4.3 Aquatic food production systems

Significant ideas

- Aquatic systems provide a source of food production.
- Unsustainable use of aquatic ecosystems can lead to environmental degradation and collapse of wild fisheries.
- Aquaculture provides potential for increased food production.

Big questions

As you read this section, consider the following big questions:

- What strengths and weaknesses of the systems approach and the use of models have been revealed through this topic?
- To what extent have the solutions emerging from this topic been directed at *preventing* environmental impacts, *limiting* the extent of the environmental impacts, or *restoring* systems in which environmental impacts have already occurred?
- How are the issues addressed in this topic of relevance to sustainability or sustainable development?
- In what ways might the solutions explored in this topic alter your predictions for the state of human societies and the biosphere some decades from now?

Knowledge and understanding

- Demand for aquatic food resources continues to increase as human population grows and diet changes.
- Photosynthesis by phytoplankton supports a highly diverse range of food webs.
- Aquatic (freshwater and marine) flora and fauna are harvested by humans.
- The highest rates of productivity are found near the coast or in shallow seas where upwellings and nutrient enrichment of surface waters occur.
- Harvesting some species can be controversial (e.g. seals and whales). Ethical issues arise over biorights, rights of indigenous cultures, and international conservation legislation.
- Developments in fishing equipment and changes to fishing methods have led to dwindling fish stocks and damage to habitats.
- Unsustainable exploitation of aquatic systems can be mitigated at a variety of levels (international, national, local, and individual) through policy, legislation and changes in consumer behaviour.
- Aquaculture has grown to provide additional food resources and support economic development and is expected to continue to rise.
- Issues around aquaculture include loss of habitats, pollution (from feed, antifouling agents, and antibiotics and other medicines added to the fish pens), spread of diseases and escaped species (some involving genetically modified organisms).

Aquatic food production systems

Aquatic systems provide a source of food production.

Demand for aquatic food resources continues to increase as the human population grows and as more people become wealthy, more health conscious, and change their diet to include more meat, fish, and dairy products.

World fisheries

World fisheries and aquaculture produced almost 150 million tonnes of fish in 2010, valued at over US$215 billion (Figure 4.12). Over 125 million tonnes were used as food for people. The world's fish food supply has grown dramatically since 1961, with an average growth rate of 3.2 per cent per year compared with a growth rate of 1.7 per cent per year for the world's population (Figure 4.13). World food fish supply increased from an average of 9.9 kg *per capita* in the 1960s to 18.4 kg in 2009. Fish consumption was lowest in Africa, while Asia accounted for two-thirds of total consumption. Consumption in Asia reached 85.4 million tonnes, of which 42.8 million tonnes was consumed outside China.

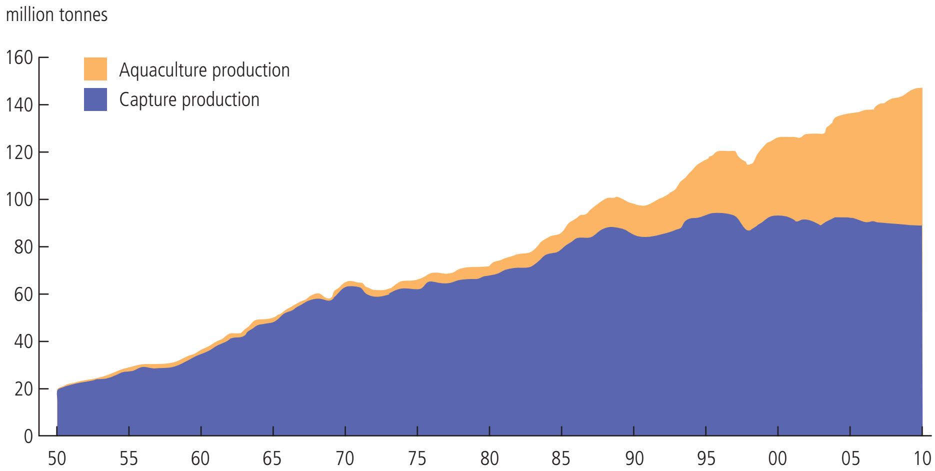

Figure 4.12 World capture and aquaculture production

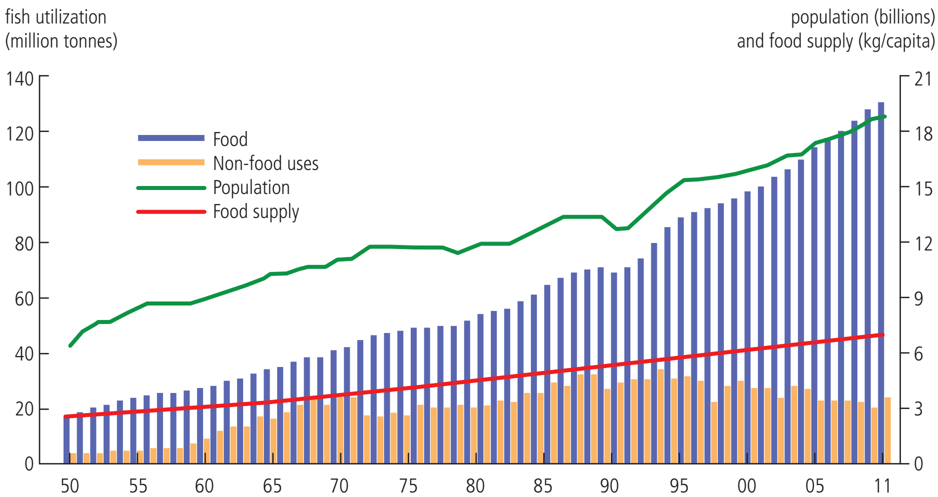

Figure 4.13 World food utilization and supply

Although annual *per capita* consumption of products has grown steadily in LEDCs, it is still considerably lower than in MEDCs, although the gap is narrowing.

China has been responsible for much of the increase in world *per capita* fish supply because of a substantial increase in aquaculture. China's share in world fish production grew from 7 per cent in 1961 to 35 per cent in 2010.

In 2009, fish accounted for 16.6 per cent of the world population's intake of animal protein. Globally, fish provides about 3.0 billion people with almost 20 per cent of their intake of animal protein.

Overall, global capture fisheries production remains relatively stable at about 90 million tonnes. Between 2004 and 2010, catches of all marine species except the Peruvian anchovy (*Engraulius ringens*, anchoveta) ranged between 72.1 million and 73.3 million tonnes. However, anchoveta catches in the south-east Pacific decreased from 10.7 million tonnes in 2004 to 4.2 million tonnes in 2010. This was due, in part, to fishing closures to protect the high number of juveniles present as a consequence of the La Niña event (intensification of 'normal' weather conditions).

To learn more about El Niño and La Niña, go to www.pearsonhotlinks.co.uk, enter the book title or ISBN, and click on weblink 4.1.

The Tokyo fish market – unsustainable demand for fish (shown here are tuna)

The north-west Pacific is still by far the most productive fishing area. Catches peaked in the north-west Atlantic, north-east Atlantic, and north-east Pacific temperate fishing areas many years ago, and total production has declined continuously from the early 2000s, but in 2010 this trend was reversed. Total catches grew in the west and east Indian Ocean and in the west central Pacific.

Fish stocks

Photosynthesis by phytoplankton supports a highly diverse range of food webs.

Production of the world's marine fisheries increased from 16.8 million tonnes in 1950 to a peak of 86.4 million tonnes in 1996, and then stabilized at about 80 million tonnes. Global recorded production was 77.4 million tonnes in 2010. The north-west Pacific had the highest production with 20.9 million tonnes (27 per cent of the global marine catch) in 2010, followed by the west central Pacific with 11.7 million tonnes (15 per cent), the north-east Atlantic with 8.7 million tonnes (11 per cent). After 1990, the number of over-exploited stocks continued to increase, albeit at a slower rate (Figure 4.14).

Food production systems can be compared and contrasted in terms of their trophic levels and efficiency of energy conversion (Figure 4.15). You have already seen that the second law of thermodynamics means that energy conversion through food chains is inefficient, and energy is lost by respiration and waste production at each level within a food web.

In terrestrial systems, most food is harvested from relatively low trophic levels (producer and herbivores). Systems that produce crops (arable) are more energy efficient that those that produce livestock. This is because in the former, producers are at the start of the food chain and contain a greater proportion of the Sun's energy than subsequent trophic levels.

In aquatic systems, perhaps largely due to human tastes, most food is harvested from higher trophic levels where the total storages are much smaller. This is less energy

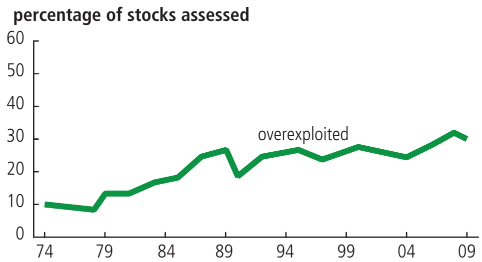

Figure 4.14 Global trends in the state of the world's marine fish stocks since 1974

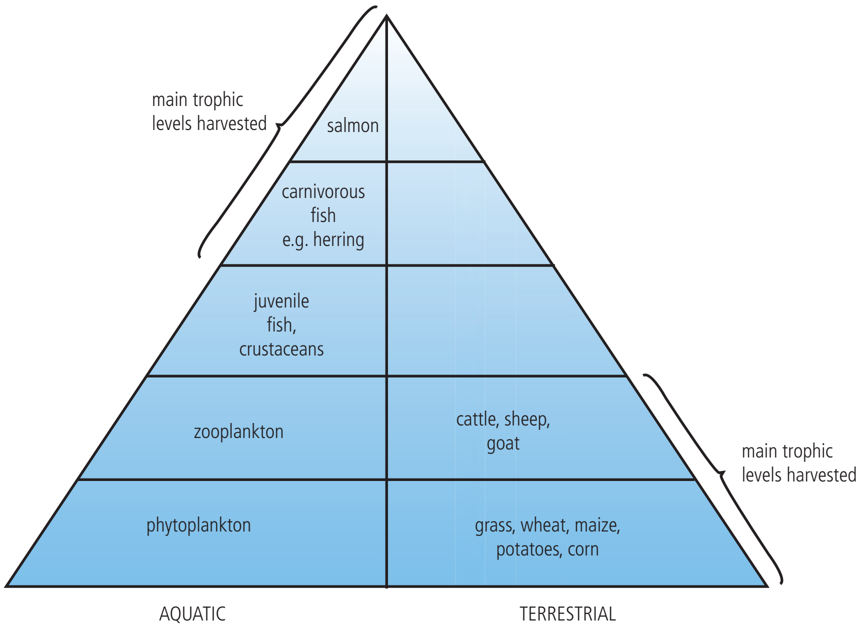

Figure 4.15 Aquatic and terrestrial food production systems

efficient than crop production (i.e. crops capture energy directly from the primary source; fish are several steps away from primary production). Although energy conversions along an aquatic food chain may be more efficient than in a terrestrial chain, the initial fixing of available solar energy by aquatic primary producers tends to be less efficient due to the absorption and reflection of light by water.

In the oceans, photosynthesis by phytoplankton supports a highly diverse range of food webs. Some ecosystems are more productive than others – coral reefs and those with an abundant supply of light and nutrients tend to support a greater range of food webs.

The highest rates of productivity are found near the coast in shallow waters where upwelling currents cause nutrient enrichment of surface waters (e.g. off the coast of Peru). However, during El Niño episodes, the nutrient enrichment occurs further from the coast, beyond the reach of small boats.

Sustainability

Sustainable yield (SY) is calculated as the rate of increase in natural capital (i.e. natural income) that can be exploited without depleting the original stock or its potential for replenishment. Exploitation must not decrease long-term productivity. So, the annual sustainable yield for a given crop may be estimated as the annual gain in biomass or energy through growth and recruitment (in-migration of species).

SY is the amount of increase per unit time (i.e. the rate of increase).

Where

t = the time of the original natural capital

$t + 1$ = the time of the original capital plus yield,

SY = (total biomass at $t + 1$) – (total biomass at t)

or

SY = (total energy at $t + 1$) – (total energy at t)

The relationship can be simplified as:

SY = (annual growth and recruitment) – (annual death and emigration)

Maximum sustainable yield (MSY) is the largest yield (or harvest) that can be taken from the stock of a species over an indefinite period. MSY aims to maintain the population size at the point of maximum growth rate by harvesting the individuals that would normally be added to the population, allowing the population to continue to be productive indefinitely (Figure 4.16). MSY is the point where the highest rate of capture fisheries can occur (this is often difficult to determine). It is used extensively by fisheries management (Figure 4.17). Populations of cod have been particularly affected by over-fishing in the North Atlantic (Figure 4.18).

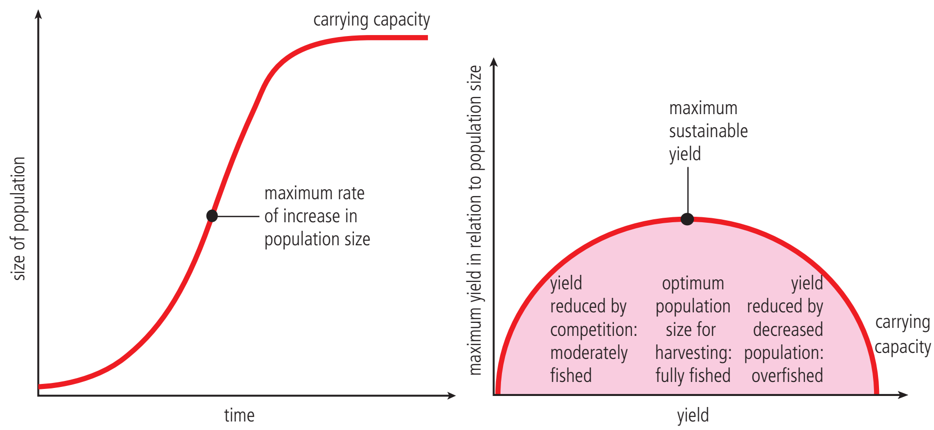

Figure 4.16 Maximum sustainable yield occurs at maximum. rate of increase in population. Near the carrying capacity, the yield reduces.

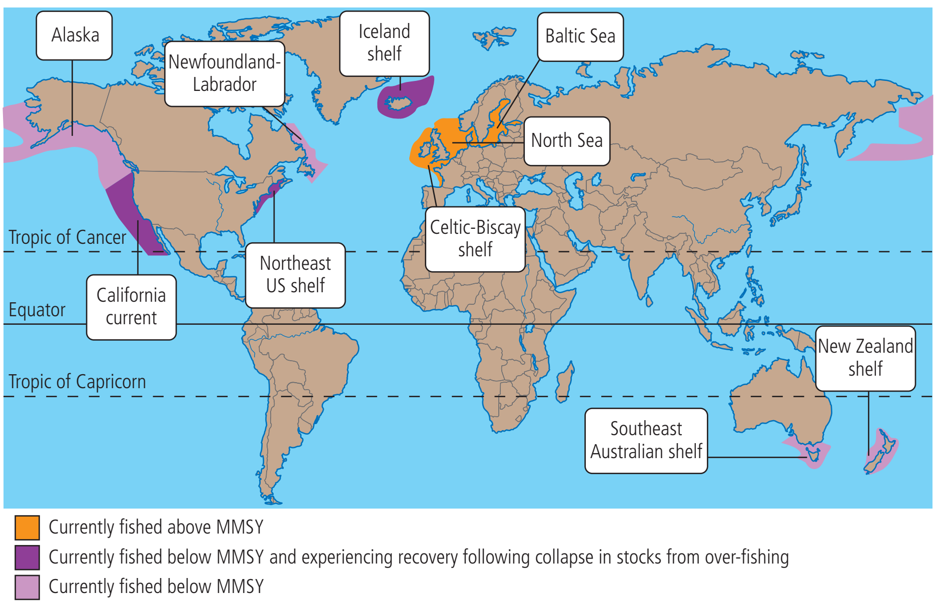

Figure 4.17 Multi-species maximum sustainable yield (MMSY): MSY values for whole fish communities worldwide

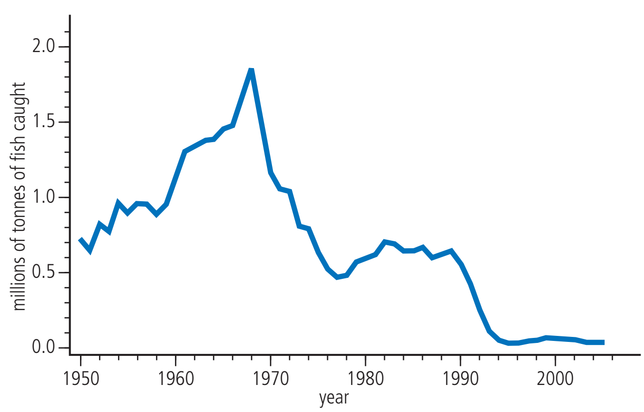

Figure 4.18 North-west Atlantic cod populations, off the coasts of the USA and Canada, were particularly affected by over-fishing. By 1992, cod populations were only 1 per cent of their 1960 levels.

Most of the stocks of the top 10 species, which account in total for about 30 per cent of world marine capture fisheries production, are fully exploited and, therefore, have no potential for increases in production. The two main stocks of anchoveta in the south-east Pacific, Alaska pollock in the north Pacific, and blue whiting in the Atlantic are fully exploited. Among the seven principal tuna species, one-third were estimated to be over-exploited.

CONCEPTS: Sustainability

The declining global marine catch over the last few years together with the increased percentage of over-exploited fish stocks and the decreased proportion of non-fully exploited species suggests that the state of world marine fisheries is worsening and has had a negative impact on fishery production. Over-exploitation not only causes negative ecological consequences, but it also reduces fish production, which further leads to negative social and economic consequences.

The Johannesburg Plan of Implementation that resulted from the World Summit on Sustainable Development, demands that all over-exploited stocks be restored to the level that can produce maximum sustainable yield by 2015, a target that seems unlikely to be met.

Global overfishing

Developments in fishing equipment and changes to fishing methods, coupled with over capacity in fleets and inadequate international management, have lead to dwindling fish stocks and damage to habitats.

Modern fishing ships are able to stay at sea for months, while freezing and storing their catch. Consequently, they can fish further out at sea than was previously possible, often in international waters. In smaller-scale (but often more damaging) fishing, dynamite and cyanide are still used in some areas to stun reef fish to bring them to the surface. The explosions and poisons also kill the reefs. Fuelled in part by subsidies, many fishing fleets have grown beyond the point of sustainability. This overcapacity has led to overfishing and, indirectly, to issues such as Somali piracy. Each year the UN FAO State of World Fisheries and Aquaculture (SOFIA) report examines global fisheries production and shows that overfished fisheries gradually increased up to a peak of 32 per cent of global fisheries in 2010.

The solutions to such a complex issue are not simple. It is an irony that the technological developments that can lead to overfishing can also contribute to a solution. One example is in northern European mackerel and herring fleets: sonar techniques used to find fish can now distinguish between shoals of the two species. This allows boats to target only herring when they are in season, avoiding the mixed shoals or wrong fish. This selectivity contributed to the herring fishery's Marine Stewardship Council certification as a sustainable and well-managed fishery.

While the statistics often paint a bleak picture, there are examples of success: fisheries that have recovered, stocks that are improving and environmental impacts that have moved to a sustainable basis. There is also a growing body of opinion that suggests the tide is changing on unsustainable fishing practices. In Europe, an EU-wide ban on discarding is being implemented, largely driven by consumer and political pressure to end the wasteful practice of discarding over-quota, undersize and low-value fish at sea. In future, all catches will have to be landed, increasing the pressure for more selective fishing.

In the developing world, governments are partnering with international NGOs to drive change through Fisheries Improvement Projects (FIPs). In the SOFIA reports, the overfished fisheries have gradually decreased, dropping to 28.8 per cent by the 2014 report. At the same time, the percentage of fisheries fully exploited (defined as fished at Maximum Sustainable Yield) has gradually increased from 47 per cent in 2002 to 61.3 per cent in 2014, while under-exploited fisheries have dropped from 25 per cent to 9.9 per cent over the same period.

Nearly 70 per cent of the world's stocks are in need of management. Cod stocks in the North Sea are less than 10 per cent of 1970 levels. Fishing boats from the EU now regularly fish in other parts of the world, such as off the coastlines of Africa and South America, to make up for the shortage of fish in EU waters. More than half the fish consumed in Europe is now imported.

The closure of Grand Banks

Once a fish stock is over-fished to the point of collapse, it is very difficult for it to recover. The Grand Banks off Newfoundland were once the world's richest fishery. In 1992, the area had to be closed to allow stocks to recover. It was expected to be closed for 3 years, but fish numbers, especially cod, have not yet recovered and the areas is still closed. The cod's niche in the ecosystem has been taken by other species, such as shrimp and langoustines. (Langoustine stocks were previously kept low as young langoustine were predated by mature cod. Now the situation is reversed and young codlings and eggs are predated by mature langoustine.)

Unsustainable exploitation of aquatic systems can be mitigated at a variety of levels (international, national, local, and individual) through policy, legislation, and changes in consumer behaviour.

Managing fisheries

Many argue that measures such as quotas, bans, and the closing of fishing areas still fail to address the real problems of the fishing industry: too many fishermen are chasing too few fish and too many immature fish are being caught. For the fisheries to be protected and for the industry to be competitive on a world scale, the number of boats and the number of people employed in fishing must be reduced. At the same time, the efficiencies which come from improved technology must be embraced.

A World Bank and FAO report in 2008 showed that up to US$50 billion per year is lost in poor management, inefficiency, and overfishing in world fisheries. The report puts the total loss over the last 30 years at US$2.2 trillion. The industry's fishing capacity continues to increase. The number of vessels is increasing slowly. However, each boat has greater capacity due to improved technology. Because of the increase in capacity, much of the investment in new technology is wasted. The amount of fish caught at sea has barely changed in the last decade. Fish stocks are depleted, so the effort to catch the ones remaining is greater.

Figure 4.19 Logo of the Marine Stewardship Council

Consumer behaviour is changing in some societies. Awareness of biorights and the problem of over-fishing has led some people to demand that the fish they consume are taken from sustainable sources. The Marine Stewardship Council identifies and labels sustainable fisheries. Its website states that by 'choosing MSC labelled seafood, you reward fisheries that are committed to sustainable fishing practices' (Figure 4.19). MSC-labelled seafood is now available in 140 countries around the world and the certified fisheries represent 10 per cent of global wild-capture seafood. Researchers have identified nearly a thousand improvements made by MSC-certified fisheries in the past 10 years, improving the sustainability of the fisheries to global best-practice levels of environmental performance.

A number of publications and films have promoted sustainable fishing practices or highlighted unsustainable ones. These aim to further change consumer behaviour and to put pressure on governments and the fishing industry to stop unsustainable fishing.

Strategies for the European fishing industry

The table below suggests some possible strategies for the future, but there are clearly no simple solutions to the problems associated with such a politically, economically and environmentally sensitive industry.

Action	Type of measure	Objectives
Conservation of resources		
technical measures	• small meshed nets • minimum landing sizes • boxes	• protect juveniles and encourage breeding • discourage marketing of illegal catches
restrict catches	• total allowable catches (TACS) and quotas	• match supply to demand • plan quota uptake throughout the season • protect sensitive stocks
limit number of vessels	• fishing permits (tradable within and between countries)	• restrict numbers of EU and other countries' vessels fishing in EU waters
surveillance	• check landings by EU and other vessels (log books, computer/satellite surveillance)	• apply penalties to overfishing and illegal landings
structural	• structural aid to the fleet	• finance investment in fleet modernization (although commissioning of new vessels must be closely controlled) • provide reimbursement for scrapping, transfer, and conversion
reduction in employment leading to an increase in productivity	• inclusion of zones dependent on fishing in European Regional Development Fund	• facilitate restructuring of the industry • finance alternative local development initiatives to encourage voluntary/early retirement schemes
Markets		
tariff policy	• minimum import prices • restrictions on imports	• ensure EU preference (although still bound under WTO)
Other measures		
restrict number of vessels	• fishing licenses	• large license fees would discourage small, inefficient boats
increase the accountability of fishermen	• rights to fisheries	• where fish stay put (e.g. shellfish) sections of the seabed can be auctioned off

Table 4.13 Possible strategies to manage fisheries in the European Union

A fish farm

Issues around aquaculture include loss of habitats, pollution (feed, antifouling agents, and antibiotics and other medicines added to the fish pens), spread of diseases, use of wild-capture fish to make fish-meal, and escaped species.

Fish farming (aquaculture)

Fish farming was first introduced when over-fishing of wild Atlantic salmon in the north Atlantic and Baltic seas caused their populations to crash. Open-net fish farming was introduced in Norway in the 1960s. Since then, the industry has expanded to Scotland, Ireland, Canada, the USA, and Chile, and is dominated by a handful of multinational corporations. Aquaculture involves raising fish commercially, usually for food. (In contrast, a fish hatchery releases juvenile fish into the wild for recreational fishing or to supplement a species' natural numbers.) The most important fish species raised by fish farms are salmon, carp, tilapia, catfish, and cod. Salmon make up 85 per cent of the total sale of Norwegian fish farming, but most global aquaculture production now uses non-carnivorous fish species, such as tilapia and catfish. Technological costs are high, and include using drugs, such as antibiotics, to keep fish healthy, and steroids to improve growth. Breeding programmes are also expensive. Outputs are high per hectare and per farmer, and efficiency is also high.

There are many issues related to aquaculture. One is the loss of natural habitats. In some cases, aquaculture may occur in sea lochs. In other cases, it occurs in fish pens off the coastline. In both cases, natural ecosystems are transformed into commercial operations, in which human activities interfere with natural processes, such as migration, predator–prey relationships, removal of competing species and vegetation, and so on.

Environmental effects can be damaging, especially with salmon farming. Salmon are carnivores and need to be fed pellets made from other fish. It is possible that farmed salmon actually represent a net loss of protein in the global food supply, as it takes 1–5 kg of wild fish to grow 1 kg of salmon. Fish like herring, mackerel, sardines and anchovies are used to produce the feed for farmed salmon, so the production of salmon requires the capture of other fish species on a global scale. Other environmental costs include the sea lice and disease that spread from farmed fish into wild stocks, and pollution (created by uneaten food, faeces, and chemicals) contaminating surrounding waters. Accidental escape of genetically modified fish can affect local wild fish gene pools when the escaped fish interbreed with wild populations. This reduces the wild fish genetic diversity, and potentially introduces non-natural genetic variation. In some parts of the world, escapes from farmed salmon threaten native wild fish, as it may be an alien species. For example, the British Columbia salmon farming industry has inadvertently introduced a non-native species – Atlantic salmon – into the Pacific ocean.

Despite the disadvantages, the positive environmental benefits of not removing fish from wild stocks, but growing them in farms, are great. Wild populations are allowed to breed and maintain stocks, while the farmed variety provides food.

Global aquaculture

Between 1980 and 2010, world food fish production by aquaculture grew by, on average, 8.8 per cent per annum. World aquaculture production in 2010 was about 60 million tonnes (Figure 4.20), worth US$125 billion.

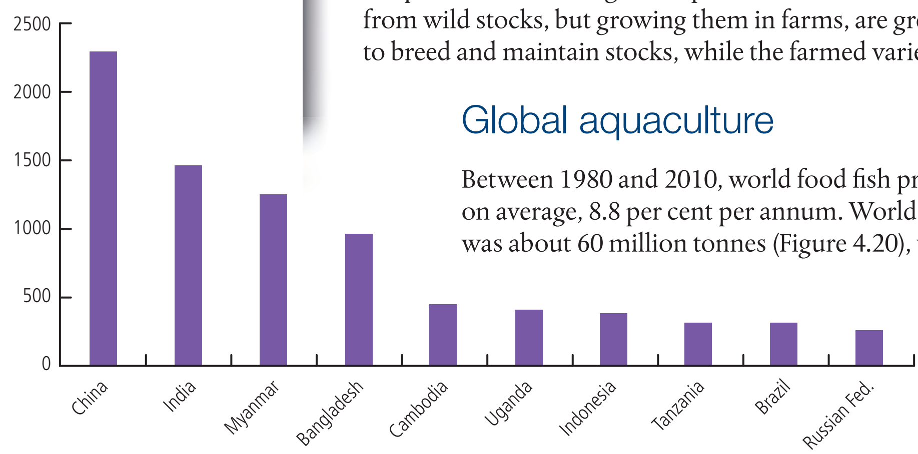

Figure 4.20 Aquaculture production in thousands of tonnes, 2012

Aquaculture production is vulnerable to adverse impacts of disease and environmental conditions. Disease outbreaks in recent years have affected farmed Atlantic salmon in Chile, oysters in Europe, and marine shrimp farming in several countries in Asia, South America, and Africa.

The global distribution of aquaculture remains imbalanced. In 2010, the top 10 producing countries accounted for 87.6 per cent by quantity and 81.9 per cent by value of the world's farmed food fish. Asia accounted for 89 per cent of world aquaculture production by volume in 2010. In Asia, the share of freshwater aquaculture has been gradually increasing, up to 65.6 per cent in 2010 from around 60 per cent in the 1990s.

LEDCs, mostly in sub-Saharan Africa and in Asia, remain minor in terms of their share of world aquaculture production.

Case study

Rice–fish farming in Thailand

Rice–fish farming in Thailand. Once the newly planted rice is established, fish are released into the flooded fields from holding pens.

Cultivating rice and fish together has been a tradition for over 2000 years in South East Asia. This **polyculture** system (paddy rice field stocked with fish) was gradually abandoned due to population pressure and decreasing stocks of wild fish. The fall in fish stocks was due to the toxic effects of the pesticides and herbicides used in high-yield rice monoculture. However, this farming method experienced a revival in the early 1990s, as concerns over the widespread use of pesticides emerged. Implementation is relatively inexpensive and low risk.

The system requires farmers to dig small ponds or trenches in low-lying areas of rice, which become refuges for fish during rice planting and harvesting, or when water is scarce. The excavated soil is used to raise banks around the field to grow other crops on (e.g. vegetables and fruit trees). Once the paddy fields are flooded, young fish (fingerlings) are introduced to the trenches: carp, tilapia, catfish, or other species. After 3 weeks, when the rice is well established, the fish are let into the rice fields. They obtain their food from the fields, but carnivorous species can be fed if necessary. The fish contribute to a decrease of disease and pest incidence in the rice, and rice yields are higher. Because rice productivity increases, farmers do no need to use fertilizers (the fish produce faeces and excreta which naturally fertilize the soil). Rice–fish culture may increase rice yields by up to 10 per cent, and increase income by 50–100 per cent over rice alone, while providing farmers with an important source of protein.

The process counters the decrease in available wild fish in many countries. The most common and widespread fish species used in rice–fish farming are the common carp (*Cyprinus carpio*) and the Nile tilapia (*Oreochromis niloticus*). Both feed on the vegetation and plankton available and do not attack

continued

CHALLENGE YOURSELF

ATL Communication skills

Organize a class debate. Choose one of these topics.

- To what extent do the disadvantages of aquaculture outweigh the advantages?
- Can sustainable fishing ever be achievable?

other fish, so they are preferred species in the culture systems. Other species such as catfish (*Clarias* spp.) are well adapted to the swamp-like conditions of rice fields, but are carnivorous and will feed on other introduced fish.

This food production system is an example of intensive subsistence farming. The cost of feeding the fish is low but demands on labour are high. Technology is low. Other inputs include water for irrigation, and the cost of the breeding stock. The outputs are high per hectare but low per farmer, but overall efficiency is high, and yields of rice improve significantly with this system compared to monoculture rice agriculture. Environmental impacts are low, but include change in the nutrient balance, and the introduction of alien species, which may have impacts for local biodiversity – both plant and animal.

There are several cultural issues regarding the system: other sources of animal protein may be preferred (e.g. poultry, beef, and pork), and the commonly cultured fish species (e.g. tilapia and carp) are not highly valued by people who have access to marine species and wild species. Fish predators such as snakes can lower the fish yield. The system may only be appropriate if there is a reliable water supply, a source of young fish, and fields located close to the family house so they can be monitored.

Harvesting some species can be controversial (e.g. seals and whales). Ethical issues arise over biorights, rights of indigenous cultures, and international conservation legislation.

Whaling – contrasting views

Harvesting some species (such as seals, sharks, and whales) is controversial. There are ethical issues regarding biorights – the rights of an endangered species, a unique species, or landscape to remain unmolested. The rights of indigenous culture and international conservation legislation also should be considered

In the late 1930s, more than 50 000 whales were killed annually. The International Whaling Commission (IWC) was set up to decide on hunting quotas based on the findings of its Scientific Committee. In 1982, the IWC voted to establish a ban on commercial whaling, which took effect in 1986. Japan now wants to lift the ban on stocks that have recovered. However, anti-whaling countries and environmental groups believe that whale species remain vulnerable and that whaling is both immoral and unsustainable.

According to the IWC, indigenous subsistence whaling occurs in Greenland (fin, bowhead, humpback, and minke whales), in Siberia, (gray and bowhead whales), St Vincent and The Grenadines (Bequia, humpback whales) and North America (bowhead whales; Washington State, gray whales).

Inuit and whaling

North American whaling is carried out by small numbers of the Inuit population. The only species hunted is the bowhead whale. Whaling is a central part of Inuit culture and provides a vital source of protein in their diet (see also TOK chapter, page 454).

Indigenous Inuit catching a whale

The 10 000 Inuit in Alaska are allowed to kill a total of up to 336 bowhead whales between 2013 and 2018, with no more than 67 whales in any one year. This represents about half of the meat in the Inuit diet. Scientific research suggests that the bowhead whales are not an endangered species, and their hunt is sustainable. But conservationists take a very different view and state that whales have biorights and should not be killed, especially in a way that causes them great pain and suffering.

The Inuit hunt a variety of animals for meat – including caribou, walrus, seal, and geese – depending on the season and the migratory movements of the species.

In Greenland, Inuit whalers catch around 175 whales per year, making them the third largest hunt in the world after Japan and Norway, which annually averaged around 730 and 590 whales, respectively from 1998 to 2007. The IWC allows the more densely populated west coast to take over 90 per cent of the catch. In a typical year around 150 minke and 10 fin whales are taken from west coast waters and around 10 minkes are from east coast waters.

Japan and whaling

Japan was, for many years, the greater hunter of whales. It reluctantly stopped commercial hunting in 1986. However, it continued to hunt whales for 'scientific research' to establish the size and dynamics of whale populations.

Japan clashed repeatedly with Australia and other western countries, which strongly oppose whaling on conservation grounds. Australia took a case to the UN's International Court of Justice (ICJ) and argued that Japan's scientific research whaling programme was simply commercial whaling in disguise. Japan argued that the suit brought by Australia was an attempt to impose its cultural norms, and furthermore, that minke whales and a number of other species are plentiful and that its whaling activities are sustainable.

In 2014 the ICJ ruled that the Japanese government must halt its whaling programme in the Antarctic. The ICJ believed that the programme was not for scientific research as claimed by Tokyo. It claimed Japan had caught some 3600 minke whales since its current programme began in 2005, but the scientific output was limited. Japan agreed to abide by the ruling but added it 'regrets and is deeply disappointed by the decision'.

There are other threats to whales apart from whaling. These include collision with ships, chemical pollution, habitat degradation, noise pollution, and by-catch (the unintentional capture of whales in fish nets). To protect whales, the Southern Ocean around Antarctica was declared a whale sanctuary in 1994.

Exercises

1. Describe the trend in world fish capture and aquaculture between 1950 and 2010, as shown in Figure 4.12.

2. Compare the trends in population growth, food supply, food, and non-food uses as shown in Figure 4.13.

3. Comment on the changes in world fish stocks, as shown in Figure 4.14.

4. Examine the importance of global fisheries.

5. What is meant by the term 'predatory fish'?

6. Visit the hotlink opposite and answer the following questions.
   - **a.** When was the Common Fisheries Policy of the European Union introduced?
   - **b.** What happened to North Sea cod stocks in 2008?
   - **c.** What are the arguments for and against a common fisheries policy?
   - **d.** Define the term *aquaculture*.

7. Figure 4.20 shows global aquaculture production for 2012.
   - **a.** What was the level of aquaculture production in (i) China and (ii) India?
   - **b.** What proportion of the production shown in Figure 4.20 is from Asian countries?
   - **c.** Suggest two or more reasons why the five largest aquaculture producers are from Asia.

8. To what extent was whaling part of (a) Inuit culture and (b) Japanese culture.

9. Define the term *biorights*. Should all species of whales have biorights? Give reasons to support your answer.

continued

To learn more about the Common Fisheries Policy of the European Union, go to www.pearsonhotlinks.co.uk, enter the book title or ISBN, and click on weblink 4.2.