Offshore exploration and exploitation activities include oil and gas development, as well as renewable energy generation and seabed mining for minerals, sand and gravel. This Future Brief presents currently available evidence on the environmental impacts of these activities, focusing on the oil and gas sector in the context of political concerns following the 2010 Deepwater Horizon disaster in the Gulf of Mexico. Such activities are increasing in the Mediterranean marine environment, which is particularly vulnerable due to its semi-closed configuration and significant seismic activity.

The value of marine and coastal ecosystems can be understood in economic terms through the ecosystem services they provide. These include raw materials and fisheries, and recreational benefits, as well as regulating services, such as climate regulation through the uptake of greenhouse gases (GHGs). In 2010, the Mediterranean marine environment was conservatively valued at €10,000 per square kilometre, with most of the benefits emerging from amenities and recreation (Tinch & Mathieu, 2011). Offshore exploration, particularly by the oil and gas industry, represents a risk to marine and coastal environments and the value they hold.

In the EU, various policies help protect the marine environment from damage caused by offshore exploration, including the Marine Strategy Framework Directive (2008/56/EC). Companies involved in offshore oil and gas exploration are granted licences under Directive 94/22/EC. However, there is no legislation specific to the oil and gas sector. Two separate policy instruments may rectify this in the near future:

2. Planned new legislation on the safety of offshore oil and gas prospection, exploration and production activities (European Commission, 2011b), prompted by the Deepwater Horizon oil spill in the Gulf of Mexico in 2010.

The EU is already a contracting party to the Barcelona Convention – shorthand for the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean. The European Commission took an important step in October 2011 with a proposal to ratify the Convention’s Offshore Protocol, which protects the Mediterranean against pollution from offshore exploration and exploitation activities. The Protocol requires systems to be put in place for monitoring and compensating damage caused by offshore activities. In addition, under the planned legislation, the responsibility for environmental clean-up following any offshore incident would fall wholly upon the operator, extending liability from 22 kilometres offshore (under current legislation) to 370 kilometres.
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Oil and gas: major incidents

The 2006 spill at the Jiyeh power station in Lebanon on the Mediterranean coast was one of the largest spills affecting European waters in recent years. A UNEP report suggests that serious long-term damage to the marine environment was avoided (UNEP, 2007), but the Lebanon spill was small compared to the Deepwater Horizon incident.

Major incidents at oil platforms in Norway and the UK in the 1980s killed hundreds of workers, but there have been few spills in Arctic waters. Currently, there are around 1000 offshore installations in the EU (including Norway), and nearly half are in the UK (EUROPA, 2011). The industry is not as well established in the Mediterranean region, but there are now 400 wells in Spain and Italy alone, and intensive prospection activities are taking place in the south-eastern Mediterranean.

There is concern that lack of resources and effective regulation in the Mediterranean, as well as its specific physical characteristics, may expose its marine and coastal environment to greater risks.

Earthquakes occur more frequently in the Mediterranean than in northern Europe, potentially interfering with offshore operations, while deeper waters and the enclosed nature of its marine environment may affect the fate of oil after an incident. The region is also a popular tourist destination and a major spill could represent large economic losses.

Key Facts: Offshore Exploration and Exploitation

- Damage to the region considered to be most affected by the Deepwater Horizon spill (the Mississippi River Delta) could reduce the value of the ecosystem services it provides by more than $20 billion a year (Tinch & Mathieu, 2011).

- Most offshore oil and gas installations in Europe are in the UK, Norway, the Netherlands and Italy. Denmark, Germany, Ireland, Spain, Greece, Romania, Bulgaria and Poland have fewer, and more are planned in Cyprus and Malta (EUROPA, 2011).

- Many of the impacts of offshore activities on marine environments are uncertain, due to the complex interactions between many different species within marine ecosystems and difficulties associated with conducting research at depth.

- The capacity of the European offshore wind energy sector is currently 4 GW. The European Wind Energy Association has set a target to raise this to 460 GW by 2050 (Jeffrey & Sedgwick, 2011).

Oil and gas: main impacts

There is limited scientific understanding of the effects of oil on marine organisms and biological systems and processes (Upton, 2011), but direct impacts could include:

- Death of a wide variety of marine species
- Behavioural disturbances, including changes in feeding, reproduction and migration
- Airborne emissions of chemicals from controlled burns
- Microbial blooms
- Hypoxia – lowering of oxygen concentrations in water
- Toxic effects of chemicals used to disperse oil

Beached birds killed by oil are closely monitored and provide an indication of the scale of an oil spill’s impact. Following an oil spill in 2002 near the coastal region of Galicia in Spain, 90 different species of bird were collected in Spain, France and Portugal. However, Castege et al (2007) suggest that this type of data underestimates the problem as total numbers of seabirds killed may exceed beached numbers by more than ten times. This perhaps illustrates the difficulty of understanding the scale of pollution effect's at sea.

In the Gulf of Mexico, the National Oceanic and Atmospheric Administration (NOAA) is still carrying out a damage assessment to ascertain the impact of the oil spill (NOAA, n.d.). NOAA-funded researchers have observed dying or discoloured deep sea corals seven miles from the site of the spill (NOAA, 2010). A study published in August 2010, four months after the initial explosion, identified a two-kilometre wide plume of oil that had travelled 35 kilometres from the spill and was
degrading more slowly than expected (Camilli et al., 2010).

Coastal areas, including wetlands and salt marshes [see Box 1], are vulnerable; oil washes ashore with the tide but then becomes stuck. The Gulf Coast Restoration Task Force announced its strategy in May 2011, saying it would focus on protecting wetlands, sand barriers and beaches, and reducing the flow of excess nutrients into the Gulf (Environmental Protection Agency, 2011). However, the scale of the spill and complexity of marine ecosystems makes it difficult to estimate the true impact of the disaster.

Despite limited evidence, it is clear that any spill of a similar magnitude in Europe would have far-reaching consequences for the European marine environment. The interconnectedness of food webs and nutrient cycles means a large spill would effect more than just the local environment and its inhabitants, potentially for years following the incident. In addition, it should be noted that although smaller spills receive less attention, they are responsible for more of the pollution caused by oil spills overall. Satellite mapping of European waters between 1996-2004 revealed that spills (including from ships) covering less than 100 square kilometres account for a third of the total oil pollution in the region, compared to a sixth for spills over 340,000 square kilometres (Redondo & Platonov, 2008). These frequent smaller spills may be more important in the long term.

One important point to consider is that oil and gas exploration is shifting to deeper regions of the ocean, where even less is known about effects on the species that inhabit them (Andrade & Renaud, 2011). In addition, climate change is rapidly changing the environment for offshore activities, particularly in the Arctic, where there the ice is becoming less extensive, but severe storms may become more common in future, potentially increasing the risk of offshore incidents (Harsem et al., 2011). In the Mediterranean, a shorter history of oil and gas production in the region may heighten the risk associated with planned facilities until safety regulations and practices are improved.

Oil spills are not the only potential hazards posed by offshore oil and gas activities. Other important considerations are:

- Noise
- Seafloor and geological disturbances caused by explosions and drilling
- Drill cuttings (barium rich drilling by-products deposited on the seabed)
- Produced water (seawater mixed with oil)

Scientists are only just beginning to understand the impact that noise disturbances may have on marine life. A US report of the Joint Subcommittee on Ocean Science & Technology (Southall et al., 2009) prioritised controlled studies on key species, including baleen and beak whales. Noise associated with offshore activities may interfere with communication calls and displace species to new habitats. Potentially

[BOX 1] Case study: Deepwater Horizon and the Louisiana salt marshes

Salt marshes are widely distributed worldwide, including in Europe. They act as wind and tide buffers and as nurseries for shrimps, crabs, birds and fish. Vegetation in salt marshes tends to be more sensitive to oil than vegetation in freshwater marshes.

A 2012 study by US researchers (Mishra et al., 2012) provided an insight into the effects of a major oil spill on these vulnerable environments, which can retain oil for up to a decade. The study assessed the impact of the spill using canopy chlorophyll content (CNC), an established indicator of the health of vegetation in a region – it measures the ‘greenness’ of vegetation via concentrations of the pigment (chlorophyll) required for photosynthesis.

Prior to 2010, the salt marshes along the Louisiana coast had been experiencing a period of poor growth due to flooding caused by hurricanes. According to the study, the added impact of the Deepwater Horizon spill mid-growing season appeared to slow the recovery of the marshes. The enduring presence of oil is also likely to affect the health of the marshes in the longer term.
permanent damage may result from the use of explosives in the decommissioning of offshore installations (Faber Maunsell & Metoc, 2007).

Two recent studies investigated the impact of drill cuttings from offshore installations on marine species. The first tested the effects of drill cuttings from Norwegian offshore installations on coldwater corals (Larsson & Purser, 2011). Corals were resilient and had the ability to self-clean, but continual deposition over a matter of weeks – intended to mimic the situation during exploration of a well – resulted in smothering, and the corals started to die.

In the second study, Lira et al (2011) found that populations of marine worms declined when exposed to concentrations of barium (a heavy metal) similar to those in drill cuttings. The species studied, *Rhabditis (Pellioditis) marina*, is relatively resistant to environmental stresses, so the researchers reasoned that other species could be worse affected.

Produced water comes from oil reservoirs under the seafloor and is sometimes mixed with water injected into the reservoirs to force out the oil. It is treated, but still contains some dispersed oil. The components in produced water thought to be the most toxic are polyaromatic hydrocarbons (PAHs) and alkylated phenols.

There is limited evidence for significant negative effects of produced water at offshore installations, with the possible exception of bioaccumulation in shellfish (Ekins et al, 2007).

One recent modelling study found that concentrations of alkylphenols in produced water were probably too low to affect fish populations in the North Sea (Beyer et al, 2011).
In the EU, rare metals used in high-technology industries are mostly imported. Some of these are essential to new green technologies, such as electric vehicles. Therefore, it would be beneficial for the EU to secure European sources of important mineral deposits, some of which are beneath the seabed (European Commission, 2008). Deep sea mining is one focus of the European Technology Platform on Sustainable Mineral Resources.

Because we know little about some deeper areas of the ocean, possible effects on marine species are uncertain. One study warned against mining near hydrothermal vents, which are important habitats for seafloor ecosystems (Halfar & Fujita, 2007). Nutrients released from the deep sea by mining may also pose a problem if they migrate upwards to contaminate shallower waters, potentially causing algal blooms and problems for fisheries.

In addition to mineral mining, offshore sand and gravel extraction disturb benthic (seafloor) communities. The cumulative effects of activities at several nearby dredging sites, rather than one-off dredging activities, need to be considered (Steele et al, 2010).

Research on benthic communities at dredging sites in UK waters has hinted that recolonisation is a slow process, with communities still not fully re-established six years after dredging ceased (Boyd et al, 2005). Relatively little is still known about the role of benthic communities in marine ecosystems and there may be wider unintended consequences of mining at sea.

**[BOX 2] Offshore energy**

**According to the European Ocean Energy Association** (EU-OEA), offshore wind, wave and tidal facilities could theoretically produce enough energy to meet Europe’s entire electricity demand through renewable sources (Jeffrey & Sedgwick, 2011).

The most immediate opportunities for offshore energy are in two hotspots where wind, wave and tidal energy could be produced at combined platforms: along the Atlantic coast, off of the UK, Ireland, Spain and Portugal; and in the North Sea between Norway and the UK. However, technologies suitable for deeper waters will need to be developed to fully exploit these resources, particularly in the Mediterranean and Black Sea, where most facilities would need to be built in waters deeper than 60 metres – currently the limit for fixed foundation wind turbines.

As well as seafloor disturbances, potential threats to the marine environment include seabird collisions with blades, and noise. A recent study focusing on threats to cetaceans in Scottish waters, including dolphins, harbour porpoises and minke whales, concluded that strong best environmental practice guidelines are still needed for developers of offshore renewable energy facilities (Dolman & Simmonds, 2010). Threats considered include risks of collision and disturbance caused by increases in vessel activity and the impacts of noise.

The authors also called for regionally focused research on habitats that could be affected by the facilities, partly to establish distributions, densities and population trends, and also for developers to take on the responsibility for monitoring and mitigating impacts on marine populations in the long-term.

**[BOX 3] ‘Eco-efficiency’ in the Netherlands**

One interesting example of national-level policy can be found in the Netherlands. Here, major oil and gas producers are bound by an agreement with central government to reduce emissions of harmful substances from oil and gas production, through a concept called ‘eco-efficiency’, which can be defined as ‘the environmental impact per unit of economic value’ (Huppes, 2007).
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Summary and conclusions

Catastrophic oil spills on the scale of the Deepwater Horizon disaster represent perhaps the greatest threat to marine and coastal environments from offshore activities.

However, the effects of more frequent small spills are not to be underestimated. Seafloor disturbances and noise effects are common to a number of different offshore activities, and have uncertain impacts.

Decisions to undertake offshore exploration and exploitation activities are clearly not based on environmental factors alone. The potential economic and societal benefits of the ocean's exploitable resources may outweigh the environmental costs.

For example, a strong argument can be made for renewable energy production at sea on the basis of reduced GHG emissions from fossil fuels.

Certainly, cooperation between government and industry is required to address the environmental consequences of increasing offshore activities. However, whether enough weight is given to environmental concerns, as compared to economic stability and energy security, is questionable.

In the long-term, environmental degradation also becomes an economic concern, owing to its impacts on industries including fisheries and tourism.

References


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