05

Marine and coastal environment

5 Marine and coastal environment

Source: Mediterranean Sea, Cyprus © George Buttner

Key messages

- The 1995 Dobris report provided the first major review of the state of seas in the pan-European region, while the subsequent 2003 Kiev report focused only on some key issues. The overall picture in 2007 has hardly changed from that in 1995: pressures on the seas and coasts continue to be high.

- Goods and services from pan-European marine and coastal ecosystems support major economic activities: In 2004, the EU-15 marine industry had an estimated value of EUR 310 billion. This is additional to other, less obvious, services including climate change regulation, flood protection, nutrient cycling and harbouring a wide array of animal and plant species. All of these are put at risk if human activities are not well managed.

- EU policies and action from regional sea conventions have led to improvements in water quality in the western seas. A single-issue approach is, however, not enough to halt or reverse the generally poor state of marine and coastal ecosystems. New EU policies, following an ecosystem-based approach such as the proposed Marine Strategy Directive, are now being developed or implemented. These policies offer an opportunity for the integration of existing measures.

- The Black and Caspian Seas are generally in a poorer state than western seas. This is partly due to their natural vulnerability and partly because modern environmental policies have not been sufficiently introduced, adopted or implemented across the EECCA region. EU and global instruments can offer support to the development of such policies. In addition, EECCA countries have environmental opportunities to benefit from, as many of their coastal ecosystems remain unaffected by tourism, and water quality is not always under as much pressure from nutrient-intensive agricultural practices as in the EU.

- Eutrophication remains a problem in all enclosed seas and sheltered marine waters across the pan-European region. There have been some improvements in the western seas, extending to the north-western shelf of the Black Sea, as a result of large cuts in point sources of nutrient pollution from industry and wastewater by EU-15 Member States. However, diffuse nutrient sources, particularly from agriculture, remain a major obstacle for recovery and need increased control throughout Europe. EECCA countries need to both reduce point sources and prevent the export of nutrients to marine waters from further agricultural expansion and intensification.

- Overfishing is still widespread in all pan-European seas. Stocks in the North and Celtic Seas — and probably the Black Sea — are in the poorest condition, whereas stocks around Iceland and east Greenland are in the best. However, most commercial fish stocks are not assessed and fishing quotas tend to be beyond limits recommended by scientists. Improved fisheries policies and stricter enforcement are needed, especially to stop illegal fishing. There is evidence that fish stocks with high reproductive rates can recover where proper measures are implemented.

- Destructive fishing practices continue, though it is hard to assess their extent. Bottom trawling keeps benthic ecosystems in a juvenile stage with low biodiversity. This also affects fish and the whole marine ecosystem negatively. By-catch and the discard of non-target fish, birds, marine mammals and turtles also contribute to the large-scale impacts of fisheries on the ecosystem.

- The wider impacts of increasing aquaculture were highlighted in the Kiev report, but still seem largely unresolved. Increased demand for fish feed from the growing mariculture industry adds to the already high global fishing pressures and appears to be an inefficient way of producing marine proteins for humans.

- Measures taken to reduce concentrations of some well-known hazardous substances, such as heavy metals and certain persistent organic pollutants (POPs), have generally been successful in the western seas. Sparse data indicate high levels of hazardous substances, particularly POPs, in the Black and Caspian Seas. POPs, which can have serious detrimental effects on marine organisms, are transported over long distances and can be found even in the remote Arctic.

- Major accidental oil spills have generally decreased in pan-European seas. However, oil discharges from regular activities, such as transport and refineries, are still significant along major shipping routes and at certain hot spots along coasts, for example in the Caspian Sea. Without effective countermeasures, the expected increase in oil transport, especially in the Arctic, Baltic, Black, Caspian and Mediterranean Seas, will add significantly to the risk of regional oil pollution.

- Alien species are a major cause of biodiversity loss and continue to invade all seas in the pan-European region mainly via ships' ballast water. The highest numbers are found in the Mediterranean Sea. The collapse of the Black Sea ecosystem in the 1990s demonstrates how alien species can aggravate other pressures and cause great economic losses.

- Population densities along the coasts of the pan-European region are high and continue to increase — with built-up areas growing at the expense of agricultural, semi-natural and natural land in all EU Member States. Tourism has played a crucial role, in particular along the Mediterranean coast, and is becoming a driver of development on the Black Sea coast. The EU Integrated Coastal Zone Management Recommendation has resulted in some beneficial initiatives in the Baltic, Black and Mediterranean Sea regions and should be extended to prevent further conflict of uses.

- Climate change will very likely cause large scale alterations in sea temperature, sea level, sea-ice cover, currents and the chemical properties of the seas. Observed biological impacts include altered growing seasons, and shifts in species composition and distribution. Further impacts could also include the loss of marine organisms with carbonate shells as a result of acidification. Adaptation policies should include measures to reduce non-climatic impacts in order to increase the resilience of marine ecosystems and the coastal zone to climate change.

- Lack of comparable data across all seas still presents a major obstacle for pan-European marine assessments, even of well-known problems such as eutrophication and overfishing. More and better data are needed to develop a pan-European marine protection framework that addresses environmental issues in a cost-effective way.

5.1 Introduction

This chapter provides a general pan-European review of the main issues of concern on the state of seas and coasts, as far as current EEA and other data allow. Such a review has not been undertaken since the first assessment of Europe's environment, the 1995 Dobris report. It updates the partial assessment carried out for the 2003 Kiev conference by reporting, as far as possible, on progress made since then, both in terms of general policy development (Section 5.2) and our understanding of certain marine and coastal issues (Section 5.3).

The seas and oceans covered in this chapter are highlighted in Map 5.1. They are as diverse in their structure and functioning as their terrestrial counterparts. Stretching from the sub-tropical Atlantic to the high, ice-covered Arctic, the pan-European marine environment includes the open oceans, seas forming the edge of ocean basins as well as semi-enclosed, fully enclosed, and brackish seas. Such physical diversity is also well-reflected in their chemistry and biology. Differences in their resilience mean that some are particularly vulnerable to certain drivers and pressures (ELOISE, 2004; EEA, 2005a).

The seas and coasts in the pan-European region are a vital resource upon which many millions of people depend. Some of the ecosystem services and resources they provide have been valued in monetary terms as they form the basis of major economic activities. For example, the marine industry in the EU-15 had an estimated value of EUR 310 billion in 2004 (Marine Institute, 2005). Extraction of marine resources, such as fishing, and oil and gas production, represented a value of EUR 37 billion. But the largest value stemmed from marine services, such as shipping and tourism, at EUR 239 billion (Marine Institute, 2005). However, marine and coastal ecosystems provide other goods and services with high value for humans, which are not always so obvious or quantifiable in monetary terms. Examples are regulation (e.g. for climate change and flood protection), cultural (e.g. leisure and recreation), and supporting services (e.g. nutrient cycling and biologically-provided habitats) (Beaumont *et al.*, 2006). Thus it follows that some of the environmental changes described in this chapter are likely to have significant economic and social consequences.

Pressures and drivers

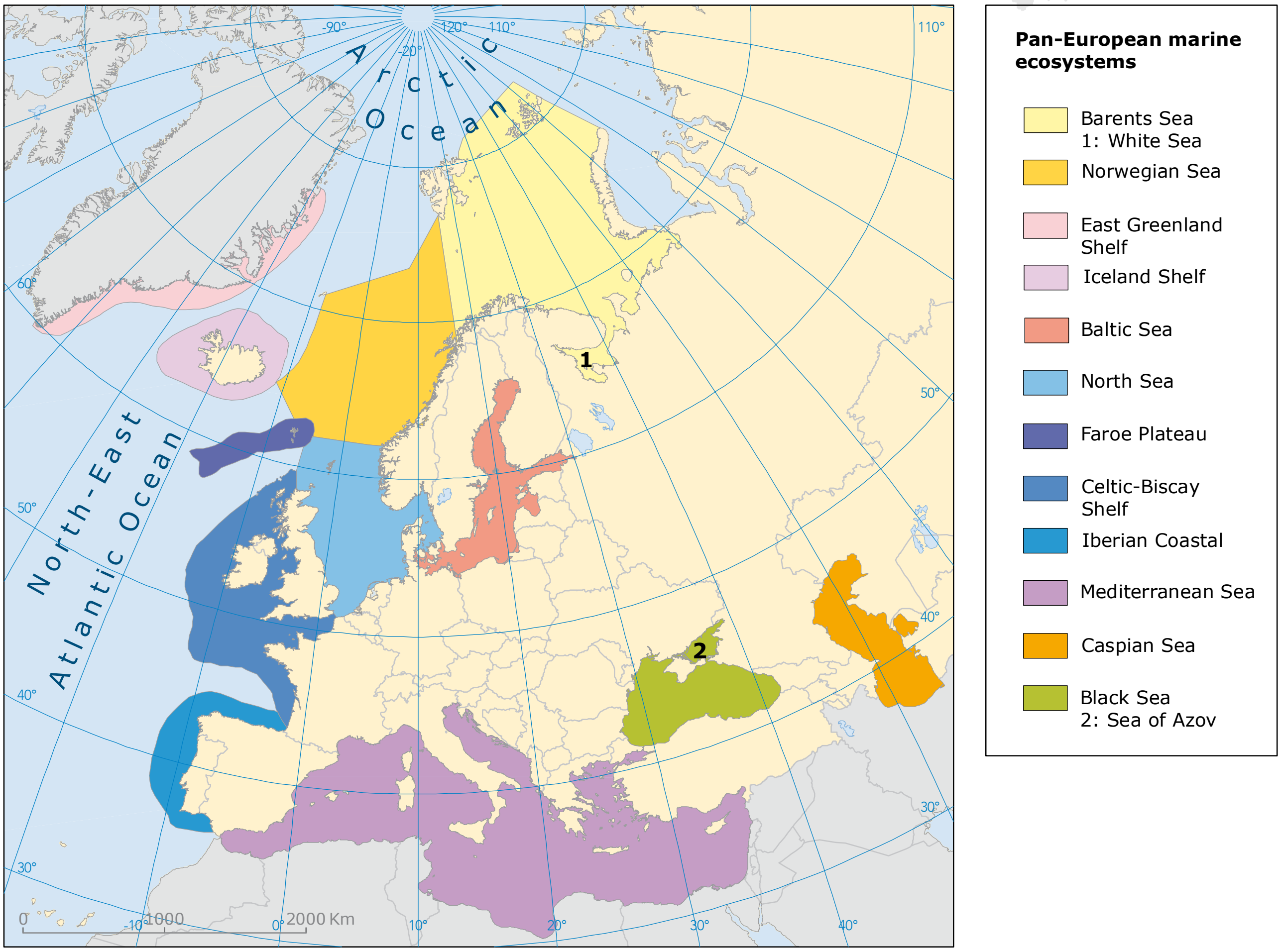
The state of the marine and coastal environment is the combined effect of human pressures interacting with one another, and natural variability. The pressures and drivers on pan-European marine and coastal ecosystems (Table 5.1) are not evenly distributed around the region.

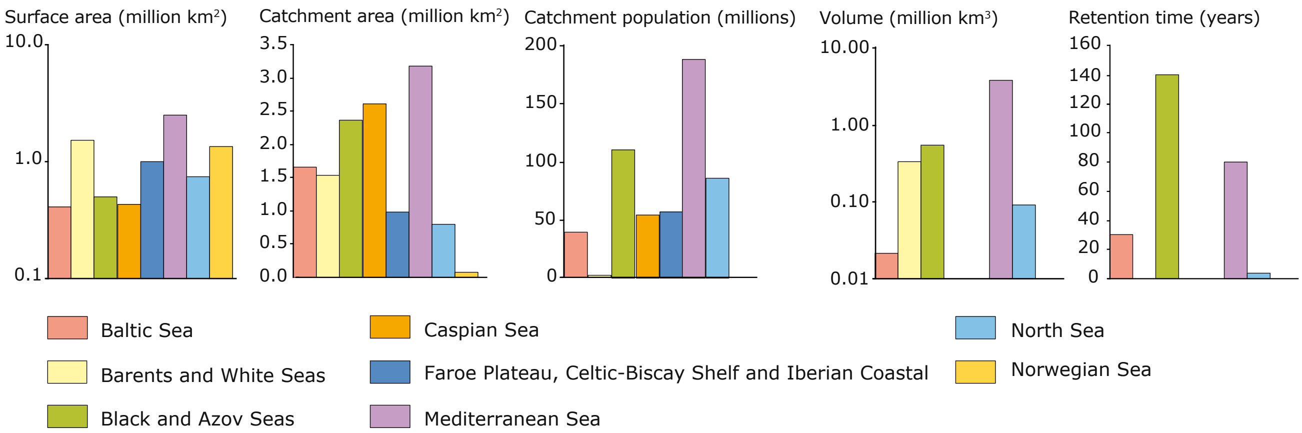
Table 5.1 Impacts related to main pressures on the coastal and marine environment

Pressures	Main impacts
Climate change	Increased/changed risk of floods and erosion, sea-level rise, increased sea surface temperature, acidification, altered species composition and distribution, biodiversity loss
Agriculture and forestry	Eutrophication, pollution, biodiversity/habitat loss, subsidence, salinisation of coastal land, altered sediment balance, increased water demand
Industrial and infrastructure development	Coastal squeeze, eutrophication, pollution, habitat loss/fragmentation, subsidence, erosion, altered sediment balance, turbidity, altered hydrology, increased water demand and flood-risk, seabed disturbance, thermal pollution
Urbanisation and tourism	Coastal squeeze, highly variable impacts by season and location, artificial beach regeneration and management, habitat disruption, biodiversity loss, eutrophication, pollution, increased water demand, altered sediment transport, litter, microbes
Fisheries	Overexploitation of fish stocks and other organisms, by-catch of non-target species, destruction of bottom habitats, large-scale changes in ecosystem composition
Aquaculture	Overfishing of wild species for fish feed, alien species invasions, genetic alterations, diseases and parasite spread to wild fish, pollution, eutrophication
Shipping	Operational oil discharges and accidental spills, alien species invasions, pollution, litter, noise
Energy and raw material exploration, exploitation and distribution	Habitat alteration, changed landscapes, subsidence, contamination, risk of accidents, noise/light disturbance, barriers to birds, noise, waste, altered sediment balance, seabed disturbance

Sources: Based on ELOISE, 2004; the proposed EU Marine Strategy Directive — European Commission, 2005a.

Map 5.1 Pan-European marine ecosystems





Note The assessment in this chapter focuses on the Barents, Baltic, Black, Caspian, Mediterranean, North-East Atlantic, Norwegian, and Russian Arctic Seas. Where relevant, details have been provided for other seas e.g. the Azov and White Seas.
The different seas on the map are defined following the Large Marine Ecosystems (LMEs) approach (http://woodsmoke.edc.uri.edu/Portal/jsp/LME_EA.jsp). However, this approach is not always followed in the chapter.
Not all the seas that appear on the map are covered by the statistics below it.

Sources: EEA, 1995; GISCO/Eurostat, 2006; ICES, 2007; LandScan, 2005; OSPAR, 2000; UNEP, 2004a.

Pressures resulting from global processes leading to, for example, increased temperatures, rising sea-levels and altered weather conditions, clearly affect the whole pan-European region. Land-based socio-economic activities are more national, regional or local in nature, while the pressures from shipping and fishing are often transboundary. Unfortunately, the sum of current knowledge informed by the latest assessments, particularly on the synergies between pressures, is yet to be fully recognised in policy development and management.

5.2 Policies to protect pan-European seas

At the global level, the primary legal instrument governing the use of the oceans and seas is the UN Convention on the Law of the Sea (UNCLOS), which came into force in 1994. It establishes a comprehensive legal regime, including important provisions for marine environmental protection and the management of fish stocks. There are several other global conventions, including those aiming specifically at reducing the impacts of shipping within the framework of the International Maritime Organization (IMO) (see reviews in European Commission, 2005c; European Science Foundation, 2002; see also Annex on 'Conventions' to this report). However, some of these are awaiting sufficient ratification to come into force.

In the pan-European region, several international regional sea conventions combine with these global policy frameworks and agreements to protect the marine environment. These include:

- the Barcelona Convention for the Protection of the Mediterranean Sea against Pollution, in force since 1978;
- the Bucharest Convention on the Protection of the Black Sea against Pollution, in force since 1994;
- the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR), in force since 1998;
- the Convention on the Protection of the Marine Environment of the Baltic Sea (HELCOM), in force since 2000; and
- the Tehran Framework Convention on the Protection of the Marine Environment of the Caspian Sea, in force since 2006.

All of these have specific strategies, plans and programmes to control all sources of pollution and to improve the state of the marine environment in relation to other main pressures and impacts. They are all, therefore, relevant when dealing with all the environmental issues highlighted in this chapter.

The International Council for the Exploration of the Sea (ICES) provides scientific advice on the management of fish and shellfish stocks, the marine environment and the state of marine ecosystems. This is used for developing management measures by its 20 member countries and international organisations, such as HELCOM, OSPAR and the European Commission.

Although the implementation of strategies and measures from global and regional sea conventions are difficult to enforce (European Commission, 2005b), the ratification of particularly those that are yet to come into force (see annex on 'Conventions' to this report) is important. In the EECCA region, the coming into force of outstanding international agreements could fill some of the regulatory gaps that arise from the lack of an adequate regional framework for the protection of the marine environment.

EU framework
A wide range of EU policies and legislation address specific environmental problems relevant for the North-East Atlantic, Baltic, Mediterranean and Black Seas, including:

- Birds Directive (79/409/EEC)
- Bathing Waters Directive (76/160/EEC); new directive entered into force in 2006 (2006/7/EC)
- Nitrates Directive (91/676/EEC)
- Urban Waste Water Treatment Directive (UWWT) (91/271/EEC)
- Habitats Directive (92/43/EEC)
- for hazardous substances: Integrated Pollution Prevention and Control (IPPC, 96/61/EC), controls on emissions of dangerous substances to the aquatic environment (76/464/EEC), limits to the marketing and use of both hazardous

substances (76/769/EEC) and plant protection products (91/414/EEC).

Internationally, it has been recognised that human activities need to be managed at an ecosystem level if they are to be effective in halting or reversing environmental degradation. However, a lack of coordination between existing global and regional commitments and mechanisms prevents this from happening (European Commission, 2005c). The EU has, therefore, reconsidered the way it deals with environmental protection beyond the single-issue policies highlighted above — indeed the ecosystem-based approach has been enshrined in the 2005 European Marine Strategy (EMS) (European Commission, 2005b).

The Water Framework Directive was, in fact, the first EU tool to adopt an ecosystem-based approach — taking into account pressures and impacts across the whole catchment, including coastal waters, in order to achieve good ecological and chemical status by 2015 (see Section 2.3, Inland waters). This directive answers the Dobris report's call for better catchment management, control and regulation in order to reduce riverine pressures on the marine environment.

A Marine Strategy Directive (MSD), which aims to achieve good environmental status of European marine waters by 2021, is being negotiated by the European Parliament and EU Environment Ministers in order to make the EMS operational. This directive, in combination with the WFD for coastal waters, should provide a much needed impetus for fully meeting the objectives of existing single-issue policies since it provides a horizontal dimension for their integration, and would thus allow for positive synergies in their implementation.

Following the Sixth Environment Action Programme (EAP, 2002), other significant EU developments intended to protect marine and coastal ecosystems are:

- *Integrated Coastal Zone Management (ICZM)*. Most national strategies were adopted by EU Member States in 2006 following the ICZM Recommendation (2002). One key achievement has been the codification of a common set of principles underpinning sound coastal planning and management. Another benefit has been its role in stimulating the development of relevant legal instruments in the Baltic, Mediterranean and Black Seas.
- *Application of the Natura 2000 ecological network to the marine environment*. Establishing a coherent network of ecologically representative and well-managed protected areas should be a key element of the ecosystem-based approach to managing and safeguarding the marine environment, including improving the sustainability of fisheries. The implementation of the Habitats and Birds Directives requires designation and adequate management of marine sites as part of the Natura 2000 network. However, progress in fulfilling this has been slow, in particular when comparing it to what has happened on land, and may be insufficient for 'full implementation' of these directives. By 1 December 2006, EU-25 had designated 4 133 purely land-based SPAs ([1]) and 19 614 purely land-based SCIs ([2]), but only 484 marine SPAs and 1 248 marine SCIs (European Commission, 2007a). Most of these so-called 'marine sites' are located in coastal waters and usually form a natural seaward extension of the land site. Very few are actual offshore marine sites, which is a problem as Natura 2000 should extend, beyond territorial waters, to all marine areas where Member States claim sovereignty or jurisdiction over the exploitation of natural resources (European Commission, 2006a). Considerable efforts will, therefore, be required, not only to fulfil obligations under the Habitats and Birds Directives, but also to meet the Convention on Biological Diversity (CBD) targets of halting marine biodiversity loss by 2010, and of establishing a global network of marine protected areas by 2012 (see also Chapter 4, Biodiversity).

  Making progress with proposing Natura 2000 sites in the marine environment has been difficult, in part, because it presents more

([1]) Special Protection Areas under the Habitats Directive.
([2]) Sites of Community Interests under the Habitats Directive.

challenges than originally expected. These relate, *inter alia*, to a lack of scientific knowledge on the distribution and abundance of species and habitats, and the high costs of carrying out research and surveys in offshore marine areas (European Commission, 2005d). As a result, the EU is taking several actions. These include developing practical guidelines in order to facilitate the designation and future management of marine Natura 2000 sites, and considering how to improve the annexes of the Habitats Directive to ensure that the most relevant marine habitats will be adequately protected and managed. Further, the *EU Action Plan to 2010 and beyond* ([3]) includes objectives on the finalisation of the marine Natura 2000 network by 2008, and on the establishment of management priorities and necessary conservation measures of both Natura 2000 sites and other designated protected areas in the wider marine environment by 2012 (European Commission, 2006b).

- *Review of the Common Fisheries Policy (CFP) and integration of environmental issues.* A number of proposals have recently been put forward as part of the implementation of the revised CFP. These aim to control not only the decline in fish stocks, but also the general fishing impacts on the wider marine environment because existing measures have, in many cases, failed to show the desired effect, in particular on the recovery of fish stocks. Success will depend on whether or not they are now sufficient to achieve these goals but, most importantly, on Member States' commitment to implement them (see also Section 5.3.2, Fisheries).

The EU has also started developing an overall Maritime Policy, of which the proposed MSD will constitute the environmental pillar. The further development of this policy should ensure closer integration of coastal zone management, marine environmental protection and socio-economic activities, such as shipping, oil exploitation, and fisheries. It is positive that the Maritime Policy Green Paper recognises climate change as a major threat, and discusses ways of adapting to changing coastal risks across Europe (European Commission, 2006c).

SEE and EECCA frameworks

The Barcelona Convention includes the Adriatic Sea and is of utmost relevance to SEE countries. Further, those that are EU candidate countries will have to align their marine and coastal protection policies to the EU framework. There are already some positive examples of this, for example in Croatia (Box 5.8).

The EECCA Environmental Strategy (UNECE, 2003) shows that the marine and coastal environmental policy gaps highlighted in the Dobris and Kiev reports have not yet been taken up in the region as a whole. Although the strategy acknowledges the problems — degradation of ecosystems, habitat destruction, chemical pollution, invasive alien species, overfishing and lack of conservation — action to address them has been unfocused and insufficiently developed. The recently ratified Teheran Convention for the Caspian Sea could be a notable exception — all the governments of the Caspian states have committed themselves to implement National Caspian Action Plans. Nonetheless, ongoing negotiations about the legal status of the sea, and hence the division of its resources including oil, may seriously limit the effectiveness of this convention.

Policies similar to those of the EU and international conventions, if properly implemented and enforced, could also have positive effects in the SEE and EECCA regions. The WFD already extends voluntarily to other countries sharing EU catchments. Implementation of the MSD could also be extended to other countries sharing regional seas with EU Member States, with support from the relevant regional sea conventions, and influence marine protection policies there. Both the EU Water Initiative and the European Neighbourhood Policy (ENP) are very relevant to promoting the development of environmental policies in SEE and EECCA. The recent proposal to strengthen the ENP, supported by relevant funding, focuses on cooperation in the Black Sea and Mediterranean regions. This may even extend to the neighbours of EU's neighbours, and reach the Caspian Sea area (European Commission, 2006d). However, it is up to

([3]) Annexed to the European Commission Communication on *Halting the loss of biodiversity by 2010 — and beyond — Sustaining ecosystem services for human well-being.*

the relevant countries to prioritise and negotiate the inclusion of measures to improve the situation of the coastal and marine environment in their ENP Action Plans.

Support from the international community can also come from the UNEP Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA). This is a source of conceptual and practical guidance to be drawn upon by national and regional authorities, which is uniquely positioned to facilitate improved cooperation and coordination of sustainable management of freshwater, coastal and marine environments.

Governance

Governance determines whether the objectives and instruments defined in policies are first implemented and then enforced. Across the pan-European region, policy implementation and enforcement lags behind legislation. In the EU, this is due, *inter alia*, to conflicts between environmental and other policy objectives, for example agriculture and transport. That is also the case in the EECCA region, due in part to the stronger focus on short-term economic recovery (OECD, 2005). Both the legal mandate and capacity of most environmental institutions in EECCA countries have strengthened in the past decade, but a lack of funds and human resources remain among the challenges that countries will have to confront if they are to improve the state of their marine environment (OECD, 2005).

Assessments of the marine environment

There is growing recognition of the need for sound and comparable data and indicators to support marine policy development and management, both at the pan-European and regional levels. Whilst the lack of knowledge is worse in some areas, such as the Caspian Sea, than in others, there is room for significant improvement across Europe. For example:

- both HELCOM and OSPAR have fairly well-developed regional assessments, although limited to the priority issues for the Baltic and North-East Atlantic Seas;
- assessments of the Mediterranean Sea by UNEP/MAP/MED POL ([4]) do not consistently extend to the whole region;
- despite efforts from the Black Sea Commission, regional assessments of the Black Sea are not very developed;
- reports from global organisations such as the UNEP/GEF Global International Waters Assessments (GIWA) are valuable, in particular for EECCA seas;
- the EU is now working closely with regional sea conventions to develop a system for monitoring and assessment that can assist the implementation of the MSD in the North-East Atlantic, Baltic, Black and Mediterranean Seas. Such a framework, however, does not extend beyond these.

5.3 Main issues on the state of the marine and coastal environment in the pan-European region

This section reviews, as far as possible, progress made since the Kiev report (EEA, 2003) on several key issues for the state of the marine and coastal environment across pan-European seas: eutrophication, overfishing, pollution from oil and hazardous substances, coastal zone degradation and climate change. The assessment now extends to new issues: invasive alien species and ecological impacts of climate change, and highlights areas on which further action is needed. The order in which these issues are addressed below does not imply any particular priority. The better-known problems are dealt with first, followed by others that have intensified over time.

5.3.1 Eutrophication

Nutrients such as nitrogen and phosphorus are essential to maintaining primary production

([4]) Mediterranean Action Plan under the Barcelona Convention under which the 1975 Programme for the Assessment and Control of Pollution in the Mediterranean region (MED POL) was initiated.

and thus the healthy structure and functioning of aquatic ecosystems. Eutrophication, however, is defined as the overload of nutrients in water causing an accelerated growth of planktonic algae and higher plant forms. It can lead to depletion of oxygen (anoxia) followed by loss of bottom-dwelling animals and shifts in the structure of the food web.

There is a lack of comparable data and harmonised methods as needed to assess trends in nutrient loads. Further, existing nutrient concentrations, mainly internal loads from sediments, and changed ecological structure in eutrophic areas may delay recovery once nutrient loads are reduced. This makes it difficult to judge the success of policies to combat eutrophication across the pan-European region as a whole. What is clear is that it continues to affect most seas, although there have been reductions in some areas, including parts of the North Sea and also the north-western shelf of the Black Sea. These seem to mainly result from efforts to control point sources of nutrients in the EU-15. In contrast, diffuse sources, mainly from agriculture, are still a problem across the region. In the EU, but mainly in EU-15, this could be linked to the fact that agriculture is highly intensive and measures to counter eutrophication, such as the Nitrates Directive, are either insufficient or poorly implemented (EEA, 2005a; 2005b; European Commission, 2007c).

Extent of eutrophication

The extent of eutrophication varies across pan-European seas:

- it is a major problem in the eastern and south-eastern parts of the Baltic Sea, which has changed from nutrient-poor, clear water in the 1800s to its present eutrophic state (HELCOM, 2006a);
- in the North Sea, it is found particularly in the estuaries, fjords and coastal areas of the southern and eastern part, in the Kattegat, the Skagerrak and, to a lesser extent, in the English Channel (OSPAR, 2003);
- it occurs in some bays and estuaries in the Celtic Sea (OSPAR, 2003);
- in the Mediterranean Sea, it is common in sheltered water bodies near coastal towns. The north Adriatic Sea is considered eutrophic due to large riverine nutrient inputs, mainly from the Po (EEA, 2006a);
- it is largely associated with increased river loads of nutrients in the Black Sea, particularly on the north-western shelf (Box 5.1), but it only appears to have been a major problem since the 1970s (EEA, 2005a; 2005b);
- the Caspian Sea, particularly around the Volga river delta, has steadily deteriorated since the early 1980s. However, eutrophication is not a basin-wide problem (Salmanov, 1999);
- it does not appear to be a problem in the Russian Arctic, including the White Sea (UNEP, 2005a; Filatov *et al.*, 2005); the Barents Sea (UNEP, 2004b); or in the Arctic region of OSPAR, including the Norwegian Sea (OSPAR, 2000).

Loads and sources of nutrients

In north-western Europe and the Danube river catchment, diffuse pollution from agricultural run-off contributes to 50–80 % of the total load of nitrogen. Industry and household wastewater used to be the main contributors to phosphorus pollution, but reductions in point-source discharges over the last 30 years mean that agriculture has also become the main source in some countries (EEA, 2005a; see also Section 2.3, Inland waters).

These phosphorous point-source reductions have been achieved in the EU despite a lack of full compliance with the UWWT Directive (EEA, 2005a; 2005b; Greenpeace, 2006a; European Commission, 2007b; see also Section 2.3, Inland waters), showing that, when applied, relevant measures can be efficient. Further, some of the measures taken in the EU to reduce diffuse losses of nitrogen to water on agricultural land are beginning to show results in a few areas, such as certain Danish coastal waters (Andersen *et al.*, 2004). Although further action is needed to reduce the export of agricultural nutrients to the sea, these achievements may serve as a model to other countries.

In countries bordering the Azov, Black, and Caspian Seas both point-source discharges of nutrients, mainly as a result of inadequate wastewater treatment, and diffuse-source discharges from agriculture are significant.

Further industrial and agricultural development in countries bordering these seas should be carried out in ways that do not increase these loads (see also Sections 7.1, Agriculture, and 2.3, Inland waters).

Reported trends in loads of nutrients from rivers and direct discharges to pan-European seas affected by eutrophication are less clear:

- trends in the OSPAR region between 1990 and 2004 remain uncertain. Detailed analysis of OSPAR's Riverine Inputs and Direct Discharges Study, which includes data up to 2002, revealed significant increases in the total loads of nitrogen and phosphorus to Arctic waters, reductions in total inputs of nitrogen and phosphorus to the North Sea, and reductions of phosphorus to the Celtic Sea. Most of these changes were associated with increases or decreases in loads from direct discharges, rather than detectable changes in riverine inputs (OSPAR, 2005a);
- riverine inputs are responsible for 77 % of the total nitrogen and phosphorus inputs to the Baltic Sea. There has been a significant decrease in the average phosphorus concentrations between 1994 and 2004, whereas there is no equivalent trend in average nitrogen concentrations. Inputs have varied depending on hydrological conditions in the catchment area, and there is no significant change in riverine nutrient loads in the 1994–2004 period (HELCOM, 2005a);
- the Black Sea Commission has reported a steady decline in the discharges of nutrients from land-based sources between 1996 and 2000 (BSC, 2002) (Box 5.1);
- data on riverine discharges and other loads of nutrients to the Mediterranean Sea are scarce. Most rivers that drain into the sea, even though they are important, are not adequately monitored for loads of organic and inorganic pollutants (EEA, 2006a);
- riverine inputs — in particular the Volga — dominate the loads of total nitrogen (95 %) and total phosphorus (87 %) discharged into the Caspian Sea (CEP, 2002a).

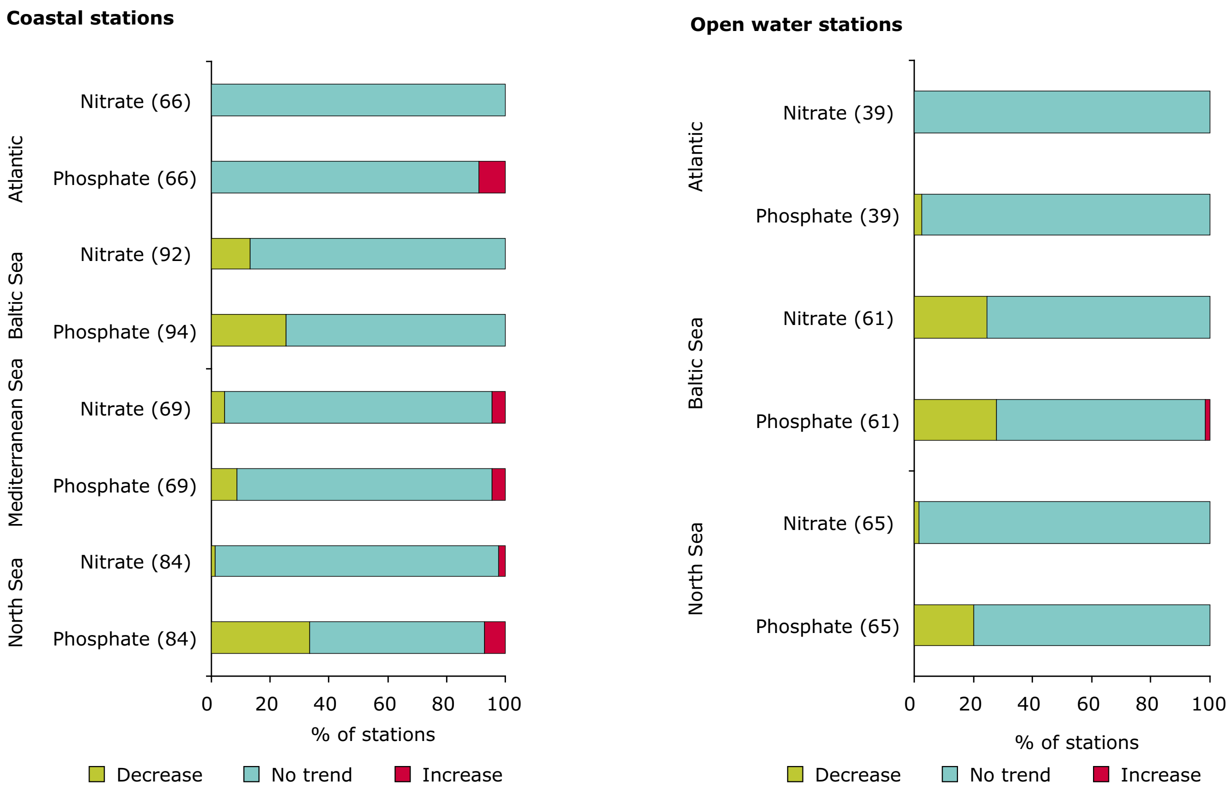
Nutrient concentrations

The distribution of nutrient concentrations in pan-European seas affected by eutrophication reflects the main sources of nutrients and their mixing with recipient waters.

In the north-eastern Atlantic — mainly the Celtic Seas, the Baltic Sea, the Italian coast of the Mediterranean Sea, and the North Sea the majority of the monitoring stations show no significant change in nutrient concentrations between the mid-1980s and 2004/2005 (Figure 5.1). However, there is evidence that both nitrate and phosphate concentrations are decreasing in some areas of the Baltic Sea. Additionally, phosphate concentrations are decreasing at some Dutch North Sea stations (MNP, 2006). The results possibly indicate that measures to reduce nutrient loads are beginning to have an effect both in coastal and open waters. This is particularly so for Danish and Swedish coastal waters, where 20 % and 8 % of the stations, respectively, showed a decreasing trend in nitrate concentrations and there were no stations showing an increasing trend. A greater proportion of all stations overall reported decreasing trends in phosphate concentrations than for nitrate concentrations, for example 67 % of the Dutch and 36 % of the Danish coastal stations. The only increases in phosphate concentrations were found in Irish, Italian and Norwegian coastal waters (Figure 5.1).

Information on concentrations of nutrients in the Caspian Sea is very limited and not geographically specific. Average nitrate levels are estimated at less than 1 µg/l, whereas for phosphate, the averages range between 1 and 10 µg/l (CEP, 2002a). For nutrient concentrations in the Black Sea see Box 5.1.

Figure 5.1 Change in winter nitrate and phosphate concentrations in coastal and open waters of the north Atlantic (mostly Celtic Seas), Baltic, Mediterranean (Italian coastal waters only) and North Seas (% of stations, 1985–2004/2005)



Note: This is part of the EEA core set indicator 21 (http://themes.eea.europa.eu/Specific_media/water/indicators). 'Monitoring stations' refer to those reporting to the EEA by its member countries from the seas shown above. Other seas not included as riparian countries are either not EEA member countries or, if they are, they did not report to the EEA over 2004–2005.

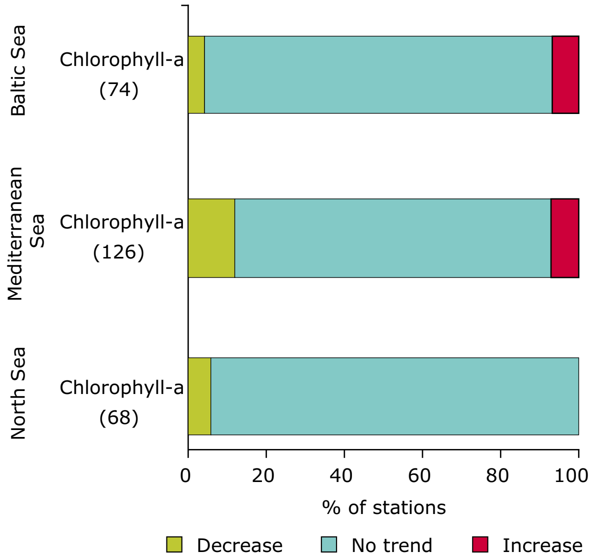
Source: EEA Waterbase, 2006.

Chlorophyll-a

The biomass of planktonic algae (phytoplankton) is most frequently measured as the concentration of chlorophyll-a in the part of the water column reached by sunlight. In general, there has been no decrease in eutrophication — expressed as changes in summer chlorophyll-a concentrations — in the coastal waters of the Baltic Sea, the North Sea or the Italian coast of the Mediterranean Sea since 1985 (Figure 5.2). However, by 2004/2005 decreasing trends were observed for 12 % of the Italian coastal stations and 6 % of North Sea stations, respectively, while 7 % of the stations in the Baltic Sea and along the Italian coastline showed an increasing trend (Figure 5.2).

Used with care, satellite imagery provides a useful tool to monitor the concentration of chlorophyll-a. Map 5.2 provides a snapshot of some of the seas that have not been covered in Figure 5.2 where the generally clear, chlorophyll-poor waters of the Mediterranean Sea can be contrasted with the rather eutrophic waters of the Black Sea (see also Box 5.1). The main exception to this is in the highly eutrophic system of the north Adriatic Sea (EEA, 2006a). In the Caspian Sea, the highest chlorophyll concentrations are observed in the northern, shallower part of the sea and close to the Volga delta.

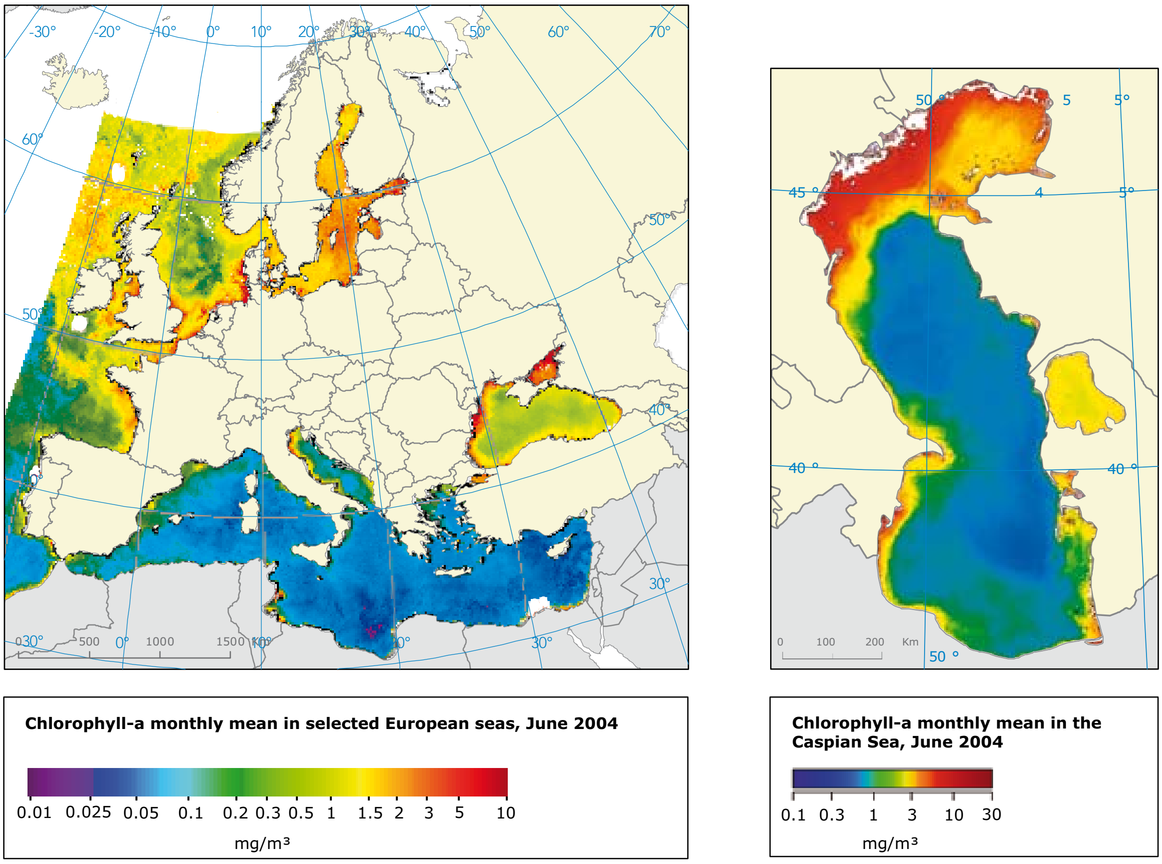
Figure 5.2 Change in summer chlorophyll-a concentrations at coastal stations of the Baltic, Mediterranean (Italian coastal waters only) and North Seas (% of stations, 1985–2004/2005)



Note: This is part of the EEA core set indicator 23 (http://themes.eea.europa.eu/Specific_media/water/indicators). 'Monitoring stations' refer to those reporting to the EEA by its member countries from the seas shown to the left. Other seas not included as riparian countries are either not EEA member countries or, if they are, they did not report to the EEA over 2004–2005. Only coastal data are presented as no trends were found at the open water stations in the Baltic (27 stations) and North (56 stations) Seas. For a more detailed map presentation of the data see: http://themes.eea.europa.eu/IMS/IMS/ISpecs/ISpecification20041007132031/IAssessment1116504836843/view_content.

Source: EEA Waterbase, 2006.

Map 5.2 Satellite imagery of chlorophyll-a concentrations in selected pan-European seas (mg/m³)



Note: Information on the performance of methodologies for the processing of SeaWIFS ocean colour data to retrieve geophysical and biological variables (e.g. chlorophyll) can be found in the Joint Research Centre (JRC), Institute for Environment and Sustainability (IES), website http://marine.jrc.ec.europa.eu. Data from the Caspian Sea, in particular, should be treated with special care.

Source: European Commission, DG JRC, IES, 2006.

Box 5.1 Eutrophication in the Black Sea

The input of nutrients to the Black Sea from the rivers Danube, Dnieper and Don increased approximately 10-fold between the 1960s and the 1990s as fertiliser use in agriculture grew dramatically (Borysova *et al.,* 2005). Since the 1970s, this has caused severe eutrophication problems, including anoxia. Together with pressure from overfishing, this made the Black Sea a very sensitive ecosystem aiding the massive invasion of the alien comb jelly *Mnemiopsis leidyi*, which caused the collapse of anchovy, chub and mackerel stocks, oyster fisheries, and jellyfish populations (EEA, 2005a; see also Sections 5.3.2, Fisheries, and 5.3.5, Invasive alien species).

The Black Sea Commission (BSC) has reported a steady decline in the discharges of nutrients from land-based sources between 1996 and 2002 (BSC, 2002). This observation is supported by the modelled nutrient emissions in the Danube basin, which indicate that phosphorus loads from the Danube river in 2000 had decreased by around 30–50 % compared to loads in the 1980s (Danubs, 2005). The assessment of changes of nitrogen loads was not so conclusive because of the variability of the river flow.

Although the overall background concentration of nitrate in the Black Sea is very low (1.4 µg/l), elevated concentrations are observed along the Turkish coast, and relatively high concentrations are found at certain locations on the north-western shelf, for example in Romanian coastal waters (EEA, 2005b). Between 1990 and 2003, there appears to have been an increase in nitrate concentrations in the north-western shelf waters of Bulgaria, Romania and Ukraine. However, these do not reflect the general decreasing trend of inorganic nitrogen concentrations in the Danube river (Parr *et al.,* 2005). The phosphate background concentration is relatively high (around 9 µg/l) probably due to the naturally anoxic conditions in the bottom waters of most of this sea, which prevent phosphate being bound into the sediments. Phosphate concentrations are lower than in the open sea along the Turkish coast, but higher in the Romanian coastal waters influenced by the Danube river (EEA, 2005b).

The decrease in nutrient inputs has been reflected in improvements in the ecological health of some areas of the Black Sea. Satellite images taken between 1998 and 2004 show a clear downward trend in chlorophyll concentrations during the natural seasonal peaks on the north-western shelf (Parr *et al.,* 2005). The more recent years of 2003 and 2004 are characterised by low chlorophyll concentrations and small or absent areas of low oxygen. Other reported indications of recovery in the area include increasing plankton and fish diversity (Zaika, 2006), decreasing mussel mortality (Mee, 2006), zoobenthos recovery (Parr *et al.,* 2005), and the reappearance of some indigenous species of crabs, fish and dolphins (Aleksandrov, 2006; Zaika, 2006).

Nutrient reductions are expected to continue in the Danube basin as a result of the implementation of EU environmental policies, in particular the WFD. However, nutrient loading is expected to increase in the basins of the rivers Dnieper and Don as a result of the development of the agriculture sector in the Russian Federation, Belarus and Ukraine (Borysova *et al.,* 2005). The development of policies ensuring that further expansion of agriculture in those countries occurs in a sustainable manner is essential to guarantee the continued recovery of the Black Sea (see also Section 7.1, Agriculture). Agreement on the need to reduce nutrient pollution to the Black Sea at the February 2007 meeting of the Environment Ministers of all the 16 countries of the Danube and Black Sea regions is a positive step in that direction.

5.3.2 Fisheries

This assessment is concerned with the pan-European region's marine environment, although its fishing fleets are active across the world's oceans. Thus the figures and analyses presented here reflect only fish caught by the pan-European fleet within pan-European marine waters.

Though many commercial fish stocks have not been assessed, the available data indicates that overfishing is still widespread across the pan-European region. Fishing practices also continue to affect other organisms, destroy bottom habitats and cause large scale ecological changes through alterations of the overall food web. The consequences include increased vulnerability to other pressures, especially pollution and climate change, and freeing of ecological space for alien species.

Effective management has allowed some fish stocks with high reproductive rates, such as Norwegian spring spawning herring (ICES, 2006a), to recover from past overfishing. However, most stocks show few signs of recovery. This highlights the need for urgent improvement in the overall management of fisheries through a wide range of measures, backed by effective implementation and enforcement in all European seas. The EU has developed many measures in recent years, under the revised CFP, but it is too early to asses the effects of some of these, while others, such as the protection of certain deep-sea fish species — for example roundnose grenadier and orange roughy — appear to be failing (European Commission, 2007d).

Deep-sea fishing is increasing as a result of declining catches close to shore. Commercial fishing is thus turning to deeper waters — defined by the EU as beyond 400 metres — threatening species that live there before sufficient information is available on which to base management advice (European Commission, 2007d). This is putting at risk the least sustainable of all fish stocks, as some deep species do not mature until they are 40 years old and then may live 240 years (Marine Conservation Biology Institute, 2007). The EU is currently reviewing the management of deep-sea fish stocks because it considers that current levels of exploitation must inevitably be reduced (European Commission, 2007d).

Urgent efforts are needed to reduce fishing impacts on bottom habitats in general. Further, establishing a network of marine protected areas should become a priority to improve the sustainability of fisheries, given the link between biodiversity-poor ecosystems and increased rates of collapse of remaining fish stocks (Worm *et al.*, 2006).

Fish catches ([5])
Over the period 1990 to 2005, fish ([6]) catches within pan-European waters ([7]) increased overall by 9 %, mostly in the North-East Atlantic (12 %). Expressed regionally, increases can be seen in EFTA, SEE and EECCA countries, but a decrease in EU-25 (FAO, 2007a) (Table 5.2). However, considering the 2000–2005 period, fish catches decreased overall by 13 % and this affected all regions (FAO, 2007a) (Table 5.2).

Table 5.2 Change in marine fish catches in pan-European waters (%)

Country grouping	1990–2005	2000–2005
EECCA	91	– 5
SEE	19	– 19
EFTA	34	– 13
EU-25	– 15	– 15

Source: FAO, 2007a.

The pan-European overall fish capture ([8])([9]) amounted to approximately 11 million tonnes (Mt) in 2000 and decreased to 9.45 Mt in 2005: 4.1 Mt from EU-25, 4 Mt from EFTA, 1 Mt from EECCA and 0.4 Mt from SEE (FAO, 2007a). Around 90 % of this came from north-eastern Atlantic waters, where over a quarter of assessed commercial fish stocks are already outside safe biological limits (see below).

To this should be added estimates for illegal, unreported and unregulated landings, which the EU is trying to counter *inter alia* through the establishment of the Community Fisheries Control Agency. However, full implementation of the EU Action Plan for the eradication of illegal, unreported and unregulated fishing adopted in 2002 (European Commission, 2002) has not been achieved yet (European Parliament, 2007). These landing are considerable, for example:

- around 35–45 % of Baltic cod is being caught illegally, but in some countries figures could be

([5]) See also the indicator on 'Total and marine catches' in the 'International comparisons' annexed to this report. This considers the WCE country grouping, which includes both EU-25 and EFTA groupings used in this section.
([6]) Marine fish catches as included in the FAO International Standard Statistical Classification of Aquatic Animals and Plants Division on 'marine fishes'. This means that crustaceans, molluscs, other marine animals and also plants as well as mariculture production are excluded. Catches of fish that migrate between fresh and salt waters ('diadromous fishes', e.g. sturgeon) have also been included.
([7]) For the whole European region, these correspond to two major FAO fishing areas — number 27 (Atlantic, Northeast) and 37 (Mediterranean and Black Sea) — and the Caspian Sea (in the FAO category 'Asian-Inland waters'), see http://www.fao.org/fi/website/FISearch.do?dom=area. However, because of the country groupings used, the Faroe Islands have not been included in this assessment.
([8]) Note that, for reason of data availability, the overall pan-European production in 1990 includes values for the Socialist Federal Republic of Yugoslavia as a whole. However, when calculating the trend for the different country groupings, there are no data for Slovenia, Croatia, and Serbia and Montenegro over 1990–1991 (those became part of the EU-25 and the SEE assessments, respectively, from 1992).
([9]) Excluding the Faroe Islands, which contributed with an additional 0.55 Mt to the pan-European overall marine fish capture in 2005.

much higher (ICES, 2005a; Scientific, Technical and Economic Committee for Fisheries, 2006);
- the illegal catch of east Atlantic and Mediterranean bluefin tuna is estimated to be at least 40 % above the legal quota (WWF, 2006a);
- demand for swordfish from Europe is driving illegal fishing in the Mediterranean Sea. The impact of these illegal activities is exacerbated by considerable shark and dolphin by-catch (WWF, 2006b).

Fishing fleets

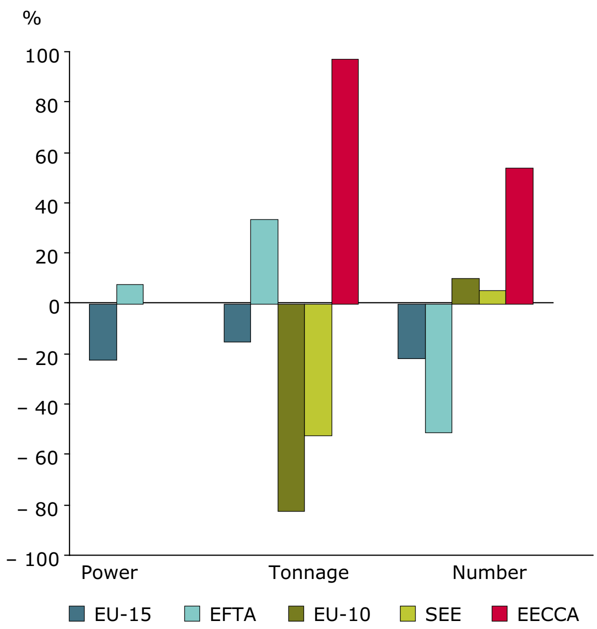
Overcapacity of the fishing fleet is one of the major factors leading to the overfishing of pan-European seas (Figure 5.3), where:

- between 1989 and 2005, the capacity of the EU-15 fishing fleet decreased in power by 23 %, in tonnage by 15 % and in number of vessels by 22 %. However, advances in technology and design mean that new vessels can exert more fishing pressure than older ones of equivalent tonnage and power. As a result, a chronic overcapacity persists, undermining the conservation measures that have been introduced (European Commission, 2003);
- similarly, the 2004 (10) EFTA fleet (Norway and Iceland) had fewer vessels (– 52 %), but increased its power (8 %) and tonnage (34 %) as well as benefiting from improved technology;
- in 2005, Norway (15 % of the total European fleet) and Italy (14 %) had the most powerful fishing fleets within the EU and EFTA countries. By tonnage, the largest fleets were from Spain (20 %) and Norway (16 %), while Greece (19 %) and Italy (15 %) had the most vessels.

Data for other countries is not available over the same period as above. However, the main trends are:

- the EU-10 fleet decreased in tonnage (– 83 %) but increased in numbers (10 %) between 1992 and 2005;

Figure 5.3 Change in the pan-European fishing fleet capacity (%, 1989–2005)



Note: The time period is not uniform for all country groupings. EU-15: 1989–2005; EFTA: 1989–2004; EU-10: 1992–2005; SEE: 1989–1995, and EECCA: 1991–1995. Comparison of figures related to the newer EU Member States (EU-10) before and after their EU membership is open to potential errors because of the different reporting mechanisms applied over the two periods. Regarding 'power', there is no EU-10 bar as data only exists for two years (2004–2005).
SEE = Only Croatia and Turkey as well as Bulgaria and Romania, which belonged to this group at the time; EECCA = Ukraine and the Russian Federation only.

Source: EEA CSI34.

- the SEE fleet decreased in tonnage (– 52 %), but increased its number of vessels (5 %) from 1989 to 1995 (11). In 1995, Turkey had the vast majority of the SEE fleet, and accounted for 7 % of the total number of vessels in Europe;
- the Russian fleet (12) was the largest in Europe in 1995 (58 % of total tonnage). However, it had decreased in size by around 40 % by 2005, mostly as a result of reduced fishing outside Russia's EEZ. Both the Russian and Ukrainian fleets are regarded as old, which could result in the scrapping of more vessels within the next decade (FAO, 2004a; 2004b).

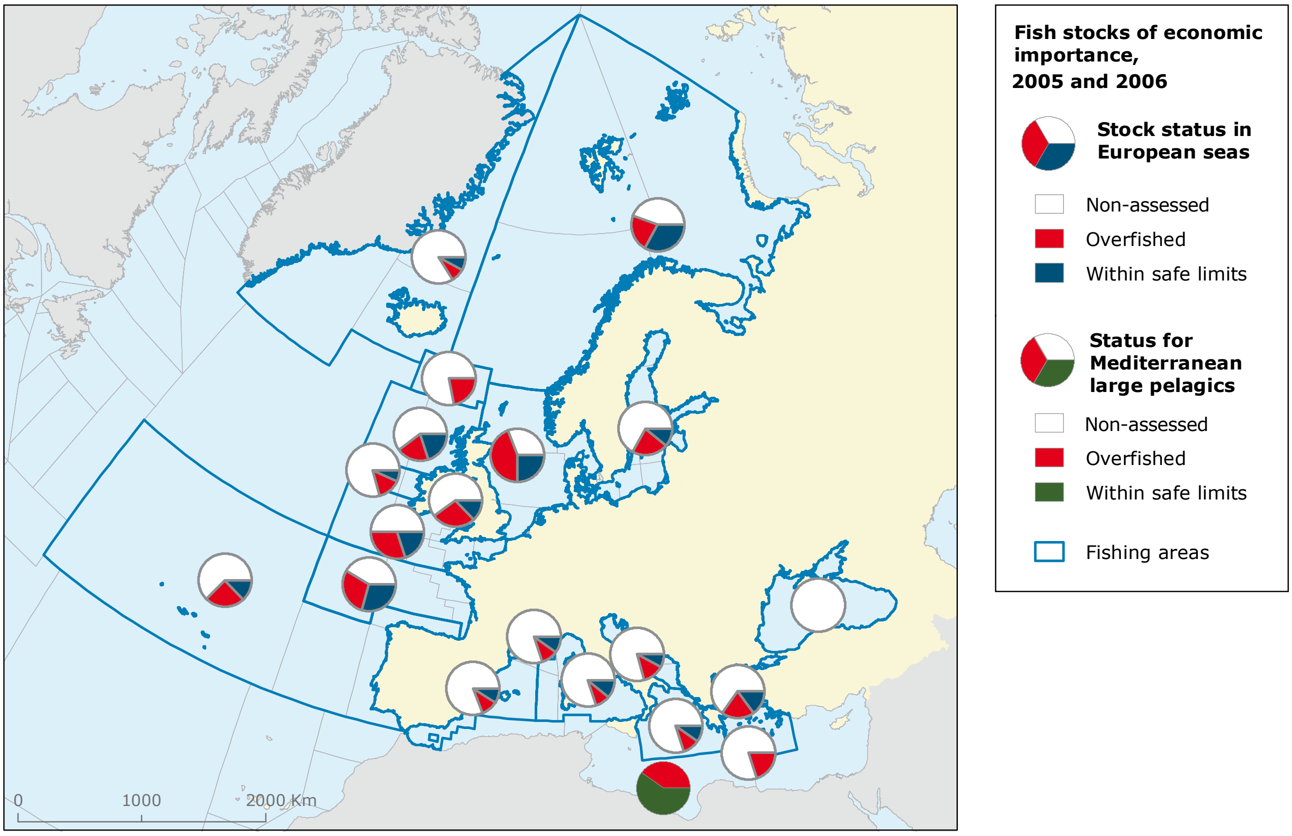
(10) No data for Iceland for 2005.
(11) Although more recent data exist in the case of Croatia, this is not the case for the remaining SEE countries, so the figures for the whole group have to be limited to the period 1989–1995.
(12) Exceptionally, this figure covers all the seas where the Russian fleet was active at the time.

Status of fisheries

Despite reduced fish landings since 2000, overfishing is still widespread in all pan-European seas. This, in contrast, has not led to an improved assessment of the state of commercial fish stocks. For example, 81 % of Arctic, 67 % of Baltic Sea and 54 % of north-eastern Atlantic commercial fish stocks remained unassessed in 2006. Of those stocks that had been assessed, 14 % in the Arctic were outside safe biological limits ([13]), whilst for the North-East Atlantic and Baltic Seas this was 26 %. Whitin the North-East Atlantic, the North Sea was the most severely affected with 44 % of the assessed commercial fish stocks outside safe biological limits, followed by the Celtic Sea with 30 % outside them (Map 5.3). The Arctic waters of Iceland and east Greenland were in the best condition overall, with only 8 % of the assessed commercial fish stocks outside safe biological limits, followed by the western Ireland area (14 % outside) and the western Scotland area (20 % outside) (Map 5.3).

In the Mediterranean Sea, the percentage of assessed commercial fish stocks outside safe biological limits in 2005 ranged from 10–20 %, with Aegean and Cretan stocks being in the worst condition (Map 5.3). In the large pelagics group (including tuna and swordfish), bluefin tuna stocks both in the eastern Atlantic and Mediterranean Seas have been identified as being near collapse (see reviews in WWF, 2006a and Greenpeace, 2006b).

Map 5.3 Commercial fish stocks outside safe biological limits (2005 and 2006)



Note: Assessment based on the EEA CSI32, but with a different aggregation for Iceland, East Greenland and the Faroe Islands following the ICES fishing areas. Not all the seas assessed in this chapter are represented above.
All data are from 2006 except for the Mediterranean Sea, which are from 2005 (GFCM, 2005; ICCAT, 2005a; 2005b).

Source: EEA CSI32.

([13]) Safe biological limit: a limit reference point for a specific fishery, usually the stock biomass below which recruitment will decline substantially.

The Black Sea has been characterised as severely impacted by both overfishing and destructive fishing practices (Mee, 1992). By the 1980s, only five stocks could be exploited compared with 26 in the 1960s and 1970s (BSC, 2002). During the last half of the 1990s, continuous overfishing, the invasion of an alien comb jelly (see Section 5.3.5, Invasive alien species) and pollution resulted in the near commercial extinction of bluefin tuna, bonito, mackerel, anchovy, sprat, whiting and other stocks (Kideys *et al.*, 2005). Since then, the invasion by a second comb jelly that preyed on the former species, combined with a decrease in fishing pressure, has led to some improvements in fish stocks (Shiganova and Bulgakova, 2000). However, there is no quantitative assessment of fish stocks in the Black Sea despite efforts from the Black Sea Commission.

In view of the above, the EU ([14]) and other relevant bodies — including the General Fisheries Commission for the Mediterranean (GFCM) and the International Commission for the Conservation of the Atlantic Tuna (ICCAT) — are developing a series of measures including:

- *Improving the thinking behind the current system of catch limits by Total Allowable Catch (TAC).* Instruments for achieving fishing at maximum sustainable yields will also be introduced. However, the TACs set for 2007 (European Council, 2007) have been the subject of severe criticism, particularly for disregarding scientific advice. This has been the case, for example, for deep-sea fisheries such as orange roughy (WWF, 2006c). Other examples include North Sea cod, where for the last seven years EU Fisheries Ministers have ignored ICES advice to close the fishery and, instead, continue to issue TACs. Similarly, because of EU pressure, the overall ICCAT TAC for bluefin tuna has been set at 29 500 ([15]) tonnes in 2007, compared to the recent ICCAT recommendation for 15 000 tonnes (NOAA, 2006). ICCAT scientists believe that the stock is heading towards commercial collapse.
- *Promoting fish stock recovery by targeted measures to reduce fishing effort and the closure of certain fisheries*. For example, the anchovy fishery in the Bay of Biscay was closed in 2006 due to a severe risk of collapse (European Commission, 2006f). The 2007 TAC has been kept at zero, although 'experimental fishing' by a maximum of 10 % of the Spanish and French fishing effort has been allowed in the first half of the year. This is to gather information on the state of the stocks until new scientific advice is provided, although catches can be commercialised (European Council, 2007).
- *Limiting and improving fishing fleet capacity and improving fishing methods*. However, the 2002 total EU ban on driftnets has recently been superseded in the Mediterranean Fisheries Regulation. This allows the use of bottom-set gillnets (European Council, 2006), which can indiscriminately catch non-targeted fish and endangered species including turtles (WWF, 2006c) (see also Ecological impacts below).
- *Better data*. The implementation of a revised Data Collection Regulation under the CFP and the GFCM new database for the Mediterranean and Black Seas should facilitate assessing the state of fisheries resources and the fishing industry.

In the western Russian Arctic, there has been a significant decline in fish landings, down to around 60 % in the mid 1990s, in particular of whitefish (UNEP, 2005a). Northeast Arctic cod stocks in the Barents Sea are overexploited (Box 5.2).

The status of Caspian Sea fisheries seems to be uncertain. For example, the Caspian Environment Programme (CEP, 2005) reported rapid growth of the kilka fishery over the last two decades, while the UNEP/GRID-Arendal (2006) reported a 50 % drop in the kilka caught by Iranian fishermen between 1998 and 2001. CEP (2002a) has also reported declines in catches of cyprinids, small pelagics and salmonids, all stocks of which appear to be in a very poor condition, whereas herring and mullet stocks are reported to be in a better state (see Box 5.3 for sturgeon).

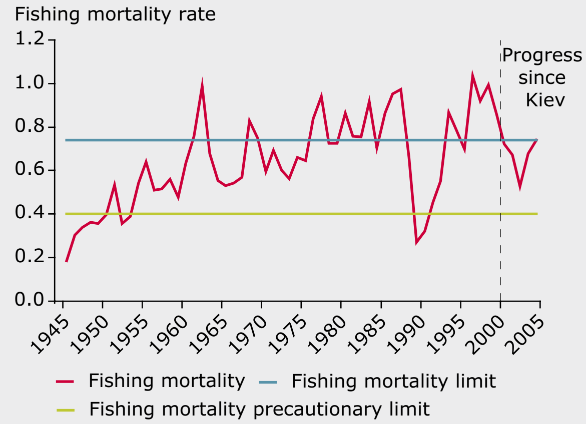
([14]) See examples in *Fishing Opportunities for 2007: Policy Statement from the European Commission* (European Commission, 2006e).
([15]) The EU quota is 16 779.55 tonnes in 2007 (European Commission, 2007e).

Box 5.2 Overfishing in the Barents Sea

As a result of an upwelling of nutrients, associated with the polar front, and the shallow waters, the Barents Sea supports some of the world's largest fish stocks (WWF, 2004), including the Northeast Arctic cod fishery — the largest remaining cod stock in the world. However, the highly variable nature of physical and chemical factors combined with intense overexploitation has resulted in considerable fluctuation in the mortality of this cod species over the last 50 years (Matishov *et al.,* 2004) (Figure 5.4).

Although the Northeast Arctic cod stock is classified as overexploited, the catch is much greater than intended under the management plan set by the Joint Russian-Norwegian Fisheries Commission (ICES, 2006b). Illegal fishing of cod is a serious problem, increasing official catches by around 35 % (ICES, 2006b). Furthermore, discards are estimated at 5–13 % of the total catch of all fish (UNEP, 2004b).

Figure 5.4 Fishing mortality of Northeast Arctic cod stocks



Note: Fishing mortality (a measure of the proportion of fish taken from a stock each year by fishing activity) rate is for ages 5–10.

Source: ICES, 2006b.

Box 5.3 Overfishing of Caspian Sea sturgeon

The Caspian Sea supports 85 % of the world's sturgeon and is the main producer of wild caviar (83 % in 2003) (UNEP/GRID-Arendal, 2006). However, there has been a 40-fold reduction in catches between 1977 and 2005, when production fell to less than 800 tonnes (FAO, 2007a) (Figure 5.5).

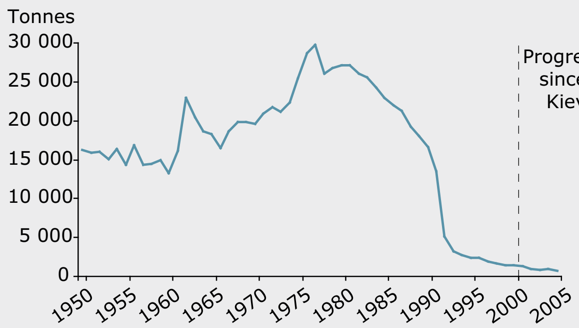
Hydroelectric development is one of the main factors behind this drastic decline. For example the damming of the Volga river destroyed approximately 90 % of sturgeon spawning grounds. Sturgeon populations also suffer from a disease that destroys muscle fibres (periodic myopathy), which is thought to be linked to heavy metal and oil pollution.

Illegal fishing has had a major impact as well, with an estimated 5–12 illegally captured sturgeon sold for each legally captured specimen. The EU is the biggest market for the ensuing illegal caviar (European Commission, 2006g; European Commission and CITES ([16]), 2006).

Since 1998, international trade in all species of sturgeons has been regulated under CITES to control the global illicit trade and, in particular, declining sturgeon populations in the Caspian Sea. All sturgeons and parts or derivatives thereof (caviar, meat, skin, etc.) that enter international trade require the issuance of CITES permits or certificates. A number of other conservation management initiatives have also been developed and improved under CITES, including fishery management programmes, improving legislation, promoting regional agreements, and development of marking systems and aquaculture.

In May 2006, the European Commission adopted new rules to implement the universal labelling system for caviar introduced under CITES. The new regulation updates an existing regulation of 2001 in that it requires that all caviar containers, no matter their size and whether the caviar is imported, re-packaged or to be exported, bear a label specifying the source of the caviar and the year of harvest. Moreover, all re-packaging plants for caviar in the EU have to be licensed and registered (European Commission, 2006m).

Figure 5.5 Total sturgeon catch in the Caspian Sea



Source: FAO, 2007a.

([16]) Convention on International Trade in Endangered Species of Wild Fauna and Flora in force since 1975. It aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival.

Ecological impacts

Fisheries can have a severe impact on the ecosystem as a result of both direct and indirect pressure.

Direct pressures include:

- removal of target species leading to changes in the size and age structure of their populations and others (decline in trophic level);
- mortality of non-target species (by-catch and discard), including other fish, seabirds, marine mammals, turtles and benthic marine life; and
- structural alterations to the seabed habitat, including damage to sea-mounts and cold-water corals.

Indirect pressures include:

- changes in the food web;
- pollution from dumping discards and organic detritus (e.g. offal); and
- mortality caused by lost gear (ghost fishing).

Examples of the ecological impacts of fisheries in the pan-European region are:

- *Decline in trophic level.* Evidence suggests that overall changes within fisheries of both the abundance of large individuals, together with concomitant increases in small individuals, and the composition of predominant species, are linked to the overall level of exploitation. Research has shown a steady drop in the average trophic level of landed fish in several European seas (EEA, 2005a; SAUP, 2006). Top predators such as swordfish, tuna and mackerel have practically disappeared from Black Sea nets, while in the northern Atlantic, the biomass of these top predators has decreased by two-thirds in the last 50 years. Catches tend to consist of smaller, plankton-eating species such as anchovy in the Black Sea and sprat in the Baltic Sea, and equivalent small species in the Mediterranean and North-East Atlantic Seas (Caddy and Garibaldi, 2000). Such changes can weaken the ecological web by, for example, freeing 'space' for invasions of alien species (see status of Black Sea fisheries above and Section 5.3.5, Invasive alien species)
- *By-catch and discard of fish.* Incidental captures and discarding of non-target fish species is a major problem. In the North Sea, overall discards are estimated to be around 22 % of the total fish catch by weight, but this is below estimates for other north-eastern Atlantic waters, where it reaches at least 30 % by weight. Discard is lower in the Mediterranean and Black Seas (4.9 %) and the Baltic Sea (1.4 %) (FAO, 2005). Some species are particularly vulnerable: in the North-East Atlantic, 75 % of hammerhead sharks, 65 % of blue sharks, and 75 % of thresher and white sharks have been lost in the last 18 years, largely as victims of by-catch (Baum *et al.*, 2003).
- *Mammal by-catch*. Lack of adequate monitoring means that data on populations of cetacean and reporting of by-catch are rather uncertain. The situation seems to have been better studied in the North-East Atlantic and Baltic Seas, where small cetaceans, such as dolphins and the harbour porpoise, are the most affected by pelagic trawls, bottom-sea gillnets and driftnets. Annually, around 2 200 and 8 000 harbour porpoises are caught in the Celtic and North Seas, respectively (see review in Greenpeace, 2004). Given the high uncertainties in estimating 'sustainable' cetacean by-catch, several international organisations have set up precautionary limits — for example, 1 % of estimated abundance for harbour porpoise according to the International Whaling Commission. On top of reducing overall fishing pressure, there are technical measures to reduce by-catch, for example acoustically alerting the animals to the presence of the fishing gear and exclusion grids to liberate them if trapped (see review in Greenpeace, 2004).
- *Turtle by-catch*. Over 50 000 turtles in the Mediterranean Sea had been taken each year by surface longlines and driftnets as well as bottom trawls and gillnets; and mortality rates ranged from 10–50 % amongst these already endangered species (Lee and Poland, 1998). More updated surveys are not readily available.
- *Destruction of bottom habitats*. Seabed surveys of several European seas have revealed massive impacts from mainly bottom trawling in high intensity fishing areas, which reduces biomass, production and species richness (Auster and Langton, 1999; Hiddink *et al.*, 2006) keeping the ecosystem in a low-diversity, juvenile state (ICES, 2002). The situation of the North Sea

appears to be one of the best documented, but the impacts and how to mitigate them are likely to be common to all seas. For the North Sea, modelled data shows that the bottom-trawl fleet reduced benthic biomass and production by 56 % and 21 % respectively, compared with an unfished situation (Hiddink *et al.*, 2006). This is because trawling gear destroys biogenic structures that provide a habitat for many organisms, for example mussel beds, cold-water corals and *Sabellaria* (worm) reefs, and seagrass beds. Changes in habitat structure are then followed by changes in species assemblages (OSPAR, 2000). The EU has acknowledged that recovery from damage to highly sensitive deepwater habitats in the Atlantic, in particular coral reefs, produced by fishing gear is either impossible or very difficult and slow. Therefore, the EU considers it appropriate to prohibit the use of fishing gear likely to cause damage to habitats in areas where these are still in a favourable conservation status (European Council, 2005).

Some measures to reduce the ecological impacts of fisheries exist as a result of:

- global agreements such as the UNCLOS 1995 Agreement on Fish Stocks for by-catch;
- EU policies: several CFP regulations and the Habitats Directive are directly relevant in the case of by-catch and impacts from bottom trawling. Specific measures to reduce unwanted catches and eliminate discards, by establishing a progressive fishery-by-fishery discard ban and setting standards for maximum acceptable by-catch, are now also being considered in the context of the CFP (European Commission, 2007f);
- most European regional sea conventions, for example OSPAR as well as the ASCOBANS ([17]) and the ACCOBAMS ([18]) agreements regarding mammal by-catch for the Baltic and North Seas and for the Black and Mediterranean Seas and contiguous Atlantic area, respectively.

Nonetheless, these have not been very effective because the problems are not well understood due, *inter alia*, to a lack of monitoring, so science and management lag behind the industrial, extractive activity (Sheppard, 2006), or because they are insufficient, or not adequately implemented (Greenpeace, 2004; European Commission, 2006h). Improving and/or fully implementing these measures will be key if the CBD target of halting marine biodiversity loss by 2010 is to be met. Regarding the destruction of bottom habitats, it is significant that the UN General Assembly failed to adopt a global moratorium on bottom trawling in the high seas in December 2006.

A note on aquaculture

Aquaculture is a growing alternative to wild fish for human consumption, which in 2005 was estimated to provide 45 % of the world's fish and fish products against 9 % in 1980 (FAO, 2007b). Indeed, between 1990 and 2005, the pan-European ([19]) production increased by 38 % reaching 2.2 million tonnes (Mt): 1.3 Mt from EU-25, 0.7 Mt from EFTA, 0.2 Mt from EECCA and 0.2 Mt from SEE, of which around 72 % was marine aquaculture (mariculture) (FAO, 2007c).

While this might be seen to be beneficial for the marine environment, in reality it brings with it a wide range of new impacts, for example:

- eutrophication and localised enrichment of sediments. The inputs of nutrients from mariculture are becoming significant in certain seas and areas of production. In Norway, for example, the nutrient loading from fish farming contributes to over 60 % of the total phosphorus loading and around 20 % of the total nitrogen loading to the sea (OSPAR, 2006a);
- use of wild fish to feed farmed fish and of wild-caught fish for fry and rearing in fish farms, contributing to overfishing (Box 5.4);
- use of antibiotics and chemicals (disinfectants, pesticides, biocides and anti-foulants);
- potential transfer of parasites and diseases to wild fish populations — for example, there is

([17]) Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (in force since 1994) under the Bonn Convention on Migratory Species of Wild Animals.
([18]) Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (in force since 2001) under the Bonn Convention on Migratory Species of Wild Animals.
([19]) Because of the country groupings used, the Faroe Islands have not been included in this assessment, but their contribution was not very significant.

emerging scientific evidence that fish farms are responsible for the deaths of up to 95 % of young wild salmon migrating out to sea (US National Academy of Sciences, 2006);
- accidental introduction of non-indigenous species — for example associated with the deliberate introduction of shellfish (see Section 5.3.5, Invasive alien species). The EU is trying to reduce impacts of non-native species in aquaculture such as the Pacific oyster (European Commission, 2006i);
- genetic impoverishment of wild-fish stocks due to breeding with fish that have escaped from farms;
- competition for space, interaction and conflict with predators.

Special attention should thus be placed on policies regulating the wider environmental impacts of aquaculture in all pan-European seas, in particular the paradox that fishing for food becomes fishing for feed.

Box 5.4 How aquaculture can contribute to overfishing

Most of the fish feed used in aquaculture is made of wild-caught fish in the form of fish oil and fishmeal. It normally takes around 4 kg of wild fish to grow 1 kg of farmed salmon. In this way, instead of relieving pressure on the marine environment, fish farming is actually contributing to the overfishing of the world's fisheries. Thus, the aquaculture industry consumed 70 % of the global production of fish oil and 46 % of total fishmeal in 2002. If fish farming continues to grow at the current rate, then by 2010 the aquaculture industry could well be using all of the world's fish oil and half of its fishmeal, when the sustainability of wild fish stocks is already far from certain. In fact many are already fished at or over their safe biological limits. The trophic level of the species used for fishmeal is also rising, implying that fish species previously used for human consumption are being diverted to fishmeal.

Sources: FAO, 2006; Malherbe, 2005; SAUP, 2006; WWF, 2003.

5.3.3 Pollution from hazardous substances

Data on concentrations and impacts of hazardous substances on the marine environment are scarce and fragmented. However, there is clear evidence that exposure to these substances can cause significant negative immunological, hormonal and reproductive effects in marine organisms, particularly top predators. Human health can also be affected by the consumption of contaminated marine food.

Policies have been developed at the global, regional and national levels to both reduce emissions and regulate the marketing and use of hazardous substances, including plant protection products. Global mechanisms include the UN Stockholm Convention on Persistent Organic Pollutants ([20]) (POPs), in force since 2004, and the IMO Convention on the control of harmful anti-fouling systems, adopted in 2001, but yet to come into force. Where policies have entered into force and are being implemented, improvements can be seen, especially in north-western Europe. However, due to the persistence of many substances already dispersed in the environment or used in technical products, the legacy from earlier emissions will remain for decades (Box 5.5).

New chemicals are continually being introduced, some as alternatives to phased-out substances. Over time, some of them have already been proven to have negative impacts (Box 5.5), and this could also be the case for others. In the EU, the new regulatory system for chemicals, REACH, will provide the future legal framework for limiting the use of industrial problem chemicals. A strategy for the sustainable use of pesticides has also been proposed recently in the EU (European Commission, 2006j).

Hazardous substances

Hazardous substances of particular concern for the marine environment include metals, e.g., cadmium, lead, mercury, zinc and copper; and POPs. POPs can be:

([20]) The Stockholm Convention seeks to eliminate or restrict production and use of all intentionally produced POPs as well as to minimise and, where feasible, eliminate releases of unintentionally produced POPs such as dioxins and furans.

- pesticides (for example, lindane/HCH, hexachlorobenzene/HCB and DDT);
- biocides (for example, tributyltin/TBT);
- industrial chemicals (for example, polychlorinated biphenyls/PCBs); and
- other chemicals that originate from activities such as combustion and transport (for example, dioxins and polycyclic aromatic hydrocarbons/ PAHs).

POPs are stable in the environment and accumulate in the food chain. Their toxic effects include the ability to disrupt the normal functioning of the hormonal systems of animal species, even at very low doses ('endocrine-disrupting substances' or 'hormone mimics') (Box 5.5). Many POPs are transported over long distances in the air and in water and consequently circulate globally, so they can be found almost anywhere (see Arctic case study in Section 2.5, Hazardous chemicals).

Inputs and sources of hazardous substances
Main sources of hazardous substances to the marine environment are:

- industry, including industrial processes and manufactured products, such as furniture containing fire retardants;
- mining (both extraction and processing of minerals);
- agriculture, because of the use of pesticides and insecticides;
- land transport, including vehicle emissions; and
- shipping via, for example, oil discharges (see Section 5.3.4, Oil pollution) and the use of anti-foulants (Box 5.5).

Hazardous substances can be transported by air, in rivers and in ice before reaching the sea. Once there, they can be taken up by marine organisms as they move with currents and eventually sink from the water column into the sediments. In particular:

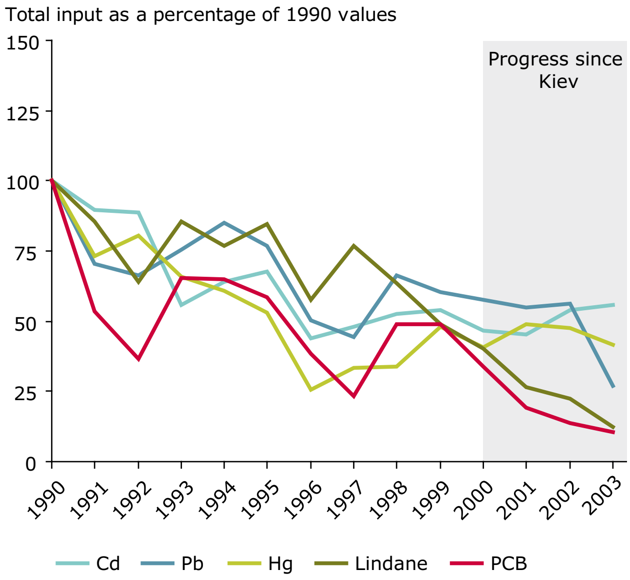
- since most of the Mediterranean coastal area hosts chemical, oil, and mining industries, waste from these activities is a key source of hazardous substances. Marine shipping processes and accidents as well as oil terminals are considered the main sources of PAHs in the area. Untreated wastewater discharges together with large stores of obsolete chemicals, including PCBs and pesticides, are also significant (EEA, 2006a);
- in the Black, Azov and Caspian Seas, direct wastewater discharges from industries, many of which use outdated and highly polluting technologies, and from coastal municipalities with inadequate or no treatment, are major sources of hazardous substances (UNEP, 2005b; UNEP/GRID, 2002; see also Section 2.3, Inland waters). For example, in the Azov Sea, discharges from intensive coal and metal production and manufacturing as well as agricultural activities in the surrounding catchment have resulted in considerable pollution (UNEP/GRID, 2002). Pesticides, considered to be the most harmful pollutants in the Caspian Sea, are largely associated with the agricultural areas of river deltas and those along the coast of Iran. Although the use of DDT was prohibited as early as 1970, local authorities in the region fail to control both its market supply and use (for other sources of pollution in the Caspian Sea, see Section 2.5, Hazardous chemicals);
- there are few local sources of contaminants in the Arctic, with some notable exceptions such as the big mining and mineral processing complexes in the Kola Peninsula. Most of the contamination of this remote region, therefore, comes from industrialised areas further south. Ocean currents are one of the transport pathways for hazardous substances from Europe into the Barents and Russian Arctic Seas (AMAP, 1998; AMAP, 2002). Large rivers, such as the Ob, Pechora, Yenisey and Lena are also significant, as they transport a high percentage of the Russian territory's total pollutant burden to the Arctic (UNEP, 2005a).

In EU-15 and EFTA, policies to control pollution have resulted in marked reductions in inputs of prioritised hazardous substances to some sea areas. The countries collaborating in HELCOM, OSPAR and also at the Ministerial level (for example, the North Sea Conference) are at the forefront. Positive results include:

- reported discharges of cadmium, lead, mercury, lindane and PCB have decreased from the countries bordering the North-East Atlantic from 1990 to 2003 (OSPAR, 2005a) (Figure 5.6);

- loads to the Baltic Sea of some hazardous substances have also been reduced considerably over the past 20–30 years. The 50 % reduction target of 46 hazardous substances included in the 1988 Ministerial Declaration has been largely reached. However, problems still persist with POPs, such as PCBs, DDTs, dioxins, organotin compounds, and brominated flame retardants. Between 1994 and 2004, riverine heavy metal loads, notably of cadmium and lead, seem to have decreased for most of the Baltic Sea Contracting Parties (HELCOM, 2005b);
- despite decreasing inputs, concentrations of some of these hazardous substances are still up to 20 times higher in the Baltic Sea than in the North-East Atlantic (see also Baltic case study in Section 2.5, Hazardous chemicals).

Figure 5.6 Direct and riverine inputs of hazardous substances into the North-East Atlantic



Note: It includes the North Sea.
PCB = Sum of polychlorinated biphenyl (PCB) congeners 28, 52, 101, 118, 138, 153 and 180.

Source: Compiled by EEA-ETC/WTR from OSPAR's Riverine and Direct Input Study, 2005a.

Trends in concentrations and impacts of hazardous substances

The main trends in the concentrations of hazardous substances in pan-European seas, based on the limited data available, can be summarised as follows:

- concentrations of heavily-regulated metals in blue mussels have generally been decreasing in many areas of the North-East Atlantic, Baltic and Mediterranean Seas, even near well-known point sources (EEA, 2006b). The decrease in one of these, lead, is mainly due to the phasing-out of lead in petrol in north-western Europe in the 1990s. Thus, atmospheric depositions of lead to the North Sea decreased by up to 65 % between 1987 and 1995 (OSPAR, 2000);
- there is some indication that concentrations of PAHs and some organochlorines found in marine organisms in the Mediterranean, Baltic and North-East Atlantic Seas have also generally decreased (EEA, 2006a; 2006b);
- in the Black Sea, there are indications of high levels of POPs in fish and mammals as well as seawater and sediments in some coastal areas, including DDT, PCBs, HCHs, and HCB (see review in UNEP, 2002; see also Maldonado and Bayona, 2002; Parr *et al.*, 2005);
- in the Caspian Sea, high concentrations of DDT compounds, chlordanes, PCBs, HCHs, as well as zinc, copper, cadmium and lead, have been measured in sturgeons (CEP, 2002a);
- ringed seals and minke whales in the Kara Sea show the highest levels of organochlorines in Arctic cetaceans. High levels of PCBs and DDTs have been found in seabirds, including the glaucous gull, in the Barents Sea. Polar bears from Franz Josef Land and the Kara Sea have the highest PCB and DDT levels in the Arctic (AMAP, 1998; AMAP, 2002). Also, dioxin concentrations in fish still exceed the new EU food safety limits in some areas of the Russian Arctic. Chemical identification of PCB and DDT suggest new sources of these banned substances in the Russian Federation (AMAP, 2004).

There are also some hopeful signals of reduced biological impacts. Eggshell thickness of marine birds is used as an indicator of the effects of hazardous substances in the Baltic Sea, since thin shells can prevent their reproductive success. Thin eggshells observed in the 1960s were attributed especially to DDT contamination. Swedish data from the 1990s show that guillemot eggshell returned to thicknesses observed prior to 1940s. Similar recovery can also be seen in Swedish time series of white-tailed eagle brood size and nesting success (HELCOM, 2006b).

Box 5.5 Anti-fouling substances: substituting one problem with another?

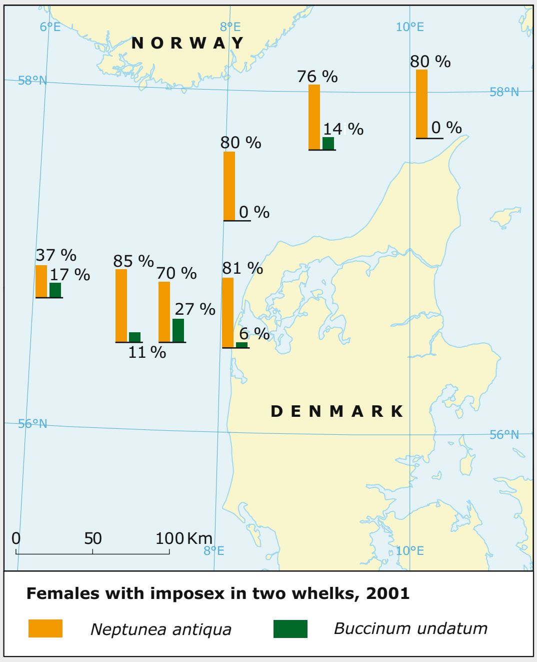
Tributyltin (TBT), an organotin compound widely used as an anti-fouling agent in paint for ships, causes endocrine disruption even at very low levels. It has been linked to widespread imposex (females developing male characteristics, threatening reproduction) in whelk species in the water and sediments of ports and harbours in the North and Baltic Seas (OSPAR, 2000). In the open North Sea, the occurrence of imposex in the common whelk (*Buccinum undatum*) is strongly correlated with shipping traffic intensity (Ten Hallers-Tjabbes *et al.*, 1994).

Under the IMO Convention on the control of harmful anti-fouling systems, organotin coatings will be prohibited on all ships by 1 January 2008. However, ratification is slow ([21]). For example, none of the five Caspian Sea and none of the four Black Sea non-EU riparian countries has ratified it. In accordance with the convention, the EU banned the application of new organotin coats on EU ships in 2003, with the exception of warships. From 1 January 2008, the EU will also outlaw any presence of organotins on ship hulls within its ports.

The total amount of TBT lost per year from anti-fouling coatings from ships in the greater North Sea was estimated to range from 120 to 134 tonnes between 1997 and 2003 (OSPAR, 2006b). Despite efforts to restrict its use, widespread imposex in dog whelks (*Nucella lapillus*) shows that TBT is still above acceptable levels there (OSPAR, 2005b). The number of large dog whelk populations in the Netherlands has actually fallen by two-thirds since 1965 (MNP, 2004a). In inner Danish waters, imposex in another whelk species (*Neptunea antiqua*) has been increasing (Figure 5.7), reaching 99 % in 2003 (OSPAR, 2005b). However, in the North-East Atlantic as a whole, TBT concentrations measured in blue mussels have not changed significantly over the last ten years (OSPAR, 2006c).

'Booster biocides' have been developed to substitute the banned TBT. However, they appear to be particularly toxic to marine plants and corals depending on the compound. An estimated 4–5 tonnes of booster biocides per year entered the greater North Sea from anti-fouling coatings between 1997 and 2002 (OSPAR, 2006b).

Figure 5.7 Percentage of females with imposex in the whelks *Neptunea antiqua* and *Buccinum undatum* in the Danish North Sea (2001)



Source: OSPAR, 2005b.

Diuron and Irgarol 1051 are the booster biocides causing the most widespread contamination in north-western Europe. They are now banned as anti-foulants in the United Kingdom, but they are still used in other European countries (Price and Readman, 2006). The above-mentioned IMO Convention also aims at preventing the potential future use of other harmful substances in anti-fouling systems and should be applied to booster biocides.

Heavy-metal based anti-fouling coatings, mostly copper and zinc, are also a problem for the marine environment and they remain so, even if there has been some success in limiting their impact. Demark has reduced copper emissions from anti-fouling paints by around 7.5 tonnes annually during 2003–2006 through the cooperation of boating/sailing organisations and harbour masters, and by using eco friendly tools and techniques to control emissions.

5.3.4 Oil pollution

Oil pollution can impact marine ecosystems through physical and chemical alterations of natural habitats as well as by smothering and poisoning flora and fauna. The spill of large volumes of oil in a small area can have disastrous consequences, especially in cold environments.

([21]) See latest update at http://www.imo.org/includes/blastDataOnly.asp/data_id%3D17632/status.xls.

Estimates of oil entering the world's oceans tend to fall between 1 and 3 million tonnes per year. Of these, approximately:

- 50 % comes from land-based sources (for example, urban runoff and discharges from industry);
- 24 % comes from marine transport (18 % from operational ship discharges and 6 % from accidental spills);
- 13 % comes from atmospheric sources (from oil handling facilities and vehicle exhaust);
- 10 % comes from natural sources; and
- 3 % comes from offshore extraction (EEA, 2006c; Global Marine Oil Pollution Information Gateway, 2006).

The number of accidental oil spills in most pan-European seas has decreased over the last 15 years. The EU has implemented several measures for ship safety and prevention of accidental oil spills, including speeding up the introduction of double hull tankers, as a result of UNCLOS and IMO agreements. These have also influenced strategies to combat oil pollution from regional sea conventions.

Although there have been important reductions in the Baltic Sea over the last ten years, operational oil discharges, mainly along major shipping lanes, continue to pose a serious problem across pan-European seas. Emissions from oil exploration, production, land transport and refining are in general smaller, but they can be significant in some areas. The north-eastern Atlantic is one of those affected, though important progress has been made there in reducing many of the impacts. Nonetheless, hot spots remain throughout the region, especially in EECCA countries where generally there is little government control of oil pollution and the legal consequences of exceeding pollution limits are rarely significant (UNEP, 2004b; 2005a; 2006). In contrast, there is a great risk of future oil pollution in the EECCA seas as a result of the expected increases in oil production and transport (Box 5.6). This is particularly worrisome in the Arctic as it will pose a major threat to this particularly vulnerable environment.

There is also a continuing need to tackle the problem of chronic oil pollution from land-based sources, through limiting direct discharges and improving the treatment of wastewaters and storm waters, in particular in the EECCA region. In the EU, this would require, *inter alia*, improved implementation of the UWWT and IPPC Directives.

Accidental oil spills

Oil spills can have catastrophic effects on coastal and marine ecosystems, which can then take several years, even decades, to recover. The effects of accidental oil spills on seabirds and marine mammals are particularly well known. Spills can also have socio-economic impacts by causing the closure of fisheries, limiting tourism, and reducing clean water supplies for industry as well as affecting human health.

There are few studies on the long-term ecosystem effects of oil spills, although these are known to continue for longer in cold ocean environments than in warmer ones. One of the few studies is on the 1989 Exxon Valdez spill in Alaska, and shows the unexpected persistence of toxic sub-surface oil and that chronic exposure, even at sub-lethal levels, had continued to affect wildlife ten years after the event (Peterson *et al.*, 2003). In the summer 2006 armed conflict in Lebanon, a major oil spill (10 000–15 000 tonnes) from a damaged power station affected 150 km of Mediterranean coastline reaching as far as Syria. Parties to the Barcelona Convention, in the context of its Emergencies Protocol and REMPEC ([22]), took prompt action to monitor the extent of the spill and to coordinate clean-up efforts. However, full effects are still to be studied and understood.

The total amount of crude oil transported by tankers through EU waters is at least 1 billion tonnes per year, approximately 60 % of the global total (Oceana 2003; UNEP/GRID-Europe, 2006). Despite an increase in tanker transport, the number of accidental oil spills in the North-East Atlantic, Baltic, Mediterranean and Black Seas has decreased over the period 1990–2005 (Figure 5.8). To date, there have been no severe accidental oil spills in the Caspian Sea, and figures describing the size and the

([22]) Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea.

extent of the impacts of lesser spills are not available (UNEP/GRID-Arendal, 2002).

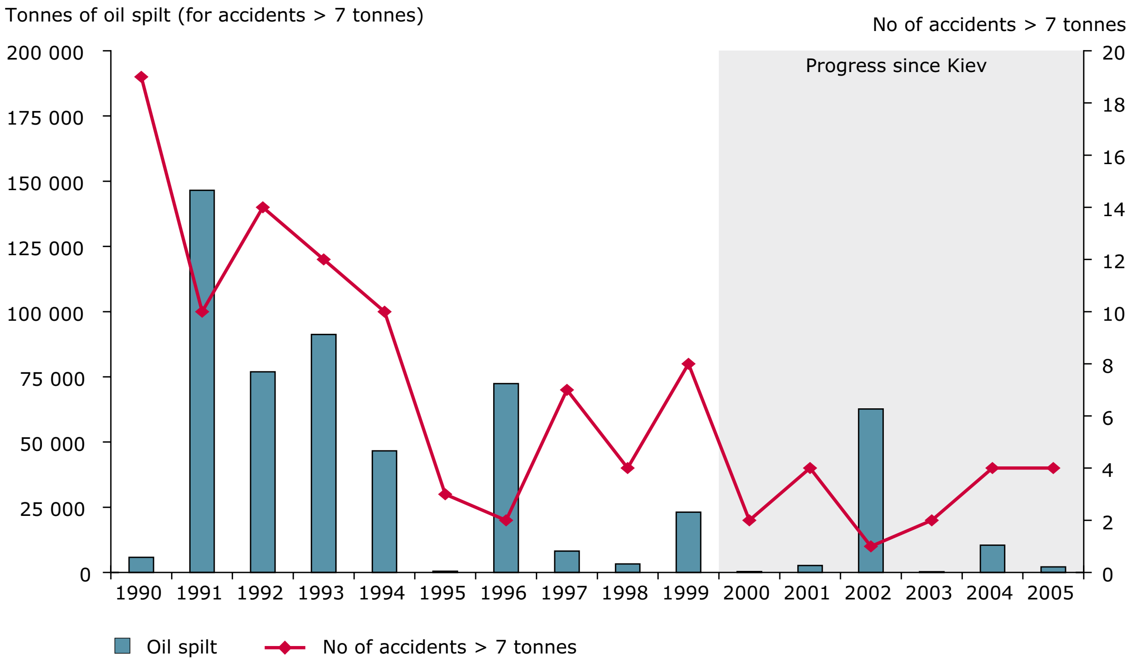
Nevertheless, major spills still occur across the pan-European region even in EU waters (EEA, 2006d), such as the Erika in 1999 (20 000 tonnes) and the Prestige in 2002 (64 000 tonnes). Experience from these shows the difficulties in containing and collecting the spilled oil from the sea and coastal areas, emphasizing that measures to prevent oil spills should always be the top priority in combating oil pollution. The EU is learning these lessons: in 2003 single-hull oil tankers carrying heavy-grade oil were banned from EU ports, while a ban on all single-hull oil tankers flying a flag of an EU Member State has now been proposed (European Commission, 2006k). Efforts are also being made to limit the routing of ships through areas of high environmental sensitivity: for example, the Baltic and Wadden Seas have been designated as 'particularly sensitive sea areas' by the IMO. This requires ships to take special care and allows the IMO to choose the best protective measures. Similarly, 32 Marine Environmental High Risk Areas have recently been identified around the United Kingdom's coast, of which crews are expected to keep clear or exercise extreme care when navigating them (DFT/DEFRA, 2006).

Policies and legislation that set out responsibility for oil pollution and provide effective measures to prevent and respond to oil spills are notably lacking within the EECCA region (UNEP, 2004b; 2005a; 2006). And although regional and bilateral oil spill preparedness agreements and some national contingency plans exist for the Black, Russian Arctic and Barents Seas (ITOPF, 2006b), UNEP believes that these plans are unlikely to be effective in the event of a large oil spill (UNEP, 2004b; 2005a; 2006).

Operational oil discharges from ships

Operational oil discharges occur during ship deballasting, tank washing and from the normal workings of engine rooms. The North, Baltic,

Figure 5.8 Accidental oil tanker spills in European seas



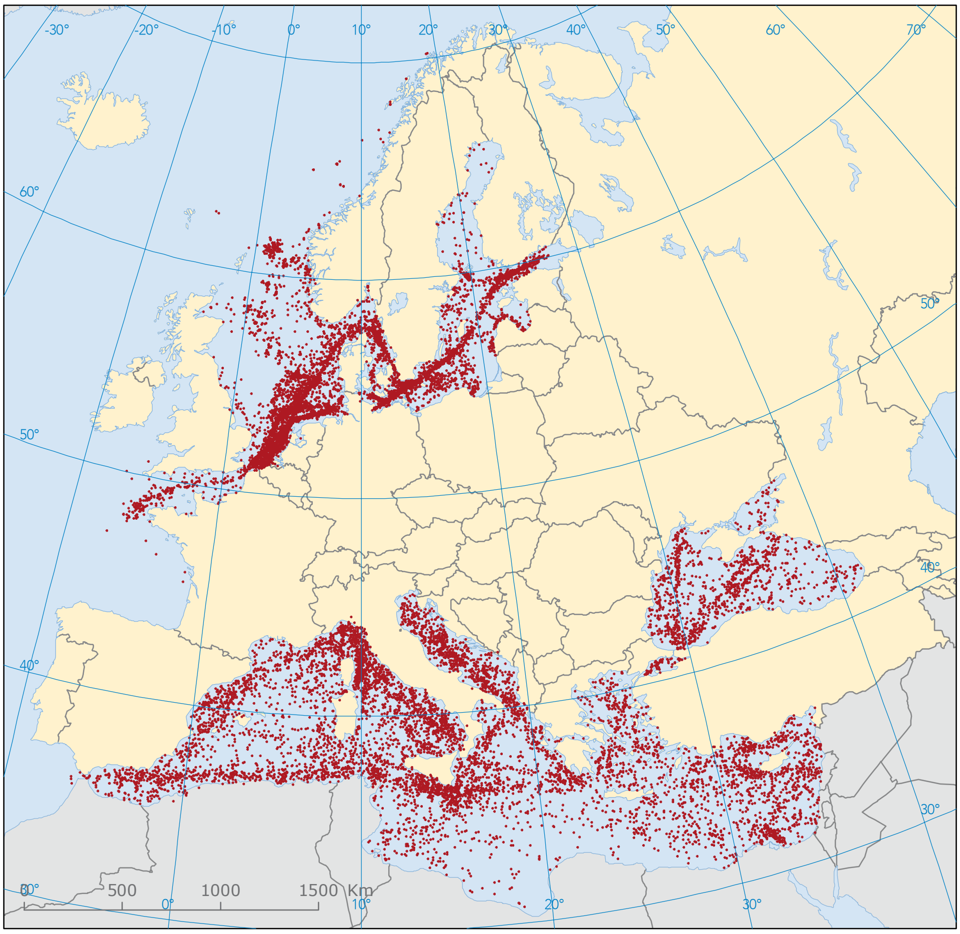
Note: 'European seas' as used here covers the North-East Atlantic, Baltic, Mediterranean and Black Seas. Spills shown are over 7 tonnes. Oil spilt in an incident means all oil lost to the environment, including that which is burnt or remains in a sunken vessel. Despite the fact that the vast majority of spills are less than 7 tonnes, data on numbers and volumes for small spills are unreliable and such accidents are regarded to have a relatively small contribution to the overall quantity of oil spilled into the marine environment as a result of tanker accidents.

Source: International Tanker Owners Pollution Federation Ltd (ITOPF), 2006a.

Mediterranean and Black Seas have the status of 'special areas' under the IMO MARPOL73/78 ([23]), which prohibits almost all operational oil discharges. However, surveillance of these seas shows large numbers of illegal operational oil discharges, mostly within shipping corridors (DG JRC/IPSC, 2000–2004) (Map 5.4). Unfortunately, the rest of the seas in the pan-European region are not covered by similar extensive monitoring schemes.

The number of illegal operational oil discharges in the Baltic Sea has been regularly observed since 1988 and has reduced by 50 % since 1999. At that time, there were 488 discharges compared to 224 in 2005 and, a slight increase, to 236 in 2006. This is despite rapid increases in shipping density in the last decade (HELCOM, 2006c; 2007), and has been attributed to the adoption of a Baltic Strategy and the MARPOL 'special area' designation. Any discharge of oil, or diluted mixtures containing oil in any form, or refined products, is prohibited. Measures such as providing waste reception facilities in ports and removing fees for waste delivery have also been implemented (HELCOM, 2006d).

Map 5.4 Illegal operational oil discharges in designated European MARPOL 73/78 special sea areas (2000–2004)



Note: This map covers the North, Baltic, Mediterranean and Black Seas only. In the North and Baltic Seas, illegal operational oil discharges were detected by aerial surveillance. In the Mediterranean and Black Seas, these have been detected by radar satellite images (i.e. 'probable' spills), but not been cross-validated by aerial surveillance. Further, the varying extent of surveillance in different seas may lead to over or under representing the degree of pollution.

Sources: European Commission, DG JRC, Institute for the Protection and Security of the Citizen (IPSC), 2005.

([23]) Convention for the prevention of pollution from ships in force since 1983. It aims at minimizing marine pollution, including dumping, oil and ship exhaust. It designates 'special areas' where oil discharges from ships are prohibited, with minor and well defined exceptions.

No change in illegal operational oil discharges has been observed in the North Sea over the past 15 years and long-term monitoring data is not available to establish a trend for the Mediterranean and Black Seas.

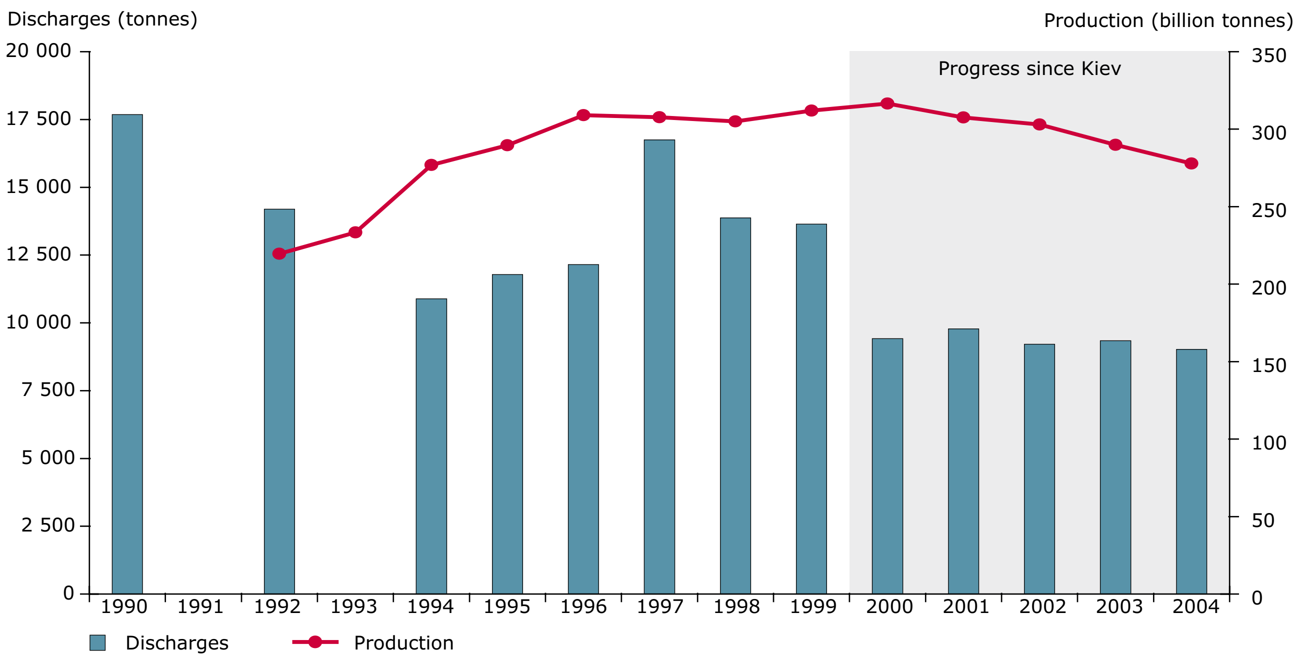
Shipping traffic in pan-European seas is likely to increase rapidly in the next decade. In order to offset up to 95 % increases in inland freight predicted to occur in the EU by 2020, the European Commission is currently promoting the trans-European 'motorways of the sea', short-haul shipping lanes, linking the Baltic, Barents, Atlantic, Mediterranean, Black and Caspian Seas through defined shipping corridors (European Commission, 2006l). Though the increase in shipping intensity in these corridors will increase the efficiency of freight transport, it is also likely to greatly increase pressure on the marine and coastal environment, in particular from operational oil discharges.

The Northern Sea Route (NSR) can potentially almost halve the shipping distance between Europe and northeast Asia. Only parts of the route are used now in the summer and very few ships navigate through the whole distance (UNEP, 2005a). With Arctic summer sea ice predicted to melt possibly as early as by the middle of this century (see Section 5.3.7, Climate change and seas), this will gradually increase the navigation season for the NSR, and shipping could reach several million tonnes by 2020 (UNEP, 2005a). However, both direct routes across the North Pole and the North-West Passage may also become navigable alternatives. If large increases in shipping traffic do occur in the Arctic seas, the risk of major oil spills and other shipping pollution will increase significantly, with impacts on the sensitive Arctic marine environment likely to be considerable and long-lasting.

Pollution from the oil industry

Offshore oil installations, the majority of which are located in enclosed and shallow sea areas, can have a significant impact on these more sensitive areas. Considerable progress has been made in reducing their impacts particularly in the North-East Atlantic, where between 1992 and 2004, despite increasing production, oil discharges from offshore installations have decreased by 35 % (OSPAR, 2000) (Figure 5.9).

Figure 5.9 Oil production and discharges from offshore installations in the North-East Atlantic



Note: Data available from Denmark, Germany, Ireland, the Netherlands, the United Kingdom and Norway only; hence the assessment is restricted to the North-East Atlantic. Data not available for discharges in 1991 and 1993 nor for production in 1990 and 1991.

Sources: OSPAR, 2006d; Eurostat, 2006.

Box 5.6 Potential for future oil pollution in EECCA seas

Rapidly increasing world demand for oil, and a desire to move away from dependence on politically sensitive Middle East supplies, has increased attention on oil reserves in the Russian Arctic and Caspian Sea areas (IEA, 2005).

Caspian region production and export routes

Oil production in Kazakhstan and Azerbaijan is predicted to increase more than three-fold between 2002 and 2010 (IPIECA, 2005), by which time approximately 160 million tonnes of crude oil will be transported each year via either pipelines or shipping, across the Black Sea and through the Bosporus (CERA 2003 cited in IPIECA, 2005). For example:

- current Black Sea oil tanker transport is expected to increase by 52 million tonnes by 2010 (CERA, 2003 cited in UNEP/GRID-Europe, 2006);
- 50 million tonnes of Caspian oil a year will be carried through the Baku-Tbilisi-Ceyhan pipeline, which began operation in 2005, directly linking the Caspian and the Mediterranean Seas (Map 5.5).

Russian export routes

The Russian Federation's oil production is predicted to grow between 15 % and 30 % in the period 2002–2020 (IEA, 2004). Much of this will come from the development of new fields in western and eastern Siberia, with additional offshore production expected from the Barents and Pechora Seas (Bambulyak and Frantzen, 2005).

The export routes for Russian oil and gas are highly dependent on the future oil markets and the development of infrastructure, both pipelines and ports. Nonetheless, traffic along all three westward shipping routes, the Barents Sea, the Baltic Sea, and the Black–Mediterranean sea route, is expected to grow.

The Russian Federation exported 12 million tonnes of oil from the Barents Sea region in 2004, but this is likely to rise to 50 million tonnes per year in the next decade, even without a trunk oil pipeline from the western Siberian oil fields to Murmansk. This could mean that ships of up to 250 000 tonnes deadweight destined for Europe and North America will pass through the harsh conditions in the Barents Sea on a regular basis (Bambulyak and Frantzen, 2005). Oil transport in the Baltic Sea is also expected to increase significantly as a result of the construction of the Baltic Pipeline System carrying oil from north-western Russia to the port of Primorsk. Oil is also exported from Poland and other Baltic states (Bambulyak and Frantzen, 2005).

Additionally, Russia has several oil terminals along the Black Sea including its largest, Novorossiysk, with a capacity of approximately 100 million tonnes a year.

Map 5.5 Selected oil and gas installations and projects in the Caspian Sea

Selected oil and gas installation in the Caspian Sea

- Oil and gas field
- Prospective field
- Existing oil pipeline
- Existing gas pipeline
- Planned, proposed, or under construction oil pipeline
- Planned, proposed, or under construction gas pipeline
- Refinery

Source: Redrawn after DI Cartography Center, US Government, 2006.

Tankers from these terminals are part of the heavy traffic through the Bosporus and Dardanelles, which several pipeline initiatives are seeking to relieve. However, some of these would still end up in the Mediterranean Sea, such as the Burgas-Alexandroupoli pipeline linking the Bulgarian Black Sea and the Greek Aegean, and would increase tanker traffic and, therefore, risks there.

Increased risks

The projected rapid rise in oil production and transport brings with it concomitant risks of serious environmental damage in EECCA and other seas both from accidental oil spills and operational oil discharges along the sea routes followed by tankers. For example, it is estimated that concentrations of petroleum hydrocarbons in the northern Caspian Sea from operational discharges could at least double by 2020, reaching 200 µg/l (Berkeliev, undated). The potential for large oil spills will also rise as a result of increased oil tanker traffic, and the installation of deep-water pipelines, such as that planned between Aktau and Baku (Berkeliev, undated; see also Section 7.3, Energy).

Over a similar period, oil discharges from North-East Atlantic refineries have also decreased by 77 % (OSPAR, 2000). Offshore activities and refineries are less of an issue in the Baltic and Mediterranean Seas (ESPON, 2006), whereas systematic information for other seas is not readily available.

Pollution from oil industry hot spots, such as those near leaking capped oil wells or areas where water level rises have encroached on well-oiled soils, is regarded as one of the most immediate threats to the Caspian Sea and its biodiversity. Additionally, obsolete and poorly maintained oil production and transport infrastructure in areas such as Baku Bay, Cheleken, Makhachkala and Atarya have already led to high concentrations of petroleum hydrocarbons in the water and sediments (CEP, 2002a; UNEP/GRID-Arendal, 2002). This contamination has been linked to general ecosystem degradation, the disappearance of fish stocks including zander and herring, and periodic mass waterfowl deaths (CEP, 2000). However, away from such hot spots, most Caspian Sea waters have internationally acceptable levels of hydrocarbons, with the oil industry estimated to contribute just 8 000 tonnes/year or 5 % of the total oil in the Caspian Sea (CEP, 2002a; UNEP/GRID-Arendal, 2002). Nevertheless, illegal oil discharges have increased in recent years and, in some cases, their sources, which are not always easy to establish, have been traced to industrial activities (CEP, 2002a; UNEP/GRID-Arendal, 2002).

Practically all oil pollution in the Arctic seas, particularly the Kara Sea, is run-off from areas of inland oil production especially in western Siberia, carried to the sea by the Ob and Yenisei rivers (UNEP, 2005a).

5.3.5 Invasive alien species

Invasive alien species are non-native species that become established in a new environment, and then proliferate and spread in ways that damage native biodiversity and human interests, including economic ones. They can affect marine ecosystems through predation, competition, mixing of exotic genes, habitat modification and the introduction of pathogens.

Alien species are now considered to be the second leading cause of biodiversity loss after habitat alteration (UNEP/CBD, 2006) and are found in most pan-European seas. Significantly, they often become established more easily in ecosystems that are already degraded by other pressures such as overfishing and pollution. This was the case of the Black Sea, which is now recovering from ecological collapse due, *inter alia*, to an alien species invasion.

Modes, rate of introduction and responses
More than 1 000 alien marine and estuarine species have been introduced to several seas in the pan-European region, the majority in the last century (Gollasch, 2006). The Mediterranean Sea has suffered most, with approximately 740 introduced species mainly associated with the opening of the Suez Canal. But the Black, North, Celtic-Biscay Shelf, Baltic, Caspian, Iberian Coastal and Norwegian Seas are also all affected (Figure 5.10) by invasive aliens from all over the world — with the east coast of North America contributing approximately a third of all known introductions.

Taken on board at a ship's origin, ballast water ([24]) can harbour large numbers of organisms, which are then released at the ship's destination. Shipping transfers approximately 3–5 billion tonnes of ballast water internationally each year (Globallast, 2006), making it the most prominent vector for alien introductions, with ship hull fouling and aquaculture as additional significant sources. The spread of invasive alien species to the enclosed seas in the pan-European region is then facilitated by inland shipping canals linking the Mediterranean, Black, Baltic and Caspian Seas (Map 5.7).

The overall rate of invasive alien species introductions peaked in the 1980s and 1990s but continues at a steady rate today (Figure 5.10). For

([24]) Water taken up or released by a ship to stabilise it or to raise/lower it in the water column.

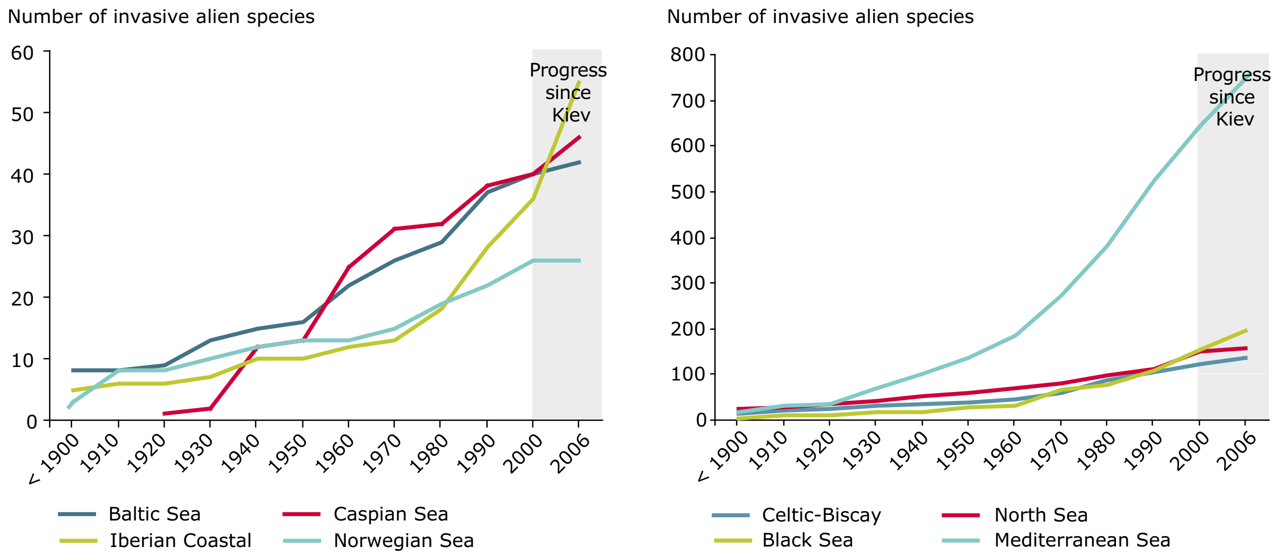
example, since the year 2000, 105 new species have been reported in the Mediterranean Sea, 10 of them in 2006 alone (Zenetos *et al.*, 2006).

The high number of new introductions makes record keeping difficult, and highlights the need for continuous research on the issue.

The Bern Convention ([25]) has developed a European Strategy on Invasive Alien Species, which offers specific advice to countries and international organisations on measures to combat the threat. A new IMO Convention ([26]) to control these invasions, adopted in 2004 but not yet in force, will initially require ships to exchange their ballast water in the open sea, and later will introduce ballast-water quality standards. Since ratification is only proceeding slowly, additional effort will be needed to bring the Convention into force. Both the European strategy and the IMO Convention are relevant to EECCA seas.

Another positive initiative is the SEBI 2010 ([27]) process in the framework of the CBD, which monitors the worst invasive alien species, including the marine environment. Linked also to commitments under the CBD and following from the 6th EAP, the *EU Action Plan to 2010 and beyond* ([28]) (European Commission, 2006b) includes an objective on the control of alien species (see also Chapter 4, Biodiversity).

Figure 5.10 Change in marine invasive alien species in eight pan-European seas



Note: Data for the Baltic Sea is for parts of the sea with a salinity of > 5 psu

Sources: Derived by EEA-ETC/WTR, 2006 from the following sources:
- Baltic Sea: BMB-NEMO, 2006; Javidpour *et al.*, 2006;
- Caspian Sea: Shiganova *et al.*, 2006;
- Iberian Coastal: Rico and Cabal, 2006; Martínez and Adarraga, 2006;
- Norwegian Sea: Botnen, 2006.

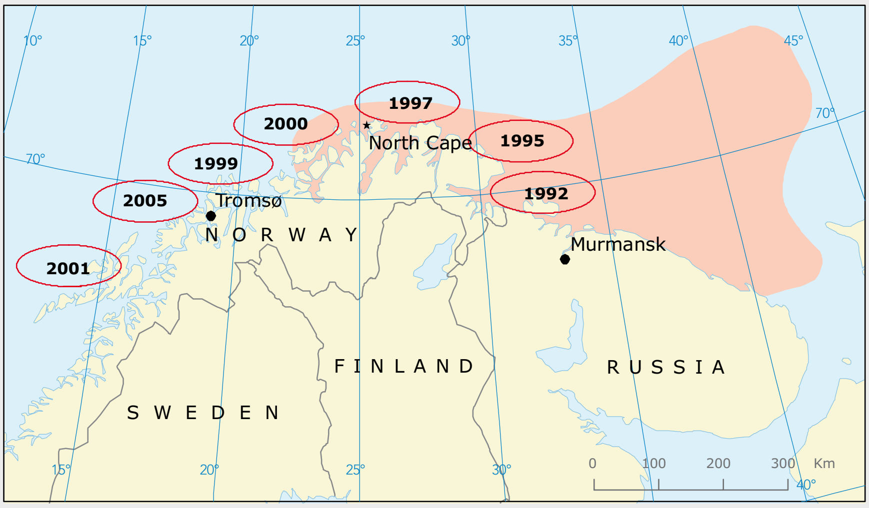
Sources: Derived by EEA-ETC/WTR, 2006 from the following sources:
- Celtic Biscay Shelf: HCMR ([29]) based on contributions to the SEBI 2010 workshop, Athens, 2006;
- North Sea: Gollasch (pers. comm.); Hansson, 2006;
- Black Sea: HCMR based on Alexandrov *et al.*, 2006; Cinar *et al.*, 2006; Micu (Romania) (pers. comm.); and Shiganova (Russia) (pers. comm.);
- Mediterranean Sea: Streftaris and Zenetos, 2006.

([25]) Convention on the Conservation of European Wildlife and Natural Habitats in force since 1982.
([26]) Convention for the Control and Management of Ships' Ballast Water and Sediments, which would introduce measures to control and manage ballast water and sediments in ships to prevent alien species introductions.
([27]) Process for Streamlining European Biodiversity Indicators to meet the CBD target of halting the loss of biodiversity by 2010.
([28]) Annexed to the European Commission Communication on *Halting the loss of biodiversity by 2010 — and beyond — Sustaining ecosystem services for human well-being*.
([29]) Hellenic Centre for Marine Research (http://www.hcmr.gr/).

Box 5.7 Examples of impacts from marine invasive alien species

The Red King crab (*Paralithodes camtschatica*) was intentionally introduced into the Barents Sea in the 1960s by the Russian Federation as a potential new food source. It spread over a large area and flourished (Map 5.6), becoming an important fishing commodity. However, this crab has also become such a by-catch nuisance for the Norwegian gillnet fishery that its eradication has been called for (Streftaris *et al.*, 2005). In addition, its rapid population growth has limited food availability for other benthic organisms, including fish fry, and threatened cod fisheries as it is an intermediate host of an important cod fry parasite.

Map 5.6 Spread of Red King crab in the western Barents Sea



Red King Crab distribution in the western Barents Sea, 2006

Core area of distribution

Red circles indicate the approximate location and the year of the first observations

Source: Institute of Marine Research (IMR), Tromsø, Norway, 2007.

The American comb jelly *Mnemiopsis leidyi* has recently played a significant role in modifying the structure and functioning of the Black Sea food web. *M. leidyi* is a voracious predator, feeding excessively on zooplankton, depleting stocks and altering the food web and ecosystem functions. And, under favourable conditions, it reproduces rapidly.

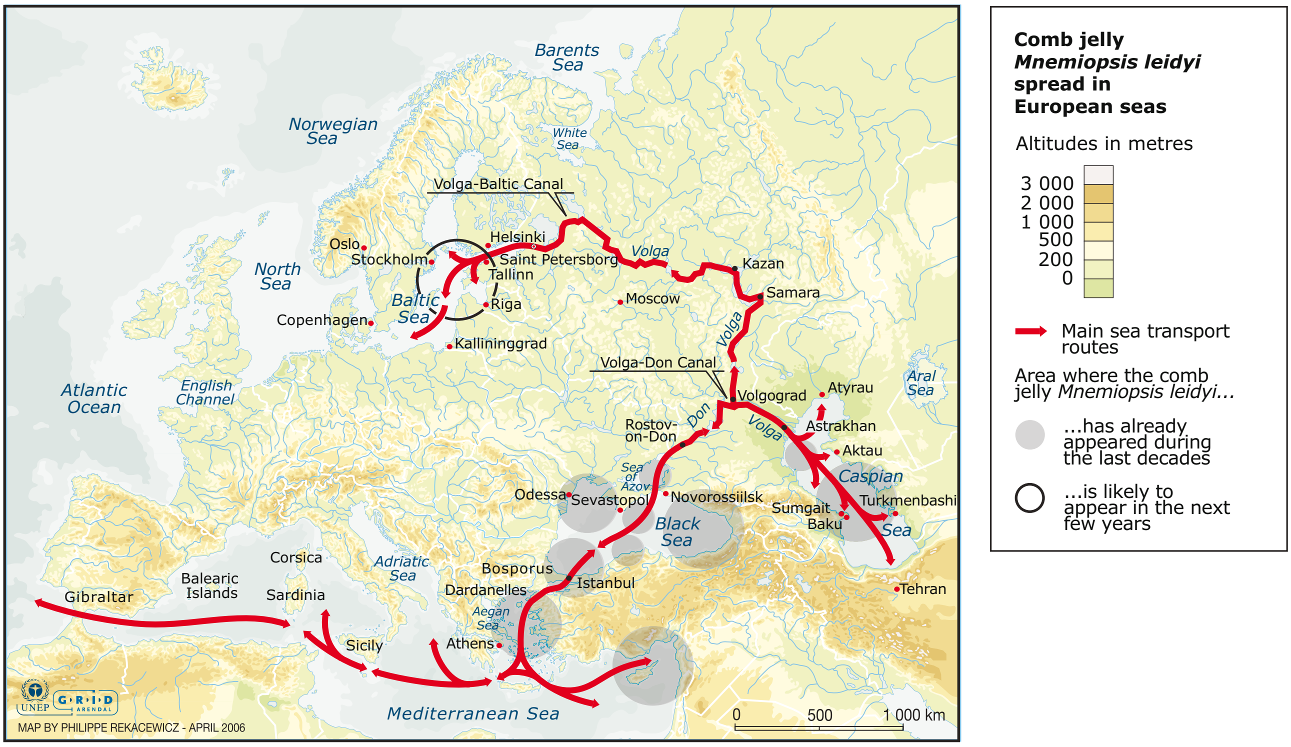
M. leidyi contributed significantly to the collapse of fisheries in the Black and Azov seas in the 1990s, which had serious economic and social ramifications. For example, the collapse of anchovy and sprat fisheries, which had a combined turnover of around EUR 200 million/year in the 1980s (Zaitzev and Mamaev, 1997). The zooplanktonic species on which *M. leidyi* feeds have recently shown signs of relative recovery after the invasion of another comb jelly, *Beroe ovata*, which appears to prey exclusively on *M. leidyi* (Kamburska *et al.*, 2006). However, during the spring and summer absence of *B. ovata, M. leidyi* still reach densities as high as before (CEP, 2005).

M. leidyi has already spread to the Caspian Sea resulting in a depletion of kilka fish stocks (Shiganova *et al.*, 2001). Were the comb jelly's Caspian populations to develop similarly to those in the Azov and Black Seas, fisheries could be totally destroyed in 2012–2015, with ensuing economic losses likely to be around EUR 4.5 billion/year (Berkeliev, 2002).

M. leidyi is predicted to invade the Baltic Sea next due to major shipping linkages from the Caspian Sea (UNEP/GRID-Arendal, 2006) (Map 5.7). Indeed, during late summer and autumn 2006, it has already been found in the south-western Baltic, along the Swedish North Sea coast, and along the south and south-western Norwegian coasts. From the size of the observed populations, it is clear that the comb jelly must have been introduced before 2006, but has remained unrecorded until now (Hansson, 2006) and this is why it does not feature on Map 5.7.

Photo: *Mnemiopsis leidyi* © Tamara Shiganova

Map 5.7 Main routes for the spread of the comb jelly *Mnemiopsis leidyi* in pan-European seas (2006)



Source: UNEP/GRID-Arendal, 2006.

5.3.6 Coastal zones

Large parts of the unique coastal ecosystems and landscapes in the pan-European region are vulnerable to intense human pressures, and these are mounting. Development of the relatively small area along the coast brings a number of conflicting demands for land, water, energy and biological resources, often followed closely by habitat destruction and general ecosystem degradation. Coastal populations and the economic value of their assets are rising rapidly, frequently in those places that are already in high demand and environmentally overexploited. Now climate change is expected to exacerbate many of the problems already faced by pan-European coastal zones.

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.

Concentration of population and major urban developments

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). The situation of the different coastal regions is as follows:

- the Mediterranean, Iberian and North Sea coasts have the highest population densities, all with more than 500 inhabitants/km^2, but there are very different regional situations along them. Tourism continues to seriously increase these populations — more than 170 million international tourists visited the Mediterranean coast in 2000, an increase of 44 % since 1990 (Blue Plan, 2005) — at least seasonally (see also Section 7.4, Tourism);

- approximately 110 million people live in the Black Sea basin (Mee, 2000). The Istanbul region has over 12 million inhabitants, while Romania and Bulgaria have high population densities around harbours and tourist resorts. In Ukraine, the Russian Federation and Georgia, higher population densities are centred around inland urban-industrial centres;
- the population around the Caspian coastline is estimated to be 11 million, with the main urban centres concentrated on the western and southern shores (CEP, 2005); urbanisation is likely to increase with the expected expansion of oil and gas activities (CEP, 2002b);
- urbanisation and population density in the Arctic coastal region is low at around 1 inhabitant per km^2.

Box 5.8 Environmental threats from Caspian Sea level changes

Multiannual oscillation of the Caspian water level is a natural cyclic phenomenon reflecting the respiration of the basin, and is linked to atmospheric circulation in the Atlantic-European sector. The water level retreated during the 20th century and the sea area decreased by approximately 40 000 km^2. This decrease was exacerbated by intense water regulation and the damming of the rivers that feed the Caspian Sea. Many coastal areas were taken over for human use during the low sea-level period (Kosarev, 2005), but were claimed back as a rapid rise began in 1978. This water level rise can cause flooding and increase the risk of coastal erosion and salinisation. In turn, this can displace thousands of people, destroy investments in industry and infrastructure, and cause severe pollution through the inundation of coastal waste sites and oil extraction facilities (CEP, 2006). The possibility of sea-level changes of 1–1.5 m over the next few decades should, therefore, be taken into account when developing and implementing economic plans in the Caspian coastal zone (Kosarev, 2005).

Natural assets and protected areas

Large areas of wetlands have been lost in the EU since the beginning of the 20th century (ESL/JRC, 2006). The less disturbed EECCA coastlines, therefore, still represent an important natural resource. For example:

- the coastal zones of the Caspian Sea are characterised by a wide range of habitats, but due to varying water levels (Box 5.8), these are in a state of constant flux. The area is of particular environmental significance as it lies at the crossroads of bird migration routes and is a vital staging point for an estimated 10 million birds each year during spring and autumn (CEP, 2002a);
- there are 80 major coastal wetlands in the Black and Azov Seas. Thirty-two of them have been designated as Ramsar ([30]) sites, representing a total area of almost two million hectares (Wetlands International, 2003a). Deltas of large rivers such as the Danube, Dniestr, Dnieper, Don and Kuban are complemented by the smaller deltas of the Turkish coast. The largest of all, the Danube Delta, shared by Romania and Ukraine, is particularly well-known for its abundance of birds and as one of the last refuges for several mammal species (Box 5.9). The northern coasts of the Black and Azov Seas include extensive coastal lagoon systems and similar coastal water bodies; there are also numerous coastal lakes along the Romanian and Bulgarian coastline and marsh systems in the Kolkheti lowland of Georgia. Wetlands International has proposed a strategic initiative, BlackSeaWet, for the sustainable use and conservation of coastal wetlands in the Black Sea region (Wetlands International, 2003b).

Different protection regimes are implemented across pan-European coastal zones in an attempt to preserve their outstanding diversity of landscapes and ecosystems:

- Due to its high nature value, an important 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. Not

([30]) Under the so-called Ramsar Convention on wetlands in force since 1975, which provides a framework for the conservation and wise use of wetlands and their resources, including coastal wetlands (http://www.ramsar.org/).

all economic activity in the sites is excluded, but Member States must 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 (landwards and seawards) (Map 5.8). More than 40 % of the total area covered by coastal Natura 2000 sites is represented by habitats of European interest (listed in Annex I of the Habitats Directive) (EEA, 2006e; see also Section 5.2, Policies to protect pan-European seas, and Chapter 4, Biodiversity).

- SEE countries have almost completed, and EECCA countries have made efforts to determine, their candidates for the Emerald Network ([31]) of protected sites. The Emerald Network is based on the same principles as the EU's Natura 2000, and represents its *de facto* extension to non-EU countries. It will, therefore, form the basis for SEE country participation in the Natura 2000 process (see also Chapter 4, Biodiversity).
- The Caspian Sea coast has few protected areas, but those that exist include the Astrakhan Reserve in the Russian Federation and the Khazar Reserve in Turkmenistan. In the south, the lowland coastal areas are almost entirely cultivated and few natural habitats have been preserved (TACIS-CEP, 2001).

Box 5.9 The Danube — Black Sea navigation route across the Danube Delta

Some branches in the Danube Delta are adapted for navigation from the inland to the Black Sea and vice versa. The Danube — Black Sea deep water navigation route is being dredged by Ukraine across the Danube Delta, bordering Romania; from the city of Ismail seawards via the Chilia branch and the natural Bystroe channel and outlet towards the Black Sea. It will provide access to the Danube river for larger ships to support the economic development of upstream regions. It is anticipated that the Danube river may develop into an important cargo route between the Atlantic, European and Asian regions.

The Danube Delta, the second largest delta in Europe, is a pristine area of high environmental value and an important wildlife habitat. It has the highest number of birds of any southern European wetland, being a key area of passage for migrating species and an over-wintering habitat for others, with a total of more than 320 bird species of European importance. Around 90 fish species and threatened mammals such as the European mink, the wildcat, the freshwater otter and the globally threatened monk seal are also found in the delta.

A large part of the delta is incorporated into a transboundary Biosphere Reserve established in 1998 between the two countries. Most of the Reserve's wetlands fall in Romanian territory and have been inscribed in the World Heritage List. Furthermore, 580 000 ha of the Romanian and 32 800 ha of Ukrainian wetlands are designated as Wetlands of International Importance under the Ramsar Convention (UNESCO-MAB, 2005).

There has been international concern around the potential environmental impacts of the Danube — Black Sea deep-water navigation project, in particular from the Romanian authorities The concern of the Romanian Government resulted in the initiation of an inquiry procedure under the UNECE Convention on Environmental Impact Assessment in a Transboundary Context ([32]), the first time such a procedure has been put in place, to advise on the likelihood of significant adverse transboundary impacts. In July 2006, the Inquiry Commission concluded, among other things, that:

- the navigation route is likely to have a number of significant adverse transboundary impacts on inter alia habitats, fisheries and birdlife;
- the provisions of the Convention applied and, therefore, Ukraine was expected to send a notification about this project to Romania;
- the procedure for transboundary impact assessment should start, including communication between and public participation in the two countries.

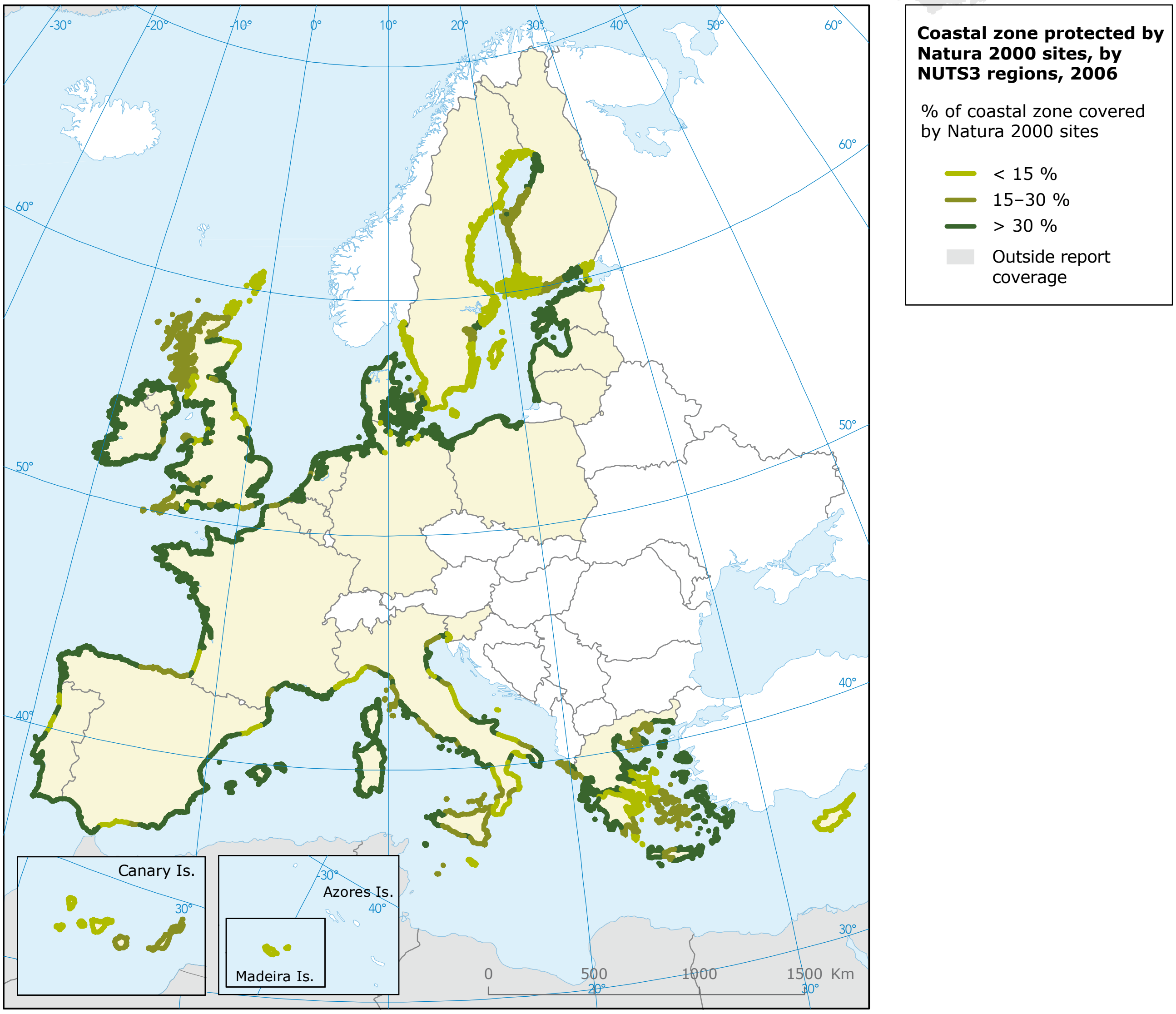
The works were ongoing over 2006 and the navigation route is expected to open this year. For further information see http://www.unece.org/env/eia/news_old.htm.

Source: Based on the Espoo Inquiry Commission report on the likely significant adverse transboundary impacts of the Danube — Black Sea navigation route at the border of Romania and the Ukraine, UNECE, 2006.

([31]) The Emerald Network is an ecological network made up of 'areas of special conservation interest', which was launched by the Council of Europe as part of its work under the Bern Convention (http://www.coe.int/t/e/cultural_co-operation/environment/nature_and_biological_diversity/ecological_networks/The_Emerald_Network/).

([32]) Called the Espoo Convention after the Finnish city where it was adopted in 1991.

Map 5.8 Coastal zone protected by Natura 2000 (%, 2006)

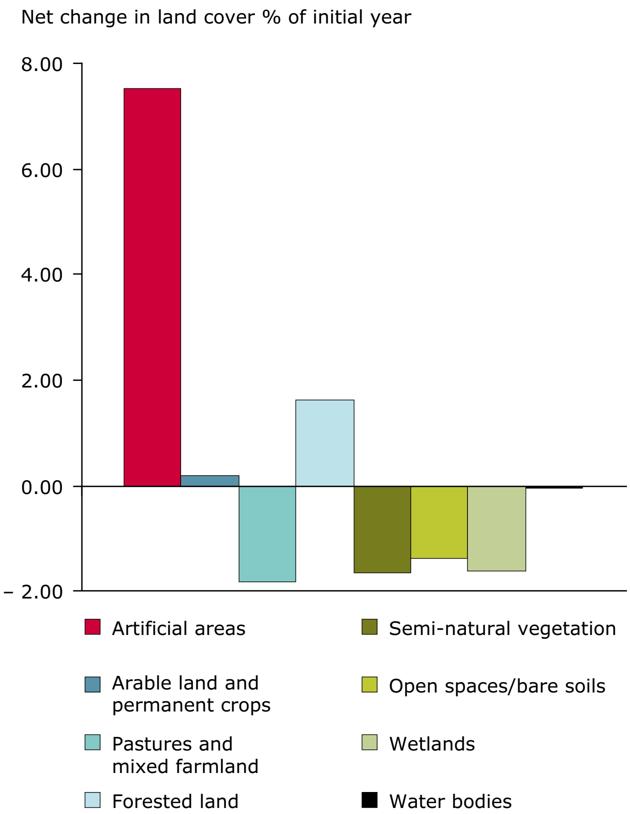


Source: Based on the Natura 2000 database from EEA-ETC/BD.

Development of coastal zones and related habitat loss

Between 1990 and 2000, development within the 10 km coastal zone increased in all countries of the enlarged EU, with the highest increases of soil sealing and urbanisation, 20–35 %, in the coastal zones of Portugal, Ireland and Spain (EEA, 2006e) (Figure 5.11). Today, across the EU, the proportion of built up areas in the first kilometre from the coastline, the coastal strip, is in many cases 15 % to 45 %. This can be even higher along a number of coastal stretches in the western part of the Mediterranean Sea, especially Spain and France, and on the North Sea coast, for example in Belgium. Such rate of development is driven by several human activities including particularly tourism and transport infrastructure, but also shipping, fisheries, aquaculture and offshore energy installations, with each increasingly demanding their share. For example, more than 2 720 km^2 of semi-natural, natural and agricultural land (especially mixed agriculture and pasture), were lost in the EU predominantly to artificial surfaces during this period. Intensive agriculture has also claimed natural land and wetlands (EEA, 2006e).

Figure 5.11 Land-cover change within the 10 km coastal zone of 17 EU countries (1990–2000)



Note: Countries included here are 17 out of the 22 EU coastal Member States (the exceptions are Cyprus, Finland, Malta, Sweden and the United Kingdom).

Source: EEA, 2006e.

Tourism is the main source of income in many EU coastal areas and has played a crucial role in the growth of settlements along the shore (see also Section 7.4, Tourism). Turkey's Mediterranean coast, as well as the Dalmatian (Croatia) and Bulgarian coasts, have also seen spectacular tourism development. In the EECCA countries bordering the Black Sea, tourism diminished during the 1990s, but is now showing signs of recovery.

Tourism development brings economic benefits, but also environmental problems. New housing is not just needed for the visitors but also for those who staff the resorts. More freshwater and more sanitation are needed as well as food, which itself requires more freshwater. Roads, airports, ports, waste-disposal facilities and increasing leisure amenities, including often 'thirsty' golfcourses, are required too. All of these are taken from coastal lands such as wetlands, woodlands and even farms. Additionally, some new resorts have been built on the beach, directly threatening wild species including turtles (see also Section 7.4, Tourism). However, tourism development does not necessarily have to be unsustainable and ICZM approaches should be used to ensure that this is not the case (Box 5.10).

Box 5.10 Application of Integrated Coastal Management on the Croatian Dalmatian coast: Sustainable tourism through public participation

The COAST ([33]) project for sustainable coastal development was developed using a wide participatory approach.

Natural and cultural attractions along the Dalmatian coast in Croatia are extraordinarily favourable for tourism, which has a long tradition there and is one of the most important economic sectors. However, illegal construction on biodiversity-rich sites is rather frequent and has serious environmental impacts, as do increasing demands for water, energy and food as well as associated waste production. Further, misbehaviour by tourists can cause habitat degradation, waste pollution and forest fires, especially on the area's islands (UNDP, 2005).

Even though tourism is one of the most important economic activities in coastal Croatia, there are a number of other initiatives that compete with or impact negatively on it, such as placing tuna farms in tourist areas. This has caused conflict among the local population but, by applying an ICZM approach, it has been possible to achieve a comprehensive understanding of the relationships between coastal resources, their users and the impacts of development. These relationships need to be understood and expressed not only in physical and environmental but also in economic terms. As coastal resources are simultaneously used by different economic and social sectors, integrated management can only be successful when all these uses, users and relationships are clearly understood.

Within the COAST project, activities of key industrial sectors — fisheries, agriculture, banking and particularly tourism — will be modified and adapted in order to prevent negative impacts on each other and on biodiversity.

Source: Croatian Environment Agency, 2006.

([33]) The Conservation and Sustainable Use of Biodiversity in the Dalmatian Coast through Greening Coastal Development (COAST) is a UNDP-GEF project.

Many coastal zones along the Mediterranean Sea, particularly in southern Spain, and the Black and Caspian Seas, are now suffering from water shortages as a result of the introduction of intensive agriculture in already water-limited areas. Indeed in southern Spain, competition is developing between two thriving industries, tourism and agriculture, for increasingly scarce freshwater (see Section 2.3, Inland waters).

Climate change will have profound impacts on the coastal environment for example: desertification along the Caspian and Mediterranean coasts; sea-level rise affecting low lying areas; increased erosion of coastlines and deltas; and higher frequency of sea storms in the North and the Baltic Seas. Coastal ecosystems, and particularly coastal lagoons along the shores of semi-enclosed seas, could be severely reduced or even disappear during this century. This is particularly so in areas with low tidal ranges backed by intense human use, which limits the scope for onshore migration and coastal subsidence (Nicholls and Klein, 2005). More flooding events, too, are expected because of both climate change and reduced natural retention capacity of the land following its sealing or conversion from, for example, coastal wetlands.

5.3.7 Climate change and seas

Global climate change is very likely to give rise to large-scale impacts on the physical and geochemical characteristics of the oceans and coasts including:

- increases in sea surface temperature and sea level;
- decreases in sea-ice cover;
- changes in salinity, alkalinity and wave climate;
- increased freshwater and land-based pollutant run-off.

and possibly:

- changes in ocean mixing, deep-water production and coastal upwelling, and in the general ocean circulation;
- impairment of the oceans' ability to act as a sink for atmospheric CO_2 due to positive marine feedback loops, which will thus stimulate further global warming.

These impacts will, in turn, modify the ecological structure of oceans and coasts, their functions and the goods and services they provide. Furthermore, the IPCC (2001) indicates that vulnerability to climate change increases in areas that are already under considerable stress from other non-climatic pressures, particularly human activities. This would be the case for the marine and coastal environment.

Climate change impacts on marine biology are becoming more and more obvious. They include disturbances to the growing season of marine organisms and changes in the species composition of marine communities. Additionally, pressure from increased levels of atmospheric CO_2 is likely to alter the water chemistry of the oceans, increasing its acidity and thereby preventing calcification. Experimental evidence suggests that this could eventually cause difficulties for marine organisms that build calcareous shells and skeletons, such as cold-water corals.

Strong mitigation policies at the global level have to be given the highest priority. However, adaptation policies at the regional and local levels are also needed to tackle climate change impacts on coastal and marine ecosystems. Adaptation strategies must, therefore, include measures to reduce anthropogenic non-climatic impacts in order to improve the resilience of these ecosystems to climate change. For example, changes in species composition, abundance and spatial distribution of fish stocks are one of the major challenges and should be taken into account by the CFP. Both the WFD and the proposed MSD provide an overall framework for developing and implementing catchment and marine management strategies, and their full implementation should not only reduce pressures on coastal and marine waters but also take into account and allow adaptation to climate change (EEA, 2007).

The sequestration of CO_2 in geological formations under the sea floor or its injection into the deep sea is now being considered worldwide as part of climate change mitigation strategies. These options require more research and testing in view of potential environmental risks, quite apart from the resolution of legal issues (UNFCCC, 2006; see also Chapter 3, Climate change). The latter is now ongoing as, for example, the IMO London

Protocol ([34]) has recently been amended to allow the storage of CO_2 in sub-bed geological formations and OSPAR has initiated procedures to amend the text of the Convention in order to regulate CO_2 capture and sequestration.

Sea surface temperature

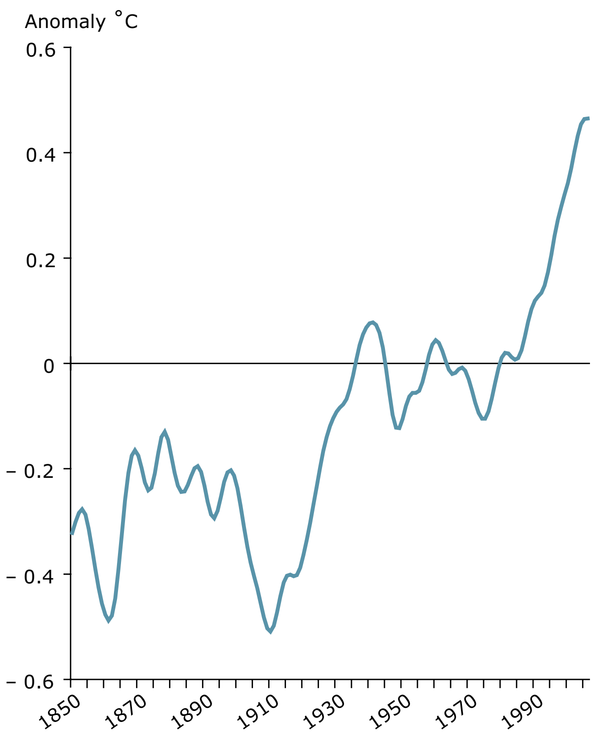
Changes in the sea surface temperatures (SST) of the world's oceans have been reported and seem consistent with variations and changes in the global climate system, particularly the atmospheric temperature. Over the past 100 years, an initial warming phase (1910–1945) was followed by a period of nearly constant temperature. A second warming began during the 1970s and is still continuing (Rayner *et al.*, 2006) (Figure 5.12).

The linear warming between 1850 and 2004 was 0.5 °C for the globe, and overall, global SST is expected to increase by between 1.1 and 4.6 °C from 1990 levels by 2100 (IACMST, 2004), with increases in SST in pan-European seas also predicted.

Long-term observations of several pan-European seas already indicate a marked increase in SST although there have been periods of nearly constant temperature in specific places, extending for a decade or more, for example during the 1970s and 1980s in the North-East Atlantic. Nonetheless, most seas have shown significantly increased SST as follows:

- the Baltic and North Seas have warmed approximately 0.5 °C over the last 15 years (IACMST, 2004; ICES, 2005b);
- in the south east of the Bay of Biscay, the average SST has increased by around 0.6 °C per decade since the mid 1970s (Koutsikopoulos *et al.*, 1998; Planque *et al.*, 2003);
- the temperature of the northward flowing Atlantic water in the eastern Norwegian Sea has been extraordinarily high during the period 2000–2004 (IMR, 2006), although a general increasing trend of 0.3 °C per decade is observed;
- in the Barents Sea, the mean SST has increased around 1 °C over the past 30 years (ICES, 2005b);
- in the Mediterranean Sea, the average increase in SST has been 2.2–2.6 °C between 1982 and 2003 (Map 5.9).

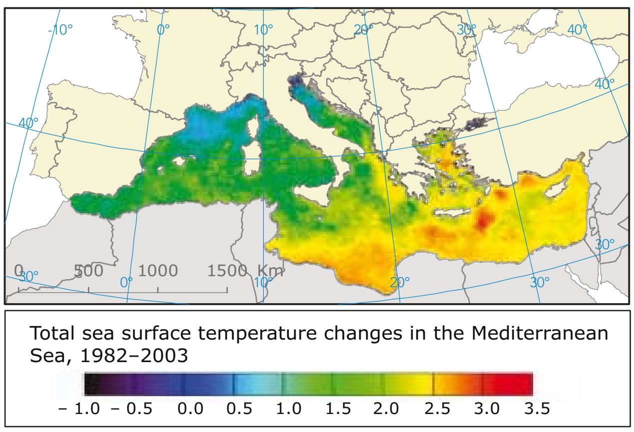
Figure 5.12 Anomalies in Northern Hemisphere average sea surface temperature from HadSST2



Note: HadSST2 = Hadley Centre SST data set. Anomalies are relative to 1961–1990. Annual series are smoothed with a filter. The line shows the best estimate removing all uncertainties (station, sampling, coverage and bias).

Source: Rayner *et al.*, 2006.

Map 5.9 Total sea surface temperature changes in the Mediterranean Sea (°C, 1982–2003)



Source: European Commission, DG Joint Research Centre, IES, 2006.

([34]) Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, in force since 1972.

Sea-level rise

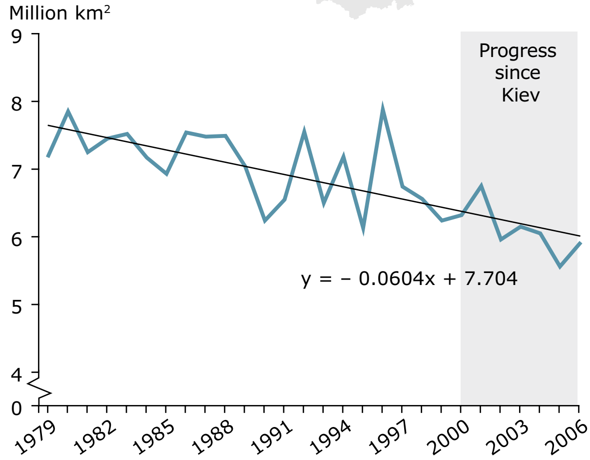
The global average sea level rose by 0.17 m over the whole of the 20th century. Sea-level rise increased in the decade 1993–2003 to 3.1 mm/year compared to the average of 1.8 mm/year for the years 1961–2003. The main reason is because water expands as temperature rises, though losses from ice sheets in Greenland and Antarctica are very likely to have contributed in recent years. Sea-level rise at the end of this century is projected to be 0.18–0.59 m. This estimate does not take into account increased melting rates of ice sheets because of high uncertainties in the estimates (IPCC, 2007). There will be regional differences in the way these global averages will be expressed across the pan-European region due to, for example, differences in ocean currents, air pressure and land level — of particular concern are low-lying areas and intertidal habitats (see also Section 5.3.6, Coastal zones, and Chapter 3, Climate change).

Arctic ice cover

The annual average Arctic sea-ice extent has shrunk by an average of 2.7 % per decade between 1978 and 2005. The decreases in summer are larger, with 7.4 % on average per decade (IPCC, 2007) (Figure 5.13). In September 2005, the end of the summer melt period and the time when it typically reaches its minimum, the northern hemisphere sea-ice extent fell to a record low 5.6 million km^2 (Richter-Menge *et al.*, 2006).

Measurements of sea-ice thickness are less reliable. A 10–15 % reduction between 1960 and the late 1990s has been observed for the Arctic as a whole, with large regional variations and reductions of up to 40 % (ACIA, 2004). The thickness of late summer sea ice drifting in the polar ocean decreased around 20 % in the decade 1991–2001 (Haas, 2004). If current rates of decline in sea-ice cover and thickness continue, the Arctic could be completely ice-free in summertime by the end of this century (Johannessen *et al.*, 2004; NSIDC, 2005). However, recent studies suggest an accelerated melting, with ice-free summers becoming a reality from 2040–2050 (Holland *et al.*, 2006).

Figure 5.13 Change in September Arctic sea-ice extent



Note: The 'extent' column includes the area near the pole not imaged by the sensor. It is assumed to be entirely ice covered with at least 15 % concentration. However, the 'area' column excludes the area not imaged by the sensor. This area is 1.19 million km^2 for SMMR ([35]) (from the beginning of the series through June 1987) and 0.31 million square kilometres for SSM/I ([36]) (from July 1987 to present). Therefore, there is a discontinuity in the 'area' data values in this file at the June/July1987 boundary.

Source: Fetterer and Knowles, 2002, updated 2006.

Climate change impacts on marine ecosystems

Climate change can affect marine ecosystems in a variety of ways (see reviews in EEA, 2004 and ACIA, 2005):

- Temperature changes may affect the metabolism and distribution of organisms, and even cause death. Mass mortalities of marine animals and outbreaks of harmful algal blooms are considered to be related to anomalies of sea water temperature and climate periodicity. Examples are the massive gorgonian (soft coral) and coral mortality in the Mediterranean Sea in 1999 (Garrabou *et al.*, 2001);
- Changes in sea ice may result in changing light penetration, salinity and habitat availability. Shrinking sea ice endangers the whole ice-associated ecosystem, from ice-algae to seals, walruses and polar bears. Reduced sea ice also weakens the protection of coasts against severe weather and increases erosion, flooding

([35]) SMMR = Nimbus-7 Scanning Multichannel Microwave Radiometer.
([36]) SSM/I = Special Sensor Microwave/Imager.

and dispersal of water pollutants. Secondary environmental pressures can arise from the opening of new sea routes and increase in fisheries as well as oil and gas exploration and transport options (see Section 5.3.4, Oil pollution).

These ecological changes could affect fisheries and aquaculture production, and increase risks to human health by enhanced epidemic bacteria incidents and harmful algal blooms.

Marine growing season

There are many examples of changes in the growing season (i.e. peak annual growth) of marine organisms across pan-European seas:

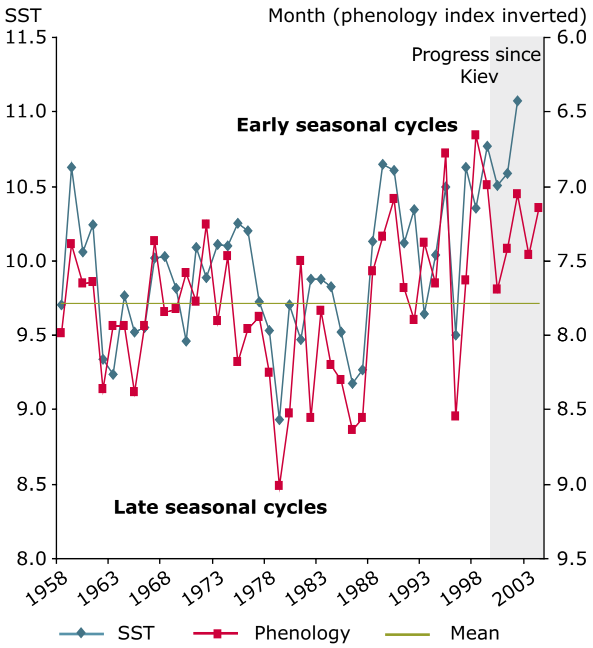
- the phytoplankton spring bloom in the Baltic Sea begins earlier (HELCOM, 2006e);
- in the Russian Arctic, removal of light limitation due to reduced ice cover results in longer phytoplankton growing season and increased primary production;
- in both the Celtic, Biscay, North and Norwegian Seas, phytoplankton biomass and the length of the growth period have increased (EEA, 2004; Edwards *et al.*, 2005);

Changes in primary production will also affect species in the rest of the ecosystem. For example, the seasonal cycle of different zooplanktonic larvae is earlier than the long-term average in the central North Sea, mainly because of changed SST (Edwards *et al.*, 2006). As a result, the annual peak seasonal abundance of decapod larvae has shown a major trend towards an earlier seasonal peak since 1988, with the exception of 1996 (a negative NAO year). It has been up to 4–5 weeks earlier in the 1990s than the long-term mean, which is highly correlated to increased spring SST (Edwards *et al.*, 2006) (Figure 5.14).

Northward movement and changes in species composition

Marine ecosystems are in many ways more sensitive to environmental variability than their terrestrial counterparts. Over the last 20 years, a wide range of plankton and fish species have shifted their distribution ranges northward as a result of warming in pan-European waters. As sea temperature increases, cold-water species move northward, being replaced by warm/temperate water species. For example:

Figure 5.14 Inter-annual variability in the peak seasonal development of decapod larvae in the North Sea in relation to SST



Note: Phenology is the timing of recurring natural phenomena, in this case the peak seasonal development of decapod larvae. With warmer temperatures there is an earlier seasonal peak, and with colder temperatures a later seasonal peak.

Source: Edwards *et al.*, 2006.

- in the Celtic-Biscay Shelf, North and Norwegian Seas, there has been an overall downward trend in the abundance of copepod zooplankton and a shift in the species composition from cold to warm-water species (for a synthesis see WWF, 2005). Between the 1960s and the late 1990s, the total biomass of the copepod *Calanus* in the North Sea declined by 70 %, which has had significant consequences for other marine wildlife including fish larvae (Edwards *et al.*, 2006). In terms of species composition, a useful indicator of the warming trend in the North Sea is the shift from cold-temperate *Calanus finmarchicus* to warm-temperate *Calanus helgolandicus* copepod species (Figure 5.15). In the Norwegian Sea, a temperature increase and a reduction in overturning circulation is very likely to result in a shift from Arctic to Atlantic zooplankton species;

- in the Baltic Sea, high spring and early-summer temperatures, mild winters and reduced salinity, due to increased precipitation, have resulted in changes in the species composition of zooplankton and of the phytoplankton spring bloom (Viitasalo *et al.*, 1995; Vuorinen *et al*. 1998; Dippner *et al.*, 2000; Möllmann *et al.*, 2002);
- in the Barents and White Seas, marine communities are strongly dependent on the dynamics of Atlantic and Arctic water masses (Hop *et al.*, 2002) and so significantly affected by climate change. For example, in the Barents Sea, the ice edge, which serves as the main feeding area for capelin, is retreating. So the capelin are now moving northwards, following the retreating ice-edge, with some other ice-associated species likely to follow;
- in the Russian Arctic, marine algae under the ice have been replaced by species usually associated with fresher water due to ice melting (ACIA, 2005);
- in the Mediterranean Sea, plankton species that were thought to have a southern distribution appear to now be extending their ranges all over the sea. In contrast, species associated with cooler waters are now only being found at greater depths (Boero, 2005 in Brooker and Young, 2005);
- also fish movements seem to be influenced by climate change, evidenced by the increase in the scaldfish and lesser weaver populations along the Dutch North Sea coast possibly as a result of warmer waters (MNP, 2004b).

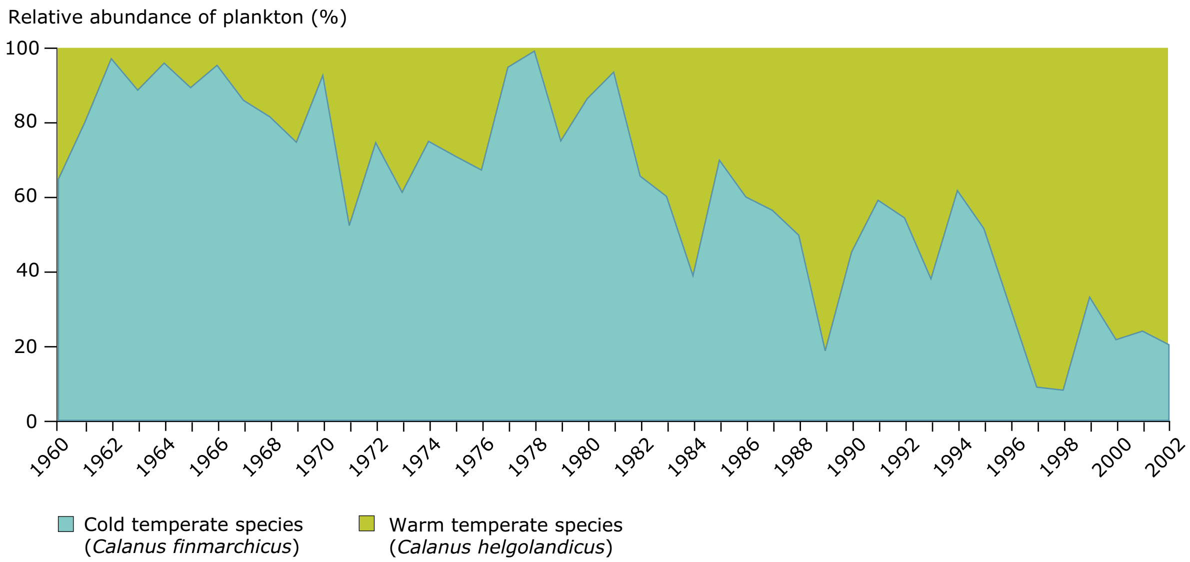
Projections of future impacts

The observed ecological changes reported above are all likely to continue under future predicted climate conditions (see Brooker and Young, 2005). However, increasing SST does not always imply increased plankton abundance, since warming could increase water stratification and prevent the mixing of nutrient-richer bottom layers with the upper layers decreasing plankton biomass (Behrenfeld *et al.*, 2006). Further, there is a clear risk of mismatches between the timing of the presence of predators and their specific prey, which could lead to a reduction of the transfer of energy up the food chain (Hiscock *et al.*, 2004).

Acidification of the seas

Increasing levels of CO_2 in the atmosphere lead to CO_2 uptake across the air-sea interface and increased hydrogen ion concentrations in the ocean, raising the acidity of seawater and reducing its pH. Surface waters of the world oceans have already experienced an average pH reduction of around 0.1 pH units (OSPAR, 2005c). Further reductions of the order of 0.14 to 0.35 units are predicted over this century (IPCC, 2007). Even larger reductions may occur

Figure 5.15 Changes in species composition between a cold and a warm temperature copepod in the North Sea



Source: Edwards, 2003.

thereafter depending on future emission scenarios (Orr *et al*., 2005; OSPAR, 2005c; Royal Society, 2005).

Experimental evidence suggests that if these lowered pH trends persist, key marine organisms, such as corals and some plankton species, will have difficulties in growing and/or maintaining calcareous skeletons and shells (Orr *et al.*, 2005). These are made of calcium carbonate, which will be difficult to produce at certain low pH concentrations, such as some of those predicted by the IPCC. At even lower pH, shells of, for example, mussels could dissolve according to experimental evidence (Gazeau *et al.*, 2007). Globally, tropical and subtropical corals are expected to be among the worst affected. However, cold-water coral reefs that are found in many parts of the North-East Atlantic and the Mediterranean Seas could also be adversely affected (Orr *et al*., 2005). Further, given that the shells and external skeletons of marine organisms, where the carbon is trapped, would have eventually sunk to the sea bottom, acidification is likely to reduce an important global sink of atmospheric CO_2.

Ocean acidification is essentially irreversible during our lifetimes: it will take tens of thousands of years for ocean chemistry to return to a condition similar to that occurring in pre-industrial times, around 200 years ago (Royal Society, 2005).