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RAPID RESPONSE ASSESSMENT

THE LAST STAND OF THE ORANGUTAN

STATE OF EMERGENCY: ILLEGAL LOGGING, FIRE AND PALM OIL IN INDONESIA'S NATIONAL PARKS

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STATE OF EMERGENCY: ILLEGAL LOGGING, FIRE AND PALM OIL IN INDONESIA'S NATIONAL PARKS

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PREFACE

Globalization and international trade are generating wealth on an unprecedented scale and lifting millions out of poverty. However, the growth of global markets is also putting pressure on the Earth's ecosystems or natural assets that in many ways are the foundation of wealth creation in the first place.

The planet's tropical forests are some of these extraordinary and economically important assets – ecosystems playing a vital role in moderating the atmosphere, sequestrating greenhouse gases, delivering watershed management and are home to a rich and biologically important array of plants and animals.

This UNEP Rapid Response report, carried out on behalf of the UN-led Great Ape Survival Project, has used the latest satellite imagery and data from the Government of Indonesia to assess changes in the forests in one part of south-east Asia.

The results indicate that illegal logging, fires and plantations of crops such as palm oil are now intruding extensively into Indonesia's national parks which, for example, are the last safe-holds of the orangutan.

In the past five years more than 90% of over 40 parks have now been impacted putting at risk national and regional attempts to meet the 2010 biodiversity target. The driving forces are not impoverished farmers, but what appears to be well-organized companies with heavy machinery and strong international links to the global markets.

UNEP applauds the Indonesian government's new initiative focusing on new and specially trained ranger units to win back the national parks. It is starting to show some promising results with illegal logging halted in two parks in 2006. But the authorities need more assistance. National parks represent a common heritage and their protection and enforcement is essential in international conservation. UNEP therefore hopes to work even more closely with Indonesia's government in the coming years and support them in this vital work that may hold promise for other nations too.

Achim Steiner
Executive Director
United Nations Environment Programme

SUMMARY

Orangutans are native to Indonesia and Malaysia. Their survival is seriously endangered by illegal logging, forest fires including those associated with the rapid spread of oil palm plantations, illegal hunting and trade. In the last few years, timber companies have increasingly entered the last strongholds of orangutans in Indonesia: the national parks. Official Indonesian data reveal that illegal logging has recently taken place in 37 of 41 surveyed national parks in Indonesia, some also seriously affected by mining and oil palm plantation development. Satellite imagery from 2006 document beyond any doubt that protected areas important for orangutans are being deforested. The use of bribery or armed force by logging companies is commonly reported, and park rangers have insufficient numbers, arms, equipment and training to cope.

If current logging trends continue, most of Indonesia's national parks are likely to be severely damaged within the next decade, because they are amongst the last areas to hold valuable timber in commercially viable amounts. The situation is now acute for both the Bornean orangutan and Sumatran orangutan. These species are classed as Endangered and Critically Endangered respectively by the World Conservation Union (IUCN), and are listed on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The rapid rate of removal of food trees, killing of orangutans displaced by logging and plantation development, and fragmentation of remaining intact forest constitutes a conservation emergency. More than one thousand orangutans are living in rescue centres in Borneo alone, with uncertain chances of ever returning to the wild.

A series of international and national initiatives have been developed to address illegal logging. However, it is evident that Asian, European and North American markets are still major recipients of illegally logged wood products, which often change ownership and recorded country-of-origin multiple times during transport. An estimated 73–88% of all timber logged in Indonesia is illegal. Less than 20% is smuggled out as logs, and the remaining wood is processed in saw, paper or pulp mills and later exported. These mills have a capacity of two to five times greater than the legal supply of timber.

This assessment, based on a series of independent studies, shows that the disastrous situation in Indonesia's forests is driven mainly by international markets and well-organised timber supply networks. This pattern is also seen in other tropical areas including Latin America and Africa. If the immediate crisis in securing the future survival of the orangutan and the protection of national parks is not resolved, very few wild orangutans will be left within two decades. A scenario released by UNEP in 2002 suggested that most natural rainforest in Indonesia would be degraded by 2032. Given the rate of deforestation in the past five years, and recent widespread investment in oil palm plantations and biodiesel refineries, this may have been optimistic. New estimates suggest that 98% of the forest may be destroyed by 2022, the lowland forest much sooner. Since mature forest is being lost from large areas, the supply of timber will decline further. This means that the incentive to log protected areas will grow. The rate and extent of illegal logging in national parks may, if unchallenged, endanger the entire concept of protected areas world wide. At current rates of intrusion into national parks, it is likely that many protected areas will already be severely degraded in three to five years, that is by 2012.

Indonesia has worked extensively with other countries to reduce illegal logging, but this objective requires the substantial support of the international community, including recipients of illegally logged timber. Efforts to introduce timber certification, and other work to reduce levels of illegal trade are critical, but most likely to have impacts over the long-term. The recent Indonesian initiative of better training and equipment of park rangers, including the development of Ranger Quick Response Units (SPORC – Satuan Khusus Polisi Kehutanan Reaksi Cepat) is therefore the most promising countermeasure, but requires substantial strengthening to deal with the scale of the immediate problem. Currently, 35 national parks have 2 155 ordinary field rangers to patrol an area of 108 000 km^2.

These rangers have little access to ground vehicles, helicopters, aeroplanes, communication, necessary arms or paramilitary long-range patrol training that would enable them to intercept and stop illegal intrusions at these scales. The training, sufficient arming and equipping of these rangers and SPORC units to locate, intercept, arrest and repel companies from protected areas appear to be among the most promising critical emergency responses. If such programmes are strengthened to become fully operational in the most threatened parks, they may serve as global role-models for the continued protection of national parks for biodiversity conservation.

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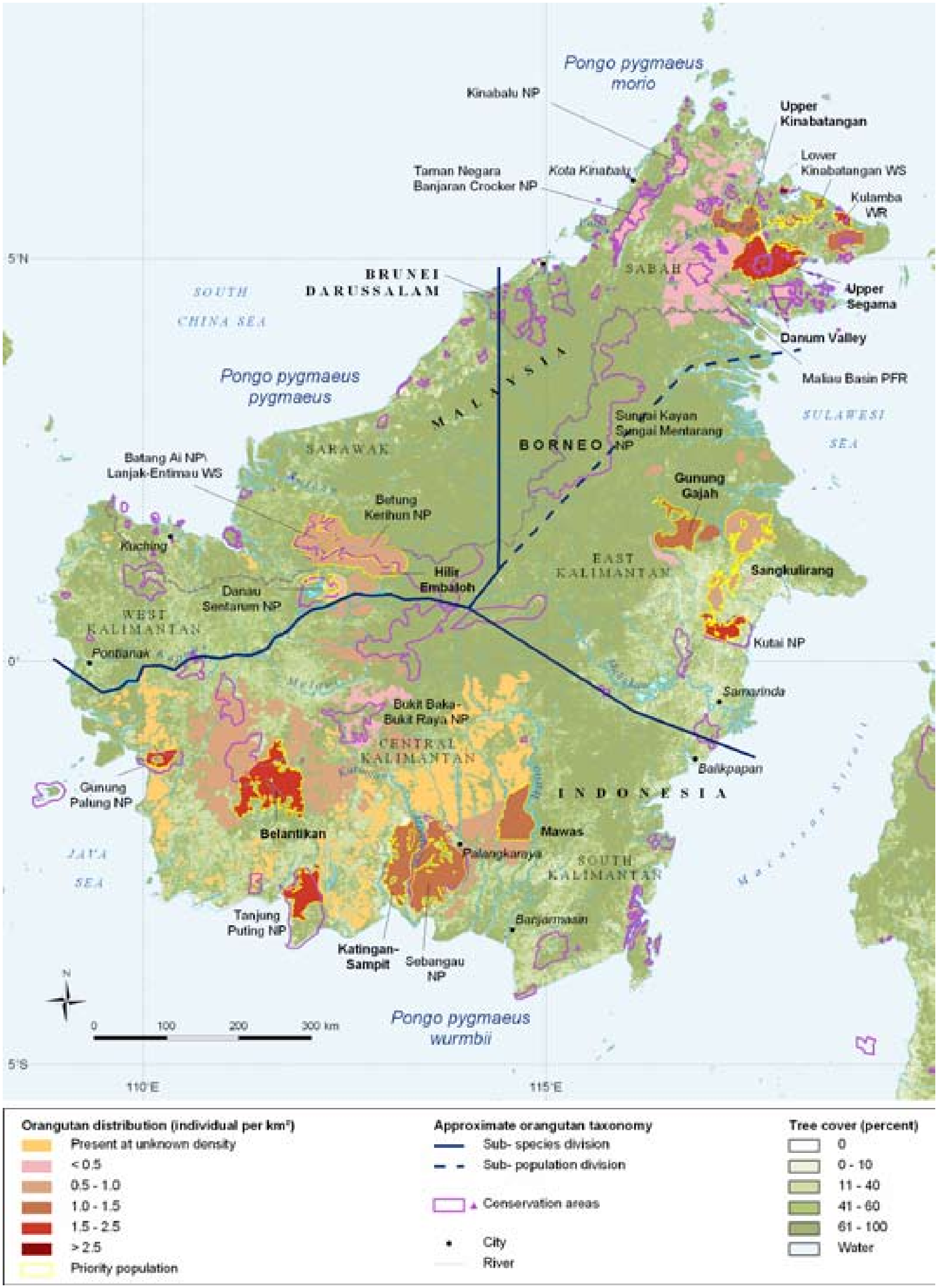

Figure 1: Bornean orangutan distribution, with priority populations highlighted. Reproduced from Caldecott & Miles (2005); updated with GRASP priority populations. Sources: Ancrenaz & Lackman-Ancrenaz (2004); Meijaard *et al.* (forthcoming); Meijaard *et al.* (2004); Singleton *et al.* (2004).

ORANGUTANS ON THE EDGE

Orangutans survive only in the dwindling tropical rainforests of Borneo and northern Sumatra, being dependent on the forest for food and nesting sites. Orangutan populations are seriously affected when their forest is destroyed or logged, not least because they are often killed for meat or to protect newly planted crops. For example, in the Sebangau swamp forests of central Borneo, orangutans fled from illegal logging operations, moving into less ideal habitat (Husson *et al.* 2002). The resulting overcrowding led to an increased death rate among young orangutans, and fewer births amongst females. When the forest started to regenerate, the orangutans were able to return. In Malaysia, the Kinabatangan Orangutan Conservation Project has studied the effects of the transformation wrought by logging on dipterocarp forests. The removal of most large trees means that the heavy adult male orangutans were forced to move along the ground, increasing their vulnerability, but on the other hand, the invasion of the logged forest by vines and pioneer species soon resulted in an increased abundance of fruit (Ancrenaz *et al.* 2005). If they are not killed in the process, orangutans in these habitats can survive selective logging. Evidence from Ketambe and Gunung Leuser in Sumatra suggests that the ability of these forests to support orangutans initially declines with selective logging, but can recover over time. Over Borneo and Sumatra as a whole, illegal logging has led to huge declines in orangutans and other wildlife. Where forests are converted to plantations of oil palm (*Elaeis guineensis*) or other crops, the consequences are even more serious, with many orangutans starving.

Like all great apes, orangutans have long lifetimes, long "childhoods" and relatively low reproductive rates, which makes it difficult for them to recover when large numbers are killed. Recent estimates suggest that there are 45 000 to 69 000 Bornean orangutans and only 7 300 Sumatran orangutans remaining in the wild (Caldecott & Miles 2005). The Bornean orangutan is classified as Endangered by IUCN (the World Conservation Union), indicating that it has a very high risk of extinction in the wild in the near future. There are at least three subspecies of Bornean orangutans: *Pongo pygmaeus pygmaeus* (northwest), *Pongo pygmaeus wurmbii* (central) and *Pongo pygmaeus morio* (northeast) (Figure 1). The central Bornean orangutan is the largest, followed by the northwest subspecies, and the northeast subspecies is the smallest.

Orangutan biology

Orangutans are intelligent, strong, large primates, and live a semi-solitary life in the trees. A balanced orangutan diet consists of fruits and seeds, but they are also able to eat foodstuffs such as bark, leaves and insects to survive in times of shortage. Fresh sleeping nests are built from branches and leaves almost every evening.

Sumatran orangutans (*Pongo abelii*) are only found in Indonesia, and Bornean orangutans (*Pongo pygmaeus*) only in Indonesia and Malaysia, with occasional males reported as wandering into Brunei Darussalam. The Bornean and Sumatran species have formed separate breeding populations for around one to two million years, differing in genetics, behaviour, diet, life history and morphology (MacKinnon *et al.* 1996; Delgado & van Schaik 2000, Wich *et al.* 2004; McConkey 2005; Wich *et al.* 2006a, b; Taylor 2006). Neither species is territorial, but fully developed adult males tend to avoid one another, and occasionally fight if they do meet.

The Sumatran orangutan is classified as Critically Endangered by IUCN, indicating that it has an extremely high risk of extinction in the wild in the near future. Since 1900, the number of Sumatran orangutans is thought to have fallen by about 91%, with a rapidly accelerating loss towards the end of the twentieth century (McConkey 2005). As a result of logging, infrastructure development, internal migration and plantation development, Sumatra's

forest area was reduced by 61% between 1985 and 1997. The remaining orangutan population is therefore fragmented, with the core of its range being the Leuser Ecosystem. This conservation area is itself recognised in Indonesian law, and contains the Gunung Leuser National Park, which forms part of the Tropical Rainforest Heritage of Sumatra World Heritage Site.

There is a serious need for conservation action on both islands, because even within these formally protected areas, orangutans are under pressure. Priority populations for conservation action (Figure 1, 2) have been identified by scientists working with the Great Apes Survival Project (GRASP). The goal is to retain viable populations of both orangutan species and all three Bornean subspecies in their natural habitats wherever they exist, conserving their genetic, cultural and ecological diversity.

Figure 2: Sumatran orangutan distribution, with priority populations highlighted. Reproduced from Caldecott & Miles (2005); updated with GRASP priority populations. Sources: Dadi & Riswan (2004); Singleton *et al.* (2004).

AN IRREPLACEABLE HABITAT

Orangutans share their forests with a wide range of other threatened and ecologically important species. The tropical rainforests of Borneo and Sumatra have a biological richness and diversity (Table 1) that reflects their unique history, climate and ecology. The most species-rich are the lowland dipterocarp forests, so named because of the predominance of trees from the Dipterocarpaceae family. These dipterocarp trees tend to fruit simultaneously, producing very large amounts of fruit at the same time every two to five years. In these "mast years", there is an abundance of food for seed-eaters, meaning that most of the seeds escape uneaten. Conversely, there is less fruit in other years, meaning that fruit-dependent animals such as orangutans need to occupy large ranges.

The peat swamp forests of Borneo and Sumatra have fewer endemic species than the dipterocarp forests, but they have a high density of fruiting trees, and do not have mast years which results in a more stable fruit supply, making them extremely important for orangutans.

Orangutans play a crucial role in the forests they inhabit: their diet of fruit and their mobility means that they are excellent seed dispersers. Orangutans are thus responsible in part for maintaining forested ecosystems that provide important environmental services to humanity, from water resources to climate regulation.

Table 1: Species richness and endemism in Sumatra (475 000 km^2) **and Borneo** (740 000 km^2).

Island	Birds	Mammals	Reptiles	Fresh-water fish	Selected plant taxa
Number of native species					
Sumatra	465	194	217	272	820
Borneo	420	210	254	368	900
Percentage of endemic species					
Sumatra	2	10	11	11	11
Borneo	6	48	24	38	33

Source: Kapos & Caldecott 2005.

Flagship species of the lowland rainforests of Sumatra and Borneo

There are no more than 400 to 500 **Sumatran tigers** left in the wild (Macdonald 2006). It is thought that orangutans travel in the treetops to avoid tigers. Like the Sumatran orangutan, the Sumatran tiger is Critically Endangered according to the IUCN Red List (Cat Specialist Group 1996). The Bali, Caspian and Javan subspecies of tiger have already been lost.

The **Sumatran rhinoceros** is the smallest, hairiest and probably most endangered of the five rhino species. This is a mountain rain forest rhino, which browses on woody vegetation and occasionally fruit. At most 300 individuals remain in the wild and their numbers are declining as a result of illegal hunting and habitat fragmentation.

The **Asian elephant** has a widespread distribution, but the two small, forest-dwelling subspecies found in Borneo and Sumatra are unique. Elephants come into conflict with humans when their forests are destroyed and they seek food in croplands. Sumatran elephants made the news in 2006, when at least seven elephant deaths were associated with new oil palm plantations. The Indonesian government responded in June 2006 with a commitment to increase the size of the Tesso Nilo National Park.

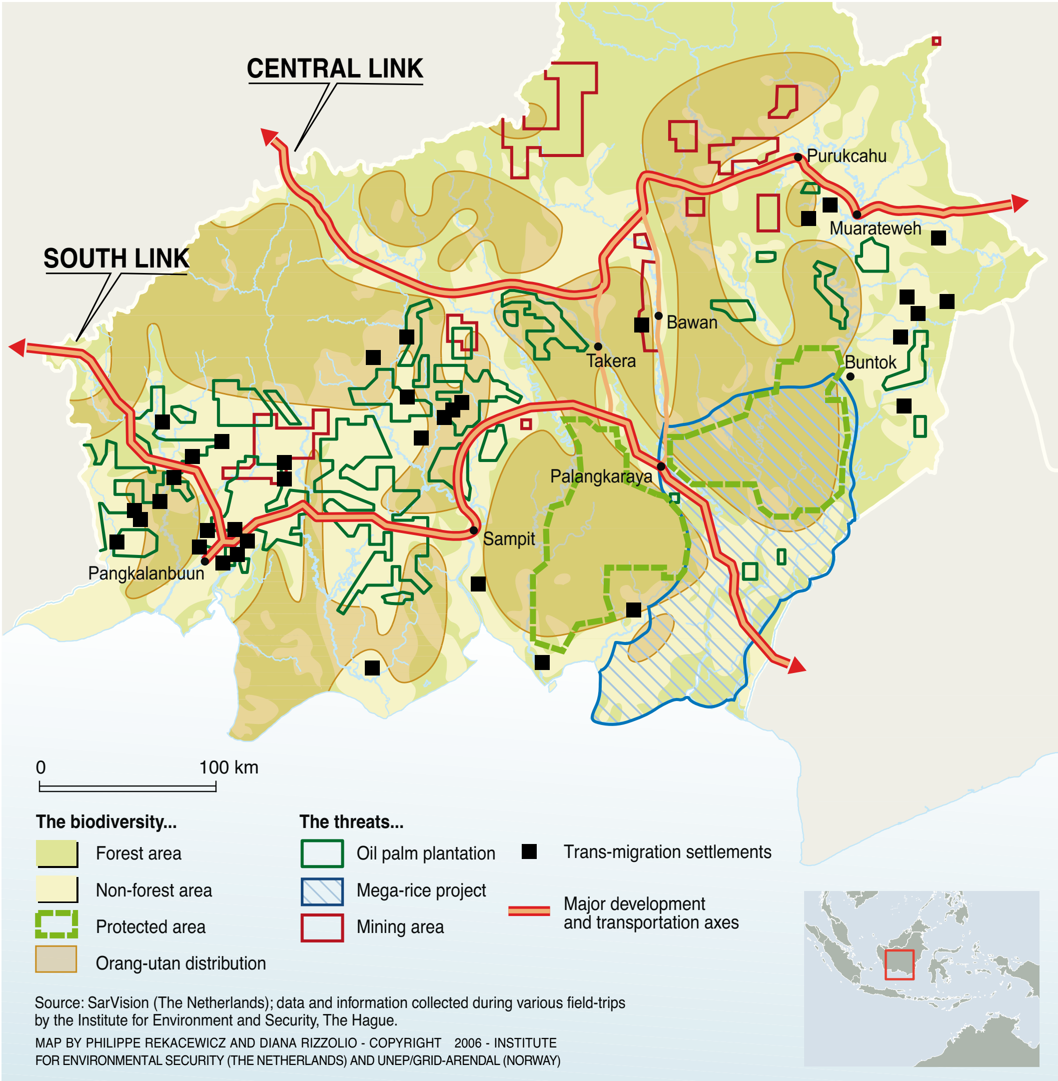

Figure 3: Loss of orangutan habitat resulting from logging, plantations, rice-fields and mining operations in southern Kalimantan. Note that this map does not show the Tanjung Puting National Park or Lamandau Nature Reserve. The illustration mainly serves to demonstrate how the range of pressures work together.

ORANGUTAN UPDATE: SITUATION DETERIORATING

To conserve the priority populations of orangutans identified as crucial for the species' survival, it is critical to tackle the loss of forest cover within their range. Indonesian forests are being destroyed or degraded by **(1)** illegal logging for timber, pulp, paper and plywood; **(2)** conversion to industrial timber and crop plantations, such as oil palm; **(3)** clearing for small-scale shifting cultivation; and **(4)** fire (Schroeder-Wildberg and Carius 2003). The trade in wood products and palm oil is largely conducted by multinational networks based in Asia, Europe and North America.

ILLEGAL LOGGING

Illegal logging includes "all forestry practices or activities connected with wood harvesting, processing and trade that do not conform to Indonesian law" (FWI/GFW 2003; Schroeder-Wildberg and Carius 2003). Illegal timber ranges from 73–88% of the total volume logged in 2003, by far the largest share of all logging in Indonesia (Schroeder-Wildberg and Carius 2003). Legal timber concessions can also be detrimental when granted in priority areas for biodiversity conservation, but illegal logging currently has far greater impacts.

Whilst the forestry sector is very important to the Indonesian economy, illegal logging is costing Indonesia at least 3 billion USD a year in lost revenues alone (Jakarta Post 2003). Officially exported wood products accounted for 6.6 billion USD in 2003, and unreported exports at least an additional 2.4 billion USD, suggesting that direct illegal export is at least 30% of the total export (Sizer 2005; White *et al.* 2006). A considerable share of this passes through Malaysia, whose mill capacity far exceeds its national wood production.

According to the Ministry of Forestry, legal timber supplies from natural forests declined from 17 million m^3 in 1995 to less than eight million m^3 in 2000, but logged timber estimated to be at least 70–80 million m^3 (Schroeder-Wildberg and Carius, 2003). While several hundred logging concessions exist, the Indonesian government attempted to reduce legal as well as illegal logging in the late 1990s. In 2004, it even proposed a law that would punish convictions for illegal logging or the setting of fires by a minimum jail sentence of 12 years, or death in exceptional cases (McConkey *et al.* 2005).

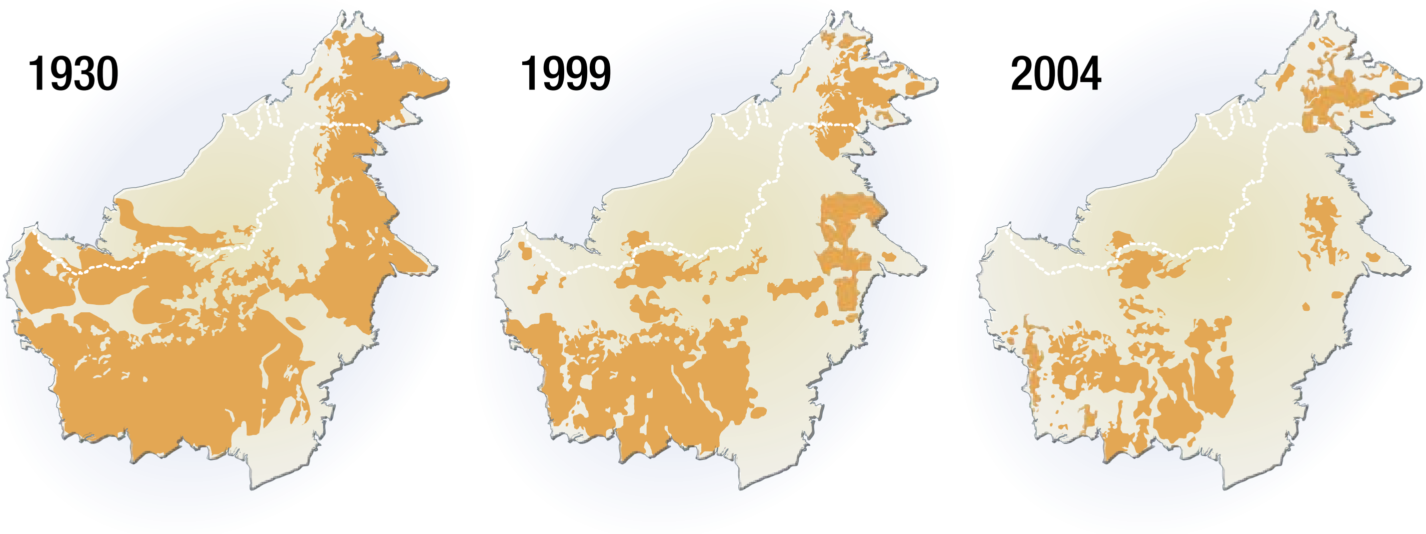

Figure 4: Changes in orangutan distributions 1930–2004. Source: WWF.

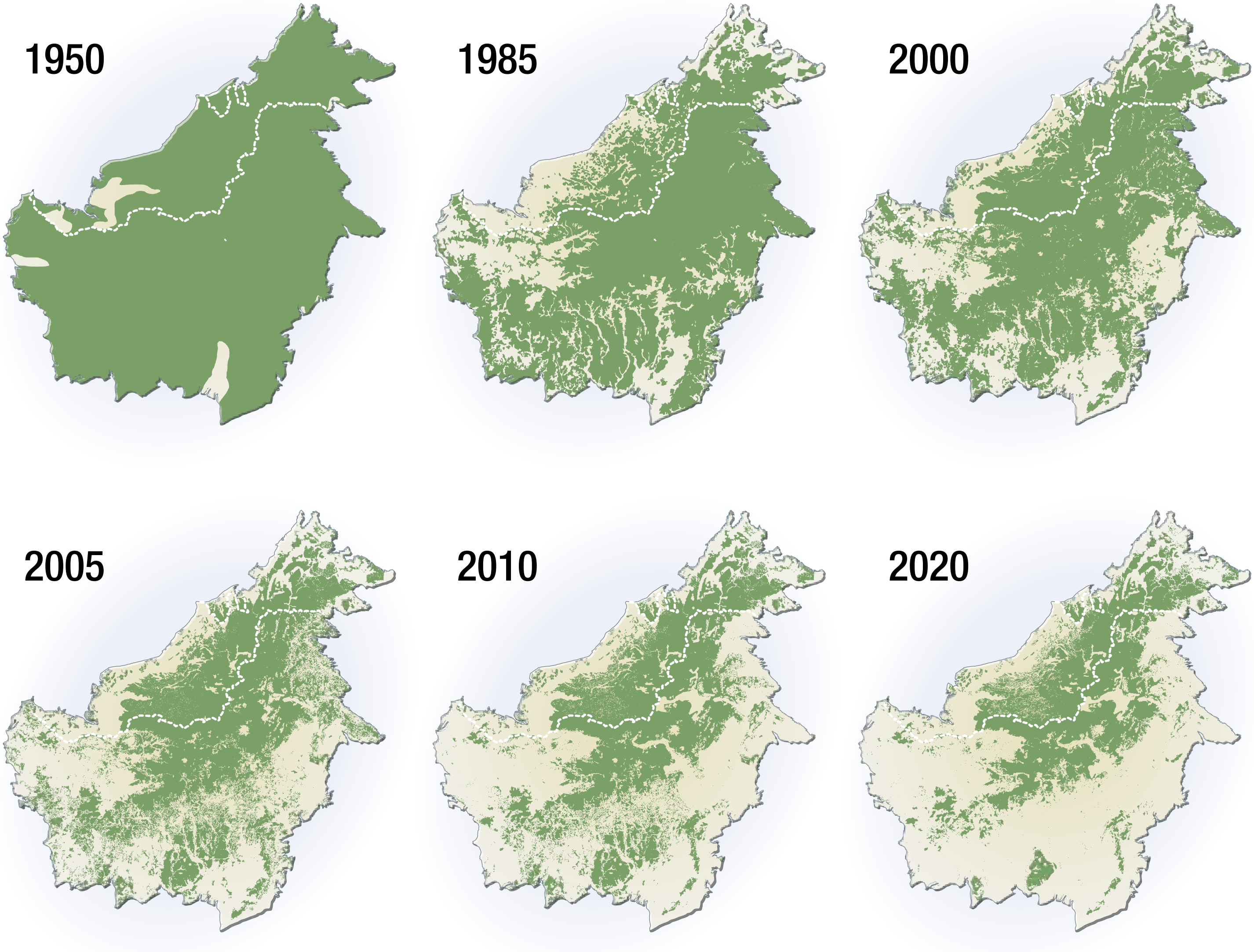

Figure 5: Extent of deforestation in Borneo 1900–2005, and projections towards 2020. Source: WWF.

ILLEGAL EXPLOITATION OF NATIONAL PARKS

Illegal logging occurs in 37 of the 41 national parks of Indonesia, but is most severe in Gunung Palung, Kutai, Danau Sentarum, Gunung Leuser and Tanjung Puting (Ministry of Forestry 2006b). Several of these parks host priority populations of orangutans and form part of the UNESCO World Network of Biosphere Reserves.

Satellite imagery confirms that in the worst cases, up to half the protected area has been exposed to heavy logging (Curran *et al*. 2004). Illegal mining is also a major threat in national parks. The miners frequently employ their own security companies and guards, which makes monitoring and enforcement difficult for rangers with very limited equipment, mandate and arms. Illegal hunting occurs in virtually all protected areas, but to varying degrees. It is highest in the areas with the fewest rangers. Projections for 2005–2010 from the Ministry of Forestry indicate that the situation will continue to deteriorate.

Assessing pressures and threats in National Parks

The WWF Rapid Assessment and Prioritization of Protected Area Management Methodology (Ervin 2003) was used at a 2004 workshop organised by the Ministry of Forestry to assess the pressures that have affected national parks over the last five years, and future threats to their integrity (Figure 7, 8). An index of Degree of Pressure (or Threat) was produced, with a scale of 1 to 64. The index multiplies scores for:

- the extent of the pressure (or threat...) over the national park, from (1) localized to (4) widespread;
- the impact of the pressure, from (1) mild to (4) severe;
- and the permanence of the pressure, from (1) <5 years to (4) permanent.

A value of 1 would indicate a short-term, mild, pressure affecting less than 5% of the national park. To be allocated a value of 64, the pressure must affect more than 50% of the park AND be severe in impact AND be permanent. Detailed guidelines are provided for allocating and analysing the scores (WWF 2003).

Ervin (2003). WWF: Rapid Assessment and Prioritization of Protected Area Management (RAPPAM) Methodology. WWF, Gland, Switzerland.

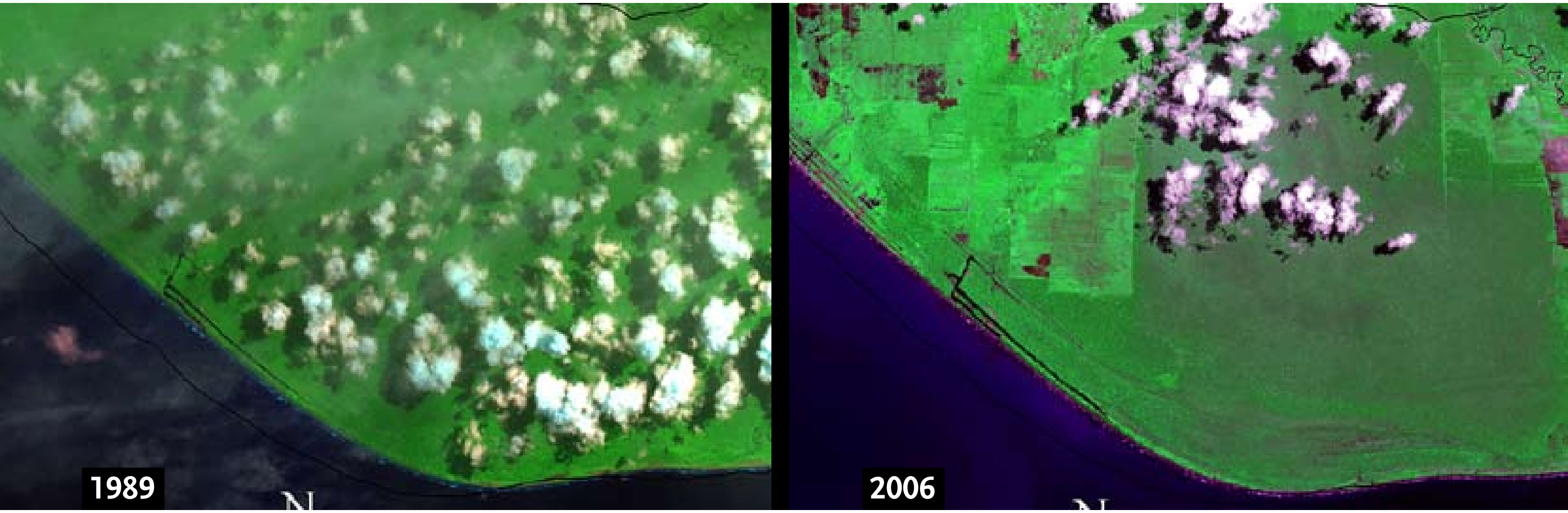

Figure 6: Loss of critical orangutan forest in the Leuser Ecosystem, Sumatra from satellite (Landsat 1989 and ASTER 2006).

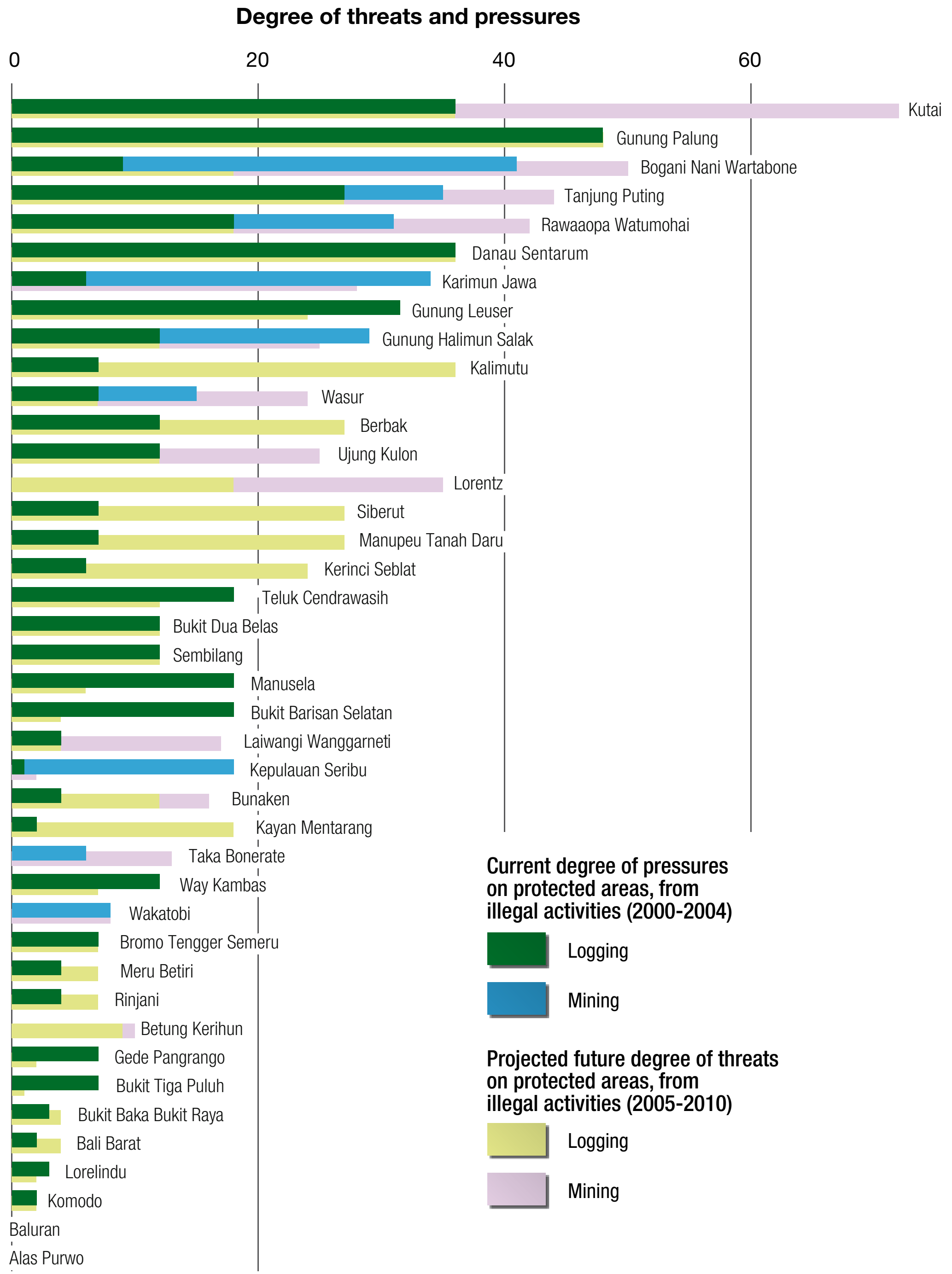

Figure 7: The extent of illegal logging and mining in national parks, Indonesia. Source: Ministry of Forestry (2006b).

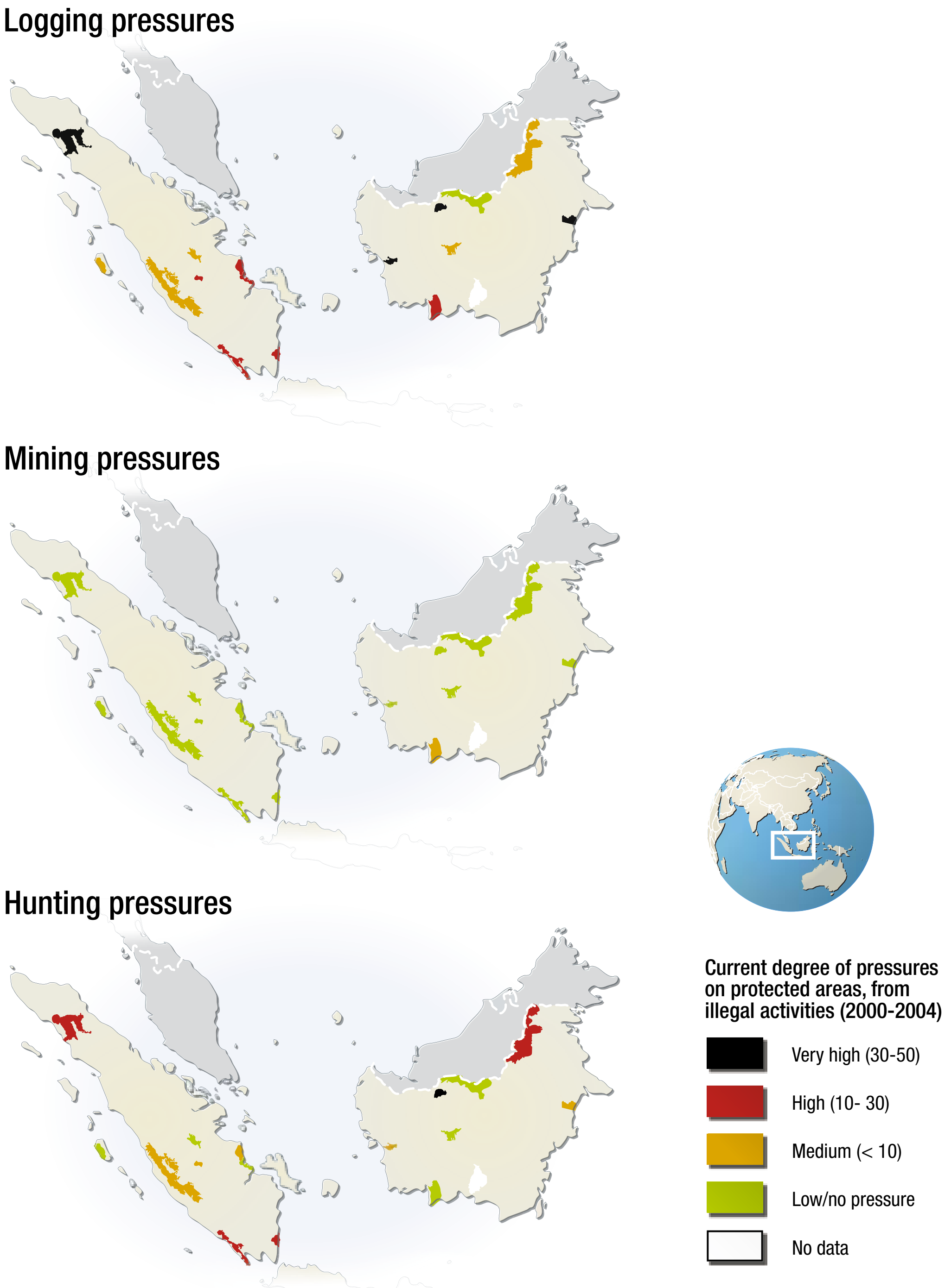

Figure 8: Illegal logging, mining and poaching in national parks. Source: Ministry of Forestry (2006b).

CASE STUDIES

After the fall of the Suharto regime in 1998, central management of protected areas was compromised. In the following few years, Tanjung Puting National Park was amongst those to suffer from illegal logging and mining. Logs were floated from the park down the Sekonyer River; the park offices in Kumai were destroyed; and rangers were unable to keep control. This exploitation was difficult to control until early 2003, the first 'Operasi Wanalaga' enforcement operation was carried out in the west of the park, involving police, military and forestry officers. Twenty-nine boats transporting around 20 000 m³ of illegal timber from the park were confiscated and over 35 km of logging rails and numerous logging camps were destroyed (EIA/Telapak 2003). Logging in the east of the park continues, and oil palm development within the park is also an issue.

Gunung Palung National Park contains highly diverse lowland forest, hosting 178 bird species and 72 mammal species (Curran *et al.* 2004). In 2003, after many years of gradual encroachment into the park (Figure 9), illegal loggers reached the research station – one of the last untouched areas deep within the park. Several illegal logging crews began actively cutting down trees, including many that had been continuously monitored for over 20 years. The illegal loggers posed an immediate threat to safety, so the Gunung Palung Orangutan Programme/Yayasan Palung (GPOPC) was forced to shut down operations.

Now, after intensive conservation efforts in the area by the GPOPC as well as other organizations and the intervention of the national government, a major percentage of Gunung Palung National Park has been cleared of illegal logging activities. It is now safe to return to the park and a consortium of national park stakeholders has developed an agreement for the re-opening and management of the park going forward and the research station will be re-built in mid-2007.

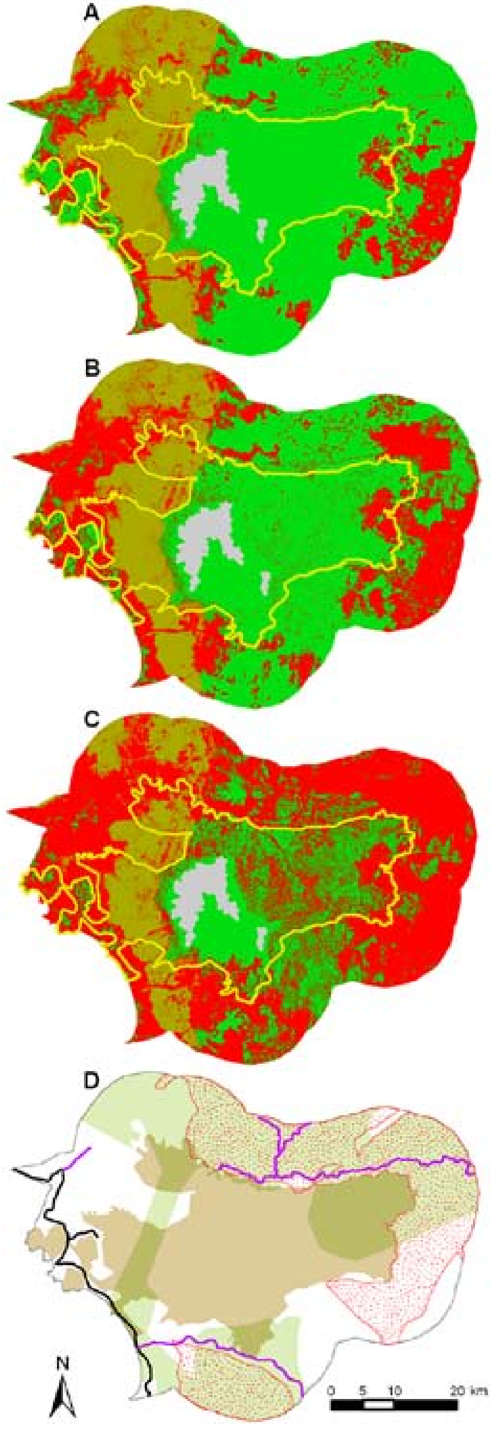

Figure 9: Cumulative forest loss within the Gunung Palung National Park boundary (yellow) and its surrounding 10 km buffer. Forest classifications are based on a Landsat Thematic Mapper time series are shown (1988 (A), 1994 (B), and 2002 (C). The well-defined degraded forest area that appears northeast of GPNP in (B) has been clear-felled for an oil palm plantation. (D) Industrial land uses – areas formerly allocated to timber concessions (green) and current plantation allocations (dotted red) account for most of the degradation within the buffer area (Curran *et al.*, 2004).

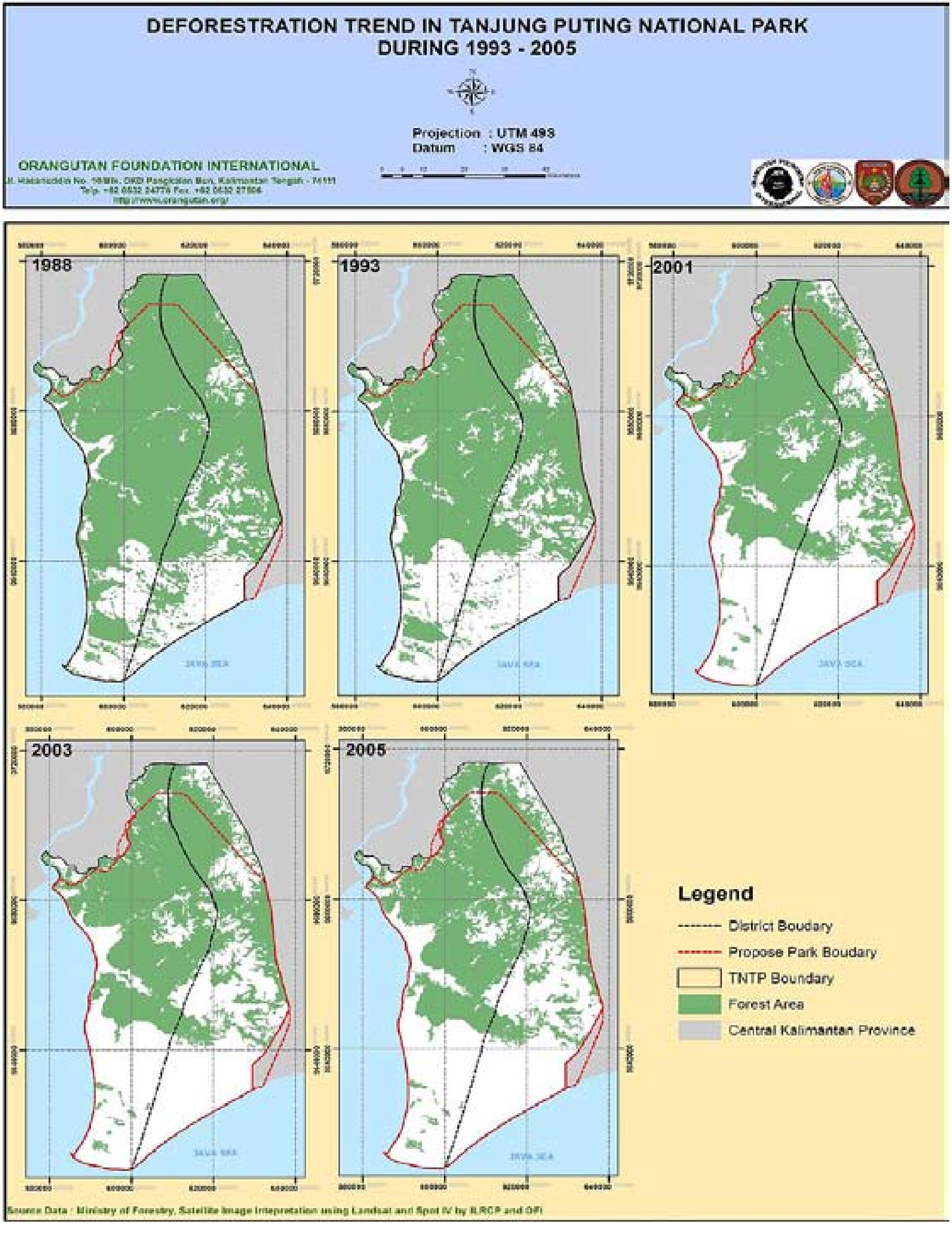

Figure 10: Deforestation in Tanjung Puting, one of the 37 national parks affected by logging and oil palm plantations.

INTERNATIONAL DRIVERS OF ILLEGAL LOGGING

GLOBAL AND DOMESTIC DEMAND EXCEEDS SUPPLY

The present reality is that domestic demand for timber from Indonesian industries exceeds the supply that can be met from the legal and licensed harvest. This domestic timber shortage is exacerbated by the fact that trading logs on the international market is more profitable than trading logs within Indonesia. As many pulp, saw and paper mills in Indonesia are largely owned or controlled through multinational parent companies (Schroeder-Wildberg and Carius 2003), the products of illegal logging easily find their way to the international market.

The combined annual raw demand of wood by the approximately 1 600 mills in Indonesia is at least 70–80 million m^3, which far exceeds the legal cut by a factor of two to five (Schroeder-Wildberg and Carius 2003).

INDONESIAN TIMBER MILLS HAVE EXCESS CAPACITY

A related problem is the fact that many of the mills are designed to process much larger volumes of timber than what can possibly be sustainably harvested from Indonesia's forests. In order to operate at a profit, timber companies are forced to seek out cheap and readily available sources of wood. This means that illegal logging has, in recent years, spread to protected areas, as they are among the few places left with valuable timber in commercial volumes (Wardojo *et al.* 2001, Curran *et al.* 2004). These areas are protected for their high biodiversity value, so enforcement is critical but generally lacking to a large extent.

TIMBER PROCESSING COMPANY DEBT COMPLETES THE CIRCLE

There is a serious debt problem associated with investments in the Indonesian industrial forestry sector. Unless the financial problems linked to the timber industry are somehow resolved, the need to get returns on these investments will remain a driving factor in the unsustainable use of forests.

One consequence of this burgeoning international trade is that Indonesia cannot address the growing problem of illegal logging alone. It requires the full assistance and co-operation of timber importing countries, including other countries in the region.

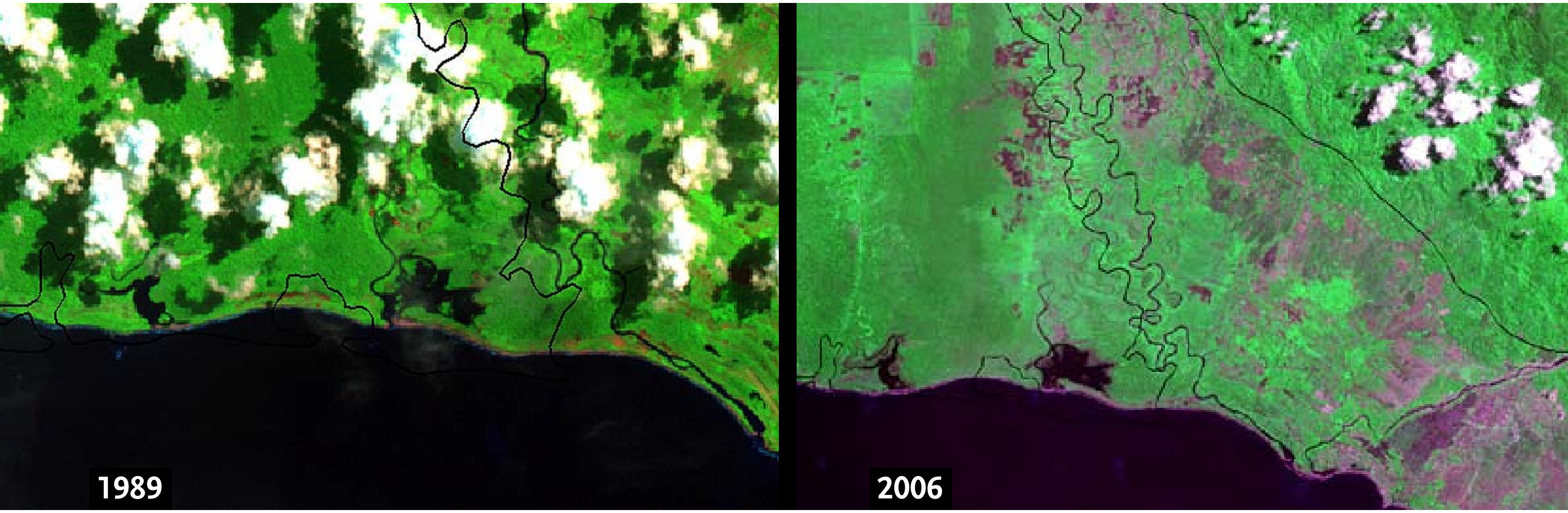

Figure 11: Loss of critical orangutan forest in the Leuser Ecosystem, Sumatra from satellite (Landsat 1989 and ASTER 2006).

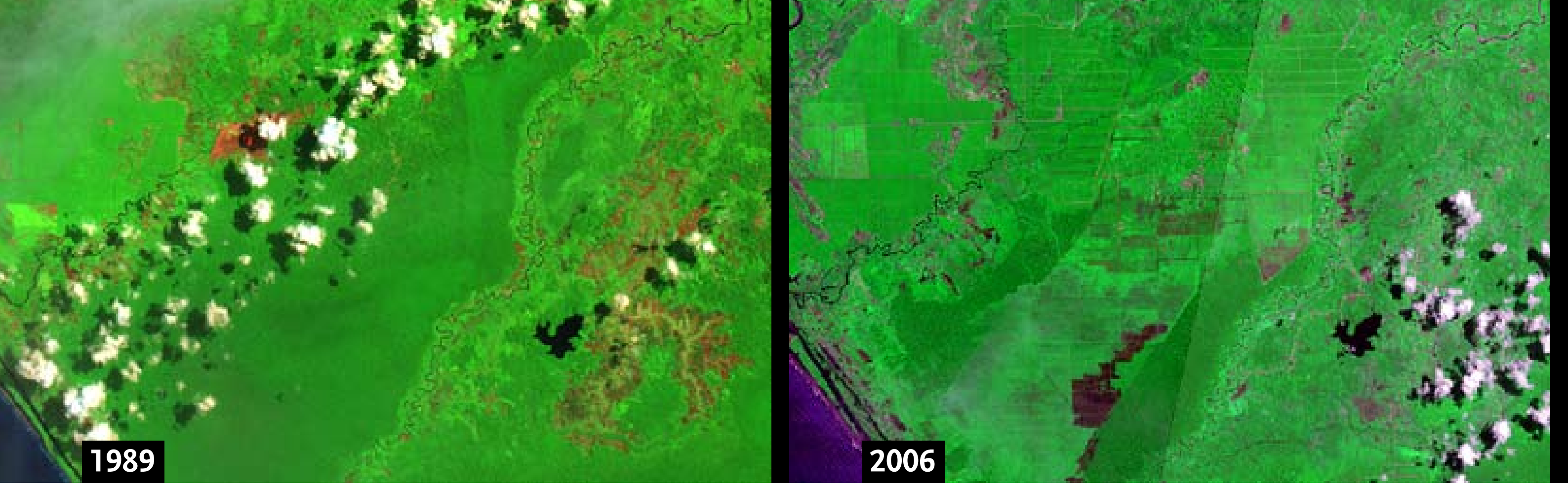

Figure 12: Loss of critical orangutan forest in the Leuser Ecosystem, Sumatra from satellite (Landsat 1989 and ASTER 2006).

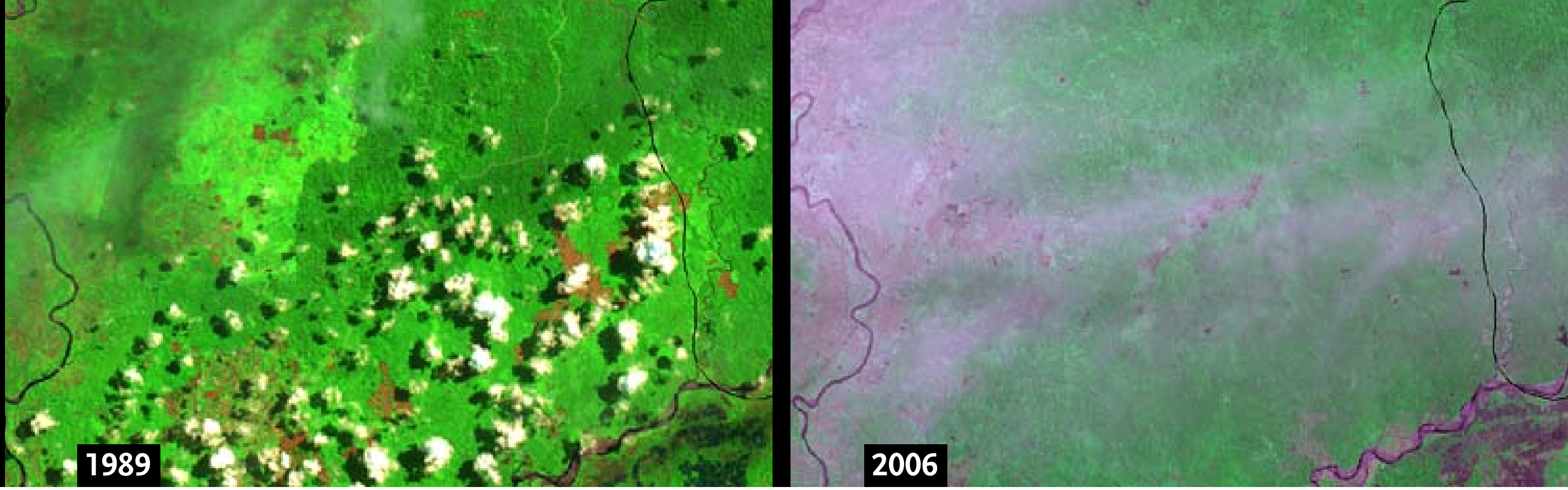

Figure 13: Loss of critical orangutan forest in the Leuser Ecosystem, Sumatra from satellite (Landsat 1989 and ASTER 2006).

MULTINATIONAL NETWORKS

The forestry sector in Indonesia includes a number of actors, including concession holders, mill operators and wood manufacturers. Most of the logging companies operating on Borneo and Sumatra are subsidiaries or contractors of multinationals or their networks, some changing names and ownership fairly rapidly, thus eluding monitoring. While many contractors are Indonesian based or owned, multinational networks, foreign investors and recipients play a crucial role in the industry.

Several mills, for example, are owned by or through subsidiaries of UFS (United Fiber System), a consortium of companies from eight countries, with its headquarters in Singapore. In 2002, ten companies controlled 45% of the total logging concessions in Indonesia (WRI 2002). And in 2005, logging concessions on 11.6 million hectares of forests in Papua province alone were granted to 65 different logging companies.

A considerable share of the timber and pulp mills are subsidiaries of multinational companies and processed in Indonesia, but 10–15% of the logs are exported directly to Malaysia or other Asian destinations (Figure 147) (Schroeder-Wildberg and Carius 2003; Currey *et al.* 2001). The remaining large share of timber, most of it illegally logged, is processed in sawmills, plywood mills, pulp mills and chip mills prior to export.

The forestry and wood-processing industry of Indonesia make up around 10% of the GDP and plywood, pulp and paper exports account for 10–20% of the total export earnings. China and Japan receive near half of all the wood products exported from Indonesia. Other Asian countries, Europe and North America account for the rest. China's import of wood products overall increased from 40 million m^3 in 1997 to over 140 million m^3 in 2005 (White *et al.* 2006).

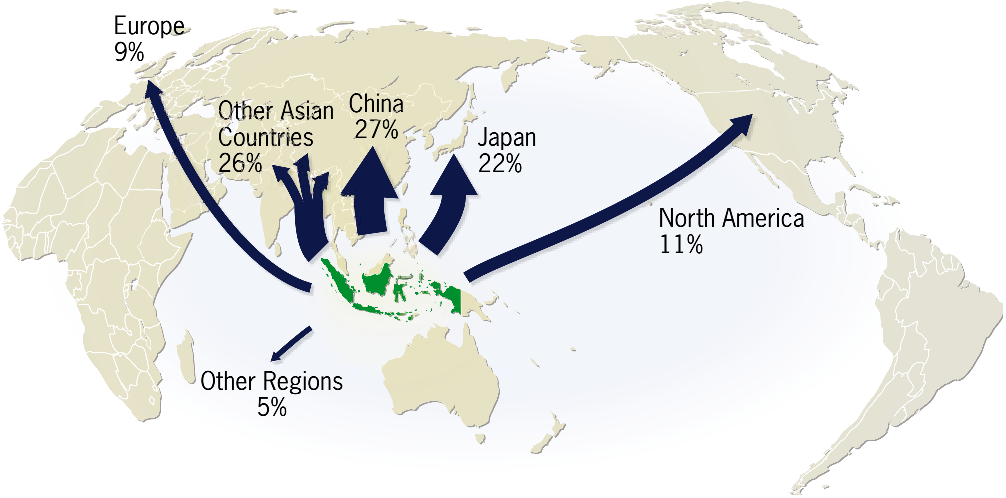

Figure 14: Export of wood products from Indonesia, a large proportion travels through Malaysia.

Figure 15: Smuggling routes of illegally logged ramin timber from Indonesia, including from national parks and protected areas (Currey *et al.*, 2005).

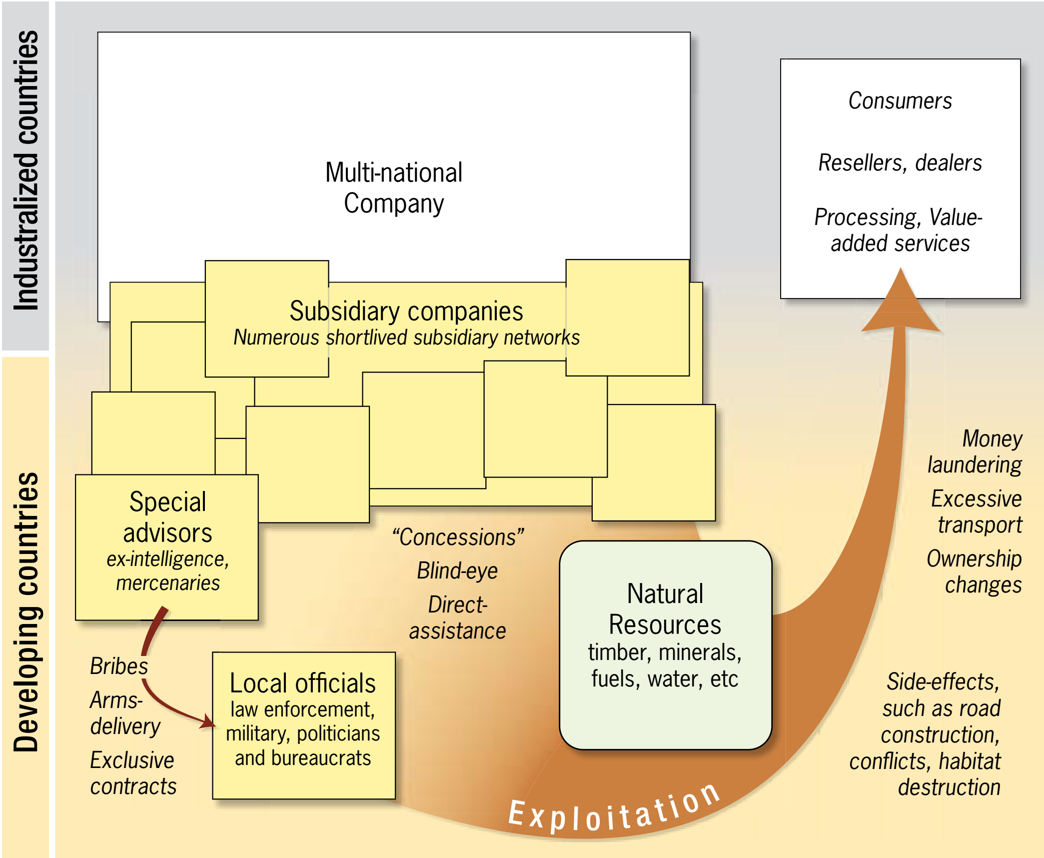

Figure 16: A generalized diagram of how multinational networks exploit natural resources by developing numerous temporary subsidiaries and use corruption and security firms to ensure rapid exploitation and maximum profits. Arms trading has been reported from the Democratic Republic of the Congo, while the bribes and "security firms" also play a major role in Indonesia.

Illegal logging may be conducted by companies with no right to be in the area, but also by legal concession holders, operating in several ways. Concession holders may over-harvest from the lands granted to them, or they may exploit areas outside these lands. In a 2001 survey, loggers from 14 out of 18 surveyed concessions illegally expanded their operations into protected areas (Curran *et al.* 2004). The timber or processed wood products may be smuggled secretly from the country, or sold and transported as if produced from a legal concession. To avoid international tracking of the timber or wood products, the products often change ownership multiple times in transit. Hence, when the wood products arrive in port in another country, it is no longer recorded as Indonesian timber.

The extent to which smuggling poses a problem can be seen in official trade data. Import figures from many countries including China, Taiwan and Malaysia, to mention a few, are generally far above that of officially reported exports from Indonesia (Schroeder-Wildberg and Carius 2005). A comparison of the official import data for a series of countries compared with Indonesia's export figures suggests discrepancies in magnitudes of up to a hundred, typically a factor of three to five. Once again, the looting and destruction of Indonesia's rainforests is an international concern, with multinational networks operating openly, while the protection of the parks is a primary law enforcement issue of Indonesia.

OIL PALM PLANTATIONS

Large areas of Indonesian and Malaysian forest have been converted to oil palm plantations, in which multinational networks are also implicated. The cheap vegetable oil is becoming increasingly popular, because, despite being high in saturated fats, it is an alternative to trans fats, which are more closely associated with heart disease, and increasingly being banned in Western countries. It is stable at high temperatures, making it very popular with food manufacturers. Already, it is found in one in ten supermarket products, including margarine, baked goods, sweets, detergents and lipsticks.

There is also an increasing market for vegetable oil as a renewable fuel (biofuel), in response to the need to reduce global carbon dioxide (CO_2) emissions. In Europe, this market was stimulated by the Biofuels Directive of 2003, which aims to reduce greenhouse gas emissions and dependence on fossil fuels. This directive promotes the use of renewable fuels for transport. Palm oil is currently considered the most productive source of biodiesel fuel.

Palm oil and palm kernel oil now make up one of the largest shares of global vegetable oil supply. Indonesia and Malaysia account for 83% of the global production of palm oil. Several African countries are also developing palm plantations to meet the expected biofuel demand. Experiences from Indonesia in improving environmental management may therefore be relevant to the sustainable development of oil palm plantations in other countries.

Today, the rapid increase in plantation acreage is one of the greatest threats to orangutans and the forests on which they depend. In Malaysia and Indonesia, it is now the primary cause of permanent rainforest loss. The huge demand for this versatile product makes it very difficult to curb the spread of plantations. Palms tend to be planted on newly-cleared forest land, rather than abandoned agricultural land, despite the availability of large amounts of suitable cleared areas. As palms do not begin to produce a crop for five years after the area is planted, the ability to sell the timber to subsidize these first non-productive years is attractive. Between 1967 and 2000, the total oil palm area in Indonesia grew from less than 2 000 km^2 to over 30 000 km^2 (FWI/GWF 2002)]. The

Plantation development in Ketapang

In Ketapang regency (kabupaten), on the south coast of western Kalimantan, there are ten large oil palm companies operating, mainly the southern part of the regency (Dinas Perkebunan pers. comm.). Eight of these companies will soon be operating around Gunung Palung National Park. The planned oil palm plantations will be developed on various habitats, such as logged over areas and peat swamp forest. These companies have been granted permission from the Ketapang regency since 2004. The oil palm plantations may increase human-orangutan conflict, locust plagues, river pollution levels and the risk of flooding.

Human – orangutan conflicts are reportedly widespread. As forests are cleared for plantations, confused orangutans can be found wandering in the newly planted areas that used to form part of their range. An adult orangutan can be intimidating to humans, so it is common for them to be killed by plantation workers. With their habitat gone, hungry orangutans will turn their attention to the young palm trees, where they can cause considerable damage, thus exacerbating the conflict.

"There's human – orangutan conflict indications in Nanga Tayap district. According to local people and workers, there were two orangutans shot last year because they entered the nursery area. The company also pays local hunters to kill sun bears and wild pigs that enter the plantation area."

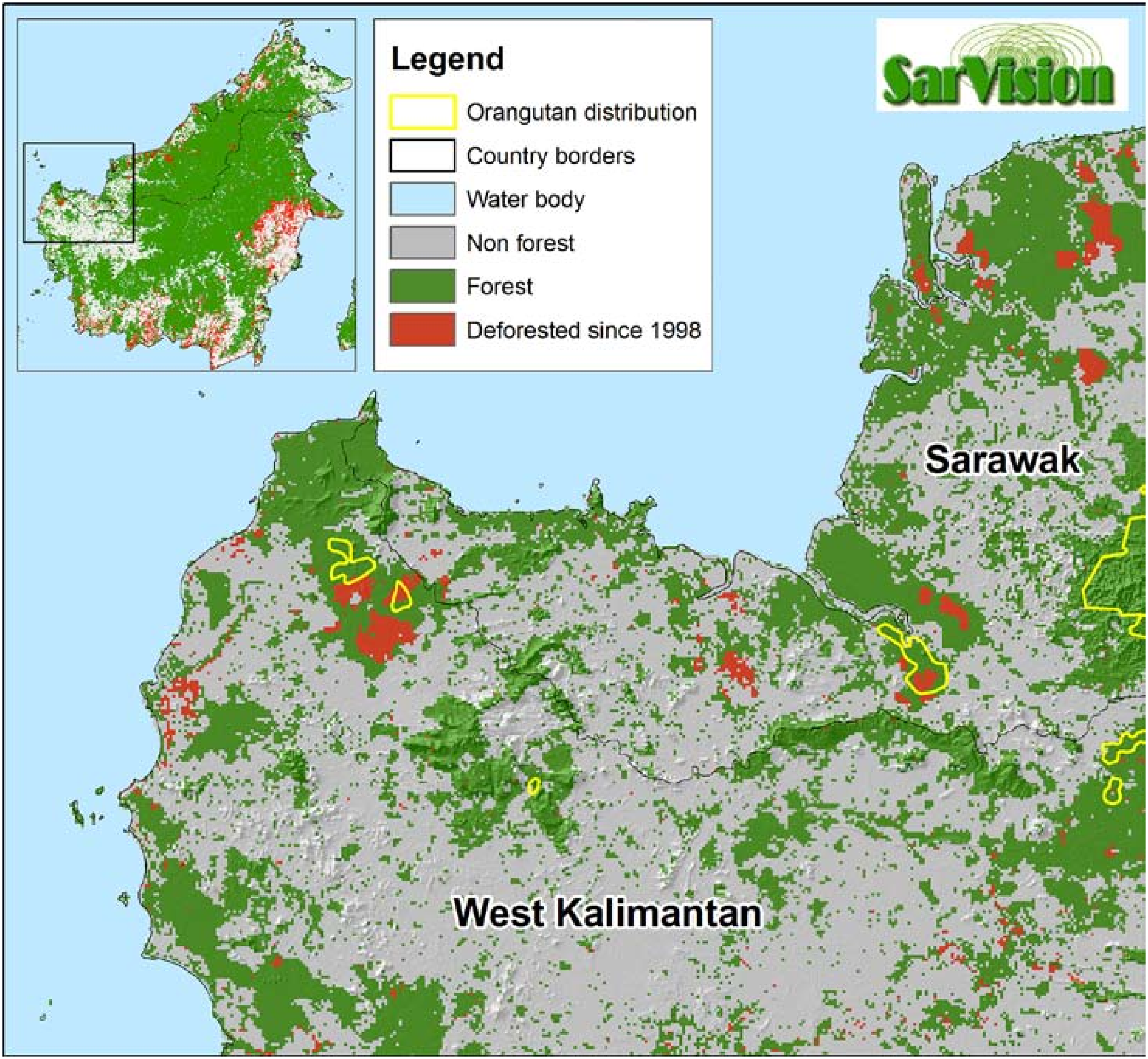

Figure 17: Deforestation and plantation development in western Borneo.

demand for palm oil is expected to double this area by 2020, which implies the annual conversion of another 30 000 km2 of forest.

The ongoing conversion of tropical rainforest for biofuel production has been a cause of concern for conservationists (Buckland 2005). But new analysis shows that CO_2 emissions from conversion of peat swamp forest in particular are far greater than gains from substitution of fossil fuels with palm oil (Hooijer *et al.* 2006). The land is drained, the trees are cut, and the peat soil that has built up over thousands of years breaks down. When fire used to clear forests for biofuel spreads into additional forest land, even more CO_2 is released. While fire fighting and emergency measures are helpful in the short-term, long-term change in the management of peatlands in Indonesia is required if the CO_2 is to remain stored in peatlands.

Ironically, in the desire to cut CO_2 emissions, western markets are driving ecosystem destruction and producing vast and significant CO_2 emissions through forest burning and peat swamp drainage. The most effective measure to achieve this is conservation of remaining peatland forests, alongside rehabilitation of degraded peatlands and improved management of plantations and agricultural areas (Hooijer *et al.* 2006).

There are signs that the world is waking up to this issue. While no certification mechanism yet exists to identify sustainably-produced palm oil, the Roundtable on Sustainable Palm Oil has been set up to bring the commercial sector together with conservation organisations, civil society groups, governments and other stakeholders. So far it has devised Principles and Criteria for sustainable palm oil production (RSPO 2006), and a broad code of conduct for members. In late 2006, there were some signs of response in the energy industry. The Dutch power company Essent has pledged to stop using palm oil (Wetlands International 2006), and one British power company in the UK that was testing the use of palm oil has dropped its plans. But the legal and illegal spread of oil palm plantations, and development of biodiesel refineries, continues.

FORESTS ON FIRE

Insular Southeast Asia endures months of smoke-filled air every year during the dry season. Farmers and plantation developers deliberately and illegally set fire to the forest to clear the way for crops, and in logged-over forest, fire spreads rapidly. When peat swamp forests catch alight, the peat burns as well as the trees. These fires can spread underground, and persist for long periods, destroying natural habitats and releasing substantial volumes of greenhouse gases.

The annual burning in Southeast Asia is usually worst in El Niño years, which are exceptionally dry. The worst recorded so far, in 1997–8, destroyed 95% of the forest in Kutai National Park: this protected area had previously been subject to high levels of logging, and may no longer be viable (Rautner *et al*. 2005). In 2006, fire levels peaked again in what is thought to be the start of an El Niño season that could continue through March 2007 (Figure 18; CPC/NCEP 2007).

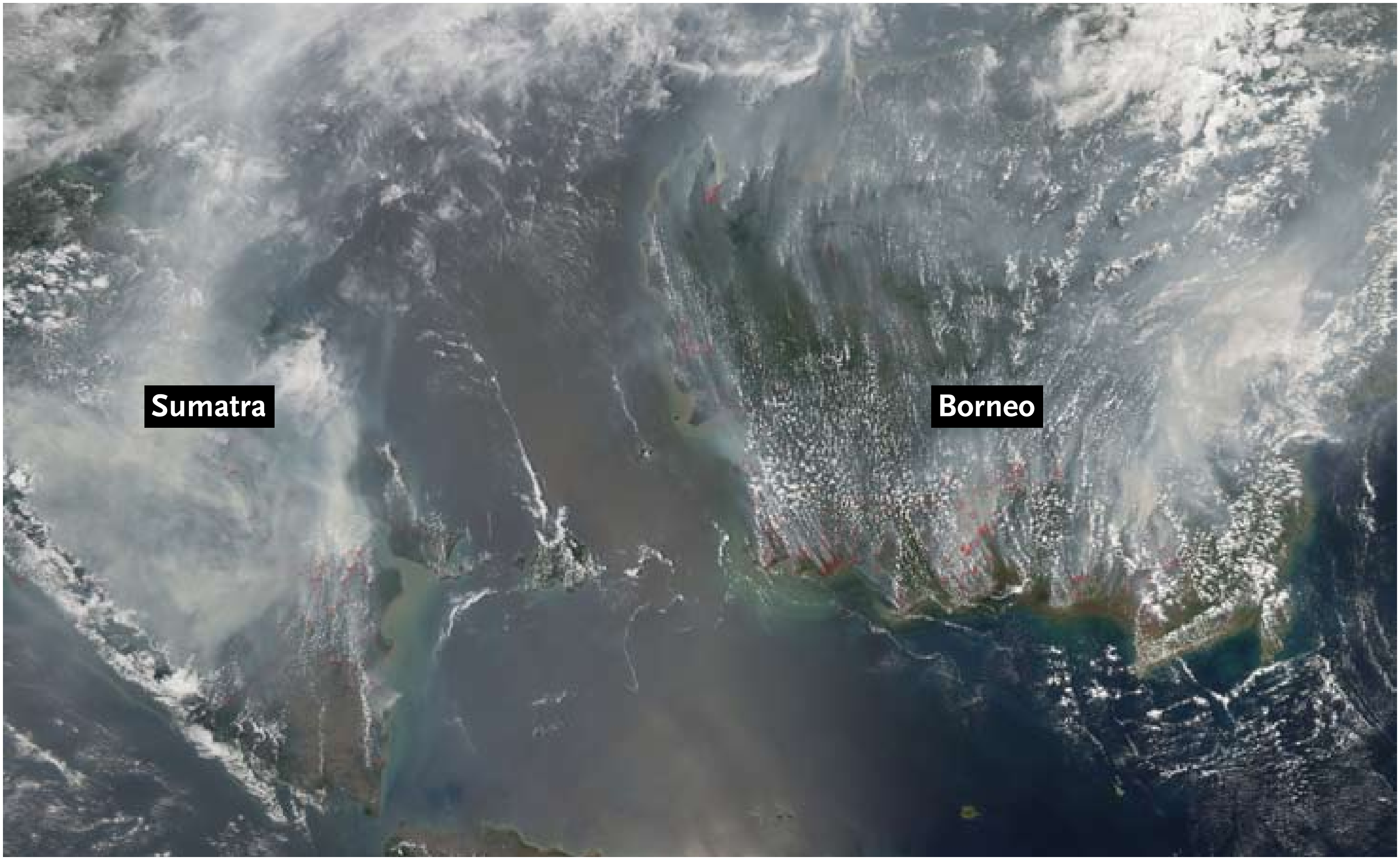

Figure 18: Fire and smoke over Borneo and Sumatra, late September to October 2006 (© Jesse Allen, Earth Observatory/MODIS Rapid Response team).

The expansion of oil palm plantations is thought to be a major driver of this fire peak. In 2006, the leaders of Singapore, Malaysia, Brunei, and Thailand urged Indonesia to do more to stop the annual fires because the regions' citizens suffer both economic losses and health problems from the resultant haze. It is worth noting, however, that several of these countries are also recipients for illegally logged products from Indonesia.

In central Kalimantan, hundreds of orangutans may have died in the fires (Sastrawan 2006). If they can, orangutans flee the flames, but if they reach cultivated areas, they are often attacked by residents out of fear, for meat or to protect crops. The most fortunate individuals are taken in by rescue centres and, when possible, are released into the wild. In 2006, at least 120 Bornean orangutans were rescued suffering from dehydration, smoke inhalation or wounds inflicted by villagers; a number of others had to be translocated from a release site because it was on fire (Sastrawan 2006).

Protected areas including national parks are not immune from fire. As the number of plantations increase adjacent to and even within national parks, so do the numbers of wildfires. Table 2 shows that in 2002 and 2004, more than 50% of all recorded burnt area was in conservation forest (mainly in national parks and nature reserves).

Table 2: Estimated forest fire occurrences, 2000 to 2005.

Forest categories	Area burnt (hectares) 2000	2001	2002	2003	2004	2005
Conservation forest	**1 216.85**	**1 927.45**	**19 938.96**	**267.95**	**2 422.56**	**1 251.35**
Protection forest	117.65	4.25	160.50	0.50	20.43	4 002.12
Production forest	1 682.00	12 397.80	15 396.77	3 277.00	886.00	82.00
Other forest	0.00	0.00	0.50	0.00	15.00	167.00
Total burnt area	**3 016.50**	**14 329.50**	**35 496.73**	**3 545.45**	**3 343.99**	**5 502.47**

Source: Ministry of Forestry 2005, 2006.

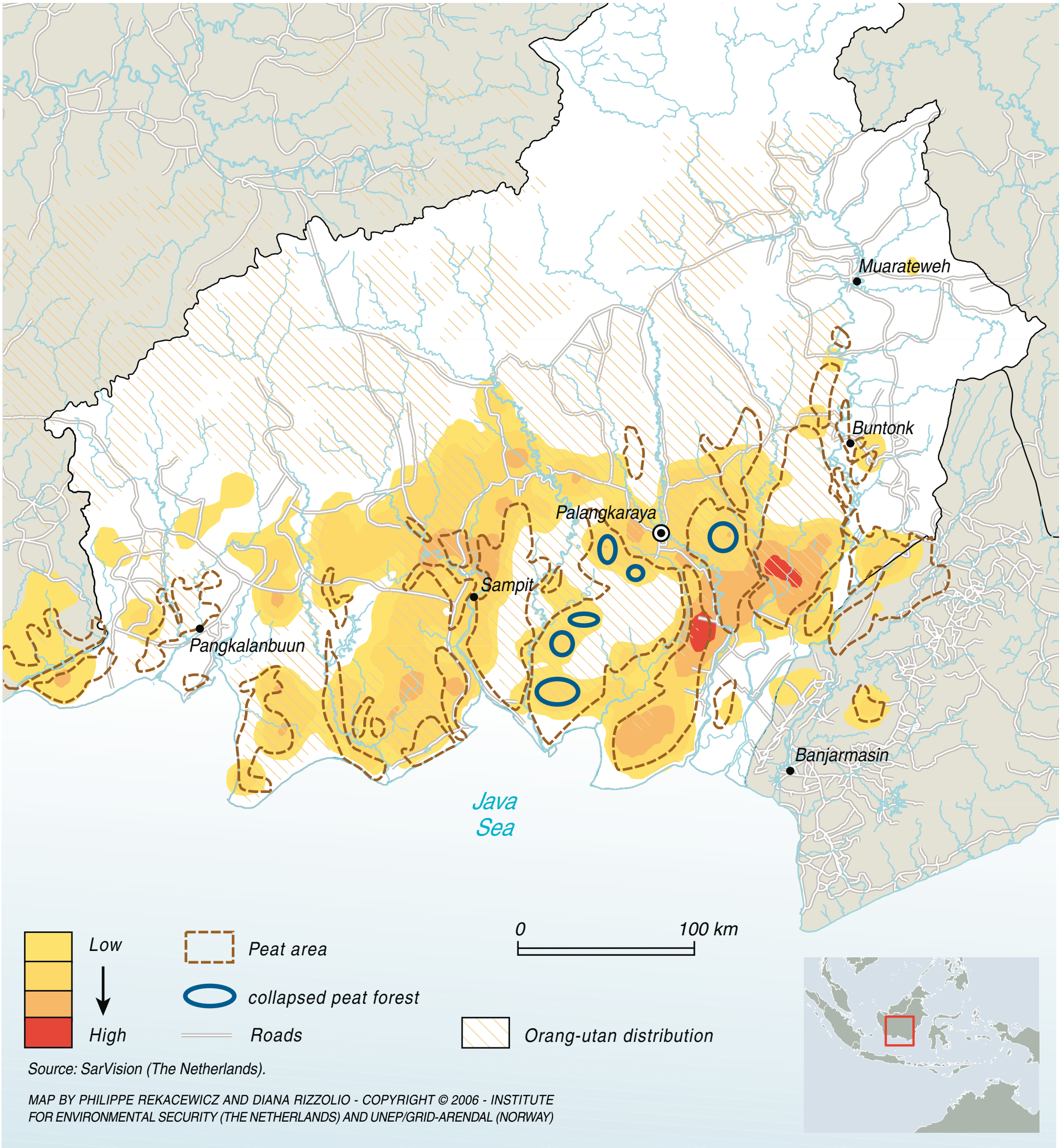

Figure 19: Fire density in southern Borneo.

ILLEGAL INTERNATIONAL TRADE IN LIVE ORANGUTANS

A by-product of forest clearing and the timber trade is the illegal international trade in live orangutans. A UNEP special mission team learned in 2006 that many illegally-caught orangutans, destined for illicit international trade, are removed from forest areas on the riverboats that carry timber that has been legally and illegally extracted. These orangutans are bought by the boats' crews and conveyed either directly to other countries or to major ports in Indonesia, where they will be transferred to other vessels operated by foreign crews and owners. Orangutans are also sometimes sold to the crews of foreign fishing vessels, such as boats from Thailand. This illicit trade includes an opportunistic element, as well as involving illegal traders who deliberately seek out orangutans (CITES/UNEP 2006).

The increase in oil palm plantations and general reduction of orangutan habitat increases the frequency of opportunistic capture of young orangutans.

A fraction of the apes that are taken from the forest find their way are brought to "rescue" or "rehabilitation" centres. In Borneo alone, this number is close to 1 000 orangutans in 2006 (CITES/UNEP 2006). Many of the others find their way to zoos, "Safari World"-type facilities and private ownership. Recent cases involving Cambodia, Thailand, Malaysia and Saudi Arabia have come to the attention of the CITES secretariat. In 2006, orangutans confiscated in Thailand and Malaysia were repatriated to Indonesia.

FORMER SCENARIOS TOO OPTIMISTIC: 30% INCREASE IN ORANGUTAN HABITAT LOSS

Scenarios released by UNEP in 2002 suggested that most of the natural rainforest in Indonesia would be degraded by 2032 (UNEP 2002). At the same time, the World Bank estimated that this would include the loss of all Kalimantan's lowland forest outside protected areas by 2010 (World Bank 2001). These estimates were based on information from the 1980s and 1990s on the rate of deforestation and human impact zones.

By 2005, much of the easily accessible timber had been exploited, yet illegal logging continued. Many kilometres of logging roads have been constructed within in protected areas (Curran *et al.* 2004). As the forest product industry has maintained its capacity and even expanded, the demand for both valuable timber and pulp wood for the mills has not declined. The pressures on the remaining forest fragments are therefore even greater than initially predicted by UNEP. In addition, palm plantations have taken up an estimated 12 000 km² in the last decades and are rapidly growing, and the area may be tripled by 2020; many plantation concessions have been granted but not yet developed (Curran *et al.* 2004, Rautner *et al.* 2005). Peat swamp forests, which host high densities of orangutans, are targeted for palm oil production (Caldecott & Miles 2005, Wetlands International 2006). Palm oil plantations are also being developed on logged-over forest land, preventing recovery and further reducing the future timber stock outside protected areas.

There are three primary factors that have changed since the late 1990s, influencing the rate of orangutan habitat loss. First, the rate of deforestation and logging has increased. The deforestation rate in the late 1990s was at least 1.5% or 20 000 km² annually for Indonesia as a whole, with losses concentrated in Sumatra and lowland Borneo (UNEP 2002; Schroeder-Wildberg and Carius 2003; Rautner *et al.* 2005); Second, the development of oil palm plantations, often by draining peat swamps, has decreased orangutan habitat further. Plantation development often involves fire, which spreads, further reducing available habitat. Third, the rising scarcity of accessible valuable timber has increased the extent of illegal logging in national parks.

Scenarios of forest cover loss by WWF, based on Landsat imagery for 2000, and annual forest loss figures, suggest that Kalimantan's well-drained lowland forest will be lost by 2012 to 2018, even within protected areas (Rautner *et al.* 2005) (Figure 5). This, in combination with the figures above and the recent 2006 satellite images, suggest that the rate of loss of orangutans and their habitats may be at least 30% higher than projected only a few years back.

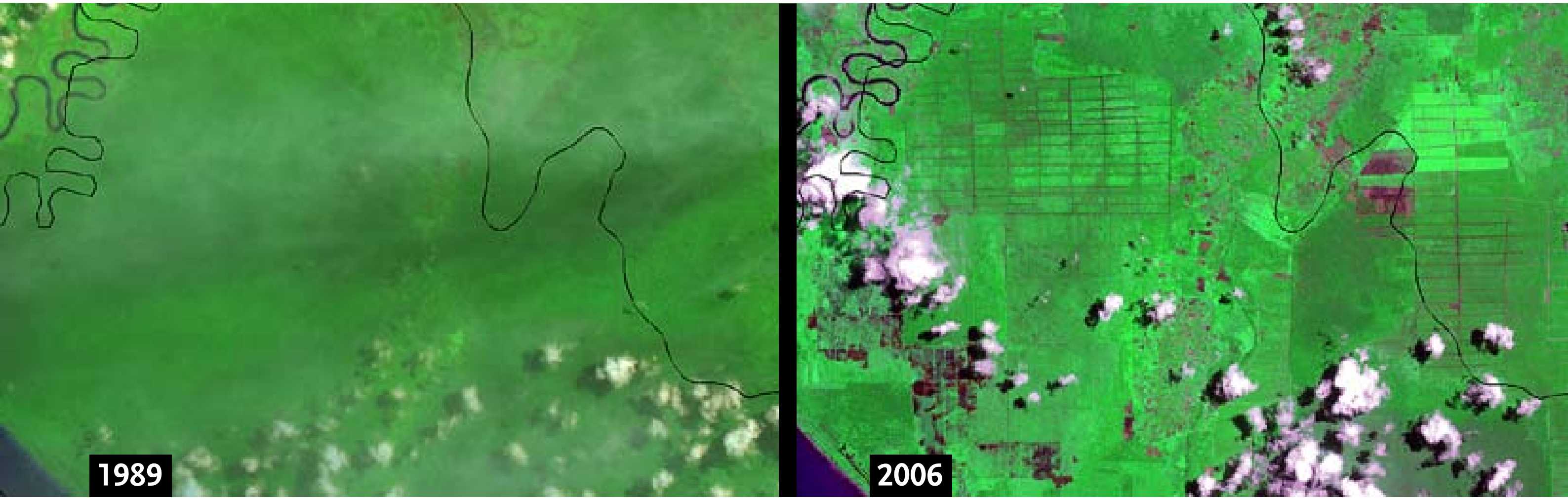

Figure 20: Loss of critical orangutan forest in the Leuser Ecosystem, Sumatra from satellite (Landsat 1989 and ASTER 2006).

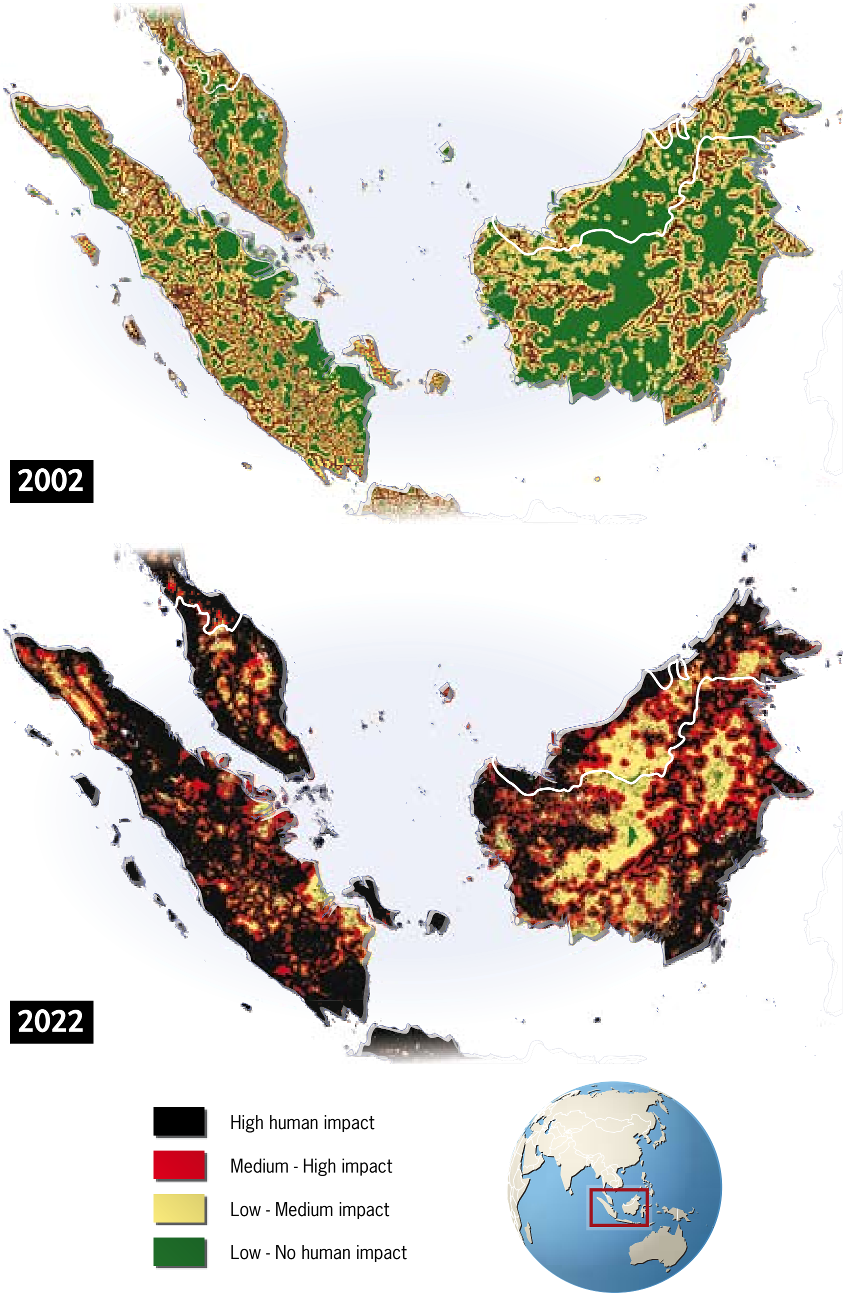

Figure 21: Degree of human impact. Green areas in Borneo and Sumatra indicate remaining undesturbed areas, while black-to yellow indicate loss, an estimated 98% by 2022, mainly due to oil palm plantation development and illegal logging in protected areas.

LAW ENFORCEMENT RESPONSES TO ILLEGAL FORESTRY ACTIVITIES

Several government agencies share the responsibility or authority to enforce Indonesia's wildlife-related laws, including Customs, the Forest Department, the police, the military police and the Quarantine Service. However, the agencies with primary responsibility for such work are the Directorate of Biodiversity Conservation, Directorate General of Forest Protection and Nature Conservation and the Ministry of Forestry, also often known as the Department of Forestry.

The Forest Department has an Animal Protection Unit, within which there is a general wildlife crime unit and four species-specific units for the protection of tigers, elephants, rhinos and orangutans. However, rangers face major logistic challenges in Indonesia, given the extent of the national park network.

To improve overall effectiveness, the government in 2004 launched a Ranger Quick Response Unit (SPORC – Satuan Khusus Polisi Kehutanan Reaksi Cepat), an elite unit of rangers trained to confront illegal loggers. The Forestry Ministry has expressed an ambition to train a total of 1 500 SPORC personnel before 2009. It plans to assign them to regions prone to illegal logging. Most of the first 299 SPORC personnel were recruited from existing forest rangers and they underwent 38 days of special training in shooting, self defence and ambush skills.

In addition to their rapid response duties, SPORC personnel also undertake patrol duties to detect and deter illegal logging, poaching and illegal trade. Some SPORC staff will also be deployed to guard posts situated at the entry and exit points to protected areas and on the rivers that flow through many forest areas. It appears that SPORC units will often become involved in the confiscation of animals (including parts and derivatives) or timber that is possessed or being traded illegally.

Although SPORC units and other Forest Department staff will respond to information received from local people, NGOs and other sources, they currently have limited resources in terms of covert work, surveillance and intelligence gathering. Forest Department staff has no access to any reward scheme to either recruit or pay informants. They are not currently available in sufficient numbers to prevent heavily organized intrusions into the parks. And yet, these units represent the greatest on-the-ground opportunity to stop illegal logging and agricultural encroachment in protected areas.

As in many other parts of the world, forest and wildlife law enforcement staff in Indonesia receives less in the way of salaries, training and equipment than the armed forces and regular police units. Consequently, these rangers have very variable levels of training and background. Even well trained staff receives little training in patrolling or combat skills, which is required to take on the massive well-organized intrusions into the park. There is also a general lack of vehicles, aeroplanes or helicopters, boats and arms. Neither does their ordinary training include the military long-range patrol skills or combat training required to take on the massive well-organized intrusions into the parks. Their counterparts working for logging companies, however, include security guards, sometimes with a foreign military background, automatic weapons and tactical training. When making encroachments into parks, they are often present in large numbers, bringing heavy machinery deep into the protected area. Ordinary rangers face high and sometimes lethal risks in confronting these organized invasions.

COUNTERING ILLEGAL LOGGING – MEASURES AND THEIR EFFECT

The "Forest Law Enforcement and Governance (FLEG)" process is a particularly important response to the current wave of forest crime in Indonesia. FLEG is a continuous harnessing of national efforts and improvement of international collaboration to address violations of forest laws and illegal activities. The aim of FLEG is to eradicate illegal logging and associated illegal trade and corruption, and in the long term to promote sustainable management and protection of the world's remaining forests. FLEG is a global effort, and in East Asia it started with a series of consultations leading up to a political commitment known as the Bali Declaration in 2001. Although not legally binding, the declaration is considered a significant step by governments in acknowledging the need to combat corruption in the forestry sector. It recognizes the responsibilities of both producing and consuming countries to eliminate illegal logging and illicit trade and corruption, and provides a base for bilateral and international cooperation in harmonizing forest law enforcement and protection programmes.

To implement FLEG, a number of potential responses are possible. While all are rational and well intended, only a few can be expected to have any significant short term impact on the current state of rapid deforestation and degradation of critical orangutan habitat. The empowerment and sustainable development of local communities is critical to enable their custodianship of natural habitats over the longer term, but immediate targeted actions are required to deal with the existing crisis. Effective responses must:

- target root causes and key actors
- be rapid in effect
- be effective in the face of existing power structures (risk of coercion and reprisals, corruption, dysfunctional institutions)
- address impacts over large areas to avoid simply displacing the problem.

Table 3: Probable timescale and effects of impacts of conservation measures on illegal logging.				
	Probable effects			
Responses	Short term	Long term	Conditions, forces	Recommended actions
International law enforcement	Moderate	High	Potentially highly effective, but politically, legally, institutionally and economically very demanding	Laws in consumer countries against imports of illegally harvested timber. Embargos, trade control International agreements on law enforcement and prosecution International surveillance and reporting on crimes
Domestic law enforcement	High	High	Highly and directly effective if implemented efficiently and extensively in threatened areas. May increase violence, but can result in increased deterrence of future illegal activities	Specialized enforcement units Arming and paramilitary training of sufficient numbers of rangers under a separate command, extensive collaboration with police, Army and Navy and international experts and sufficient equipment
Amend national laws and regulations to strengthen law enforcement efforts	Low	Moderate/ high	Lack of common jurisdiction and sanctions across administrative borders hinders effective national law enforcement efforts	Update and harmonize regulations across administrative borders, facilitate investigation and prosecution
Logging moratorium	Moderate	Moderate – high	Can effectively curb legal and partly, illegal logging if sufficient surveillance is present	Implement moratoriums in highly impacted areas, secure regional political and institutional support
Log export ban	Low – moderate	Moderate	Smuggling will still prevail, corruption hinders effective control in most places	Task force to control ports and transportation corridors
Reduce demand	Low	Moderate/ high	Impossible to achieve in short time due to market mechanisms. Questionable at large scale even in the long run due to the diversity and elusiveness in corporate structure and market mechanisms	Laws in consumer countries against imports of illegally harvested timber, national compliance with FSC in major consumer countries
Reduce supply of illegal timber	Low	High	Very difficult or impossible to achieve in the short term. Highly effective in the long run if supply can be controlled	Implement systems of chain-of-custody to eliminate illegal wood from supply chain Compliance with FSC
Strengthen governance	Low	Moderate	Requires institutional change to break link between conflict timber and corruption	Minimize and control corruption Enhance fair law enforcement Resolve property conflicts

Table 3: Probable timescale and effects of impacts of conservation measures on illegal logging (continued).

Responses	Probable effects		Conditions, forces	Recommended actions
	Short term	Long term		
Combat corruption	Low	Moderate	Corruption is rampant at all levels of institutions, affects all elements in supply chain of timber harvesting and concession system	Prosecution of actors involved Public disclosure of cases involving public officials, timber mafia heads and corporations
Cut off shipping routes	High	High	Very effective, but difficult to implement due to large number of ports, vessels and shipping lanes. Requires massive monitoring and law enforcement	Task force to control ports and transportation corridors, seizure of log shipments at ports, quarantines of ships, prosecution of shipping compani4es and owners
Controlling access to protected areas	High	High	Very effective but requires clear mandate, massive equipment, training and law enforcement	Surveillance and patrolling of salient timber and biodiversity habitats, blocking of illegal constructed roads, confiscation of equipment, closing of saw mills operating without concession
Financial regulation	Low	Moderate	Good systems for private sector financing of the forest industry are lacking, creates unsustainable use and inappropriate incentives. Release of debt pressure on forest processing plants can have major effect on demand for forest resources	Increase investments in the legitimate forest industry Resolve bank and debt issues related to forestry assets and non-performing loans
Monitoring	Low	Low (High)	Important for assessment of forest conditions and response measures, no direct effect on actions	Include monitoring in management plans for all national parks and buffer zones
General education	Low	Low/ moderate	No short term effect on major driving forces or impact factors, possible moderate long term effects through increased awareness	Integrate knowledge on environmental concerns and sustainable development in education curricula, both in consumer and producer countries
Public information disclosure	Low	Low	Increased transparency and disclosure of critical information can sensitize some stakeholders and increase awareness	Consumer awareness campaigns Ensure public access to monitoring data, especially within producer country
Advocacy	Low/ moderate	Low/ moderate	Well targeted advocacy can disclose criminal actions, and/or mobilize powerful interests	Targeting of root causes vs. powerful institutions

Table 3: Probable timescale and effects of impacts of conservation measures on illegal logging (continued).

Responses	Probable effects		Conditions, forces	Recommended actions
	Short term	Long term		
Strengthen public procurement and corporate social responsibility	Low	Moderate	Improve corporate performance and transparency with time	Transparent and reliable procedures for procurement, environmental actions and interactions with stakeholders
Community development/ stakeholder participation	Low	Low – High	While usually important in all resource management, can be ineffective against rapid, capital intensive resource exploitation by outsiders	Compensation schemes, direct payments for conservation efforts; strengthening land rights (below); reduce poverty/improve livelihoods (below)
Strengthen land rights	Low	Low/ moderate	Land tenure issues are generally disregarded by key actors in this context; but ownership creates an incentive to defend resources	Land registration schemes, formalize land rights of indigenous populations. Support local communities in exercising forest related rights, entitlements and responsibilities
Promote sustainable development	Low	Low/ moderate	Requires good governance, equitable management, land tenure control and inclusion of all actors. Sustainable land use strategies usually overrun by corporate interests	Forestry information systems Management plans Public-private alliances to combat illegal logging Community development/stakeholder participation (above)
Reduce poverty/improve livelihoods	Low	Low/moderate	Significant improvement in local livelihoods can offset unsustainable resource use, can be a slow process with minimal effect on rapid environmental degradation	Development of sustainable income generating activities, regional development programs, social services, training, education

Sources: Illegal Logging Response Center 2006, USAID 2005, World Bank 2006, InWent 2003, FLEG 2006, Global Forest Watch; Schroeder-Wildberg & Carius 2003, FLEG 2006, CIFOR 2005, Wahli 2007.

Measures are therefore required to directly intervene with exploitation and distribution of timber *in situ*. Law enforcement including surveillance, patrolling, arrest and prosecution of actors involved in illegal harvesting will require a massive input to staffing, training and equipping/arming of personnel working in the national parks, but are of utmost importance to achieve a reduction in illegal logging. At a higher level, international cooperation around legal instruments and procedures to detect and seize illegal timber, and prosecute key players, thus cutting off the trade routes could have a very positive effect. Root causes such as supply and demand can be addressed with time and political will, but implementation is too complex to expect predictable results for the current crisis.

In 2005, the President of Indonesia issued Presidential Instruction No. 5 requiring government agencies with law enforcement responsibilities (a total of 18 altogether) to increase their efforts to combat illegal logging and also to increase efforts to combat

illegal trade in wildlife. Indonesia has signed the Kinshasa Declaration, adopted at the Intergovernmental Meeting on Great Apes held in Democratic Republic of the Congo, in September 2005. This declaration sets the target of securing a constant and significant reduction in the current loss of great ape populations by 2010 and to secure the future of all species and subspecies of great apes in the wild by 2015 (GRASP 2005).

Illegal logging and oil palm plantations in protected areas are the result of poor law enforcement and lack of resources to allow effective monitoring and inspection. Illegal practice begins with the issue of permits and licenses to harvest timber and runs through to forest management regulation and inspection. Concessionaires easily get away with over-harvesting or harvesting outside areas allocated for exploitation, and purchasing wood on the black market from illegal sources. Punishment and fines for any such violations are rare. Combating illegal logging through certification processes, increased transparency, lowering corruption and strengthening systems for concessions is only possible with effective enforcement by well-trained and coordinated staff.

COMPANIES USE UNDERHAND METHODS

Currently, logging companies not only extensively use bribes, they are also better armed and equipped than most rangers, frequently employing security guards including foreign nationals and former police and military officers. Where efforts have been made to prosecute illegal loggers, the cases have often failed to make headway in the judicial system. Indeed, only around 10% of cases ever reach the courts.

Better coordination between government departments would also help to resolve the issue. The wood industry has an annual capacity for processing around 74 million m^3 of timber, but the licensed harvest is in the region of only 23 million m^3 (Schroeder-Wildberg and Carius 2003). Hence, the general capacity of the various mills is two to five times higher than the legal amount available. Despite knowledge of this state of affairs, it has proved difficult to reduce industry capacity because the Ministry of Forestry lacks the authority to withdraw operating licenses, a responsibility which lies with the Ministry of Industry and Trade.

LACK OF ENFORCEMENT CAPACITY

Indonesia has 9 700 forest rangers. Thirty-five national parks that the team was able to secure information from through the Ministry of Environment and Ministry of Forestry had 2 155 field rangers to patrol an area of 108 000 km^2 and generally no access to helicopters, aeroplanes, necessary arms or military patrolling skills that would enable them to prevent illegal activity. Currently, logging companies not only extensively use bribes, they are also better armed and equipped than most rangers, frequently employing security guards. If the rangers had the necessary training, communication, transport and arms, even a relatively small force would be able to effectively conduct surveillance and reconnaissance, and when required, prevent illegal intrusions with the appropriate force.

CONCLUSIONS AND RECOMMENDATIONS: STATE OF EMERGENCY FOR ORANG-UTANS AND NATIONAL PARKS

A series of national and international measures have been implemented or are evolving in response to the crisis situation in Indonesia. Most of these have a long-term rather than immediate effect. Given the extent and severity of the intrusions into protected areas and the international involvement in the theft of timber and land from these reserves, the situation must now be characterized as a state of emergency.

This review shows that the responsibility for this situation, including the massive pollution and greenhouse gases generated from burning of forests, is shared by Indonesia and consumer countries. Protected areas are being destroyed to feed an international market for wood products and vegetable oil.

Unfortunately, most long-term initiatives like reducing corruption and certification of timber require the substantial support of the international community including recipients of illegally logged timber. Furthermore, most responses require massive changes in management regimes and actions, long-term institutional change, financial, technical and human resources support, changes in market mechanisms and demand structures, as well as international cooperation in monitoring trade and prosecuting criminal actors including corporations. Some or all of these responses may potentially have paramount effects in the long-term, but they will generally take too much time to develop to an effective level and will fall short of the immediate crisis in securing the future survival of the orangutan and the protection of national parks. Immediate on-the-ground action is required to back up the global-scale efforts towards sustainable wood production.

Without direct intervention in the parks, orangutans and other forest-dependent wildlife will become progressively scarcer, until their populations are no longer viable in the long-term. Previously released scenarios suggested that most natural rainforest in Indonesia would be degraded by 2032. Given the rate of deforestation in the past five years, and recent widespread investment in oil palm plantations and biodiesel refineries, new calculations suggest that 98% of lowland forest may be destroyed by 2022. Since mature forest is being lost from such large areas, the supply of timber will decline further. This means that the incentive to log protected areas will grow. It is possible that many protected areas will already be severely degraded by 2012.

Among the most promising and important Indonesian government initiatives is the further development, support and training of the 'SPORC' rapid response ranger units. However, it is essential that these units and selected parks have the necessary paramilitary training, equipment and mandate to prevent illegal loggers from operating inside protected areas.

Protected areas including national parks form a cornerstone of international conservation efforts, including the 2010 globally-agreed target to reduce the rate of biodiversity loss. Reducing the rate of deforestation over Indonesia as a whole will also have a dramatic impact on regional carbon dioxide emissions, and thus help to prevent dangerous levels of global climate change. If the logging of national parks continues unchallenged, it could undermine the protected area concept worldwide. The Indonesian initiatives to strengthen protection of their parks therefore urgently need substantial support from the international community if the orangutan habitats and national parks are to be rescued from this growing state of emergency.

Recommendations

Based on these findings, it is recommended that Indonesia and countries involved in processes such as FLEG consider the following actions:

1. Substantially strengthening the Indonesian initiative of SPORC units to ensure the necessary para-military skills and equipment for securing national parks, including evaluation of the combined joint operations conducted in recent years between the Ministry of Forestry, police and Joint Chiefs of Staff of Navy and Army. This could include bringing in expertise from other Indonesian and international agencies in training and countering illegal activities at these scales
2. Rapid deployment of reconnaissance units to collaborate with the relevant law enforcement and forest rangers, to secure information from the individual parks
3. Rapid development of training units to prepare existing rangers locally for future enforcement
4. Removal of illegal plantations, mining and agricultural development inside the national parks
5. Strengthening surveillance and intelligence units in this work
6. Further strengthening international programmes of law enforcement against illegal logging and activities, including support from Interpol
7. Establishing a small, strategic cross-sectoral coordination unit, including selected international specialists, with sufficient presidential mandate to assist in operational planning and monitoring of the programme to win back the parks

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RAPID RESPONSE ASSESSMENT

IN DEAD WATER

MERGING OF CLIMATE CHANGE WITH POLLUTION, OVER-HARVEST, AND INFESTATIONS IN THE WORLD'S FISHING GROUNDS

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PREFACE

The world's oceans are already under stress as a result of overfishing, pollution and other environmentally-damaging activities in the coastal zones and now on the high seas.

Climate change is presenting a further and wide-ranging challenge with new and emerging threats to the sustainability and productivity of a key economic and environmental resource.

This new, rapid response report attempts to focus the numerous impacts on the marine environment in order to assess how multiple stresses including climate change might shape the marine world over the coming years and decades.

It presents worrisome findings and requests governments to respond with ever greater urgency in order to combat global warming and to conserve and more strategically manage the oceans and seas and their extraordinary but shrinking resources.

The challenge of the seas and oceans in terms of monitoring has always been a formidable one with the terrestrial world more visible and easier to see. This is despite fisheries contributing to the global food supply and a supporter of livelihoods and cultures for millennia.

However, there is growing and abundant evidence that the rate of environmental degradation in the oceans may have progressed further than anything yet seen on land. This report highlights the situation in 2007 in the economically important 10 to 15% of the oceans and seas where fish stocks have been and remain concentrated.

These fishing grounds are increasingly damaged by over-harvesting, unsustainable bottom trawling and other fishing practices, pollution and dead zones, and a striking pattern of invasive species infestations in the same areas.

According to the report, these same areas may lose more than 80% of their tropical and cold water coral reefs due to rising sea temperatures and increasing concentrations of carbon dioxide (CO_2) leading to a decrease in seawater pH (acidification).

Finally, these same areas are also facing rapidly growing pollution from coastal development, potential consequences of climate change such as possible slowing of 'flushing' mechanisms and increasing infestations of invasive species.

We are now observing what may become, in the absence of policy changes, a collapsing ecosystem with climate the final coup d'grace. There are many reasons to combat climate change, this report presents further evidence of the need to act if we are to maintain ecosystems and services that nourish millions; provide important tourism income and maintain biodiversity.

Achim Steiner
Executive Director
United Nations Environment Programme

SUMMARY

The World's oceans play a crucial role for life on the planet. Healthy seas and the services they provide are key to the future development of mankind. Our seas are highly dynamic, structured and complex systems. The seafloor consists of vast shelves and plains with huge mountains, canyons and trenches which dwarf similar structures on land. Ocean currents transport water masses many times larger than all rivers on Earth combined.

In this report, the locations of the most productive fishing grounds in the World – from shallow, coastal waters to the deep and high seas – are compared to projected scenarios of climate change, ocean acidification, coral bleaching, intensity of fisheries, land-based pollution, increase of invasive species infestations and growth in coastal development.

Half the World catch is caught in less than 10% of the ocean

Marine life and living resources are neither evenly nor randomly distributed across the oceans. The far largest share of marine biodiversity is associated with the sea bed, especially on the continental shelves and slopes. Seamounts, often rising several thousand meters above their surroundings, provide unique underwater oases that teem with life. Environmental parameters and conditions that determine the productivity of the oceans vary greatly at temporal and spatial scales. The primary and most important fishing grounds in the World are found on and along continental shelves within less than 200 nautical miles of the shores. The distribution of these fishing grounds is patchy and very localized. Indeed more than half of the 2004 marine landings are caught within 100 km of the coast with depths generally less than 200 m covering an area of less than 7.5% of the world's oceans, and 92% in less than half of the total ocean area. These treasure vaults of marine food play a crucial role for coastal populations, livelihoods and the economy.

Whether they will provide these functions and services in the future depends on needed policy changes and the continuation of a number of environmental mechanisms to which marine life has evolved and adapted. These natural processes include

clean waters with balanced temperature and chemistry regimes as well as currents and water exchanges that provide these areas with oxygen and food, to name just a few. However, there are alarming signals that these natural processes to which marine life is finely attuned are rapidly changing.

With climate change, more than 80% of the World's coral reefs may die within decades

In tropical shallow waters, a temperature increase of up to only 3° C by 2100 may result in annual or bi-annual bleaching events of coral reefs from 2030–2050. Even the most optimistic scenarios project annual bleaching in 80–100% of the World's coral reefs by 2080. This is likely to result in severe damage and wide-spread death of corals around the World, particularly in the Western Pacific, but also in the Indian Ocean, the Persian Gulf and the Middle East and in the Caribbean.

Ocean acidification will also severely damage cold-water coral reefs and affect negatively other shell-forming organisms

As CO_2 concentrations in the atmosphere increase so does ocean assimilation, which, in turn, results in sea water becoming more acidic. This will likely result in a reduction in the area covered and possible loss of cold-water coral reefs, especially at higher latitudes. Besides cold-water corals, ocean acidification will reduce the biocalcification of other shell-forming organisms such as calcareous phytoplankton which may in turn impact the marine food chain up to higher trophic levels.

Coastal development is increasing rapidly and is projected to impact 91% of all inhabited coasts by 2050 and will contribute to more than 80% of all marine pollution

Marine pollution, more than 80% of which originates from land-based sources, is projected to increase, particularly in Southeast and East Asia, due to rising population and coastal development. Increased loads of sediments and nutrients from deforestation, sewage and river run-off will greatly diminish the resilience of coral reefs. The effects of pollution are exacerbated by the destruction of mangroves and other habitats due to the rapid construction taking place on coastlines. As much as 91% of all temperate and tropical coasts will be heavily impacted by development by 2050. These impacts will be further compounded by sea level rise and the increased frequency and intensity of storms that easily break down weakened or dead corals and are likely to severely damage beaches and coast lines.

Climate change may slow down ocean thermohaline circulation and continental shelf "flushing and cleaning" mechanisms crucial to coastal water quality and nutrient cycling and deep-water production in more than 75% of the World's fishing grounds

Of major concern is that many of these productive fishing grounds depend extensively upon sea currents for maintaining life cycle patterns for the sustainable production of fish and other marine life. Large scale water exchange mechanisms, which periodically "flush and clean" continental shelf areas, are observed in and near at least ca. 75% of all the major fishing grounds. These mechanisms, however, depend entirely on

cooler and heavier seawater sinking into the deep sea, often using and carving channels and canyons into the continental shelf. New research suggests that while climate change may not necessarily stop the major thermohaline currents, climate change may potentially reduce the intensity and frequency of the coastal flushing mechanisms, particularly at lower to medium latitudes over the next 100 years, which in turn will impact both nutrient and larval transport and increase the risk of pollution and dead zones.

Increased development, coastal pollution and climate change impacts on ocean currents will accelerate the spreading of marine dead zones, many around or in primary fishing grounds

The number of dead zones (hypoxic or oxygen deficient areas) increased from 149 in 2003 to over 200 in 2006. Given their association with pollutants from urban and agricultural sources, together with the projected growth in coastal development, this number may multiply in a few decades, unless substantial changes in policy are implemented. Most dead zones, a few of which are natural phenomena, have been observed in coastal waters, which are also home to the primary fishing grounds.

Over-harvesting and bottom trawling are degrading fish habitats and threatening the entire productivity of ocean biodiversity hotspots, making them more vulnerable to climate change

Recent studies indicate that fishery impacts in shelf areas may potentially become even worse in deeper water. Due to advances in technology and subsidies, fishing capacity is now estimated to be as much as 2.5 times that needed to harvest the sustainable yield from the world's fisheries. Up to 80% of the worlds primary catch species are exploited beyond or close to their harvest capacity, and some productive seabeds have been partly or even extensively damaged over large areas of fishing grounds. With many traditional, shallow fishing grounds depleted, fisheries (especially large industrial vessels/fleets operating for weeks/months at sea) are increasingly targeting deep-water species on the continental slopes and seamounts. Over 95% of the damage and change to seamount ecosystems is caused by bottom fishing, mostly carried out unregulated and unreported with highly destructive gear such as trawls, dredges and traps.

Trawling has been estimated to be as damaging to the sea bed as all other fishing gear combined. Unlike only a decade ago, there are now numerous studies from nearly all parts of the world, documenting the severe long-term impacts of trawling. The damage exceeds over half of the sea bed area of many fishing grounds, and worse in inner and middle parts of the continental shelves with particular damage to small-scale coastal fishing communites. Indeed, while very light trawling may be sustainable or even increase abundance and productivity of a few taxa, new studies, including data from over a century ago, clearly indicate damage to the sea bed across large portions of the fishing grounds, and at worst reductions in pristine taxa of 20–80% including both demersals and benthic fauna. Unlike their shallow water counterparts, deep sea communities recover slowly, over decades and centuries, from such impacts. Some might not recover at all if faced with additional pressures including climate change and might lead to a permanent reduction in the productivity of fishing grounds. There are now discussions ongoing within several bodies including the FAO on developing better international guidelines for the management of deep-sea fisheries in the high seas, but substantial action is urgently needed given the cumulative threats that the oceans are facing.

Primary fishing grounds are likely to become increasingly infested by invasive species, many introduced from ship ballast water.

The vulnerability of impacted ecosystems to additional stresses is also demonstrated by the increase of invasive species infestations that are concentrated in the same 10–15% of the World's oceans. Heavily disturbed and damaged marine areas are more likely to have a higher vulnerability to infestations brought in by ships plying the World's oceans despite recommendations in many areas for mid-ocean exchange of ballast water. Geographical distribution of invasive species suggests a strong relationship between their occurrence and disturbed, polluted and overfished areas and in particular the location of major shipping routes at a global scale. It appears that the most devastating outbreaks of such marine infestations have been brought in along the major shipping routes and primarily established in the most intensively fished and polluted areas on the continental shelves. Growing climate change will most likely accelerate these invasions further.

The worst concentration of cumulative impacts of climate change with existing pressures of over-harvest, bottom trawling, invasive species, coastal development and pollution appear to be concentrated in 10–15% of the oceans concurrent with today's most important fishing grounds

Climate change, with its potential effects on ocean thermohaline circulation and a potential future decline in natural 'flushing and cleaning' mechanisms, shifts in the distributions of marine life, coral bleaching, acidification and stressed ecosystems will compound the impacts of other stressors like over-harvest, bottom trawling, coastal pollution and introduced species. The combined actions of climate change and other human pressures will increase the vulnerability of the world's most productive fishing grounds – with serious ecological, economic and social implications. The potential effects are likely to be most pronounced for developing countries where fish are an increasingly important and valuable export product, and there is limited scope for mitigation or adaptation.

A lack of good marine data, poor funding for ocean observations and an 'out of sight – out of mind' mentality may have led to greater environmental degradation in the sea than would have been allowed on land.

The lack of marine information and easy observation by humans as land-living organisms, along with insufficient funds for monitoring, may result in these and other pressures to progress farther than anything we have yet seen or would have permitted without intervention on land, even though the oceans represent a significant share of global economies and basic food supply. Lack of good governance, particularly of the high seas, but also in many exclusive economic zones (EEZs) where the primary focus is economic gain, and has resulted in limited flexibility or incentive to shift to ecosystem based management. The potential for climate change to disrupt natural cycles in ocean productivity, adds to the urgency to better manage our oceans. The loss and impoverishment of these highly diverse marine ecosystems on Earth and modification of the marine food chain will have profound effects on life in the seas and human well-being in the future.

Substantial resources need to be allocated to reducing climate and non-climate pressures. Priority needs to be given to protecting substantial areas of the continental shelves. These initiatives are required to build resilience against climate change and to ensure that further collapses in fish stocks are avoided in coming decades.

Urgent efforts to control accelerating climate change are needed, but this alone will not be sufficient. A substantially increased focus must be devoted to building and strengthening the resilience of marine ecosystems. Synergistic threats and impacts need to be addressed in a synergistic way, via application of an ecosystem and integrated ocean management approach. Actions for a reduction of coastal pollution, establishment of marine protected areas in deeper waters, protection of seamounts and parts (likely at least 20%) of the continental shelves against bottom trawling and other extractive activity, and stronger regulation of fisheries have all to go hand in hand. Unless these actions are taken immediately, the resilience of most fishing grounds in the world, and their ability to recover, will further diminish. Accelerating climate change and in-action risks an unprecedented, dramatic and wide-spread collapse of marine ecosystems and fisheries within the next decades.

CONTENTS

WHY OCEANS MATTER

Oceans are crucial to life on Earth, support livelihoods and are vital to the World economy in numerous ways, including food as fish, income to coastal communities from tourism, shipping and trade, and through petroleum reserves, to mention a few (FAO, 2006).

Benefits from Marine and Coastal Ecosystems and Activities

Coastal tourism

The volume of global tourist arrivals increased more than 20 times between 1950 and 1995, making tourism the world's fastest-growing industry. The present number of tourists is expected to double by 2010 – particularly in the Caribbean and Asia-Pacific regions, where much of the industry is concentrated in coastal areas.

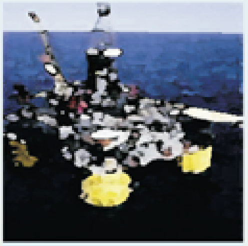
$ 161 billion

Trade and shipping

Since the 1950s, the annual volume of shipping and seaborne trade has risen sixfold, to more than 5 billion tonnes of oil, dry bulk goods and other cargo. In 1995, there were 27,000 freighters over 1,000 tonnes in operation. Industrial countries account for 50% of the cargo loaded – and 75% of that unloaded.

$ 155 billion

Offshore oil and gas



Since gasoline was first used in California a century ago, the oil and natural gas industry has skyrocketed to meet soaring energy demands. Today, about 20% of the world's oil and natural gas comes from offshore drilling installations in the Middle East, the United States, Latin America, and the North Sea.

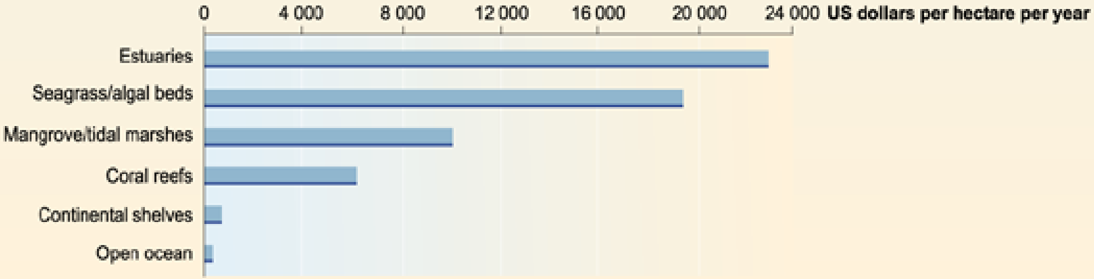
$ 132 billion

Fisheries

Between 1950 and 1997, global fish production from capture and culture fisheries grew from 20 million tonnes to 122 million tonnes, with the per capita supply doubling from 8 kg to 15 kg. Over 200 million people rely on fishing for their livelihoods, with more than 80% of all fish (by value) sold in industrial countries.

$ 80 billion

Estimated Mean Value of Marine Biomes



UNEP

DELPHINE DIGOUT
MAY 2002

Source: Anne Platt McGinn, *The Health of Oceans*, Worldwatch paper 145, Worldwatch Institute, 1999, Washington DC (www.worldwatch.org) ; Costanza, R., et al, *The Value of the World's Ecosystem Services and Natural Capital*, Ecological Economics, 1998.

THE SEA – ONE OF THE LARGEST FOOD FACTORIES ON THE PLANET

The World's oceans provide one of the largest (not domesticated) food reserves on the planet. Overall, seafood provided more than 2.6 billion people with at least 20 per cent of their average per capita animal protein intake (FAO, 2006). Capture fisheries and aquaculture supplied the world with about 106 million tonnes of food fish in 2004, providing an apparent per capita supply of 16.6 kg (live weight equivalent), which is the highest on record (FAO, 2006). Capture fishery production has, however, remained static, and it is only the rise in aquaculture, now accounting for 43% of the total consumption, that enabled this increase (FAO, 2006). Worldwide, aquaculture has grown at an average rate of 8.8 per cent per year since 1970, compared with only 1.2 per cent for capture fisheries in the same period. Despite fishing capacity now exceeding current harvest four-fold, marine capture has declined or remained level since 2000, reflecting over-harvest in many regions (Hilborn *et al.*, 2003; FAO, 2006). A major reason why the decline has not become more evident is likely because of advances in fishing efficiency, shift to previously discarded or avoided fish, and the fact that the fishing fleet is increasingly fishing in deeper waters.

The overall decrease in landings is mostly related to declines in fishing zones in the Southeast and Northwest Pacific oceans (FAO, 2006). In addition, the living resources in the World's oceans, including those so essential to mankind, are not randomly or evenly distributed. They are largely concentrated in small regions/areas and hotspots, of which continental shelves and seamounts – under-water mountains – play a crucial role. The safety of the World's oceans as a food source for future generations is however insecure. Over the last decades, there has been continuing exploitation and depletion of fisheries stocks. Undeveloped fish reserves have disappeared altogether since the mid-1980s. During the last decades, there has been a continued decline in fish resources in the 'developing' phase, and an increase of those in the depleted or over-exploited phase. This trend is somewhat offset by the emergence of resources in the 'recovering' phase (Mullon *et al.*, 2005; FAO, 2006; Daskalov *et al.*, 2007). There is little evidence of rapid recovery in

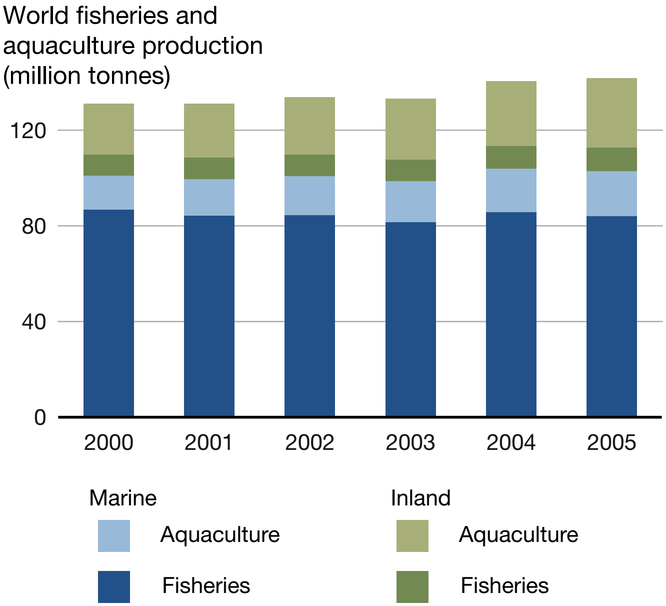


Figure 1. The World's marine fisheries have stagnated or slightly declined in the last decade, offset only by increases in aquaculture production (Source FAO, 2006).

heavily harvested fish populations, except, perhaps herring and similar fish that mature early in life. An investigation of over 90 different heavily harvested stocks have shown little, if any, recovery 15 years after 45–99% reduction in biomass (Hutchings, 2000). This is particularly true as most catch reductions are introduced far too late (Shertzer *et al.*, 2007). Indeed, marine extinctions may be significantly underrated (Casey and Meyers, 1998; Edgar *et al.*, 2005). More importantly in this context is not the direct global extinction of species, but the regional or local extinctions as abundance declines. Local and regional extinctions are far more common than global extinctions, particularly in a dynamic environment like the oceans.

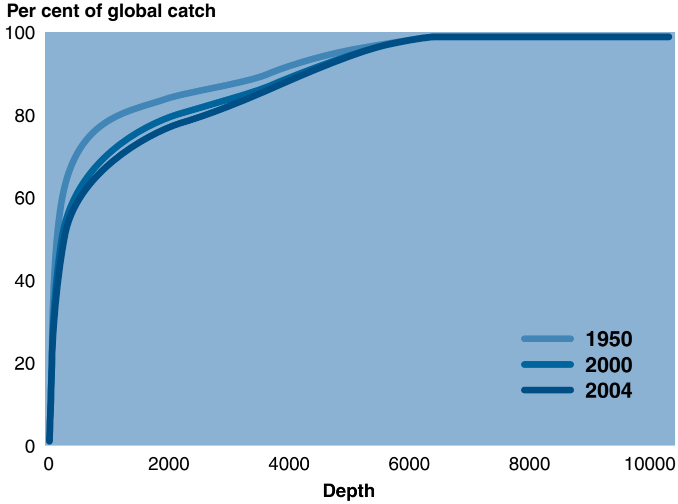


Figure 2. Estimated per cent of the global catch taken at depths for the years 1950, 2000 and 2004, which illustrates how fishers are moving further offshore (and often deeper) to catch fish.

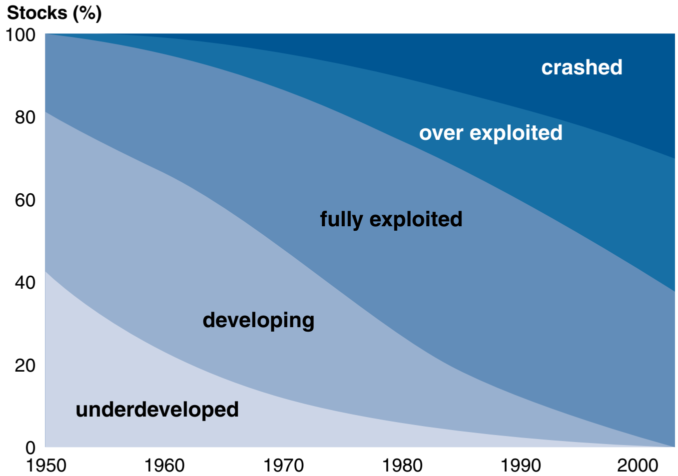


Figure 3. The state of the World's fishery stocks.

SEAMOUNTS AND CONTINENTAL SHELVES – THE OCEAN'S UNPROTECTED TREASURE VAULTS

Continental shelves are the gently sloping areas of the ocean floor, contiguous to the continent, that extend from the coastline to the shelf-break. The shelf break, which is located around 150–200 meters depth, is the area of the continental margin where there is an abrupt change between the shelf and the steeper continental slope.

Primary production in the oceans, i.e. the production of organic compounds from dissolved carbon dioxide and nutrients through photosynthesis, is often associated with upwellings (Botsford *et al.*, 2006). Upwelling occurs when winds blowing across the ocean surface push water away from an area and subsurface water rises up from beneath the surface to replace the diverging surface water. These subsurface waters are typically colder, rich in nutrients, and biologically productive. The relation between primary production and coastal upwelling, caused by the divergence of coastal water by land or along-shore blowing winds, is clearly shown in ocean primary production maps. Therefore, good fishing grounds typically are found where upwelling is common. For example, the ecosystems supporting the rich fishing grounds along the west coasts of South America and Africa are maintained by year-round coastal upwelling. However, these systems are affected by changing oceanographic conditions and how they – and the dependent fisheries – will respond to sea temperature change as a consequence of climate change is highly uncertain. These upwelling fishing grounds, especially in South America provide the raw materials for feeds used in intensive animal production and so any decreases in production will have effects on the price of farmed fish, chicken and port.

The far largest share of all life in the oceans is in direct contact with or dwells just above the sea floor. Continental shelves and seamounts host – in addition to petroleum and mineral reserves – by far the largest share of the World's most productive fishing grounds (Ingole and Koslow, 2005; Roberts *et al.*, 2006; Garcia *et al.*, 2007; Mossop, 2007). Technological advances have made continental shelves and shallow seamounts easily accessible to the World's fishing fleet and to coastal communities all across the planet. However, they are also critically placed in relation to threats from (land-based) pollution, sea bed and habitat destruction from dredging and trawling, and climate change. With traditional fishing grounds depleted and/or heavily regulated, fisheries are increasingly targeting productive areas and new stocks in deeper waters further offshore, including on and around seamounts.

Seamounts are common under-water features, numbering perhaps as many as 100,000, that rise 1000 m or more from the seabed without breaking the ocean's surface (Koslow *et al.*, 2001; Johnston and Santillo, 2004). The rugged and varied topography of the seamounts, and their interaction with nutrient-rich currents, creates ideal conditions and numerous niches for marine life. Compared to the surrounding deep-sea plains and plateaus, they are some of the primary biodiversity hotspots in the oceans.

Seamounts can be home to cold-water corals, sponge beds and even hydrothermal vents communities. They provide shelter, feeding, spawning and nursery grounds for thousands of species, including commercial fish and migratory species, such as whales (Roberts and Hirschfield, 2004; Roberts *et al.*, 2006; UNEP, 2006). Separated from each other, seamounts act like marine oases, often with distinct species and communities. Some, like the Coral Sea and Tasman seamounts, have endemism rates of 29–34%.

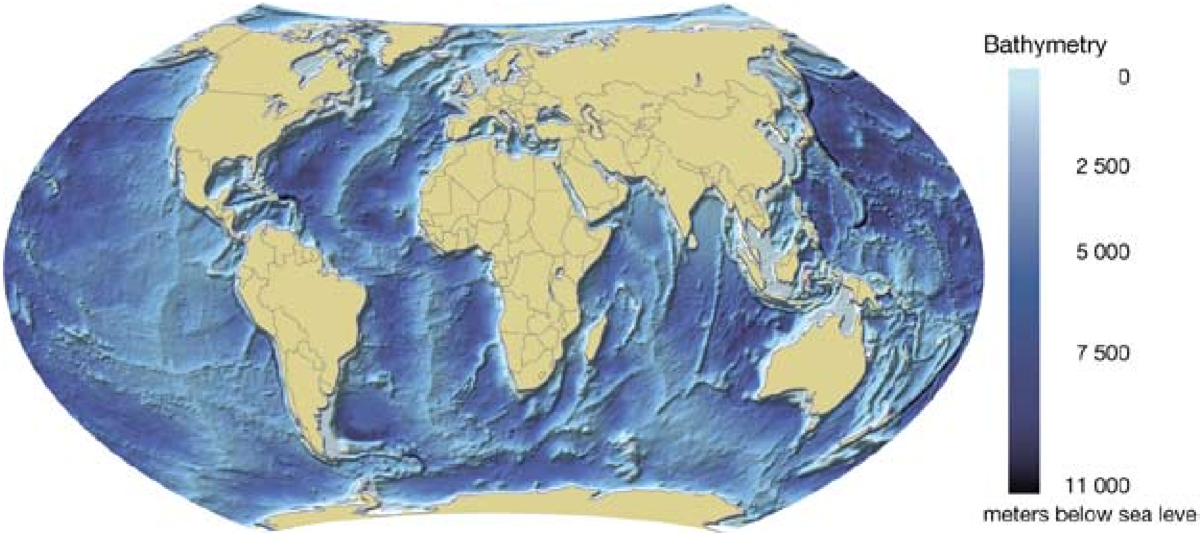


Figure 4. The continental shelves and under-water mountain ranges, so called seamounts (light blue shaded areas), are of immense importance to fisheries. Indeed, over half of the World's marine landings are associated with ca 7.5% of the oceans, concentrated on the continental shelves.

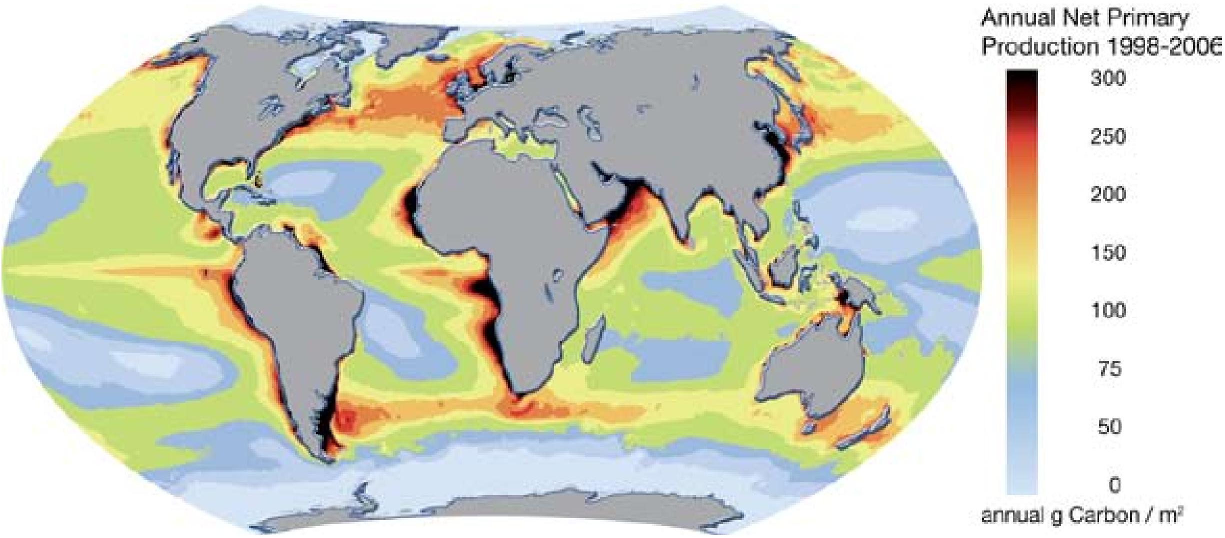


Figure 5. Primary production in the World's oceans provide a quite similar pattern to the World's fisheries (see Figure 6), concentrated along the continental shelves.

These unique features make seamounts a lucrative target for fisheries in search of new stocks of deep-water fish and shellfish, including crabs, cod, shrimp, snappers, sharks, Pacific cod, orange roughy, jacks, Patagonian toothfish, porgies, groupers, rockfish, Atka mackerel and sablefish. Our knowledge of seamounts and their fauna is still very limited, with only a tiny fraction of them sampled and virtually no data available for seamounts in large areas of the world such as the Indian Ocean (Ingole and Koslow, 2005). Often, fishermen arrive before the scientists. For a short time period, sometimes less than 3 years, the catches around seamounts can be plentiful. However, without proper control and monitoring, especially in areas beyond national jurisdiction, stocks are exploited unsustainably and collapse rapidly. The reason for this 'boom and bust' are the characteristics of many deep-water organisms: unlike their counterparts in traditional, shallow-water fishing grounds, the deep-sea fish targeted around seamounts are long-lived, slow to mature and have only a few offspring (Glover and Smith, 2003; Johnston and Santillo, 2004). This makes them highly vulnerable to over-fishing by industrial fishing practices (Cheung *et al.*, 2007). In addition, the benthic communities, which support these fish stocks and their recovery, are seriously damaged or completely destroyed by the impact of heavy bottom trawling and other fishing gear

(Johnston and Santillo, 2004; Morato *et al.*, 2006b). Once depleted and devastated, often for decades to centuries, fishermen move on to the next seamount to start the next cycle. However, with many known seamounts already (over)exploited, recovery of fish stocks on seamounts varies with each species. Stocks of orange rough on the Chatham Rise in New Zealand, for example, show possible improvements after 5 years, whereas the grenadier stocks in the Northwest Atlantic show no signs after a number of years of reduced quotas.

The depletion of seamount populations indicates that the current focus and levels of fishing on seamounts is not sustainable. More depletion, extirpations, and even species extinctions may follow if fishing on seamounts is not reduced (Morato *et al.*, 2006). Very common however, rather than fishing until near extinction, is that the fishing vessels will move on to the next location as soon as the first is exhausted. With the large capacity of the fleet, the result is that more and more locations become impacted and damaged.

When primary production and bathymetric maps (showing the distribution of continental shelves) are compared to the intensity of fisheries (catch), a clear pattern erupts, reflecting the productivity and accessibility of these ocean hotspots.

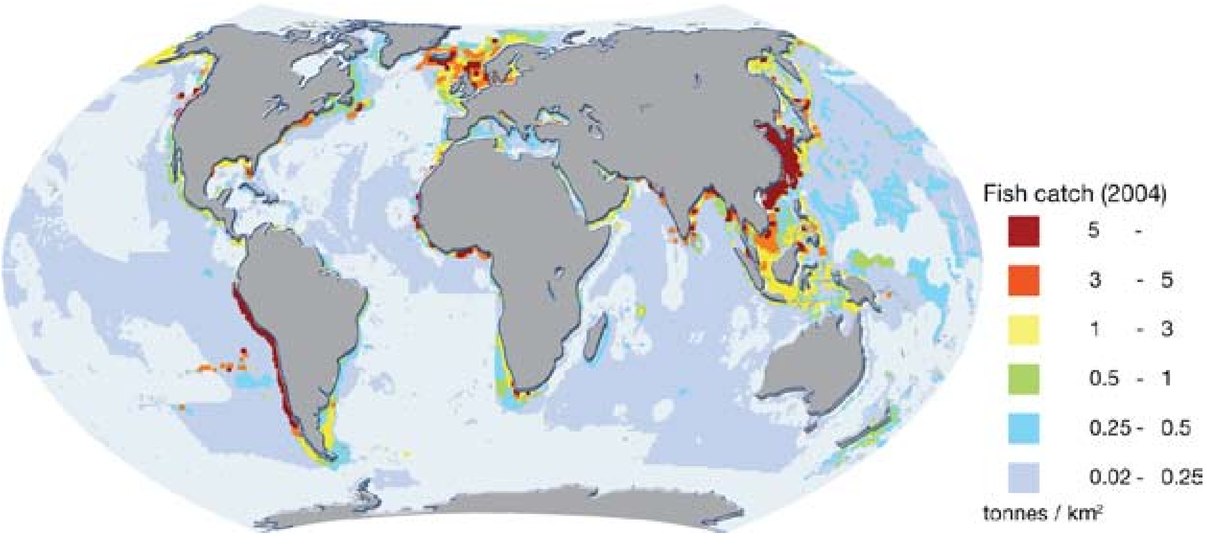


Figure 6. The World's most productive fishing grounds are confined to major hotspots, less than 10% of the World oceans. The maps shows annual catch (tonnes per km^2) for the World's oceans. Notice the strong geographic concurrence of continental shelves, upwelling and primary productivity (see Figures 4 and 5) and the amount of fish caught by fisheries.

CORAL REEFS

Coral reefs are marine ridges or mounds, which have formed over millennia as a result of the deposition of calcium carbonate by living organisms, predominantly corals, but also a rich diversity of other organisms such as coralline algae and shellfish.

Coral reefs provide a unique habitat able to support a high diversity and density of life. They occur globally in two distinct marine environments; deep, cold water (3–14°C) coral reefs, and shallow, warm water (21–30°C) coral reefs in tropical latitudes.

Cold-water corals have been recorded in 41 countries worldwide (Freiwald *et al.*, 2004), but they are most likely distributed throughout the World's oceans. They occur wherever the environmental conditions (cold, clear, nutrient-rich waters) are present, from Norwegian fjords in 39 meters depth to several thousand metres in the deep-sea. Living mostly in perpetual darkness, cold-water corals do not possess symbiotic, single-celled algae, and rely solely on zooplankton and detritus, which they capture with their tentacles. Some species, such as *Lophelia*, can form large, complex, 3-dimensional reef structures several metres in height. The largest reef so far was discovered in 2002 is the Rost reef off the Norwegian coast. It spans twice the size of Manhattan, is part of the *Lophelia* reef belt stretching all along the eastern Atlantic continental shelf and slopes from within the Arctic Circle to the coast of South Africa. Other soft corals living in colder waters such as *Gorgonia* species do not form reefs but large 'gardens', covering vast areas for example around the Aleutian island chain in the North Pacific. The ecological functions of such reefs and gardens in the deeper waters are very similar to tropical reefs: they are biodiversity hotspots and home, feeding and nursery grounds for a vast number of other organisms, including commercial fish and shellfish species.

Living in highly productive areas, cold-water coral reefs and gardens are threatened by bottom fishing, especially with trawls and dredges. Observations with submersibles and remotely

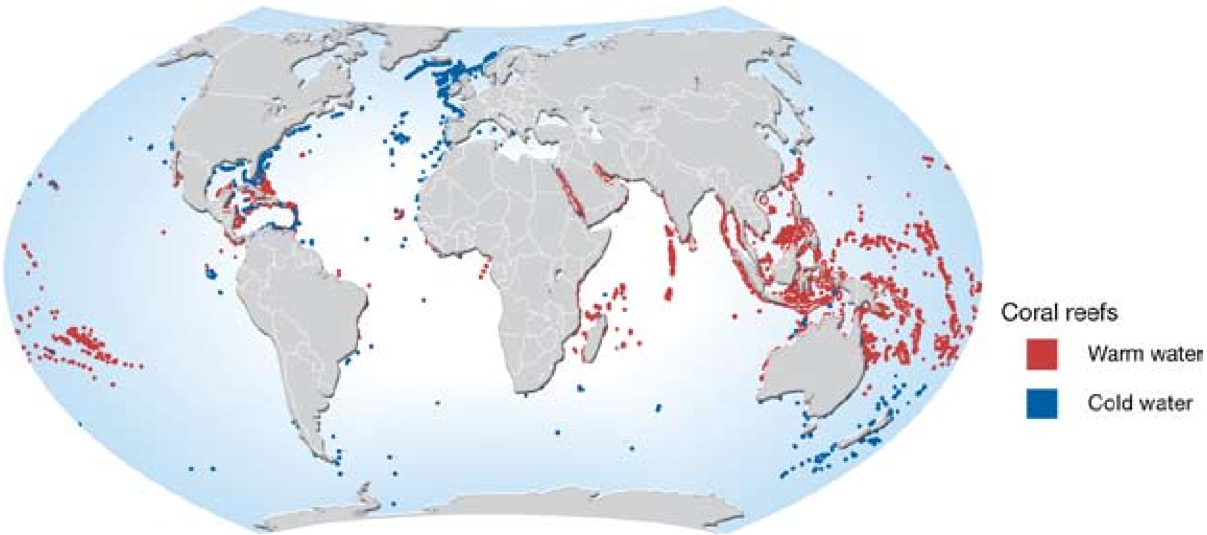


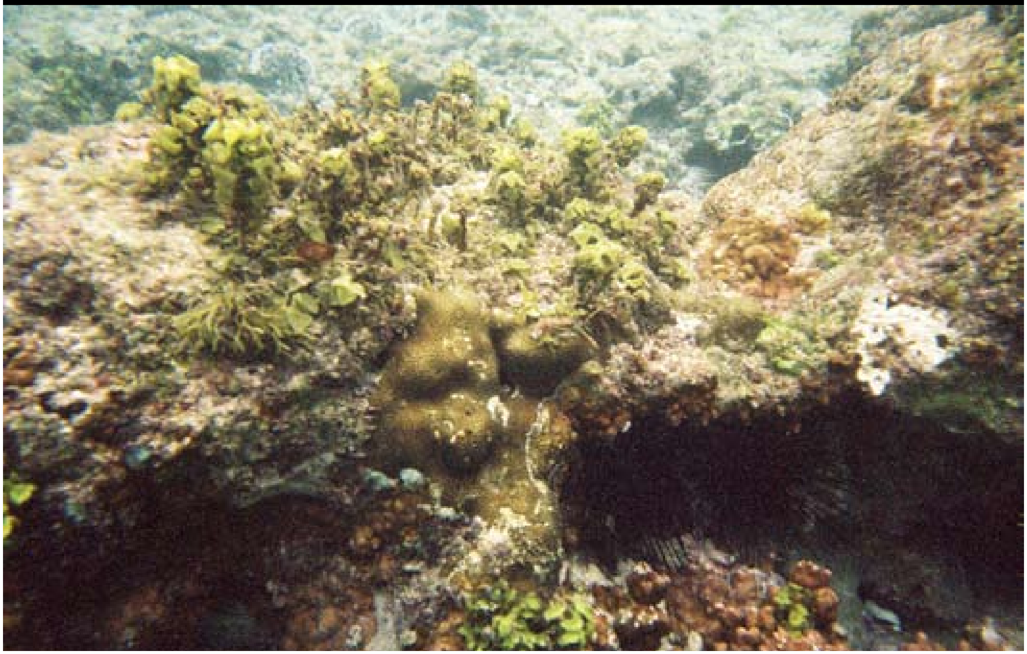
Figure 7. Distribution of coldwater and tropical coral reefs. The coldwater reefs are highly susceptible to deep-sea trawling and ocean acidification from climate change, which has its greatest impacts at high latitudes, while tropical reefs will become severely damaged by rising sea temperatures.

operated vehicles revealed that most of the reefs found on the continental shelf in the North Atlantic show signs of impact by trawling. Lost fishing gear entangled in the corals, and scars from the heavy net doors, rollers and lines, are a common sight. In some places reefs that took over 8.000 years to grow have been completely destroyed, leaving only coral rubble behind.

Warm-water coral reefs are found in circum-tropical shallow waters along the shores of islands and continents. Here, corals feed by ingesting plankton, which the polyps catch with their tentacles, and also through the association with symbiotic algae called zooxanthellae. Stony corals deposit calcium carbonate, which over time forms the geological reef structure. Many other invertebrates, vertebrates, and plants live in close association to the scleractinian corals, with tight resource coupling and recycling, allowing coral reefs to have extremely high biodiversity in nutrient poor waters, so much so that they are referred to as the 'Tropical Rainforests of the Oceans'. Corals have certain ranges of tolerance to water temperature, salinity, UV radiation, opacity, and nutrient quantities. The extreme high diversity of coral reefs have led to the erroneous belief that they prefer nutrient rich environments, but, in fact, corals are extremely sensitive to silt and sewage at far lower concentrations that what is classified as hazardous to humans (Nyström *et al*. 2000). Hence, even minor pollution in apparently clear waters can severely impact coral reefs and their ability to support thousands of fish species and other marine life. Sea water quality and human impacts are particularly critical to coral reefs when they are exposed to other stressors or when they are recovering from storms or bleaching events (Burke *et al*., 2002; Wilkinson, 2002; Brown *et al*., 2006; UNEP, 2006)

Corals are beautiful living animals that are enjoyed by millions of snorkelers and divers world wide, but they are also of vital importance for the whole coral reef ecosystem and for coastal fisheries. One of the largest declines in fishing has, in fact, been recorded in the catches of coral reef fishes, probably as a result of overexploitation of the more vulnerable species (Cheung *et al*., 2007). If corals die, the characteristic three dimensional structure of reefs that is essential to so many of the services provided, will be lost through natural physical and biological erosion as waves, storms, tsunamis, predators, and other factors affecting corals break it down to rubble. Coral reefs support over a million animal and plant species and their economic value exceeds US$30 billion a year.

More and more coral reefs are being degraded and destroyed by human impact and climate change



THREATS TO THE MARINE ENVIRONMENT

Each of the big five stressors (not in order of magnitude), 1) **Climate change**; 2) **Pollution** (mainly coastal), 3) **Fragmentation and habitat loss** (from e.g. dredging/trawling, use of explosives in fishing on coral reefs etc.), 4) **Invasive species infestations**, and 5) **Over-harvest from fisheries** may individually or combined result in severe impacts on the biological production of the worlds oceans and the services they provide to billions of people today. If climate change accelerates, the impacts on marine life from the other stressors will become severely exacerbated and the ability of ecosystems to recover will be impaired.

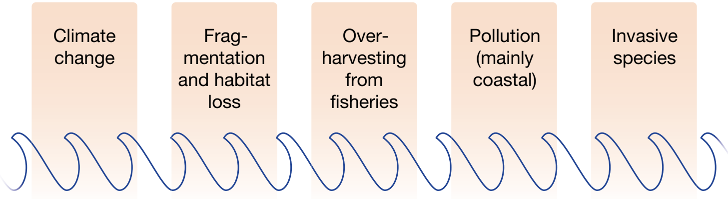


Figure 8. Primary threats to the Worlds oceans include the 'Big Five' stressors.

CLIMATE CHANGE IN THE SEA

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change states that warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level. Natural systems, including oceans and coasts, are being affected by regional climate changes, particularly by temperature increases. Besides rising surface water temperatures and sea level, impacts are or will be associated with changes in the wave climate, circulation, ice cover, fresh water run-off, salinity, oxygen levels and water acidity.

Shifts in ranges and changes in algal, plankton and fish abundance have already been observed in high-latitude oceans. Besides these there are other effects that, based on published literature, have not yet become established trends as they are difficult to discern due to adaptation and non-climatic drivers. Sea level-rise is negatively contributing to coastal erosion, losses of coastal wetland ecosystems, including salt marshes and mangroves, and increasing damage from coastal flooding in many areas. These effects will be exacerbated by increasing human-induced pressures on coastal areas.

CORAL BLEACHING

Corals, especially those which build reefs in tropical, shallow waters, are highly attuned to their environmental surroundings. Bleaching occurs when the corals are subjected to repeated and/or sustained stresses which exceed their tolerances. When this occurs, the symbiotic algae living in the coral tissue are ejected. The corals loose their colour and their white, calcerous skeleton shines through the transparent tissue. Corals can survive this condition for a short time and even take up their symbionts if the stresses subside. However, if the stresses persist, the corals will die. One well documented cause of bleaching is increase of sea surface temperatures (SSTs). A prolonged rise in SST during the hottest months of the year by as little as 1°C above the usual monthly average can result in a bleaching event (Glynn, 1996). The first major

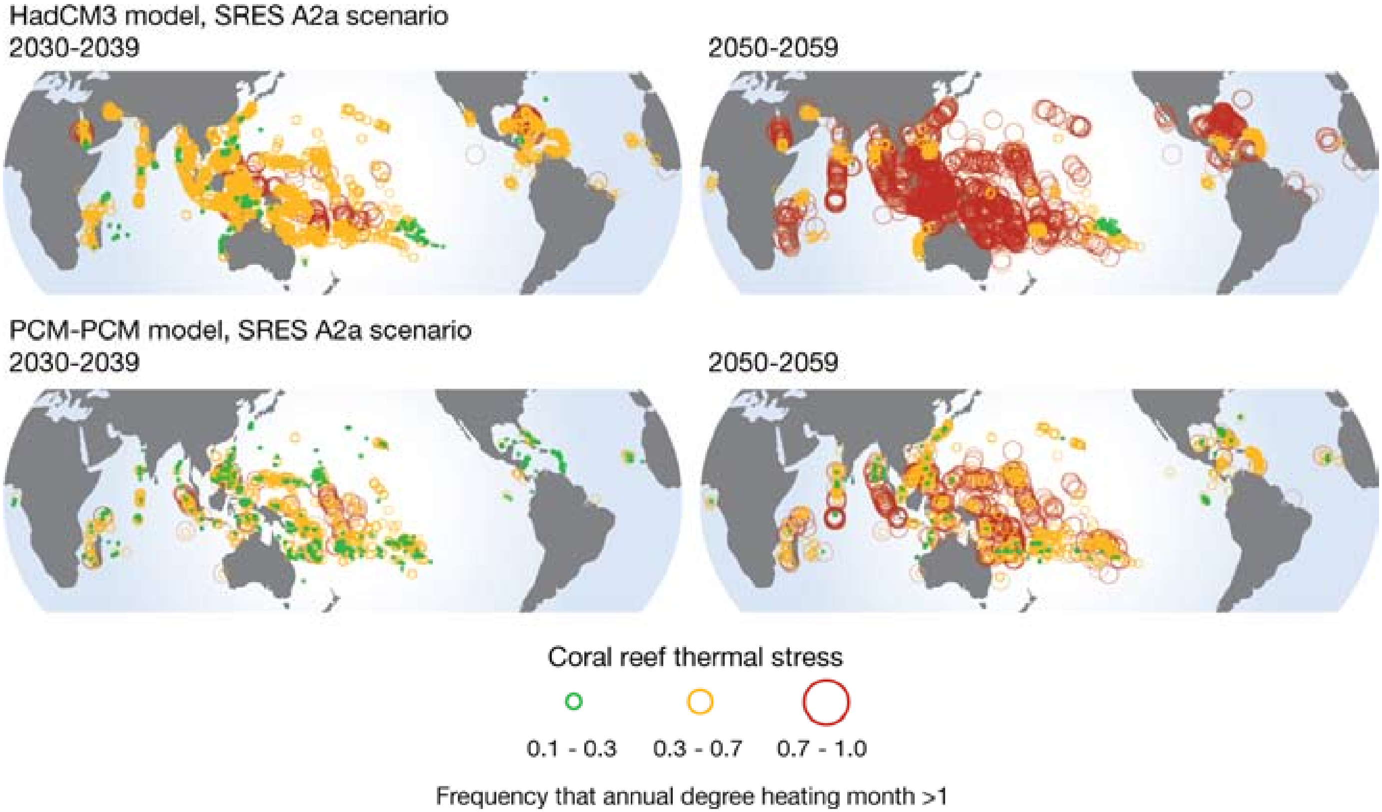


Figure 9. Projected areas of above normal sea temperature where coral bleaching is likely to occur for the SRES A2 scenario by two different models, the PCM (1.7°C increase in 100 years) and the HadCM3 (3°C increase in 100 years) by ca. 2035 (a) and by 2055 (b). Both models project severe annual bleaching in more than 80% of the Worlds coral reefs by 2080 (Donner *et al*., 2005).

global bleaching event was recorded in 1998. Since then, several regional and local events occured, such as in the Caribbean in 2005 (Wilkinson, C. and Souter, D., 2008). Bleaching affects the majority of the tropical reefs around the World, with a large proportion dying. The rate of recovery is different from region to region, with healthy reefs (i.e. reefs not or only marginally stressed by other pressures) generally recovering and re-colonising quicker than reefs in poor condition. Some of the latter did not recover at all. The dead coral skeletons are broken down by wave activity and storms into coral rubble, leading to a change in the whole ecosystem from a rich and diverse coral reef into a much more impoverished community dominated by algae.

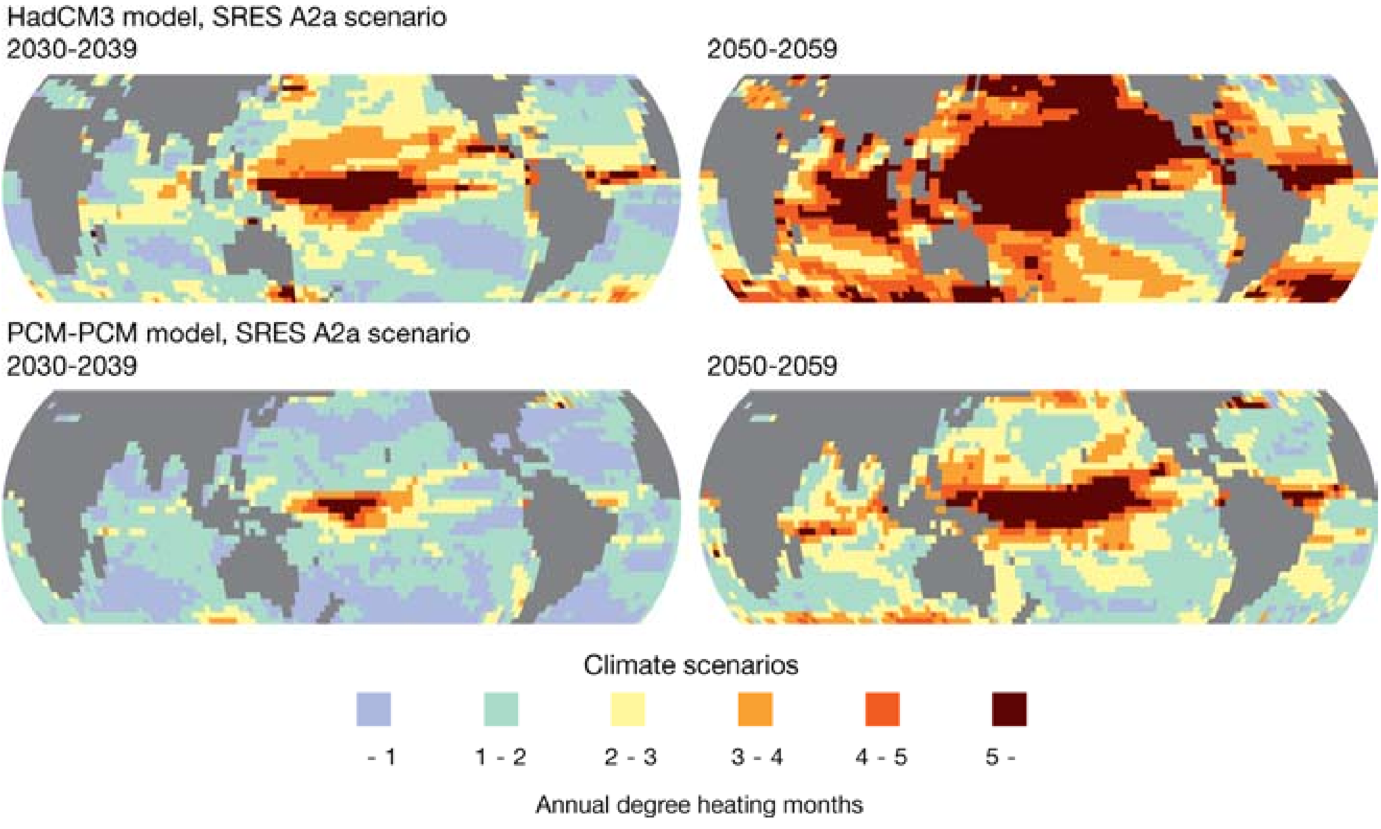


Figure 10. The impacts of coral reefs from rising sea temperatures. When coral reefs become heat-exposed they die, leaving the white dead coral, also known as bleaching. With even moderate pollution, the coral are easily overgrown with algae, or broken down by wave activity or storms, leaving only 'coral rubble' on the ocean bed (Donner *et al.*, 2005).

EXTREME WEATHER AND HURRICANES IMPACT COASTS

With growing population and infrastructures the world's exposure to natural hazards is inevitably increasing. This is particularly true as the strongest population growth is located in coastal areas (with greater exposure to floods, cyclones and tidal waves). To make matters worse any land remaining available for urban growth is generally risk-prone, for instance flood plains or steep slopes subject to landslides.

The amount of sediments and nutrients into the ocean from rivers associated with unsustainable land uses, as well as from storms and sewage, also result in the eutrophication of some coastal ecosystems and the coverage of corals by silt or algae, reduced visibility and light in the water column, and hence, subsequently dramatically reduced ability of corals to recover.

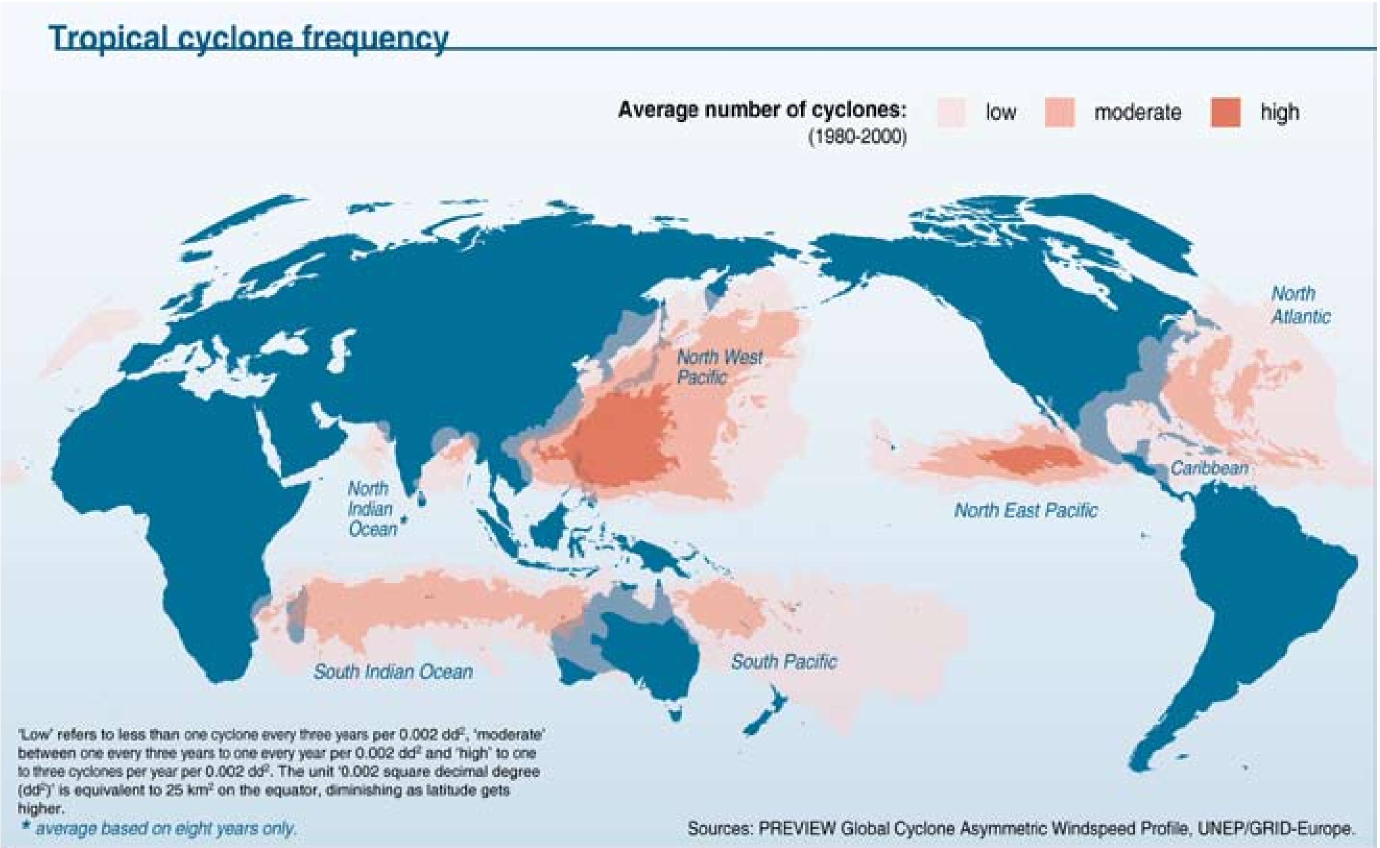
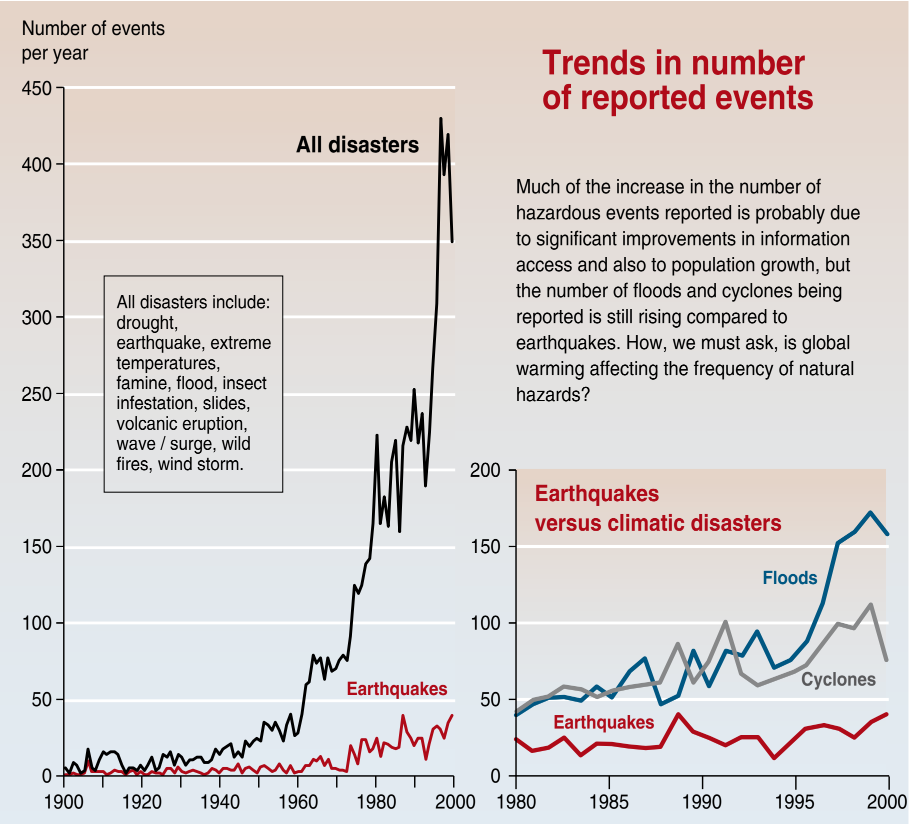


Figure 11. Tropical cyclones, or hurricanes or typhoons, are storm weather systems, characterised by a low pressure centre, thunderstorms and high windspeeds. As the name testifies, these occur in the tropical areas. Cyclones can, after they have formed in the oceans, move in over populated areas, creating much damage and even natural disasters. They erode beaches and destroy coral reefs, and loss of natural flood-buffers like mangroves due to coastal development increases damage further.



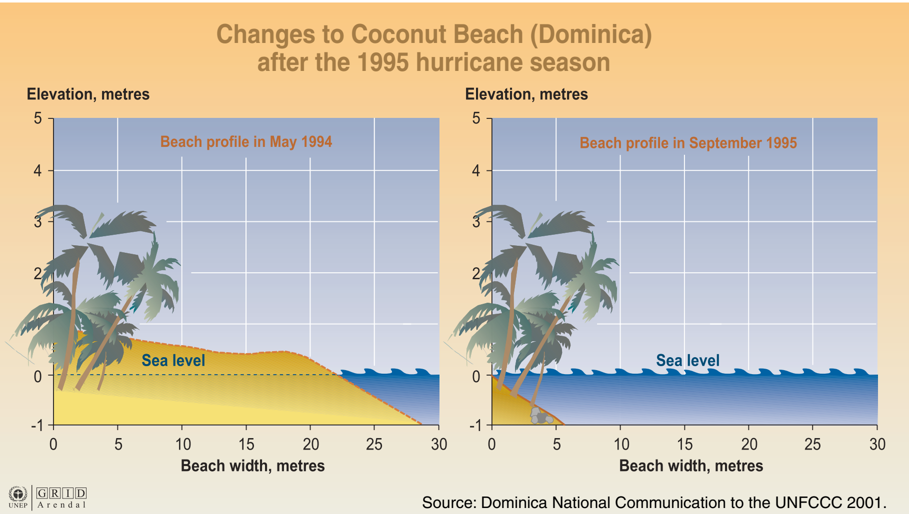


Figure 12. The number of reported extreme climatic based disasters is increasing dramatically worldwide (IPCC, 2006). While part of this increase in the number of weather related disasters, as claimed by some, may be due to better reporting mechanisms and communication, similar increases in reports has not taken place in relation to other types of disasters like the number of reported earthquakes.

Figure 13. During a period between May 1994 to September 1995 the profile of Coconut Beach dramatically changed as a result of storm surges washing away the sand. A rising sea level in the future, combined with more storms, will wash away vulnerable beaches. With the sand gone, the coast is more vulnerable to waves going further inland, threatening fresh water wells with salinisation, leading to land erosion, and making the areas less attractive for tourism. When a beach starts to deteriorate, the process can be amazingly quick. It is very likely that the 20th century warming has contributed significantly to the observed rise in global average sea level and the increase in ocean heat content. Warming drives sea level rise through thermal expansion of seawater and widespread loss of land-based ice. Based on tide gauge records, after correcting for land movements, the average annual rise was between 1 and 2 mm during the 20th century.

SEA LEVEL RISE

A significant sea level rise is one of the major anticipated consequences of climate change (IPCC, 2007; UNEP 2007).

Global warming from increasing greenhouse gas concentrations is a significant driver of both contributions to sea-level rise. From 1955 to 1995, ocean thermal expansion is estimated to have contributed about 0.4 mm per year to sea level rise, less than 25 per cent of the observed rise over the same period. For the 1993 to 2003 decade, for which the best data are available, thermal expansion is estimated to be significantly larger, at about 1.6 mm per year for the upper 750 m of the ocean alone, about 50 per cent of the observed sea level rise of 3.1 mm per year. Scientists estimate the melting of glaciers and ice caps (excluding the glaciers covering Greenland and Antarctica) contributed to sea level rise by about 0.3 mm per year from 1961 to 1990 increasing to about 0.8 mm per year from 2001–2004.

Even for today's socio-economic conditions, both regionally and globally, large numbers of people and significant economic activity are exposed to an increase and acceleration of sea level rise. The densely populated megadeltas such as those of Ganges-Brahmaputra, Mekong and Nile are especially vulnerable to sea level rise. Some 75 per cent of the population affected live on the Asian megadeltas and deltas, with a large proportion of the remainder living on deltas in Africa. Globally, at least 150 million people live within 1 metre of high tide level, and 250 million live within 5 metres of high tide (UNEP, 2007).

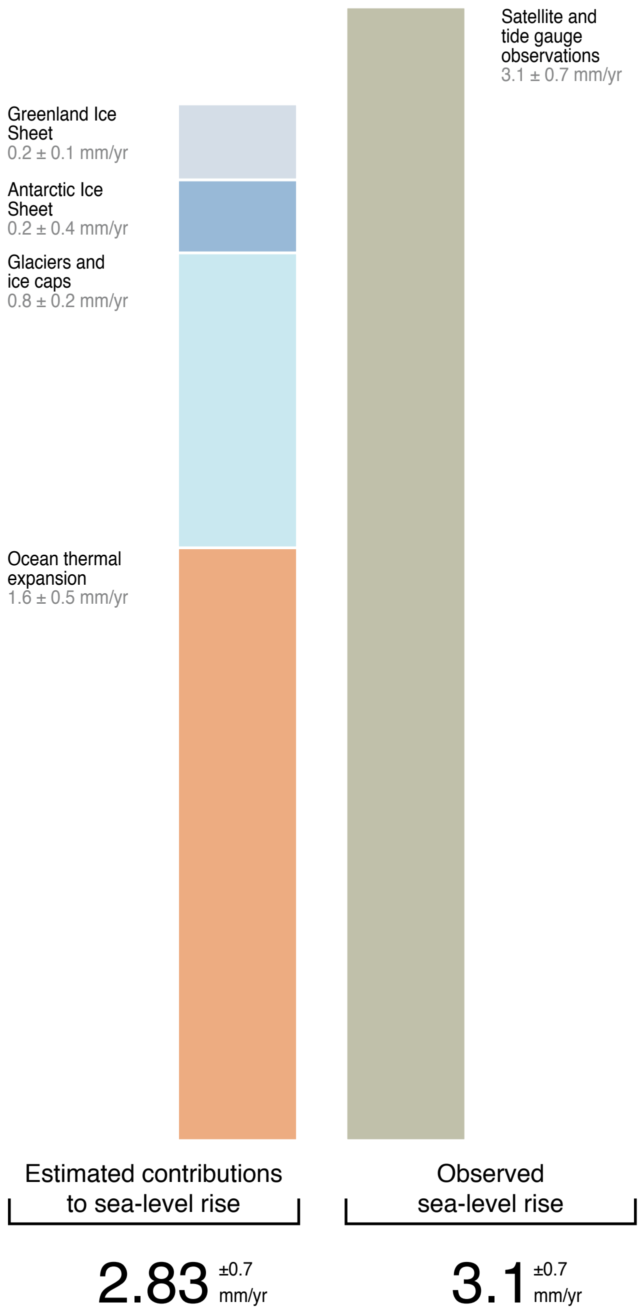
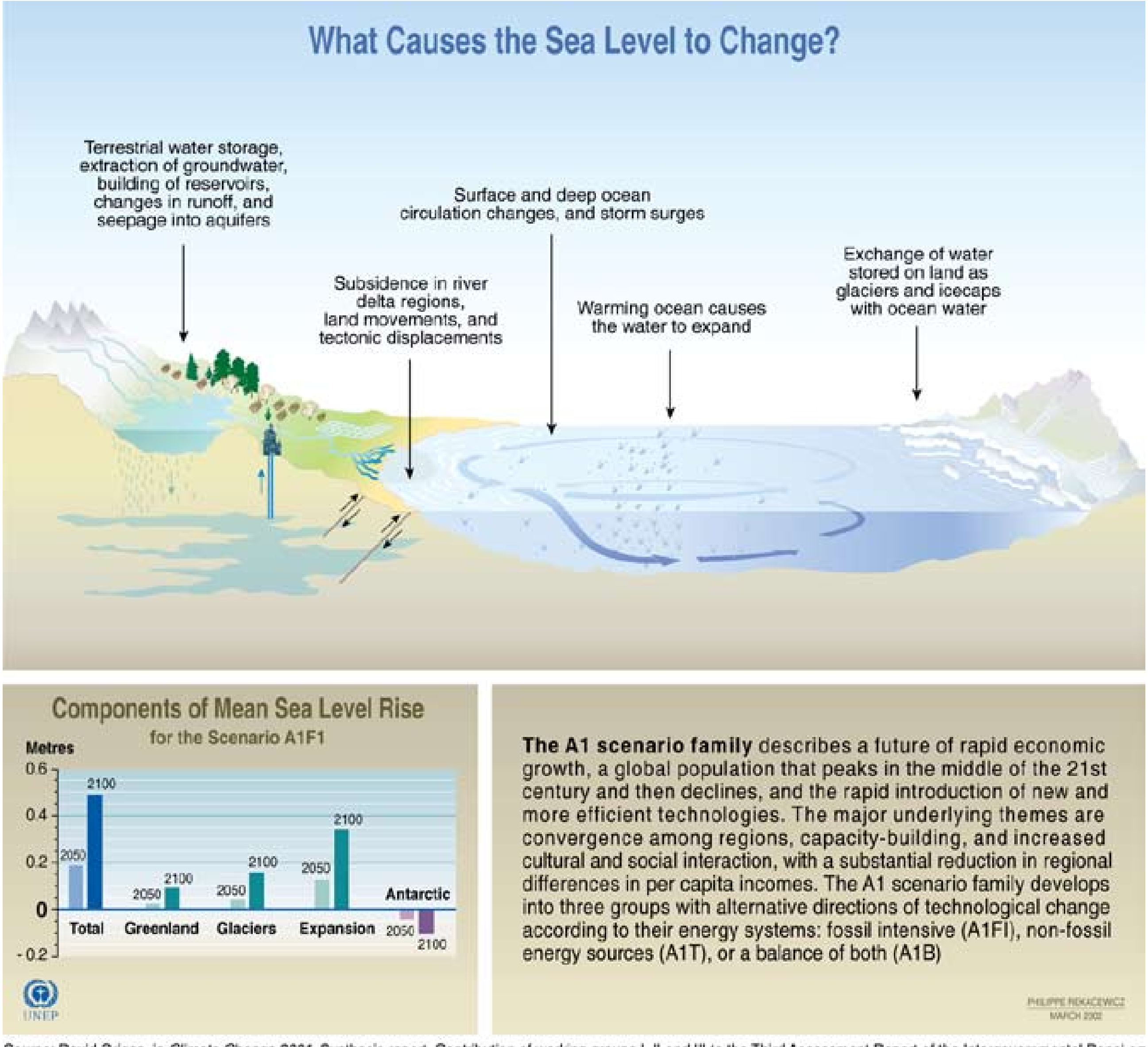


Figure 14. The projected and observed sea level rise. Observed sea level rise is currently larger than that projected by current climate models. The bar to the left also shows the contribution of different factors to sea level rise, the two most important being a) thermal expansion of ocean waters as they warm, and b) increase in the ocean mass, principally from land-based sources of ice (glaciers and ice caps, and the ice sheets of Greenland and Antarctica).



Source: David Griggs, in *Climate Change 2001*, Synthesis report, Contribution of working groups I, II and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press , 2001.

Figure 15. How sea level rise will happen. Expansion of the ocean and melting of land ice are two of the largest contributing factors to sea level rise.

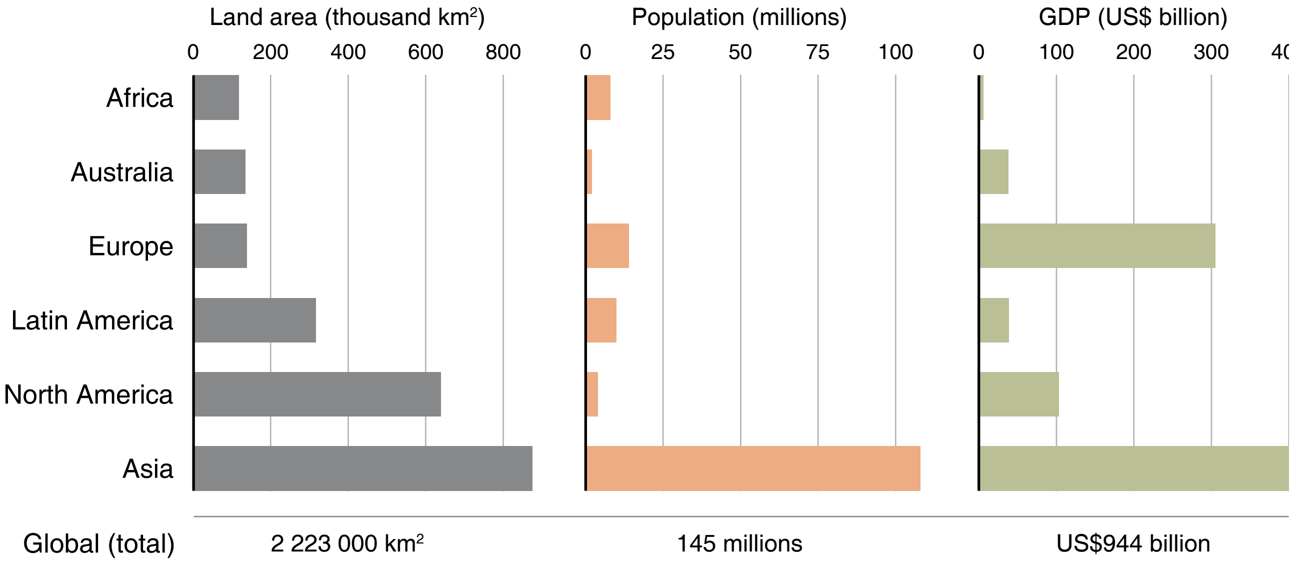
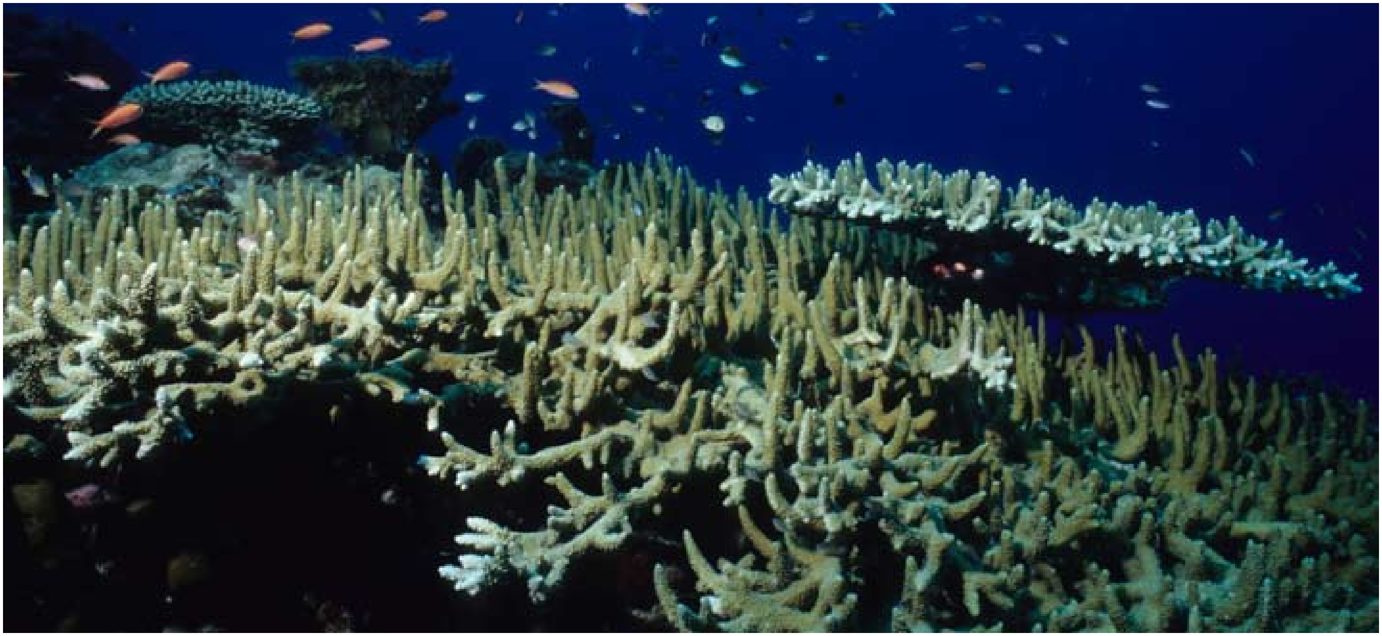


Figure 16. Land area, number of people impacted and projected economic losses from a 1 metre uniform sea level rise in different regions (Anthoff *et al*., 2006; UNEP, 2007).

OCEAN ACIDIFICATION

The oceans act as a natural reservoir for CO_2. The dissolved CO_2 reacts with the seawater to form hydrogen ions. The uptake of anthropogenic carbon since 1750 has led to the ocean becoming more acidic, with an average decrease in pH of 0.1 units. However, the effects of observed ocean acidification on the marine biosphere are yet mostly undocumented. Progressive acidification of the oceans due to increasing atmospheric carbon dioxide is expected to reduce biocalcification of the shells, bones and skeletons most marine organisms possess. Though the limited number of studies available makes it difficult to assess confidence levels, potentially severe ecological changes would result from ocean acidification, especially for corals both in tropical and cold water, and may influence marine food chains from carbonate-based plankton up to higher trophic levels.

The oceans are naturally alkaline, with an average pH of around 8.2, although this can vary up to 0.3 units depending on location and season. Atmospheric carbon dioxide dissolves naturally in the ocean, forming carbonic acid (H_2CO_3), a weak acid. The hydrogen ions released from this acid lower the pH. These reactions are part of a natural buffer system, but recent studies have shown that the huge amounts of CO_2 created by burning fossil fuels are over-stretching the rate by which the natural process can neutralise this acidity. The pH of the oceans has decreased 0.1 unit compared to pre-industrial levels, which equals an increase of 30 per cent in hydrogen ions. While records show that the pH of the seas can vary slightly over time and in certain areas, the continued increases in atmospheric CO_2 are expected to alter ocean pH values within a very short time – an effect greater than any experienced in the past 300 million years (Caldeira *et al.*, 2003).



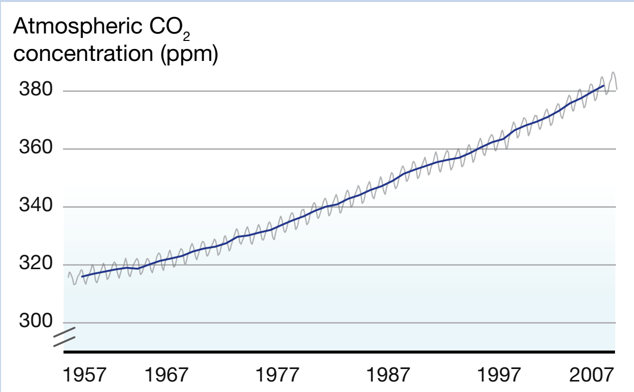


Figure 17. Atmospheric concentration of CO_2 is steadily rising, and oceans directly assimilate CO_2. As ocean concentration of CO_2 increases, the oceans automatically become more acidic. This, in turn, may have severe impacts on coral reefs and other biocalcifying organisms. There is little debate on the effect as this is a straight-forward chemical process, but the implications for marine life, that may be severe due to many very pH-sensitive relationships in marine ecosystems, are still unknown.

More parts of the oceans will become undersaturated with calcium carbonate, even most or all surface waters in the polar regions. All marine organisms which need carbonate to build their calcareous skeletons and shells, such as corals, seashells, crabs and crayfish, starfish and sea urchins, could be affected. Even single-celled, planktonic organisms with calcareous shells (e.g. coccolithospores, certain foraminifera etc.), which form the basis of many marine food chains, may be affected.

The impacts of ocean acidification are potentially widespread and devastating, and may change marine life as we know it. The first effects will be felt in deeper waters and the polar regions. It is expected that by 2100, around 75% of all cold-water corals will live in calcium carbonate undersaturated waters. Any part of their skeleton exposed to these waters will be corroded. Dead coral fragments, important for the settlement of coral larvae e.g. to re-colonise a reef after a bleaching event, will be dissolved. The base of the reefs will be weakened and eventually collapse. Even those organisms which might be able to cope with the undersaturated conditions will have to spent more energy in secreting their shells and skeletons, which makes them more vulnerable to other stresses and pressures.

Tropical areas will remain saturated, but experience a severe fall from the optimal aragonite (a metastable form of calcium carbonate used by corals) concentrations in pre-industrial times to marginal concentrations predicted for 2100. This will add to the already increasing stresses from rising sea temperatures, over-fishing and pollution.

Ocean acidification may have severe impacts on scleractinian cold-water and deep-sea corals (Royal Society 2005; Guinotte *et al.* 2006; Turley *et al.*, 2007). Projections suggest that Southern Ocean surface waters will begin to become undersaturated with respect to aragonite by the year 2050 (Orr *et al.*, 2005). By 2100, this undersaturation could extend throughout the entire Southern Ocean and into the subarctic Pacific Ocean. Studies have suggested that conditions detrimental to high-latitude ecosystems could develop within decades, not centuries as suggested previously (Orr *et al.*, 2005).

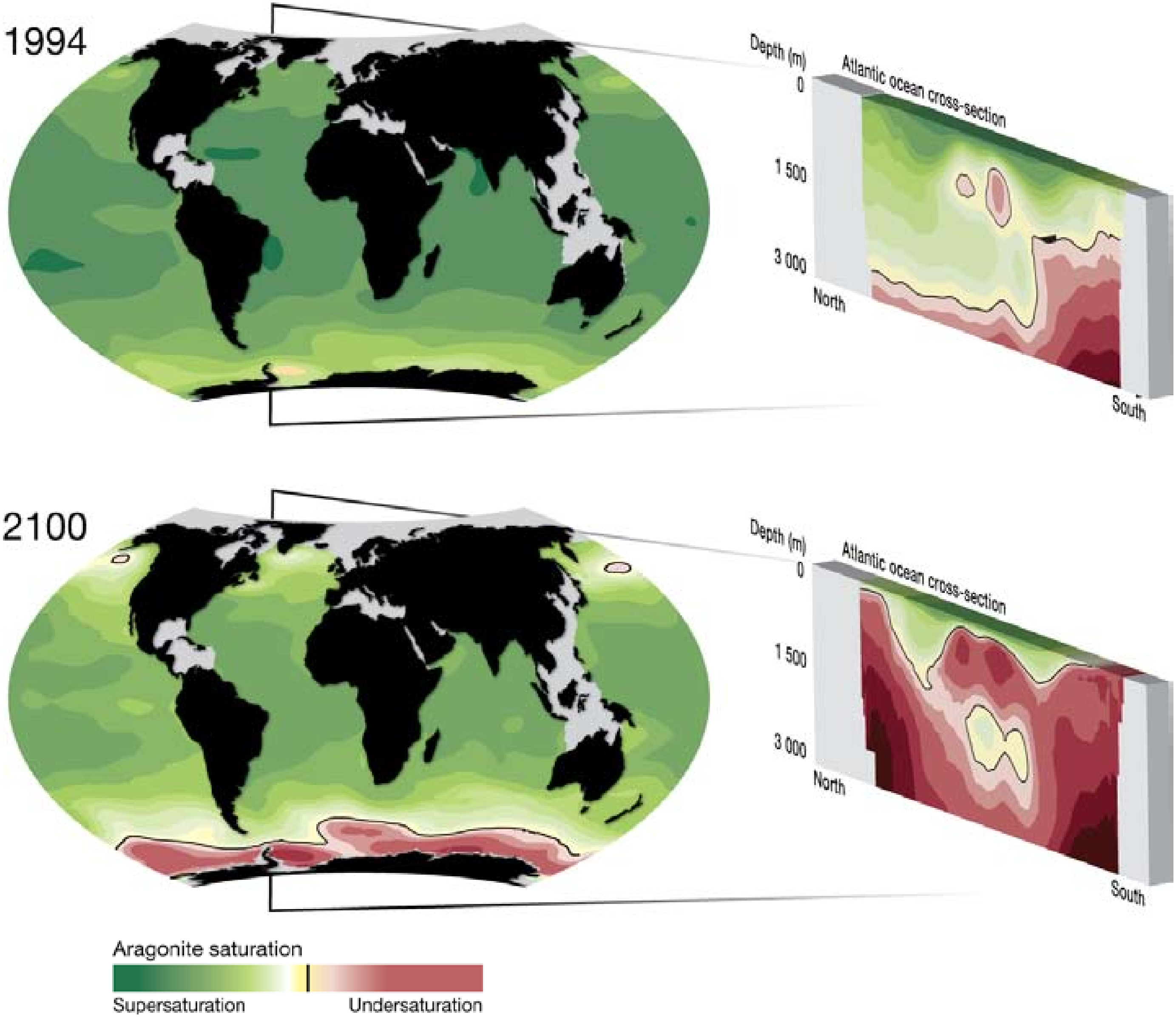


Figure 18. As carbon concentrations in the atmosphere increase, so do concentrations in the ocean, with resultant acidification as a natural chemical process. The skeletons of coldwater coral reefs may dissolve, perhaps already within a few decades. The impacts will be greatest at high latitudes.

INCREASING SEA TEMPERATURES ALREADY CAUSE CHANGES IN DISTRIBUTION OF MARINE LIFE

There is increasing evidence from a number of regions in the world of a poleward movement of warmer water species of plankton, fish, benthic and intertidal organisms in the last 50 years. These biogeographic changes have been observed in both the northern and southern hemispheres (e.g. NE Atlantic, Tasman Sea, China Sea, Bering Sea). The clearest evidence of the changes has been obtained by the Continuous Plankton Recorder (CPR) survey in the Northeast Atlantic. Here, warmer water copepod species (crustaceans) moved northwards by 10° of latitude (~1000 km) within 40 years up to 1999, a pattern that has continued since.

Species that are representative of Arctic and cold temperate waters have shown a similar movement, retreating to the north. Other studies have shown an increase in the northerly range of a number of warm temperate and subtropical fish species with evidence for dispersion along the continental slope to the west of Europe and in some cases establishment of breeding populations of species such as red mullet, anchovies and sardines in the North Sea, much further north than ever recorded before.

In the case of the Northeast Atlantic the changes are clearly linked to rising sea temperatures and are correlated with Northern Hemisphere temperature and the North Atlantic Oscillation (NAO), the dominant mode of atmospheric variability in the North Atlantic. These correlations suggest that the changes may be a response at an ocean basin scale to what may be a global signal. The changes observed so far in the North Sea have taken place with a temperature increase of only about 0.5°C. Temperatures are expected to continue to increase, with a possible annual average increase of 6°C north of the latitude of Scotland by 2100 which, if it occurs, will lead to a further poleward movement of marine organisms.

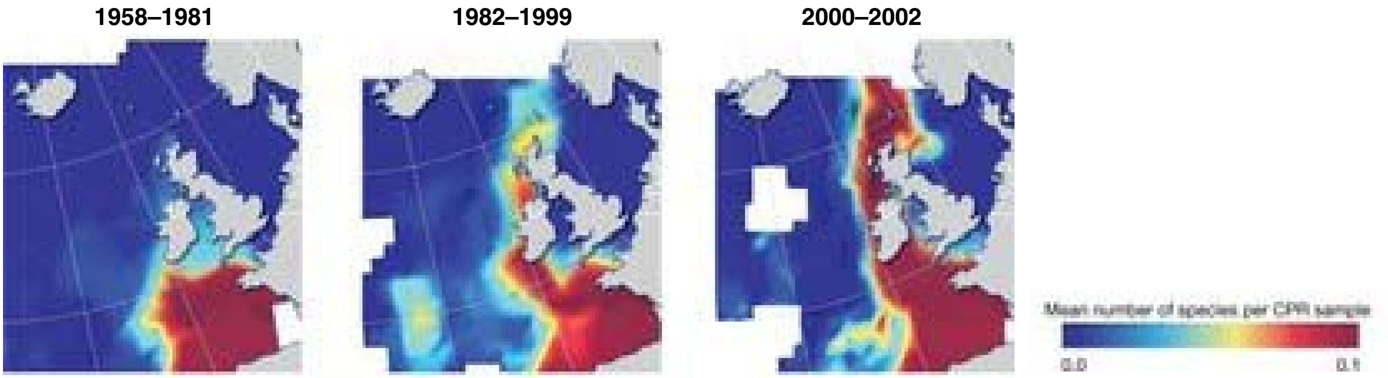


Figure 19. With melting sea ice and warming of the oceans, marine species change their distributions, affecting entire food chains and ocean productivity. In 2005 the subtropical dinoflagellate *Ceratium hexacanthum* was found in CPR samples from the North Sea at levels that were 6 standard deviations above previous measurements since 1958. Further evidence of this warning signal is seen in the appearance of a Pacific planktonic plant (a diatom *Neodenticula seminae*) in the Northwest Atlantic for the first time in 800,000 years, by transfer across the top of Canada due to the rapid melting of Arctic ice in 1998.

SLOWING DOWN OF THERMOHALINE CIRCULATION AND CONTINENTAL MARGIN DENSE-WATER EXCHANGE MECHANISMS

A fifth very serious impact of climate change may be on ocean circulation. Palaeo-analogues and model simulations show that the Meridional Overturning Circulation (MOC) can react abruptly and with a hysteresis response, once a certain forcing threshold is crossed. Discussion on the probability of the forcing thresholds being crossed during this century lead to different conclusions depending on the kind of model or analysis (Atmosphere-Ocean General Circulation Models, Earth system models of intermediate complexity or expert elicitations) being used. Potential impacts associated with MOC changes within the marine

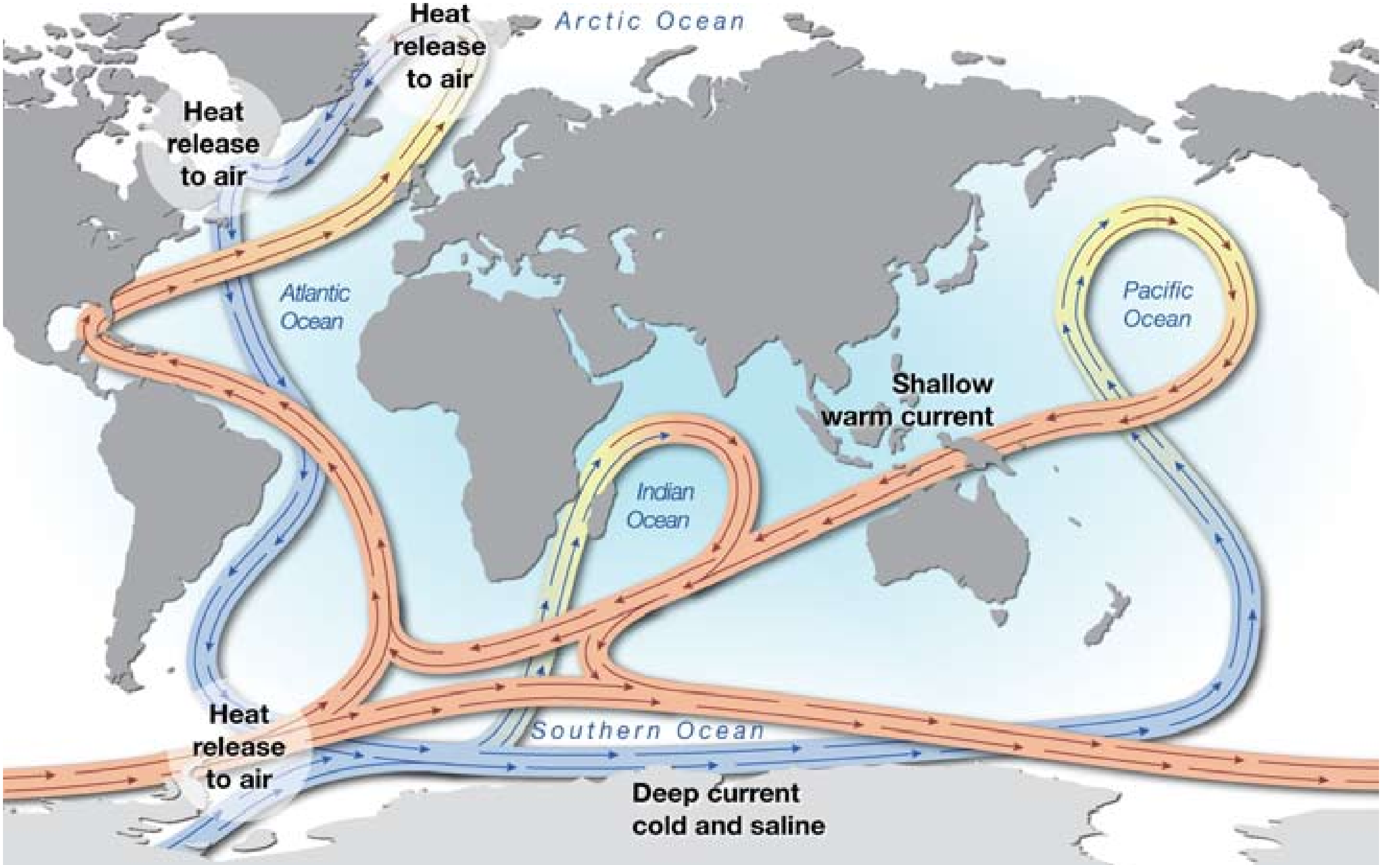


Figure 20. The Meridional Overturning Circulation plays a crucial role for life in the oceans. If this ocean conveyor belt slows down or changes as a result of melting ice and increasing ocean temperatures, the impacts on marine life may become severe.

environment include changes in marine ecosystem productivity, oceanic CO_2 uptake, oceanic oxygen concentrations and shifts in fisheries. Adaptation to MOC-related impacts is very likely to be difficult if the impacts occur abruptly (e.g., on a decadal time-scale). Overall, there is high confidence in predictions of a MOC slowdown during the 21st century, but low confidence in the scale of climate change that would cause an abrupt transition or the associated impacts. However, there is high confidence that the likelihood of large-scale and persistent MOC responses increases with the extent and rate of anthropogenic forcing.

Dense shelf water cascading is a type of marine current driven exclusively by seawater density contrast. The cascading process is normally seasonal and triggered by the formation, on the shelf, of dense water by cooling and/or evaporation and its sinking down slope towards deeper offshore areas.

There are a number of places around the world where dense water masses flow 'over the edge' of the continental shelf into the deep sea, often using and carving submarine canyons. This margin exchange process provides an essential link/exchange between shallow and deep waters and involves water and considerable particulate and dissolved loads, especially when operating in a 'flushing' pattern.

Due to their proximity to land areas, continental shelves are the locus of input, transit and accumulation of land born particulate substances, including pollutants. Dense shelf water cascading transports these particulate substances for recycling into the deep sea. Any future climate change driven alterations in the temperature regime of the oceans, such as the predicted increase in the horizontal layering ('stratigraphy') of water masses, will have a significant impact in the frequency and intensity of cascading events, and thereby on the biogeochemical budgets of shallow waters and the ventilation of deep water areas.

Scientists working under the large deep-sea research project HERMES (Hotspot Ecosystem Research on the Margins of Eu-

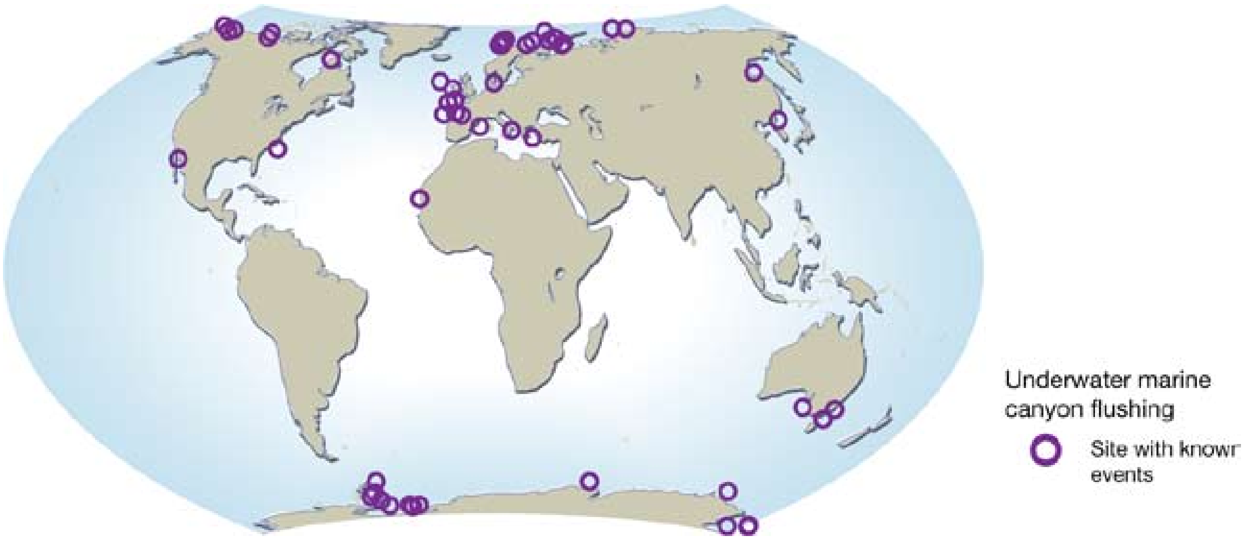


Figure 21. Coastal regions in the World where dense shelf water cascading 'flushing' has been observed. Knowledge and mapping of these processes is still scarce due to uneven research effort. The map shows sites with known dense shelf water cascading phenomena, which often may involve the 'flushing' effect (Ivanov *et al*., 2004; Durrieu *et al*., 2005; Heussner *et al*, 2006). It is most likely that this phenomenon is also active off the coast of Alaska, Chile, Argentina and West and southern Africa and in parts of the Indian Ocean. Dense shelf water cascading is highly sensitive to increases in temperature, and hence, climate change. Data from Canals *et al.* (2006).

ropean Seas) – of which UNEP is a partner – documented, three years ago, the occurrence and effects of a dense shelf water cascading phenomenon in the Gulf of Lions (North-western Mediterranean) (Canals *et al.*, 2006). The amount of water transported in 4 months from the Gulf of Lions to the deep Western Mediterranean, via the Cap de Creus canyon, equalled around 12 years of the water input from the river Rhone, or 2 years of input from all rivers draining into the Mediterranean. How this dense shelf water cascading in the Gulf of Lions affects the population of the deep-sea shrimp *Aristeus antennatus* (marketed as 'crevette rouge') was only recently discovered (Company *et al.*, 2008). Initially, the strong currents (up to 80 centimetres per second) associated with intense cascading events displace shrimp populations from the normal fishing grounds, producing a temporary fishery collapse. However, despite this initial negative effect, the food (particulate matter) provided by the currents soon leads to a large increase in recruitment and juveniles of this highly valuable species. This mitigates overexploitation, and results in plentiful landings of large, adult deep-sea shrimp between 3 and 5 years after major cascading events.

A decrease of winter deep water formation in the Gulf of Lions is expected to occur during the twenty-first century according to modelling results using the IPCC-A2 scenario which could obviously decrease the frequency and intensity of dense shelf water cascading events. Without this regenerative mechanism, fishery pressure could quickly deplete the stocks of *Aristeus antennatus* and other valuable deep-sea living resources in the area. If the predicted reduction of deep water formation in high latitudes as in the Nordic and Arctic regions (Gregory *et al.*, 2006) would affect the frequency of dense shelf water cascading in the margins of the polar regions, the impacts on the biogeochemistry of the global ocean could be considerable.

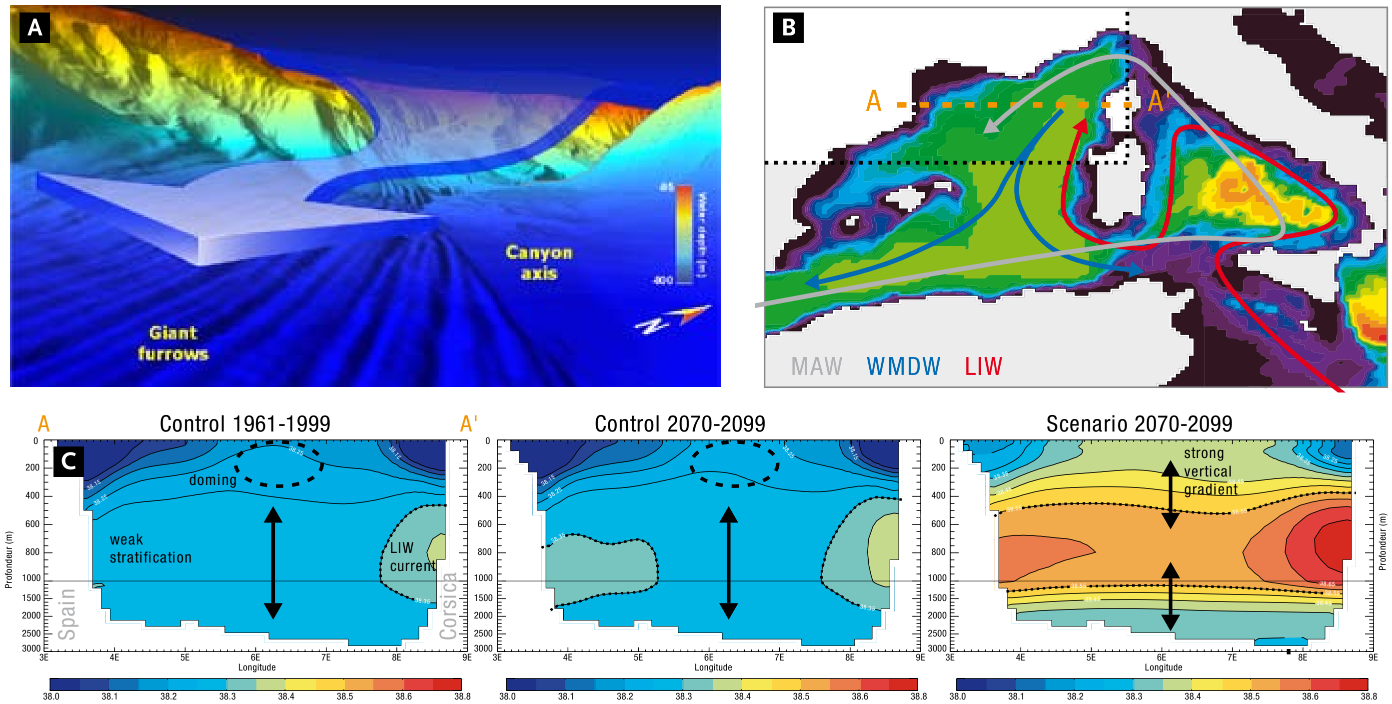


Figure 22. Climate change models (B, C1–3) predict that the flow of dense shelf water (DSW) into the deep sea (A) will decrease in the next 100 years. (A: Courtesy of GRC Marine Geosciences-University of Barcelona, CEFREM-CNRS/University of Perpignan, and ICM Barcelona-CSIC; B,C: Based on Somot *et al*, 2006.)

MARINE POLLUTION AND COASTAL DEVELOPMENT

A major threat beyond overexploitation of fisheries and physical destruction of marine coastal habitats by unsustainable fishing practices is undoubtedly the strong increase in destruction of coastal habitats (Lotze *et al.*, 2006) by coastal development and discharge of untreated sewage into the near-shore waters, resulting in enormous amounts of nutrients spreading into the sea and coastal zones (Burke *et al.*, 2002; Wilkinson, 2002; Brown *et al.*, 2006; UNEP, 2006).

Around 60% of the waste water discharged into the Caspian Sea is untreated, in Latin America and the Caribbean the figure is close to 80%, and in large parts of Africa and the Indo-Pacific the proportion is as high as 80–90% (UNEP, 2006). An estimated US$ 56 billion is needed annually to address this enormous waste water problem. However, the costs to coral reefs, tourism and losses in fisheries and human health risks may be far more expensive. Waste water treatment is also one of the areas where least progress is being made globally. Many marine species, including cold-water corals like *Lophelia* sp., are highly sensitive to temperature changes and dissolved oxygen, making them highly vulnerable to climate change and pollution (Dodds *et al.*, 2007). This, in turn, makes them vulnerable to diseases (Hall-Spencer *et al.*, 2007). The poor management of sewage not only presents a dire threat to health and ecosystems services, it may also increase poverty, malnutrition and insecurity for over a billion people (UNEP, 2006).

Marine pollution includes a range of threats including from land-based sources, oil spills, untreated sewage, heavy siltation, eutrophication (nutrient enrichment), invasive species, persistent organic pollutants (POP's), heavy metals from mine tailings and other sources, acidification, radioactive substances, marine litter, overfishing and destruction of coastal and marine habitats (McCook 1999, Nyström *et al* 2000, Bellwood *et al.* 2004). Overall, good progress has been made on reducing persistent organic pollutants (POPs), with the exception of

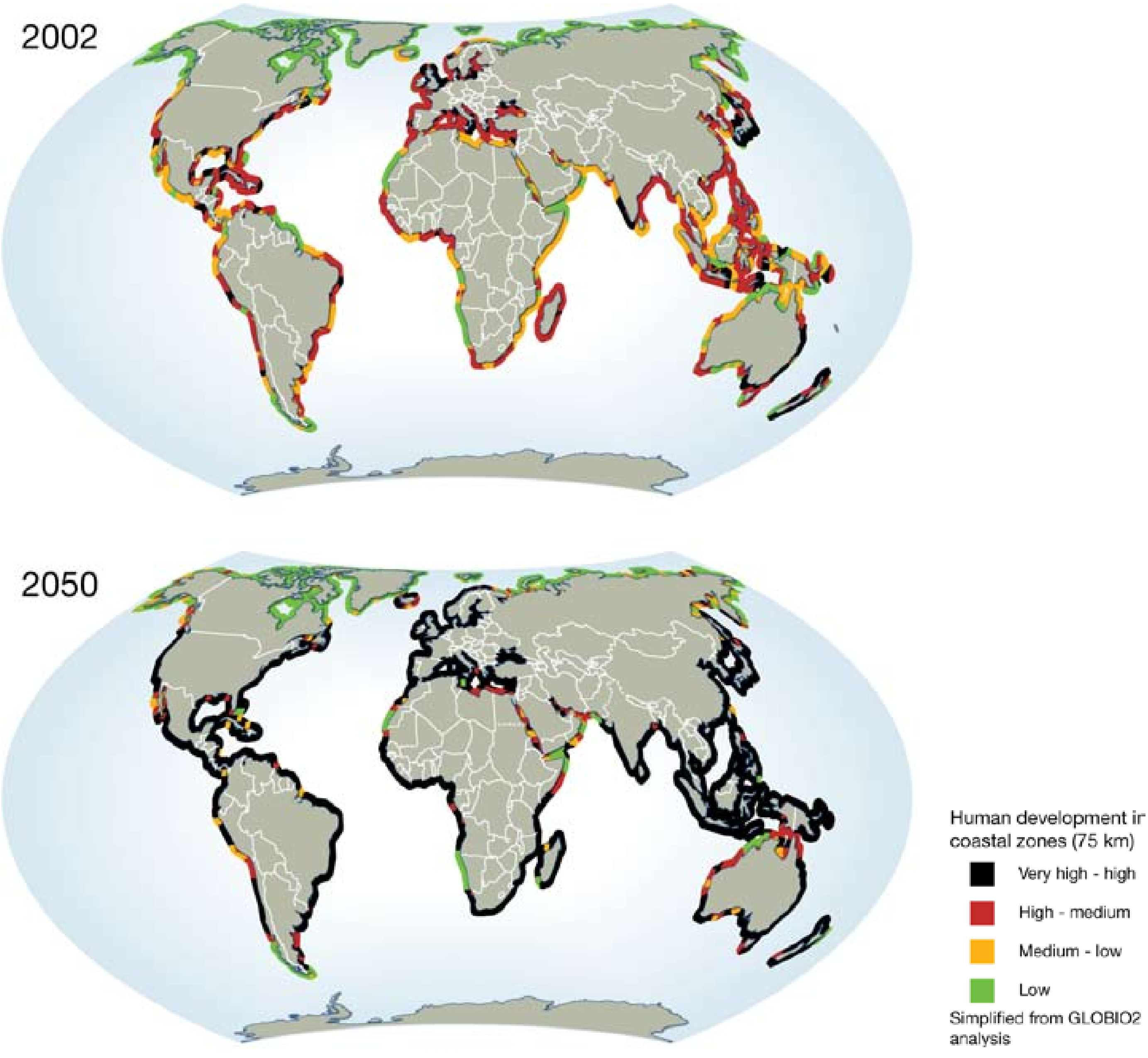


Figure 23. Infrastructure development, intensive agricultural expansion, urbanisation and coastal development are increasing the flow of sediments and sewage into the ocean. The situation is most severe around Europe, the East coast of the United States, East of China and in Southeast Asia. These are also primary fishing grounds.

the Arctic. Oil inputs and spills to the Seas has been reduced by 63% compared to the mid-1980s. Oil releases from tanker accidents have gone down by 75%, from tanker operations by 90% and from industrial discharges by some 90%, a result partially obtained through the shift to double-hulled tankers (UNEP, 2006; Brown *et al.*, 2006). Progress on reducing emissions of heavy metals is reported in some regions, while increased emissions are observed in others, including from electronic waste and mine tailings in Southeast Asia. Sedimentation has decreased in some areas due to reduced river flows as a result of terrestrial overuse for agricultural irrigation, while increasing in other regions as a result of coastal development and watershed deforestation as well as declines in mangroves (Burke *et al.*, 2002; McCulloch *et al.*, 2003; Brown *et al.*, 2006; UNEP, 2006).

Together with agricultural run-off to the sea or into major rivers and eventually into the ocean, nitrogen (mainly nitrate and ammonium) exports to the marine environment are projected to increase at least 14% globally by 2030 (UNEP, 2006). In Southeast Asia more than 600,000 tons of nitrogen are discharged annually from the major rivers. These numbers may become further exacerbated as coastal population densities are projected to increase from 77 people/km^2 to 115 people per km^2 in 2025. In Southeast Asia, the numbers are much higher and the situation more severe. Wetlands and mangroves are also declining rapidly, typically by 50–90% in most regions in the past 4 decades (UNEP, 2006). This, in turn, will severely exacerbate the effects of extreme weather, the ability of coral reefs to resist and recover from climate change and reduce the productivity of coastal ecosystems which supply livelihoods and basic food to the impoverished.

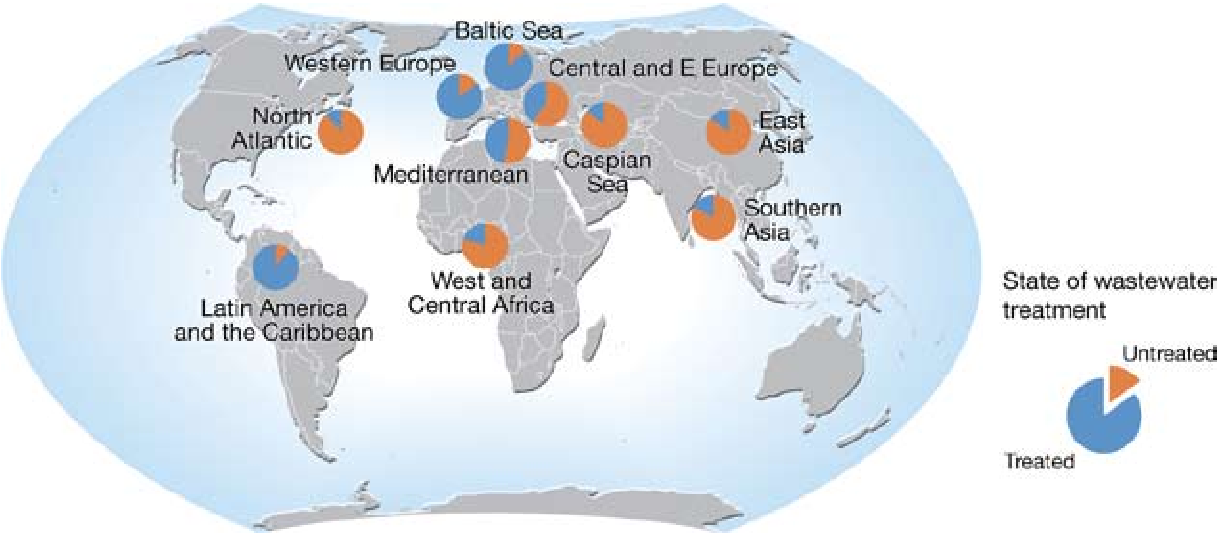


Figure 24. Sewage treatment is low or absent in many parts of the World, leading to eutrophication of the coastal zone, (toxic) algae blooms and dramatically reduce the ability of coral to recover from bleaching events dramatically.

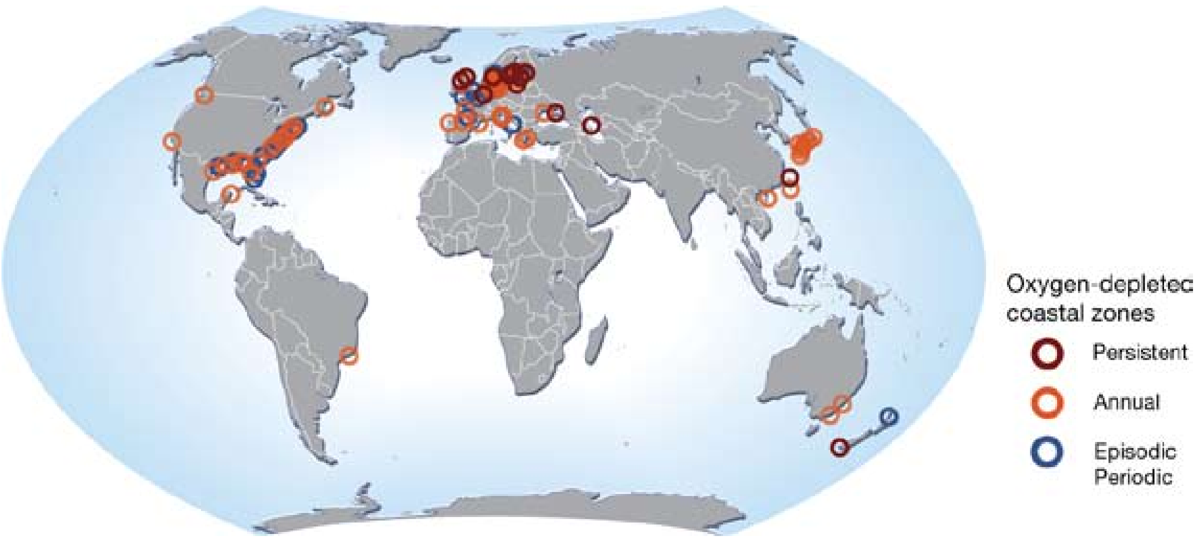


Figure 25. Dead zones (hypoxic i.e. oxygen deficient water) in the coastal zones are increasing, typically surrounding major industrial and agricultural centers.

IMPACT OF UNSUSTAINABLE FISHING PRACTICES ON SEA BED AND OCEAN PRODUCTIVITY

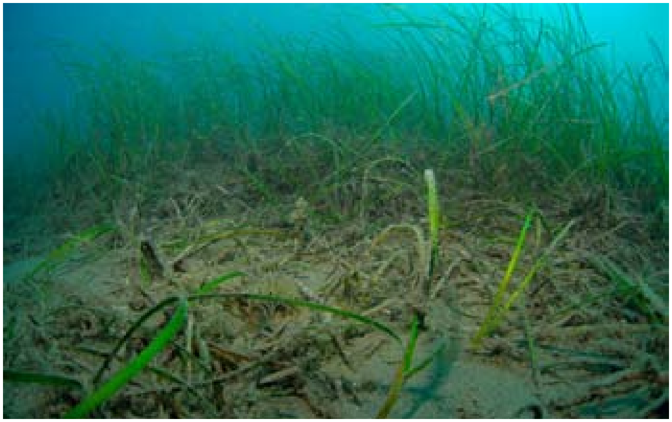
Fishery resources, the harvest of the oceans, are concentrated in marine areas where the environmental conditions support a high productivity. Such areas are found in coastal waters as well as in deeper waters on the continental shelves and around seamounts (Roberts *et al.*, 2006; Garcia *et al.*, 2007).

The severe decline of stocks in many traditional coastal fishing grounds has given rise to an increase in regulations. This, in turn, has intensified the search for new and less controlled fish stocks and fishing grounds. Modern technology, such as remote sensing, sonar and Global Positioning Systems, together with incentives and subsidies, has brought deep-water and high sea areas and habitats with high production, such as continental slopes, seamounts, cold-water coral reefs, deep-sea sponge fields, into the reach of fishing fleets trying to exploit the last refuges for commercial fish species. Fishing vessels are now operating at depths greater than 400 metres, sometimes as great as 1,500 to 2,000 metres (Morato *et al.*, 2006a). New species are being targeted, often with great success and large catches in the first 2–3 years.

However, this success is in most cases only short-lived, and followed quickly by a complete collapse of stocks ('boom and bust' cycle). Especially seamounts with their unique and often endemic fauna are particularly vulnerable to trawling (Koslow *et al.*, 2001; Morato *et al.*, 2006b). The reason for this is the special life history of many deep-water organisms, including fish species of commercial interest. Unlike their counterparts which are adapted to live in the much more variable and dynamic shallow waters systems, deep sea fish species are characterised by low reproduction and fecundity, long life, and reach maturity at a late stage. Orange roughy, one of the species often targeted by deep-water and seamount fisheries, matures from 20 to 30 years of age. Individuals can live to more than 200 years of age, which means that a fish ending up on a dinner plate could have hatched at the time of Napoleon Bonaparte. These traits render deep-water fish stocks highly vulnerable to overfishing with little resilience to over-exploitation (Morato *et al.*, 2006b; Cheung *et al*, 2007). With very few exceptions, and especially without proper control and management, deep-sea fisheries cannot be considered as a replacement for declining resources in shallower waters (Morato *et al.*, 2006a).

Among the most destructive fishing methods in the World is bottom trawling (Thrush and Dayton, 2002; Pusceddu *et al.*, 2005; Tillin *et al.*, 2006; de Juan *et al.*, 2007, Hixon *et al.*, 2007). Large nets, kept open and weighted down by heavy 'doors' and metal rollers, are dragged by a trawler across the sea bed. This virtually plows and levels the seafloor, picking up fish and shrimps but also catching, crushing and destroying other marine life.

The North Sea and Grand Banks have been major sites of bottom trawling, with some traditional and easily accessible areas being trawled multiple times per year. Indeed, landings data collated for round- and flatfish caught in the northern, central and southern North Sea from 1906 to 2000 as proxies for total otter and beam trawl effort, respectively, indicate that the southern and much of the central North Sea were fished intensively throughout the 20th century, whilst the northern North Sea was less exploited, especially in earlier decades. The fisheries efforts intensified markedly from the 1960s onwards. Biogeographical changes from the beginning to the end of the century occurred in 27 of 48 taxa. In 14 taxa, spatial presence was reduced by 50% or more, most notably in the southern and central North Sea; often these were long-lived, slow-growing species with vulnerable shells or tests. By contrast, 12 taxa doubled their spatial presence throughout the North Sea. Most biogeographical changes had happened by the 1980s. Given that other important environmental changes, including eutrophication and climate change, have gained importance mainly from the 1980s onwards, the study concluded that the changes in epibenthos observed since the beginning of the 20th century have resulted primarily from intensified fisheries (Callaway *et al.*, 2007). Whereas trawling in shallow coastal waters is often carried out by smaller vessels, deep-water and high sea bottom trawling requires large and powerful ships. Such fleets are mostly based in industrialised countries, but fish intensively and for months at a time across the World's oceans. Often these distant water fishing fleets are fuelled and kept afloat (literally) by subsidies and incentives, without which their operation would hardly be economically viable.



A decade ago, there was still much debate on the impacts on bottom trawling, as summarized in several reviews including those by the FAO. Today, there is a much larger growing body of empirical evidence, along with improved models, that document severe impact of trawling worldwide (Hiddink *et al.*, 2006a, b, c; Hiddink *et al.*, 2006; 2007; Callaway *et al.*, 2007; Davies *et al.*, 2007; Gray *et al.*, 2006; Tillin *et al.*, 2006). This includes, but is not limited to, China (Yu *et al.*, 2007); the North Atlantic region (Tillin *et al.*, 2006; Callaway *et al.*, 2007; Eastwood *et al.*, 2007; Kensington *et al.*, 2007; Liwuete *et al.*, 2007; Waller *et al.*, 2007); the Wadden Sea (Buhs and Reise, 1997; Lotze, 2005); the Mediterranean (Coll *et al.*, 2007); the Caribbean (Garcia *et al.*, 2007); the East and Western Pacific (Pitcher *et al.*, 2000; Hixon and Tissot, 2007; Fergusson *et al.*, 2008); and the South Atlantic (Keunecke *et al.*, 2007). Several of these studies have reported reductions in taxa and/or abundance in the range of 20–80% following years of intensive trawling (compared to pristine and/or historic data). This is especially so for demersals and benthic fauna, with reductions reported up to 80% on fishing grounds. The damage exceeds over half of the sea bed area of many fishing grounds, and is worst in inner and middle parts of the continental shelves, severly affecting in particular small-scale coastal fishing communites (Dcruz *et al.*, 1994; Liquete *et al.*, 2007). Unlike their shallow water counterparts, deep sea communities recover slowly, over decades. Indeed, the impact varies with type of trawl, habitat and frequency and intensity of trawling (Kaiser *et al.*, 2006; Quieros *et al.*, 2006). Trawling at the scales frequently observed today accounts for a major or even the most damaging practice in the fisheries industry. Studies have suggested that the impacts of trawling on the seabed equals or exceeds the impact of all other types of fishing combined (Eastwood *et al.*, 2007).

Bycatch is also a major problem associated with trawling (Kumar and Deepthi, 2006). For many coastal populations, large-scale, industrial bottom trawling of their tradional fishing grounds (often carried out unregulated illegally and unreported by distant fishing fleets) ruins local fisheries with devastating effects on local fishermen, industry and livelihoods. Many of the larger ships process the fish directly onboard in enormous quantities. Most likely over one-third of the World catch is simply discarded due to inappropriate fish sizes, or simply due to unintended bycatch, particularly as a result of bottom trawling (Kumar and Deepthi, 2006).

Bottom trawling physically impacts the seabed and thereby some of the most productive marine habitat. Moreover, the intensity of the fisheries is a critical factor as it may take place simultaneously with other pressures, including land-related or climate change threats. Over 65% of the World's seagrass communities have been lost by land reclamation, eutrophication, disease and unsustainable fishing practices (Lotze *et al.*, 2006), and nearly all cold-water coral reefs observed in the North East Atlantic show scars and impacts from bottom trawling.

It is important, however, to realize that many types of fishing gear other than trawling may be severely damaging as well. A major challenge is the fact that very modest levels of trawling may increase productivity of certain genera, and localized small-scale trawling practices will likely have limited impact. Much debate has taken place on fisheries and particularly bottom trawling, and many reviews have pointed to the effect that the practice sometimes may be sustainable in some regions. However, given the capacity of most of the world's fishing fleet, of growing pollution, climate change and coastal development, little doubt now remains that trawling practices in very many places are quite unsustainable (Callaway *et al.*, 2007; Davies *et al.*, 2007).

In the light of the impact which bottom trawling has on the marine fauna, ecosystems and biodiversity, more than 1,400 scientists and marine experts have signed a petition. International policy and decision makers started to address this issue in 2003/4, and the 58th session of the United Nations General Assembly considered proposals for a moratorium on bottom trawling and called for urgent consideration of ways to integrate and improve, on a scientific basis, the management of risks to the marine biodiversity of seamounts, cold water coral reefs and certain other underwater features.

However, without marine protected areas and appropriate enforcement, especially in the deeper waters and the high seas, these damaging practices are continuing. Without increased regulation, governance, enforcement and surveillance on the high seas and on the continental shelves in many regions, unsustainable and damaging fishing practices will continue. Currently, there is virtually no protection of the vulnerable marine ecosystems and biodiversity occurring on continental shelves. Indeed, in most regions, marine protected areas (MPAs) are non-existent, in others they only amount to less than 1% of the marine area. Targets have been set for setting up MPA networks and systems, however, it is apparent that under the current rate of establishment, the CBD's target and the WPC (World Park Congress) target will not be met (Wood *et al.* in press).

Several countries have started some restrictions on bottom trawling in their national waters, but bottom trawling in areas beyond national jurisdiction is mostly unregulated. A few regional fisheries management organisations, such as the North East Atlantic Fisheries Commission (NEAFC), have (temporarily) closed some high risk areas beyond national jurisdiction to bottom fishing in order to protect vulnerable ecosystems. However, these measures apply only to member states (i.e. not to foreign fishing fleets) and cannot be properly controlled and enforced, which seriously weakens their effectiveness. There are now discussions ongoing with several bodies including the FAO on developing better international guidelines for the management of deep-sea fisheries in the high seas, but urgent action is needed.

EXOTIC AND INVASIVE SPECIES INFESTATIONS – THE NEW PIRATES OF THE WORLD'S OCEANS

All across the planet, the number and severity of outbreaks and infestations of invasive species (i.e. species purposefully or accidentally introduced in non-native environments) is growing, and invasions of marine habitats are now occurring at an alarming rate (Ruiz *et al.* 1997). Exotic and invasive species have been identified by scientists and policymakers as a major threat to marine ecosystems, with dramatic effects on biodiversity, biological productivity, habitat structure and fisheries (Carlton 1999, Lotze *et al.* 2006). The combined number of invasive marine plant and invertebrates in Europe and North-America has increased from some 25 around 1900 to over 175 in 2000, and is still rising, particularly concurrent with the intensification of fishing and bottom trawling after 1950.

Although no habitat is immune to invasions (Lodge 1993), some habitats are more invaded than others. This can be explained in two, not mutually exclusive, conceptually different ways. The first is that the number of established exotic species is a direct function of the number introduced. Thereby, habitats that are more influenced by introduction vectors than others will harbour more exotic species (Williamson 1996). The second explanation is that some habitats are more readily invaded than others due to physical or biological factors that facilitate or prevent the success of exotic species (Elton 1958). One factor that may contribute to the success of exotic species is when the recipient ecosystem is heavily destabilized (Vermeij 1991) by human disturbance (e.g. pollution, overfishing etc.). In the Black Sea, overfishing and eutrophication triggered a trophic cascade leading to a massive bloom of the invasive comb jelly (*Mnemiopsis leidyi*) (Daskalov *et al.* 2007). In this study the depletion of marine predators was detected as the first 'regime shift'. There are several reports from around the world demonstrating a decline in the abundance of marine predators caused by intensive fishing (trawling etc.) (e.g. Stevens *et al.* 2000, Graham *et al.* 2001), probably resulting in habitats that are more susceptible to exotic species.

Most introductions of exotic and invasive species result from anthropogenic dispersal (Ruiz *et al.* 1997). The relative importance of different mechanisms of dispersal varies spatially and temporally, but the worldwide movement of ships seems to be the largest single introduction vector (ballast water and ship fouling) (Ruiz *et al.* 1997, Gollasch 2006). Indeed, the patterns of dispersal are strongly concurrent with major shipping routes, while the establishment globally appears to be strongly concurrent with intensity of fisheries, bottom trawling, pollution and other stressors. Hence, while some species may become invasive or exotic species may become infestations, it is clear that this pattern is so strongly concurrent with other man-made pressures to the oceans that their dispersal and establishment as pests appear to be caused by severe man-made disruptions of the marine ecosystems.

It may be true that exotic and invasive species have not caused extinction of native marine species (Briggs 2007), but there are examples of invasive species totally changing the relative abundance of species within a community (Daskalov *et al.* 2007). Thus, the invasions of exotic and invasive species to marine habitats becoming a subject of global environmental concern seem legitimate.

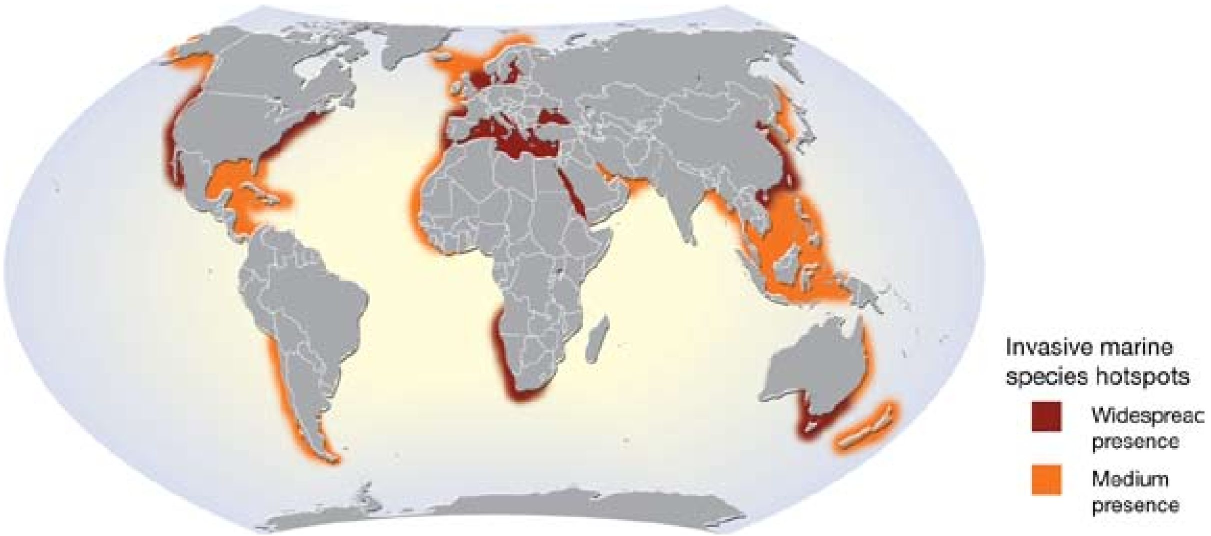


Figure 27. The locations of major problem areas for invasive species infestations or occurrence of exotic species in the marine environment. The impacted areas are concurrent with the areas subjected to the worst pollution, the most intensive fisheries and bottom trawling, and major shipping routes.

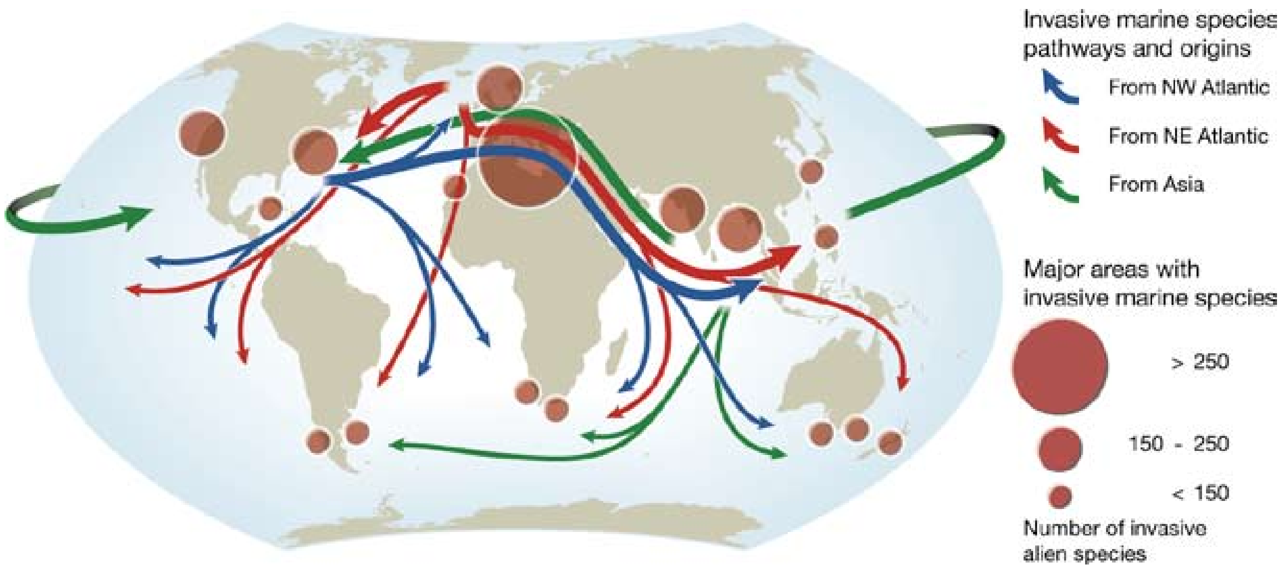
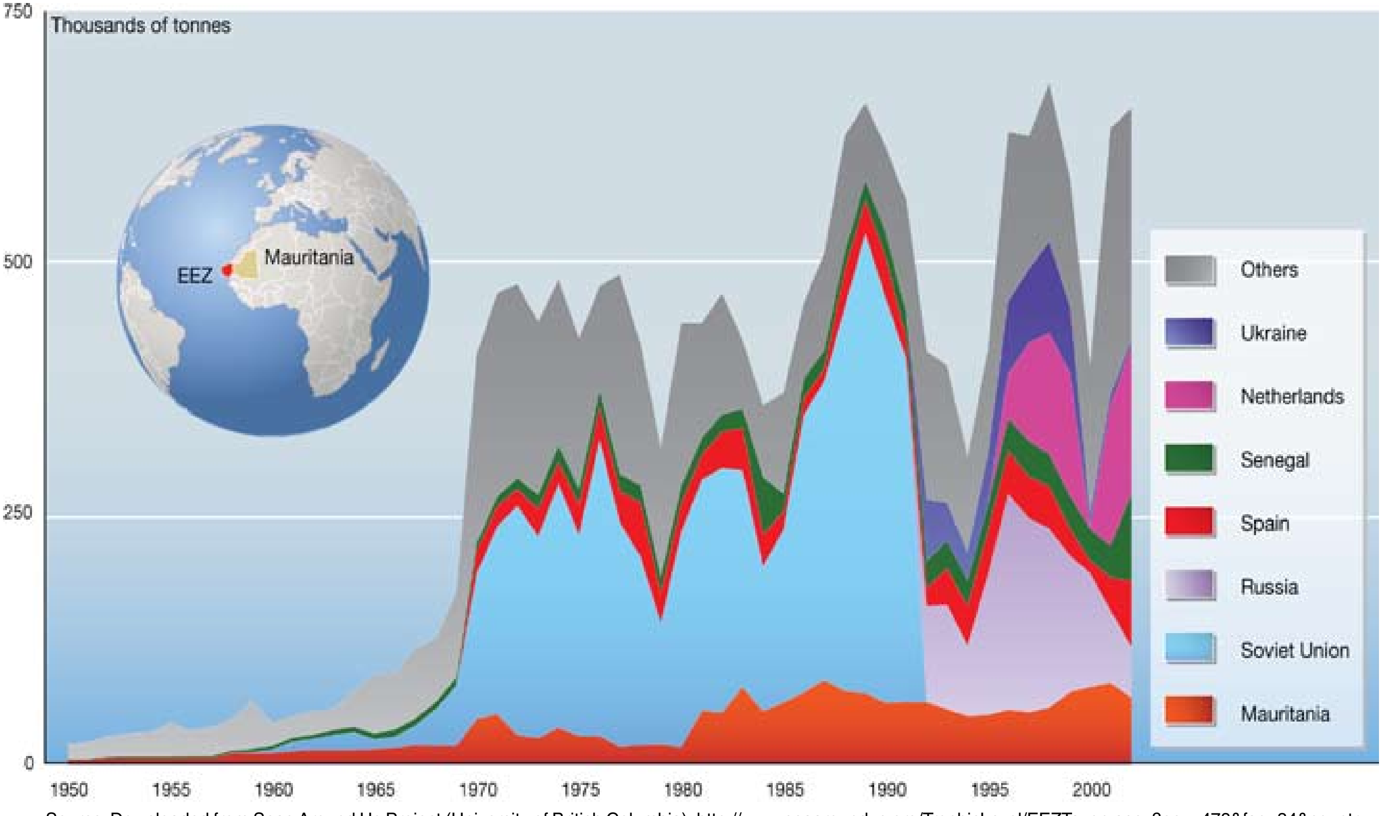


Figure 28. The major pathways and origins of invasive or exotic species infestations in the marine environment. These patterns are strikingly concurrent with major shipping routes.

THE PRESSURES AND FATE OF THE CONTINENTAL SHELVES IS BOTH A NATIONAL AND INTERNATIONAL RESPONSIBILITY

Marine fisheries represent a significant, but finite, natural resource for coastal countries. The majority of the catches in some offshore areas are not primarily by the coastal countries concerned. Most of the fisheries off the coast of Mauritania (Figure 29), for example, are by countries from Europe and Asia (Japan and South Korea are in the 'others' group). According to this esti-



Source: Downloaded from Seas Around Us Project (University of British Columbia), http://www.seaaroundus.org/TrophicLevel/EEZTaxon.aspx?eez=478&fao=34&country=Mauritania&Hasnote=1&typeOut=4&Tx=1 (Accessed January 2006).

Figure 29. Intensity of fisheries off the coast of Mauritania, West-Africa. While the country's often impoverished coastal population is strongly dependent on the fisheries, the largest share of the fishing is done by an international fishing fleet.

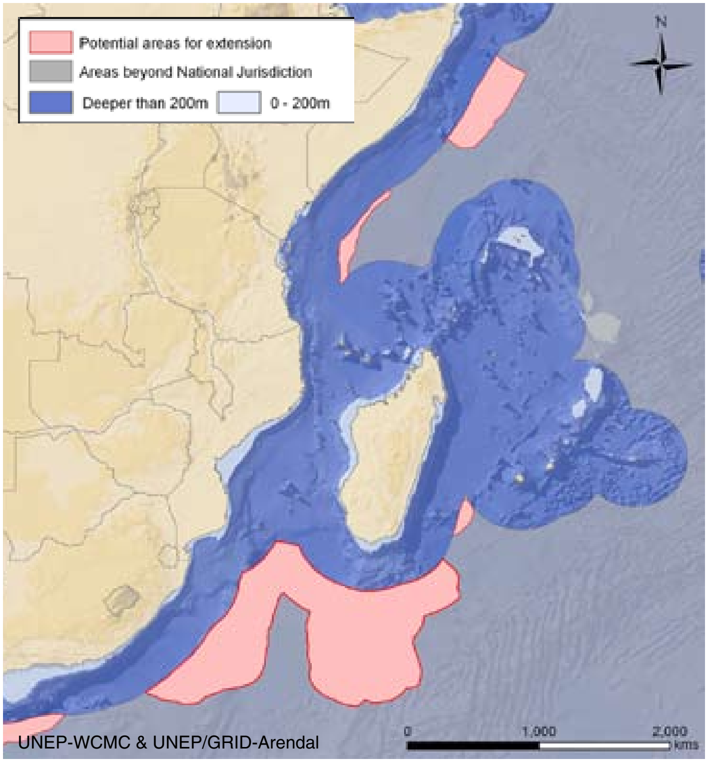


Figure 30. Deep waters within and beyond areas of national jurisdiction in East Africa. The figure demonstrates that the overwhelming majority of marine areas under national jurisdiction in East Africa are deeper than 200 metres (dark blue). Areas in red indicate where the geology/geomorphology might justify (subject to further research and interpretation) a submission/claim to be made by coastal states individually or jointly to increase their national seabed and subsoil areas, which, in turn, may be of major economic potential.

mation, Mauritania only landed about 10% of the total catch in 2002, with The Netherlands as the nation with the largest catch (23%) in this zone. For developing countries, the intensive fisheries by foreign countries and climate change may become severe for income, livelihoods and food security for coastal communities. Fishery products are becoming one of the most important rising exports from developing countries (FAO, 2006). The fishery net exports of developing countries (i.e. the total value of their exports less the total value of their imports) showed a continuing rising trend in recent decades, growing from US$4.6 billion in 1984 to US$16.0 billion in 1994 and to US$20.4 billion in 2004.

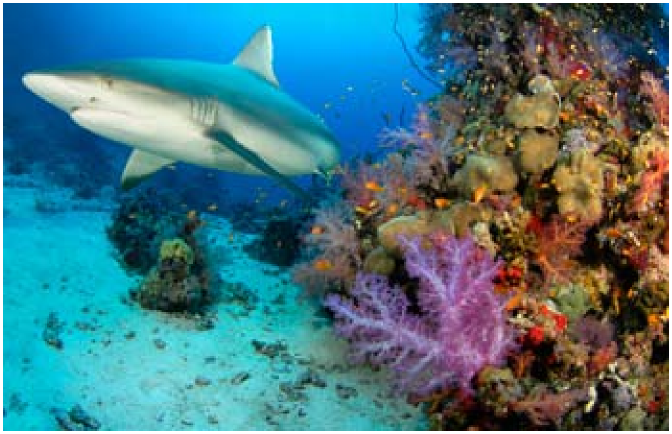
Waters below 200 metres depth cover around 336 million square kilometres world-wide, and can be found in areas within and beyond national jurisdiction. Overview analyses show that the total area of national waters deeper than 200 metres is around 124 million square kilometres, i.e. about five times larger than the total of national waters shallower than 200 metres (approximately 25 million square kilometres). In accordance with the provisions set out in Article 76 (Definition of the continental shelf) of UN Convention on the Law of the Sea, 1982 (UNCLOS), certain geologic and physigraphic conditions (more precisely sediment thickness and/or change in slope gradient) of the continental margin might give a coastal State the right to delineate the outer limits of its continental shelf beyond 200 nautical miles (i.e. the limit of the Exclusive Economic Zone). This applies only to the seabed and the subsoil of the legal continental shelf, not to the water column. The procedure to identify whether there is a scope for such a claim, and to compile and interpret the necessary data for a submission to the Commission on the Limits of the Continental Shelf set up under UNCLOS, is complex and time-limited, as submissions have to be made by the year 2009 for most countries, and support is given through the UNEP Shelf Programme.

THE CUMULATIVE IMPACTS

One of the main obstacles to assessing the state of the oceans and in planning for the conservation, protection and sustainable management/use of the marine environment is the slow responses of the seas to pressures. Many processes and changes in the oceans take place below the surface, silently, on large scales and over long time periods, i.e. they are not on the 'radar screen' of human perception. It can take more than 100 years for a deep-sea water molecule to come to the surface. The signal from the increased CO_2 released by anthropogenic activities in the last 50–100 years has so far penetrated to only around 3,000 meters water depth. An example of the time lag in response is the absorption of CO_2 in the oceans, with the signal of increased CO_2 concentrations. The oceans have a huge capacity to cope with impacts and change without apparent effect. However, once their resilience threshold has been overstepped, and effects are detected and becoming obvious, it is often too late to reverse the trend. Even if CO_2 emissions would stop today, it would take the oceans many decades to respond.

The combined effects of the 'Big Five' environmental threats provide a grim outlook to the sustainable future of the World's oceans, and the billions of people who depend on marine resources. Many marine areas and species may be exposed and impacted simultaneously by all or several stressors, often acting in synergy and thereby amplifying their effects and impacts (Harley and Rogers-Bennett, 2004). Climate change will provide numerous changes in oceans. It will affect physical parameters such as temperature, strength of currents and the chemistry of the oceans, which, in turn, will invariably impact fisheries (MacKenzie *et al.*, 2007). Climate change is increasingly likely to put substantial strain on the productivity of the World's oceans, along with pollution, over-harvesting and unchecked coastal development. Disease and infestations often follow in the wake of the other stressors.

However, of perhaps even greater concern, is the fact that in the light of the accelerating climate change, the natural resilience of the oceans, such as their capacity to act as natural buffers, is likely to diminish in future. Heavily harvested fish stocks and populations will be even further reduced by impacts on their vulnerable spawning grounds from other activities. As long as deep-water seamounts and the continental shelves remain nearly completely unprotected, their important roles as nursery grounds is threatened by the expansion of fishing and mineral resource exploitation (Thrush and Dayton, 2002; Pusceddu *et al.*, 2005; Tillin *et al.*, 2006; Hixon *et al.*, 2007). Projections show that the coral reefs of the World are likely to meet, in the worst case, biannual bleaching events within a few decades. Healthy reefs might be able to recover from these impacts, but reefs already stressed and degraded by other factors (e.g. coastal development and pollution, overfishing etc.) will most likely succumb. It is critical that the areas with projected high risk to coral bleaching become



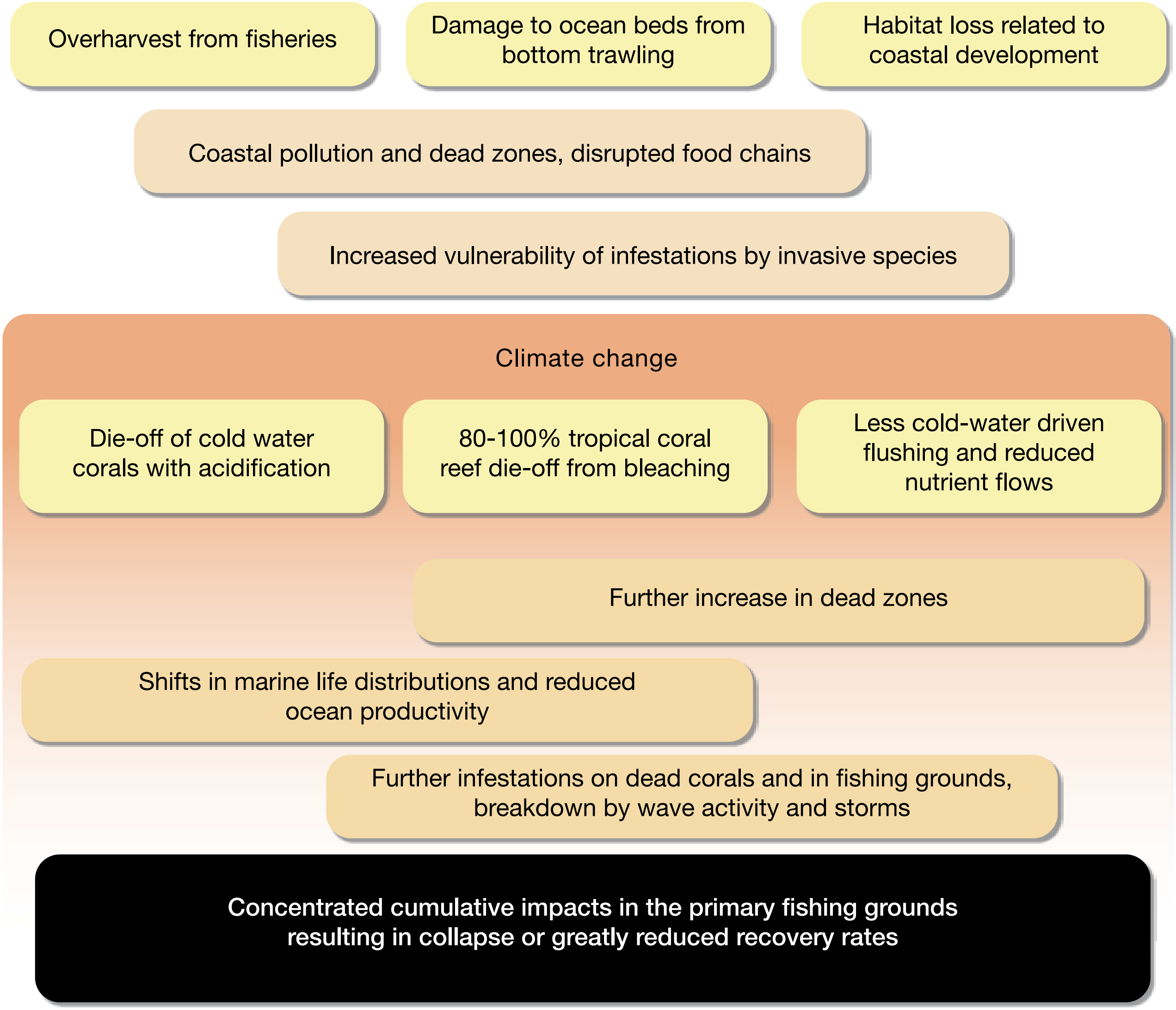


Figure 31. Climate change may, *inter alia* through effects on ocean currents, elevated sea temperatures, coral bleaching, shifts in marine life, ocean acidification, severely exacerbate the combined impacts of accelerating coastal development and pollution, dead zones, invasive species, bottom trawling and over-harvest. These impacts will be the strongest in 10–15% of the World's oceans, which harbour the most productive fishing grounds today, responsible for more than half of the marine landings globally.

priority zones for reductions in coastal pollutions to prevent a collapse of the reefs and the associated loss of their functions.

Similarly, it is also evident that the majority of the Worlds most damaging marine infestations have taken place in areas with large stresses and diminished resilience due to human activities (e.g. in heavily harvested fishing grounds with extensive trawling/dredging). Hence, building resilience and strengthening the natural buffers of marine (eco)systems has to become an essential element and consideration in the conservation, protection and sustainable management/use efforts at all levels, such as in the creation of system of marine protected areas spanning from coastal waters to the high seas.

Of critical concern is the current lack of policies and protected areas covering deeper waters on the continental shelves and the high seas, including seamounts (Davies *et al.*, 2007; Mossop, 2007). On average, around 70% of the waters under national jurisdiction (e.g. within the EEZs of coastal states) are deeper than 200 meters, rising to over 95% in some island states. However, few countries are aware of their deep-waters and the need to explore, protect and manage the important services and resources these areas provide.

Biodiversity hotspots form the basis of the Worlds fisheries, but have currently no basis in either marine protected areas or in specific management. It is absolutely crucial that the management of these hotspots becomes an international environmental priority with regard to identifying areas where multiple stressors are likely to leave these water as death zones, lost fisheries and lost recreational and tourist income regions. While there are projections of collapse in the World's fisheries alone as a result of over-harvest, it is far more likely that such collapse may arise even earlier as a result of the rapid growth of multiple stressors, including climate change, acting in combination. Unless these interlinked and synergistic processes are seen and addressed together, the environmental and socio-economic impacts, particularly for impoverished coastal populations, may become severe. Building resilience by giving climate impact hot-spots priority with regard to reducing other stressors should become focus for future environmental programmes.

The impacts of climate change on the marine environment are growing rapidly, and are likely to become much severe in coming decades. The lack of marine information and easy observation by man as a land-living organism has permitted these and other pressures to progress much farther than anything we have yet seen or would have permitted without intervention on land, in spite of the fact that the oceans are crucial for life on Earth and represent a significant share of global economies and basic food supply.

Unless other pressures are reduced in some of the primary fishing grounds, including bottom trawling and pollution, the impacts may become catastrophic, resulting in wide-spread death or strongly depleted fishing grounds, with severe impacts on countries, coastal economies, livelihoods and food supply. There are currently no international or widespread implemented national policies in place to ensure that such disaster is prevented. The urgency and relation to the continental shelves is critical, given the short time frame, severity and catastrophic nature of the already emerging impacts.

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