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Worldwide rigs-to-reefs experiences: considerations and motivation for a Living North Sea

Would the North Sea benefit from reusing offshore materials for artificial reefs?

Report Feasibility Update
Living North Sea Initiative

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Contents

List of abbreviations

BOEM	Bureau of Ocean Energy Management (former BOEMRE)
BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement (former MMS)
BSSE	Bureau of Safety and Environmental Enforcement (former BOEMRE)
CEQA	California Environmental Quality Act
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CNS	Central North Sea
COE	United States Army Corps of Engineers
DFG	Department of Fish and Game
DMR	Department of Marine Resources
EARRN	European Artificial Reef Research Network
EPA	Environmental Protection Agency (USA)
GoM	Gulf of Mexico
MGFB	Mississippi Gulf Fishing Banks
MMCC	Mississippi Marine Conservation Commission
MMS	Minerals Management Service
MPA	Marine Protected Area
NNS	Northern North Sea
OPC	Ocean Protection Council
OSPAR	Oslo Paris Convention
PSC	Production Sharing Contracts
SCB	Southern California Bight
SLC	State Lands Commission
SNS	Southern North Sea
UASC	United Anglers of Southern California
USCG	United States Coast Guards
UTS	University of Technology Sydney

1. Introduction

Rigs-to-reefs is the process of converting obsolete offshore oil and gas structures into artificial reefs. Since the 1980s this approach is used as an alternative to full removal to shore in the USA, and in particular in the Gulf of Mexico. In several states of the Gulf of Mexico special reefing programmes have been developed with government support. In this report we analyse existing experiences of leaving platforms offshore for artificial reef purposes, in order to understand what would be key lessons that need to be taken into account, if setting up similar programmes in the North Sea.

This study is part of the Living North Sea Initiative, which aims to contribute to improving the ecological status of the North Sea and to develop a funding mechanism for the design and implementation of improvement plans (OSPAR, 2010; IMSA Amsterdam, 2011). In the first place, LiNSI focuses on the potential opportunities provided by the upcoming process of decommissioning of offshore oil and gas installations.

1.1. Objectives and study approach

This report is part of the Feasibility Update of the Living North Sea Initiative and follows on Phase 1, a study phase to asses the economic, ecological, political and legal feasibility of leaving offshore oil and gas structures for artificial reefs in the North Sea. In Phase 1 it was concluded there are overriding indications that leaving in place oil and gas installations (jackets) would have no negative effect on the North Sea ecosystem. Since these installations have become part of this system in the past 30 years, it might even have a negative effect to remove them. It was also concluded that cost savings can be significant and that if political and societal will is there, legal obstacles can be overcome. The observations and interpretations of this report are based on desk research and expert interviews (see annex I for details interviewees).

Objectives

- To understand the functioning of current rigs-to-reefs programmes in other parts of the world and to analyse the successes and failures.
- To analyse similarities and differences between the context of rigs-to-reef programmes elsewhere and in the North Sea region.
- To translate these learnings into recommendations for a potential rigs-to-reefs programme for the North Sea, including an assessment of what this would mean in terms of programme objectives, spatial positioning, costs and legal arrangements.

Geographical scope

The reference areas used to draft North Sea perspectives are the Gulf of Mexico and California. Both regions have the administrative and legal frameworks for rigs-to-reefs in place, but specifics of their programmes differ. The Gulf of Mexico experiences are very extensive with 30 years of rigs-to-reefs, while California started only two years ago.

2. Rigs-to-reefs: worldwide experiences

The term "rigs-to-reefs" describes a type of artificial reefing, using materials of offshore oil and gas structures. Before we go into the worldwide rigs-to-reefs experiences, we will describe the knowledge (gaps) of and experiences with artificial reefs applications.

2.1. General facts and figures on artificial reefs

An artificial reef is "a submerged structure placed on the seabed deliberately, to mimic some characteristics of a natural reef […] specifically built for protecting, regenerating, concentrating and/or increasing the production of living marine resources, whether for fisheries or nature conservation. This includes the protection and regeneration of habitats ", according to the guidelines of OSPAR (1999). Artificial reefs have been used for centuries, but the active construction and design started in the 17th century in Japan. Especially in the USA, Japan and Italy artificial reefs are frequently used for fisheries and mariculture. Japan is leading in artificial reef research on efficiency and design (Fabi et al., 2011).

Artificial reefs have been placed in European waters since the 70's and 80's. Italy is most progressive for European standards, with well-organized scientific programmes and involvement of governments and fisheries stakeholders (Baine, 2001; Jensen, 2002). Over 56 artificial reefs have been created or are planned in the OSPAR Maritime Area, of which the majority is located in the Bay of Biscay and the Iberian Coast (Jensen, 2002; OSPAR, 2009; Fabi et al, 2011). Also in the North Sea some artificial reefs have been developed, such as at Noordwijk at the west coast of the Netherlands (Leewis & Hallie, 2000). This scientific reef project started in 1992 and showed increases in local marine biomass. It was halted early on, because fishers felt constrained by the reef and opposed to it.

Objectives of artificial reefs

The impact of man-made constructions offshore has proven to influence the surrounding marine life. The addition of artificial hard substrates enhances certain marine ecological conditions and has therefore become a popular tool for governments and private parties, using it for different purposes (Nautilus Consultants, 2003; OSPAR, 2009) including the following.

- Nature conservation: habitat restoration and compensation of habitat loss. Artificial reefs - like other habitats - support the development of some species, but not of all. They can increase the ecological connectivity and can have important biogeographical consequences. Depending on the type of species, this can be positive, neutral or negative. Sessile species cover the hard substrate, varying with location and depth, so for these species artificial reefs are supportive. The reef can develop into a small, well-functioning ecosystem where various species reside and spawn. The bigger pelagic fish species are primarily attracted for food and shelter and do not seem to spawn at the artificial reefs (Pickering, 1997). Artificial reefs have a different purpose than fish aggregation devices. They also attract and aggregate fish, but have the aim to create a functioning ecosystem by capturing energy (sunlight) and nutrients and magnifying and exchanging these (Pickering, 1997; Baine, 2001; personal communication Q. Dokken, see annex I).

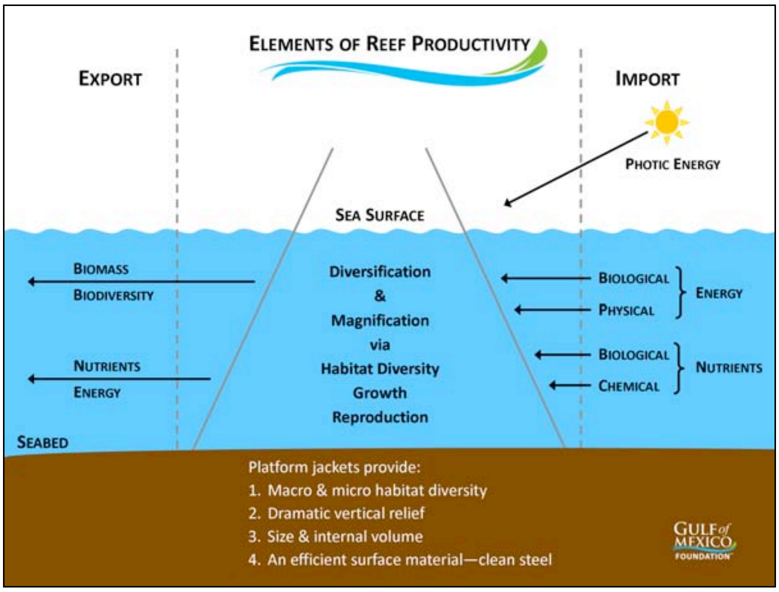


Figure 2.1. Ecological impact of platform structures as artificial reefs (Dokken, 2012)

- Fisheries and maricultures: providing habitat for crustacean fisheries (e.g. lobster); aquacultures for molluscs, algae, sponges, worms, etc.; and increasing pelagic fish stocks. Reefs are associated with high catch rates of economically important fish species (Grossman et al., 1997). Increases of fish catches around artificial reefs of 5% to 4000% have been documented (Santos et al., 1996). From a fish experiment at the Ekofisk platform the researchers concluded that platforms enhance fishing operations, because aggregations of large fishes such as cod and saithe are significant (Soldal et al., 2002).

- Sea defence and wave reduction device: creating shelter areas for shipping and other offshore activities; and expanding the barrier structures near-shore.

- Recreational activities such as sport fishing or diving; in the Gulf of Mexico many people approach the platforms to spend their weekends diving and fishing around the structures.

Beneficial effects of artificial reefs

The creation of an artificial reef has two main effects.
- It provides hard substrate habitat.
- It forms a barrier structure and locally excludes trawl fisheries.

Artificial reefs are used to imitate natural reefs. However, they are not equal to natural reefs; often the reef communities differ, even after longer time spans of 30 years (Perkol-Finkel et al., 2005). Artificial reefs can function as stepping-stones for both sessile and mobile species (Langhamer, 2007), by providing the necessary habitat for hard-substrate species that would otherwise be absent. Artificial reefs provide food, shelter and nesting sites for fish. As a result stock sizes may increase. If a species population is habitat-limited (low availability of suitable habitat) or recruitment-limited (bounded by survival, dispersion and settlement of larvae) due to lack of hard substrates, the addition of artificial reefs can result in sustained increase in biomass (Macreadie, 2011; Bohnsack, 1989). The regional impact depends on a) interconnectivity of populations, b) the total platform reef area compared to total reef areas and c) the effect on specific key species that favour the conditions of platforms (Holbrook et al., 2000).

At the same time artificial reefs can form shelter areas, excluding trawl fishing where the material is located. In 2011 Greenpeace even purposely placed stones at the Cleaver Bank area of the North Sea to obstruct trawl fisheries. The presence of oil and gas structures also function as fisheries exclusion zones, in the first place by creating a network of steel beams and offering shelter space for marine organisms, and in the second place by its safety zone with a radius of 500 meters around the structure (Schroeder & Love, 2004).

Adverse effects of artificial reefs

Artificial reefs may also have adverse effects. As they form stepping-stones for sessile and mobile species, they can also be stepping-stones for invasive species that could benefit from additional hard substrates offshore. Research programmes on wind parks in the North Sea have shown the settlement of some exotic species (e.g. Japanese oyster, New Zealand barnacles) on the foundation of the turbines, but it is possible that these already attached near shore (Page et al., 2006; Krone et al., 2007). However, the addition of hard substrates is not the critical factor for the spreading of invasive species; the most important factors that promote settlement of exotic species are ballast water from the shipping industry and climate change (Hewitt et al., 2011). It is unlikely that the presence of an artificial reef will cause widespread ecological damage (Grossman et al., 1997).

Material and design of artificial reefs

The size of a reef, the type of material and its location define the artificial reef development and impact. The diversity of species and their possible production rate is assumed to increase with reef complexity. The importance of design complexity, configuration of the reef, size and volume are noted by many researchers (Baine, 2001). The impact of artificial reefs may be maximized by placing the reef material on specific locations related to larval dispersal routes (Macreadie, 2011; Cowen & Sponaugle, 2009).

The materials used for artificial reefing influence the settlement of corals, sponges, anemones, etc. Especially materials with an open, complex structure are effective for creating a reef, because it creates shelter without stopping light from coming through and because it maximises the amount of substrate to which sessile species can attach themselves (Baine, 2001).

2.2. Rigs-to-reefs programmes

The first conversion of an oil and gas structure into an artificial reef took place off the coast of Florida in 1979. Since then, other states and countries have started rigs-to-reefs programmes, in which reefing of offshore oil and gas structures is a well organised and documented alternative to full removal to shore. In most cases, reefing entails the towing of a structure to a designated reefing site and only incidentally the leaving of a structure in its original place. Table 2.1 describes the background of rigs-to-reefs programmes and initiatives worldwide.

Table 2.1. Rigs-to-reefs worldwide

Where	Description & status
Gulf of Mexico	Since the late 80s and 90s, the states of Louisiana, Alabama, Texas and Mississippi have artificial reef plans that allow for rigs to be towed to designated reefing areas. Of the more than 4000 platforms, about 2000 structures have already been decommissioned: 10% of these platforms have been reefed and the others have been removed. For more information, see paragraph 3.1. The initiative Save the Blue is promoting to change the current policy of the Gulf of Mexico rigs-to-reefs programmes to a format in which platforms are always left in place, unless they appear to be contaminated. They claim the ecological and recreational value of the platforms is so high that they should be protected instead of removing them (www.save-the-blue.org).
California	Off the California coast there are 27 platforms that will need to be decommissioned in the coming years. Since 2010 the artificial reef plan, and administrative and legal frameworks are in place but no rigs-to-reefs have been applied so far. For more information, see paragraph 3.2.
Brunei Darussalam	Two major rig to reef programmes also took place in the waters of Malaysia and Brunei. In 1985, Brunei Darussalam launched an Artificial Reef Programme to enhance local fish productivity. Artificial reefs were established near Berakas, far away from commercial shipping lanes. In 1988 BSP placed two rigs to build a Rig Reef, and in 1994 five extra jackets formed a second Rig Reef. These structures were located in water depths ranging from 16m to 60m. The artificial reef functions as breeding ground for fish and supply to surrounding coastal waters. The reef was also made accessible as a diving hotspot to recreational divers (Yus et al., 1999; Twomey, 2012).
Malaysia	In 1975 the Baram 8 structure of Shell Malysia was damaged in a storm and collapsed on the seabed. In 2004 the structure was sunk near the natural Sarawak Siwa reef to become Malaysia's first artificial reef. Malaysia does not have a clear regulatory framework on decommissioning and reefing. In this specific case many stakeholders worked together to get permission to leave the rig in place , including local and federal governments and the Sarawak Tourist Board. The area selection for rig-to-reef is now done by Production Sharing Contracts (PSC) and cost/benefit analyses are conducted on a case-by-case basis (Twomey, 2012; Boothby, 2010).
Australia	In Australia about 60 oil platforms are to be decommissioned, but reefing options are not allowed yet. Government and oil and gas industry stakeholders are considering the potential for rigs-to-reefs, but are not rushing the process. Scientists of the University of Technology Sydney (UTS) urge the stakeholders to start with scientific studies to test the actual impact of rigs-to-reefs. They have preliminary data that suggest that platforms are important sites of fish production and propose leaving part of them in place or towing them to reef areas for ecological purposes. They even assess rigs-to-reefs at locations of more than 500 meters deep for deep-sea habitat creation, meaning a relocation of oil and gas structures to deeper waters (Macreadie et al., 2011; Macreadie et al., 2012; personal communication P. Macreadie, see annex I).

Focus of this report

In this report we will focus on the USA experiences in the Gulf of Mexico and California so far (see chapter 3), to analyse the potential of North Sea rigs-to-reefs. These programmes already have the legal frameworks, administration tools and reef management in place and can help us understand if similar programmes are possible for the North Sea case.

3. Lessons to be learned from the USA

In this chapter we discuss first the Gulf of Mexico, which has about 30 years of successful artificial reef experiences which was initiated by sport fishers and divers. Secondly, we describe the rigs-to-reefs developments in the California Bight, where political stakeholders have recently introduced the rigs-to-reefs programme and received quite some resistance.

The US has committed itself to national standards for artificial reefs under the National Fishing Enhancement Act of 1984. NOAA (2007) has translated the act into practical guidelines "National Artificial Reef Plan". The guidelines indicate rigs-to-reefs should a) benefit marine living resources, b) not be used to dispose of contaminated materials, and c) try to leave the structure in place and add other materials to create an artificial reef (Wilson, 1991; Schroeder & Love, 2004). All national rigs-to-reefs programmes need to take these into account.

In the paragraphs below we separately elaborate on both rigs-to-reefs regions. We start with a geographical outline and the oil and gas programmes that have developed in each region. Then we focus on the evolvement, support, practices, finances and legal issues of the rigs-to-reefs programme.

3.1. The Gulf of Mexico

The Gulf of Mexico covers nearly 600,000 square miles across five US states (Alabama, Florida, Louisiana, Mississippi and Texas), six Mexican states and Cuba. The Gulf has a variety of coastal and marine habitats, including wetlands, barrier islands, beaches, and coral and oyster reefs. These habitats are rich in biodiversity. Coastal and near-shore habitats are major nurseries and foraging and stopover sites for birds, whereas near-shore habitats have a nursery function for several important species of fish and invertebrates. Offshore, the Gulf supports biologically diverse marine habitats and species, including deepwater corals, sponges, fish stocks and other unique communities (Gulf Coast Ecosystem Restoration Task Force, 2011).

These habitats provide a broad range of ecosystem services, including "fisheries, wildlife-related activities, food production, energy production, infrastructure protection and recreational opportunities". The economic value of these ecosystems is significant as the Gulf of Mexico produces 30% of the nation's gross domestic product in 2009; e.g. 90% of the nation's offshore oil and natural gas production and 33% of the nation's seafood (Gulf Coast Ecosystem Restoration Task Force, 2011). In the last decades large parts of the coastal marine habitat was lost (estimated up to 50%) due to hurricanes and human activities, i.e. mineral mining, oil and gas pollution, coastal development, oyster exploitation, etc.

The oil and gas offshore production started in 1947 and approximately 4000 offshore oil and gas structures have been/are in use in the Gulf of Mexico, at depths varying from 3 to 1830 meters (see figure 3.1). More than 2200 structures have already been decommissioned and in the last ten years an average of 125 structures have been removed annually (Kaiser & Pulsipher, 2005). These structures provide additional hard substrate in the Gulf of Mexico.

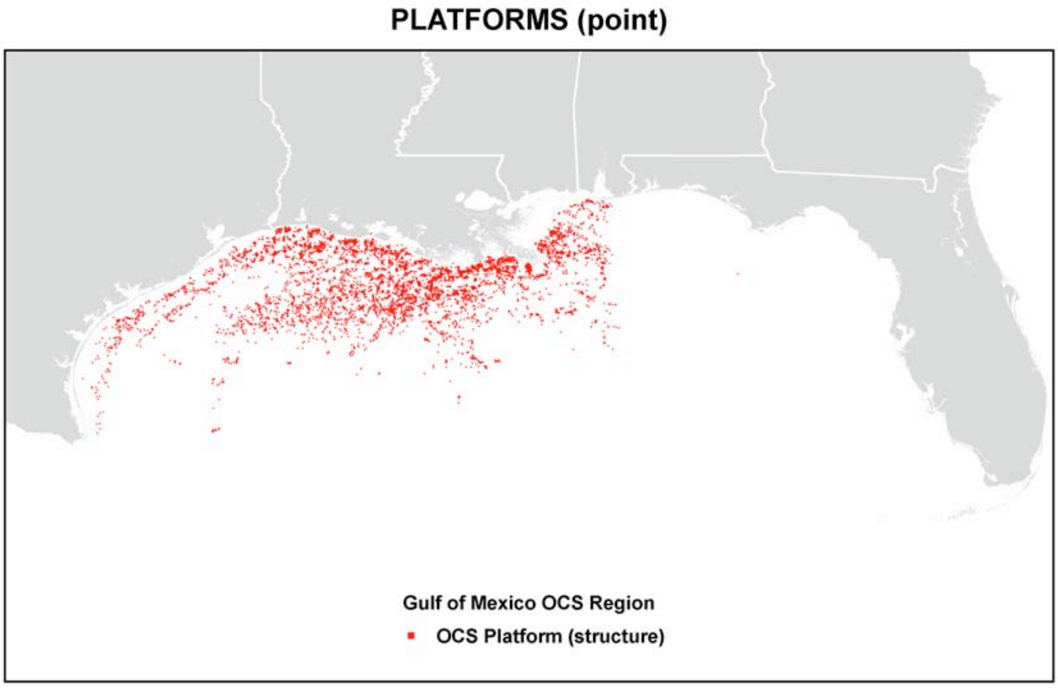


Figure 3.1. Distribution of platforms in the Gulf of Mexico (BOEM, 2012; for illustrative purposes only)

The Outer Continental Shelf is regulated by the federal regulation of the Bureau of Ocean Energy Management (BOEM) and the general requirement is that all platforms are removed to shore. In state waters the state agencies are responsible for decommissioning practices (Kaiser & Pulsipher, 2005).

The five coastal states of the Gulf of Mexico (Alabama, Florida, Louisiana, Mississippi and Texas) all have artificial reef programmes, but only Texas and Louisiana have included platforms as a common reef attribute. Alabama, Mississippi and Florida have accepted some structures. Reef creation is currently also recommended as an ecosystem restoration measure. Reefing in territorial and coastal waters for instance could restore and protect oyster and coral reefs (Gulf Coast Ecosystem Restoration Task Force, 2011).

Rigs-to-reefs programmes in the Gulf of Mexico

History and current status

First reefing of a rig occurred in 1979; an Exxon subsea production system in the waters of Louisiana was towed to a reef site off the coast of Florida, followed by the reefing of an obsolete jacket in 1982. The Minerals Management Services (MMS), the federal agency responsible for submerged lands, took the initiative of assessing the recreational use of oil and gas structures at the beginning of the 80s. Together with the National Marine Fisheries Service they studied the impact of the structures on the local ecosystems. The original aim of rigs-to-reefs was to enhance sport fisheries (Dauterive, 2000).

The programmes of Texas and Louisiana are the largest; they have the highest activity of the oil and gas industry, the largest structures and the longest coastlines. These states have similar reef plans, with the difference that Louisiana has a few designated reefs, while Texas uses exclusion mapping within a dedicated reefing zone. The zone runs from about 100 miles offshore to 160 miles offshore and was selected on the highest concentration of operational platforms. Next to the rigs-to-reefs programme these states also have 'community programs', which allow locals to create their own aggregation devices for fishing and define a limited amount of components, which need to be approved by the artificial reef agency.

The states of Alabama, Mississippi and Florida also have artificial reef programmes, but the oil and gas industry has not been so active in these state waters, so rigs-to-reefs programmes are limited. The community programmes are relatively large and the designated reef area covers the whole coast. In Florida the reef programme tries to convince operators from Texas and Louisiana waters to bring their structures to Florida.

So, in general the reef programmes are only allowed in designated reef areas. However, some states have designated (almost) the whole coastal waters (i.e. Alabama, Mississippi), while others use zones or smaller reef areas (i.e. Texas, Louisiana).

For more specific information on the programmes, see box 1 below.

Stakeholder positions

In the Gulf of Mexico several stakeholders have a positive view on the presence of platforms with respect to the regional ecosystem. As there a no safety zones around structures, vessels are not prohibited to come near structures. As fishers and divers are allowed to use the sites for recreation they have been promoting leaving structures offshore. Many anglers, especially, approach the platform sites and even tie up to the structures (Gordon, 1993).

Several stakeholder groups have been involved in the debates: government agencies, sport fishers, oil and gas industry, scientists and environmentalist groups. All of these groups had specific reasons to join the discussion (ecosystem knowledge and benefits, commercial fish increase, financial incentives). They participated in an environmental discourse and developed a shared vision of a 'desirable ecosystem' and the main function of rigs-to-reefs, as 'creating fishing places for recreationally and commercially valuable species'. The presence of offshore oil structures made reaching this goal possible (Jørgensen, 2009).

The supportive attitude of the society of the Gulf of Mexico towards rigs-to-reefs has resulted in a lack of controversy. It has also been expressed in the low social demand for scientific proof of ecological impacts.

Decommissioning and reefing practices

About 200 structures, which form some 10% of the decommissioned platforms in the Gulf of Mexico, have been reefed so far. The others are brought onshore, due to high stripping and cleaning costs. If reefing does not lead to significant cost savings, often the operators prefer full removal (Schroeder & Love, 2004; Kaiser, 2006).

Various scenarios are studied, amongst which are reefing options. The artificial reef programme reaches out to operators with upcoming decommissioning projects, to explain to them the alternative decommissioning options and the reef programme (personal communication C. Ledford). Costs, techniques and safety are analysed, as well as the reefing quality of the structure. In general the jackets are considered for reefing, while the topsides are removed to shore.

All platforms that are to be left offshore are left in designated reef sites of 30 to 75 meters deep. The reef areas have been selected by exclusion mapping (absence of navigation fairways, pipeline corridors, military zones, fishing grounds, geological features, etc.) and by optimal added value (highest absence of hard substrates). The main reason for using designated areas is to avoid prolonged permit processes; the areas already have the permits to contain artificial reefs so no legal processes are needed for bringing the platforms there. Within a designated area, many separate small reef sites can exist, i.e. in Louisiana more than 80 reef sites have been created in the nine approved reef areas. In the Gulf of Mexico Chevron and Apache are responsible for about 80% of the rigs-to-reefs activities.

It is not allowed to leave a total jacket standing. Coast guard agencies demand a minimum water clearance of 85 feet (26 meters), instead of the IMO directive of 55 meters. Artificial reef programmes can apply for special permits for smaller water clearances if needed. In Texas waters a group of stakeholders is trying to get permission for a leave-in-place option and also maintain the upper part for ecosystem purposes. It will probably be difficult to convince coast guards and operators to approve; such a structure will need costly maintenance to comply with safety standards. Especially the steel that rises above the water corrodes quickly (personal communication C. Ledford).

Toppling involves explosives to sever the base of the structure below the mud line. Photo: Louisiana Department of Wildlife and Fisheries

Safety and Environmental Enforcement has been under pressure for insufficient performance during Katrina and has amplified safety regulations for these toppled structures; they decided no exceptions could be made and the damaged structures should be relocated to reef, which is complex and costly.

Liability and cost savings

The platforms are donated to the artificial reef programme that is owned by state agencies and the companies hand over the liability to the state by means of a contract. The artificial reef areas are also owned by the state.

As part of the deal, the operating companies donate 50% of the calculated saved costs to the reef programme/state. Originally cost savings were estimated by a third-party comparing the full removal with the reefing option (Kaiser, 2005). In practice it is negotiated between operator and state what is included in the calculations and what is not. Often, there is no third-party check on the cost savings calculations made by the operator and saving estimates vary from platform to platform (personal communication C. Ledford, see annex I).

The trust supports park management, maintenance, research, monitoring, navigation aids, etc. The program trust is managed by the fisheries commission, appointed by the government, and stakeholders can bring in their wishes and demands in the public meetings of the trust. Stakeholders are also critical to the trust spending; i.e. part of the stakeholders does not agree with the relative large funding of educational programmes by the trust.

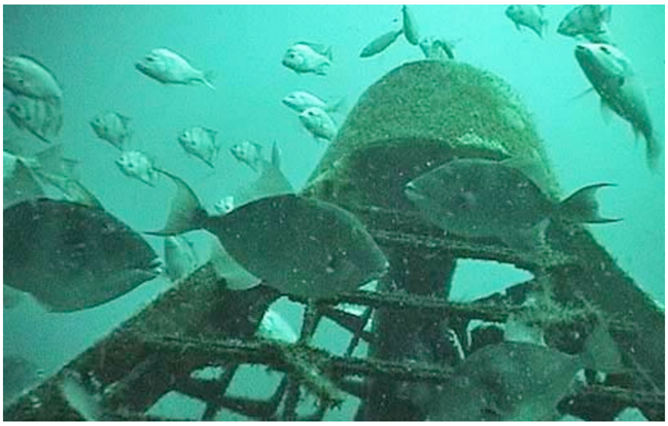
Donation sums depend on the decommissioning costs, which vary with size/complexity of the structure and type of decommissioning (i.e. toppling in place versus towing to reef). Donations for Louisiana and Texas by 2004: Louisiana had 120 structures donated for $ 20.8 million in 16 years (1987-2003), and Texas had 73 structures donated for $ 9.6 million in 13 years (1990-2003).

Environmental impacts and benefits

The total number of platforms (active and inactive) present in the Gulf of Mexico increase the available hard substrates with approximately 4%, especially in the Louisiana region where the Mississippi River discharges large amounts of clay. (Stanley & Wilson, 1991). Stanley & Wilson estimate that each standing platform provides habitat for on average 10.000-20.000 fish.

Texas Parks and Wildlife Department funded a study to define whether platform reef communities add to the biological productivity in the Gulf of Mexico (Dokken et al., 2000). The study concluded especially from the sessile fauna that it is clear that the reef communities positively affect the biology and ecology of the Gulf of Mexico. However, for the socio-economic targeted fish species, it is not yet understood how they are impacted by the reefs. They recommend creating reefs at optimal sites, between 40 and 75 meter depth contours.

Any type of structure, like this pyramid reef, will attract and hold a number of saltwater species, including gray triggerfish (near bottom of reef), spadefish and the ever popular red snapper. Photo: David Walker, ADCNR



The production of some commercial fish populations, such as the Red Snapper in the Gulf of Mexico, has been increased, due to the establishment of a significant amount of artificial reefs. This population used to be rather small, but nowadays it is doing very well, being the favourite catch of (sport) fishers. The population is not declining due to catches, because licences and catches are limited and well registered (Gallaway et al, 2009; Dokken et al., 1993; personal communication Q. Dokken).

Legal frame and precedent effects

The US has a National Artificial Reef Plan (NOAA, 2007) to give guidelines for the development of artificial reefs. Each Gulf of Mexico state has formulated their specific artificial reef plan. The artificial reef plan of Texas needs to be in accordance with the Artificial Reef Act of 1989 of the state of Texas.

To create an artificial reef in federal waters two federal agencies are involved; the US Army Corps of Engineers (COE) reviews and issues the permit; the US Coast Guards (USCG) need to determine the markings for navigation obstruction, considering distance to shipping lanes, size of reef and minimum clearance between reef top and surface water.

For every material in a new reef area, the necessary permits need to be acquired, which can take a long time, depending on the state preconditions and processes. All states have appointed specific areas to allow artificial reefing. These areas already have the needed permits, so oil and gas operators and other parties providing artificial reef materials can easily bring their objects, avoiding prolonged legal processes (Wilson & Van Sickle, 1987). In Louisiana nine areas have been designated, while Texas works with artificial reef zones (between about 100-160 miles offshore) and Alabama and Mississippi designated the whole coastal area.

A water clearance of -85 feet (26 meters) is required by the state, which deviates from the IMO standard of -55 meters. The water clearance is based on the maximum vessel draft and 85 feet of regarded sufficient for a safety standard.

If explosives are used for the cutting, the operator needs to apply for an Endangered Species Act Section 7 consultation.

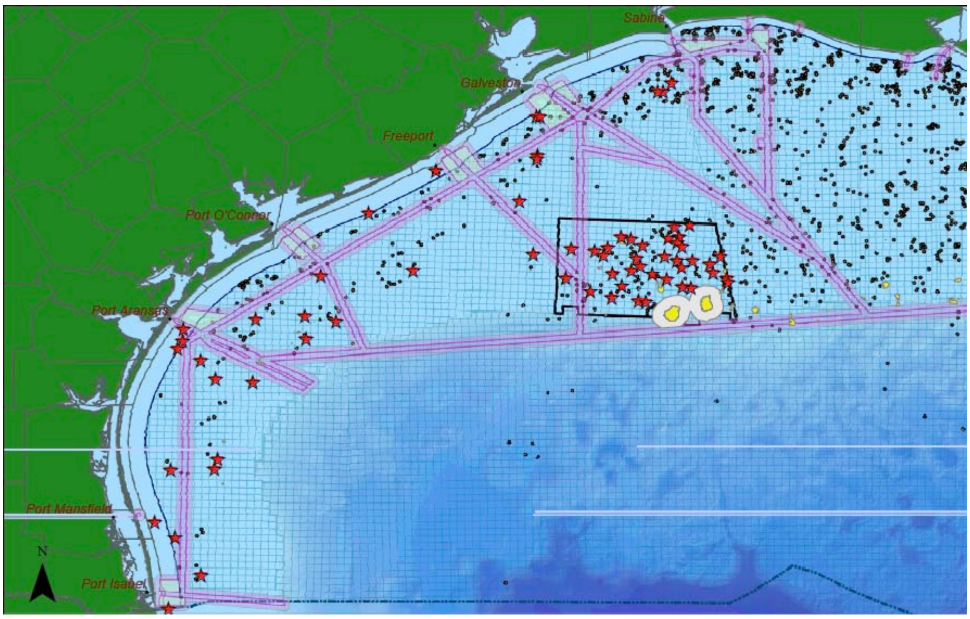


Figure 3.2. Map Texas Artificial Reef Programme (Texas Parks and Wildlife, 2012)

Box 1. Details of state reef programmes in the Gulf of Mexico

Louisiana started in 1987 (Louisiana Artificial Reef Plan: Wilson et al., 1987) and has more than 80 artificial reef sites. Louisiana has designated 9 approved sites for the disposition of oil and gas structures (Kaiser, 2006) and in the period 1987-2006 about 147 structures have been reefed. In Louisiana the Artificial Reef Council oversees the Artificial Reef Development Program and gives guidance on policy-making, site selection, procedures and allocation of funds, while the Department of Wildlife & Fisheries is in charge of monitoring and managing the Artificial Reef Development Plan. Louisiana operators that leave their structures offshore donate to the Artificial Reef Trust Fund.

Texas started in 1990 (Texas Artificial Reef Fishery Management Plan: Stephan et al., 1990) and now has up 66 artificial reef sites and more than 114 platforms, as well as additional non-oil and gas structures (vessels, materials of opportunity, prefabricated reefs, etc.), reefed in a designated artificial reef zone, covering an area from about 100 miles to 160 miles offshore (where most platforms are located, see figure 3.2). Up until the Rigs-to-Reefs Policy Addendum (MMS, 209) was put into effect in 2010, they were able to create individual reef sites outside of the planning zone. 30 reef sites have been created outside of the planning zone, and although they are no longer allowed to create new reef sites outside the planning zone, they are still allowed to place reef materials at the existing sites. Texas Artificial Reef Plan has been the result of a stakeholder process, reviewed by the Texas Artificial Reef advisory Committee, including representatives of the sport fishing, oil and gas industry, tourism industry, shrimp industry, diving club, university, NGOs, and the government. The Texas Artificial Reef Plan had to be in accordance with the Artificial Reef Act of 1989. Texas is working on the permits for two extra reef zones, which are closer to the shore. In general it takes a long time to receive reefing permits and in this case even longer due to governmental changes. At this moment they are waiting for the final written approval for two new planning zones. They drafted the reefing zones together with stakeholders, i.e. fishers. In Texas Artificial Reef Projects are funded by Artificial Reef funds and Sportfish Restoration Funds (personal communication C. Ledford).

Alabama's artificial reef program began in 1953 as a cooperative program between state and private interests; a fisher organisation asked the authority to place car bodies off shore, which was approved and had successful results. In 1987 a general permit was issued to create artificial reefs at specific offshore areas (over a total area of more than 3100 km^2) and more than 10.000 small reefs have been created nowadays. Alabama now has the largest artificial reef programme in the USA, where different kinds of materials are reefed, like car bodies, military tanks, liberty ships, toilets, etc. (Marine Resources Division, 2008). Unfortunately, Alabama did not properly select a few reefing areas, which has resulted in a collection of many small reefs with each little added value. Moreover, private parties are allowed to reef material wherever they like, to use these as fish aggregation devices. These small spots of dumped material cannot be seen as artificial reefs (personal communication Q. Dokken).

Mississippi defined their Artificial Reef Plan in 1999 (Mississippi Department of Marine Resources (DMR, 1999). The MMS and coastal states developed the Rigs-to-Reef program to stimulate the reuse of oil and gas production platforms for offshore hard bottom habitat. The Mississippi DMR, MMS and oil companies work together to use decommissioned oil and gas platforms for offshore artificial reef development. The artificial reefs are mainly created to stimulate growth of fish stock for commercial and recreational fishermen (www.dmr.ms.gov/marine-fisheries/artificial-reef/75-rigs-to-reef). The experience with artificial reefing dates back to the 1960s were a wide diversity of materials and structures was used to create artificial reefs, among which five World War II vessels. The Mississippi Marine Conservation Commission (MMCC) gives permits to the Mississippi Gulf Fishing Banks (MGFB), a local non-profit fishermen's organisation, to clean structures and to use them to develop extra reef habitat. There are numerous inshore reef sites and 15 offshore reef sites, where reefing is allowed. Until now 8 platforms have been donated by oil companies, which donate part of their avoided decommissioning costs to the Mississippi Artificial Reef Fund.

Florida was the first to reef a platform from Louisiana waters in 1979. The community of Florida has been much against the oil and gas industry and its production, but the abandoned structures are welcome for its artificial reef programme. In Florida the reefing programme is very popular; the warmer water and good visibility make diving popular and often the divers are the stimulators of the reefing of material. They even convince operators in other Gulf of Mexico waters to bring their materials to Florida, by lack of natural hard substrates and materials for creating artificial reefs such as oil and gas structures. The artificial reef plans are not planned at state level, but every county has its own plan. This is probably due to the differences of marine ecosystems between the west (Gulf of Mexico) and the east (Atlantic) coasts. At the eastern coast there are more natural hard substrates, formed by coral reefs (personal communication C. Ledford).

Conclusion

In the Gulf of Mexico platforms are in general towed to designated reef areas that already have reef permissions. 50% of the cost savings are to be donated to the reef fund at the moment of transferring liability. In general stakeholders in the Gulf of Mexico are positive towards the rigs-to-reefs programmes and have played an active role in achieving them.

3.2. California

The Southern California Bight (SCB) encompasses the region of 78.000 km^2 (Dailey et al., 1994), extending west and south of Point Conception to the US international border with Mexico. The region includes a diversity of coastal and marine habitats of the Californian mainland and of eight Channel Islands. The SCB is a transition zone between the cold temperate area created by the California Current to the north and the warm temperate fauna from the south. Habitats include sandy beaches near the mainland and rocky reefs (Pondella et al., 2012). The coastal habitats of the mainland consists of sandy beaches and rocky shores and the Channel Islands provide coastal habitats for marine organisms and serve as breeding areas for migratory birds (Dailey et al., 1994). The region is particularly rich in benthic fauna species, important fisheries and other marine life, including endangered white abalone, deep-sea corals and sponges.

Southern California is one of the most densely populated areas in the US and the SCB is a heavily exploited sea in the US, among other by oil production, port activities of Los Angeles and Long Beach and onshore industrial activities.

In California offshore oil and gas production has been encouraged by the state and federal governments in the 1960s. In 1969 a major oil leak occurred during offshore drilling and the coastline of Santa Barbara was covered with oil. California stopped the development of new drilling platforms in its state waters, but the federal government permitted new oil drilling projects until 1984. California has a total of 27 platforms offshore, which are located in both state (4) and federal waters (23). The platforms are located at different depths; 8 are situated at about 120 meters, others reach depths of about 300 meters.

Rigs-to-reefs programmes in the Southern California Bight

History

In California the rigs-to-reefs discussion did not start before the 1990s, when Chevron submitted a decommission proposal for four platforms. Chevron, being one of the key players in the Louisiana artificial reef program, was asked by the regulatory agencies not to include rigs-to-reefs scenarios. The United Anglers of Southern California (UASC) got involved and plaid for reef conversion, but due to slow permit processes this was not possible.

In 1998 industry and interested parties as the UASC started by submitting an assembly bill to the senate to request the allowance of rigs-to-reefs. It took several bills and fierce debates until in 2010 the act "Ocean resources: artificial reefs" (act AB2503, 2009-2010) was passed. At that time the debate had not changed, but it was accepted by the government that consensus was not possible. So since 2010 the conversion of platforms into reefs is allowed, but opponents still try to influence the process by participating in the public permitting processes, needed for applying for a reef area (personal communication D. Jørgensen).

Stakeholder positions

In California the social perception of the oil and gas industry has been different from the Gulf of Mexico. There has been a strong opposition to the industry's exploration and exploitation and platforms are perceived as polluting with the risk of harmful oil spills (as happened in 1969) and as landscape contamination. In the rigs-to-reefs debate platform material is referred to as "debris" and "industrial junk".

The resistance towards the industry is also reflected in the resistance to the rigs-to-reefs programme. Main opponents have been environmental groups, trawler fisheries organisations, agencies and legislators from the Santa Barbara area (here is the highest concentration of offshore platforms).

It is interesting that opponents and proponents of rigs-to-reefs both claim to support environmental goals; some stakeholder groups claim that the platforms are unnatural, polluting devices, while the others claim that they can be nature enhancing and compensating (personal communication D. Jørgensen).

Decommissioning and reefing practices

California has an artificial reef plan, but this plan does not include policies in favour of or against rigs-to-reefs.

The legislation of AB2503 allows for partial removal of platforms, based on case-by-case approval. The platform owner is allowed to design a partial removal plan and submit this proposal to the state government for permission. So far, no platforms have been proposed or approved for partial removal.

Liability and cost savings

The cost savings are transferred to a fund. Part of the savings is required to be transferred, upfront, which stakeholders may perceive as compensations to the declining economic conditions of the state.

Between 55% and 80% of the cost savings resulting from partial removal as compared to full removal need to be transferred to and divided among several parties: the California Endowment for Marine Resources, the county immediately adjacent to the location of the facility, the Fish and Game Preservation Fund, the Coastal Act Services Fund, and the General Fund.

The State Lands Commission calculates the removal costs, with input of data and information of the operator. The exact donation percentage is determined by the year of commitment of the decommissioning plan.

The California Endowment for Marine Resources, subject to the Nonprofit Public Benefit Corporation Law, will be used as a source of funding for projects and programs with the objective to conserve, protect, restore, and enhance the open coastal and marine resources of the state. The fund is governed by a board of directors, with membership and duties prescribed by the bill (Assembly California, 2010; Hecht, 2010; www.calost.org).

Environmental impacts and benefits

There has been little research on the artificial habitats to understand the impact of platforms offshore in California. Scientists call for a regional-scale assessment, to include the interconnectivity between the hard substrates (Holbrook et al., 2000)

There is an extensive variability in impact on marine life concerning the platform ecosystems, varying with depth and offshore location; biogeographical and oceanographical influences.

Research has shown that invertebrate organisms that attach to the beams also create habitat for fish. At the base of most platforms a shell mount of ceased mussels and other invertebrates has formed, creating feeding grounds for other species. The study of Love et al. (2003) showed some 35 species use the platforms for feeding and shelter and about 18 species of rockfish use the platforms as a nursery. It is also concluded that there is increasing evidence that platforms can even be fish producing devices, while other fish (i.e. kelp bass) tend to relocate there as adults (Helvey, 2002, Love et al., 2003).

The fish biomass at a platform left in place appears to be greater than at other reef sites or at toppled or partly removed platforms (Wilson, 2003).

Legal frame and precedent effects

For each platform reefing project the operator needs to apply for a reef permit, which are regulated by a public permitting process. Three agencies of the California Natural Resources Agency are responsible for the review of the application: the Department of Fish and Game (DFG), the California Ocean Protection Council (OPC), and the California State Lands Commission (SLC). The OPC needs to decide whether the partial removal has a net benefit for marine life compared to full removal. The DFG is responsible for the public hearing and registration of public comments.

The partial removal projects must agree with the California Environmental Quality Act (CEQA). This means agencies have to define all potentially significant environmental impacts, study alternatives to the project, and mitigate negative impacts.

The State will take over ownership of any platform in federal waters before it may be partially removed. The owner/operator will be liable for the well abandonment and maintenance, associated with seepage or release of oil.

Conclusion

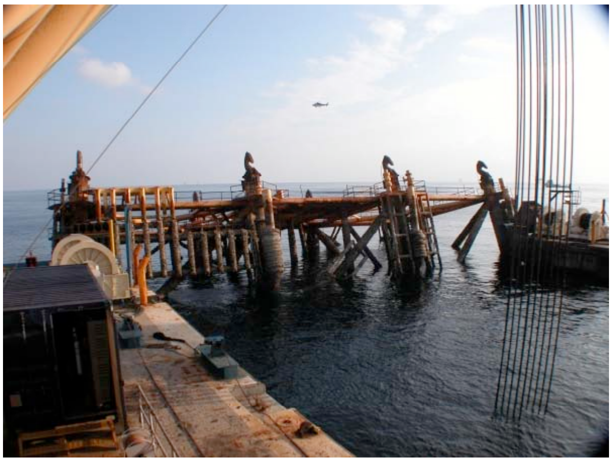
In California platforms are allowed to be partially removed and partially left in place. The reefing permits need to be applied for case-by-case. The legal and management framework for rigs-to-reefs are in place, but no platforms have been reefed so far. 55-80% of the cost savings are to be donated to the state, of which part is dedicated for a coastal and marine fund, the California Endowment for Marine Resources. The stakeholder debate in California is highly polarized, influenced by the bad reputation of the oil and gas industry since the oil spills in Santa Barbara. There is no consensus on rigs-to-reefs.

3.3. Comparing Gulf of Mexico and California

There are striking differences between the Gulf of Mexico and California.

- In the Gulf of Mexico rigs-to-reefs programmes are about adding platform materials to designated artificial reef areas, while in California rigs-to-reefs is about partial removal in situ.
- In the Gulf of Mexico stakeholders positions are positive and supportive towards rigs-to-reefs, while in California there are many opponents and no consensus has been reached.
- In the Gulf of Mexico the designated reef areas are put in place to avoid timely permit processes, while in California a case-by-case approach is used for the permitting process.
- In the Gulf of Mexico operators calculate the cost savings and donate 50% to a reef trust, while in California The State Lands Commission calculates the cost savings and 55-80% needs to be donated to several state parties, amongst which a coastal and marine trust.

Eugene Island 331A platform being partially removed in the Gulf of Mexico. Photo: Louisiana Department of Wildlife and Fisheries



4. Rigs-to-reefs in the North Sea? Issues and lessons

In the North Sea region, the debate about artificial programmes and the potential role of decommissioned manmade structures started in the mid 1980s, following the growth of artificial reefing programmes in the US and with an eye to upcoming decommissioning projects for offshore oil and gas structures in the North Sea. As OSPAR[1] was set up in the early 1990s, part of its agenda was to develop guidelines for the construction of artificial reefs in the region and to determine to what extent it would be acceptable to reuse man-made structures (“waste”) for such purposes. Eventually, this debate became dominated by the public outcry against the Brent Spar disposal in deep water (Baine, 2001; Jørgensen, 2012a). The result in fact was a moratorium on the use of offshore platforms or other non-virgin materials as artificial reefs (OSPAR 98/3 and the OSPAR Guidelines on Artificial Reefs in relation to Living Marine Resources (OSPAR, 1999) and a politicization of the scientific debate about the value of man-made hard substrate.

Photo: Cor Kuyvenhoven

In this and the following chapter, we discuss the key issues dominating the OSPAR debate about artificial reefs and the reuse of offshore structures for such purposes and try to apply lessons from the US experiences to the North Sea situation.

[1] OSPAR is the mechanism by which fifteen governments of the western coasts and catchments of Europe, together with the European Community, cooperate to protect the marine environment of the North-East Atlantic. It started in 1972 with the Oslo Convention against dumping. It was broadened to cover land-based sources and the offshore industry by the Paris Convention of 1974. These two conventions were unified, up-dated and extended by the 1992 OSPAR Convention. The new annex on biodiversity and ecosystems was adopted in 1998 to cover non-polluting human activities that can adversely affect the sea. In 2010, OSPAR produced a Quality Status Report on the North-East Atlantic – the result of ten years of monitoring and research by a wide group of scientific experts.

Box 2. OSPAR Guidelines on Artificial Reefs in relation to Living Marine Resources (1999, art. 4.1)
11. Artificial reefs should be built from inert materials. For the purpose of these guidelines, inert materials are those, which do not cause pollution through leaching, physical or chemical weathering and/or biological activity. Physical or chemical weathering of structures may result in increased exposures for sensitive organisms to contaminants and lead to adverse environmental effects.
12. Materials used for the construction of permanent artificial reefs will of necessity be bulky in nature, for example geological material (i.e. rock), concrete or steel.
13. No materials should be used for the construction of artificial reefs, which constitute wastes or other matter whose disposal at sea is otherwise prohibited.

4.1. Geographical settings

As defined by OSPAR, the Greater North Sea has a surface area of about 750,000 km^2 and a volume of about 94,000 km^3 (OSPAR, 2000). The North Sea area has a high diversity of substrate types (fjords, chalk cliffs, subtidal banks, mud substrates, etc.) with characteristic regional variations in depth, temperature, and water and sediment type. Consequently, the North Sea accommodates many different biotopes and associated species. It is a productive ecosystem, due to the terrestrial and oceanic inputs of nutrients. Especially in the shallow coastal regions and the tidal fronts biodiversity and biomass are high.

The northern part is comparatively deep and has a large exchange of water with the Atlantic Ocean. The southern part is less deep and is connected to the Atlantic Ocean via the Channel; it has strong tidal currents, a large amount of land-based inputs and high levels of sediment load. We distinguish three main regions, including an southern, central and northern region.

The *southern* part typically has coarse-grained sands, while fine sands and clays are more common in the northern part. Hard substrates like gravel and oyster beds used to be more widely available in the past, but with the extensive fisheries at the oyster grounds in the 19th and 20th centuries, most of the biogenic structure has disappeared. Boulder fields occur in the German Bight and off the coasts of Scotland, Orkney and Shetland. And parts of the coasts of Norway and the UK are of rocky substrates. If we only count bedrock (including boulders) as hard substrate, then in the southern North Sea 0.5% of the seabed surface is hard substrate and in the *central* and *northern* North Sea 3.1%; approximately 18,000 km^2 of natural hard substrate for the total North Sea or 2.4% (IMSA Amsterdam, 2011a). Man-made hard substrates in the North Sea provide about 34 to 58 km^2 of artificial hard substrates below the water surface, mainly formed by platforms (~3.7 km^2), wind turbines (~0.17 km^2) and wrecks (~30-54 km^2). They have a more significant impact on the southern North Sea where only 900 km^2 of natural hard substrates is available, compared to the central and the northern part where 17,100 km^2 of natural reefs occurs (IMSA Amsterdam, 2011c).

The North Sea region is also densely populated and worldwide is one of the most heavily exploited marine ecosystems. About 200 million people live in the vicinity of the North Sea, with seven countries directly adjacent to it: the UK, Norway, Denmark, Germany, the

Netherlands, Belgium and France. For centuries the people of the North Sea have benefited from the services offered by the sea: food, energy, transport, a stable, comfortable climate, etc. But for decades also the growing intensity of human activities has been negatively affecting the quality of this ecosystem and possibly also its stability and ecosystem functions.

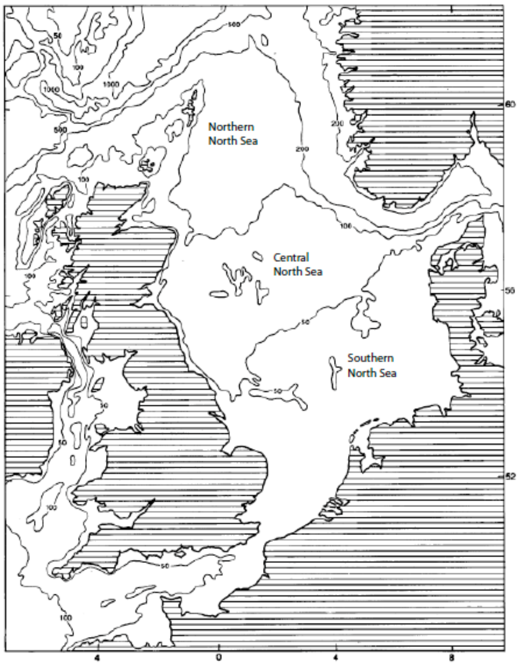


Figure 4.1. Map of the North Sea zoning (edited from Gerrard et al., 2000). Three main zones:

The southern North Sea (SNS), up to 50 m of depth, including the Doggerbank;

The central North Sea (CNS), from 50 to 100 m depth;

The northern North Sea (NNS), from 100 m up to the continental margin. Parts of the northern North Sea are even deeper: the Norwegian trench reaches to 270 m and the Skagerrak to 700 m of depth.

The OSPAR Quality Status Review (QSR) 2010 observes that:

- biodiversity is changing and species and habitats that used to be abundant in the past are now declining
- the quality of the North Sea ecosystem has deteriorated over the past century, largely as a result of human pressures
- some human impacts show signs of improvement, e.g., because of better fisheries management and reduced inputs of phosphorus, mercury and lead
- the effects of tourism, offshore renewable energy and mariculture are expected to increase, while the different effects of shipping show a mixed picture.

4.2. Cultural & political context of the North Sea rigs-to-reefs debate

In the North Sea the public perception of oil and gas structures is totally different from the Gulf of Mexico.

In the Gulf of Mexico fishers and divers frequently approach platforms for recreational purposes, because there is no safety exclusive zone. They are familiar with the underwater life surrounding and in between the cross beams and understand the impact it has on the biodiversity. These stakeholder groups were the original initiators of rigs-to-reefs programmes in the Gulf of Mexico and still support and encourage these initiatives.

The North Sea itself is not easily accessible for the majority of citizens living around it. Their main physical contact with this sea is at the beach, where they are sometimes confronted by plastic waste, oil pollution and sea life that has been washed onto the shore and by the growing amount of offshore structures arising on the horizon. The North Sea is experienced by most of the public as something we need to protect ourselves against. Oil and gas structures are (mostly) far from the coast and cannot be approached by other users as fishers and divers, due to strict and high safety standards, which are expressed in a 500m exclusive zone around all platforms. They are perceived as industrial, unsafe and polluting.

Though OSPAR is dedicated to an integrated ecosystem approach to the North Sea, the public debate tends to focus on pollution prevention and potentially polluting sectors rather than on broader measures for nature conservation (see figure below). Consequently, the focus of debate about the impact of offshore oil and gas structures is primarily on potential chemical pollution rather than on the value of marine growth on these structures.

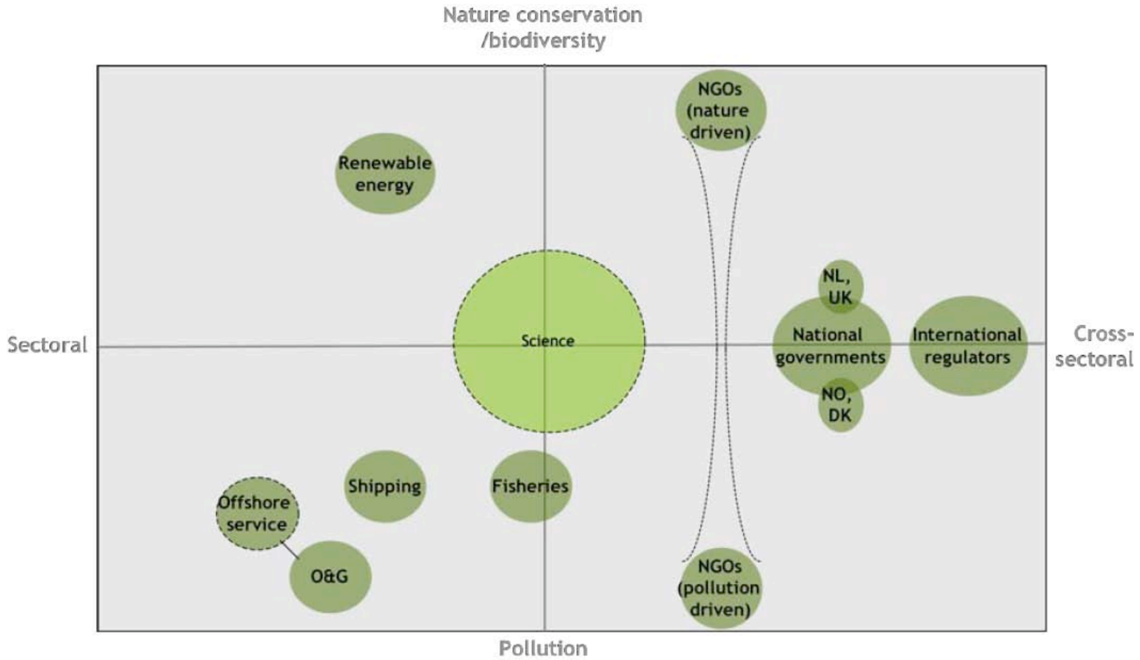


Figure 4.2. Stakeholder map of the positions of the stakeholder groups on cross-sectoral views and ecosystem approach (according to IMSA Amsterdam).

The pollution-focus has been strengthened - or possibly even triggered - by the events around the proposed disposal of the Brent Spar platform to deep-waters. While in 1995 Esso Norge had just submitted a proposal for the first North Sea rigs-to-reefs programme, Greenpeace started the campaign against Shell and the decommissioning of Brent Spar.

The critique on the deep-water disposal of this platform resulted in a public movement against Shell, with its stronghold in Germany. Since then the rigs-to-reefs concept has been perceived by the larger public of the North Sea countries as a matter of dumping waste.

5. Key issues in the North Sea rigs-to-reefs debate

From stakeholder analysis done by IMSA in Phase 1 of LiNSI and from scientific research into OSPAR debates (Baine, 2002; Jørgensen, 2012a) it is clear that a number of mantras dominate the debate about rigs-to-reefs in the North Sea and block the road to creative thinking.

1. *"The different ecosystem of the North Sea implies that artificial reefs here will not be as valuable as they are in the Gulf of Mexico."*
2. *"The spatial pressure in the North Sea makes it unsafe to leave offshore structures in the sea."*
3. *"Oil and gas structures are polluting the sea; if we want artificial reefs, then the material used should be virgin."*
4. *"Rigs-to-reefs programmes are primarily driven by cost-savings for the oil and gas industry - there is no societal benefit."*
5. *"Nobody wants to be liable for offshore structures left in the North Sea."*
6. *"Rigs-to-reefs programmes are not possible within the current legal frameworks (OSPAR 98/3 and the Artificial Reef Guideline)."*

Below these mantras are discussed in detail, bringing in lessons from rigs-to-reefs programmes in the US.

Mantra 1: *"The different ecosystem of the North Sea implies that artificial reefs here will not be as valuable as they are in the Gulf of Mexico"*

Reasoning behind the mantra

Since the Brent Spar discussion, it is a widely held belief that the North Sea ecosystem is so different from that of the Gulf of Mexico - colder climate, lower light penetration levels, different geology and unique species compositions - that the positive results of rigs-to-reefs programmes in the Gulf of Mexico cannot be expected to occur here. Some argue that artificial reefs are only "fish attracting devices" that do not really add value to the ecosystem, others claim that fish in the North Sea do not need the shelter function of hard substrates.

Facts and lessons learned

This mantra is only partly supported by scientific evidence. Most scientists emphasise that of course, North Sea platform ecosystems will be different from those of the Gulf of Mexico, but that it is likely it has an added value, as in the Gulf of Mexico. Hard substrates are not alien to the North Sea, but they are scarce and species depending on hard substrate are under pressure. The endangered cold-water coral *Lophelia Pertusa* (CITES list) benefits from the available artificial hard substrate created by the oil and gas structures in the northern North Sea. This received a lot of (scientific) attention, also because the growth rates are relatively high and the coral colonies create complex habitats, attracting other species and increasing biodiversity (Bell &

Smith, 1999; Gas & Roberts, 2006). In the past, the North Sea seabed used to include much more hard substrates than nowadays, formed by oyster beds that have been eliminated by intensive fisheries which in turn led to failing settlement of oyster larvae. The potential socio-economic and environmental benefits of artificial reefs for the North Sea area have been assessed and confirmed by OSPAR: "It can therefore be concluded 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" (OSPAR, 2009). It will depend on the location and depth of the hard substrate what the specific effects on the local or regional ecosystem are.

Scientific evidence from the Gulf of Mexico suggests that artificial reefs function both as aggregation devices for several fish species that approach the structures for shelter and food and as separate ecosystems that add to the biomass of hard-substrate-liking species. There is a concern that artificial reefs may also negatively impact fish species, because of intensive local fishing of certain commercial species that are attracted by the artificial reef. Overfishing in artificial reefs areas can, however, be avoided by effective regulation.

Essentially, the debate about artificial reefs is a principal debate about the extent to which humans should actively interfere with nature in order to create/restore/protect certain ecosystems to the benefit of certain species. This debate is complicated by the fact that the regional impact of artificial biodiversity hotspots, such as platforms, is not yet sufficiently understood.

In the US, rigs-to-reefs programmes serve a clear purpose that determines their position, design and the types of human access allowed to the reefing areas.

For the North Sea, a clearly defined objective for artificial reefing will also be fundamental to any discussion about leaving offshore structures in sea. The impact and functions of artificial reefs vary with depth, location, and substrate and ecosystem composition. Next to that the size and design define local impacts and possibly even regional impacts. Other human activities offshore can also influence the success and impact of artificial reefs. Artificial reefs can fulfil different functions in different areas; e.g. recreation and (line) fishing and aquaculture (oysters, lobsters and mussels) near the coast and habitat creation further off the coast.

Recommendations for the North Sea

If we want to open up for rigs-to-reefs programmes in the North Sea, there are some key conditions.

- Well-defined objectives, based on a regional vision and strategy for the whole North Sea (volumes, functioning).
- Well-defined areas where artificial reefs are allowed, i.e. where it is allowed to leave offshore structures in sea (leave-in-place or towed from a place where artificial reefs are not allowed) under certain conditions. There are several mapping tools to designate optimal reef sites: exclusion mapping (e.g. avoid shipping lanes, areas for future offshore developments), inclusion mapping (e.g. combine wind parks, marine protected areas and artificial reef sites), mapping on desired function (e.g. biodiversity increase, MPA, fishing or recreational area (factors: distance to shore, depth, currents, photic zone). Develop reef designs that favour specific functions.
- Consider protection of offshore structures with specific ecological features; e.g. some of the platforms in the northern North Sea are overgrown with the protected cold coral species *Lophelia Pertusa*.
- Set up an artificial reef agency, which is responsible for the composition of and compliance with the legal frameworks (e.g. liability exchanges, reefing permits, etc.), management (safety standards, education etc.), regular monitoring and research and also holds liability of reefed structures. Both in the UK and the Netherlands, special agencies have been set up for the decommissioning of nuclear power plants. It might be possible to learn from these experiences with regard to how to handle long-term liabilities.
- Clearly define the functions of specific reef areas and take this into account when setting the rules for human activities in the area, e.g.:
  - Ecological function: create MPAs (Marine Protected Areas) around the structures and apply reef designs and locations that support optimal ecosystem development.
  - Fisheries and recreational functions: allow activities that do not compromise safety of the users (e.g. line fishing; aquaculture, dive recreation under certain conditions, etc.) and set up regulation that prevents overuse (fish quota).
- Consider reef designs for multifunctional use: i.e. create a buffer reef around a core reef. E.g., the outer area of the buffer reef can be approached by trawlers who benefit from the presence of hard substrates, while the core reef is excluded from trawls. In this way the material itself is the reef protection tool.

Mantra 2: ***"The spatial pressure in the North Sea makes it unsafe to leave offshore structures in the sea"***

Reasoning behind the mantra

The North Sea is one of the most heavily used seas in the world; it has a high number of shipping movements, especially in the southern North Sea (for more information, see also IMSA Amsterdam, 2011b), is heavily fished and the spatial pressure from renewable energy production is increasing, while oil and gas production is declining.

The high concentration of offshore structures, shipping movements and other activities makes the risk of an accident significant. Therefore, many stakeholders are convinced that full removal of abandoned structures is necessary in order to create space for new activities (e.g. wind parks), while maintaining space and safety for shipping and fisheries.

The IMO demands that everything is removed until 55 meters below sea level. In most of the North Sea, cutting off the structures to -55 meters is not an option: at its deepest the southern North Sea is about 50 meters. The leave-in-place option would therefore always leave material in the upper 55 meters of the water column, even if a structure were toppled.

Facts and lessons learned

In the SNS spatial pressure indeed is a growing problem. In the central and northern North Sea, shipping movements are much less intensive and also less space is claimed for e.g. renewable energy. At the same time, decommissioning of offshore structures will be complex and hazardous in this deeper region.

The IMO guidelines do ask for a water clearance of -55 meters. However, the national authorities (jurisdiction) may decide to adopt smaller water clearances for specific areas as is done in the Gulf of Mexico; they demand 85 feet (26 meters) clearance, based on the vessel depths sailing the region. The vessels crossing the southern North Sea need also pass the Channel, which is accessible for ships with limited drafts up to 22 meters. However, the strong undulation in the North Sea results in vertical variations, also decreasing the distance from submerged object to water surface. This should be taken into account in setting the standard clearance depth.

Recommendations for the North Sea

Clearly, it is key to ensure that leaving structures offshore will not significantly decrease safety for North Sea users, nor reduce the space available for e.g. renewable energy production. Some measures could be taken to meet these demands.

- Artificial reefing can be excluded from areas with intensive shipping movements and trawling. In fact, shipping lanes have already been taken into account with the positioning of existing structures.

- Reefing areas can be marked as exclusion areas, where the shipping and fishing are not allowed. For the fishing industry the marking of designated areas will be sufficient to navigate around the hard substrates. The shipping industry knows much more incidents, due to inattention. Navigation tools and radar can be added to these exclusion areas.
- In the SNS, it could be a best-fit solution to imitate the Gulf of Mexico artificial reef programmes and designate areas where platforms are gathered and large reefs created. The relative small structures of the SNS can probably easily be towed and relocated. For these cases financial savings will probably be limited.
- Designated reefing areas in the SNS could be combined with areas reserved for e.g. wind parks or used as outer reefs for protection of MPAs. In those areas, shipping and fishing are not allowed anyway, so the risk of incidents would be reduced, just as the amount of additional space taken up by artificial reefs.

Mantra 3. "*Oil and gas structures are polluting the sea; if we want artificial reefs, then the material used should be virgin.*"

Reasoning behind the mantra

In the North Sea rigs-to-reefs are discussed in the context of platform disposal projects and dumping of waste. Stakeholders are concerned that waste and polluted materials will be left offshore. Therefore, the OSPAR artificial reef guidelines prescribe the use of virgin materials, i.e. exclude the use of waste materials.

Facts and lessons learned

In the US, rigs-to-reefs programmes are not about dumping waste, but about creating artificial reefs, to create breeding, foraging and shelter areas for marine life. Consequently, in the Gulf of Mexico only the jackets are left in place, which are plain steel legs and cross beams, and which never had contact with oil or other contaminating materials. Only material is used that is really suitable for reef construction. The topside, pipelines and elements that could have negative environmental impacts are brought onshore, cleaned and where possible recycled. These regulations are legally fixed.

In the OSPAR discussions about designing and implementing artificial reefs the reuse of materials has been excluded, amongst others to avoid the use of offshore oil and gas structures. This proposal seems odd considering that used steel and concrete materials are fit for creating an artificial reef and in particular the complexity of the structures makes them interesting objects for creating reefs. Also from an environmental point of view it would be better to reuse materials already present offshore than to introduce virgin materials into the sea, because of the reduced energy use and because of the reduced risk of introducing invasive species into the marine environment.

Recommen-dations for the North Sea

Artificial reefs certainly should not be constructed with the use of materials that may pollute the water or facilitate invasive species. In order to avoid this, we recommend the following.

- In general it is only the jackets that are to be left in placed or reefed. These are steel (cross) beams, overgrown with sessile species. Potentially contaminated pipelines, anodes and the topsides are removed and decommissioned at shore.
- Set strict criteria for selection suitable reef material (complexity and type of material) and assessment of absence of pollution. One set of rules account for all sectors and objects. Probably, criteria and procedures could be largely copied from the Texas Artificial Reefing Programme.
- Create an expert committee to examine the applicability of a platform for reefing. Ensure the transparency and objectivity of this process, but avoid complex approval procedures that will scare away operators for applying for reefing.
- Inform and educate stakeholders on the oil and gas structures that are considered for artificial reefing. Show that no polluted material is left behind. Education programmes can include documentaries and aquaria to actually show the public what the underwater effects are leaving a structure for a long time offshore (Jørgensen, 2012c).
- It is more energy efficient - from a material and transport point of view - if offshore available materials that are suitable for reefing are reused to create an artificial reef than introducing new virgin materials transported from shore.

Mantra 4. "*Rigs-to-reef programmes are primarily driven by cost-savings for the oil and gas industry - there is no societal benefit*"

Reasoning behind the mantra

Leaving offshore structures offshore saves costs compared to taking them to shore for cleaning and waste treatment. Ever since the Brent Spar debate, the public perception is that the costs saved by leaving oil and gas installations offshore are enormous. Based on this perception, it is assumed that rigs-to-reefs programmes e.g. in the US are initiated by oil and gas companies in order to save money. Since many green NGOs perceive oil and gas structures as polluting waste and fishers and shipping industry have a strong preference for a clean seabed, the overall image is that rigs-to-reefs programmes in the North Sea is not an option.

Facts and lessons learned

Rigs-to-reefs programmes in the US have not been initiated by the oil and gas industry, but by other stakeholders, primarily sport fishers and recreational divers. In the Gulf of Mexico governments often have to persuade companies to donate their platforms to the rigs-to-reefs programme; it results in extra work and procedures, and since the majority of the structures need to be towed to and placed at a new designated location, cost savings are limited. Also, operators are concerned that they will still be held responsible for safety incidents, even though they have formally transferred liability.

In the Gulf of Mexico 50% of the calculated cost savings are donated to a reef fund. There are strong indications that these donations do not reflect the real cost savings, as very different donations are received for platforms that are being decommissioned under very similar circumstances. Since the calculations are not verified by an independent third party, there is no way for the government to know what are the real savings (personal communication C. Ledford). The average donations in Louisiana are $ 117.000 for structures towed to reef and $ 233.000 for structures partially removed (left in place), depending on the size, type and location of the platform (Kaiser, 2006).

In California operators that commit themselves to the artificial reef programme at an early stage, contribute about 60% of the estimated cost savings to reef fund. If they make the decision and donate at the moment of decommissioning, then they contribute about 80% of the estimated cost savings.

In the North Sea, cost savings are probably much larger than the official numbers from the Gulf of Mexico suggest. The cost savings that could be realised in the North Sea have been estimated at GBP 4 to 10 billion, depending on which spatial criteria are applied in order to determine which platforms are removed to shore, which ones are left in place and which ones are towed to specific reefing sites (see IMSA, 2013, Scenario Assessment, LNSF297). The largest cost savings can be made when platforms are left in place rather than towed to a designated reef area.

In the North Sea the majority of cost savings (50% to >80%) would directly benefit society (government) rather than the operators. In the North Sea region, most governments are co-owners of the structures and, therefore, also responsible for part of decommissioning costs. Thus, reduced decommissioning costs are equal to reduced government spendings. Moreover, decommissioning costs are deducted from profits and hence from taxes in all North Sea countries. Consequently, reduced decommissioning costs also imply a smaller loss of tax income for governments. This is a big difference with the Gulf of Mexico, where the operators pay for the full costs of decommissioning.

Recommendations for the North Sea

Rigs-to-reefs programmes in the North Sea could well turn out to entail much larger benefits for society than for the operators, if designed in the right way.

- First of all, such a programme needs to be designed with clear objectives that enhance the quality of the North Sea ecosystem and also provide benefits for other stakeholders (see recommendations of mantra 1).
- Probably the main societal benefit could be achieved by putting part of cost savings in a fund that could (co)fund the implementation of measures that would have a significantly positive effect on the North Sea system. Such a fund would need clear objectives, criteria and a management structure independent of normal governments budgets in order to provide maximum societal benefit. This kind of visible sharing of cost savings would also help reduce the impression that operators are making huge profits by leaving their structures offshore.
- A key success factor for a North Sea Fund would be to set the criteria for cost saving estimates and to involve third parties to calculate or analyse the cost saving estimates.
- Accept that part of the cost savings need to be for the oil and gas operators in order to make it attractive for them to leave structures offshore.
- By allowing only sustainable fisheries in the reef areas (i.e. lobster pots or angling) this could also be an impulse for a transition towards more sustainable fishing practices and "farming at sea": the transition from "fish from the sea" to "proteins from the sea", focusing more on the broad array of proteins, e.g. algae, crabs, seaweeds, worms, while fish is becoming scarce.
- Designate an expert committee and create a transparent, objective and efficient process around reefing decisions, incl. the definition of cost savings and the transfer of money to an independent fund that has a clear vision and strategy to supports a sustainable North Sea.
- Avoid timely and costly case-by-case approaches and approval processes, which form a continuous invitation to opposing stakeholders to restart negotiations for each decommissioning programme.

Mantra 5. ***"Nobody wants to be liable for offshore structures left in the North Sea"***

Reasoning behind the mantra

Considering the intensive use of the North Sea - especially the large amount of shipping movements - and the harsh weather conditions, safety risks of leaving structures offshore are very high. Therefore, it is expected that few parties will be interested in bearing liability for the abandoned structures.

This reasoning is reinforced by the negative image of the oil and gas industry. Especially since the Macondo disaster, public trust in the extent to which the oil and gas industry operates in a responsible manner has severely declined.

Facts and lessons learned

During operation, operators are fully liable for their structures offshore. In most North Sea countries (Netherlands, Denmark, Norway, Germany), government takes over liability for any material left offshore, provided that the necessary permissions have been given to do so. In the UK, however, this liability stays with the operating company forever. Considering rigs-to-reef programmes, liability has to be transferred to a permanent (i.e. semi-)government body; operators will not be interested in leaving material offshore and for society long-term management of offshore materials is essential for safety and environmental reasons. In the US liability is transferred to the government when rigs are reefed.

The extent to which society will be interested in taking over liability for structures left offshore, depends on the context in which this is done: societal benefits need to outweigh liability risks. Societal benefits depend on the way in which the programme is designed and what is done with the cost savings (see also mantras 1 and 4).

Recommendations for the North Sea

The liability issue clearly is a deal breaker in the success of a rigs-to-reefs programme: operators will not donate their structure to an artificial reef programme if they remain liable. In a North Sea setting, this implies the following.

- It is essential that liability will be transferred to long-term players, such as governments; only they can ensure society a continuous monitoring and management of the materials offshore. Lessons may also be drawn from experiences with decommissioning of nuclear power plants, where special agencies have been set up secure the standards are respected, also on the long term.
- Special attention should be paid to liability issues in relation to a North Sea programme: should North Sea wide agency be liable or national governments?
- Liability transfers should be well regulated and managed. In the Gulf of Mexico and California the operator and the state sign a contract to make the transfer of the structure and the related

donation official.
- Transfer of liability implies also a transfer of money as a form of compensation. This fact in itself underpins the need for operators donating a significant part of their cost savings to the body taking over liability.

Mantra 6. "*Rigs-to-reefs programmes are not possible within the current legal frameworks (OSPAR 98/3 and the Artificial Reef Guideline)*"

Reasoning behind the mantra

The OSPAR 98/3 protocol is often interpreted as to legally exclude oil and gas structures for artificial reef purposes, with only a few derogations for very large, heavy or complex structures. OSPAR 98/3 claims that "the dumping, and the leaving wholly or partly in place, of disused offshore installations within the maritime area is prohibited" (OSPAR, 1998). Moreover, the OSPAR Guidelines on Artificial Reefs in relation to Living Marine Resources (1999) have been designed with the aim of excluding the use of offshore installations for the construction of artificial reefs.

Facts and lessons learned

In the North Sea region the OSPAR agreement on decommissioning (OSPAR 98/3) and Guidelines for Artificial Reefs are affirmed by most of the North Sea countries. Except for Norway, who did not sign the Guidelines for Artificial Reefs. This means the UK, the Netherlands, Denmark and Germany have committed themselves to only allow for some derogations and specific reuse of platforms after their operational life. The OSPAR Guidelines for Artificial Reef prescribe specific criteria for the materials that are allowed to use, excluding "waste".

Taking a closer look at the OSPAR formulations, it is questionable whether OSPAR necessarily excludes the use of offshore structures for artificial reef purposes If the political will is there, the OSPAR agreement affords room for (re)interpretation.

OSPAR 98/3 states that an offshore installation "serving another legitimate purpose in the maritime area authorized or regulated by the competent authority of the relevant Contracting Party" is not a "disused offshore installation". Since the creation of an artificial reef is a legitimate purpose, there is no legal exclusion of rigs-to-reefs programmes, if the competent authority wants such a programme to be there.

Considering the OSPAR Guidelines on Artificial Reefs in relation to Living Marine Resources (1999), the requirements for materials seem to exclude used offshore oil and gas installations by stating that waste materials are not allowed (see box 2, paragraph 4.1.), but installations with a reuse function for artificial reef building materials could be considered different from "waste", because they are excluded under OSPAR 98/3 as waste materials if they are used for another legitimate purpose.

Until now decision-making has been dominated by the mantras discussed above and by a fear that reopening the discussion about leaving installations offshore would either lead to even stricter demands for a clean seabed and consequently even higher decommissioning costs or that it would lead to exactly the opposite: entering a slippery slope towards allowing for dumping of all kinds of waste in the sea. Though the legal framework may not have to be changed; a shift in political mind-set is essential to allow for a more open-minded discussion about rigs-to-reefs in the North Sea.

Recommendations for the North Sea

The Gulf of Mexico shows that it is very well possible to design a reef programme in such a way that it does not open up for general dumping of waste, but allow for only reefing of material that actually has a value as a reef. For the North Sea we need consider the following.

- If reuse of platforms is considered an artificial reef application then OSPAR 98/3 allows for reefing options. If platforms are found suitable to reuse for artificial reefs then they could be considered other than "waste". So, the legal framework does not have to be the limiting factor for reefing platforms. It is above all a political consideration, drawn by the negative event of Brent Spar in 1995.
- The North Sea will need a regional spatial plan that defines where platforms can be left in place, where they need to be removed and which areas could be used for designated artificial reef developments.
- If reefing permits are obtained case-by-case as occurs in California, a complex and time-consuming public permitting process can make reefing costly and difficult. Therefore a similar solution as used in the Gulf of Mexico could be considered. Here the designated reef areas already have permission to reef material. In this way, not the location but only the material needs to be approved, which can be done relatively quickly by the reefing expert authority.
- A stakeholder approach is essential to create a functioning artificial reef programme. In California rigs-to-reefs has been approved by the government, lacking consensus among the stakeholders. Many of the involved parties question whether this programme will work. Opponents of the programme have already indicated they will attend the public permitting process and stop reefing case-by-case.
- The narrow vision of rigs-to-reefs excludes other industries, which is unnecessary, and can lead to opponents. If the artificial reef programme has adequate criteria for suitable materials and a clear vision with a set of rules of the volume and extent of artificial reefs

at the North Sea, there is no need to exclude other industries, like offshore wind, from the programme.

- Do not discuss rigs-to-reefs involving only the oil and gas industry, but instead consider reuse of offshore materials for artificial reefs, which includes all sectors and which is most energy efficient. From an energy perspective it makes more sense to focus on materials that are already offshore instead of transporting shore materials to the reefs.
- Realise the impact of the historical event of Brent Spar and the political setting when OSPAR was agreed upon. If alternative decommissioning projects of leaving platforms offshore will be no more than disposal at sea, it is not feasible. If platforms are becoming artificial reefs instead, they can be of socio-economic and environmental benefit and interesting for society.
- The language needs to be in accordance with what is to be achieved; rigs-to-reefs are not about “dumping” or “disposal”. However, these terms are often used while discussing the reefing programmes and have reduced the conversation from a reef construction debate to a waste and pollution debate.

6. Conclusions and recommendations

Main conclusion

Based on the experiences in the USA and the potential benefits of rigs-to-reefs programmes, we conclude that there are no specific arguments why reusing offshore oil and gas structures for artificial reefing could not work for the North Sea. However, there are several underlying perceptions and issues that have to be overcome to make such a programme work for this region.

Probably the most significant win-win of creating a North Sea artificial reef programme is the potential of cost savings created by limiting decommissioning activities for the oil and gas industry and the reallocation to a North Sea Fund, with the primary objective of supporting a sustainable and positive contribution to improvement of the North Sea ecosystem.

Main lessons from former experiences

- Show that the savings made by using rigs-to-reefs in the North Sea are available for society and improvements for the North Sea ecosystem.
- Make transparent which parts of the installations are opted for rigs-to-reefs programmes and assure that no polluted parts are used.
- Present the results of current artificial reefs in the North Sea, to prove the benefits and the potential of rigs-to-reefs in the North Sea, even in deeper waters.
- Involve stakeholders in the rigs-to-reefs programme; it is bounded by political positions and not by legal frameworks.
- Use unbiased, neutral language to communicate rigs-to-reefs programmes; avoid words as "disposing" and "dumping", because it diverts from the real aims of rigs-to-reefs.
- Liability and ownership of the platforms need to be transferred to governments.
- Carry out ongoing monitoring and marine research to continue to increase scientific knowledge of rigs-to-reefs.

Three overall strategies

North Sea approach The quality of the North Sea ecosystem has deteriorated over the past century, largely as a result of human pressures.Concerning all these developments a regional spatial plan is needed that also elaborates on the upcoming decommissioning process. Define where platforms can be left in place, where they need to be removed and which areas could be used for designated artificial reef developments. Distinguish between the SNS and the CNS/NNS considering the decommissioning and reefing options: they have different morphologies, ecologies, safety

issues, socio-economic activities, etc.
Classify offshore structures using three decommissioning alternatives.

1. Full removal to shore: these are not interesting for reefing programmes or have potential negative environmental impacts.
2. Leave in place (partially) as an artificial reef: these are probably mostly located in the quieter, deeper CNS and NNS, but structures in the SNS could also be considered.
3. Relocation to designated reef areas (partially): structures that cannot be left in place, due to safety issues or non-optimal ecological circumstances, but which are suitable for artificial reefing

Ecosystem approach

Considering alternative decommissioning options to full removal to shore, the leave-offshore options - whether left in place or towed to elsewhere – should be about maintaining or creating artificial reefs and not about disposal of material offshore.

Define which ecological goals are to be achieved with the programme.

- Direct effects from the addition of hard substrates.
- The potential of creating a North Sea Fund with significant financial donations of participants to a fund supporting the transition towards a "Sustainable North Sea".

The North Sea artificial reef programme should not be about "rigs" to reefs, but about "reusing offshore materials" for reefs, including also other sectors and focusing on suitable material (complexity and type) and energy efficiency.

Stakeholder approach

The Brent Spar event has strongly influenced the political decision-making on decommissioning practices and artificial reefs. The OSPAR 98/3 act is the result of a long process and many stakeholders assume this is the most optimal outcome that could be expected. They fear the debate will open up the process again. Remember the motivation and context of the Brent Spar event and take that into account in potential future discussions regarding platforms for reefs in the North Sea. If decommissioning projects are nothing more than disposal, they will not be feasible politically.

Do not follow a fully scientific or technical approach, because this issue is more a social and political issue. It is recognized that artificial reefs can have environmental and socio-economic benefits, so concentrate on defining explicit management goals with respect to the ecological performance of artificial reef programmes and specific reef sites. Involve stakeholders in setting criteria for strategic planning, artificial reefing, and independent fund management.

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