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Coastal and marine areas

Global overview

Progress in protecting the marine and coastal environment over the past 30 years has generally been confined to relatively few, mostly developed countries, and to relatively few environmental issues. Overall, coastal and marine environmental degradation not only continues but has intensified. The major threats to the oceans that were recognized in 1972 — marine pollution, the overexploitation of living marine resources and coastal habitat loss — still exist, despite national and international actions to address these problems.

There have, however, been significant changes in perspective, and new concerns have emerged. The exploitation of living marine resources and loss of habitats are now recognized as being at least as great a threat to ocean health as marine pollution. The perspectives of developing countries were embodied in the Founex Report on Development and Environment that was produced in preparation for the 1972 Stockholm Conference. Their response in 1972 was that degradation was a developed-country problem; for them poverty, not pollution, was the problem (Brenton 1994, Caldwell 1996).

Marine and coastal degradation is caused by increasing pressure on both terrestrial and marine natural resources, and on the use of the oceans to deposit wastes. Population growth and increasing urbanization, industrialization and tourism in coastal areas are root causes of this increased pressure. In 1994, an estimated 37 per cent of the global population lived within 60 km of the coast — more people than inhabited the planet in 1950 (Cohen and others 1997). The effects of population are multiplied by both poverty and human consumption patterns.

Marine pollution

Prior to 1972, the crash of some seabird populations caused by DDT, outbreaks of Minamata disease in Japan from mercury-contaminated seafood, and the *Torrey Canyon* and other oil spills focused the attention of the Stockholm Conference on marine pollution. Policy responses included bans on production and use of some substances, regulations to reduce discharges, and the prohibition of ocean dumping, as well as a significant scientific effort to improve the status of knowledge about these

pollutants. These responses are enshrined in a number of international agreements, including the 1972 London Dumping Convention and its 1996 Protocol, the 1989 Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal, and the 1995 Global Programme of Action for the Protection of the Marine Environment from Land-based Activities. Marine pollution is also an important focus of UNEP's Regional Seas Programmes that have been established in many parts of the world.

Globally, sewage remains the largest source of contamination, by volume, of the marine and coastal environment (GESAMP 2001a), and coastal sewage discharges have increased dramatically in the past three decades. In addition, because of the high demand for water in urban neighbourhoods, water supply tends to outstrip the provision of sewerage, increasing the volume of wastewater.

Public health problems from the contamination of coastal waters with sewage-borne pathogens were well known in the 1970s, and in many developed countries improved sewage treatment and reduction of the disposal of industrial and some domestic contaminants into municipal systems have significantly improved water quality. In the developing world, however, the provision of basic sanitation, as well as urban sewer systems and sewage treatment, has not kept pace. High capital costs, the explosive pace of urbanization, and in many cases limited technical, administrative and financial capacities for urban planning and management and ongoing operation of sewage treatment systems are barriers to efficient sewage treatment (GESAMP 2001a). Removal of these barriers, as well as alternative approaches, is urgently needed.

Recent evidence suggests that bathing in waters well within current microbiological standards still poses significant risk of gastrointestinal disease, and that sewage contamination of marine waters is a health problem of global proportions (see box, GESAMP 2001a, WHO 1998).

A primary concern at the Stockholm Conference was the introduction of nutrients to coastal and marine waters. Human activities now account for more than half of global nitrogen fixation (Vitousek and others 1997a), and the supply of fixed nitrogen to the oceans has greatly increased. Sewage discharges are often the dominant local source near urban areas but global inputs are dominated by agricultural run-off and atmospheric deposition. The highest rates of riverine transport of dissolved inorganic nitrogen to estuaries from all sources occur in Europe and in South and East Asia (Seitzinger and Kroeze 1998). Nitrogen levels are exacerbated by widespread loss of natural interceptors such as coastal wetlands, coral reefs and mangrove forests.

At the time of Stockholm, agricultural nutrient run-off was 'not yet a major global problem'. Most fertilizer use was in developed countries but the rapid increase of fertilizer use in developing countries was already foreseen (SCEP 1970). Fertilizer use has stabilized in developed countries but is increasing in developing ones (Socolow 1999), a trend expected to continue. Fertilizer use has undoubtedly been enhanced by widespread subsidies, which reflect the high political priority of increasing food production and reducing food costs.

Atmospheric inputs, derived primarily from vehicle and industrial emissions and in some areas evaporation from animal manure and fertilizer, dominate anthropogenic nitrogen inputs to some coastal areas. They are expected to rise with increasing industrialization and vehicle use, especially in developing regions (GESAMP in prep.). Atmospheric nitrogen inputs to the nitrogen-limited

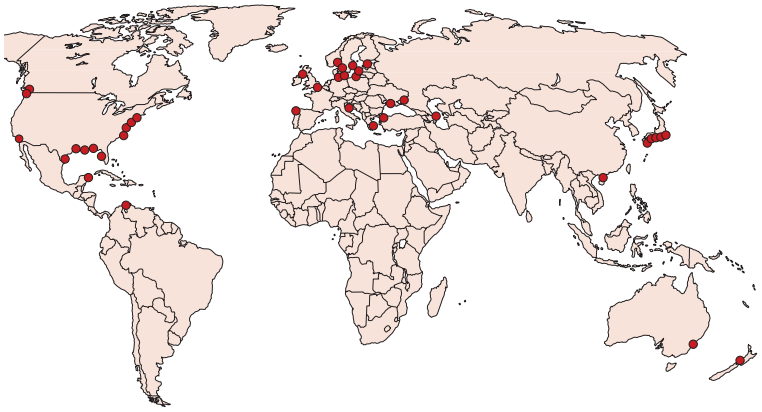
Disease burden of selected common and marine-related diseases

disease	*DALYs/year (millions)*	*economic impact (US$billion)*
malaria	31.0	124.0
diabetes	11.0	44.0
trachea, brachia and lung cancer	8.8	35.0
stomach cancer	7.7	31.0
intestinal nematodes	5.0	20.0
upper respiratory tract infections	1.3	5.2
trachoma	1.0	4.0
dengue fever	0.75	3.0
Japanese encephalitis	0.74	3.0
diptheria	0.36	1.4
diseases related to marine contamination		
related to bathing and swimming	0.4	1.6
seafood consumption (hepatitis)	1.8	7.2
seafood consumption (algal toxins)	1.0	4.0
sub-total	**3.2**	**12.8**

Note: one DALY (Disability-Adjusted Life Year) equals one person-year of productive life lost through death or disability

Source: GESAMP 2001a

Seasonal zones of oxygen-depleted waters



Red dots on the map indicate seasonal zones of oxygen-depleted waters resulting from human activities

Source: Malakoff 1998 after Diaz and Rosenberg 1995

open oceans will also increase, with potential significant impacts on primary production and the carbon cycle.

Marine and coastal eutrophication from elevated nitrogen inputs has emerged as a worrying trend not foreseen three decades ago. There is increasing evidence that blooms of toxic or otherwise undesirable phytoplankton are increasing in frequency, intensity and geographic distribution (Richardson 1997). Severe eutrophication has occurred in several enclosed or semi-enclosed seas, including the Black Sea (Zaitsev and Mamaev 1997, Balkas and others 1990). Elsewhere, elevated growth and subsequent decay of phytoplankton has caused widespread areas of seasonally oxygen-depleted water (see map). Phytoplankton blooms can have major economic impacts on fisheries, aquaculture and tourism (see table below left).

Economic losses from red tides in fisheries and aquaculture

date	*location*	*species*	*loss (US$million)*
1972	Japan	yellowtail	~47
1977	Japan	yellowtail	~20
1978	Japan	yellowtail	~22
1978	Republic of Korea	oyster	4.6
1979	Maine, United States	many	2.8
1980	New England, United States	many	7
1981	Republic of Korea	oyster	>60
1985	Long Island, United States	scallops	2
1986	Chile	red salmon	21
1987	Japan	yellowtail	15
1988	Norway and Sweden	salmon	5
1989	Norway	salmon, rainbow trout	4.5
1989–90	Puget Sound, United States	salmon	4-5
1991	Washington State, United States	oyster	15-20
1991–92	Republic of Korea	farmed fish	133
1996	Texas, United States	oyster	24
1998	Hong Kong	farmed fish	32

Source: Worldwatch Institute 1999

At the time of the Stockholm Conference concerns for ocean health centred on pollution by POPs (particularly DDT and PCBs), heavy metals and oil (Goldberg 1976, Matthews and others 1971, UN 1972a, SCEP 1970). Some response measures have been effective, for example, introduction of unleaded gasoline helped to reduce lead levels in Bermuda (Wu and Boyle 1997, Huang, Arimoto and Rahn 1996); national regulations and international agreements such as the Convention on the Prevention of Pollution from Ships (MARPOL) resulted in the reduction of operational oil discharges from ships; and North American seabird populations affected by DDT recovered after this chemical was banned in the region.

In other cases, improved information has clarified some concerns. High levels of mercury in tuna and swordfish, for example, have been shown to have natural sources; the most dramatic effects of oil spills have proved to be localized and relatively transient; and heavy metal contamination, except for lead and mercury, has been found to be highly localized and has relatively minor impacts except at high concentrations.There are, however, other continuing concerns about these pollutants. The chemical residues of oil spills may have subtle long-term effects (Heintz, Short and Rice 1999), and chronic, small releases cause seabird mortality and other environmental effects (GESAMP in prep.). The effects of heavy metal contamination can be severe and are a significant concern in the Arctic (AMAP 1998).

The most serious concerns globally relate to POPs, many of which are transported globally via the atmosphere and are ubiquitous in the oceans. There is growing evidence that long-term, low-level exposures to some POPs cause reproductive, immunological, neurological and other problems in marine organisms, and possibly in humans, but the evidence for widespread ecological or human health impacts at current levels of contamination remains equivocal.

Another threat to the oceans, and in particular to living organisms, is non-biodegradable litter which enters the sea. Each year, large numbers of seabirds, sea turtles and marine mammals are killed by

entanglement in or ingestion of non-biodegradable litter.

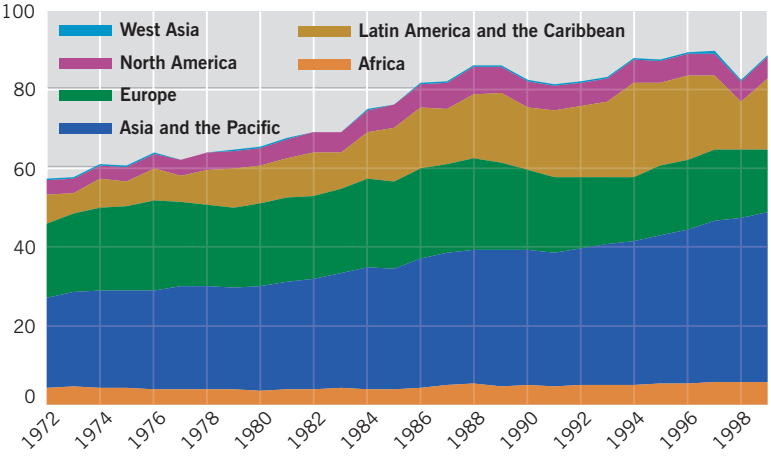
Human-induced changes in the natural flow of sediment have emerged since the Stockholm Conference as a major threat to coastal habitats. Urban and industrial development drives the construction of residential and industrial infrastructure which, depending on its nature, can alter sediment flow. In addition, agriculture, deforestation and construction typically mobilize sediments. Deltas, mangrove forests, beaches and other coastal habitats are sustained by the supply of sediment, while other habitats, such as coral reefs and seagrass beds, may be smothered or deprived of light. Sedimentation is one of the major global threats to reefs, particularly in the Caribbean, Indian Ocean, and South and Southeast Asia (Bryant and others 1998, Wilkinson 2000).

Fisheries

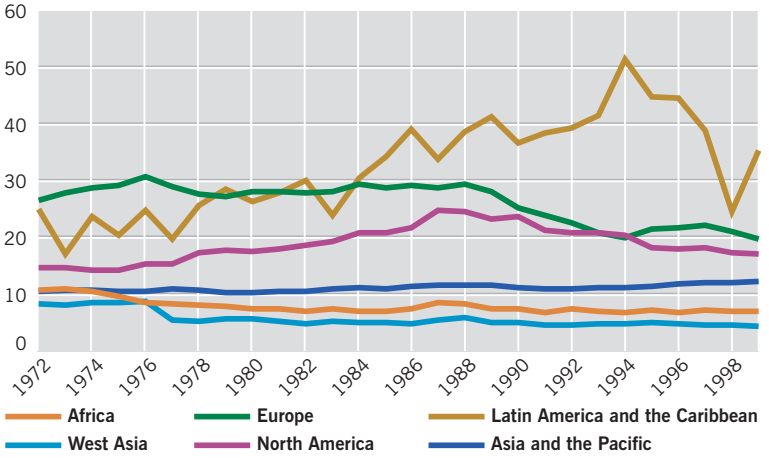
The Stockholm Conference projected that annual harvests could approximately double from 1970 levels to 'rather more than 100 million tonnes' (UN 1972b), although the depletion of some fisheries by overexploitation was also recognized. In the same year the world's largest fishery, the Peruvian anchovy, crashed spectacularly, a result of years of unsustainable harvests precipitated by a strong El Niño event. Harvests from marine capture fisheries did rise but failed to reach 100 million tonnes, fluctuating around 80-90 million tonnes from the mid-1980s (see graph). Contrary to indications that the global fisheries catch is stable, a recent study reveals that catches have actually been declining for more than a decade (Watson and Pauly 2001). The study shows that vast overreporting of catches by some countries combined with the large and wildly fluctuating catch of the Peruvian anchovy, have painted a false picture of the health of the oceans. Aquaculture production, by contrast, has risen sharply but is entirely dominated by Asia and the Pacific (see graph).

The Stockholm Conference recommended two basic approaches to fisheries management: improving management information through research, assessment and monitoring, and international cooperation. Despite great improvement in the quality and scope of fisheries information, better fisheries management has generally not been achieved. There has been an almost inexorable global trend towards increasingly intense exploitation and depletion of fisheries stocks (see figure), three-quarters of which

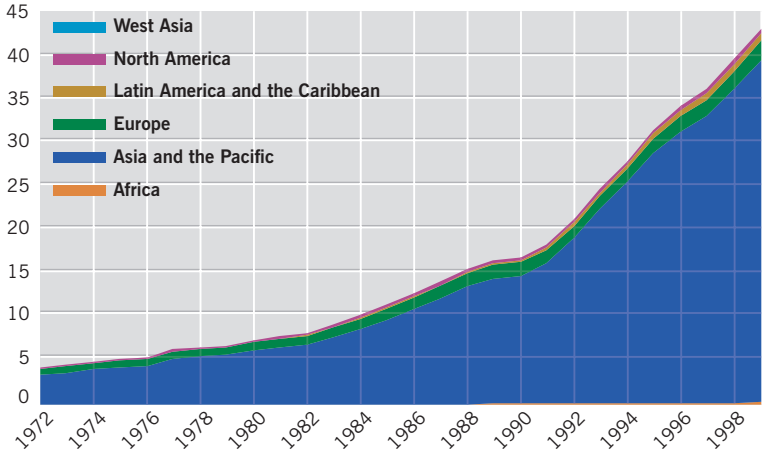
Annual fish, mollusc and crustacean catch (milllion tonnes) by region



Annual fish, mollusc and crustacean catch per capita (kg) by region



Annual aquaculture production (million tonnes) by region



Global fish, mollusc and crustacean catch seems to have stabilized at around 90 million tonnes but per capita values have declined in Europe and North America; note Latin American variations due to fluctuations in the Peruvian anchovy fishery. Aquaculture production has risen steeply for more than a decade, and is dominated by Asia and the Pacific

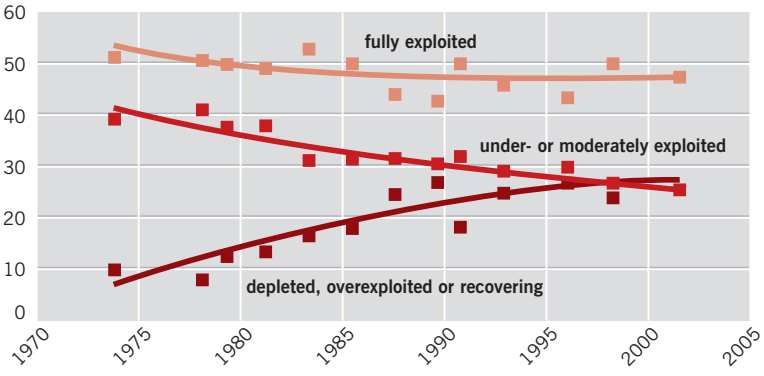
Source: compiled from Fishstat 2001 and United Nations Population Division 2001

are maximally exploited (FAO 2001), and many have collapsed. Global agreements aimed at sustainable fisheries exploitation include the adoption in 1995 of an Agreement on the Conservation and Management of Straddling and Highly Migratory Fish Stocks, and the Code of Conduct for Responsible Fisheries developed by the FAO.

Thirty years ago fisheries issues were considered almost entirely in economic and political terms. Today fisheries activities are increasingly recognized as environmental problems in the broader sense. The global expansion in yields has been delivered by fishing on progressively smaller species at lower levels in the marine food web (the knock-on effects of which are not fully understood) as the top predators have been depleted (Pauly and others 1998). The global by-catch of many million tonnes (Alverson and others 1994) includes not only charismatic animals such as dolphins and turtles but many other species. Effects on marine and coastal ecosystems are poorly known but are probably substantial (Jennings and Kaiser 1998, McManus, Reyes and Nañola 1997). Negative ecosystem impacts also result from some types of fishing gear (such as that used for bottom trawling) and destructive practices (such as blast fishing) which cause physical damage to the habitat. Recognition of the complex inter-relationships between fisheries and marine ecosystems, and the need for ecosystem considerations in the management of capture fisheries, is reflected in the FAO Reykjavik Declaration (2001) on Responsible Fisheries in the Marine Ecosystem.

While seafood is the primary source of protein for many coastal people, especially the poor, the global demise of fisheries has not been driven only by nutritional needs. Much of the catch is for luxury foods, or is processed into livestock feed. The 'tragedy of the commons' — the absence of a rational reason to restrain harvests that are freely available to all — is one root cause of overfishing while at the other end of the spectrum is so-called 'Malthusian overfishing' (Pauly 1990), when the desperately poor have no choice but to glean the last of the resource. Many attempts to manage fisheries sustainably have degenerated into a 'division of the spoils' (Caldwell 1996). Political imperatives to maintain employment, international competitiveness or sovereign rights of access have led to fisheries subsidies estimated at up to US$20 billion annually (Milazzo 1998), although these are probably now declining.

Global trends in world fisheries stocks (%)



Percentage of world fish stocks that are under- or even moderately exploited is falling; depleted, overexploited and recovering stocks are becoming more common

Source: FAO 2001

Physical alteration

The Stockholm Conference and contemporary reports recognized the importance of estuaries and other coastal habitats but the primary concern was the effects of pollution on them. Direct physical alteration and destruction of habitats is now viewed as arguably the most important single threat to the coastal environment (GESAMP 2001a). The driving force for physical alteration is ill-planned, and accelerating, social and economic development in coastal areas, which itself results from such increasing pressures as population, urbanization and industrialization, maritime transport and tourism.

Habitat alteration results from activities such as port dredging, landfill, coastal solid waste dumps, coastal construction and road building, the cutting of coastal forests, beach and reef mining, and trampling, anchor and diver damage from tourism and recreation, to name some prominent examples. Failure to consider the economic value of these habitats exacerbates the problem. Mangrove forests, for example, are generally regarded as wastelands ripe for 'reclamation', despite an economic value estimated at around US$10 000/ha/year (Costanza and others 1998). Globally, about one-half of the wetlands and more than one-half of mangrove forests have been lost over the past century (OECD and IUCN 1996), largely because of physical alteration. An estimated 58 per cent of the world's coral reefs are threatened, with direct physical destruction among the most important causes (Bryant and others 1998).

Part of the fishing industry's inadvertent by-catch — a seal ensnared in broken fishing net

Source: UNEP, L. K. Nakasawa, Topham Picturepoint

Global climate and atmospheric change

The rapid global warming caused by human-induced changes in the atmosphere that is projected by the IPCC would have dramatic effects on the ocean (IPCC 2001), threatening valuable coastal ecosystems and the economic sectors that depend upon them. Other potential impacts are complex and poorly understood. Polar warming, and melting of the ice caps, could slow down the global atmosphere/ocean 'heat engine', potentially altering the flow of major ocean currents (Broecker 1997). The warming of the ocean's surface layers, and an increased input of fresh water, could reduce the upwelling of nutrients that supports much of the ocean's productivity. On the other hand, the highly productive upwelling on the eastern side of some oceans could intensify if, as some projections predict, relatively greater warming occurs there (Bakun 1996). The IPCC predicts that storms and other extreme weather events will increase in frequency and intensity (IPCC 2001), increasing natural disturbances to coastal ecosystems and perhaps reducing their ability to recover.

There is particular concern about the possible effects of global warming on coral reefs. During the intense El Niño of 1997-98, extensive coral bleaching occurred on coral reefs worldwide (Wilkinson 1998, Wilkinson and others 1999). While some reefs quickly recovered, others, particularly in the Indian Ocean, Southeast Asia and the far western Pacific, suffered significant mortality, in some cases more than 90 per cent (Wilkinson 1998, 2000).

Some models predict a long-term shift to an increased frequency and intensity of El Niño events or similar conditions. If this occurs, bleaching could also become more frequent and intense, with irreversible damage to reefs. There is evidence that a long-term decline of reefs in the remote Chagos archipelago in the Indian Ocean is related both to El Niño events and to a long-term rise in surface temperature (Sheppard 1999). Mass bleaching of reefs in various parts of the world was also observed in 2000, a possible sign that bleaching is becoming more frequent. Reefs may also be threatened by a higher concentration of CO_2 in seawater which impairs the deposition of their limestone skeletons.

Jellyfish in the Black Sea

The effect of a jellyfish invasion on the Black Sea is one of the best documented examples of the far reaching economic and ecological consequences that can follow the introduction of an alien species into an environment favouring its almost unlimited expansion.

Mnemiopsis leidyi, a comb jellyfish, originates on the eastern seaboards of both North and South America. It abounds in ports and harbours, and is pumped in ballast water into cargo ships. These jellyfish can live for 3–4 weeks without food, by reducing the size of their bodies, so they can easily survive the 20-day voyage to the Black Sea. They were first found in the Black Sea, off the south-east Crimea, in 1982.

Damaging human activities — including overfishing, pollution, water extraction and barrages on rivers running into the sea — had set the stage for its entrance. Overfishing and eutrophication seem to have combined to remove top predators such as turbot, bluefish and monk seals and to cut the numbers of plankton-eating fish severely, opening up a niche for the jellyfish. Meanwhile plankton proliferated.

Hermaphroditic and self-fertilizing, the numbers of jellyfish exploded from 1988 onwards. The populations of plankton crashed as the invaders ate them. Fish stocks collapsed, partly because the jellyfish deprived them of their food and ate their eggs and larvae. The catch of the former states of the Soviet Union plummeted from 250 000 to 30 000 tonnes a year, and it was much the same story in Turkey. At least US$300 million was lost in falling fishery revenues between the mid-1980s and the early 1990s, with grave economic and social consequences. Fishing vessels were put up for sale, and fishermen abandoned the sea.

Source: GESAMP 2001b

Proposed protection measures to address a sea-level rise caused by climate change have shifted away from solid constructions such as seawalls in favour of a mix of soft protection measures (such as beach nourishment and wetland creation), adaptive planning (such as new building codes), and managed retreat, including cessation of new coastal construction (IPCC 2001). Some proposals to address global climate change are themselves a cause for concern, particularly those to short-circuit the natural transfer of CO_2 from the atmosphere to the ocean by fertilizing large areas of the ocean surface with nitrogen or iron to enhance phytoplankton growth, or to inject CO_2 directly into deep waters. The effects of these large-scale measures cannot be predicted but are potentially enormous.

Small island developing states (SIDS) and low-lying coastal areas are particularly vulnerable to the effects of rising sea levels and more extreme weather. Furthermore, they are essentially entirely coastal and therefore more dependent upon coastal and marine resources. Recognition of this special vulnerability in *Agenda 21* of the UN Conference on Environment and Development (UNCED) led to the adoption in 1994 of the Barbados Programme of Action on the Sustainable Development of Small Island States.

The introduction of exotic species

Another serious problem is the introduction of marine species to distant habitats where they can multiply uncontrollably, sometimes with devastating effects on the economy and marine biodiversity. Such invasions are occurring around the world with increasing frequency. The most common medium for species introductions is in ships' ballast water, with about 3 000 species of animals and plants transported every day (GESAMP 2001a). Efforts to control species introductions in ships' ballast include the development of new regulations by the International Maritime Organization for ballast water management which is expected to be adopted by 2003.

Conclusion

The Stockholm Conference marked a sea change in our approach to environmental issues by linking environment and development issues. This step towards a holistic approach has been particularly important with regard to the coastal and marine environment which is inevitably affected by different sectors of human activity. The need for a cross-sectoral, holistic approach to managing marine and coastal environments, and their watersheds, is now widely recognized and has been formalized as the discipline of Integrated Coastal Management (ICM).

The Global International Waters Assessment (GIWA) implemented by UNEP is focusing on transboundary water bodies, including marine and coastal areas. This systematic assessment of the environmental conditions and problems, and their social causes, in international waters, includes the development of scenarios of the future condition of the world's water resources and analysis of policy options. Recognition of the increasing degradation of the coastal and marine environment is also reflected by a request of the UNEP Governing Council in 2001 for the conduct of a feasibility study for the establishment of a regular process for global marine assessment.

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Coastal and marine areas: Africa

Africa's 40 000 km of coastline are characterized by a diversity of ecosystems and an abundance of natural resources. The ecosystems include mangrove swamps, estuaries, rocky shores, coastal wetlands and coral reefs; they moderate storm impacts and protect coastal features, recycle nutrients, absorb and break down wastes, provide human and wildlife habitat and maintain biodiversity, and present opportunities for recreation, tourism, transport, trade, and employment.

Africa's coral reefs — an important source of tourist revenue — are under threat from both coastal development and from potential global warming

Source: UNEP, David Fleetham, Still Pictures

Coastal and marine resources include fish and shellfish, seaweed, wood and fibre, and oil and gas. Mangrove forests extend from Mauritania to Angola on the west coast and from Somalia to South Africa on the east coast, supporting a diversity of species, many extensively used by local communities. Commercial fisheries contribute significantly to GDP and employment (particularly in small islands). Oil and gas reserves, and other mineral deposits, are also important resources for coastal countries. The growing population and its demands on these resources, however, is causing widespread degradation and pollution of marine and coastal habitats and resources. An additional cause for concern is the threat of sea level rise.

Resource degradation

Coastal and marine habitats are being physically eroded and biologically degraded through unsustainable rates of resource extraction (including intensive commercial fishing, mining of sand dunes and clearing of mangrove forests). The harvesting methods are also damaging, as in coral extraction and the use of dynamite in fishing. Activities further inland, such as damming of rivers, increased use of fertilizers and clearing of natural vegetation, also affect the coastal zone. Population growth and migration to the coast, together with rapidly expanding tourism and industrial activities, encourage high rates of infrastructure development, modifying the physical and ecological environment of the coastal zone. Lack of formal protection, sustainable development policies and inadequate resources to implement coastal and marine management have contributed to the pressures, although the situation in many countries is now changing.

Coastal drift (erosion and deposition of dunes, beaches and shoreline) is a natural phenomenon but human action can alter natural patterns. Clearing of forests and natural vegetation inland leads to increased soil erosion and increased sediment load in rivers. Sediment is eventually deposited on the seabed, smothering benthic communities and coral reefs. In contrast, when rivers are dammed upstream, sediment settles before reaching the river mouth, thus depriving coastal zones of sediment. In Western Africa, damming of the Upper Niger, Benue and Volta rivers has altered the flow reaching the Niger Delta, and local subsidence is proceeding at 25 mm per year (World Bank 1996). In Ghana, construction of the Akosombo dam in 1965 accelerated coastal erosion west of Accra to 6 metres per year, and in Togo and Benin coastal retreat has exceeded 150 metres over the past 20 years (UNEP 1999).

In Northern Africa, 40-50 per cent of the population in the Mediterranean countries lives in coastal areas (UNEP 1996), with population densities reaching 500-1 000 inhabitants/km^2 along the Nile Delta (Blue Plan 1996). In Western Africa, about one-third of the total population is concentrated on a

coastal band 60-km wide between Senegal and Cameroon, and large-scale urban growth has occurred from Accra to the Niger Delta, an environmentally sensitive portion of the African coastline.

The coastal zone is also receiving increasing numbers of tourists — in South Africa, for example, the industry grew at 7 per cent a year during the late 1990s (SADC 2000). According to FAO (1998), 38 per cent of Africa's coastal ecosystems are under high levels of threat from development-related activities. The exceptional demand for infrastructure development often results in uncoordinated and poorly planned or sited construction which can in turn cause habitat loss, destabilization or mining of dunes for construction materials, and draining of coastal wetlands. Economic costs are further inflated as governments and investors have to spend large budgets on mitigation and rehabilitation.

The demand for fisheries resources is also increasing. The marine fisheries of Africa have developed significantly over the past 30 years, and most demersal stocks are now thought to be fully exploited (FAO 1996, FAO 1997). The fishery sector contributes more than 5 per cent to GDP in Ghana, Madagascar, Mali, Mauritania, Mozambique, Namibia, Senegal and Seychelles, and the shrimp fishery on the Sofala Bank in Mozambique contributes 40 per cent of the country's foreign exchange (FAO 1997). From 1973 to 1990, fisheries supplied some 20 per cent of the animal protein intake of the population of sub-Saharan Africa. However, per capita fish catch (see figure) has been fairly static since 1972, except in Southern Africa where it has fallen sharply (FAO 1996, FAO 1997). The Cape rock lobster and abalone catches have declined steadily since the 1950s, causing concern over the sustainability of these populations and leading to the setting of annual catch limits (FAO 1997).

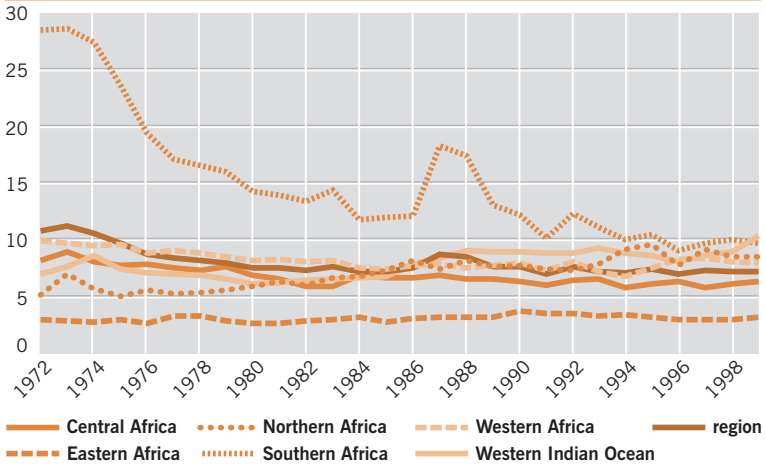
In Southern Africa, declining catches, together with a decrease in the mean sizes of fish caught, have led to calls for the protection of line fish stocks. Today fisheries management measures include minimum size limits, bag limits, use of appropriate fishing gear, closed seasons, control agreements with foreign fleets and establishment of marine reserves. In Western Africa, a Sustainable Fisheries Livelihoods Programme aims to develop social and human capital in fisheries-dependent communities, whilst enhancing natural habitats in those communities.

Addressing coastal and marine degradation

The Convention for the Protection, Management, and Development of the Marine and Coastal Environment of the Eastern African Region (Nairobi Convention) of 1985 is a UNEP Regional Seas Programme initiative, under which the erosion-associated impacts on ecosystems and species are dealt with proactively. Although all affected countries are party to the convention, it is not legally binding, and has received insufficient funding for application of many of the activities.

National efforts to regulate coastal development include the introduction of integrated coastal management policies, requirements for environmental impact assessments to be conducted, and establishment of marine national parks. The Indian Ocean Commission has facilitated the development of a Regional Sustainable Development Policy and a coral reef monitoring and action programme. In Central and Southern Africa, most countries have, or are preparing, Integrated Coastal Zone Management Plans. Africa is the top regional recipient of GEF biodiversity funds, about one-third of which are directed towards projects in coastal, marine and freshwater ecosystems.

Annual fish catch per capita (kg): Africa



In Africa and most of its sub-regions, the per capita fish catch has stagnated for some 30 years — but in Southern Africa it has fallen sharply

Note: fish catch includes marine and freshwater catches but excludes crustaceans and molluscs

Source: compiled from Fishstat 2001 and United Nations Population Division 2001

Coastal and marine pollution

The waters of the Western Indian Ocean are major sea routes for an estimated 470 million tonnes of oil every year (Salm 1996). More than 100 million tonnes of oil are transported annually through the Red Sea alone (World Bank 1996). This level of shipping incurs a high risk of disastrous oil spills. Furthermore, oil tankers frequently empty ballast and wash engines on the high seas, causing residues of degraded oil to end up on the shore. Port petroleum and oil handling activities also pose threats to the marine and coastal environment. Accidental leakage from ships, refineries and transport systems are common, especially in Mombasa.

Clean-up and disposal of oily wastes is difficult and expensive. Several oil spills off the South African coast have affected African penguins and other marine life. In response, national and regional oil spill contingency plans have been established in several African regions.

Effluent from fish processing plants, abattoirs, and chemical and manufacturing industries is frequently discharged into the sea. In Mozambique, for example, more than 100 factories in and around Maputo do not have waste treatment plants and drain toxic wastes, poisons, non-degradable substances and organic matter into coastal waters (Chenje and Johnson 1996). Most of Tanzania's textile mills release dyes, bleaching agents, alkalis and starch directly into Msimbazi Creek in Dar es Salaam (Chenje and Johnson 1996). Residues of fertilizers and pesticides washed down in rivers are prevalent in Western Africa, around cities such as Lagos, Abidjan, Conakry and Dakar. Contaminated shellfish can severely reduce economic returns on the catch and may also expose people to gastric and other infections as a result of swimming in contaminated waters or eating the contaminated food. Domestic solid and liquid waste is also a source of marine and coastal pollution, as municipalities frequently do not have the capacity to deal with the large volumes of waste produced. Solid waste is often dumped on beaches from where it can be blown or washed out to sea.

National responses to marine and coastal pollution have included public health legislation and municipal cleaning of coastal areas. International initiatives include the Convention for the Prevention of Pollution from Ships (MARPOL) and the Convention for Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region (Abidjan Convention). However, difficulties have been experienced in monitoring and enforcement, mainly because of the size of the territories requiring policing and a lack of efficient surveillance systems.

Other responses have had more success. In Northern Africa, regional emergency plans for containment and clean-up of oil spills have been put in place for the Mediterranean region and the Red Sea. The GEF's US$6 million Industrial Water Pollution Control in the Gulf of Guinea project, which aims to improve the health of the coastal waters between Guinea-Bissau and Gabon, has been instrumental in the adoption of the Accra Declaration, a regional policy for long-term sustainable development in the region.

Climate change and sea level rise

Current predictions for sea level rise over the next 100 years indicate that human settlements in the Gulf of Guinea, Senegal, Gambia, Egypt and along the East African coast, including the Western Indian Ocean islands, would be at high risk of flooding and land recession (IPCC 2001a). The Nile delta, for example, would suffer enormous economic losses due to salt-water contamination and inundation. The delta accounts for 45 per cent of national agricultural production and 60 per cent of national fish production. Sea temperature is also predicted to increase due to global climate change, which would damage coral reef ecosystems and the economic activities that they support (IPCC 2001a).

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Coastal and marine areas: Asia and the Pacific

In the past 30 years, depletion of coastal resources such as fisheries, mangroves and coral reefs has emerged as a critical issue in Asia and the Pacific. Increasing urbanization, industrialization and tourism, coupled with a growing coastal population, have degraded coastal areas, reduced water quality and increased pressures on marine resources. These pressures are exacerbated by poverty. For example, in Viet Nam poor people have become increasingly dependent on marine resources for their livelihoods (MoSTE Viet Nam 1999), and significant beach pollution occurs in the vicinity of Sihanoukville and Kep, both important tourist destinations (ADB 2000). Similar trends have been observed in almost all countries of the region.

Fisheries and aquaculture

Fish production and aquaculture are practised extensively in the region. Overexploitation of fish stocks and poor aquaculture practices are of concern in Bangladesh (DoE, SACEP and UNEP 2001), India (ESCAP and ADB 2000), Pakistan (ESCAP 1996), Sri Lanka, many Pacific Island countries (PICs) and some other countries. Overexploitation of shrimp resources in coastal waters has reduced exports from capture fisheries and encouraged the growth of aquaculture in almost all countries of the region.

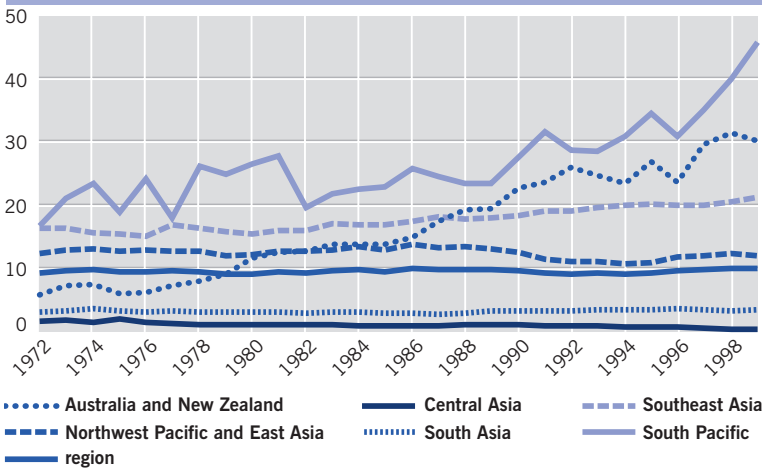
Mangrove clearance for shrimp culture has emerged as a major issue in recent years. It is estimated that more than 60 per cent of Asia's mangroves have already been converted to aquaculture farms (ESCAP and ADB 2000). Besides encroaching on mangroves, aquaculture has led to the release of nutrients, pathogens and potentially hazardous chemicals into marine waters. In India, prawn farms have been constructed in low-lying coastal areas, depriving impoverished farmers of agricultural land, causing salinization of groundwater in coastal villages and polluting waterways with excess nutrients (Subramaniam 1994 in ESCAP and ADB 2000).

A number of countries including Australia, India, Maldives, New Zealand, Philippines and Sri Lanka have developed legislation to address problems associated with pollution and overexploitation of fish stocks. Governments have also initiated steps for fisheries management by reducing fishing subsidies and regulating fishing access rights. The South Pacific tuna fishery offers a model of international cooperation for open sea fishing that may prove to be the first sustainable, multinational ocean fishery in the world. Despite these positive initiatives, the pelagic and near-shore fisheries continue to be overexploited by multinational corporations as well as local fishermen, and negotiations are required to ensure that the benefits of sustainable exploitation remain with Pacific communities.

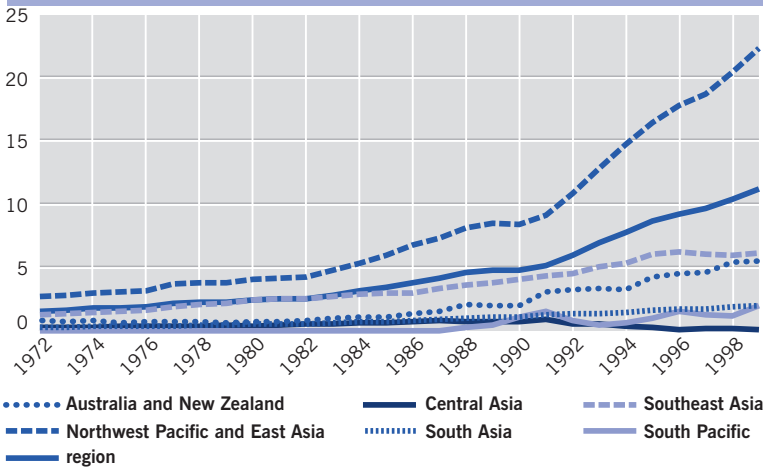
Coral reefs and coastal resources

Coral reefs are under stress in many areas, especially those near shallow shelves and dense populations. More than half of the world's coral reefs are located in the PICs, and large areas are already degraded. The causes range from global, large-scale changes in the

Annual fish catch per capita (kg): Asia and the Pacific



Annual aquaculture production per capita (kg): Asia and the Pacific



While regional fish catch has changed little over 30 years, aquaculture production has increased markedly

Note: fish catch includes marine and freshwater catches but excludes crustaceans and molluscs

Source: compiled from Fishstat 2001 and United Nations Population Division 2001

ocean environment and global warming to tourism and recreation, high population density and economic development in coastal areas since the late 1980s.

Most coral reefs in South Asia were adversely affected by coral bleaching in mid-1998. Extensive damage to reefs has been reported from the Andaman Islands, the Gulf of Mannar in India, Lakshadweep, Maldives, Sri Lanka and the PICs. Increasing water temperatures and increased levels of dissolved carbon dioxide in seawater have resulted in the widespread death of stony corals throughout the tropics (Wilkinson 2000). An important development in coral reef conservation and management was the establishment of the Global Coral Reef Monitoring Network (GCRMN) for South Asia in July 1997 by the International Coral Reef Initiative (ICRI) to facilitate monitoring, training, networking and management of coral reefs.

Marine and coastal pollution

Pollution has considerably degraded the coastal and marine environment, including estuaries, of the region over the past 30 years. Increased wastes from land-based urban, industrial and agricultural activities as well as from offshore oil and gas exploitation are discharged untreated in the coastal region (MoSTE Viet Nam 1999).

The most significant sources of pollution include oil from ships, sewage and other domestic wastes, and industrial effluents. The main route of marine transport of oil from the Gulf is across the Arabian Sea, and accidental oil spills have been frequently reported along oil transport routes, at points of discharge and loading of oil carriers. The shipping of oil coupled with increasing emphasis on offshore oil exploration makes the northern Indian Ocean extremely vulnerable to oil pollution. Oil spills also cause severe pollution in ports in Bangladesh, Indonesia, Malaysia and Pakistan (DoE Malaysia 1996, 1998). In addition, the cleaning of oil tanks in and around ports has led to the frequent formation of tar-balls on the southwestern beaches of Sri Lanka. In the PICs, marine pollution from ships is a threat that is likely to increase as trade and economies develop further.

The enhanced use of agrochemicals on land and discharge of chemicals into seawater is a common problem. An estimated 1 800 tonnes of pesticides enter the Bay of Bengal every year (Holmgrem 1994). In the Sea of Japan, a survey has revealed high concentrations of mercury, the source of which could have been wastewater from chemical plants (MSA 1997), while the Russian Federation admitted in 1993 that the former Soviet Union had dumped nuclear wastes there 'for decades' (Hayes and Zarsky 1993). In spite of international regulations, marine pollution in the Sea of Japan and the Yellow Sea has continued to worsen.

Tourism and other recreational activities also pose a threat to coastal ecosystems in many countries. The construction of tourism infrastructure has both a direct and indirect adverse impact on coastal environments through infilling, dredging and re-suspension of contaminated silts, discharge of untreated or partially treated sewage, operational leaks, and discharge of hydrocarbons and waste dumping. Sand dunes, an important component of coastal ecosystems in the region, have also been eroded as a result of tourism activities.

Sediment load in the coastal zones of South Asia is high, mainly as a result of soil erosion caused by poor land-use practices and construction activities. Annually, about 1.6 billion tonnes of sediment reach the Indian Ocean from rivers flowing from the Indian

Managing ballast water discharges in Australia

The annual discharge of ballast water in Australian coastal waters is about 150 million tonnes from international vessels and 34 million tonnes from coastal vessels. A major incursion of black-striped mussels in Darwin Harbour in early 1999 prompted the establishment of a National Task Force on the Prevention and Management of Marine Pest Incursions. A major recommendation of the task force was the establishment of a single national management regime for vessels. Its recommendations are implemented through the National Introduced Marine Pests Coordination Group which was established under the Ministerial councils for environment, fisheries and aquaculture, and transport. The Consultative Committee on Introduced Marine Pest Emergencies, a mechanism for emergency responses to introduced marine pests, was introduced in 2000.

Since 1990 the Australian Quarantine and Inspection Service (AQIS) has adopted voluntary guidelines and measures to manage ballast water. In July 2001, Australia introduced mandatory ballast water management for international vessels entering its waters. Vessels are assessed by AQIS: high risk vessels are required to fully exchange ballast water at sea, while low risk vessels are allowed to exchange within coastal waters.

Source: Environment Australia 2001

sub-continent. The total sediment load of the river system of Bangladesh alone amounts to about 2.5 billion tonnes, of which the Brahmaputra carries 1.7 billion tonnes and the Ganges 0.8 billion tonnes (UNEP 1987). Coastal erosion is severe in many areas including the Andaman coast, the Gulf of Thailand, Japan and the PICs.

Policy responses

The gradual move towards integrated planning and development of coastal and marine areas, through national, regional and global initiatives, is an encouraging trend. Many countries have adopted the two major international agreements on marine pollution: the London Convention of 1972 and the International Convention for the Prevention of Marine Pollution from Ships (MARPOL) of 1973, with its 1978 Protocol.

ESCAP has instituted studies relating to a Coastal Environmental Management Plan for a number of countries in South Asia, including Bangladesh, Pakistan and Sri Lanka. The Plan requires intensive multidisciplinary studies encompassing socio-economic dynamics, industry, agriculture, fishery, forestry, water resources, energy, ecology and health, as well as close collaboration between the scientific community and governments, other institutions and experts. Mechanisms for implementing coastal environmental management continue to be developed, and Sri Lanka appears to have made more progress than other countries.

Another major multilateral effort that aims at marine and coastal environmental protection at the regional level is UNEP's Regional Seas Programme initiated in 1974. At the sub-regional level the South Asian Seas Action Plan was adopted in 1995 and includes Bangladesh, India, Maldives, Pakistan and Sri Lanka. In 1995, 108 governments across the world adopted the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities. Many countries have also introduced national legislation and projects to address marine pollution.

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Coastal and marine areas: Europe

Europe is almost surrounded by semi-closed and closed seas, such as the Adriatic, Mediterranean, Black, Azov, Caspian, Baltic and White seas. Coastal landscape features range from dunes, cliffs, lagoons and river deltas to very diverse islands, with numerous important marine and bird areas, including 449 Ramsar sites in Western Europe. The Danube has the largest delta in Europe, encompassing about 580 000 ha (113 000 ha of which are permanently covered by water). The limited water exchange of the semi-closed and closed seas with the open ocean makes these seas very sensitive to pollution, which increased dramatically between the 1970s and 1990s, although this trend has been halted and even reversed in a few places in the past ten years. The open coasts of the Atlantic show impacts from land-based pollution, offshore oil and gas, and shipping operations and accidental oil spills.

Infrastructure development

Some 85 per cent of European coasts are at high or moderate risk from development-related pressures (Bryant and others 1995). The rapid development of tourism, increasing transport, intensive agricultural and industrial activities, and continuing urbanization have all put pressures on coastal areas. As a result of infrastructure development and other construction activities, as well as natural causes, coastal erosion is a major issue in some areas, with 25 per cent of the European coast subject to erosion (CORINE 1998). The challenges for coastal areas are to cope with further economic development and hence growing environmental pressures.

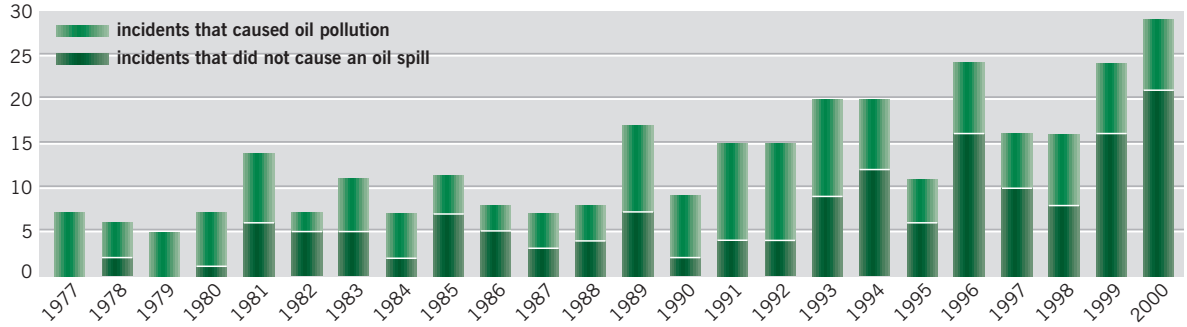
Tourism is important for the coastal areas of Europe, considering that they host two-thirds of the region's tourism (Europe attracts 60 per cent of all international tourism). The Mediterranean is the world's leading destination, accounting for 30 per cent of international tourist arrivals and for one-third of the receipts from international tourism. The number of tourists on the Mediterranean coast is expected to rise from 135 million in 1990 to 235-353 million in 2025 (EEA 1999a). Tourism is growing at a rate of 3.7 per cent a year (EUCC 1997) and its demands consume increasing amounts of land. Similar developments can be observed in other important tourist areas along the Baltic, North Sea and northeast Atlantic coasts. Tourism accounts for 7 per cent of pollution and makes a huge contribution to water scarcity, water consumption by this sector being three to seven times higher than for local populations (EEA 2001).

Pollution

Although shipping is considered to be an environmentally friendly mode of transport, it can have major negative environmental impacts if standards are not observed or enforced. Maritime transport increased in the EU by 35 per cent between 1975 and 1985 but has since levelled off (EUCC 1997). This has had an impact on SO_2 emissions: maritime transport now accounts for 10-15 per cent of total SO_2 emissions (EEA 1999b). It is estimated that 30 per cent of all merchant shipping and 20 per cent of global oil shipping (see map) crosses the Mediterranean every year (MAP and REMPEC 1996b).

Pollution from land-based sources is still serious in many areas. Many of the 200 nuclear power plants operating throughout Europe (EEA 1999b) are located in coastal regions or along major rivers, because of the large volume of cooling water needed. Since the 1960s, radioactive discharges from the nuclear fleets of the former Soviet navy have affected remote areas of the Arctic and Pacific Oceans (Yablokov 1993). About 150

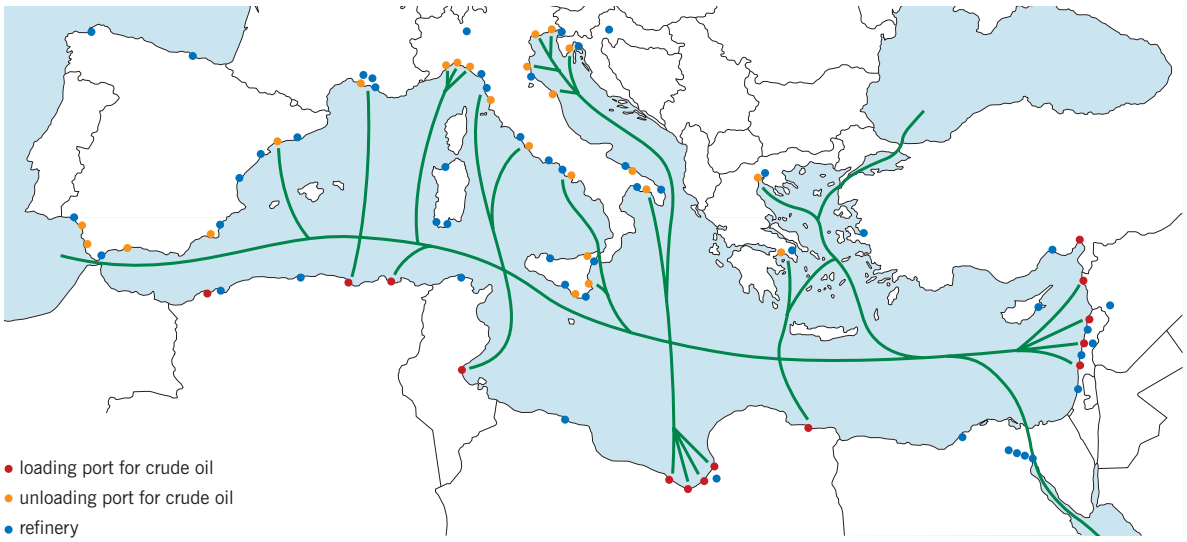
Marine oil transport incidents (number) in Europe



Although the number of incidents related to oil transportation has risen over the past two decades, the proportion that actually results in oil spills is decreasing

Source: MAP and REMPEC 1996a

Oil tanker routes in the Mediterranean



Some 30 per cent of all merchant shipping and 20 per cent of global oil shipping crosses the Mediterranean every year

Source: MAP and REMPEC 1996b

decommissioned nuclear submarines are rusting in harbours on the Kola Peninsula, Kamchatka and the Russian Far East, representing a potential environmental threat. Although the Helsinki Commission (HELCOM) reports that there is no environmental threat from chemical munitions or radioactive substances in the Baltic marine environment, citizens groups are still concerned (HELCOM 2001). Discharges from nuclear reprocessing plants originating from the United Kingdom and France are also a matter of concern in the maritime area of the North Sea and the Atlantic (OSPAR 2001).

Pollution by heavy metals and persistent organic pollutants, and contamination by microbes and other substances, occur in all European seas. However, there have been some significant improvements:

- Inputs of hazardous heavy metals and organic substances into the northeast Atlantic fell significantly between 1990 and 1998 after increasing for several decades. Atmospheric inputs of heavy metals into the North Sea also fell, showing the effect of air pollution abatement policies in the surrounding countries (EEA 2001).
- Between 1985 and 1998, nitrate concentrations decreased by 25 per cent (against a 50 per cent target) in the coastal areas covered by the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) and the Baltic Marine Environment Protection Commission (EEA 2000).
- The reduced phosphate content of detergents and other measures such as wastewater treatment in catchment areas have resulted in an average decrease of phosphate concentrations in some regions, including the Skagerrak, Kattegat, the German Bight and the Dutch coastal zone (EEA 2000).

Wastewater treatment still needs to be improved, however. High population concentrations also result in high levels of wastewater, which is often not sufficiently treated — for example, in the Mediterranean, Adriatic and Black seas. Until the end of the 1980s, large cities on the shores of the Baltic Sea such as St Petersburg (4 million inhabitants) and Riga (800 000 inhabitants) had no wastewater treatment plants (Mnatsakanian 1992).

Solid waste is also a problem in some European seas. A recent study showed that the main sources of solid waste on the coast, sea surface and sea bed in the Mediterranean region are direct disposal from households, tourist facilities and run-off from coastal landfill sites.

Policy measures

Global, regional and national measures are being taken to reduce the input of polluting substances into marine waters. International agreements such as OSPAR, HELCOM and the Mediterranean Action Plan (MAP) provide a binding legal framework. In the OSPAR and Baltic Sea areas, for example, targets have been set to

Hazards and contingency planning for oil spills

The main principles for international cooperation in preparedness for and response to marine pollution incidents are defined by the Emergency Protocol to the Barcelona Convention. In order to assist coastal states in its implementation, the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC) was established in Malta in 1976. Since 1977, REMPEC has systematically collected reports on incidents causing or likely to cause pollution of the sea by oil. Some 311 incidents were recorded between August 1977 and December 2000, 156 of which actually resulted in the spillage of oil. Spill response operations in the Mediterranean between 1981 and 2000 were regularly conducted either by national or local authorities or by the spill clean-up contractors under their supervision. To date, nearly 2 000 people have participated in a training programme developed by REMPEC to assist coastal states in developing their own capabilities for effective responses to pollution incidents. The only case that necessitated mutual assistance between neighbouring countries (France and Italy) was the spill from the tanker *Haven* near Genoa in Italy, with the loss of 144 000 tonnes of oil in 1991.

Source: REMPEC 2000

reduce emissions, losses and discharges of hazardous wastes with the ultimate aim of achieving concentrations near background values for naturally occurring substances and close to zero for synthetic substances by 2020 (HELCOM 1998).

Some states have difficulties in implementing their obligations under these agreements, and this reduces the effectiveness of regional MEAs such as MAP and the Black Sea Convention. Assistance programmes from wealthier states may play an important role in improving implementation and compliance in relation to regional and sub-regional MEAs.

Enforcement has improved significantly in some CEE countries, and the introduction of economic instruments has had an impact. For example, the European Bank for Reconstruction and Development (EBRD) has made funding available for infrastructure improvements in the transition countries in cooperation with HELCOM. However, the slow transformation of large, polluting, state-owned enterprises continues to present obstacles.

The recently adopted European Water Framework Directive provides a strong instrument for the control of pollutants and monitoring in the catchment and coastal areas and improvement of water quality for all EU States and incoming accession States.

A recent example of a non-binding agreement at the global level is the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA). Its implementation will require new forms of collaboration between governments, organizations and institutions concerned with marine and coastal areas at all levels — national, regional and global. Although still in its early stages, the interest and commitment shown by governments in Europe are encouraging.

The main challenge in coastal areas is the implementation of Integrated Coastal Zone Management which aims at harmonizing the various, sometimes conflicting, uses of the coastal zone. In regions such as the Baltic Sea, bordered by several independent nations, transboundary and international cooperation is a basic requirement.

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Coastal and marine areas: Latin America and the Caribbean

The key environmental problems facing the coastal and marine areas of the Latin American and Caribbean Region are related to habitat conversion and destruction, pollution produced by human activities and overexploitation of fisheries resources. The underlying causes of these problems are linked to the development of coastal areas for tourism, infrastructure and urbanization, and to the conversion of coastal habitats for uses such as agriculture and aquaculture. In addition to diminished natural productivity of coastal areas, most coastal and offshore fisheries are severely overexploited. These problems are expected to be significantly exacerbated by climate change and sea-level rise (UNEP 2000), particularly in the Caribbean. The state of coastal areas throughout the region is illustrated in the table on the right. Coastal areas that are heavily populated and exploited require intensive management and infrastructure to sustain coastal ecological systems. However, complicating coastal zone management are multiple physical and political jurisdictions dividing ecological boundaries and scales.

Exploitation of coastal and marine resources

The region's coastal zones are the foundation of its economy and sustainability — 60 of the 77 largest towns are on the coasts, and 60 per cent of the population lives within 100 km of the coast (Cohen and others 1997). Development of residential areas and tourism infrastructure has greatly changed the features of coastal areas in the region. Physical alterations of coastlines due to urban growth and the construction of ports and industrial infrastructure are among the major factors that impact the region's coastal and marine ecosystems.

Tourism represents around 12 per cent of the GDP of the region, much of which is concentrated along the coasts. Some 100 million tourists visit the Caribbean each year and contribute 43 per cent of GDP and one-third of export revenue (WTTC 1993). The direct and indirect effects of tourism on coastal and marine areas can be seen in the increasing conversion of coastal habitats and subsequent impacts. For example, overextraction of ground water by expanding tourism infrastructure results in the intrusion of brackish or salt water into coastal aquifers, eventually contaminating the groundwater system and coastal soil.

Management status of principal coastal and marine areas

Conditions of use	*Management and infrastructure support*	*Biogeographical zones*
Intensively used and heavily populated coastal areas Intensive fishing pressure from both coastal populations and offshore fisheries High density or concentration of oil terminals, ports and shipping lanes	Intensively managed – high infrastructure support – regulatory, conservation and education efforts	Some areas of the tropical northwestern Atlantic, including Cancun, Mexico. Southeast Atlantic: Brazil
	Moderate management – regulatory efforts with limited enforcement, limited conservation and education efforts	Most areas of the tropical northwestern Atlantic, such as Puerto Rico, parts of US Virgin Islands, Barbados and most islands of the Lesser Antilles Warm temperate northeastern Pacific, including Mexico Galapagos Islands
	Little to no region-wide management	Most areas of the tropical eastern Pacific, warm temperate southwestern Atlantic, including Argentina, Brazil, Uruguay Some areas of tropical eastern Pacific
Moderately used coastal resources	Intensively managed	Areas of the warm temperate southeastern Pacific, including Peru and Chile — especially those related to coastal shelf fisheries
	Moderate management	Cold temperate South America, including Chile and Argentina
	Light management	Tropical southwestern Atlantic: Brazil
Lightly used coastal resources	Intensive management	Only a few examples of lightly used, intensive management in high profile remote marine protected areas
	Moderate management to little to no management	Very few areas under this category — even large, remote areas such as the Orinoco River delta are affected by land use alterations in the delta and upland watershed areas, even though use of the estuarine resources may be low Also Juan Fernandez and Desventuradas Islands

Pollution

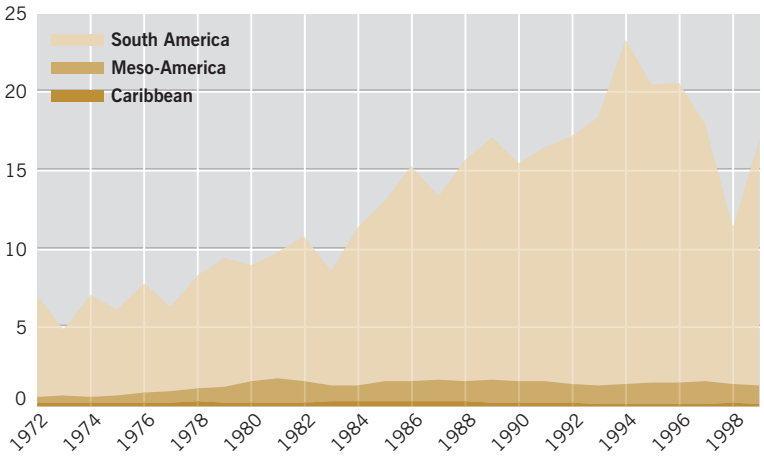
Pollution is mainly caused by discharge of municipal and industrial solid waste and wastewater, run-off from agricultural fields, and maritime transport (especially of hazardous substances), as well as oil and gas extraction, refining and transport. Regional capacity for wastewater treatment is low; some 98 per cent of domestic wastewater is discharged into the northeast Pacific and 90 per cent into the wider Caribbean without treatment (UNEP 2001).

The effects of pollutants from land-based activities are exacerbated in large watersheds, and in turn may affect distant states. The transboundary effects of five major watersheds are especially notable: the Mississippi, the Amazon, the Plata, the Orinoco and the Santa Marta. Satellite images have shown large sediment discharges from coastal rivers and some large islands travelling across thousands of kilometres

of ocean. During a fish kill episode in the Windward Islands in February 2000, pathological bacteria were detected that previously had been reported only in continental freshwater systems (Caribbean Compass 1999). It was suggested that the pathogens had been transported in sediments originating in floods in the Orinoco basin.

Maritime transport is a significant source of coastal and marine pollution in the region especially the release of oil through dumping of bilge water and tank rinsing. Other threats from maritime transport include discharge of sewage, garbage and hazardous chemicals, and introduction of exotic or invasive species to new areas through loading and off-loading of ballast water.

Fish catch (million tonnes): Latin America and the Caribbean



Regional fish catch peaked in 1994 but collapsed later as a result of a strong El Niño event

Note: includes inland fisheries but excludes molluscs, crustaceans and aquaculture

Source: compiled from Fishstat 2001

The ports in the region are the second most important destination for containerized goods from the United States, and the Panama Canal is a principal link for global maritime trade. Between 1980 and 1990, maritime transport in the region increased from 3.2 to 3.9 per cent of global trade, and significant increases are expected to continue as a result of trade liberalization and privatization of regional ports (UNCTAD 1995). Without counter measures, environmental problems related to maritime transport are expected to worsen in the future.

The marine and coastal areas of Latin America and the Caribbean are among the most productive petroleum-producing areas in the world. The most important pressure on the marine and coastal environment in specific localities is the risk of oil spills from oil and gas exploration, production and distribution systems. The world's largest recorded oil spill was the Ixtoc submarine oil blow-out in the Bay of Campeche, Mexico, on 3 June 1979 with a total estimated outflow of oil greater than the volume from the *Exxon Valdez* spill. In 1999 and 2001, significant coastal spills and pipeline ruptures in Brazil and Colombia caused both active public concern and new restrictions to control future spills. All oil and gas exploration operations have the potential to cause severe damage to the coastal and marine environment as a result of large and small spills, and chronic leaks.

Fisheries

Overexploitation of fisheries resources and the problems of by-catch and discards have become features of the regional fisheries regime. The catch from the region's seas has generally increased over the past 30 years (see figure). Total fish catch (including inland fisheries but excluding molluscs, crustaceans and aquaculture) reached a regional peak of more than 23 million tonnes in 1994 (nearly 30 per cent of the global total). From 1985 to 1995, many South American countries doubled or tripled their catch, and Colombia's catch increased five-fold. However, in 1998 the regional catch dropped considerably to 11.3 million tonnes (15.9 per cent of the global total), due to adverse climatic factors caused by the El Niño.

A recent study that established geographic priorities for marine conservation in the Central Caribbean ecoregion indicated that excessive exploitation was a threat in 34 of the 51 local production systems (Sullivan and Bustamante 1999). The region also faces the problem of large quantities of by-catch and discards that include turtles, marine mammals, marine birds and other smaller but ecologically important species. At present, the region has no system to record indicators on the health of resources and ecosystems that would gear actions to the recovery of overexploited species and their environment (UNEP 2001).

Measures to halt overexploitation of fisheries have been implemented in some countries. In January 2000, the Government of the Bahamas and local NGOs agreed to the establishment of five 'No Take' marine reserves near the offshore islands of Bimini, Berry, South Eleuthera, Exuma and northern Abaco. The objective is to establish, with full community participation, a complete system of such reserves, to

aid in the prevention of overfishing and loss of marine biodiversity. This would result in the protection of 20 per cent of the coastal and marine environment (NOAA 2001).

Policy responses

International policy responses to the problems described above have been many and varied. Most of them are based on fisheries conventions, international shipping conventions, or the large number of agreements tied to the United Nations Convention on the Law of the Sea. At the same time, institutional and organizational weaknesses in the countries of the region, and the myriad authorities responsible for marine and coastal management, make the implementation of policies a difficult task.

The following are among the most important multilateral agreements and action plans:

- The Convention on the Protection and Development of the Marine Environment of the Wider Caribbean ('The Cartagena Convention') (1983) and its protocols (on oil spills and protected areas and land-based pollution).
- UNEP's Regional Seas Programme, and the international project for the elimination of barriers to implement ballast water controls and management measures for developing countries, proposed for the period 2000-2002 by the International Maritime Organization (IMO).
- The International Coral Reefs Action Network (ICRAN), an important effort to halt the degradation of coral reefs, which is supported by the United Nations Foundation (UNF).
- The Caribbean Planning for the Adaptation of Global Climate Change (CPACC) project which assists the 12 Caribbean CARICOM countries to prepare for the negative impacts of possible global climate change, especially with respect to the rise in sea level, by measuring their vulnerability and planning for the adaptation and development of their capacity to deal with the problem.

Few of the conventions mentioned, however, have been in force long enough, and with adequate established infrastructure, to assess their strengths and weaknesses. It is clear, however, that regional environmental monitoring processes need to be geared to assessing environmental conditions as well as monitoring implementation activities designed to restore sustainability of coastal and marine areas and their resources.

Capacity for wastewater treatment is low; 98 per cent of domestic wastewater is discharged into the northeast Pacific and 90 per cent into the wider Caribbean without treatment

Source: UNEP, David Tapia Munoz, Topham Picturepoint

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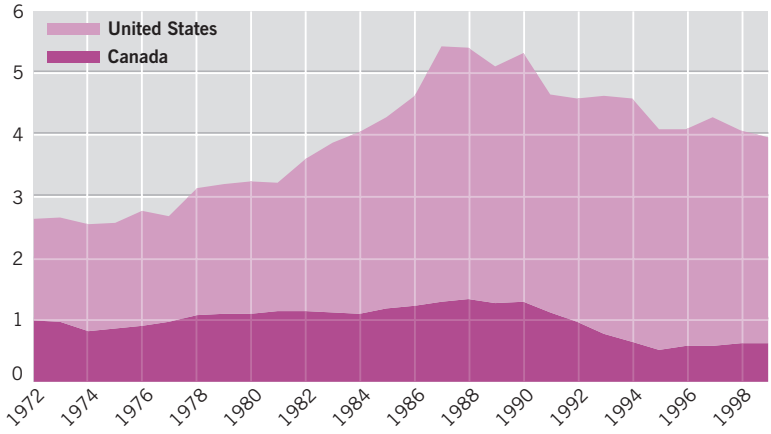
Coastal and marine areas: North America

Almost 25 per cent of Canada's and about 55 per cent of the United States' populations live in coastal areas (CEQ 1997, EC 1999). The US coastal population is growing at four times the national average, with some of the highest levels of urban growth taking place in small coastal cities (CEC 2000a). This is of concern because coastal ecosystems are among the richest storehouses of marine biodiversity and provide important ecosystem goods and services. Conversion of these fragile systems to urban uses can lead to physical degradation, exploitation of marine resources and pollution.

Annual fish catch (million tonnes): North America



North American fisheries have been in severe decline since the late 1980s, with at least one-third of all species overfished

Note: fish catch includes marine and freshwater catches but excludes crustaceans and molluscs, and aquaculture production

Source: compiled from Fishstat 2001

Issues of particular concern for the region are the excessive input of nitrogen from land-based activities and the precipitous decline in fisheries (see graph): 21 of the 43 ground-fish stocks in Canada's North Atlantic are in decline and nearly one-third of US federally managed fisheries are overfished (CEC 2000a).

Pacific Northwest salmon fishery

The Pacific Northwest supports rich fishery resources, of which salmon is of primary importance. Historically abundant in many Pacific coastal and interior waters, salmon runs and species diversity have been shrinking since the late 19th century, due to dam construction (particularly in the United States), rockslides, poor management and overfishing (DFO 1999a). By the late 1980s, both countries had imposed severe restrictions on harvests of some salmon species but, despite these and other measures, by the early 1990s salmon catch and value showed significant declines; by 1999, 24 sub-species of west coast salmon had been listed under the US Endangered Species Act and Canada had closed or curtailed salmon harvests for some species in a number of its major rivers (Carlisle 1999, TU and TUC 1999).

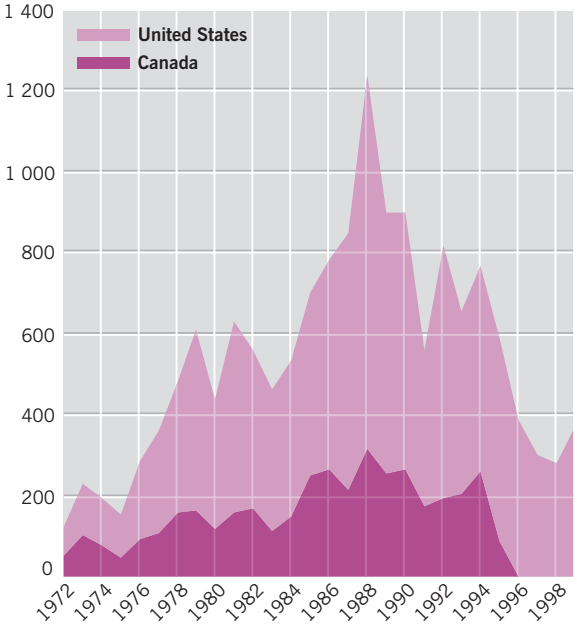
Complicating the issue have been the two international borders that separate British Columbia's waters from Alaska's and those of the northwest United States (DFO 1999a, TU and TUC 1999). During their life cycle, salmon of US origin travel through Canada's waters and vice versa, resulting in a history of intercepting fishery practices that has encouraged unsustainable harvests (DFO 1999a). The1985 Pacific Salmon Treaty attempted to resolve this issue but broke down in 1992 because of disagreements. A 1999 amendment to the treaty based on sustaining wild stocks, sharing costs and benefits, and a common basis to assess stocks, monitor fish and evaluate performance is more promising (DFO 1999b, NOAA 1999).

The combined effects of fishing, climate change (see box below) and habitat conditions have prompted a number of status reviews, renewed fishing agreements and new management approaches. For example, in 1998 Canada initiated the Pacific Fisheries Adjustment and Rebuilding Program to conserve and rebuild Pacific salmon stocks and to revitalize Pacific salmon fisheries. It has also implemented a precautionary approach to salmon management, resulting in significant harvest reductions to protect stocks at risk (DFO 1999c). In December 2000, the United States released a comprehensive, long-term

Impacts of climate change on Pacific salmon and other wild fish stock

Both Canada and the United States are concerned about the potential effects of climate change on salmon populations and other wild fish stocks in North America's coastal and oceanic waters. Studies by Canadian government scientists that simulated expected changes from a doubling of CO_2 in the atmosphere indicate that the resulting change in climate could virtually eliminate salmon habitat from the Pacific Ocean (NRC 1998). A 1994 Environment Canada study of the impact of climate change on Fraser River salmon reported that altered flow regimes, aquatic temperatures, river hydrology and seasonal run-off will intensify competition among water users in the watershed (Glavin 1996). A recent US report on climate change impacts notes that a projected narrowing in the annual water temperature range in many estuaries may cause species' ranges to shift and increase the vulnerability of some estuaries to introduced species (US GCRP 2000).

Pacific Northwest salmon catch value (US$million/year)



Value of North American salmon catch has plummeted since 1988 as a result of declining stocks and attempts to protect stocks

Source: DFO 2000b, NMFS 2000

federal strategy to help restore the 14 salmon sub-species in the Columbia River Basin listed on the Endangered Species Act.

As those dependent on salmon for income struggle to survive (see graph), both countries are taking additional measures to help restore these and other wild fish stocks to the region's coastal and marine waters and to enhance and maintain global biological diversity. Recent restrictions have indeed improved the ocean survival of some important stocks but it remains to be seen if all Pacific salmon species rebound (DFO 2000a, 2001).

Nutrient loading

Nutrient inputs to marine and coastal ecosystems have increased dramatically over the past three decades due to large increases in population density, fossil fuel use, sewage inputs, livestock production and fertilizer use (EC 2000). These activities release nitrogen and phosphorus, which can enhance plant growth in aquatic systems and lead to oxygen depletion and multiple effects on the ecosystem including destroyed fish habitat, coastal pollution and harmful algal blooms (EC 1999, 2000).

In many parts of North America, nutrients from non-point sources come mainly from fertilizer and manure run-off. Over the past 30 years, fertilizer use has increased by almost 30 per cent while a trend towards rearing livestock in intensive feedlots has led to the release of large amounts of manure to surface and coastal waters (Mathews and Hammond 1999). Atmospheric inputs of nitrogen derived from manure, as well as from vehicles and electric utility power plants, are also significant (NOAA 1998a).

Since the early 1970s, anti-pollution legislation has greatly reduced point sources of nitrogen and phosphorus, principally from the discharge of municipal sewage and industrial wastes and the control of phosphates in laundry detergents (NOAA 1998a, EC 2000). However, most municipal wastewater discharged into Canada's coastal waters is still either untreated or only partially treated (EC 2000). Canadian estuaries in the North Atlantic are less severely affected by nutrient loading than more southerly ones due in part to a cooler climate and significant flushing of coastal waters (NOAA 1998b). Along the north Atlantic coast, non-point sources of nitrogen are some ninefold greater than inputs from wastewater treatment plants (EC 2000).

In 1998, more than 60 per cent of US coastal rivers and bays were moderately to severely degraded by nutrient contamination, and nitrogen was found to be the single greatest environmental threat in some 'trouble' spots on the Atlantic coast (NOAA 1998b, Howarth and others 2000). The US Clean Water Act and the 1972 Coastal Zone Management Act directed states to develop management plans for non-point contamination sources and provided funding and incentives to implement them (NRC 2000). The 1987 US National Estuary Program aims to minimize regional nutrient contamination (see box).

Nutrient enrichment is probably a contributing factor in the recent dramatic increase in the intensity, frequency and spatial extent of algal blooms or red

Chesapeake Bay

The 1987 Chesapeake Bay Program was set up under the US National Estuary Program. It is a federal-state-local partnership to reduce nitrogen and phosphorus loading to the Bay by 40 per cent. This region has a population of more than 15 million people, and important commercial fish and shellfish harvests, and is a major stopover for migratory birds. By the late 1990s, only the phosphorus reduction goal had been met. Progress in reducing nutrients is being hampered by population growth and development.

tides, causing increased economic losses and health impacts. The number of coastal and estuarine locations in the United States with major recurring incidents of Harmful Algal Blooms (HABs) doubled between 1972 and 1995 (US Senate 1997).

The impacts of HABs can include human illness and death from eating contaminated fish or shellfish, mass mortalities of wild and farmed fish, and changes in marine food webs. In response to incidents of human illness from contaminated shellfish, both Canada and the United States have developed testing and water quality programmes to identify phytoplankton toxins and to provide information about them to the public.

Ocean acts in both countries (1997 in Canada and 2000 in the United States) establish frameworks for improving the stewardship of North America's coastal and ocean waters (EC 1999). Since 1996, the North American Commission for Environmental Cooperation has been facilitating regional implementation of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities in North America (CEC 2000b).

As yet, there is no regional strategy to address nutrient loading in North America's coastal waters, and coordination among the various agencies responsible for their management is inadequate (NRC 2000). Evidence suggests that the situation can be reversed, but the need remains for increased political action and changes in the activities in the watersheds and airsheds that feed coastal streams and rivers.

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Coastal and marine areas: West Asia

The coastal zones of West Asia are under various degrees of stress as a result of major demographic shifts from rural to coastal urban areas, intense urbanization of coastal zones and dumping of untreated waste. Furthermore, regional wars and internal conflicts have introduced new dimensions to the region's environmental problems and have stressed both financial and natural resources.

Actions at national and regional levels, the latter through the Regional Organization for the Conservation of the Marine Environment of the Red Sea and Gulf of Aden (PERSGA countries) and the countries of the Regional Organization for the Protection of the Marine Environment (ROPME countries, under the UNEP Regional Seas Programme's Kuwait Action Plan) focus on the key environmental issues that have emerged in the region: physical alterations, overexploitation of marine resources and marine pollution (UNEP and PERSGA 1997, UNEP 1999, UNEP MAP 1996).

Coastal development and physical alteration

Rapid urbanization has occurred in most of the countries of the region over the past three decades, particularly in the smaller countries such as Bahrain, Iraq, Jordan and Lebanon. By the early 1990s, some of the GCC countries had developed more than 40 per cent of their coastline (Price and Robinson 1993), and recent estimates indicate coastal investments in the region to be worth US$20–40 million/km of coastline (UNEP 1999).

In Lebanon, more than 60 per cent of the population of about 3.5 million live and work along a very narrow coastal strip (Government of Lebanon 1997, Grenon and Batisse 1989). Some 64 per cent of the population of all the Gulf Cooperation Council (GCC) countries except Saudi Arabia live along the western coasts of the Gulf and the Arabian Sea (ROPME 1999). More than 90 per cent of the population of Bahrain and 37 per cent of Kuwaitis live along the coast.

Coastal populations are expected to increase — for example, the population of Aqaba is predicted to more than double from 65 000 to 150 000 by 2020 (UNEP and PERSGA 1997). Increasing urbanization, accompanied by ill-planned coastal tourism and/or industrial projects, has resulted in the degradation of coastal and marine environmental quality. The Mashriq sub-region and the smaller states of the region are also unable to deal with the large quantities of domestic litter generated along the coasts, due to space limitations and inadequate waste disposal systems.

Dredging and land reclamation are also intensifying in most countries. Major landfilling has occurred along the western coasts of the Gulf countries such as Bahrain, Saudi Arabia and the United Arab Emirates. These activities have led to destruction of marine habitats and ecologically productive areas, coastal erosion, and loss of coastal stretches in many countries.

Coastal and marine action plans in West Asia

Three major action plans in the region are aimed at preserving the coastal and marine environment and promoting the sustainable development of the coastal zones:

- the Mediterranean Action Plan: Lebanon, Syria and the Mediterranean countries of Europe and North Africa;
- the Kuwait Action Plan: Bahrain, Kuwait, Iran, Iraq, Oman, Qatar, Saudi Arabia and the United Arab Emirates; and
- the Red Sea and Gulf of Aden Action Plan: Jordan, Saudi Arabia and Yemen.

The Red Sea and Gulf of Aden Action Plan was specifically formulated to protect the region from the impacts of land-based activities. The Mediterranean Action Plan was updated in 1995 together with the Barcelona Convention and its protocols.

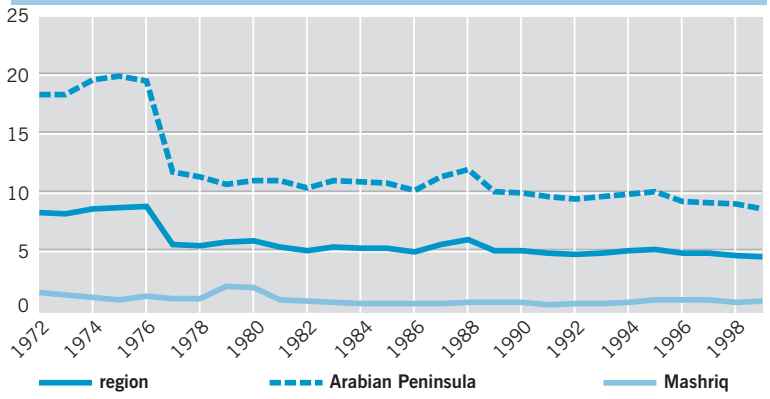
The need for environmental impact assessments and integrated coastal zone management has been recognized by most countries since the early 1990s and a number of coastal and marine action plans have been developed (see box above). A new methodology for integrated coastal zone management was developed by UNEP's Mediterranean Action Plan (MAP), and a Coastal Area Management Project (CAMP) for the south of Lebanon was launched in 2001 by MAP and the Lebanese Ministry of Environment. Nevertheless, with the exception of a regional programme under MAP aimed at safeguarding 100 historical sites notably in the Mashriq region, no concerted effort has been undertaken to protect other historical sites, including submarine structures, from the ravages of dredging and landfill activities.

Fisheries and marine resources

The fisheries of West Asia are diverse and continue to provide protein and revenue. However, per capita fish catches have been falling (see graph), albeit slowly, because of adverse climatic and ecological conditions, and unsustainable fishing practices. The most visible signs of deterioration are the overexploitation and loss of shrimp nursery grounds. Furthermore, fish kill phenomena have often been observed along the shores of the Gulf Area and the Arabian Sea (ROPME 2000). Fishery regulations are lacking or not enforced, particularly in the Mashriq, and regional cooperation for improved fisheries management is weak. However, a range of policy measures, including the introduction of fishing licences, gear and area restrictions, closed seasons and the banning of certain fisheries, have recently been implemented in the GCC countries.

Initial steps have been taken in several countries to supplement fish protein by aquaculture and/or importation. As aquaculture is expected to increase in both the sub-regions, measures will need to be taken to prevent the accidental introduction of alien species into the wild, which could have adverse impacts on coastal and marine ecosystems.

Annual fish catch per capita (kg): West Asia



West Asian fisheries have not kept pace with population growth, with the per capita catch falling slowly over 30 years

Note: fish catch includes marine and freshwater catches but excludes crustaceans and molluscs, and aquaculture production

Source: compiled from Fishstat 2001

Marine pollution

The Mashriq and GCC countries have different sets of pollution-related pressures to contend with. Whereas in the GCC countries the challenges are from oil-related industries and desalinization plants, in the Mashriq the challenge is primarily from major rivers that discharge domestic and municipal wastes, agricultural chemicals and hazardous industrial substances into the sea.

Due to heavy oil traffic in the Gulf, and the Gulf's unique geographical location and sensitive biological nature, this sea could become the most polluted in the world unless strict measures are implemented and enforced. The Gulf and the Red Sea are the oil tanker highways of the world: more than 10 000 vessels a year pass through the Straits of Hormuz, about 60 per cent of which are oil tankers (ROPME 1999), and some 34 offshore oil and gas terminals exist in the region (UNEP 1999). About 1.2 million barrels of oil are spilled in the region every year from routine discharge of ballast water (UNEP 1999). Since 1996, facilities for treating oil-contaminated ballast water have been established in the ROPME area, and a task force involving the GCC secretariat, the International Maritime Organization, UNDP, UNEP and the EU was set up through the Marine Emergency Mutual Aid Centre. A regional steering committee was established and a schedule for implementation of oil reception facilities is now under way (Al-Janahi 2001).

More than 360 million tonnes of oil are transported annually in the Mediterranean Sea (EEA 1999) which, though constituting only 0.7 per cent of the global sea surface, receives 17 per cent of global marine oil pollution (ESCWA 1991). Around 2 000 vessels, of which 250–300 are oil tankers, cruise the Mediterranean daily. It is estimated that more than 22 000 tonnes of oil entered the Mediterranean during 1987–96 as a result of shipping incidents (EEA 1999).

Regional wars have also contributed to the degradation of coastal and marine resources. The Iran/Iraq war (1980–88) contributed 2-4 million barrels of spilled oil (Reynolds 1993) and 6-8 million barrels were spilled into the Gulf and the Arabian Sea during the Second Gulf War (ROPME 2000).

The region has made some advances in combating accidental oil spills, particularly in the PERSGA and ROPME countries but in the Mashriq countries and some countries in the PERSGA region, there are no mechanisms to deal with major catastrophes (UNEP and PERSGA 1997). For example, there are no emergency contingency plans to deal with accidents to the 30-odd oil pipelines in Lebanon (Government of Lebanon 1997).

Most countries in the region have recognized pollution from land-based sources as a major threat to the coastal and marine environment. Sewage disposal is a major issue. Most coastal cities in the Mashriq sub-region have outdated sewerage systems, and the

discharge of untreated sewage into coastal zones, mainly close to the major cities, continues to be common practice in most of the Mashriq and some parts of the GCC countries. Elsewhere, as in Bahrain, Kuwait, United Arab Emirates and western Saudi Arabia, all sewage is treated prior to discharge and some is recycled. The risk of eutrophication in semi-closed and closed areas is constantly present since most of the seas in the region are oligotrophic (poor in nutrients).

Discharges from desalinization plants of brine, chlorine and heat continue to pose another serious threat to the environment. Nearly 43 per cent of the world's desalinated water is produced in GCC countries (UNEP and PERSGA 1997) and the trend is increasing.

Soil erosion and sedimentation pose another threat to the coastal zone. With an annual estimated soil loss of about 33 and 60 tonnes/ha in Lebanon and Syria respectively, the amount of eroded soil discharged into the Mediterranean from both countries may reach 60 million tonnes annually (EEA 1999). In the absence of adequate river basin management programmes, riverine and estuarine water quality will continue to deteriorate with harmful effects on public health. It is expected that, following the completion of new dams in eastern Turkey, there will be a change in water quantity and quality of the Euphrates River flowing into Syria and Iraq, which in turn will have a major impact on the agricultural areas and estuaries of the Shatt Al-Arab waterways.

Although there is great variation in levels of heavy metals in the region, screening tests show acceptable values in most areas (UNEP MAP 1996, ROPME 1999). Some countries have begun setting standards for environmental quality through international and regional agreements. For example, Lebanon has recently started to develop environmental and developmental indicators and standards within the framework of the Barcelona Convention. Pollution from land-based activities has also been incorporated into protocols in both the Mediterranean and the Kuwait Action Plans.

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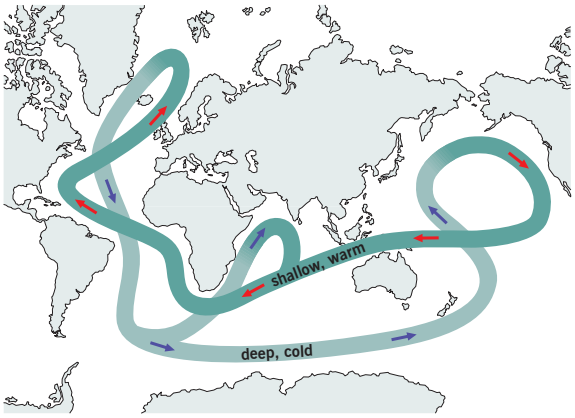
Coastal and marine areas: the Polar Regions

THE ARCTIC

The Arctic marine environment covers approximately 20 million km^2 and includes the Arctic Ocean and several adjacent water bodies. Nearly half of the ocean floor is continental shelf, the highest percentage among all oceans. Movements of Arctic waters play a significant role in the global ocean regime (AMAP 1997), and in regulating the global climate (see figure).

The global ocean circulation



When warm, salty North Atlantic water reaches the cold Arctic, it becomes denser as it cools, and therefore sinks to deeper layers of the ocean. This process of forming deep water is slow but takes place over a huge area. Every winter, several million cubic kilometres of water sink to deeper layers, which move water slowly south along the bottom of the Atlantic Ocean

Source: AMAP 1997

The Arctic marine environment is rich in fish biodiversity and abundance. The commercial fisheries of the Barents and the Bering systems are among the most productive in the world (Kelleher, Bleakly and Wells 1995), with the Bering Sea accounting for 2–5 per cent of the world's fisheries catches (CAFF 2001, Bernes 1996). Resident and migratory marine mammals include whales, seals and sea lions. The polar bear is also often classified as a marine mammal because it frequents sea ice in search of prey. Many of the indigenous communities of the Arctic have traditionally depended on these marine resources for their livelihood. Other natural resources include vast oil and gas reserves along the continental shelves as well as important mineral deposits. However, there are growing concerns about the negative impacts of development activities on the ecology of the Arctic especially in ice-prone areas and critical habitats.

Resource degradation

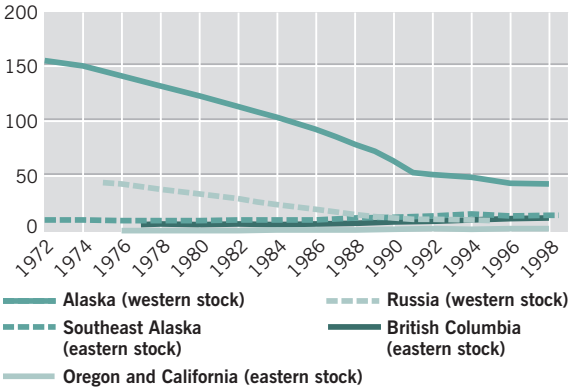
Overexploitation of fisheries is a major concern in the Arctic. Since the 1950s, there have been spectacular crashes of populations of commercially important species such as the cod and Atlantic salmon off the coasts of Canada and Greenland, and herring in the Norwegian and Icelandic waters. Despite strict conservation measures including no-catch zones, recovery has been slow and uncertain. Other species such as the haddock stocks between northern Norway and Svalbard have declined more steadily (Bernes 1993, 1996, CAFF 2001).

Between the 16th and 20th centuries, massive overexploitation of several whale species occurred. Although some species have recovered to sustainable levels, others have not and are still subject to strict domestic or international regulations (for example, the bowhead whale through International Whaling Commission quotas). Illegal exploitation, including of endangered species, and overly generous quotas are a constant threat (CAFF 2001).

Pollution

Contaminants are another source of pressure on the Arctic marine environment. The annual spring influx of meltwater carries contaminants which accumulate in the estuaries and deltas and also enter the mixed layer where they are transported to the North American coast. Airborne contaminants from industrial and agricultural activities at lower latitudes are also deposited in the ocean where they can accumulate in sea ice. These contaminants are bioaccumulated in sea mammals and in turn are taken up by Arctic peoples (AMAP 1997, Crane and Galasso 1999).

Stocks of Arctic fisheries (thousands of adults)



Stocks of commercially important species such as the cod, Atlantic salmon and herring have declined in many of the Arctic fisheries; despite strict conservation measures, recovery has been slow and uncertain

Source: CAFF 2001

Radioactive contamination is a further threat, sources including former nuclear weapons testing, the Chernobyl accident, and ocean dumping of radioactive solid wastes which was common until the London Dumping Convention came into effect.

Climate change

Most of the major changes observed in the Arctic marine environment are believed to be attributable to global warming. For example, the Arctic pack ice is showing noticeable thinning from an average thickness of 3.12 m in the 1960s to 1.8 m in the 1990s (CAFF 2001). There has been an observed 2.8 per cent/decade negative trend in the ice seasonal cover over the period November 1978 to December 1996. Changes in seasonal patterns of sea ice will affect ocean currents and weather patterns. It is predicted that globally the largest temperature increase will occur in the Arctic (IPCC 2001).

Policy responses

Arctic countries are taking steps to protect the marine environment. Since the late 1980s they have increasingly engaged in circumpolar cooperation on the marine environment through fora such as the International Arctic Science Committee and the intergovernmental Arctic Council. Cooperative initiatives have included:

- adoption of a Regional Programme of Action for Protection of the Arctic Marine Environment against Land-based Activities in 1998;
- establishment of a trilateral Russian/United States/Norway Arctic Offshore Oil and Gas Regime that aims to develop a safety and environmental regime for Russian offshore oil and gas operations;
- production of circumpolar guidelines for regulations of offshore oil and gas activities (PAME 1997);
- development of a circumpolar protected areas network to include a marine component (CAFF 2001); and
- sponsorship of a circumpolar marine workshop with IUCN which developed a set of recommendations to improve the protection and management of the Arctic marine environment (CAFF, IUCN and PAME 2000).

Given the current warming trend and interest in resource exploitation in the Arctic, it is expected that there will be further exploitation of the Arctic marine environment and increased competition for strategic advantages (Morison, Aagaard and Steele 2000). However, if the UNCLOS rules for defining limits to resources on the sea bed (International Seabed Authority 2001) are applied to the Arctic sea, the wide continental shelves will transfer almost all the Arctic sea bed to national control under the Arctic States (by 2001 only the Russian Federation and Norway had ratified UNCLOS).

THE ANTARCTIC

The Southern Ocean represents approximately 10 per cent of the world's oceans. Vast areas of the Southern Ocean are subject to seasonal sea ice which expands from around 4 million km^2 in the austral summer to 19 million km^2 in the winter (Allison 1997).

The extent of Antarctic sea ice has been estimated using Southern Ocean whaling records dating back to 1931 (de la Mare 1997). Research suggests a decline in sea ice cover of almost 25 per cent early in this period. However, satellite observations suggest that there has been little change in Antarctic sea ice distribution during the 1970s and 1980s (Chapman and Walsh 1993, Bjørgo, Johannessen and Miles 1997); on the contrary, it seems that the Antarctic sea ice extent increased slightly during these decades (Cavalieri and others. 1997). One climate model suggests an ultimate reduction in Antarctic sea ice of about 25 per cent with a doubling of CO_2, with these changes relatively evenly distributed around the entire continent (IPCC 1998).

Resource degradation

There is little doubt that current fisheries activities constitute the single greatest environmental problem in the Southern Ocean. Antarctic fisheries began in the late 1960s with exploitation of the marbled rock cod, a species decimated in the first two years of the fishery. Krill and mackerel ice fish have also formed the basis of substantial fisheries. Fin fish catches declined in the 1980s but the development of longlining for toothfish (*Dissostichus eleginoides* and *D. mawsoni*) has caused a resurgence of exploitation (Constable and others 1999). Southern Ocean fisheries are regulated and managed by the Commission on the Conservation of Antarctic Marine Living Resources (CCAMLR).

Pollution

Hydrocarbon contamination of the Southern Ocean is very low and difficult to resolve against natural background levels (Cripps and Priddle 1991). A few spill incidents have been reported in Antarctica during the past decade (COMNAP 2000), the largest of which occurred when the *Bahia Paraiso* ran aground in the Antarctic Peninsula in 1989, leaking 600 000 litres of fuel.

Small diesel spills have been shown to have minor, localized and short-term impacts on the Antarctic marine and coastal environment (Green and others 1992, Cripps and Shears 1997). However, a large hydrocarbon spill in the proximity of breeding grounds, rookeries or important species habitats could have significant impacts. This is an issue of growing concern as the level of vessel operations, including tourist vessels, in Antarctic waters is expected to increase.

Policy responses

The Antarctic Treaty Consultative Parties have urged those countries which have not yet become Parties to the Protocol on Environmental Protection to the Antarctic Treaty, particularly those with Antarctic tourist activities organized in their territory, to adhere to the environmental provisions of the Protocol as soon as possible. In 1999, the Antarctic Treaty Parties gave priority to the development of safety and environmental guidelines for Antarctic shipping, pending the finalization of the IMO Code of Practice for ships operating in the Polar Regions.

Following the decision by Australia and France not to sign the Antarctic Minerals Convention (CRAMRA) in 1989, the Antarctic Treaty Parties negotiated and then agreed to the Protocol on Environmental Protection to the Antarctic Treaty — the Madrid Protocol — in 1991. The Protocol includes provisions that establish environmental principles that govern the conduct of all activities carried out in Antarctica, prohibit mining, establish a Committee for Environmental Protection (CEP) and require development of contingency plans to respond to environmental emergencies. Annex IV of the Protocol includes specific measures relating to the prevention of marine pollution.

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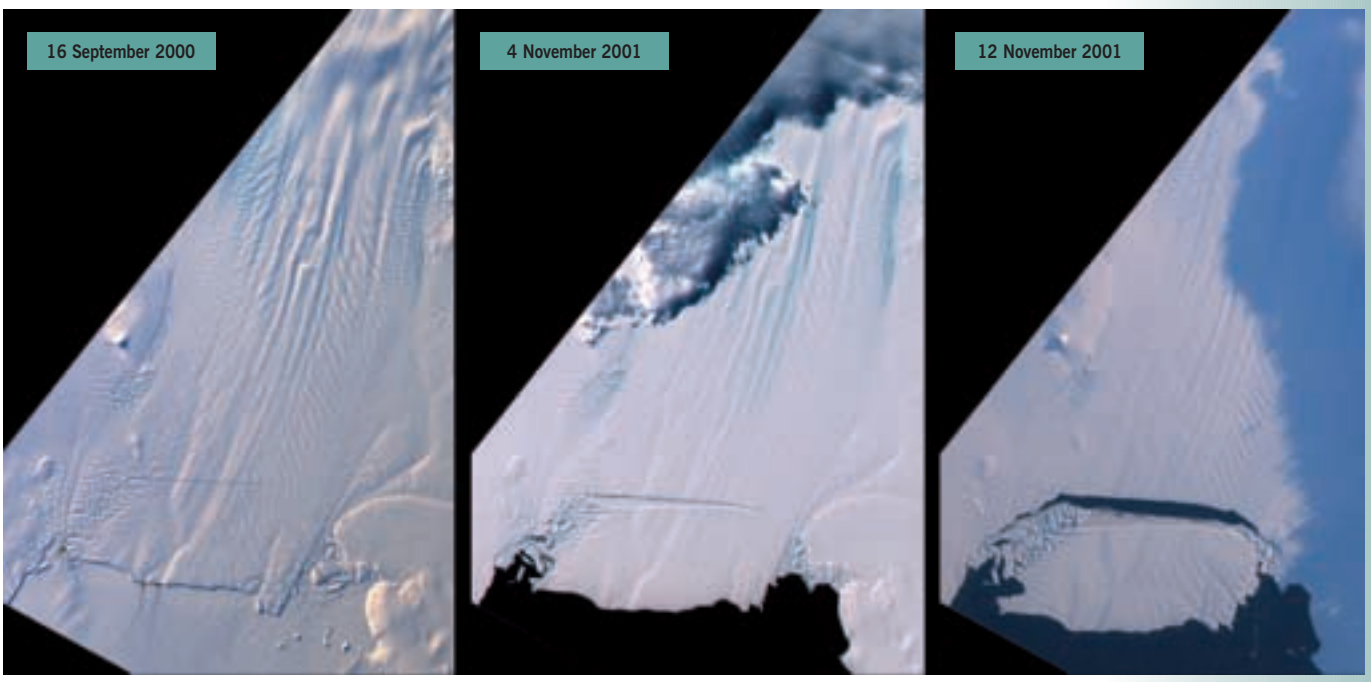
OUR CHANGING ENVIRONMENT: Pine Glacier, Antarctica



The images above show the break-off of a large iceberg from the Pine Island Glacier in West Antarctica. This event occurred sometime between 4 and 12 November 2001, and provides powerful evidence of rapid changes under way in this area of Antarctica. The iceberg measures about 42 x 17 km.

Pine Island Glacier is the largest discharger of ice in Antarctica and the continent's fastest moving glacier. It is located in an area of the West Antarctic ice sheet that is believed to be the most susceptible to collapse, making the evolution of this glacier of great interest to the scientific community.

In mid-2000, a large crack formed across the glacier, and then began to grow rapidly. Data indicated the crack was growing some 15 metres a day. The images show that the last 10-km segment that was still attached to the ice shelf snapped off in a matter of days.

The first image in this set was captured in late 2000, early in the development of the crack. The second and third views were acquired in November 2001, just before and just after the formation of the new iceberg.

The newly hatched iceberg represents nearly seven years of ice outflow from Pine Island Glacier released to the ocean in a single event. The climatic significance of this calving event is not yet clear. However, when combined with previous measurements from this instrument and data from other instruments cataloguing the retreat of the glacier's grounding line, its accelerating ice flow, and the steady decrease in the sea ice cover in front of the glacier, it provides scientists with additional evidence of rapid change in the region.

Text and imagery: NASA/GSFC/LaRC/JPL, MISR Team