ISBN 978-92-64-04048-9
OECD Environmental Outlook to 2030

Chapter 15

Fisheries and Aquaculture

Without better fisheries management, overfishing and ecosystem damage is likely to lead to significantly reduced incomes or even the collapse of a number of fisheries in the coming decades. There will be severe consequences for local populations dependent on these resources for food and economic development. This chapter reviews the environmental pressures both from and on fisheries and aquaculture and projects the global trends in production and consumption. Looking to 2030, it will be important for governments to address gaps in the institutional and legislative framework for managing the environmental impacts of fisheries and aquaculture, and to strengthen implementation of the existing agreements. At the same time, environmental degradation driven by activities in other sectors is also affecting the economic viability of fisheries. Policies are needed to tackle pollution from land based sources and shipping, to reduce or halt the introduction of invasive alien species, and to help fishing communities adjust to the impacts of global climate change.

KEY MESSAGES

Overfishing remains a major challenge. An estimated 25% of world fish stocks are over-exploited or depleted, and 52% of stocks are producing catches near maximum sustainable limits. Marine and freshwater ecosystems also experience a range of other pressures from capture fishing if it is not conducted responsibly, including destruction of habitats and incidental kill of non-target species. Aquaculture increases pressure on species used for fishmeal and fish oil and can contribute to habitat destruction and pollution.

The economic sustainability of both capture fisheries and aquaculture is itself at risk from environmental pressures – including pollution from land-based sources and ships, the spread of invasive alien species and the impacts of global warming. Climate change is likely to affect the number and distribution of fish stocks, the acidity of marine waters, and the resilience of some aquatic ecosystems.

The rapid expansion of aquaculture is expected to continue to 2030, compensating for declining or stagnant wild fish harvests, but its environmental consequences deserve attention.

Policy options

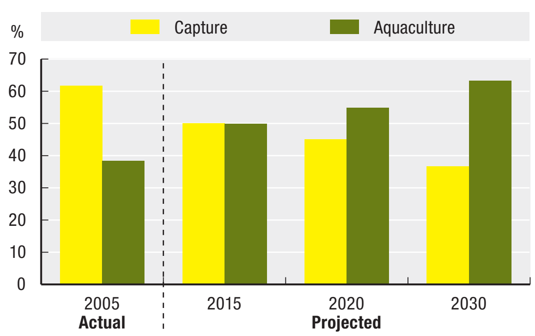
- Reduce the environmental impacts of capture fishing by limiting total catch levels, in particular through setting total allowable catch (TAC) levels and the use of market-based instruments such as individually transferable quotas (ITQs), fishing seasons and zones; regulating fishing methods and gear use; eliminating environmentally harmful subsidies; reducing fishing effort and existing over-capacity; improving the environmental performance of fishing vessels; and ensuring that consumer prices incorporate environmental costs of production. Set total allowable fish catch levels based on scientific advice.
- Reduce the environmental impacts of aquaculture by: developing national aquaculture plans; regulating the location and operation of aquaculture farms to minimise negative environmental impacts (*e.g.* release of nutrients or antibiotics, escape of organisms, destruction of habitat); and developing alternative feeds that reduce the reliance on capture fisheries.
- Increase the resilience of fisheries communities through strengthening policies and increasing enforcement of existing measures to address the impacts of environmental degradation on the fisheries sector, and to help fisheries activities adapt to climate change.
- Continue to pursue international co-operation to strengthen the management of straddling, highly migratory and high seas stocks. Use regional fisheries management organisations (RFMOs) to help co-ordinate management of regional fisheries. OECD countries have a role to play to ensure policy coherence for development and in helping developing countries to build capacity for sustainable fisheries management.
- Implement policies and surveillance systems to prevent illegal, unreported and unregulated fishing.

Consequences of inaction

- Without better fisheries management, overfishing and ecosystem damage are likely to lead to significantly reduced incomes or even the collapse of a number of fisheries in the coming decades, with severe consequences for local populations dependent on these resources for food and economic development.
- Pollution can decrease the value of fish products and can destabilise aquatic ecosystems that provide essential services for the fisheries sector. Consumers are increasingly concerned about the possible impacts on human health, for example from eating fish with high mercury levels.

Global fisheries and aquaculture production increased by 2.6% annually between 1988 and 2004, but limitations in supply are projected to slow this to an average of 2.1% annually between 2005 and 2030. The 2.1% total fisheries growth rate assumes robust growth in aquaculture, but no growth in capture fisheries. This implies an average growth rate in aquaculture of 3.9% annually to 2030.

Projected composition of world fisheries to 2030: capture and aquaculture



StatLink http://dx.doi.org/10.1787/261537433485

Introduction

Almost one-quarter of the world's capture fisheries are now classified as over-exploited, depleted or recovering (FAO, 2006). In addition to overfishing, fishing can also damage ecosystems through incidental catch of non-target species (by-catch), overfishing of young stocks, pollution and habitat destruction (*e.g.* through bottom-trawling).

Ecosystem change or damage can, in turn, affect the economic viability of fisheries. Some fisheries have faced economic collapse due to decimated fish stocks. Changes to marine ecosystems from climate change or pollution can upset ecosystems and lead to a decline or geographical shift in key fish stocks. The associated economic losses and disruption to fisheries dependent communities may be significant. The first section of this chapter outlines the inter-relationship between fishing and the environment. The second examines the recent trends and projections for the sector, and the third outlines the key policy options.

Environmental pressures from fisheries and aquaculture operations

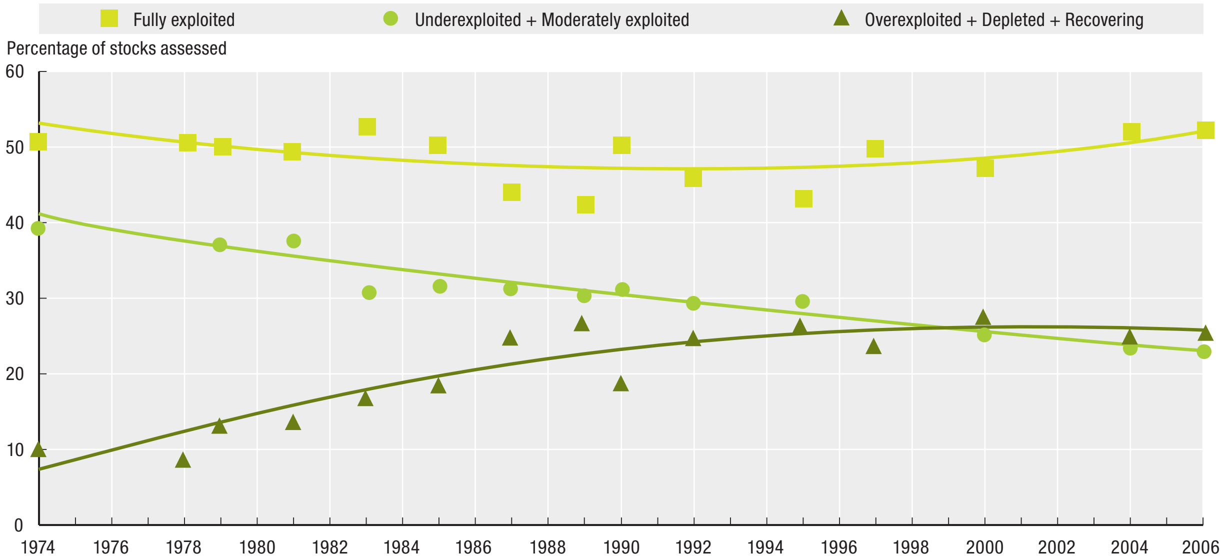
Overfishing has traditionally been seen as the major environmental pressure from fisheries activities. But the incidental catch of non-target species, physical damage to habitats caused by destructive fishing practices and construction of aquaculture installations also may have significant impacts on aquatic stocks and ecosystems. In short, how many fish are harvested and how fishing is carried out in a given fishery, in addition to the state of the marine environment, are important.

Overfishing and by-catch

While we lack sufficient information for many species, the overall status of marine fish stocks exploited by commercial capture fisheries is of concern. Since the FAO first started monitoring the global state of fish stocks in 1974, there has been a consistent downward trend in the proportions of under-exploited and moderately exploited stocks (FAO, 2006). About 25% of stocks are classified as over-exploited or depleted, 52% as fully exploited, and only about 23% of commercially exploited marine stocks are considered to have some potential for further development (Figure 15.1; FAO, 2006). Similar global data are not available for inland fish stocks, but regional data suggest that the majority are heavily over-fished.

Depletion of fish stocks can disrupt ecosystems by distorting food webs and changing population dynamics. In over-fished regions, as stocks with high commercial value become depleted the size composition of the entire community is likely to change. This increases fishing pressure on smaller fish of the exploited species, as well as on other species of lower commercial value. Over-exploitation of fish stocks can also have severe impacts on income and employment in fishing communities. For example, it has been estimated that the closure of Atlantic cod fishing in 1992 led to income losses in Canada of CAD 250 million in the short-term, and potential long-term losses of CAD 1 billion per year (OECD, 2008 forthcoming).

Figure 15.1. **Global trends in the state of world marine stocks, 1974-2006**



Source: FAO, 2006.

While in some cases heavily depleted stocks have recovered when fishing pressure was reduced, in others important fish stocks have failed to rebound even years after their fishing was reduced. When a species is functionally absent[1] from an ecosystem for an extended time, shifts in predator-prey interactions and in food web structures can lead to alternative states that effectively reduce the likelihood of re-establishment of the depleted species.

Capture fishing can also deplete populations of non-target organisms, including birds, sea mammals, crustaceans and finfish which are inadvertently killed by fishing nets or lines. Such "by-catch" is typically discarded overboard if the organisms have low commercial value, are below minimum size, or do not fit one of the boat's quotas. Trawlers targeting shrimp and flatfish are estimated to discard up to 50% of their catches (FAO, 2004b), although technical measures are available that could reduce these rates substantially. The FAO estimates that global discards declined from 27 million tonnes (Mt) in 1994, to 20 Mt in 1998, and to 7.3 Mt in 2004, although data on by-catch is limited. Such a downward trend in global discards can in part be explained by changes in estimation methods; however, the by-catch intensity of certain fisheries is believed to have diminished in recent years due to the wider use of selective fishing gear and "best practice" fishing techniques.

Habitat destruction and pollution

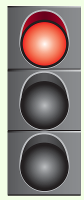
Fishing and aquaculture can also contribute to the physical degradation of aquatic habitats, sometimes so badly that the local fishing industry may be threatened. Some fishing gear and methods may damage various features of marine communities and habitats. Mobile bottom-contacting fishing gear (*e.g.* bottom trawls, dredges) can be so by-catch-intensive or damaging to ecosystem components such as sea beds that the damage can be irreversible. While for some communities infrequent disturbance (including trawling) may increase biodiversity, very frequent trawling of an area is correlated with a loss of biodiversity. As a result, some countries have restricted or prohibited the use of such gear as a complement to other management measures such as area or time closures.

Without the right policies, the development of aquaculture farms can contribute to the destruction of habitats in coastal and inland areas. In a number of marine areas, littoral or estuarine waters that are most commonly developed for aquaculture are also of high ecological importance, having a key role in development and/or recruitment of young organisms.

Discharges from fishing vessels and aquaculture units can contribute to pollution of marine and inland waters. Fishing vessels generate air and water pollution and waste products, and older fishing vessels generally lack modern pollution control equipment. Water pollution from aquaculture farms comes from uneaten food fish, excreta, chemicals and antibiotics used to control diseases.

The impact of environmental pressures on fisheries and aquaculture

The economic viability of fisheries and aquaculture depends on functioning aquatic ecosystems which deliver essential ecosystem services. Long-term climate change, *El Niño* events (Box 15.1) and other environmental changes threaten the sustainability of fisheries and aquaculture. In addition, pollution can degrade the health of aquatic ecosystems, and thus destabilise the resource base supporting fisheries. Contamination of fisheries products by pollutants lowers their economic value.



Climate change is likely to affect the number and distribution of fish stocks, the acidity of marine waters, and the resilience of some aquatic ecosystems.

Environmental perturbations

Anthropogenic climate change is expected to increase the mean temperature of sea surface waters and to cause the mean sea level to rise by 2100 (IPCC, 2007). Based on current model simulations, it is very likely that there will be a slowdown of the oceans' thermo-haline circulation by 2100, with severe consequences for fisheries and aquatic ecosystems. As ocean circulation drives larval transport, the recruitment patterns and population dynamics of marine organisms will be altered worldwide.

The pH of ocean surface waters is projected to fall by 0.14 to 0.35 pH units by 2100, due to the uptake of rising levels of atmospheric CO_2 (IPCC, 2007). The consequent acidification of surface waters will change the saturation horizons of aragonite, calcite and other minerals which are essential for calcifying organisms (Feely *et al.*, 2004). While many

Box 15.1. ***El Niño* Southern Oscillation**

The term "*El Niño*" refers to periods of strong and prolonged warm weather in the Eastern Pacific, accompanied by surface waters that are 0.5 to 3°C warmer than usual. Because changes in air pressure, called "the Southern Oscillation", typically accompany these periods, the whole phenomenon is referred to as the "*El Niño* Southern Oscillation" (ENSO). During an ENSO event, the upwelling of cold, nutrient-rich waters declines significantly, and primary productivity plunges in the eastern Pacific, resulting in a decrease in fish production. At the same time, the phenomenon disrupts weather patterns worldwide, leading to unusually high precipitation along the eastern coasts of the north and south Pacific. The frequency of occurrence of ENSOs is projected to increase with global warming.

aquatic organisms are adapted to thermal fluctuations, the expected changes in pH are higher than any pH changes inferred from the fossil record over the past 200 to 300 million years (Caldeira and Wickett, 2005).

The frequency and severity of a number of extreme weather events, such as tropical cyclones, are expected to increase as a result of global warming in the 21st century (see also Chapter 7). The consequent damage to equipment and infrastructure may compromise the productivity of fishing and aquaculture activities, as did the 2005 tsunami in the Indian Ocean which destroyed fishing boats, aquaculture installations and equipment. Developing countries suffer disproportionately from extreme weather events, as they often have weak response capacities.

Environmental pollution

Elevated levels of nutrients (eutrophication) contribute to algal blooms which cause hypoxic zones (areas deficient in oxygen, often referred to as "dead zones") in marine coastal areas and inland water bodies. The number and extent of such zones have increased since the 1970s, with some 200 persistent dead zones identified in 2006 (UNEP, 2006). Although estuaries and bays are most affected, eutrophication is also apparent in many semi-enclosed seas. For example, eutrophication affects almost all areas of the Baltic Sea, with the frequency and the spatial extent of toxic blooms both increasing since the mid-1990s, reducing the reproductive success of cod and other fish species (EEA, 2002).

Exposure to inorganic pollutants can compromise the breeding success, immunity and health of aquatic organisms. As they have the tendency to bioaccumulate in the body fat of fish, such pollutants can also pose health risks to humans eating them. Since the late 1990s, Baltic Sea countries have faced restricted market access for herring due to dioxin contamination. Inorganic pollutants are often found in fish products from near-shore areas, estuaries and rivers, as well as from regional seas that have relatively little exchange with the open ocean (*e.g.* Baltic, Mediterranean). Such contamination of fish products can lower their market value or block market access altogether (*e.g.* arsenic-contaminated mussels, mercury-contaminated fish). For example, after a 2004 study found that dioxin concentrations were higher in farmed salmon than in wild salmon, consumer concern led to a 25% drop in retail orders (FAO, 2004a).

It is estimated that about 80% of all marine pollution comes from land-based sources (UNEP, 2006). In most OECD countries, considerable progress has been made to reduce land-based discharges to the sea, particularly from municipal wastewater outfalls and industrial effluents (see Chapter 10). Diffuse pollution from agriculture and urban areas remains a big challenge, however, with nitrogen loading to some marine waters degrading ecosystems and damaging coastal fisheries. The Baseline for this *Outlook* projects a 4% increase in the global flux of nitrogen compounds from rivers to coastal marine systems to 2030, with the associated risk of coastal water eutrophication (see Chapter 10 on freshwater). The sources include increasing fertiliser run-off from agriculture and nutrient-loading from untreated urban wastewater. The most notable increases are expected from China and OECD countries, with more moderate increases projected for coastal zones around Africa due to lower fertiliser use in agriculture. Developing countries face a particular challenge in putting in place the necessary regulations and infrastructure to reduce land-based pollution of coastal zones and inland waterways.

The global shipping fleet[2] generates air and water pollution, including considerable operational and accidental discharges of oil. For example, European ships emitted an estimated 2.6 Mt of SO_2 and 3.6 Mt of NO_x to the air in 2000 (Richartz and Corcoran, 2004). Ships are also major sources of solid waste. An estimated 70 000 m^3 of litter enters the North Sea every year, 95% of it non-biodegradable plastics (Richartz and Corcoran, 2004). Exposure to tributyltin (TBT), an anti-fouling compound used worldwide on ship hulls, has been linked to reproductive anomalies in molluscs and other marine life.

Oil and gas production platforms, present on most continental shelves, also contribute to marine pollution levels through operational and accidental discharges of oil and chemicals. In the North Sea, operational discharges from the 475 offshore installations amount to 16 000 to 17 000 tonnes of oil per year (EEA, 2002). Elevated levels of hydrocarbons can be found in the sediment up to 8 km from offshore platforms, and levels of cadmium, mercury and copper are also high in some locations (Richartz and Corcoran, 2004). A number of the chemicals discharged in the "produced water" from platforms have been implicated as endocrine disruptors which reduce the breeding success of certain fish stocks.

Coastal development, aggregate extraction and dredging also destroy or damage key near-shore habitats for juvenile marine organisms.

Introduction of invasive alien species

Invasive species, spread worldwide by "hitch-hiking" in ship ballast waters or on hulls, have in some cases accelerated the collapse of fish stocks (*e.g.* the comb jellyfish and the Black Sea anchovy). Strengthened legislation and better implementation of existing provisions is needed to control the introduction of invasive aquatic species (see also Chapter 9 on biodiversity). Ballast water is essential for the safe and efficient operation of ships, by providing balance and stability, but its transfer worldwide can have serious ecological, economic and health implications.

The spread of invasive species and pathogens can also be facilitated by fisheries and aquaculture. Fishmeal and seed stock used in aquaculture farms are traded internationally, and can spread pathogens and parasites from one marine region to another. Organisms that escape from aquaculture farms often survive in the wild where they compete with native species for habitat and food, and may spread diseases and parasites (*e.g.* sea lice spread by escaped sea trout). In some cases, they can also interbreed with native species, leading to "genetic pollution".

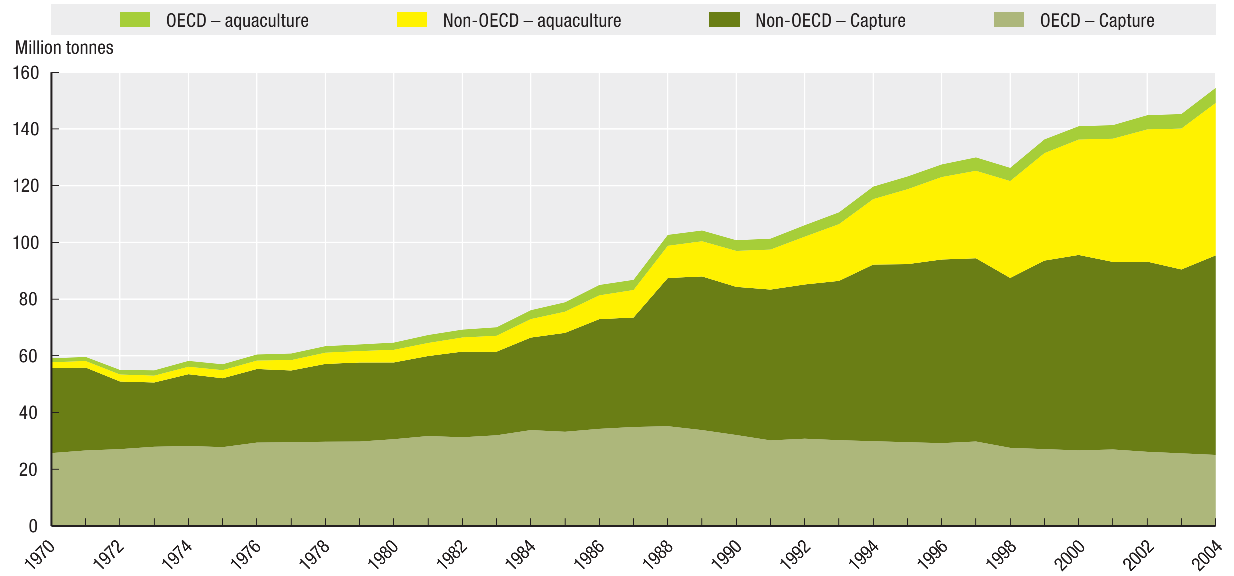
Key trends and projections

Global trends in production and consumption

Average consumption of fish per person has nearly doubled since 1960 worldwide, reaching 16.2 kg per year in 2002. Actual consumption varies widely among regions, with per capita demand highest in OECD countries and in China, and lower in Africa and South America. It is projected that per capita demand for fish will continue to rise by a further 18% to 2015, driven by economic growth and increased awareness of the benefits of consuming fish (FAO, 2004a). Improved access to international markets will further increase pressures on aquatic ecosystems, particularly in developing countries.

Global fisheries production, including both capture fisheries and aquaculture, has risen sharply during the past three decades, reaching 140.5 million tonnes in 2004 (Figure 15.2). Since 1988, total world fisheries production has grown by 2.6% annually.[3] Most of the increase in fisheries has come from new aquaculture development, primarily in non-OECD regions. A very large share of this has come from China.

Figure 15.2. **World fisheries production, 1970-2004**

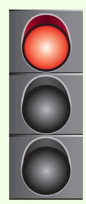


StatLink http://dx.doi.org/10.1787/261532376188

Source: Based on FAO, 2007.

Global capture fisheries production has levelled off at between 90 and 95 Mt since the late 1990s, with marine capture fisheries contributing about 85 Mt, and inland freshwater fisheries the remainder (in Figure 15.2 this is seen by combining OECD and non-OECD capture fisheries). This levelling off reflects the fact that an estimated 52% of the world's fisheries are now fished at their maximum limit, and 24% are overfished, depleted or recovering (FAO, 2006). OECD regions have been reducing their catches in recent years, by 40% between 1988 and 2004. Non-OECD regions increased their capture fisheries production by 35% over the same period.

During the 1970s and 1980s, the rate of growth of the total catch slowed to about 2% per year, before approaching zero in the 1990s, and declining slightly since 2002 (FAO, 2004a). OECD countries landed 27% of the world capture fisheries catch in 2002, with the United States (4.9 Mt), Japan (4.4 Mt) and Norway (2.7 Mt) among the world's top ten producing countries. China (16.6 Mt) and Peru (8.8 Mt) led the list, together landing 27% of world catch (Box 15.2).



Overfishing is likely to lead to economic collapse of some fisheries and disruption of marine ecosystems.

Inland fisheries

Global landings from inland capture fishing have reportedly been stable at about 8.6 Mt since 2000.[4] The bulk of this inland capture is landed in Asia (66% in 2002) and Africa (24%), with South America (4%), Europe (4%), North and Central America (2%) and Oceania (0.2%) having minor shares. China is the world's top producer, landing about 26% of global inland catch, while other developing countries together produce an additional 68%. In 2002, no OECD countries ranked among the top ten world producers of inland capture fisheries.

Box 15.2. **China: the world's largest producer and consumer of fish products**

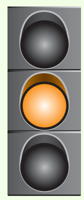
China is the world's largest producer of fish, and its per capita fish consumption (27.7 kg per annum) is about twice the world average. Its reported total fisheries production was 44.3 Mt in 2002, roughly one-third of global production.* Two-thirds of the output comes from aquaculture, a sector which is rapidly expanding. From 1970 to 2000, China's inland aquaculture production increased at an average annual rate of 11%, compared with 7% for the rest of the world. Similarly, the country's aquaculture production in marine areas increased at an average annual rate of 11%, compared with 6% for the rest of the world (FAO, 2004a).

China is home to about one-third of the world's fishers and aquaculture workers. In 2002, 8.4 million Chinese worked in capture fisheries, and 3.9 million in aquaculture. But looking to 2030, China's employment in the fisheries primary production sector is expected to decline, as fleet-size reduction programmes are implemented in response to overfishing. Indeed, such programmes implemented from 2000 to 2006 are projected to already shift 4% of Chinese capture fishers to other jobs by 2007 (FAO, 2004a). Policy tools used to accomplish these shifts included scrapping some fishing vessels and training redundant fishers in aquaculture.

* The FAO has issued caveats about the accuracy of statistics on China's capture fisheries and aquaculture production, suggesting that they are likely too high. Thus, these figures should be seen as indicative rather than authoritative.

Aquaculture

In 2004, global production from aquaculture totalled 59 Mt of fish, crustacean and mollusc products, and aquatic plant products,[5] and constituted 38% of global fisheries production by weight. According to FAO simulations, aquaculture will contribute about 43% of global fish production by 2020 (FAO, 2004b). Worldwide, aquaculture has grown at 8.9% per annum since 1970 (compared with 1.2% for capture fisheries and 2.8% for terrestrial farmed meat-production systems). Freshwater aquaculture systems are the main contributors to overall aquaculture output (58% by weight), followed by marine (36%) and brackish aquaculture systems (6%). Since 1990, the growth has been even faster. To a large extent, the rapid increases in aquaculture have been a response to the increasing demand for fish products combined with the biological limits reached in capture fisheries.



Aquaculture can help to alleviate pressures for fish production from capture fisheries, but its environmental impacts need to be addressed.

Developing countries produce about 90% of aquaculture food fish output, cultivating mainly freshwater species that are herbivorous, omnivorous, or filter feeding. China and India are the world's top two producers of aquaculture, with annual outputs of 27.8 Mt and 2.2 Mt respectively. Three OECD countries (Japan, Norway, United States) rank among the world's top ten aquaculture producers, but OECD countries altogether account for less than 10% of world aquaculture production by weight (20% by value) (OECD, 2004). However, OECD countries may be heavy investors in aquaculture development in developing countries (as well as developing country investors themselves).

In OECD countries, capture-based aquaculture (CBA) has expanded considerably, particularly for high-value fish such as bluefin tuna. CBA involves capturing young organisms, or "seed", from the wild and raising them in captivity to marketable size. For example, high-value species such as bluefin tuna are being caught as juveniles and then raised or fattened in offshore "sea pens". CBA already makes up 20% of food fish production from aquaculture by weight (FAO, 2004a).

The outlook to 2030

The Baseline developed for this *Outlook* determines growth in the demand for fisheries products through increases in population and economic productivity. The Baseline for the *OECD Environmental Outlook* is an analytical tool for projecting developments into the future assuming that no new policies will be introduced. It is thus not a forecast of what is most likely to happen. Under these conditions, and based on recent historical developments, the OECD Baseline does not project as strong a fall in production as forecast by the FAO.[6] The *Outlook* Baseline projects that the supply of fisheries products, particularly from aquaculture, increases as a result of price increases that provide strong incentives for the sector's expansion. The population and wealth increases to 2030 that underlie the Baseline would require much stronger increases in prices to suppress demand sufficiently to lower fisheries growth to the FAO's projected 1.6% (recall that global GDP growth in the Baseline is over 2.5% per year to 2030, and no new policies are assumed in the Baseline that would affect fisheries demand).

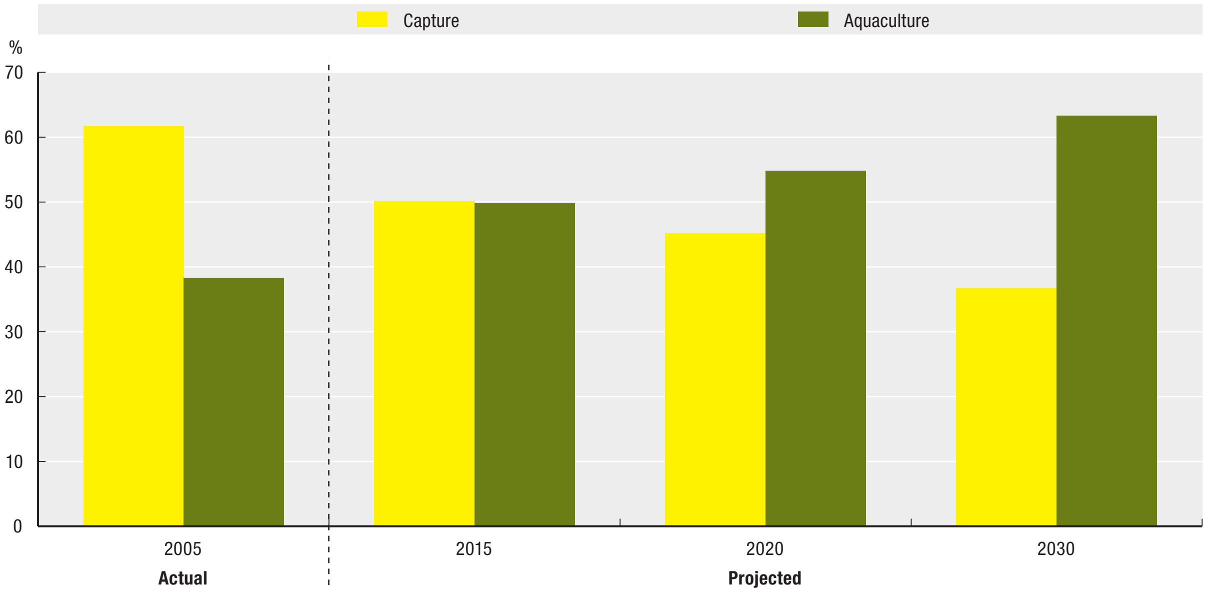
Assumed limitations in the supply from capture fisheries lead to a combination of aquaculture output increases and price increases – the price increases implicitly help overcome barriers to the continued expansion of aquaculture. Global fisheries production increased by 2.6% annually between 1988 and 2004, but limitations in supply are projected to slow to an average of 2.1% annually between 2005 and 2030 – a combination of higher growth in the initial years, followed by lower growth in the later years.

Since 2000, catches have decreased or stagnated in marine areas adjacent to most OECD countries, as the majority of fish stocks in their Exclusive Economic Zones (EEZs – see below) are already being exploited fully or beyond maximum sustainable levels. Catches have only been increasing in the tropical Pacific and Indian Oceans, and in high seas areas. Even these areas, however, are not expected to be able to significantly increase output further. Future growth is thus assumed to come from aquaculture. In the *Outlook* projection, therefore, the 2.1% total fisheries growth rate assumes robust growth in aquaculture, but no growth in capture fisheries. This implies an average growth rate in aquaculture of 3.9% annually to 2030 (compared to 8.1% annual growth between 1992 and 2005). This is induced endogenously in the Baseline by a roughly 67% increase in the real price of fish by 2030 (relative to 2001). To understand how strongly this motivates aquaculture development, it is worth pointing out that the real price of almost all fish consumed fell sharply between 1970 and 2000 (Sumaila *et al.*, 2005). Figure 15.3 illustrates the projected evolution of relative shares of capture fisheries and aquaculture production to 2030. Capture fisheries remain roughly constant in landed quantity, but decline as a share of total fisheries production.

Of course, aquaculture is in part dependent on capture fisheries for fishmeal feed. Recent expansion of aquaculture has augmented demand for fishmeal, with 2 to 12 kg of fishmeal feed required to produce one kg of farmed fish or prawns, depending on the species. However, as the price of fish products increases, it is projected that substitutes for

 OECD ENVIRONMENTAL OUTLOOK TO 2030 – ISBN 978-92-64-04048-9 – © OECD 2008

Figure 15.3. **Projected composition of world fisheries to 2030: capture and aquaculture**



StatLink http://dx.doi.org/10.1787/261537433485

Source: *OECD Environmental Outlook* Baseline.

fish feed for aquaculture, such as soya-based feed, will become more economically viable for those species that can be fed a vegetarian diet. Thus, the FAO projects that the portion of fisheries output used to make fishmeal and oil will decline from 35 million tonnes in 2000 to about 26 million tonnes in 2030 (FAO, 2004a). Other factors influencing demand for fishmeal and oil include trends in the broiler chicken and pork industries, and changes in the price ratio between fishmeal and its close substitutes.

Policy implications

Looking to 2030, it will be important for governments to address gaps in the institutional and legislative framework for managing the environmental impacts of fisheries and aquaculture, and to strengthen implementation of the existing agreements.

At the same time, environmental degradation driven by activities in other sectors is also affecting the economic viability of fisheries. Policies are needed to tackle pollution from land-based sources and shipping, to reduce or halt the introduction of invasive alien species, and to help fishing communities adjust to the impacts of global climate change. The consequences and costs to the fisheries sector of environmental policy inaction in these other sectors should be made explicit in policy decisions (Box 15.3).

Greater understanding is also needed of the potential impacts of climate change and other weather phenomena (*e.g. El Niño*) on fisheries and aquaculture activities. Developing countries may need help to develop appropriate measures to adapt to climate change, and more broadly to support sustainable fisheries management.

International governance

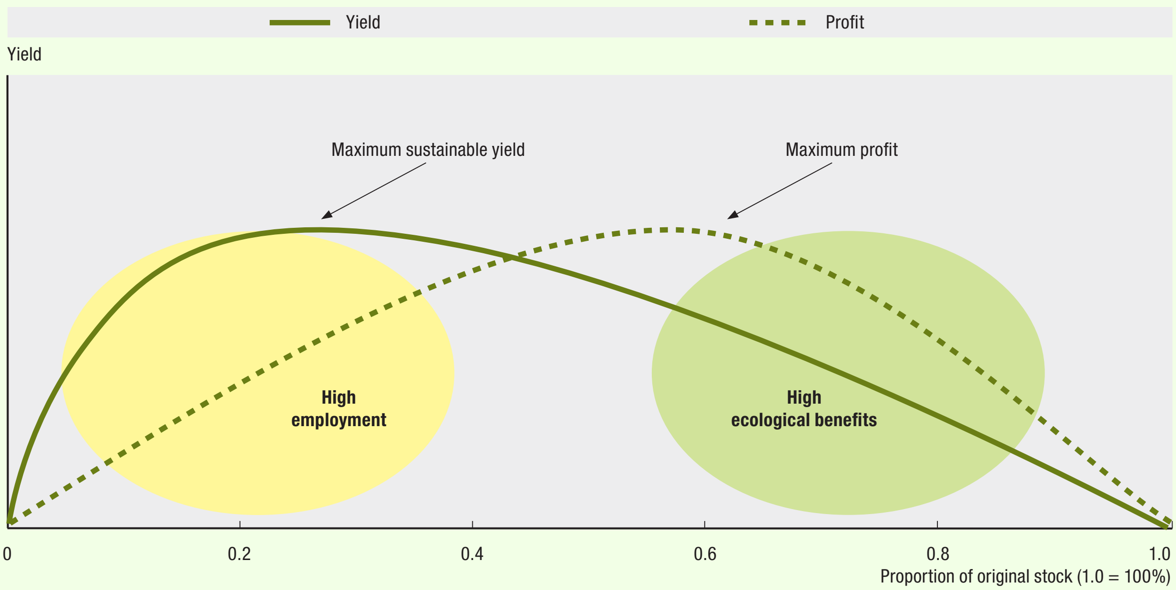
Global governance of fisheries is managed through international bodies such as the UN, the FAO's Committee on Fisheries, and regional fishery management organisations (see below) through which countries agree legally-binding instruments and frameworks for

Box 15.3. **The evolving nature of fisheries management objectives**

Attention has recently been drawn to management objectives in fisheries, especially the need to balance the different objectives of maximising profits, maintaining or increasing employment, ensuring sustainable fish harvests over time, and maintaining a given level of ecosystem integrity. A number of governments have adopted an ecosystem-based approach to fisheries management, recognising the intrinsic link between a sound ecological system and sustainable fisheries over the long-term, although implementing such an approach is often challenging.

Hilborn (2007), and Hilborn *et al.* (2006) illustrate how different fisheries management objectives will engender different levels of fishing activity. Figure 15.4 illustrates a simplified hypothetical fishery similar to many of the world's actual fisheries. The solid line represents yields at various levels of the original stock. In this example, the maximum sustainable yield occurs when the remaining stock is at roughly 20-30% of the original stock. This line roughly corresponds to employment in the fisheries sector – that is, maximum employment generally occurs at the point that maximum yield is attained. Hilborn argues that a number of the world's fisheries have been managed to maximise yields or employment, so the stock of fish has been brought down to these "low" levels. This is borne out by the FAO's reporting that 52% of species are near their maximum yield, while another 25% are either over-exploited, depleted or recovering. The dashed line in the figure represents total economic profits from fisheries. It shows that to maximise profits from fishing, the harvesting of fish should be reduced below the maximum sustainable yield (thereby inducing a higher price for fish caught with less effort). Overfishing leads to economic losses.

Figure 15.4. **Alternative fisheries management profiles**



Managing with a biodiversity or ecological perspective would entail a level of fishing that is closer to the profit maximising level, rather than the yield maximising level. A substantial reduction in current fishing levels for many fisheries could allow good management from a biodiversity perspective, as well as maximise profits for the industry. Box 15.4 contains a policy simulation of such an approach.

Box 15.4. **Policy simulation: economic effects of limiting global fisheries catch**

Figure 15.4 above illustrated that managing for maximum profit implied a lower catch level than managing for maximum sustainable yield (MSY). Managing for a high level of biodiversity or ecosystem benefits from fisheries would imply a catch that is closer to, though still lower than, managing for maximum profit. But in unmanaged fisheries, the move first to MSY, then to maximum profit, and finally to high ecosystem benefits is a significant challenge that must work against the "global commons" problem of open access fisheries. Indeed, just to get fisheries to MSY, governments need to implement management schemes and impose catch restrictions to overcome easy access to the harvest areas. Within a managed fishery, movement to the high ecological-value region of Figure 15.4 still requires substantial government commitment to act for the benefit of non-fishers and the environment. This may potentially lead to reduced income to the fishing community in the short-term as catch levels are reduced, although it may lead to a more sustainable economic basis for the fishing industry over the longer-term.

A policy simulation was undertaken using the ENV-Linkages model to examine the impacts of reducing fish catch, as an illustrative example of a policy aiming to manage fisheries in a way that might maximise fisheries profit or even ecological values. The simulation modelled an idealised implementation of internationally tradable quotas, set to bring about a 25% reduction in global fish catch.[1] To actually implement such a reduction, agreement would have to be reached that reduced global fisheries by the right mix (because not all species are at the same point in Figure 15.4). Safeguards of minimum stock levels of specific species would likely have to be put in place to ensure that valuable species were not over-fished. Such safeguards would also have to account for illegal, unregulated, and unreported fishing.

Quotas were applied in the ENV-Linkages model that limited capture fishing to 75% of 2005 levels. The analysis assumed that countries would individually manage fisheries, within their overall quota, so that no individual species was aggressively over-fished. The simulation examined the economic impacts of applying internationally tradable quotas within six geographical areas: trading was permitted *within* those regions, but not *between* those regions. The simulation illustrates – in aggregate – the economic impact of reduced capture fishing and its geographical distribution. Given the projections in the *OECD Environmental Outlook* Baseline for the growth of aquaculture and limited capacity for additional capture fishing (as discussed above), it was found that the 25% reduction in capture fishing would, under this simulation, lead to only a 14% reduction in total fisheries catch[2] (capture plus aquaculture) in 2010 compared with the Baseline. This would fall to a 11% reduction in the value of fisheries catch by 2020 compared to the Baseline, and 9% by 2030.

The policy simulation showed considerable trade in quotas, and thus heterogeneity across countries within a given trading region in terms of the impacts on the fisheries sector. The simulation also showed that these impacts would be expected to evolve over time. Since such trade is always indicative of economic gains relative to the initial allocation of quota, the implication is that any non-quota based international scheme to tackle overfishing would need to have considerable flexibility (mimicking the flexibility inherent in a tradable quota scheme). This flexibility needs to be implemented within a strong framework for co-operative decision-making.

1. There is no clear agreement on how much overfishing is occurring at a globally aggregated level, and thus what level of fish catch reduction would be appropriate to achieve a high ecological outcome. Based on FAO (2004a) estimates that 24% of fisheries are currently over-fished, depleted or recovering, the policy simulation for this *Outlook* was run with a 25% reduction in fish catch as a purely illustrative example of the economic effects such a reduction in catch might have.
2. That is, in terms of the constant-dollar *value* of fish – which approximates fishing tonnage if the composition of fish caught does not change substantially.

managing common fish stocks. The UN's *Convention on the Law of the Sea* (1982) codified the practice of state jurisdiction over marine fisheries resources within 200 nautical miles of their coastlines, referred to as Exclusive Economic Zones (EEZs). It is estimated that EEZs cover about 90% of the world's marine capture fisheries. The creation of EEZs aimed to assign national ownership and management responsibility for fisheries within these zones. International governance remains important for setting the right international legal frameworks for fisheries management, and not least for addressing the management of high seas fisheries (outside the EEZs) and straddling fisheries.

At the 2002 World Summit on Sustainable Development in Johannesburg, governments jointly declared the objectives of restoring global fish stocks to sustainable levels by 2015 and of significantly reducing the rate of biodiversity loss by 2010. In 2006, the UN General Assembly adopted a Sustainable Fisheries Resolution, calling on all nations to apply an ecosystem-based approach to the management of fish stocks, and to protect vulnerable marine ecosystems from destructive fishing practices. A number of specific international fisheries arrangements adopted since the 1992 Earth Summit have helped to strengthen international approaches to fisheries management and global oceans governance, such as the 1995 UN Fish Stocks Agreement, the 1993 FAO Compliance Agreement, the 1995 FAO Code of Conduct for Responsible Fisheries, and the "London Convention" and the UNEP Global Programme of Action for the Protection of the Marine Environment from Land Based Activities. In 2007/2008, the FAO Committee on Fisheries will work to develop an international legally-binding instrument on minimum standards on port state measures, which will be an additional tool in the suite of international fisheries governance measures.

The role of regional fishery management organisations (RFMOs) in managing wild stocks of marine fish has developed considerably in recent years. Whereas in the 1980s the mandates of many RFMOs were limited to research and advisory functions, since the Earth Summit many of these mandates have strengthened and expanded in order to implement modern approaches to fisheries management, including an ecosystem approach, and greater co-operation with developing countries. However, the success of RFMOs largely depends on the ability of their member states to agree co-ordinated approaches to fisheries management, and to delegate sufficient monitoring and enforcement powers to RFMOs to implement their mandates. Non-members can undermine RFMO conservation and management measures. Lack of political will and capacity to implement internationally or regionally agreed fisheries management policies remains a challenge. Efforts are needed to build capacity in developing countries to manage fishery resources in a sustainable manner.

Economic instruments

There is an increasing recognition that market-based instruments can improve the efficiency of fisheries resource allocation and use, and help to align fishers' economic incentives with societal objectives (OECD, 2006a). They do this by limiting fishing pressure (*e.g.* through tradable quotas, access charges), providing fishers with incentives to reduce fishing effort (*e.g.* through vessel buyback schemes), or encouraging compliance with regulations (*e.g.* fees and fines). Limiting access to wild stocks through the allocation of catch permits is a widely used approach to reducing fishing pressure. Some of these measures have proven more effective than others. For example, vessel and license buy-back schemes have often proven ineffective at reducing capacity unless they are accompanied by changes in fisheries management regimes that effectively limit the amount of fishing effort in a fishery (OECD, 2006b).

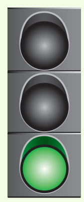
OECD ENVIRONMENTAL OUTLOOK TO 2030 – ISBN 978-92-64-04048-9 – © OECD 2008

Historically, some subsidies for shipbuilding and fleet enhancement have contributed to excess fishing capacity. Government financial transfers to the fishery sector in OECD countries amounted to USD 6.4 billion in 2003, or about 21% of the landed value of the catch (OECD, 2006b). Increasingly, government support to fisheries is shifting towards more sustainable fisheries management, rather than increasing fisheries production. Thus, for OECD countries, 38% of government financial transfers now supports research, management and enforcement; 35% goes to infrastructure and the remainder to cost-reducing or income-enhancing measures. Negotiations are underway in the World Trade Organisation (WTO) to clarify disciplines on fisheries subsidies.

Regulatory approaches

Regulatory approaches are being used, for example, to limit fishing effort and gear types, and to optimise the location and operation of aquaculture farms (*e.g.* total catch limits; spatial planning and zoning; and effluent discharge permits). Sensitive habitats or important breeding or feeding grounds for at-risk species could be set aside as conservation areas. Marine Protected Areas declared for fisheries purposes (such as areas closed to specific gear types, or set up to protect key habitats) can also support biodiversity conservation goals, as well as improve the productivity of capture fisheries (Ward and Hegerl, 2003).

Regulatory standards for fishing gear can also be effective means of reducing impacts on habitats and non-target species (*e.g.* requiring turtle excluder devices, seabird-scaring streamers or acoustic deterrent devices for sea mammals and seabirds). But adoption of these "gear fixes" in the global fisheries has been slow, and where regulations for their use do exist, monitoring and enforcement may be poor. Many of these measures are required in southern ocean fisheries, but are not yet mandatory in northern hemisphere fisheries, even though they also have a high bird by-catch intensity (*e.g.* off the coast of Scotland).



Wider use of remote sensing and GPS technologies can help surveillance and monitoring of illegal fishing activities.

Illegal, unregulated, and unreported (IUU) fishing contributes to overfishing by making it more difficult to ensure that fishing limits are respected and by making it harder to develop the robust stock assessments necessary for biologically sound management decisions. IUU fishing has been increasing in recent years, driven by the rising value of certain scarce species and facilitated by new technological developments. IUU fishing is difficult to control due to the open access nature of most open seas fish stocks outside of EEZs and areas controlled by regional fisheries management organisations (RFMOs), and due to the expense and technical challenge of monitoring vast marine zones. The recent introduction of trade and catch certification schemes, coupled with rapidly evolving information technologies, is helping in a number of regions. However, a number of challenges remain for tackling IUU fishing, including ensuring adequate capacity for monitoring and enforcement, and addressing the use of flags of convenience.

Reducing fishing effort, including through the use of catch limits and fishing capacity, is an important regulatory measure to rebuild stocks of depleted species. Other measures include policies aimed at reducing by-catch; reducing or eliminating environmental degradation; and enhancing factors of growth, for example through stock enhancement and habitat rehabilitation. Species that are particularly vulnerable to fishing pressure, such as those that are long-lived and only start breeding after a relatively long period of immaturity,[7] may especially require long-term management recovery plans.

Regulation of aquaculture has progressed considerably since the 1990s, with most OECD countries now requiring operators to acquire permits or licenses to establish a farm. Environmental impact assessments are generally required for new facilities, and licenses typically specify some operating conditions designed to limit environmental impacts.

Information-based approaches

Voluntary and trade-related approaches are used to encourage the spread of best practices among fishers and fish farmers (*e.g.* codes of practice, eco-labels, and catch certificates). As major consumers and importers of fish products, OECD countries have an interest to promote measures that will ensure the long-term sustainability of capture fisheries in developing countries. The link between pollution and food safety in fish production, including pollution sources from outside the sector, will receive more attention worldwide in the future. Trade related measures can be used to raise the accountability of producer countries (*e.g.* catch certificates, trade certificates).

Eco-labelling of fisheries products began only in the late 1990s. The Marine Stewardship Council (MSC) eco-label is perhaps one of the earliest and best known voluntary schemes, and is used to indicate products sourced from sustainable fisheries, defined as those that "ensure that the catch of marine resources are at levels compatible with long-term sustainable yield, while maintaining the marine environment's biodiversity, productivity and ecological processes". More recently a plethora of different eco-labelling schemes for fish products has emerged, including ones that indicate the origin of fish products, the sustainability of their harvest, whether aquaculture products were produced organically, etc. However, the number of competing schemes, the range of issues that they address and the lack of rigour or clarity about the independent monitoring of some of them have led to some consumer confusion and distrust of eco-labelling. The FAO is working to establish an international set of guidelines for eco-labelling to support more rigorous and reliable eco-labels in fisheries and aquaculture, while the European Commission is looking to develop guidance on eco-labels for use in European Union countries.

Notes

1. A species can be considered to be functionally absent from an ecosystem if the number of individuals is so low that it cannot fill its usual niche in the ecosystem.
2. The global shipping fleet includes some 60 000 vessels with tonnage over 250 gross registered tonnes.
3. The large increase in capture fish production seen in 1988 in Figure 15.2 represents the year when information became available on Russian and Eastern European catches.
4. The FAO warns that global inland catch data are only indicative due to gaps in reporting on catch quantities and species composition.
5. This figure includes aquatic plant production of roughly 13 Mt. Unless otherwise noted, most figures below do not include aquatic plants.
6. The FAO projects an increase in total fisheries production of 43 Mt from 2000 to 2015, the bulk (73%) of it coming from aquaculture. Even so, the FAO expects average annual growth in world fish production to trail off, going from the 2.7% seen in the 1990s to 2.1% per year from 2000 to 2010, before dipping to 1.6% per year from 2010 to 2015 (FAO, 2004b).
7. Sharks, rays and skates, and many species of fish in deep water fall into this category.

OECD ENVIRONMENTAL OUTLOOK TO 2030 – ISBN 978-92-64-04048-9 – © OECD 2008

References

Caldeira, K. and M. Wickett (2005), "Ocean Model Predictions of Chemistry Changes from Carbon Dioxide Emissions to the Atmosphere and Ocean", *Journal of Geophysical Research*, Vol. 110, C09204.

EEA (European Environment Agency) (2002), *Europe's Biodiversity Bio-Geographical Regions and Seas: Seas Around Europe*, EEA, Copenhagen.

FAO (UN Food and Agriculture Organization) (2004a), *The State of World Fisheries and Aquaculture: 2004*, FAO, Rome.

FAO (2004b), *Future Prospects for Fish and Fishery Products: Medium-Term Projections to the Year 2010 and 2015,* FAO Fisheries Circular FIDI/972-1, FAO, Rome.

FAO (2006), *The State of World Fisheries and Aquaculture: 2006*, FAO, Rome.

FAO (2007), *Fishery Statistics Programme*, Fisheries and Aquaculture Department, FAO, Rome (*www.fao.org/fi*).

Feely, R. *et al.* (2004), "Impact of Anthropogenic CO_2 on the $CaCO_3$ System in the Oceans", *Science*, 305: 362-366.

Hilborn, R. (2007), "Defining Success in Fisheries and Conflicts in Objectives", *Marine Policy*, Vol. 31, pp. 153-158.

Hilborn, R., J. Annala, and D.S. Holland (2006), "The Cost of Overfishing and Management Strategies for New Fisheries on Slow-Growing Fish: Orange Roughy (*Hoplostethus atlanticus*) in New Zealand", *Canadian Journal of Fisheries and Aquatic Sciences*, Vol. 63, pp. 2149-2153.

IPCC (Intergovernmental Panel on Climate Change) (2007), *Fourth Assessment Report, Working Group 1: The Physical Science Basis, Summary for Policymakers,* IPCC, Geneva.

OECD (2004), *Review of Fisheries in OECD Countries: General Survey 2004*, OECD, Paris.

OECD (2006a), *Using Market Mechanisms to Manage Fisheries: Smoothing the Path*, OECD, Paris.

OECD (2006b), *Financial Support to Fisheries: Implications for Sustainable Development*, OECD, Paris.

OECD (2008), *Costs of Inaction: Draft Technical Report* [ENV/EPOC(2007)6/REV2], OECD, Paris, forthcoming.

Richartz, S. and E. Corcoran (2004), *The State of Europe's Regional Seas – Are we Meeting Conservation Targets?* A briefing paper written in preparation for the conference "*Sustainable EU Fisheries: Facing the Environmental Challenges*", European Commission (DG Fish), the Esmée Fairbairn Foundation, FISH and English Nature.

Sumaila, U.R. *et al.* (2005), *Global Ex-Vessel Fish Price Database: Contruction, Spatial and Temporal Applications*, University of British Columbia Fisheries Centre Working Paper Series No. 2005-01, Vancouver, BC.

UNEP (United Nations Environment Programme) (2006), *The State of the Marine Environment: Trends and Processes*, United Nations Environment Programme, Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities, The Hague.

Ward, T. and E. Hegerl (2003), *Marine Protected Areas in Ecosystem-Based Management of Fisheries*, Natural Heritage Trust, Canberra.

ISBN 978-92-64-04048-9
OECD Environmental Outlook to 2030

Introduction: Context and Methodology

Purpose of the report

The purpose of the *OECD Environmental Outlook* is to help government policy-makers to identify the key environmental challenges they face, and to understand the economic and environmental implications of the policies that could be used to address those challenges.

The *Outlook* provides a baseline projection of environmental change to 2030 (referred to as "the Baseline"), based on projected developments in the underlying economic and social factors that drive these changes. The projections are based on a robust general equilibrium economic modelling framework, linked to a comprehensive environmental modelling framework (see below, and Annex B, for more details). Simulations were also run of specific policies and policy packages that could be used to address the main environmental challenges identified, and their economic costs and environmental benefits compared with the Baseline.

This is the second *Environmental Outlook* produced by the OECD. The first *OECD Environmental Outlook* was released in 2001, and provided the analytical basis on which ministers adopted an *OECD Environmental Strategy for the First Decade of the 21st Century*. This second *Outlook:*

- extends the projected baseline used in the first *Outlook* from 2020 to 2030, and even 2050 for some important areas;
- is based on a stronger and more robust modelling framework;
- focuses on the policies that can be used to tackle the main challenges;
- expands the country focus to reflect developments in both OECD and non-OECD regions and their interactions.

Many of the priority issues and sectors identified in this *Outlook* are the same as those highlighted as needing most urgent policy action in the first *OECD Environmental Outlook* (2001) and in the *OECD Environmental Strategy for the First Decade of the 21st Century*. These include the priority issues of climate change, biodiversity loss and water scarcity, and the key sectors exerting pressure on the environment (agriculture, energy and transport). Added to these is a new priority issue: the need to address the health impacts of the build-up of chemicals in the environment. The 2001 *Outlook* indicated the environmental challenges expected in the next couple of decades; this *Outlook* not only deepens and extends this analysis, it also focuses on the policy responses for addressing these challenges. It finds that the solutions are affordable and available if ambitious policy action is implemented today, and if countries work together in partnership to ensure comprehensive action, avoid competitiveness concerns and share the responsibility and costs of action fairly and equitably. This latest *Outlook* analyses the policies that can be used to achieve the *OECD Environmental Strategy*. It will provide the main analytical material to support discussions on further implementation of the *OECD Environmental Strategy* at the OECD Meeting of Environment Ministers planned for early 2008.

Policy context

Why develop an environmental outlook? Many of the economic or social choices that are being made today – for example, investments in transport infrastructure and building construction, fishing fleets, purchase of solar heating panels – will have a direct and lasting affect on the environment in the future. For many of these, the full environmental impacts will not be felt until long after the decisions have been taken. These factors make policy decisions difficult: the costs of policy action to prevent these impacts will hit societies today, but the benefits in terms of improved environmental quality or damage avoided may only be realised in the future. For example, the greenhouse gases released today continue to build up in the atmosphere and will change the future climate, with serious impacts for the environment, the economy and social welfare.

But politicians tend to reflect the short-term interests of the voting public, not the long-term needs of future generations. They also tend to focus on the immediate costs and benefits to their own populations of a given policy approach, rather than on the global impacts. But many of the main environmental challenges countries face in the early 21st century are global or transboundary in nature, including global climate change, biodiversity loss, management of shared water resources and seas, transboundary air pollution, trade in endangered species, desertification, deforestation, etc. Building public understanding and acceptance of the policies that are needed to address these challenges is essential for policy reform.

These political challenges are exacerbated by uncertainty about the future. Often the exact environmental impacts of social and economic developments are poorly understood or disputed. In some cases, scientific uncertainty about environmental or health impacts is a main cause of policy inaction, while in others it is used as a justification for precautionary action. Scientific understanding and consensus about environmental change has been developing rapidly in a number of areas in recent years, for example through the 2005 Millennium Ecosystem Assessment and the 2007 IPCC Fourth Assessment Report on the Science of Climate Change. Despite the improvements in the scientific understanding of such issues, a gap remains in the development and implementation of effective environmental policies based on this scientific understanding.

This *Environmental Outlook* examines the medium to long-term environmental impacts of current economic and social trends, and compares these against the costs of specific policies that could be implemented today to tackle some of the main environmental challenges. The purpose is to provide more rigorous analysis of the costs and benefits of environmental policies to help policy-makers take better, more informed policy decisions now.

Many environmental problems are complex and inter-connected. For example, species loss is often the result of multiple pressures – including hunting, fishing or plant harvesting, loss of habitat through land use change or habitat fragmentation, impacts of pollutants – and thus a mix of policy instruments is needed to tackle the various causes of this loss. These policy packages need to be carefully designed in order to achieve the desired environmental benefits at the lowest economic cost. This *Outlook* examines the policy packages that could be used to tackle some of the key environmental challenges, and the framework conditions needed to ensure their success.

The transboundary or global nature of many of the most pressing environmental challenges identified in this *Outlook* require countries to increasingly work together in partnership to address them. The ways in which OECD environment ministries can work together in partnership with other ministries, stakeholder partners and other countries are explored in this *Outlook*.

A special focus on the emerging economies in the *Outlook*

This *Outlook* identifies the main emerging economies as the most significant partners for OECD countries to work with in the coming decades to tackle global or shared environmental problems. This is because these countries are responsible for an increasingly large share of the global economy and trade, and thus have an increasing capacity to address these challenges, in part because their economies are so dynamic. Moreover, the pressures that they exert on the environment are also growing rapidly.

In some chapters, where data are available and relevant, the BRIICS countries (Brazil, Russia, India, Indonesia, China and South Africa) are highlighted for attention as a country grouping. In other chapters, the smaller country grouping of BRIC (Brazil, Russia, India and China) is examined, or even further disaggregated to each of these four countries individually. The BRIC grouping is used for most of the modelling projections and simulations in the *Outlook*.

Modelling methodology and sources of information

The analysis presented in this *Environmental Outlook* was supported by model-based quantification. On the economic side, the modelling tool used is a new version of the OECD/World Bank JOBS/Linkages model, operated by a team in the OECD Environment Directorate and called ENV-Linkages. It is a global general equilibrium model containing 26 sectors and 34 world regions and provides economic projections for multiple time periods. It was used to project changes in sector outputs and inputs of each country or region examined to develop the economic baseline to 2030. This was extended to 2050 to examine the impacts of policy simulations in specific areas, such as biodiversity loss and climate change impacts. The economic baseline was developed with expert inputs from, and in co-operation with, other relevant parts of the OECD, such as the Economics Department, the International Energy Agency and the Directorate for Food, Agriculture and Fisheries.

The Integrated Model to Assess the Global Environment (IMAGE) of the Netherlands Environmental Assessment Agency (MNP) was further developed and adjusted to link it to the ENV-Linkages baseline in order to provide the detailed environmental baseline. IMAGE is a dynamic integrated assessment framework to model global change, with the objective of supporting decision-making by quantifying the relative importance of major processes and interactions in the society-biosphere-climate system. The IMAGE suite of models used for the *Outlook* comprises models that also appear in the literature as models in their own right, such as FAIR (specialised to examine burden sharing issues), TIMER (to examine energy), and GLOBIO3 (to examine biodiversity). Moreover, for the *Outlook* the IMAGE suite included the LEITAP model of LEI at Wageningen and the WaterGap model of the Center for Environmental Systems Research at Kassel University. IMAGE and associated models provided the projections of impacts on important environmental endpoints to 2030, such as climate, biodiversity, water stress, nutrient loading of surface water, and air quality. Annex B provides a more detailed description of the modelling framework and main assumptions used for the *Outlook* report.

The Baseline Reference Scenario presents a projection of historical and current trends into the future. This Baseline indicates what the world would be like to 2030 if currently existing policies were maintained, but *no new policies* were introduced to protect the environment. It is an extension of current trends and developments into the future, and as such it does not reflect major new or different developments in either the drivers of environmental change or environmental pressures. A number of major changes are possible in the future, however, that would significantly alter these projections. A few of these were examined as "variations" to the Baseline, and their impacts are described in Chapter 6 to show how these changes might affect the projections presented here.

Because the Baseline reflects no new policies, or in other words it is "policy neutral", it is a reference scenario against which simulations of new policies can be introduced and compared. Simulations of specific policy actions to address key environmental challenges were run in the modelling framework. The differences between the Baseline projections and these policy simulations were analysed to shed light on their economic and environmental impacts.

The simulations undertaken for the *Environmental Outlook* exercise are illustrative rather than prescriptive. They indicate the type and magnitude of the responses that might be expected from the policies examined, rather than representing recommendations to undertake the simulated policy actions. As relevant, some of the policy simulation results are reflected in more than one chapter. The table below summarises the policy simulation analyses and lists the different chapters containing the results.

Sensitivity analysis was undertaken to test the robustness of key assumptions in ENV-Linkages, and some of the results of this analysis are presented in Annex B. This, in conjunction with the Baseline variations described in Chapter 6, provides a clearer picture for the reader of the robustness of the assumptions in the Baseline.

Throughout the *Outlook*, the analysis from the modelling exercise is complemented by extensive data and environmental policy analysis developed at the OECD. Where evidence is available, specific country examples are used to illustrate the potential effects of the policies discussed. Many of the chapters in this *Outlook* have been reviewed by the relevant Committees and Expert Groups of the OECD, and their input has strengthened the analysis.

The *Outlook* is released at about the same time as a number of other forward-looking environmental analyses, such as UNEP's Fourth Global Environment Outlook (GEO-4); the IPCC Fourth Assessment Report (AR-4); the International Assessment of Agricultural Science and Technology for Development supported by the World Bank, FAO and UNEP; and the CGIAR Comprehensive Assessment of Water Use in Agriculture. Through regular meetings and contacts, efforts have been made by the organisations working on these reports to ensure co-ordination and complementarity in the studies, and to avoid overlap. The *OECD Environmental Outlook* differs from most of the others in its emphasis on a single baseline reference scenario against which specific policy simulations are compared for the purpose of policy analysis. Most of the others explore a range of possible "scenarios", which provide a useful communication tool to illustrate the range of possible futures available, but are less amenable to the analysis of specific policy options. The *OECD Environmental Outlook* also looks at developments across the full range of environmental challenges, based strongly on projected developments in the economic and social drivers of environmental change, while many of the other forward-looking analyses focus on a single environmental challenge.

Table I.1. **Mapping of the *OECD Environmental Outlook* policy simulations by chapter**

Simulation title	Simulation description	Chapters in which the results are reflected	Models used
Baseline	The "no new policies" Baseline used throughout the *OECD Environmental Outlook*.	All chapters	ENV-Linkages; IMAGE suite
Globalisation variation	Assumes that past trends towards increasing globalisation continue, including increasing trade margins (increasing demand by lowering prices in importing countries) and reductions in invisible costs (*i.e.* the difference between the price at which an exporter sells a good and the price that an importer pays).	4. Globalisation 6. Key variations to the standard expectation	ENV-Linkages; IMAGE suite
High and low growth scenarios	Variation 1: High economic growth – examines impacts if recent high growth in some countries (*e.g.* China) continues, by extrapolating from trends from the last 5 years of growth rather than the last 20 years. Variation 2: Low productivity growth – assumes productivity growth rates in countries converge towards an annual rate of 1.25% over the long-term, rather than 1.75% as in the Baseline. Variation 3: High productivity growth – assumes productivity growth rates in countries converge towards an annual rate of 2.25% over the long-term.	6. Key variations to the standard expectation	ENV-Linkages
Greenhouse gas taxes	Implementation in participating countries of a tax of USD 25 on CO_2eq, increasing by 2.4% per annum. OECD 2008: only OECD countries impose the tax, starting in 2008. Delayed 2020: all countries apply the tax, but starting only in 2020. Phased 2030: OECD countries implement the tax from 2008; BRIC countries from 2020, and then the rest of the world (ROW) from 2030 onwards. All 2008: in a more aggressive effort to mitigate global GHG emissions, all countries implement the USD 25 tax from 2008.	7. Climate change 13. Cost of policy inaction (Delayed 2020) 17. Energy 20. Environmental policy packages	ENV-Linkages; IMAGE suite
Climate change stabilisation simulation (450 ppm)	Optimised scenario to reach a pathway to stabilise atmospheric concentrations of GHG at 450 ppm CO_2eq over the longer term and limit global mean temperature change to roughly 2 °C. A variation on this case was developed to explore burden-sharing, using a cap and trade approach to implementation.	7. Climate change 13. Cost of policy inaction 17. Energy 20. Environmental policy packages	ENV-Linkages; IMAGE suite
Agriculture support and tariff reform	Gradual reduction in agricultural tariffs in all countries to 50% of current levels by 2030. Gradual reduction in production-linked support to agricultural production in OECD countries to 50% of current levels by 2030.	9. Biodiversity 14. Agriculture	ENV-Linkages
Policies to support biofuels production and use	Demand for biofuels growing in line with the IEA *World Energy Outlook* (2006) scenario. DS: a scenario whereby growth in biofuel demand for transport is driven by exogenous changes, keeping total fuel for transport close to the Baseline. OilS: a high crude oil price scenario to determine the profitability of biofuel in the face of increasing costs of producing traditional fossil-based fuels. SubS: a subsidy scenario in which producer prices of biofuels are subsidised by 50%.	14. Agriculture	ENV-Linkages
Fisheries	Global fisheries cap and trade system, representing a 25% reduction in open fisheries catch, with trading allowed within six geographical regions.	15. Fisheries and aquaculture	ENV-Linkages
Steel industry CO_2 tax	Implementation of a carbon tax of 25 USD per tonne CO_2, applied respectively to OECD steel industry only, all OECD sectors, and all sectors worldwide.	19. Selected industries – steel and cement	ENV-Linkages
Policy mix	Three variations of policy packages were modelled, depending on the participating regions: OECD countries only OECD + BRIC Global The policy packages included: • reduction of production-linked support and tariffs in agriculture to 50% of current levels by 2030. • tax on GHG emissions of USD 25 tax CO_2eq, increasing by 2.4% per annum (phased with OECD starting in 2012, BRIC in 2020, ROW in 2030). • moving towards, although not reaching, Maximum Feasible Reduction in air pollution emissions, phased over a long time period depending on GDP/capita. • assuming that the gap to connecting all urban dwellers with sewerage will be closed by 50% by 2030, and installing, or upgrading to the next level, sewage treatment in all participating regions by 2030.	8. Air pollution 10. Freshwater 12. Health and environment 20. Environmental policy packages	ENV-Linkages; IMAGE suite

Structure of the report

The *OECD Environmental Outlook* is divided into two main parts:

i) *The World to 2030 – the Consequences of Policy Inaction:* describes the Baseline, *i.e.* the projected state of the world to 2030 in terms of the key drivers of environmental change and the developing environmental challenges, as well as analysing some possible variations to the Baseline.

ii) *Policy Responses:* focuses on the policy responses at both the sectoral level and in terms of implementing a more comprehensive and coherent policy package.

The first part describes the key elements of the Baseline to 2030, including the main drivers of environmental change (consumption and production patterns, technological innovation, population dynamics and demographic change, economic development, globalisation, and urbanisation) and the key environmental challenges (climate change, air pollution, biodiversity, freshwater, waste and material flows, health and environment). For each of these, the key recent trends and projections to 2030 are presented, as well as some of the policy approaches that are being used to address the environmental challenges. Chapter 6 describes some key variations to the Baseline – for example, how the Baseline would differ if key economic drivers (such as economic growth or global trade) were changing faster than projected in the Baseline. The chapter also explores other sources of uncertainty in the *Outlook* projections. Finally, this first part of the report examines the consequences and costs of policy inaction – essentially the environmental, health and economic impacts embodied in the "no new policies" Baseline scenario.

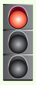
The second part of the *Outlook* report examines the possible policy responses to address the key environmental challenges, and assesses the economic and environmental impact of these responses. The key sectors whose activities affect the environment are examined, with a brief summary of the trends and outlook for their impacts, followed by an assessment of the policy options that could be applied in that sector to reduce negative environmental impacts. This section assesses the environmental benefits of specific policy options and their potential costs to the sector involved and/or economy-wide (and disaggregated by region where appropriate). This analysis can be used by environment ministries in discussing specific policy options for tackling environmental challenges with their colleagues in other ministries, such as finance, agriculture, energy or transport. The sectors examined include those that were prioritised in the *OECD Environmental Strategy* – agriculture, energy and transport – and also other sectors which strongly affect natural resource use or pollution, such as fisheries, chemicals and selected industries (steel, cement, pulp and paper, tourism and mining).

In addition to analysing sector-specific policies, this part of the *Outlook* also examines the effects of a package of policies (the EO policy package) to tackle the main environmental challenges. The analysis of this EO policy package highlights the potential synergies between policies (*i.e.* where the benefits of combining two or more policies may be greater than the simple sum of their benefits as separate policies), or potential conflicts where policies may undermine each other. Chapter 21 outlines the key framework conditions needed to ensure the successful identification and implementation of appropriate environmental policies at the national level, in particular institutional capacity and policy implementation concerns. Chapter 22, on global environmental co-operation, highlights the issues for which OECD countries will need to work together in partnership with other countries in order to reduce overall costs of policy implementation and maximise benefits. It also assesses the costs of inaction.

 OECD ENVIRONMENTAL OUTLOOK TO 2030 – ISBN 978-92-64-04048-9 – © OECD 2008

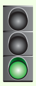
Traffic lights in the *OECD Environmental Outlook*

As with the 2001 *Outlook*, this report uses traffic light symbols to indicate the magnitude and direction of pressures on the environment and environmental conditions. Traffic lights are used to highlight the key trends and projections in the summary table in the Executive Summary, in the Key Messages boxes at the start of each chapter and throughout the chapters. The traffic lights were determined by the experts drafting the chapters, and then refined or confirmed by the expert groups reviewing the report. They represent the following ratings:



Red lights are used to indicate environmental issues or pressures on the environment that require urgent attention, either because recent trends have been negative and are expected to continue to be so in the future without new policies, or because the trends have been stable recently but are expected to worsen.

Yellow lights are given to those pressures or environmental conditions whose impact is uncertain, changing (*e.g.* from a positive or stable trend toward a potentially negative projection), or for which there is a particular opportunity for a more positive outlook with the right policies.



Green lights signal pressures that are stable at an acceptable level or decreasing, or environmental conditions for which the outlook to 2030 is positive.

While the traffic light scheme is simple, thus supporting clear communication, it comes at the cost of sensitivity to the often complex pressures affecting the environmental issues examined in this *Outlook*.

While each of the individual chapters discusses the regional developments for the drivers or environmental impacts analysed, Annex A also provides an easily accessible "summary" of the economic, social and environmental developments in the Baseline for each region. Annex B provides a more detailed analysis of the modelling framework used in the development of the *OECD Environmental Outlook*. A number of background working papers, which provide further information on specific issues addressed in the *Outlook*, were developed to complement the report (see: *www.oecd.org/environment/outlookto2030*).

Table of Contents

II. Impacts of Environmental Change

 OECD ENVIRONMENTAL OUTLOOK TO 2030 – ISBN 978-92-64-04048-9 – © OECD 2008

POLICY RESPONSES

III. Sectoral Developments and Policies

IV. Putting the Policies Together

List of boxes

OECD ENVIRONMENTAL OUTLOOK TO 2030 – ISBN 978-92-64-04048-9 – © OECD 2008

List of tables

 OECD ENVIRONMENTAL OUTLOOK TO 2030 – ISBN 978-92-64-04048-9 – © OECD 2008

List of figures

OECD ENVIRONMENTAL OUTLOOK TO 2030 – ISBN 978-92-64-04048-9 – © OECD 2008

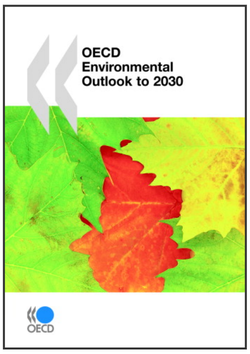
OECD ENVIRONMENTAL OUTLOOK TO 2030 – ISBN 978-92-64-04048-9 – © OECD 2008

Acronyms and Abbreviations

BRIC	Brazil, Russia, India and China
BRIICS	Brazil, Russia, India, Indonesia, China and South Africa
CBD	Convention on Biological Diversity
CCS	Carbon capture and storage
CDM	Clean Development Mechanism
CFC	Chlorofluorocarbon
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2eq	Carbon dioxide equivalents
CSD	Commission on Sustainable Development
DAC	OECD Development Assistance Committee
EJ	Exajoules
EU15	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom
EU25	Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom
EUR	Euro (currency of European Union)
FAO	Food and Agriculture Organization of the United Nations
GBP	Pound sterling
GDP	Gross domestic product
GHG	Greenhouse gas
GJ	Gigajoules
GNI	Gross national income
Gt	Giga tonnes
GW	Gigawatt
HFC	Hydrofluorocarbon
IEA	International Energy Agency
IMAGE	Integrated Model to Assess the Global Environment
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land use, land use change and forestry
MAD	Mutual Acceptance of Data
MDGs	Millennium Development Goals
MEA	Multilateral environmental agreement
MNP	Netherlands Environmental Assessment Agency
MSA	Mean species abundance

Mt	Million tonnes
MWh	Megawatt-hour
NO_2	Nitrogen dioxide
N_2O	Nitrous oxide
NO_x	Nitrogen oxides
ODA	Official development assistance
ppb	Parts per billion
ppm	Parts per million
PFC	Perfluorocarbon
PM	Particulate matter
$PM_{2.5}$	Particulate matter, particles of 2.5 micrometres (µm) or less
PM_{10}	Particulate matter, particles of 10 micrometres (µm) or less
ppmv	Parts per million by volume
ROW	Rest of world
RTA	Regional trade agreement
SO_2	Sulphur dioxide
SO_x	Sulphur oxides
SF_6	Sulphur hexafluoride
TWh	Terawatt hour
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar
VOC	Volatile organic compound
WHO	World Health Organization
WSSD	World Summit on Sustainable Development
WTO	World Trade Organization

OECD ENVIRONMENTAL OUTLOOK TO 2030 – ISBN 978-92-64-04048-9 – © OECD 2008


OECD
Environmental
Outlook to 2030