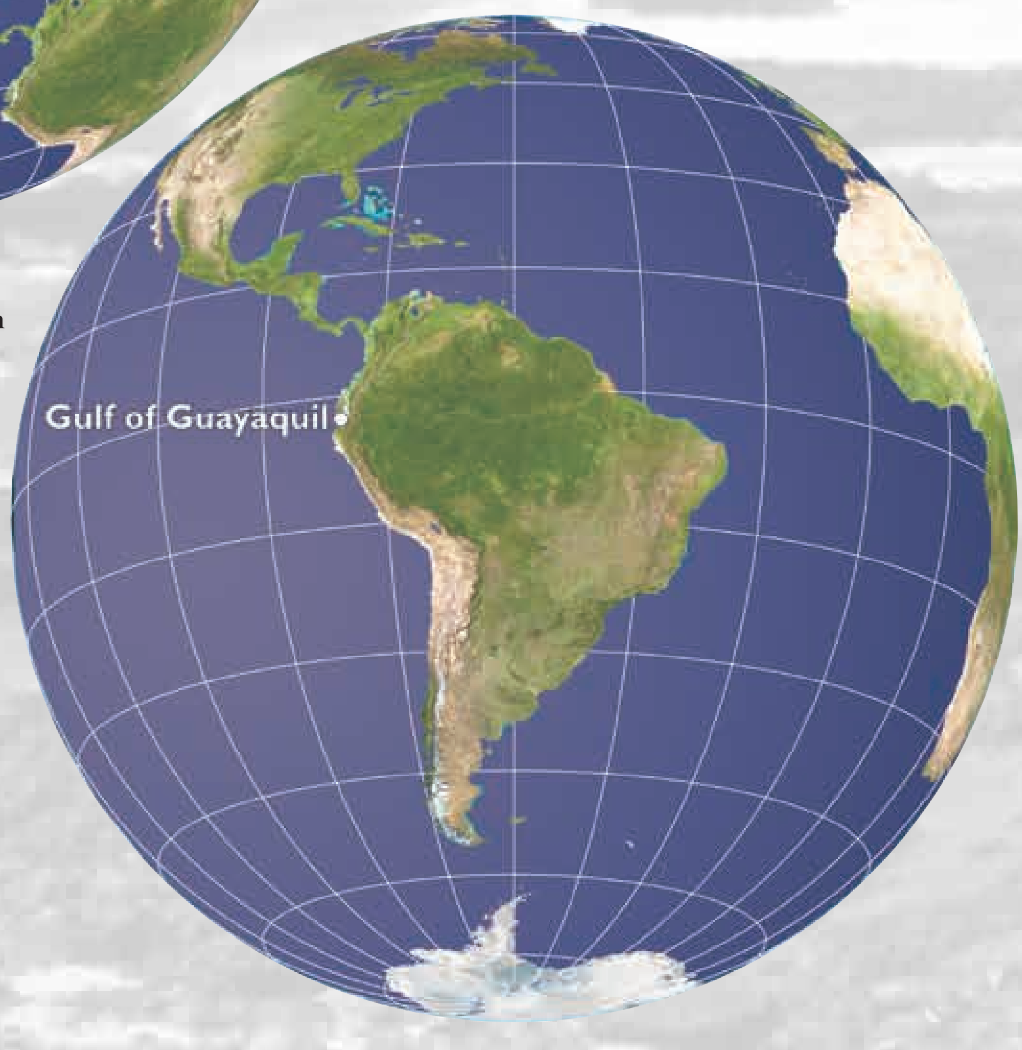
Credit: Darren H.Holto/UNEP/Topfoto

3.2 Coastal Areas

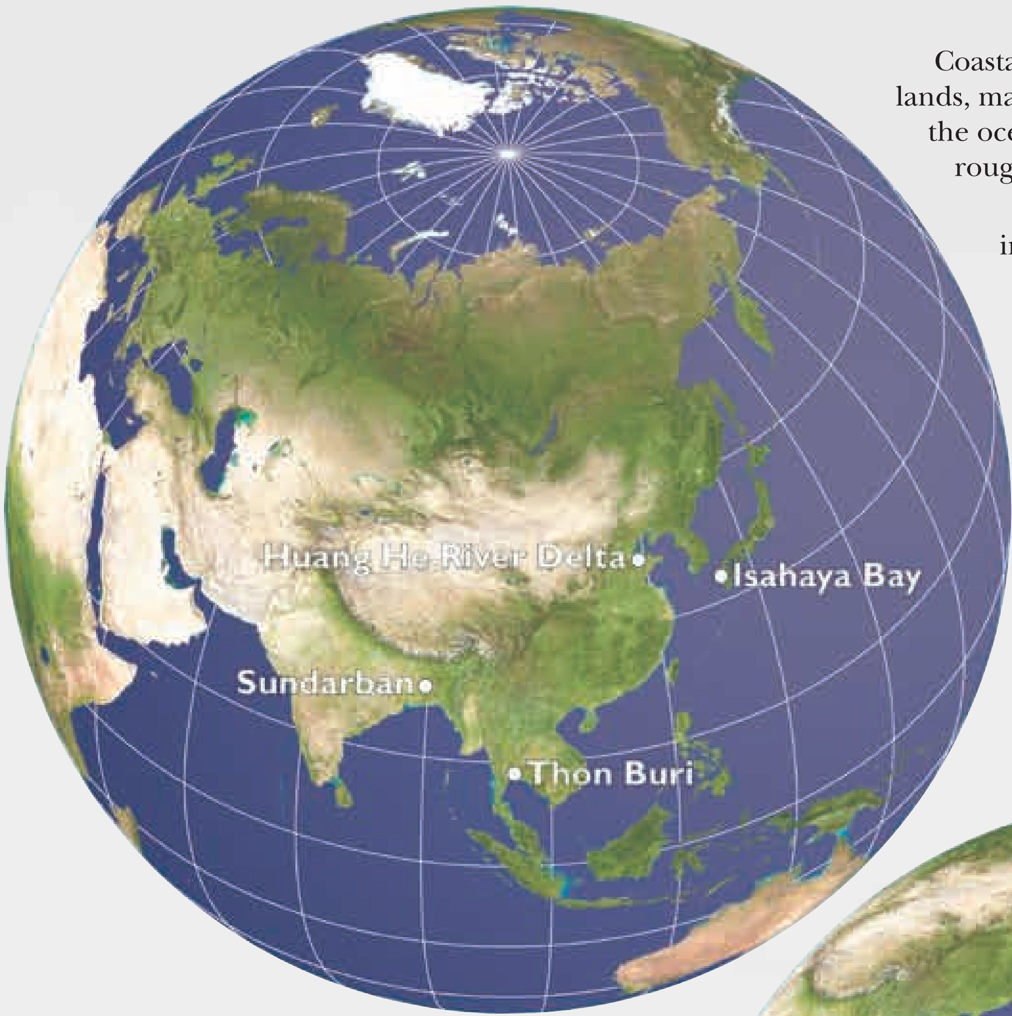
Oceans cover roughly 70 per cent of the Earth's surface and make up some 90 per cent of space habitable by living things. They contain a vast, and largely unexplored, diversity of life, from the smallest of microorganisms to blue whales, the largest mammals on the Earth. Oceans are essential for the ecological functions and resources they provide, including food, medicines, and energy for millions of people worldwide (UNEP-WCMC 2003).

The world's oceans have a great effect on global climate. Water has a high capacity for retaining heat. Because so much of the Earth's surface is covered by oceans, the temperature of the atmosphere is kept fairly constant and within the range necessary to support life. Currently, the oceans also moderate climate change by absorbing a third of the carbon dioxide (CO_2) emitted into the air by human activity (Harrison and Pearce 2001). However, global warming may reduce the ocean's capacity to act as a CO_2 sink by 10 to 20 per cent over the next century (Houghton et al. 2001).

Different parts of the global ocean affect climate in different ways. The Indian Ocean/West Pacific Warm Pool, for example, is an enormous expanse of warm surface water. It extends almost half way around the Earth, stretching along the equator south of India, through the waters off Sumatra, Java, Borneo, and New Guinea, and into the central Pacific Ocean. The waters of the Warm Pool are warmer than any other area of open ocean on the Earth. Because these waters are warm to enough to drive moisture high into the atmosphere, the Warm Pool has a large effect on the climate of the lands that surround it. The slow fluctuations in size and intensity of the Warm Pool may be linked with the intensity of the El Niño phenomenon.

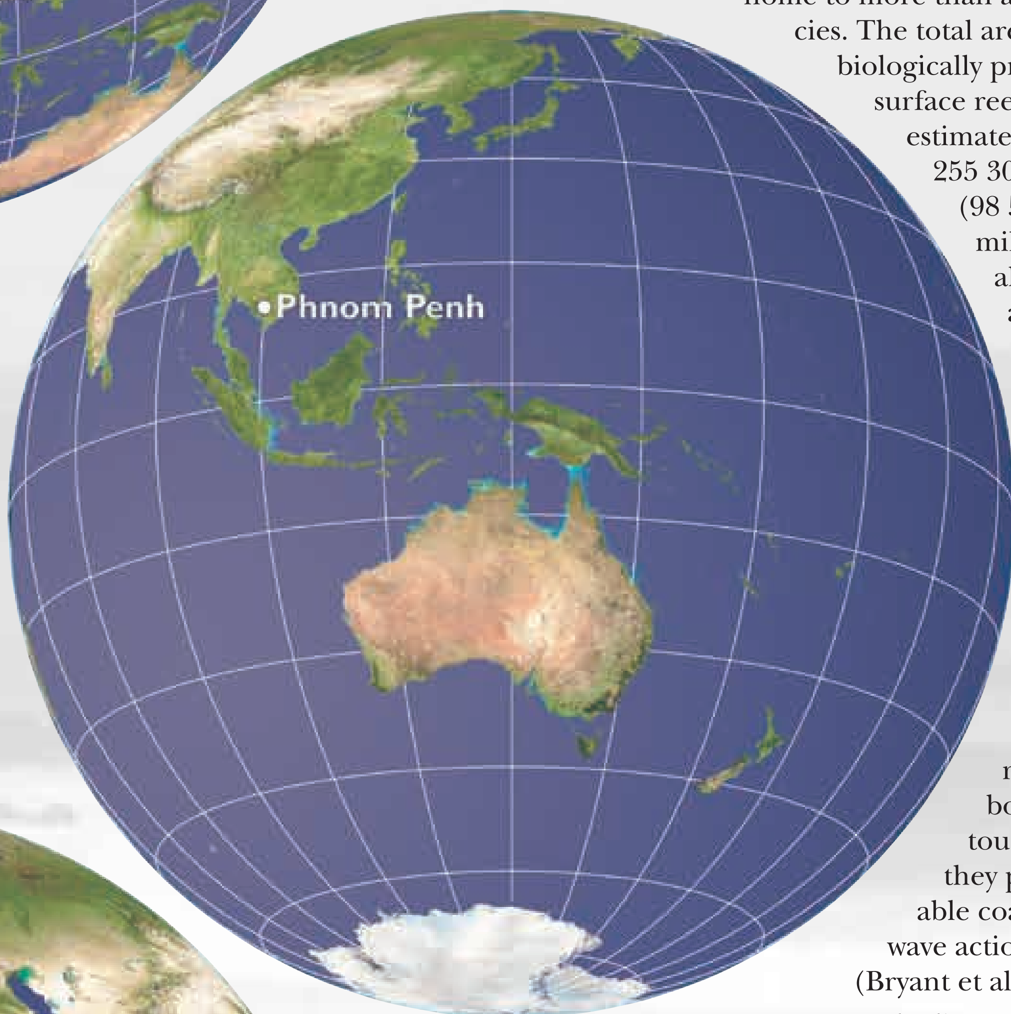


In addition to the ocean's climate-buffering capacity, its salty waters contain billions of tiny algae and other planktonic organisms. These life forms carry out a large part of the oxygen-generating photosynthetic processes that occur on the planet (Biomes Group 1996). For people, oceans represent one of the greatest sources of food on the Earth as well. Global fish production exceeds that of cattle, sheep, poultry, or eggs. It represents the largest source of wild or domestic protein in the world (UNEP-WCMC 2003). Marine fish catch rose from 51 million metric tonnes in 1975 to nearly 70 million metric tonnes in 1999 (UNEP 2002).



Coastal zones, which include bays, tidal lands, estuaries, marine wetlands, mangroves, and coral reefs, form an interface between the land and the ocean. The total length of all the world's coastlines is estimated to be roughly 1.6 million km (1 million miles) (Burke et al. 2000).

Many coastal marine ecosystems are among the most productive in the world, rich in living and nonliving resources. Mangroves, for example, extend over 18 million hectares (44 million acres) worldwide, covering a quarter of the world's tropical coastlines (Choudhury 1997). Mangroves protect coastlines by absorbing the force of storms. They provide large quantities of food and fuel, building materials, and even medicines. Mangroves are also characterized by nutrient-rich waters that support large numbers of marine organisms and, in many cases, form nursery grounds for fish and other marine species. Because of their tremendous productivity, mangroves and other coastal ecosystems provide food and livelihood for millions of people.



In many warm-ocean regions of the world, coral reefs are also associated with coastal zones. Coral reefs occupy less than one tenth of one per cent of the oceans (UN 2002), yet they are among the most biologically diverse ecosystems on the Earth, home to more than a million species. The total area of the most biologically productive near-surface reefs has been estimated at around 255 300 km^2 (98 572 square miles) (Bryant et al. 1998). About a quarter of the world's fish feed, reproduce, and live on or near coral reefs (Harrison and Pearce 2001). Coral reefs are a major global biological and economic resource for both fisheries and tourism, because they protect vulnerable coastlines from wave action and storms (Bryant et al. 1998).

Land adjacent to the ocean is a tremendously valuable resource. Coastal zones are economically, politically, and socially critical to many nations. They are hubs of commerce and home to many major corporations and transportation networks.

Coastal landscapes offer fertile soils, flat land for urban development, and sheltered, deep-water bays for harbors and ports. Coasts are used by millions of people annually for recreation and they support a growing tourist trade. Although coastal zones account for only 20 per cent of the world's land area, a majority of the world's human population inhabit them. Half of the world's population—some 3 000 million people—lives within 200 km (124 miles) of a coast. By 2025 that figure may double, rising to six billion people (Cohen et al. 1997).

The oceans are a seemingly limitless and enduring resource. But they, and the coastal zones that encircle them, are currently at risk along many fronts. In 1995, FAO reported that 52 per cent of the

Credit: Chansareek/UNEP/Topfoto

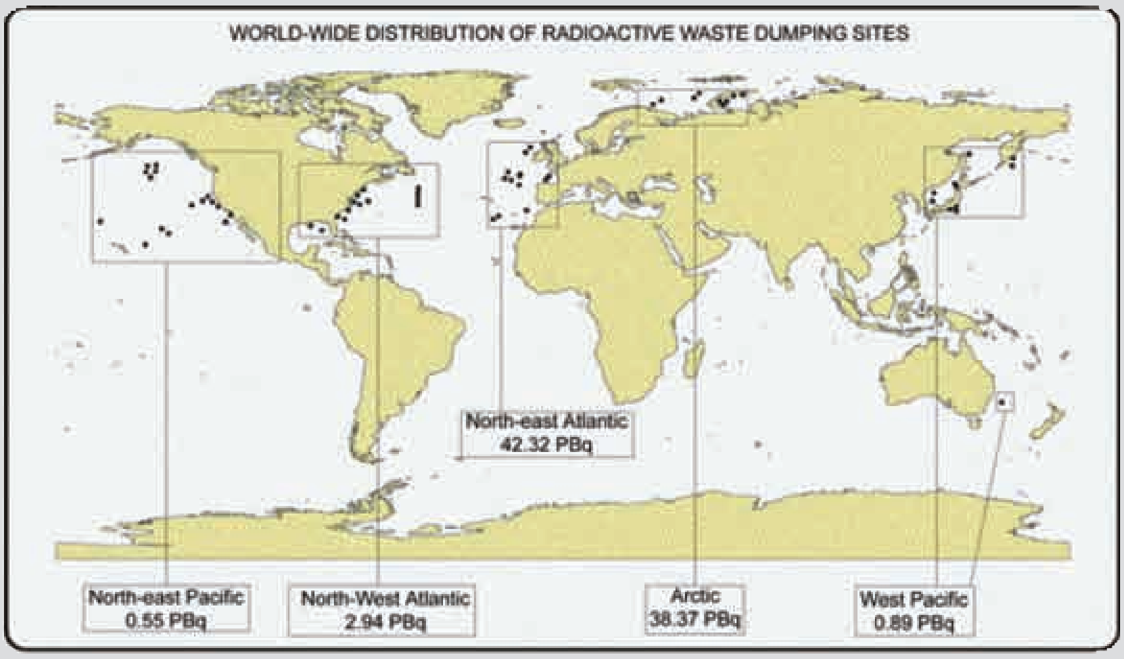
oceans' wild fish stocks were being exploited at the maximum sustainable limit, 16 per cent were already overexploited, and seven per cent were depleted. Only 23 percent will be able to sustain further expansion. (FAO 2005). In 24 countries for which sufficient data were available, trawling grounds encompass 8.8 million km^2 (3.4 million square miles), of which about 5.2 million km^2 (2 million square miles) are located on continental shelves. This represents about 57 per cent of the total continental shelf area of these countries (Burke et al. 2000).

However, not all of the decline in ocean fisheries may be attributed to fishing. Global warming may also be partly to blame (Beaugrand et al. 2003). The depletion of natural fish stocks has prompted expansion of aquaculture—the farming of fish—in many areas, a reaction to ocean degradation that does provide employment and food, but also carries with it the potential for pollution and other concerns.

Case Study: Dumping of Radioactive Waste at Sea

The Report of the United Nations Conference on Human Environment held in Stockholm in 1972 defined the principles for environmental protection, specifically for the assessment and control of marine pollution. These were forwarded to an Inter-Governmental Conference held in London later that year, where the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (also known as the London Convention of 1972) was adopted and which entered into force on 30 August 1975.

The contracting parties to the London Convention agreed to promote the effective control of all sources of pollution of the marine environment and to take all practicable steps to prevent the pollution of the ocean by dumping of waste and other matter that is liable to create hazards to human health and to harm living resources and marine life. The International Atomic Energy Agency (IAEA) was designated as the international body that should oversee matters related to the disposal of radioactive wastes in the ocean.



The first reported ocean disposal operation of radioactive waste was carried out by the USA in 1946 in the North-East Pacific Ocean and the latest was carried out by the Russian Federation in 1993 in the Japan Sea/East Sea. During the 48 year history of sea disposal, 14 countries have used more than 80 sites to dispose of approximately 85 PBq (1 PBq = 1015 Bq) of radioactive waste.

The figure shows the geographical distribution of disposal operations.

Source: Modified from http://www.oceansatlas.org/servlet/CDSServlet?status=ND0xNDExMyY3PWVuJjYxPSomNjU9a29z. Figure has been modified from http://www.oceansatlas.com/unatlas/about/physicalandchemicalproperties/radiosp/index.htm.

Global Map of Dead Zones

Ocean pollution is a growing and serious problem. Most of the wastes and contaminants produced by human activities eventually end up in the oceans. Chemical contamination and litter exist from the poles to the tropics and from beaches to ocean depths. Some pollutants are directly drained or dumped into the oceans, either intentionally, or accidentally as in the case of oil spills. Currently, the oceans must absorb an estimated 3 million tonnes of oil spilled annually from ships and, predominantly, from sources on land (Harrison and Pearce 2001). Other ocean pollutants first enter the atmosphere and later settle on ocean waters. Rivers that flow into oceans carry runoff from city streets, sewage, industrial wastes, pesticides and fertilizers from cropland, and silt from land-clearing and construction projects. Because of their proximity to land, coastal waters tend to have far higher concentrations of pollutants than the open ocean (UNEP-WCMC 2003).

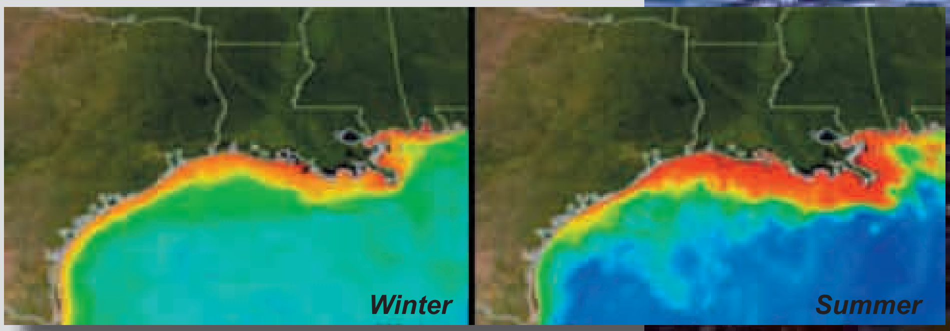
Polluted waters can upset the ecological balance among species in marine systems. For example, the number of poisonous algal species identified by scientists has nearly tripled since 1984, increasing fish kills, beach closures, and economic losses. Large parts of the Gulf of Mexico are now considered biological dead zones due to algal blooms (UN 2002). Dead zones are coastal areas in which bottom waters (those near the ocean floor) contain very little dissolved oxygen. This condition is called hypoxia, meaning "low oxygen" (ESA 2003). Very few organisms are able to survive in ocean dead zones (Figure 3.20). The dead zone in the Gulf of Mexico is the largest hypoxic zone in the Western Hemisphere and is also one of the largest in the world (Downing 1999; Greenhalgh 2003). In many places, the hypoxic waters of dead zones are gradually spreading out to cover larger and larger areas of ocean floor (Kempler 2000).

Figure 3.20: The map above shows 58 reported ocean dead zones in 1995. The oldest and most well-studied marine dead zones are found in the Gulf of Mexico, the Black Sea, and the Baltic Sea. In 1995, the most severe case of hypoxia was in the Baltic Sea, in which about one-third, or 98 800 km² (38 000 square miles), of the body of water was reported lifeless. *Source: Modified from: http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/OCDST/dead_zones.html*

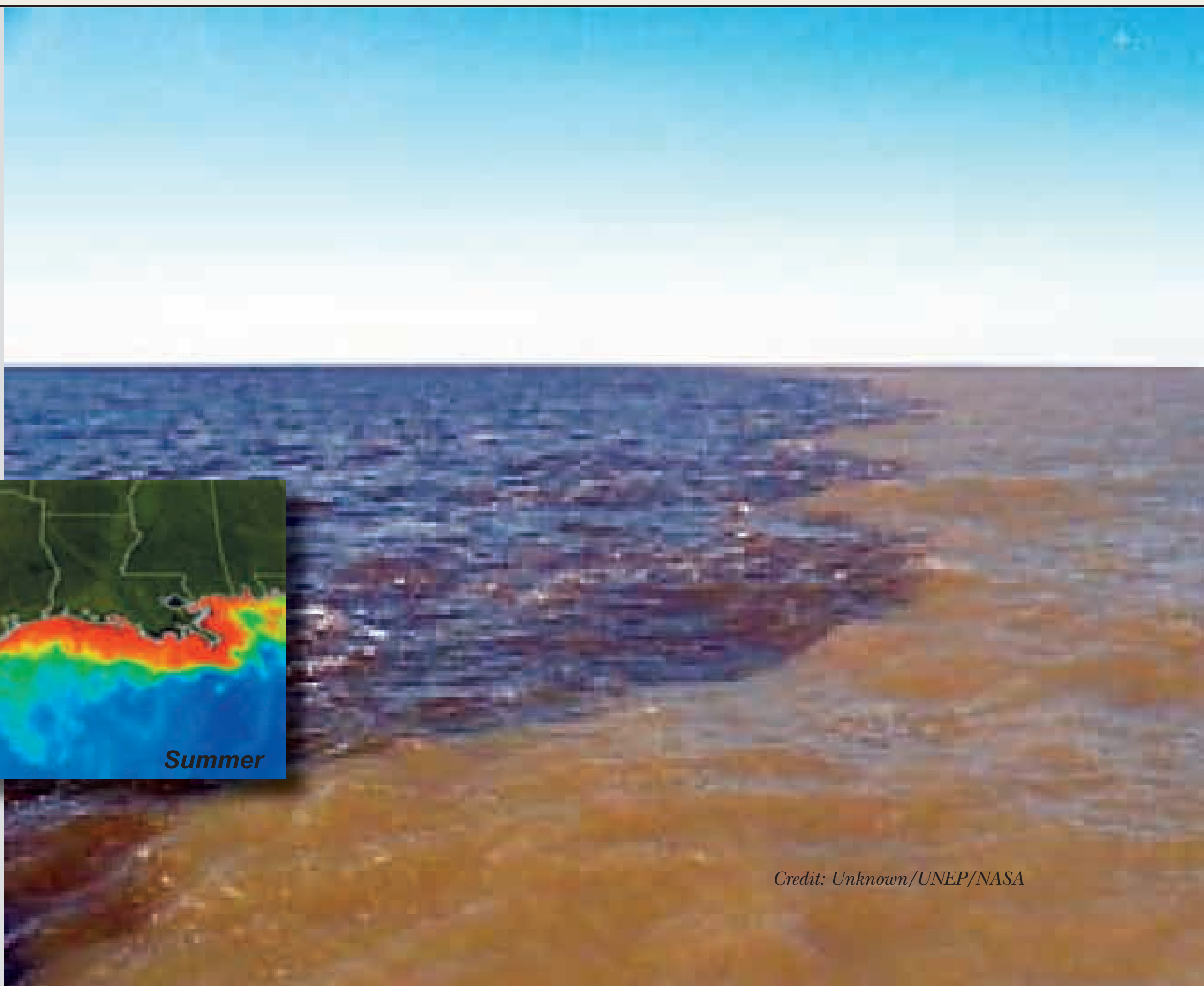
Marine bio-invasions have also become major global environmental and economic problems. At any one time, several thousand species are estimated to be in

Case Study: Mississippi Dead Zone 2004

Recent reports indicate that the large region of oxygen-depleted water—a dead zone—spreads across nearly 15 080 km² (5 800 square miles) of the Gulf of Mexico in what appears to be an annual event. NASA satellites monitor the health of the oceans and spot the conditions that lead to a dead zone. The photo (right) shows sediment-choked water from the Neuse River flowing out into the Gulf of Mexico near the coast (NASA 2004h).

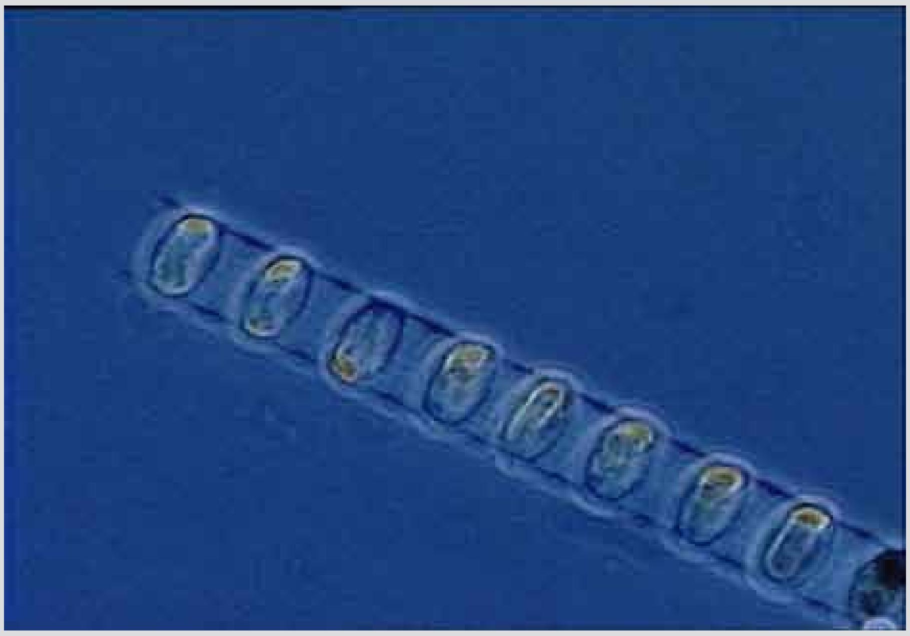


Source: Mississippi Dead Zone, 2004 http://www1.nasa.gov/vision/earth/environment/dead_zone.html



Credit: Unknown/UNEP/NASA

Phytoplankton bloom off Denmark, 2004 (shown in light blue color). *Source: http://rapidfire.sci.gsfc.nasa.gov/gallery/?2004153-0601/Denmark.A2004153.1145.1km.jpg*



The ocean is filled with life. One of the most important varieties found there are photosynthetic phytoplankton, tiny organisms that form the base of the oceanic food web. *Source: http://www1.nasa.gov/vision/earth/environment/dead_zone.html*

Coccolithophore bloom off Brittany, France, 2004. *Source: http://rapidfire.sci.gsfc.nasa.gov/gallery/?2004167-0615/France.A2004167.1335.148.1km.jpg*

Case Study: Red Tides

Throughout the oceans, there are places where strong currents bring nutrient-rich deep waters to the surface. These upwelling nutrients nourish tiny, free-floating microscopic algae and other photosynthesizing planktonic organisms collectively known as phytoplankton. Most species of phytoplankton are not harmful. Rather, they form the base of the marine food web. Occasionally, however, phytoplankton grow and reproduce very quickly—they "bloom"—and accumulate into dense, visible patches near the water's surface. Some phytoplankton blooms are called "red tides," especially when the species involved contain red pigments and so cause the water to turn pink or red when a bloom is in progress. Phytoplankton blooms, however, have nothing to do with tides.

When phytoplankton die, they sink to the ocean floor where their remains are broken down by different kinds of bacteria. Some of these bacteria emit hydrogen sulfide gas as a by-product of decay reactions. The gas collects on the ocean floor until it bubbles up toward the surface and combines with oxygen to yield water and sulfur. The sulfur precipitates as a white solid.

Hydrogen sulfide gas by itself is toxic to fish. But its ability to bind with oxygen also depletes that essential gas from the water column. If enough oxygen is removed, deadly low-oxygen (hypoxic) conditions are created in the ocean.

the ballast tanks of the world's shipping fleet, enroute to other parts of the world. The Atlantic box jelly, believed to have been released in a ship's ballast water, has wrought ecological havoc in the Black Sea. Scientists estimate that in San Francisco Bay, a new foreign species takes hold every 14 weeks (UN 2002).

The problems are not confined to ocean waters. Many coastal ecosystems have been destroyed, and many more degraded, often as a result of human activities. Mangroves, wetlands, seagrass beds, and coral reefs are all disappearing at an alarming rate. Anywhere from 5 to 80 per cent of original mangrove area in various countries has been lost, particularly in the last 50 years (Burke et al. 2000). A major contributor to this loss is the conversion of mangroves to rice paddies and shrimp farms. With coastal regions set to double their human populations over the next 25 years, coastal ecosystems are coming under increasing threat (Harrison and Pearce 2001).

Coral reefs are particularly vulnerable to environmental change and damage from human activities. Nearly two thirds of all the world's coral reefs are deteriorating (Pomerance 1999). They are dismembered by souvenir-seeking divers, mined for building materials, and damaged by the anchors of cruise ships. Silt from dredging, deforestation, and urban sewage smothers and kills coral, or fosters the growth of suffocating and sometimes toxic algae (Harrison and Pearce 2001). Coral reefs are also subject to remote threats. Dust carried aloft by storms in Africa (Figure 3.21), and then spread across the Atlantic on prevailing winds, may have introduced bacterial infections to Caribbean reefs (USGS 2003).

Global warming is also a threat to coral reefs. Higher concentrations of carbon dioxide in the air make surface waters more acidic and reduce coral growth rates

Credit: Shoukyu/UNEP/Topfoto

(Kleypas et al. 1999). The rise of ocean temperatures by half a degree or more in recent decades has already placed many reefs at the top end of the temperature ranges they can tolerate without undergoing “bleaching” (Harrison and Pearce 2001). As corals reach the limits of their heat tolerance, they expel symbiotic algae from their bodies and become “bleached.” Epidemic coral bleaching in the 1990s, which peaked with the El Niño-induced warming of 1998, is believed to have killed more coral in the last few years of the 20th century than from all human causes to date (Pearce 1999). Continued warming could cause sea levels to rise at a rate that coral reefs cannot match.

Coastal lands have been greatly impacted by human activities. Fifty-one per cent of the world’s coastlines are under “moderate” or “high” threat from development activities (Bryant et al. 1995). Nineteen per cent of all lands within 100 km (62 miles) of the coast (excluding Antarctica and water bodies) are classified as “altered,” having been turned into agricultural or urban areas; 10 per cent are “semi-altered,” involving a mosaic of natural and altered vegetation; and 71 per cent fall within the “least modified” category. A large per centage of the coastal lands in this least modified category, however, includes many found in uninhabited areas in northern latitudes (Burke et al. 2000).

The destruction of coastal ecosystems and the deterioration in the quality of ocean waters, together with overexploitation of resources, are seriously impacting the survival of the ecosystems and the people that depend on them (SIDA n.d.).

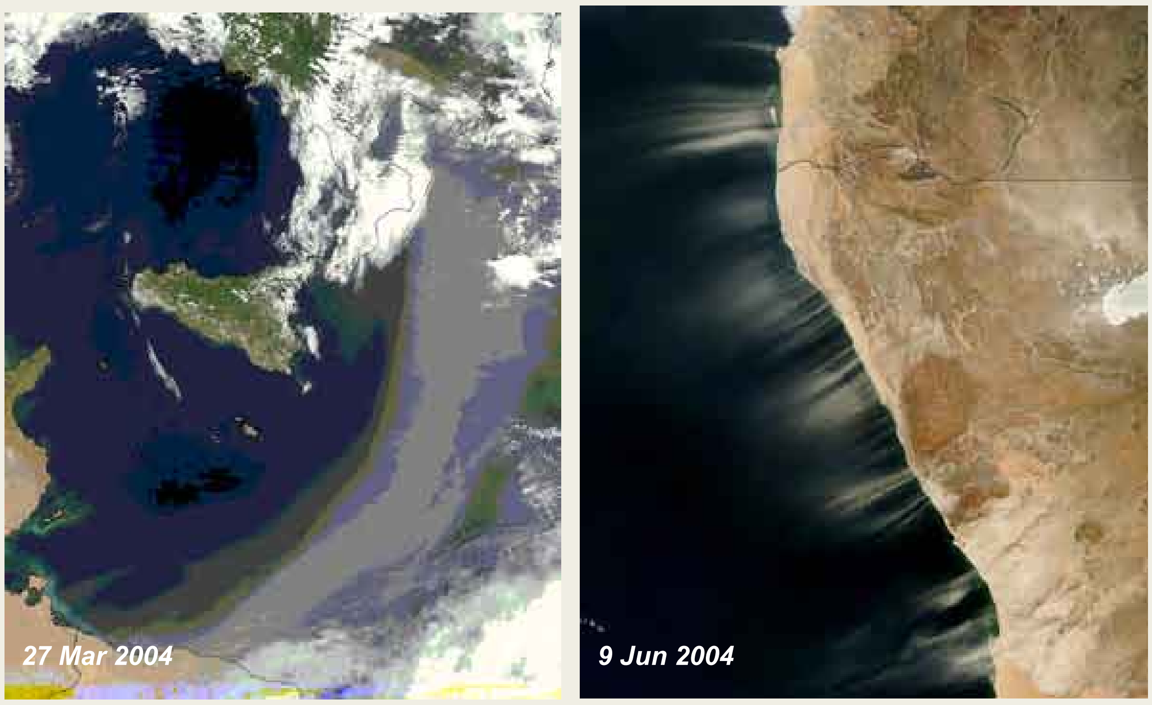
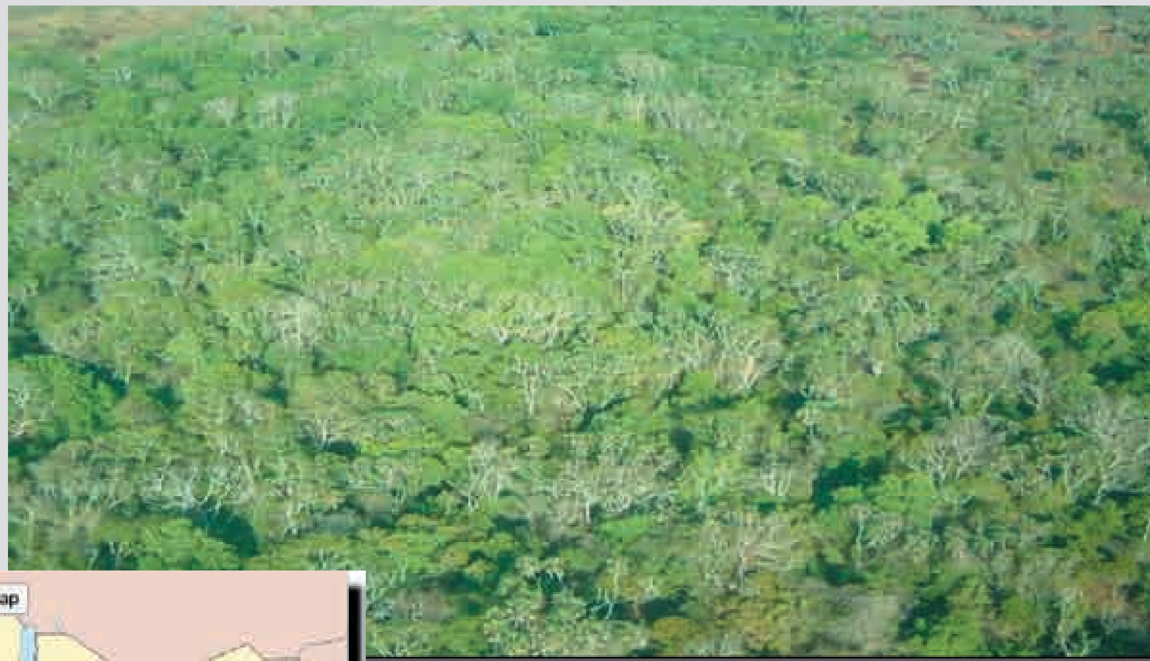


Figure 3.21: While Saharan dust provides coral reefs with essential nutrients like iron and copper, Saharan dust also introduces bacterial infections to coral reefs. The image to the left is a Saharan dust storm spreading out over the Mediterranean in 2004. The image to the right is of large dust plumes off Namibia in 2004. *Source: http://rapidfire.sci.gsfc.nasa.gov/gallery/?2004125-0504/Libya.A2004125.0940.1km.jpg, http://rapidfire.sci.gsfc.nasa.gov/gallery/?2004161-0609/Namibia.A2004161.0930.1km.jpg*

Credit: Denjiro Sato/UNEP/Topfoto

Case Study: Africa's Kipini Wildlife and Botanical Conservancy

Christian Lambrechts



Credit: Christian Lambrechts/UNEP/UNEP-GRID Nairobi

The coastal region of Kenya is famous for its natural beauty, rich culture, diverse communities, and as a recreational resource. This has ensured economic benefits for Kenya from mainly non-consumptive utilization of its natural resources through tourism. Yet this development has not taken place without considerable environmental cost. Excessive construction along the coastline, uncontrolled access to marine environments, factory fishing operations, and poor planning have led to a decline in the quantity and quality of both land and marine resources. This has been reflected in loss of biodiversity, dwindling fish stocks, and declining employment and tourism figures, although the latter are also attributable to recent security concerns.

The Kipini Wildlife and Botanical Conservancy is located along the coast of eastern Kenya. It lies within the Lamu and Tana River districts, but is connected ecologically to the Ijara District. It is a well-preserved area with high biodiversity, although few conservation projects have ever been implemented and current protection is inadequate with wildlife reserves only on paper. With increasing population pressures on the natural resources there is a need for prompt action.

Credits: Christian Lambrechts/UNEP/UNEP-GRID Nairobi

The Kipini Conservancy initially focuses on what was once known as Nairobi Ranch, an area approximately 16 000 hectares (40 000 acres) in size that is situated between the historical towns of Kipini, Witu and Lamu. The Swaleh Nguru (Sherman) family secured the land under a freehold arrangement and has maintained it even at a loss under livestock operations. Development of the ranch is necessary, as Kenya can ill afford idle land. But development is being undertaken with considerable care to ensure adequate environmental conservation. By creating an easement on this freehold land, the Swaleh Nguru family has put it in trust for future generations of Kenyans as well as visitors to the country. The conservancy will need to be vigorously managed and will involve a transition from a cattle-based ranching system to a more natural landscape populated by native species. Income generation will be based on heritage value and donor support in the short term, with increasing reliance on eco-tourism.

In the future, the Kipini Conservancy is expected to be expanded to include the range of critically endangered species. In a recent study funded by the Finnish Embassy, Ader's duiker, an extremely rare mammal once thought to be virtually extinct in Kenya, was found in the area near the Conservancy. Expansion of the Conservancy will also help to preserve highly diverse habitat corridors between the coast and the interior and will involve surrounding communities in conservation efforts.

The coastal marine ecosystem adjacent to the Conservancy is part of the Global 200 ecoregion. It supports a great diversity of animal and plant life and is known as a turtle nesting area. Several species of whales and dolphins are found in the waters offshore, as well as the globally threatened dugong (*Dugong dugon*). The part of the Conservancy that borders the Tana River delta is a stop-over and wintering grounds for many migratory bird populations. The area also provides habitat for threatened shorebirds and seabirds (UNEP/GRID–Nairobi).

Credit: Unknown/UNEP/Topfoto

Coastal Areas
Gulf of Fonseca, Honduras

Honduras is second only to Ecuador in the production and export of cultured shrimp from Latin America. Vast areas of the delta have been converted into farms for the cultivation of shrimp.

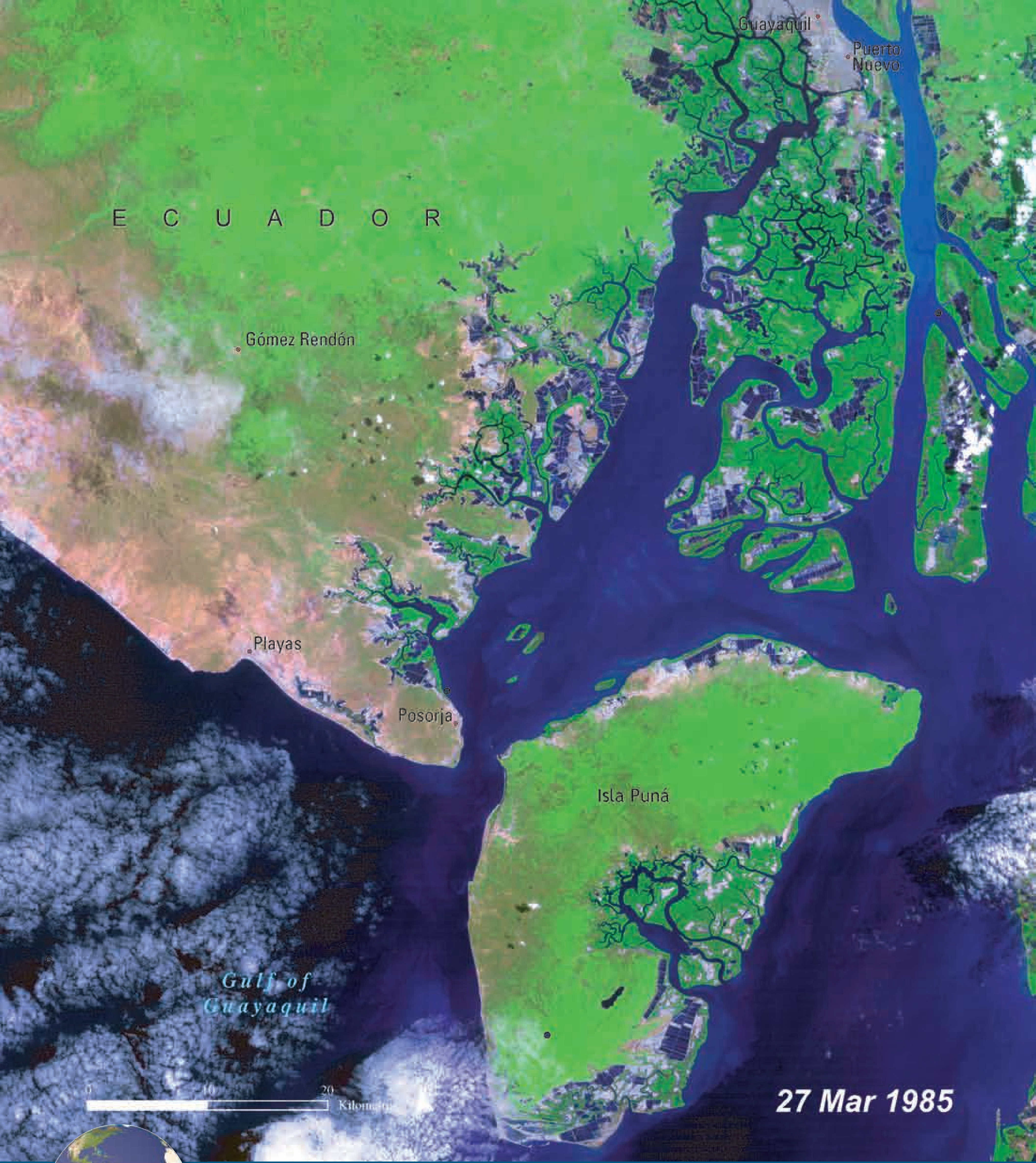
The rapid growth of shrimp aquaculture in Honduras has caused both environmental and social

Shrimp aquaculture in Honduras began in the early 1970s and continued in the 1980s in the hands of both national and international enterprises.

Credit: Unknown/UNEP/Topfoto

problems. Shrimp farmers are depriving fishers, farmers and others of access to mangroves, estuaries and seasonal lagoons; destroying mangrove ecosystems, altering the hydrology of the region, destroying the habitats of other flora and fauna and precipitating declines in biodiversity; contributing to degraded water quality; and exacerbating the decline in Gulf fisheries through the indiscriminate capture of other species caught with the shrimp post larvae that are used to stock ponds.

These two images provide a visual comparison of the increase in coverage by shrimp farms in the Gulf of Fonseca over time. It is evident from the images that between 1987 and 1999, a period of about 12 years, the total area under shrimp farming has increased tremendously.



Coastal Areas
Gulf of Guayaquil, Ecuador

Guayaquil is Ecuador's largest city and primary sea port. It is located on the Guayas River, which empties into the huge Gulf of Guayaquil along the country's southern coastline. Throughout the Gulf, mangroves have been steadily converted to shrimp aquaculture ponds for producing farmed shrimp. In a 15-year pe-

riod, coastal area developed for shrimp aquaculture grew by approximately 30 per cent, from 90 000 hectares (222 395 acres) in 1984 to 118 000 hectares (291 584 acres) in 2000 (CLIRSEN 2000). Roughly 70 per cent of Ecuador's shrimp farming activities are located in the Gulf of Guayaquil.

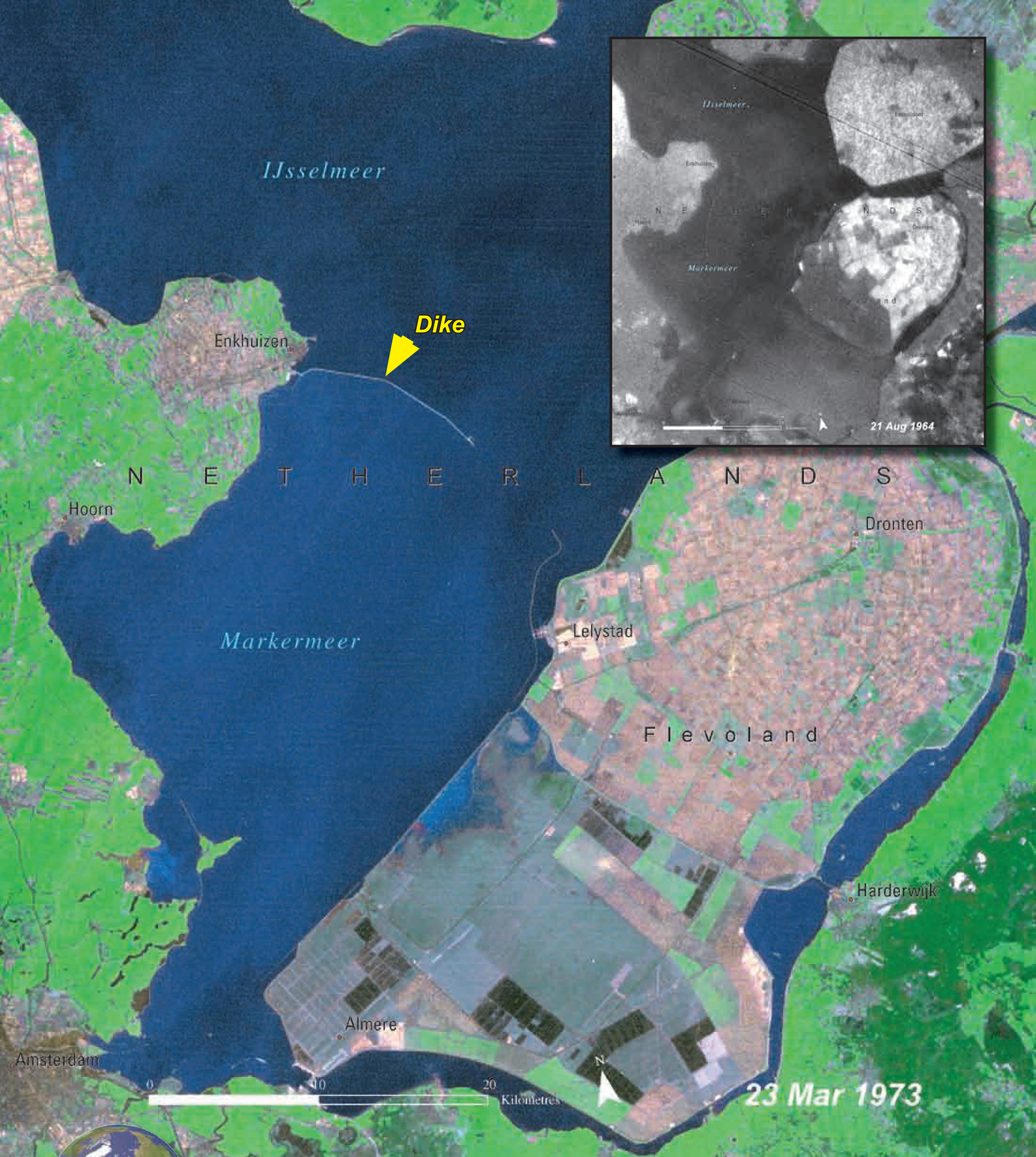
In this pair of satellite images, the loss of mangroves and growth of the aquaculture industry can be seen along the coast and in the altered dendritic patterns (branching like a tree) of coastal waterways, especially those on the large island of Puna. Mangroves provide fish breeding grounds and wildlife habitat, act as natural barriers against storm surge, and filter groundwater. Converting mangroves to aquaculture ponds has wide-reaching environmental implications.

Coastal Areas
Huang He Delta, China

The Huang He (Yellow River) is the muddiest river on Earth and is China's second longest river, running 5 475 km (3 395 miles) from eastern Tibet to the Bohai Sea. The Huang He's yellow color is caused by its tremendous load of sediment, composed primarily of mica, quartz, and feldspar particles. The sediment enters the

water as the river carves its way through the highly erodable loess plateau in north-central China. (Loessial soil is called huang tu, or "yellow earth," in Chinese.)

Centuries of sediment deposition and dike building along the river's course has caused it to flow above the surrounding farmland in some places, making flooding a critically dangerous problem. Where the Huang He flows into the ocean, sediments are continuously deposited in the river delta, where they gradually build up over time. Between 1979 and 2000—as these satellite images show—the delta of the Huang He expanded dramatically. Several hundred square kilometres of newly formed land were added to China's coast during this period.



Coastal Areas
IJsselmeer, Netherlands

The Zuiderzee is a large body of water along Holland's northeastern coast. Between 1927 and 1932, a 30 km (19 miles) dam, known as the Afsluitdijk, was built across the Zuiderzee, separating it into the outer Waddenzee, which is open to the North Sea, and the inner IJsselmeer (Lake IJssel) where areas of reclaimed

land—called polders—are used for agriculture and as villages. Dikes built since that time created additional polders that were drained using pumps and, at one time, wind mills.

These images, from 1964, 1973, and 2004, show the transformation of polders into useable farming land. The 1973 image shows a partially completed dike that, when completed allowed for the creation of the southernmost polder visible in the 1973 image. At that time, draining of the land had been completed and soil cultivation began. By 2004, this area of reclaimed land was covered with farms. The area of lighter blue water visible in the left of the 1973 and 2004 images is the Markermeer—a polder that was created but not drained. It forms a freshwater reservoir that acts as a buffer against floodwaters.

Coastal Areas

Isahaya Bay, Japan

Land reclamation began in Japan's Isahaya Bay in 1989 to separate approximately 3 000 hectares (7 413 acres) of tidal flats from the Ariake Sea and turn what was Japan's largest area of tidal lands into farmland. As these three satellites images show, the project has steadily progressed. In the 2001 image, the straight line of a 7-km (4 mile) sea wall is visible separating areas

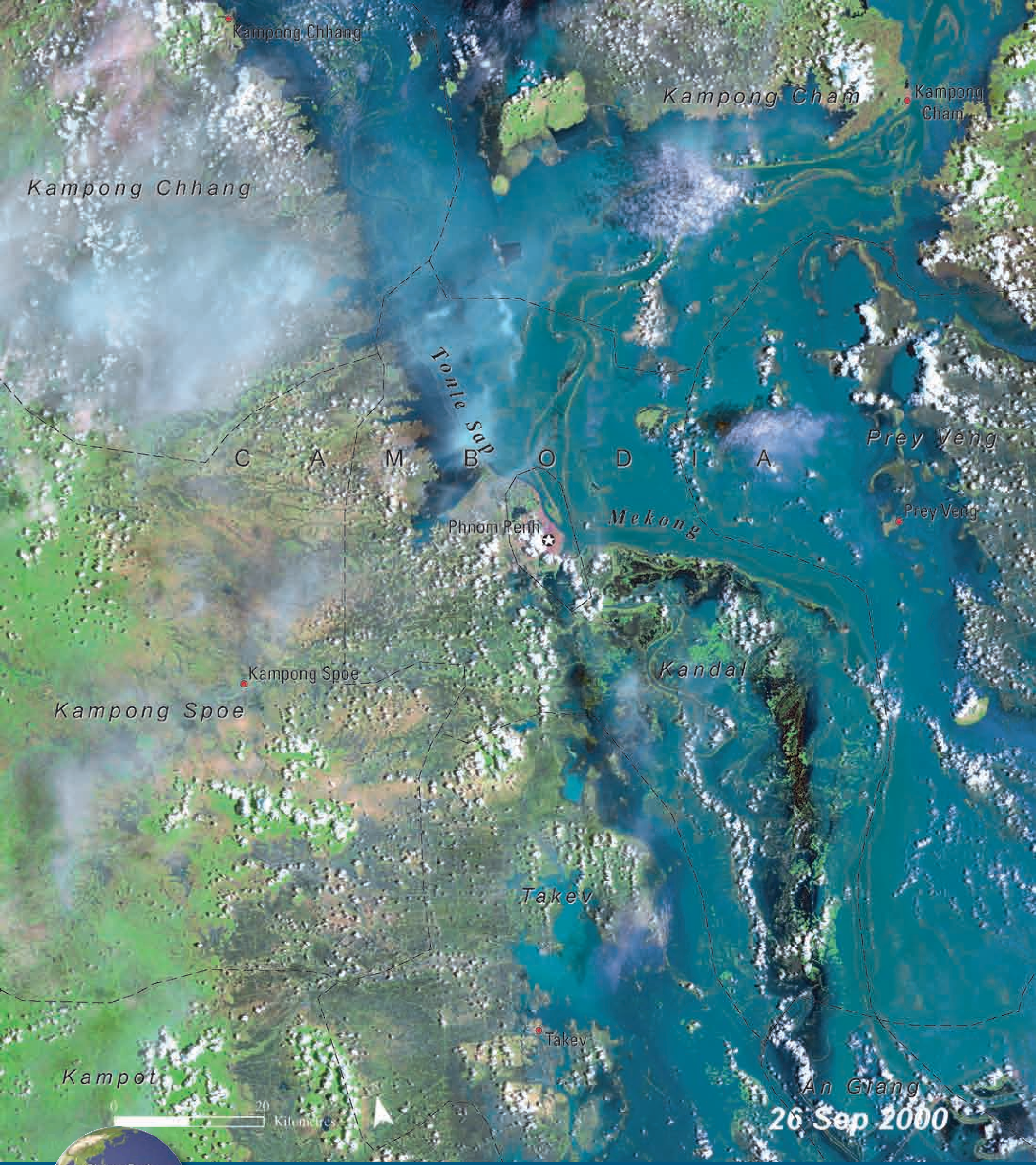
of light- and dark-colored water. Behind the sea wall, tidal flats can be seen drying as water is slowly drained away. In the 2003 image, that area has been fully reclaimed from the sea.

The Isahaya Bay Reclamation project has been fraught with controversy. Environmental groups have criticized the project for its destruction of wetland habitat. The Isahaya Bay area is known for its production of nori (seaweed), and local farmers have complained that the reclamation project has negatively impacted the quality and abundance of the nori growing in the bay. The Isahaya project prompted the formation of the Japan Wetlands Action Network, a group of grassroots and national conservation organizations who are protesting the project and recommending that the sea wall gates be opened to restore ecological balance.

Coastal Areas
Knife River Delta, Canada

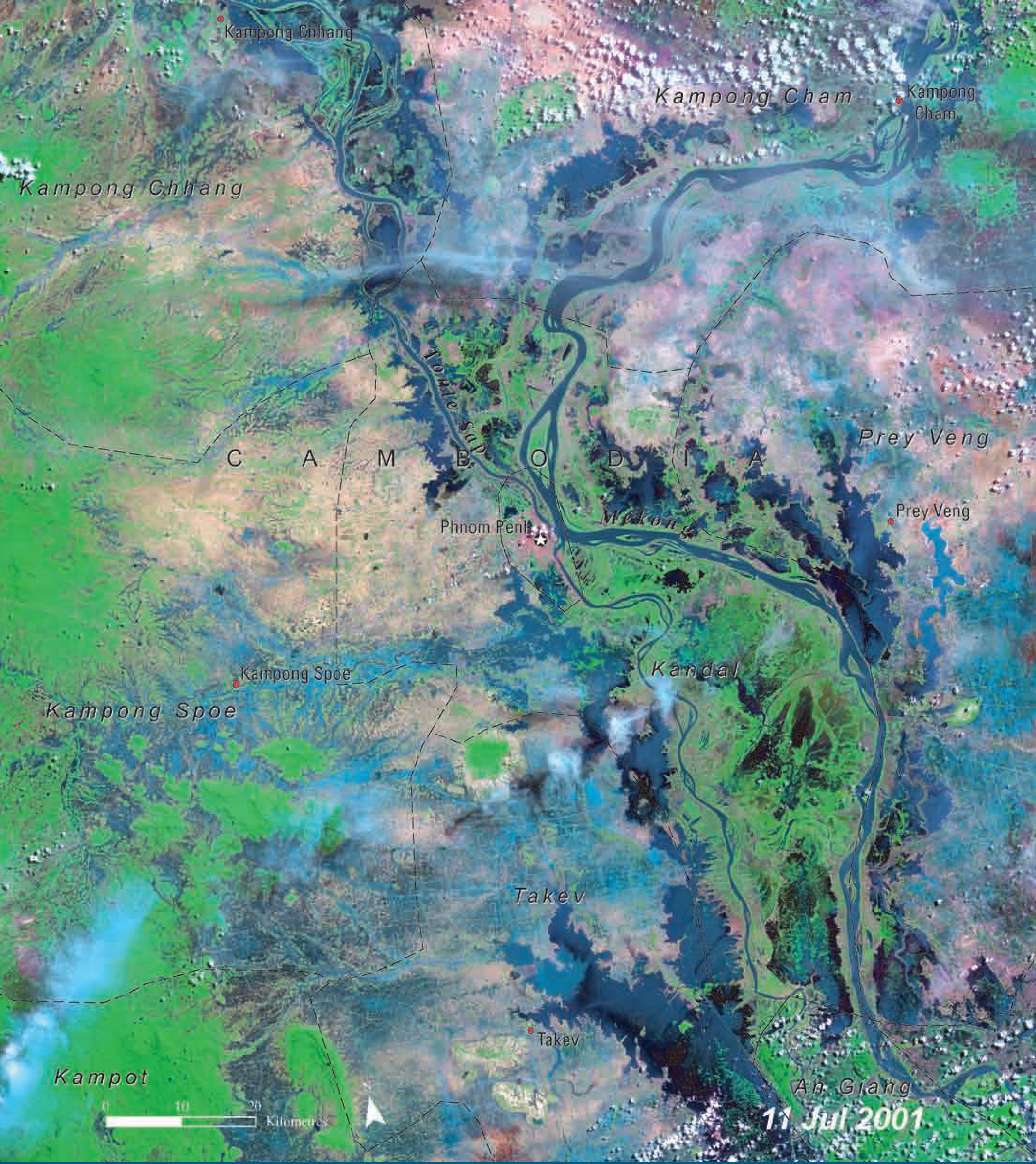
Snow geese migrate each spring to the shores of Hudson Bay, Canada, to breed and to raise their chicks. Over the past few decades, the numbers of geese descending upon the Bay's Knife River delta area have increased substantially. Their impact on coastal vegetation can clearly be seen in this pair of satellite images.

In the image on the right, notice how the vegetation (green) has receded from the shoreline north of the delta. Snow geese have overgrazed this area and turned the shoreline into an enormous mudflat. Having denuded the shoreline of vegetation, the geese have also moved inland in search of food on the tundra, where overgrazed soil quickly becomes barren and develops a crust of salt due to evaporation. The salty layer prevents the regrowth of plants, and ultimately leads to erosion. Some researchers have suggested lifting restrictions on the hunting of snow geese in an attempt to reduce their numbers and control the overgrazing problem. Others believe such measures are "too little, too late."



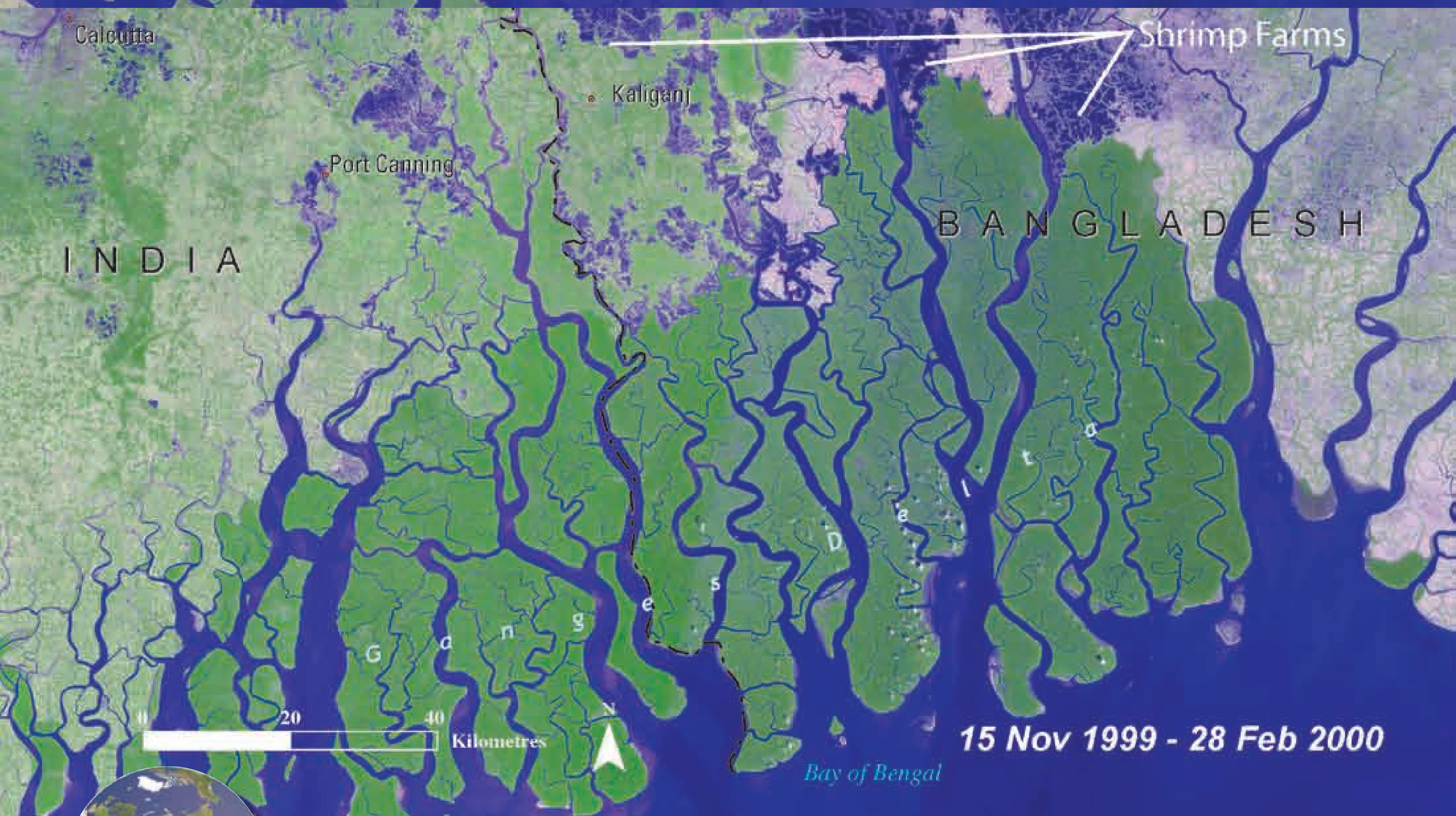
Coastal Areas
Phnom Penh, Cambodia

Phnom Penh (pronounced p-NOM PEN) is the capital city of Cambodia. It is just west of the four-way river intersection, which is called the Chattomukh ("Four Faces"). From the northwest and northeast, respectively, flow the Tonle Sap and Mekong Rivers. These waters merge and split into the Basak River and the Mekong,



which flow southeast to the South China Sea. The Mekong River is the 12th longest in the world, flowing from western China to the Mekong Delta in southern Vietnam. Every autumn, monsoon rains are too great for the Mekong to carry, and it floods a large area of Cambodia. This flood even reverses the flow of the Tonle Sap River, northward to the Tonle Sap ("Great Lake") which can expand to ten times its normal size.

This pair of images show the extent of flooding associated with the two rivers. The 2000 image was taken during a period of flooding while the 2001 image was taken after the flood waters had receded. Visible also in the images, especially in the south-central area of the 2001 image, are extensive ditches and canals that are used in irrigation.



Coastal Areas

Sundarban, India/Bangladesh

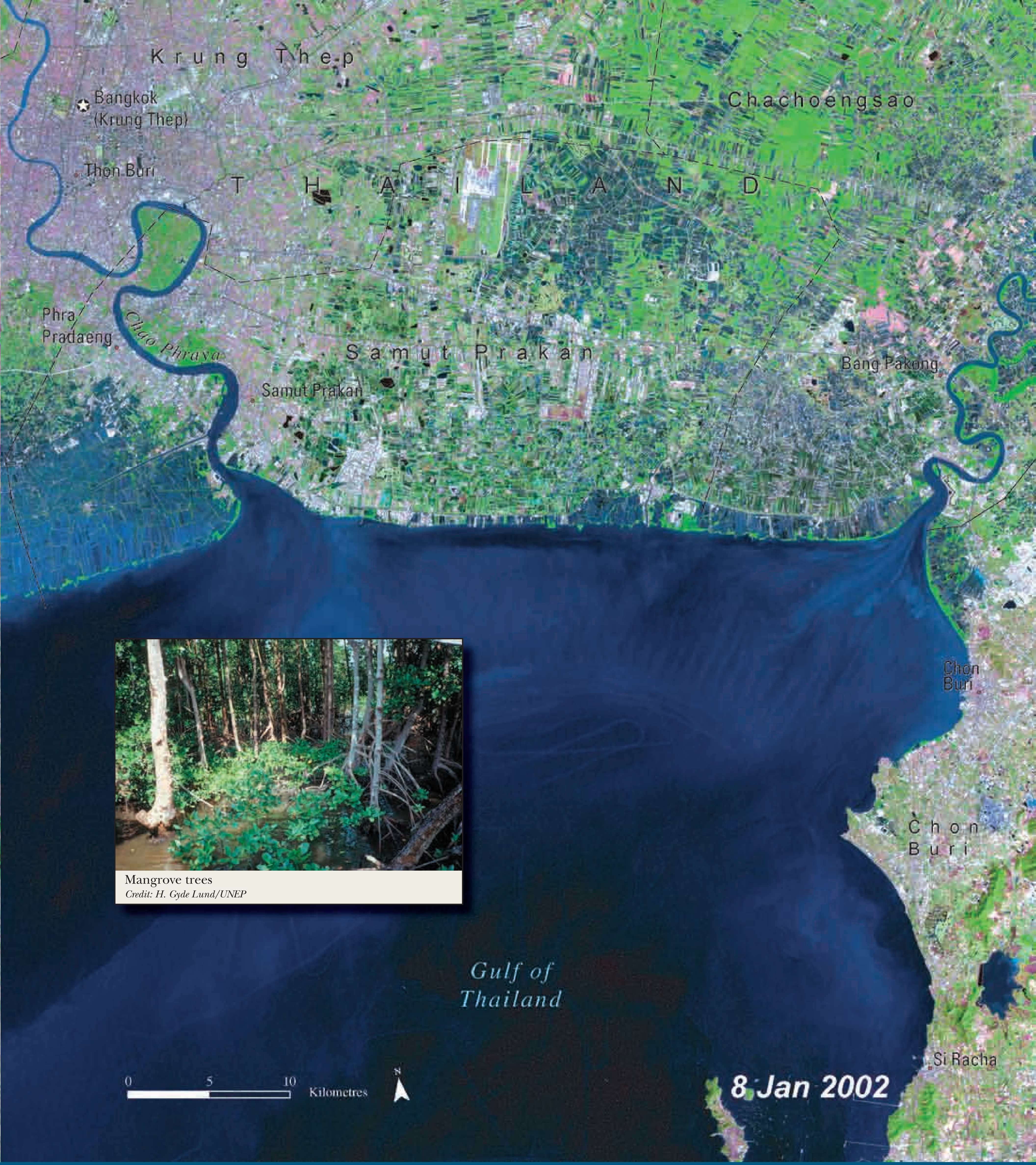
Sundarban, the largest mangrove forest of the world, is situated in the southwestern part of Bangladesh and in the West Bengal of India. Guarded by the Bay of Bengal, Sunderban is an excellent example of the coexistence of human and terrestrial plant and animal life. Despite

high population pressure and environmental hazards such as siltation, cyclone flooding and sea level rise, the aerial extent of the mangrove forest has not changed significantly in the last 25 years. In fact, with improved management, the tiger population has increased from a mere 350 in 1993 to 500-700 in 2000 and ecotourism is progressing well. However, while sufficient data is not available, several reports suggest that forest degradation has been occurring in many parts of Sundarban. The Sundarban's mangrove forests are also becoming more vulnerable due to the significant rise of shrimp farming in the region. The increase of shrimp farming has negatively affected agriculture and also contributed to the loss of mangrove forests during the past two decades.

Shrimp farm
Credit: H. Gyde Lund/UNEP

Coastal Areas
Thon Buri, Thailand

As the city of Bangkok, Thailand, has grown, the need to provide food and an additional economic base for its burgeoning population has been a primary concern. Parts of the Thai coastline, including those near Bangkok, offer conditions favorable to aquaculture,



Mangrove trees
Credit: H. Gyde Lund/UNEP

especially shrimp aquaculture. Over time, as these satellite images from 1978 and 2002 reveal, the mangroves that once lined the coast near Bangkok, as well as the rice paddies that lay further inland, have been replaced by aquaculture ponds (blue patches inland) and urban structures (light purple). The promotion and development of aquaculture has led to the current situation, where farmed shrimp and fish production now exceeds that of shrimp and fish capture by traditional methods. The development of this coastal industry has raised environmental concerns, as extensive areas of mangroves have been destroyed to make way for aquaculture ponds. The challenge of balancing the needs of people living in coastal areas versus the welfare of the coastal areas themselves is ongoing, and repeated along many coastlines worldwide.