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Background document to the EURECA spotmeter on Breaking the Waves

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The following document was prepared as a background for discussion to a possible expert workshop on EURECA spotmeters to be organised by the European Environment Agency.

The expert meeting will explore the potential of a story-line based assessment, including on which 'hotspots' to focus in order to illustrate state and trends of areas/issues of particular interest - from an ecosystem service perspective - within major ecosystems in Europe.

This Background Document introduces some of EEA's ideas on what the "Breaking the Waves" Spotmeter could look like, based on consultation with different stakeholders since the 1st EURECA general expert meeting of January 2008, and puts forward some key considerations for its further development.

Definition of 'Coastal Zone' in the context of this report: The definitions of the coastal zone are numerous and varied. For the purposes of this report the definition used is that given in the EEA report on "The Changing Faces of Europe's Coastal Areas"; where coastlines are determined from the Corine land cover data base (CLC). The terrestrial portion of the coastal zone is defined by an area extending 10 km landwards from the coastline. Where relevant, assessment of the basic coastal zone is enhanced by comparisons between the immediate coastal strip (up to 1 km), the coastal hinterland (coastal zone between 1 and 10 kilometre line) and the non-coastal national territory, called inland. The marine part of coastal zone is defined as a zone extending 10 km offshore (which also conforms to Natura 2000 coverage analysis) or a variable zone of shelf sea depending on the issue analysed (e.g. navigation routes, territorial waters, fisheries, coastal dynamics). The territorial coverage of the report is EEA member and collaborating countries.

Breaking the waves
Coastal ecosystems under pressure

1 Introduction

Through the ages, coasts have captured the collective imagination and have provided the inspiration for a vast range of artistic and technological creativity. Early civilizations such as the Phoenicians and the Greeks explored the world by navigating along the coasts and their sphere of influence was mainly focused on the shores of the Mediterranean and Black Sea. The coasts also played an important role in European mythology: Aphrodite was born out of the foam of the waves breaking on the shores of Cyprus and Europa was abducted by Zeus on the Phoenician shores. Odysseus' return from Troy to Ithaca brought him to the beaches of many an enchanted island and coastal site.

Through their obvious gateway function between the seas, the oceans and the hinterland, coastal areas have since time immemorial been the preferred places of trade, meeting places for cultural exchange, innovation and generators of prosperity and development. Many great historic cities in Europe such as Venice, Amsterdam, London, Lisbon, Rome, Tallinn, Helsinki and Istanbul owed their influence and prosperity to their location on the coast. The coast provided access to the oceans leading to far-away empires and colonies, sources of valuable raw materials that underpinned the wealth and prosperity of European nations, and was the place where maritime and overland trading routes met. The Hanseatic League, forebear of a globalised economic model and of European integration was a trading union of (mainly coastal) cities centred on the North and Baltic seas.

Figure 1: Coastal habitat and use in South Western Turkey. (Source: Lawrence Jones-Walters)

The interplay of climate and geology has resulted in a wide range of coastal geomorphologies, some of which have been very beneficial to human settlement and development. Sheltered bays such as the *rias* of Northern Spain and Norway's *fjords*, but also river deltas and especially estuaries offered the right conditions for settlement, economic activity and trade, and protected communities against the elements and their enemies. However, some coastal areas were much less favourable for development, especially

small isolated islands or inaccessible coastlines (where harbour construction was problematic), and these areas lagged far behind in prosperity.

The historic seaside concentration of economic activity (trading, fishing, manufacturing) and the infrastructure this activity required (urbanisation, transport, industry) have resulted in a wide array of pressures (including pollution, habitat destruction, land conversion, overexploitation of natural resources and disturbance) on Europe's coasts.

This long history of human settlement, use of and activity on coastal areas has undergone a significant acceleration in modern times and especially in recent decades. Vast stretches of coastal habitat have been converted to agricultural land, destroyed by industrial estates and transport infrastructure, polluted by oil spills as well as ship and land based pollution. The migration of populations to the centres of coastal economic activity has led to unprecedented urban development giving a further boost to the pressures on the habitats, species and environment. Indeed, large parts of the unique coastal ecosystems and landscapes in the pan-European region are vulnerable to intense and increasing human pressures. Around 16 % of EU citizens live in coastal municipalities, although the coastal zone only represents 11 % of the EU's land area (European Commission, 2004). There are around 280 coastal cities with more than 50 000 inhabitants in the pan-European region (EEA, 2006e).

Figure 2: A busy port on the European North Sea coast (Source: Helen Chambers)

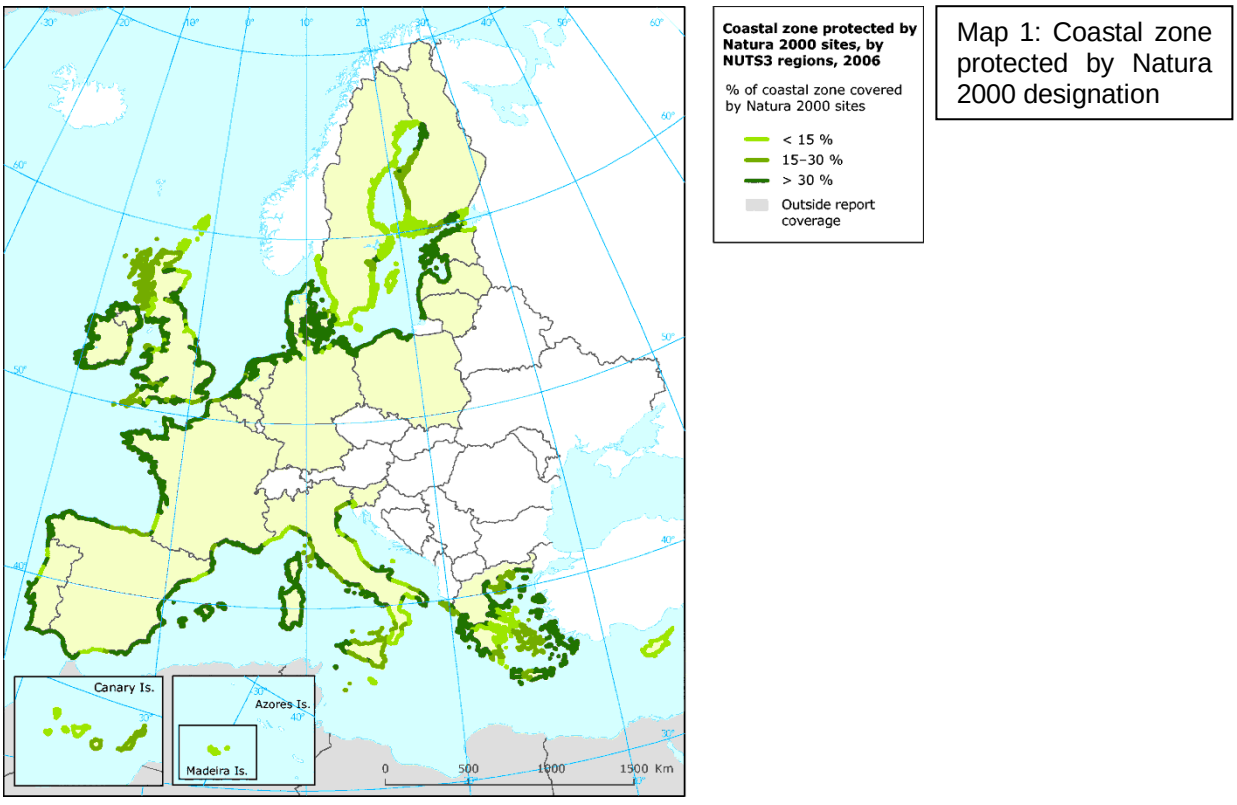
Besides their obvious strategic importance for industry, commerce and warfare, coasts have, especially in more recent times, also attracted the crowds because of their beauty and natural inspiration. Living by the sea and spending holidays along the coast is considered very attractive. Nowadays, over 50% of Europeans live within 50 km of the sea. Moreover, each summer, mass tourism floods the shores of the Mediterranean and other seas with entire populations/cohorts requiring accommodation, infrastructure, water and food, and most importantly vast stretches of sandy beaches. This so called "coastal strip development" results in unprecedented rates of destruction of fragile coastal habitat and indirect pressures such as water depletion, salination of ground water, pollution and disturbance.

Because of their multiple benefits to society, coastal regions have been the subject of significant attention from the scientific community, civil society organisations, policy and decision-makers. For instance, from 1996 to 1999, the Commission operated a Demonstration Programme on Integrated Coastal Zone

Management (ICZM) which resulted in a Communication from the Commission to the Council and the European Parliament on "Integrated Coastal Zone Management: A Strategy for Europe".

In relation to civil society initiatives, the Neptune Coastal Campaign, started in 1965, has been the National Trust's most successful public fundraising action ever and resulted in the purchase of 1,142 km of the UK's threatened coastline. In France, the most successful nature conservation organisation is the *Conservatoire du littoral,* which ensures the protection of coastline and sites that are potentially vulnerable to development pressure, touyrism and public access and recreation, by acquisition and adaptive management. It currently owns and manages 125,000 hectares, 1,000 km of coastline and 600 nature sites. Other coast conservation organisations include *Stichting Duinbehoud* (The Netherlands). EUCC-The Coastal Union, which plays a pivotal role at the interface between science, civil society and policy at a European level in coastal conservation matters, provides a focus for the convergence of many such initiatives.

Different protection regimes are being implemented across pan-European coastal zones in an attempt to preserve their outstanding diversity of landscapes and ecosystems. Due to its high nature value and vulnerability to environmental change and other impacts, a significant proportion of the EU coastal zone is expected to be protected, both on the land and at sea, by the designation of Natura 2000 sites. Member States will ensure that this is carried out in a way which is compatible with the conservation of the habitats and species living and growing within them. In general, the establishment of the network is almost complete in EU-15, and the analysis of the proposed sites for EU-10 is ongoing. For EU-15, Natura 2000 sites cover more than 50 000 km2; approximately 15 % of the coastal zone, including land and sea (see Map 1).



Map 1: Coastal zone protected by Natura 2000 designation

Source: EEA, 2007 accessed through:
http://dataservice.eea.europa.eu/atlas/viewdata/viewpub.asp?id=3125 (N2K and coastal zone map).

In addition to Natura 2000 designations across European coastal zones, there have been efforts to identify protected sites withint the context of the Emerald Network. The Emerald Network is expected to form the basis for non-EU country participation in the Natura 2000 process.

As climate change is increasingly recognised as a serious threat, particularly to coastal areas, adaptation and compensation measures (the latter also in relation to the requirements of the Habitats Directive on Natura 2000 sites), need to be taken into account in developing the context and frameworks for Integrated Coastal Zone Management and protected area management across Europe. Coastal and estuarine wetlands and dune systems will be particularly under threat from rising sea levels and changing erosion and accretion patterns; however, they also play an extremely important role in providing natural 'buffers' and protection from, for instance, extreme storm events and the increasingly high tides that are both cyclic and associated with rising sea levels. In the context of socio-economic issues conflicts may occur in relation to the protection of homes, property and industrial infrastructure (through the strengthening and construction of man-made sea defences) and the presence of important habitats and species. New coastal habitat may therefore need to be created in some areas to compensate for losses in others; (see also below).

2 Issues at stake

2.1. Coastal ecosystem goods and services (ES)

Coastal ecosystems provide a wide range of goods and services to society; many of which are based on the position of the coast as an 'interface between the land and the sea'. Indeed, the interface also provides a major contributing factor to the fantastic richness, abundance and productivity of biodiversity supported by the coastal zone: measured at gene, population, species, ecosystem, and regional levels. Neither is the coast a static interface; the movement and activities of people (in exploiting its goods and ecosystem services and in utilising its natural resources), the tidal cycle, currents and sedimentation regimes and the climate add an element of dynamism and unpredictability.

In terms of goods and services, provisioning services include the supply of food, fibre, fuel wood, energy resources and natural products, and cultural (amenity) services, such as tourism and recreation. In addition, coastal ecosystems offer important regulating services, such as shoreline stabilisation and buffering from natural hazards, storm protection, water flow regulation, human disease control, waste processing and carbon sequestration. Finally, coastal ecosystems provide a number of supporting services such as nutrient regulation and cycling, providing habitat for plants and animals and primary productivity or detoxification of polluted waters.

In this context, biodiversity provides resilience to ecosystems and the opportunity for the provision of most other ecosystem services. For example, more vigorous fish populations occur within more and intact assemblages of native species and ecosystems; ecosystems that have higher biological diversity tend to be more resilient to disturbances; and recently it has been suggested that bivalve shellfish (like oysters) are organisms that physically, biologically or chemically modify the environment around them in ways that influence the health of other organisms to such an extent that the sustainable management of shellfish beds could be a key to the log term provision of a range of other ecosystem services (see, for instance, Brumbaugh and Torporva, 2008).

Table 1. Examples of goods and services provided by coastal ecosystems

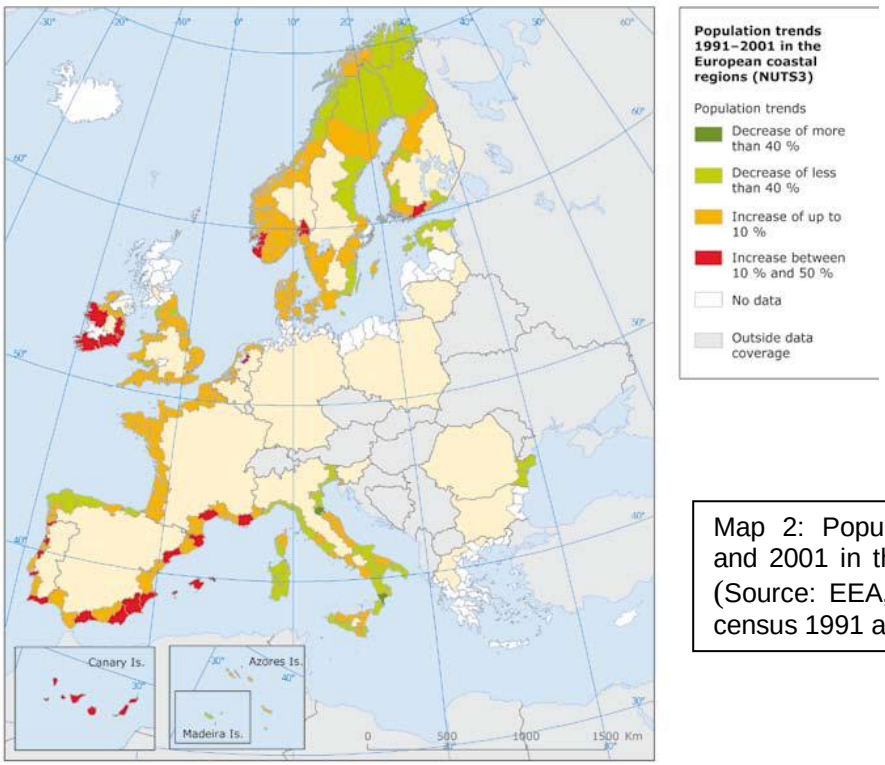
Ecosystem service	Definition	Examples
Provisioning		
Food	Biomass for human consumption, provided by a web of coastal organisms and a functioning coastal ecosystem (see biodiversity definition above).	Game, fish, seaweed, shellfish
Materials	Biological materials used for medicines, fuel, and building.	Coastal forests and trees for timber and firewood, conical mollusc shells used for anti-cancer drugs, oil.
Regulating Services		
Shoreline Stabilization	Keeping shorelines in a state of equilibrium with ocean waters, especially in the face of rising sea levels.	Rocky shores, seagrass beds, wetlands, and estuaries trap sediments and sand that allow land accretion which can balance or exceed subsidence or erosion.
Storm Protection	Mitigation or attenuation of the effects of wind, waves, and flood waters on coastal land and communities.	Estuaries and coastal wetlands absorb wave energy and flood waters from ocean storms, thus reducing damage to coastal property.
Water Flow Regulation	Retention and storage of fresh water.	Estuaries and coastal wetlands store fresh water and keep salt water from intruding upon fresh water supplies.
Human Disease Control	Undisturbed ecosystems keep in check organisms which can cause disease in humans.	Coastal waters with proper nutrient, oxygen, and pH levels prevent algal blooms that produce toxins which are poisonous to humans via shellfish consumption from affected areas.
Waste Processing	Detoxification or absorption of natural or human-made contaminants.	Wetlands take out excess nitrogen and biologically breakdown contaminating bacteria from human waste, thus preventing release to marine waters.
Carbon Sequestration	The capture and long-term storage of carbon is part of the global carbon cycle. The coastal shelves play an important role in climate stabilization.	Coastal marshlands and seas contribute to the absorbtion of carbon, both chemically and biologically. Surface absorption occurs over short time frames (1 year); deep water mixing allows long-term storage and more surface absorption; phytoplankton fix carbon through photosynthesis. The coastal and continental shelves provide further benefits in terms of 'managing' the carbon cycle.
Supporting		
Nutrient Regulation and Cycling	Transfer of nutrients from one place to another; transformation of critical nutrients from unusable to usable forms.	Estuaries are zones of mixing of nutrients from fresh water and saltwater systems, making them very productive.
Habitat	Providing for the life history needs of plants and animals.	Estuaries provide nursery habitat (relatively more protected places where fish and other sea animals hatch then mature to a life stage where they can handle harsher environments)
Primary productivity	Fixing of carbon by plants; provides basis of all terrestrial and most marine food chains.	Situated at the highly dynamic interface between land and sea, coastal habitats (estuaries in particular) generally have a very high productivity, evidenced by the large numbers of shellfish, water birds and waders and the diversity of other fauna

Ecosystem service	Definition	Examples
		and flora that they support. Ecosystems fix carbon and produce oxygen. Agricultural lands provide food plants for humans and livestock. Phytoplankton plays a crucial role as the basis of marine food webs and in the global carbon cycle.
Cultural		
Spiritual	The role which ecosystems and their components play in the spiritual beliefs of people. This is especially important for indigenous cultures. These values do not lend themselves well to economic quantification.	Coasts played a key role in ancient mythology (e.g. Venus, Europa, Aeneid, Odyssey, etc) and have been and remain a source of inspiration for artists (e.g. Turner, Vettriani, etc). It is a key element of the collective imagination.
Scientific and educational	Ecosystems are the subject of much scientific study for both basic knowledge and for understanding the contribution of functioning ecosystems to human wellbeing.	Research institutions focused on marine habitats and sustainable use of coastal resources contribute economically and socially significant knowledge to society.
Tourism	The explicit role that intact land and seascapes play in attracting people to areas for vacationing	Visits to protected areas to enjoy coastal landscapes, hike and nautical sports, and to see wildlife. Visit to beaches for sun and sand. Use coastal areas for tour boating, hobby fishing, swimming, diving and windsurfing.
Aesthetic	The role which natural beauty plays in attracting people to live, work and recreate in an area	The financial values of homes with coastal views are higher than homes without.
Recreation	The contribution of ecosystem features like biological diversity and clean water play in attracting people to engage in recreational activities.	Clean water and marine animals attract (e.g.) kayakers and scuba divers.

2.2. Drivers and pressures

As coasts have increasingly assumed a 'gateway' function in global trade and logistics, they have become more and more developed and ecosystem services have been degraded as a result. The main drivers affecting the state of coastal ecosystems and their ability to provide the ecosystem goods and services to society in Europe are associated with human economic activity and settlement.

Demographics: Natural growth and net immigration to coastal zones result in a sharp increase in population densities along many of Europe's coastlines. This increase results in a permanent pressure on the coastal spatial and natural resources. In many European regions this pressure has a strong seasonal component due to tourism (see below). Net coastal population growth is not the only demographic driver that results in pressure on coastal zones. Indeed, some coastal areas are plagued by emigration, because of their remoteness and lack of employment opportunities. Traditional and sustainable land use systems, some of which support a high biodiversity, are abandoned with a resulting decrease in species and habitat diversity. The demographics of the hinterland also strongly affect the coastal environment because of the connectedness through the river systems (impact of land based activities on coastal and marine areas).



Map 2: Population trends between 1991 and 2001 in the European coastal regions (Source: EEA, 2005, based on population census 1991 and 2001, Eurostat.)

Changes in land use

Destruction of habitat: Coastal habitats are fragile and are being destroyed to make way for housing (urban sprawl), industry, agricultural land, tourism infrastructure, transport infrastructure. To date over 50% of Europe's coastal wetlands have been destroyed and converted into arable land, industry or urban areas. This has severely reduced their ability to provide a multitude of services (see Table 1), many of which are not valued in economical terms as they are considered as externalities in traditional economic analysis.

Built development/sprawl (urban and tourism related): Population growth and migration result in a net increase of population in coastal areas. People are attracted by the beauty of the coast or by employment opportunities offered by the industrial zones associated with ports and harbours or the tourism sector. The growth of tourism has also caused significant impacts because the massive, seasonal (and therefore temporary) in-migration of tourists and the workforce to serve them must be housed, fed and entertained. Housing, hotels, a variety of facilities and urban infrastructure (roads, sewers, surface drainage, sewage treatment plants, public buildings, sports amenities, hospitals, etc) must be built to absorb the growing permanent and temporary population at the cost of coastal ecosystems.

Agricultural land conversion: Pressure on coastal areas to be converted to new forms of land use is great, as coastal areas often have productive soils and are located near local markets and transport hubs (such as ports which ease the overseas market access). The type of land conversion is determined by the local biophysical conditions. Large parts of European coastline (especially the most biodiverse and valuable ecosystems such as coastal wetlands) have been reclaimed and converted to (irrigated) intensive agriculture; for example, to grow paddy rice, vegetables and wheat. This does not only result in direct habitat loss and fragmentation but is also associated with increased water use, pollution and eutrophication. It has been estimated that over half of the Mediterranean salt marshes have been progressively reclaimed and converted to arable and industrial land.

Mining and extraction: Increased energy needs have led to the development of various forms of energy generation in coastal areas. Many of Europe's coastal areas are rich in oil and gas; and exploitation of these is usually quick to follow discovery. The direct impacts of oil and gas field development are the disturbance to the sea floor; the laying of pipelines to transport oil and gas from the fields to coastal and inland locations can cause permanent fragmentation and direct damage to habitats; the potential for pollution due to oil spills and leakage also increases. Some regions suffer from land subsidence as the oil and gas reserves collapse. The same can happen with salt mining. Many estuaries and coastal sand banks provide a source of sand for construction and the glass-making industries and the process of removal (using large machinery) and the removal itself, of large quantities of mineral, can have significant impacts on intertidal and sub-tidal habitats and coastal sedimentation patterns. When combined with sea level changes, changes in extreme weather patterns, and coastal erosion, many of the above activities (which often occur together and can therefore be cumulative) can result in increased threats of coastal flooding.

Renewable energy generation: The dynamics of coastal regions (tides, currents and waves, wind and storms) make them an attractive place to develop renewable sources of energy. These developments are positive in the sense that they contribute to climate change mitigation by providing energy with low or zero CO_2 emission. However many of these constructions are highly impacting on the landscape and the wildlife it supports. For example, badly located wind farms can interfere with coastal breeding bird colonies and birds migrating along the coastline. The vibrations caused by the drilling of heavy foundations into the sea floor and the infrasound produced by wind power generators when located at sea, have been shown to disturb the orientation of sea mammals such as dolphins; similar impacts have recently been shown for fish. The geographic requirements of tidal power plants mean they are ideally situated in estuaries, where they have a severe impact on the local ecosystem which may often, already be under stress from other factors; although the studies at the La Rance plant in France (the largest in the world) has shown a certain degree of ecological recovery after ten years of operation.

Development of industrial infrastructure: Due to the proximity of ports, coasts provide a prime location for the development of industry and other economic activities. Ports are often situated in deltas and estuaries because these offer shelter and a transport route to the hinterland *via* the rivers which drain into them. Ports are important hubs for the distribution of imported and exported goods, and their easy access from the sea make them ideal locations for heavy industries (including chemical and petro-chemical). Important flows of raw materials are most easily delivered by maritime transport. Development of industrial infrastructure has direct and indirect impacts on the coast and its ability to provide other services: direct destruction of valuable coastal habitat for the location of infrastructure, indirect demand for further transport infrastructure and urban development to accommodate the industrial workforce, pollution and water extraction.

Figure 3: Multiple land use and pressure on agricultural land on the Humber Estuary, UK. The land outlined in red is proposed for industrial development. (Source: North Lincolnshire District Council, UK)

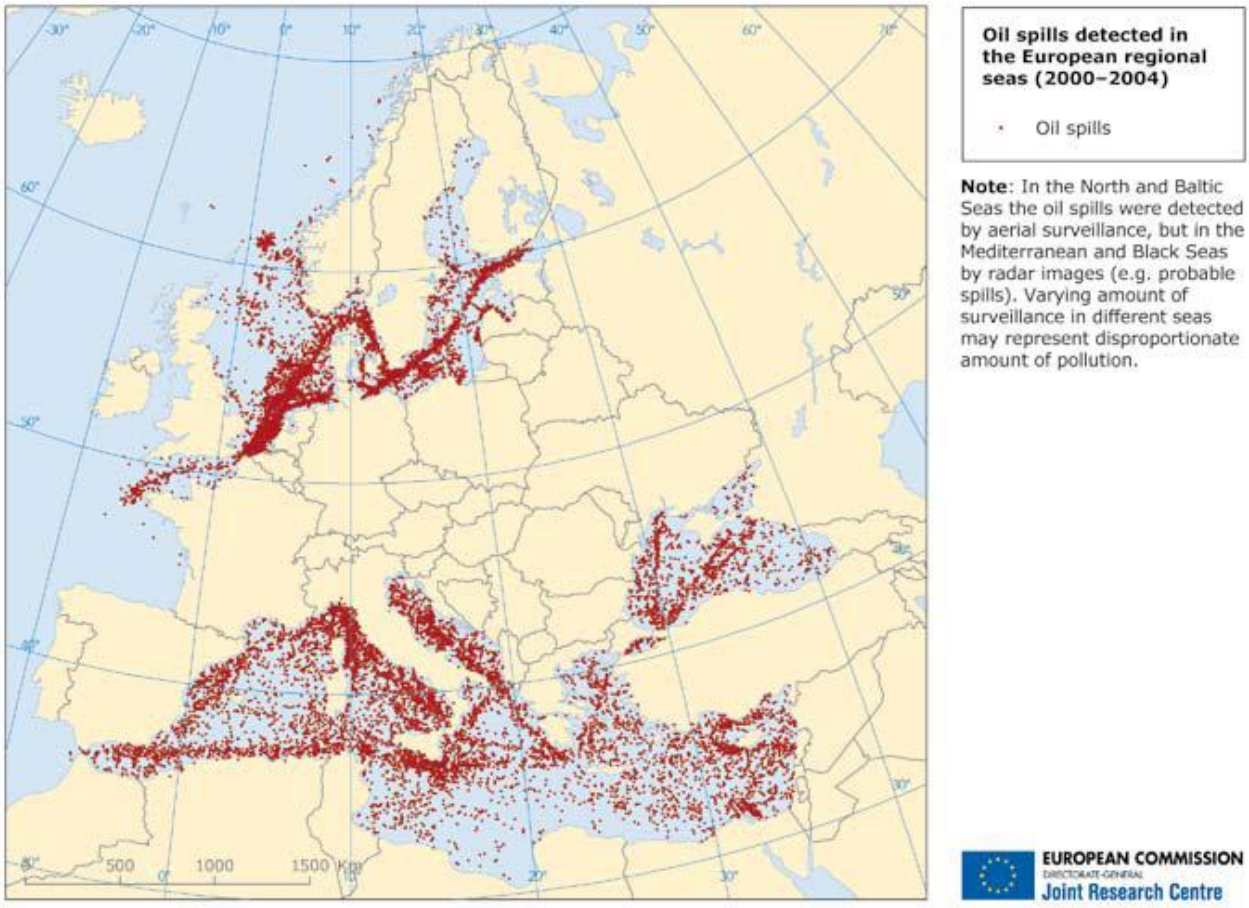
Development of transport infrastructure: In an increasingly globalised world and with the creation of an internal market in the EU, the movement of goods has sharply increased. A transport system requires infrastructure, space and fuel. All of these aspects create pressures on the environment (e.g. illegal dumping of crude oil, air pollution by maritime transport, etc) and can cause fragmentation, direct loss and indirect damage to species and habitats.

Erosion and siltation: Dynamic coastal processes (geomorphological) are essential to keep coastal environments in steady state equilibrium with the other environmental factors. If currents are disturbed by important coastal infrastructure constructions (e.g. coastal defence, sand traps, breakers, piers, port and harbour expansion and development, land reclaim, pipeline construction, etc) the dynamic equilibrium between erosion and accretion is lost and unwanted changes in the coast morphology and functions can be the result. Important changes in river discharges (as a result of climate change, increased irrigation, canalization) also impact upon these coastal processes. Land based activities which alter the flow and sediment load of rivers can also have profound effects on the geomorphodynamics of coastal ecosystems, in particular coastal wetlands and intertidal habitats situated in estuaries and deltas. If the annual discharge of rivers is decreased, this influences the sediment balance in estuaries and river deltas and can lead to increased erosion or accretion. The same holds for changing sediment loads as the result of inland dam construction which captures the river sediments.

Figure 4: Coastal Erosion on the Yorkshire Coast, UK (Source: Robbie Fisher)

Pollution

Pollution: Coastal areas are particularly prone to pollution. Pollution is therefore an important pressure for coastal ecosystems, affecting their capacity to provide goods and services. As coasts are the transition zones from terrestrial to marine environments, they are affected by a wide range of pollution point and diffuse sources on land at sea and in the coastal zone itself. Pollution from land based activities (in cities, industries and agriculture) reaches the coast through rivers which accumulate significant quantities/loads of agro-pesticides, nutrients, heavy metals, industrial chemical compounds and biological chemicals (e.g. oestrogens). Inland, human activity also tends to be concentrated along rivers, which were until recently and still are in some parts of Europe, used as open sewage systems. In some countries, sewage and industrial waste water are also still spilled directly into the sea without any prior treatment. Other sources of pollution include dumping from ships and aircraft. Ships and tankers clean their oil reservoirs at sea causing small oil spills that reach the coastline. Larger unintended oil spills as a result of ship wreckages can have catastrophic local impacts upon the whole range of coastal ecosystems. Solid waste disposal is also a problem in coastal areas. Some of it reaches the coastal zone through rivers but much of it is directly dumped from ships. They accumulate along the flood line on beaches and in lagoons and on the sea floor where get ingested by a wide range of animals (e.g. pinnipeds, cetaceans, seabirds and fish) causing serious health damage and death.



Map 3: Oil spills in European regional seas (2000–2004) (Source: JRC, 2005.)

Eutrophication - Coastal ecosystems, in particular coastal wetlands suffer from increased loads of nutrients carried downstream by rivers as a result of land based activities such as chemical fertilization in agricultural lands. The high nitrate loads lead to the flourishing of blue green algae which can choke all other aquatic life through its high oxygen consumption. Blue green algae can present a direct human health threat in bathing areas.

Introduction of Invasive Alien Species (IAS) - Coastal waters are especially prone to the introduction of IAS, both intentionally and unintentionally. A recent report estimates at 11,000 the number of IAS in Europe. Alien species are sometimes introduced as a new source of commercially produced food and can become invasive if they escape and do not encounter natural predators. However, the greatest threat to coastal biodiversity is posed by alien organisms travelling in the ballast water of large ocean-going vessels. This water, carrying many unwanted species, is released in harbours. Globally, over 10,000 species are estimated to be travelling in ballast water, and can become IAS if this water is released. The IAS can compete with or predate on the native species and significantly upset coastal ecosystems. IAS represent a significant cost to society through the efforts of containment or eradication but more so through the impact on ecosystem goods and services..The introduction of the American comb jelly (*Mnemiopsis leidyi*) into the Black and Azov Seas, caused the near extinction of the anchovy and sprat fisheries; and the Chinese Mitten Crab (*Eriocheir sinensis*) has become a serious threat in many western European estuaries where it may threaten native crab populations and their harvesting and its burrowing activities can clog drainage systems and undermine the foundations of sea walls and defences, threatening their potential collapse with subsequent impacts on homes, industrial and business locations and property.

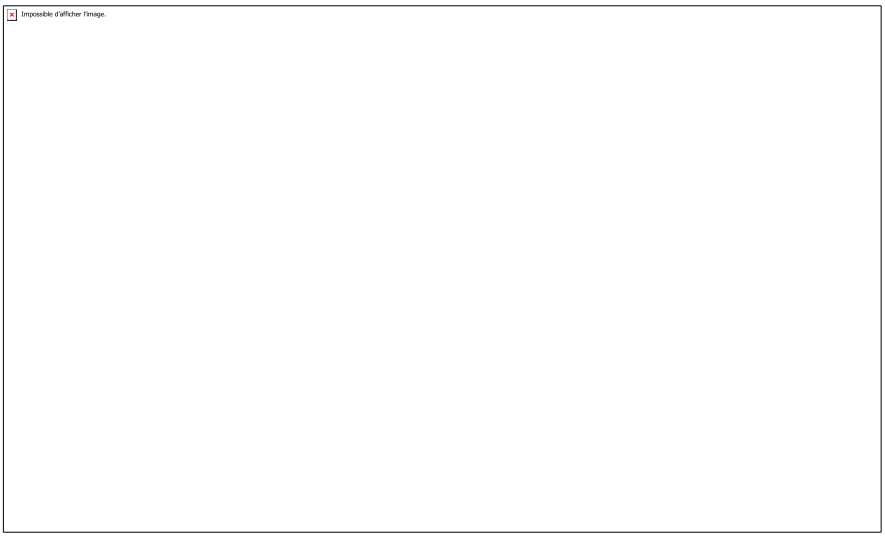


Figure 5: The Chinese Mitten Crab (*Eriocheir sinensis*)

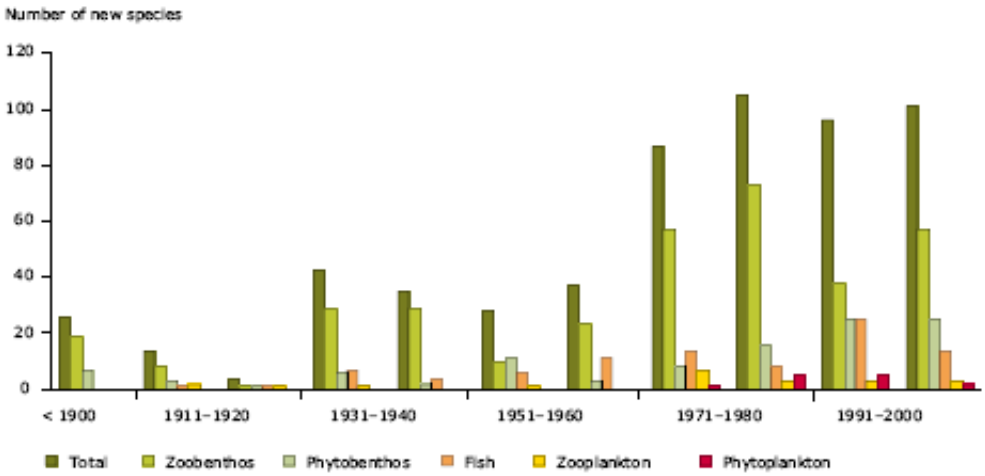


Figure 6: Rate of detection of exotic species in the Mediterranean Sea (Source: UNEP/MAP, 2004. Marine pollution indicators fact sheets.)

[Note that coastal and estuarine aquaculture/fish farms (also covered below under 'activities') can have polluting and eutrophicating effects and may introduce alien species *via* escapes.]

Activities

Fishing: Coastal fisheries are potentially very productive and produce a wide range of products (shrimp, lobster, molluscs, fish, etc). However, certain fisheries have direct impacts on other fishery-based sectors. Trawling for shrimp or mussels in coastal lagoons disturbs the ecosystems that are crucial as nurseries for many species of ocean/high sea fish. The more general impact of fisheries on the coastal (and marine) environments is over-fishing; that is: "fishing beyond a sustainable yield". This has led to the collapse of many fisheries in and around Europe and is a direct impact of a human activity on the ecosystem service. Since the growth of global fishing enterprises after the 1950's, intensive fishing has gone from a few concentrated areas to encompass nearly all fisheries. The scraping of the ocean floor in bottom dragging is devastating to coral, sponges and other long-lived species that do not recover quickly. This destruction alters the functioning of the ecosystem and can permanently alter species composition and biodiversity. Bycatch, the capture of unintended species in the course of fishing, is typically returned to the sea only to die from injuries or exposure. Bycatch represents approximately one quarter of all marine catch. In the case of shrimp capture, the bycatch is five times larger than the amount of shrimp caught.

Shellfishery: Shellfisheries are highly productive, particularly in estuaries. However, damage has been caused by overexploitation (for instance through the use of industrial collection methods) but also pollution, mineral extraction and the modification of sedimentation regimes (by the construction of port related infrastructure, upstream catchment and river management, etc). As stated above, it has been suggested that sustainable management of shellfisheries can have a major contribution to maintaining other ecosystem services. The gathering and harvesting of shellfish from mud flats at low tide can have a negative impact on bird disturbance and commercial shellfisheries, for example involving the suspension of growing mussels on plastic strips in the main watercourse, can alter downstream water quality.

Aquaculture: Aquaculture has a positive impact on biodiversity in that it reduces the world's dependence on wild fish stocks. However aquaculture also impacts on the coastal ecosystems through the nutrients and antibiotics it releases to the environment. The farmed fish can also be sources of disease infecting wild coastal fish populations. For example, in 1989, a sudden and catastrophic collapse of wild seatrout populations in areas close to salmon rearing cages in Ireland gave aquaculture critics a focus for protest. Although a link between fish farming and the decline of natural stocks cannot always be established, some environmental effects are clear. Unlike mollusc farming, many species of fish depend on a diet of artificial feed in pellet form. This feed is broadcast onto the surface of the water, and is consumed by the fish as it settles through the water column. Because not all the feed is eaten, a great deal of feed can reach the bottom where it is eaten by the benthos or decomposed by microorganisms. This alteration of the natural food web structure can significantly impact the local environment. Intensive aquaculture can be the cause of localised pollution and eutrophication. The accidental escape of farmed species may cause the introduction of alien invasive species or the hybridisation of native species with introduced non-native species.

Fresh water use: Increasing coastal populations and related activities (agricultural, industrial and tourism) have stepped up the demand for fresh water (for direct consumption, recreation, irrigation and industrial processes). In semi arid areas of the Mediterranean in particular, this has led to severe water shortages and depletion of the ground water reserves. Moreover, in low lying coastal alluvial areas, lowering of the ground water level leads to seepage of salt water from the sea, affecting future fresh water supplies, agriculture and ecosystems and their services.

Disturbance: Many coastal wetlands play an essential role in the life cycle of migratory species, especially birds. Many migratory birds such as the Knot (*Calidris canutus*) lead a "life on the edge", to be able to cover the long distances between their breeding and wintering grounds. Along their flyways, they hop from one wetland to the next and nearly consume all their energy reserves in the meantime. They

must rest and replenish their fat reserves during these “pit stops”. Disturbance by recreationists and fishermen in key stop-over coastal wetlands jeopardize the recovery of the birds and their ability to safely continue their journey. Coasts are also important areas for the breeding and reproduction of birds and other coastal animals such as sea turtles. Disturbance on beaches (as a result of increased tourism and recreation) has led to the dramatic decline of specialized species such as the Little Tern (*Sterna albifrons*), the Kentish Plover (*Charadrius alexandrinus*) and the Loggerhead Sea Turtle (*Caretta caretta*).

Figure 4: The Avocet (*Recurvirostra avosetta*); a migratory species that breeds in the coasts and estuaries of Europe; a species sensitive to disturbance. (Source: RSPB)

Tourism: Tourism is an increasingly important sector of the economy and represents an important part of the GDP of many European countries. In the Mediterranean in particular, mass tourism has resulted in the rapid urbanization of the coasts with summer accommodation (hotels, second houses etc). Certain forms of tourism, such as eco tourism, have a lesser impact on the coast, and can actually contribute to its protection and management through the local income it generates. Tourism also has indirect impacts on the coast through its contribution to climate change as a result of air (and other) travel; (see also above under 'Built Development').

2.3. Climate change

The fact of climate change and the impacts it will have are no longer in doubt and there are numerous European web sites and publications which testify to this fact. Over the past century the average temperature has risen by more that 0.7°C globally and by almost 1°C in Europe (Figure 1). Climate change affects natural systems, such as glaciers and ecosystems, as well as societal and economic systems, such as human health and agriculture. For instance, we are likely to see:

- increased temperatures
- a rise in the frequency of extreme weather events
- increased coastal erosion
- sea level rise
- rising water levels in tidal rivers
- increased flooding and bushfires
- pressure on water resources
- changing agricultural landscapes and agricultural production
- changes in habitats and species distribution
- impacts on people, property, industry and infrastructure from effects such as increased subsidence and risk of storm damage.

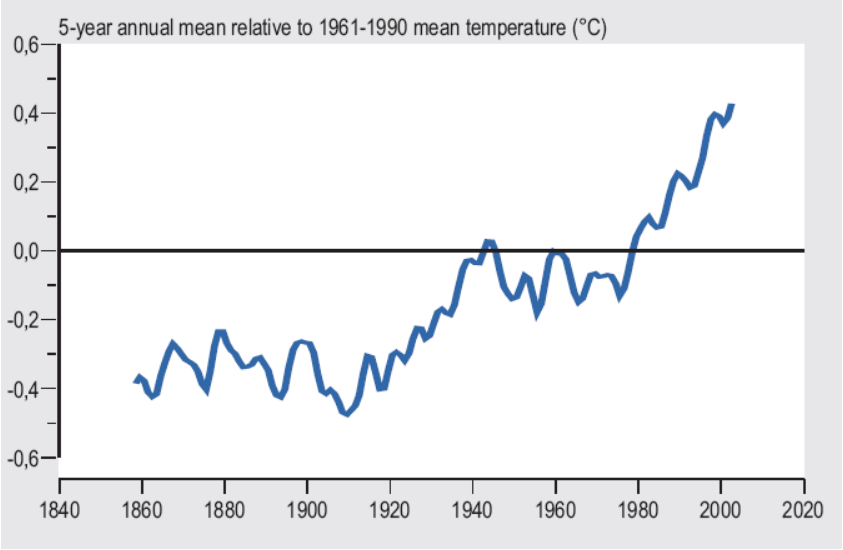


Figure 5: Increase in global mean surface temperature (Source: Climate Research Unit www.cru.uea.ac.uk/cru/data/).

As is clear from the 2005 Millennium Ecosystem Assessment, climate change is impacting more and more on biodiversity, both worldwide and in Europe. Scientific results into the possible impact on climate change increasingly provide evidence of considerable consequences for habitats and species. Species migrations, extinctions and changes in populations, range and seasonal and reproductive behaviour are among the responses that have been recorded, and these are likely to continue apace as climate continues to change in decades to come.

The alarm bells are therefore ringing across Europe in relation to the impact of climate change on society, the economy and our environment. Maintaining ecosystems that can function as a resource for biodiversity and a source of tranquil enjoyment, recreation and economic benefit, whilst at the same time providing mitigation and adaptation against climate change is one of the great challenges of the 21st Century. There is now widespread awareness and acceptance at political and policy-making level that the significant problems we are facing due to the changing climate and its associated impacts are largely a direct result of human activity. A history of poor management, uninformed decision-making in relation to our environment and a lack of effective co-ordination between sectoral interests has led to unsustainable development. 'Climate change' is now specifically used to describe human influence on the climate.

The threats of climate change to (low lying) coastal areas are of particular concern to governments at all levels. Climate change is already having an impact on the sea levels around the globe. The changes in sea level are not however expected to be equal all around the globe (some regions may even actually experience a lowering of the sea level[1]), as they are the result of a complex interplay of factors. Moreover, the relationship between temperature rise and sea level change is expected to be non linear and depending on reaching certain critical threshold values (tipping points). Extrapolation of correlations between observed increase temperature and sea levels do not therefore provide accurate and reliable predictions for the future.

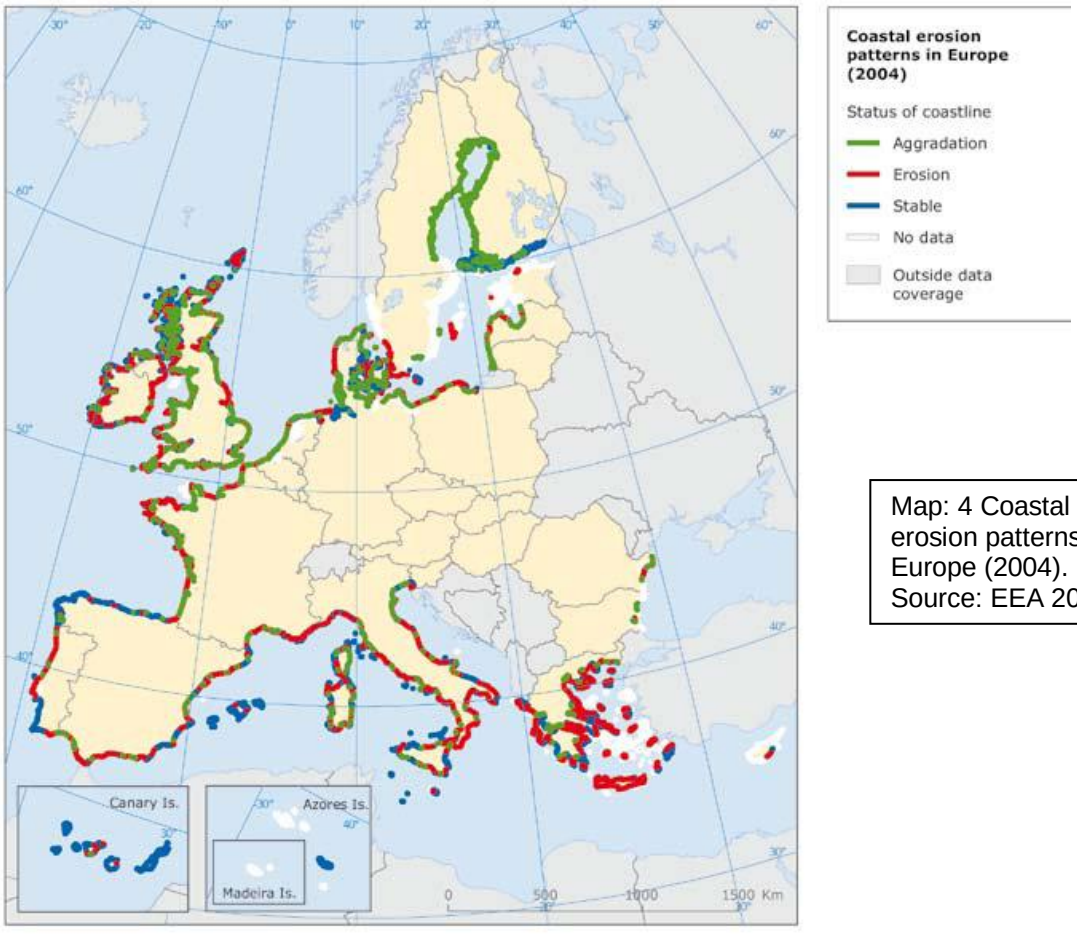
Once a tipping point has been reached a sudden surge can occur (for example the accelerated melting of the Antarctic and Greenland ice caps), leading to a sudden and dramatic rise in sea level. Climate change, and the resulting change in sea water temperatures, is also having a severe impact on water physics and chemistry of the oceans, influencing ocean life and indirectly impacting on the coastal zones. The accelerated release of large quantities of fresh water from glacier melting into the oceans affects the thermohaline circulation. As a consequence, the Gulf Stream which is responsible for Western Europe's

[1] For Western Europe, the melting of the Greenland ice cap could result in a lowering of the sea level because of the reduced gravitational attraction of the shrinking ice cap on the ocean water.

mild and temperate climate might substantially lose power, resulting in more extreme weather patterns (especially cold winters) in spite of globally increasing temperatures.

Coastal ecosystems and (human) communities will have to adapt to these sudden climatic changes. Climate change also affects weather patterns, with a marked increase in the frequency and power of extreme weather events (storms, precipitation, etc). In combination with sea level rise, land subsidence (due to extractive activities and peat oxidation in reclaimed lands, see above) and degraded or disappearing coastal habitats (loosing their wave attenuation function), this puts the coastal areas at an increased risk of flooding.

Adaptation and compensation measures (the latter also in relation to the requirements of the Habitats Directive on Natura 2000 sites), will need to be implemented (in particular) in order to take into account the loss of intertidal habitat as a result of rising sea levels. Coastal and estuarine wetlands and dune systems will be particularly under threat from rising sea levels and changing erosion and accretion patterns; however, as already stated above, they also play an extremely important role in providing natural 'buffers' and protection from, for instance, extreme storm events and the increasingly high tides that are both cyclic and associated with rising sea levels.



Map: 4 Coastal erosion patterns in Europe (2004). Source: EEA 2006

The effects of 'coastal squeeze' are already beginning to be seen. This is a phenomenon that can be observed in the North Sea (on a large scale) and in individual estuaries. For example, the combination of a high tide, when 'squeezed' into an estuary combined with the impact of water moving at speed down inland water courses (as a result of storm conditions and exacerbated by canalisation of rivers and streams) together with sea level rise, results in extreme high water levels, flooding and consequent environmenat, social and economic impacts.In the context of socio-economic issues conflicts may occur in relation to the protection of homes, property and industrial infrastructure (through the strengthening and

construction of man-made sea defences) and the presence of important habitats and species. New coastal habitat may therefore need to be created in some areas to compensate for losses in others; (see also below).

2.3. Knowledge fragmentation and gaps

Throughout the EU there are more than 300 institutes for coastal and marine research, employing some 10,000 scientists. The number of organisations dealing with policy and managerial issues related to the coastal zones and adjacent seas is even larger. Many similarities exist among studies and projects carried out in Europe and there is clearly a great potential for optimisation by learning from mutual experiences and by joining research efforts. However, fragmentation over many countries, administrations and institutes is a serious obstacle to taking full advantage of Europe's rich capital of knowledge and experience.

In addition there remain significant gaps in our knowledge; for example there is a huge gap in finding data in relation to coastal areas in particular EECCA regions.

Knowledge fragmentation and gaps might therefore be a barrier to collecting the relevant data for the analysis and is an issue that should be kept in mind when discussing the Spotmeter process (see below and also www.Encora.eu).

3 Relevant policies

The EEA report on 'The Changing Faces of Europe's Coastal Areas' states that: "The implementation of new EU mechanisms, including the WFD, the proposed MSD and a future Maritime Policy, should act as drivers for improved coastal zone management. Further policies to address coastal issues in a coherent or holistic manner, such as Integrated Coastal Zone Management (ICZM), are being developed and implemented within the EU and under the regional conventions for the Baltic, Mediterranean and Black Seas, but are still needed in the EECCA region. Key to their long-term success will be the promotion of public participation and the introduction of adaptation measures for climate change. There is also a need for independent land-use monitoring and improved data, especially in the EECCA region". Relevant conventions include:

- The 1974 Helsinki Convention was the first time ever that all the sources of pollution around an entire sea were made subject to a single convention, signed the then seven Baltic coastal states. The 1974 Convention entered into force on 3 May 1980. The new 1992 Convention was signed in the light of political changes and developments in international environmental and maritime law, by all the states bordering on the Baltic Sea, and the European Community. After ratification the Convention entered into force on 17 January 2000. The Convention covers the whole of the Baltic Sea area, including inland waters as well as the water of the sea itself and the sea-bed. Measures are also taken in the whole catchment area of the Baltic Sea to reduce land-based pollution.
- The Mediterranean Action Plan (MAP), as part of the UNEP Regional Seas Programme, was estab lished in 1975 and the Barcelona Convention adopted in 1976
- The 1975 Ramsar Convention is an international treaty for the conservation and sustainable utilization of wetlands, i.e., to stem the progressive encroachment on and loss of wetlands now and in the future, recognizing the fundamental ecological functions of wetlands and their economic, cultural, scientific, and recreational value. It is named after the town of Ramsar in Iran.
- Council Directive 79/409/EEC on the conservation of wild birds
- EIA Directive (EU legislation) on Environmental Impact Assessment of the effects of projects on the environment was introduced in 1985 and was amended in 1997 (Council Directive 97/11/EC of 3 March 1997 amending Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment)

- Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora
- The Convention on the Protection of the Marine Environment of the Baltic Sea Area, 1992, entered into force on 17 January 2000. The governing body of the Convention is the Helsinki Commission - Baltic Marine Environment Protection Commission - also known as HELCOM. The present Contracting Parties to HELCOM are Denmark, Estonia, European Community, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden. The ratification instruments where deposited by the European Community, Germany, Latvia and Sweden in 1994, by Estonia and Finland in 1995, by Denmark in 1996, by Lithuania in 1997 and by Poland and Russia in November 1999.
- The Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) is the largest of its kind developed so far under CMS. It was concluded on 16 June 1995 in The Hague, the Netherlands and entered into force on 1 November 1999 after the required number of at least fourteen Range States, comprising seven from Africa and seven from Eurasia had ratified. Since then the Agreement is an independent international treaty.
- The 1996 OSPAR Convention is the current legal instrument guiding international cooperation on the protection of the marine environment of the North-East Atlantic. Work under the Convention is managed by the OSPAR Commission, made up of representatives of the Governments of 15 Contracting Parties and the European Commission, representing the European Community.
- Communication from the Commission to the Council and the European Parliament on integrated coastal zone management: a strategy for Europe COM/2000/0547 final
- Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive)
- 2002/225/EC: Commission Decision of 15 March 2002 laying down detailed rules for the implementation of Council Directive 91/492/EEC as regards the maximum levels and the methods of analysis of certain marine biotoxins in bivalve molluscs, echinoderms, tunicates and marine gastropods (Text with EEA relevance) (notified under document number C(2002) 1001)
- Recommendation 2002/413/EC of the European Parliament and of the Council of 30 May 2002 concerning the implementation of Integrated Coastal Zone Management in Europe [Official Journal L 148 of 06.06.2002].
- Recommendation of the European Parliament and of the Council of 30 May 2002 concerning the implementation of Integrated Coastal Zone Management in Europe
- Com(2003) 262 Final/2 Communication From The Commission To The Council And The European Parliament On The Development Of Energy Policy For The Enlarged European Union, Its Neighbours And Partner Countries
- COM(2006) 475 final Communication From The Commission To The Council And The European Parliament Establishing an Environment Strategy for the Mediterranean
- Communication from the Commission - Report to the European Parliament and the Council: an evaluation of Integrated Coastal Zone Management (ICZM) in Europe COM/2007/0308 final Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment
- Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control.

4 Preliminary ideas

The coastal zone could be one of the Spotmeters where an assessment of the value of ecosystems might be achievable through a meta data analysis focusing on the cost of replacement (or similar) approach. Given its position as a 'gateway' and a natural interface between land and sea it should also include a consideration of a range of socio-economic issues. Indeed, 'state and impact' refer largely to ecological factors and processes, whereas 'drivers, pressures and response' reflect the socio-economic issues. See also the next section for ideas in relation to process.

Figure 6: Container transport and wind farm development in the Irish Sea (Source: Bernard Fleming.)

5 Process

There are already a number of studies that have assessed the value of coastal ecosystem services, and to a certain extent the coastal system can be quite easily conceptualized. This process is outlined under 3 below (in very general terms) This, and the other preliminary ideas outlined below, is one of the approaches that could be discussed in the Spotmeter workshop.

1. What is the current state of coastal ecosystems? *European coastal ecosystem health check*

- expert knowledge
- literature review
- workshop

2. What are the projections in terms of pressures / sustainable development / conservation for the next 10 (?) years? *European coastal ecosystem health prognosis*

- expert knowledge
- literature review
- workshop

3. How to value the social and economic benefits of coastal ecosystems? *European coastal ecosystem health benefits*

Meta analysis of economic valuation of European coastal ecosystems

- develop a simplified and workable typology of coastal systems in Europe
- if needed make a selection of particularly threatened / valuable ecosystems
- development of a conceptual model (systems approach)
- translate conceptual model into system dynamics and object-based modelling
- select valuation methods
- defining / specifying the data needs
- collecting results / data of partial specific studies (see knowledge fragmentation)
- input results of partial analysis in model to carry out meta analysis
- disseminate results among stakeholders for comments
- report, conclusions and recommendations

Important issues to bear in mind for the selected approach (possible discussion items for expert meeting), i.e., how to address:

- **The role of scale:** Ecosystem accounting for coastal wetlands: need to distinguish the analysis between macro, meso and micro scale

- **Non linearity of coastal system dose responses, thresholds, tipping points, positive/ negative feedback loops:** Need to address/ reflect the non linear relationship between coastal ecosystem structure and function, using EBM.

- **Multifunctional uses of coastal ecosystems:** In general, ecosystem degradation results from the preference given to a particular or a limited number of target ecosystem services or goods: in particular food, fibre or energy crops in agriculture, timber in forestry, fish in fisheries and fish farming, navigation in estuaries or delta's. It leads to ignore other ancillary products, recreational services, regulating services (soil or fish stock regeneration, water regulation, carbon storage or sequestration).

- **Trade off issues:** In multifunctional uses of ecosystems there is always an element of trade-off between different uses based on costs and benefits to different sectors to society. The balance between these is often struck based on political, economic and social criteria.

- **Integrated/ holistic system dynamics approach to valuation:** Linked to the above; thinking needs to be factored in to decision making in relation to methodology.

Ecosystem valuation systems approaches

There are various ways to assess the values of ecosystem services; (to be able to compare them). The following is a list of approaches that may be considered in the context of developing an ecosystem assessment methodology for coastal areas:

- IPAT equation
- Green accounting
- Cost of replacement
- Carrying capacity
- Critical natural capital
- Ecological economics (Note: this is an overarching approach which encompasses several of the others: e.g. green accounting, cost of replacement, critical natural capital, ecosystem accounting, etc)
- Material flow analysis
- Ecological footprint
- Ecosystem accounting
- Ecosystem approach

Inspiration for approaches
http://rael.berkeley.edu/ebamm/FarrellEthanolScience012706.pdf

6 Data availability

UNEP GRID Arendal www.grida.no

UNEP WCMC World Conservation Monitoring Centre www.unep-wcmc.org

World database on protected areas WDPA www.wdpa.org

Ramsar Sites Information Service http://ramsar.wetlands.org/

Eurostat http://ec.europa.eu/eurostat/

UN Statistics Division http://data.un.org

INSPIRE Geoportal – The EU Portal for Geographic Information www.inspire-geoportal.eu/

Waterbase - Transitional, coastal and marine waters:
http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=1045

SMAP Clearing House - Euro-Mediterranean Programme for the Environment
http://smap.ew.eea.europa.eu/

EUNIS Database http://eunis.eea.europa.eu/index.jsp

Global Monitoring for Environment and Security (GMES) http://gmesdata.esa.int/home

Group on Earth Observations GEO www.earthobservations.org

UN Stat http://unstats.un.org/unsd/environment_main.htm

Millennium Development Goals Indicators http://mdgs.un.org/unsd/mdg/Default.aspx

Figure 7: Spurn Point at the mouth of the Humber Estuary, UK, showing salt marsh and sedimentation patterns. (Source: ABP, UK)

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http://ec.europa.eu/environment/nature/biodiversity/economics/pdf/teeb_report.pdf UNEP (200X) Mediterranean Strategy for Sustainable Development - A Framework for Environmental Sustainability and Shared Prosperity. www.planbleu.org/actualite/uk/MediterraneanStrategySustainableDevelopment.html

8 Relevant research projects

Links:

Black Sea Commission: www.blacksea-commission.org/main.htm

Baltic Sea Commission: www.balticseacommission.org

European Commission Coastal Zone Policy - Integrated Coastal Zone Management (ICZM) http://ec.europa.eu/environment/iczm/home.htm

Coastweb www.coastweb.info

Projects:

Ecosystem Accounting for the Cost of Biodiversity Losses: Framework and Case Study for Coastal Mediterranean Wetlands

http://www.eea.europa.eu/highlights/understanding-the-full-value-of-biodiversity-loss/ecosystem-accounting-for-the-cost-of-biodiversity-losses-framework-and-case-study-for-coastal-mediterranean-wetlands-abstract-2013-31-march-2008

The ENCORA initiative, launched in 2006, addresses the issue of fragmentation in European approaches to coastal and marine management. ENCORA stands for European Network on Coastal Research, a Coordination Action co-funded by the EU 6th Framework Programme.
Encora www.encora.eu