation and donation of reef material •the management, monitoring and exploitation of reefs, and, •the transfer of liability from reef donor to the State.

11. There are no high profile steel artificial reefs in the North Sea, and no platform has been deliberately used to create a reef.

Knowledge of the reef effect of decommissioned platforms in the North Sea

12. Studies at several working platforms in the UK and Norwegian North Sea show that these structures are acting as *de facto* artificial reefs. Qualitative and quantitative information shows that North Sea platforms: •aggregate populations of commercially valuable pelagic and demersal fish, including cod, saithe, whiting and Norway Pout •provide an environment in which the fish are healthy and grow at least as well as fish in the "open sea" •do not give rise to fish which are tainted, or contaminated by metals.

13. These findings strongly suggest that a reef effect would continue to be exhibited by totally submerged inert steel jackets following decommissioning.

Potential benefits of creating reefs in N.Sea from decommissioned platforms

14. Platform reefs could be used **either**:- •to increase the ease with which target species can be caught, under the auspices of a managed fishery, **or**, •protect fish, particularly juveniles, from fishing mortality, thus increasing the stocks available to the fishery.

15. Platform reefs may also have a more general effect of habitat protection, encouraging increased local biodiversity and mature ecosystems.

16. The other possible benefits of the creation of reefs as a disposal option, such as improvements in safety risks, and cost savings, were beyond the scope of this study.

Scenarios for reef-building using North Sea platforms

17. It is suggested that inert steel jackets would provide a suitable material for the creation of reefs in the North Sea. Their structure, size, shape, durability and large "enclosed volume" make them ideal components or modules for high profile reefs. Two legally permissible options are available for the creation of reefs:- •toppling structures *in situ*, to create small individual reefs, or, •clustering several structures at one site, possibly around concrete gravity based structures, to create large reef complexes.

18. *Nearshore*, individual **reefs** or **reef groups** could be established to provide sites for managed fishing, by static gear or sports anglers; they would benefit *fishermen*. *Offshore*, **cluster reefs** could be created using large platform components, to provide sanctuaries to support and increase overall fish populations; they would benefit *fisheries*.

19. Plans are well advanced for the construction of an experimental *inshore* reef in the Moray Firth. The report suggests possible scenarios for the creation of *offshore* cluster reefs in the UK and Norwegian North Sea.

The need for further research

20. The present level of knowledge is insufficient to estimate with a high degree of confidence if there would be measurable benefits to fishermen or fisheries from the creation of artificial reefs using decommissioned platforms.

21. Further information is needed to enable all parties to assess reliably the potential of platform reefs, both as a means of habitat or fisheries enhancement and as a suitable decommissioning option.

Proposed programmes of work

22. Two parallel, complimentary studies should be undertaken to provide additional data. •A small inshore reef should be studied, as a testing ground and to determine how such nearshore reefs could best be exploited. The proposed reef in the Moray Firth is the candidate site for this study, and it is hoped that such a reef will be in

place by mid 1998. •A larger, inert, offshore platform should also be studied, to provide information on the possible wider effects on local fish populations and the surrounding ecosystem.

23. Although the programmes at the two sites will differ in emphasis and to some extent in study techniques, both will attempt to gather information on the following broad topics: •the number, variety and biomass of species which move on to and live at the reef •the residence times of reef fish, and the rate of turnover between reef fish and open sea fish •the extent to which reef fish derive measurable benefit from the reef, for example by increased growth rates, increased longevity or increased reproductive capacity •the extent to which North Sea reefs could be of benefit to other parts of the ecosystem, by protecting habitats and increasing biodiversity.

24. The indicative budget for a full 5 year programme to deploy, study and retrieve the inshore reef is £1.3 million. The 5 year multi-disciplinary study at an offshore structure would cost some £2.4 million.

25. Successful acquisition of such data would be a significant aid in answering the two fundamental questions regarding the use of high profile steel reefs in the cool temperate waters of the North Sea:-

- ***Could North Sea platform reefs be sustainably exploited by commercial fishermen?***

- ***Could North Sea platform reefs be used to protect and enhance fish populations?***

Contents

1 Summary of the Main Report

1.1 Introduction

In the continuing debate on the decommissioning and disposal of North Sea oil and gas platforms, the use of redundant structures as artificial reefs remains an untried possibility. It has been suggested that selected, clean, inert steel components could be used to create offshore reefs to attract finfish, to the benefit of *fisheries* and *fishermen*. This might be an innovative and cost-effective use of these "materials of opportunity", and therefore should be examined more fully before the predicted 20-30 year period of steady decommissioning activity in the North Sea begins in earnest.

In November 1996, the Offshore Decommissioning Communications Project (ODCP), a project team sponsored by, The Oil Industry International Exploration and Production Forum (E & P Forum), The UK Offshore Operators Association (UKOOA) and The Norwegian Oil Industry Association (OLF), met to assess present knowledge on artificial reefs and to discuss further work. As a result of that meeting, a team of consultants and scientists were invited to prepare a report with the following aims:-

- to describe the structure, functioning and purposes of artificial reefs,
- to review briefly present scientific knowledge on their effects and effectiveness,
- to summarise their application world-wide and current programmes of research,
- to describe the use of decommissioned platforms as reefs
- to summarise information on the reef-effects of working North Sea platforms, and,
- to propose a programme of study that would provide necessary additional information on the possible effects of platform reefs in the North Sea
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2 Definition of an artificial reef

Artificial reefs are "submerged structures which have been deliberately placed on the seabed to mimic some of the characteristics of a natural reef". By altering the existing natural habitat, they can be used by humans to derive direct or indirect benefits.

3 What artificial reefs do

Artificial reefs can have four primary effects. The perceived benefits of reefs, and the justification for their placement and presence, all stem from the changes caused by these effects. A reef may exhibit some or all of these effects:-

- they can provide new hard surfaces on which fixed animals and plants can grow,
- they can provide a new habitat for those animals, particularly some types of shellfish, that require a solid structure, as a resting place, "home", or nesting place,
- they can cause mobile marine life, including shellfish and fish, to aggregate around them, with individuals living either temporarily or permanently on or close to the structure, and,
- they can result in the attraction to a site of species which were not previously found there.

In general, artificial reefs exhibit a species composition and community structure which is similar to that of natural reefs in the same area, assuming they are subject to the same environmental conditions. The final composition and abundance of the artificial reef community depends on the composition of the substratum, the season the material was deposited and numerous environmental variables, including water movement, water temperature and water chemistry.

4 The uses of artificial reefs

Artificial reefs have been used for centuries by coastal communities and are well-established fisheries management tools world-wide. Traditionally, artificial reefs have been constructed for fishery enhancement, i.e. to attract and concentrate fish at a particular location to make them easier to catch, but they may now be built to serve any of the following purposes:

- to improve the size or quality of catches of finfish or shellfish
- to provide spawning areas, or protected habitats for juveniles
- to permit shellfish and finfish to be "ranched"
- as shore protection and to control of beach erosion

- to prevent trawlers from using certain areas
- to reduce fishing pressure on particular stocks
- to help to mitigate damage, or to restore degraded habitats
- to provides sites for recreational diving
- for scientific experiments
- to recycle nutrients in areas where bivalves (molluscs) are farmed
- to help to control potential conflicts of use in multi-user environments

5 Types of artificial reef

Artificial reefs have been constructed from many types of material, both natural and man-made. Two main types of reef may be classified:

1. Those that are purposefully built from "new" or unused materials. These may range from simple structures made out of wood or from the more or less controlled dumping of stones or rocks, through concrete or steel units (for example, in the shape of cubes or short pipes), to large, complex steel and concrete structures.
2. Those that are created from the deployment of "materials of opportunity". Predominantly such reefs comprise worn-out, obsolete, waste or redundant materials or structures such as tyres, cars, or ships.

6 Structure and construction.

Artificial reefs are generally fixed, immobile structures placed on the seabed and totally submerged. They may comprise a single reef unit, a group of units, or an arrangement of several groups of reef units to form a large reef complex.

Reefs can be classified according to the height to which they extend above the seabed. "Low profile" reefs are generally less than 2m high, and are usually constructed from rocks, blocks or concrete cubes with holes and spaces, for the purposes of creating individual habitats for shellfish or small fish. "High profile" reefs are constructed from large concrete blocks or steel lattice-type structures, and extend several metres from the seabed into the water column. Their main purpose is to attract shoaling or migratory fish.

7 How artificial reefs work

Artificial reefs function as fishery enhancement devices because they resemble natural reefs. A wide variety of environmental cues play a role in attracting fish to such devices, including: current patterns; shadows; species interactions; sound; touch; pressure and visual cues of size, shape, colour and light. The abundance and diversity of species at an artificial reef depends on suitable living conditions, including access to food, shelter from predators, and normal environmental conditions that are within the biological tolerances of the species.

The majority of research on reefs has focused on establishing what happens when a reef is deployed, considering speed and "naturalness" of colonisation by animals and plants and the implications of this for habitat protection of fisheries exploitation. Less effort has been expended on long-term monitoring of fish populations. Despite the large investment in artificial reefs in certain countries, the ecological basis behind artificial reef function and biology is poorly understood. The variety of materials used and the broad range of conditions in which reefs are deployed limits the conclusions that can be made. Nevertheless, at artificial reefs, high fish densities, biomass and catch rates, in addition to rapid colonisation, are well documented, and are often found to be higher on artificial reefs than on natural reefs or randomly selected bottom controls. Evidence from several studies indicates that reef deployment increases the population size of particular species without interfering with the natural fisheries of adjacent habitats. Over-exploitation of reef-associated fish stock is generally not expected as a consequence of artificial reef deployment, because artificial reefs can generally be expected to provide both fish aggregating and biomass producing qualities.

Artificial reefs are thought to aggregate exiting scattered individuals and allow secondary biomass production by;

- increasing survival and growth of larvae and juveniles by providing a settlement substratum, shelter from predation and additional food resources
- creating new food webs by providing new spaces, habitats and colonisation patterns
- protecting the sea-bed and nursery grounds
- recycling energy by retaining a localised ecosystem

An artificial reef can be important for the fish stocks of a much larger area than the reef itself, because it gives protection to the fish during their most vulnerable stages. Some Japanese reefs, for example, are built to improve spawning, recruitment and survival of animals during the early stages of their life histories.

8 World-wide application of artificial reefs

Artificial reefs in all their various designs and sizes have been created or deployed by many countries around the world. The great majority have been developed according to local requirements, using affordable available materials which were judged to be suitable. Only Japan and the USA have a national artificial reef development plan.

8.1 Japan

The Japanese have been creating artificial reefs since at least the 18th century and over the last 20-30 years have carried out a planned development programme to sustain and improve coastal shellfish and finfish fisheries. They are currently in the third phase of reef development, creating entire new fishing grounds where none had previously existed. This is a significantly more sophisticated philosophy than the patch-work development of structures seen elsewhere in the world.

The creation and deployment of artificial reefs in Japan is highly regulated, and once built they are frequently managed by the local coastal community. To qualify for government certification and subsidy, the developer must comply with quality standards regarding building materials, design, location and construction.

Most modern artificial reefs in Japan are built from concrete or steel (with some in GRP); generally, waste materials are not used. Artificial reef technology in Japan has turned from an art into a science, and a great deal of quantitative design data has been generated relating to the sizes, proportions and configurations of reef units and groups for attracting or retaining particular species of fish and shellfish. The effectiveness of these designs is generally determined by measuring the increase quantity or quality of subsequent catches; the biological appraisal of artificial reef performance has, until recently, received less attention.

8.2 USA

American experience of reef construction (in both freshwater and the sea) dates back over 100 years and in that time a variety of materials has been used. In contrast to the present Japanese programme, most American reefs in the past 30 years have been constructed from "waste" materials including concrete, rock, construction rubble, scrap tyres, cars, railway carriages and ships. The most active state for the construction of marine reefs is Florida, which has placed over 100 structures along its Atlantic and Gulf coastlines, and there are significant numbers of reefs off Louisiana and Texas. Reefs are also present off California, New Jersey, North and South Carolina, New York, Delaware, Hawaii and Oregon.

The artificial reef programmes of many Maritime States are run to benefit sports fishing, but reefs are also created to benefit recreational diving, or commercial fishing, or to assist with waste disposal, or to provide environmental mitigation. The success of such reefs is generally determined by assessing the catches taken by rod and line, or the number of people fishing or using the reef, rather than a cost benefit analysis of commercial fisheries. The use of rod and line appears to pose no serious threat to the fish populations attracted to these structures, and such generalised reefs appear to increase the overall local biodiversity.

The use of oil platform jackets in the Gulf of Mexico is now fully integrated into the National and State-wide artificial reef plans.

8.3 European Union

In Europe, artificial reefs were pioneered in Monaco for nature conservation in the late 1960s. Artificial reef research programmes have now been initiated in eight countries of the European Union; Italy, Spain, Portugal, United Kingdom, Germany, the Netherlands, Finland and France. There is a Greek reef programme, and deployment should happen soon.

European researchers and scientists are collaborating in The European Artificial Reef Research Network (EARRN), which started in May 1995. It consists of 51 scientists from 31 laboratories throughout the EU and the programme will run initially for 3 years. Funded by the EU, the objectives of the programme are to exchange information on European reef research, and to determine how future European research in this field should be managed and co-ordinated.

8.4 United Kingdom

There are two marine artificial reefs in the UK, one in Poole Bay on the central southern English coast (built in June 1989), and one in the Firth of Forth near Torness (created in 1984).

The Poole Bay reef was built as a material test experiment and consists of pyramid-shaped groups of blocks made from stabilised Pulverised Fuel Ash (PFA) (a waste material from coal-fired power stations), bound with cement and aggregate. The reef has been continuously monitored to investigate the biological colonisation and the fate of the heavy metals bound within the coal. Results suggest that the heavy metals are secure within the blocks, that colonisation is rapid and that reefs provide a good habitat for lobsters and other commercial shellfish. The Torness reef is a long, low-profile reef constructed from rock excavated during the construction of a nuclear power station. The reef is investigated infrequently to determine biological colonisation, fin-fishery potential and shellfish fishery potential. To date the reef has not been found to support significant numbers of any commercially valuable fish or shellfish species, although biological colonisation has been good. The Torness reef has not proven to be a success as a commercial fishery site; catches are obtained but they are not of sufficient size to make the reef a preferred site for fishermen.

8.5 Italy

The Italians were among the first serious European users of artificial reefs and are well organised on a national basis. Many programmes have been assisted by 50% EU funding.

The *Loano artificial reef* is an "anti-trawling" reef system set up in the Ligurian Sea during 1986 to protect the natural environment and, in particular *Posidonia* beds, from bottom fishing gear towed by trawlers.

In the *Gulf of Castellammare* (North west Sicily), a project run by the government-funded CNR laboratory has evaluated benthic and nekton colonisation, the fishing yields and the trophic relationship between the resident fish and the benthos in the reef area.

In the *Mazara del Vallo reef* (South west Sicily), a reef was constructed by the planned deposition of shipwrecks on the seabed.

In the *Adriatic Sea*, there are at present at least 11 artificial reefs. The aims of the scheme were: anti-trawling protection, repopulation of biota, and development of new sessile biomass, especially mussels and oysters, through the introduction of suitable surfaces. Data obtained showed that initial costs were recovered three times over in about four years through small scale fisheries and collection of the mussels settled on the artificial substrata.

8.6 France

French activity started in the 1970s with both car bodies and concrete cubes being used in early constructions. Much work focused on the benefits that reefs could make to mariculture, an important element in French coastal economics. Results from these programmes concluded that artificial reefs provided good fish habitat, the artificial reefs sometimes holding more fish than comparable natural reefs.

8.7 Portugal

Two programmes are active in Portugal, one off of Maderia, the other on the southern mainland. The aim of the projects is to enhance the fisheries potential of the areas, and research is being carried out to evaluate the impact of artificial reefs at both ecological and fishing levels, and to determine in which way the artificial reefs in the Algarve can be useful as an instrument for fish stock management and to increase coastal resources.

8.8 Spain

There is extensive reef building activity in Spain. Over 100 reefs have been placed as part of a co-ordinated National Government programme, with considerable input from local government and, in most cases, 50% funding from the EU. The main purpose of most reefs was to provide habitat protection and/or enhance artisanal fishery. Five areas are worthy of note.

In *Balearic coastal waters*, reefs have been deployed to examine the fisheries enhancement potential, the processes of benthic colonisation and the role of artificial reefs in the regeneration of damaged sea bed.

At *El Campello* (Alicante, Iberian South-eastern), artificial reefs have been used to protect meadows of the seagrass *Posidonia oceanica* from damage caused by illegal trawling.

At *Tabarca Island* (SE Iberian peninsula), a reef was created in 1989 to protect seagrass meadows and it includes some experimental structures to attract/concentrate pelagic and demersal fish.

At *Galicia*, Ria de Arousa, (Province of Pontevedra, NW Spain), a programme of scientific research will be conducted to determine the influence on artificial reefs of depth, degree of exposure and level of organic matter on the ocean floor.

In *Santa Agueda Bay,* to the south of Gran Canaria Island, an artificial reef composed of 84 concrete modules of 5 different types was built in 1991. An overall increase in species diversity and biomass has been noted. New species were still colonising the reef two years after deployment. Seasonal and successional patterns of colonisation have started to emerge.

8.9 Holland

In September 1992 an experimental artificial reef consisting of four, more or less circular, heaps of basalt blocks in a row perpendicular to the prevailing current direction was placed 8.5km off the Dutch coast at Noordwijk. The aim of the project is to investigate the colonising capacity, possible morphological effects on the surrounding sea bottom, and potential modification of the distribution of biomass in the area caused by the reef.

8.10 Finland

The reef programme in Finland started in late 1993, and is concerned primarily with the problems of the management of waste from fish farms. The main aim is to experiment with the possibility of using artificial reefs in nutrient and biomass removal. The project will study whether the growth capacity of fouling communities in the Finnish Archipelago, Gulf of Bothnia is high enough to be used in catching significant amounts of nutrients released by the fish farms.

8.11 Outside the European Union

Poland has deployed experimental structures in the Baltic, Turkey has a small experimental programme based in Ege University, and Romania has placed some reefs for experiments into biofiltration in the Black Sea near Constanza. Israel has been active in the field for some time, deploying tyre structures in the Mediterranean and having an interest in structures placed in the Red Sea. Russia is involved with reef interests in the Baltic and has built reefs in the Caspian sea.

9 Concept of "rigs-to-reefs" and world wide application

The phrase "rigs to reefs" refers to the use of decommissioned offshore oil and gas platforms as artificial reefs. The possibility of using platforms as reefs first arose in the Gulf of Mexico and stemmed from the fact that existing manned structures off the coast of Louisiana attracted significant numbers of game fish, forming the basis of a substantial sports fishing industry where none previously existed.

Many qualitative and quantitative studies over the last 15 years have confirmed that the open lattice-type configuration of steel jacket structures exhibit good reef characteristics, attracting a variety of mid-water and demersal fish species. Platform jackets, or parts of platform jackets, may therefore be classified as high profile reefs, and there main effect is to attract and retain midwater and bottom water shoaling fish, and midwater migratory fish.

In general, platforms make good artificial reefs because they provide:

- a large area of new, hard surface, on which fixed plants and animals can grow
- structural openness permitting adequate circulation of water within the interior
- an additional source of food, from fixed and mobile plants and animals
- a visual, tactile or auditory reference point for fish
- a complex design which can provide shelter from strong currents and predators
- a range of habitats throughout the water column

The degree of importance of each of these factors depends on the particular species and life cycle stage of the species involved.

By far the greatest concentration of oil-related artificial reefs is found in the Gulf of Mexico. These reefs consist of jackets or topsides which have been totally submerged *in situ* or at another chosen location, for the specific purpose of creating an artificial habitat.

Both operational platforms and decommissioned structures deployed as artificial reef components have been investigated, and both have been found to exhibit the same reef characteristics. Fish studies around Gulf of Mexico platforms have revealed that fish are present at all depths, with greatest variety in the range 30 - 70m depth. It is believed that the platforms provide the basis for a substantial food chain and that their presence has changed relatively unproductive areas into diverse, dynamic and highly productive ecosystems.

The species composition on Gulf of Mexico platform reefs resembles the nearby natural reef communities. It has been estimated that there are 20 - 50 times more fish around platform than at soft bottom control areas of the same size, and 5 times more fish than on nearby natural reefs.

Artificial reefs programmes in the Gulf of Mexico, using materials of opportunity from decommissioned oil platforms, have proved highly successful and cost-effective. Oil platforms appear to be almost ideal reef components for some purposes, and, if carefully selected, can satisfy many of the design criteria for artificial reefs constructed to attract fin-fish.

By the year 2,000 it is expected that 1,625 platforms will have been removed from the continental shelf of Louisiana. The high cost of removal and the potential loss of this commercially important habitat have been the incentives for rigs-to-reefs initiatives. Under new US federal policy guidelines, many of these platforms will be used for artificial reef construction. Without these structures, offshore sport fishing activities in Louisiana would be greatly reduced.

Outside the USA, no offshore platform has been deliberately used to create an artificial reef. The majority of the jackets of existing, working platforms at marine locations around the world will, however, be causing some reef effects, and are likely to be providing some degree of benefit to local populations of plants and animals.

10 Status of "rigs-to-reefs" in the North Sea

There are no high profile steel reefs in the North Sea. Our appreciation of how such reefs might function is derived entirely from the study of existing working platforms or structures that have been accidentally sunk without being planned as an artificial reef. Several research studies, funded by the United Kingdom Offshore Operator's Association Ltd (UKOOA) and individual operators, have been undertaken to investigate the interaction between fish and oil-related structures in the North Sea. The topics that have been studied around North Sea platforms are:-

- the numbers, species and densities of fish present at working oil platforms
- the numbers, species and densities of fish present at a deep wreck
- the hydrocarbon contamination and the flavour of fish living close to platforms
- the concentrations of certain metals in fish living close to platforms
- the general health and the growth rates of fish living close to platforms

Together, these studies have extended knowledge on the interaction between platforms and their associated fish, and on the likely response of fish to, and their utilisation of, large inactive oil-related structures at offshore locations. The overall findings derived from these studies are:-

- North Sea oil platforms aggregate mid-water and bottom-dwelling fish. The great majority of structures examined on video have high concentrations of fish around them (in comparison to the nearby "open sea"), and these concentrations decline sharply at distances of more than 50-100m from the platforms. The platforms are therefore acting as *de facto* reefs. It is likely that the principal attracting feature of the structures, the cause of the aggregating effect, is the physical presence of a large structure at the offshore location.

- Inert, deep water structures lying below the photic zone also attract fish. It is therefore postulated that toppled, inert steel jackets would also attract and retain fish, in the same way that working jackets do.
- Fish living around platforms have elevated concentrations of hydrocarbons in their tissues, some of which may be derived from the oils in cuttings piles.
- The fish around platforms do not have elevated concentrations of metals in their tissues.
- No tainted fish have been found around platforms. Flatfish living on or close to the cuttings piles at Beatrice Platforms may have a "tendency to tainting".
- There is no evidence of any correlation between the concentrations of hydrocarbons in the flesh and the taste of the fish.

All the evidence obtained to date indicates that fish living in the vicinity of structures are in as good a condition as those collected from the open sea. There may be evidence to show that fish frequenting platforms are in better condition, and growing more quickly, than those at open sea sites.

11 North Sea knowledge of fish activity around platforms

11.1 Fish aggregation at working platforms

The first studies on this subject were carried out in the Norwegian sector, where fish densities at different distance from platforms were determined by fishing. Studies completed in 1977 and 1978 indicated that cod aggregated in substantial numbers in the proximity of the installations, whereas only scattered concentrations were present in the surrounding areas. The greatest fish densities (both demersal and pelagic) were observed in the vicinity of the structures, being 3 and 10 times higher for cod and saithe respectively in the distance interval 0-200m from the structures.

In 1987, the numbers and variety of fish species found in the vicinity of installations in the UK sector were ascertained by examining incidental fish activity seen on videotapes taken during annual subsea inspections of 15 platforms in the UK North Sea.

Of the 134 videos viewed, 77% showed some degree of fish activity. The most abundant species was the saithe (*Pollachius virens).* Steel structures in the northern and central sectors had large shoals of saithe swimming around and within the lattice work of the jacket, particularly in the mid-water region. Other fish seen at these depths included cod (*Gadus morhua),* haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*). A variety of species was found immediately above the seabed, and around any small pieces of debris lying within confines of the jacket, including ling (*Molva molva*), wolf fish (*Anarchichas lupus*), Norway pout (*Trisopterus esmarkeii*) and red fish (*Sebastes marinus*)(Tables 1 & 2).

Table 1. Depth range, abundance and density for the major species recorded around structures in the northern North Sea

Major Species	Depth Range	Maximum Numbers	Maximum Densities
Saithe	-21m to seabed	2,000	2.0 m^{-3}
Cod	-40m	30	0.2 m^{-3}
Ling	-100m to seabed	50	0.5 m^{-3}
Norway Pout	-140m to seabed	5,000	5 m^{-3}

Table 2. Depth range, abundance and density for the major species recorded in the central North Sea

Major Species	Depth Range	Maximum Numbers	Maximum Densities
Saithe	-2m to seabed	500	3.0 m^{-3}
Cod	-12m to seabed	100	0.2 m^{-3}

In the southern North Sea, saithe and cod were less abundant, but the variety of species near the seabed in an around platforms increased, with plaice (*Pleuronectes platessa*), dab (*Limanda limanda*), bib (*Trisopterus luscus*) and sole (*Trisopterus minutus*).

Concrete structures also had small shoals of saithe swimming in the mid-water region, and numerous fish close to the horizontal tops of the tanks at about 70m depth, and the usual variety of species on the seabed at the base of the platform.

Fish were observed at platforms under both ambient and artificial lighting, at all times of the day, and at all seasons. It was clear that fish were spending some time, at least, in the close vicinity of the structure. The densities of fish and variety of species were much higher close to platforms than at distances of more than 50-100m away from them.

Once attracted to a natural or artificial structure, fish tend to assume one of three particular positions relative to the structure, and the species found around North Sea structures may approximately be assigned to these patterns:

1. Upper and mid-water swimmers, such as saithe, congregate over or around structures. They tend to hover, remaining in the upper layers as a shoal.
2. Bottom layer swimmers which gather around the structure, but are not sedentary, such as cod and Norway pout.
3. Sedentary fish which inhabit holes and spaces such as ling, wolf-fish and redfish.

Platforms do not provide all the food necessary to sustain the high densities of fish living around them. The many thousands of fish found around North Sea structures must therefore continue to derive the bulk of their food from off-reef sources.

A second survey of fish numbers and densities was conducted by sonar in 1990. Four installations, Brae Bravo, Maureen, MCP-01 and Tartan, were visited to provide a range of structural types, and open sea areas were also surveyed for comparison.

Three types of fish were observed; fish closely associated with the seabed, individual mid-water fish, the third were mid-water shoals (Table 3).

Table 3. Abundance and biomass estimates within 100m of each installation and for an equivalent water volume in the open sea, for comparison

	Pelagic Fish		Demersal Fish	
Platform	Abundance	Biomas (Kg)	Abundance	Biomass (Kg)
Brae Bravo	4,140	5,796	10,764	23,681
Maureen	115,128	253,281	16,848	50,544
Tartan	78,804	110,340	---	---
MCP-01	79,815	95,778	7,956	10,353
Open Sea ($7x10^6m^3$)	565	1,131		

The evidence from this study suggested that the aggregations that might be present around fixed platforms in the central and northern North Sea may account for 0.7% to 3% of total saithe stocks and 0.08% to 0.6% of total cod stocks.

In all of these studies, the weight of fish per unit volume of enclosed space within the reefs created by the presence of platforms in the North Sea ranges from 0.055kg.m^{-3} to 0.62kg.m^{-3}. From these data, it is suggested that the average weight of fish per unit volume of enclosed space at North Sea platforms is about 0.3kg.m^{-3}.

The mass of fish found around working North Sea platforms, although locally high, is still very small in relation to the overall stocks of fish in the North Sea. If an "average" steel jacket has an enclosed volume of some 300,000m^3, the mass of fish it might attract would be about 90,000kg (90te). In comparison, the total allowable catch for North Sea saithe in 1992, for example, was 110,000te.

The most recent study of the presence of fish at platforms was completed in 1995 when a video survey of fish at an inert jacket in the Ekofisk complex was analysed. Qualitative and semi-quantitative estimate of the fish populations were obtained. Saithe appeared the most numerous fish around the jacket. As a large pelagic species it was commonly seen in shoals in the open spaces between the structural members and lying in the water column a few metres away from the outside of the structure. Red fish, whiting and ling were also frequently observed.

Within the short time scale of the project, it was not possible to analyse in detail diurnal migrations and changes in occurrence. It was evident from the videos, however, that the pelagic fish were absent or difficult to locate during the night and morning. Most of these fish were seen in the middle to late afternoon, strongly indicating that there was a diurnal migration to and from the structure. No substantial diurnal migration with respect to depth was observed.

11.2 Numbers and variety of fish at a deep, submerged structure

The wreck of Transocean 3, lying in 110m of water in the Beryl Field, had the same varieties, and approximately the same densities if fish, as the working jackets. This suggests that it is the physical presence of a steel structure, rather than any noise, heat, light or vibration, that attracts fish to it.

11.3 Monitoring the residence times and movements of fish at platforms

In 1988 a feasibility study was carried out to ascertain if the acoustic transmitters that could be implanted in fish could be successfully monitored in the relatively noisy environments around working platforms. This study was successful, with both transmitter and receiver functioning well around a platform and the wreck of Transocean 3. It was concluded that acoustic monitoring of the presence of tagged fish would be feasible.

11.4 The contamination and taint of fish at platforms

Several studies have been carried out, in both the UK and Norwegian areas of the North Sea, to determine if the fish caught around working platforms show evidence of contamination by petrogenic hydrocarbons or metals, or are tainted. The species studied have been dab, saithe and cod. In all studies, the hydrocarbon concentrations in the liver and muscle flesh were determined, and prepared samples were presented to experienced taste panels. In several studies, fish caught at "open sea" sites, many kilometres from platforms, were also analysed for comparison.

Flavour is assessed by a taste panel, who are presented with samples of fish which have been prepared in a standard way. The members of the panel do not know where the sample come from, and do not participate in the preparation of the samples. Panels usually consist of 8-10 members, and they are asked to assess the flavour of the fish in relation to their previous experience of the flavour of the species, and to rate any taint on a 5-point scale. Taint is defined as "a flavour or odour foreign to the product", and a fish is judged to be tainted if at least 50% of the panel members record some level of taint in the sample.

In the studies reviewed, no platform or open sea fish was found to be tainted by the criterion described above. All platform fish were therefore judged to be untainted, entirely acceptable and no different in quality, appearance, smell or texture from the open sea fish. It was concluded, however, that Dabs caught close to the Beatrice platform had "a tendency to tainting" and this was attributed to the fact that, because they are bottom-dwelling fish that rest on the seabed, they are more likely to have prolonged intimate contact with any contaminated sediments at cuttings piles.

Elevated concentrations of petrogenic hydrocarbons have been found in many of these samples, and there are indications that platform fish are exposed to contamination from the low-toxicity base oils used in drilling muds. It appears that no taint is caused by the levels of contamination found in these fish, and there has been no increase in the concentrations of mercury or cadmium in the fish flesh.

The platform fish studied so far tend to have higher concentrations of hydrocarbons in their muscle tissue than open sea fish, but in only a few cases could these elevated concentrations be attributed to low-toxicity oil-based drilling muds. Fish caught at platforms where no drilling had taken place exhibited broadly similar concentrations of hydrocarbons in flesh and liver to those caught at multi-well production platforms. There were indications that the flavour of the fish caught at production platforms was 'fuller' or 'stronger' than that of open sea fish, but they were not tainted and there was no correlation between their mean taint scores and the hydrocarbon concentrations of flesh or liver. No damaged, sick or moribund fish has been observed or caught in the course of these studies.

11.5 Health and growth of fish around oil platforms

The effects that the platform environment may be having on individual fish were investigated in a study on fish growth and condition, funded by Mobil North Sea Ltd. The primary aim of this study was to estimate the growth rates of individual saithe caught around drilling platforms within the Beryl Field at different times of the year. Seven different indicators were used to estimate the growth rates of the oilfield fish and comparisons were made between them.

Secondly, using the same biochemical and physical measures, the platform fish were compared with fish of the same species caught at the same time in other open sea sites, away from potential hydrocarbon pollution and any "reef" influence of the physical presence of a platform,

The study found that both platform and open sea fish exhibited seasonal cycles of positive and negative growth, and concluded that it did not appear that the saithe found in the Beryl Field were growing any less well than saithe found at the other sites sampled.

12 Potential benefits of the use of artificial reefs in the North Sea

12.1 Introduction

The immediate platform environment is one which fish find acceptable, to which they are attracted, and one which apparently produces no adverse effects in terms of physiology, biochemistry or commercial value. A growing body of evidence indicates that offshore platforms can create new habitats and augment carrying capacities, therefore increasing the diversity, numbers, size range and growth rates of desirable commercial fish.

There are several ways in which the possible presence of deepwater artificial reefs in the North Sea could benefit *fisheries* or *fishermen*, and these are outlined below. Any possible benefit must be considered within the framework of a Common Fisheries Policy, and consequently involves consideration of a range of aspects including fish concentration, stock enhancement, fishing effort and fisheries management.

The main direct and indirect benefits that might be gained from the creation of offshore reefs from platforms are as follows. A particular reef may provide some but not all of these benefits, and some are obviously mutually exclusive.

Direct benefits

- **Increase in the biomass (stock) of particular species**

- This could be brought about by reducing natural or fishing mortality, or by improving growth rates, or by increasing reproductive output.

- **Increase in the ease with which fish can be caught**

  This would be achieved by concentrating the desired species in high numbers at a fishable location.

Indirect benefits

- **Provision of new habitat**

  Artificial reefs are usually constructed to provide a hard substratum where formerly there was none. Artificial reefs mimic natural reefs but can be built to provide greater surface area, elevation, current shadow/disturbance, or niches/crevices to favour target species. This would be likely to lead to an increase in the local biomass of a number of species of fish and shellfish.

- **Biodiversity management**

  By permitting the manipulation of habitats, artificial reefs have the potential to increase the number of species in a given area and to provide specific purpose-designed habitats for target species.

- **Restoration of damaged habitat**

  The deployment of reefs can help to reduce the incidence of damage caused by heavy mobile fishing gear, and promote the recovery of damaged areas of seabed. In turn, this may lead to an increase in biomass of fish and shellfish species, and an increase in the biodiversity of the area.

- **Protection of existing habitat**

  Most artificial reefs in the Mediterranean Sea have been placed as nature conservation and/or habitat protection structures. At least 100 artificial reefs have been deployed for habitat protection by Israel, Italy, France and Spain. Their prime role is to prevent the destruction of sea-grass meadows by trawling. Others are used to enforce the creation of marine reserves or parks where fishing activities are regulated. North Sea reefs could play such a role; protection of habitats would in turn promote an increase in biomass and in biodiversity.

13 Possibilities for the creation of artificial reefs within the Common Fisheries Policy

Largely because of ever-increasing criticism of the Common Fisheries Policy (CFP), the European Union is currently accepting suggestions and examining new ways of managing and conserving stocks that can be implemented from 2002. The potential for the use of redundant offshore structures as artificial reefs therefore comes at a particularly auspicious time. There are several ways in which reefs could be incorporated into the policy:-

- As part of protected areas, in order to enhance or protect stocks

  There is currently a precedent under national and EU regulations for the implementation of closed or restricted fishing zones. Further work and consultation is required to confirm that artificial reefs could be incorporated in such zones to enhance their effects.

- As open-access fishing sites

  The alternative to reef-specific management would be to allow the reef to be exploited as any other area in the fishery. Market forces in the form of fishing yields may then govern fishing on the reef, though exploitation is unlikely to be optimal. In such circumstances it is possible that the platform reef could be managed by:-

  - national fisheries ministries
  - the EU within the CPF
  - a scientific reef advisory committee
  - the original operator of the platform
  - a contracted commercial group
  - a fishermen's co-operative

  From a purely practical viewpoint, returning management of the reef to a fishing co-operative has much to commend it. The fishermen themselves would take care of the reef and associated stocks. At present such an option is unlikely to be legally feasible, but it deserves further consideration at a time when the CFP is being reviewed and new radical alternatives are being sought.

14 Implementation of the rigs to reefs concept in the North Sea

14.1 Introduction

If jackets are to be utilised as artificial reef material in the North Sea the following related factors need to be considered:-

- what types of material may be used in reefs
- how the structures are to be prepared and deployed
- where the reefs are to be sited
- what the primary purpose of each reef or reef group is

14.2 Material that may be used in reefs

In theory, any solid, inert steel or concrete materials of opportunity from redundant offshore oil and gas structures could be deployed as components of reefs. Decommissioned pipelines, subsea completion units, wellhead templates, loading buoys, "cleaned" topsides, and the whole range of steel and concrete jackets and substructures, could all be considered for inclusion.

In practice, we believe that only steel jackets are likely to be seriously considered as artificial reefs or as components of reefs. They alone would provide components that would permit the construction of inshore or offshore high profile steel reefs that would have a good prospect of yielding measurable benefits on a local or even a national scale. The desired characteristics of platform reef components are as follows:

- Strength and durability, to withstand North Sea conditions and have a long effective life
- Positive influence on fish or shellfish life, as known or inferred from existing studies
- Permanence, to remain intact at desired location and not be a source of movable debris

14.3 Scenarios for the creation of artificial reefs from jackets

Artificial reefs could be created from North sea platforms in at least three different ways. In each, it is understood that the topsides would have been totally removed, for disposal elsewhere, prior to the reef deployment operations. There are potential advantages and disadvantages associated with each scenario, as shown in the summary tables. The "potential uses" are shown in decreasing order of importance for that scenario: the "advantages" and "disadvantages" apply to the scenario, not the individual potential uses.

- *Abandon in place*

  In this scenario the inert jacket would be left standing upright in place, with no further treatment.

Potential Uses	**Advantages**	**Disadvantages**
1.Individual fishing sites	"Simple" option	Small sites, with marginal effects
2.Protection of local populations	Range of habitats; reef extends through entire water column	Difficult to manage
3.Protection of habitat		Eventually deteriorates and collapses
Overall View	A small localised benefit that would be outweighed by the safety and liability fears associated with a collapsing structure that would be a source of debris	

- *Topple* in situ

  In this scenario, the inert jacket would be toppled in place, and independently of the timing of the abandonment of other structures.

Potential Uses	**Advantages**	**Disadvantages**
1.Individual fishing sites	"Simple" option	Small sites, with marginal effects
2.Protection of local populations	Reef totally submerged	Difficult to manage
3.Protection of habitat		
Overall View	A small localised benefit that would be difficult to manage to derive the maximum benefit.	

IMO guidelines recommend that there should be at least 55m clearance above the remains of any structures left on the seabed. Although this provision may not apply to the material from a jacket that may be deposited as a managed artificial reef, it is prudent to consider as candidate structures only those that would provide such a clearance.

In the UK North Sea, there are 23 platforms that stand in water deep enough to provide 55m clearance if the whole jacket were to be toppled. If these jackets were toppled individually as reefs they would cover some 150,000 m^2 of seabed at 20 separate sites.

In the Norwegian North Sea there may be about 37 steel platforms that are in water depths suitable for the creation of reefs.

In 1995 a study was completed to examine the possibility of using parts of the Odin jacket in situ as an artificial reef. The Norwegian Parliament (the Storting) subsequently approved a plan for the total removal and onshore disposal of the platform, but the analysis of the reef concept concluded as follows:-

- the site was suitable for an artificial reef because of its water depth, the absence of contamination by of oil based muds, and the level, featureless nature of the seabed.
- the jacket would be the most likely reef component. If topside modules were to be used, they would require total stripping which would probably be costly.
- the presence of the reef would not cause significant negative impacts on the physical and biological environment at the site.
- the reef would attract a variety of fish species from the surrounding area.
- the creation of a reef at the ODIN site would present an ideal opportunity to obtain essential data, hitherto lacking for the North Sea.

In a separate study, around 25 structures from the Ekofisk area were evaluated as elements in one or several artificial reefs. It was concluded that:-

- the area was suitable for reef creation although some of the sites contained large piles of oil based drilling muds and should be avoided.
- all the steel structures, including bridge supports and flare towers, had a configuration that was optimal for use on reef modules.
- the presence of the reef may enhance standing stocks of fish in the area.
- if the structures and the sediments on which the reefs were placed were properly decontaminated prior to reef creation, no negative impacts on the biological community would be expected from the reef.

- a clustered reef configuration comprising several installations and modules was likely to be of great potential and would also reduce the region covered by reef components, so reducing the negative impacts to other users of the sea.

- *Grouping of jackets in clusters*

In this scenario, inert jackets would be moved and deployed on the seabed at one of a small number of pre-determined offshore reef sites. Selected steel jackets could be clustered around the redundant support structures of decommissioned concrete platforms. The concrete structure would provide a "hub" on which navigation aids, and possibly equipment for remotely monitoring and managing fishing activity in the area of the reef, could be sited.

Potential Uses	**Advantages**	**Disadvantages**
1.Protection and augmentation of local stocks of fish	Large, well known sites: benefit of scale	Requires greater engineering effort to create
2.Breeding site	Possibility of choosing optimum (or at least "good") reef sites	
3.Protection of habitat	Possibilities to be monitored and managed within a broader fisheries policy	
	Reduces possibility of unplanned interference with mobile fishing gears	
	Reefs could be created away from existing oil cuttings piles	
Overall View	A workable possibility on a scale that might have impact on regional populations. Sites to act as "reservoirs" of fish to support wider populations; not to be fished directly.	

14.4 Potential locations for cluster reefs in the UK North Sea

Potential sites have been identified by examining the present disposition of large steel platforms and their relation to possible concrete hub structures. In the absence of any detailed information about the possible effectiveness of different potential hub sites as reef locations, the criterion used to determine which steel jackets should be grouped around which hub structures was the simple one of minimising the distances that steel jackets would have to be transported to the proposed concrete hubs.

This resulted in the identification of one possible scenario in which 6 hubs would be designated with 23 steel jackets grouped around them in clusters of 4 - 6 platforms. The total enclosed volumes of the clustered steel jackets at each hub would range from 765,438 m^3 to 2,810,175 m^3. It is stressed that this scenario was derived on the basis of published data, without reference to any of the operators of the individual structures, or any detailed assessment of the engineering procedures that would be employed to relocate the candidate steel jackets.

14.5 Suitable areas for cluster reefs in the Norwegian North Sea

The following criteria were used to identify possible sites for cluster reefs:

- the area must hold a large number of steel jackets.
- the area must hold one or more concrete installations acting as a hub.
- the area should not interfere with known spawning ground for fish stocks

There are thirteen operating concrete installations in the Norwegian North Sea, and on the basis of the above criteria, two areas appear particularly suitable for the construction of clustered artificial reefs.

Area 1 - the Ekofisk area

This area has a high density of platforms suitable as elements in an artificial reef. If structures are going to be moved from their present location to become part of reef clusters, the location of the bigger structures should be selected as the destination for the reefs, assuming that any seabed contamination at these sites is within acceptable limits. This will reduce costs and disturbance to the sea bed, as well as simplifying toppling and movement operations.

Area 2 - the Statfjord/Gullfaks area

This area also has a high density of concrete platforms, three at the Gullfaks area and three at the Statfjord area. Steel jackets would have to be brought in from other fields, but the area, included the UK sector, has a high density of steel jackets making it possible to create a large artificial reef.

Other areas that may prove suitable are the Sleipner area, the Frigg area and the Oseberg/Troll area.

In total, there are 35 steel structures in the Norwegian North Sea which stand in water more than 75m deep and weigh more than 4,000te in air. The individual enclosed volumes of these jackets ranges from 39,900m^3 to 650,000m^3.

15 Need for further work on North Sea artificial reefs

The work reviewed in the report has indicated that:-

- artificial reefs are increasingly used as part of wider fisheries management practices around the world, to augment or protect commercially valuable species of fish and shellfish, or to provide a means of harvesting such stocks in a more cost-effective and sustainably manageable way
- high profile steel reefs are one of a range of types of structures that are being deployed in different marine environments (both tropical and temperate, shallow and deep) to attract mid-water and bottom-dwelling fish
- selected inert steel components from decommissioned oil and gas platforms are being used as reefs or reef components
- deep water steel platforms in the North Sea are causing a reef effect; they aggregate different species, and these fish do not appear to be adversely affected by living for an unknown period of time in close proximity to the working platforms
- inert steel structures totally submerged in deep water in the North Sea continue to exhibit a reef effect similar to that of working platforms. There is strong evidence to suggest that if a steel platform were to be decommissioned and completely submerged it would continue to exhibit a reef effect

There is therefore a strong *prima facie* case that decommissioned North Sea platforms could be used to make artificial reefs that might be of benefit to North Sea *fisheries* or *fishermen.* Because no such large, high profile steel reefs exist in the North Sea, and because there are differences between the North Sea and existing reef sites in terms of both their environments and fishing practices, further study is desirable to determine how any materials of opportunity from decommissioned platforms might be deployed and exploited to the greatest advantage.

The following topics require further study in the North Sea. They may be conveniently grouped into those that measure the direct effects that platforms may be having on fish, and those that measure important potential effects on other aspects of the environment.

Direct effects on fish

- Assessment of standing stocks around platforms
- Assessment of the residence times of fish
- Monitoring the "exchange" of fish between the platform and the open sea
- Assessment of the breeding success/potential of platform fish
- Measurements of growth, health, contamination and taint

Effects on other parameters

- Monitoring the development of biofouling
- Determining changes in local benthic populations
- Assessing local plankton populations

An integrated programme incorporating these elements would yield a detailed, quantitative assessment of the effects that platforms were having as reefs, and provide essential additional information with which to judge:-

- if high profile reefs could be deployed effectively in the North Sea
- if decommissioned steel jackets would make good reef components in the North Sea

16 Proposed programme of work on North Sea platform reefs.

16.1 Introduction

A programme of work is proposed that would acquire data relevant to the consideration of two possible options:

1. the redeployment of selected jackets at inshore locations to provide artificial reefs for commercial and sports fishing, or other types of exploitation, and/or play a possible role in coastal fishery resource partitioning.
2. the use of selected jackets at offshore sites to create single or complex artificial reefs to facilitate the management of habitats, commercial fishing or fisheries.

The programme would provide essential data with which to determine the potential advantages and disadvantages of reefs constructed from platforms in the North Sea, as well as providing more detailed information about the present influences of operating structures on fish populations. The results would be published in peer-reviewed journals.

16.2 Study of an inshore reef

Purpose of the study

The purposes of the proposed programme of work at an inshore reef are:-

- to construct the first UK high profile steel reef, which would be a test and research site that would provide data and knowledge on this topic to all of interested parties.
- to study the response of fin fish to the presence of the reef
- to apply, evaluate and develop methods for assessing fish populations and fish movements around high profile steel reefs in the North Sea
- to acquire reliable data with which to determine the potential benefits, if any, of creating such artificial reefs in the context of near-shore fisheries in the UK
- to examine ways in which such reefs might be exploitable by the communities they serve.

Status of proposed reef and research

Wood Group Engineering in Aberdeen, with the support of Cordah Environmental Management Consultants, have submitted an application for a FEPA licence to build an experimental steel reef in the Moray Firth. The proposed study would last five years, after which the reef module would be removed to shore and recycled.

The application for building the reef is supported by the results of a feasibility study which identified possible sites for the reef, assessed how it could be built, and outlined a programme of scientific study. During the feasibility study, consultations were held with many parties, and the proposed site in the Moray Firth was selected with advice from, and the support of, the local fishermen's organisations.

The reef would comprise a single module derived from a tubular, lattice-type, welded steel crane tower, approximately 50x17x17m in size and weighing some 500te in air. The module would be placed on the seabed about 9km off Brora, Sutherland, in 40m of water.

The creation of artificial reefs is one of the specific support actions for fisheries of the Highlands and Islands Regional Plan (Scottish Office, 1994) and is incorporated into the UK Fisheries Sectoral Plan. Consequently, the proposed pilot reef is intended as the UK's investigation site on the long-term utilisation of high profile artificial reefs for fisheries resource management, establishing the basis for technology transfer and diversification to other suitable locations in the UK and Europe.

Scientific research at Moray Firth inshore reef

The study of the pilot inshore reef would investigate:

- the numbers, varieties and biomass of fish and shellfish
- the rate of colonisation by fish, and the movements of fish around the reef
- the health and growth rates of fish, and their reproductive status
- the potential sustainable yields for the various types of fishing activity on the reef
- environmental, social and economic costs and benefits of the reef
- the possible benefits of creating larger inshore reefs or reef complexes

16.3 Study of the reef effect at oil-related structures offshore

Introduction

Inshore reefs and offshore reefs in the North Sea would be likely to be "exploited" in different ways; in particular, inshore reefs may be of most benefit to *fishermen* and local communities through some type of direct exploitation, whereas offshore reefs may be of most benefit to *fisheries*, as "reservoirs" or "sanctuaries". The Moray Firth reef would provide information on inshore reefs, as well as being a proving ground for sampling and remote sensing techniques that would be employed offshore. Additional research is required, however, at an oil-related structure offshore to provide information specific to larger structures in deep water.

Non-operational platforms

Since there are no high profile steel reefs in the North Sea, the best site for the proposed study would be an inactive platform with a steel jacket. Being inactive, any observed reef effect would be attributable solely to the presence of the steel jacket. Ideally, the platform should be at a distance from other jackets that would permit the observation of (a) a discrete reef effect centred on the study site, and (b) the exchange of fish between the reef and nearby structures and/or the open sea. In addition, the preferred study site should:-

- have an accessible deck structure where scientific equipment could be mounted
- be located away from important spawning areas or areas that are heavily fished

Suggested sites

Several areas in the North Sea meet these specifications. One would be platform 2/4F at Albuskjell, which was shut down several years ago. The jacket weights approximately 7,300te including piles included, and has an enclosed volume of 182,000 m^3. It is located 8km from the nearest platform (1/6A), and 13km from the Ekofisk Centre.

Aims of proposed study at offshore site

As a result of this review, it is proposed that a programme of work is completed at an offshore site with the following aims:-

- to determine the residence times of fish
- to determine if the platform reef is having any measurable beneficial or detrimental effect on the health, growth and commercial value of the fish it retains
- to determine if the platform reef enhances the reproductive capability of fish
- to determine if the platform reef acts as a nursery site for juvenile fish
- to determine if the platform reef is having any measurable effect on the pelagic and benthic environments in its immediate vicinity
- to assess if a platform reef could be fished sustainably by commercial fishermen
- to describe and evaluate the "fouling organisms" on the platform reef as a food supply for commercial species and for nature conservation value.

To achieve these objectives, an integrated programme of work is proposed, with an emphasis on the fin fish. In outline, the programme will:-

A) Select a non-operational steel jacketed platform which could be used with minimal hindrance as a survey site

B) Determine, by means of an initial ROV/sonar survey, that the selected platform has a rich and diverse "resident" fish population suitable for the purposes of this study

C) Carry out a three year programme of survey, sampling, measurement and analysis, to address the main topics of research listed above.

This programme would involve:-

- periodic offshore surveys to obtain a wide range of chemical and biological samples
- routine, longer term monitoring of fish by remote sensing equipment on the seabed or on the platform

- a small number of visits by a fishing vessel, to determine the commercial fishing potential of the site

Although the programmes at the two sites will differ in emphasis and to some extent in study techniques, both will attempt to gather information on the following broad topics:

- the numbers, varieties and biomasses of species which move on to, and live at, the reef
- the residence time of reef fish, and the rate of turnover between reef fish and open sea fish
- the extent to which reef fish derive measurable benefit from the reef, as measured by increased growth rates, increased longevity or increased reproductive capacity
- the extent to which North Sea reefs could be of benefit to other parts of the ecosystem, by protecting habitats and increasing biodiversity.

Costs

Introduction

Each study programme comprises a series of related, complimentary but separate lines of research. These can be amended as each programme proceeds, in the light of findings at each site. It is anticipated that both the nearshore and the offshore programmes would attract funding from a range of research bodies. Once established, the offshore and nearshore sites will rank as very valuable study sites on which a diverse range of complimentary scientific programmes could be based. In this way, the maximum amount of information would be obtained from these two research initiatives.

A summary of the indicative costs for the inshore reef study is given in Table 4, and for the offshore study in Table 5.

Table 4. Indicative costs for proposed research programme at inshore reef. Rounded figures in £000s.

Component	Cost per year								
	Pre	1	2	3	4	5	Post	Tot	%
Deploy & retrieve	20	232	12	12	12	32	60	380	28.0
Study fish movement	17	85	156	107	83	84	27	559	41.2
Study health/ growth	0	0	0	47	38	34	10	129	9.5
Analysis of samples	15	30	3	30	0	33	15	126	9.3
Environment studies	25	3	3.5	4	4.5	34	0	74	5.5
Meetings/ conferences	0	3	3	5	6	6	8	31	2.3
Administration	5	7	11	7	11	7	10	58	4.2
Totals	82	360	189	212	155	230	130	1357	100
Annual % of total	6.0	26.5	13.9	15.6	11.4	16.9	9.6	100	

Key:-

Pre = Pre-deployment baseline studies and preparatory work

Post = Post-retrieval surveys, analysis and final reporting

Tot = Totals

Table 5. Indicative costs for proposed research programme at an offshore "reef" site. Rounded figures in £000s.

Component/Activity	Cost per Year						
	1	2	3	4	5	Total	%
Planning & mobilisation	9	9	9	9	0	36	1.5
Sampling & fieldwork	113.3	413.8	517.4	333.6	0	1378.1	57.2
Analysis	0	77	129.5	66	0	272.5	11.3
Evaluation of data	40.5	114.5	132.5	116.7	0	404.1	16.8
Reporting	9	18	18	38.3	47.3	130.5	5.4
Meetings	9	12.6	12.6	12.6	3.6	50.4	2.1
Transport equipment etc	4	20	20	20	0	64	2.7
Admin/ Co-ordination	10.8	21.6	21.6	21.6	0	75.6	3.0
Totals	195.6	686.5	860.6	617.8	50.9	2411.2	100
Annual percent of total	8.1	28.5	35.7	25.6	2.1	100	

17 Conclusions

1. Artificial reefs are an acknowledged tool in fisheries management, and are being used in many countries. Japan and the USA have National Artificial Reef Programmes, and the EU has a co-ordinated programme of reefs research.

2. The USA has a well-documented programme of deploying selected decommissioned platforms as high profile reefs at approved sites in the Gulf of Mexico and elsewhere.

3. There are two, low profile artificial reefs near the UK coast, but no purposefully-created high profile reefs in the North Sea.

4. There is a body of evidence from studies at working North Sea platforms which indicates clearly that these platofrms are acting as reefs, at that when decommissioned they would continue to act as reefs.

5. Further studies are needed to determine how effective reefs could be in the North Sea, at both inshore and offshore locations.

6. Successful acquisition of such data would be a significant aid in answering the two fundamental questions regarding the use of high profile steel reefs in the cool temperate waters of the North Sea:-

- ***Could North Sea platform reefs be sustainably exploited by commercial fishermen***?

- ***Could North Sea platform reefs be used to protect and enhance fish populations***?