10 messages for 2010
Marine ecosystems

European Environment Agency

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This document is the 4th in a series of '10 messages for 2010'. Each message provides a short assessment focusing on a specific ecosystem or issue related to biodiversity in Europe. The remaining messages will be published at various intervals throughout 2010. More detailed information on the published and forthcoming messages can be found at www.eea.europa.eu/publications/10-messages-for-2010.

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Marine ecosystems

Key messages

- Marine ecosystems provide key services both globally and locally, which are essential for maintaining life on our planet. However, marine biodiversity faces an unprecedented range of pressures. In recent years climate change has caused changes in species distribution and presents new challenges for marine biodiversity as oceans become more acidic.
- Most of the problems facing marine biodiversity were identified some time ago. Despite this there is a lack of integrated data and information to document the extent and severity of problems or progress towards solutions. Data compiled under Article 17 of the Habitats Directive reveal that the unknowns for marine species and habitats are much bigger than those for terrestrial ecosystems.
- European marine biodiversity is primarily protected by establishing Natura 2000 sites under the Habitats and Birds Directives but there are serious delays in identifying areas and even greater delays in establishing their status. There is evidence that marine protected areas support marine biodiversity and fisheries and that the extent of recovery increases with the age and size of the protected area.
- EU Governments agree that an ecosystem-based approach is the best means to manage and govern activities affecting the marine environment. This is the aim of Europe's integrated cross-sectoral strategy for sustainable use of the marine environment, which is now being implemented via the Marine Strategy Framework Directive and its link to the Integrated Maritime Policy (targeting 'good environmental status' for Europe's seas by 2020).
- Synergies between this marine/maritime policy framework and well-established marine nature protection policy will benefit European marine biodiversity.

1 Marine ecosystems provide key services

Life on Earth started about 3.5 billion years ago in the oceans. Today, nobody knows the number of organisms living there, merely that it is very large and that only a small fraction is known to humans. While roughly 18 million km^2 of land are protected globally, only 10 % of this area is protected in the oceans, even though oceans cover 71 % of the surface of the Earth.

Marine ecosystems are a complex of habitats defined by the wide range of physical, chemical, and geological variations that are found in the sea. Habitats range from highly productive near-shore regions to the deep sea floor inhabited only by highly specialised organisms.

Oceans and seas cover more than half of the territory of the EU-27. Marine ecosystems are important to humankind both ecologically and economically, providing numerous vital goods and services, and supporting the processes that sustain the entire biosphere. Unfortunately, in spite of their widely recognised value, human activities are putting marine ecosystems under pressure across Europe.

Marine ecosystem services are provided at the global scale (for example. oxygen production, nutrient cycles, carbon capture through photosynthesis and carbon sequestration) and at the regional and local scales (for example stabilising coastlines, bioremediation of waste and pollutants, and a variety of aesthetic and cultural values) (MARBEF, 2008). Marine services include several important economic benefits such as food provision and tourism (Kettunen, 2007).

Some of the environmental changes taking place at the global and European levels are likely to have significant and far-reaching consequences for marine biodiversity. Changes in marine biodiversity are extremely complex processes driven by numerous factors, making it difficult to determine precisely which changes are results of direct human influence. It is clear, however, that deteriorating biodiversity impairs a marine ecosystem's capacity to provide food, maintain water quality, and recover from perturbations (Worm *et al.*, 2006).

2 European marine biodiversity faces an unprecedented range of pressures

The list below summarises the main pressures on marine ecosystems, which are explored in more detail in the following sections (adapted from EC, 2002):

- pollution, including land-based coastal and marine pollution due to poorly managed sewage and industrial waste and agricultural run-off;
- overexploitation of marine resources;
- climate change and acidification of the sea;
- sea uses (transport, construction, mineral extraction, etc.);
- introduction and spread of invasive alien species.

2.1 Despite specific policies targeting them, eutrophication and pollution will continue to have negative impacts for years to come

Eutrophication continues to be a major problem affecting most European seas. Despite reduced point source nutrient pollution in some regions, diffuse pollution sources, especially intensive agriculture, continue to be a problem (EEA, 2005a, 2005b; EC, 2007a). For instance, Denmark and Sweden have reduced the point source input of nutrients to the marine environment to levels significantly lower than 20 years ago. However, these reductions have not yet been sufficient to reduce harmful effects of eutrophication and to improve the ecological status (Andersen and Conley, 2009).

As a key action against pollution, policies to reduce emissions and to regulate the use of hazardous substances have been developed at global, European and national levels. In general, concentrations of hazardous substances in European seas have been decreasing. However, the persistence of many such substances and the amounts already released in the environment mean that negative effects will continue for decades. In addition, new substances that cause concern, will continue to appear, such as residues from pharmaceutical products. Diffuse inputs into the marine environment are now recognised as highly significant for some heavy metals. In some specific cases it is almost impossible to reduce pollution levels any further because of the residues contained in many estuarine sediments (Rodrigues *et al.*, 2009).

Table 1.1 Examples of goods and services provided by the marine environment

Category	Marine goods and services
Production services	Food provision
	Raw materials
Regulation services	Gas and climate regulation
	Disturbance prevention and alleviation
	Bioremediation of waste (removal of pollutants from human activities through storage, dilution, transformation and burial)
	Hydrological climate balance/cycle
Cultural services	Cultural heritage and identity
	Cognitive values (cognitive development, including education and research)
	Leisure and recreation
	Non-use values (bequest and existence)
Supporting services	Nutrient cycling (storing, cycling and maintaining the availability of nutrients mediated by living marine organisms)
	Biologically mediated habitat (habitats provided by living marine organisms)
Option use values	Optional future use (the currently unknown extent of potential future uses of the marine environment)

Source: Adapted from Beaumont *et al.*, 2008.

Marine litter is increasingly recognised as a modern source of pollution. Large-scale accumulation of floating waste (particularly microscopic plastics) has been observed in very large areas of the central Pacific in the past 10 years (in an area also known as the 'Great Pacific Garbage Patch') and has recently also been recognised as a problem in the Sargasso Sea. More widely recognised problems arising from marine litter are associated with entanglement, ingestion, suffocation and general debilitation (Gregory, 2009). Microscopic plastics cause harm to animals because they ingest the plastic as part of their foraging. For example it has been documented that the Laysean Albatross has a sub-optimal diet comprised of large amounts of plastic (Young *et al*., 2009).

2.2 *Overexploitation of fish stocks and other marine organisms has significant impacts on the provision of ecosystem goods and services*

Fishing fleet overcapacity is a severe problem for European marine ecosystems (EC, 2009a). Eighty-eight per cent of Community fish stocks are harvested beyond Maximum Sustainable Yields, whereas less fishing pressure now would allow stocks to recover, delivering greater yields in future years. Thirty per cent of overfished Community fish stocks are even outside safe biological limits that may not allow recovery (EC, 2009b).

Besides overexploitation of commercial fish stocks, current fishing practices can also threaten other marine ecosystem components, e.g. marine mammals, reptiles, seabirds and bottom habitats. As a consequence marine habitats are more vulnerable to other pressures — especially pollution and climate change — and ecological space develops in which alien species can flourish (EEA, 2007). Reduced biomass and fragmented habitats resulting from fishing have led to local extinctions, especially among large, long-lived and slow-growing species with narrow geographical ranges (MEA, 2005). For example, many stocks of the Atlantic Cod (Gadus morhua) have declined dramatically. The Atlantic Cod is one of the most economically important fish species in European waters (Lindegren *et al*., 2009). In addition to overfishing, climate-driven declines in plankton productivity has impacted food resources for larval cod in the North Sea (Beaugrand *et al*., 2003), causing some commercially relevant fish species to change their geographical distribution northward.

Destructive fishing practices, in particular trawling and dredging, change the structure of marine ecosystems with consequences for their capacity to provide ecosystem services (MEA, 2005).

In view of the severe ecosystem pressures linked to fisheries, the European Union's recent 'green paper' on the reform of the Common Fisheries Policy (EC, 2009c) calls for better stewardship of marine resources. In order to face these challenges, fisheries communities would need to be supported in adapting to an ecosystem management approach. In this way, these communities could be considered as stewards for the marine resources, much as is increasingly the case with farmers on land. This approach has been articulated in the EU Pesca programme (EC, 2010b), which aims to help the fisheries sector adapt to changing circumstances by, for example, diversifying into tourism and conservation activities.

2.3 *Climate change and ocean acidification impacts on marine biodiversity are already visible and are very likely to cause large-scale alterations within marine ecosystems*

Climate change impacts on marine biodiversity and ecosystems are becoming more and more obvious: sea surface temperatures and sea levels are rising; sea-ice cover is decreasing; and the chemical, physical and biological characteristics of the sea are changing.

Several studies in Europe confirm that marine fish and invertebrate species respond to ocean warming by shifting latitudinal and depth range (Cheung *et al.*, 2009). For instance, the fish species composition in the North Sea has changed from 1985 to 2006 related to higher water temperatures. In general, small-sized species of southerly origin increased while large northerly species decreased, although this can also be partly explained by commercial overexploitation of large predator fish species (Hiddink and Hofstedt, 2008). In the central Baltic Sea ecosystem, the sudden increase in temperature due to changed atmospheric forcing in the late 1980s and unsustainable cod fishing triggered an ecosystem regime shift. When temperature decreased again, the biotic component of the ecosystem had shifted to a new regime (Möllmann *et al*., 2009).

Fish in warmer water are caught in a bind: as they adapt, their metabolism speeds up, they grow more quickly, although often to a smaller adult body size, and they need more food and more oxygen to support their higher metabolism. At the same time, as the temperature of the water increases, the amount of oxygen it contains decreases. Many fish experience what is an 'oxygen squeeze' — their needs go up and supply goes down (EEA, 2010).

Ocean acidification may cause serious adverse impacts on the marine environment, particularly as carbon dioxide (CO_2) emissions continue to increase. As atmospheric CO_2 increases, more dissolves in the ocean, increasing its acidity and preventing the process of calcification (see Hoegh-Guldberg *et al.*, 2007). Even if atmospheric CO_2 levels were reversed, it would take tens of thousands of years for ocean chemistry to return to a condition similar to that occurring in pre-industrial times (Orr, 2005). Marine species that build up a calcified skeleton such as plankton (coccolithophores, foraminifera), corals, and pelagic mollusks may be hindered in their growth. Besides harming such species, this impairs the capacity of marine ecosystems to act as a global carbon sink (Burkill *et al.*, 2009).

2.4 *Rapidly changing environmental conditions provide the ground for invasive species which in turn affect the integrity of marine ecosystems*

Marine invasive alien species cause biodiversity loss by eliminating local species, which can significantly alter ecosystem structure and functioning, and damage economic activities and human health. This is particularly the case when such species affect an ecosystem already vulnerable due to other pressures. For example, in the Black Sea a chain of events involving the invasive alien species *Mnemiopsis leidyi* led to the collapse of the very important anchovy fisheries in the early 1990s. *Mnemiopsis* and anchovy compete for the same food source (zoo plankton). When nutrient enrichment and sea temperatures favourable for enhanced growth of *Mnemiopsis* were combined with high fishing pressure on anchovy, an ecological niche for *Mnemiopsis* was created. This enabled it to consume such a large portion of the zoo plankton biomass that the anchovy stock collapsed (Oguz, 2009). The anchovy fisheries have since recovered due to less favourable environmental conditions for *Mnemiopsis leidyi* and the presence of another accidentally introduced species in the Black Sea (*Beroe Ovata*) that feeds on it (Mutlu, 2009). However, it has since spread to the Mediterranean, the North Sea and the Baltic Sea. It is a cause of particular concern in the Baltic Sea because the low salinity conditions there are thought to be favourable for supporting it in large numbers.

Jellyfish outbreaks, whether from local or invasive species, are now seen as a global phenomenon. Jellyfish domination of the world's oceans, leading to a so-called 'gelatinous sea', is regarded as a nuisance to tourists, swimmers, fishermen and

Table 2.1 Examples of invasive species in Europe

Lagocephalus sceleratus	The pufferfish (*Lagocephalus sceleratus*) is a toxic fish from the Indo-Pacific region. It was first discovered south of Turkey in 2003 and has since spread dramatically in the eastern Mediterranean, also reaching the northern Aegean (Greece) (Zenetos *et al.*, 2007). The species contains tetrodotoxin, a very powerful neurotoxin (Katikou *et al.*, 2009), which may cause poisoning and even death if the fish is eaten without adequate preparation. In 2005–2008, 13 people were hospitalised in Israel after consuming this fish (Bentur *et al.*, 2008).
Apollonia melanostoma	First observed in 1990, the round goby (*Apollonia melanostoma* or *Neogobius melanostomus*) has now become widespread in the Bay of Gdansk and is now one of the most common near shore fish in the southern Baltic Sea. It was observed in Finnish and Swedish coastal waters in 2005 and 2009 respectively. Introduced with ballast water from the Black Sea, it has rapidly adapted to Baltic conditions and can locally dominate coastal fish populations, such as the flounder. It has also become a significant contribution to the diet of important predatory fishes, such as cod and perch. It may promote bioaccumulation of persistent toxic pollutants by transferring toxic substances accumulated in common mussels to cod (and ultimately to humans). There is also concern that its parasites may spread diseases to other fish species and birds (Kvach and Skóra, 2007).
Paralithodes camtschaticus	The Red King Crab (*Paralithodes camtschaticus*) was deliberately introduced into the Eastern Barents Sea during the 1960s for commercial purposes and has subsequently thrived in its new environment, spreading both east along the Kola Peninsula and west into the Norwegian zone (EEA, 2007). This crab has an enormous impact on local species because it eats them (it is an opportunistic omnivorous feeder) or competes for their food and overpowers them. According to local divers, scallop-beds (*Chlamys islandica*) and flatfish populations along the Norwegian coast have being reduced due to their predation. A single mature crab has been found to consume an impressive 400–700 g of scallops in 48 hours (ICES, 2003). Fortunately this crab has a high market value. The Red King Crab fishery has increased in value from 1.3 million Norwegian krone in 1994 to 75 million krone in 2004 (Jørgensen, 2006), and in areas where fishing pressure is high the population does not appear to be increasing (ICES, 2009).

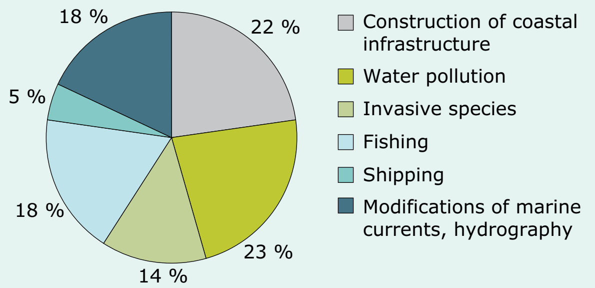
Seagrass meadows as an indicator of a well-functioning marine ecosystem

Seagrass meadows represent some of the most productive ecosystems on earth. They are sources of primary and secondary productivity, carbon sequestration and oxygen production (Boudouresque *et al.*, 2006; Borum *et al.*, 2004). For example it is estimated that 1 m^2 of seagrass meadow contributes to the production of 14 litres of oxygen per day (Bay, 1978). In addition, seagrass meadows reduce the hydrodynamic force of the waves and consequently protect the coast (Boudouresque *et al.*, 2006; Borum *et al.*, 2004).

Posidonia oceanica is distributed along almost the entire Mediterranean coastline (Boudouresque *et al.*, 2006; Borum *et al.*, 2004). More than 400 plant species and thousands of animal species have been found within *Posidonia oceanica* communities. These meadows are spawning and nursery areas for many species of economical interest such as crustaceans, molluscs and fish. They also provide protection from predators, thereby promoting the survival of juveniles and benefiting a range of commercial species (Boudouresque *et al.*, 2006; Valle *et al.*, 2001).

The EU Habitats Directive (92/43/EEC) specifically lists *Posidonia* beds as a natural habitat type whose conservation requires the designation of special areas of conservation. Despite this, recent data suggest that *Posidonia* beds are under threat. The reporting process carried out by the Mediterranean Member States under the Habitats Directive indicates that the habitat's general conservation status in the Mediterranean is 'unfavourable-inadequate' (ETC/BD, 2009). The main groups of threats affecting the long-term viability of *Posidonia oceanica* meadows include water pollution, construction of coastal infrastructure, fishing, shipping, invasive species and changes to water currents (Figure 2.1).

Figure 2.1 Grouped threats to *Posidonia oceanica* beds as reported by Mediterranean EU Member States under the EU Habitats Directive



Source: ETC/BD, 2009.

fish-farmers alike (Richardson *et al.*, 2009). Other examples of invasive species found in Europe are shown in Table 2.1.

3 Establishing Natura 2000 sites under the Habitats and Birds Directives is a key instrument for protecting marine biodiversity

Marine protected areas are now being nominated rapidly in Europe but coverage is not yet as extensive as for terrestrial habitats. In part this is because effective protection of marine areas requires international collaboration. For example, France started identifying Marine Protected Areas already in the 1960s but adequate protection measures require international collaboration. In some marine regions, biodiversity protection measures were developed in cooperation with regional sea conventions, which provide advanced mechanisms and guidance to halt the loss of marine biodiversity (EC, 2009a).

The EU Natura 2000 network of protected sites is a key response to biodiversity loss and ecosystem degradation. It originates in the Habitats Directive, which requires Member States to establish a coherent European ecological network of special areas of conservation under the title of Natura 2000. The network is intended to enable natural habitat types and species habitats to be maintained or, where appropriate, restored to a favourable conservation status within their natural range. The sites, referred to individually as 'marine protected areas' or 'Natura 2000 sites', are considered crucial for protecting marine biodiversity. Designating and adequately managing a sufficient number of marine Natura 2000 sites is seen as contributing significantly to marine biodiversity protection in Europe, although marine habitats and species are listed in a much lower degree of detail than their terrestrial counterparts in the Annexes to the Habitats Directive

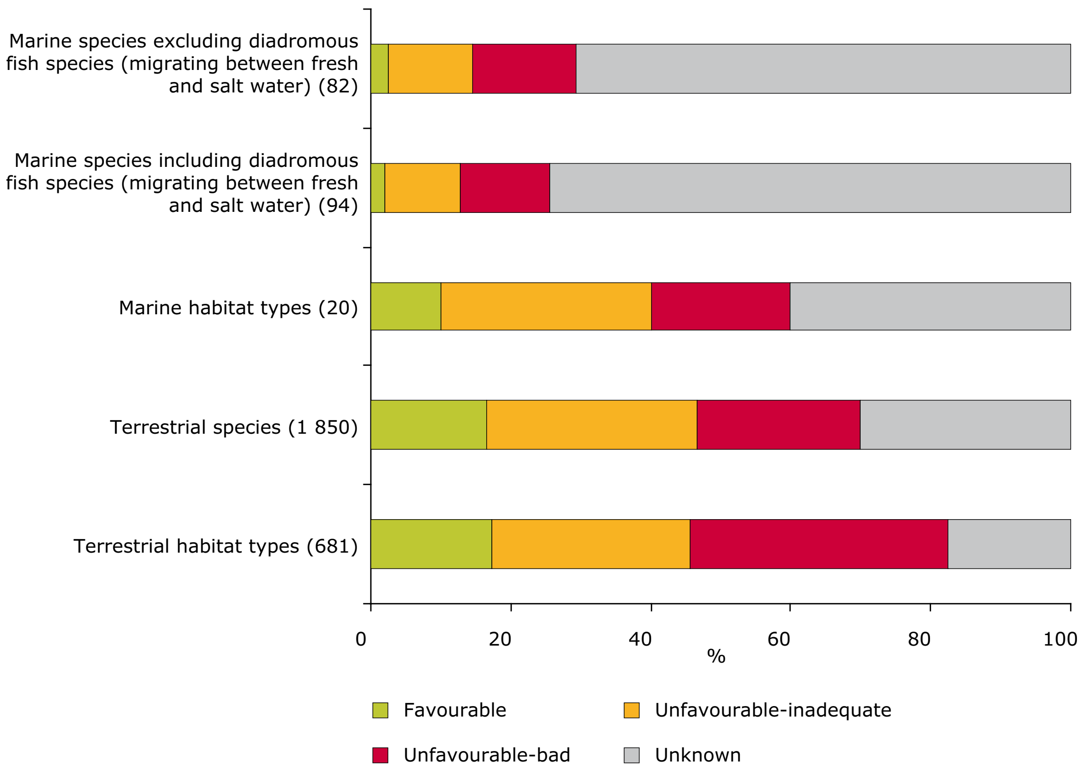
By December 2009, about 2 000 sites had been proposed or classified under the EU Habitats and Birds Directives that are either fully or partly marine. Together they cover an area of approximately 167 000 square kilometres (about twice the terrestrial area of Austria). Currently, most of these sites are near-shore areas. A coherent network is currently lacking, particularly in offshore areas (ETC/BD, 2009; EC, 2009b).

Under the Habitats Directive, countries have to provide an assessment of the conservation status of habitats and species every six years, including several marine features such as reefs, *Posidonia* beds, marine turtles and mammals (Figure 3.1). Less than 5 % of marine species and less than 10 % of marine habitats listed in the Habitats Directive have been assessed as being in 'favourable conservation status'. Our poor knowledge of the marine environment is evident in the overwhelming majority of features whose status is assessed as 'unknown'.

It has been documented that Natura 2000 sites and other marine protected areas help conserve marine habitats, particularly when the protection measure includes a 'no take' provision towards fisheries. In a large study of marine protected areas in the Mediterranean, it was shown that establishing a protected area helped increase abundance and biomass of individuals, raised the proportion of larger and older individuals, enhanced the fisheries yield outside the protected area, and increased the dominance of large predator species (Garcia-Charton *et al.*, 2008). Other studies have shown that increasing the duration and size of the protected area enhances these effects (Claudet *et al.*, 2008).

Compared to the terrestrial environment, however, there are serious delays in identifying areas needing protection and even greater delays establishing their management status. This difference between marine and terrestrial may have a historical explanation in the sense that the marine environment was long regarded and managed as a resource, rather than as a habitat supporting biodiversity that should be conserved. But as both the richness of marine biodiversity and the threats become more and more visible, it is ever more obvious that an ecosystem approach to managing our seas is needed to conserve biodiversity and maintain resources.

Figure 3.1 Conservation status of marine habitat types and species listed in Annex I of the EU Habitats Directive



Source: ETC/BD, 2009.

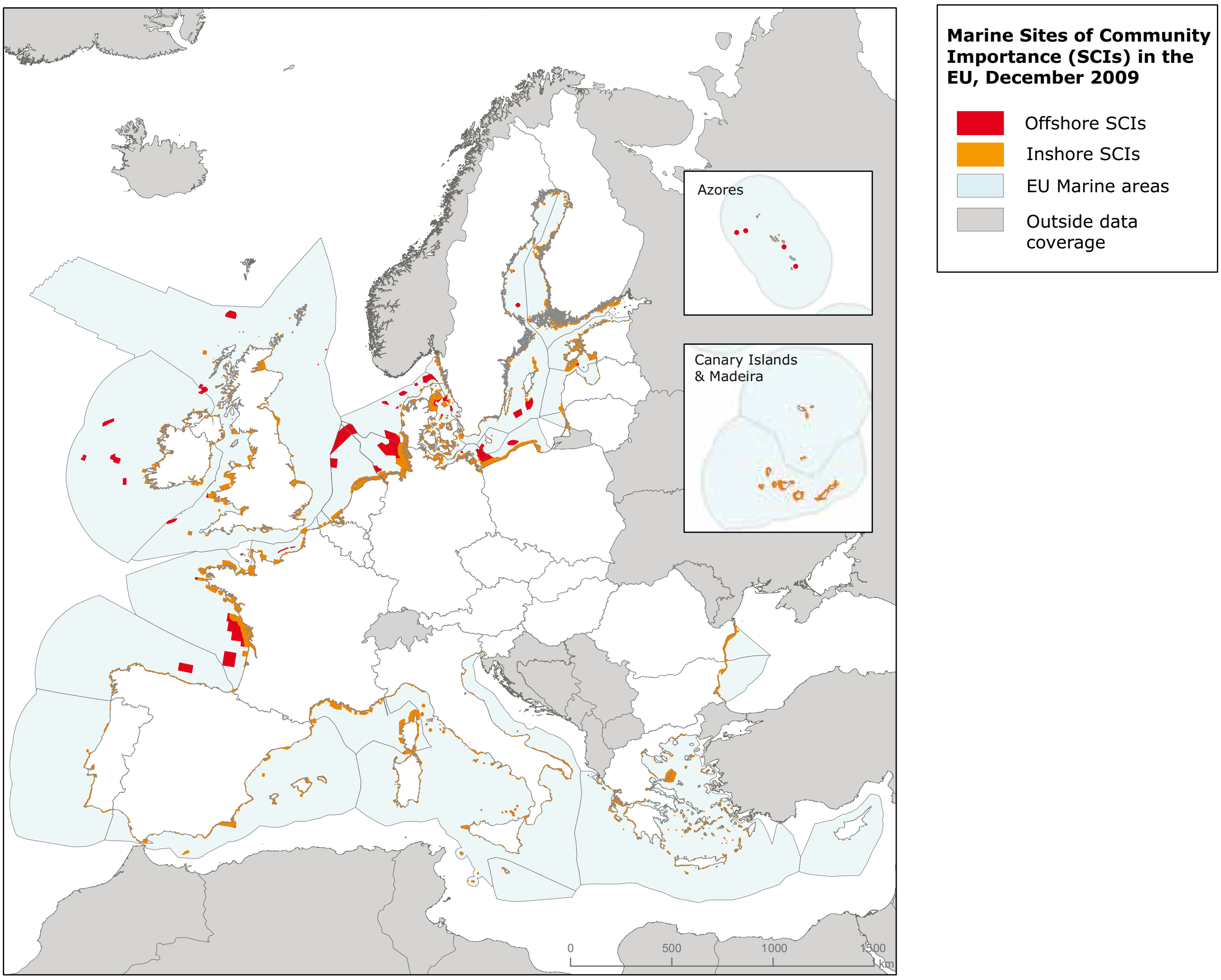
In order for an ecosystem approach to be successful, the focus of marine protected areas should shift from individual sites to networks (Gaines *et al.*, 2010). Given the complex interactions and the mobility of species at different stages in their life cycle, current marine protected areas may need to be extended significantly to allow for a true ecosystem approach.

4 The EU Integrated Maritime Policy complements the Natura 2000 network of marine protected areas

The EU Marine Strategy Framework Directive, adopted in 2008, completes the coverage of the whole water cycle by EU legislation and makes use of the approaches already enshrined in the EU Water Framework Directive, adopted in 2000. Crucially, it applies an ecosystem-based approach to managing human activities that impact the marine environment. In addition, it specifies the designation of Marine Protected Areas as a means for Europe's seas to achieve 'good environmental status' by 2020.

In 2007, the European Commission presented its vision for an Integrated Maritime Policy (IMP) for the European Union, with the Marine Framework Directive serving as its environmental pillar. Member States adopted the IMP — often referred to as the 'Blue Book' — along with a detailed Action Plan (EC, 2007b). Among other things, the IMP refers to the maritime spatial planning and integrated coastal zone management (ICZM) as key planning tools for sustainable development of marine areas and coastal regions; calls for national integrated maritime policies in the EU Member

Map 4.1 Marine Sites of Community Importance (SCIs) in the European Union, December 2009



Source: ETC/BD, 2009.

States; and envisages a European network for maritime surveillance (EC, 2007b).

The 2009 European Commission's progress report of the IMP sets out six future priorities (EC, 2009d), namely:

- enhancing integrated maritime governance;
- further developing cross-sectoral instruments of the Integrated Maritime Policy;
- defining boundaries of sustainability for implementing the EU Marine Strategy Framework Directive;
- supporting sustainable economic growth for maritime activities;
- enhancing the sea basin approach to address the specific maritime challenges and priorities of Europe's sea basins;
- actively promoting the global nature of many maritime issues through relevant international forums (for example the United Nations Convention on the Law of the Sea and the International Maritime Organization).

The Green Paper on Reform of the EU Common Fisheries Policy, adopted by the European Commission in 2009, assesses the status of the Common Fisheries Policy and its difficulties delivering its objectives. It proposes that a new fisheries policy should recognise that without ecological sustainability, no economic or social advantages can be obtained. It proposes a vision for 2020, in which overfishing is terminated and fish stocks targeted by the European fleets are at maximum sustainable yield (EC, 2009c).

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