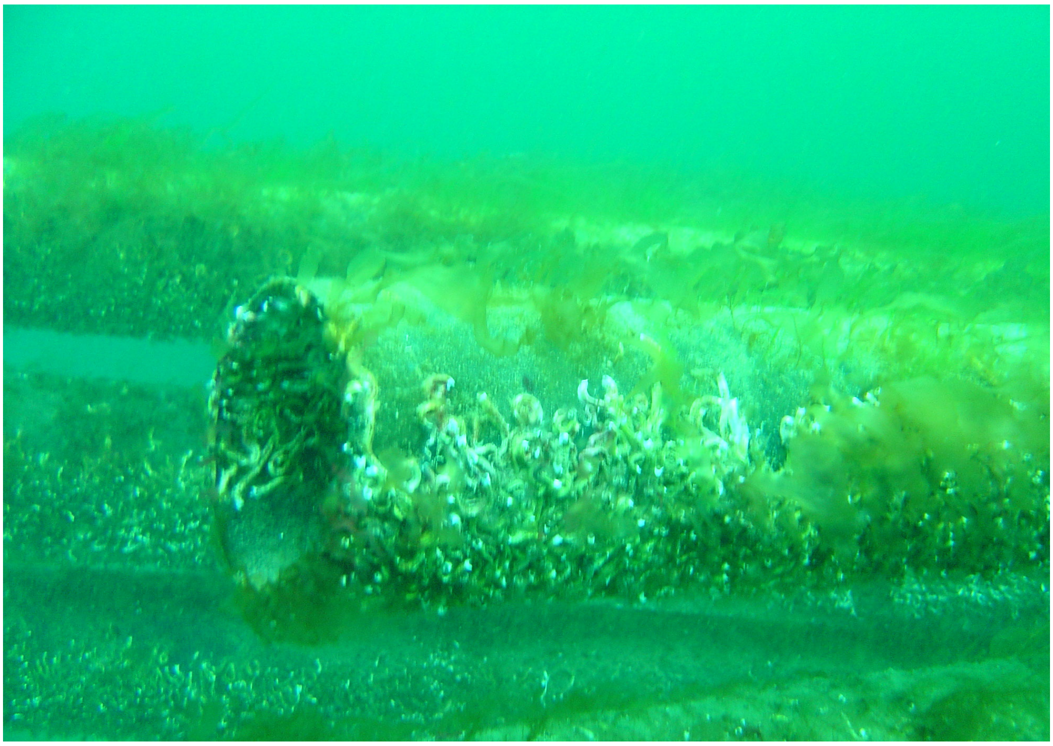
OSPAR COMMISSION

Assessment of construction or placement of artificial reefs



Biodiversity Series

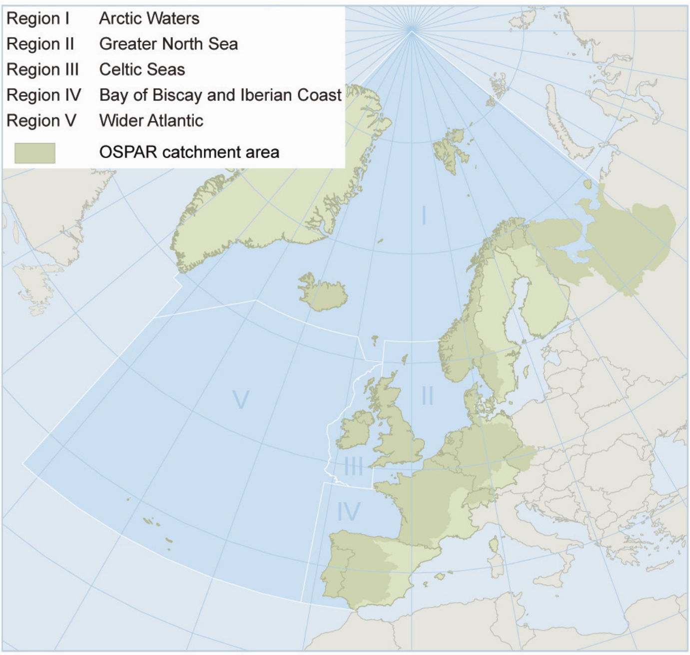
2009

OSPAR Convention

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Community and Spain.

Convention OSPAR

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998.
La Convention a été ratifiée par l'Allemagne, la Belgique, le Danemark, la Finlande, la France, l'Irlande, l'Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d'Irlande du Nord, la Suède et la Suisse et approuvée par la Communauté européenne et l'Espagne.



The OSPAR maritime area and its Regions.

Acknowledgement

This report has been prepared by Dr Lynette Frances Jackson, assisted by Mr José L. Buceta Miller.

Cover photo provided by the Norwegian Institute for Water Research (NIVA).

Contents

Executive summary

There are only a few artificial reefs in the OSPAR Maritime Area, but the number is growing

Some 56 artificial reefs have been constructed or are being planned in the OSPAR Maritime Area. The overwhelming majority have been constructed in the last two decades. Artificial reefs are now present in all regions except the Wider Atlantic. The driving force behind this expansion is the potential for socio-economic benefits such as the enhanced production of living marine resources, protection of existing resources from human activities, such as bottom trawling, and increased opportunities for recreation and tourism – all important components of the European economy.

Potential negative impacts can be minimised by careful planning

Artificial reefs may, however, also have negative impacts such as changes to waves and currents – which can lead to erosion – displacement of and changes to biological communities, including the introduction of invasive species, and exposure to pollution. For the most part, these negative impacts can be minimised by careful selection of sites, design and construction materials based both on the purpose of the reef and the oceanographic and ecological conditions at the proposed site. However, artificial reefs are generally constructed in relatively shallow coastal waters, and even limited impacts will contribute to the cumulative impacts of all the many human activities concentrated in these areas.

Though not strictly regulated, construction of artificial reefs is subject to environmental impact assessments

While there are currently no binding regulations on the construction of artificial reefs, OSPAR, in 1999, adopted the "OSPAR Guidelines on Artificial Reefs in relation to Living Marine Resources". Despite the fact that these appear not to have been used by most Parties, most of the reefs constructed over the last decade have been carefully planned, subjected to environmental impact assessments, and are being carefully monitored. Perhaps as a result, relatively few negative impacts have been reported. Nevertheless, given the potential for expansion and the possibility of cumulative impacts, OSPAR should consider establishing a reporting system.

Récapitulatif

Quelques récifs artificiels seulement dans la zone maritime OSPAR, mais nombre en hausse

Quelque 56 récifs artificiels ont été construits ou sont prévus dans la zone maritime OSPAR. La plupart des récifs construits l'ont été au cours des vingt dernières années. Il existe maintenant des récifs artificiels dans toutes les régions, à l'exception d'au grand large de l'Atlantique. Les avantages socio-économiques potentiels constituent la force motrice à l'origine de cette expansion. Il s'agit notamment de la production accrue de ressources marines vivantes, de la protection des ressource existantes contre les activités de l'homme, telles que le chalutage de fond, et les opportunités croissantes de loisirs et de tourisme – tous étant des composantes importantes de l'économie européenne.

Impacts négatifs potentiels minimisés par une planification soigneuse

Les récifs artificiels risquent cependant d'avoir des impacts négatifs tel qu'une modification des vagues et des courants qui peut entraîner une érosion – le déplacement et la modification de communautés biologiques, notamment l'introduction d'espèces invasives et une exposition à la pollution. La plupart de ces impacts négatifs peuvent être minimisés en sélectionnant soigneusement les sites, la conception et les matériaux de construction, en se fondant aussi bien sur les utilisations du récif que sur les conditions océanographiques et écologiques du site proposé. Les récifs artificiels sont cependant construits généralement dans des eaux côtières relativement peu profondes et même des impacts limités peuvent contribuer aux impacts cumulatifs de nombreuses activités humaines concentrées dans ces zones.

Construction de récifs artificiels faisant l'objet d'évaluations de l'impact environnemental mais pas strictement règlementée

Alors qu'il n'existe actuellement aucune réglementation contraignante relative à la construction de récifs artificiels, OSPAR a adopté, en 1999, les "Lignes directrices OSPAR sur les récifs artificiels construits aux fins des ressources marines vivantes". En dépit du fait que celles-ci ne semblent pas avoir été utilisées par la plupart des Parties contractantes, la grand majorité des récifs construits au cours des dix dernières années ont été planifiés soigneusement, faisant l'objet d'évaluations de l'impact environnemental et d'une surveillance attentive. En conséquence, peut être, relativement peu d'impacts négatifs ont été notifiés. OSPAR devra cependant envisager de mettre en place un système de notification étant donnés le potentiel d'expansion et la possibilité d'impacts cumulatifs.

1. Introduction

1.1 Background

Artificial reefs are one of a number of human activities identified in the OSPAR Biodiversity Strategy as having actual and/or potential adverse effects on the marine environment. As such, they have been included in a series of assessments through the OSPAR Joint Assessment and Monitoring Programme (JAMP) which will provide the basis for the OSPAR Quality Status Report 2010.

This report provides a preliminary assessment of artificial reefs in the OSPAR Maritime Area, their effects on ecosystems and biological diversity, and the effectiveness of the current regulatory framework. As far as possible, it gives some insight into differences between the OSPAR regions.

1.2 Artificial reefs in the OSPAR Maritime Area

Artificial reefs and other structures are used in many countries and regions across the world for coastal management purposes, including the enhancement or concentration of living marine resources, compensation for habitat loss, and coastal protection. However, different countries – and regions – have different definitions thereof and, as a result, have differing opinions as to what structures are considered as artificial reefs. The OSPAR Guidelines on Artificial Reefs in relation to Living Marine Resources (OSPAR, 1999) define artificial reefs as follows: “An artificial reef is a submerged structure placed on the seabed deliberately, to mimic some characteristics of a natural reef. It could be partly exposed at some stages of the tide.” For purposes of this report, it is understood that the definition excludes artificial islands, or structures, such as breakwaters, established for coastal defence purposes.

The development of artificial reefs in the OSPAR Maritime Area has been relatively limited. Nevertheless, the past two decades have seen an increase in such activities for purposes such as fisheries protection and production, habitat protection and enhancement, research and recreation. The majority of these reefs have been purpose-built, primarily in concrete, although natural rock has also been utilised. In a few cases, disused vessels have been placed to create opportunities for recreational diving. The number of OSPAR countries deploying reefs has also expanded, and artificial reefs can now be found in all OSPAR regions with the exception of Region V – the Wider Atlantic. The largest concentration of reefs is in Region IV – the Bay of Biscay and Iberian Coast (Figure 1.1).

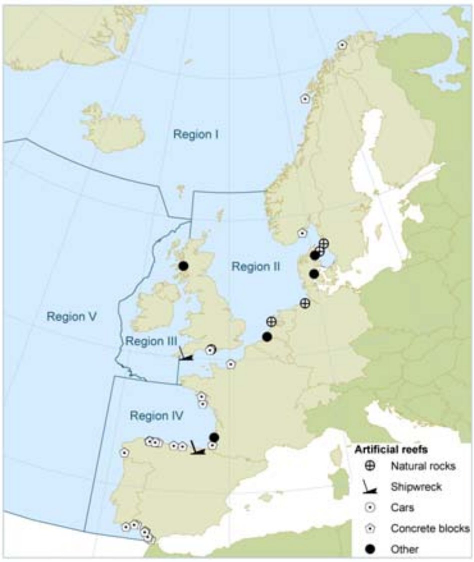


Figure 1.1. Location of artificial reefs in the OSPAR area

1.3 Vulnerability of ecosystems of the OSPAR Maritime Area

Despite the potential benefits of certain artificial reefs – such as biodiversity and habitat protection and enhancement – they may also have negative impacts on the marine environment. Since they are generally constructed in relatively shallow coastal areas, it is these coastal ecosystems which may be impacted.

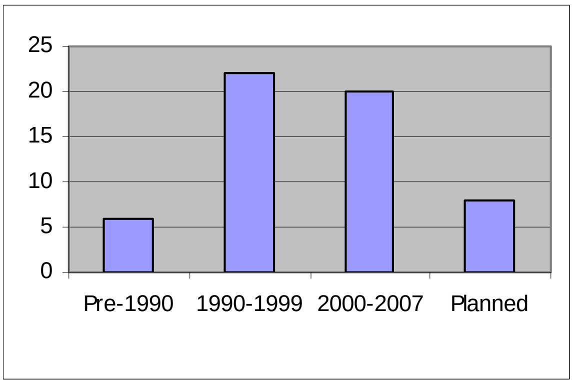
Although there are a relatively small number of reefs currently present in the OSPAR Maritime Area, potential impacts need to be considered in the broader context of the cumulative impacts of all human activities in the coastal zone. Thus densely populated coastal areas in Region II (the Greater North Sea), part of Region III (Celtic Seas) and Region IV (the Bay of Biscay and Iberian Coast), where there is already considerable pressure on coastal ecosystems, and where the majority of the reefs are situated, are likely to be most vulnerable to the negative consequences of artificial reef construction. Coastal bays and fjords, where there is a limited turnover of water, not only provide suitable conditions for artificial reef construction, but are particularly susceptible to problems of contamination.

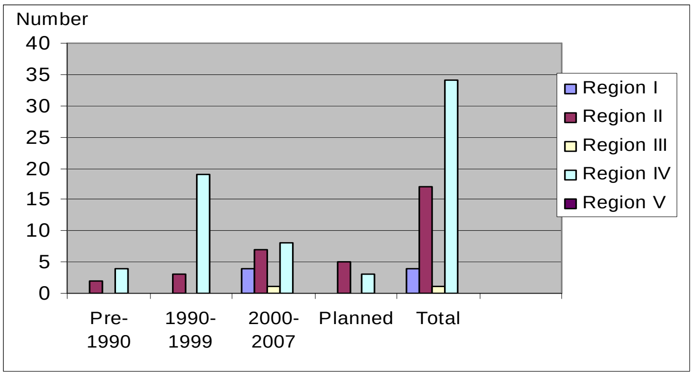
2. Driving forces and pressures

Artificial reefs are constructed because of their anticipated benefits – both socio-economic and environmental, including:

- promotion of tourism and recreational activities such as angling and diving which can also divert existing tourist pressure away from sensitive natural ecosystems;
- concentration or attraction of target species for angling and diversion of angling pressure away from sensitive natural ecosystems;
- enhanced production of living marine resource stocks through habitat creation;
- mitigation of some of the impacts of activities such as caged fish aquaculture, by absorption of excess organic matter and thereby improving water quality;
- research and educational opportunities;
- protection of vulnerable ecosystems from destructive/illegal fishing techniques;
- increasing or altering biodiversity;
- compensation for habitat loss elsewhere as a consequence of, for example, port construction;
- restoration of biological communities following habitat damage.

Some 48 artificial reefs have been constructed in the OSPAR Maritime Area, the overwhelming majority in the last two decades. Another 8 are in the planning phase, 5 of which have already been approved and are likely to be constructed during 2008. This growth has been accompanied by a geographical expansion so that whereas until the end of 1999 artificial reefs were limited to the Greater North Sea, Bay of Biscay and Iberian Coast, they are now present in all regions except the Wider Atlantic (Figure 2.1).





a. b.

Figure 2.1. (a) Numbers of reefs constructed in OSPAR Maritime Area between 1960 and the present, and (b) showing the spread of the reefs across OSPAR Regions.

The artificial reefs in the OSPAR Maritime Area have been constructed for a variety of purposes (Figure 2.2). Those constructed for fisheries management purposes are most common, although it is notable that the large majority of these occur in Region IV. Reefs for fisheries protection purposes are, in fact, restricted to this region. Region IV also has the greatest diversity of artificial reefs, with Region II having reefs of all categories except fisheries protection reefs.

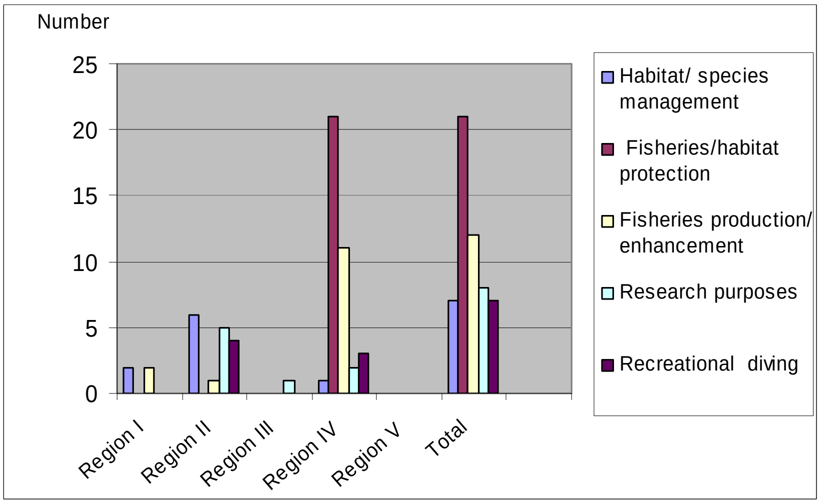


Figure 2.2. The purposes of artificial reefs constructed in the OSPAR Maritime Area.

Commercial fishing is important to most OSPAR Contracting Parties, but has led to the overexploitation of many fish stocks, as well as having direct and indirect impacts on marine ecosystems. It therefore seems inevitable that the opportunities presented by artificial reefs to prevent damage to threatened habitats by illegal trawling, and to boost certain fish stocks by providing additional habitat, will become a major driving force behind the further development of reefs in the region. Indeed, much of the current research is already focussed on improving reef design to this end (see the Loch Linnhe, Gothenburg and Hammerfest Reef case studies in Appendix A).

Another important sector of the European economy is tourism, with the coast becoming an increasingly popular tourist destination. Visitors create a diverse array of pressures on coastal resources from recreational facilities to food and water, and could stimulate an expansion in the development of recreational reefs.

3. Regulatory framework

While there is currently no legally binding international agreement dealing specifically with the regulation of artificial reefs, there are some which include provisions which are pertinent to the issue. There are also a number of initiatives at regional and national levels.

3.1 International

Both the London and Basel Conventions are pertinent in as much as they are concerned with the pollution potential of waste materials which could be utilized in artificial reefs/structures.

3.1.1 The 1972 London Convention and its 1996 Protocol

The primary business of the "Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter, 1972" (commonly called the "London Convention") and the 1996 London Protocol thereto are to prevent the dumping of waste and other matter into the sea. However, Article III(1)(b)(ii) of the Convention and Article 1 (4) (2)(3) of the Protocol expressly state that "Placement of matter for a purpose other than the mere disposal thereof" is not included within the definition of "dumping", although this statement is qualified by the words: "..provided that such placement is not contrary to the aims of this Convention". Despite this qualification, there has been some concern that the placement or construction of artificial reefs and other such structures, could be used to circumvent the provisions of the Convention by utilising waste materials to ostensibly build reefs.

In light of these concerns, the Contracting Parties to the London Convention have recently initiated the development of guidelines on the construction and placement of artificial reefs with a view to ensuring that such activities are not in contravention of the Convention and its Protocol. It is anticipated that these guidelines will be completed and adopted during the course of 2008.

3.1.2 The Basel Convention

The Basel Convention on the Control of Cross-Border Movements of Dangerous Waste and their Elimination has developed "Technical guidelines for the environmentally sound management of the full and partial dismantling of ships" (Basel Convention, 2002). Of relevance is that the guidelines also cover vessels requiring only partial dismantling, for example, vessels requiring decontamination with a view to use as an artificial reef.

3.2 Regional conventions and initiatives

3.2.1 The OSPAR Convention

The OSPAR Convention does not specifically provide for the regulation of artificial reef construction or placement. However, Contracting Parties do have a general obligation to protect the maritime area against the adverse effects of human activities (Article 2.1a), including pollution from various sources (Articles 3, 4, 5 and 7).

Despite these obligations, a proposal to develop guidelines on artificial reefs under the Convention revealed differences of opinion amongst Contracting Parties. Some parties were concerned that such guidelines would create a mechanism to circumvent certain provisions of the Convention – namely, the ban on dumping of waste and disused offshore installations – by allowing some waste materials to be used as building material for artificial reefs. Other points raised were that artificial reefs designed and constructed on land fell outside the scope of Annexes II and III (under which the Guidelines were to be developed); and that artificial reefs were only one aspect of the requirement, in the OSPAR Action Plan 1998-2003, to develop appropriate criteria, guidelines and procedures with regard to matter placed in the maritime area for a purpose other than that for which it was originally designed and constructed. There were also varying opinions as to whether OSPAR Decision 98/3 (OSPAR, 1998) on the Disposal of disused offshore installations, covered the placement of offshore installations as artificial reefs.

Nevertheless, development of the "OSPAR Guidelines on Artificial Reefs in relation to Living Marine Resources" went ahead, and they were ultimately adopted in 1999 with a reservation from Norway on the basis that they went beyond the legal basis provided by the Convention.

The purpose of the OSPAR Guidelines is to assist Contracting Parties in considering the consequences for the marine environment of the placement of artificial reefs on the seabed. They provide guidance on the studies which should be undertaken prior to approval of artificial reefs, as well as on, amongst others, materials, design, location, monitoring and experiments.

3.2.2 The Barcelona Convention

The Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention 1976 and amended in 1995) has similar provisions to OSPAR and is pertinent only in that it is applicable to those OSPAR Contracting Parties which also have a Mediterranean coastline.

3.2.3 European Community

A number of initiatives within Europe have a bearing on artificial reef development – either directly or indirectly. The EC, for example, has responsibility for managing fish stocks across the region, and measures regulating fisheries activities will also apply to fishing over reefs. The EC nevertheless supports reef development, and has provided funds for a number of national artificial reef programmes. In 1995 the EC funded the establishment of the European Artificial Reef Research Network (EARRN), with 51 scientists from 36 laboratories, to promote collaboration, provide recommendations for the direction of future research, and promote awareness of issues around artificial reefs.

3.3 National regulations

A number of Contracting Parties have national legislation which, although not specific for that purpose, is used to regulate artificial reef development. In most cases this includes a requirement for an Environmental Impact Assessment. The available information is summarised in Table 2, Appendix C.

3.4 Effectiveness of existing measures

As is evident from the preceding sub-sections, there are no binding regulations specific to artificial reefs in OSPAR countries at international, regional or national level. Specific guidelines are only now being developed under the London Convention/Protocol, and while OSPAR has guidelines in place, the majority of countries that participated in this assessment indicated that they had not made use of these to date. On the other hand, OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations – which is mandatory - has effectively stopped the use of such structures as artificial reefs since its adoption.

At the same time, it appears from the information received – including case studies – that many, if not most, reefs constructed over the last decade have been carefully planned, have been subjected to environmental impact assessments, and are the subject of significant research and/or monitoring programmes. Perhaps as a result, relatively few negative impacts have been reported. Nevertheless, given the potential for cumulative impacts, consideration should be given to reviewing measures under the Convention.

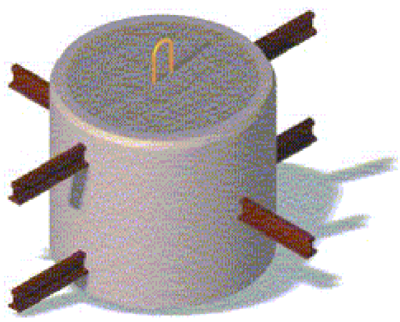
4. Impacts, their trends and effects in the marine environment

Artificial reefs clearly have socio-economic benefits. They provide additional substrate for the commercial culture of a variety of shellfish species, serve to protect fish stocks from illegal fishing activities and provide educational and recreational opportunities (see case studies in Appendix A). However, some of the perceived environmental benefits are more contentious. For example, there are differing opinions as to whether reefs actually increase the productivity of fish species, with the opposing view being that they just serve to concentrate them and in fact, make them easier to catch. Similarly, not everyone supports the contention that placing a reef on a sandy plain increases biodiversity. What it does is to facilitate the replacement of the biodiversity associated with a sandy substrate with that of a rocky reef, and if placed in an area which is important for sandy-bottom species, may actually have a negative impact.

Moreover, reefs may also have directly negative impacts, both during the construction phase and once the reef has been established. These include changes in wave action, current velocities and direction, and patterns of sediment distribution (leading to erosion in some areas and smothering in others); sediment chemistry; displacement of and changes to the biological communities of the area, including the introduction and establishment of potentially invasive alien species; and exposure to chemical contaminants as a result of leaching from the reef structures. Where reefs are not sufficiently robust, they may fragment, contributing to the problem of marine debris. Material may be displaced into adjacent areas of high conservation or productive value causing damage to these ecosystems.

For the most part, the negative impacts of artificial reefs can be mitigated by careful planning and appropriate selection of sites, design and construction materials based both on the purpose of the reef and the oceanographic conditions at the proposed site. The OSPAR Guidelines cover each of these aspects, although perhaps not in sufficient depth, as well as making recommendations on administrative requirements, monitoring, ownership and liability.

The OSPAR Guidelines recommend the use of inert materials not susceptible to leaching, physical or chemical weathering, or biological activity, for construction of reefs. The majority of the reefs constructed in the OSPAR Maritime Area are, in fact, constructed of concrete or a concrete mix, many with polyethylene pipes or deterrent arms radiating from a central core of concrete (see Figures 4.1 and 4.2, and case studies in Appendix A). Other materials used include natural rock and decommissioned vessels. In some cases the materials have been specifically tested for robustness and chemical inertness prior to deployment – for example, in the case of the Loch Linnhe reef constructed on the West coast of Scotland. Vessels which have been placed more recently have been thoroughly cleaned prior to being sunk, in accordance with relevant guidelines under the London Convention.



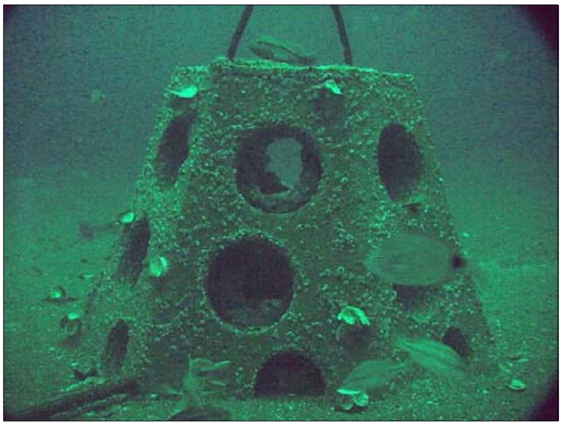


Figure 4.1. Artificial reef module designs for a protection reef (left - with deterrent arms); and a reef intended to provide habitat for marine organisms (right). Source: General Secretariat of Marine Fisheries: Spain

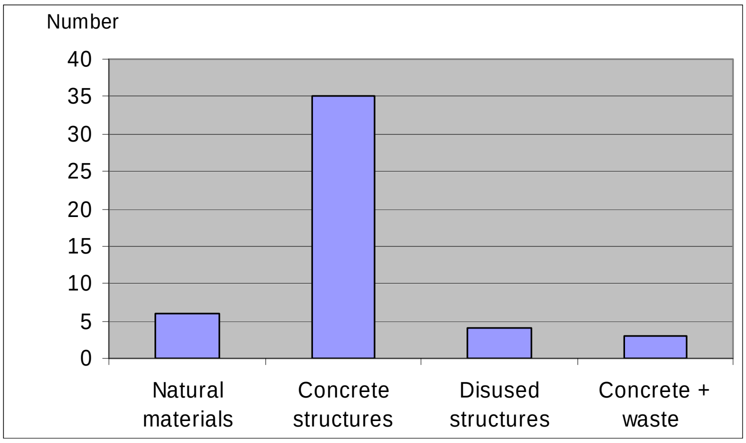


Figure 4.2. Materials used for artificial reef construction in the OSPAR Maritime Area.

Research and monitoring programmes have, to date, reported only relatively minor, localised environmental impacts. For example, reduced current flows at the reef edges of the Lock Linnhe reef resulted in an accumulation of detritus with consequential decreases in sediment oxygen levels and associated changes in the biological community. Similarly, low oxygen conditions were detected in some parts of the Gothenburg reefs.

In light of the localised nature of the environmental impacts demonstrated to date, it seems that unless there is a massive increase in the number of reefs – and especially in the more vulnerable ecosystems such as coastal bays and fjords – and provided that the relevant guidelines are followed, the artificial reef development in the OSPAR area will not have major negative environmental effects. Nevertheless, given the potential for cumulative impacts, it is recommended that OSPAR continues to monitor this activity.

5. Conclusions and recommendations

The information provided suggests that not only is there a relatively limited number of artificial reefs in the OSPAR Maritime Area, but that even where they are present, the negative effects have been very localised (for example Loch Linnhe and Gothenburg reefs). At the same time, all of the reefs profiled in the case studies seem to have been very successful in terms of achieving their objectives, with the Loch Linnhe, Hammerfest and Gothenburg reefs all rapidly attracting the target species and the protection reef in the Gulf of Cadiz achieving a dramatic reduction in illegal fishing activities. Similarly, the diving reef established off of Cornwall in the United Kingdom, has been an unqualified success in terms of recreation and education in that area.

It can therefore be concluded that at present, the potential benefits of reefs, aiming at enhancing production of living marine resources and restoring or protecting natural habitats, outweigh their negative impacts. However, these benefits and in particular the socio-economic benefits of artificial reefs made for other purposes such as recreation are likely to become a significant driving force for the expansion of artificial reef development. Given the potential for cumulative negative impacts – both as a result of increasing numbers of artificial reefs as well as an escalation in coastal zone usage in general – it is suggested that OSPAR establish a database or inventory of all artificial reefs and in order to provide a holistic picture, consider including other structures as well.

Linked to the above, the following can be recommended:

- In order to facilitate the establishment of an accurate database, OSPAR should introduce reporting for artificial reefs. This should include reporting on the establishment of new reefs, as well as submission of monitoring reports on existing reefs;

- In light of the discussions preceding the development and adoption of the OSPAR Guidelines on Artificial Reefs, OSPAR should examine the provisions of the Convention so as to provide a clear basis for management of artificial reefs.

6. References and literature

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Appendix A

Case study 1: Loch Linnhe

Location: West coast of Scotland off the island of Lismore. The site is in an area with little fishing activity. It is sheltered from the weather, has a varied current regime, and a depth of 12 – 30 metres.

Source: Map and photograph: Tom Wilding

Authorisation: the reef was licensed under the Food and Environment Protection Act, and was the first to be issued under the OSPAR Guidelines, and a devolved Scottish Executive.

Date of construction: 2001 – 2006.

Purpose of reef: to facilitate research between artificial reefs and the environment, including potentially beneficial effects on fisheries and local biodiversity. The long-term aim is to boost fish stocks by creating commercially viable man-made habitats.

Size, design and materials: The main reef complex comprises 30 reef modules, each of which consists of around 4 000 concrete blocks. Each reef is roughly conical, stands 3 – 4.5 metres above the seabed, and is 10 – 15 metres in diameter. Some of the blocks are solid, while others have voids to create “nesting spaces”. The total weight is just over 6 000 tonnes. The concrete contained a blend of cement and coal-ash (8%), and quarry dust. The blocks were tested prior to construction and were shown to be physically robust and chemically inert.

Monitoring programmes: There is ongoing monitoring as part of the research, to see what species are attracted to the reef.

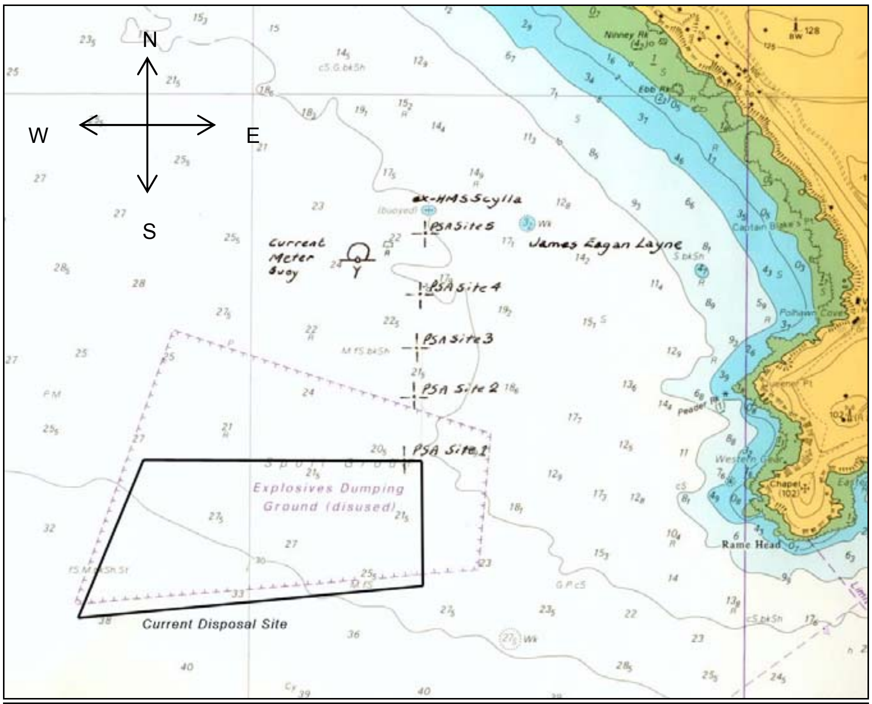
Did the reef fulfil its purpose? There is an active, multidisciplinary research programme associated with the reef including both fundamental and applied research. This covers: environmental impacts; impacts on the local current regime; water flows around the reef and associated sediment movements; an evaluation of the habitat complexity offered by the reef to crustaceans and fish of commercial importance (especially cod and lobsters); opportunities for seafood production; and comparison of productivity between natural and artificial reefs.

Environmental impacts: The most significant impact detected to date is a reduction in the oxygen levels in the sediments at the edges of the reef as a result of the accumulation of detritus, itself a consequence of reduced current flow. Associated with this is a change in the biological community, with a decrease in species sensitive to low oxygen, and a corresponding increase in those which are more tolerant of such conditions. These effects are more pronounced during summer and autumn, but are at all times limited to within 1 metre of the edge of the reef.

Further reading/information: http://www.sams.ac.uk/research/departments/ecology/ecology-projects/reef-ecology/researchproject.2007-03-09.9122641718

Case study 2: HMS Scylla

Location: Whitsand Bay, Cornwall, United Kingdom, in 23 – 28 metres of water close to the James Eagan Lane, a World War II vessel, and the most dived wreck in British waters, but which was disintegrating.



Extract of Admiralty Chart 1900 showing the positions of the Scylla, the James Eagan Layne, the Nortek current meter, and the grab sample sites for the particle size analysis of sediment. © *Crown Copyright. Reproduced from Admiralty Chart 1900 by permission of the Controller of Her Majesty's Stationary Office and the UK Hydrographic Office (www.ukho.gov.uk). Not to be used for Navigation.*

Authorisation: the reef was licensed by Department for Environment, Food and Rural Affairs under the Food and Environment Protection Act, following the completion of an Environmental Impact Assessment. One of the conditions was the implementation of a monitoring programme.

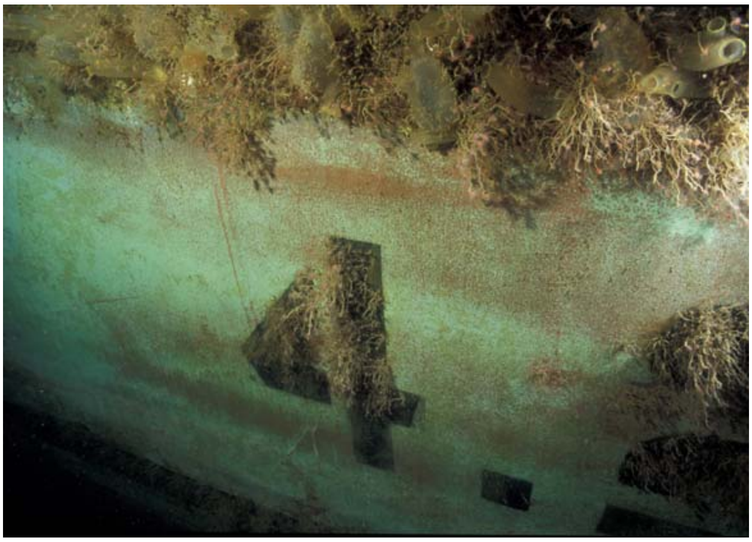
Date of placement: 2004.

Purpose of reef: the primary purpose was to provide a venue for recreational diving, but the reef has now also become an education and research centre linked to the National Aquarium in Plymouth.

Size, design and materials: The vessel was a decommissioned Royal Navy Frigate. It is 113 metres long, made of steel, and weighs 2 300 tonnes. It was thoroughly cleaned both during decommissioning and again prior to placement on the seabed.

Monitoring programmes: A 10 year monitoring programme is underway looking at the following:

i) Migration of Tributyltin (TBT) from the hull paint into the surround area



Differences in colonization between areas with and without an antifouling paint covering. (Photograph taken by Keith Hiscock 23rd April 2005).

ii) Changes in sedimentary processes as a result of the placement of the vessel

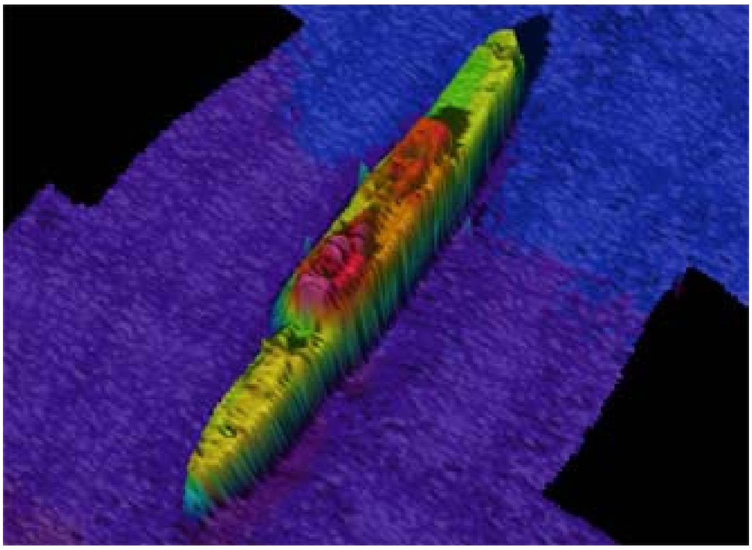
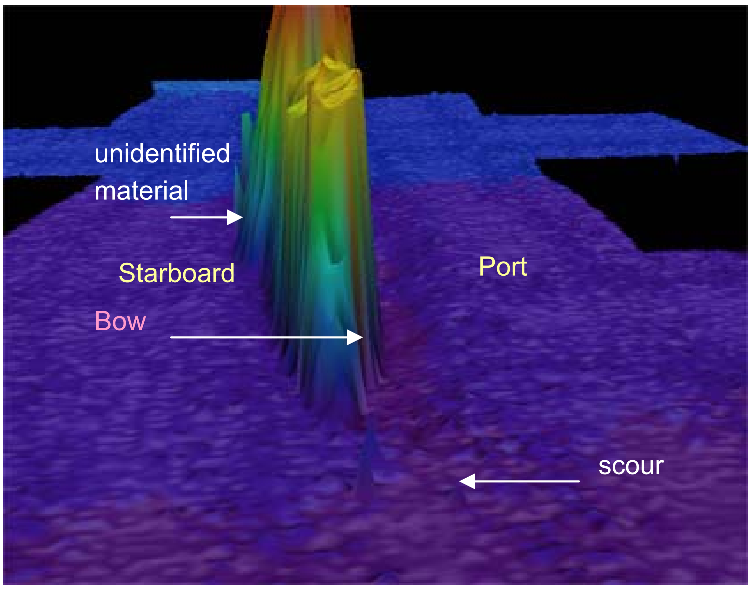
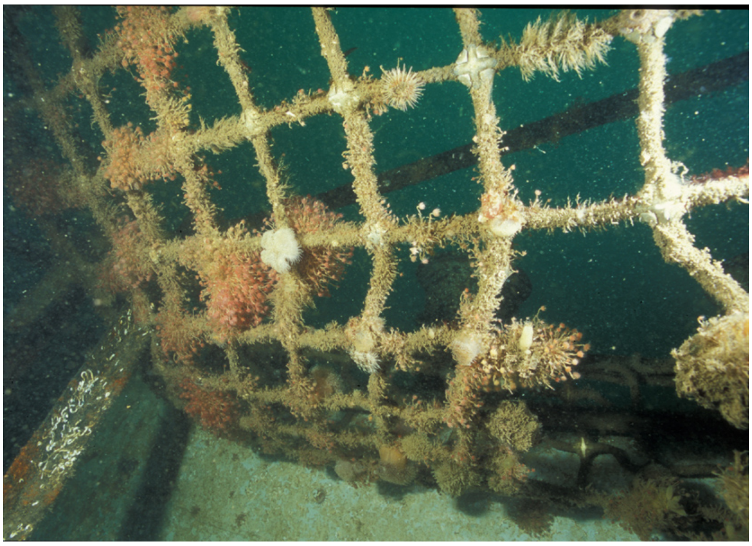


Image courtesy of the Royal Navy, Maritime Warfare School,
Hydrographic and Meteorological Training Group, HMS Drake, Plymouth.



Close up Fledermaus 3D image showing scour especially on port side. Image courtesy of the Royal Navy, Maritime Warfare School, Hydrographic and Meteorological Training Group, HMS Drake, Plymouth.

iii) Colonisation of the vessel



Colonization on deck netting including *Metridium senile*, and *Tubularia sp.* (Photograph taken by Keith Hiscock 23rd April 2005).

Scylla, starboard side. (Photograph taken by Keith Hiscock - 28th January 2006).

Scylla is now closely resembling the reference vessel, the James Eagan Layne (approx.600 m south-east from Scylla).

Video image of the James Eagan Layne, bow - April 2005.

A number of other organizations have been involved, to varying degrees, with data collection and analysis including Plymouth Marine Laboratory, University of Plymouth, University of Southampton, the Royal Navy, Unicomarine Ltd, Marine Life Information Network and Center for Environment, Fisheries and Aquaculture Science (CEFAS).

Did the reef fulfil its purpose? The artificial reef was primarily created as a resource for divers. A study carried out shortly after Scylla was placed indicated that Scylla Reef was a popular dive site (there was an increase in boat traffic in Whitsand Bay of between 200-300% in the first six months following placement), which generated additional income for the local economy.

Scylla Reef has also proved to be an excellent platform for science and education for example:

- Approximately 230 species have been recorded on or around Scylla to date, including the nationally rare nudibranch, *Trapania maculata;*
- Various in-house displays and out-reach programmes;
- The Virtual Scylla project, carried out in partnership with the University of Birmingham and the Marine Biological Association, uses computer gaming technology to create a three dimensional

model of the reef and run artificial life programming to enable prediction of the responses of marine life to environmental change.

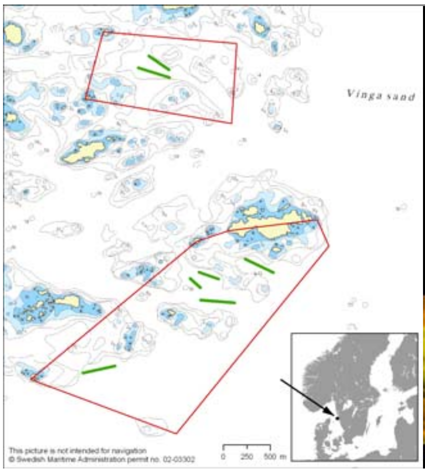
Environmental impacts: Tri-butyl tin has been found in biota samples collected from Scylla. This was not unexpected: DEFRA decided that the antifouling paint need not be removed from the hull due to the length of time since Scylla was last painted, and the environmental issues surrounding disposal of TBT containing paint. To date, there has been little, if any, colonisation on areas of Scylla still coated with antifouling paint, although it is expected that this will change over time. It should be noted that biota samples collected from the nearby wreck of the James Eagan Layne, as part of the baseline survey, also contained elevated levels of TBT before Scylla was placed on the seabed – the source of this TBT is unknown as it is outside the scope of the monitoring programme.

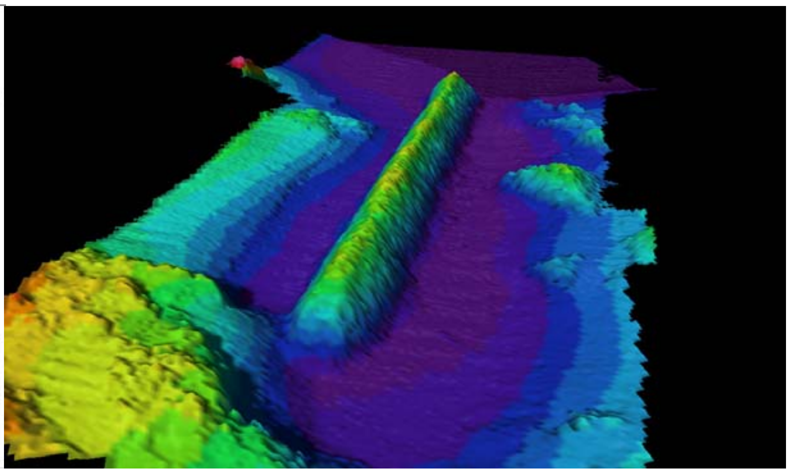
There has been anecdotal evidence of some siltation on the reef, the source of which has been suggested as the Rame Head disposal site located nearby – again investigation of this is outside the scope of the monitoring programme.

Further reading/information: www.national-aquarium.co.uk for background information on the project. For details of the monitoring programme (up to and including data for 2007) a report was completed by the National Marine Aquarium and sent to DEFRA.

Case study 3: Gothenburg Reefs

Location: Within two protected areas (Tanneskar and Buskar) outside of Gothenburg Harbour, Sweden, on a sandy bottom and in depths between 20 and 37 metres.





Authorisation: a permit was issued by the Swedish Environmental Protection Agency following an environmental impact assessment.

Date of construction: 2003.

Purpose of reef: to compensate for the loss of habitat caused by the deepening of the shipping channel into Gothenburg Harbour, in particular habitat utilised by lobster.

Size, design and materials: The project involved the construction of 7 reefs, each 130 – 380 metres long, 30 – 45 metres wide and 4 – 14 metres high. They were made of approximately 800 000m^3 of rocks excavated during the deepening of the shipping channel.

Monitoring programmes: A significant monitoring programme to track the development of biological communities on the reefs – and to assess their effectiveness in terms of increasing productivity of particular species (lobster, brown crab, cod, saithe, pollack and whiting) - was conducted with EU funding between 2002 and 2007.

Did the reef fulfill its purpose? The monitoring programme showed that certain species – including lobster and commercial fish species such as cod – were strongly attracted to the reefs. Lobsters, for example, migrated onto the reefs within 4 weeks of construction. However, the monitoring period was too short to allow conclusions on increases in productivity.

Environmental impacts: biodiversity was negatively influenced by heavy sedimentation at some parts of the reef and, at some sites, by the development of sulphur bacteria, indicating a lack of oxygen.

Further reading/information: http://www.lansstyrelsen.se/vastragotaland/English

Case study 4: Hammerfest Reefs

Location: Off Hammerfest in the very north of Norway, at the islands Seiland and Soroya, in a depth of 10 – 20 metres.

Authorisation: a permit was issued by local harbour authorities with the support of the environmental official in the Hammerfest community administration.

Date of construction: 2006.

Purpose of reef: i) to enhance and re-establish kelp and other seaweeds, and marine animals, including fish, in an area where sea urchins have grazed the kelp forests; and ii) to study the development of fouling organisms and mobile organisms at the reefs in relation to sea urchin recruitment and density in the area.

Size, design and materials: 24 units of Runde reef, 12 at each of two locations. Each element consists of a central cylinder made of concrete (2.5 meters in height and 1.4 metres in diameter).

The cylinder is filled with stones to increase weight and stability. From the cylinder 14 vertical rows of 2.5m long polyethylene pipes – with a diameter of between 9 and 18 cm – radiate outwards. Together, the cylinder and plastic pipes on each unit provide an external and internal surface area of 250m^2, the pipes provide 300m pipe length, and the total weight is 9 metric tonnes.

Monitoring programmes: The studies will begin in April 2008, but preliminary observations showed that after the first day of exposure in July 2006, the reefs had attracted juvenile cod, and by the spring of 2007 the reefs were overgrown with kelp and other macroalgae and additional species of fish were observed. The reefs will be visited two or three times in 2008, 2009 and 2010, but further funding of monitoring is so far unsure. In 2008 the reef units were even more overgrown by kelp, particularly sugar kelp, and juvenile fish were also exploiting the reefs as habitats.

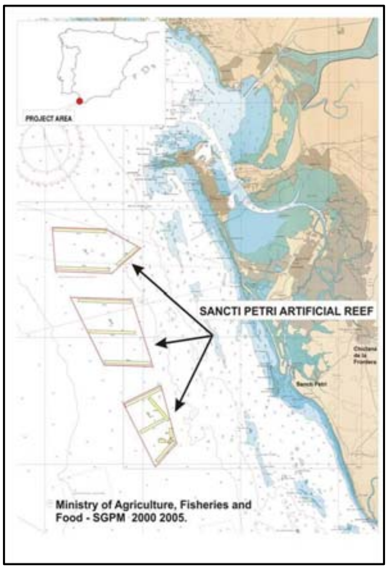
Did the reef fulfil its purpose? The preliminary studies have shown that kelp and other seaweeds are growing on the structures, and that the reef has attracted a number of sessile and mobile animals, including fish. The presence of juvenile cod and saithe in the summers of 2006 and 2007 indicates that they are providing suitable shelter to replace that lost with the disappearance of the kelp forests.

Environmental impacts: No environmental impacts have been observed.

Further reading/information: No scientific publications yet available.

Case study 5: Sancti Petri Artificial Reef

Location: Coast of Cadiz, SW Spain between depths 15 – 40 meters and parallels 36º 29.229´N and 36º 19.807´N near the Gibraltar Strait. The site is in an area with sand-mud bottom bordered by a rocky area on the east side towards the shore, and it supports a high artisanal fishing activity.



Authorisation: the reef was developed by the Spanish Ministry of Agriculture, Fisheries and Food (at present Ministry of the Environment and Rural and Marine Affairs) and licensed under the Shores Act and under Royal Decree 798/1995 and financed by the EEC-FIFG.

Date of construction: 2000 - 2005.

Purpose of reef: to protect fish populations from the action of illegal bottom trawlers (forbidden in the area, which is 6 miles from the shore), reducing catch pressure, avoiding damages to artisanal fishing gears and reducing social conflicts.

Size, design and materials: The artificial reef complex comprises 3 Reef Zones, each of which consists of 3 “barriers” placed perpendicular to the trawling routes with a 1-mile distance of free area between each one.

Each protection barrier is rectangular, between 2 000 to 4 000 meters long and 200 meters wide, each one with a variable number of artificial reef units (81 to 41) placed on the sea floor at distances of 75 to 200 m, preventing the passage of the bottom trawling gears. All the artificial reef units are reinforced concrete blocks of about 5.5 tonnes, with a cross-shaped base of 3 by 3 meters in order to prevent them sinking in the sediment. The cylindrical upper part incorporates protruding steel girders.

The total number of artificial reef units placed is 569. The total protected area is 4 818 ha with only 2 845m^2 occupied by the artificial reef units (0.006 % of the protected area).

Monitoring programmes: Three studies (one every two years) by means of a side scan sonar for the monitoring of structural and functional quality of the artificial reef are made. Controls over the artisanal fishing catches and the activities of trawlers are made, and opinion polls among fishermen carried out.

Did the reef fulfil its purpose? The results of the studies show a dramatic decrease of illegal trawling activity in the area. In the opinion of artisanal fishermen, the fish catches are consequently starting to increase and stabilize.

Environmental impacts: Due to the small sea-bed footprint by the reef units and their physical and chemical stability, no significant impacts have been detected. Entanglement of some trammel nets has occurred, but with no resultant “ghost fishing”.

Further reading/information: There are only unpublished technical reports about the issues mentioned above.

Appendix B

Table 1: Summary of existing and planned artificial reefs in the OSPAR Maritime Area

Country	**Location**	**Date**	**Purpose of reef/s**	**Design and materials**	**Size**	**OSPAR Region**
Belgium	None					
Denmark	Vejle Fjord	2005	Habitat enhancement	Sacks of blue mussel shells	0.2 km^2 (20ha)	Region II
Denmark	Laeso Trindel (Northern Kattegat) 12 km offshore.	Summer 2008	Restoration of natural habitats and species of Community interest	Natural rocks	45 000m^2 (4.5ha)	Region II
Denmark	Limfjord	Under consideration	Research on hard substrate as a habitat for marine algae and algal growth in relation to nutrient concentration. 2009 report: http://www.blst.dk/English	Not yet decided	Not yet decided	Region II
France[1]	Mimizan	1983, 1990-2006	Research and public awareness on the protection of the marine environment	1983 – a combination of tyres (2 800), ropes and concrete blocks. 1990 (40 tonnes) 1994 – a barge (20 tonnes) 1996 – 3 000 tyres 2002 – 14 x 3.5tonne concrete blocks 2004 (142 tonnes) 2005 (40 tonnes) 2006 (51 tonnes)	Over an area of 2ha	Region IV

[1] For statistical purposes the “reef” construction in each area (*i.e.* Mimizan and Capbreton Vieux Boucau Moliets) have been treated as a single reef.

Country	Location	Date	Purpose of reef/s	Design and materials	Size	OSPAR Region
France	Capbreton Vieux Boucau Moliets	1999 - 2004	Enhancement of local fisheries and research on protection and conservation of the marine environment.	Concrete pipes	3 areas of 16ha, with 800m^3 /site.	Region IV
France	Ile d'Ýeu – Le Croisic	2003	Experimentation on the durability of the structures and production	Concrete modules: i) Protection modules – 6m^3 (13 tonnes) ii) Large modules – 156m^3 (57 tonnes) iii) Small modules – 5m^3 (3 tonnes).	3 areas of 500 x 1000 metres (50ha).	Region IV
France	Etretat	2008	Experimental reefs to evaluate marine resource enhancement effectiveness	169 concrete blocks (1.4m^3) Exterior circle of 25 units Interior circle of 9 reefs of 16 blocks 1 large central module of reinforced concrete (54m^3).	500 x 500 meters (25ha)	Region II
Germany	Bremerhaven (3 sites)	2004	Compensation for habitat lost during port construction.	Natural rocks	5 000m^2 (0.5ha) 2 000m^2 (0.2ha) 2 000m^2 (0.2ha)	Region II
Iceland	None					
Ireland	None					
Nether-lands	8.5 km offshore of Noordwijk aan Zee	1991	Research into changes in habitat and biodiversity (Monitored between 1991–1995).	4 mounds of basalt rock	Each mound 8 x 14 meters Total 448m^2 (0.04ha)	Region II

Country	Location	Date	Purpose of reef/s	Design and materials	Size	OSPAR Region
Nether-lands	Easterscheldt (to be decided)	Planned	Recreational diving	To be decided		Region II
Norway	Risør (2 units)	2002	Fish attraction, marine resource enhancement & research	Concrete and plastic units	Each reef unit has a diameter of 6m and upright height of 2.5m	Region II
Norway	Lofoten (2 reefs)	2004	Fish attraction	Concrete walls and pyramids with windows/ holes	Each group of walls and pyramids covers ca 50 x 50 meters (0.25 hectares)	Region I
Norway	Hammerfest (24 reef units/ 2 locations)	2006	Re-establishment and enhancement of kelp, other seaweeds & associated animals.	Central cylinder of concrete with radiating polyethylene pipes	Each reef is 6m in diameter, and each group of 12 reef units covers ca 80 x 60 meters (0.48 hectares).	Region I

Country	Location	Date	Purpose of reef/s	Design and materials	Size	OSPAR Region
Portugal[2]	Faro and Olhão reefs, Algarve coast near Faro	1990	Experimental reefs to evaluate ecological impacts, & effectiveness in terms of fish stocks and coastal resource management.	Concrete lattice units and blocks		Region IV
Portugal[3]	Ancão reef, Algarve coast near Faro	2002	To increase and diversify fishing yield for commercial purposes, diving and research.	19,000 concrete modules.	35km^2 (3 500 hectares)	Region IV
Portugal[4]		Under consideration	Recreational diving	Disused vessel		Region IV
Portugal	São Pedro do Estoril, Municipality of Cascais	Under consideration	Surf reef	Rock or sediment filled geotextile bags	Not known	Region IV
Spain	Pais Vasco	1960	Recreational diving	Disused steel vessel		Region IV
Spain	24 reefs in various locations (Asturias, Cantabria, Galicia, Andalucia Cadiz, & Andalucia Huelva).	1986 - 2005	Mainly fisheries management (deterrent or production units, which may also serve to attract fish)	Mainly concrete units with dissuasive elements		Region IV.
Spain	Pais Vasco	2003	Recreational diving	Several disused steel vessels (after clean-up)		Region IV
Spain	External waters of Huelva-Cadiz	2008	Fisheries protection and enhancement	2 polygons	9211.9 ha 2,257.7 ha	Region IV

[2] *Ibid.*

[3] *Ibid.*

[4] Information from OSPAR Secretariat.

Country	Location	Date	Purpose of reef/s	Design and materials	Size	OSPAR Region
Sweden	Gothenburg	2003	Compensation for habitat loss and enhancement of living marine resources	Natural rock excavated during deepening of entrance to Gothenburg Harbour.	130 – 380 meters and 4 – 14 meters high.	Region II
UK	Poole Bay	1989	Research on use of waste from coal-fired power station in artificial reef construction	Purpose-built modules using stabilized waste from coal-fired power station	8 modules each 1m high and 4m diameter – total 50 tonnes	Region II
UK	Poole Bay	1998	Extension to the above research project using tyres and concrete in place of concrete and coal ash in artificial reef construction	Purpose built modules using scrap tyres and concrete	500 tyres	Region II
UK	Whitsand Bay, Cornwall	2004	Leisure diving/education & research. Linked to National Aquarium in Plymouth.	Decommissioned frigate (HMS *Scylla*)	Length: 113m	Region II
UK	Loch Linnhe - Scotland	2006	Research on beneficial effects on fisheries and biodiversity	Purpose-built reef complex	30 units of 10 – 15 meters diameter, and 3.5 – 4 meters high.	Region III
UK	Boscombe, Bournemouth	Approved for construction	Surf reef	Geotextile bags filled with gravel and sand	5 450m2	Region II

Appendix C

Table 2: Summary of national regulations on artificial reefs

Country	Competent Authority	Legislation/regulations/guidelines	EIA Requirements
Denmark	Ministry for Transport	No specific legislation, but Act for the Marine Environment covers permissions for offshore constructions in the marine environment (Miljømålsloven).	Yes – as part of construction phase (Environmental Impact Assessment, Regulations)
Germany	Devolved to state level – see next column for details.	Federal Nature Conservation Act and Water Resources Act and corresponding laws of the Federal States; and National Park Law. Federal states include: a) Schleswig-Holstein: Ministry of Agriculture, Environment & Rural Areas; Agency for Coastal Defence; National Park and Marine Conservation (for Wadden Sea). b) Hamburg: Authority for Urban Development and the Environment; c) Bremen: Senator for the Environment, Building, Transport and Europe. d) Niedersachsen: Ministry for the Environment, Climate Protection, Water Management and Coastal Defence; Nature Conservation Agency.	In principle, impact assessments are required within legally protected areas according to EU legislation (Natura 2000).
Ireland	Function is being transferred to Dept of Environment, Heritage and Local Government.	Foreshore Act, 1933 (as amended) and European Communities (Environmental Impact Assessment) Regulations, 1989 to 1999. European Communities (Natural Habitats) Regulations, 1997.	No specific legislative requirement but and EIA may be required at the discretion of the Minister.
Netherlands	Ministry of Transport, Public Works and Water Management	Law for the Management of National Infrastructure	Yes (if > 10m x10m)

Country	Competent Authority	Legislation/regulations/guidelines	EIA Requirements
Spain	Ministry of the Environment and Rural and Marine Affairs	The Shores Act, 1988 Maritime Fisheries Act, 2001 Royal Decree 798/95 (criteria and requirements for AR projects for fisheries purposes) Methodological Guidelines for Artificial Reefs Placement, 2008	In principle, impact assessments are required within legally protected areas according to EU legislation (Natura 2000).
Sweden	Swedish environmental protection agency and Swedish board of fisheries	The Environmental Code and The Fisheries Act	The Environmental Code requires an EIA for both the reef and other activities that may affect the artificial reef.
UK	Department for Environment, Food and Rural Affairs (DEFRA): Marine Consents & Environment Unit	Food and Environment Protection Act, 1985 (as Amended); and Coast Protection Act, 1949 (as Amended).	Yes – under Marine Works (Environmental Impact Assessments) Regulations, 2007

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