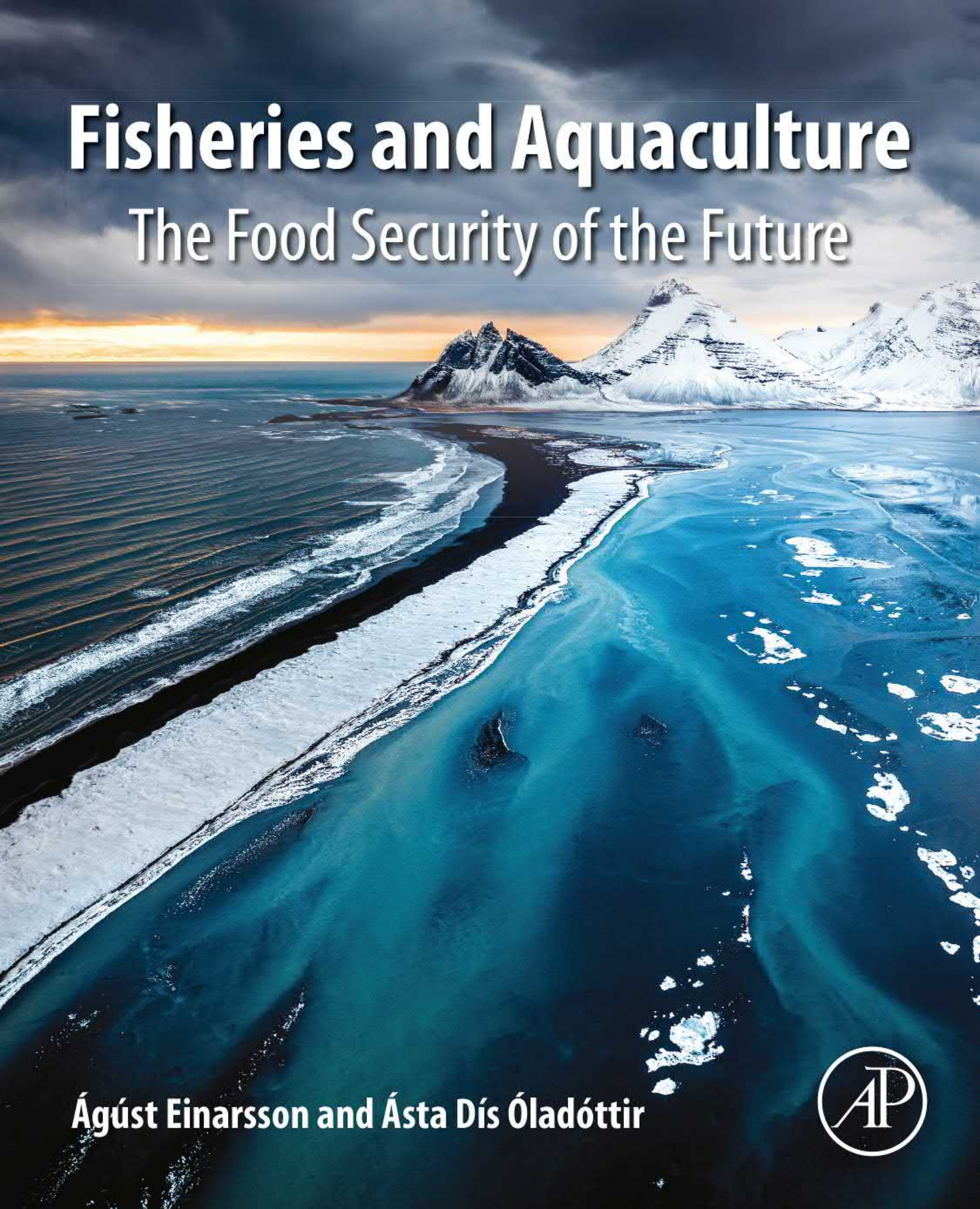
Fisheries and Aquaculture

The Food Security of the Future



Ágúst Einarsson and Ásta Dís Óladóttir

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To the children and young people of the world and the role of fisheries and aquaculture in their future.

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Foreword

Although the oceans constitute the dominant feature of the Earth's surface and lakes and rivers make water a significant character of the planetary landmass, the attention of scholars and policymakers has in modern times been predominantly focused on other directions.

Yet, the oceans and water resources are a crucial dimension in the future of all nations, a key determinant in the evolution of the climate and the food security of coming generations.

This volume is a pioneering endeavour to provide a comprehensive analysis of these planetary basics and how humanity can in environmentally responsible and economically successful ways make the most of rich ocean and aquaculture resources.

The authors benefit not only from their advanced scholarship but also from the inspiring history of their native country, the people of Iceland, who within the lifespan of a single generation successfully transformed themselves from a nation of poor fishermen into a global leader in modern, sustainable, high-tech, and uniquely profitable fishing industries.

Iceland provides, together with some of its Arctic neighbours, an inspiring example of how it is possible to combine the preservation of ocean resources with the evolution of an innovative and technology-driven market fishing economy, where local family-based companies have served as the foundation for modern corporations which have become global leaders in their field.

Like other fishing nations, Iceland concentrated for decades on maximising the market value of filets and other products from the core mass of the fish. In the 21st century, our attention has moved to utilising every aspect of the fish: the skin, the bones, the guts—in order to create highly valuable health and pharmaceutical products. Thus the combination of biotechnology and information technology has made us a leader in this new era where the aim of 100% use is the guiding principle of the modern Icelandic fishing industry, realising that what was previously thrown away could in this new century have even greater market value than the traditional products.

Iceland has also become a leader in creating a comprehensive IT-based tracking system applied by every vessel in our waters, producing real-time data on their movements as well as the catch and the fishing gear. This information system enables Icelandic companies to market their products in such a way as to attract informed and environmentally conscious customers in high-end markets all over the world.

Inspiration from the Icelandic model allows the authors to present their global analysis and world-based data in a way which will guide policymakers, experts, and entrepreneurs to more fully understand how the sustainable use of ocean and aquaculture resources can lead to prosperous, high-tech modern economies.

This contribution is furthermore highly relevant in times when too many mistakenly believe that our choice is restricted to the predicament between total ban or total destruction, between environmental ocean purity and economic greed. Thus the book can be an informed guide to multiple demonstrations of how we indeed have a wealth of other choices.

The Icelandic tradition in which the authors have been schooled also connects to the emerging relevance of the Arctic, which until a few decades ago was mostly unknown to the enlightened world. Now, the newly founded Arctic Circle draws over 2000 participants every year from more than 60 countries to each annual Assembly in Iceland: heads of states and governments, ministers, members of parliaments, officials, experts, scientists, entrepreneurs, business leaders, indigenous representatives, environmentalists, students, activists, and others from the growing international community of partners and participants interested in the future of the Arctic.

In addition to these unique Assemblies, the Arctic Circle has in recent years convened Forums in Europe, Asia, and North America, giving the dialogue and cooperation on the Arctic a new and fascinating global dimension.

All these Arctic Circle gatherings have hosted a great variety of sessions on the oceans and modern fisheries, even leading to participation from leaders of Pacific Island States who travelled across the globe to learn from the Arctic fishing nations.

The evolving wide-ranging Arctic cooperation, manifested both in the Arctic Circle and the Arctic Council, has also led to an international agreement to govern the potential fisheries in the emerging Arctic Ocean with a science-based system; when in future decades, due to the melting of the ice, there will be a new ocean on our Planet for the first time in human history.

I have been privileged throughout my life to witness the transformation described in this book: brought up in a small and poor fishing village in Northwestern Iceland, serving as President of a nation which secured through hard struggle its Exclusive Economic Zone and made its fishing sector a global model, and now leading multiple Arctic partners in a new cooperative endeavour to preserve our rich ocean resources as the foundation of successful 21st century economies.

My personal story thus enables me to appreciate the unique value of this pioneering volume.

Ólafur Ragnar Grímsson
Chairman of the Arctic Circle
President of Iceland 1996–2016

Preface

The objective of this book is to describe and analyse world fisheries and aquaculture in the context of food security. Food safety and food security, or rather the lack thereof, are among the most serious challenges faced by the world. Food safety refers to whether foodstuffs are safe to eat and not hazardous to health; this needs to be ensured at all stages of production, from harvesting through processing, packaging, transporting, storing, and serving. Food security, on the other hand, refers to the need to ensure the availability at all times of a sufficient quantity of food containing the nutrients necessary to preserve life and health.

The oceans, covering a large part of the world, have been harvested since the dawn of human history and they have played an important role in the human quest for sustenance. The same applies to lakes and rivers. Although fish farming also has a long history, it is not until in recent decades that aquaculture has become a major economic sector. In a historical context, humankind has forever struggled to combat hunger, and this applies even in our modern times, largely because of the huge population growth of the last 100 years, especially in the developing countries. Food security has thus been a dominant theme in human society across the world, with fisheries and aquaculture playing a prominent role. By describing these sectors in an organised manner, the authors hope to contribute to a better understanding of the importance of these industries for the food security of the future. The book is intended as an aid in addressing future environmental and other challenges, and as a source of knowledge, particularly for the benefit of the developing countries, where fisheries and aquaculture can play a key role in improving living conditions in the coming decades.

The structure of the book is that the introductory chapter describes the development of fisheries in a historical context and outlines the characteristics of fisheries and aquaculture. The discussion touches on the biology of fish and the importance of fish for human nutrition, and also how fish have featured in culture and religion. An account is provided of sustainability and the important role of fisheries and aquaculture in the light of growing populations and the increased need for food in a time of serious and increasing environmental problems.

The text outlines the scope of fishing and aquaculture in different countries, where fisheries and aquaculture are in some areas highly advanced technologically, while in other places working methods are much the same as they were about a century ago. An account is given of the principal fishing and fish farming countries and the most common fish species that are harvested. Finance in fisheries and aquaculture is discussed, and the composition of the workforce in the two sectors. The use of breeding and genetic modification in aquaculture is illustrated. There are figures on fish consumption by country and on the different economic situations of countries. Methods are described of assessing the importance of fisheries and aquaculture for the countries of the world, resulting in a list of the principal countries that are highly dependent on these sectors.

The market forces of the economy are described that are useful for the analysis of fisheries, aquaculture, and food security, including demand, supply, and price. It is shown how market laws operate in real life, and factors of production and economies of scale are explained, as well as the many effects of cost. The importance of ownership and externalities and the conditions that lead to market failure are described. Environmental issues and the numerous challenges that the world is facing in that regard include climate change and pollution, the impact of global warming and increasing acidification on the oceans, the effects of plastic pollution, and the consequences of environmental changes, such as the melting of the glaciers in the Arctic and Antarctic. The United Nations Sustainable Development Goals are described to highlight their relevance to fisheries and aquaculture and their importance as signposts on our route into the future. There is a discussion of overfishing, fisheries management, and models based on marine biology and fisheries economics.

The biggest fisheries nation in the world, the Chinese, not only catch more fish than any other nation, but also have an aquaculture sector that is larger than all the world's other aquaculture sectors combined. In the space of just a few decades, China has grown to become the largest economic power in the world, and it is foreseeable that China will play an important role for the world's future food security, particularly in fisheries and aquaculture.

An account is provided of the situation of the developing countries, as for those countries fisheries and aquaculture will be of special importance, particularly small-scale fisheries and aquaculture. A discussion is included of how focusing on improved infrastructure through better education and more advanced technology could return significant results. The reinforcement of these sectors, combined with greater gender equality, could be a positive contribution to better living standards. There is also a discussion of distant water fishing, which includes fishing by foreign developed countries in the economic jurisdictions of many developing countries. These fisheries have proven to be a problem with regard to pressure on the fish stocks and a lack of regulation and transparency. An account is provided of corruption, a widespread problem, particularly in the developing countries, but also in developed countries.

Handling of catches and processing fish are complex matters, requiring professional working methods to ensure the best possible quality of products for sale and consumption. Enterprises, governments, universities, research institutions, and clusters play a key role in contributing to technological advances in processing. There is a discussion of innovation and the value chain in fisheries and aquaculture, where value is added at each stage. It is recounted how technological advances have led to increasing investment in high-tech equipment to improve the quality of seafood, and how traceability is becoming an increasingly important concern.

The huge significance of commerce and trade is placed in a historical context, and it is explained how progress was driven by international trade in the wake of the Industrial Revolution of the 18th century. An account is provided of the market for seafood, with a description of some of the many marketing models used in the sector. A light is shed on exports and imports of fish and fish products by continent and on the impact of globalisation on fisheries and aquaculture. There is a discussion of theories in international studies that provide a convenient way to describe and analyse conditions relating to food security. A number of enterprises have expanded into foreign markets, so there is a discussion of the reasons for that and other related trends. The largest seafood companies in the world are listed, with a discussion of their principal characteristics and increasing tendency in the direction mergers and partnerships.

The basics of finance in fisheries and aquaculture are described. A discussion is included of the substantial state aid being granted to fisheries in the world. An account is provided of management and how management theory is put to use in fisheries and aquaculture, with special reference to family firms, women's participation in management, strategic planning, competitive position, and knowledge management. There is also a discussion of legislation in fisheries and aquaculture, which is partly international. There is a discussion of education and research and the UNESCO Fisheries Training Programme in Iceland. An overview is provided of artistic creation relating to the sea, and of whaling, which was a big business in earlier times. An account is also provided of angling and recreational fishing. Finally, the book proposes a forecast of what supply and demand might look like in fisheries and aquaculture in the future and predicts that these sectors could contribute to improved food security in the world.

The book is dedicated to the youth of the world and the increased role of fisheries and aquaculture in the future of those who are young today. The authors are convinced that fisheries and aquaculture will play an important role in both future food security and living standards. In part, the authors are thinking of their own children and grandchildren.

A number of people have been involved in the creation of this book, in one way or another, by reviewing the chapters and providing advice. Particular thanks go to the university professors Sigurjón Arason, Thráinn Eggertsson, Axel Hall, Rögnvaldur Hannesson and Marina Papanastassiou, in addition to experts Berglind Ásgeirsdóttir, ambassador; Jakob Bjarnason, current and former chairman of the board of a number of seafood companies; Anna María Clausen, angler; Berglind Hrönn Einarsdóttir, linguist; Sigurdur Gudjónsson, Director of the Marine & Freshwater Research Institute in Iceland; Jónas Jónasson, CEO; Ólafur Kristjánsson, graphic designer; Óli Haukur Mýrdal, Ozzo photography; Árni Pétursson, graphic designer; Paul Richardson and Jón Skaptason, translators; and Grímur Valdimarsson, FAO (retired). The authors also wish to thank Thórólfur Gíslason, CEO of Kaupfélag Skagfirdinga; Jón Ólafur Halldórsson, CEO of Olís; and Gunnthór Ingvason, CEO of Síldarvinnslan, for their support, and the staff of Elsevier for their work. Special thanks go to Ólafur Ragnar Grímsson, Chairman of the Arctic Circle and President of Iceland 1996–2016.

Others that the authors would like to thank specifically are Ágúst Ólafur Ágústsson, Member of Parliament; Einar Ágústsson, CEO; Ingólfur Ágústsson, astrophysicist; Kolbrún Ingólfsdóttir, biomedical scientist and historian; Jóhanna Helga Jensdóttir, student; Thuridur Anna Reynisdóttir, student; Thurídur Anna Steingrímsdóttir (retired); and Óli H. Thórdarson, CEO (retired). Nevertheless,

any deficiencies that may be found in this book are no fault of these good people, but entirely the responsibility of the authors.

The authors are both born and bred in Iceland, a large country with a small population near the Arctic Circle. Like many inhabitants of island states, they are familiar with the sea and the struggle of making a living from the sea. Iceland's history is inextricably linked to the sea, not only in terms of the role of the Atlantic Ocean in the economy, but its impact on the society of a country that has been shaped by the sea for 1200 years, since the Viking Era, when the country was settled by Norsemen. Both authors grew up working in fisheries, fish processing, and sales of fish, like so many other Icelanders, young and old. This life experience has shaped our views on the task of writing a book that describes these sectors and their current and prospective role in ensuring the food security of the future.

Ágúst Einarsson
Ásta Dís Óladóttir

CHAPTER

Introduction

1

Fisheries have been a human activity since the dawn of the human race, whatever time we decide on as the 'dawn' of the human race. *Homo sapiens*, in more or less the current form of the species, appeared on the scene some 300,000 years ago, and we can safely assume that wherever humans lived near water, and wherever that water was the habitat of fish, humans will have devised a means of catching fish for food, notwithstanding the rather more problematic task of catching fish than other foraging by hunting and gathering. It can be argued that catching prey for food in an environment that is fundamentally hostile to most terrestrial animals, humans being no exception, required a degree of ingenuity and problem-solving skills that foraging for plants, and even hunting land animals, did not call for. Fishing and fish farming, as modern industries, continue to face some of the same challenges, but also other challenges that do not affect other industries.

1.1 The dawn of human communities and the origins of fisheries

Fish has historically been an important element of the human food supply. About 12,000 years ago a new trend is known to have begun, which has been known as the Agricultural Revolution, when humans began taking up fixed residence, cultivating the soil and domesticating animals. This trend originated in the basins of two great rivers, the Euphrates and Tigris in Mesopotamia, which is now known as Iraq, and by the river Nile in Egypt, sowing the seeds of great future empires and the beginning of the recorded history of humankind. A similar trend began in the basins of other great rivers in regions now known as China and India.

As in the case of other living beings, the strife of human life included seeking nutrition and shelter, adapting to adverse conditions, and propagating. But although this struggle was common to all animals, the human endeavour took a more diverse form, and in time Man became the ruler of the world, with the ability to communicate complex thought in language and pictures being a key factor.

In contemplating the development of industries, such as the fishing and fish farming industries, it is interesting to survey all the premises for their development and the time that it took to construct a workable system of trading. Written text is a *sine qua non* for all but the simplest commercial transactions, and in fact for all human

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communication of information of any complexity.[a] Long before the time of the written language, everything that was thought to be worth remembering, or necessary to remember, was preserved in an oral tradition, including laws and lore.

However, writing did not begin with written language as we now know it. Clay tablets were first used to inscribe symbols, as it is an easy matter to etch symbols into soft clay and then allow the clay to harden. The principal purpose of these tablets was to keep count of things when numbers and figures needed to be known and remembered, for instance the quantity of fish sent from one village to another, and, no less importantly, to keep records of debts and balances. This innovation can be traced back to about 3500 BCE (Fig. 1.1).[b]

Throughout this time, of course, hunting, slaughtering, and processing marine animals for food continued, and it continued everywhere, on the shores of rivers, ponds, lakes, and the sea. We can assume that hooks and lines were early inventions, perhaps following rudimentary spears, and skills at setting traps for fish eventually evolved. Small boats of various kinds allowed fishermen to escape the confines of the shore and seek deeper and richer fishing grounds, and in time larger vessels enabled navigating streams, large lakes, and the seas, first along coasts and later into the vast oceans to discover new fishing grounds and, incidentally, new and unknown lands.

FIG. 1.1

Ancient stone fish hook from Easter Island in the Pacific Ocean (Ólafur Kristjánsson).

1.2 The role of fish and the sea in religion and lore

The ocean features prominently in ancient religion and lore. In Norse religion, the god Ægir reigned over the sea. The Greek god of the sea, Poseidon, was the brother of Zeus, king of the gods of Olympus. As in the case of Ægir in Norse mythology, Poseidon is depicted as a powerful personage, to be offended at one's own peril, as Odysseus, or Ulysses, learned to his cost. Neptune of the Romans was their god of the sea and shared most attributes with Poseidon.

As a result of the long-standing relationship between fish and humans, fish have been depicted in all the various art forms—music, paintings, sculptures, lyrics, and narratives—over the centuries. Fish have also been used as a symbol, the most prominent in Western culture probably being the use of the outlines of a fish to indicate sanctuaries for Christians in the time of the Roman Empire, when Christians were being mercilessly persecuted. Jesus Christ, of course, had close links to fishermen, from whose ranks he recruited many of his followers on the Sea of Galilee, and for centuries the Pope's signet ring was the Fisherman's Ring, or *Annulus piscatoris*, which was used as a seal for official papal documents. The reference is to Simon Peter, one of the fishermen on the Sea of Galilee, who became the first bishop of Rome, which later became the office of the Pope (Fig. 1.2).

In most of the religions of the world, fish is seen as a food of choice. Judaism and Islam have strict rules on diet, particularly as regards mammals, what can be eaten and how animals should be slaughtered and prepared.[c] Not so with fish, neither in those religions nor in Christianity, although there are various caveats regarding the consumption of crustaceans, no doubt rooted in fears of food poisoning. Judaism, however, forbids the consumption of fish without scales, such as sharks and rays, and also whales, which before the invention of taxonomy were generally lumped with fish.

FIG. 1.2

The Ring of the Fisherman, carried by Pope Francis (AM113).

Fish also has a positive image in Buddhism, where it symbolises happiness, among other things. Buddhism imposes various restrictions on the consumption of meat, but none on the consumption of fish, while the Hindu religion has restrictions on both. Many of these old customs linked to fish are outdated in modern society and no longer strictly observed, but their remnants can be widely observed. Religion and custom therefore remain relevant to fisheries and the consumption of fish products in our time. In Catholicism, for instance, there is a tradition of serving fish on Fridays, a remnant from earlier times, when eating flesh other than fish on that day was strictly forbidden. Fish is also traditional fare in the week of Lent among Catholics. As a matter of fact, fasting is not an uncommon religious custom, as in the case of the fasting month of Ramadan in Islam, and the Jewish fast during Yom Kippur, although these fasts have no particular relevance to fish or fish products.

In all countries there are myths, legends, fanciful tales, and seamen's yarns relating in one way or another to the sea, rivers, and lakes, which, with their aura of profound mystery, have provided both substance and a setting for innumerable stories expressed in narratives or lyrics, ranging from the sirens of the Odyssey and the story of the Lorelei in the river Rhine to the Little Mermaid in Hans Christian Andersen's fairy tale, and the modern-day giant dinosaur Godzilla, created by the Japanese Ishirō Honda in the mid-20th century and subsequently the subject of countless movies, comics, and computer games. This literary tradition has continued to our day, and the sea will no doubt provide material for fiction and fantasy for as long as the oceans remain the areas of the Earth that we know the least about.

1.3 The oceans and marine taxonomy

The animal kingdom is divided into two main categories: vertebrates and invertebrates.[d] Detailed taxonomy lies beyond the scope of this book, but in brief terms vertebrates are animals that have vertebra (a spine or an internal skeleton) while invertebrates are either made up entirely of soft tissue or have a stiff supporting structure (exoskeleton) on the outside of their bodies. Vertebrates include the familiar fish, amphibians, reptiles, birds, and mammals, all normal household words, while invertebrates include the somewhat less familiar arthropods (shrimps, lobsters, crabs, etc.), molluscs (oysters, clams, octopuses, etc.), Parazoa (sponges) and echinoderms (sea stars, sea urchins, sea cucumbers, etc.). The fauna is extremely diverse, and although not all its members have commercial value, all of them have a role in the food chain of the aquatic environment and in the viability of the biosphere.[e]

Another way of classifying the living creatures that inhabit the aquatic biosphere is to divide them into plankton (floaters), that is to say living organisms that drift with currents of wind and water, which in turn can be divided into phytoplankton (drifting algae) and zooplankton (drifting animals); nekton (swimmers), that is to say animals that are capable of swimming against currents; and, finally, benthos (bottom dwellers), that are often immobile organisms that are fixed to the sea bed.

Although the most prominent aquatic animal of commercial interest is fish and some species of crustaceans, other animal and plant species have played a commercial role at various times in history—whales, seals, walruses, and other marine mammals being prominent examples. But fish are not the only natural resources of the sea.

Benthic organisms, or bottom dwellers, can be either plants or animals. The plants in the ocean are primarily algae, which are increasingly harvested for use as feed for farmed fish; they are also cultivated for use in various industrial products, including food, drugs, and cosmetics. The benthic animals include molluscs, which are widely harvested as food, and then there are the crustaceans, such as crabs, shrimps, and lobsters, which are extremely valuable marine products.

In our modern age, fish are the only wild animals that are still hunted commercially as food, apart from some limited and mostly indigenous hunting of whales, seals, and birds. This is a totally different activity from breeding animals such as cattle and poultry, which are either kept in enclosed areas or herded into enclosed areas for feeding and subsequent slaughter. Breeding livestock as an industry bears no resemblance to fisheries, although modern-day fish farming can be said to share some characteristics with traditional farming.

Fish can travel fast in the oceans, and they can travel far and wide with their migratory patterns governed to a great extent by ocean currents and temperatures, which presents two immediate problems of harvesting: where and how. Commercial fishing requires a great deal of very specialised equipment, first to find the fish, the right fish, and then to catch it. Fish cannot generally be seen in the sea, and so needed in the past to be hunted blindly on the basis of instinct, experience, and certain natural signs of their presence, such as circling birds, feeding whales, and other signals. This problem has been mitigated to a great extent by the invention of location devices of various kinds, echo sounders ('fishfinders') and the like. Another problem that deserves mention is of course the elements themselves, as the weather can play a restricting role, especially in the not-very-distant past, when seamen would leave their home ports for far-off fishing grounds in hope and expectation, but no real certainty, of returning home (Fig. 1.3).

The continental shelves, where a large part of all fishing takes place, represent only a small fraction of the world's oceans. Away from the continental shelves, the oceans stretch down to extraordinary depths, largely unexplored for reasons of inaccessibility, darkness, and pressure. There is a more than a grain of truth in the often-cited contention that we know more about the surface of the moon, or even Mars, than the most extreme depths of the oceans.

In addition to being hard to find and catch, fish is an extremely delicate product, as it will decompose relatively rapidly if not properly handled and it will soon develop an unpleasant odour and taste. Meat from mammals and poultry will generally keep better, not to mention vegetables with their far better keeping qualities. The sensitivity of fish flesh to decomposition led quite early to advanced methods of processing and preserving, especially using salt. In the Mediterranean area, processing salt from seawater and using the salt to preserve foodstuff for the longer term began relatively soon. The Greeks and Romans led the way, followed, much later, by

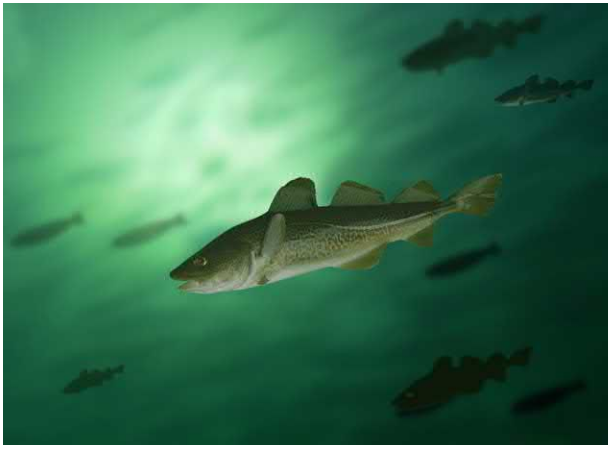

FIG. 1.3

Atlantic cod in the sea (Krasowit).

the Spanish and Portuguese, who became experts at processing salted fish and rapidly developed into prominent fisheries nations.

The oceans produce a vast abundance of food, not only in the form of fish, but also in the form of harvestable plants. Advances in fish farming have long been a cause for optimism in the face of foreseeable future food shortages resulting from the growing world population, but the same cannot be said of fishing, neither in sea nor in fresh water, as there is a very fine line between sensible harvesting and overfishing. Crossing that line can be perilous, as experience has shown. Estimating the recruitment and growth of wild fish stocks, where a multitude of species interact in very complex ways, is inherently much more difficult than planning for aquacultural production, where humans have much greater control. Yet, classic fisheries science is providing constantly improving estimates, and modelling of fish stock interactions is becoming more and more advanced.

A large part of the biomass of the sea serves as feed for the fish that is actually harvested by humans.[f] This applies particularly to the continental shelves of individual countries, where the richest and most productive fishing grounds are located. Vegetation in the sea is mostly phytoplankton, which provides food for various species of fish, while other fish survive on zooplankton, which in turn feeds on phytoplankton. So, generally speaking, the food chain in the ocean has some predatory fish that eat smaller fish, that eat zooplankton, that feeds on phytoplankton. The food chain involving fish is complex and multifaceted, and the complete picture can only be obtained by looking at the role of individual links of the chain.

The phrase ‘fishing down the food chain’ is used to describe the catching of fish, usually larger fish, that are high up in the food chain and feed on other smaller fish, that are lower in the food chain. The result is that the stocks of large fish decline, and then the fishing descends down the food chain. This fishing then also declines and that further reduces the life expectancy of the fish at the top of the food chain, as there is less food. The problem of maintaining a balance is therefore not a simple one. Among the suggestions that have been made is to demarcate areas, or enlarge already demarcated areas, where fishing is prohibited in order to build up fish stocks.

The production of one kilogramme of fish protein requires a considerable mass of other protein. Fish farming therefore causes a growing demand for fish meal, as most of the popular farmed fish are fish eaters (carnivorous). This can be a dangerous policy in the long term, and in fact there is an increasing trend in the direction of feeding farmed fish on feed made from plants, which is also a much cheaper option.

1.4 Fisheries in a historical context

Before the introduction of modern navigation technology, it was difficult for seamen to find their way around the sea. Seamen navigated by the sun in daytime and by the stars at night, but the safest way to navigate without getting lost was to keep within sight of land.

The Mediterranean seafarers, Phoenicians, Greeks, and Romans, would generally avoid losing sight of land, but this is somewhat more problematic in lands facing open oceans, let alone islands lying hundreds of miles from the nearest continent. But there were numerous seafaring nations, such as the Arabs and Japanese, and in particular the Chinese, who long commanded the world's largest fleets. The Vikings, or Norsemen, would first try to sail using coastal navigation, but were sometimes forced to take to the open oceans, which could be perilous in the event of fog, or even just overcast skies, in which case there was little to do except wait it out. The Viking ships, in particular the so-called long ships, were quite fast, and numerous replicas of these vessels have been made in recent times that have demonstrated that they were seaworthy vessels.[g]

Fishing vessels have changed radically through the ages, although a large proportion of the fishing vessels of the world remains of a very basic design. Apart from modifications for improving strength, power, speed, manoeuvrability, and comfort, the key modifications have concerned improvement of stability. Ship design is an exacting science requiring extensive knowledge of technical areas with exotic names, such as hydrostatics and hydrodynamics.

However, once a vessel has been launched and its seaworthiness proven, there is the problem of navigating it: that is to say establishing its precise location and plotting the best route to the desired destination, whether a fishing ground or a port. Anything but the most rudimentary coastal navigation required charts, accurate charts, and creating those required extraordinary effort and delicate skills, including knowledge of the way in which the heavenly bodies move in the skies and, just as importantly, a means of establishing the precise time of day. In the course of time this became a science in itself, which is now taught in specialised schools.

Technology has, of course, radically changed navigation. Radar, perfected in the years leading up to World War II, has made it possible to discern any solid objects, even low-density objects such as icebergs, in pitch darkness and fog using reflected radio waves, and a similar technology now makes it possible to measure ocean depth, chart ocean beds, and even locate schools of fish.

In earlier times, fishing had been conducted using small rowboats and hand lines or cast nets, but in the 19th century more ambitious fishermen had begun laying long lines on a grand scale, a far more efficient gear, but at the same time requiring far greater quantities of bait. The use of hand lines, known as 'jigging', usually involved casting a line with a sinker and a single baited hook down to the seabed and then 'jigging' the line, both to attract fish to the bait and to check whether there was a bite, or even to hook a passing fish. With the introduction of hand-driven winches and stronger filaments it became possible to attach a greater number of hooks to the same line and still use the jigging method. However, long lines were far more efficient; as the name indicates, this method of fishing involves attaching baited hooks to a long line at set intervals, laying the line on the seabed, and leaving it for a certain amount of time before pulling the line in again. An even more efficient method was the use of nets, particularly in lakes and rivers, but also in the sea, by sinking the net to the bottom and keeping it upright using floats.

Many communities engaged in fisheries in distant areas. Among the most proficient of them were the Basques of northern Spain and several regions in France, who sailed as far as the exceptional cod-fishing grounds off Newfoundland, the same general area where the Icelander Leif Eiríksson had passed through several centuries earlier.[h] According to lore, the Basques told no one of their fishing grounds to keep them secret, but the grounds were later discovered by the English in the late 15th century, when ships started sailing northwards from the Caribbean Islands discovered by Columbus and others and along the coast of North America. The first such journey of discovery was made on the instruction of Henry VII, King of England, under the leadership of the Italian Giovanni Caboto, later known under the more familiar name of John Cabot.[i] The discovery of the fishing grounds led to the emergence of Bristol as an important English fishing port.

For centuries, large fishing vessels were sent to the fishing grounds off Newfoundland and New England. These were fast sailing ships, schooners, carrying a number of small rowboats, or dories, that were sent out, manned by one or two seamen equipped with hand lines, and then returned with their catch to the mother ship. This was the most common method of fishing on distant fishing grounds for centuries despite the hardship, high risk, and high rate of casualties. But the frequency of accidents has always been high among seamen, and not only were dories frequently lost, but the schooners themselves would not always return to their home port.

Accounts of cod fishing in this region of the world may be familiar to readers from Rudyard Kipling's book, *Captains Courageous*, which tells the story of Harvey Cheyne, who falls overboard from a passenger ship and is saved by a dory fisherman who takes him aboard the mother ship. The boy has no option but to remain on the vessel, crewed by seamen from Gloucester, for the season and absorb the experience of life aboard a fishing vessel and among the seamen who make their livelihood from their dangerous occupation.

The invention of the steam engine completely transformed fisheries, particularly ocean fisheries on distant fishing grounds after oil replaced coal as a fuel in the 20th century.[j] Not only were the ships themselves now independent of the wind for power, but the establishment of railroads enabled swift transport of fish overland. The railroads effectively transformed transportation in the 19th century, and the wholescale laying of railroad tracks throughout the world brought about enormous economic changes. As regards fisheries, mechanisation and powerful engines and winches brought about the introduction of a new method of catching fish: the trawl, which not only revolutionised fishing, but also had an unprecedented environmental impact.

The trawl, first used to some extent in the 19th century, consists of a long, bag-shaped net which is dragged behind a vessel, or sometimes two vessels, and held open by a pair of trawl doors, or otter boards, one on each side of the opening of the bag, or purse. The trawl is weighed down using iron spheres that are dragged along the bottom, acting as wheels, and at the top there are floats to keep the purse open. The idea is that the fish swim into the gaping opening and wind up in the bottom of the purse, known as the cod-end (Fig. 1.4).[k]

The trawl and purse seine, and other fishing gear, such as the Danish seine, are extremely efficient, and in recent years there has been fervent debate, and heated arguments, over the extent of the damage caused by trawls to the seabed and thereby the habitats and spawning grounds of fish; among the concerns are the disturbance to the seabed fauna and flora and indiscriminate fishing, as the trawls are said to capture or destroy

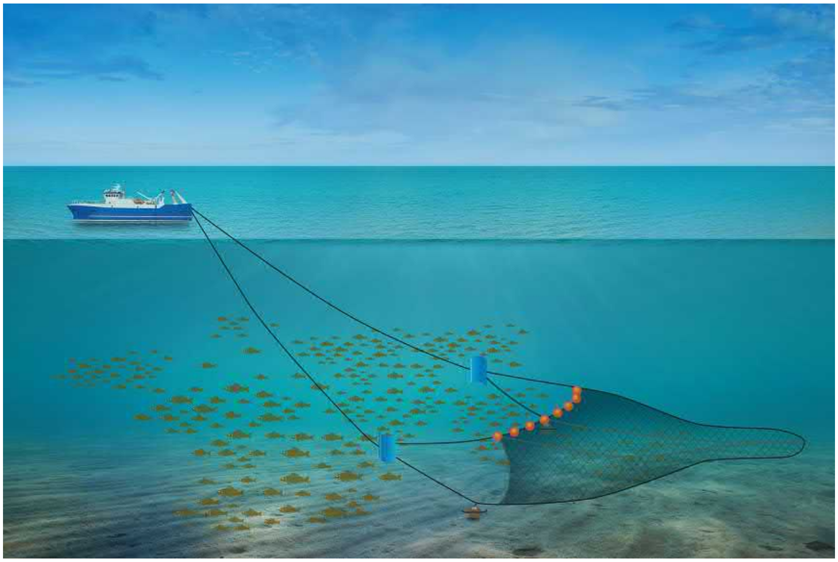

FIG. 1.4

Bottom trawling (Ólafur Kristjánsson).

FIG. 1.5

The British Frigate HMS Scylla rams the Icelandic coast guard vessel Óðinn, in the Cod War in April 1976 (Wikimedia Commons—Issacs Newton).

everything that gets in their way. Generalisation in this regard is futile, as the extent of damage depends very much on the nature of the seabed, but in any case, trawling has been banned in some regions on the grounds of its environmental impact. Arguments between those who use trawls and those who use other gear are as old as the trawl itself, but in truth disputes on different types of fishing gear have been ongoing for centuries.

The problem of overfishing was largely unknown in earlier centuries, for the simple reason that the fishing effort and effectiveness never achieved the level needed to have a sufficient impact to endanger fish stocks.[1] There were natural fluctuations, of course, and sometimes fish would vanish from traditional fishing grounds, but they always returned. However, with the rapid technological advances of the 20th century, and in fact before that time with the advent of coal-driven and subsequently oil-powered vessels, efficiency and effectiveness increased exponentially, and by the turn of the last century, in 1900, there was already evidence of declines in fish stocks. By the early 20th century concerns were being expressed about the condition of some fish stocks and the risks of overexploitation (Fig. 1.5).[m]

An illustration of the Cod Wars

Fishing and control over territorial waters are vital for many countries. The Icelandic struggle for the extension of its territorial waters, and subsequently its economic jurisdiction, began in the late 19th century and lasted for almost 80 years. In 1901 the Danes and English agreed that the Icelandic fisheries jurisdiction should be three nautical miles; this agreement remained in effect for decades. Nevertheless, this jurisdiction was not universally accepted by foreign fishing vessels, and stories of conflicts between Icelandic fishermen and foreign trawlermen abound.

Immediately after Icelanders achieved home rule in 1904 they began their campaign to extend their territorial waters, but with little success, as the country's foreign affairs were still in the hands of Denmark. It was not until 1944, when Iceland achieved full independence, that it became possible to extend the territorial waters based on Icelandic viewpoints. In fact, Icelanders took the lead in the world in the extension of their fisheries jurisdiction, and subsequently economic jurisdiction, first by extending the boundary of the territorial waters to four nautical miles in 1952, drawing the baseline points so that all fjords and bays fell within the territorial waters. The territorial waters were then extended to 12 miles in 1958, 50 miles in 1972, and 200 miles in 1975.

When evidence emerged of a decline in the fish stocks around Iceland, particularly cod, the government needed to respond; otherwise, there was a risk that the cod stock would collapse, as the herring stock had in the late 1960s. However, the struggle was not without conflict, and there were skirmishes on the fishing grounds when the British, in particular, but also the Germans, tried to thwart these decisions of the Icelanders. Nevertheless, Icelanders won a decisive victory in the end, not least due to the effectiveness of the Icelandic Coast Guard. Under international law the economic jurisdictions of coastal states, referred to as exclusive economic zones (EEZ), are now set at 200 nautical miles. Where the distance between coastal states is less than 400 miles, the centreline between the states is set as the boundary. Iceland's determination to extend its territorial waters in the decades following World War II, together with the first decisions of the newly founded republic, proved more than favourable. These measures laid the foundation for the current prosperity of Icelanders as an independent nation.

Icelanders are now among the wealthiest nations in the world, with one of the highest standards of living, in a large part thanks to fisheries, the modernisation of the fisheries sector, and control over their own territorial waters and economic jurisdiction.

The introduction of steam power in the mid-18th century brought external energy to human society for the first time on any significant scale. Before that, all work had largely been done by the muscle power of people and animals, although wind and water had been harnessed to some extent, especially to drive mills and propel sailing vessels. Some 250 years ago a period of rapid progress began, with no end yet in sight; but this progress, combined with a rapidly growing world population, has brought a complex set of problems, including difficulties of ensuring an adequate supply of food for everyone and growing strain on the environment. It remains to be seen whether solutions will be found to these problems, and what form the solutions will take, in order to secure the food security of the future.[n]

1.5 Fisheries and aquaculture in modern times

The business environment of the fisheries sector has undergone a profound transformation in recent years and decades. Until the 20th century, the general assumption was that the fish stocks of the world were inexhaustible and that no special regulation of fisheries was needed. This notion turned out to be wrong, as a number of fish stocks have been depleted through overfishing, and some are still at risk of extinction. At the same time, the world population has grown at an unprecedented pace and all those people need food.

As shown in Fig. 1.6, the population of the world remained more or less unchanged for the first 1000 years of the period depicted, at about 300 million.[o] The next 800 years showed relatively small increases, by about 110 million, and by 1800 the figure stood at about 410 million. Then, in the 19th century, the

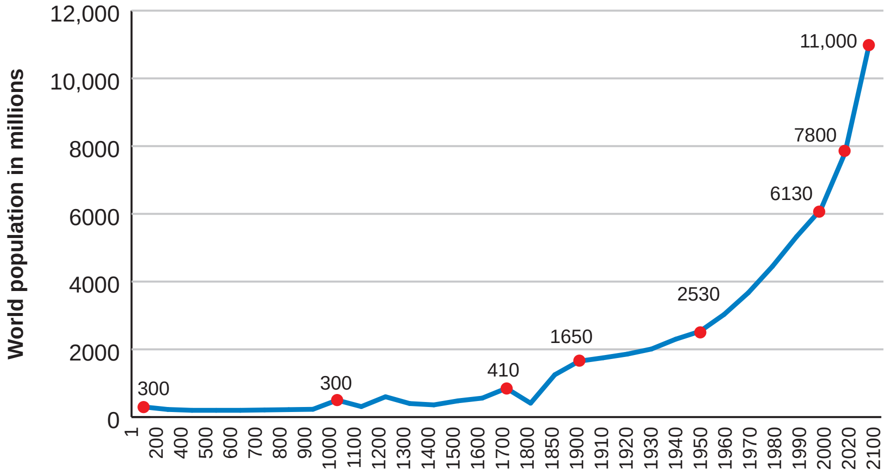

FIG. 1.6

World population in millions from 1 to 2100 CE.

population grew rapidly with the Industrial Revolution in full swing. By 1900, the world population had grown by about 1240 million and stood at about 1650 million. But the biggest surge came in the 20th century, with the population growing by four and a half billion people to about 6130 million. In the first 20 years of the 21st century the population continued to grow, by some 1700 million, bringing the total to 7800 million by 2020. By the end of the 21st century the world population will stand at about 11,000 million, at which time the anticipation is that the growth will cease, among other things because families in the developing countries will have fewer children. A large majority of the world population will live in Asia and Africa. This population growth will have occurred almost exclusively in the developing countries, with little or no growth in many of the richer countries.

This huge population growth of recent decades has been accompanied by the greatest and fastest technological and scientific advances in human history. As a matter of fact, one of the principal reasons for the population growth is the advances in medical sciences, with average life expectancy increasing significantly. The difference between today's population size and the population size of earlier times is so vast that comparison with history is meaningless for any analysis of the current situation (Fig. 1.7).

Technological advances, particularly in agriculture, have made it possible to feed all these people, although not everywhere. Severe shortages of food remain a problem in many parts of the world, and each year millions of people die from diseases resulting from malnutrition.[p] Food shortages and climate change are the most serious problems confronting the world in our times, not least because of ever stronger

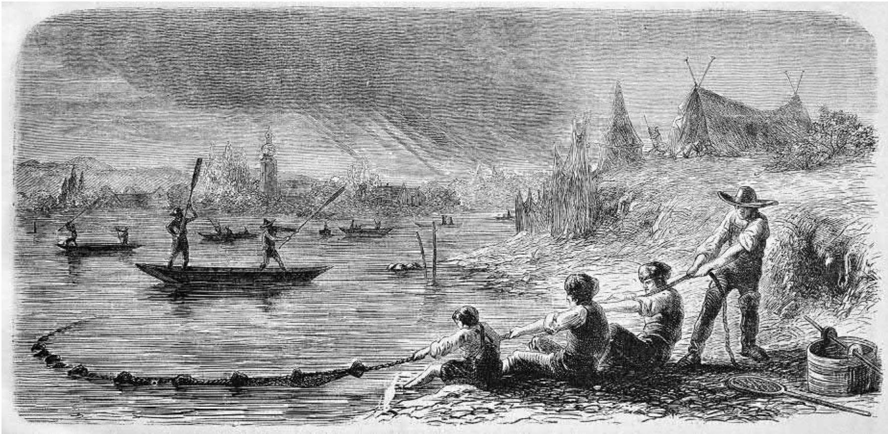

FIG. 1.7

Fishing in earlier times (Jundt).

evidence of links between food shortages and regional conflicts and outright wars. Both problems are relevant to fisheries, but unfortunately neither has been given sufficient attention in discussions of fisheries and aquaculture.

Many aspects of fishing, and fish farming, are in most respects similar to those of any other production industry and subject to the same general conditions as other industries, for instance with regard to production planning, marketing, competition, and business environment in general. Poor nations have assumed a larger role in world fisheries, both in fishing and fish processing, particularly in Asia, where the population growth has been greatest. These countries are in precisely the same position as Icelanders were over 100 years ago, to take one example, with the exception that technology is now far more advanced. However, very few of these countries command the most recent fisheries technology.

The oceans have long been regarded as an endless source of food for the growing world population, but the vastness of the ocean is deceptive, as the preponderance of the fish harvested from the ocean is caught relatively close to land and at relatively shallow depths. Better results have been achieved in recent decades in managing fisheries, and the number of species at risk of actual depletion has fallen; nevertheless, we are still a long way from utilising fish stocks in a sensible manner, or optimally, from the point of view of marine sciences, and we are still farther from the goal of organising fisheries on a worldwide basis to achieve the best possible efficiency and maximum yield.

The total world catch of fish has remained virtually stagnant in recent years, while the output from fish farming has increased exponentially, responding to the need to increase the supply of fish products for the growing world population. Around 1950, the world population stood at about 2.5 billion, as shown in Fig. 1.6, and shortly after that time and into the 1960s the effect of the Green Revolution, as it has been called, began to be felt.[q] The Green Revolution brought about enormous progress in agriculture, with new varieties of high-yield cereals and vast increases in crops. The increased use of fertilisers and larger areas devoted to farming, in addition to the use of chemicals to combat pests and weeds, resulted in vastly increased production of food.

Despite the success of the Green Revolution, there is still need for increased production of food, as it is estimated that the world population will grow by over 3 billion, to 11 billion, by 2100. Feeding an estimated 11 billion people will require a massive amount of food. Some success can be achieved simply by eliminating waste. In fisheries, a starting point would be to eliminate the discarding of fish, that is to say when fish is tossed overboard because of low value or small size, or even because bringing it ashore is illegal.

It is estimated that almost a billion people in the world are suffering from hunger, and about three billion out of the little less than eight billion that currently inhabit the world are struggling with some consequences of malnutrition. It has also been estimated that about 30% of all produced food is destroyed in the course of production or distribution by insects and rodents. Another large proportion is also destroyed when food passes its selling date and goes to waste. Bear in mind that when this happens, it is not only the food itself that is wasted, but all the effort that went into its production and distribution, including raw material, labour, water, and energy. This is an extraordinary amount of waste, and it is a matter of great urgency for producers, distributors, and vendors to improve this situation. Another urgent task is to take up more environmentally sound farming, to use water more sensibly, to reduce the energy that is expended on food production and, last but not least, to use the oceans and their resources for food production, whether by fishing or fish farming.[r] The key concept here is sustainability—the utilisation of natural resources in a manner that preserves them for the coming generation in the same quantities and quality as the current generation.[s]

Virtually all the countries in the world engage in some form of fisheries, in the sea, lakes, or streams, and although fisheries have been a human activity since the earliest times, as mentioned at the outset of this chapter, it is not until about the mid-20th century that fisheries begin to take shape as a full-scale modern industry, as illustrated in Fig. 1.8.[t]

Fig. 1.8 shows the extraordinary growth of the industry, stemming not only from the pressures of increasing demand because of population growth, but from the technological advances, with the larger, better built vessels, bigger more powerful engines to drive not only the vessels themselves but their winches and other gear, synthetic filaments, fish finding equipment, not to mention advances on shore in the form of production plants, and so on.

In 1950 the total world catch was 19.2 million tons. By 1990 this figure was up to 86 million tons, and by 2019 it was 96 million tons. This is a fivefold increase, while the world population in the course of the same period grew from 2.5 billion people in 1950 to 7.7 billion, a threefold increase. The catch figures have thus done better than just to keep up with the population growth. However, as Fig. 1.8 also shows, the catch

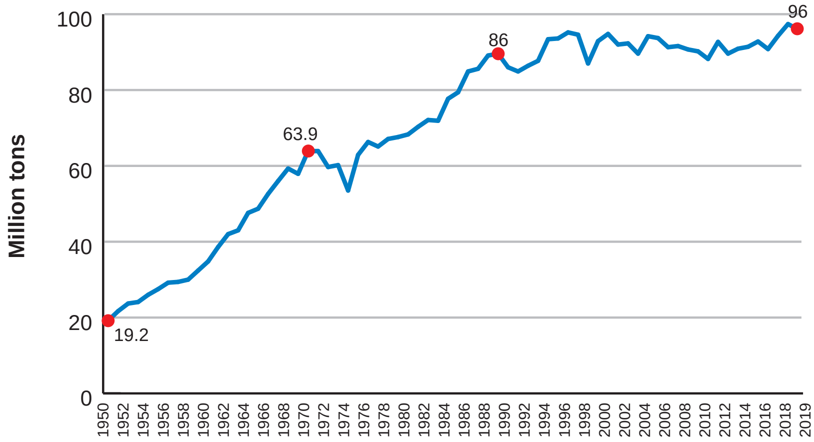

FIG. 1.8

World catch in million tons 1950–2019.

has been largely stagnant over the last 25 years, at around 90 million tons. Of this total catch, about 10 million tons are harvested from lakes and rivers, while about 80 million tons are harvested from the oceans.

Looking at value, it is estimated that catches from the sea, lakes, and rivers in 2017 were worth about 130 billion US dollars (USD), but this tells only a part of the story, as the value of the catch increases significantly with processing and packaging. It needs to be borne in mind, however, that the value of individual catches is extremely variable, so that adding together a hundred kilograms of sardines and a hundred kilograms of lobster makes no sense in terms of value. Nevertheless, the numbers in both Figs 1.8 and 1.9 give a good idea of the increase in output in both ocean fishing and fish farming, respectively. As in the case of ocean fisheries, the output of fish farms has grown exponentially, as shown in Fig. 1.9.

As the chart in Fig. 1.9 shows, the output from fish farms stood at a mere 0.6 million tons in 1950, but by 1970 the numbers were up to 3.6 million tons, by 1990 they were 17.3 million tons, by 2000 they were 43 million tons, and by 2019 they were 116 million tons, with aquatic plants, such as seaweed, included. Looking at value, it is estimated that outputs from fish farms were worth about 250 billion USD in 2017. The world catch and fish farms accounted at first sale for an amount of about 380 billion USD in 2017. Overall, the total quantity of global capture and farming has increased 10-fold in just over half a century, up to a combined total of 210 million tons per year, of which about 180 million tons are fish and 30 million tons are plants, which are partly used for feeding farmed fish.

Fish is now by far the most traded food product in the world, with almost 40% of all fish produced being sold across borders. More than half of the fishery products in international trade now originates in developing countries. Some of this fish trade involves imports of unprocessed fish to developing countries, where it is processed

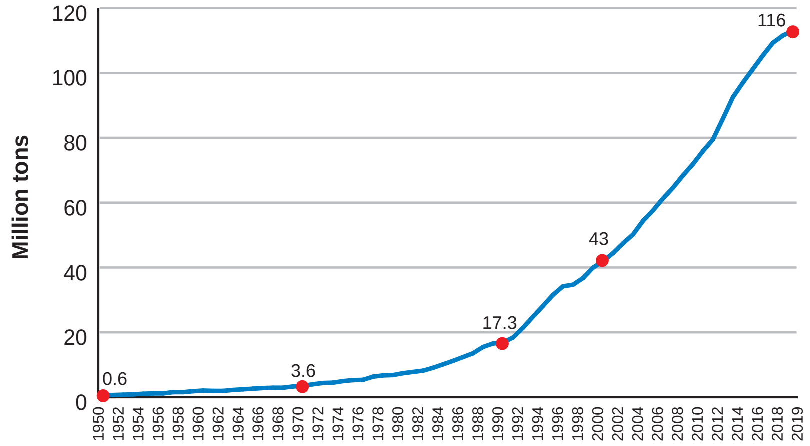

FIG. 1.9

World fish farming output in million tons, 1950–2019.

and portioned for export to developed countries. In terms of foreign currency earnings, fish has for decades been more important in this respect than the combined exports of coffee, tea, cacao, and bananas.

As Fig. 1.10 shows, the catch is by some distance the greatest in Asia, where catches grew from 44 million tons in 2000 to 49.9 million tons in 2018. Asia's share in the total catch was 51% in 2018, up from 47% in 2000. Other continents lag far behind Asia, with the Americas coming second with 21% of the world catch in 2018. By far the largest fishing country in the world is China, with a catch of 15 million tons in that year.

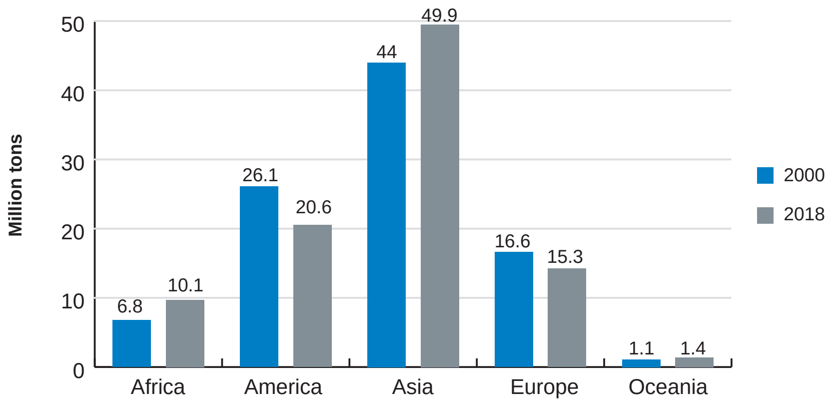

FIG. 1.10

World catch by continent in 2000 and 2018.

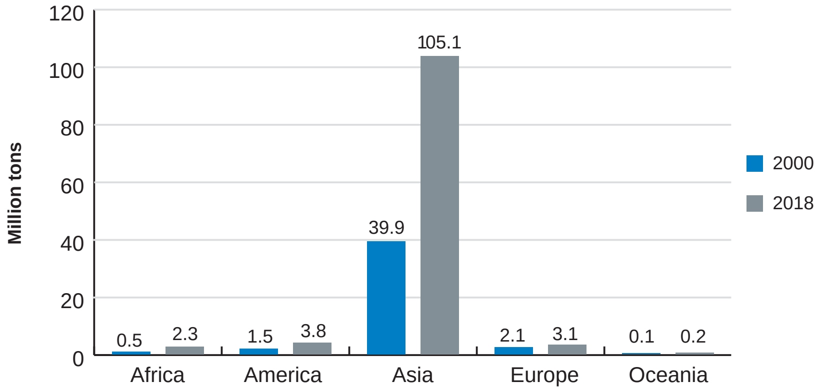

FIG. 1.11

World fish farming by continent in 2000 and 2018.

As Fig. 1.11 shows, the greatest quantity of farmed fish is produced in Asia. In 2018 the quantity in Asia was 105.1 million tons, corresponding to 94% of the world production. In 2000 the quantity produced of farmed fish in Asia was 39.9 million tons or 91% of the total world fish farming production. As in the case of fisheries, China is by far the biggest producer of farmed fish, with 66 million tons produced in 2018.

Fish farming as an industry has grown rapidly in recent years. However, the potential for growth is not unlimited, partly as a result of the need for feed for farmed fish, nor is fishing in the sea, streams, and lakes unlimited, as we have come to understand in recent decades. These limitations are compounded by challenges such as greenhouse gases, climate change, and growing pollution on land and offshore, in part resulting from fish farming. It is therefore paramount for the nations of the world to address the serious problem of nutrition in the world and to establish priorities in that context to ensure the food security of the world.

Since fish farming has grown to such an extent as a viable industry, the question arises whether fish farming could to some extent alleviate the food problems of the future, perhaps even replacing catching fish in the wild to some degree, a farmed fish is so much cheaper to produce that it can push ocean catches off the market. The market will seek a balance, and this balance will be determined by efficiency. In the case of some species, such as salmon, the supply is already mainly from farms.

The price that consumers are willing to pay for fish must cover the cost of production. Suppose that wild fish and farmed fish are perfect substitutes. Wild fish must be caught with expensive equipment and is, for that reason, more expensive than farmed fish that simply swims around waiting to be slaughtered. But wild fish procure their own food, while farmed fish must be fed, and feed costs are often the largest part of the farming cost. With the same price for both, the cheapest source will win. Logistics could also be a factor; deliveries of farmed fish can be scheduled according to market demand, while supplies of wild fish are subject to the vagaries of nature. For the supply of wild fish, preservation over days, weeks, or even years is therefore an important consideration.

Environmental awareness has been growing in recent years, and a number of companies, such as the British–Dutch food production giant Unilever, one of the largest producers of foodstuffs in the world, are working in close cooperation with environmental organisations like the World Wildlife Fund (WWF). Fish products are increasingly being environmentally certified to provide assurance that the fish is caught and processed in accordance with recognised environmental standards.[u] One of the most prominent organisations working in this area is the Marine Stewardship Council, founded in 1996 by Unilever and the World Wildlife Fund.

Many fisheries enterprises have not always shown great awareness with respect to cooperation between manufacturers and environmental organisations. However, it has now become a matter of urgency for the fishing industry to understand that when it comes to natural resources we are all in the same boat, and our common interests rest on sustainability of utilisation. All extraction industries with the potential of negatively affecting the natural environment must conduct their business operations in a responsible and transparent manner, at peace with the general public. Otherwise, we will not manage to resolve the huge problems of the environment and the future population growth.

The world is currently confronting a number of problems relating to food shortages, actual and potential, and environmental challenges, compounded by ongoing turmoil in international, and in fact human, relations. The world population is growing rapidly, and providing food for all these people will be a formidable task.

All nations are hugely dependent on finding solutions to the global problems of pollution and greenhouse gases, both of which have a profound influence on the environment. We need to make people understand that fisheries and aquaculture, if conducted in a sensible manner, are an important factor in food production and necessary to ensure food security in the world.

Endnotes

a. For a discussion of the origin and development of writing see, e.g., Coulmas (1991).
b. The universal abbreviations 'CE' (Common Era) and 'BCE' (Before the Common Era) are used throughout the book in preference to the Dionysian 'BC' and 'AD'.
c. For a discussion of various religious customs see, e.g., Coogan (2003).
d. For easily accessible works on animals and their habitats see, e.g., Walters and Johnson (2007), Dinwiddie et al. (2014), and Attenborough (2018).
e. For a description of the basics of fisheries biology see, e.g., Walters and Martell (2004) and Castro and Huber (2013).
f. Since fish live in water, in what we might call a 'weightless' environment, the texture of their flesh and strength of their muscles are completely different from the corresponding features of land animals. Cod can be preserved for 15 days at 0°C, but at the same

temperature lamb can be preserved for 15 weeks. It is estimated that about 10 kg of live fish are needed to produce 1 kg of a larger fish, meaning that 1 kg of cod requires 10 kg of, say, capelin; in a fish farm, however, this need is at least halved, with only 5 kg of capelin needed to produce 1 kg of farmed cod (S. Arason, personal communication, March 24, 2020).

g. For a discussion of ancient navigation see, e.g., Beresford (2012) and Karlsen (2018).

h. For an interesting discussion of cod, its consumption, and related traditions see Kurlansky (1998).

i. For information on voyages to North America in the 16th century see, e.g., Hunter (2011) and Einarsson (2016).

j. For details of the industrialisation of fisheries and mechanised winches and vessels see, e.g., Cushing (2008).

k. For a discussion of different fishing gear and its use see, e.g., Hastings (2015) and Muus, Nielsen, Dahlstrom, and Bente (2014).

l. Thomas Huxley (1825–95), one of the best known scientists of his time, once said: "I believe, then, that the cod fishery, the herring fishery, the pilchard fishery, the mackerel fishery, and probably all the great sea fisheries, are inexhaustible; that is to say, that nothing we do seriously affects the number of the fish. And any attempt to regulate these fisheries seems consequently, from the nature of the case, to be useless." (Haddon, 2001, p. 1).

m. Concerns about overfishing are discussed in Edward Stuart Russell's book, *The overfishing problem*, published in the United Kingdom in 1942.

n. The definition of food security according to the Rome Declaration of 1996 is as follows: "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life." (World Food Summit, 1996, November 13).

o. For information on population see Worldometer (n.d.).

p. For a discussion of hunger, undernourishment, and its consequences see, e.g., World Health Organization (2000), Van den Berg (2012), and Ababa (2019, February 13).

q. For a discussion of the Green Revolution see, e.g., Evenson and Gollin (2003) and Cunningham (2015).

r. For a discussion of feeding the world in the future see, e.g., Nellemann et al. (2009) and Thomson Reuters (n.d.).

s. For a discussion of the sustainable harvesting of fishing grounds see, e.g., Greenberg (2010) and Sankar (2015).

t. Information on catches and fish farming in the world by continent, as shown in Figs 1.8–1.11, is obtained from the publications and databases of the FAO see Food and Agriculture Organization of the United Nations (2020, n.d.-a). The figure for 2019 is estimated based on data from FAO and other sources see Food and Agriculture Organization of the United Nations (2019c, April, 2019d, October).

u. For a discussion of ecolabelling of fish products see, e.g., Gudmundsson and Wessells (2000) and Roheim (2009).

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CHAPTER

Fishing and fish farming

2

Fishing and fish farming are studied in a variety of scientific disciplines and from a number of viewpoints. From a statistical standpoint, however, comparisons of fisheries between countries are not simple, largely because records are inadequately kept in many countries, and where they are kept the data are not always in a form that allows comparison. For both organisations and countries, good statistical information is crucial to all research and analysis. Internationally, the work of the Food and Agriculture Organization of the United Nations (FAO) is most prominent, as the Organisation has collected extensive data from individual countries and published the data in accessible form, including in databases and in the publication *The State of Fisheries and Aquaculture*, which is published biannually, with the latest current edition dating from 2020. The following sections are mainly based on statistical data collected by FAO, with the data organised to provide a consolidated view of fishing and fish farming in the world.

2.1 Fishing, the principal fishing countries and harvested species

Some 25,000 species of fish exist in the world; just over half of these species are marine species, while just short of half live in fresh water, while a few species inhabit both sea and fresh water. The total quantity of fish harvested by fishing and fish farming in the world in 2019 was about 212 million tons, of which most was for human consumption.

The FAO keeps records of some 600 fish stocks worldwide. Fig. 2.1 shows the harvest of the world's fish stocks over a 40-year period. As shown in Fig. 2.1, 40% of these fish stocks were considered underutilised in 1975; 40 years later, however, this proportion was down to 7%. Half of the fish stocks was considered fully utilised in 1975, but by 2015, this proportion was up to 60%. In 1975, 10% of the world's fish stocks were considered to be overfished, but 40 years later this proportion was up to 33%.

This comparison brings home to us how little has been achieved in most countries of the world as regards fisheries management. In 1974 the total world catch was 63 million tons, or about two-thirds of the catch in 2019, 45 years later. Overfishing is one of the most serious challenges facing global capture fisheries in the world, if not the most serious problem. In many places the situation is actually dire as a result of

Fisheries and Aquaculture. https://doi.org/10.1016/B978-0-12-821056-7.00008-1

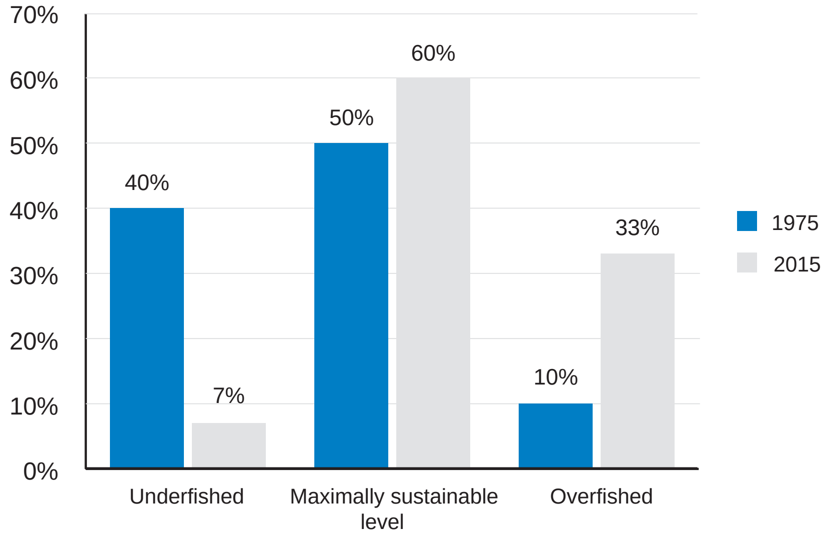

FIG. 2.1

Utilisation of the world's fish stocks in 1975 and 2015.

overfishing, especially in areas like the Mediterranean Sea, the Black Sea, the Southeast Pacific, and the Southwest Atlantic. On the bright side, a degree of success has been achieved in reducing fisheries from overutilised stocks in some places, like in the United States, Australia, and the Northeast Atlantic.

The value of exported fish in the world in 2018 was 164 billion USD, about half of which originated in the developing countries, illustrating the importance of fishing and fish farming for the poorest nations of the world. In fact, fish exports from developing countries have generated more revenue for them than exports of meat, tobacco, rice, and sugar combined.[a] Although much of the fish caught for human consumption is sold to customers either fresh or chilled, about a third is sold frozen. Fishery products are by far the most internationally traded food product. That quantity has increased by a factor of 2.5 since 1975, that is to say over a period of 40 years. The value of this trade has increased from 8 billion USD since 1975 to 164 billion USD in 2018, with the growth most prominent in the developing countries.

In 2018 China was the largest exporter of fish in the world, ahead of Norway, Vietnam, India, Chile, Thailand, and the United States. The largest market for products deriving from fisheries and aquaculture is the European Union (EU), ahead of both the United States and Japan. These three areas account for about 60% of the total value of all imported fishing and fish farming products. By far the largest ocean fishing area in the world is the Pacific Ocean, followed by the Atlantic Ocean. Both the Pacific and the Atlantic, the two largest oceans in the world, are divided into a number of fishing areas (Fig. 2.2).

FIG. 2.2

British fishing boats head out to sea (Alan Smillie).

The primary sectors of capture fisheries and aquaculture employ a large number of people in the world, about 60 million people, most in Asia. Of these 60 million, 40 million engage in fisheries and 20 million in fish farming. Approximately 14% of the 40 million are women, about 6 million. The number of fishermen, however, has declined in recent years in Europe and North America, although the number has grown significantly in Asia and somewhat in Africa, Latin America, and Oceania.

As Table 2.1 shows, it is estimated that about 4.6 million vessels engage in fishing in the world. This number has remained stable in recent years. Most of the vessels are based in Asia. Of the total of 4.6 million vessels, 1.7 million are nonmotorised, that is to say 37% of the entire world fishing fleet. Some 2.9 million are motorised fishing vessels, and the majority of those vessels, about 2.4 million, are under 12 m in length. What this description of the fishing vessels of the world shows is that in most places fishing is conducted in small vessels, many of which are not motorised. Larger

Table 2.1 Distribution of the number of fishing vessels in the world in 2018.

	No. in millions	**Proportion (%)**
Number of vessels, nonmotorised	1.7	37
Number of vessels, motorised, but under 12 m	2.4	52
Number of vessels, motorised, over 12 m, under 24 m	0.4	9
Number of vessels, motorised and over 24 m	0.1	2
Total	**4.6**	**100**

vessels of over 24 m and 100 tons in gross tonnage (GT) number less than 100,000 and represent a very small proportion of all motorised fishing vessels. This fleet, which is also the most technically advanced, is mostly based in Europe, North America, and Oceania.

As Table 2.2 shows, China is the biggest marine fishing country of the world, with a catch of 12.7 million tons per year. China is followed by Peru, with about half of China's catch. In total, the 25 countries in Table 2.2 caught about 68 million tons of the 84 million tons caught that year, or just over 80%. Twelve of the countries in the table are in Asia, five are in Europe, with Russia at the top. Of the five European countries three are Nordic countries: Norway, Iceland, and Denmark. Seven countries are in the Americas, with Peru heading the list, and two countries are in Africa. The United States is among the largest and most populous countries in the world with the world's strongest economy by most standards, but it is also a strong fisheries country. This is not entirely surprising, though, as the country has an extremely long

Table 2.2 Largest marine fishing nations of the world in 2018 and their total catches in millions of tons.

	2018	Rank
China	12.7	1
Peru	7.2	2
Indonesia	6.7	3
Russian Federation	4.8	4
United States of America	4.7	5
India	3.6	6
Vietnam	3.2	7
Japan	3.1	8
Norway	2.5	9
Chile	2.1	10
Philippines	1.9	11
Malaysia	1.6	12
Mexico	1.5	13
Thailand	1.5	14
Morocco	1.4	15
Korea, Republic of	1.3	16
Iceland	1.3	17
Myanmar	1.1	18
Mauritania	1.0	19
Spain	0.9	20
Argentina	0.8	21
Taiwan Province of China	0.8	22
Denmark	0.8	23
Canada	0.8	24
Iran	0.7	25

coastline and borders on two of the world's major oceans. The same countries will usually head the list year after year.

In 2018 the most harvested species in the world was anchoveta, followed by the Alaska pollock, as shown in Table 2.3. There are no significant changes between years as regards the most prominent species, except in the case of anchoveta, which is caught off the coasts of Peru and Chile and is very dependent on the variations in winds and sea surface temperatures in that area, a climate phenomenon known as *El Niño*, whose impact is felt every few years in these waters.

Catches of the most valuable marine species, such as shrimp, crab, and lobster, have fluctuated in recent years, but the total value of the catches of these species has been going up rapidly in recent decades. The rising prices of each kilogramme of the harvested species lead to increased fishing, thereby increasing the risk of overfishing. This is of particular concern with regard to the most valuable species. Marine catches have increased the most in warm climates, the environment where most of the developing countries do their fishing. Cold water fishing is mostly the domain of the industrialised countries, and in those areas catches have remained more or less unchanged over the last few decades.

An interesting comparison can be made of the Nordic countries and their respective fisheries. Of the five Nordic countries, three are prominent fishing countries, that is to say Norway, Denmark, and Iceland. Fisheries in Finland and Sweden are much smaller sectors, as the home waters of those two countries are limited, apart from access to the Baltic Sea, and even only a part of that sea. Interestingly, however, the Finns and Swedes consume more fish per capita than the Danes.

Norway is at the forefront of the Nordic countries, both as regards marine captures and fish farming, the latter being far in advance of the aquaculture sectors of the other Nordics. In fact, Norway ranks seventh in the world in aquaculture and is a world leader when it comes to salmon. Looking at the value of first-sale captures (the general term for the value of a fish catch from a vessel) of recent years for the three

Table 2.3 Ten of the principal marine species harvested in the world in 2018.

Species	Quantity in millions of tons 2016
Anchoveta	7.0
Alaska pollock	3.4
Skipjack tuna	3.2
Atlantic herring	1.8
Blue whiting	1.7
European pilchard	1.6
Pacific chub mackerel	1.6
Yellowfin tuna	1.5
Scads	1.3
Atlantic cod	1.2

countries, with an average calculated for several years, Norway has an annual value of about 2000 million USD, Iceland about 1000 million USD, and Denmark about 500 million USD.[b] For comparison, over the same period, using the same method of calculation, Sweden's catch value is estimated at about 100 million USD, and Finland's at about 40 million USD. In Norway, the export value of fisheries and aquaculture products is about 12 billion USD. Just short of three quarters of this value derives from aquaculture and about one quarter from fishing.[c] This export value of the Norwegians is six times the export value of fisheries and aquaculture products from Iceland.

The Norwegians are quite conscious of the importance of farmed salmon for the Norwegian economy. Erna Solberg, Norway's prime minister, has said that farmed salmon is a first-class trademark for Norway that the media should give greater attention. In Solberg's opinion, salmon should be symbolic of Norway, just as IKEA is symbolic of Sweden.[d]

Several species make up the substance of Norway's catch value: cod, saithe, haddock, herring, mackerel, and blue whiting.[e] Although Norway is a prominent fishing nation, fisheries are mostly important in certain rural areas of the country, particularly the northern regions. Fishermen make up only about 0.5% of the total labour force in Norway while, for comparison, they are about 2% of the Icelandic labour force.

Denmark is a prominent fishing nation. Denmark's export value from products deriving from fisheries and aquaculture in 2017 amounted to 4.6 billion USD. Denmark imports fish in great quantities from other countries for further processing and repacking and thereby creates far greater value of fish exports from catches other than their own. The Danes are among the largest exporters of fish products in the world.[f] This is worthy of note, as Denmark does not have access to any abundance of natural resources. Using their imagination and resources bought from other countries the Danes have managed to rise to one of the highest standards of living in the world. Denmark is well positioned to import fish from other countries and re-export to Europe, as in the case of fresh salmon bought from Norway to be smoked and resold. As in Norway, fisheries in Denmark have some regional importance, particularly in western and northern Jutland and Bornholm in the Baltic Sea.

To assess with some degree of precision the impact of individual sectors on a country's economy, the contribution of that sector to domestic product gives a good indication. By studying the impact of ancillary economic activities, for instance the manufacturing of technical equipment, fishing gear, transport, and other factors, it is possible to assess the total contribution of the sector to the economy. Such studies have been conducted for Iceland, for example, where the contribution of fishing, fish farming, and fish processing to gross domestic product (GDP) is assessed at 9%, but if all related economic activities are included the contribution of fisheries and aquaculture in Iceland to gross domestic product becomes as high as 20%–25%.[g]

An illustration of productivity trends in fishing

Productivity is the term used for the efficiency of production. Productivity in fisheries can be calculated in a number of ways, for instance by dividing the catch value at a fixed price level over time by the number of fishermen. This gives us the change in the productivity of fishermen or the labour force. This is a simple way to measure productivity, as it is not based on complex data, which makes it suitable for individual enterprises and environments where numerical data are scarce or unreliable.

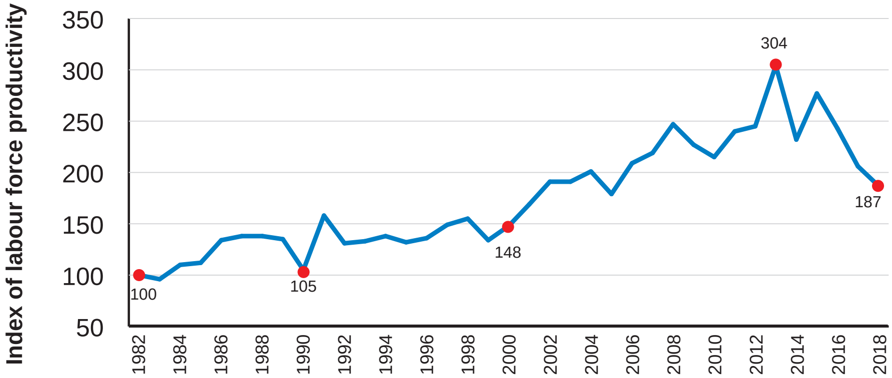

FIG. 2.3

Labour productivity index in fishing 1982–2018.

An example of simple calculations of this kind is the productivity trend in fisheries in Fig. 2.3 for Iceland over 35 years using an index of 100 at the start of the period in 1982.[h]

As shown in Fig. 2.3, productivity increased in most of the years during this 35-year period. By 2000 the increase had grown to just short of 50% and the index reached 304 in 2013 and 187 in 2018. After 2012 the chart shows a decline in productivity. Nevertheless, productivity almost doubled over the 36 years. Fig. 2.3 gives a good indication that performance in fisheries has improved in Icelandic fisheries over the period, although not in recent years. The improvement is partly a result of technological advances and the operational discipline imposed by the fisheries management system.

It is possible to examine the amount of capital tied up in fisheries; this is the value of the assets used in fishing, especially ships and boats. If this is compared to catch value, that gives us the capital productivity, as exemplified by Iceland in Fig. 2.4, where the index is set at 100 at the beginning of the period.

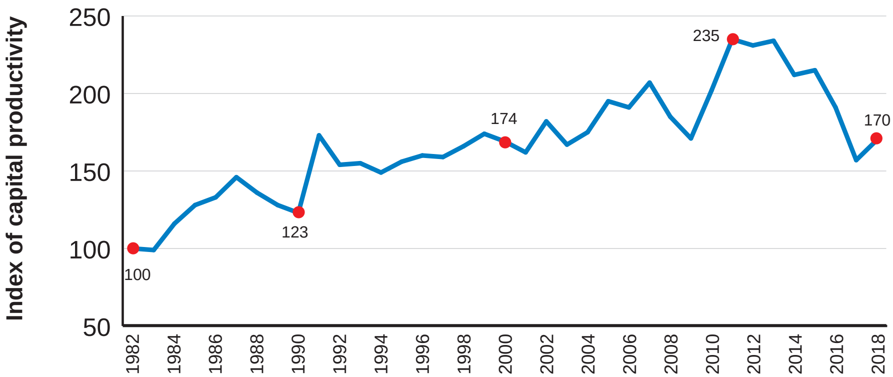

FIG. 2.4

Index of capital productivity in fishing in 1982–2018.

As shown in Fig. 2.4, the index of capital productivity grew by 74% from 1982 to 2000 and continued to grow until 2011, when it began to decline and ended at 170, which translates into an average annual growth of 1.5% over the 36-year period.

[h]The calculations of productivity shown in Figs 2.3 and 2.4 are based on data from Statistics Iceland see Einarsson (2016).

The earlier calculations of productivity, as illustrated in Figs 2.3 and 2.4, indicate that the productivity of fishermen and capital has increased somewhat, although the increase has slowed in recent years. Comparable calculations of productivity are an important aid to monitoring trends in fishing over the long term. Using this simple method, individual firms can compare between years whether a certain value of production has been achieved with fewer employees this year than last year, or whether the value of production of each dollar invested in fishing is growing between years. By the same token, government authorities and scientists can conduct measurements of this kind to observe the trends in a specific economic sector in comparison with other sectors.

As numerical data become more extensive and reliable, more complex calculations can be made of productivity and other matters relating to fisheries and aquaculture. To give an example, two factors, labour and capital assets, can be compared to assess sector productivity. Account can also be taken of a third factor, i.e., the fish stocks, in which case the stock sizes of different years are assessed. The conclusion of these calculations in the case of Iceland, for instance, is that the increase in productivity in fisheries in the past decades is largely due to the growth of the fish stocks, that is to say the stocks are now larger than they were, which supports the conclusion that fisheries management can be successful.[i] Larger fish stocks not only mean more fish to catch, process, and sell, but also more efficient harvesting, as the catch per unit of effort is greatly increased.

Inland fishing in lakes and rivers represents a significant proportion of world fisheries, with some 12 million tons caught in the world in 2018, which corresponds to about 12% of the total world catch.[j] Most inland fishing is conducted by poor people in the vicinity of lakes or rivers who owe their sustenance in part to these fisheries. The fishing itself is conducted on a small scale, as is often the case in coastal fisheries, on small boats using nets and hand lines; nevertheless, it is an important factor for the food security of these people. Lakes and rivers are often isolated ecosystems and therefore need special attention; however, research into the capacity of these fish stocks is often deficient.

Inland fishing is often conducted far from the sea, which means that these fisheries are not in competition with coastal fishing, which usually returns much larger catches. This creates separate economic territories with their own internal trading in inland fisheries captures, which often have no direct connection with other fisheries in the same country. But inland fishing can be very dependent on environmental elements such as changes in climatic conditions, and also any changes in the local water budget may affect fisheries, as in the case of increasing draughts resulting from global warming.

About 80% of all inland fishing takes place in only 16 out of the 200 or so countries of the world. Of the total catch, Asia accounts for about a 65% share, including China with 20%, followed by India, Bangladesh, Myanmar, and Cambodia. Africa accounts for about 25%, with Uganda and Nigeria at the forefront. So, clearly inland fishing is virtually confined to Asia and Africa, accounting for over 90% of the total world catch. Other continents account for less than 10% of the total catch.

About half of the world's inland fisheries take place in low-income food-deficit countries, the poorest countries in the world, where imports of food exceed exports.[k] The total value of inland fisheries catches amounts to about 40 billion USD. The total value of recreational fishing, including angling, amounts to approximately 80 billion USD, bringing the combined annual value of global inland fishing to about 120 billion USD. It should be kept in mind that figures relating to catches and value in inland fishing are neither precise nor reliable in many cases, although records are improving. Approximately 20 million people are employed in inland capture fisheries, about half of them women, particularly in processing and marketing.

Knowledge of the oceans of the world and their complex ecosystems has progressed enormously in recent decades. With increased focus on the environment, far more attention is now being paid to pollution of the ocean and the plastic debris that is being spread by ocean currents all over the globe. Increasing levels of carbon dioxide in the atmosphere are having a huge impact on the oceans and have led to rising temperatures and acidification due to more carbon dioxide being dissolved in seawater. The acidification of the seas is one of the most serious environmental challenges we face, as it can have very serious implications for life in the oceans. The world's oceans supply humankind with food, and a large proportion of the world's oxygen, in addition to controlling the climate and weather. Humankind therefore has a challenging task ahead.

2.2 Fish farming and principal fish farming countries

Aquaculture can be described as a combination of fishery and agriculture. It is conducted in sea water and fresh water, in open waters or in man-made ponds or tanks on land. Modern fish farming is a diverse sector and exists in most countries of the world. Over 300 species of fish are now farmed, in addition to a variety of crustaceans, arthropods, echinoderms, and plants, bringing the total number of farmed living organisms to some 600 species. The cultivation of both marine and freshwater species has a long history, as evidenced by illustrations and accounts from China, Egypt, and the Roman Empire depicting aquaculture in lakes and cages thousands of years ago. Carp was among the earliest fish to be cultivated, and China has a history of raising carp that goes back thousands of years in ponds next to people's homes, particularly in the vicinity of the Yangtze River.[l]

Salmon has also been farmed for a long time, and salmon farming was known as early as the 15th century in France; currently, however, salmon is cultivated mostly in Norway, Chile, and Scotland. Norway is the largest producer of Atlantic salmon in the world. Prior to the Industrial Revolution, wild salmon existed in far greater quantities in rivers than in the present, for instance in the Great Rivers like the Rhine in Germany and the Thames in Great Britain. There are even accounts of frequent prisoners' revolts in England and Scotland over complaints that salmon was too frequently on the menu (Fig. 2.5).

FIG. 2.5

Fishermen gutting fish in Matanzas in Chile (Abriendomundo).

Successful salmon farming is greatly dependent on favourable natural conditions, and one of the chief environmental risks of salmon farming, apart from the waste produced, is that occasionally farmed salmon will escape from pens and mix with wild salmon stocks with undesirable consequences. There is much dispute over the question of where salmon farming should be conducted, that is to say whether the salmon should be kept in pens made of nets in the sea, where it can escape due to ruptured pens or bad weather, or in tanks on land, where this risk is eliminated. That option, however, is far more expensive than the traditional pen culture. The production of farmed salmon now far exceeds the supply of wild salmon, with Norway excelling in this area. Through selective breeding, the growth rate of farmed salmon has increased substantially.

Aquaculture is conducted both on sea and on land, although the majority of the production takes place in land-based stations using fresh water, with some fish cultivated both in fresh water and sea water. Aquaculture at sea is normally located along coastlines, although large-scale offshore operations are beginning to be realised in the open sea. Of crucial importance to aquaculture is the quality of the water used. Aquaculture, like any other food production, requires a great deal of attention to detail in order to avoid all the attendant risks. These risks include disease agents from purchased smolt or outside sources, environmental changes such as nutrient enrichment, pollution of various kinds, and poaching by predators. This means that monitoring requires continuous measurement of factors such as water acidity, salinity, temperature, etc.

Aquaculture can be conducted either in open or closed systems. In an open system the cultivation takes place in nature, and the water, whether fresh water or seawater, is renewed by natural means. In a closed system, the same water is used over and over, but purified on a regular basis. There is also the option of semiclosed systems, which are located in the open air, using equipment such as cages, lines, poles, or pens to mark off and protect the cultivated stock. Most aquatic species suited for aquaculture have to be fed, often using compounded feeds made of fishmeal and plant materials. However, some cultured species, such as water carps in ponds and shellfish, can live on vegetative feeds that occur naturally in their environments. The most significant expense in aquaculture is feed, the largest cost element of the sector. Temperature is a determining factor for the growth of all organisms, and fish grow faster in warm water, so greenhouses in some form are sometimes built to utilise solar energy or geothermal energy efficiently. The density of fish in pens and tanks also has a great impact on cost and quality.

As in the case of fishing, a variety of equipment is needed for aquaculture. To take some examples, pumps are essential, as well as filters of various kinds and other technically complex equipment designed to improve water and air quality. The variety of species of fish farmed is quite extensive and each species may need a different approach and different controls. Governments put in place laws and regulations regarding aquaculture operations. These relate to a variety of issues, such as water quality, importation of species from other countries, disease control, treatment of effluents from aquaculture, as well as internal monitoring and record keeping by the companies themselves. Moreover, all aspects of the fish farming operations are subject to monitoring and controls by independent government agencies.

The operation of aquaculture organisations shares many of its features with fisheries. Equipment needs to be purchased; the production needs to be planned and managed; the products need to be sold and distributed; and a keen eye needs to be kept on demand, financing, cost, competition, and profitability. In aquaculture, factors of production need to be procured, such as roes, fry (smolt), or fingerlings.

However, the expenses of fisheries are still somewhat different from the expenses of aquaculture. In fisheries it is not uncommon for the largest expense to be wage costs, which is frequently in the range of 45% of income; fuel costs account for about 10% and maintenance about 15%. This adds up to 70% of income. In aquaculture, on the other hand, feed costs can amount to 50% of income, while payroll costs can be about 10%, energy costs about 5%, and maintenance about 5%. This also adds up to 70% of income; the comparison highlights the profound operational differences between these two sectors, even though their products in both cases are fish products.[m] Table 2.4 shows this comparison.

One of the characteristics of fish that enhances fish farming as an important form of food production is that fish do not need to contend with gravity, nor do they have warm blood, which means that they need far less energy to survive than land animals, besides the fact that they do not need drinking water. In this context we should be reminded that producing 1 kg of beef requires some 15,000 litres of fresh water.[n] As a result, farmed fish has great potential to meet the ever-growing need of humans for environmentally friendly animal protein in the future.

Table 2.4 Division of expenses in fishing and aquaculture.

	Fishing (%)	Aquaculture (%)
Wages	45	10
Fuel/energy	10	5
Maintenance	15	5
Feed	0	50
Other	30	30
Total	**100**	**100**

It has been argued that modern fishermen have become herders rather than hunters. In well managed fisheries, fish are counted every year and growth rates and sizes measured. Harvesting strategies are then carefully planned by deciding on the mesh sizes of nets to control the size of fish to be caught. As a result, fishery has become much more akin to farming or herding than hunting. Fishery could even be given a name, like Open Ocean Fish Mariculture or Ocean Farming.[o] The cultivation of marine products is the fastest growing food production sector in the world, with products from farmed fish now accounting for about 50% of the total consumption of fish in the world.

Plants or plant products, such as soybean meal and plant-based oils, are being used in increasing quantities for the production of feed for fish, and plants have been used in the cultivation of carp species in China for thousands of years. Many of the plants that are cultivated in aquaculture are used for human consumption, while others are used for the production of feed for fish farms or for the cultivation of snails. But although seaweed can be wholesome and nutritious, it is used not only for feed, but also for various other products, such as medicinal and cosmetic products and food additives.

Another role of aquaculture worth mentioning is the production of nonfood products such as shells and pearls, in addition to the medical and cosmetic products referred to earlier. Numerous accounts exist of large pearls being found by divers, but nowadays pearls are almost exclusively cultivated, particularly in the warm oceans of southern countries.

In almost all the countries of the world aquaculture exists in some form, although by far the greatest production of farmed fish takes place in Asia. The total world aquaculture production in 2018 amounted to 114 million tons, and the value of the production at first sale was about 260 billion USD. Of the total production, about 82 million tons were aquatic animals, and about 32 million tons were aquatic algae. Of the 82 million tons of aquatic animals, 54 million tons were fin fish. The biggest aquaculture countries are China, Indonesia, India, Vietnam, and Bangladesh. China cultivates about 60% of the world production. Other Asian countries produce about 30%. Other continents, Africa, the Americas, Europe, and Oceania, account for only about a 10% share in the world production.

Of the farmed fish, the principal species are grass carp, silver carp, and Nile tilapia, with about 5 million tons produced per year of each of these three species. The quantity of farmed shrimp is about 4 million tons per year, and the quantity of farmed Atlantic salmon, a popular food fish in many countries, is just over 2 million tons per year.

About 20 million people are employed in fish farming in the world, most of them in Asia. The number of people employed in fish farming has doubled in the last decade in most countries, but by far the most in Asia. Taking fisheries, aquaculture, and processing together, women form about half of the workforce, although there are examples of women forming 90% of the labour force in fish processing facilities.[p] In evaluating all these facts and statistics, it is worth bearing in mind that fisheries and aquaculture support the jobs and living conditions of about 10%–12% of the world's population, or just short of one billion people.

However, it should also be borne in mind in the evaluation of world figures that statistics for many areas in fisheries and aquaculture are sketchy. Nevertheless, they provide the best information available for comparison, and in any case they give an idea of the importance of the fishing industry, fish farming, and related industries and their opportunities, both for the industrial countries, and perhaps still more for the developing countries.

A fish species originally cultivated in Vietnam and known as 'pangasius' or 'tra' has become a widespread farmed species, with over 2 million tons produced on farms in a number of countries. It feeds mostly on plants and organic waste, which makes the production cheap. The pangasius has one unusual characteristic, in that it can breathe oxygen from the atmosphere at the water's surface.

The Nile tilapia, or tilapia for short, is originated in Egypt, one of the more prominent fish farming countries in the world; tilapia is now mostly farmed in Asia, but also widely elsewhere. Originally, the pangasius and tilapia were principally cheap food for consumption in poor countries, but gradually both species have been marketed in the West. The problem with tilapia was that the water it inhabited was not refreshed regularly enough, which led to the fish having a rancid taste. Once this had been rectified, the offending taste was eliminated.

There is some hope that cod farming will come into its own in time, as cod is known worldwide as an excellent food fish and has been for centuries. Norwegians and others have experimented with cod farming, but the feed cost has proven excessive in comparison with other species. The general consensus is that areas suitable for farming cod are also suitable for farming salmon, but the current price of salmon is significantly higher than the price of cod, making it hard for cod farming to compete with salmon farming. However, developments are rapid in this area, so it would be premature to exclude any possibilities for individual species such as cod.

Advances in selective breeding have been rapid and extensive in agriculture, and fish farmers have of course put these advances to use for their own purposes. In simple terms, selective breeding involves mating individuals with certain desirable characteristics, with perhaps the examples best known to the public being breeding of pedigreed horses and dogs. The aim is to produce the best individuals in each

FIG. 2.6

Size of a 56-day-old chicken in 1957 and 2005 (Ólafur Kristjánsson).

population with certain desirable characteristics. In the case of food, the main objectives are to increase growth rate, increase resistance to disease, improve quality, and lower production cost. This is far from a new trend; in fact, it dates back thousands of years.

To give a relatively recent example, see Fig. 2.6, a broiler chicken in 1957 would be on average 905 g. In 2005, 48 years later, a chicken of the same age weighed on average 4202 g, i.e., four times the weight of an ancestor from only 50 years earlier.[q] Breeding has long been used in aquaculture, and huge progress has been made in selecting pedigreed fish populations, this includes Atlantic salmon, rainbow trout, coho salmon, arctic char, several shrimp species, some carp species, and tilapia.

In addition, genetic modification is now common practice, and the use of genetically modified plants is extensive. Genetic modification involves blending genes from different species, thereby promoting certain characteristics, such as rapid growth or resistance to disease or adverse climatic conditions. It is difficult to point out any reliable scientific evidence that genetically modified plants are harmful to people or the environment; nevertheless, food produced from genetically modified species is viewed with suspicion in many quarters. Many countries, most notably the European Union, have direct import bans or specific labelling requirements when it comes to genetically modified foodstuffs.

By genetically modifying fish, its rate of growth can be dramatically increased. In the United States, for instance, genetically modified salmon has been produced, where genes from Pacific salmon are combined with those of Atlantic salmon, with the result that the fish grows to its full size in 16–18 months instead of 30 months. This represents almost a doubling of the growth rate. Fig. 2.7 shows an Atlantic salmon and a genetically modified Atlantic salmon; both fish are 18 months old.[r]

As Fig. 2.7 shows, the difference in the size of the two fish is striking; the pictures are drawn to scale. The traditional Atlantic salmon is 33 cm long and weighs 1.3 kg,

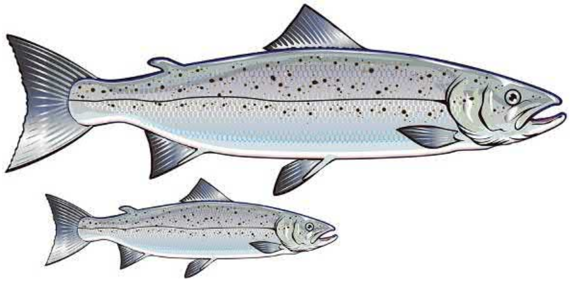

FIG. 2.7

Traditional Atlantic salmon and genetically modified Atlantic salmon (Ólafur Kristjánsson).

while the genetically modified Atlantic salmon is 61 cm and weighs 3 kg. The upper salmon is fully grown, while the lower salmon still has a year to go. The genetically modified salmon needs 25% less feed, which makes its cultivation extremely efficient, since feed and costs, including the cost of the technology required, are the largest expense in aquaculture, as mentioned earlier.

Sales of genetically modified salmon have been the subject of heated dispute.[s] It is to be expected that genetic modification of this kind in aquaculture will become steadily more common, notwithstanding widespread current opposition, especially in Europe, which will make this form of cultivation less expensive than traditional cultivation. However, this new method could represent a serious threat to ocean fisheries. If it becomes possible to cultivate similar fish with a far greater rate of growth, thereby making it much cheaper to produce, this could alter the proportions in the supply of marine products permanently and place marine fisheries in a difficult position. It has been revealed earlier that for many recent years the increase in the supply of fish products has resulted largely from the increase in aquaculture, while marine captures have remained unchanged for quite some time.

2.3 Consumption of fish

The consumption of fish in the world was 9 kg per person per year in 1961, as compared to 20.5 kg in 2018, meaning that the consumption of fish per person has grown at double the rate of the population growth over the same period. The consumption is not evenly distributed, however, as in some small island communities it may be in the range of 50 kg per person, or more, while it is a mere 2 kg per person in Central Asia and various landlocked countries. About 17% of all animal protein in human consumption of food comes from fishing or fish farming, which represents about 7% of all the protein consumption. For 3.2 billion of the 7.8 billion people populating the world, fisheries and aquaculture account for 20% of their consumption of animal protein.[t]

The greatest consumption of fish is in Asia and Australia, at about 24 kg per person on average, and Europe and North America are not far behind, with 22 kg per capita. As regards individual countries, the consumption is greatest in China, with 56 million tons consumed at a rate of over 40 kg per person. In contrast, the consumption in Africa is a mere 10 kg per person, and the same applies to South America. It is clear, therefore, that fish consumption could increase significantly in the coming decades, to the benefit of the comparatively poor people who inhabit these regions. However, it should be borne in mind in analysing these data that it is precisely in the poorest regions that records of fish consumption are least reliable, and on that note it should be added that the consumption of fish is of particular importance in the developing countries, as fish provides a supply of a number of vitamins, animal proteins, minerals, and fatty acids which are necessary for human nutrition. Fish is generally regarded as a wholesome food, not least for pregnant women and small children, so that even in small quantities fish has a very positive impact on the health of people enduring shortages of many kinds in the world.[u] Although fish as food does not provide a great deal of energy, it is an important source of animal protein, vitamins, and minerals. One meal of high quality fish with the right composition will supply a large part of the protein needed by a person each day.

In many countries the tradition of eating fish is firmly entrenched, for instance among the Japanese, who inhabit an island and engage in extensive fisheries. The Nordic nations are also great fish eaters with their long tradition of fishing for food. The same applies to the Mediterranean countries and places like Lake Victoria in Africa, where proximity to fishing grounds and favourable conditions influence local diets.

With the expansion of aquaculture, the share of farmed fish in human consumption of food has grown at an extraordinary rate. Aquaculture has also had the effect that the supply of fish of uniform and proper quality is steadier than before and less dependent on natural circumstances, such as weather, which has a significant impact on the supply of fish from captures. Technological advances in processing, packaging, shipping, and marketing fish products have led to increased world trade in fish and fish products, and it is not uncommon for fish to be caught or raised in one country, processed in another, and consumed in a third.

Increasing urbanisation also has a positive impact on the distribution and consumption of fish products. Modern supermarkets, with their state-of-the-art coolers and immaculate fish counters, have proliferated in virtually all the urbanised centres of the world. Prepared dishes are a common staple of the modern diet, and fish is prominent among these dishes, together with a number of other food types. But fish is in competition with various other foods, in particular poultry, the fastest growing of all food types in recent decades. Even though the consumption of fish has increased in the world, there are still many people in many countries, most notably in the rural regions of many less developed countries, that do not receive adequate nutrition; in particular, they lack some of the wholesome nutrients that are essential to human health and well-being and that are abundant in fish.

No doubt a part of the reason for the increased popularity of fish is its wholesomeness. Fish protein is easily digestible and fatty fish is rich in polyunsaturated fatty acids that are beneficial for the human health. Moreover, fish nourishes without accumulating in the body in the form of body fat—an important consideration in light of the growing problem of the obesity epidemic in the Western World.

Although humans are by nature omnivorous, there is a trend in the direction of vegetarianism, where no meat or fish or any products from slaughtered animals are consumed and, to a slightly lesser extent, in the direction of veganism, which excludes all food from the animal kingdom, including dairy products and eggs.

The reasons for the trend range from concerns about the wholesomeness of food from the animal kingdom to a general opposition to slaughtering animals for human consumption. Although it is possible to obtain all the nutrients that the human body needs from vegetables alone, this requires quite a bit of awareness and greater care and attention to detail in preparing menus that ensure diversity and thereby an adequate supply of necessary nutrition. This is less of a problem for vegetarians than vegans, and in fact the spectrum is wider, with some groups, 'pescetarians', accepting fish, and others accepting fish, eggs, and dairy products in their diets. Generally speaking, the current dietary trends in the developed world would seem to have the greatest impact on red meat production and a lesser impact on fisheries and aquaculture, and, for that matter, on the poultry industry.

2.4 Importance of fisheries and aquaculture for countries and island states

The importance of fisheries and aquaculture varies from one country to another. In fact, the difference is not only between countries, but also within countries. Obviously, the importance of fisheries and aquaculture is greater in coastal areas than inland areas. To give an example from the United States, fisheries are bound to be far more important to Massachusetts than to Colorado, the former being a coastal state with a long history of fisheries and the latter being landlocked with no direct access to the ocean. A number of countries are island states, whether single islands like Nauru, part of an island, like Haiti, or an archipelago, like Indonesia. Some of these countries are prominent in the fisheries and aquaculture sectors. The same can be said of some states that are not island states, but are largely coastal, some with a number of outlying islands, like Denmark, which shares only one border with another country (Germany) and consists of a number of islands.

Countries are classified in a number of ways for statistical comparison with other countries. The World Bank describes the economic position of countries using gross national income (GNI) per capita. Gross domestic product (GDP) reflects the final value created by the production of goods and services in a country and corresponds to the value that is available for distribution among the country's citizens. The measure of the standard of living for the purpose of comparison between countries is usually based on GDP per capita. Using what is known as purchasing power parity (PPP)

Table 2.5 Income classification by the World Bank.

Group	Income (USD)	Number of countries
High-income group	12,376 or more	59
Upper-middle income group	between 3996 and 12,375	59
Lower-middle income group	between 1026 and 3995	46
Low-income group	1025 or less	31

enables comparison of economic indicators between countries, allowing for the inclusion of purchasing power and the currency value in the countries being compared. The difference between GDP and GNI is, in general terms, that GNI is GDP with the addition of the income of the residents of a country earned abroad, subsidies from abroad and any net interest surplus or deficit. The World Bank uses the so-called Atlas Method to smooth fluctuations in prices and exchange rates to divide countries by GNI per capita into four categories in 2020, which are shown in Table 2.5.[v]

As Table 2.5 shows, 59 countries fall into the top category of countries with incomes per capita of over 12,000 USD per year. The bottom category comprises the 31 poorest countries of the world, where annual income is around or below 1000 USD per capita.

Another measure of economic position is the Human Development Index, created by the United Nations (UN) and published annually.[w] This index compares factors such as education and income, and, as in the case of the World Bank classification, the world's countries are divided into four categories, as shown in Table 2.6. In the table, there are 62 countries in the top group and 36 in the bottom group. Generally, a country in the top group in Table 2.5 will also be in the top group in Table 2.6. This double comparison of annual income per capita and the Human Development Index can be used to analyse the situation of a country with regard to fisheries and aquaculture.

An overview can be obtained of the importance of fisheries and aquaculture for different countries. In any such comparison it is important to rely on figures that are

Table 2.6 Classification based on the Human Development Index.

Group	Human Development Index	Number of countries
Very high human development	0.80 or more	62
High human development	between 0.70 and 0.79	54
Medium high human development	between 0.56 and 0.69	37
Low human development	0.55 or less	36

not only available, but reliable. Consideration needs to be given to the importance of fish in the local diet and whether and to what extent the country's trade with other countries is dependent on fish. Huge quantities of fish are transported between countries, and in many countries fisheries and aquaculture are an important source of foreign currency, particularly for the poorer countries.

Here, we have chosen the option of assessing the importance of fisheries and aquaculture by looking at the combined value of exports and imports of fisheries and aquaculture products in individual countries, adding the value of the domestic consumption of fish, whether fished or farmed, and placing the resulting figure in the context of the country's GDP. The higher the ratio, the more important fisheries and aquaculture are for the country. If the ratio is higher than 2% it is assumed that fisheries and aquaculture have a high level of significance for that country. This is a simple method of comparison that gives a fair view of the economic impact of fisheries and aquaculture and enables easy observation of changes between years and over long periods, but everything depends on to the availability and accuracy of data.

Table 2.7 lists the African countries where the application of this method of calculation shows fisheries and aquaculture to be of high importance. It needs to be underscored here that the averages for individual countries are not representative of individual regions, where fisheries and aquaculture may be the most important economic sectors.

As Table 2.7 shows, fisheries and aquaculture are important sectors in 11 out of the 54 counties of Africa. Most of the countries are sparsely populated, with the exception of Madagascar, Mozambique, and Senegal, and also Morocco, which is one of the top 25 fisheries countries of the world. Six of the countries are island states and most of them are in the third income category, but two, Madagascar and Mozambique, are in the fourth and lowest category. Five states are in the lowest category in terms of human development. The economic situation is best in the Seychelles and Mauritius, both island states. Fig. 2.8 shows a map of Africa with the 11 countries highlighted.

As Table 2.8 shows, 8 out of 35 countries in the Americas have fisheries and aquaculture sectors that are significant to a high degree. None of the countries are island states, and three countries, Chile, Ecuador, and Peru, are populous states and rank among the 25 countries with the largest catches of fish in the world. The living standards of Ecuador and Peru fall short of those in Chile. The rest of the countries have smaller populations, and their respective living standards lag behind those of Chile; however, these countries are by no means among the poorest in the world. Fig. 2.9 shows a map of the Americas with the eight countries highlighted.

As Table 2.9 shows, fisheries and aquaculture are significant to a high degree in 10 out of the 48 countries of Asia. The Maldives are a sparsely populated island state with good living standards. China, Indonesia, Myanmar, Philippines, Thailand, and Vietnam are populous states and among the 25 top fisheries countries of the world. Living standards in these countries are acceptable, having improved greatly in recent years. Three of these countries, Indonesia, Maldives, and the Philippines, are island

Table 2.7 Countries in Africa where fisheries and aquaculture have a high level of significance.

Country	Population in millions	Island state	Income group	Human development
Cabo Verde	0.6	Yes	Lower-middle income group	Medium high human development
Comoros	0.9	Yes	Lower-middle income group	Low human development
Madagascar	27.7	Yes	Low income group	Low human development
Mauritania	4.7	No	Lower-middle income group	Low human development
Mauritius	1.3	Yes	Upper-middle income group	High human development
Morocco	36.9	No	Lower-middle income group	Medium high human development
Mozambique	31.3	No	Low income group	Low human development
Namibia	2.5	No	Upper-middle income group	Medium high human development
São Tomé and Príncipe	0.2	Yes	Lower-middle income group	Medium high human development
Senegal	16.7	No	Lower-middle income group	Low human development
Seychelles	0.1	Yes	High-income group	High human development

states. The biggest fishing country in the world, China, is among the countries where fisheries and aquaculture are of notable significance. All of the 10 countries belong to the two central groups as regards income, i.e., the lower-middle income or upper-middle income groups. One country, Malaysia, is included in the very high human development group. None of the countries occupy the low income or low human development groups. Fig. 2.10 shows a map of Asia with the 10 countries highlighted.

As Table 2.10 shows, 6 countries out of the 44 independent countries of Europe are countries where fisheries and aquaculture have a high level of importance. Three of the countries are Nordic countries, that is to say Denmark, Iceland, and Norway, where fisheries have existed successfully for centuries, where the fishing grounds are nearby and where technology is advanced. These 3 countries also have a place on the list of the 25 biggest fisheries countries of the world. The populations of the countries

FIG. 2.8

Location of countries in Africa where fisheries and aquaculture are economically significant (Ólafur Kristjánsson).

Table 2.8 Countries in the Americas where fisheries and aquaculture have a high level of significance.

Country	Population in millions	Island state	Income group	Human development
Belize	0.4	No	Upper-middle income group	High human development
Chile	19.1	No	High-income group	Very high human development
Ecuador	17.6	No	Upper-middle income group	High human development
Guyana	0.8	No	Upper-middle income group	Medium high human development
Honduras	9.9	No	Lower-middle income group	Medium high human development
Nicaragua	6.6	No	Lower-middle income group	Medium high human development
Peru	33.0	No	Upper-middle income group	High human development
Suriname	0.6	No	Upper-middle income group	High human development

in Table 2.10 range from just over 300,000 to 10.2 million, not the biggest in the world. Two of the countries, Iceland and Malta, are island states. All the countries are in the highest bracket as regards gross national income, as shown in column 4 of Table 2.10, and the Human Development Index, as shown in column 5 of Table 2.10. Fig. 2.11 shows a map of Europe with these six countries highlighted.

As Table 2.11 shows, fisheries and aquaculture are important sectors in 10 out of the 14 countries of Oceania. None of them are among the top 25 fisheries countries of the world. All of them are island states with relatively small populations, ranging from 10,000 to just short of a million people, except Papua New Guinea. All the countries are in the upper-middle income group or lower-middle income group; none are in the lowest income group. As regards human development, two of the countries, the Solomon Islands and Papua New Guinea, are in the lowest group, while the others are further up in the scale. It should be noted that aquaculture is not a significant economic sector in any of these countries. Fig. 2.12 shows a map of Oceania with the 10 countries highlighted.

Of the approximately 200 independent countries in the world, some 50 are landlocked and about 150 are coastal. Of the coastal countries, 50 are island states. The countries where fisheries and aquaculture are significant to a high degree are 45, as shown in Tables 2.7–2.11. Of those 45, 13 are on the list of the 25 top fisheries

FIG. 2.9

Location of countries in the Americas where fisheries and aquaculture have a high level of significance (Ólafur Kristjánsson).

Table 2.9 Countries in Asia where fisheries and aquaculture have a high level of significance.

Country	Population in millions	Island state	Income group	Human development
Bangladesh	164.7	No	Lower-middle income group	Medium high human development
Cambodia	16.7	No	Lower-middle income group	Medium high human development
China	1439.3	No	Upper-middle income group	High human development
Indonesia	273.5	Yes	Lower-middle income group	Medium high human development
Malaysia	32.4	No	Upper-middle income group	Very high human development
Maldives	0.5	Yes	Upper-middle income group	High human development
Myanmar	54.4	No	Lower-middle income group	Medium high human development
Philippines	109.6	Yes	Lower-middle income group	Medium high human development
Thailand	69.8	No	Upper-middle income group	High human development
Vietnam	97.3	No	Lower-middle income group	Medium high human development

countries. This means that more than the half of the top fisheries countries are very dependent on fisheries. Of the 45 countries, 21, or almost half, are island states, representing about 40% of all the island states in the world where fisheries and aquaculture are a significant proportion of the economy.

Two of these 45 countries fall into the lowest income group, both in Africa, and 7 of them fall into the lowest human development group, 5 of them in Africa and 2 in Oceania. The lowest income group includes about 30 independent countries, and the lowest human development group has about 35 countries. In the poorest countries of the world fisheries and aquaculture are economically insignificant. Many of these countries are island states and should for that reason have at least potential opportunities to utilise marine resources or aquaculture to increase their value creation. In many of these 45 countries living standards have improved significantly in recent years. One should be wary about drawing overarching conclusions from the impact of fishing and farming on development. Other related variables can also be important factors. Access to the sea, for instance, can be a prerequisite for trade. Countries with

FIG. 2.10

Location of countries in Asia where fisheries and aquaculture have a high level of significance (Ólafur Kristjánsson).

Table 2.10 European countries where fisheries and aquaculture have a high level of significance.

Country	Population in millions	Island state	Income group	Human development
Denmark	5.8	No	High-income group	Very high human development
Iceland	0.3	Yes	High-income group	Very high human development
Lithuania	2.7	No	High-income group	Very high human development
Malta	0.4	Yes	High-income group	Very high human development
Norway	5.4	No	High-income group	Very high human development
Portugal	10.2	No	High-income group	Very high human development

FIG. 2.11

Location of countries in Europe where fisheries and aquaculture have a high level of significance (Ólafur Kristjánsson).

Table 2.11 Countries in Oceania where fisheries and aquaculture have a high level of significance.

Country	Population in millions	Island state	Income group	Human development
Federated States of Micronesia	0.1	Yes	Lower-middle income group	Medium high human development
Fiji	0.9	Yes	Upper-middle income group	High human development
Kiribati	0.1	Yes	Lower-middle income group	Medium high human development
Marshall Islands	0.06	Yes	Upper-middle income group	High human development
Papua New Guinea	8.6	Yes	Lower-middle income group	Low human development
Samoa	0.2	Yes	Upper-middle income group	High human development
Solomon Islands	0.7	Yes	Lower-middle income group	Low human development
Tonga	0.1	Yes	Upper-middle income group	High human development
Tuvalu	0.01	Yes	Upper-middle income group	N/A
Vanuatu	0.3	Yes	Lower-middle income group	Medium high human development

access to the sea often have better opportunities for development than landlocked countries. However, none of this detracts from the importance of fisheries and aquaculture in human progress and development.

World fisheries can be divided into two categories. On the one hand there are the fisheries of the industrialised nations, where large, well equipped, and technologically advanced vessels are used, with huge capacity and relatively few people engaged in the actual fishing. On the other hand, there are the fisheries of poorer countries, where technology is far less advanced, the vessels are many, mostly small and many nonmotorised. This division is also reflected among the 45 countries that are significantly dependent on fisheries and aquaculture. The same applies to aquaculture and fish processing: some countries are technologically advanced in these areas, while others are not. There is no reason to doubt that the less technologically advanced countries, many of them developing countries, or even least developed countries, will gradually become more technologically advanced in fishing, fish farming, and fish processing, and, like the more technologically advanced countries, they could retain their status of ranking among the countries that are significantly dependent on fisheries and aquaculture.

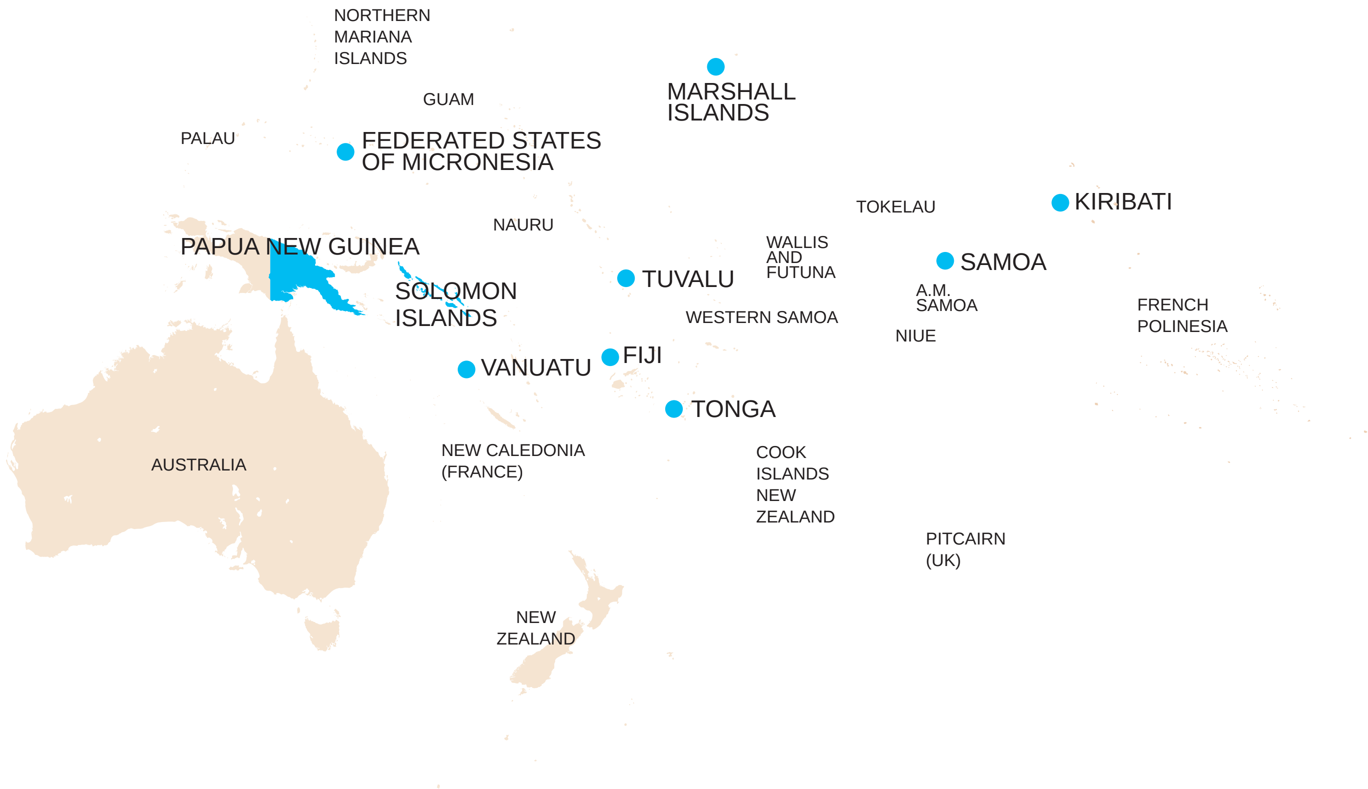

FIG. 2.12

Location of countries in Oceania where fisheries and aquaculture are economically significant (Ólafur Kristjánsson).

Endnotes

a. For a discussion of exported fish in the world in 2018, number of fishing vessels, largest fishing nations and marine species see Food and Agriculture Organization of the United Nations (2019b, January), Food and Agriculture Organization of the United Nations (2020), and Food and Agriculture Organization of the United Nations (n.d.-a).

b. For a discussion of the first sale value of fish landings in the Nordic countries see Nordic Statistics database (n.d.).

c. For a discussion of the export value of fisheries and aquaculture in Norway see Norwegian Seafood Council (2019).

d. The comments made by the Norwegian prime minister appear in 'Salmon is Norway's IKEA', PM claims (2015, January 7).

e. For a discussion of Norwegian fisheries see, e.g., Steinsham (2010).

f. For a discussion of Danish fisheries see, e.g., Semrau and Ortega Gras (2013) and Eurofish (n.d.).

g. For a discussion of such studies in Iceland see Árnason and Sigfússon (2012) and Einarsson (2016).

h. The calculations of productivity shown in Figs 2.3 and 2.4 are based on data from Statistics Iceland see Einarsson (2016).

i. For a discussion of productivity calculations of this kind see Árnason (2003), Agnarsson (2008), and Guo et al. (2019).

j. For a discussion of inland fishing and related statistics see Youn et al. (2014), Funge-Smith (2018), and Food and Agriculture Organization of the United Nations (2020).

k. For a discussion of low-income food-deficit countries see Food and Agriculture Organization of the United Nations (n.d.-b).

l. For a discussion of aquaculture and its principal features see, e.g., Landau (1992), Engle (2010), and Food and Agriculture Organization of the United Nations (n.d.-c).

m. For a discussion of the costs of fisheries and aquaculture see Anderson and Valderrama (2009).

n. For a discussion of the amount of water needed in the production of beef see, e.g., Nason (2018, February 12).

o. For a discussion of the future prospects of the cultivation of individual species see, e.g., Greenberg (2010) and Nielsen, Asche, and Nielsen (2016).

p. For a discussion of women in fisheries and aquaculture see, e.g., Monfort (2015) and Willson (2016).

q. For a discussion of the chicken size difference shown in Fig. 2.6 see Fredman (2015, March 12).

r. For a discussion of genetically modified Atlantic salmon and Fig. 2.7 above see Boyd (2013, April 26) and Einarsson (2016).

s. For a discussion of the FDA's approval of genetically modified salmon see, e.g., Abel (2015, November 19) and Blank (2018, August 8).

t. For a discussion of the world consumption of fish see Food and Agriculture Organization of the United Nations (2020).

u. For a discussion of the wholesomeness of fish see, e.g., Roberts (2009), Thorgilsson, Nunes, and Gudmundsdóttir (2010), and Bogard, Farmery, Little, Fulton, and Cook (2019).

v. For a discussion of classification of countries by income see World Bank (2018, September 9) and World Bank (n.d.-a).
w. For a discussion of the Human Development Index see Human Development Reports (n.d.).

CHAPTER

3 Market forces and tools to analyse fisheries and aquaculture

The basic principles of economics that need to be taken into consideration in discussing fisheries and aquaculture and which are referred to in this chapter are the same as in other industries; however, where the application of some of these principles differs, this is noted specifically. A market is an arrangement used by people to engage in trading; it is where supply meets demand. Demand is the quantity of goods and/or services that people want to acquire and are able to buy. Although ‘market’ in its generic sense applies to all trading, each market has its own characteristics, and the market for fish and fish products has its own special features. Some explanation is therefore needed of what the factors are that shape the demand for marine products and what the nature is of the supply, that is to say how demand is met by production in the fisheries and aquaculture sectors. As a reminder, the concept of market equilibrium denotes a situation when supply is equal to demand, and in that equilibrium prices are established. These factors decide the volume of the products made available in the market and reflect their value.

3.1 Companies and individuals

Studies in the social sciences focus on humans and human behaviour, communities of people, their interaction, their need for things that can be assigned a value, and their systems of satisfying those needs. Economics, as a discipline of the social sciences, examines the broad aspects of the economic environment, categorises them, and analyses the economic interactions of units, whether individuals or corporations. Terms connected to economics include exchange rates, the labour market, foreign trade, interest rates and their impact, state finances, and economic growth, all of them important factors in the field of fisheries and aquaculture.

The focus of economics is on markets, where goods and services are traded and enterprises produce and sell a boundless variety of goods. The focus is also on individuals, their needs and the fulfilment of those needs, and the creation of value and how economic growth fuels the prosperity and well-being of both individuals and nations, all being dependent on economic conditions. The concept of the ‘blue economy’ is often used in the context of fisheries and aquaculture to refer to the utilisation

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of marine and coastal resources in an efficient and sustainable manner in the interest of better living conditions for the world's population.[a]

Economies of scale is a key concept in economics. Economies of scale is seen as having two facets: on the one hand, there is internal economies of scale, which, broadly speaking, refers to the way in which each unit becomes cheaper as more units are manufactured and cost is spread over a greater number of manufactured items, although other factors also come into play, such as labour specialisation, mechanisation, etc. This comes into play in mass production, as in the case of the production of most fish products. On the other hand, there is external economies of scale, where conditions are created in a delimited area that promote or facilitate related production by many participants, with the result that one participant's cost is reduced by the business activities of another. This is referred to as cluster formation. The best-known clusters of this kind are no doubt Silicon Valley in California in the field of information technology and computers, and Hollywood, or rather Los Angeles, the undisputed leading centre of the film industry.

One of the fundamental concepts of economics is the right of ownership and the ability to prove ownership. In our times, we regard it as somewhat self-evident to know what we own: our car, furniture, clothes, etc., and even our homes. Some of these possessions are registered in an indisputable manner. To give an example, a ship is officially registered as the property of its owner. Cars are registered in official records, and it is assumed that the contents of an apartment are owned by its resident, except as otherwise may be provided by contract, for instance a rental agreement. The subject matter of contracts frequently concerns the issues of ownership and rights of use. The ability to prove ownership rights, which in most places in the world is regarded as a matter of course, is a prerequisite for any production, value creation, and livelihood. The implements needed by an enterprise to carry out its business, such as fishing vessels, are assets, and the value of assets constitutes capital. Ownership and user rights are important for the efficient utilisation of natural resources, including marine resources, which in many ways present problems that most land-based resources do not.

Ownership recording also includes the registration of who owes what to whom. If the operator of a fishing vessel delivers a pallet of fish to a processing plant, the seller needs a record of the value of the fish and the amount of the debt: one person's debt, or liability, is another person's asset. Without such records it would be easy to make parts of consignments quietly disappear, whether in the case of fish transported overland between villages by camel or fresh fish shipped in a refrigerated container across the world by a jet aircraft (Fig. 3.1).

In many parts of the world the registration, and enforcement, of ownership rights remains primitive, which is cited by some economists as one of the principal explanations of the widespread and persistent poverty in the developing countries.[b] Official registrations of title make it possible to apply for credit, as assets can then be posted as security for loans and their repayment. The loans can then be used to create value. This arrangement, which is now commonplace in modern societies, was not at all commonplace in the past, and developing and perfecting the system took centuries or even millennia.

FIG. 3.1

Fish feast (Ozzo Photography).

Advances in commerce and trade have been a driver of economic growth and thereby improved living conditions. Economic growth represents the increase in the creation of value each year.[c] The dissemination of knowledge reduces the cost of production and thereby results in increased efficiency.

Enterprises were originally formed with the discovery of the efficiency of manufacturing in units with clearly demarcated functions. Division of labour, which marks the start of trading, also marks the origin of business enterprises. It became obvious that it was efficient for one person to specialise in a single skill, for instance, in house building, while another specialised in different skill, like constructing wagons. People engaging in specialised fields would then trade, initially through bartering, for instance by exchanging eggs for meat or milk for fish, and subsequently in more sophisticated and complex ways using various forms of currency that eventually took the form of money, that is to say cash and equivalents of cash.

One important factor of any economy is the rules that apply. They influence, or even determine, human behaviour and thereby human decisions. Discussions of the impact of law and rules fall within a perspective of economics known as new institutional economics.[d] In addition to rules, institutional economics covers such varied matters as social custom, the cost of establishing trade, the organisation of the utilisation of natural resources, and means of improving efficiency in the economy. Productivity in the economy refers to the ratio of resources to products and the ways in which resources are used in manufacturing. The tools of the new institutional economics serve an important purpose for analysis in fisheries and aquaculture.

In economics, externalities play a role. These are influences that the production of goods and services has on third parties, or the community as a whole, without any involvement of the third party in the production or commerce in any way. Thus the production of certain goods, or cigarette smoking, for that matter, can result in pollution and health consequences for anyone in the near vicinity, who will bear a resulting cost. Externalities can often be the source of market failures, meaning that the market does not supply goods and services in an efficient quantity, i.e., the production is either excessive or falls short of needs. Such a situation can call for the intervention of government to promote greater efficiency, for instance through taxation or tax incentives. Externalities are an important consideration in fisheries, as fishing and the use of natural resources can impact the citizenry in many ways, for instance in the context of environmental issues and the quest for sustainable development.

Externalities can be positive or negative. Pollution, which can result in cost, is a negative externality. In the case of fisheries, there is the possibility of destroying bountiful fishing grounds in the absence of restraint. The cost takes the form of environmental damage and is borne by society as a whole, and rarely by the person causing the damage. As regards pollution caused by an identified economic activity, the logical response is to regulate the activity in such a way that the polluter bears the cost that results from the pollution. In environmental law this approach has been called the 'polluter pays' principle. In an economy, individuals and corporations bear the cost and benefits of trade, which results in efficiency. Negative externalities therefore constitute a sort of wedge in the economy, causing increased cost and leading to wrong decisions, where account is not taken of the entirety of costs and benefits. One example of a positive externality is education, which improves society and increases productivity in manufacturing, for instance through technological advances that to some extent benefit others than those who actually acquired the education (Fig. 3.2).

FIG. 3.2

Fish farming in China (Atiger).

A basic tenet of human economic activity is that the resources available for use are limited. There is not enough for everyone and there are serious shortages of some goods, for instance food, work, and education, for billions of people. Therefore, what is available has to be allocated in the most efficient manner possible, whether natural resources, such as fish stocks and energy, or labour. The production of goods and services, and thereby supply, meets demand in a world of shortage, where choices are constantly being made between a diversity of alternatives. The principal question to be answered by economics is what should be produced, in what quantities, how, and for whom.

It is sometimes said that in their daily lives people confront certain fundamental economic questions, and it is generally accepted that the following fundamental tenets apply.[e]

The first is that in a world characterised by shortage, people need to make a choice regarding the way in which they spend their time or money. For example, they need to decide how much to spend on clothing, and if too much is spent there will be less money available for other things, such as tickets to the theatre. The second is that when something is done, something else will not be done. Someone who goes fishing on a Sunday will not go to the movies at the same time on that day. This exemplifies opportunity cost.

The third is that people will generally behave sensibly and take account of changes in conditions. For instance, if there is a change in the price of goods or services, attitudes towards the goods and services will also change.

The fourth is that trade is advantageous for all the parties participating in the trade. It is of no benefit to an economy for individuals or nations to exist in isolation. Trade between countries and specialisation by individuals in the areas of their expertise, or areas where their expertise can be used to their advantage, work to everyone's advantage. This is of particular importance for fisheries and aquaculture, fish products being an extensively and internationally traded commodity.

The fifth is that markets provide a good way of organising an economy. A market refers to circumstances where supply and demand meet and prices are formed, as in the case of fish markets. Experience has proved this to be a favourable system.

The sixth is that government can have a positive impact on a market, with its main role being to take action in the event of market failure. In the case of fisheries, government plays a role by funding and supporting marine research, regulating fisheries, etc.

As noted earlier, economics is all about determining and analysing what is produced, in what quantities, how, and for whom. This determination relies to a large extent on the price formation system. What this means is that prices are formed in the market and are decided primarily by supply and demand. The general rule is that if the price of a product, say tuna, increases, then the quantity demanded will decrease. Those who fish for tuna, on the other hand, will rejoice in the price increase and attempt to catch more tuna; if they are successful, the price will fall.

Participants in an economy will fall into two main categories, if we set government apart. On the one hand, there are enterprises that produce goods and offer services for others, and on the other hand, there are consumers, individuals, families, and households, who use the goods and services. The link between individuals and firms is that individuals sell their work, receive pay as remuneration, and use their pay to buy what is produced by firms. Firms produce and sell, using factors of production such as labour.

The availability of food and energy in the world is limited. Therefore a choice needs to be made between options, that is to say how to make the best use of resources and limited raw materials. Choosing between options entails decision making. However, some goods and services are in fact free, a classic example being the atmosphere, where everyone can breathe in air without obstruction or cost. The same might be said of water, except that water is not abundant everywhere, and in some places, where it is especially scarce, it is an expensive commodity.

3.2 Demand and utility

The demand for goods, or products, depends on their usefulness to consumers, referred to in economics as 'utility'. Consumers have use for the goods and services that they buy, and in fact they use their income for a lot of things, but usually they cannot afford everything they want or feel that they need for the simple reason that their income is rarely sufficient to fulfil all wishes. They therefore have to make choices. To complicate things further, it is not income alone that restricts the possibilities for acquisition, but also time. People do not have enough time to do everything they may want to do.

The demand for fish products results from vastly differing needs, ranging from the distress of acute hunger in the developing countries to the sophisticated longing for exotic fish dishes, caviar, for instance,[f] in exorbitantly expensive restaurants.

To clarify an important point, goods and services are often bundled together, although a differentiation is also often made between goods on the one hand and services on the other. Whatever the preference, there is a close relationship between the price of goods and services and the quantity demanded of the same goods and services. Consumer demand is not dictated only by price, but also by income and the price of similar products, not to mention taste and expectations.

Eq. (3.1) describes a simple demand function, where the demand for a product (D) is a function (f) of several factors.

$$D = f\,(\text{price of product, price of similar products, advertisements, quality of product, expectations, taste}) \tag{3.1}$$

The function (f) is determined by a number of factors, as demonstrated in Eq. (3.1). The demand curve is often simplified, with the demand seen as dependent only on the price (p) of a product, with other factors regarded as a constant. In that case, the demand curve is described as follows in Eq. (3.2), where $h(p)$ denotes the mathematical relationship in a function between the demand (D) for a product and its price (p).

$$D = q = h(p) \tag{3.2}$$

Eq. (3.2) shows how the quantity of a good demanded (q) is dependent on price (p), where other factors are now included in the function h. This relationship is reflected in a model which gives a simplified picture of reality. The model is used to explain the factors affecting demand for fish products, but also applies to other goods and services. As the price becomes higher the quantity demanded falls, and as the price becomes lower, the quantity demanded rises.[g] This relationship is known as the law of demand, illustrated by the demand curve in Fig. 3.3.

In Fig. 3.3 the quantity of a good (q), in this case using fish as measured in kilogrammes, is shown on the x-axis and the price of the good (p) is shown in dollars per kg of fish on the y-axis. When the price exceeds 32 dollars per kg there is no demand. When the price is 16 dollars per kg the quantity demanded is 400 kg and when the price is 6 dollars the quantity demanded is 650 kg. Fig. 3.3 assumes a linear relationship between quantity and price, expressed in Eq. (3.3) as the inverse demand function (l).

$$p = l(q) = 32 - 0.04 \cdot q \tag{3.3}$$

The lower the price, the more people want to buy the good or service. However, a deciding factor can also be the cost of buying other goods, such as chicken or pizza, so fish products are in constant competition with other products, just like marine products also compete among themselves, say cod vs halibut. The choice is up to the consumer.

The quality, or condition, of food has also a significant impact on demand. Consumers want the food they ingest to be of good quality at a reasonable price. This is particularly important in the case of perishable food, such as fish, and tastes can vary depending on custom. In areas close to the sea or a bountiful lake, residents may prefer fresh fish, straight out of the water, while in landlocked areas the preference may actually be for frozen products, or there may be little or no demand for fish at all due to a lack of tradition.

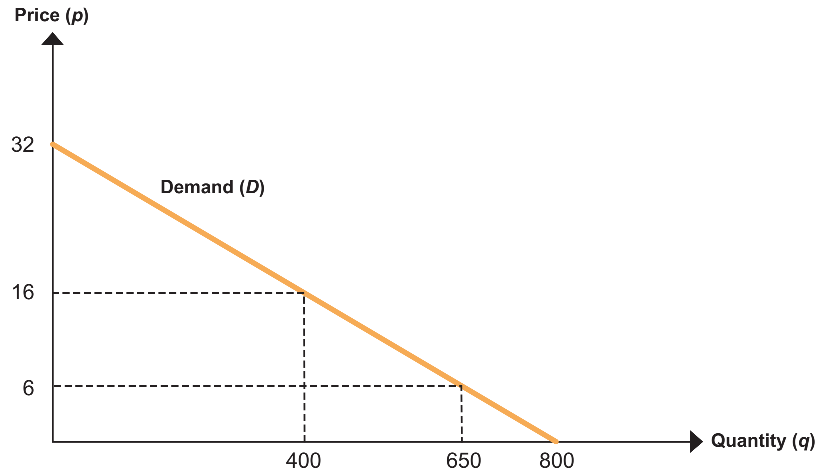

FIG. 3.3

The demand curve in sales of fish.

The demand curve in Fig. 3.3 slopes downwards, because as the price of a product falls the quantity demanded increases. A distinction needs to be made between, on the one hand, whether the quantity demanded changes, as in the case of the price of a kg of fish falling from 16 dollars to 6 dollars, as shown in Fig. 3.3 and, on the other hand, whether the demand changes, which causes the curve to shift. If there is a rise in income among consumers, they may be willing to buy 500 kg at the price of 16 dollars per kg, and not 400 kg, as shown in Fig. 3.3. The demand has thus increased. If something changes that has an impact on demand, and the change is not a change in price of the goods or services, then the general norm is that demand changes and the curve shifts (Fig. 3.4).

There can be any number of reasons for the changes. First, the demand curve may shift because of a shift in income. If disposable income increases, then demand will generally increase, even if the price of a product remains unchanged. If there is an increase in purchasing power in a community, increased demand for fish products may be expected, and the demand curve will shift to the right.

A second reason for changes in the demand curve could be a change in the price of a substitute product, that is to say a product that can replace another. One example in fisheries could be cod and haddock. An even simpler example is Coke and Pepsi, which can replace one another and most consumers can switch without serious difficulty. In the case of two substitutable products, such as chicken and fish, if the price of fish rises the demand for fish will fall and consumers will turn their attention to chicken. Thereby the demand for chicken will increase, even though there has been no change in the price of chicken. It is comparison with other goods and other options that will determine the behaviour of consumers and enterprises in the economy. It is

FIG. 3.4

Dried cod (stockfish) in Lofoten in Norway (Kadrina).

therefore not the price by itself of a product that determines consumer demand, but the price in comparison with other prices.

A third reason may be a change in price of a complementary good. Examples of such goods are potatoes and fish, or bread and spreads. If the price of fish falls, the quantity demanded of fish will increase. This has the result that the demand for potatoes or rice may also increase, even if the price of potatoes or rice has not changed at all. This is assuming, of course, that people will generally serve fish with potatoes or rice.

A fourth possibility is that there may be changes in consumers' expectations. If consumers believe that the price of certain goods is about to rise in the near future, the demand for the goods rises before the price will rise. To give a different example, an announcement of a reduction in tariffs on computers will cause the demand for computers to plunge until the change in tariffs has taken effect. In that case the demand curve will shift to the left, as consumers will be reluctant to buy the same quantity at the same price as before the tariff reduction.

A fifth reason for a change in demand is a change in consumer tastes. This can happen quite suddenly, as in the case of clothing or music, which are both subject to changes in fashion. In that case, the demand curve will shift to the right or left, all depending on taste or trends. Increased consumption of fish will not result only from increases in population, but from people's needs for healthier food. New trends, such as an increased craving for sushi, a Japanese dish prepared mainly with rice and raw fish, have also contributed to increased demand for fish products. Sushi has even been said to have attracted people to fish who earlier had largely avoided fish.

The slope of the demand curve is one way to determine sensitivity to price changes. The slope illustrates the way in which the quantity demanded changes in units if the price changes by one unit. The shape of the demand curve is one way of measuring sensitivity to price changes. Another measure of this sensitivity is to look at the ratio of the proportional change in the demand and the proportional change in the price. The ratio in this context is referred to as the price elasticity of demand. If the price of fish falls by 10% and the quantity in demand thereby increases by 15%, then the elasticity of demand is 15% divided by 10%, or 1.5.

Another useful concept relating to the demand for fish is income elasticity. Income elasticity is a concept in economics that is used to assess changes in sales when people's incomes change. Like price elasticity, income elasticity describes proportional changes. Income elasticity is the proportional change in quantity divided by the proportional change in income. If a person's income increases by 10% and the demand for a certain product increases by 5%, then the income elasticity is 5% divided by 10%, or 0.5. If the income elasticity is greater than one, say 1.2, then demand will grow proportionally more than the increase in income. If the income elasticity is 1.2, then a 10% increase in income will have the result that demand will increase by 12%.

Consumer demand for a product depends on the utility that results from the consumption of the product. The more a consumer consumes of a product, the greater the consumer's utility, i.e., the benefit gained by its consumption, as illustrated in

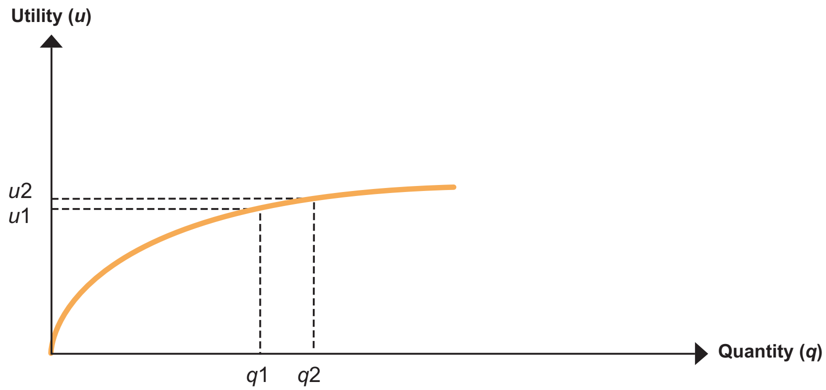

FIG. 3.5

Traditional utility function.

Fig. 3.5, where q is the quantity of a product on the x-axis, and u is the utility, on the y-axis.

The usual properties of consumers' taste, as shown in Fig. 3.5, is that as the consumer acquires a greater quantity of a specific good, the consumer's needs will gradually be saturated. Fig. 3.5 shows that a change in quantity (q) from $q1$ to $q2$ will result in a relatively small increase in utility (u), i.e., from $u1$ to $u2$. This means that a degree of saturation has been achieved. To give an example, most people will not collect clothing endlessly or increase their consumption of fish endlessly. As regards food, people will eat their fill and that is the end of it. Even though consumer behaviour as regards fish differs from one country to the next, access to fish and traditions being different, it has been shown that in Europe, for instance, consumers generally perceive fish as a safe food, wholesome, nutritious, and tasty, but expensive.[h]

An illustration of demand for fish

The growing prosperity in the world over the last 100 years has had the effect that people take a greater interest in their dietary regimes; they give their food more thought with regard to nutrition value and wholesomeness. Interest in cooking has also increased, as apparent from the huge number of cooking shows on television and the reams of cookbooks that are being published.

Fisheries have benefited from this trend, and no restaurant of any quality can afford to leave fish off the menu—fish counters have also proliferated in food stores and supermarkets, which was not at all common just a few years ago. To be sure, this is to a large extent made possible by fish farming, in particular salmon farming, with much of the fish sold in shops being farmed salmon. Many executives who operate large supermarket chains, mostly in developed countries, in particular those who feature sophisticated fish counters, say that there would be no fish counters in their outlets if it were not for farmed salmon.

The most common species of salmon in the northern hemisphere is the Atlantic salmon, or *Salmo salar* in Latin. Farmed salmon, in fact, is sometimes denoted in Latin as *Salmo domesticus*, being a domesticated animal. There are famous fish soups, with the French bouillabaisse probably the best known. It exists in a variety of versions, made with vegetables and spices, such as onions, tomatoes, saffron, celery, and other ingredients, including fish stock and white wine and, of course, various types of fish. Preparation takes about an hour, and the final product is served with white wine and baguettes. A feast for all fish food lovers.

Word of mouth can have a decisive impact on markets, and in this regard fish may enjoy a bit of an advantage in the coming years, as many foods are perceived as being undesirable for a variety of reasons. This is less true of fish, which is perceived as nutritious and wholesome and abundant in a number of necessary vitamins, minerals, and healthy omega-3 fats. Even people living in landlocked countries, who may never have seen the sea, will still know fish from rivers and lakes as part of their diets. There is no reason, therefore, to doubt that fish will be caught and farmed for food into the distant future.

3.3 Supply

Humans fulfil their need for goods by producing them. This requires resources. In fishing, this would, at the simplest level, require the resources of a hook, line, and bait, resulting in fish as a good or product. The economy involves the production of both goods and services. Goods can be preserved as inventory that can be stored for use later over a long or short period of time, such as food and drink. Service, however, cannot be preserved; utility derives from a service at the time that the service is provided. In fisheries, an example could be a mechanic fixing a winch. In that case, the utility comes into existence at the time that the mechanic works on the winch.

However, goods and services are often interrelated, as in the case of a meal at a restaurant, where the fish and what comes with it form the goods, while the ambience and preparation have the form of a service. Thus, eating out at a fine restaurant is an experience, and in addition it fulfils the need for nutrition, and in combination the two constitute the utility of the consumer.

The factors of production that come into play in the creation of goods and service are of four kinds: labour, capital, natural resources, and managerial factors. The fourth factor encompasses activities such as planning, organisation, management, and knowledge, as shown in Fig. 3.6, which gives an example of the operation of a fishing vessel.

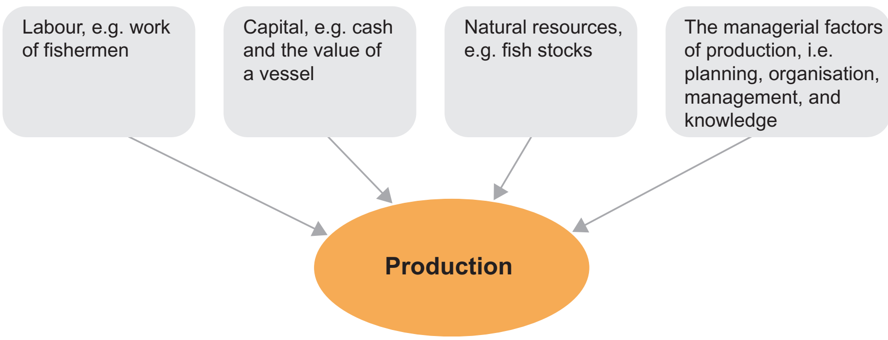

FIG. 3.6

Relationship of factors of production and production.

Fishing requires a natural resource, mainly fish stocks. It also requires specialised labour, both aboard the fishing vessel and on shore. The venture also requires capital to acquire and operate the vessel and purchase fuel and fishing gear, as obtaining the returns from the catch can take time.

The managerial factors of production are fundamental to modern business operations. A plan involves preparing in an organised manner a decision-making process for the future. The plan addresses what needs to be done, when, how, and by whom. A decision involves choosing one option over another. Choosing the right option is possible only by referring to the objective or objectives of the organisation. The plan is manifested in a decision or series of decisions that are used to manage the activities of the organisation.

Contemporary management relies on knowledge, one of the most important factors of production. Knowledge consists of all the information available inside and outside an organisation that is used to achieve the organisation's objectives. Among other things, knowledge comprises education, technical know-how, and the capacity to collect and process information that in our times is growing constantly in volume and complexity. Knowledge is the factor of production that is perceived as becoming the most decisive factor in fisheries and aquaculture and other sectors of the economy in the coming decades. The organisations and countries that use knowledge in the most efficient manner will probably have a significant advantage in their competition with others.

The flow of information is one of the most important aspects of the running of any organisation. The information needs to be timely and accurate. Contemporary business operations, with their complex manufacturing processes and faster lines of communication, require great adaptability among employees and management to respond to new information.

Training, both within and outside organisations, is an important component of business operations, as knowledge quickly becomes obsolete and new perspectives and possibilities are constantly emerging, especially in the form of technological advances that organisations and their employees need to stay abreast of.

Information on the performance of the employees must reach them regularly. This can be achieved through scheduled staff meetings, interviews with employees, and open discussions of any problems of an operational or personal nature that may arise. However, measures need to be taken to avoid repeatedly processing information that no one looks at or makes any practical use of. Precise information on the proper matters at the proper times to the proper persons is invaluable for business operations and a prerequisite for the successful management and operation of an organisation.

A basic premise of economics is that resources are needed to make a product. This is commonly described by means of a production function, where a certain quantity of factors of production, that is to say resources, are needed to produce a certain quantity of goods. The production function describes the technical relations and conditions available.

Once the production function has been established it becomes possible to examine whether any factors of production can be substituted by other factors. To give an example, a given quantity of fish can be caught using two fishing vessels, but it may also be possible to catch the same quantity using a single, larger, better equipped, and differently manned vessel. The goal in business operation is maximum output at given costs or minimum cost at given output. The last dollar spent on acquiring individual factors of production should return an equal additional production for all the factors. Otherwise, it would make sense to substitute the factors. The result should be the cheapest combination of factors of production to produce a specific quantity of goods. If the sale price of the goods per unit is known and the price applies to everyone, then the aim should be to produce each unit as cheaply as possible, assuming that the quality or condition of the goods is acceptable to the buyer or consumer.

If the price of a factor of production goes up it may be feasible to reduce its use and attempt to use other less expensive factors. The production is therefore in a constant flux, taking account of different technical combinations of factors of production and their cost.

In many ways, supply is subject to similar laws as demand. Supply is the quantity of goods and/or services that a firm produces and offers for sale. Supply is subject to factors such as the price of the goods, the price of similar goods, technical development, and the price of resources. Technology and technical advances play a dominant role in supply. If a technological advance occurs that reduces cost, this will lead to an increase in supply, as the cost to the firm of the production falls. Conversely, if the price of a resource rises, such as the price of oil, production will become more expensive—a fisheries operator may decide not to send out the fleet at all—and supply will then decrease in quantity.

The price elasticity of supply describes the impact of price changes on changes in the quantity supplied, as explained earlier in connection with the price elasticity of demand. Also, the number of competitors may influence an enterprise's supply. The supply function describes the supply (S) of an enterprise as a function of factors. Eq. (3.4) describes a simple supply function of product A.

$$S = f\,(\text{price of product A, price of related products, price of sources, technology expectations}). \tag{3.4}$$

Eq. (3.4) is not exhaustive, as there are other factors that can influence the supply of a product. If all the factors in Eq. (3.4) are known, and if it is possible to assess their influence on supply, the function in Eq. (3.4) describes possible changes. Like in the case of demand, the presentation is simplified, and it is assumed that the impact of all the factors other than price is stable and immutable. Other factors that previously had an influence are now included in the form of the function. In that case, supply as a function (h) of price (p) is shown in Eq. (3.5).

$$S = h(p) \tag{3.5}$$

It generally applies that if the price of a product goes up then the quantity supplied of the product will increase. The reason is that an organisation will anticipate more profit as prices rise, all other things being equal, and therefore increase the quantity supplied. Fig. 3.7 shows this relationship in the form of the short-term supply curve of an enterprise.

At the price of 500 dollars per unit firms will offer the quantity of 14 units. If the price rises for any reason to 600 dollars per unit, the quantity supplied will be increased from 14 units to 18 units. The reason is that with the price hike the product becomes proportionally more valuable than other products manufactured by the enterprise. It therefore becomes more profitable for the organisation than other products it offers. This leads to changes, in that manufacturers will now begin to produce and offer this proportionally more profitable product instead of other products, and current producers will also increase their quantity supplied. A rise in price can also be seen as making it possible to produce more despite increased cost. Many fishing companies will not change their production even if prices of fish rise. However, the general effect of a rise in price of fish is that it will become more advantageous to make that product than to make other products. A change in the price of a product will lead to a movement along the supply curve.

Fig. 3.7 shows that if the price is lower than 130 dollars per unit, there is no supply. This is because the price has to reach a certain minimum for the product to be worth making at all. Any production requires some preparation, which has its cost. All the fixed cost will accrue in the short term, so that a certain minimum price has to be obtained for the product in order for it to make any sense to offer it.

Firstly, the supply curve can shift as a result of changed circumstances, meaning that other factors than the price of the product change. A reduction in the price of resources will have the effect that supply increases, the reason being that the product is then more profitable to produce than other products.

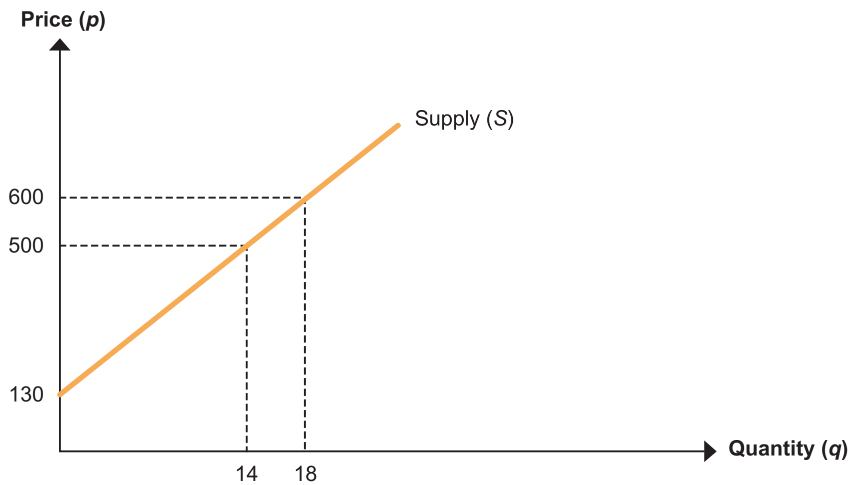

FIG. 3.7

The supply curve and changes in the curve.

Secondly, the supply curve can shift as a result of changes in technology. An enterprise's supply depends, among other things, on technology. If there are technological advances within an enterprise, or generally in a sector, for instance if relatively cheap equipment enters the market which renders the work of a certain number of workers redundant, then production cost will fall. A concrete example from the fisheries sector is a baiting machine that was introduced decades ago that made it possible to bait hundreds of hooks in a fraction of the time that it took humans. A more obvious example outside the fisheries sector is the computer, which has steadily fallen in price and improved in efficiency as a result of technological advances.

Thirdly, the supply curve can shift as a result of changes in expectations; as in the case of demand, any foreseeable or anticipated changes may have the effect of changing supply. In fisheries, a highly regulated industry, plans by government to curtail fishing quotas or introduce licence fees may influence management decisions regarding supply.

As it happens, supply in fisheries does not follow all the usual laws of economics. To give an example, if the price of cod rises, then it is tempting for fishermen to catch more cod and less other fish; in extreme cases this will lead to a depletion of the cod stock and thereby a reduction in the supply of cod.

Time is essential with regard to supply from organisations. In the very short term, most organisations can do little to increase their supply. In the longer term it may be possible to add means of production, such as fishing vessels. This means that supply will not change much in the short term, while in the long term all factors can be modified, and supply thereby significantly altered.

Production is subject to certain conditions, technological, economic, and organisational. The technological dimension relates to the availability of technical means of producing the goods in question. If the aim of an organisation is to maximise profit, the factors of production must be utilised in the most economical manner if the selling price of the product is known.

The context of production and factors of production is of a technical nature, and this is often depicted using a production function, as discussed earlier. Changes in the production function can occur for various reasons, and a distinction has to be made as to whether the quantity of factors of production changes or the function itself, for instance if the factors of production are put to a different use. To give some examples of changes in the quantity of factors of production, the number of vessels on a certain fishing ground can be increased and workers can be asked to work overtime, with the limitation that there are only 24 hours in a day for each worker, giving rise to the need for shift work, which is common in fish farming and fish meal processing plants (Fig. 3.8).

If there are two factors of production, then there are two possible relationships between them. On the one hand, the factors can be substituted for one another, making them substitute factors of production, for example labour and machines. The other possibility is that both factors may be needed in certain proportions, for instance in the case of one vessel and one captain, in which case the factors are complementary factors of production.

FIG. 3.8

Supply of fish in the Solomon Islands (Wikimedia Commons).

Goods, or products, are of many kinds and they can be categorised in a variety of different ways based on a number of viewpoints. There is the economic aspect, for instance value, the nature of demand, social viewpoints, and technological circumstances. The economic perspective could be the value of a catch or the nature of the demand; for example, capelin products are in high demand in Japan because of the belief that they enhance sexual drive. Social factors include considerations such as whether fisheries and aquaculture should be conducted from rural areas rather than urban centres. Technical considerations could focus on whether it is more feasible to use trawls or long lines.

The production process, where resources, such as energy, water, and raw material, are transformed into goods, thereby creating supply, often results in pollution of air, soil, and water, in addition to waste and undesirable by-products. Many of these matters are a serious concern for fisheries, aquaculture, and fish processing. Various measures are being taken to prevent pollution, environmental damage, and waste, but there is a long way to go in many parts of the world.

3.4 Cost

The most common classification of cost is to divide it into fixed costs and variable costs. Variable costs are the costs that change depending on volume of production, while fixed costs do not change in line with volume of production. Fixed costs include depreciation, rental cost, and interest on initial borrowings, to give some examples. In the short term nearly all costs are fixed, while in the long term all costs are variable.

In the production of fish products, wage costs are usually the predominant expense in fishing, and feed costs in aquaculture, and this expense can be either variable or fixed. Wage contracts can be of various kinds, involving either fixed wages or bonus payments, and in the case of fisheries catch shares are a common arrangement, perhaps the most common arrangement, with fishermen being paid by share in the catch.

One of the basic principles of economics is that the use of time and assets on one option involves forgoing another option. This is known as opportunity cost, that is to say the cost that accrues from choosing to forgo something, which is then often labelled as the second choice. In economics, another concept that underlies the benefit of trade and diversification is that of advantage, which can be either absolute advantage, in that one person can manufacture a product faster than another, which is measured simply in minutes, or comparative advantage, which is measured on the basis of opportunity cost. The reason these particular concepts are mentioned specifically is that they are among the most significant concepts underlying all economic activity, whether fisheries, aquaculture, or other activities.

The subsistence economy of earlier times, when the ideal was to produce in the immediate vicinity all that was needed, meaning that factors of production, such as labour, were used to produce things that could be better produced by others who were more capable, better equipped, or more favourably located. Conversely, people could concentrate on doing things that they were good at, as compared to others, then engage in trade between areas or countries. The theory of trade on the basis of comparative advantage demonstrates that everyone has a comparative advantage in some respect and can therefore specialise in that area and then profit from trade.

In trade and commerce the aim is usually to minimise costs; one component of costs is known as transaction cost. An example of transaction cost is the marketing cost of establishing a business relationship between a buyer and a seller. Transaction cost is a significant part of the total cost in an economy, and for this reason awareness of this cost is as important in fisheries and aquaculture as in any other commercial activity.

The reduction of transaction cost over time has had the effect of creating vast opportunities for business, including business in fish products, where previously there had been unsurmountable obstacles to any business other than direct exchanges of goods, or bartering. Transaction cost can also serve as protection for enterprises that are already in business. To give an example, domestic enterprises may possess a certain type or degree of knowledge that foreign enterprises may not possess and have to purchase and pay for, knowledge of the local language and social attitudes being prime examples.

Cost will change, and of course rise, if the price of factors of production rises. Increased use of these factors of production will also often mean increased demand for them and thereby higher prices. Technical progress can also occur, with the result that the price of production factors decreases. This will result in greater use of those factors. Firms will normally produce many products from a number of factors of production, such as a variety of packaging of a fish product. The price of the products, the factors of production, and the production function need to be known to make it possible to establish the most feasible production. The simplest approach is to assume a certain price of production factors at the outset and fixed production functions that predict the context between resources, or supplies, and products and calculate the cost per unit of products; this approach is frequently used in business operations.

Competition generally forces business undertakings to attempt to achieve the lowest possible average cost of their production. It is by no means certain that the economies of scale of an enterprise's business operations will increase with the size of the enterprise. It can, in fact, cause difficulties for an enterprise to grow too fast or too much. One risk is that management could lose its oversight of the operations and become less flexible than the managers of smaller firms in their ability to adapt to new conditions. Although no overall generalisations are possible in this regard, the fact is that small undertakings can actually have lower production costs per unit than large undertakings.

It is important in all business operations, and no less important in fisheries and aquaculture, to have a clear view of cost and to explore the differences between various cost factors. This is an aspect of an enterprise's strategy. In this context the managerial factors of production, i.e., planning, organisation, management, and knowledge, have a significant impact. All of this results from the fact that enterprises are normally in competition with other enterprises in an open market. In order to succeed, opportunities need to be utilised to the extent possible. Production cost will tend to fall when more units are produced, people will tend to learn their craft in the course of time and become more skilled at what they do, all of which will tend to reduce the average cost per manufactured unit. Fig. 3.9 shows this context.

Total production (q) is shown on the x-axis in Fig. 3.9, and the y-axis represents the cost per unit produced, or average cost (c). The upper cost curve represents the average cost, $c3$, in the production of the quantity $q1$, which corresponds to point A. As a greater quantity is produced, the average cost is reduced, and when $q2$ units are produced, the average cost has fallen to $c2$, which is at point B in Fig. 3.9. This reflects economies of scale.

The lower cost curve in Fig. 3.9 shows what happens when employees become more proficient in their work, for instance a year after start-up. Learning and knowledge accumulates, with the effect that the capacity of employees increases gradually over time. By the time that the quantity $q2$ is produced, average cost has fallen as a result of the improved skills of employees, and the average cost is $c1$, which corresponds to point C in Fig. 3.9. This curve, from point B to point C in Fig. 3.9 is the learning curve, which describes how average cost of production decreases with the increasing skills of employees, as represented by the shift of the curve. Trained or experienced people can therefore be an extremely valuable resource for an enterprise. This context is important in fisheries and aquaculture, because trained people are often the difference between profit and loss, and in fact performance and wages are often linked in fish processing in order to reward efficient employees.

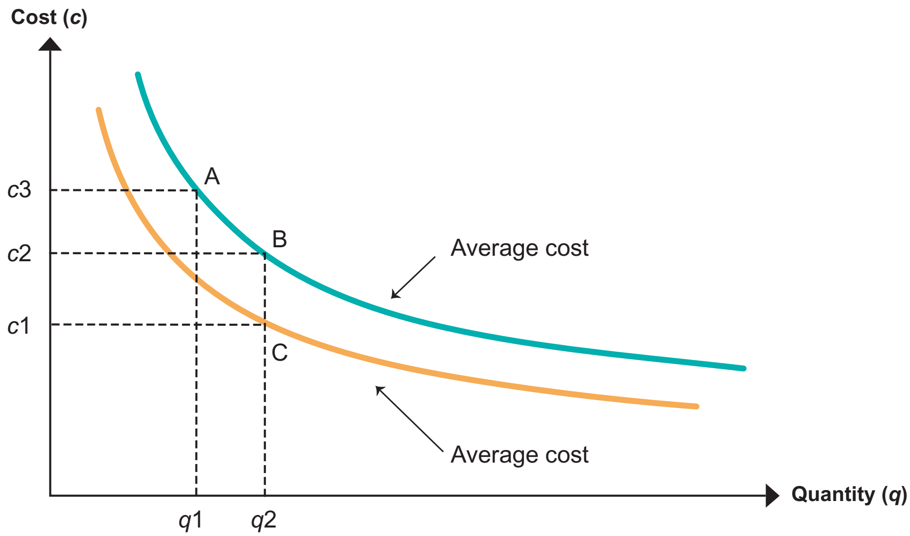

FIG. 3.9

Economies of scale and the learning curve.

There is no certainty of a free market, even when there are many buyers and sellers, as market dominance can still emerge, or even monopolies of certain enterprises. Despite these reservations, the market economy, driven by competition, has proven to be the most effective means of ensuring maximum prosperity in communities, as evidenced by the living conditions in many societies of the world.

Domestic product per person, that is to say the creation of value per person, is the measurement normally used in measuring well-being in any country. However, in using this measurement it has to be borne in mind that it is an average, and a very unequal distribution of wealth can exist, even where domestic product per person is high on average.

In business operations, external circumstances are frequently subject to risk or uncertainty; this is of particular importance in the management of fisheries operations for a number of reasons, including the vagaries of uncontrollable natural forces, such as the weather, or migrations of fish stocks. Risk is the term used when it is possible to estimate the probability of a certain situation arising. Uncertainty applies when it is impossible to estimate the probability of prospective scenarios. Two managers may take different decisions in the same circumstances depending on their respective degrees of risk aversion or risk appetite. Lenders and financiers also have to take account of risk. Among other things, the risk is reflected in the interest charged on credit. If a bank lends the sum of 1 million dollars each to two individuals and the bank considers it more likely that one will default on the loan than the other, for instance due to poor collateral or a weaker financial situation, then the bank will charge higher interest on that loan. What the bank is then doing is reflecting its required rate of return by means of an increased risk margin for the riskier borrower, but at the same time increasing the bank's default risk.

3.5 Supply and demand in equilibrium

Where demand and supply come together, circumstances are formed which determine and shape price and market activity. A market may be a physical location, such as a fish market or fish shop, or a site for currency transactions on the Internet. Supply and demand meet and create an equilibrium in the market at a certain price. However, once an equilibrium has been reached much can happen to disrupt it. For instance, a change may occur in buyers' tastes, which changes everything. If fish becomes more fashionable as part of a healthy diet, then the demand for fish and prepared fish dishes will increase. If the demand for a product decreases, producers will attempt to respond to the decrease in one way or another. They will increase their advertising efforts and attempt to combat the falling demand, which can often result in success but often in failure. Thus there are all kinds of forces at work, with the effect that the market is in a constant state of flux, resulting in periodic imbalances deriving from the factors that shift supply and demand, as described earlier. However, the market will continue to converge to an equilibrium. This characteristic of competitive markets of seeking an equilibrium requires further examination.

Supply and demand meet in an equilibrium. Fig. 3.10 shows that excess demand emerges at the price of USD 40/unit. Consumers wish to buy 70 units, but the market is offering only 30 units. The excess demand is 40 units. This means that inventories decrease to begin with, and some sellers increase their production as prices rise.

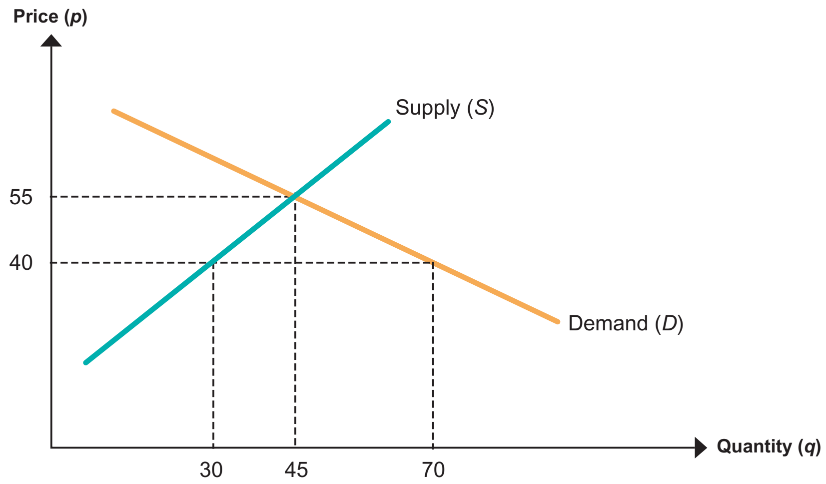

FIG. 3.10

Excess demand and equilibrium.

Some buyers are at the same time not getting the product that they want or need and are willing to pay a higher price than before to acquire the product. In this example, for the sake of simplicity, it is assumed that there is only one type of the same product in the market.

A price hike has the result that manufacturers increase their production capacity and thereby the quantity supplied. The price hike also has the result that fewer people wish to buy the product, which reduces the quantity demanded and this reduces the excess demand. In this way, excess demand has the effect of promoting an increase in produced quantity and in price. As the price rises beyond USD 40/unit there is a movement along the demand curve and the quantity demanded decreases. At the same time, the quantity supplied increases, i.e., there is a movement along the supply curve. Gradually, this results in an equilibrium at USD 55/unit and the quantity of 45 units. One manifestation of excess demand is temporary queues of buyers.

However, at the price of USD 70/unit (see Fig. 3.11) excess supply is created. Consumers only wish to buy 20 units, but the market is offering 55 units. The excess supply is 35 units. This has the effect, at first, that inventories swell. Some sellers reduce their production, while others cut prices. Some will do both. This reduces the quantity supplied, attempts are made to cut inventories and push for price cuts in order to increase volume in the market. Buyers buy more of the product as prices fall. As the price falls from USD 70/unit, the quantity demanded increases, which simultaneously reduces the quantity supplied. This process gradually leads to an equilibrium. The excess supply has the effect that production is reduced and prices fall. The excess supply leads to temporarily increased inventories for sellers.

Gradually, the behaviour of participants in the marketplace will lead to an equilibrium where supply is equal to demand. The balance in Fig. 3.11 is achieved at the

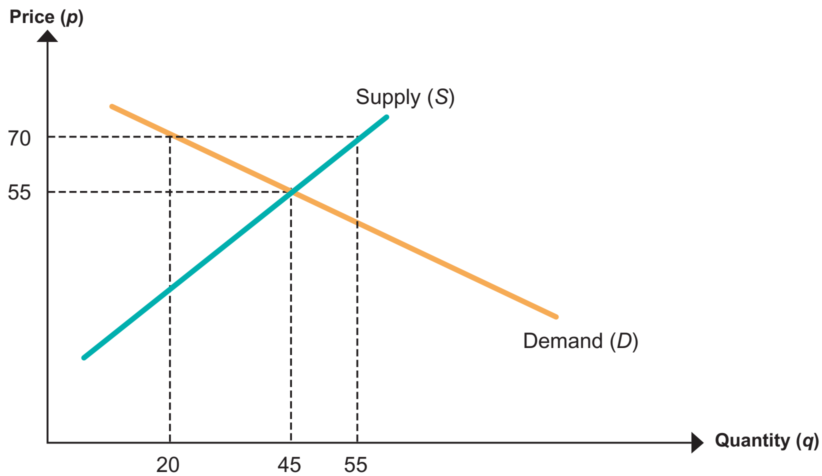

FIG. 3.11

Excess supply and equilibrium.

price of USD 55/unit; at that price consumers wish to buy 45 units and producers produce and sell 45 units. This is known as market equilibrium. There is sufficient demand for goods and services and sufficient supply to meet the demand. No inventory exists under such conditions (Fig. 3.12).

Where there is an imbalance, the market will attempt to find the price equilibrium where supply and demand are equal. In a free market, system imbalances, that is to say excess demand or excess supply, will only last for a limited period, as an adjustment will follow in the wake of price changes. This crucial fact is known as the law of supply and demand, and it applies to fish products as much as it does to any other product. This assumes a market where price formation is free, which is not the case in all markets or all countries. The theory of demand and the law of supply and demand, which determines price in competitive markets, is a fundamental aspect of economics.

The question now is what the benefit is to a society of this equilibrium. Useful concepts in this context are consumer surplus and producer surplus. If a fish dinner is sold at USD 15, but the consumer would have been prepared to pay USD 20, then the difference in prices is known as consumer surplus. The concept of willingness to pay refers to the price that the consumer would have been willing to pay. In this case the consumer surplus is USD 5. If the seller of the fish would have been willing to sell the fish dinner at USD 13, but it is sold at USD 15, then the difference in the two prices is USD 2, referred to as producer surplus. In any economy, the free market will seek to maximise the combined consumer surplus and producer surplus, as this makes production profitable.

FIG. 3.12

Aquarium (tbd).

Total surplus is a measure of efficiency in the economy; it constitutes the total value to buyers, net of the cost of sellers. If the use of raw materials, for instance the cod stock, or factors of production maximises total surplus, then the use is efficient. If the use is not efficient greater efficiency can be achieved by free trade between buyer and seller. The aim in any economy is therefore for a product or service of a certain quality to be produced by a seller who produces it at the lowest possible cost and sells it to a consumer who values it the most. The market system will normally lead to this conclusion. A change from a producer who produces at high cost to a producer who produces at low cost increases the total surplus in the economy. This applies to fish products in the same way as it does to other products. In this way, competition helps to weed out producers who underperform.

Consumers choose between product types and services, and they assess their needs themselves. People have different needs, tastes, and incomes, and these influence consumer behaviour. But consumer preferences may also change with the passing of time. The basic idea is that each individual tries to make the most of his possibilities in his or her own interest. Each participant in the economy attempts to bring about the optimal results for himself or herself, and this applies to purchases of fish or other marine products in the same way that it applies to other goods and services.

The core aspects of economic activity can be defined using the example of a baker who bakes bread that is sold in a market or a shop. The baker gets up at four in the morning to bake the bread and has warm, fresh bread for sale in his bakery at 8 o'clock for hungry buyers. The baker is not getting up at 4 o'clock for the benefit of his prospective customers; he is doing so for himself. The baker makes a living by baking and selling bread, and a part of this existence requires waking up and going to work early in the morning, because the morning is when the demand is greatest. Adam Smith, often referred to as the 'father of economics', suggested that an invisible hand was at work, driving the baker and others to work in their own interests.[i] In this way they also benefit others, as evidenced by the availability of new and fresh bread every morning for prospective buyers at an appropriate cost.

Most of the economy operates in this manner. If demand exists for goods and services, there will be no lack of providers of those goods and services for prospective buyers, all things being equal. These providers will compete with one another in price and quality. The baker who sells bread at higher prices will sell less bread or no bread at all. The baker who sells bread of poor quality will likewise sell little or nothing. Bakers therefore have to make good bread at the right time and sell it at similar prices as other bakers. This is what constitutes a market economy, and this arrangement has been in existence for millennia, at least in its simplest and most basic form. The present is a bit more complicated, but the fundamental feature has not changed: people work in their own interest and seek success for themselves and their families; in so doing, they benefit others.

In the case of our baker, a market will probably materialise at some point for a different kind of bread introduced by another progressive baker. If the new bread sells well and can be sold at a higher price than other types of bread, then other bakers will start to make this new kind of bread and offer it for sale. An increased supply of the new bread will eventually lead to a reduction in its price, because competition prevents one supplier from selling a product at a higher price than others and competition therefore leads to efficiency.

Endnotes

a. For a discussion of the blue economy see, e.g., Silver, Gray, Campbell, Fairbanks, and Gruby (2015) and Michel (2017).
b. For a discussion of the importance of property rights for the relations and economic growth of countries see, e.g., De Soto (2003) and Eggertsson (2005).
c. For a discussion of economic growth in earlier times and its reasons see, e.g., Mokyr (2006) and Van den Berg (2012).
d. For a discussion of institutional economics and its application see, e.g., Eggertsson (1990) and Groenewegen, Spithoven, and Van den Berg (2010).
e. Basic principles of economics are discussed, e.g., in Krugman and Wells (2009), Mankiw and Taylor (2010), and Wöhe, Döring, and Brösel (2016) and a number of other works on economics.
f. Caviar is mentioned as an example, as the price of caviar can be up to £20,000 for 1 kg of Beluga caviar, probably the most expensive food in the world see Guinness World Records (n.d.).
g. For a discussion of aspects of demand see, e.g., Einarsson (2005) and Mankiw and Taylor (2010).
h. For information on research into consumer attitudes to fish consumption see Brunsø (2009) and Gagne and Medrano (2009).
i. For information on Adam Smith's depiction of the market economy see Smith (1994).

CHAPTER

4 Environmental issues

Concerns regarding environmental damage and deteriorating natural conditions are not new concerns in the world's food production, as all food ultimately comes, and has always come, out of natural raw material originating in the environment. Man has long been quite conscious of the role of nature, for instance in agriculture, and understood that it makes good sense to treat the resources of the world with care. To give an early example, leaving fields fallow for a season to enhance later crops has long been common practice in agriculture.

In our time it is of crucial importance for all planning regarding environmental matters to be conducted on the basis of clear targets and assessment of the resulting impact of the endeavour to achieve those targets on the environmental fabric in its entirety and its sustainability. In the absence of careful planning, there is a risk of actions going wrong and even creating more severe future problems. Account also has to be taken of all the millions of inhabitants of the Earth, many of whom are dependent upon fisheries and aquaculture, and many of whom are also disadvantaged. Although free trade generally finds efficient solutions, we are now dealing with an entirely new problem of unknown dimension and level of seriousness, and of a more urgent and pressing nature.

4.1 Climate change and changing ecosystems

One of the principal measures of environmental risk is the gases in the atmosphere that have been labelled 'greenhouse gases'. Although these gases are necessary for life on Earth because of the thin layer that they form around the planet, that is to say the Earth's atmosphere, excessive quantities of greenhouse gases increase the density of the atmosphere, with the effect that radiation that would otherwise travel out into space is reflected back to the Earth, causing a warming of its surface. Global warming occurs in particular as a result of emissions of greenhouse gases created by burning fossil fuels, such as coal, oil, and natural gas, and as a consequence of the destruction of forests to make room for agriculture or other activities, for instance for the production of electricity, which is common in Africa, and general encroachment on vegetated land.

The causal links between excesses of greenhouse gases and rising temperatures on our planet have been studied for a long time by thousands of scientists, and despite objections from some quarters these links have been proven beyond any reasonable

Fisheries and Aquaculture. https://doi.org/10.1016/B978-0-12-821056-7.00006-8

doubt.[a] It is also evident, and proven, that burning fossil fuels and other carbon material contributes to increases in greenhouse gases in the atmosphere. Burning fossil fuels is virtually an exclusively human activity, as are many other activities, so there should be no dispute that humans are to a significant degree responsible for the current environmental threats. However, the consequences threaten not only humans, but virtually all life on Earth. Humankind has never before in its history of some 300,000 years had to confront environmental problems of the kind that can be traced directly to human behaviour. The only solution, therefore, is for humans themselves to modify their behaviour. If they do not, then living conditions in our world will radically change in the coming decades with potentially disastrous consequences for living beings.

Among the greenhouse gases are carbon dioxide (CO_2), which is released into the atmosphere when energy sources such as coal or oil are burned, and methane, which is formed, among other things, in the digestive systems of cattle and other ruminants. Plants derive energy from sunlight by transforming carbon dioxide and water into carbon and oxygen in a process known as photosynthesis. This process is of crucial importance to all life on Earth. Plants, especially forests, are therefore important factors in curbing the accumulation of carbon dioxide in the atmosphere. Global warming can disrupt a number of ecological equilibria, and this applies not least to the sea. The common struggle to counteract global warming is manifested in its clearest form in the contemporary environmental goals.

Fig. 4.1 shows global carbon dioxide emissions from 1950 to 2019.[b] Carbon dioxide is the most prominent greenhouse gas in the total emissions of such gases, accounting for approximately a three quarters share. In 1950 emissions of carbon dioxide amounted to 6 billion tons, but by 1980 this volume had tripled to 19 billion tons. The volume of emission was 37 billion tons in 2019, up sixfold in just short of 70 years, which is double the increase in the size of the world population over the same period. This is a tremendous increase over a relatively short period.

One of the most effective ways to combat global warming is to reduce emissions, which, among other things, will require a change in energy sources, combined with reduced overall energy use. About 50% of all releases of greenhouse gases result from energy production, e.g., for electricity and heating; about 20% result from transport. Agriculture also contributes large quantities of greenhouse gases, and in fisheries releases stem mostly from fuel consumption by fishing vessels.[c]

Aquaculture is in many respects similar to agriculture and entails significant releases of greenhouse gases. Aquaculture also creates a strain on the environment, as it depends both on fisheries and harvests of sea plants for the production of feed and feed supplements. Both the fishing and harvesting require energy produced by burning fossil fuels and thereby increase the release of greenhouse gases. Thus these problems are linked.

Fig. 4.2 shows the global temperature change from 1850.[d] It shows that the temperature has changed significantly in recent decades. From 1850 to 1950, in less than a century, the temperature increased by 0.36°C. From 1950 to 2018 the temperature increased by just short of one degree, which means that from 1850 to 2018, in less

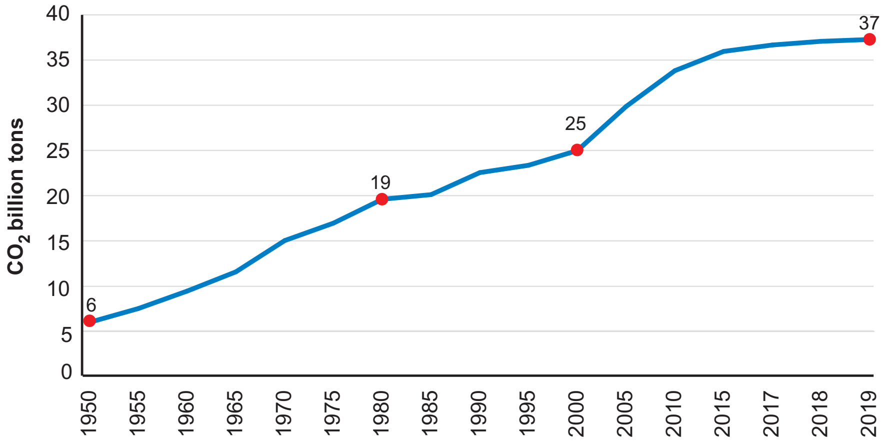

FIG. 4.1

Global CO_2 emissions in billion tons 1950–2019.

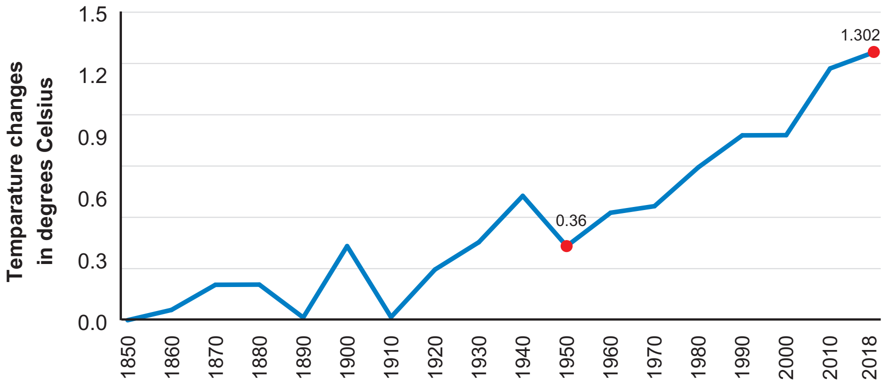

FIG. 4.2

Changes in global temperature 1850–2018 in degrees Celsius.

than 170 years, the temperature in the world has gone up by 1.302°C, as shown in Fig. 4.2. The current discussion focuses on keeping the rising global temperature within 2°C from 1850, when the Industrial Revolution began. Although 1.5°C is sometimes used as the reference, Fig. 4.2 shows that this limit has almost been reached already.

In the reference year of 1850 there were only 1.3 billion people in the world; they are now 7.8 billion. This tremendous increase has called for far greater production, not only of food, but also other goods of all kinds, largely because of the population growth, but partly also because of the improved overall economic prosperity in the world. The population growth and increased production call for greater fuel consumption, for instance in premise heating and cooling, and air, sea, and land traffic, with a resulting rise in global temperature. Forecasts of temperature changes in the coming decades rely mostly on the scenarios used for reference, but the future is not bright in this regard unless radical measures are taken.

Sometimes it appears that the environmental problems of the present are not placed sufficiently well in the context of the unprecedented population growth of the last 200 years, which has called for increased energy needs and energy use, all of which have contributed to global warming. As an illustration, the population of the world has tripled since 1950, from about 2.5 billion to about 7.8 billion, while the energy consumption of the world has increased more than fivefold, as shown in Fig. 4.3.

Fig. 4.3 shows the global energy consumption since 1950.[e] It clearly shows the huge increase in energy use. In 1950 the energy consumption was 28 TWh, but the consumption then tripled to 1980, rising to 83 TWh. Energy consumption increased by 50% over the next 20 years, to 2000, and in this century the consumption has increased by 40%, to a total of 157 TWh. This is a tremendous increase, and it is the cause of the most serious environmental problems of our day.

As mentioned earlier, there has been a population explosion in this period, but that explosion alone does not explain the huge increase in energy consumption; the average energy used by each person in the world has also grown. Fig. 4.4 shows the energy consumption per capita.[f] The energy consumption per capita was 1337 kg of oil equivalent in 1971, but by 2018 this figure had reached 2004 kg of oil equivalent per capita, up by 50%. This is explained, among other things, by the fact that prosperity, and thereby consumption, has increased significantly in many countries,

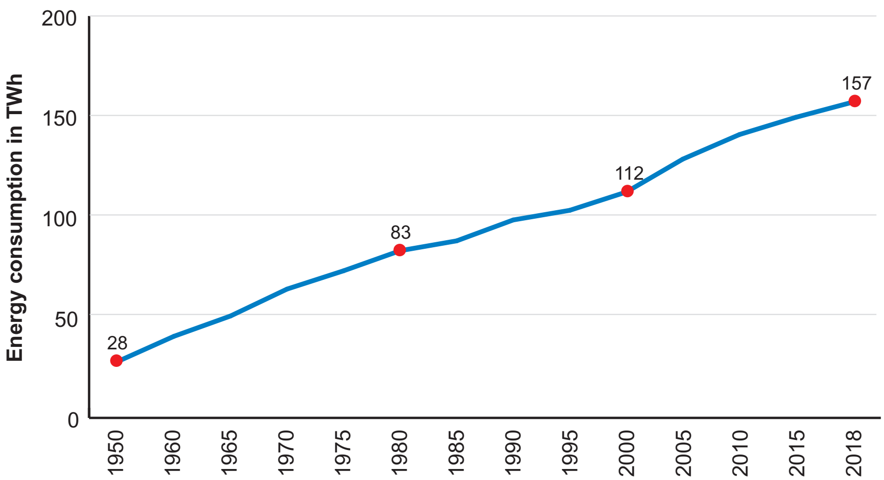

FIG. 4.3

Global energy consumption in terawatt hours 1950–2018.

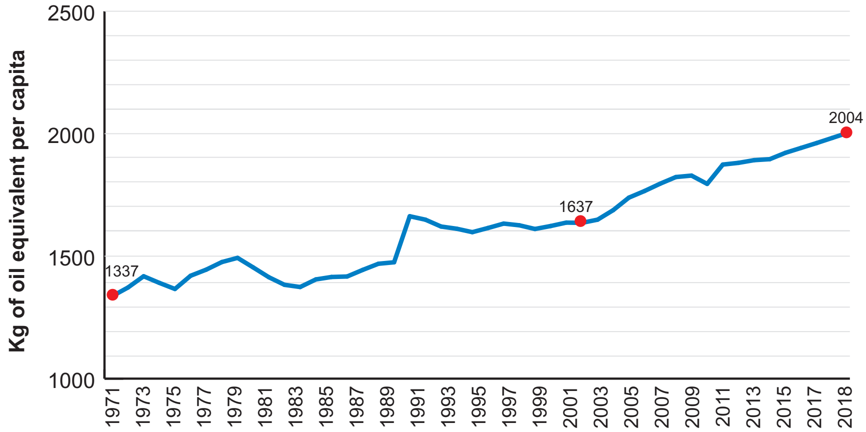

FIG. 4.4

Energy use in kg of oil equivalent per capita 1971–2018.

particularly in China, and with increased prosperity comes increased energy consumption. Figs 4.3 and 4.4 clearly demonstrate the urgency of finding other environmental energy sources and changing the human use of energy.

The most used energy sources in the world are oil and coal, both extremely 'dirty'; in addition, both are nonrenewable resources that will eventually dry up. Admittedly, there are enormous quantities of coal in the world, but the use of coal is being curtailed because of its negative impact on the environment. About 60% of the world's energy needs are currently met by coal and oil, a similar proportion as 70 years ago. The world's supply of oil, on the other hand, is not as large, although there is no shortage of oil as yet, and new sources have also been found, some of those in the seabed. Norway, for example, became one of the major producers of oil in the world in the space of a few decades when oil was discovered in the North Sea within Norway's economic jurisdiction. The problem with this is that extracting oil from the seabed entails a greater risk of environmental disasters than extraction on land, and accidents have in fact happened despite the great care taken to prevent them. One relatively recent example is an explosion that occurred in 2010 in an oil rig operated by British Petroleum in US waters in the Gulf of Mexico, resulting in an oil spill with serious consequences for the local ecosystem.

Energy sources that are less polluting than coal and oil have attracted increasing attention in recent years and decades, including hydroelectric power, natural gas, wind power, and solar power. Windmill farms are proliferating in many areas of the world, often offshore, where winds can be strong and steady, creating ideal conditions for power generation. Significant progress has also been made in the use of solar power, which is set to become far more important in the future than it is at present. In any case, energy and energy production are the key to all economic activity, and fisheries and aquaculture are no exceptions. Fish farming will no doubt be able to take advantage of all kinds of innovations and progress made in power generation on land, but fishing vessels will be difficult to power by any means other than oil to any great extent, at least in the near future.[g]

The extensive use of oil by the current fishing fleet of the world is one of the reasons that many people, politicians in particular, argue for more environmentally friendly ways of fishing, for instance using small boats, as small-scale fisheries can adapt quickly to changes. Different interests can therefore come into conflict in environmental debates, in this case large-scale fisheries operators versus small-scale fishermen. As far as the competitiveness of fisheries in comparison with other food production is concerned, it is worth noting that the energy that goes into producing protein from fish is similar to that used in poultry farming, but far less than the energy used in the production of pork and beef.

Overgrazing and overfishing have long existed despite all the efforts made to combat them. In part this is a result of the problems inherent in the utilisation of common resources, but the environmental problems of our times are much more serious problems. A number of plant and animal species face extinction, some raw materials that were readily available before are now scarce, and anthropogenic global warming is putting environmental problems into an entirely new context.

People are generally more aware of environmental problems than before, and it is dawning on an ever greater number of people that the Earth may well become largely uninhabitable by humans if no action is taken. Politicians are mostly speaking in this vein, and agreements and action plans have been drawn up, but there are many who believe that these plans and actions fall far short of what is needed. There is no unity in the world as regards the impact of greenhouse gases,[h] but the doubters are fewer than before (Fig. 4.5).

Children's and young people's concerns about their future have now become a part of the environmental debate in a new turn on history, where the views of those who will eventually inherit the world are being taken seriously. A prominent example of the campaign being conducted by young people in support of environmental issues is the large following of Greta Thunberg of Sweden, a young girl who took time off from school on Fridays to call for greater action on environmental affairs, particularly as regards global warming. Her campaign attracted extensive attention and provided a model for similar actions by schoolchildren across the world. Also worthy of note is the change in the diets of many young people, as vegetarianism and veganism have become significantly more widespread than before in that age group. This leads to changes in food production, and some of these changes will contribute to a decrease in the release of greenhouse gases, as beef production is a major source of greenhouse gases.

While public awareness and the resulting pressure on politicians are important, it is equally important for politicians to plan and organise actions against global warming carefully and understand the potential consequences of the actions themselves for the ecosystem as a whole, and at the same time to adapt to new changes in the climate and other natural conditions. Also, politicians need to understand that many of the people who work in fisheries and aquaculture and are dependent on those sectors

FIG. 4.5

Greta Thunberg in a protest in front of the Swedish parliament (Wikimedia commons—Andreas Hellberg).

for their subsistence and nutrition are poor people. Climate change will to a large extent affect people who are already vulnerable and finding it difficult to secure for themselves a decent livelihood. Food security is a vital aspect of the struggle to eradicate poverty, and fisheries and aquaculture will play a key role in that respect.

The world's oceans have absorbed over 90% of the additional energy produced from 1971 to 2010 and bound 30% of the carbon dioxide, which has resulted in increased acidification of the sea; this trend is set to continue, although its projected scope depends on the scenarios used in predicting future climate change. Climate change will reduce the biological capacity of the seas, including the fish stocks, by about 3%–12%, particularly in the South Pacific regions.[i] Ocean acidification is measured on the pH scale, which is a logarithmic scale.[j] This acidification has increased by somewhere near 30% in the last 250 years or so. This translates into a 0.1 pH unit drop, from 8.1 to 8.0, with lower pH meaning more acidic. A change of 0.1 may not seem like much, but since the pH scale is logarithmic, even a small change in pH can represent a substantial actual change. For comparison, another logarithmic scale is the Richter Scale, which is used to measure the strength of earthquakes. An earthquake measured at 7 on the Richter Scale releases ten times more energy than an earthquake measured at 6 on the scale and a hundred times more than an earthquake measured at 5. It has been suggested that if nothing is done, the acidification of the oceans over the years left to 2100 will increase by 150%. This illustrates the unprecedented changes that have been occurring in the oceans over a relatively few years in comparison with earlier times.

One of the most serious consequences of global warming is the rise of the sea level. This has two main causes: on the one hand the warming itself causes the seawater to expand and increase in volume; this cause explains about half of the rise. On the other hand, the melting of the Greenland glaciers and the Antarctic ice, as well as glaciers outside the Arctic and Antarctic, causes more meltwater to find its way into the sea.[k]

The temperature of the surface of the sea, which is regarded as extending to a depth of 700 m, increased by just over 0.7°C in the 20th century, with the greatest increase in the North Atlantic. The level of the sea is up by 20 cm in just over a century, since 1900. It has been estimated that the surface of the sea will rise by about 50 to 120 cm from 2000 to 2100, depending on the climatic scenario used. The rise will differ by location, with the most profound changes in living conditions occurring on low-lying seashores and islands, and one of the consequences could very well be an increase in the number of migrants seeking higher ground and liveable conditions.

Fisheries management systems will need to take account of these changes in order to mitigate the threats caused by climate change to the marine ecosystems; it needs also be borne in mind that the effects will be different from one region of the world to the next. Fishing using oil-burning vessels, which cause extensive pollution, will face challenges. Ship designers have responded to this situation, and all new vessels, including fishing vessels, are now designed with a view to conserving energy.

Climatic change can also affect ocean currents, such as the Gulf Stream, a current of warm water flowing from the Gulf of Mexico northwards and eastwards to Europe and Africa. The Gulf Stream has the effect that the climate in Europe is warmer than it would otherwise be. Potential changes in the Gulf Stream are therefore a serious matter for a number of countries, even though changes in climate and ocean currents will normally occur over very long periods of time. The same applies to other ocean currents of the world. Ocean currents impact fish migrations and fisheries, so that uncertainty regarding the implications of climate change for ocean currents is worrying. The degree of the uncertainty is evident from changes in *El Niño* in recent decades, which in many ways have been unexpected. Climate change also has an impact on the world's lakes, and droughts may be expected to last longer than before, which impacts the volume of water in rivers; for the same reasons, famines may become more common than before.

Of the approximately one billion people that live in dire poverty and hunger, many live in areas where small-scale fishing and fish farming are a significant source of nutrition; these people, living in a subsistence economy, already worry about finding food for themselves and their families on a day-to-day basis. This can also apply to areas where conditions are, on average, quite good. It needs to be underlined that there may be regions in a country that face severe problems of poverty and food shortages and are heavily dependent on fisheries and aquaculture, even when the country as a whole does not face the same problems. Those regions are particularly vulnerable to climate change for both geographic and economic reasons.

In comparison with the industrialised countries, pollution originating in some of the developing countries has been limited, but there are indications that this may change in the near future as the populations of these countries grow, and it is increasingly common for these countries to use materials in their production that have been banned in more developed countries because of the hazards they pose, including dangers of pollution.[l]

The impact of climate change on aquaculture in the short term will be reflected in increased flooding; greater risk of diseases, parasites, and harmful algal blooms; and deteriorating farming conditions resulting from rising temperatures and increasing acidification of the oceans. Population growth will also increase the demand for water. In many countries the negative impact on fresh water will have the greatest consequences for aquaculture. Among the remedies available to aquaculture in response to climate change will be to improve the choice of farmed species, improve planning and management, and increase monitoring of environmental elements. Shortages of water will also lead to increased competition for water between aquaculture and traditional agriculture.[m] The modern environmental problems therefore have the potential of seriously disrupting the world's food production, particularly in vulnerable regions which have the least capability to respond to these new threats.

Increased aquaculture may present a solution if and when fisheries decline. In many regions where aquaculture is an important sector there is often a lack of expert knowledge of the impact of climate change on aquaculture and its various socioeconomic consequences. Climate change will affect farmed organisms, so that increased monitoring and preventive measures will be required to take on challenges. Adaptation to changed circumstances in fisheries and aquaculture resulting from climate change will require measures for improvement both in government agencies and in the management of fisheries and aquaculture companies. Biological factors will need special attention, and benchmarks will need to be developed to assess threats. For example, it could make sense to assess fish stocks as natural capital and incorporate them into national accounts. Everything relating to environmental matters and sustainable development could be regarded as an investment in the future, which is an essential mindset (Fig. 4.6).[n]

Many of the problems that have not been successfully tackled to date have the consequences of impairing quality of life or preventing quality of life from being what it could be; these problems include the inability to harvest fish in the most efficient manner possible and the inability to prevent wastage of food. The fact that quality of life is not as good as it could be is, of course, a bad thing, but for most of the Earth this can be tolerated. The environmental problems that we face in our times, with climate change at the forefront, are of a different nature. They have the potential effect of making the world uninhabitable for a large part of humankind.

Global warming will have, and is already having, a significant impact on the economies of a number of countries. A study[o] has shown that the impact is greatest in the countries where global warming will be most severe; as it happens, fisheries and aquaculture are important sectors for the economies of precisely these countries, which are mainly low-income, economically vulnerable developing countries and island states.

FIG. 4.6

A hand water pump in Manica in Mozambique (Ivan Learning Portfolio).

The impact of the greenhouse effect is an external impact, that is to say an impact caused by someone who burns fossil fuel, to give an example. The consequences do not affect that someone specifically; they affect a third party, that is to say the public, which has to deal with serious environmental problems such as global warming, acidification of the sea, depletion of oxygen in the sea, and a rising ocean surface. It is urgent, therefore, to seek all means of reducing emissions of greenhouse gases, not only by reducing emissions of carbon dioxide by appealing to the public and enterprises, but also by utilising market principles. This can be done in a number of ways, for instance by allocating emission allowances and permitting trade in such allowances.[p] This has, in fact, been done, and market transactions have the effect that emission allowances gravitate towards those who are able to reduce emissions with the least cost, that is to say most efficiently.

Pollution taxes are a very efficient way to combat pollution, in addition to generating revenue for government that can be used for further mitigating measures. The main thing is for the party causing the pollution, such as emissions of greenhouse gases, to bear the cost resulting from the pollution, or at least a part of it. This arrangement, known as the 'polluter pays principle', as mentioned earlier, is enshrined in a number of international treaties on environmental protection, such as the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter.[q] Best, of course, would be for the polluter to pay all of the cost resulting from his pollution, giving polluters an incentive to try to keep their pollution at a minimum and thereby reduce their cost. Pollution is a negative externality and results in cost to the public. With the imposition of pollution taxes, enterprises and individuals will take into account the cost that results from pollution, which will encourage more sensible behaviour.

Taxation of polluting energy sources is in fact quite widespread in the world, but could no doubt be more common; however, the interests of those who oppose such taxes also carry significant weight. The short-term financial interests of big business are frequently a cause of delays in addressing the public interest. The task of the politicians, whose job it is to chart the way forward, is therefore not an easy one. The reality is that the interests of the Earth, its future, and coming generations have not always been in the foreground. Waste and poor use of the Earth's resources have been a prominent feature of human history, as evidenced, for instance, by the fact that about a third of all foodstuff in the world goes to waste, as mentioned earlier. However, we have now reached the limits of the Earth's capacity, if most of the world's scientists are to be believed, and so humankind needs all the tools at its disposal. Although there is every reason to take environmental problems very seriously, these problems can be overcome with a concerted effort, and the technological advances of the coming decades will contribute to the resolution of many of them.

4.2 The United Nations Sustainable Development Goals and their impact on fisheries and aquaculture

There has long been a call for responsible environmental behaviour in fisheries and aquaculture. One example of such a call is the FAO Code of Conduct for Responsible Fisheries, dating from 1995 and setting standards for responsible fisheries in order to secure efficient use, management, and development of biological resources, taking account of biodiversity and the marine ecosystem. It covers the fisheries and aquaculture chain from resource research to fishing and farming, processing, marketing, and trade.[r] Regulation of food production, including in fisheries and aquaculture, has increased in recent years and decades, but this has not sufficed to turn around the overexploitation of natural resources.

One of the key issues for world fisheries is the United Nations Sustainable Development Goals. There are 17 goals, all established in 2015. Among other things, they address development with regard to the world's oceans and lakes. The 14th goal calls for measures to "Conserve and sustainably use the oceans, seas and marine resources for sustainable development", and, more precisely, to "effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics". The Paris Agreement of the UN Framework Convention on Climate Change, also dating from 2015, on maintaining the increase in the global average temperature well below 2°C above preindustrial levels and pursuing efforts to limit the temperature increase to 1.5°C above preindustrial levels, will restrict the current scope for fisheries and fish farms in the same manner that it will affect other economic activity in the world. The United Nations Sustainable Development Goals are therefore an important factor in the environment of fisheries and aquaculture.[s]

Among other things, the United Nations Sustainable Development Goals entail the placement of sustainable development at the centre of all human behaviour. For fisheries and aquaculture, the 14th goal is of the greatest consequence. However, achieving the goals will come at a cost to the countries of the world, and a number of countries will face difficulties in funding their achievement.

The United Nations Sustainable Development Goals constitute an action plan for the benefit of humankind, the Earth, and prosperity. The goals, and the plans to achieve them, also represent an attempt to promote peace across the world. Clearly, the eradication of poverty in all its forms, including extreme poverty, is the largest global task and an unavoidable condition for sustainable development. A key factor is food security, where fisheries and aquaculture will have a large role. Through project-level cooperation, all the countries of the world will be set to implement this action plan. The countries that adopt the Sustainable Development Goals will aspire to liberate the world from the shackles of poverty, increase the Earth's vegetation, or at least prevent loss of vegetation, and improve food security. They will undertake to take decisive steps in the direction of the changes that are necessary to place the world on a path that will entrench sustainability and improve the Earth's resilience.

The 17 goals of sustainable development and the numerous subgoals established in the context of the United Nations Sustainable Development Goals bear witness to the scope of this new, universal and ambitious plan. The goals are based on the United Nations Millennium Development Goals dating from the year 2000 (Fig. 4.7).

Among other things, Goal 14 entails promoting sustainable development; adopting sensible fisheries management practices; reducing the acidification of the oceans and coastal pollution; curtailing illegal, unreported, and unregulated fishing; banning state subsidies that encourage overfishing and overcapacity; enlarging protected areas; expanding research; recognising the special circumstances of developing counties and the least developed countries; and incorporating these considerations into the World Trade Organization talks on state aid.

Goal 14 thus involves protection of the oceans and the sustainable utilisation of their resources. It is underscored that the oceans are a prerequisite for human life on Earth and that about three billion people, just short of a half of the human race, rely on the biodiversity of the sea for sustenance and survival. At the same time, 1/3 of the world's fish stocks are overexploited, the oceans absorb about 20%–30% of all the carbon dioxide of anthropogenic origin and about 40% of the world's oceans are tainted by man-made pollution.[t]

All of this indicates that the United Nations are aiming for an extensive and general consensus on fisheries and aquaculture in the coming years with the aim of promoting food security. Fisheries and aquaculture, as commercial sectors that owe their existence to the oceans, still have strong ties with land-based processing industries and they are frequently woven into the fabric of local culture. Fisheries and aquaculture can have a significant impact on the goals of ensuring food security, reducing poverty, promoting community well-being, strengthening gender equality, and increasing economic growth, all of which are elements of the United Nations Sustainable Development Goals.

FIG. 4.7

Pictogram for the 14th United Nations Sustainable Development Goal (Wikimedia Commons).

4.3 Effect of climate change on fisheries and aquaculture

Global warming has the effect that the surface of the oceans is rising, which will have an impact throughout the world, with special implications for small island states in various parts of the Pacific and Indian Oceans. Many of these island states are also dependent on fisheries and aquaculture. The acidification of the oceans and depletion of oxygen in the sea have a negative impact on marine life, and signs of deterioration are already seen in various areas, such as the coral reefs of the south seas, algae, and shellfish. Among other effects of pollution of the seas is the presence of hazardous substances, such as heavy metals and chemical contaminants in marine organisms.

The impact of global warming on the marine ecosystem is significant, affecting, among other things, the spawning grounds of fish, causing changes or even disappearances of fishing grounds and potentially reducing the availability of food. Warming of the sea also reduces plant activity in the sea and inhibits photosynthesis. Thus fisheries and aquaculture are highly dependent on efforts to combat global warming.

Because of the growing public awareness of environmental issues, and because of increasing surveillance by national and international supervisory measures, the traceability of products has become an increasingly common requirement in marketing fish products, whether caught or farmed. It has therefore become important for businesses to be able to demonstrate that fish and its products were obtained by means of sustainable fishing, farming, and processing. If this cannot be demonstrated, there is a risk of the fish fetching a lower price, or even being impossible to sell through established retail channels.

Taking into account the fact that about 33% of all fish stocks are currently overexploited, as compared to only 10% some 40 years ago, the trend would appear to be away from sustainable fishing. For this reason, it is more urgent than ever before to set the environment and sustainability as principal aims in world fisheries, not least in the interests of food security for the world population. This is especially important in Asia, which is not only the region of the world where fisheries and aquaculture are most prominent, but also the region where many of the poorest countries in the world are located and where an improved position in fisheries could have significant benefits. Similar results could also be achieved in Africa, also the location of numerous developing countries. Fisheries where account is taken of environmental concerns, and where fish stocks are built up, can thus have a significant impact on the economic position of developing countries.

The benefit of an improved system of management would be manifested principally in a lower cost of fisheries and increased fishing for more valuable species. However, it is far from easy to achieve optimality in fisheries and fishing efficiency. This will require a significant reduction of effort, for instance by reducing fleets, introducing more efficient engines and fishing methods, and encouraging technical progress in the form of robots and increased automation. The routes to improvements in fisheries include restrictions on fishing gear, closures of fishing zones, reductions of total allowable catches (TAC) to bring them nearer maximum sustainable yield and maximum economic yield, temporary closures of fishing zones, restrictions on fishing licences, charges for fishing rights, and management systems based on individual transferable quotas. The optimal condition of the fish stocks does not automatically lead to the most efficient fisheries, as the most efficient fishery is the fishery that maximises profit. The reason that profit is placed in the foreground is that this creates value that otherwise would not exist. This value can then be used to support vulnerable regions in the country in question, support research and management, or whatever may be most needed.

It has been estimated that if fishing is conducted in a sustainable manner and optimality is achieved as regards biomass and effort it could be possible to increase the profitability of fisheries by about 80 billion USD. If this is compared to the first sale value of the world catch of fish, which is about 130 billion USD, we can see that the benefit of placing environmental objectives and efficiency in the foreground is significant. One major result of strengthening fish stocks is that it makes it possible to increase the utilisation of more valuable fish species, which in turn leads to rising prices per kg. Building up fish stocks by suspending fisheries entirely for a specific amount of time is not a realistic option, but reducing the effort annually by 5% for 10 years could result in the fish stocks achieving the desired biomass in about 30 years (Fig. 4.8).[u]

Achieving the goal of sustainable and effective fisheries management will require a great deal of investment in government regimes involving matters such as scientific advice on fisheries and monitoring, control, and surveillance. Governments in

FIG. 4.8

Pollution in the sea at Borneo (Josephine Julian).

individual countries will have to be prepared to make this investment, and the cost will need to be reflected in decisions made in the sector itself, including decisions by the fishermen themselves. It would therefore be reasonable for countries that lease out fishing rights in their jurisdictions to charge an adequate price in order to meet the costs of scientific research and surveillance of fisheries. About half of all the exclusive fishing zones of the world are subject to agreements with foreign entities, and the fact is that countries that act together fare better in such agreements.

If fisheries are conducted in the most cost-effective way, the benefit will therefore far outweigh the cost of achieving the set goals. The problem of achieving these results is a political one, that is to say a global accord needs to be reached on curtailing fisheries in order to replenish fish stocks and thereby to catch greater quantities in the future, for the benefit of all humankind.

This is a comparable situation to the one reflected in the goals of the Paris Accord of curbing global warming. But that discussion has reached a much more advanced stage than the discussions of global fishing. It is therefore important to encourage a political consensus, under the auspices of the United Nations, for example, in order to curtail fisheries and bring the world's fish stocks up to a desirable size.

But even if the fish stocks are in fact brought to a desirable size, fisheries must still be conducted so as to maximise yield. It is not a simple task to unite the nations of the world on this path, especially as the circumstances of the nations as regards fisheries are so different. Many of the fish stocks of the world are subject to agreements between a number of countries, and within individual countries there are divergent interests that cannot always be reconciled. It is clear that all of this work will require extensive funding of a number of factors while the fishing effort is reduced in an organised manner.

The fishing effort has been increasing in recent years because of the greater number of vessels and fishermen, particularly in the developing countries, and because of greater and better technology, which has the result that fish are finding it increasingly harder to evade human fishing gear. A simple example of a technological advance that increases the fishing effort is the motorisation of small-scale fishing vessels, which will generally increase the effort significantly. Since the world catch has not increased on the whole in the global context in recent years, it is obvious that productivity in fisheries has fallen. However, the impact of the growth in the number of vessels and fishermen and the advances in technology differ both by species of fish and from one country to the next. Thus productivity, e.g., with regard to number of fishermen, has actually increased in some places.

4.4 Plastic pollution in the oceans

Certain aspects of the general environmental concerns are more prominent than others in the public discussion, and one of these is all the plastic that is floating around in all the world's oceans and threatening marine life.[v] The feature of plastic that makes it so insidious is that it is a synthetic material that does not decompose, or takes a long time to decompose, in nature, and none of the polymers that are most commonly used in plastics will break down under natural conditions. Plastic can cause the death of fish and other marine organisms in a number of ways, the most recent fear being microplastic, tiny plastic particles that could threaten the reproduction of fish and even zooplankton. This is illustrated in a vast number of easily accessible documentary programmes on television and elsewhere. The reduced use of plastic, for instance in packaging, and more extensive cleaning and recycling of plastic is a prerequisite for any extent of success in grappling with this problem. However, plastic is one of the most widely dispersed materials on Earth, so the problem is not an easy one to deal with.

Plastic is one of Man's most important discoveries. It is manufactured mostly out of crude oil and can be formed into endless shapes using temperature and pressure. The use of plastic has been growing, particularly in recent decades. Plastic is now used in most human activity and in the manufacturing of most goods, especially in the form of packaging, such as bottles and shopping bags. In addition, much of the gear used in fisheries is made of plastic materials, including lines, nets, and tubs. In aquaculture, plastic is used in packaging, tubs, fish tanks, and a myriad of other things. Plastic pollution has become a term in most of the languages of the world, which is evidence of the problematic nature of plastic as a pollutant (Fig. 4.9).

Fig. 4.9 shows the volume of plastic production in the world in 1950–2018.[w] The illustration shows that production was relatively limited in the first 30 years of the period, but the production increases significantly after 1980, tripling to the year 2000 to 213 million metric tons. By 2018, the production is estimated at up to 432 million tons, double the 2000 figure. It is projected that the production could reach a thousand million tons by 2050.[x] It has been suggested that by about 2050 there will be

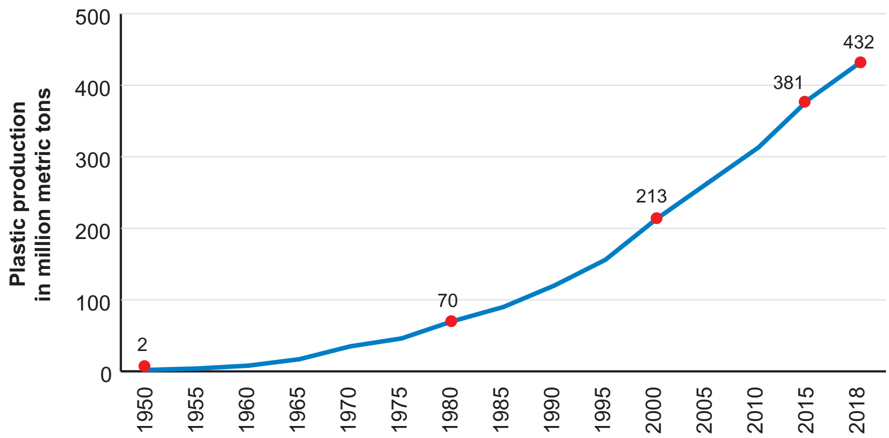

FIG. 4.9

Global plastic production in millions of metric tons 1950–2018.

more plastic in the oceans than fish. To put these figures into perspective, the amount of plastic manufactured is double the quantity of the world catch in the oceans and the output of fish farms each year. Plastic is usually quite light, as everyone will know from using plastic shopping bags; yet, the quantity of plastic manufactured in the world is almost equal to the body weight of all 7.8 billion members of the world population. Although the annual production of plastic in the world amounts to some 400 million tons, it is worth mentioning in comparison that waste from humans amounts to over 2 billion tons each year. The comparison brings home to us the amount of work that remains undone in waste management in the world.

The quantity of plastic that enters the oceans each year probably amounts to about 10 million tons. As mentioned earlier, the plastic does not decompose or break down in the sea, so it accumulates, and each year more plastic is added as waste in the world's oceans. Quite apart from other problems caused by plastic, fish and other animals can become entangled in plastic waste and die. Great quantities of plastic are swept into the seas as deposits from rivers and sewage systems; although most rivers running through urban or industrial areas will carry some plastic to sea, it is estimated that the largest share, about 90%, of the plastic transported by 1350 rivers in the world is carried by 10 great rivers, 8 in Asia and 2 in Africa.[y]

Fisheries themselves also generate plastic waste, for instance in the form of fishing gear that is lost at sea, or deliberately jettisoned into the sea and lakes, and in the form of general waste from freighters, passenger vessels, and fishing vessels. Plastic is also washed up on the world's beaches and can be an eyesore, quite apart from other more insidious effects. As noted earlier, the plastic manufactured never completely breaks down. Minute particles of plastic, referred to as microparticles or nanoparticles, have been detected in the innards of marine organisms that travel up the food chain and wind up on consumers' plates. The plastic particles are so small that they can penetrate human cells and cause damage to health.[z] However, it should be noted that in most cases the innards of fish are discarded before the fish is consumed—not that this is any great comfort (Fig. 4.10).

Whether anything can ever replace plastic is not a simple question; plastic is cheap in production and, as in the case of other matters in the human economy, efficiency decides the use of factors of production. Consumer habits will therefore have to change if any success is to be achieved in the battle against plastic. The market economy suggests that if there is a will to reduce the use of plastic, the simplest remedy is to impose charges on its use or production, thereby raising its price and reducing demand. However, special plastic taxes have received little discussion, although, to be sure, various charges are levied on waste and pollutants. There are in fact bans on the use of plastic bags in some places and these are on the increase; but the fact remains that the carbon footprint, that is to say the emission of greenhouse gases, resulting from the manufacture of substitute products for plastic bags, such as cloth bags and paper bags, is also significant. A cotton shopping bag, for example, needs to be used several hundred times to offset the carbon footprint of a plastic bag. All of these aspects therefore need to be taken into consideration to evaluate the total impact.

A large portion of the plastic manufactured in the world, about 40%, is used in packaging, and much of that is only used once. The huge volume of plastic manufactured in the world therefore mostly ends its life cycle in one of three ways: about 55% is discarded or deposited in landfills, 25% is incinerated, and about 20% is recycled.[aa] Note the small amount that is recycled. Although it is safe to say that plastic is not the worst environmental problem faced by humankind, it is a big part of the

FIG. 4.10

Plastic pollution on a beach near the Panama Canal (Fotos593).

problem in the sense that changed consumer behaviour and consumption patterns are a prerequisite for any success in resolving the massive environmental challenges of our times.

To give an example of changes in the disposal of plastic in the countries of the world, China announced around mid-year 2017 that an import ban would be imposed on waste, including plastic; the Chinese have imported and disposed of about 56% of the world's plastic waste, including almost 87% of the plastic waste originating in the European Union. In January 2018 the European Union presented a new strategy aiming at increased recycling, a reduction in the use of plastic, and the elimination of plastic pollution of the seas by the year 2030.[ab]

4.5 Antarctica and the Arctic

The regions surrounding the South and North poles are important for fisheries, and the impact of global warming in those regions is therefore a significant threat, not only to the regions themselves, but to the world in general. There are seven continents on Earth, although North and South America are sometimes referred to jointly as the Americas. By far the largest continent is Asia, covering 45 million square kilometres, which represents approximately 30% of the Earth's total land area. The continent is home to some 60% of the Earth's population and the site of the most extensive fisheries and aquaculture in the world. Antarctica covers about 10% of the Earth's land area; it is considerably larger than Europe and Oceania but hardly inhabited at all. The Arctic is about the same size as Antarctica, but it is an ocean area, not a continent.

Seven countries lay claim to Antarctica: Argentina, Australia, Chile, France, New Zealand, Norway, and the United States. A number of other countries have interests in the area, which is subject to an international agreement known as the Antarctica Treaty. The international cooperation on Antarctica engaged in by some dozens of countries emphasises environmental matters, but fisheries and research into fisheries are very limited (Fig. 4.11).

The Arctic refers to the regions extending from the North Pole. Eight countries are referred to as 'Arctic', all of them member states of the Arctic Council: Canada (i.e., Yukon, the Northwest Territories, and Nunavut), Denmark (i.e., Greenland), Finland, Iceland, Norway, Sweden, Russia, and the United States (i.e., Alaska) (Fig. 4.12).

The Arctic Region is sometimes defined as the area where the average summer temperature is below 10°C, as shown by the red line in Fig. 4.12. The most common definition, however, is the area north of the Arctic Circle, just over 66°33′ north of the Equator, as shown by the blue circle in Fig. 4.12.

The Arctic is sometimes divided into three parts, the first being the area extending into Canada and Alaska; the second being the area pertaining to Russia, i.e., Siberia; and the third being the central area, extending from Finland, Sweden, and Norway across the Atlantic, over Iceland and Greenland.[ac] The Arctic region features a

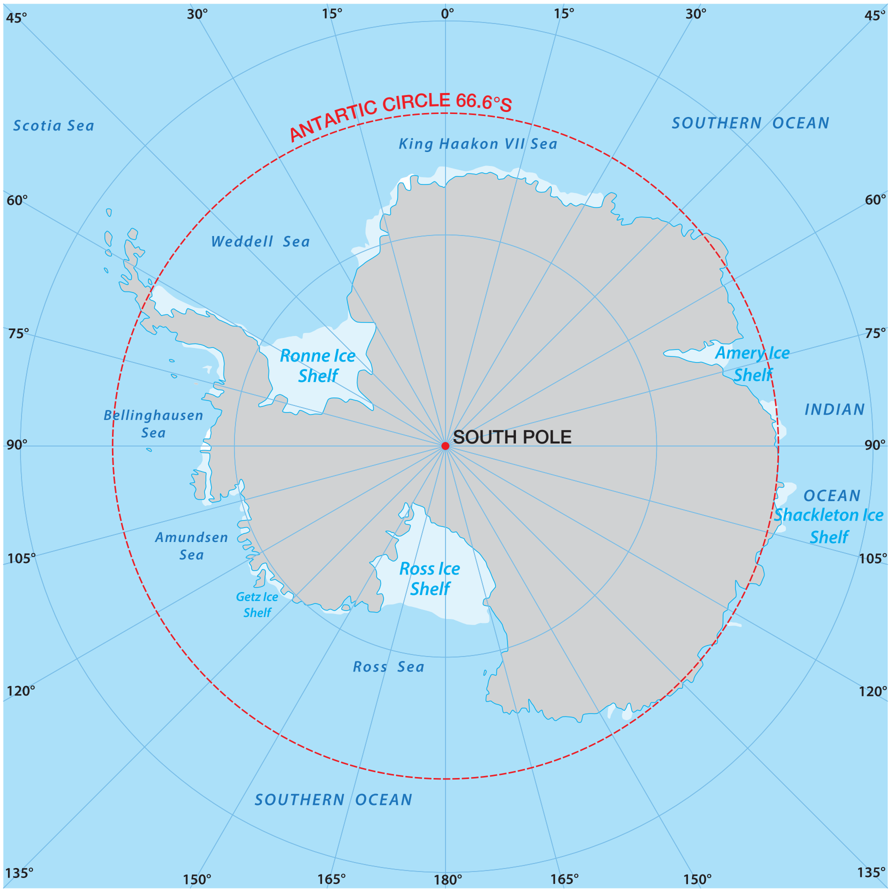

FIG. 4.11

Antarctica (Rainer Lesniewski).

number of rich and bountiful fishing grounds, and the principal means of subsistence of the indigenous people populating the region are fishing and hunting for whales and seals, in addition to some cultivation of sheep and reindeer. The proportion of animal products is therefore much higher in the diets of the people of the North than of the people in other regions. But in addition to bountiful fishing waters, the region has other valuable natural resources, such as oil and gas, nickel, copper, diamonds, and coal. The region is therefore important for the future, not only for the people who actually live there, but the world as a whole. Also, the military importance of the region is growing. A number of countries and regions other than the eight member states of the Arctic Council have shown interest in the Arctic, including China and the European Union.[ad]

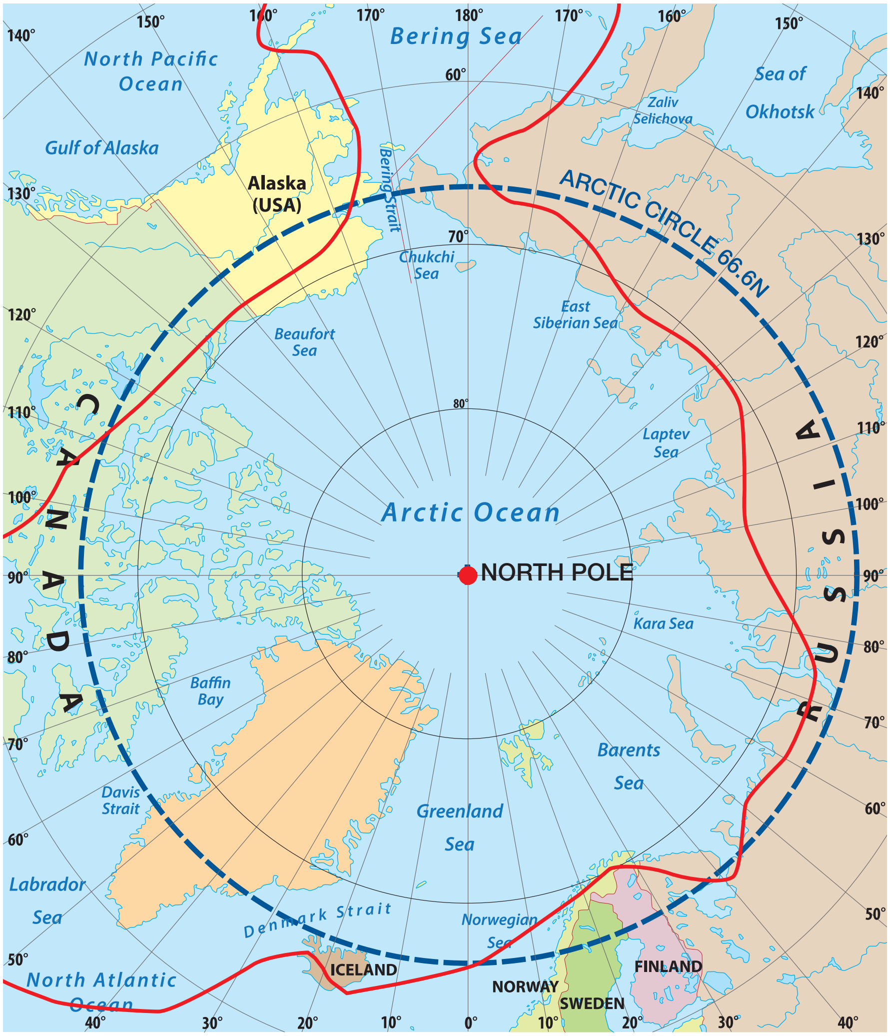

FIG. 4.12

The Arctic (Ólafur Kristjánsson).

One of the effects of global warming will be the opening of navigation routes in the Arctic. Military perspectives come into question here, as these areas become more navigable, and the world's superpowers will consider themselves to have interests in the area. The impact of environmental changes, such as global warming, will be significant in the Arctic Region, and they are in fact already significant. A great deal of research is conducted under the auspices of the Arctic Council, and the Council is complemented by a separate forum, the Arctic Circle, where a number of entities, nations, organisations, and scientists work on Arctic affairs through research and conferences. The Arctic Circle engages in extensive work intended to combat environmental change in the Region and promote sustainable exploitation activities.

An illustration of sinking islands and melting glaciers

The impact of climate change is felt in a variety of ways, and one of these is that a rising sea level will eventually submerge low-lying islands, as exemplified by a number of such occurrences in the Pacific Ocean and elsewhere. The Maldives in the Indian Ocean, home to about 500,000 people, are an archipelago that will disappear from the surface of the Earth with the rising sea level. The Maldives are an independent country and one of the countries of the world that are especially dependent on fisheries and aquaculture. They cover approximately 300 km^2 in area, about double the area of the US capital of Washington, D.C., with its population of about 800,000 people. Even though the Maldives do not cover a huge area, and even though they do not have a huge number of people, those people find themselves in a gravely serious situation. Admittedly, there are numerous examples in history of changes resulting from occurrences such as natural disasters or even human activities that impact more people and larger areas. But the rise of the sea level this time is the result of a specific cause: the Maldives will disappear because humans are not taking sufficient regard of the impact of their actions on nature. There is not much we can do when natural disasters occur, apart from saving people and animals and salvaging property, preferably in a timely manner. In fact, a number of natural disasters may stem from human actions, as when installations are poorly constructed, dams fail, or forest fires and brush fires are caused by arson.

One example of extensive developments that led to the evacuation of large numbers of people was the Three Gorges Dam in the Yangtze River, which forced more than a million people to abandon their homes as entire cities were submerged in water. This development not only resulted in a gigantic power plant producing an enormous quantity of renewable clean energy, the dam and reservoir also had the effect of enabling better control of the rivers in the vicinity of the power plant, thereby preventing floods that had been both common and destructive. Even though the development certainly had various negative effects on its surroundings, its intent was to improve living conditions on the whole in the long term.

The rising sea level is an entirely different matter altogether. It will have no benefits and cause severe damage in the long term. It should also be borne in mind that the rising sea level is only one of many consequences of the increased greenhouse effect caused by humans.

The glaciers of the world, particularly in the Arctic and Antarctica, play a key role in the living conditions of the world and they are melting at a rapid pace. The ongoing melting of the northern glaciers became the subject of world attention in August 2019, when a symbolic commemorative service was held in honour of the glacier Ok in Iceland, which had melted in its entirety as a result of climate change and had in fact been pronounced dead in 2014. The ceremony was symbolic also in that it followed in the wake of news reports to the effect that July 2019 had been the warmest month in recorded climate history. A commemorative bronze plaque was installed at the site of the dead glacier with the following inscription: “OK is the first Icelandic glacier to lose its status as a glacier. In the next 200 years all our glaciers are expected to follow the same path. This monument is to acknowledge that we know what is happening and what needs to be done. Only you know if we did it”.

Both the Arctic and the Antarctic are important for the world’s ecosystem and they are the habitats of a number of species of animals, many of which are in danger of extinction; also, both areas are breeding areas for various fish stocks and include a number of fishing zones. But these areas are equally important as reserves of enormous quantities of water bound up in huge glaciers. Temperature rises are

FIG. 4.13

Starving polar bear (Wikimedia Commons—Andreas Weith).

significantly greater in Antarctica and the Arctic than in other regions of the world. The melting of the cryosphere in the Antarctic and Arctic could result in severe environmental disaster, partly as a result of the rise of the ocean surface, which could cause a submersion of a number of low-lying islands and coastal settlements. This melting, which is set to increase drastically in the coming decades, will cause significant disruption throughout the world and represent one of the most serious environmental threats of modern times because of the importance of the glaciers for the world's climate and ecosystem (Fig. 4.13).[ae]

As noted earlier, there are significant fishing grounds around Antarctica and the Arctic, notably in Alaska, but in fact fisheries are limited and the emphasis is instead on scientific research.[af] Since the ice caps are the habitat of a number of animals, their reduction, resulting from rising temperatures, causes serious problems for the survival of some of those animals for various reasons, including scarcity of food.

The environmental problems of our times represent a challenge for all humankind; as Ólafur Ragnar Grímsson, former President of Iceland and current Chairman of the Board of the Arctic Circle, said in 2017, "Climatic change is something that the general public has difficulty relating to policies and trends; trends in nature are not political or ideological. They are not abstract, but concrete. The ice and glaciers have no political attitude. They are neither right nor left. The ice is simply melting, whether the sea ice in the Arctic Ocean or the glaciers in Greenland and Iceland".[ag]

Endnotes

a. For a discussion of scientific conclusions regarding the impact of greenhouse gases see, e.g., Intergovernmental Panel on Climate Change (2018), Magnason (2019), and NASA (n.d.).

b. For a discussion of CO_2 emissions and estimates for 2018 and 2019 see, e.g., Ritchie and Roser (2019, December).
c. For a discussion of the fuel consumption of fishing vessels and the release of greenhouse gases see, e.g., Parker et al. (2018).
d. Changes in temperature from 1850, as shown in Fig. 4.2, are referenced to temperature as described anomalies relative to the average temperature 1951–80 see Berkeley Earth (n.d.).
e. For a discussion of energy production in a historical context see Ritchie and Roser (2018a, July).
f. For a discussion of energy consumption per capita see World Bank (2014). The numbers in Fig. 4.4 are estimates for 2015–18 based on the energy consumption trends of the preceding years.
g. In 2015 carbon-free whale watching was offered for the first time in the world in Húsavík in Iceland. Only wind was used, combined with electricity, to power a whale watching vessel on a tour lasting 3 h.
h. For a discussion of extremism in environmental matters see, e.g., Hannesson (2014).
i. For a discussion of the greenhouse gases released by fisheries and aquaculture see, e.g., Food and Agriculture Organization of the United Nations (2018b) and Yuan et al. (2019).
j. For a discussion of ocean acidification and the pH scale see, e.g., Solnes (2019), Borunda (2019), and National Oceanic and Atmospheric Administration (n.d.).
k. For a discussion of the rise of the sea level see, e.g., Church et al. (2013) and Al (2018).
l. For a discussion of prospective atmospheric pollution in the developing countries see, e.g., Marsh and Grossa (2002).
m. For a discussion of water management in the developing countries see, e.g., Honah, Johnson, and Smakhtin (2016).
n. For a discussion of profitable investment in environmental matters see, e.g., Ambec, Cohen, Elgie, and Lanoie (2013).
o. For a discussion of the impact of global warming on countries' economies see Allison et al. (2009).
p. For a discussion of trading in emission allowances see, e.g., Murray (2009) and Munro (2018).
q. For a discussion of international efforts to combat the pollution of the seas see, e.g., International Maritime Organization (n.d.) and United Nations Development Programme (n.d.).
r. For a discussion of the FAO Code of Conduct for responsible fisheries see, e.g., Food and Agriculture Organization of the United Nations (n.d.-d).
s. For a discussion of the United Nations Sustainable Development Goals of 2015 and the Paris Agreement of 2015 see Sustainable Development Goals (n.d.) and United Nations Climate Change (n.d.).
t. For a discussion of Goal 14 see, e.g., Sustainable Development Goals (2019) and United Nations Development Programme (n.d.).
u. For a discussion of the benefit of achieving optimality in fisheries and the means of achieving optimality see World Bank (2017).
v. For a discussion of plastic and fisheries and aquaculture see, e.g., Jambeck et al. (2015), Lusher, Hollman, and Mendoza-Hill (2017), and Nordic Council of Ministers (2019).

w. For a discussion of the manufacture of plastic, i.e., Annual global polymer resin and fibre production in million metric tons, as shown in Fig. 4.9 see Geyer, Jambeck, and Law (2017) and Qualman (2017).
x. For a discussion of plastic manufacturing in the world in the future and its extent see, e.g., *The Economist* (2018, March 3).
y. For a discussion of the transport of plastic by rivers see Schmidt, Krauth, and Wagner (2017).
z. For a discussion of the fish and plastic in the seas and the impact of plastic in fish food see, e.g., the European Commission (2018a, January 16) and European Food Safety Authority (2016, June 23).
aa. For a discussion of the disposal of plastic in the world see, e.g., Claudio (2012) and Ritchie and Roser (2018b, September).
ab. For a discussion of the new policies regarding the disposal of plastic see Velis (2014), The State Council—The People's Republic of China (2017, July 27), and European Commission (2018b, January 16).
ac. For a discussion of the Arctic and its division into three areas see Einarsdóttir (2018, November).
ad. To give an indication of the increased interest in the Arctic, US President Donald Trump made an offer in 2019 to buy Greenland from Denmark; the offer was declined by the Danes out of hand.
ae. For a discussion of the melting of the cryosphere see, e.g., Intergovernmental Panel on Climate Change (2019).
af. For a discussion of fisheries in the Arctic and Antarctica see, e.g., NOAA Research News (2017, September 8) and The Antarctic Wildlife Research Fund (n.d.).
ag. For these comments of Ólafur Ragnar Grímsson, former President of Iceland, and current Chairman of the Board of the Arctic Circle see Hardarson (2017, October 14).

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CHAPTER

Fisheries management

5

Why do fisheries have to be more extensively managed than just about any other economic activity? The market and free competition will normally suffice to resolve economic problems relating to the efficient use of resources. But this does not apply to fisheries. Why? The answer lies in the unique nature of fish stocks. If fisheries are not managed, then they are very likely to be inefficient, fish stocks will almost invariably be overexploited and in the worst case some species of fish may even disappear. However, it makes a difference how fisheries are managed, and numerous approaches have been used. Issues such as management systems, charges for fisheries licences, ownership rights, transfers of quotas, regional perspectives, etc. are only a few of the problematic aspects of fisheries management.

5.1 Common resources

Goods and service are often divided into four categories based on the presence or absence of two features, as shown in Table 5.1.

As a matter of fact, this division into four categories is not entirely accurate, as the borderlines between the categories are not always clear and may be more dependent on external organisation, technology and form of ownership than on the nature of the goods themselves.

In Table 5.1 the goods identified as private goods are placed in the first category. This category encompasses the largest proportion of goods and services. Their characteristic is that the others can be excluded from using them, and the use by one will necessarily restrict the use by others. An example could be a prepared portion of fish bought at a supermarket, or a seat in a movie theatre. The person who bought the fish has thereby acquired the right to eat it and it cannot be eaten twice. The purchase also means that there is less available for others. Anyone can go see a movie in a movie theatre, but first they have to buy a ticket. The ticket confers the right to a seat, which cannot then be shared by another, and if one seat is sold, then there are fewer seats left for others. The result is competition for use.

The second category comprises goods and services that fall under the heading of toll goods. This means that persons can be excluded from enjoying the goods, but the use by one person does not restrict use by others, although this is true only up to a point. An example could be a road tunnel. If there are very few drivers, use by one driver does not limit the use of the tunnel by other drivers. If there are a great many

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Table 5.1 Classification of goods and services by use and excludability.

		Competition for use, i.e., the use by one restricts use by others	
		Yes	**No**
Others can be excluded from use	Yes	Private goods, such as food products	Toll goods, such as road tunnels with tolls
	No	Common resources, such as fish stocks	Public goods, such as defence

drivers, a toll—a price—can be used to regulate the traffic and eliminate the externalities. Hence the name, toll goods.

The third category relates to public goods, where it is not possible to exclude others from using the goods, and the use by one does not limit use by others. Examples of these types of goods are national defences and traffic lights. Everyone benefits from defence if such defences are in fact in place. Everyone can also use traffic lights at crossroads, and even where one person benefits from the existence of defences or traffic lights this will not curtail the benefit to others.

When scientists engage in basic research their work becomes a public good at the time that the results are made public and become available for use by anyone without payment. If a mathematician discovers a new formula it becomes a public good once it has been published. While this does not apply to research that can be patented in the form of technological discoveries, progress made in science generally enters the public domain once it becomes public knowledge. This is one of the principal reasons that government supports basic research through funding, knowing that the results will benefit the general public. Another familiar example of public goods is lighthouses. They are run by government to prevent accidents at sea, and they cannot be built without a joint effort, usually sponsored by government.

This brings us to the fourth category, that is to say common resources. Others cannot be excluded from benefitting from the goods if there is no ownership right or right of use, but use by one has the result that use by others is curtailed. An example is open pasture, which can be overexploited by overgrazing, much like fish stocks can be depleted by overfishing.

Fish stocks that can be freely harvested by anyone without any ownership rights or rights of utilisation are categorised as common goods. The tragedy of the commons is a phrase frequently used, referring to the fact that common resources can be destroyed, or overexploited, as in the case of pastures and fish stocks, if they are not managed in a sensible manner.[a] The reason, in the case of fish, is that with free access there will simply be too much fishing, as the interests of each individual fisherman do not go hand in hand with the public interest, or those of other fishermen. The best outcome for each fisherman or fisheries company is to catch as much as possible, which will eventually lead to the collapse of the fish stock being exploited. No regard is given to the fact that the fishing effort will deplete the common resource and have other external effects, with the result that the size of the stock is reduced. A frequently cited example of the extermination of a common good is the American buffalo, which was almost wiped out by unbridled hunting in the 19th century. Another example, closer to the subject of this book, is the Canadian Newfoundland cod stock, which collapsed in 1992.

An example of a common resource could be a village in the Middle Ages surrounded by extensive pastures, as was often the case. Anyone was permitted to release their flocks of livestock into the pasture and no problems ensued. Gradually, however, the population of the village grew, the flocks of livestock also grew, and the pastures no longer sufficed to feed the livestock. The result was barren pastures and starving livestock and eventually famine. Although this particular example is made up, it is not without foundation; history has numerous examples of precisely this course of events, and we see them occurring even in our times, as reflected also in problems of deforestation and land erosion in many regions of the world (Fig. 5.1).

In the earlier example, the local authorities would have needed to intervene. This could have been done, for example, by setting a rule that each household could only possess a certain maximum size of livestock, or by levying a tax on livestock, or by issuing grazing permits.

However, there is a simpler method, namely, to allocate the land in portions to a fixed number of people, that is to say to privatise the pastures. That way, each household would have its own area of land. As a result, the area would be fenced, cultivated and cared for, and encroachment by others would be prevented. In fact, right of ownership is not necessary, as a similar result could be achieved by allocating rights of use; ideally for the user, the right of use would be granted for the long term, giving the

FIG. 5.1

Pine tree forestry in the Highlands of Scotland (Marten House).

user an opportunity to maximise the returns from the land and an incentive to take good care of it and improve it in order to preserve its value.

In the earlier example, those who wished to withdraw from the cultivation of livestock to engage in some other activity could then sell their areas of land to another, or sell the right of use. That way, the private lands would gradually increase in size and the owners, or lessors, would ensure that there is no overgrazing. This was done in England in the 17th century, and a more recent and perhaps more familiar example is the 'range wars' between cattle ranchers and squatters in the United States in the second half of the 19th century. Cattle ranchers wanted open pastures, while sheep farmers and vegetable farmers wanted to fence off their lands to prevent grazing. These disputes provided the background for a number of films about the Wild West.

The general rule with regard to common resources is that the use by one restricts the use by another. The earlier example of the mediaeval village is easily applied to fisheries management, which also centres on common resources. This is the core of the concept of the tragedy of the commons: unrestricted access has the effect that there is little incentive to ensure the growth and improvement of the resource, which leads to competition for use, which in turn leads to overexploitation.

There are cases where goods can shift between categories. Lighthouses, for instance, were once private property. The other three categories can be explained using the example of tunnels for vehicle traffic. If using a tunnel is free of charge and traffic is moderate, then we have a case of public goods. If the tunnel is free of charge and there is heavy traffic, then we have a case of a common resource. If there is a charge for use of the tunnel and there is moderate traffic, then that is a case of a toll good.

5.2 Overfishing and its consequences

Fish stocks are natural resources, and, as in the case of other resources, it makes sense to harvest them in an efficient manner. Some natural resources are renewable, as in the case of fish stocks, or they are not renewable, as in the case of coal and oil. It is therefore of crucial importance to allow renewable resources to renew themselves steadily and to utilise them in a sensible and sustainable manner. A proper fisheries management system enables the achievement of greater profit, or value creation, which leads to improved living conditions, in addition to the fact that various resources are important sources of nutrition for millions of people.

The best-case scenario in the management of fish stocks is characterised by the interaction of scientific disciplines like fisheries and economics. There are not very many masters of both disciplines, as simultaneous expertise in multiple scientific disciplines is not normally needed. To give an example, a house builder will not need to know a great deal about forestry even if his materials of choice for house building include timber.

In fisheries it can be quite difficult to prove beyond doubt that a stock is being overfished and to convince people, in particular the fishermen themselves, that a situation is becoming serious. An official inspector who had closed a sea snail harvesting ground off a Pacific island for reasons of overharvesting once caught a poacher red-handed the day after the closure. The fisherman had caught some sea snails and protested the intervention. He objected to the closure and asked what the area was being closed for, saying “we haven’t killed all the sea snails; there are still sea snails out there” (Greenberg, 2010, p. 231). He was right, of course, but one of Iceland’s foremost experts on herring put it this way in the presence of one of the authors of this book: “You can get a good haul out of the last shoal of herring in the sea”.

In order to prevent overfishing, a certain maximum allowable catch needs to be decided and it needs to be ensured through surveillance and monitoring that the actual fishing does not exceed the allowed total. It also has to be ensured that all the fish that is caught is also landed—that is to say, none of the catch must be thrown overboard, i.e., discarded—and that the catch is weighed and recorded at the point of landing. These decisions, and compliance with them, are in fact independent of the fisheries management itself. First comes the decision on a total allowable catch (TAC), which should be based on the advice of fisheries scientists; this then needs to be followed by the design and implementation of a system of controls that results in maximum efficiency of the fisheries (Fig. 5.2).

Accusations abound that a large portion of catches is discarded, and estimates have been suggested that the discarded catches could amount from 7 to 27 million tons.[b] Although estimates in this regard are difficult, the discarding of fish deserves recognition as a serious international problem.

Another problem is that government will frequently be tempted to decide on a larger total allowable catch than recommended by scientists, despite the crucial

FIG. 5.2

Discards of fish (RAX).

importance of observing the advice of the experts who are most knowledgeable about the condition of the fish stocks. Generally speaking, however, there is a growing understanding among government authorities that it is unwise to go against the recommendations of scientists and experts.

Utilising renewable resources like fish stocks requires investment in a wide array of expensive equipment and facilities to catch the fish, process it, and sell it. These investments have to return a profit sufficient to cover all costs, as in the case of any other business investments; however, the profit does not always materialise.

Overinvestment in vessels is a huge problem that needs to be confronted in most fisheries management systems, i.e., too many vessels are chasing too few fish. This problem is often 'solved' by means of state support. If a fishing licence is curtailed or withdrawn in order to protect a fish stock or fishing ground, the vessels will often go elsewhere and fish where there is less control or where the management system is less rigorous. This contributes to overexploitation in those areas, so that the problem has simply been shifted elsewhere, and most often the shift is to the developing countries.[c]

5.3 Basics of fisheries economics

One special feature of fisheries is the fact that the principal resource needed is swimming around in the sea, which means that the principal factor of production of the sector has for the most part not belonged to anyone and is not the property of the person doing the harvesting. In most places, the government has taken possession of the resource, usually in the name of the citizenry. However, whoever utilises the resource can earn working rights and utilisation rights, which then become an asset in the form of a licence or a catch quota, and that person can then utilise those rights like any other rights. Where the rule of law prevails, assets can generally not be expropriated or curtailed except against a reasonable consideration; numerous and complex legal issues can arise in connection with the utilisation of fish stocks, and many such issues have in fact arisen in recent years.

The origin of fisheries economics as a specific field within economics can be traced back more than a century, when a Danish professor, Jens Warming, published in 1911 an article on the subject where he analysed the basics of fisheries economics. However, contemporary fisheries economics are usually traced back to several scientific articles that were published shortly after 1950; their authors were English speakers, who were unaware of Warming's writings of almost half a century before.

One of the principal goals of fisheries management is to contribute to efficiency and to maximise the value creation that can result from harvesting a renewable resource; the same applies, of course, to other comparable resources, such as water rights and rights to geothermal energy. Resources of this kind are generally under the control of an entity, usually a government entity, that grants utilisation rights to other entities. If utilisation rights are entrusted to someone, it makes a real difference for how long the utilisation rights will endure. If the utilisation right is restricted in time, then it has to be clear what rules apply to an extension of the right or what happens after the right expires. Generally speaking, however, the rule is that the longer the utilisation right, the greater the efficiency.

A management system of this kind results in the creation of resource rent, that is to say the excess value of products, net of all economic cost, meaning all the cost of the community and a reasonable return on equity. The resource rent is therefore an extra profit formed by means of a restricted and organised access to a resource. Poor organisation in utilising resources has the result that little or no resource rent, or excess profit, is created.

The following discussion will focus on a simple model that shows the relationship between fisheries and stock sizes. It is assumed in the model that fishing is conducted in a responsible manner, so that the fish stock is not depleted, as in the case of the principal in a bank account which is left untouched and only the interest withdrawn. The relationship between the size of a fish stock, its growth, and its yield is in many ways interesting. It will be demonstrated how fishing from the stock can be maximised, what the relationship is between fisheries and the effort spent on harvesting the resource, and how fisheries are linked to income, cost, and performance.

Models used in fisheries research are based on biology. Basic models focus on a single fish stock. The size of a fish stock is normally expressed in terms of the biomass of the stock in question, although sometimes in terms of numbers of fish.[d] The size of the fish stock is here denoted as q. What causes change (Δ) in the size of the stock, for instance in a year, is what is known as recruitment, that is to say the increase in number or mass of fish by propagation (n), and the growth of already existing fish (g), as fish will normally grow in size with increasing age, meaning that a hundred young fish will generally be much lighter than the same number of older fish.

What contributes to the depletion of a fish stock is death by natural causes, including from being eaten by other creatures, from disease or even old age (d). In addition, the stock diminishes in size as a result of the fishing or the caught quantity (v), which, in turn is dependent on what is known as 'fishing effort' (e). It is this last factor, that is to say e, that needs to be decided in a sensible manner.[e] Eq. (5.1) shows the relationship of these values.

$$\text{Change in stock size} = \Delta q = n + g - d - v \tag{5.1}$$

When the stock size is in balance, then there is no change, and the outcome of Eq. (5.1) is zero, since recruitment and growth are equal to depletion by natural death and the caught quantity, as shown in Eq. (5.2).

$$\text{Change in stock size} = \Delta q = 0 = n(q) + g(q) - d(q) - v(e) \tag{5.2}$$

Eq. (5.2) shows that recruitment, growth, and death from natural causes are dependent on stock size (q) while the caught quantity or fishing is dependent on effort (e). Rewriting Eq. (5.2) gives us Eq. (5.3), which shows the caught quantity, or the catch (v), when there is no change in the stock size:

$$v(e) = n(q) + g(q) - d(q) \tag{5.3}$$

Fishing effort is dependent on the time spent fishing, vessel size, engine power, number of crew, fishing gear, and crew competence, including the captain's knowledge and ability.[f] The time spent fishing has the greatest impact on the catch and is therefore the factor in the effort that carries greatest weight. Sometimes the fishing will be conducted around the clock, sometimes for just a limited time and sometimes the fishing gear is in the sea gathering more fish while the catch of the last haul is being processed.

Vessel size and engine power usually go hand in hand, and attempts are made to ensure not to have too large an engine in a vessel, which only results in unnecessary expense, including excessive fuel cost. Fishing gear is of various kinds and suitable for different conditions and also dependent on type of vessel. The general rule is that at the planning stage the fisheries operator and the captain pick the fishing gear that is most suitable for the fishing being done and the selection includes taking account of the expense of the gear (Fig. 5.3).

The number of a crew is generally kept at the minimum needed to fully utilise the engine capacity, and thereby the size, of the vessel, and to ensure a sufficiency of manpower over the time that the fishing is in progress. The catch share system, which is a widely used basis for the determination of wages, provides an incentive to keep manpower at a minimum. Under the catch share system the value of the catch is divided, which means that the smaller the crew the larger the share of each member.

To give an example of a catch share system, the value of the catch in a single fishing trip may be 100,000 USD. The value is shared out and the crew receives 40%. This means that 40,000 USD are divided among the crew. If there are 10 members of the crew this means that each receives 4000 USD, but if there are 12 their

FIG. 5.3

Ilulissat in Greenland (Ozzo Photography).

respective shares are 3333 USD. The catch share system therefore has a built-in incentive to keep the crew of the vessel as small as possible. In actuality, the normal arrangement of a catch share system is that the captain, engineer, and first mate receive a larger share that reflects their added responsibility. This system has given good results, but it does not always reflect the actual work of the fishing. For instance, catching cod requires the same amount of work as catching saithe or pollock, but a catch of cod may be twice as valuable as a catch of saithe, meaning that it returns twice the wages.

If we take a look at living organisms like fish, a fish stock will grow at first, then reach an apex and then be reduced again. One of the reasons for this is that if a stock grows excessively, there will be less food to share. This link was first demonstrated mathematically by a Belgian scientist, Pierre F. Verhulst, and his conclusions are now used in the fundamental models of fisheries economics.

The growth in the size of a fish stock is expressed as a function of the stock size and denoted as $f(q)$, which shows the change in stock size when no account is taken of the fishing or the caught quantity; that is to say, this is Eq. (5.1) with caught quantity, or the catch (v), not included. The growth of the stock increases at first, peaks, and then falls in size to zero, when the natural equilibrium has been achieved. This is shown in Fig. 5.4, where the stock size (q) is shown on the x-axis and the growth of the stock size $f(q)$ is shown on the y-axis.

Fig. 5.4 shows that the growth curve is bell shaped—it rises at first and reaches maximum height at q_{msy}, which denotes the stock size at the maximum sustainable yield (msy), which is the stock size at which the greatest quantity can be caught without any resulting changes in the stock size. However, what the chart does not show is

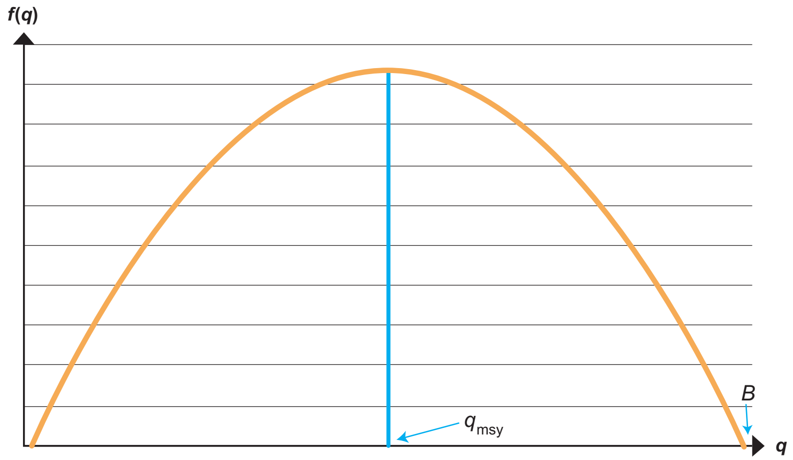

FIG. 5.4

Relationship of stock size and growth.

whether the fisheries are worth the expense, as that will depend on the income and expense of the fishery.

When the maximum sustainable yield has been achieved, as shown in Fig. 5.4, the growth slows, and eventually falls to zero. The growth curve intersects the x-axis, where the stock size is at its biological equilibrium, marked by B, as shown in Fig. 5.4. The curve $f(q)$, the parabola, is described in Eq. (5.4).

$$f(q) = r \cdot q(1 - q/B) \tag{5.4}$$

Eq. (5.4) is based on the Verhulst equation referred to earlier and is a more specified case of Eq. (5.1) without fishing. The constant r is the natural growth of the fish stock, and B is the natural equilibrium of the stock size. The equation excludes the impact of fisheries in observing the growth of the stock. The relationship of caught quantity (v) and effort (e) is shown in Eq. (5.5).

$$v = s \cdot q \cdot e \tag{5.5}$$

In this equation, s is a coefficient reflecting the technology or capacity used based on a set stock size. It is assumed that the fishery is linear in effort and also linear as regards stock size assuming a given effort. If $f(q)$ is equal to the caught quantity (v), there will be no change in the stock size. If $f(q) = v$ and Eq. (5.5) is inserted into Eq. (5.4), this will result in Eq. (5.6).

$$v = s \cdot q \cdot e = f(q) = r \cdot q(1 - q/B) = r \cdot q - r \cdot q2/B \tag{5.6}$$

If Eq. (5.6) is rewritten for the stock size q, this gives us Eq. (5.7), where the intention is to obtain the caught quantity (v) as a function of the effort (e).

$$\begin{aligned} & s \cdot q \cdot e = r \cdot q(1 - q/B) = r \cdot q - r \cdot q^2/JB \\ & \Rightarrow s \cdot e = r - r \cdot q/B \Rightarrow B \cdot s \cdot e = r \cdot B - r \cdot q \Rightarrow r \cdot q = r \cdot B - B \cdot s \cdot e \\ & \Rightarrow q = B - B \cdot s \cdot e/r \end{aligned} \tag{5.7}$$

The equation gives a stock size that is based on the assumption that the harvest is consistent with the growth of the stock, i.e., a steady state harvest. It therefore shows a stock size that remains fixed and is determined by the effort (e) spent on harvesting. It is of interest to examine the catch, i.e., caught quantity, resulting from this effort, where it is assumed that the stock size is maintained (kept at a fixed size). Eq. (5.5), which gives us the catch, will result in Eq. (5.8).

$$v = s \cdot q \cdot e \Rightarrow q = v/(s \cdot e) \tag{5.8}$$

Eq. (5.7) (q) is equal to Eq. (5.8) and that gives us Eq. (5.9).

$$q = B - B \cdot s \cdot e/r = q = v/(s \cdot e) \Rightarrow B - B \cdot s \cdot e/r = v/(s \cdot e) \tag{5.9}$$

If Eq. (5.9) is rewritten for v this gives us Eq. (5.10).

$$v = s \cdot B \cdot e - \left(s^2/r\right) \cdot B \cdot e^2 \tag{5.10}$$

In Eq. (5.10) the values s, r, and B are fixed coefficients, while the effort (e) is a variable. If the effort (e) is placed on the x-axis in a two-dimensional figure and the caught quantity (v) on the y-axis, this gives us a parabola like the one in

Fig. 5.4. This parabola shows the link between catch and effort, where the stock size is maintained at a fixed level. As in the case of Fig. 5.4, a maximum catch does not necessarily reflect optimal yield, since no account has been taken of the price of the catch or the cost of the effort.

Income and cost can be linked to catch by multiplying the caught quantity or the catch, stated in kg, with the price per kg (p), which gives us the income (I) from the fishing, as shown in Eq. (5.11).

$$I = v \cdot p = s \cdot B \cdot p \cdot e - \left(s^2/r\right) \cdot B \cdot p \cdot e^2 \tag{5.11}$$

Eq. (5.11) thus reflects the income from the fishery, as the effort is geared so that the caught quantity is equal to the change in the stock size, and therefore the income is a function of the effort, where the stock size is kept fixed.

It is assumed that the cost per unit of effort is stable, so that for instance if each unit of effort costs 100,000 USD, then 20 units of effort will cost 2 million USD, that is to say, the cost in effort is linear. Although his is a premise assumed for the purposes of simplification, it is not at all unrealistic. The cost of the effort (C) is shown in Eq. (5.12).

$$C = c \cdot e \tag{5.12}$$

Fig. 5.5. shows the relationship between the income and the cost on the y-axis and the effort (e), which is the variable in the function, shown on the x-axis.

With increased effort, income from fisheries increases to a maximum, as shown in Fig. 5.5, which corresponds to the stock size of the permanent maximum catch and the effort e_{mse}. The growth of the stock size reaches a maximum at the size of q_{msy} in

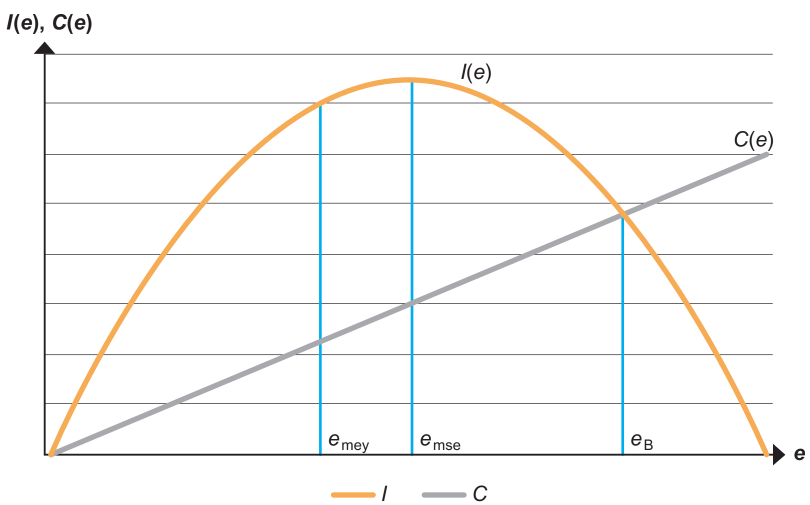

FIG. 5.5

Relationship of income and cost to fishing effort.

Fig. 5.4 and income is at the same time maximised. The effort then increases, and the income declines, which is why this income curve is bell shaped, that is to say has the form of a parabola. With the effort at e_B in Fig. 5.5, income is equal to cost, meaning that there is no profit. This is what the effort will be in a scenario where there are no restrictions on fishing.

It is clear from Fig. 5.5 that the optimal situation is to maintain the greatest possible gap between income and cost, as profit (P) is equal to income (I), net of cost (C), as shown in Eq. (5.13).

$$P = I - C \Rightarrow \text{maximise} \tag{5.13}$$

The most favourable outcome is to maximise profit, and this is shown in Eq. (5.13). The question now is how to find the most profitable effort, that is to say, at what point is the gap between income and cost widest? Fig. 5.5 shows that this point is at the effort of e_{mey}, that is to say the maximum economic yield.

In economic terms, overfishing means that it costs more to bring in the catch than necessary. In some places, the sensible measure is taken of never catching more than what corresponds to the growth of the stock. But the maximum sustainable yield, in a biological sense, which is achieved with the effort e_{mse} and maximises income is not necessarily the best option in the economic sense, as the cost of catching the last fish in order to reach the permanent maximum catch may be excessive. For this reason, economists look to the most profitable catch that is achieved with the most efficient effort, e_{mey}, which is the point at which marginal income is equal to marginal cost; this is the point at which the distance between the parabola of the income curve and cost curve is greatest. At that point profit is maximised.

If we begin at point zero in Fig. 5.5, that is to say with no effort, and then set out to sea, we move to the right along the x-axis and income increases significantly at first, and additional income is greater than additional cost. In that situation it pays to add to the effort. Gradually, the gap between marginal income and marginal cost narrows, and when marginal income falls to less than marginal cost, then it makes sense to reduce the effort and fall back to the left along the x-axis. The most efficient effort, that is to say the optimal position, or the maximum economic yield, is therefore achieved at the point of effort, e_{mey}, where marginal income is equal to marginal cost. The calculations in this regard are shown in a separate example in an illustration in the next section.

With the effort at e_B, income is equal to cost, meaning that there is no profit. Unrestricted fisheries therefore lead to a profit of zero. To explain this conclusion we need to examine how cost is calculated. The cost reflects all the expenses of the fishery, and this cost includes a reasonable profit from the fisheries, that is to say a profit similar to the profit that could be achieved in another business operation where the risk is similar. Positive profit in this example therefore reflects the additional profit that the sector returns in excess of other sectors, that is to say the resource rent. This means that when fishing is unrestricted, new entrants will flock to the sector until the excess profit disappears and the effort exceeds both the effort that maximises profit and the effort that maximises income. The effort reaches the point where income is equal to cost, and the excess profit equals zero, that is to say the resource rent vanishes.

An illustration of the most efficient fishing effort

A government is responsible for the management of a valuable fish stock in its jurisdiction, a species of fish known as diamond cod, and a government agency is set up to study what quantity of fish it would be most advantageous to harvest; the stock has been studied by fisheries scientists for a number of years. The government seeks the advice of economists and asks them to determine what quantity it makes sense to catch in order to maximise profitability.

The economists study the available figures. Quantities are in thousands of tons and amounts in million USD. The fisheries scientists explain to the economists that the long-term equilibrium of the stock is 45,000 tons, meaning that B is 45. The permanent maximum sustainable yield is half of that figure, as shown in Fig. 5.4. The price per kg of diamond cod from the sea is 5 USD per kg, or 5 million USD per 1000 tons, which is p. Each unit of effort costs 7000 USD per ton, or 7 million USD per 1000 tons, which is c. The technical constant s is 0.1, and the constant for the natural growth of the cod stock r is 2. Entering these data into Eq. (5.11) for income (I) gives us Eq. (5.15).

$$I = v \cdot p = s \cdot B \cdot p \cdot e - \left(s^2/r\right) \cdot B \cdot p \cdot e^2 = 0.1 \cdot 45 \cdot 5 \cdot e - \left(0.1^2/2\right) \cdot 45 \cdot 5 \cdot e^2 = 22.5 \cdot e - (2.25/2) \cdot e^2 \tag{5.14}$$

If the data are entered into Eq. (5.12) for cost (C) this gives us Eq. (5.15).

$$C = c \cdot e = 7 \cdot e \tag{5.15}$$

Fig. 5.6 shows the income and cost curves as a function of effort.

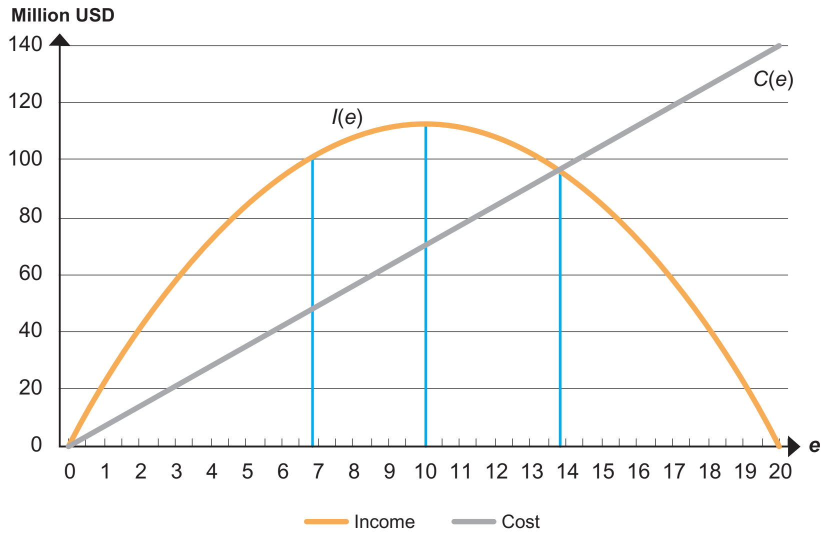

FIG. 5.6

Income and cost as a function of effort in an example.

An illustration of the most efficient fishing effort—Cont'd

As shown in Fig. 5.6, income increases with increasing effort, but then income decreases after the effort of 10, which corresponds to the effort that yields the maximum sustainable yield. When the effort reaches 20, the income has fallen to zero. Profit is income net of cost, and the target is to find the effort where the gap is largest between income and cost. Profit (P) is shown in Eq. (5.16).

$$P = I - C = 22.5 \cdot e - (2.25/2) \cdot e^2 - 7 \cdot e = 15.5 \cdot s - (2.25/2) \cdot e^2 \tag{5.16}$$

In order to find the most efficient effort, or the value of e, which maximises profit, Eq. (5.16) is differentiated with reference to e and placed as equal to zero. This shows the maximum profit, provided that the second derivative is less than zero. The differentiation function, or marginal profit (P'), is set out in Eq. (5.17).

$$P' = \mathrm{d}P/\mathrm{d}e = 15.5 - (4.5/2) \cdot e = 0 \Rightarrow e = 31/4.5 = 6.89 \tag{5.17}$$

The optimal effort, the maximum economic yield, is therefore at 6.89 units of effort, and the second derivative is less than zero. The catch (v) is obtained using Eq. (5.10), as shown in Eq. (5.18).

$$v = s \cdot B \cdot e - \left(s^2/r\right) \cdot B \cdot e^2 = 0.1 \cdot 45 \cdot 6.89 - \left(0.1^2/2\right) \cdot 45 \cdot 6.89^2 = 31 - 21.4/2 = 31 - 10.7 = 20.3 \tag{5.18}$$

The optimal catch is 20,300 tons, as this catch will maximise the profit from fishing for diamond cod.

The profit is shown in Eq. (5.19).

$$P = I - C = v \cdot p - c \cdot e = 20.3 \cdot 5 - 7 \cdot 6.89 = 101.5 - 48.23 = 53.27 \tag{5.19}$$

The profit is just over 53 million USD, which represents the maximum profit. If we want to look at profit at the effort of 10, which corresponds to the maximum sustainable yield, i.e., 22.5 thousand tons, Eq. (5.20) will show us that profit.

$$P\,(e = 10) = I - C = v \cdot p - c \cdot e = 22.5 \cdot 5 - 7 \cdot 10 = 112.5 - 70 = 42.5. \tag{5.20}$$

As Eq. (5.20) shows, profit at the effort of 10, that is to say the effort returning the maximum sustainable yield, amounts to 42.5 million USD, or 20% less than at the effort of 6.89. This is a remarkable conclusion that shows that it does not pay to set the effort of 10, and thereby obtain a larger catch, even if this effort is safe for the preservation of the fish stock. The optimal position from the point of view of economics maximises profit and advises less fishery than suggested by the biological potential of the stock.

The problem is that the most efficient effort cannot be found by isolating catch and income; cost also has to be taken into account. The interaction of these factors is displayed in the profit, and this is explained by looking at the average profit (AP) and the marginal profit (MP); these values are shown in Table 5.2.

As Table 5.2 shows, the marginal profit is equivalent to zero at the effort of 6.89, as calculated; at that point profit is at its peak. However, fisheries operators do not consider marginal profit, but average profit, which is profit divided by effort. As long as the average profit is more than zero, it pays for some operators to add to the effort, and this is what they will do if there are no restrictions on fisheries. They do not cease their fishing at the effort of 6.89, nor at the effort of 10, where the average profit is 0.4, as shown in Table 5.2. It is not until at the effort of 13.78 that the average profit falls to zero; at that point total income and total cost are equal, as shown in Fig. 5.6.

Table 5.2 Effort, average profit, and marginal profit in an example in the illustration.

e	AP	MP	*e* (continued)	AP (continued)	MP (continued)
1	1.4	1.3	11	0.3	−0.9
2	1.3	1.1	12	0.2	−1.2
3	1.2	0.9	13	0.1	−1.4
4	1.1	0.7	13.78	**0.0**	−1.6
5	1.0	0.4	15	−0.1	−1.8
6	0.9	0.2	16	−0.3	−2.1
6.89	0.8	**0.0**	17	−0.4	−2.3
8	0.7	−0.3	18	−0.5	−2.5
9	0.5	−0.5	19	−0.6	−2.7
10	0.4	−0.7	20	−0.7	−3.0

Only at that point do they bring the fishing to a halt. This is the tragedy of the commons in a nutshell: the resource rent is wasted. The effort continues long after the point of the most efficient effort has been reached, and also long after the point of effort that reflects the permanent maximum catch. Finally, it should be noted that the example and basic models of fisheries economics assume that the catch is equal to the growth of the resource, but there is no guarantee that this will be the case. That means there is no guarantee that stocks will be harvested in a manner consistent with zero depletion.

As shown in Fig. 5.6 and the earlier example, with open access fisheries operators will continue to fish until the effort of 13.78, when income is equal to cost and there is no profit. That effort falls far short of any efficiency, although it prevents depletion of the stock. This brings us to the principal problem of exploiting common resources, namely the fact that the interests of individual entities do not go hand in hand with the public interest. Each entity ignores the consequences of its actions for others and does not, therefore, take into consideration all the factors that make up the model described earlier and the interaction that secures the maximisation of profit.

It is for this reason that official authorities need to step in and decide on a total allowable catch, the best option in this case being 20,300 tons, which results in the most efficient effort. This quantity can then be allocated in individual transferable quotas or effort quotas against payment of a charge. The result will then be that the fish will be caught in a cost-effective manner and significant profit can be achieved, as happens in fisheries when the recommendations of fisheries scientists are observed and a sensible management system is in place. The example shows in a simple and clear manner the importance of linking fisheries sciences and economic sciences to arrive at a sensible utilisation of valuable and renewable resources, where the permanent renewal of the resource and sustainability is the guideline.

The earlier analysis is based on fishery on a single fishing ground, but if there are others the same will apply: if the marginal income on each fishing ground is equal to the marginal cost, then the optimal situation is achieved. The simple wishful thinking in connection with fisheries of saying that the best course is to catch the maximum that the stock will yield without being depleted is incorrect; fishing and effort of that kind will not return the greatest benefit. In the foreground should be the ideal of utilising a resource in a sensible manner and not overexploiting it. The additional point of view taken in economics regarding optimal effort is that the maximum economic yield leads to reduced effort and a smaller total catch than might be possible, as illustrated in Figs 5.5 and 5.6. The economic vision of harvesting fish stocks therefore entails protection beyond that afforded by the determination of the maximum potential catch.

Bear in mind that the earlier example is fictional, but the question is whether it has a lesson to teach. It shows that a sensible total allowable catch can be decided based on scientific reasoning, as in the case of establishing the effort at 10. This effort will not lead to overfishing, and that is a tolerable outcome and provides an acceptable profit, as shown in Fig. 5.5. Nevertheless, it entails waste, as the profitability of the fishing waters is not maximised. At the point of the effort where income is equal to cost, that is to say at the effort of 13.78, there is still more waste than at the effort of 10, because by the point of 13.78 there is no profit. State subsidies to fisheries, which are common and widespread, increase still further the risk of overfishing. The example also shows that effort can be reduced from 10 down to the effort 6.89, which maximises profit, or value creation. Government authorities therefore confront the decision of whether, and to what extent, to follow the recommendations of fisheries scientists and what management system to use to catch the quantity decided and how to use the economic incentives inherent in the management system.

So, there are many factors that influence decisions on fisheries. Fisheries vary depending on season and fishing grounds. Price fluctuations in the market are typically seasonal, particularly in the case of fresh products, and market prices, seasonal or not, influence the effort of fisheries companies that control their entire value chain. The simple model described here identifies a position we would like to achieve for the sake of efficiency. In practice, this could be achieved by setting a total catch quota corresponding to that ideal position and then dividing it into individual quotas and letting the enterprises in the industry buy and sell as they like; they would then arrive at the economically efficient position identified in the model (Fig. 5.7).

It needs to be kept firmly in mind that the models discussed earlier, and the examples are not sacred truth in all circumstances, but are based on a number of assumptions for the purpose of simplification in the extremely complex environment of the fishing industry. In any case, history shows us, and this is confirmed by the literature in the field, that unrestricted fisheries lead to overfishing and, in extreme cases, even to the depletion of fish stocks. But maximising income from fisheries need not necessarily result in maximisation of profit, which is also confirmed by experience and the literature.

FIG. 5.7

A scene from the Kota Kinabalu market in Malaysia (Illpaxphotomatic).

5.4 Different management systems and fishing licence fees

Objectives set in harvesting fish from the sea can take various forms. Over the last centuries fish stocks have generally been harvested with the objective of maximising catch volumes. The effort has therefore corresponded to the point e_{mse} in our earlier analysis, and sometimes it has been even greater, up to the point where income equals cost. Also, the rule has not always been observed of fishing with a view to maintaining an unchanged stock size. The objective of fisheries management in many regions of the world is now generally to achieve the greatest possible efficiency in fisheries, i.e., reach the point e_{mey}.

But different countries may have different objectives in harvesting their fishing grounds. To give an example, one of the principal objectives in harvesting the fish stocks in Norway is to support rural regions. To this end, up to 2/3 of the cod catch quotas are allocated to small vessels, and the sale of the fish at a minimum price is guaranteed by the government. Unlike the situation in many other countries, there are no links between fish processing and fishing operations. However, this has been changing in recent years, and Norway has shifted towards what constitutes the mainstream in some other countries, where a single entity operates throughout the entire value chain, i.e., fishing, fish processing, and marketing.

In order to promote efficiency, transfers of quotas are a necessary option to some degree; however, in many countries a maximum of the quota that can be held by a single entity is restricted by law. In essence, fisheries management needs to address four questions: how much can be caught of individual species of fish; how should the fish be caught, meaning fishing gear, zonal closures, size limits, etc.; who should do the fishing; and, finally, how the profit from the fisheries should be shared.

At the last turn of the century, 5 countries had in place a system of individual transferable quotas, known as ITQs; by 2010, 22 countries were managing their fisheries using that system, accounting for about a quarter of the world catch.[g] A fisheries management system of this kind creates conditions and incentives for fisheries operators to manage their operations as efficiently as possible, so as to maximise profit.

It should be borne in mind that there are viewpoints other than profitability that can apply, but those viewpoints will be of a political nature and not based on a desire to achieve the best economic results, but rather on value judgements and the will of the voting public. Such viewpoints can of course be justifiable. However, it needs to be clear what is being sacrificed and what is being gained. In the mix are also the special interests of groups that can be quite influential, and politics, which by its very nature concerns the protection of interests. The influence that special interest groups may have on efficiency is often underestimated, and concessions to special interest groups can often lead to waste. When resources are used for the protection of interests, this is known as rent seeking. But it needs to be kept in mind that no arrangement is absolutely perfect, and all systems devised by humans will need a certain degree of flexibility and deviation. The extent of the deviation may differ, but extensive deviation may contaminate the entire system by skewing the competitive position of the entities that are subject to the system.

Other governmental measures that can undermine efficiency in fisheries management include restrictions on transferring quotas. The transfer of fishing quotas is a way to ensure efficiency, so that the fish is utilised optimally by the vessels or operators that are best equipped to achieve optimum results. Quota transfers may also occur when fishing vessels are sold, and even relocated from one seaport or region to another.

Although there are more things than the fisheries management system that can impact the situation of individual communities and regional affairs in general in a country where fishing is an important economic sector, there are many coastal areas where fisheries are of crucial importance. Economies of scale in fish processing and food production in general have often made life difficult for small communities. The most convenient and efficient location for fish processing plants is not always the most efficient location for fishing. The most efficient location can also change, both for fishing and fish processing.

If transfers of quotas are restricted for the purpose of discouraging disruption to certain regions, then this can have a negative impact on efficiency in the long term, even though it might temporarily improve the situation of a sparsely populated and disadvantaged area. A strong and profitable fisheries sector, like profitable economic sectors in general, creates increased revenue for government, for instance from taxes, to allocate to regional development.

Fisheries management can also be approached from the point of view of competition. It is not only companies that are competing among themselves; communities are also in competition with one another. Opening avenues for competition has led to progress in many areas in recent years, domestic competition being one of the basic conditions for building internationally competitive economic sectors.

As a general rule, economics as a scientific discipline supports the contention that free trade is the most auspicious way of ensuring maximum value creation and optimal living standards, even though the distribution of the quality of life may not be equal. Quota transfers have the effect of culling nonperforming entities and enhancing efficiency. They can also mean that large firms can take advantage of their size and catch fish at a lower average cost than smaller firms. But there are other things that can change unexpectedly in the fishing industry; for example, fish can easily migrate between fishing grounds and even between fishing jurisdictions. Quota transfers enable adaptation to changes in circumstances—in fact, it is one of the characteristics of markets that they adapt to changes (Fig. 5.8).[h]

The market economy, however, also means that some operators will fall by the wayside. Normally, the free transfer of factors of production is a feature of a market economy that focuses on public welfare, which is the economic management system that prevails in the countries that are best known in the world for their public welfare, and fishing permits can be regarded as a factor of production.

Other systems of fisheries management are often fraught with problems, such as illegal, unreported, and unregulated fisheries and discarding. Illegal fishing is a problem in many regions of the world, but can be addressed through rigorous surveillance. Discarding is a more difficult problem to deal with, although modern technology, such as real-time video recordings, could provide at least a partial solution.

FIG. 5.8

Setting out to sea in 1916 (National Museum of Iceland).

Economists are rarely in agreement on many things, but one thing that they are generally in agreement on is that the transfer of quotas improves efficiency, and that the experience of fisheries management systems based on quota transfers supports this opinion.

As regards the prioritising of profit, or value creation, in the utilisation of marine natural resources, it is not disputed that as a general rule the value creation, another word for profit, should have the primary objective of creating maximum value for sharing. This leads to the following question, which was mentioned previously: who should receive the profit from the utilisation of these common resources, that is to say the fish stocks? Should the profit go to the owners of the fishing vessels, the fisheries operators, should the entire country benefit, should it form a tax base for government, or should it be used for the benefit of economically weak regions or fishing ports?

It needs to be borne firmly in mind that a management system creates value by allocating fishing licences. A fishing licence, such as the right of use of a permanent quota share, is a cheque representing value. Accordingly, this gives rise to discussions that operators of fisheries companies should pay a charge for the fishing licences, that is to say a licence fee.

Licence fees can take various forms. They can be levied on allocated catch quotas, they can be collected after fish has been landed and based on the quantity of landed fish, or a higher income tax can be levied on companies that utilise fish stocks to generate income. This last approach can be problematic, as it is a complex matter to analyse what part of the income derives from catching fish, and what income derives from other value creation, for instance in the case of companies engaging in a mix of business operations, that is to say fisheries and fish processing.

Fishing licences are an asset created when government restricts access to a resource by legislation. This arrangement is efficient, which is evident, for instance, from the fact that catch quotas are rented and/or bought and sold at high prices. The price of catch quotas partially reflects anticipated future profit, in the opinion of those who deal in catch quotas.

Under quota transfer arrangements, the catch quotas will gravitate towards those who are best capable of making use of them, and as a result they will be the ones willing to pay the highest prices. That is the nature of business. The business is conducted by those who are most qualified, and others fall by the wayside when they find themselves unable to cope with the competition.

It is sometimes suggested that catch quotas should be auctioned and sold to the highest bidders. Under an auction system, bids would be made for the catch quotas corresponding to the anticipated future profit from the fishery. But auctions can have the effect that larger companies acquire a still larger share of the catch quotas because of their financial strength, although it might be possible to arrange the auctions in stages and hold separate auctions for smaller entities; however, this arrangement could reduce efficiency. It can also be difficult, or near impossible, to predict with any precision a reasonable price in an auction of catch quotas, simply because of the general uncertainty of sectors like the fisheries sector. This arrangement can therefore be extremely risky, both for the seller, who does not know whether the buyers can honour their bids when the time comes, and for the buyer, who may overestimate the potential future gains. Also, uncertainty of the success of bidding at auctions can weaken investment ability, and short-term viewpoints may gain the upper hand over long-term perspectives. Auctions of catch quotas have been tried on a small scale, for instance in Russia and Estonia, but the practice was abandoned after a relatively short time.[i]

Resource charges are in fact levied in many countries and many sectors. In Norway, for instance, most of the profit from the petroleum industry is collected in taxes, a resource tax or oil tax, and the profit is not channelled into the economy, as this would cause overheating of the economy and excessive strengthening of the currency. Among other things, the Norwegians have used the funds for investment, not domestically, but overseas, and to pay off all of Norway's foreign debt.

All sorts of charges are common in connection with the utilisation of natural resources, as in mining for metals, and gas and oil production, where government places restrictions on utilisation and allocates permits. Charging fees for the utilisation of natural resources may have two government objectives. First, the charges may be used to cover the costs arising from the economic sector for the government, and thereby taxpayers. In the case of fisheries, these costs may be marine scientific research and other research, data recording, expenditures on education, monitoring, control, and surveillance at sea, and the operation of harbours. Many countries impose charges on the fisheries sector in order to cover the costs to the government relating to the sector, including Chile, the Faroe Islands, Greenland, Iceland, Canada, New Zealand, and other countries.

On the other hand, government may also impose licensing fees in order to secure for itself a reasonable share of the profit that results from the restrictions on fisheries and licensing. A licensing charge has been imposed with good results in the Falkland Islands and Iceland, with the charge higher than the cost of the fisheries management.[j] Special taxation of fishing licences in fisheries in excess of government expenditures is not widespread, and in fact fisheries are subsidised in many countries. However, taxation of this kind is common in other sectors, such as mining and the oil industry.

As recounted earlier, fisheries economics and its related issues are quite complex, although an attempt has been made here to simplify matters to the extent possible. Resource management, including fisheries management, is a complex matter and Mankind has not had to deal with such issues until recently. As it is, many of the world's natural resources are already overexploited, and many living resources that were previously utilised are already depleted or even close to extinction. Environmental matters revolve to a large extent around resource management, where the value judgements and sense of justice of the general public are important factors that need to be taken into account. Views in the matter are therefore varied, and no single opinion trumps all other opinions.

5.5 Fisheries management around the world

Fisheries management is a subject of discussion in a number of international organisations, including the Organisation for Economic Co-operation and Development (OECD), which has produced a number of reports on the subject. In the opinion of the OECD, better results have been achieved in fisheries management than before, and the success is measurable, both in biological and economic terms. Economic instruments are used to determine the quality of a fisheries management system when the management is based on fishing rights.[k] These instruments are shown in Table 5.3.

The first instrument applied to concessions, or permits, for fisheries, as shown in Table 5.3, is exclusivity, meaning the extent to which the concession is secured and protected against encroachment. It needs to be emphasised that concessions are not seen as property, but as a harvesting right allocated by government. The second instrument, duration, refers to the number of years for which the concession is granted. In some cases the duration may be indefinite, although this can be changed at reasonable notice. In other cases, the rights may be restricted to a certain number of years, for instance 10 or 15 years. The third instrument, quality, refers to the security of the system and the government's ability to ensure its enforcement. The fourth instrument, transferability, is a measure of the extent to which concessions can be transferred between fishing entities. The fifth instrument, divisibility, refers to the extent to which a concession can be divided, from no option of division at all to the option of dividing among a number of units. The sixth instrument, flexibility, refers to the extent to which entities are free to conduct the business activities of their own enterprises and in their fisheries.

The OECD has conducted a quantitative assessment of the fisheries management systems of three countries, Iceland, South Korea, and Japan. The results are shown in Table 5.4, where grades are given from 0 to 10.

As Table 5.4 shows, Iceland fares well in the comparison, with top scores in four out of the six instruments, but performs slightly worse as regards transferability and flexibility. What this means is that transfers are not completely free, as certain general operational conditions need to be met, and there are restrictions on the share that individual companies are permitted to control of the catch quotas of individual

Table 5.3 Economic instruments in OECD fisheries.

Fisheries management instrument	Description of instrument
1	Exclusivity
2	Duration
3	Quality of title
4	Transferability
5	Divisibility
6	Flexibility

Table 5.4 Assessment of OECD criteria for fisheries management in three countries.

Instruments	Iceland	South Korea	Japan
Exclusivity	10	10	10
Duration	10	8	8
Quality of title	10	10	10
Transferability	8	6	6
Divisibility	10	8	8
Flexibility	8	8	8
'Average grade'[a]	9.3	8.3	8.3

[a]*In the article about the OECD criteria, no average is calculated, as averages are difficult to calculate because of possibly different weightings of the criteria. The presentation of averages in this table is therefore on the responsibility of the authors of this book and is intended only to explain the methodology used.*

species. South Korea shows similar results, as shown in Table 5.4, and it is principally restrictions on transfers that drag those countries down in this comparison.

Methods of fisheries management, mainly in OECD countries, can be divided into nine categories, which are briefly described later. The first category involves regional rights, where an entity, or entities, are issued rights to fish in certain delimited zones. In this sort of system it is also possible to distinguish between bottom fisheries and epipelagic fisheries (close to the ocean surface) in certain areas. Regional fisheries management systems of this kind are also used in part in Chile and Japan.[1]

The second category features quotas allocated to geographical districts, a system used in Japan, South Korea, and in the United States for Inuits and indigenous Alaskans. In New Zealand, the same system is used for aborigines. The system is also used in Canada in part. It is common for indigenous groups to enjoy special, less restrictive, fishing rights. In most places, their special situation and historic rights are recognised by means of privileges.

In the third category, involving limited catches per vessel, restrictions are imposed on the amount of the catch that each vessel is permitted to land over a specific period, per week, per month or per fishing trip. Systems of this kind are used in Australia, the United States, the United Kingdom, Denmark, France, Italy, the Netherlands, Canada, Norway, New Zealand, and Germany.

The fourth category features individual nontransferable quotas, usually a share of the total allowable catch. Systems of this kind are used in the United States, Belgium, Denmark, France, Italy, Canada, Norway, Portugal, and Germany.

The fifth category involves individual transferable quotas. Systems of this kind are used in a number of countries, including Australia, the United States, Denmark, the Netherlands, Iceland, Canada, New Zealand, and Norway.

The sixth category, nontransferable permits, features the allocation of permits to vessels and/or vessel operators. This system is in effect in Australia, the United

States, Belgium, the United Kingdom, France, Greece, Iceland (e.g., in whaling), the Netherlands, Italy, Japan, Canada, and Spain.

In the seventh category, permits are issued with restricted rights of transfer, where a fishing permit may be transferred under certain conditions; this system is in effect in Mexico, the United Kingdom, Norway and, to a limited extent, in France.

The eighth category features individual nontransferable effort quotas, where an effort permit, for example in the form of allowed fishing days, is allocated and cannot be transferred. This system is in use in Belgium, and, to a limited extent, in Australia, the United States, the United Kingdom, France, and Canada.

The ninth and last category features individual transferable effort quotas, where, for example, fishing days are allocated, as is the case in Spain and Sweden.

As the previous listing shows, there are many systems in use in various countries. OECD countries have been trending in the direction of managing their fisheries through fishing rights, either in the form of individual quotas, general fishing licences or regional licences, with the rights sometimes transferable, but often not transferable or transferable only with stringent restrictions.

The opposition to government allocations of fishing rights is frequently based on the contention that the rights entail privatisation of common resources. However, in reality this is not the case at all. Rights are not conferred on others as property; rights of use are allocated in a specific way to organise fisheries in a cost-effective manner. Since the rights are valuable, it is reasonable for the user of the rights to be subject to payment of a charge, as discussed earlier.

In the opinion of the OECD, restricted rights, transferable or not, are preferable to no control over fisheries at all, or ineffective control. There is so much variety in types of fisheries that it is impossible to devise a system that will cover all situations; in fact, a number of countries have in place several management systems, as the list above of systems in use illustrates. Most countries impose restrictions on transfers to foreign enterprises, although there are many examples of foreign entities responding by forming organisations in the country in question or buying operational enterprises that have been issued fishing rights (Fig. 5.9).

Some species of fish straddle the economic jurisdictions of several states (known as shared fish stocks), in which case fisheries from the stock need to be negotiated among the states in question. Other species travel far and wide through the oceans, changing location frequently. An example is tuna, which in fact is a stateless fish, making effective fisheries management extremely difficult; in fact, tuna fisheries are often referred to as the last instance of gold fever in hunting for wild species.

Opposition to reforms of fisheries management systems often stems from the fact that the participants in the sector will frequently need to carry additional cost resulting from the reforms, while a part of the benefit is reaped in the long term and may not accrue to those who paid the additional cost. Those who need to pay in the short term may therefore oppose any changes, and often do. In many countries stakeholders in the fisheries sector, in particular employers, are extremely well organised in the protection of their interests. However, it needs to be emphasised that changes

FIG. 5.9

Brown bear catching salmon in North America (djavitch).

in fisheries management should in any case be made in consultation with stakeholders, as this makes their successful implementation more likely.

In many countries special efforts are made to ensure that fishing rights do not accumulate within few organisations, which frequently happens. To give an example, in New Zealand it is quite common with regard to a variety of fish species for the fishing rights to be mostly in the hands of two enterprises, or even a single enterprise.

Shared fish stocks pose various complications. Fisheries management in Norway is based to a large extent on agreements with other countries on Norway's share in straddling fish stocks. The agreements are mostly with Russia, the European Union, the Faroe Islands, and Iceland. Unfortunately, the fish stocks in the North Sea are not in good condition, which has an impact on agreements between Norway and the European Union.

In agreements of this kind the total allowable catch for individual fish species is decided and the catch then divided among countries, often on the basis of historical fishing experience. For this reason, many companies in a number of countries are in the process of accumulating fishing experience outside national economic jurisdictions in order to be better positioned in any potential future negotiations.

The principal fish species in Norway are allocated as individual quotas, which are formally nontransferable. For other species a certain total allowable catch is determined, which can be freely caught until the allocated quota is reached. As regards quotas that are allocated to vessels, a vessel may be decommissioned (or temporarily decommissioned) and its quota transferred to another vessel. This is therefore a restricted transfer of fishing rights and can only be applied within the same category of vessel.

In Norway, the arrangement of allocating the cod quota is that two-thirds are earmarked for coastal fisheries, and one-third for trawlers. A similar arrangement applies to haddock. The reason for this arrangement is the importance of coastal fisheries for certain coastal regions, some of them remote. Saithe and pelagic species, such as herring and mackerel, are shared among inshore fishing boats, trawlers, and pelagic fishing vessels. Attached to all of this is a complex regulatory framework regarding vessel sizes and time limits within delimited fishing zones. Transfers are possible to a certain degree, so quotas and permits may change owners.

The objectives of fisheries management in Norway are varied; earlier, there was great emphasis on preserving jobs in coastal areas, but currently there is greater focus on efficiency and profit, as it is a is a simple matter of fact that inefficient and unprofitable fisheries will secure neither jobs nor habitation for the long term.

Norwegians are keen on observing the advice of fisheries scientists, and the fish stocks around the country are generally in good shape, and some show good yield. Here, again, the difference needs to be underscored between biological overfishing and economic overfishing. Biological overfishing happens when too great a quantity is caught; economic overfishing happens when the fisheries do not maximise the returns from fishing, as described earlier (Fig. 5.10).

The Faroe Islands are about 1400 km^2 in area and populated by about 50,000 people. Even though the Faroes are a part of Denmark, they are independent in a number of areas. For instance, Denmark is a member of the European Union (EU), while the Faroe Islands are not. The Faroe Islands are also hugely dependent on fisheries and aquaculture. Ships carrying the Faroese flag have to be owned at least two-thirds by Faroese entities and be subject to the Faroe Islands' tax regime. Fish products

FIG. 5.10

Melting glaciers in Juneau in Alaska (Evan Hallbeck).

represent about a 95% share of the country's exports, and the contribution of fisheries and fish processing to domestic product is about 20%.

The Faroese set up a management system in 1994, which was similar to the Icelandic system, with transferable catch quotas, but they abandoned the system after only 2 years. Since that time they have managed their fisheries using fishing days, zonal closures, and technical conditions for fisheries. Vessels are classified by size, and each class is allocated a certain number of fishing days per year. Fishing days can be transferred between vessels in the same class, as long as the right holder has utilised at least 60% of his allocated fishing days. There have been significant fluctuations in the catches of cod and haddock in the Faroe Islands in recent decades.[m] The Faeroese manage their pelagic fisheries and the fisheries in distant waters by individual quotas.

Greenland is about 2.2 million square kilometres in area and populated by about 55,000 people. Greenland is a part of Denmark, but the country has a significant degree of self-determination. Greenland joined the European Union (EU) in 1972, but left again in 1985. Marine products represent about a 90% share of the country's exports, and the contribution of traditional fisheries to domestic product is about 25%.[n] The fisheries and population are dispersed along the coastline, as the largest part of the country is uninhabitable glacier. One company, Royal Greenland, dominates the Greenlandic fisheries. The catches are mostly shrimp, Greenland halibut, and cod, and a certain total allowable catch is established for individual species. Greenland has entered into several mutual fisheries agreements with other countries, and so there are Greenlandic vessels conducting fisheries in a number of areas in the North Atlantic.

The European Union (EU) has 27[o] member states, most of them coastal and all featuring rivers and lakes, some with extensive fisheries. Three quarters of the EU's total catch comes out of the north-east Atlantic Ocean. The member states jointly decide on a total allowable catch in consultation with fisheries scientists. The EU's management system is known as the Common Fisheries Policy. It used to form a part of the Common Agricultural Policy (CAP) but this was changed in 1976, when the Fisheries Policy underwent extensive changes. Under the current system no country is issued a share in the catch quota unless it can demonstrate fishing experience, and allocations are based on historical participation in fishing for the species in question. This is known as the principle of relative stability, meaning that this share continues unchanged from year to year; in addition, account is taken of the needs of regions that are particularly dependent on fisheries.[p]

Decisions within the EU are taken at the lowest possible administrative level. This means that the member states decide for themselves how they conduct their fisheries, but on certain conditions: they cannot exceed the allocated quotas; they must promote downsizing of their fleets; and they must observe general rules on health, safety, conditions, and type of vessel and fishing gear.

Since 2002, a great deal of effort has been spent on improving the efficiency of EU fisheries, but the Union has a long way to go before the member states achieve maximum efficiency in their fisheries. However, the focus has been on reducing fleet sizes in terms of number of vessels and engine size, and results have been achieved in this regard, but since the total catch has shrunk, the EU cannot be seen has having had much success. Nevertheless, this differs between countries, and the Netherlands and Denmark, for instance, have adopted a system of transferable quota shares, which has shown success. In other countries transfers are restricted in a number of ways.

The United Kingdom has run into all sorts of trouble in their fisheries management. The United Kingdom has territorial waters bordering on the territorial waters of many other countries. It was a Member State of the EU in 1973–2020 and had a long tradition of fisheries prior to accession to the EU. The UK fleet is generally divided into vessels of 10 m or less and vessels over 10 m. Even though the smaller vessels outnumber the larger vessels by some distance they return only about 10% of the total catch value.

The United Kingdom took extensive government action in the 1990s and the first decade of the present century to reduce the number of smaller vessels in order to reduce their effort and make fisheries more profitable; the actions were quite successful. The number of larger vessels also shrank, but the reason for that trend was that catches and catch values decreased significantly as a result of overfishing. The most successful fisheries in the United Kingdom are pelagic fisheries, while demersal fisheries are in a much poorer state. Larger vessels are allocated catch quotas as a share of the total allowable catch, while the smaller vessels fish in competition from the total allowable catch, which is usually determined for 1 month at a time. Regional management is used in Scotland, Wales, and Northern Ireland. The United Kingdom used fishing rights based on vessel size, but abolished that system in 2007, and currently mainly use licences, which are transferable with various restrictions.

A number of management systems are in use in the United States, but in recent years the trend has been in the direction of management through rights such as individual quotas and licences. The objective of fisheries management in the United States is to prevent overfishing and obtain the most efficient returns from fisheries of individual stocks. Such objectives are commonly set, but the results are mixed, and usually not very good. Like elsewhere, the trend in the United States has been from unrestricted fishing to restrictions on gear and restricted access to fisheries and on fishing rights and management of those rights.

In one case unrestricted fisheries led to a constantly growing number of fishing vessels and shrinking fishing seasons, and in 1990 a situation occurred in the United States where the fisheries window in the Alaska halibut fishery was 24 h, with over 3000 vessels competing for the total allowable catch. The consequence was in line with the basic principles of economics and the tragedy of the commons, as described earlier. The management of rights has now had the result that there is greater emphasis on more valuable marine products than before. Local management and stakeholder input in individual areas are common, and important, in the United States. The public discussion of fisheries management in the United States has been more coloured by environmental concerns than in most other countries.[q]

In Canada, the trend in fisheries management in recent decades has been in the direction of controlling fishing rights following the spectacular collapse of the cod stocks off the eastern coast of Canada in the 1990s. Canada divides its fishing into two sectors: the Atlantic and the Pacific, as the fisheries are completely separate. Even though the caught quantity has declined in comparison with earlier decades, some stability of the fish stocks has been achieved, although the Atlantic cod stock is still depleted. The value of marine products has also increased in recent years, among other things through increased prawn fisheries. Canada has a number of management systems in place, and control of fishing rights has given good results. The Canadian government has now sharpened its focus on a cautious approach to the harvest of fish stocks off its coasts. One reason is that the country is extremely large, the second largest country in the world after Russia and larger than China, with many isolated settlements, where there are not many other job opportunities left if fisheries fail.

Japan is one of the principal fishing nations of the world, and fish is both an important staple of the Japanese diet and a delicacy, as evidenced by the extensive Japanese consumption of fish products. Marine fisheries in Japan are mainly divided into coastal, or inshore, fisheries and offshore, or ocean, fisheries. Fishing rights are rights of use and protected by law. The government decides on a total allowable catch and total effort, and then government authorities at a lower administrative level, often small municipalities, are responsible for the conduct of fisheries in cooperation with local stakeholders. Japan makes extensive use of zonal closures, for instance in the spawning season, which has given good results by preventing overfishing and supporting recruitment in fish stocks. The practice of closing zones, particularly spawning grounds, with the purpose of protecting and building up fish stocks has gained increased currency in recent years (Fig. 5.11).[r]

In many places of the world fishery is an underdeveloped industry, even where it is extensive, as in the case of Southeast Asia, where, admittedly, there has been a significant technological revolution, but accompanied by huge population growth. The population in the region has grown 15-fold, from approximately 80 million people at the beginning of the 20th century to 670 million people in 2020. Overfishing is rampant despite the fast rate of growth of fish in warm waters. The entire increase in the supply of fish products has in fact been rooted in aquaculture, as mentioned earlier. Fisheries management is often problematic due to the lack of infrastructure and effective governmental agencies. Recording of catches is also deficient, which makes all supervision extremely difficult. But this description of Southeast Asia can be applied to a number of other regions of the world, like most of Africa, notably Western Africa. In Africa, as a matter of fact, it has been common throughout the 20th century and into the 21st century for foreign fishing vessels to harvest a large portion of the fish caught in the countries' territorial waters.

Time limits, that is allocating fishing days, as a method of controlling fisheries has not proven effective, as this approach creates clear incentives for competition for the fish. This has led to huge investments in vessels and fishing gear to take the best possible advantage of the limited time that fishing is permitted. Effort controls inevitably result in overinvestment, and the resource rent is wasted. The fishing period may be extremely short, as in the case of the herring season in Prince William Sound

FIG. 5.11

Big-game fishing in Mahé, the largest island of the Seychelles, in the Indian Ocean (Anna María Clausen).

in Alaska in 1982, where the season lasted for 4h, and even so the total allowable catch was exceeded.

An interesting comparison was made of management systems in scallop harvesting in the United States and Canada over a 15-year period.[s] The fishery was comparable, but the management systems different. The principal harvesting area is George's Bank, which pertains to both countries. Canada utilises a system of transferable quota shares, while the United States use a mixture of restrictions on vessel size, effort, and harvesting areas.

In Canada, the scallop stock grew, and the harvest of small scallops decreased. In the United States, on the other hand, the stock declined, and small scallops were harvested in great quantities. Income per fishing day increased in Canada as the catch each day was seven times the size of the US catch because of the larger stock. The number of vessels engaging in scallop harvesting decreased significantly over the period in Canada but remained more or less unchanged in the United States.

Income per fishing day declined in the United States for reasons that included overfishing. In Canada, the number of fishing rights holders decreased from nine to seven, and in the 14-year period 65% of the catch quotas remained with the companies to which they were originally allocated. Both countries use a catch-sharing system in their fisheries. By far the most likely reason for the difference in results is the difference in the respective management systems. Transferable quota shares create incentives that override the temptation of overfishing and overinvestment, as discussed earlier.

There is a study available that covers 11,000 different types of fisheries in a number of countries over a more than 50-year period, from 1950 to 2003. The principal conclusion of this extensive study is that a system of individual transferable quotas has several advantages over other systems. Another study of 20 fish stocks that all were managed using a system of individual transferable quotas showed that 12 of the stocks improved, while 8 stocks declined, so the results were inconclusive.[t]

Transfers of quotas, which are permitted under individual transferable quota systems (ITQ systems) will eventually have the effect that catch quotas shift from less efficient fisheries companies to more efficient ones. Systems of this kind can also increase catch value, because the fisheries operators are no longer under the pressure of fishing as much as possible; instead, they can organise their fisheries so as to maximise the value of their catches. Iceland was one of the first countries to implement an ITQ fisheries management system, and subsequent research has shown that this system has significantly increased the economic benefits deriving from the Icelandic fisheries sector.[u]

It is important to bear in mind that a system of individual transferable quotas can result in discarding of fish, landing past weighing stations, or using deceit in landing by placing cheaper fish in the top layer of fish tubs. This has been discussed earlier, and it is a serious problem in many places. Opponents also criticise systems of individual transferable quotas on the grounds that they lead to concentrations of organisations in fisheries and hinder the access of newcomers to the industry. However, many of these objections actually apply to other management systems as well.

As regards decisions on total allowable catch based on fisheries science, it needs also to be borne in mind that there are many uncertainties to deal with, so that overestimates and underestimates of stock sizes can easily happen. Fisheries economics models, where attempts are made to decide the most efficient harvest and the management of that harvest, are also subject to these same uncertainties. For this reason, some scientists warn against overstating the usefulness of these models and recommend great caution in making decisions on total allowable catches—much greater caution than is currently the norm. What determines the success of efficient harvesting and renewal of the resource is therefore the interaction of fisheries management systems and the advice of fisheries scientists, which is based on an assessment that is not significantly far from the reality. The general truth about scientific models is that their validity is determined by the input data and assumptions used in their creation. If the assumptions are far from the reality, then any model based on the assumptions will be of little use in decision making.

As shown in this overview of fisheries management systems in several countries, there are extensive differences in the systems used between countries, and within countries. There has been a growing understanding in recent years of the importance of promoting smaller fleets, more efficient effort, and changes in the various types of fishing rights.

Endnotes

a. For a discussion of the tragedy of the commons and overexploitation of resources see, e.g., Hardin (1968), Coase (1990), and Winter (2008).

b. For a discussion of the discard of fish in world fisheries see, e.g., Alverson, Freeberg, Murawski, and Pope (1994), Kelleher (2005), and Pauly (2010).

c. For a discussion of the importance of fisheries for the developing countries see, e.g., Valdimarsson (2009).

d. The first to present a model in fisheries economics was the Canadian fisheries scientist Milner B. Schaefer see Schaefer (1954). The Canadian economist H. Scott Gordon wrote an article based on these biological models and linked them to economic theories and analyses. That article is regarded as having heralded the advent of fisheries economics see Gordon (1954). The discussion was continued in an article by Anthony Scott see Scott (1955). A book was later published by two British fisheries Scientists, Raymond J.H. Beverton and Sidney J. Holt, where these ideas were taken further see Beverton and Holt (1957). In 1963 Schaefer and Beverton jointly published an article where these models were further developed see Schaefer and Beverton (1963). These writings by the Canadian and British scientists formed the foundation of fisheries economics as a scientific discipline, although we should not forget the pioneering steps of the Danish Jens Warming, much earlier.

e. For a discussion of these basic models and the extrapolation of equations based on the models see Gíslason (1991) and Bjørndal and Munro (2012).

f. It is an interesting question why it is that some individuals will invariably be more successful in catching fish than others, even under the same conditions, In fishing, whether at sea or in rivers and lakes, it is almost a rule that one or two will be in a class of their own as regards catches—not just occasionally or randomly, but over longer periods. Stories of extraordinarily successful captains abound, and the same is true of anglers who regularly return home with the largest catch, assuming the catch is not released, of course. This is often ascribed to some sort of divine providence; whatever the case, legends of uncommonly successful fishermen have been a staple of folklore from the earliest times.

g. For a discussion of individual transferable quotas and the excessive world fleet size see, e.g., World Bank and the Food and Agriculture Organization of the United Nations (2009), Árnason (2010), World Bank (2017), and Hoshino, van Putten, Pascoe, and Vieira (2020).

h. For a discussion of transfers of catch quotas see, e.g., Hersoug, Holm, and Ranes (2000), Standal and Aarset (2002), and Tietenberg and Lewis (2015).

i. For a discussion of auctions of catch quotas see, e.g., Hannesson (2005) and Huppert (2007).

j. For a discussion of charges on fisheries permits see, e.g., Heaps and Helliwell (1985), World Bank (2004), and Einarsson (2016).

k. For a discussion of the OECD publication on fisheries management see Ridgeway and Schmidt (2010).

l. For a discussion of fisheries management in individual countries see, e.g., Wilen, Cancino, and Uchida (2012) and Connor and Shallard (2010).

m. For a discussion of fisheries in the Faroes and Greenland see, e.g., Fiski-og tilfeingismálarádid (2008) and OECD (2005).

n. The Greenlanders have always been dependent on the sea. When the Reverend Hans Egede came to Greenland in the early 18th century in search of a Nordic congregation to harden them in their faith he found only Inuits. He promptly embarked on a mission of Christianising the Inuits, learned the Inuit language, and later became known as the *Apostle of Greenland*. However, he encountered a problem in that there were no Inuit words for a number of concepts, including bread. Undaunted, Egede translated the words of the Lord's Prayer "Give us this day our daily bread" as "Give us this day our daily seal".
o. Until 31 January 2020 the Member States of the European Union were 28, but with the exit of the United Kingdom the number fell to 27.
p. For a discussion of fisheries management in the European Union (EU) see, e.g., Frost (2010) and Pascoe and Tingley (2010).
q. For a discussion of fisheries management in the United States and Canada see, e.g., Holland (2010) and Parsons (2010).
r. For a discussion of fisheries management in Asia and Africa see, e.g., Makino (2010), Williams and Staples (2010), and Satia and Jallow (2010).
s. For a discussion of harvesting time limits and a comparison of scallop fisheries in Canada and the United States see Repetto (2001) and Tietenberg and Lewis (2015).
t. For a discussion of studies of long-term harvesting of fish stocks see, e.g., Schrank (2007), Costello, Gaines, and Lynham (2008), and Chu (2009).
u. For a discussion of ITQ management systems see, e.g., Flaaten, Heen, and Matthíasson (2017).

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CHAPTER

6 China, the leading fishing and fish farming country of the world

I have three treasures which I guard well.
The first is love.
The second is frugality.
The third is humility.
Only he who loves is able to be brave.
Only he who is frugal is able to be profuse.
Only he who is humble is able to rule.

This passage is from a poem by Laozi, or Lao-Tze, the first Taoist philosopher, born in 601 BCE and died in 531 BCE.[a] He is believed to have been the author of *The Book of The Way*, although that is not entirely certain. The book describes 'Tao' ('the Way') as the real in the environment, or 'Te', which relates to the life force of objects and, among other things, concerns virtue. Courage, generosity, and leadership are virtues inherent in the system of ethics, and people are encouraged to reveal their inner emotions. This thought is enshrined in the earlier quotation. This line of thought is also extremely significant in that it sheds a light on the Chinese people, their history, and traditions.

The philosopher Confucius (551–479 BCE) spoke of virtues such as kindness and knowledge and emphasised the relationship of right to wrong. Taoists focus on peace of mind and harmony with nature, while Confucians emphasise social factors and obedience to authorities. Both these philosophies eschew extremes, which has been a characteristic of the Chinese for a long time.[b] The influence of these philosophies has been felt for centuries, with Confucius's philosophy being the justification of China's emperors for their reigns over long periods. This mode of thought remains influential in China. It is worth noting, to put things into a Western context, that these Chinese philosophers predated by over a century the Greek philosophers that still influence Western thought, Socrates being born 469 BCE and died 399 BCE.

6.1 Principal events in the context of history

China is a huge country, about 9.6 million square kilometres in area and the third largest country in the world after Russia and Canada. The population of China is about 1450 million. China's borders extend about 22,000 km, touching 14 states. China is also a very ancient culture, with ancestries dating back to the Peking Man of some 750,000 years ago. The origins of civilisation in China can be traced

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back to about 600,000–400,000 BCE and to the area around Beijing and on the banks of the Huang He, the Yellow River, that runs about 5500 km through nine provinces. The earliest signs of fixed residence have been discovered on the Yangtze River, dating from about 5000 BCE.

There are 56 different ethnic groups in China, although 92% of the Chinese people are the ethnic Chinese, or the Han. The other 55 ethnic groups, numbering fewer than 100 million people in all, mostly populate the rural areas and border regions. China is divided into 22 provinces, 5 autonomous regions, 4 direct-controlled municipalities (Beijing, Tianjin, Shanghai, and Chongqing), and the 2 special administrative regions of Hong Kong and Macau. Hong Kong became a part of China again in 1997, when the treaty under which Hong Kong had been ceded to the British Empire expired. Macau, a former Portuguese colony, was returned to China in 1999.

Most of the people of China speak a large variety of dialects, but the official language is Mandarin Chinese. The same form of writing, believed to date from about 5000 to 4000 BCE, is used throughout the country. Contrast this with India, for example, with its myriad of ethnic groups and languages. Around the time of the beginning of the Common Era, there were already some 60 million people in China, although that figure then remained more or less stable for the next 1000 years. China was built up by dynasties that succeeded one another, and it would not be inaccurate to say that China has a continuous history dating from 221 BCE and extending down to the present day.[c] The same origin of 92% of the population, the same language, the same writing system, and the same cultural traditions have always been a part of the nation's heritage—a rare continuity in the history of nations. However, each of the provinces formed its own traditions of farming, industry, cooking, and art, which is understandable in the light of the enormous size of the country.

Fig. 6.1 shows the population trend in China.[d] The beginning of the period in Fig. 6.1 is 221 BCE, when the Qin Dynasty was established by Qin Shi Huang, China's first emperor. It is estimated that the population of China at that time was about 40 million people. The population was about 60 million in CE 1000, but grew rapidly after CE 1700. By CE 1900 the population of China had reached 450 million, and by the year 2000 it had almost tripled, to 1300 million. In 2020 the population stands at about 1450 million, but that figure is projected to fall to about 1100 million by 2100, with a significant drop in the second half of the 21st century.

The Chinese Government made an attempt to curb the population growth in the last two decades of the 20th century, one of the measures being to limit the number of children per family to a single child; prior to that, parents were permitted to have two children. In fact, the one-child policy was not without exceptions, and as of 2016 China has reverted back to its earlier two-child policy.

China is now the most populous country in the world, with 20% of the total world population; for comparison, it is believed that India will outpace China by the year 2100, with a population of 1450 million. By that time China's share in the world population will be down to 10% of the total world population, which, proportionally, represents a large change for China.

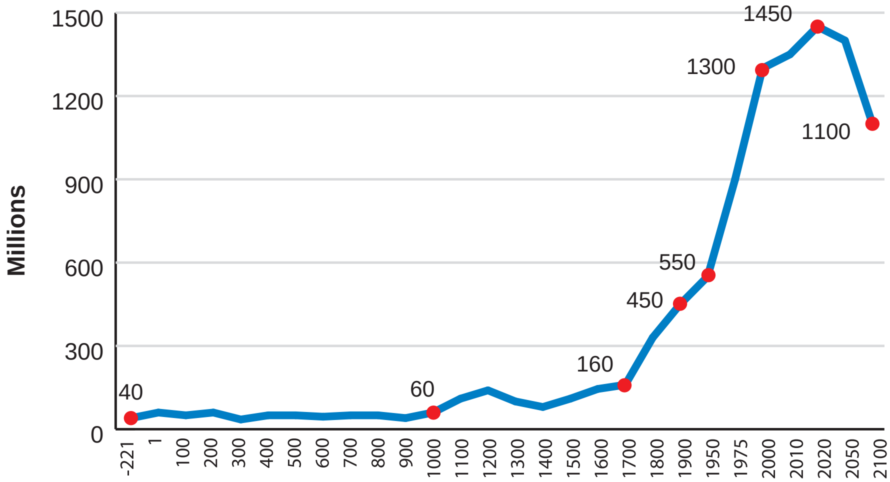

FIG. 6.1

Population of China 221 BCE–CE 2100.

Table 6.1 shows some major events and eras in the history of China. The Empire of China was established in 221 BCE, launching a sequence of dynasties that lasted over 2000 years. The empire did not end until the beginning of the 20th century. The Tang period is often referred to as the Golden Age of China, extending from about CE 600 to CE 900. By that time, the Chinese already had an eventful 1000 years of history. The city of Xian was for a long time the seat of the emperors; it is the site of

Table 6.1 Some milestones and eras in the history of China.

Year	Event
221 BCE	Founding of Qin dynasty
202 BCE–CE 220	Han dynasty
617–907	Tang dynasty (golden age)
1206–27	Reign of Genghis Kahn
1274	Marco Polo in China
1368–1644	Ming dynasty
1644–1911	Ching dynasty
1912	Fall of the Chinese Empire and the founding of the Republic of China
1949	The former government of the Republic of China lost the civil war and retreated to Taiwan Province of China
1949	Establishment of the People's Republic of China
1976	Death of Mao Zedong
2020	Present

the famous terracotta army in the tomb of the first emperor, Qin, now a museum and a UNESCO World Heritage Site.

In the West, the 11th century was a time of the Crusades, deep in the Middle Ages, followed later by the Renaissance in the 15th and 16th centuries, a defining period in Western history. Throughout its history, China enjoyed relatively peaceful relations with other countries, the exception being the time of Genghis Kahn, whose armies swept westwards in the early 13th century.

China's long history was virtually unknown in the West for centuries, and it was not until the Venetian explorer Marco Polo made his journey back from China and published his *Book of the Marvels of the World*, around 1300, that any knowledge of China reached Europe. From the year 1274, Marco Polo, his father, and uncle had remained in China in the court of the Chinese emperor Kublai Kahn, the grandchild of Genghis Kahn. Marco Polo's accounts of his journeys gave Westerners an insight into this enormous country, which by that time had been a powerful empire for 1500 years. To put things into perspective, America was rediscovered in 1492, in the middle of the Ming period, some 50 years before the Ching period, which lasted for almost 300 years.

Despite this new knowledge, however, China's relations with the rest of the world remained limited for centuries.[e] China was self-sufficient in most regards and not in any need of foreign goods to any significant extent. Although various goods, such as silk, were exported from China for centuries, this international trade was limited. China always had the capability to interact with other countries, whether by trade or war, but this capability was hardly ever exercised. As regards trade, China is so large and populous that ensuring the flow of trade between provinces was in itself a gargantuan and complex task. International trade in any scope did not come into being until the 16th and 17th centuries, and even then it came nowhere close to the trend in the 19th and 20th centuries, when international trade became the norm in the world economy, in particular after World War II.

The colonial time that arose, among other things, out of the changes resulting from the Industrial Revolution, to some extent spread knowledge around the world, but for the most part colonialism was characterised by the exploitation of poor countries by rich countries. This colonial period, which lasted several centuries, featuring slavery among other scourges, created a number of huge problems, many of which left consequences which are still being dealt with in the 21st century, particularly in Africa; incidentally, a part of this exploitation involved distant water fisheries. The colonial period, which had a huge impact on China in the 19th century and into the 20th century, was in many ways a time of humiliation for the country. In the early 20th century, in 1912, the Chinese Empire collapsed, and after that things began to happen fast. A republic was founded in China in 1912, followed after the Second World War by the People's Republic in 1949. In 1976 a new watershed was reached with the death of Mao Zedong, who had shaped China's history for most of the 20th century.

The changes in China over the past decades have been profound, and the changes that occurred with the establishment of the People's Republic in 1949 were of particular importance in China's history, marking the entry into power of the Communist Party of China under the leadership of Mao Zedong. However, the changes that have occurred since 1949 are not associated only with the name of Mao Zedong, but also with the name of Deng Xiaoping and the economic revolution that took place under his leadership. The Chinese endeavour to treat all countries equally is an important feature of their foreign policy and their relations with other states. China is a one-party state, governed by the Communist Party, although some provinces have been given extensive autonomy, one of the earliest such provinces being Shanghai, where Jiang Zemin, the former President of China, had earlier been mayor.[f]

The people in power in China in recent decades have governed in the spirit of Deng Xiaoping's policy, seeing increased trade as a route to greater prosperity. One of the manifestations of this governance is the policy of 'one state, two systems' with regard to Hong Kong. The current President of China, Xi Jinping, has had a still further impact on China's world position, and there is not much now going on in the world in international politics without some Chinese involvement or influence.[g]

China's history in the 20th century and what has passed of the 21st century can be divided into three main periods, which in turn can be linked to three names shown underneath the photographs in Fig. 6.2. The first period is linked to Mao Zedong, whose leadership role in the time leading up to the establishment of the People's Republic and the first decades that followed is unquestionable. The second period is the time of Deng Xiaoping, whose policy of reform and opening up after 1978 transformed China economically; his influence was felt in China long after he left office. Deng's policy was largely to utilise the methods of the market economy, but with the Communist Party retaining full power of the country's government. This policy has remained in full force since Deng's death in 1997. The third period can be linked to Xi Jinping, the current president since 2012. Even though Xi Jinping has only been in power for a relatively short time, profound changes have occurred in the course of his term in power, in particular as regards participation in international politics.

FIG. 6.2

Three leaders of China (Ólafur Kristjánsson).

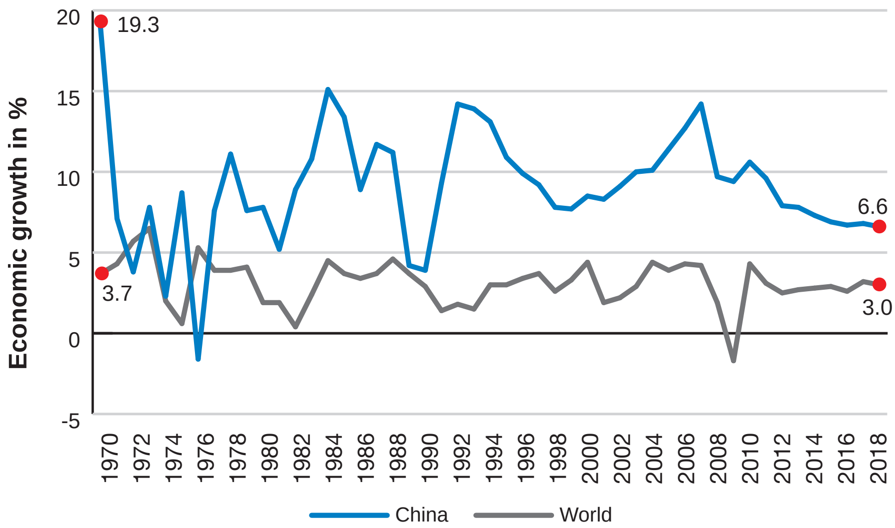

FIG. 6.3

Economic growth in China and the world from 1970 to 2018.

Economic growth in China has been quite spectacular. Fig. 6.3 shows China's growth in 1970–2018 in comparison with the world growth over the same period.[h] In this almost 50-year period the average annual economic growth in China was 9%, as compared to 3% for the world as a whole. This is a huge difference and illustrates both the scale of the growth in China over the last seven decades and the power of the economic forces that have been let loose in a relatively short time.

It is interesting to compare the gross domestic product in China and the United States over a longer period at purchasing power parity (PPP), as is done in Fig. 6.4.[i] The chart shows that in 1990 GDP in China was 1121 billion current international dollars (a unit of currency widely used in international comparisons), while in the United States GDP was 5963 billion current international dollars. In 2013 GDP was about equal in both countries, at about 16,800 billion current international dollars, with China outracing the United States. This makes China now the largest economy in the world. There are no indications that China will not retain this leadership for many years to come. In 2018 the gross domestic product was 25,362 billion current international dollars in China, as compared to 20,494 billion current international dollars in the United States. Since 1990, however, the gross domestic product in China has grown by a factor of 22, as compared to a factor of 3 in the United States. It should be noted, also, that the population of the United States grew by 30% over the same period, but by only 20% in China.

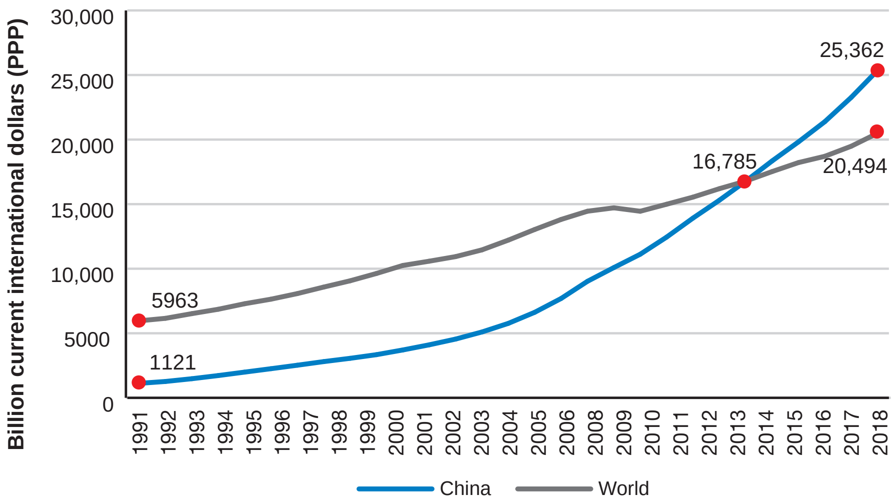

FIG. 6.4

Gross domestic product (GDP) in billion current international dollars (PPP) in China and United States 1990–2018.

Although GDP is high in China, as shown in Fig. 6.4, looking at the domestic product per person at purchasing power parity reveals a different story, as shown in Fig. 6.5. Domestic product per person was 988 international dollars in China in 1990, as compared to 23,889 international dollars in the United States, making the US figure 24 times that of China. Domestic product per person at PPP is often used to measure standards of living in a country, and according to these figures living standards were 24 times better in the United States than in China in 1990. Fig. 6.5 shows the growth of gross domestic product per capita in both counties; in 2018 GDP per capita in the United States was 62,641 million international dollars, only three times higher than the 18,210 international dollars in China. The gap between the countries as regards living standards has therefore narrowed, although China still has a long way to go before it can match the United States. It is interesting to note that in 1990 China ranked low among about 200 countries in the world with regard to GDP per capita at PPP, but by 2018 China had raised its status by a hundred seats or so on the same list.[j] The middle class in China has become large and it is growing.

This picture of the impressive growth of the Chinese economy shows that China's future potential is huge. With the improving living standards of recent years and the continuing improvement, purchasing power will increase, which will impact demand for high quality food, such as fish and fish products, which in turn will promote better consumer health.

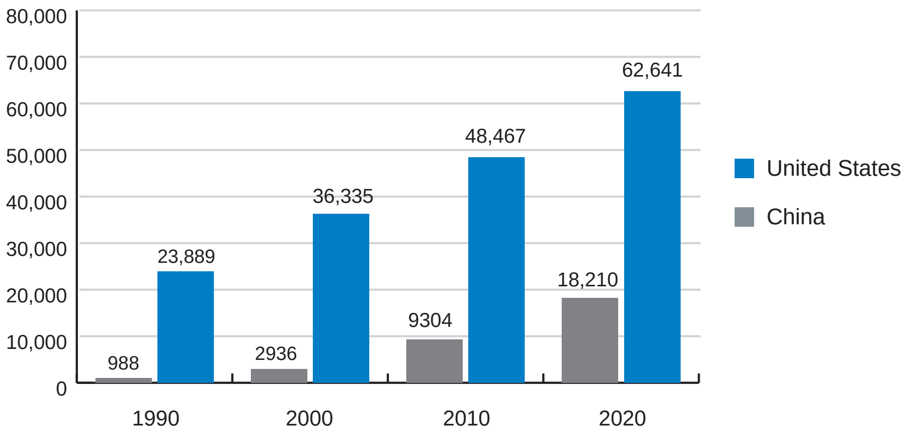

FIG. 6.5

Gross domestic product (GDP) per capita in current international dollars (PPP) in 1990, 2000, 2010, and 2018.

Illustration of China's impact

For most of its history, China has occupied itself with its internal affairs and had little to do with other countries. The centralised imperial government required a strong class of public officials, who enjoyed a great deal of respect, having been selected on the basis of tough competitive examinations to ensure the selection of the most qualified individuals for government posts. This system proved its worth, and in spite of domestic strife in the imperial period the administration worked well in this populous expanse of land, although the system stagnated in time to some extent. Many things were first and biggest in China before similar things happened in other countries. The illustration of the vessels in Fig. 6.6 is one example.

China's fleet in early times was vast, and the ships were powerful. Fig. 6.6 shows a comparison of Christopher Columbus' ship, the *Santa Maria* (the smaller ship in front in Fig. 6.6), on which he sailed to America in 1492, and a vessel from the Chinese fleet from about the same period. As Fig. 6.6 shows, the difference in size between the two vessels is quite incredible. Even though the size of a vessel does not guarantee seaworthiness, it can safely be asserted that the Chinese fleet could easily have waged war on other countries in Columbus' time, but it did not, as an imperial decision early 15th century was made to discontinue long-distance expeditions.

It is interesting to imagine the course of history had the Chinese crossed the Pacific in the 15th and 16th centuries, or even earlier, and settled in the Americas. The world and its history would certainly have been very different, as the Chinese were well equipped to settle in new countries like the Americas, unlike the Vikings, who managed only a brief foothold in North America in the year 1000, albeit 500 years earlier than the subsequent European settlers.

Even though China was under an imperial government for over 2000 years, that is to say a large portion of the human history of organised communities, this time was frequently characterised by domestic conflicts, which, of course, is no different from other parts of the world. Interspersed were long periods of peace, and, as noted earlier, if the time of Genghis Kahn is omitted, the Chinese have not in their history waged war on other countries in any significant manner, as was so commonly the case in the West.

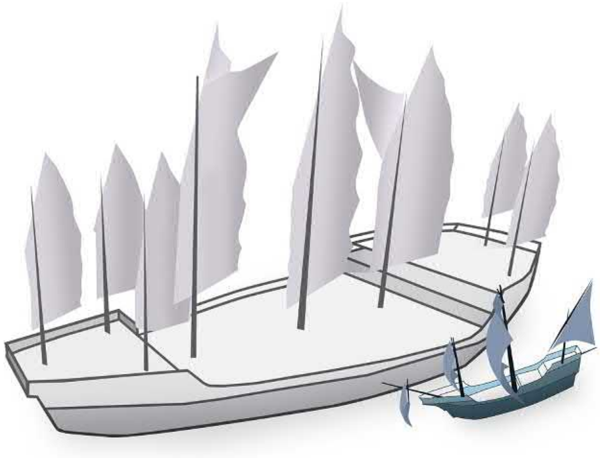

FIG. 6.6

Christopher Columbus' ship and Chinese vessel in the 15th century (Ólafur Kristjánsson).

6.2 Development of fisheries and aquaculture

The Chinese have a long history of catching and eating more fish than people in other countries, and fish has always been an important staple of the Chinese diet, albeit more so on the coasts than inland, for obvious reasons. There are rich fishing grounds off the coasts of China, as in the case of many countries in similar latitudes, and China's coastal waters are also extensive in area. The large population meant that food needed to be obtained from every possible source, including the sea, so fisheries in China have a long history. The widespread use of fish for food led over time to extensive local knowledge of fisheries, fish, and fish products, with the result that fish consumption in China is among the highest, not only in Asia, but in the world. With the combination of the large population and that population's appetite for fish, it goes without saying that a great deal of raw material has always been needed to satisfy demand. Fish processing has also played an important role in China's import and export of fishery products.

Aquaculture was known and used in China from the earliest times, so that knowledge of fish and fishery products, whether from the wild or from farms, may be said to be ingrained in the Chinese DNA. Trade between provinces in China began early, and as the country soon became a single state, an empire with a strong administration and effective system of public officials, work began early on improving communications between the provinces and from the sea to inland regions. Parts of the trading routes led through rivers and channels, as the Chinese soon mastered the use of rivers for transport. This was to the advantage of trade, and traders in fish products seized that advantage in no lesser degree than other traders.

To turn to modern times, fishing and fish farming have increased tremendously over the last few decades. This trend is best observed by looking at volume of production. Statistics on catches are not always reliable, although it is safe to say that catch statistics in many countries are improving. One problem is that there may be incentives for fishermen to report smaller than actual catches. One reason may be to conceal rich fishing waters, while another may be limitations on quotas. Conversely, it is sometimes said that catches are overreported, and there have been suggestions that China is reporting greater than actual catches to international organisations such as the FAO. The reason is said to be that there are incentives in fulfilling previously set catch targets.[k] This sort of conduct is not uncommon when economies are based on 5-year plans and requirements of continuous growth. In planned economy systems of that kind there is often great emphasis on meeting numerical targets and improving performance from year to year. It can be difficult to verify the facts of such matters, but in any case, fishermen's tendency to underreport, which may be assumed to exist in China like elsewhere, should weigh against overreporting by government.

In any case, there is no more reason for any specific doubts regarding Chinese catch figures now than those of any other large fishing countries, whatever may have been true in the past. However, it is proper to underscore the general reservation that official catch figures are frequently inaccurate and deficiencies in reporting are widespread. In fact, imprecision of this kind in international statistics is not uncommon in the world. What is most revealing is to look at changes over long periods in individual countries that may be presumed to employ similar methods from year to year, at least over the short term, draw conclusions from those figures and work with relatively simple measurements, as this book attempts to do throughout.

Fig. 6.7 shows the marine capture in China from 1950.[1] The chart shows that the quantity in 1950 was 0.8 million tons, it increased to 13 million tons in 2000, peaked

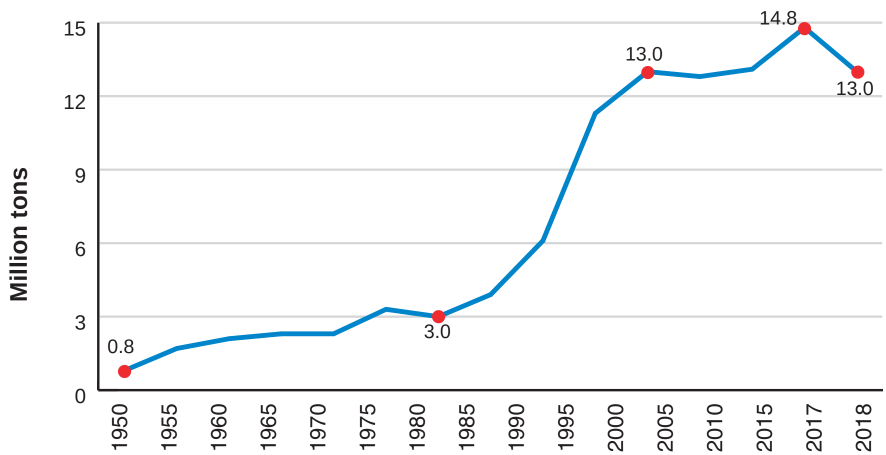

FIG. 6.7

Marine capture in China in million tons 1950–2018.

at 14.8 million tons in 2015, and fell to 13 million tons in 2018. This is not only a tremendous increase, but also a tremendous quantity in comparison with the world marine catch, which is shown in Fig. 6.8.

As Fig. 6.8 shows, China's share in the world marine capture was 5% at the beginning of the period, when Europe's share was 33%, or one-third of the total. In 2000 China's share is up to 15% and Europe's down to 19%. In 2018 China has a 15% of the total, almost matching Europe's 17% share. Since the turn of the century, China's capture has been equal in volume to that of all the European countries combined. This is an extraordinary share for a single country, and it cannot be explained solely by the population growth, as the catch per person has increased more than sevenfold, while the population has grown less than threefold.

Inland capture in China, that is to say fishing in lakes and rivers, has historically always been substantial, but like the marine fisheries, it has grown significantly in recent decades. Fig. 6.9 shows the increase in inland capture, which was 0.2 million tons in 1950, doubled to 0.4 million tons in 1980, and rose to 2 million tons in 2018. This represents a 10-fold increase in 70 years and a 4-fold increase per person.

Aquaculture has also grown significantly, as shown in Fig. 6.10. In 1950 the total production in aquaculture, including both fish and plants, amounted to 0.1 million tons, increasing to 3.1 million tons in 1980, 29.8 million tons in 2000, and 66.1 million tons in 2018. The increase from 1980 to 2018 was 20-fold. Aquaculture in China before 1980 was limited in relative terms, but increased substantially after that. The increase has been far in excess of the increase in population, and the fact is that the Chinese have put great effort into aquaculture in recent decades.[m]

As shown in Fig. 6.11, China's share in world aquaculture was 17% in 1950, 40% in 1989, 69% in 2000, and 58% in 2018. This is an extraordinary world share in a

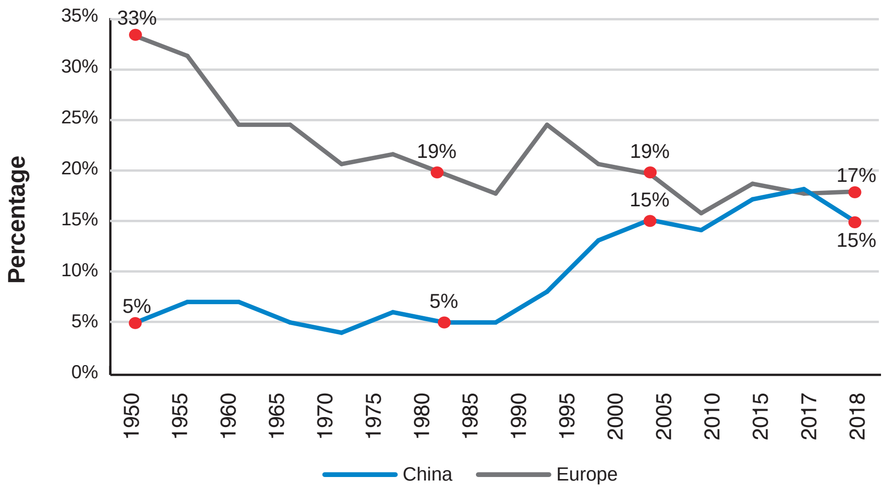

FIG. 6.8

Share of China and Europe in world marine capture 1950–2018.

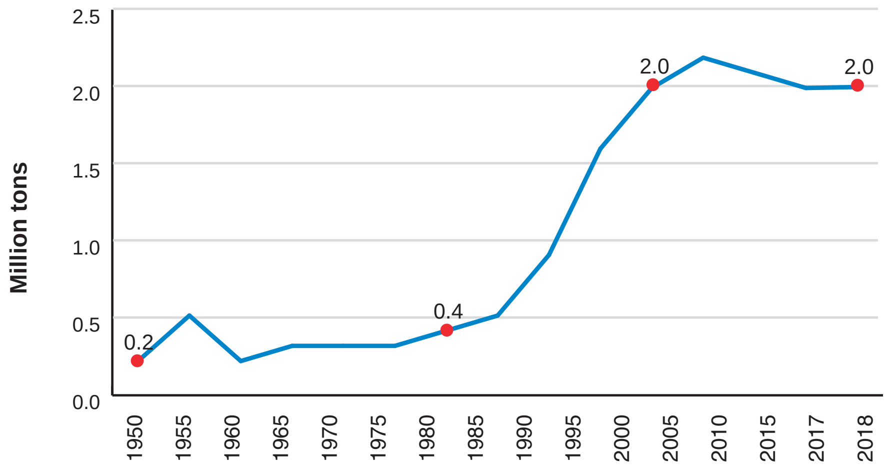

FIG. 6.9

Inland capture in China in million tons 1950–2018.

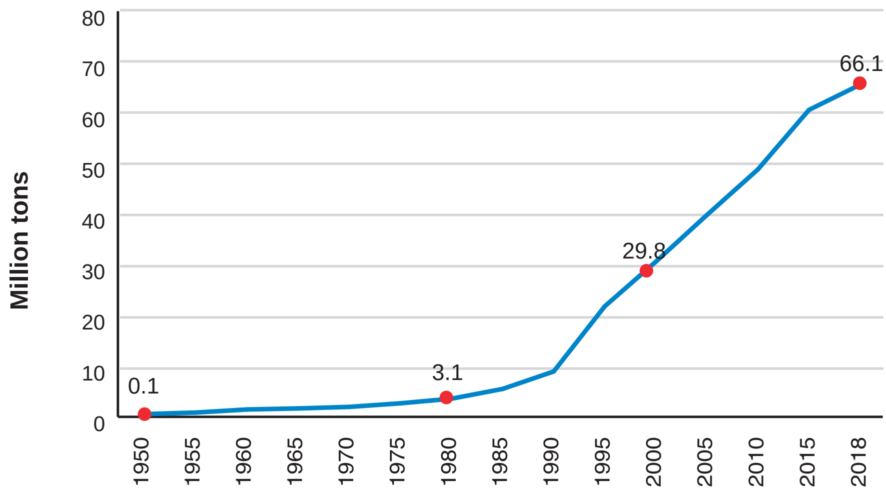

FIG. 6.10

Production in aquaculture in China in million tons 1950–2018.

sector that is open to anyone where conditions will allow. China produces more farmed fish than all the other countries of the world combined, and there is no indication that China will relinquish this leadership. Natural conditions in China for aquaculture are good, but they are by no means unique or exceptional in the world. It should be borne in mind that China's centuries of experience in aquaculture have

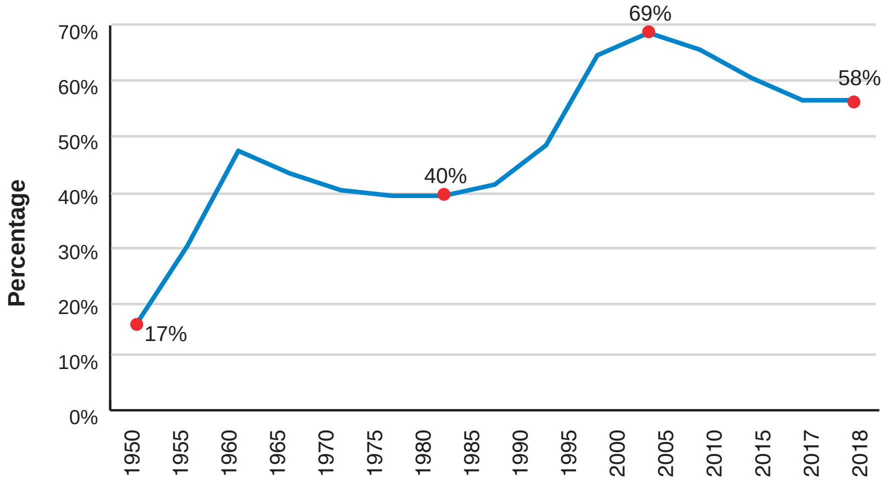

FIG. 6.11

China's share in world aquaculture 1950–2018.

served the Chinese in good stead when they began their surge in aquaculture after 1970, about 50 years ago. In many places, fish is bred in net cages in the sea, far from land (mariculture).

Advances in fisheries began in China shortly after 1950 with an increase in vessel numbers, particularly powered vessels; prior to that time, the majority of the fleet was nonpowered. Major advances, however, did not occur to any great extent until just before 1980; after that, there are significant increases and progress in all aspects of fisheries and aquaculture in China. Of approximately 1 million fishing boats currently operated in China, over 650,000 are powered, that is to say about 65%, while 350,000 are nonpowered. This shows us that fisheries in China are to a significant degree carried out at an artisanal level.

There are about 9 million fishermen in China, the largest number of fishermen in any country and three times the number of fishermen in the countries ranking immediately below, Indonesia and Myanmar, which, like China, are among the 45 countries where fisheries and aquaculture are significant to a high degree. About 20 million people work in fishing and fish farming in China, of which some 15 million work in fishing and 5 million in farming. This is the largest number of people working in fish farming in any single country in the world. China is followed by India, Indonesia, and Bangladesh as regards employment in aquaculture, all among the world's largest aquaculture countries. In addition, about 15 million people work on processing and marketing, which means that over 35 million people are employed in fisheries and aquaculture in China, about 2.5% of the country's population.

6.3 Public management and international trade

Marine fisheries management in China is based on a number of approaches, including decisions on total allowable catches (TAC). In addition, there are various rules on licences, mesh sizes, area closures, e.g., over the summertime, and restrictions on the engine power of fishing vessels to reduce effort. However, these rules are not sufficient to reduce effort adequately in line with the capacity of the fish stocks.[n] There are also a number of protected areas to preserve life forms such as algae, but also to protect fish stocks.

Fisheries management is of course not a simple matter in a large and populous country like China, where fisheries are conducted extensively on small vessels in thousands of enterprises. Management designed to prevent illegal fishing on unregistered vessels, which is not uncommon, is also difficult. However, supervision is improving in China, like other aspects of their fisheries management.

After 1970, the fishing effort increased significantly, catches became smaller, and some species were exterminated. In the 1970s and into the 1980s of the last century, fishing was characterised by low quality catches. From 1985 down to the present there have been extensive changes in fisheries management in China, with much greater emphasis placed on aquaculture, fish processing, and distant water fishing, where consistency in development and quality takes precedence. The principal viewpoints in the current policy are sustainable development with quantitative targets set regarding number of ships, their size, and engine power; in addition, a scrapping system has been set up for vessels to reduce the fishing effort. Also, there is some releasing of fish seedlings in order to increase the dynamic of fish stocks. The tools available to governmental authorities are traditional institutions, such as research and supervisory agencies, in addition to an extensive system of education on fisheries and aquaculture for participants in the sector, for instance for fishermen (Fig. 6.12).

China's coastline is long, and the most important home fishing grounds are in the East China Sea. There has been a long ongoing dispute between China and its neighbours on where the lines should be drawn between their territorial waters. Distant water fisheries are important to China's marine capture, and Chinese fishermen operate far and wide outside China's jurisdiction, including on fishing grounds off the coast of Africa.[o] Fisheries in China are subject to licences under a system that took a long time to establish, requiring, among other things, the registration of all fishing vessels. By deciding on a nationwide total allowable catch and abandoning the policy whereby local governments set targets for catches, greater success has been achieved in keeping the total catch within the set limits. To a large extent, China uses an effort quota system in its fisheries management and has not taken the route of allocating quotas to individual vessels, that is to say a system of individual transferable quotas. The Chinese are quite familiar with that system, however, and it is not unlikely that an arrangement of that kind could be as successful in China as it has been in many other places of the world.

FIG. 6.12

Hong Kong harbour (Ozzo Photography).

The Chinese have also established rules in the fish farming sector, for instance on protecting certain areas in order to ensure the dynamic of the most valuable fish stocks. But even though China is by far the largest fish farming country in the world, it has taken a long time for the public to get accustomed to the consumption of farmed fish to a significant degree, even though the fish farming tradition dates back centuries. But still, the production of fish farms is now many times greater than it was before. It is quite common for people to consider the taste of farmed fish to be inferior to that of caught fish, but this attitude gradually fades when people get used to farmed fish. It was quite common in Western countries at first, when farmed salmon was introduced in shops in competition with wild salmon, that people liked the wild salmon better; this attitude has changed, however, and farmed salmon has now virtually replaced wild salmon in retail shops around the world. Adaptation to the consumption of farmed fish in China will also help to reduce harvesting depleted fish stocks in Chinese waters.

In its fish farming activities, China now takes far greater account of environmental concerns than before and also places great emphasis on quality production and product diversity.[P] Five-year plans are used in fish farming, like in other areas of the Chinese economy. The plans call for still greater sustainability, increased value, and better use of markets than before, in addition to increasing quality and profit and limiting energy use. One of the main features of the most recent Chinese 5-year plan relating to fisheries and aquaculture is increased research, training, and education, in addition to reinforcement of various forms of private enterprise in the very diverse fish processing sector.

Recreational fishing is an important feature of Chinese culture, with a history dating back many centuries. The government places special emphasis on creating a favourable environment for fishing of this kind and supports recreational fishing using measures such as protecting fish stocks and providing necessary infrastructure.

China's influence in fisheries and aquaculture in the world is particularly noticeable in the country's participation in foreign trade. As noted earlier, international trade in fish and fish products is extensive. The following two illustrations depicting world exports and imports show the position of China in that context.[q]

Fig. 6.13 shows that the export value of fish and fish products in the world was 55.8 billion USD in 2000; at that time China's export value was 3.7 billion USD, a 7% share. Less than two decades later, in 2018, total exports were 164 billion USD, having almost tripled, and China's share had increased to 13%, or 21.6 billion USD. This is a huge growth in the export of fish and fish products, and an even greater growth in China over a period of relatively few years. China is by far the biggest exporter of fish and fish products in the world, with double the export value of Norway, in second place. All the indications are that world exports of fish, and China's exports, will continue to grow in the coming years.

Fig. 6.14 shows the import value of fish and fish products in 2000 and 2018. In 2000 total imports amounted to 61 billion USD, and China's share was 3%, at 1.8 billion USD. Less than 20 years later, in 2018, the value of world imports was 162 billion USD, and China's share had grown to 9%, at 14 billion USD. China is the third biggest importer of fish and fish products in the world, after the United States and Japan; the US imports by far the greatest quantity of fish, at 23 billion USD. It may be expected that imports of fish and fish products to China will increase significantly in the coming years and decades, both because of the increased purchasing power of the Chinese people and because of a variety of technological advances

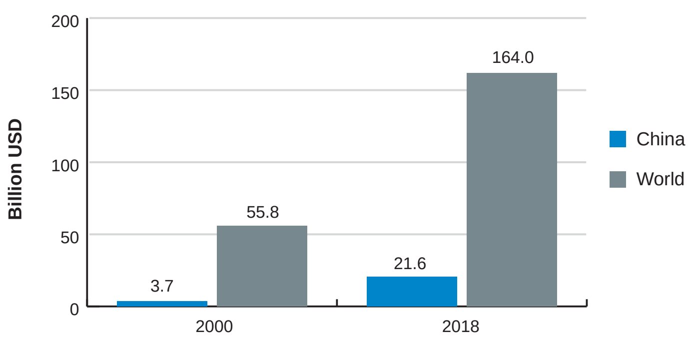

FIG. 6.13

World export of fish and fish products and China's exports 2000 and 2018 in billion USD.

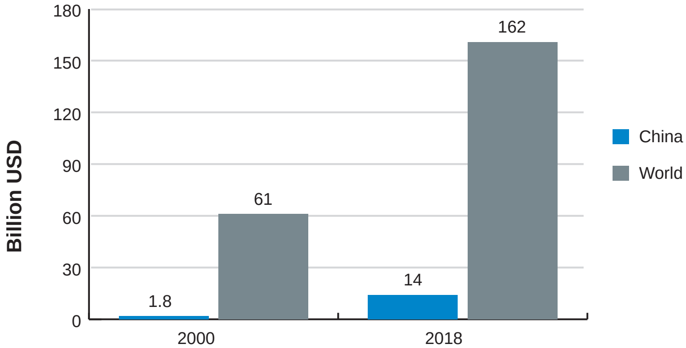

FIG. 6.14

World imports of fish and fish products and China's exports 2000 and 2018 in billion USD.

in the fish industry that will render fish processing in China for its own domestic market and for export more efficient.

6.4 China's future in fisheries and aquaculture

There is no reason to expect anything other than a continuation of China's dominance in fisheries and aquaculture in the coming decades. There are many reasons: the large population, strong fisheries and aquaculture sectors, much consumption of fish, and extensive foreign trade. The Chinese are focusing increasingly on environmental elements and increased quality, and with such policies success is likely in preventing overfishing from fish stocks, which is also an important task for other countries. By moving fisheries management further in the direction of efficiency greater catches may be expected, and fish farming will undoubtedly grow in the coming decades if environmental factors do not impose greater restrictions than currently; that scenario also applies in a number of other sectors.

The importance of China in an international context is underscored by a number of factors. Population size in comparison with other countries is one of these factors, as illustrated in Fig. 6.15, which shows the distribution of the population of the independent countries of the world.[r] The chart shows that there are only two countries with populations over one billion: China and India. No country has a population between 400 million and 1 billion. Twelve countries have populations of 100–400 million people, the largest being the United States of America, followed by Indonesia, Pakistan, Brazil, and Nigeria. Most of the world's countries, 42, have populations of between 10 and 30 million people. Thirty-nine countries, one-fifth of the independent countries of the world, have populations under one million.

An interesting comparison can be made of the 45 countries that are highly dependent on fisheries and aquaculture and other countries. Of the 45 countries where fisheries and aquaculture are important sectors, 16% have populations of

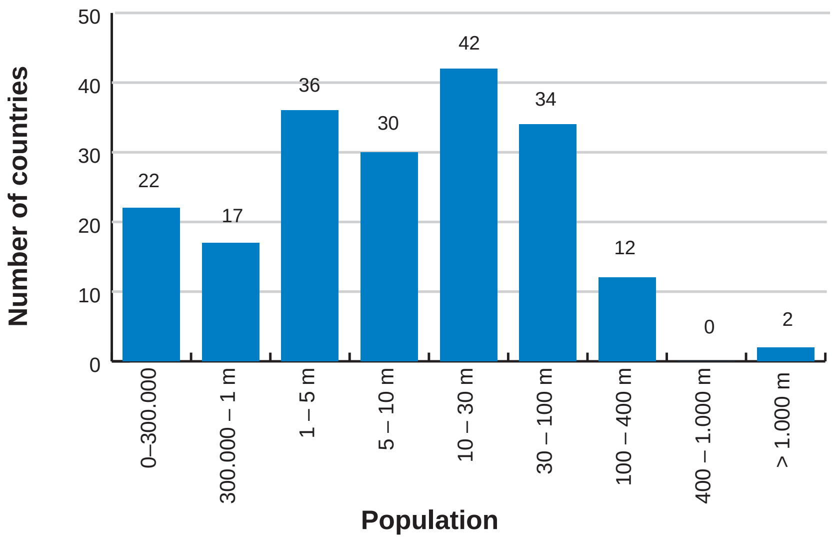

FIG. 6.15

Distribution of populations in 195 independent countries of the world in 2020.

less than 300,000, while the corresponding figure for the world in general is 11%. China is the only one of the countries with a population of over one billion. Of the 45 countries, 43% have populations of less than 1 million, while the corresponding figure for the world is 20%. It is therefore the less populous countries where fisheries and aquaculture have a high level of significance, the single exception being China.

It is difficult to predict whether China will shift further in the direction of democracy in the future. There are no specific indications that this will happen, as the Chinese have no more experience of democracy than many other countries of the world. The Chinese government has a state monopoly on news and other matters relating to the administration of the country. It is probably safe to say that while China's economy is characterised by increasing creation of value and greater economic well-being of the country's citizens, this system will work, that is to say a market economy in a variety of forms in certain areas and party dominance in other areas. But while we may not know what the trend will be in China in the coming decades, it is most probable that the policy of giving precedence to trade and increased value creation will continue.

However, the Chinese are not all in China. About 100 million Chinese live outside China, and they have a significant influence on the business environment in many countries, such as Indonesia, Malaysia, the Philippines, and Thailand. So, it is not all about the central state of China, but the surroundings in general in Southeast Asia. Averages frequently say little about China because of the country's size. The Chinese economy is only partially underdeveloped. There are certain areas of China where business is done using the latest technology. Examples of such high-tech areas are Shanghai and its surroundings and Hong Kong. The Chinese government has placed great emphasis on transforming China into a high-tech society and not only a place for manufacturing cheap consumer products and components for Western enterprises.

However, developments are proceeding at a much faster pace than Westerners are accustomed to seeing, for instance the urbanisation trend. About 60% of the population of China now live in cities, but 40 years ago this figure was only 20%. In China, things are happening on a much larger scale and at a much faster pace than they have at any time before, although it must be kept in mind that modern technology is far more advanced now than ever before. Operating in China's business environment requires a great deal of business acumen and local knowledge. While there are examples of corruption, there are also examples of severe government measures to combat corruption. A great deal of emphasis is placed on a good education for the country's citizens, including university education, and the Chinese are at the forefront in the world as regards university level education, particularly in science.

Increased participation by the Chinese in international affairs is reflected, among other things, in the Belt and Road policy, which focuses on improving infrastructure and communications, and thereby trade.[s] This means new roads and railways and increased maritime transport. The policy is sometimes called the new Silk Road, a reference to the ancient trade routes connecting the East and the West that were used, among other things, for the transport of silk from China to Europe. At that time, the routes forming the Silk Road were partly rudimentary roads for horses and camels, but today high-speed trains are the principal means of overland transport. The Chinese regard the Belt and Road policy as an important aspect of strengthening the infrastructure of other parts of the world, including Africa, where China has focused on participating in local projects in collaboration with the governments of the respective countries.

The Belt and Road policy can also play a role in fisheries and aquaculture. This is reflected, for example, in China's interest in the Arctic; even though China is nowhere near the Arctic, the Chinese have shown the region much attention, among other things by participating in the Arctic Council, where China has a permanent observer status. The Arctic is a repository of a tremendous supply of fresh water and large rivers flow into the sea, many of them featuring fisheries operations. Many of the rivers are used for the production of electricity. Some of the most bountiful fishing waters in the world are in the Arctic and Sub-Arctic region, in addition to a number of other natural resources. China's increasing interest in developing the infrastructure of these regions is therefore a logical part of their Belt and Road policy, and China's emphasis on the Arctic could be referred to as the Silk Road of the North.

It is apparent that despite the enormous technological advances in China of recent years there is still much room for further progress and rationalisation in fisheries and aquaculture, as evidenced by the fact mentioned earlier, that a large part of China's fishing fleet is still well short of modern, and there is still room also for automation in the processing sector. The same applies to China's opportunities to make still further improvements in the living standards of its people and bring them closer to the conditions in the countries with the highest standards of living in the world.

Fisheries and aquaculture can play an important role in ensuring food security for the future and thereby contribute significantly to the resolution of various problems that the world is confronting as the Earth and its environment are going through more radical changes than ever before in human history. The country that is by far the largest player in fisheries and aquaculture in the world, China, is the country that is best positioned to take the lead in that process.

Endnotes

a. This well-known poem by Lao-Tse has been translated numerous times into a number of languages including Icelandic. The version shown here is a rendering into English of Icelandic translations. See Einarsson (2008a).

b. For accessible texts on the Chinese philosophers see, e.g., Hochsmann (2003), Chin (2007), Sandel and D'Ambrosio (2018), and Le Guin (2019).

c. For a discussion of Chinese history see, e.g., Fairbank and Goldman (2006), Keay (2011), and Hansen (2015).

d. For a discussion of the population of China see, e.g., Banister (1987), Worldometer (n.d.), and United Nations, Department of Economic and Social Affairs and Population Division (2019).

e. For a discussion of events in China's past see, e.g., McLynn (2016), Wallech (2016), and Curtin (2017).

f. For a discussion of the role of the Communist Party in government policy making in China see, e.g., Zheng (2010) and Zheng and Huang (2018).

g. For a discussion of the modern history of China see, e.g., Pietz (2016), Frankopan (2017), and Mühlhahn (2019).

h. For a discussion of the economic growth in China and the world see World Bank (n.d.-b).

i. For information on the GDP of countries at purchasing power parity see World Bank (n.d.-c).

j. For information on the GDP per capita at purchasing power parity see World Bank (n.d.-d).

k. For a discussion of alleged disparities in Chinese catch figures see, e.g., Pauly (2010).

l. For a discussion of Chinese fish catches and aquaculture production see Food and Agriculture Organization of the United Nations (2019a, n.d.-a).

m. For a discussion of aquaculture in China see, e.g., Jia and Chen (2001), Cao et al. (2015), and De Silva and Li (2018).

n. For a discussion of fisheries management in China see, e.g., Shen and Heino (2014), Shen and Heino (2015), Food and Agriculture Organization of the United Nations (2018a), and Huang and He (2019).

o. For a discussion of Chinese fishing and their territorial disputes see, e.g., Muscolino (2009) and Blomeyer, Goulding, Pauly, Sanzi, and Stobberup (2012).

p. For a discussion of environmental concerns in aquaculture in China see, e.g., Hanson et al. (2011).
q. For a discussion of world exports and imports of fish and fish products and China's share see Food and Agriculture Organization of the United Nations (2006, n.d.-a).
r. For a discussion of the populations of countries of the world see Worldometer (n.d.).
s. For a discussion of the Belt and Road policy and the new Silk Road see, e.g., Wang (2016), Sun and Grimes (2017), and Maçães (2019).

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CHAPTER

Developing countries 7

There is no fixed, universal definition of what constitutes a developing country or which countries fall into the category of least developed countries, but one common standard is the World Bank's income per capita index.[a] According to that standard, developing countries are the countries that rank in the lower middle-income group and the low-income group of countries, that is to say 77 out of the 195 countries of the world. However, there are numerous other standards that are used to describe the situation of countries, such as the United Nations' Human Development Index.[b] These indices, and others, are calculated annually, and countries will shift between categories in some years. It should be noted that the use of the concept 'developing countries' is itself controversial, as the term is considered to be a 'loaded term' and even derogatory, but in actuality, the concept is simply a tool for statistical comparison, especially comparison of economic conditions.

7.1 Developing countries in fisheries and aquaculture

The term 'developed countries' is used to describe the countries that are regarded as well off economically, which in general means, for the purposes of this book, that their fisheries and aquaculture sectors, if they exist, are in a decent state. The term is also used to denote the 59 high-income countries of the world. There are 60 countries in the highest of four categories in the Human Development Index, and these are largely the same countries that are in the high-income group. At the other end of the scale is a group of 47 least developed countries; those are economically vulnerable countries where gross national income per capita is very low and human assets are limited, 'human assets' meaning the skills and knowledge that make a country's workforce productive.[c]

Of the 45 countries that have been referred to earlier, where fisheries and aquaculture have a high level of significance, 8 belong to the highest income group, most of them in Europe; these rank as 'developed countries'. Of the same 45 countries, 21 fall into the lower middle-income group and low-income group, thereby ranking as 'developing countries'. Of those 21 developing countries, 12 are among the worst situated of the developing countries and are thereby categorised as 'least developed countries'. The conclusion of all this is that fisheries and aquaculture play a significant role in the developing countries, and particularly in the least developed countries.

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Table 7.1 shows the 21 countries that fall into the category of developing countries and are also dependent to a significant extent on fisheries and aquaculture; 12 of them, falling into the category of least developed countries, are shown separately at the bottom of the table. The table also shows the population size, whether the country is an island state and in what continent they are located. The countries are listed in alphabetical order.

Table 7.1 reveals several interesting facts. Of the nine countries in the upper part of the table, that is to say the countries that are better situated economically, most have relatively small populations, with the exception of Indonesia, the Philippines,

Table 7.1 Developing countries where fisheries and aquaculture have a high level of significance, categorised by population, and continent, and as island states.

Country	Population in millions	Island state	Continent
Developing countries			
Cabo Verde	0.6	Yes	Africa
Federated States of Micronesia	0.5	Yes	Oceania
Honduras	9.6	No	Americas
Indonesia	270.6	Yes	Asia
Morocco	36.6	No	Africa
Nicaragua	6.4	No	Americas
Papua New Guinea[a]	8.8	Yes	Oceania
Philippines	108.1	Yes	Asia
Vietnam	97.4	No	Asia
Least developed countries			
Bangladesh	163.0	No	Asia
Cambodia	16.5	No	Asia
Comoros	0.9	Yes	Africa
Kiribati	0.1	Yes	Oceania
Madagascar	26.9	Yes	Africa
Mauritania	4.7	No	Africa
Mozambique	30.4	No	Africa
Myanmar	54.0	No	Asia
São Tomé and Príncipe	0.2	Yes	Africa
Senegal	16.7	No	Africa
Solomon Islands	0.6	Yes	Oceania
Vanuatu	0.3	Yes	Oceania

[a]Papua New Guinea is generally classified among the least developed countries, although there are insufficient data available to support that classification.

and Vietnam, which have populations of well over 100 million. Only two of the countries are in the Americas, three are in Asia, two in Africa, and two in Oceania. Five of the countries in the upper part of Table 7.1 are island states and four are not.

As regards the lower part of Table 7.1, which shows the 12 least developed countries, it appears that most of them have small populations and half of them, 6, are in Africa, 3 in Asia, and 3 in Oceania. All 21 countries in Table 7.1 which are dependent to a significant degree on fisheries and aquaculture have possibilities of improving their respective economic situations by increasing their emphasis on fisheries and aquaculture, first by seeking greater knowledge and improved technology, and then by expanding their aquaculture, by fishing more and by utilising the catches from their own territorial waters themselves instead of renting out fishing permits to foreign operators, as many of them do. The authors of this book have often chosen to use Iceland as an example of success in this regard, particularly in fisheries, as Iceland was more or less in a similar position as the 21 countries in Table 7.1 about 100 years ago, particularly those in the lower part of the Table 7.1. In the course of just a few decades, Icelanders managed to work their way up to the ranks of the countries that top the list of developed countries as regards living standards by utilising the resources of the sea around the country in an effective manner (Fig. 7.1).

Small-scale and artisanal operations are the most common forms of fisheries and aquaculture in the developing countries, particularly in Asia, and those operations are of crucial importance for subsistence and food security in those regions.[d] The increased consumption of fish in recent decades has been particularly prominent in the developing countries, although most of the supply still derives from small-scale fisheries and aquaculture.[e] It is estimated that some 40 million people are employed in fishing and fish farming in the small-scale sector; an additional 100 million people are employed in related occupations, such as processing and sales, a large proportion of them women.[f] Focusing on improved infrastructure relating to

FIG. 7.1

Quality control in fish processing (TemporalStreet).

small-scale fisheries and aquaculture, for example through improved education and technology, and perhaps with the support of development aid, could return significant results. However, with regard to technology as part of development assistance, it must be taken into account that the infrastructure in some of the communities in the developing countries is in many cases unprepared for new technology and may be lacking in basic resources such as water, electricity, or trained repair and maintenance people.

One important factor in small-scale fisheries, as in all business operations, is financing, and one common form of financing in small-scale industries in general in the developing countries is microfinance. Microfinance is a special form of financing for poor people who do not have access to traditional banks; it involves small loans, as the name indicates, through special organisations, many of which are operated on a social basis or with government support.[g] The loans are granted to people who have ideas of starting a small business and who are capable of doing so, in the opinion of the lender. As in banking, microfinance lenders need to take account of a number of factors, such as the feasibility of the business and its chances of success, the experience and trustworthiness of the borrower, and also seasonal fluctuations, which for various reasons can be an important consideration in microfinancing. Many of the borrowers in microfinance are women, and in many places microfinance has transformed the status of women, both as regards understanding how business works and how to run a business.

Income per capita in the developing countries is in many places a mere tenth of the income in the developed countries, or the highest-income countries of the world, at purchasing power parity (PPP), so even small gains can make a big difference. As we have seen from the example of China in Chapter 6, income growth can be quite substantial in the space of only 5 years. However, there is a reason for using the Human Development Index to categorise the least developed countries, as these countries lag behind other countries not only in terms of income, but also in terms of the need to cope with a variety of serious problems of government.

In many of these countries the tragedy of the commons, which we discussed in Chapter 5, is rampant, with ruthless overexploitation of resources. Government in many of these countries is weak and inefficient and lacks the capacity to manage fisheries and aquaculture in an effective manner, and one large part of the problem in many coastal states is that they do not utilise their own territorial waters for the benefit of their own people (Fig. 7.2).

An illustration of fisheries in Lake Victoria

Lake Victoria is no ordinary lake. It is the largest lake in Africa and the third largest lake in the world after the Caspian Sea, which borders on Azerbaijan, Kazakhstan, Russia, Turkmenistan, and Iran, and Lake Superior, on the border of Canada and the United States of America. Lake Victoria is shared by three countries: Tanzania and Uganda, with about half of the lake's shoreline each, and Kenya, with just over 5% of the shoreline. The lake is about 70,000 km^2 in area, roughly the size of the Netherlands and Denmark combined. Lake Victoria is the chief reservoir of the Nile, Africa's largest river, and, with the Amazon, the longest river in the world.[h]

Extensive fishing is conducted on the lake, with current annual catches at 1 million tons and catch value at just short of 1 billion USD. The economic importance of the lake is therefore huge. In earlier times, fishing on the lake was almost exclusively artisanal fishing on small boats, many nonmotorised, catching fish as food for the communities surrounding the lake. After 1950, fishing began on a larger scale for Nile perch, a valuable fish that is now caught for export to foreign markets in Europe, Asia, and elsewhere. Originally, the Nile Perch was introduced in Lake Victoria in the mid-20th century as a boost for sport fishing, but the stock grew rapidly. The value of the Nile perch has had the effect that the fishing effort has increased significantly, with the result that a number of fish stocks are now depleted and biodiversity has been impaired. However, the Nile perch accounts for an important part of Uganda's foreign revenue. In addition to the fisheries, there is also some aquaculture by the lake.

About 200,000 fishermen engage in fishing on Lake Victoria on about 75,000 vessels, many of them tiny. Facilities for processing on shore are primitive in many places, especially as regards hygiene, and the poor conditions have frequently led to bans on sales of Nile perch from Lake Victoria in foreign markets. Some 40 million people live in the vicinity of Lake Victoria, about double the combined populations of Denmark and the Netherlands. Over 3 million people are employed in fisheries and aquaculture around the Lake. The three countries, Tanzania, Uganda, and Kenya, jointly manage fisheries on the lake, but without much success in reducing effort and keeping the fisheries on a sustainable basis. There is also a great deal of illegal, unreported, and unregulated fishing on the lake, which makes management still more difficult. The problems of fisheries on Lake Victoria are in that regard similar to the problems faced by fisheries in other parts of the world, whether on lakes or at sea.

FIG. 7.2

Lake Victoria in Africa (Ólafur Kristjánsson).

7.2 Fishing by foreigners in the waters of developing countries

Distant water fishing is nothing new in human history. Europeans engaged in extensive fisheries off Newfoundland in North America from the 16th century, and even earlier; the Indonesians fished off northern Australia in the 17th century, and various countries on the continent of Europe fished off the coasts of Iceland as early as the 14th century. Distant water fisheries increased greatly after 1950; up until that time the main emphasis of coastal states had been to utilise their own waters.[i] Modern distant water fishing, including industrial fishing, where large fishing vessels with all the equipment needed for production, even including fish meal plants, is now the domain of the deep-sea fleets of various countries. These fisheries are carried out mostly in the southern hemisphere, commonly in the waters around Africa and South America.

The countries that engaged most extensively in fishing outside their own territorial waters in the second half of the 20th century were the former Soviet Union, Japan, and Spain. Exclusive economic zones became more widespread after the United Nations Convention on the Law of the Sea entered into force in 1982, although bringing that Convention into full force took many years.[j] That was followed by a spate of international negotiations on fisheries in the jurisdictions of other countries.

Distant water fishing can be based on agreements between two or more countries providing for mutual fishing rights; agreements can also be made between enterprises in different countries or between an enterprise operating a fleet and the government of the country that administers the fisheries jurisdiction where the fleet operates. It has become common for foreign enterprises to rent the right to fish in the territorial waters of other countries, particularly poorer countries. An enterprise in one country may also choose to rent a fishing vessel from a foreign fisheries enterprise in order to fish in the jurisdiction of the other country, sometimes in the form of a joint venture involving close cooperation. In such cases, the domestic company is the majority shareholder in the joint venture. Many countries, particularly the developing countries of Africa, have attempted in recent years to acquire for themselves a larger share of the value created by fisheries in their territorial waters.

The fish species harvested in distant water fishing range from tuna and squid, two valuable species that are caught for human consumption, to small pelagic species which are processed into fish meal, some of which is used to produce feed for use in fish farming. Today's distant water fishing fleets largely concentrate on fishing for tuna. The principal distant water fishing countries now are China, with about 40% of the fishing effort, and Taiwan Province of China, with some 20% of the effort. They are followed by Japan, South Korea, and Spain, with about a 10% share each. This means that about 90% of the world's distant water fishing is conducted by just a handful of countries. Of those countries, China and Taiwan Province of China command a 60% share. These fisheries are subsidised by the countries themselves, which constitutes state aid to fisheries.

Since distant water fishing is conducted largely in the territorial waters of the developing countries it is controversial, as it is seen to impair the ability of the countries that rent out their fishing rights to develop their own fisheries and fish processing. The increased trend towards distant water fishing has resulted in overfishing from many stocks, and the catch per unit of effort has fallen markedly. The deteriorating operating performance of distant water fishing has been met by state subsidies from the fishing countries, but at the same time the falling revenue has led to unreported, illegal, and unregulated fishing. It is also common for enterprises to use flags of convenience to reduce their operating costs, where the vessel is registered in a country other than the owner's home country. The reasons for this practice are usually that rules, for instance on manning vessels, crew wages, and terms of employment and taxation, are less burdensome than if the vessel were registered in the owner's home country.[k] Registering merchant vessels under flags of convenience is in any case common, often for the same reasons. Distant water fishing vessels are frequently registered under flags of convenience.

The use of supply vessels to take delivery of catches and take supplies and bunker out to the fishing vessels also opens avenues for concealment of illegal fishing; in fact, there is not a great deal of regulation of distant water fishing in many regions of the world. No reliable figures exist regarding the total world catch in distant water fishing, as reporting is deficient in many places. The recorded annual world catch is about 95 million tons, and it can be estimated that distant water fishing accounts for some 20 million tons. It is not known, of course, how much of the catch is illegal and unregulated, but 10 million tons is perhaps a fair estimate, since much of the catch from distant water fishing comes from regions where regulation of fishing and catch quantities is limited.

There is a great lack of transparency regarding distant water fishing as regards quantities of catches, fishing areas, beneficial ownership of fishing vessels, wages and employment terms of seamen and other employees aboard fishing vessels, and the way in which the fish is sold and brought to market. Increasing transparency is an urgent matter, as increased transparency would also make illegal, unreported, and unregulated fishing more difficult. Increased regulation could be achieved, for instance, by using equipment that automatically provides real-time information on the location of fishing vessels to the competent authorities, by increasing supervision of landing catches, and by requiring traceability of catches and fish products. In fact, increased traceability is increasingly demanded by consumers in many parts of the world (Fig. 7.3).

One particular problem of this kind of fishing is that obtaining information is difficult; the fishing vessels are often owned by enterprises registered in the home country, that is to say the country that rents out the fishing licences, but the real ownership of the enterprise is vested in a foreign company that manages the fishing itself and all matters pertaining to the fisheries based entirely on its own interests. Registration of this kind has the effect that the fishing is not categorised as distant water fishing, as the ownership of the operation is formally domestic when in reality it is not. It is important for registrations of beneficial owners of fishing vessels and other industrial

FIG. 7.3

Fishing in Africa (La Zona).

apparatus and enterprises in fishing to be both reliable and accessible to government authorities and the public. All of these measures are necessary to reduce corruption and improper business practices. The problem is that poor countries often lack the infrastructure needed to maintain effective regulation of complex industries such as fisheries.

The incentives for distant water fishing are not only that there is raw material to be had for profitable fisheries operations, but also that the operations can be conducted away from the prying eyes of regulators. In addition, many fisheries enterprises have arrived at the limits set for their home water harvests and therefore need new projects for their fishing vessels in distant countries. So, as in the case of deficiencies of the conditions or crews in small-scale fishing, similar conditions can apply to circumstances in distant water fishing.[1]

For many countries, like Kiribati and the Federated State of Micronesia, revenue from the sale of fishing licences to foreign distant water fishing fleet operators can make a large difference for state finances. Distant water fishing fleets are normally based in a few harbour towns, for instance, in the case of West Africa, in Senegal and Guinea, where the fleets obtain their bunker and other supplies and where the catch is transhipped. In fact, much of this activity may take place at sea, as mentioned previously, where supply ships provide all necessary services to the distant water fleets. Good harbour conditions and facilities for distant water fishing vessels can be an important source of revenue for poor coastal states. It is then an entirely different matter whether the income from such operation is used in support of domestic fisheries or to improve infrastructure for the benefit of fisheries.

The lack of regulation of fisheries is an incentive for many enterprises to engage in illegal, unreported, and unregulated fishing, as it is profitable, and fines, in the event of discovery, are in many places low. Illegal, unreported, and unregulated fishing is also a serious problem, as there is no control over the condition of fish stocks, and generally the fishing will continue until there is no more fish to be had. One important element of distant water fishing is political influence in the issue of permits, as bribes paid to politicians and public officials by foreign operators are not unknown, and perhaps even common.[m]

Since some of the distant water fishing is known to lead to overfishing, there is an urgent need to curb such fishing, or at least to monitor it closely, which is easier said than done. One of the simplest ways to reduce fishing in distant waters is to reduce or discontinue altogether state subsidies for these fisheries. One of the leading countries of the world in fisheries and aquaculture, China, could play a key role here by taking the initiative in reducing or discontinuing state subsidies for distant water fishing. China's distant water fishing fleet has over 3000 vessels of all types and sizes, the largest in the world. However, China's emphasis on distant water fishing, which has increased in recent years, does not have the sole purpose of obtaining raw material for its huge domestic market; the fishing also serves the ideology of the Belt and Road policy and the pursuit of increasing cooperation with the governments of other countries. So, in fact, the Chinese have in recent years taken an initiative in increasing their supervision of illegal, unreported, and unregulated fishing.

7.3 Development aid, gender gap, and corruption

There is a large difference between countries as regards level of technology and medical services, with both generally much less advanced in the developing countries than in the developed countries. Development assistance rendered by richer donor countries has as one of its main objectives to improve the infrastructure of the recipient countries and also to stem the brain drain that occurs when educated people in the developing countries emigrate, or take up residence in other countries, and do not, therefore, contribute to advances in their home countries, and also to prevent the conditions that induce poor people to flee in large numbers from their home countries to richer countries. Development assistance has also focussed on improving local technological know-how in all sectors, including fisheries and aquaculture (Fig. 7.4).

Development aid is in itself an industry, and it is huge in scale, with contributions estimated at about 200 billion USD annually.[n] This corresponds to about 0.2% of the global gross domestic product, of approximately 85 trillion USD, that is to say 85,000 billion USD.[o] The largest share of development assistance is in the form of what is known as official development assistance (ODA). None of the 45 countries that are especially dependent on fisheries and aquaculture are among the 10 countries that receive the highest contributions of official development assistance. Another means of comparison is to look at the proportion of development assistance of the gross national income (GNI) of a country.[p] Of the 10 countries receiving the greatest

FIG. 7.4

Food market in Dawei in Myanmar (Suparat).

amount of official development assistance as a proportion of GNI, 5 belong to the group of 45 countries that are particularly dependent on fisheries and aquaculture: the Federated States of Micronesia, Kiribati, Marshall Islands, Tonga, and Tuvalu. All are small island states in Oceania with small populations.

The developed countries allocate varying amounts of funds to development assistance, but the usual measure is proportion of gross national income. The United Nations are targeting a proportion of 0.7% of gross national income to development assistance from each developed country, and for the long term the target is 1% of GNI. Contributions from the developed countries to development assistance vary greatly, but at the top are the United Arab Emirates and Sweden, both of which contribute over 1% of GNI to development aid. Few countries contribute more than 0.7% of GNI to development aid, but apart from the United Arab Emirates and Sweden, these are Luxembourg, Norway, Turkey, and Denmark.[q]

It is frequently maintained that development assistance does not do enough good, and that a part of the assistance provided is not put to good use, because a great deal of the money disappears on its way to the people who need it into the pockets of various intermediaries and corrupt officials.[r] Although there are certainly examples of misuse, generalisations of this kind are unhelpful, although increased control and transparency are needed.

There are many factors that impact the developing countries, whether they relate to fisheries and aquaculture or not. One of these factors is urbanisation, which has increased significantly in recent years and decades, partly because of population growth, particularly in Africa, but also because of social change and technological advances. In fact, increasing urbanisation is also making its mark in the developed countries, where cities play an increasingly prominent role in value creation and as residential areas of choice. This trend obviously results in significantly reduced populations in the rural areas of some countries, which creates a number of social and economic problems, and these can be particularly difficult to deal with in the developing countries because of the lack of efficient infrastructure.[s] In addition, there are urgent and growing environmental problems in the developing countries which will take a long time to resolve.

There are many things that can be done to assist the developing countries, including increased education and empowering women. Fisheries and aquaculture can play a role in this regard, as women participate extensively in fisheries and aquaculture in many countries, particularly the countries that are dependent on those sectors. Although gender discrimination is widespread in the world, the discrimination is especially prominent in the developing countries. An assessment has been carried out of the differences between countries as regards the position of the genders. There are 153 countries included in the last such comparison, which resulted in what is known as the Gender Global Index, which is used here as a reference.[t] These 153 countries are here divided into four large categories of more or less equal size, with category A countries scoring highest and category D encompassing the countries where gender equality is regarded as the lowest in the world.

Table 7.2 shows the categorisation by gender equality of the 45 countries that are particularly dependent on fisheries and aquaculture; of these countries, 21 are developing countries and 24 are developed countries. The third row in Table 7.2 shows that there are two developing countries in Category A, i.e., Nicaragua and the Philippines, of the 21 that are developing countries. There are six developed countries in

Table 7.2 Developing countries and gender gap.

Gender equality categories	Gender Gap Index	Number of countries and the proportion of the 45 countries classified as developing countries	Number of countries and the proportion of the 45 countries classified as developed countries
A. 36 countries	0.740–0.900	2 (10%)	6 (25%)
B. 36 countries	0.710–0.739	5 (24%)	3 (13%)
C. 38 countries	0.670–0.709	4 (19%)	7 (29%)
D. 43 countries	0.500–0.669	5 (25%)	2 (8%)
n/a		5 (24%)	6 (25%)
Total		**21 (100%)**	**24 (100%)**

Category A: Denmark, Iceland, Lithuania, Namibia, Norway, and Portugal. There are five developing countries in Category B: Bangladesh, Cabo Verde, Honduras, Madagascar, and Mozambique, and three developed countries, Chile, Ecuador, and Peru, all in South America. There are four developing countries in Category C: Cambodia, Indonesia, Senegal, and Vietnam, and seven developed countries, Belize, China, Fiji, Malaysia, Malta, Suriname, and Thailand. There are five developing countries in Category D: Myanmar, Mauritania, Morocco, Papua New Guinea, and Vanuatu, and two developed countries, Maldives and Mauritius. Information is not available for five developing countries: Comoros, Federated States of Micronesia, Kiribati, São Tomé, and Príncipe and Solomon Islands, and six developed countries, Guyana, Marshall Islands, Samoa, Seychelles, Tonga, and Tuvalu. All these countries have relatively small populations. Iceland, in the last column of Table 7.2, is the country that in 2020 enjoyed the greatest gender equality according to the Gender Gap Index.

Table 7.2 also shows the proportional division of the countries. It shows that of the developing countries, 10% are in Category A, while the proportion of developed countries is 25%. It is interesting to note the high proportion of developed countries in Category C, at 29%. A similar proportion, about a quarter, are countries on which there is insufficient data to calculate the Gender Gap Index position. The table shows, as might have been expected, that gender equality is greater in the developed countries than the developing countries of the 45 countries that are particularly dependent on fisheries, but the difference is not particularly striking except in Category A. In fact, the proportion is similar for both groups if Categories A and B are combined, i.e., 34% for the developing countries and 38% for the developed countries. It is evident from this comparison that the struggle for gender equality is not restricted solely to the poorer of the 45 countries that are particularly dependent on fisheries and aquaculture.

Among the standards used to assess the position of countries is whether corruption is regarded as widespread. Corruption is dishonest or unlawful conduct, where trust and powers are misused for personal gain. Corruption takes a variety of forms, from favours granted by a politician to benefit his or her electorate in disregard of general principles, to pure criminal activity, where huge bribes are paid to achieve certain objectives, for instance for public officials to turn a blind eye to drug running or bypass rules in issuing fishing permits.

A commonly used benchmark of corruption is the Corruption Perceptions Index, which ranks 180 countries by their level of corruption.[u] If the 180 countries are arranged into four similar-sized categories, A, B, C, and D, as in Table 7.3, where the countries in Category A have the least corruption, we see in column 3 that of the 9 better-placed developing countries none are in Category A, three, Cabo Verde, Indonesia, and Morocco, are in Category B. Three countries, Honduras, Philippines, and Vietnam, are in Category C and two, Nicaragua and Papua New Guinea, are in Category D. No data are available for one of the countries, the Federated States of Micronesia. Column 4 in Table 7.3 shows that of the 12 least developed countries half, that is to say 6, Bangladesh, Cambodia, Comoros, Madagascar, Mauritania,

Table 7.3 Categorisation of the 45 countries where fisheries and aquaculture have a high level of significance by level of corruption.

Categories of corruption	**Corruption Perceptions Index**	**Number of better placed developing countries**	**Number of least developed countries**	**Number of countries of the 45 countries classified as developed countries**
A. 44 countries	58–88	0	0	7
B. 48 countries	37–57	3	4	6
C. 45 countries	29–36	3	1	5
D. 43 countries	10–28	2	6	0
n/a		1	1	6
Total		**9**	**12**	**24**

and Mozambique, are in Category D, where the level of corruption is highest, 1 country, Myanmar, is in Category C, and 4, São Tomé and Príncipe, Senegal, Solomon Islands, and Vanuatu, are in Category B. No data are available for one of the countries, Kiribati.

The final column of Table 7.3 includes 24 of the 45 countries that are classified as developed countries. Seven of these are in the top category, i.e., Category A: Chile, Denmark, Iceland, Lithuania, Norway, Portugal, and Seychelles. Six are in Category B: China, Malaysia, Malta, Mauritius, Namibia, and Suriname. Five are in Category C: Ecuador, Guyana, Maldives, Peru, and Thailand. There is no country in Category D, and there are insufficient data for six countries: Belize, Fiji, Marshall Islands, Samoa, Tonga, and Tuvalu. It is evident from Table 7.3 that the less developed a country is, the greater is the corruption according to the Corruption Perceptions Index. According to the Corruption Perception Index for 2018, Denmark is the country with the lowest level of corruption (Fig. 7.5).

This comparison of levels of corruption is not cast in stone, of course, as it is dependent upon the reliability and accessibility of the information used to compile the list. Notwithstanding that general reservation, the comparison gives a clear indication of the position in each country as regards corruption. Corruption is among the most serious problems of the world, as it severely hampers the quest to raise people's general living standards. Increased education is one of the most effective routes to progress for poor countries. Improved education, increased gender equality, better government, including an effective judicial system and surveillance authorities, should serve to reduce corruption. However, the problem of corruption does not

FIG. 7.5

Shrimp processing in Samutprakarn in Thailand (Visarat Sankham).

affect only the countries where fisheries and aquaculture have a high level of significance, but all the developing countries in the world. To be sure, corruption is not uncommon in the developed countries either, or the richer countries of the world, but it can be more difficult to detect. Corruption reduces efficiency, and thereby lowers living standards. It is, of course, a sad thing when attempts are made to improve fisheries management and the benefit of doing so is lost to corruption and bribes to politicians and public officials.

Tremendous amounts of money are wasted on corruption. It is estimated that about 1000 billion USD are paid in bribes each year, and that about 2600 billion USD are stolen by means of corrupt practices; that adds up to a total of 3600 billion USD, which is the cost of corruption, and to put things into perspective that corresponds to just short of 5% of the global gross domestic product.[v] For comparison, the first sale value of the world catch of fish and the output value of global fish farming in combination amount to USD 380 billion, which is just over 10% of the cost of corruption. Another comparison of corruption to fisheries is that if all marine fisheries in the world were carried out in the best possible manner,[w] it is estimated that proceeds from world fisheries would increase by 80 billion USD, as noted earlier, which represents only a fraction of the losses stemming from global corruption. These comparisons show how much money is wasted on corruption, which undermines sound business practices and leads to lower living standards than need be, particularly among the general public.

7.4 Food security of the developing countries

Ensuring food security is one of the United Nations' Sustainable Development Goals, which, for obvious reasons, applies primarily to the poorer countries of the world. Of the 77 countries ranked as developing countries, 33 are in Africa, 9 in Asia, 4 in Oceania, and 31 in the Americas. Of these 77 countries, 47 are among the least developed countries, which include 12 of the countries which are particularly dependent on fisheries and aquaculture, most of them in Africa, where poverty is the most widespread of all the continents.

It is a special feature of Africa that fish is not as much of a staple of the diet in comparison with countries on other continents. The population of Africa comprises 17% of the world population, but Africa's share in the world catch is only 10%, and its share in aquaculture is 2%. Consumption of fish per capita in Africa was estimated in 2017 at only 10 kg per year, while the global average is estimated at 20.5 kg per year.[x]

There are various factors that contribute to greater food security in the developing countries which do not always get attention. For instance, agricultural production in urban areas in many poor countries could contribute to better sustenance for people that would not otherwise be available to people living in the rapidly growing urbanised areas of the developing countries. Also, increased trade is a key factor in improving food security in the developing countries.[y]

In any discussion of the developing countries it is important to observe trends in the world population, which are shown in Table 7.4.[z] According to Table 7.4 the population of Africa is expected to grow to 4.3 billion, by about 230%, in the next 80 years, far outpacing the population of the rest of the world, where the growth is expected to be about 40%. About 17% of the world population currently live in Africa, but this proportion is expected to increase to 40% by 2100. An interesting point shown in Table 7.4 is the substantial reduction in the population of Europe,

Table 7.4 The world population divided by continent in 2020 and 2100 and changes.

Continents	Population in billions 2020	Population in billions 2100	Increase between 2020 and 2100 in billions	Increase between 2020 and 2100 in %
Africa	1.3	4.3	3.0	230
Americas	1.1	1.2	0.1	9
Asia	4.6	4.7	0.1	2
Europe	0.8	0.6	−0.2	−25
Oceania	0.04	0.1	0.1	75
World	**7.8**	**10.9**	**3.1**	**40**

at 25%. Even though China's population will have fallen by 350 million people by 2100, from 1.450 billion to 1.1 billion, a small increase is projected in Asia, which means that in other countries, like India, there will be a considerable increase. The population growth in the Americas will be in Latin America, while the population of North America is projected to decline. The principal conclusion that can be drawn from Table 7.4 is that almost all the population growth in the next 80 years will take place in Africa, some 3 billion people.

Based on the estimated level of African consumption of fish for 2020, 11 kg per person, 14 million tons of fish are needed annually; based on the same consumption per person in 2100, 47 million tons will be needed to fulfil Africa's needs. If the people of Africa were to double their consumption from 11 kg per person to 20 kg per person, which is still less than the current average world consumption of 20.5 kg per person, this would call for 86 million tons, seven times the quantity currently consumed by Africans. Assuming the human consumption of fish at 160 million tons per year, it is clear that it would be very difficult with the current supply of fish to meet the demand for fish in Africa, if the projected population growth materialises, and quite impossible if Africans begin to consume the same amount of fish as the rest of the world. To be sure, the consumption of fish in Latin America is about the same as in Africa, but the projected population of that continent will be 'only' about 700 million people and not 4.3 billion like in Africa. All of which means that increasing the consumption of fish on the poorest continent of the world in the interests of food security would pose formidable problems.

Closely linked to food security is not only the tremendous population growth in the 20th and 21st century, but also the greatest progress made in human history over this same period, as illustrated in Fig. 7.6.[aa] The chart shows that 75% of the world's inhabitants lived in extreme poverty in 1900, but now, 120 years later, that figure is

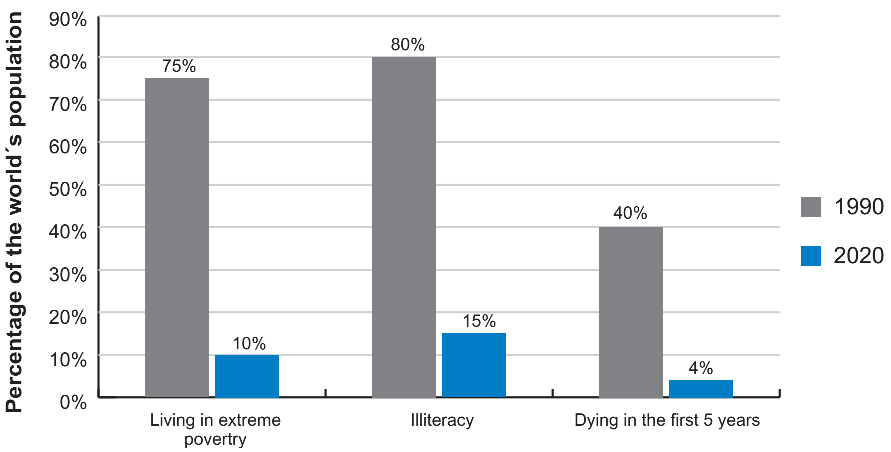

FIG. 7.6

Progress in several areas 1900–2020.

down to 10%. The level of illiteracy in the world was 80% in 1900; by 2020 the level was down to 15%. If we look at child mortality, 40% of children died within 5 years of age in 1900; by 2020 this percentage was down to 4%. These are just some examples of the progress made in just over one century. Nevertheless, vast numbers of people live in extremely poor conditions. In 1900, 10% of the world population amounted to 165 million people; in 2020 that same percentage represents 780 million people. The greatest improvement in living standards in the world has been in Asia in recent decades and most of those who now endure extreme poverty live in Sub-Saharan Africa.

Fig. 7.7 shows world spending in some policy areas. It shows that public expenditures on health[ab] amount to 7800 billion USD per year; as we will recall, the estimated cost of corruption is about 3600 billion USD. Military expenditures are not far behind, at 2000 billion USD per year.[ac] Far below those figures is the first value of catches and the output from fish farming combined, at 380 billion USD per year. Development assistance comes last in this comparison, with about 200 billion USD contributed annually to development assistance.

Public expenditures on health in the world amount to about 9% of domestic product, while military expenditures amount to over 2% of global domestic product. Of course, there are vast differences in these percentages from one country to the next. Public expenditures on health in the developed countries are in the range of 8%–10% of domestic product per year. Military spending is greatest in the United States, at about 650 billion USD per year, which is 1/3 of the annual global military spending. In Middle Eastern countries, East Europe, North Africa, and Central and South Asia, military spending exceeds health spending as a proportion of domestic product. There is a direct relationship between lack of food security and armed conflict.

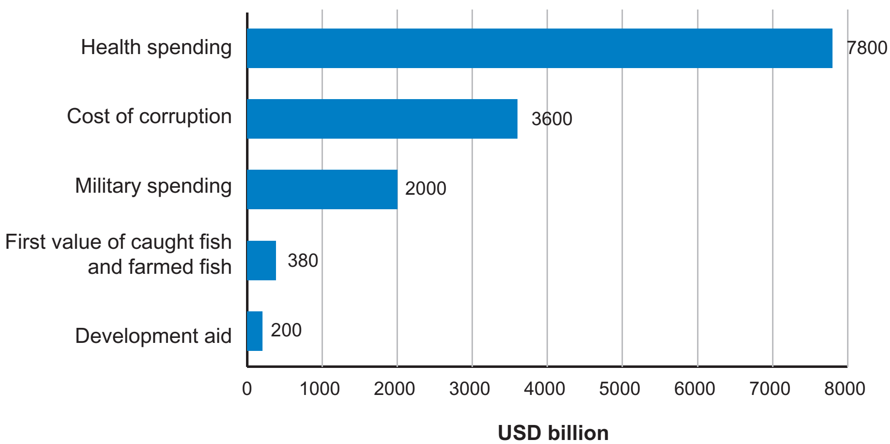

FIG. 7.7

World spending in several areas in billion USD.

Shortage of food is often the reason for armed conflict, so food security is an important premise for peace. Conversely, armed conflict frequently leads to a shortage of food. If an agreement could be reached worldwide to make significant reductions in armament it would be possible to spend greater amounts on strengthening a number of vital policy areas, such as health, development, or reducing corruption. However, there is little likelihood that the trend in world politics will be in that direction, and growing extremism in many quarters of the world does not give cause for optimism; quite the contrary, in fact.

This comparison illustrates still further the need to improve food security in the developing countries, particularly in Africa, and a key challenge in that regard will be to curb corruption and reduce its cost. At the same time it is of major importance for most of the coastal developing countries to take fishing in their territorial waters into their own hands and process and sell the catches themselves, so that a larger portion of the value created from marine resources will remain in the country for use in improving local living conditions. Increasing aquaculture is also an urgent matter. Asian countries have shown the way in this regard in recent decades, and the increase in aquaculture has led to improved living standards in many areas of Asia; this could provide valuable guidance for Africa in coping with the population growth that is anticipated in the coming decades.

Endnotes

a. The classification by the World Bank of income groups is explained in World Bank (2018, September 9) and World Bank (n.d.-a).

b. For a discussion of the Human Development Index see Human Development Reports (n.d.).

c. For a discussion of the least developed countries see United Nations Conference on Trade and Development (n.d.) and UN Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States (n.d.).

d. One of the best known stories of all times that concern fisheries is Ernst Hemingway's "The Old Man and the Sea", first published in 1951. It features an aged, Cuban fisherman, Santiago, who catches a giant fish; the story recounts his struggle to haul the fish aboard or somehow bring it ashore. The struggle is in vain, as the huge fish is eaten by sharks, so that nothing remains but bones when the old man reaches the shore. The story can be understood and interpreted in a number of ways, but the background is a portrayal of fishing by a single fisherman in primitive conditions.

e. For a discussion of small-scale fisheries and aquaculture in the developing countries see, e.g., Pomeroy and Andrew (2011) and Food and Agriculture Organization of the United Nations (n.d.-b).

f. For information on the number of people employed in small-scale fisheries and aquaculture see, e.g., Lentisco and Lee (2015) and Food and Agriculture Organization of the United Nations (n.d.-a).

g. For a discussion of microfinance in the developing countries see, e.g., Tietze and Villareal (2003) and Rutherford and Arora (2010).

h. For a discussion of fisheries in Lake Victoria and related matters see, e.g., Njiru, Kazungu, Ngugi, Gichuki, and Muhoozi (2008), East African Community. Lake Victoria Fisheries Organization (2016), and Njiru, Van der Knaap, Kundu, and Nyamweya (2018).
i. For a discussion of distant water fishing see, e.g., Tickler, Meeuwig, Palomares, Pauly, and Zeller (2018) and Shaver and Yozell (2019).
j. The third UN conference on the law of the sea ended in 1982 without the required consensus on the proposed convention. Nevertheless, most countries established their exclusive economic zones according to the proposed convention and did so even before the conference had been concluded, so one could say it became international law through practice; at the conference the 200-mile exclusive economic zone had wide support already in 1973.
k. For a discussion of the registration of fishing vessels under flags of convenience see, e.g., Galaz et al. (2018).
l. For a discussion of the conditions and wage terms in small-scale fisheries and aquaculture see, e.g., Food and Agriculture Organization of the United Nations (2016a).
m. For a discussion of corruption in connection with distant water fishing see, e.g., Standing (2008) and California Environmental Associates (CEA) (2018).
n. For a discussion of development assistance and related issues see, e.g., Sachs (2006), Swedlund (2017), and OECD (2019).
o. For a discussion of global gross domestic product see, e.g., World Bank (n.d.-c).
p. For a discussion of development assistance to individual countries see, e.g., World Bank (n.d.-e).
q. For a discussion of development assistance provided by country see World Bank (n.d.-f).
r. For a discussion of corruption in connection with development assistance see, e.g., Kenny (2017).
s. For a discussion of urbanisation in developed and developing countries see, e.g., Cohen (2006) and Florida (2017).
t. For a discussion of the Gender Gap Index see World Economic Forum (2019).
u. For a discussion of corruption measurements in individual countries see Transparency International (n.d.).
v. For a discussion of global corruption see United Nations Office on Drugs and Crime (2019) and United Nations (n.d.-a).
w. For a discussion of the added benefit of an optimal organisation of fisheries see World Bank and the Food and Agriculture Organization of the United Nations (2009) and World Bank (2017).
x. For a discussion of the world consumption of fish see Food and Agriculture Organization of the United Nations (2018a) and OECD and Food and Agriculture Organization of the United Nations (2019).
y. For a discussion of agriculture and the importance of trade for food security in urban areas in the developing countries see, e.g., Zezza and Tasciotti (2010) and Elliott (2015).
z. For a discussion of world population growth see, e.g., Ritchie (2019) and United Nations (n.d.-b).
aa. For a discussion of human progress in some areas see Rosling, Rosling, and Rönnlund (2018) and Roser (2019).
ab. For a discussion of expenditures on health see World Health Organization (2019).
ac. For a discussion of world military spending see, e.g., Perlo-Freeman (2016, April 15).

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CHAPTER

Processing and related industries 8

8.1 Handling of catches and quality control

Of all the foodstuffs produced in the world, fish is among the most difficult to handle and process. Fish is an extremely delicate and perishable product and spoils quickly. In addition, fish are of various species, sizes, and types, with each species sometimes requiring unique types of processing for sale in international markets. All of this makes fish handling and fish processing both complicated and exacting.

Among the most important factors of preserving the quality of fish products are handling at the time of catch, chilling, and hygiene, whether the product is being sold locally or exported to foreign markets, whether fresh, frozen, dried, cured, or salted. In fishing vessels, catches, such as cod, haddock, and saithe, are usually bled immediately with a knife by severing the main artery or by cutting off the gills. This way, the fish dies immediately and can be preserved, for instance by chilling or freezing. Generally, the fish is also gutted and rinsed in seawater to wash away any remaining blood.

This treatment ensures better preservation of the fish flesh and increases subsequent storage life. Usually, fish is kept on ice in boxes or tubs aboard fishing vessels, with the fish placed on a layer of ice, and further layers of ice spread over the layers of fish. Although this may seem like a haphazard operation, the ice needs to be spread in the tubs with care to ensure adequate chilling, and, in particular, plenty of ice then needs to be placed on top of the tubs to protect the fish from ambient temperature fluctuations. In some cases, sea water is added, and the fish is kept in slurry ice.

This is not possible in all fishing vessels, and before the introduction of decked vessels fish was not processed until it had been landed; this is still common practice in many places, with a resulting loss of quality. The description earlier of catch handling applies to many countries, but methods may differ for various reasons, including temperature and the level of technology available (Fig. 8.1).

The initial handling of fish is therefore crucial to its preservation and quality. There are no bacteria in the flesh of live fish, but there are bacteria in their digestive systems and gills, and on their skin. There are also compounds in fish that can be modified by contact with oxygen and enzymes, and micro-organisms begin to break their way through the skin as soon as a fish is killed. If fish is not chilled properly, and promptly, enzymes and micro-organisms will begin to cause various chemical changes, which can cause unpleasant odours and taste. Immediate blooding, gutting, washing, and chilling are therefore essential to preserve quality. *Rigor mortis* sets in

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FIG. 8.1

Red caviar processing in Khabarovsk in Russia (Konstantin Baidein).

soon after the death of the fish for reasons of chemical changes that cause muscle contraction, with the effect that the fish stiffens. *Rigor mortis* can last from several hours to several days, depending on circumstances, and it has an impact on the usability and quality of the products.[a]

There are various possible approaches when processing marine products, but the processing methods all have the common objective of maintaining a certain level of quality until the product arrives at its destination. To highlight a particular problem, if fish is not properly handled from the outset gaping may occur, which significantly reduces value.

Gaping appears when fish is filleted and holes or tears are revealed in the fillet. Gaping is a term used to describe a separation of muscles resulting from a degradation of muscle protein in fish. Gaping in fish flesh will in most cases reduce the value of the fish. It is not always preventable, as it can stem from natural causes and may for instance be particularly noticeable following spawning. Other principal reasons for gaping in fish can be temperature (impact on the degradation process of proteins) and handling (stress on the fish). *Rigor mortis* (time and temperature) also has an impact. The fishing gear used, the size of the fish, and the state of its flesh also make a difference. Gaping can be reduced by using proper chilling techniques to slow down the work of destructive micro-organisms. These techniques extend the *rigor mortis* period and thereby reduce the gaping.[b]

There are a number of methods of processing fish. To give some examples, following blooding, gutting, and washing aboard the vessel, the fish may be placed in ice and chilled aboard to preserve the quality of the raw material. Following landing, the head is normally cut off and the fish is then washed and filleted. Consumers will often want a fresh product, and if the producer has access to fresh raw material, then the process need not entail a great deal of expense. But it is the handling and preservation aboard the fishing vessel that is of crucial importance, since if anything goes wrong in those early stages there is no going back.

Fish processing has developed extensively in recent decades. To give an example, about 40 kg of fish were processed per man-hour in Iceland in 2000; the corresponding figure in 2020 is about 100 kg. The enterprises that have made the most extensive advances in automation are now targeting 200 kg per man-hour in the coming years.[c]

Assessment of quality and freshness can be done by using a method known as the Quality Index Method or by other sensory, or 'organoleptic', evaluation methods. The Quality Index Method is based on a structured scaling for quality measurements, with each quality element recorded and graded, all depending on the weight of each element. This method gives accurate and precise information on the freshness of fish and may provide indications of the remaining shelf life for species-specific fish. It is possible to predict the changes taking place in the flesh of fresh, lean fish based on sensory assessment and knowledge of the physiological reactions of proteins, but in fatty fish certain chemical reactions also need to be taken into account. In sensory assessment, the human senses are used to assess the quality of foodstuffs, i.e., by sight, smell, touch, and taste. The results of the sensory inspection are then used to determine whether a product meets quality requirements.[d] There are also various ways to analyse the quality of fresh fish apart from organoleptic assessments, such as germ counts and other methods.

Packaging is of special importance in the production and distribution of fresh fish products. Following processing the fish needs to be packed before marketing, either in wholesale or retail packaging. The purpose is to preserve the fish products on their way to market. As noted earlier, prompt chilling and cleanliness are key factors in the production of chilled marine products. It is of the utmost importance to chill fresh fish fillets before they are packed into insulated packaging and to maintain a transport temperature of close to $-1°C$, as this will increase keeping quality. Fish is a highly perishable product and extremely delicate, so packaging and handling in general are an important element of the journey of fish from ship to consumer. The introduction alone of plastic fish tubs and containers, combined with compact ice makers to keep the fish chilled, greatly improved handling both aboard the fishing vessels and in transport from the dock to the processing plant. It is also a widespread practice to place fish in what is known as modified atmosphere packaging containing a mix of nitrogen, oxygen, and carbon dioxide, which, together with low temperatures, can have a positive effect on storage life (Fig. 8.2).[e]

Correct temperature is the key to successful transport. As regards means of transport, research has shown that transport by sea gives a much more stable temperature than transport by air. Unstable temperatures affect the shelf life and quality of fishery products, and it may be difficult to establish the shelf life of the product if the ambient temperature is variable. Nevertheless, shipping by air is widely used because of the speed at which fish can be delivered to the market. The products shipped by air are necessarily high-quality and high-value products, as transport by air is expensive. It is about four times as expensive to ship each kg of fish by air than by ship.

FIG. 8.2

Salmon transport (stockfour).

In the case of fresh fish, the sale, packaging, and transport are all linked. All the work needs to be done within a fixed time frame, so the fishing, processing, packaging, and shipping need to proceed without a hitch for the product to arrive on the market in time, maintaining its quality all the way to the consumer's table, whether by reefer, i.e., a refrigerated ship, or other means. Much progress has been made in chilling fish, and one method that is widely used is supercooling, where the fish is chilled to below 0°C, but not frozen. This method keeps fish fresh for a long time and makes it possible to ship it over longer distances and still deliver it fresh in distant markets.[f]

Freezing fish can be traced back to 1861, when Enok Piper patented a method that involved mixing salt and ice.[g] Subsequently, freezing in various forms became a widespread practice in the world. However, the history best known to us of freezing food can be traced to a patent obtained by a man named Clarence Birdseye in 1927, who introduced the process of plate freezing. Birdseye applied for a patent on the first plate freezer in 1929 and received his patent on 12 August 1930 (see Fig. 8.3).[h] In that year, Birdseye began the production of frozen food in retail packaging. He founded the company Birdseye Seafoods, Inc., in 1924 to market frozen foods such as vegetables and meat and, of course, fish; this was a novelty at the time, even though the practice of freezing had begun much earlier. In 1930 Birdseye reorganised his distribution system; apart from producing food in frozen retail packaging he took the additional step of renting out freezers to retail shops to preserve the food bought from his company. Ever since, sales of frozen products have been growing, and still are, which says all that needs to be said about this method of preservation, which prevents food from spoiling by bringing the growth of micro-organisms to a halt and reducing enzyme activity.

Salting is an ancient method for preservation of food products, and in most communities of the world, salt has been one of the most important raw materials used in

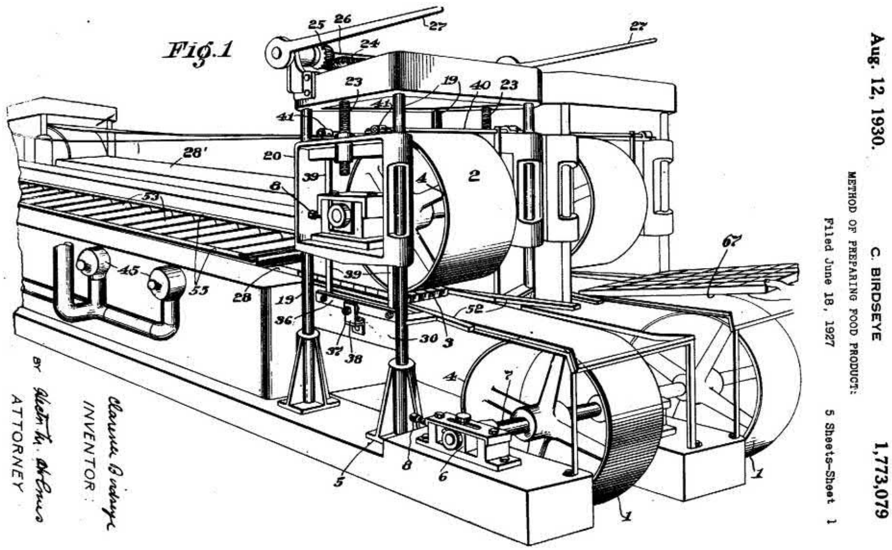

FIG. 8.3

Clarence Birdseye's application of 1927 for a patent on the first plate freezer (Wikimedia Commons).

food preservation. In Ancient Rome, one of the oldest imperial roads, leading to the salt marshes at the mouth of the Tiber, was known as the *Via Salaria* (the 'Salt Road').[i] The word 'salary' is believed to have originated in the fact that in the time of the Roman Empire soldiers were paid part of their wages in salt (*salarium*).

It is believed that the Egyptians were the first to use salt to preserve food, beginning before the year 2000 BCE. Salting and drying methods to preserve food, together with fish catching techniques, are reflected in wall paintings that depict the daily life of ancient Egypt. Since then, a number of different ways have been used to salt fish, although the basic functionality has remained the same through the ages. Processing salt from sea water is also an ancient practice of the countries around the Mediterranean, the salt being used for long-term preservation of food. In that region it was the Greeks and Romans who paved the way in salting fish, followed by the Spanish and Portuguese. In fact, these developments in processing methods no doubt contributed to increased fishing, as once it became possible to preserve foodstuffs using salt, the countries around the Mediterranean became prolific fishing countries (Fig. 8.4).[j]

The way salting works is that it accelerates dehydration and reduces the amount of water available to bacteria to survive, thereby increasing preservation properties. But processing saltfish also resulted in certain desirable qualities of taste and texture, making saltfish a delicacy, which in itself is a reason to continue the use this ancient form of preservation. It should be noted that, as in the case of other methods of preservation, the condition of the raw material at the outset is important to produce high-quality saltfish.[k]

FIG. 8.4

Salted fish in a Barcelona fish shop (Ásta Dís Óladóttir).

Another method of preserving fish and at the same time improving its flavour is smoking. Smoking is a unique method of preservation, where both physical and chemical processes are used to produce specific properties of taste, odour, and texture. Smoking greatly increases the keeping qualities of fish by depositing antimicrobial compounds in the fish, particularly in the form of formaldehyde.[l]

As regards the environment, the waste from fish processing was a problem in former times, resulting in pollution in the surroundings of fish processing plants, and some of the waste being dumped in the sea. This has been changing in recent years with increasingly efficient utilisation of raw material. The spines, offal, skin, heads, etc. that accumulate in fish processing are now being used as raw material for fish meal plants, and cut-offs and trimmings from fish processing plants have become a dominant raw material for use in fishmeal processing. Also, some innovative enterprises have begun using all of this former waste material for various purposes, with the ultimate objective of 100% utilisation of all raw material, which not only reduces waste and pollution, but creates value at the same time.[m]

Thawing of raw material that has been frozen at sea, particularly whole fish, plays a large role in the work of many fish processors. There is quite a long history of raw material being frozen prior to further processing, herring and salmon in particular. Thawing need not cause any deterioration in the quality of the raw material; however, the condition of the fish prior to freezing is, as always, of crucial importance. Thawing is, obviously, the reverse of freezing; however, it takes a long time and in fact it is a much more delicate process than the freezing itself (Fig. 8.5).[n]

FIG. 8.5

Wooden barrels in a fish sauce factory on Phu Quoc island in Vietnam (terekhov igor).

One of the oldest known methods of preserving food is air drying, which is believed to have been used by the ancient Egyptians and may even have been used in the stone age to preserve the keeping quality of food. For thousands of years, vegetables, fruit, meat, and fish have been air dried to prevent decomposition. Dried and cured fish has been a traded commodity in Europe and elsewhere for centuries, and hanging fish to dry has been done for millennia. In many places the fish is re-hydrated and boiled before consumption, for instance in Africa. Many species of fish are dried and used for human consumption, and in recent decades the practice of drying fish heads has increased significantly. It has become more common in our times to do the drying indoors using specialised equipment, which reduces the drying time from several weeks to several days; the results are also more even and the quality of the finished product better.[o]

In 1809 Nicolas Appert discovered a way to preserve food in bottles that had been kept in boiling water for a short while. It has been maintained that Appert was the discoverer of canning food, although there are sources that indicate that the Italian Lazzaro Spallanzani achieved similar results by coincidence in 1765.[p] One of the largest marine products companies in the world that specialises in canned goods (or tinned goods) is the Thai company Thai Union, which has an output of over one billion tins per year. The company was founded in 1977 as a canned tuna processor and exporter, but the company has grown rapidly since its establishment through acquisitions of other companies and subsequent sales of products in various markets under a number of brands. Their portfolio of consumer brands across North America, Europe, Asia, and the Pacific has a global reach. Among other things, the company produces about one out of every five tins of preserved tuna in the world.

All the processing methods discussed earlier are in competition among themselves, and efficiency determines the way in which catches are allocated to each form of processing; they are allocated, of course, to the methods that are likely to give the greatest profit. This is the market economy in its purest form, and its forces permeate virtually all economic sectors.

8.2 Business environment and value chain

In any business operations, including fisheries and aquaculture, proceeds from sales need to cover expenses or woe will ensue. This leads to the general objective of all enterprises to maximise profit over any given period, usually for the long term, and since profit is a measurable quantity, this objective can generally be forecast through measurement and reasoning.

Enterprises work in an environment that can be divided into three areas, as shown in Fig. 8.6. The business environment of an enterprise relates first to the internal workings of the enterprise itself, for instance management, fishing, and/or farming. Second, enterprises or firms operate in a market, or actually two markets: the factor market or resource market, where the enterprise obtains its factors of production, such as labour or fishing gear, and, on the other hand, the market for the enterprise's own goods, that is to say the environment in which the enterprise sells its products. For a fisheries enterprise this may be either processing plants, where fish is transformed into a consumer product, or the catch may be sold in a fish market, which is referred to as a product market. The third aspect of the business environment of an enterprise involves interaction with external influences, such as partners or competitors and government authorities, who exert influence through regulation, taxation, etc.

There are three principal factors at work that will determine productivity, which varies greatly between both enterprises and countries. First, there are the assets of an enterprise, that is to say its movable and immovable property. When working with well-equipped facilities and good organisation, production per person, or

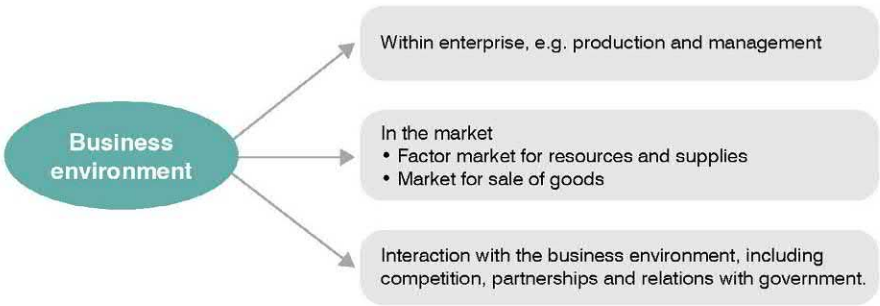

FIG. 8.6

The business environment of an enterprise.

productivity, will increase. Second, there is the education and training of employees. The better educated and trained employees are, the greater their productivity will be. Third comes technology, or knowledge of technology, as better access to advanced technology will improve productivity; this can vary from one country to the next and one enterprise to the next. It is of course self-evident that the larger the workforce, the greater will be the production output, but that does not mean that the production per worker will be greater.

What applies to natural resources and capital also applies to labour. The market will seek an equilibrium of supply and demand. A factor of production that is readily available will command a low price, while a factor of production that is scarce will command a high price. This means that if the supply of a certain factor of production decreases, then the price of that factor of production will increase. To take an example from fisheries, if the number of engineers decreases because schools that teach engineering reduce their output of engineers, then more will have to be paid for the work of engineers. If the economic policy of a government calls for high interest rates on consumer credit, this will reduce demand, firms will reduce their production and cut their staff, with the result that demand for labour decreases.

Corporate actions in the market, that is to say marketing work, constitute the activities of a corporation in the product market, one of the principal venues of business enterprises. Since consumer behaviour and demand are shaped by consumers' needs, an enterprise needs to identify consumers' needs and organise its activities in the market accordingly, whether its consumers are individuals or corporations.[q] Marketing is also a principal factor in the work of distributors and retailers.

The production of fish products can be illustrated in a value chain. In a value chain, value is added at each stage, and this chain can be simple, as in the case of a sole fisherman who catches his fish and lands it for sale in his home port, or it can have the form of an extremely complex process involving the outfitting and operating of a trawler or a very technical process in a fish farming company, processing the fish to a smaller or larger degree, marketing the products, and transporting them for sale in all corners of the world.

The creation of value in fisheries and aquaculture takes place in several stages, and the value chain can be depicted in a chart showing the individual steps along the way, as illustrated in Fig. 8.7.[r] There are four stages in the process of creating value

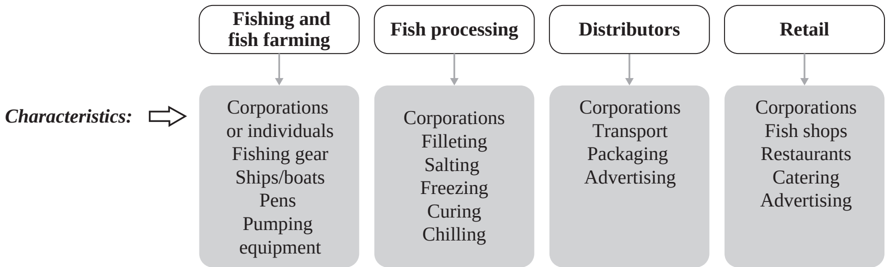

FIG. 8.7

The value chain in fisheries and aquaculture.

in fisheries and aquaculture. First there is the fishing itself and fish farming, which may or may not have the form of a company, as the fishing can be carried out in a variety of ways with various levels of complexity, ranging from artisanal to industrial. Fish farming is the cultivation of fish, or other marine organisms, which generally requires a great deal of sophisticated technological equipment, including pumps, filters, etc., as special care needs to be taken to ensure the quality of the seawater or fresh water used. The principal concern at this stage is proper handling of the catch or the farmed fish, which will determine the quality of the end product, as discussed earlier. This requires, in fishing, proper fishing gear and its proper use, early blooding and chilling, and avoidance of any rough treatment. Poor quality raw material cannot be transformed into quality products, at least not in the case of fish. In the case of fish farming, the same applies, *mutatis mutandis*.

The second stage is the processing, which takes a number of forms, as shown in Fig. 8.7. The fishing, farming, and processing may be done by the same person or enterprise. At the artisanal level a single fisherman may go out to sea, catch the fish, and then process it in a simple manner, for instance by curing. While fish products can take innumerable forms, the process will always consist in preserving the flesh of the fish and creating the best possible product for the prospective consumer.

The third stage involves a distributor to bring the product from the processor to market. As a delicate and perishable product, fish often needs to be transported using specialised equipment, such as chilled containers or reefers. Other products, such as salmon roe or caviar, may require highly sophisticated packaging. Advertising and promotion also pertain to this stage.

The fourth stage is the retail stage, which may involve specialised fish shops, supermarkets or other shops, and restaurants or canteens, or any location where the end consumer obtains the product. Again here, as in the case of the distributor, advertising and promotion come into play.

The consumer, whether an individual, household, or workplace, is not a part of the value chain. The characteristic of the consumer is primarily demand, which is dictated by factors such as price, quality, wholesomeness, nutritional value, word of mouth, and so on. With the spread of social media, word of mouth regarding fish and other consumables as food has increased vastly.

In the case of fisheries, the value chain is extremely complex, extending from ship or boat building to the manufacture and maintenance of fishing gear, processing, packaging, and sales. Services in aquaculture are also varied, as the equipment used can be extremely complex, and transport of farmed fish raises the same problems as the transport of caught fish.

The value chain is expressed in a number of different ways in different sectors; in the original value chain the stages were inbound logistics, operations, outbound logistics, marketing, and sales and service.[s] The ancillary activities were enterprise infrastructure, human resource management, procurement, and technology development. Value chains have changed in fisheries in recent years and decades, and technology, to give an example, has transformed both fishing and processing, and, in addition, the composition of consumers all over the world has changed.

8.3 Cluster collaboration and productivity

A cluster is a geographically demarcated area that constitutes a venue for cooperation among a number of enterprises, organisations, and individuals. Operation in a cluster has the potential to forge mutually beneficial links between the operators working in the cluster, which can improve their competitiveness in the long term. Clusters include enterprises in related sectors, such as suppliers, distributors, service providers, or other enterprises.[t] Through the years, a definition has taken shape of what a cluster actually is, and the factors that largely characterise clusters are geographical demarcation, collaboration, relationships among corporations and specialisation. Collaboration of this kind can be extremely meaningful, as working in clusters encourages dissemination of information among the participants. When knowledge is disseminated between enterprises this can improve both the productivity and competitiveness of the participants.

Examples of clusters can, in fact, be found even in ancient times, where certain geographical regions enjoyed dominance in certain areas, for instance in growing corn or the like. The inhabitants of such areas would achieve a degree of specialisation in their areas of expertise and become known as proficient traders in the goods in which they specialised. Leather products of various kinds from Norway and Russia were once much in demand, for instance. The closer we come to our own time the clearer this specialisation becomes. Most cities show signs of manufacturers having grouped together within certain areas, and in many places this is evidenced by streets which are named after their area of specialisation. New Delhi in India is divided in this way. In some areas washing is the area of specialisation, in others it is dyeing, tanning, etc. London is another good example; most people will be familiar with Harley Street as virtually synonymous with London's medical profession, and Fleet Street as the former centre of London's print industry. These areas are seeds of what we call clusters in our day.

Cluster collaboration involves the creation of contact networks and cooperation among enterprises in a business sector based on labour, technology, and knowledge, in particular in order to create an environment for innovation. 'Innovation cluster' is a term used to describe hot spots in a community, where new technology emerges at an extraordinary pace, and where access to capital, knowledge, and competence encourages the development of new business practices, and even entirely new economic sectors. Innovation centres attract talented individuals, investors in research and development, venture investors, and other enterprises that perceive an advantage in operating in this sort of environment. Access to capital is essential for these sorts of innovative ecosystems, where investments are clustered by region and industry sectors.

Even though clusters are often contained within political boundaries, they can reach across local or even international borders. Cooperation between entities such as research institutions, fisheries, and aquaculture enterprises and the technology and service enterprises that assist fisheries and fish farming operations are of crucial importance for rapid progress in fisheries and aquaculture, and cluster formation is therefore of great importance in those fields (Fig. 8.8).

FIG. 8.8

Fishing port in Iceland (Ozzo Photography).

Iceland provides a good example of a marine cluster. The cluster comprises enterprises that are in one way or another linked to fisheries, the sea or marine resources. The objective of the collaboration or innovation network known as the Iceland Ocean Cluster is to link these enterprises with a view to promoting innovation and value creation, improving the utilisation of raw materials, increasing knowledge, and thereby improving the competitiveness of the sector. Widening the horizons of the people working in the cluster this gives not only a new picture of the importance of the fisheries industry for the Icelandic economy, but also an entirely new scenario of the future potential for creating jobs and increasing value creation from business activities connected with the ocean and marine resources. The cluster was established in 2011 and provides a venue for cooperation among a number of enterprises in ocean-related business operations in Iceland.[u]

No two clusters are alike, as all clusters will differ by sector and between countries. Countries and regions worldwide are learning to actively build and grow future-oriented clusters on a massive scale. Clusters need to be based on an analysis of the strengths of the area where it is located, and participants in clusters need to look at the whole picture when deciding whether to operate in a cluster. They need to consider whether the proposed structure of the cluster is feasible and whether it will create value, both for the enterprise and for the cluster itself. It also needs to be considered how the cluster should be strengthened for the future and whether the ideas for value creation are realistic.

A number of Blue Tech clusters around the world have formed an association known as the Global Blue Tech Cluster Alliance. The BlueTech Cluster Alliance is an international network of industry-led BlueTech clusters focusing on collaboration and the development of joint projects, where they support one another in quest of improvement. The objective of the alliance is to foster and encourage innovation and promote economic development in coastal areas. The mission is to promote sustainable investment and growth of the knowledge-based ocean and water industries, to the mutual benefit of all parties, through active regional, national, and international collaboration.[v] The countries behind the cluster are Canada, France, Ireland, Portugal, Spain, the United Kingdom, and the United States.

The Ocean Supercluster, established in 2018, is based in Canada. About 350,000 Canadians work in Canada's ocean economy, and the objective of forming the cluster was to promote and facilitate growth in ocean-related sectors through interconnected clusters.[w] Canada's Ocean Supercluster is a cross-sectoral initiative, which includes the shared vision of leaders in fisheries, aquaculture, offshore resources, shipping, defence, marine renewables, and ocean tech.

In 2005 the Ocean Advance Cluster on ocean-related activities was formed when the government and entities in the academic sector and industries in Newfoundland in Canada joined forces. The objective was to combine the efforts of all these entities to encourage technological advances in the fisheries sector in Newfoundland and to strengthen and diversify the sector. A great deal of innovative work was carried out within the cluster, and over 80 entities now participate, including export companies, research laboratories, technological companies, and various institutions. Government is also involved, municipal, provincial, and national, together with scientific institutions and sectoral organisations. The objective is also to support future leaders in fisheries and aquaculture, so the cluster has a heavy emphasis on reaching out to young people. There are various other fisheries-related clusters, such as the Blue Maritime Cluster, which is based in the Møre region, the site of the city of Ålesund in Norway, where there is a great deal of activity connected with fisheries and aquaculture.

For sectors like fisheries and aquaculture, which compete globally, an underlying factor necessitating innovation is the high wages in many countries' labour markets—for example, average wages in Norway rank among the top five countries globally according to the OECD and other sources, meaning that Norwegian seafood companies consequently need to have much higher labour productivity than competitors in other countries; the same goes for Iceland and various other countries. As seafood markets have become increasingly global, improving productivity in seafood companies has become a more and more important management issue.[x] The terms 'seafood market' and 'seafood company' here refer to markets and companies that deal in catches from the sea, rivers, and lakes and in the output of fish farms.

Table 8.1 shows the trend in world aquaculture from 1990 to 2017.[y] The second column shows the number of fish farmers employed in aquaculture in millions; at the beginning of the period, in 1990, there were 5 million fish farmers in aquaculture, worldwide, but by the end of the period, in 2017, this number had grown to 19.5

Table 8.1 Number of people employed in aquaculture, production, value, and productivity 1990–2017.

Year	Number of fish farmers, million	Global production, million tons	Productivity, i.e., production in kg per employee	Value of global production, billion USD at the price level of 2019	Productivity, i.e., value of production in thousand USD per modified number of employees
1990	5.0	17.3	3.5	53	7.5
1995	8.0	32.4	4.1	74	6.6
2000	12.6	45.6	3.6	76	4.3
2005	15.1	59.1	3.9	94	4.5
2010	18.5	77.9	4.2	164	6.3
2015	19.3	103.9	5.4	233	8.6
2016	19.3	108.1	5.6	249	9.2
2017	19.5	111.9	5.7	261	9.6

million, having quadrupled in less than 30 years. The third column in the table shows the quantity produced in million tons increasing from 17.3 million tons to 111.9 million tons, a more than sixfold increase over the reference period. Column four in the table shows the performance in aquaculture, that is to say column three divided by column two. It shows that the output per fish farmer has gone from 3.5 kg to 5.7 kg over the reference period, increasing by 60%.

The last two columns in Table 8.1 show the change in productivity in global aquaculture based on first sale value in USD at the price level of 2019.[z] The value went from 53 billion USD at the beginning of the period to 261 billion USD, an almost fivefold increase. To compare productivity over the reference period, which is done in the sixth column of the table, it is assumed that to estimate the total number of people employed in aquaculture the number of fish farmers should be multiplied by 1.4. This multiplier is a conservative estimate of the jobs that the job of each fish farmer generates.[aa] By dividing the value by the modified number of employees we find that the production value per employee was 7500 USD in 1990 and 9600 USD in 2017, at the same price level, as shown in the final column of Table 8.1.

The discussion of the change in productivity in the world, as shown in Table 8.1, primarily has the purpose of showing the methodology of the calculation. For comparison by corporate managers or governments it is more relevant to look at changes in domestic productivity, or to compare two or more countries where conditions are similar. This is done in Fig. 8.9, which estimates the increase in productivity in fish processing in Iceland in 1990 to 2017.

The value of production, at the same price level, is divided by the number of employees in fish processing in the same year, with the index set at 100 at the

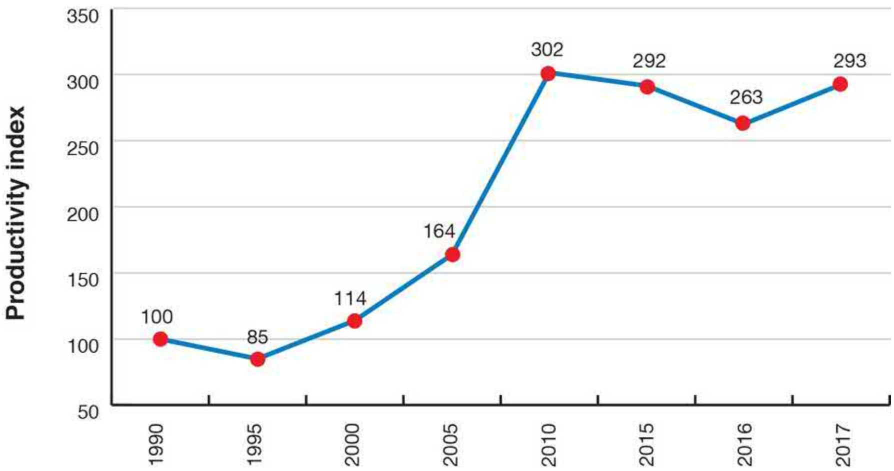

FIG. 8.9

Productivity in fish processing in Iceland, 1990–2017.

beginning of the period. The productivity index is 293 at the end of the period, meaning that productivity has almost tripled over the reference period, representing a 4% annual growth. Fig. 8.9 thus shows a simple comparison of productivity in processing, which is easy to make for enterprises and/or countries, subject to availability of data.

In discussing productivity, it needs to be borne in mind that while it is relatively easy to make good food from large and lean fish, small and fatty fish pose a much greater challenge. Millions of tons of small and fatty fish are processed for animal feed because of the prohibitive cost of making these species into products that are fit for human consumption. A great deal of effort has been made to isolate fish protein from small, low-value fish and weave the isolated protein into larger chunks. One such product, pioneered by the Japanese, is surimi, which is now a common commodity in the world markets. Efforts are also being made to create valuable products from very small crustaceans, krill, which are found in vast quantities in Antarctic waters, and the even smaller zooplankton also holds promise in this regard.

Productivity in fisheries and aquaculture has increased greatly, as we saw in Table 8.1 and Fig. 8.9. As regards fishing, an example can be taken of one fisheries enterprise in Iceland, which in 1980 landed 2400 tons and had 90–100 people working aboard its vessels. In 2016, some 35 years later, this same enterprise's catch had grown to 3200 tons, but only eight crew members manned its single vessel. This is a stark illustration of the technological development that has taken place. The same applies to the fish processing operations of the same enterprise: in 1966 there were 28 employees behind a 70-ton daily capacity. In 2017, 50 years later, there were 16 employees behind an 800-ton daily capacity.[ab] It is safe to say that with technological development having reached such an advanced stage on board vessels and in processing plants, these are almost entirely new sectors in comparison with earlier times. However, fishing has widely stagnated with regard to manpower, and even contracted in some countries, partly because natural resources are fully utilised and partly because productivity has increased so much already. Fish farming, on the other hand, is in a growth phase by virtue of increases in both output and productivity, and the same applies to processing of both caught and farmed fish.

There may be a significant drop in the number of jobs in the sector in the coming years as technology advances and automation increases, although the fact is that technology in these sectors is already quite advanced. Demography will also be a factor in the adoption of new technology; it has been theorised that ageing populations will reduce the supply of middle-age workers, causing wages to rise and making automation technology more attractive to industry.[ac]

8.4 Innovation and technological advances

The extensive technological advances in fisheries have led to improvements in just about all aspects of the entire fisheries sector, leading at the same time to improved quality and lower cost. The introduction of monofilament and multifilament synthetic thread revolutionised fishing. Not only was it lighter, but also stronger and, no less importantly, it did not absorb water and did not rot, like cotton or hemp. But other progress in other sectors, such as the transport sector, has also had an impact. Trucks, lorries, and fork-lifts replaced wheelbarrows, and even the replacement of diesel fork-lifts with electrically powered ones made a difference, as the latter could be used indoors in enclosed spaces. The introduction of tubs made from synthetic materials like fibre glass was a huge advance. In processing, the transformation has been no less dramatic. Advanced flowlines are now used to process fish, filleting, boning, cutting, and grading at a speed and with a precision that no human could possibly match.

International trade, production, and investments are increasingly being organised within international value chains, where production may even take place in a number of countries at different levels of the value chain. The purpose of this is to maximise the efficiency of production processes and take advantage of the resources available in each country. Corporations can take this route by collaborating with other corporations, by acquiring existing foreign companies or establishing new ones in other countries, and by using the advantages of outsourcing. The term 'global factory' is used to refer to the numerous entities/corporations that form a part of the international value chain. The reasons for this trend may vary, with factors such as reducing cost frequently cited. However, there are other factors at work, such as access to raw materials, resources and markets, flexibility in production and technology (Fig. 8.10).[ad]

Fisheries and aquaculture currently face a number of challenges. Climate change, acidification of the oceans, increased international competition, and increased globalisation are just some of these challenges. It is therefore important for these sectors

FIG. 8.10

Saltfish production in Reus in Catalonia (Ásta Dís Óladóttir).

to find new ways to ensure food security for the future and minimise their environmental impact to the extent possible. Innovation will have an important role to play in maintaining competitive advantages and ensuring better utilisation of marine resources, as the current population growth is quite rapid. There are also other factors that need to be taken into account, including the demand for machinery and equipment to meet the increased need for food security. These include the equipment used in aquaculture, more advanced fishing vessels and fishing gear, means of transport, people who are willing, able, and competent to work in fisheries and aquaculture, along with a number of other factors.

Traditionally, the 'fisheries sector' includes both fishing and processing; this is the case when fisheries are analysed in statistics, but this definition is too narrow. As discussed in this book, any services to fisheries pertain to the fisheries sector. This means that the manufacture of fishing gear, normally categorised under industry, in fact pertains to fisheries. The same applies to the fisheries supply chain as a whole, including specialised repair services for fishing vessels and fish processing equipment such as filleting machines and flowlines, or even the resources used in marketing marine products.

When an industry becomes more technologically advanced, a phenomenon known as 'spillover' comes into play, meaning that knowledge spreads among the employees of a company or employees in related sectors of the economy, as in the case of the clusters that we discussed earlier. This leads to fast technological advances. Numerous companies have been set up in many countries around the world that provide services to fisheries and aquaculture, which, among other things, has had the effect that the utilisation of fish flesh is better than before, and more valuable products are being made from the fish caught or farmed, while at the same time marketing has improved. The sector is driven by its own success, and at the same time creates a wide range of jobs alongside and around the core function of catching or cultivating fish. Automation will become even more prominent in the coming years, which will lead to the loss of a variety of jobs, but that is simply a part of the current ongoing technical revolution.

Extensive advances have occurred in fisheries and related sectors in the context of the 12th United Nations Sustainable Development Goal of responsible consumption and production. Sustainable consumption and production 'aims at doing more and better with less', and in the context of fisheries this means increased and better utilisation of marine resources.[ae] Table 8.2 gives an example of such utilisation of cod.

As shown in Table 8.2, a number of products are made from cod. Fish eyes are important food items in many parts of the world, especially for their content of amino acid. The eyes of cod contain a number of vitamins and lipid chemical compounds that have a beneficial effect on the human brain. The Japanese have been working on producing oils from fish eyes.[af] Research has also been done, for instance in New Zealand, on whether protein from fish eyes can be used to repair human cornea, but no conclusive results have been achieved. If this experimentation proves successful, however, fish eyes will change from being waste to being a very valuable by-

Table 8.2 Products deriving from cod.

Part of the cod	Product
Fillet	Loin, tail, centre cuts, belly flaps
Head	Fish tongues, cheeks, dried heads
Fish frames	Mince (with or without bones), dried heads
Cuttings, belly flaps, smaller pieces	Mince (with or without bones), migas
Eyes	Contain a number of vitamins and lipid chemical compounds, which are used to produce oils
Fish skin	Collagen, textiles, leather, gelatine, snacks
Roe	Caviar, smoked, boiled and salted roes
Liver	Liver oil, hot-smoked liver, paté, animal feed
Milt	Tinned and used as spread
Swim bladder	Dried consumer product, used in soups and snacks
Other offal[a]	Usually discarded

[a]*Offal refers to the innards of fish, which are separated from the abdominal cavity when the fish is gutted. The offal includes liver, roes, gametes, gall bladder, stomach, and viscera. Liver, roes, and even gametes have been utilised for many years, but other organs have normally been jettisoned into the sea. The proportion of the offal can be up to 30% of the total weight of a fish.*

product, since with increasing human longevity millions of people are awaiting cornea procedures in the world.[ag]

The company Kerecis in Iceland is an example of an enterprise that is using innovative approaches to making products from fish skin. Skin grafts are commonly used to facilitate wound closure. The grafts can come from the patient's own skin (autograft), a human donor (allograft), or from a different species (xenograft). A fish skin xenograft from cold-water fish, like Atlantic cod, is a relatively new option that shows promising preclinical and clinical results in wound healing.[ah] The products made by Kerecis are currently being used to treat lacerations, burns, and other tissue damage, including diabetic wounds.

Also, digestive enzymes, in particular trypsin, are processed from cod viscera, to give just one example. A mouth spray from the company Zymetech (ColdZyme) contains trypsin processed from cod, and trypsin is also used in some cosmetic products. Protein isolates and surimi are also processed from cuttings, and hydrolysed proteins, or peptides, are processed from paste and isolates. Looking at the 12th United Nations Sustainable Development Goal, which concerns, among other things, world food security, its implementation calls for halving per capita global food waste at the retail and consumer levels and reducing food losses along production and supply chains, including postharvest losses.[ai]

One important factor in these considerations could be better utilisation of calcium, lipids, and proteins. Marine products include large quantities of these substances, in particular the side products of traditional fillet processing, that is to say innards, spines, and heads. Increasing awareness regarding the quality and utilisation of raw materials has also led to improved raw material for the manufacture of various side products, including biological agents that can be used in producing medicinal and cosmetic products. This trend will not only promote improved utilisation, but also significant value creation, as pharmaceutical substances can be extremely valuable. There are numerous examples of significant progress being made that has resulted in the creation of a number of start-up enterprises.

Algae are the foundation of life on Earth, with about 70%–80% of the world's oxygen produced by algae. Algae bind CO_2 and produce O_2. It has been suggested that algae will be at the centre of the next revolution in food production. Innovation involving seaweeds and marine plants as a source of protein and bioactive components has already become an important element of food production.[aj] China and Indonesia are the largest growers of seaweed in the world. A large part of these harvests is used as raw material for the production of carrageenins (or carrageenans), which are exported and used in the food industry and other industries. Seaweed cultivation is an important element of China's economy and the sustenance of large groups of people. Cultivation of seaweed in China is at a primitive stage, with single families cultivating areas of about half to one hectare. The cultivation mostly takes place inshore without the use of boats. But the cultivators face threats of various kinds: storms can lay their fields bare, and changes in the temperature of the sea or its salinity can cause diseases that destroy their crops, and thereby their livelihoods.

Cultivation of seaweed is one of the avenues that the World Bank and other entities are exploring to increase the production of protein in the world. There are numerous opportunities for seabed cultivation that can at the same time have a positive impact on the Earth's biota. Part of the environmental problems of the world could be solved by producing fish feed from seaweed-based products, as seaweed cultivation is among the most environmentally sound means known of producing protein. The global nutraceutical market size is expected to reach 302 billion USD by the year 2022, up from 184 billion USD in 2015 (Fig. 8.11).[ak]

In Iceland, work has begun in a company on cultivating microalgae using energy streams from a geothermal power plant. The company designed, constructed, and now operates a growth platform called Energy to Food that can be used to cultivate multiple strains of microalgae. The idea was to come up with a way to produce food in a new way. Using the Energy to Food platform, a kilogram of protein can be produced using 1500 times less land and 500 times less water than needed to obtain the same amount of protein from soybeans.[al]

Companies today are looking for smarter and better ways to meet consumer demand for higher product quality and diversity. Changes in technology and robotisation will have the consequence that manufacturing jobs, such as traditional fish processing jobs, will to a large extent be transformed into jobs that involve controlling and servicing machinery and equipment. This applies as much in fisheries and aquaculture as in any other industry.

Smart processing in fisheries and aquaculture is now enabling the construction of one of the most advanced processing plants for groundfish in Iceland, in 2020. The installation of the processing system is scheduled for mid-year 2020; the system

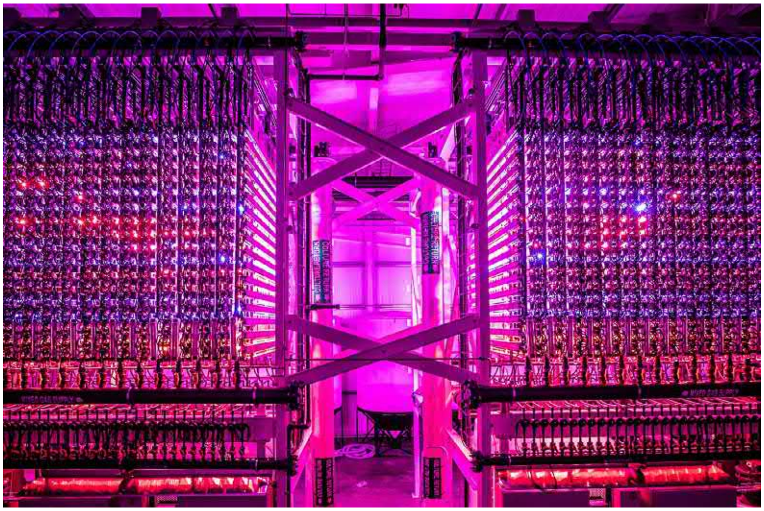

FIG. 8.11

Algaennovation's Micro-Algae Production Unit (Pétur Gunnarsson).

includes a powerful quality control system and the latest robot technology, all of which will automate and streamline virtually all the elements of the processing. The system uses water jet cutters and automatic product grading. It will also feature a high-tech packing system and a deboning system for fresh products. At the centre of the new system, software will play a key role, interconnecting the components at each stage of the processing and ensuring traceability throughout the entire process.

Modern technology also enables equipment buyers to visualise the production process before entering into a contract with the company offering processing solutions. Computer modelling makes it possible to simulate all stages of the process. Staff training also takes place in a virtual reality environment, another novelty, which will make it possible to begin production as soon as the installation is completed. A processing plant will therefore not need to wait to begin training its employees until after the equipment has been installed. Enterprises that manufacture processing equipment are increasingly using virtual reality in their production and sales to speed up development processes and reduce customers' installation costs. The introduction of robots in the fishing industry has been rapid in recent years. Robots are far more precise than humans; they do not make human errors and therefore they contribute greatly to operational security (Fig. 8.12).[am]

All of these improvements over the course of just a few decades have resulted in better quality products, made with less human effort and at a lower cost. These advances will continue at rapid pace in the coming years, although it is impossible to predict with any certainty the course that the improvements will take. The economic sectors surrounding fisheries and aquaculture include fish processing, marketing, and sales, as well as industries such as the fishing gear industry, logistics operations, research organisations, technological companies and energy producers, packaging manufacturers, administration, and biotechnology.

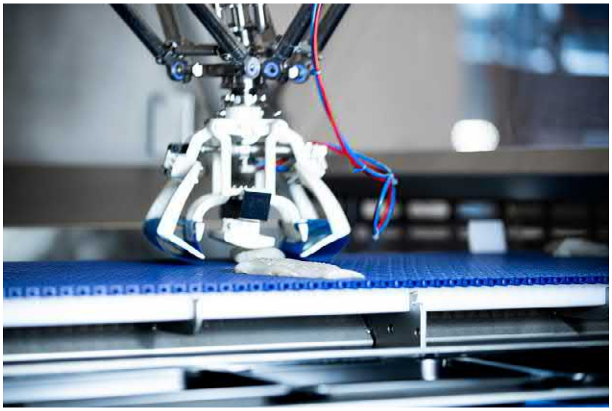

FIG. 8.12

A robot in fish processing (marel.com).

In the coming years innovations will continue to appear, both in fisheries and aquaculture. In the processing element, the advances will be in the fields of robotics, packaging, storage, and traceability. In the distributing element, there will be innovations in logistics, traceability, packaging, supermarket storage, point of sale tools, and many other areas.

An illustration of high-tech solutions in fisheries

Marel is a leading global provider of high-tech food processing solutions, including stand-alone equipment, full-line systems, software, and services to the poultry, fish, and meat processing industries. The name Marel is composed of 'marine' and 'electronic', reflecting the company's roots in its first product, an electronic marine scale that could accurately weigh fish in a rolling and pitching fishing vessel.

From design, innovation, and manufacturing to sales, service, and aftercare, Marel is now one of the world's largest manufacturers of machinery for food processing, with over 6000 employees in more than 30 countries serving customers in over 140 countries. In 2019 Marel's revenue totalled about 1300 million USD. Since its listing on Nasdaq Iceland in 1992, Marel has delivered on average a 20% growth per year, driven by innovation, market penetration, and strategic acquisitions. In 2019 Marel became a dual-listed company when its shares started trading on Euronext Amsterdam in addition to Nasdaq Iceland.

Marel's first product was the electronic marine scale that brought data processing to the fishing grounds. The scale was developed in 1978 by a group of engineers at the University of Iceland, who shared the vision that data and technology could increase yield and efficiency in the Icelandic fisheries industry. The scale, connected to a central computer, allowed fish processors to significantly increase yields and efficiency, thereby contributing to a more sustainable use of a valuable resource.

In the beginning, Marel was focused only on the Icelandic fish industry, and during the 1980s and 1990s the company introduced new technology and products, such as a flowline that would revolutionise the global seafood industry. As the company grew, the operations expanded into other industries, like the meat and poultry industry, and into new geographical regions with increasingly global operations and acquisitions of companies. One of Marel's key strategic advantages is its strong focus on innovation. Marel invests around 6% of its revenues in innovation, which translated into about 85 million USD in 2018.

Marel operates in a dynamic growth market. The company focuses on the global meat, poultry, and fish markets, which are expected to grow on average 4%–6% per year in the long term, as global demographics strongly support the anticipated market growth for animal protein consumption. While the world population is anticipated to be 11 billion people by 2100, both urbanisation and the growth of the middle class are expected to accelerate. In addition to the growing population, the main drivers of expected market growth are underlying production growth, an increased need for automation, throughput, and yield, as well as an increased focus by consumers and regulators on sustainability, food safety, nutrition, health, and wellness.

Endnotes

a. For a discussion of *rigor mortis* and chilling using ice see, e.g., Matís (2015).
b. For a discussion of gaping in fish see, e.g., Elíasson (2019).
c. For a discussion of production capacity in modern fish processing see E.S. Jóhannsson, personal communication March 28, 2019.

d. For a discussion of the Quality Index Method in fish processing and sensory inspection see, e.g., Sveinsdóttir, Hyldig, Martinsdóttir, Jørgensen, and Kristbergsson (2003) and Matís (2015).
e. For a discussion of packaging and quality matters see, e.g., Margeirsson, Arason, and Pálsson (2009) and Lauzon et al. (2010).
f. For a discussion of fish transport see, e.g., Arason and Tryggvason (2006).
g. For a discussion of chilling media and patents on methods to freeze fish see, e.g., Field (1950) and Petersen (1922).
h. For more information on Birdseye's patent see Valigra (2012, February 15).
i. For further information on the Via *salaria* see, e.g., Platner (1929).
j. Sources on salting food can be traced back to before the year 2000 BCE see, e.g., Gallart Jornet, Escriche Roberto, and Fito Maupoey (2006).
k. For a discussion of salting fish see, e.g., Matís (2012) and Sutton (2011).
l. For a discussion of smoking fish see, e.g., Matís (2014a), Arvanitoyannis and Kotsanopoulos (2012), and Roth, Birkeland, and Oyarzun (2009).
m. For a discussion of fish meal production see, e.g., Matís (e.d.).
n. For a discussion of thawing fish see e.g., Vyncke (1978), Nilsson (1994), and Arason (1995).
o. For a discussion of fish drying see, e.g., Nummer (2002, May), Matís (2014b), and Matís (e.d.).
p. For a discussion of canning fish see, e.g., Nummer (2002, May) and Matís (2019).
q. For a discussion of the role of consumer needs in marketing see, e.g., Kotler and Armstrong (2011) and Wöhe, Döring, and Brösel (2016).
r. For a discussion of the value chain in fisheries see, e.g., Knútsson, Gestsson, and Klemensson (2009) and Einarsson (2016).
s. A great deal has been written on the value chain. Specific reference can be made to Porter (1990), Porter (1998a), and Hearn, Roodhouse, and Blakey (2007).
t. For a discussion of clusters see, e.g., Porter (1990) and Porter (1998b).
u. For a discussion of a cluster in Iceland see The Icelandic Ocean Cluster (n.d.).
v. For a discussion of cluster collaboration see The BlueTech Cluster (n.d.).
w. For a discussion of clusters in Canada see The Ocean Supercluster (n.d.) and The Ocean Advance Cluster (n.d.).
x. For a discussion of the importance of productivity in a competitive market see, e.g., Bergesen and Tveterås (2019). For average annual wage figures see OECD (n.d.).
y. For statistics on fish farmers, production, and value in aquaculture see Food and Agriculture Organization of the United Nations (n.d.-a).
z. For changes of the consumer price index in the United States see the Federal Reserve Bank of Minneapolis (n.d.).
aa. For an estimate of employment in aquaculture see Valderrama, Hishamunda, and Zhou (2010).
ab. These examples of actual enterprises in Iceland were supplied by E.S. Jóhannsson, personal communication, March 28, 2019.
ac. For a discussion of the impact of ageing on the adoption of new technology see, e.g., Acemogulu and Restrepo (2018).

ad. For a discussion of the global value chain see, e.g., Barrientos (2013) and Gereffi and Lee (2016).

ae. United Nations Sustainable Development Goal no. 12 on responsible consumption and production can be accessed here see https://www.un.org/sustainabledevelopment/sustainable-consumption-production/.

af. For a discussion of utilisation of fish eyes see, e.g., Tønsberg, Wong, Hong, and Tangen (1996), McCann and Ames (2005), and Jónsson and Vidarsson (2016).

ag. Research is being conducted in the University of Auckland into the possibility of using fish eyes for cornea procedures see, e.g., Beston (2016, May 16).

ah. For information on Kerecis see, e.g., Kirsner et al. (2020).

ai. For information on the United Nations Sustainable Development Goal no. 12 and waste see http://www.fao.org/food-loss-and-food-waste/en/.

aj. For a discussion of seaweed production see World Bank Group (2016).

ak. Information about nutraceuticals markets can be found on https://www.alliedmarketresearch.com/nutraceuticals-market.

al. For a discussion of the cultivation of algae in high-temperature geothermal areas see http://www.algaennovation.com/.

am. For a discussion of modern automation in fish processing see, e.g., Marel (2019, October 22).

CHAPTER

Sales and marketing

9

9.1 The development of trade

Fish and fish products have been traded throughout all history, but trading in fishery and aquaculture products across borders is now growing at a rapid pace, and not only in the output itself of fisheries and aquaculture operations, but also in the vast variety of equipment and services needed in those two industries.

With increased trade comes increased progress in various areas. The improved living conditions that came with the industrialisation of the 18th and 19th centuries permanently transformed human communities. To give just one example, communicable diseases had decimated populations in earlier times, but vaccines, closed sewers, and improved hygiene gradually improved health conditions. In the 19th and 20th centuries opportunities arose for poor people to break off the shackles of poverty. This had not been possible on any scale in previous human history. People's average life expectancy 200 years ago was only 30–40 years, particularly as a result of widespread infant death; average life expectancy now is about 70 years, and in some places over 80 years.

From the dawn of human societies to the Industrial Revolution in the 18th century a large part of humanity was virtually destitute, that is to say they had virtually no possessions of any real worth that they could call their own; this changed in the 19th and 20th centuries for a large section of humanity, particularly for women in the second half of this period, as up until that time they had virtually no rights, they were disenfranchised, and those women who did not have the fortune of being born into wealthy families lived largely in poor conditions. The increased empowerment of women gradually began to have a positive influence on human society. Before the Industrial Revolution, men had the advantage of their muscular strength, and this advantage, in combination with other factors, meant that societies were virtually dominated by males and characterised by male privilege. When men's muscular power was no longer as important as it was before the Industrial Revolution profound changes occurred. This, together with rapid technological advances and a powerful women's rights movement, improved the situation of women in late 19th and early 20th centuries, although gender discrimination has not been totally eradicated, neither in fisheries and aquaculture nor any other industries, and remains rampant as ever in some parts of the world.

Fisheries and Aquaculture. https://doi.org/10.1016/B978-0-12-821056-7.00004-4

Many developing countries are now finding themselves in a similar situation as the developed countries were in over a hundred years ago. Although progress is admittedly rapid, among other things because of growing international trade, there are still severe shortages of various necessities of life in many developing countries that are taken for granted in the developed countries. However, the disadvantages of the developing countries now have a different form from earlier times as a result of the social changes that have occurred both in developing and developed countries. To give an example, 37% of the world population lived in poverty in 1990, with poverty defined as having less than 1.9 USD each day to survive on; in 2015 this proportion was down to 10%. About half of the world population now enjoys democratic government, which was virtually nonexistent 200 years ago. Education has also increased vastly, and illiteracy has fallen significantly over the past 200 years (Fig. 9.1).[a]

Nevertheless, there remains a huge gap between poor countries, particularly in Africa, and rich countries as regards health. In 1990 the modern technology available to 20% of the richest people of the world could have prevented 70% of all deaths and 92% of the deaths resulting from infectious diseases among the poorest 20% of the world population.[b] The rich countries would therefore do well to address with greater urgency the matter of improving the infrastructure of the poorer countries of the world.

It is safe to say that by far the most rapid and most extensive progress in human society has taken place over the last 200 years, driven to a large extent by trade. Tremendous progress was achieved in all sorts of technical equipment

FIG. 9.1

Fishing boats in Canakkale in Turkey (Zaferkizilkaya).

in all the industries in the 20th century. Jobs became more diverse and took on the form that they have now. This trend has continued in the 21st century and there is no end in sight of the profound changes and progress that now characterise human societies.

The societies that engage in the most extensive economic activity, with flourishing and diverse education and extensive international trade, are mostly democratic societies.[c] Advances in economic activity have often begun within the borders of individual countries, although it can be argued that cities, such as Beijing, London, New York, and Paris, have sometimes had greater importance by themselves than the countries where they are located, bearing in mind that borders in Europe were constantly shifting throughout the 19th and 20th centuries. But while advances may be local to start with, they can also take on a new life when different cultural worlds meet, an obvious example being the cultural melting pot of the United States of America in the 18th and 19th centuries.

Language also plays a crucial role, and English is undeniably the language of globalisation, trade, and science, having replaced Latin, the *lingua franca* of earlier times. There may have been a number of languages in trade and international relations well into the last century, but it is now English that occupies the position of supremacy. There is also a great deal more communication between countries than ever before, which has led people to seek a common ground in language. The trends since the mid-18th century, since the Industrial Revolution, have primarily emanated from the countries of Western Europe and the United States of America, which no doubt contributed to the spread of English and continues to do so.

International trade has been the driving force behind extensive changes, economic, social, and geographical. It has served to lower barriers to the flow of capital, labour, and goods across borders. Technological advances disseminated through trade have also led to more efficient management and marketing and more effective communications. Knowledge of the laws of the economy has also deepened as people's economic conditions have improved, and sometimes it can be difficult to say what came first: the knowledge or the improved economic conditions. Knowledge is now being disseminated at a rapid pace between countries. International trade is taking place in goods such as technological equipment and various other equipment and goods relating to fisheries and aquaculture, and with the goods comes knowledge.

One of the reasons for the increased world trade lies in the notion of comparative advantage. Specialisation contributes to increased production, and trade ensures the most efficient use of the production. International trade therefore enables increased international specialisation and division of labour. This way, each country can concentrate on doing what it does best, just like enterprises concentrate on doing what they do best and focus on their core competences. World fisheries and aquaculture provide a good illustration of how countries use their comparative advantage through specialisation and division of labour, with improved transport and preservation methods that enable countries to sell their catches in markets that are located far from the fishing grounds or fish farms.

9.2 The market clearing forces of price and quantity

Market forms can differ depending on the extent or intensity of competition. When there is little competition and only a few entities have command of the supply, this is known as 'oligopoly', oligo being the Ancient Greek word for 'few'; market prices are then higher and there is less supply than there would be in an environment of perfect competition. The most common form of marketing of fish products, as in the case of most other products, is that of monopolistic competition, where there are numerous buyers and sellers; this market form falls somewhere between oligopoly and perfect competition. In an environment of monopolistic competition goods in the marketplace are similar, an example being fish fillets, but not entirely the same; they can, for instance, derive from different species of fish, they can be breaded or unbreaded, of different quality, etc. Producers, distributors, or retailers thus have a sort of monopoly on their own particular products, but these products are in competition with many other comparable products from other producers, distributors, and retailers.

Marketing of fish is in many respects similar to the marketing of goods and services in general, food in particular, and revolves around creating real value for customers. Marketing is the process of helping a customer to decide on the choice and purchase of an appropriate product, which places the customer in a better position.[d] Demand and supply are usually presumed to meet at the equilibrium price and equilibrium quantity, as set out in Fig. 9.2.[e]

The circle in Fig. 9.2, where demand and supply meet, is the area, or venue, of marketing and trade. When a connection is established between the source of supply and the source of demand, this constitutes trade. Trade does not take place only

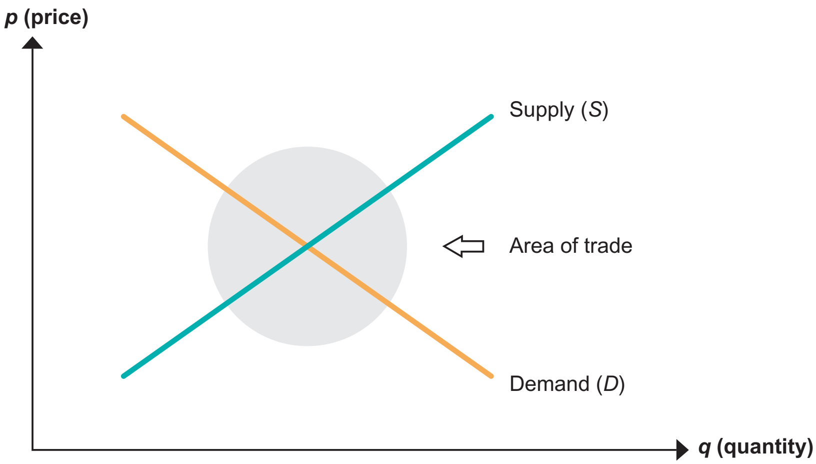

FIG. 9.2

Demand and supply and area of trade.

where supply and demand are in a near equilibrium, but also where there is excess supply and excess demand. For this reason, the circle in Fig. 9.2 is deliberately shown as relatively large to underscore the role of trade and marketing in disseminating information and incentives between supply and demand in various circumstances, in promoting lowered transaction cost and approaching an equilibrium.

An organisation has to define who its customers are and what actions or sales initiatives need to be used to attract customers or retain them. Marketing operations need to be planned and managed. This applies to marketing of fish products, just as it applies to any other goods. Good marketing is aimed at the goal of customer satisfaction. A satisfied customer is of value, and favourable discussion or a good reputation is valuable. Almost everyone has at some time received such a poor or inappropriate product or service that it results in a firm decision never to place foot again in an establishment, such as a retail outlet. A negative attitude of this kind, often communicated freely to others, particularly in the social media in our time, can pull the rug from under a business organisation's feet. Many customers will rely to a considerable extent on comments made by previous customers on the Internet before they decide to do business with an enterprise such as a hotel or restaurant, so one element of marketing is keeping such comments positive.

It is important for any business organisation to have an awareness of where it stands in the competition with other businesses. Important factors in such a comparison are market size, production capacity, state of research and development, and employee and management qualifications. Special consideration needs to be given to the quality of raw material and the quality of the end product.

Leaders of a business organisation, such as a fish processing plant or seafood restaurant, need to study various aspects of their environment when formulating their strategy. It is of major importance for them to understand where their business has a competitive advantage over other businesses with which they are competing and to use this advantage in the best possible way. A sound knowledge of the market is the most important means of achieving results in this regard. This knowledge has to be disseminated throughout the organisation using the most efficient measures needed to do so. A chef in a seafood restaurant needs to understand that a fish must not still be in the state of *rigor mortis* at the time of preparation, which in fact also applies to meat, which needs to be tenderised prior to preparation, with the time of tenderisation depending on the type of meat. The same applies to fish. Redfish, for instance, can remain for longer on ice than cod and still retain its quality. All of this is knowledge that must be channelled into the business organisation's processes (Fig. 9.3).

The costs and production processes of businesses vary and make their respective competitive positions different. The better grip that a business has on its costs and production, the better its financial performance will be in comparison with other businesses. The financial situation of businesses can also differ vastly. Some enjoy a strong financial position with abundant cash reserves, while others are weak and cash-starved. Some businesses are well placed as regards assets but may still experience operating difficulties, while others have substantial reserves of cash but are nevertheless heavily in debt. There are special circumstances with regard to fisheries,

FIG. 9.3

Fresh fish sold to a customer (Iakov Filimonov).

as fisheries, for instance, are dependent on a limited but renewable resource, and fish stocks, and changes in the fish stocks and catches, including changes from natural causes or government intervention, are a source of uncertainty. Fish farming is also subject to a number of potential uncontrollable natural occurrences, such as currents and climatic conditions, especially temperature.

The product selection of an organisation is the range of products or services that it offers, for example the variety of seafood meals or variety in the construction of fishing vessels or the manufacture of fishing gear. A distinction needs to be made between two types of product range, that is to say breadth and depth. The breadth of a range of products refers to the number of product types, for instance the number of types of fishing gear offered by a manufacturer or the number of smoked fish products offered by a seafood producer. The depth of a product range refers to the degree of specialisation offered by an enterprise, for instance, in the case of a fishing gear manufacturer that specialises in manufacturing trawling gear of various designs but leaves other types of fishing gear largely or entirely out of its product range.

One method of analysing a new product or idea is to define the purpose and form of the product, consumer expectations regarding the product, and the way in which consumers will differentiate it from other products in the market. An example of the purpose of a product type is that fish is a food product. The form of a product type refers to a fish normally having the form of a fillet or part of a fillet in a specific size or quantity, say 300 grams. Consumer expectations in this case are that the consumer will expect to enjoy the fish when it is consumed. Differentiation from competitors means, among other things, that a certain prepared meal of fish and its production is different from that of another producer.

An illustration of marketing

Cross-border trade and specialisation are not new phenomena, and history can provide numerous examples of countries attempting to corner markets and keep others out. Silk, for instance, was an important and extremely valuable export for China for centuries, and the Chinese took measures to prevent the export of the moth that made silk production possible—they were successful in this for a long time. Similar stories exist about rubber and cacao.

Some products are marketed all over the world, a case in point being the 130-year-old soft drink Coca Cola, which can be bought almost anywhere in the world. The Coca Cola brand is one of the best known and most valuable brands in the world, but a brand can take many different forms. Even the name of an artist or a building can become a sort of brand name; Pablo Picasso may attract people to Barcelona, or the Louvre may attract visitors to Paris.

Mass production has also been a feature of artistic creation for a long time. Take, for instance, the case of the well-known composer Johann Strauss the elder. In the heyday of the Vienna waltz the City of Vienna was a city of music. In this setting Strauss the elder formed a number of orchestras. The orchestras performed in the evenings in Vienna, and Strauss himself made the rounds, occasionally taking the baton himself and making his mark on the music. This was mass production, in a sense, although somewhat special in nature.

The French novelist Alexandre Dumas negotiated a contract with his publishers to be paid by the line; the stories he wrote first appeared in print in magazines in the form of series. He would decide on a plot and hire people to write drafts for him, which he then read and edited. This was a form of mass production in those times. Dumas is one of the best known writers of adventures, of all times. He was the author of books like *The Three Musketeers* and *The Count of Monte Cristo*, which immortalised his name. Charles Dickens, another writer, engaged in a similar form of mass production.

9.3 Market models of producer and consumer interaction

Every enterprise will in a number of ways confront market conditions that are unique, and very often methods used in selling goods cannot be transposed to the sale of other goods. This does not apply in any specific way to products from fisheries and aquaculture. Their marketing is similar to the marketing of other foodstuffs, although often faster shipping may be required, often by air, as fish products are delicate and highly perishable. Customer satisfaction and experience are important features of marketing, and customer loyalty to a product or service is of paramount importance to producers. As discussed in greater detail in Chapter 8, means have been devised of extending the shelf life of fresh fish fillets through techniques of chilling throughout the value chain, from the fishing vessel to the consumer's dinner plate.

Fig. 9.4 shows a model that is suitable for marketing in fisheries and aquaculture.[f] Marketing in fisheries and aquaculture, according to Fig. 9.4, starts in the enterprise, which feeds information about its production into an information system (the arrow marked 1), which forwards the information to the market (2), which provides feedback (3), which is carried to the enterprise (4). The marketing then begins in the lower part of Fig. 9.4, based on the enterprise's strategy and is carried into the market (6). The enterprise formulates a strategy based on its analysis by establishing objectives, planning, implementing the plan, and monitoring the results. For an enterprise its specialisation, or differentiation from other enterprises, is of the essence.

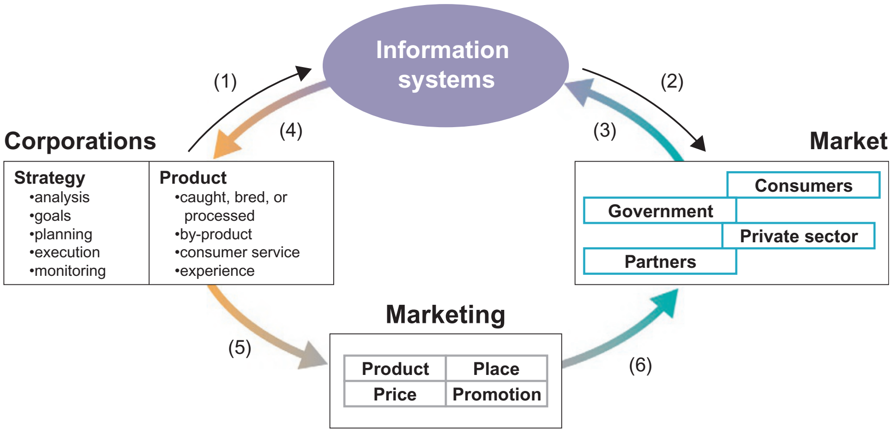

FIG. 9.4

Market model for fisheries and aquaculture.

When an entity embarks on product development and production, a number of features of the proposed product are important, but two features are particularly important: quality and price. It is possible to show in a two-dimensional market model where fish products are positioned in the marketplace based on price and quality; this is shown for some fish species in Fig. 9.5.[g]

Fig. 9.5 shows that lobster has the market position of being a high-quality product that sells at a high price. Next on the scale is farmed trout. Atlantic salmon is usually of high quality, but is sold at a low price compared to many other species because of the high supply. Jumbo shrimp, deep-sea shrimp, frozen crustaceans, and mackerel

FIG. 9.5

Fish species on a price and quality scale.

are medium quality and sell at neither a high nor a low price. Carp is by many considered low-quality, and it is priced accordingly.

Double-frozen shrimp, in the south-west part of Fig. 9.5, is not considered of high quality; in fact, double-frozen fish is rarely classified as high quality, but nevertheless frequently commands a relatively high price. Fig. 9.5 and the species of fish shown in the chart are a good example of the use of a convenient tool in marketing. A number of comparisons can be made on the basis of this model, apart from quality and price, for instance product choice and utilisation, cost, and market price. When enterprises sell the same product at different prices to many customers, this is referred to as 'price differentiation'. In a competitive market, the competition will normally preclude the possibility of different prices for the same product, but not always. An example of price differentiation could be the sale of fish products at home or abroad. The domestic price could be lower than the price elsewhere.

In marketing fish, the product is sometimes deliberately sold under a false name. For instance, ling may be sold as cod, thereby fetching a higher price. This sometimes occurs in restaurants, where cheap fish may be sold as a delicacy at a high price. Wrongly labelled fish in a restaurant, and even in supermarkets, is not uncommon. Sometimes fish are also given new names, when their previous names, like slimehead and toothfish, are neither appetising nor market-friendly. Slimehead is now commonly known as orange roughy, and Patagonian toothfish is called Chilean sea bass, both successful names in marketing fish.

In many businesses, only a small part of the product range will generate the lion's share of the sales. It is common for about 20% of the product range of a business to return about 80% of sales value. Product types are frequently categorised by sales value into three categories: A, B, and C. Category A comprises the products that sell best and account for 80% of sales. Category B comprises the products that account for the next 15% of sales, and Category C comprises the products that return the lowest income of the business in question, about 5%. These proportions are variable, but the general rule is that a small minority of product types return the largest part of the income. This type of analysis is known as ABC analysis.

An example of the use of ABC analysis is when product types are ranked by turnover, so that the product type that sells best is assigned the number one, the one that sells next best is assigned the number two, and so on. Category A then comprises product types numbers 1 and 2, that is to say the best sellers; Category B comprises the product types ranked from number 3 through 7; and Category C comprises product types ranked from 8 through 10.

Fig. 9.6 illustrates an ABC analysis and shows that 2 product types out of 10 account for 80% of an enterprise's sales, for instance where 2 smoked fish products out of 10 smoked products in a smokehouse return 80% of its revenue. Fig. 9.6 shows in general a situation where few product types account for the majority of sales, which can as easily apply to an enterprise in fisheries and aquaculture as any number of other operations.

Precise planning and market strategy are essential to success. Methods of the kind described previously are widely used with good results, and there are other methods.

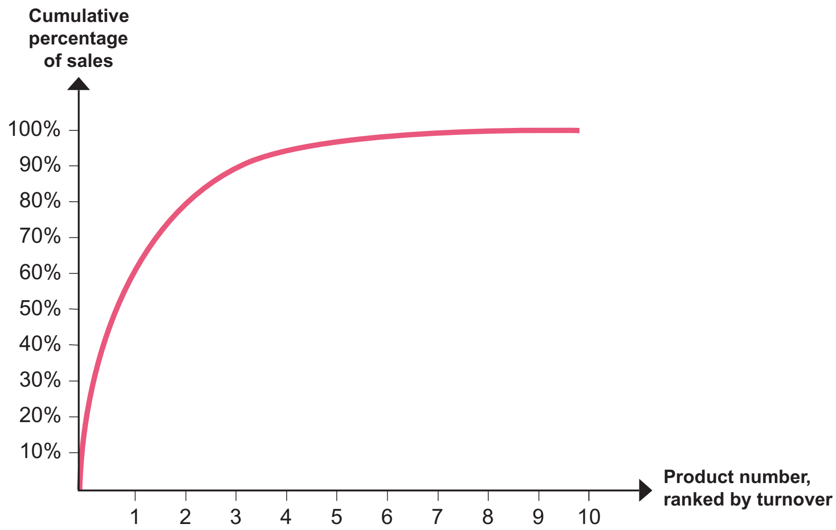

FIG. 9.6

ABC analysis.

For instance, surveys are frequently used to obtain a picture of the market. To give an example, in a survey conducted in the United States, France, the United Kingdom, Germany, Denmark, and Canada, people were asked about their interest in buying fish from each of the following countries: Iceland, Norway, Spain, the Faroe Islands, and China. Iceland received the highest mark in the survey, with 78% of responders giving Icelandic fish the grade of 8, 9, or 10 on a scale of 1–10. The survey also showed that fish was the product that responders could principally relate to Iceland. All information of this kind is important and useful in marketing.[h]

9.4 Other aspects of marketing

Markets for fish products are sometimes divided into two, that is to say a consumer market and an institutional market.[i] The consumer market refers to a market where fish is sold to a customer in a fish counter in a supermarket, a fish shop, in a street market, or at a restaurant. The institutional market comprises, for instance, cafeterias in schools or workplaces or even prisons. The latter market primarily emphasises low price and high volume, even at the expense of quality. However, the trend in recent decades has been solidly in the direction of producing more valuable products, and the value of each kg of, say, cod, salmon, and tilapia, has gone up significantly.

Marketing entails expenses of various kinds, which include making the products that the market wants, distribution cost, inventory cost, and advertising. Inventory and inventory management are an important aspect of the operation of any enterprise that manufactures goods, and perhaps this is particularly relevant in fisheries and aquaculture due to problems of preservation. The maintenance of inventory means having available at all times the goods that the customer needs or wants at the time that the customer needs or wants it, and of the quality that the customer expects. However, maintaining an inventory is expensive, so it is important for the inventory not to be too large. The delicate nature of fish flesh makes inventory management even more exacting. Distribution cost is determined largely by the type of transportation used. The lowest cost of transport per kg is by ship, followed by rail and then trucks; the most expensive means of transport is air freight. Even so, fish products are often transported by air.

The promotion of fish products has become much simpler, and at the same time much more extensive, as a result of advances in Internet and software technology. This is also apparent in the collection and processing of data: it is now much easier to find information than before and make comparisons of prices and product characteristics on the Internet, including information on buyers and their preferences. This advance in technology has enabled more accurate predictions about product sales, although this can be problematic because of the ever-changing people's attitudes and movements in the market.

If a business is in a position to decide on the price of a new product or service, various questions will arise as to what that price should be. Normally, the price will be based on the price of a similar product or service that is already in the market. However, this may not be appropriate in all cases. Perhaps an enterprise may consider it a feasible option to attempt to convince consumers, by means of an advertising campaign where the enterprise maintains (and hopefully substantiates), that its fish meals are better than the fish meals of competitors in one way or another, which justifies a higher price.

Selling a product at a good price in the long term requires stability and long-term business relationships. An enterprise needs to possess credibility, have good control over its shipments, and be able to guarantee security of supply of the product to buyers. Pricing and quality need to be stable. The enterprise has to engage in targeted product development, and the traceability of its products needs to be 100%. To that end, third-party certification can be of crucial importance.[j]

An enterprise's marketing strategy will normally have three principal aspects. A decision needs to be made on the expenditures to be allocated to marketing, including advertising, a decision has to be made on the allocation of advertising costs between individual products and market areas, and a choice has to be made of the market actions to be taken. This 'marketing mix' refers to decision making on four things: product or product type, that is to say what type product will be offered, the price of the product, the place of its sale, and the means of its promotion.

The marketing mix may have a different form, that is to say it may be focused on consumer value instead of the product itself, consumer cost instead of price, convenience instead of place of sale, and communications instead of promotion.[k] This is also better suited to the notion that value and communication are important to consumers. As Warren Buffett once said: "Price is what you pay, value is what you get" (Lowenstein, 1996, p. 114).

A key aspect of marketing is patterns of consumers' buying behaviour, which provide information on who the buyers are, from whom they tend to buy, when they buy, how, where, and why. The factors of influence in buying behaviour are many and varied and they can be of a personal, social, and psychological nature. Consumers have different patterns of behaviour in their purchases of goods and services. Some customers will focus on brand names, while others will have no interest in brand names and derisively refer to those who do as 'brand snobs'. Some will spend a great deal of time on research and thought, while others will buy goods or services without much deliberation. In the case of groceries, profound changes are occurring in consumers' buying habits, with consumers increasingly focusing on the source of their food and the sustainability of its production. Consumers are also often prepared to pay a higher price for environmentally sound and healthy food, which can heavily influence the actions of producers.

Large enterprises often entrust sales of their own proprietary brands to other companies, which means that their products can be sold in a much larger market than their domestic markets. This arrangement is well known in the fast food industry, as in the case of the American seafood restaurant chain Red Lobster and in the McDonald's fast food chain. The focus of marketing can differ. Sometimes the principal focus may be on producing large quantities of homogeneous products at a relatively low price, as in the case of Alaska pollock and capelin meal. In other cases, high-quality products may be sold at exorbitant prices, as in the case of caviar (Fig. 9.7).

FIG. 9.7

The Tsukiji fish market in Tokyo, Japan, the largest in the world (gjee).

It is common around the world for caught fish to be sold at fish auctions. Fish is usually auctioned off in limited, small lots, with each lot going to the highest bidder. There are some variations; sometimes bids get gradually higher, as bidders try to outbid one another (incremental system, also known as the English system), but sometimes the auctioneer begins with a high price and then reduces the price until a bid is made (decremental system, also known as the Dutch system). In the decremental system the bidder who makes the first bid receives the lot being auctioned in the market. The Dutch system is so called as it was first used in flower auctions in the Netherlands. Fish markets are usually regulated by government with regard to hygiene and other arrangements. The auctions are not open to just anyone, and buyers will often need to submit guarantees, such as bank guarantees, to cover their purchases.

Sales in fish markets are what is known as first sales, and the buyers will normally be restaurants, fish shops, and fish processing companies. The fish market system is a favourable form of doing business in a market economy, as the quality of the fish is reflected in the price. Fish markets therefore encourage proper handling of the raw material from the outset. The operations of fish markets will frequently engender innovations in processing and result in the establishment of small enterprises that specialise in processing species that may even have been discarded before the introduction of the markets.

When the auction at the fish market has been concluded, each buyer takes the fish purchased for transport to a fish shop, processing plant, or restaurant. Auctions of fish, and other foodstuffs, are quite common, often featuring well-established practises based on long tradition and custom. Unlike caught fish, farmed fish is often sold directly to restaurants or to processing plants for further processing without first passing through an auction at a fish market.

The trend in fisheries and aquaculture in recent years has been in the direction of high-quality products that sell at high prices. This is reflected in a constant effort to process the fish for human consumption, improve the utilisation of the fish flesh, and ready it for markets that are willing to pay high prices; also, sellers will try to be as close to their customers as possible.[1] As discussed earlier, means of transport can have huge significance, and with the growing value and rising prices of quality fish, air freight is increasingly being used despite its cost in order to get products to customers as quickly as possible.

The question is frequently raised whether fishing or fish farming and fish processing should be kept separate, meaning that the same parties should not engage in both the fishing or fish farming and the processing. This would have the benefit that fish processing enterprises would compete for all fish, for instance at auctions. However, it is not unreasonable for an enterprise to seek to have control over as much of its value chain as possible in order to maximise profit. Most of the largest fisheries and aquaculture enterprises control either their entire value chain or most of it.

9.5 Exports and imports of fishery commodities

Fish is variously processed for sale domestically or sold across borders for consumption or further processing. Exports from one country are obviously imports in another. The chart in Fig. 9.8 shows the value of the world exports of fish and fish products or fishery commodities in USD (2019 US price level).[m]

In 1980 the value of the world exports of fishery commodities was 50 billion USD; the value increased to 81 billion USD in 2000. By 2017, exports had reached 165 billion USD, more than three times the value of 1980. This is a huge growth in only 40 years at the same price level; over the same period, the world population had grown by 70%. Figs 9.9–9.13 show the exports and imports of fishery commodities for the five continents.

Fig. 9.9 shows the exports and imports of fishery products in Africa, where the value of exports was 1.6 billion USD in 1980; the value of imports at the same time was significantly higher, at 2.8 billion USD. This has now been reversed, as by 2017 export value, at the same price level, had reached 7.6 billion USD, while imports were up to only 5.3 billion USD. Africa has thus become a net exporter of fishery products, and exports could increase still more with time.

Fig. 9.10 shows the exports and imports of fishery products in the Americas, where the value of exports was 13.7 billion USD in 1980, higher than the value of imports, which at that time stood at 10.6 billion USD. Both exports and imports in the Americas increased greatly, and by 2017 exports had reached 33.5 billion USD, and imports were 30 billion USD.

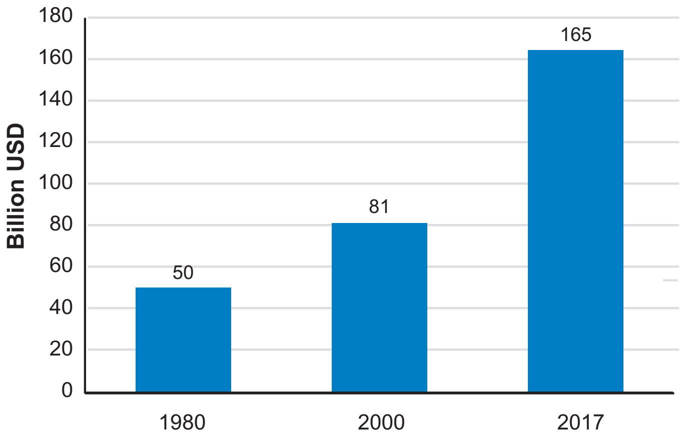

FIG. 9.8

World exports of fishery commodities in billion USD (2019 US price level) in 1980, 2000, and 2017.

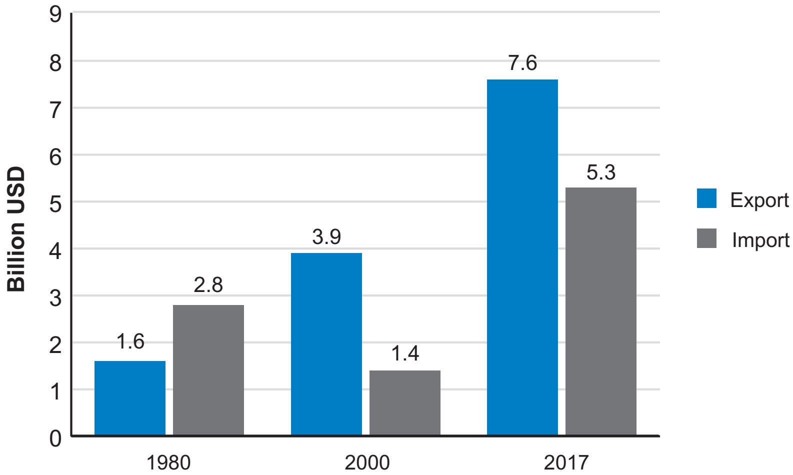

FIG. 9.9

Exports and imports of fishery commodities in Africa in billion USD (2019 US price level) in 1980, 2000, and 2017.

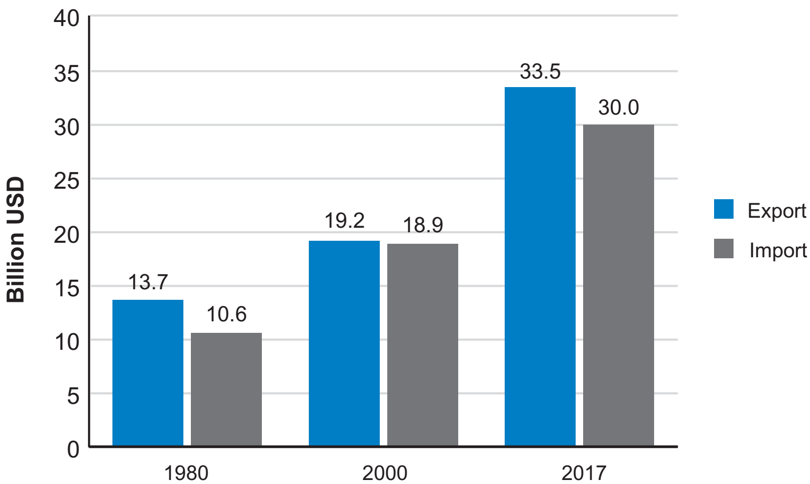

FIG. 9.10

Exports and imports of fishery commodities in the Americas in billion USD (2019 US price level) in 1980, 2000, and 2017.

Fig. 9.11 shows the exports and imports of fishery products in Asia, where the value of exports in 1980 was 13.3 billion USD, slightly less than the value of imports, which at that time stood at 14.6 billion USD. Both exports and imports in Asia increased greatly, and by 2017 exports had reached 62.6 billion USD, and imports

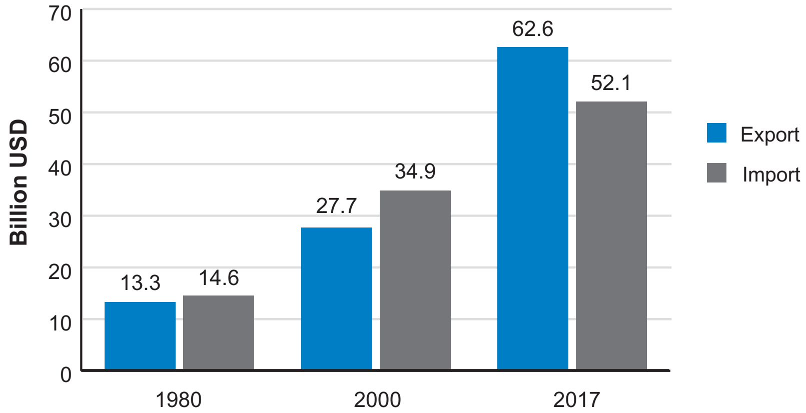

FIG. 9.11

Exports and imports of fishery commodities in Asia in billion USD (2019 US price level) in 1980, 2000, and 2017.

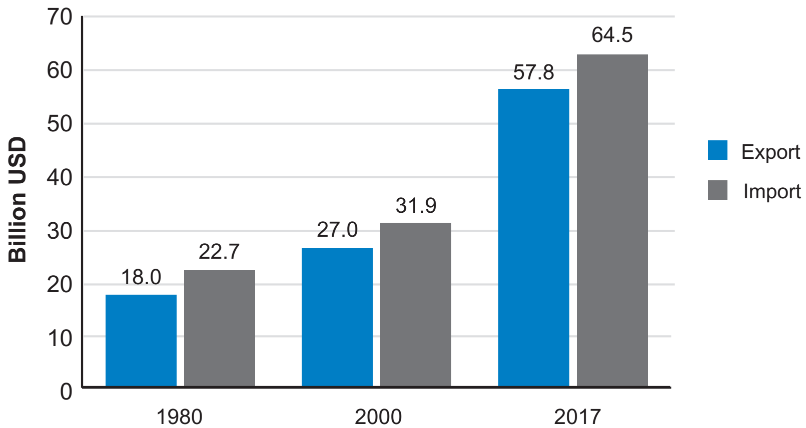

FIG. 9.12

Exports and imports of fishery commodities in Europe in billion USD (2019 US price level) in 1980, 2000, and 2017.

were 52.1 billion USD. This represents a huge increase in trading in fish over just a few decades.

Fig. 9.12 shows the exports and imports of fishery products in Europe, where the value of exports in 1980 was 18 billion USD, less than the value of imports, which at that time stood at 22.7 billion USD. Both exports and imports in Europe increased greatly, and by 2017 exports had reached 57.8 billion USD, and imports were 64.5 billion USD. This is an enormous increase in fishery product trade in just short of 40 years.

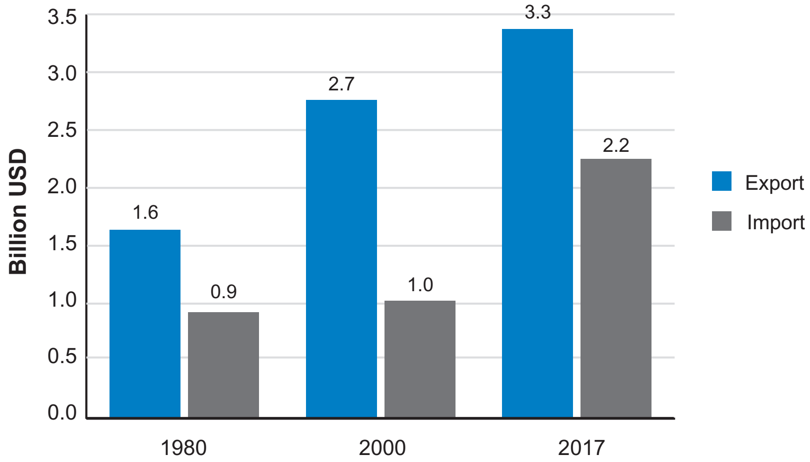

FIG. 9.13

Exports and imports of fishery commodities in Oceania in billion USD (2019 US price level) in 1980, 2000, and 2017.

Fig. 9.13 shows the exports and imports of fishery products in Oceania, where the value of exports in 1980 was 1.6 billion USD, considerably less than the value of imports, which at that time stood at 0.9 billion USD. Both exports and imports in Oceania increased significantly, and by 2017 exports had reached 3.3 billion USD, and imports were 2.2 billion USD. This is not a great deal of trade in a global context, so there is little doubt that there are various opportunities for increased business in fisheries and aquaculture in this region in the coming years and decades.

Table 9.1 shows the shares of continents in exports of fishery commodities in 2017. The table shows that Asia and Europe top the list by some distance with respective shares of 38% and 35%. The Americas lag behind with a 20% share, while the shares of Africa and Oceania are negligible in comparison with the other continents. There are many indications that Asia will extend its lead still further in exports of fishery products.

Table 9.1 Export value of fishery commodities in 2017 in billion USD (2019 US price level) by continent and relative shares.

Continents	Export value in billion USD	Share %
Africa	7.6	5
Americas	33.5	20
Asia	62.6	38
Europe	57.8	35
Oceania	3.3	2
Total	**164.8**	**100**

9.6 Dynamics of trade and increased interdependence

Technological advances have transformed trade, as they have transformed much other human activity. Electricity and its harnessing are probably the most important discovery made by humankind in the last 250 years. Electricity and external energy are among the revolutionary forces of recent centuries that have shaped today's environment, particularly from an economic standpoint, and these forces are being felt in fisheries and aquaculture. The spread of the Internet in our times is taking place even faster than the spread of electricity following its discovery.[n]

There is much talk in our times about the fourth Industrial Revolution. The idea is that the first Industrial Revolution occurred shortly after 1750, when the use of steam power was introduced. The second Industrial Revolution is seen as having originated in the late 19th century with the harnessing of electricity; this revolution is seen as having lasted into the mid-20th century. This is said to have been followed by the third Industrial Revolution, with the introduction of computers and the content industry. The fourth Industrial Revolution is seen as having started in 2016 with extensive technological advances. It is possible to see the trends of recent years as an industrial revolution, with all the progress in genetic sciences, artificial intelligence, and automation, but they are in fact a continuation of the second revolution after the Industrial Revolution and steam power around the 18th century. The technical progress in the 19th century and well into the 20th century is rooted primarily in the fact that humans became successful in utilising external energy sources, this began with the introduction of steam power.

It is not always clear whether technical progress originates in the United States, Japan, Germany, or some other technologically advanced country, but this is not really relevant in our day. Many modern corporations recognise no borders and operate in numerous countries. Economic activities no longer take any account of the old national borders, as they were forced to do in earlier times; this is particularly apparent in multinational trade.

Increased trade, featuring specialisation and division of labour, reduces the cost of production as a result of economies of scale. And it should also not be forgotten that comparative advantage, that is to say the ability to produce at lower opportunity cost, also creates opportunities for trade and greater benefit for all. Local factors of production create conditions for comparative advantage. Processes in fisheries, fish farming, and fish processing are governed largely by knowledge and by access to foreign markets, which will increasingly demand high-quality products. Increased international trade improves efficiency and improves living conditions. Transaction cost is also lower, and knowledge is disseminated much faster around the world than before.

Whether all these advantages are in fact advantages may be disputed, but it is clear that larger markets, greater speed, and lower transaction cost have a direct impact on improving living conditions (Fig. 9.14).[o] There are those who worry about globalisation, saying that it has a negative impact on the environment and that it entails only the freedom of capital, which flows across the world without restrictions

FIG. 9.14

Cargo vessel of the A.P. Møller—Mærsk Shipping company (Wikimedia Commons).

with little concern for the environment or nature in general.[p] Population growth has been extraordinary in the last century and the question is often raised whether Earth's natural resources will eventually constrain economic growth and population growth. The reasons that this has not become the problem that so many have feared is advances in technology and more efficient use of natural resources.

One of the most important factors of production in a modern society is human resources. With the increasing use of technology and the process of transformation to a knowledge society, the creation of value depends more and more on information, processing of information, and knowledge. This single factor of production has therefore become much more important in recent decades than before.

International commerce has in recent years been characterised by a significant growth in trade and services, changed communications and rules of international trade, and the endless potential of the Internet. This issue has therefore received a great deal of attention in a number of international venues and organisations, such as the World Trade Organization (WTO).[q] For years, work on reducing tariffs and eliminating restrictions on trade was conducted within the framework of the General Agreement on Tariffs and Trade (GATT). The role of GATT was subsequently assumed by the World Trade Organization (WTO), which has the objective of promoting liberalised international trade. As regards imports and exports of fish products, there has been a growing trend for fish destined for Western markets to be processed in Asian countries, where wage costs are far lower than in the west.

The economies of single countries are dependent on one another; that is to say, if there are changes in one economy the changes can affect other economies. The number of large, powerful international companies is steadily growing, and those companies exercise great influence as a result of their size. Rich countries are also dominant players, and their dominance extends to the developing countries, which can find it hard to exert any influence. The bigger and wealthier countries are therefore able to gain control of the resources of these less powerful countries, and this is sometimes reflected in fishing by powerful countries in the economic jurisdictions of poorer countries.

In any long-term planning, account must be taken of global trends. The first of those trends is the globalisation itself, which has brought about profound changes in an economic, social, and geographic sense. It has lowered barriers between countries, enabling the flow of capital and labour and merging market areas; in a relatively brief period of time the market for fish products has become the entire globe. At the same time, technological advances have contributed to more effective management, marketing, and trade. In an economy, every participant is seeking to derive the maximum benefits from any relative or absolute advantage, and, as we shall see, this is no less true of fisheries or aquaculture than of other industries, and many of the advantages and challenges faced by fisheries and aquaculture are similar to those of other industries, while others are unique to fisheries and aquaculture.

A second trend, both a consequence and a driver of globalisation, is the extraordinary transformation in the way that people and businesses communicate. All the innovations in means of communication across distances have caused revolutionary changes—the telegraph, the telephone, the telex, the facsimile machines—but the Internet, in comparison, is a quantum leap. Communication with virtually the entire world is now possible for anyone with a smart device and an Internet connection: blogs, Twitter, Instagram, Facebook, YouTube, and the list is growing, enable people—and businesses—to communicate in an entirely new way.

A third global trend that is relevant is the proliferation of nongovernmental organisations, NGOs, movements of people who will often focus their efforts on a single issue, for instance the environment, human rights, animal welfare, and so on. These organisations are playing an increasingly important role. Even though they do not always carry much weight in the economy, they can be hugely influential in politics, providing venues for individuals to express their opinions and make their influence felt; many of them directly affect fisheries and aquaculture.

Endnotes

a. For a discussion of the progress made in the countries of the world in recent decades see, e.g., Rosling, Rosling, and Rönnlund (2018), Einarsson (2019), and World Bank (2019, October 2).

b. For a discussion of the gap between rich and poor countries see, e.g., World Health Organization (2000).

c. For a discussion of globalisation see, e.g., Huntington (1984), Salvatore (2011), and Payne (2012).

d. For a discussion of corporate marketing see, e.g., Kotler and Armstrong (2011).
e. For a discussion of demand, supply and area of trade see Einarsson and Hall (2013).
f. For a discussion of marketing products see Colbert (2008).
g. For a discussion of farmed fish in a two-dimensional market model see Engle (2010).
h. For information on the survey of fish consumption in several countries see Íslandsstofa (2019).
i. For a discussion of this division of the market for fish products see, e.g., Chaston (1987).
j. To give an example of the importance of certification, the United Kingdom has been encouraged to eschew cod from the North Sea, as the Marine Stewardship Council revoked its certification of cod caught in the North Sea in 2019. The British people were also advised to consume other products instead, such as herring, plaice, or hake. Those who longed for cod were advised to pick Icelandic cod or cod from the Barents Sea.
k. For a discussion of marketing mix in this context see Bernstein (2007).
l. For a discussion of marketing in the fisheries sector see, e.g., Chaston (1987) and Knútsson, Gestsson, and Klemensson (2009).
m. For further details on the statistics of exports and imports of fishery commodities see Food and Agriculture Organization of the United Nations (n.d.-a).
n. For a discussion of the spread of electricity and the Internet see Bowden and Offer (1994) and Pew Research Center (2019, June 12).
o. The Danish shipping company A.P. Møller—Mærsk is one of the largest shipping companies in the world. For most of the 20th century the company was controlled by Mærsk Mc-Kinney Møller. He was the wealthiest man in Denmark and served on the boards of a number of companies. He was also the recipient of numerous awards. He was a generous man and donated more to science and the arts than any other Dane. His last donation was the new, magnificent opera house in Copenhagen, the city of his birth.
p. For a discussion of concerns relating to globalisation see, e.g., Auty (2001) and Kirby (2006).
q. For more information on WTO see, e.g., World Trade Organization (e.d.).

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CHAPTER

Finances

10

10.1 Basic financial principles of fisheries and aquaculture

Forming a business operation requires an assessment of capital needs; for instance, it may be necessary to buy premises or equipment. Cash will also be needed for supplies and other necessities. The first step is normally to prepare a precise capital needs assessment specifying what is needed, when it will be needed, and what it will cost. The time that this initial capital will be tied up will then vary greatly, depending on a number of factors. Capital in the form of a vessel or a factory may be tied up for 20 years, while funds invested in a small-scale fisherman's supplies may be tied up for 2 months or less. The financial situation of an individual or organisation will to a large extent be determined by the length of time that capital is tied up. Obtaining the capital necessary to start up operations is done through financing. The prospective owners of the enterprise may have their own cash that they wish to invest in the enterprise, or they may borrow cash from a financial undertaking, such as a bank.

It is not enough just to establish an enterprise with capital goods, inventory, and supplies. The enterprise also needs to be operated, and this requires cash. Working capital is needed if cash disbursements precede cash receipts in time. If 2 tons of tilapia are bought and processed, but the products are not sold until a month later, and not paid until a month after delivery, this results in a need for operating capital, because the raw material may need to be paid immediately, followed by wages for the processing and payments for supplies, such as packaging. Without capital and financing, combined with good financial organisation and targeted planning, no business will survive for long, whether in the fisheries and aquaculture sectors or any other sector.

Income (or revenue) is the proceeds from sales or production over a certain period, for instance the income of a fisheries operation deriving from the sale of a catch. Income and cash receipts are often the same amount, but can accrue at different times. Income accrues in the accounts of an enterprise at the time of sale, but the actual cash receipts often accrue later. The same applies to expenses (expenditures or cost) and cash disbursements. For example, the purchase of supplies may take place at the beginning of a month, while the cash disbursement may not take place until the end of the month. Cash receipts and cash disbursements alter the liquid assets of an undertaking, that is to say its bank deposits, or cash.

In fishing, it needs to be taken into consideration that where there are quota systems in effect, an enterprise will need to work with an issued quota, which is

Fisheries and Aquaculture. https://doi.org/10.1016/B978-0-12-821056-7.00015-9

sometimes based on past fishing experience. Those who have no such past experience are not issued any quota, in which case they need to purchase access to the resource by renting or buying quotas from other enterprises. This costs money and can often make financing difficult. These special conditions restrict recruitment in the sector, that is to say the entry of newcomers, so that the system in fact constitutes a barrier to entry (Fig. 10.1).

The need for working capital is often the most difficult problem faced by business undertakings in their day-do-day operations. This need may differ depending on the nature of the business, and periodic fluctuations can be an influential factor. It also needs to be kept firmly in mind that capital costs money. Normally, capital can be obtained on rental terms, that is to say a borrower pays interest on borrowed capital. Underestimating the need for working capital has been the downfall of many business undertakings. A carefully crafted operating plan with details of prospective income and expenses over a specified period of time, for instance the following year, is a prerequisite for successful operation. Many operational aspects of fisheries and aquaculture also entail a great deal of financial risk, so careful financial planning in the sector is a condition for successful operation. Normally, an enterprise will seek to finance assets for a period that is equivalent to their lifetimes. Thus short-term assets are frequently financed by means of short-term borrowings, while long-term borrowings, normally referring to loans taken for a period longer than 1 year, are the norm for investment in long-term assets. Financing the purchase of a fishing vessel, for instance, may require a loan term extending over decades.

FIG. 10.1

Fish farming in Greece (tetiana).

An illustration of money and its role

Money first appeared on the scene when bartering had become so complex that simplification in some form had become unavoidable. Initially, money was a representation of the value of a certain quantity of a commodity. For a long time, money had the value of the commodity that it was made of, as in the case of gold or silver coins, where the quantity of gold or silver in the coin had a specific universally accepted value. In time, kings and other personages of power began to guarantee the value of a simpler form of money, often by imprinting their coats of arms. Holders of such coins were assured that they could present themselves and obtain the value of the coins in gold or other comparable commodities. Much later, a simplified form of money was introduced, including paper money, the value of which was guaranteed by government.

A point that may be worth mentioning is that the head of state monopolising the mint could use it as a source of income by stamping a higher value on the coin than the metal it actually contained. Roman emperors used this liberally, and in the end they destroyed their own money. This is known as seigniorage, the first inflation tax.

The traditional definition of money is that it is tender that can be used to purchase goods and services, but money can actually be used in three ways. First, it is tender. A person can take money to a shop and purchase goods, where an exchange is made of the money for a certain quantity of goods. Second, money is a measure of value. A pound of cod will cost a certain amount of money, while a pound of tuna will cost another amount. Each can be valued in terms of currencies such as dollars, pounds, or euros. Among themselves, these currencies will have a relative value expressed as an exchange rate, meaning that one currency can be used as a measure of another. Third, money can be used to conserve value. The value of something can be preserved in the form of money, whether under a mattress or in a deposit account, for use at a later date.

There are numerous other assets that can perform these three functions, that is to say as tender, measures of value or means of conservation. To give an example, the tender in prison camps in World War II was not in the form of bills, which would have been worthless to prisoners in a prison camp if they existed at all, but cigarettes. A cigarette-based economy was formed with its own tender that served all three functions.

Inflation is a general increase in price levels over a longer term. Deflation, conversely, is a decrease in price levels over a longer term. Even if the price of a good goes up by 10%–20%, however, this rise does not represent inflation; that requires a general increase in prices. But although it is the increase in prices that causes inflation, the perception is that it is the money that is losing its value, and in extreme cases money may become virtually worthless. There are various examples of this happening in recent history: hyperinflation occurred in the Weimar Republic in Germany in the 1920s, in Zimbabwe after 2007, and, most recently, in Venezuela after 2016.

Money and greed for money are a recurrent theme in literature. One example is the story of Midas, an ancient king in Phrygia in Asia Minor, who made a wish to the gods that everything he touched would turn into gold. His wish was granted and everything he touched was instantly transformed into gold, including his food and his daughter, so that his happiness was short-lived. Midas appealed to the gods to take back their gift, and so they did. Another example is that “thirty pieces of silver” have become a symbol of betrayal and bribery, at least for Christians, since Judas betrayed Jesus into the hands of his executioners for that sum.

Yet another familiar story is that of the Merchant of Venice in Shakespeare’s play of the same name, where a Jew named Shylock lent a large sum of money to another merchant and accepted as security a pound of the merchant’s flesh. The merchant then suffered a series of setbacks, the loan fell due, and Shylock demanded his pound of flesh, even though an offer was made to pay back double the original sum of the loan. The matter was referred to the courts of law and the wife of one of the merchant’s friends, Portia, masqueraded as a man and defended the merchant on the grounds that Shylock could have his pound of flesh, but that if any blood were spilled in the process, the contract was null and void. The judges accepted this argument, Shylock lost the case and was ordered to pay a large fine.

10.2 Financial analysis

A fundamental feature of the finances of any business undertaking is accounting, where everything relating to the operation and finances of an enterprise is recorded in an organised manner. The annual financial statements of enterprises consist of a balance sheet, an income statement (also known as a profit and loss account or statement of earnings), and a statement of cash flows. An income statement shows the results of business operations over a fixed period, normally a year, by listing the enterprise's income and expenses. A balance sheet shows the assets and liabilities of an undertaking at a certain point in time, normally at the turn of the year. The difference between assets and liabilities is referred to as equity. The income statement reflects the flow between two points in time, often from the beginning to the end of a single year. The statement of cash flow shows changes in holdings of cash between periods.

Accounts thus provide information both on an enterprise's past performance and on its position on the date of its balance sheet, so the data that the accounts contain are useful in planning for the future. Financial accounts are also used to calculate a variety of financial ratios that are useful for a number of purposes. A financial ratio is a value expressed as a relative quantification of two figures that sheds a light on a certain aspect of a business undertaking's operation. If an enterprise's turnover in a single year is 50 million dollars, for instance, and its profit is 1 million dollars, its profitability ratio, the proportion of profit of the turnover, which is a financial ratio, is 1/50, or 2%.[a]

Analysis of financial information from an enterprise's operation can be explained using an example from a fish farming company where data are available on financial standing and operations; all figures are in USD. Bank deposits for this enterprise (cash) are 5 (5000 USD); livestock is valued at 25; housing, pumps, and other assets at 70; long-term debts at 50 and short-term debts at 20. Sold products are 120 (120,000 USD), feed cost is 50, wages 10, and other operating cost 30. Depreciation is 10 (10,000 USD), interest 8, and taxes 2. Table 10.1 shows a simplified balance sheet for this enterprise.[b]

Table 10.1 Balance sheet of a fish farming company in USD 1000.

Balance sheet			
Assets		**Liabilities and equity**	
Current assets			
Cash	5	Short-term debt	20
Livestock	25	Long-term debt	50
Fixed assets	70	Equity	30
	———		———
	100		100

To the left in Table 10.1 are assets. Assets are current assets and fixed assets. Current assets are cash, at USD 5000, and livestock, at USD 25,000, for a total of 30,000 USD. Fixed assets are USD 70,000. Total assets are 100,000 USD. To the right in Table 10.1 are liabilities and equity. Short-term debts are 20,000 USD and long-term debts are 50,000 USD. Debts, or liabilities, amount to a total of 70,000 USD. The difference between assets and liabilities, that is to say the equity, amounts to 30,000 USD. Of the equity, 10,000 USD could, for instance, be common stock of the company, that is to say shares held by shareholders, although that is not shown in this simplified example.

Table 10.2 presents the fish farm's income statement, showing income and expenses. It shows that income from sales is 120 (120,000 USD). Feed cost is 50,000 USD, wages are 10,000 USD, and other operating expenses are 20,000 USD. The subtotal of the cost is therefore 80,000 USD. If this cost is subtracted from income, the resulting figure is 40,000, which is referred to as EBITDA, that is to say Earnings Before Interest, Taxes, Depreciation, and Amortisation. EBITDA is widely used when comparing the profitability of enterprises, as it excludes the impact of the different financing methods and accounting procedures of the enterprises being compared.[c]

Financial ratios are useful tools in analysing the operations and financial standing of undertakings. Ratios can be used for three purposes. First, a ratio can be compared with the same ratio for the same undertaking from an earlier period, e.g., by comparing the profitability ratio of a fish processing enterprise in 2019 with the same ratio in 2020 to measure progress. Second, a ratio can be compared to a projected ratio of the same fish processing enterprise, i.e., reality is compared with estimates, and, third, a ratio can be compared with the corresponding ratio of another undertaking over the

Table 10.2 Income statement of a fish farming company in USD 1000.

Income statement	
Sales	120
Expenses	
Feed cost	50
Wage cost	10
Other operating cost	20
	– – –
Subtotal	80
EBITDA	40
Depreciation	10
Interest	8
Taxes	2
	– – –
Net income or profit	**20**

same period, e.g., by comparing the profitability ratio of one fish farm in the 2020 season with the corresponding ratio of another fish farm over the same period.

A number of useful ratios can be generated from the above data on a fish farm. Return on assets is profit divided by total assets at the beginning of the period. Return on turnover, or profit margin, is profit divided by turnover, that is to say sales over the period in question. This is a much used ratio in business operations. Return on equity is profit divided by equity at the beginning of the period. If equity is all the shares in a company, this ratio shows the return on share capital. As regards profitability, care must be taken to compare comparable things. The reason is that the lower a company's equity, the less profit is needed to achieve the same profitability. An example of this could be a comparison of two companies that return the same profit in absolute terms. The company with the lower equity is then delivering a higher return on equity. Nevertheless, this does not give any indication as to whether that company is better run or not, as limited equity and high leverage can result in high return on equity. The higher rate of return could have been achieved, for example, by increasing a company's debt instead of its share capital.

Current ratio is current assets divided by short-term debts, or current liabilities. This ratio can be used, for instance, to assess a company's liquidity, meaning its ability to pay its debts. Short-term debts need to be paid within the year, and current assets are assets that are tied for less than 1 year. It is often maintained that the current ratio needs to be 1, or higher, for a company to be considered sound. Equity ratio is equity divided by total assets. This ratio is often used in comparing companies. Table 10.3 shows the previously mentioned ratios and their calculation based on the fish farm in Table 10.2.

The productivity of fishing, farming, and processing can be calculated by looking at the annual sale value of production over a period of several years at a fixed price level and comparing it with the resources, that is, on the one hand, the number of all the employees in the sector in the year in question (productivity of labour), and, on the other hand, the value of the assets used in the production in that year (productivity of capital).

These kinds of calculations of labour productivity and capital productivity are of interest not only to individual companies, but also to government. Companies can compare their trends with the general domestic trend, and, using this methodology, governments can compare productivity trends in different sectors and draw conclusions that are useful in policymaking.

Table 10.3 Ratios for a fish farming company.

Return on assets = profit/total assets = 20/100 = 20%
Profit margin = profit/sales = 20/120 = 16.7%
Return on equity = profit/equity = 20/30 = 67%
Current ratio = current assets/short-term debts = 30/20 = 1.5
Equity ratio = equity/total assets = 30/100 = 30%

The performance of enterprises engaging in fisheries and aquaculture can differ greatly. As an example, Fig. 10.2 shows the distribution of performance in fishing and fish processing in Iceland.[d] As the chart shows, 50% of the total number of enterprises are operated at a loss, while 35% show relatively good performance, and about 15% show very good results, at over 20% of turnover. This is a huge variation in performance, and it shows that averages are not always to be trusted in the context of analysing the performance of all the enterprises in a sector.

The data summarised in Fig. 10.2 can be of significant help to enterprises in their operations to observe how they are doing in comparison with other enterprises. It is therefore important for national statistics offices, in collaboration with tax authorities, to gather data of this kind and make them available in an accessible form.

The purpose of the example given here is to demonstrate the great variance in performance and show the great number of enterprises that are experiencing very difficult operations at the same time that other enterprises are showing acceptable or even excellent results. It is not necessarily the largest enterprises that return the best results. Note, also, that enterprises may shift between levels of performance, i.e., they may perform well in one year and poorly in another. So, generalisations are not always helpful, and care must be taken to avoid overreliance on averages. However, although this is not highlighted in Fig. 10.2, the comparison revealed that the enterprises with the poorest results also had the poorest equity position. Those enterprises are therefore confronting difficulties in their operations. It comes as no surprise that poor results and a poor capital situation go together.

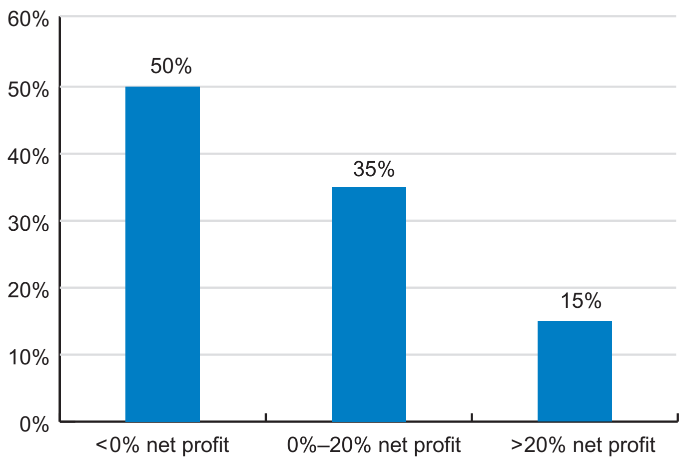

FIG. 10.2

Profit distribution of enterprises in fishing and fish processing.

10.3 Competitive advantage and investments in technology and innovation

The competitive advantage of enterprises is based on operating results; everything that is above what would be considered normal returns translates into competitive advantage. However, there are those who point out that this definition is not precise enough, because profit beyond normal profit can arise out of factors such as dominant position, which enables an enterprise to drive or keep competitors out of its market; it can also arise out of collusion, or price fixing, which enables two or more enterprises to charge abnormally high prices. Those factors have nothing to do with competitive advantage. It will be assumed here that an enterprise or other organisation has a competitive advantage if it can create more economic value than a competitor in the same competitive market.[e] The economic value created by an organisation through the production of a good or service is the difference between the perceived benefit of a buyer and the economic expense of the organisation. The first step towards achieving a competitive advantage is superior differentiation and/or lower cost.

Fig. 10.3 shows average monthly wages within the OECD on a comparable basis (PPP) in 2018 and it illustrates a huge difference in wages. Let us compare the highest and lowest wages within the OECD, that is to say in Iceland and Mexico, as shown in Fig. 10.3. Monthly wage costs in Iceland are approximately four times higher than in Mexico in USD at PPP.[f] Average wages in Iceland are about 40% higher than the OECD average, and the average wages in Mexico are about three times lower than the OECD average. Both countries compete internationally in the market for fish

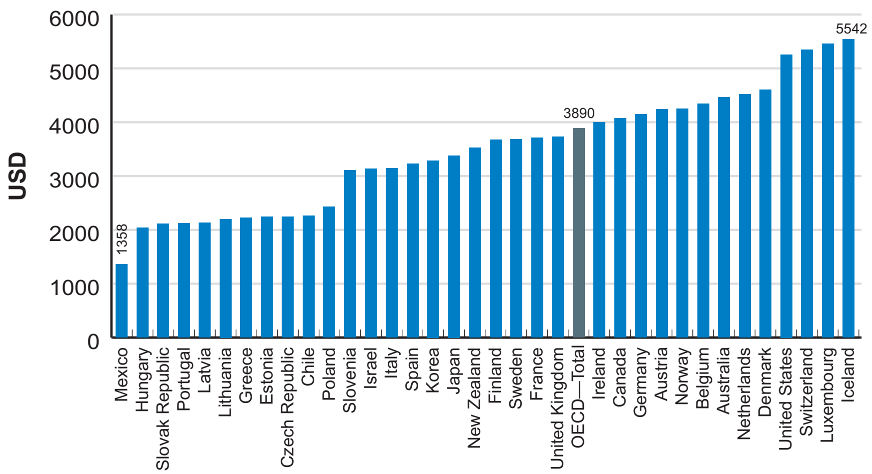

FIG. 10.3

Average monthly income in USD at purchasing power parity (PPP) in 2018 in OECD countries.

from both fishing and fish farming. This comparison highlights the different situation of enterprises in these two countries. Wages and related expenses are an important consideration for enterprises operating in a global market like the fisheries and aquaculture market, and this is an example of a simple measure that enterprises and governments can use to assess their competitive positions. However, it needs to be borne in mind that even if wages are high in a country, if productivity is also high, the weight of wages in the cost of production may not be excessive.

When enterprises create more economic value than their competitors, either by differentiating their goods or services from the competition or by operating at lower cost, they should have a competitive advantage. They are therefore in a position to create excess value for all the enterprise's stakeholders.[g] Excess value can be created for both the buyer and the seller if an enterprise has a competitive advantage. The economic cost of an enterprise is then defined as all the cost, direct and indirect, that accrues in the production of a good or service. The direct cost is wages and other operating expenses, while the indirect cost is the cost that is more difficult to perceive in an enterprise's accounts, for instance cost relating to the capital tied up in the operation in the form of equity.

If an enterprise is able to sell its goods at a higher value than the economic cost, this creates excess value. It is then the decision of the management of the enterprise how to share the excess value between the enterprise itself and its customers. It also makes a difference whether the competitive advantage is temporary or permanent, or at least long lasting. Organisations that enjoy an entrenched competitive advantage may command a value-adding strategy that can be difficult for competitors to emulate. However, even if a competitive advantage is lasting and entrenched, that does not mean that changes in the business environment cannot impact, or even breach, the competitive advantage; this can result from factors such as a catch failure, changes in technology, innovation, or even changed consumer behaviour, to mention only a few examples.

There are various methods of measuring and evaluating competitive advantage in individual countries. One example of such a measurement is the Revealed Comparative Advantage Index. This index is calculated on the basis of the share of a sector in Country A in the total exports of Country A, and the share of the sector in the world. So, if the share of a sector of Country A divided into the share of the sector in the world is higher than 1, then that would be an indication of a competitive advantage. This index is not a perfect way to measure competitive advantage, and it is more applicable to comparisons of sectors than single enterprises. The assertion that a country's sector can only have a competitive advantage if it possesses a large share in exports should therefore not be made without reservations. There are numerous factors that can affect competitive advantage, so looking only at this measure would be an oversimplification.[h]

The technological advances of recent years in fisheries and aquaculture have been nothing short of revolutionary, as discussed earlier in this book. These advances result in pressure to invest in order to secure or maintain competitiveness. If wage costs are high, that creates an incentive to invest in automation, which in turn will usually lead to investment in larger premises. Also, in the case of fisheries, requirements for better utilisation and handling of catches call for increased investment and innovation.

Innovation in fisheries and aquaculture is extremely important to boost increases in productivity, and research has indicated that investment in innovation has a positive impact on competitive advantage. The better an enterprise attends to innovation, the greater will be its competitive advantage.[i] When concentrations occur in fisheries and aquaculture, this may result in economies of scale and thereby increase investment (Fig. 10.4).

To estimate investment needs in fisheries and aquaculture, it is reasonable to assume that investments are similar in amount to depreciation of capital stock, that is to say plant, equipment, etc. There may be periods where investment falls short of the maintenance of capital stocks, and there may be periods where enterprises pay off their debts and begin preparing to meet accumulated investment needs. Investments in fisheries and aquaculture can therefore fluctuate widely, with diverse factors, such as catch projections and product prices, performance and results, trends in demand, changes in technology, and conditions in the financial markets, influencing decisions to invest. Capital stock in processing operations will, in the long term, trend upward, notwithstanding these natural fluctuations in investment. The reason is that as technological advances increase, processing operations will become more capital intensive, and the number of untrained employees will fall, offset to some degree by an increase in the number of employees with technological training.

FIG. 10.4

Salmon farming in Arctic waters (Konstantin Shevtsov).

There are numerous ways of assessing the feasibility of an investment. Returns on investments will depend, among other things, on the level of leverage of the enterprise making the investment and the amount of its equity. In evaluating investments, one common way is to compare the investment with an investment in the financial markets and the returns that can be obtained in those markets. The return in the financial market is market interest, or market yield, so the investment must give better returns than market interest to be worthwhile. If it does not, it is more profitable not to undertake the investment and invest instead in the financial markets at market interest.

Another common method of assessing an investment is the net value method, where a calculation is made of what an investment will return in the future. If the future discounted return on the investment is higher than the acquisition price of the investment, for instance a fishing vessel, then the investment is advantageous.

This can be explained using an example. A fish farm has the option of investing in specialised pumping equipment that costs 90,000 USD and will last for 3 years. It is assumed that the equipment will return income in excess of cost in the amount of 30,000 USD at the end of the first year of its life cycle, 40,000 USD at the end of the second year, and 50,000 at the end of the third year. It is then clear that if the returns of the three individual years are added up, the end result is 120,000 USD (30,000 + 40,000 + 50,000), which is more than the original acquisition price of the investment. However, a payment received at the end of a year is worth less than a payment received at the start of the year, as normally an amount can be put into savings, for instance in a bank, and return market interest for 1 year.

Accordingly, the net present value of future payments needs to be calculated; this is done in Eq. (10.1). It is assumed that the interest rate that the enterprise needs to pay (i) is 5%; (i) is therefore 0.05. This means that the invested amount is discounted using the value $(1+i)$ for each year, or $(1+0.05=1.05)$.

$$\begin{aligned}\text{Net present value} = \text{NPV} &= \frac{30{,}000}{(1+i)} + \frac{40{,}000}{(1+i)^2} + \frac{50{,}000}{(1+i)^3} \\ &= \frac{30{,}000}{(1+0.05)} + \frac{40{,}000}{(1+0.05)^2} + \frac{50{,}000}{(1+0.05)^3} = 108{,}044\end{aligned} \tag{10.1}$$

According to Eq. (10.1), the net value of the investment is 108,044 USD, which is more than the original acquisition price of 90,000 USD. The conclusion is therefore that the investment is advantageous. This example shows in a simple manner the procedure used in investment analysis, and this procedure and related procedures are used in fisheries and aquaculture like other industries.

10.4 State support in fisheries and aquaculture

Raising taxes on corporations reduces their capacity for investment, including investment in innovation. A number of studies were conducted of business enterprises in the United States in 1990–2006; their conclusions indicated that enterprises submitted fewer patent applications after tax hikes, investment in research and development decreased, and fewer new products entered the market. The studies also indicated that innovation recovers more slowly following tax hikes.[j] If innovation supports and increases competitive advantage, full government subsidisation of innovation might be seen as an appropriate government response. However, it is not quite that simple. In many countries, ways are being sought of increasing the number of start-up companies, but the indications are that heavily subsidising such companies is not necessarily beneficial. For example, incentives to a start-up enterprise in the form of rebates on income tax on their profit can have the consequence that the enterprise will take less risk. If the risk appetite is reduced, it is possible that the incentive to do still better will not prove sufficient to maintain a competitive advantage, or increase it (Fig. 10.5).

State aid, or government subsidies, to fisheries and aquaculture, fisheries in particular, is common around the world in various forms. Fishery subsidies can be defined as direct or indirect financial transfers from government to fisheries, which enable the sector to return a greater profit than otherwise would be possible. Subsidies usually take the form of direct grants to enterprises in one form or another. Around the mid-20th century, and in the following decades, subsidies in the form of state aid were seen as positive, but in recent years serious doubts have been raised as to their justification. The reason is that subsidies are now regarded as having a negative rather than a positive impact on the sector, as state grants may not only reduce efficiency and disrupt competition, but also lead to overfishing.[k]

FIG. 10.5

Luanda, capital of Angola in Africa (Adriana Mahdalova).

However, while it is generally undisputed in economics that state support distorts the competitive environment, reduces efficiency, and leads to overfishing, subsidies are distributed based on political decisions, where economic reasoning is outweighed by other reasoning, often cultural or historical, as in the case of widespread state support to agriculture in many countries.

In a report of 1993 from the Food and Agriculture Organization (FAO), the opinion was expressed that state support for fisheries represented the difference between income and expense in the fisheries sector, and that this difference amounted to 54 billion USD per year. In 1998 the World Bank assessed state support in the fisheries sector at an annual 14–20 billion USD. The Organisation for Economic Co-operation and Development (OECD) has estimated that state support in the member countries of the OECD amounted to 6.4 billion USD per year from 1996 to 2006. For comparison, grants to agriculture within the OECD amount to an annual total of approximately 300 billion USD, 50 times more than the grants in support of fisheries.[l]

State grants to the Norwegian fishing industry in the 1990s corresponded to approximately 40% of the catch value; by 2014 this amount was down to 0.5% of the catch value. These grants, which, among other things, led to a huge increase in unneeded effort or excessive fleet size, have now virtually disappeared in Norway.[m]

A report[n] issued by the European Parliament revealed that state support to fisheries has changed in recent years. Originally, the support was designed primarily to increase fleet capacity, thereby contributing to overfishing and inefficiency. Now, efforts are more in the direction of using grants to improve efficiency and prevent increases in effort and thereby overfishing. State support in fisheries is a topic of discussion in a number of international organisations, such as the Food and Agriculture Organization (FAO), the United Nations (UN), the Organisation for Economic Co-operation and Development (OECD), the European Union (EU), the World Trade Organization (WTO), and the World Bank.

About half of all the world's state support for fisheries is paid out in Asia, where fisheries are most extensive, about a quarter is paid out in Europe, and about one-sixth in North America. State support is most extensive in Japan and China, with about 20% of the support in each country. Since state support to fisheries is most prevalent in the developed countries, where the fisheries are conducted using larger, more technologically advanced and efficient vessels, state support is generally speaking to the disadvantage of the developing countries, where fishing is to a much larger extent carried out by smaller vessels.

The World Trade Organization (WTO) has specifically addressed state subsidies in fisheries, but no conclusion has as yet been reached. Various reforms regarding state support to fisheries have come under discussion, for instance reducing the subsidises, channelling them away from investments in increased effort, and thereby overfishing, increasing funding for gathering and recording data, research and education, focusing greater attention on the needs of the developing countries, and improving monitoring of state support and the implementation of fisheries management programmes.

In discussing state support to fisheries, it needs to be borne in mind that the support often stems from political reluctance to undertake the necessary streamlining and efficiency improvements needed to prevent overfishing and overinvestment. In many countries, fisheries are also a marginal issue in the context of national economies. In many cases, overfishing and overinvestment occur because of inefficient fisheries management systems and because of an unwillingness to observe the advice of scientists on harvesting that is designed to ensure the renewal of marine resources.

In the European Union, most of the fishery subsidies went to the United Kingdom, Denmark, France, Italy, and Spain. In 2009 13 countries in the European Union received grants that exceeded the value of the catch landed in their ports. No catches were landed in the ports of four countries, Austria, Slovakia, the Czech Republic, and Hungary, all land-locked countries, but they still received grants to fisheries in inland lakes and to aquaculture. Finland and Germany received state grants that by far exceeded the value of their catches; in Germany, subsidies to fisheries amounted to more than 150% of the catch value.[o]

State aid differs greatly by both type and country.[p] Table 10.4 shows that countries have used a variety of different approaches in subsidising and supporting fisheries. Subsidies have a long history and have been used, among other things, to enable selected fishing vessels to fish in the waters of other countries, and direct payments have been made to enable investment in new vessels or renovations of vessels, processing plants, etc.

Through its funding schemes, the European Union invested about 1.2 billion EUR in aquaculture in 2000–14. Another 1.7 billion EUR went to the sector in 2014–20. It has been pointed out that possibly the European Union has failed to direct its funds and investments where they could have done more good.[q] The subsidies are

Table 10.4 State aid in the fisheries sector.

Type of aid	Countries	Example of grants
State loans and guarantees	Poland, Spain, and Italy	State involvement in accident insurance and loans granted with interest below normal rates
Tax incentives	The United Kingdom, Denmark, France, Norway, and Spain	No licence fees paid, taxation allowance to seamen, tax rebates on fuel and sales tax
Direct payments to enterprises	France, Spain, and the Czech Republic	Compensation for catch failures, grants for purchases of vessels
Indirect payments to or from the sector	France, the Netherlands, Lithuania, Norway, Spain, and Germany	Ships given free access to landing ports, payments for fisheries management
Incentive in fisheries-related sectors	France and Sweden	Rapid tax depreciation, reduced capital gains tax

spread over a number of small projects, and payments are handled in different ways from one country to the next. The ideology of using state aid in aquaculture in a similar manner as in fisheries and fish processing revolves around improving production efficiency through the introduction of innovations of various kinds that can reduce average costs of production. The initial goal of grants and subsidies in aquaculture was to increase production, but care should be taken not to promote all species equally. The focus needs to be on promoting improved and more environmentally sound production of nutritive products and on meeting customer desires and needs.

Endnotes

a. For a discussion of the basics of corporate finance, among other things in fisheries and aquaculture see, e.g., Engle (2010), Kleih et al. (2013), Dorfmann (2014), and Brigham and Ehrhardt (2016).
b. For a discussion of financial ratios and financial analyses see, e.g., Chaston (1988a), Engle (2010), and Dorfmann (2014).
c. Since tax payments are omitted in the calculation of EBITDA, the financing cost of the enterprise is in fact being ignored. Since interest payments are deductible costs in the calculation of income tax, tax payments are omitted in the calculation. If this were not done, it would be very difficult to compare a lightly leveraged company that pays high taxes and a heavily leveraged company that pays lower taxes because of high interest expenses. Omitting depreciation is more controversial, as in most operations it is inevitable to incur cost sooner or later to meet the obsolescence or scrapping of assets.
d. This example of the variance in performance by fisheries and fish processing enterprises in Fig. 10.2 is based on real figures for all the enterprises engaging in fisheries in Iceland in 2001–19, about 20 years see Einarsson (2016) and Statistics Iceland (n.d.).
e. For a discussion of competitive advantage see, e.g., Porter (1998b) and Peteraf and Barney (2003).
f. For a discussion of wages in the OECD see OECD (n.d.).
g. For a discussion of economic value and excess value see Peteraf and Barney (2003).
h. For a discussion of the Revealed Comparative Advantage Index see, e.g., Polymeros and Katrakilidis (2008), Latruffe (2010), and Karelakis, Loizou, and Vladu (2017).
i. For a discussion of investment in innovation see Dereli (2015), Kuncoro and Suriani (2018), and Distanont (2020).
j. For a discussion of innovation and tax incentives see, e.g., Haufler, Norbäck, and Persson (2014) and Mukherjee, Singh, and Zaldokas (2017).
k. For a discussion of state aid to fisheries see, e.g., Schrank (2003) and Sumaila et al. (2010), and Sumaila, Lam, Le Manach, Swartz, and Pauly (2016).
l. For a discussion of state support for fisheries see, e.g., OECD (2006b) and the World Bank (2017).
m. For a discussion of state support to Norwegian fisheries see, e.g., Cox and Sumaila (2010) and Steinsham (2010).
n. The Report of the European Parliament on state subsidies in fisheries is discussed in European Union (2013).

o. For a discussion of EU state aid see, e.g., Schroeer, Sakai, Vulperhorst, and Białaś (2011) and Guillen et al. (2019).
p. For a discussion, with examples, of state aid to fisheries see, e.g., Schrank (2003), Schroeer et al. (2011), Isaksen, Hermansen, and Flaaten (2015), and OECD (2015).
q. For a discussion of the impact of grants to fisheries in the European Union see, e.g., European Court of Auditors (2014).

CHAPTER

Globalisation

11

The concept of globalisation covers an extremely varied and complex process that now affects most spheres of human life. As the term globalisation implies, these changes are not limited to regions, but extend around the globe. Profound changes have occurred in the world's economies in recent decades, with a radical transformation in the flow of capital, people, ideas, information, and goods across borders, and trade barriers have been lowered. In the popular perception, the world has shrunk, communications are immediate and contact networks have expanded exponentially. But people also perceive globalisation in different ways, and people in the developing countries experience globalisation differently from people in the developed countries. Globalisation therefore affects people in different ways, depending on where they live in the world.

11.1 Globalisation in fisheries and aquaculture

Fisheries and aquaculture go back centuries, and large-scale fishing for herring and cod is believed to have been known in Europe in the 13th century, particularly in northern countries. In the 13th to 16th centuries fish was among the principal goods traded in Europe, so the history of exporting fish is quite long. However, the world population is growing rapidly, so the need for protein-rich and wholesome food is increasing at pace, which encourages not only increased fishing and increased aquaculture, but also increased trading in the products from these sectors, facilitated by the profound economic changes of recent decades, with the flow of capital, people, goods, and services increasing steadily, which contributes to increased foreign investment.

Global markets for fish and marine products have changed radically in recent decades, particularly from the end of the Second World War, and they continue to change steadily with changing diets and lifestyles in many countries; the image of fish as a light and particularly healthy food plays an important role in that regard. It has been forecast that the markets for global seafood will reach 155 billion USD in value by 2023.[a]

The three largest markets for processed fish and seafood are China, India, and Japan, and the largest export countries are the countries of the European Union, China, and Norway. In the quest for new opportunities, with falling production costs and more efficient investments, fisheries operators in various locations in the value

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chain have turned their attention increasingly to opportunities in foreign markets. Globalisation encourages the proliferation of multinational corporations pursuing horizontal consolidation and vertical integration. These developments are fostered by new and more effective preservation and packaging technologies, as well as far more efficient distribution chains. Integration and still further globalisation are therefore the future for enterprises in the fisheries and aquaculture sectors (Fig. 11.1).

Markets have been brought much closer together, and they have become more integrated as a result of liberalisation and the removal of various barriers to trade, investment and services; at the same time, information and transport technology have also advanced. The fisheries sector has undergone steady internationalisation over the past decades, driven principally by a quest for access to resources and raw material. The increasing demand for fishery products has been reflected in steady reductions of import tariffs for fishery products in many counties. With the growth of the world population, the calls for food security and sustainability will become steadily louder, and countries will need to seek all possible ways to secure access to the resources that they need. This will have specific application to fishing and aquaculture.

There are several global trends in progress that need to be examined and understood in this context, including factors such as the impact of climate change on fisheries and aquaculture, wild fish stocks nearing or exceeding maximum sustainable yield, aquaculture's rapid expansion, the rise of online sales and product globalisation, the worldwide growth of a health-conscious middle class, and the demand for food security. All these factors contribute to opening markets for marine products,

FIG. 11.1

Globalisation (Tuomas Lehtinen).

and corporate leaders and entrepreneurs have seen various opportunities in this regard.

The processing and distribution of fish and other seafood products is increasingly being merged, driven by the need to address traceability concerns regarding seafood products and to provide more reliable services to seafood retailers. Accordingly, many seafood processors are setting up their own distribution networks, as combining processing and distribution helps these companies to better meet consumer/retailer demand and at the same time strengthen their own bargaining position vis-à-vis seafood retailers. Additionally, possessing both processing and distribution capabilities enables companies to serve major retail chains directly, offering the choice of selling under the companies' brands or the supermarket's own private labels. Private labels are gaining popularity as a relatively inexpensive alternative to branded products. The increasing variety of private-label seafood is attracting the interest of consumers who are looking to buy seafood but hesitate to pay the high price it commands.

Domestic markets are sometimes bound to be limited, whether in terms of available resources or number of customers; in response to these limitations, many enterprises will seek to expand into foreign markets. The demand for better quality and more wholesome consumer products is steadily increasing all over the world, and many consumers have become more conscious of the importance of wholesome food; also, the focus on climate change in the world has contributed to an increased call for sustainability in food production and more stringent requirements of traceability. In addition, with increasing urbanisation comes increased disposable income and an increased demand for more wholesome food.

Managers and owners of enterprises also increasingly want to reach out more directly and effectively to consumers, and manufacturers want to reduce the number of intermediaries to bring their products as fresh as possible to consumers, which at the same time boosts profit. All of this has a huge impact on the globalisation of fisheries and aquaculture.

Aquaculture has expanded significantly in scope in recent years and will continue to expand. Aquaculture has already exceeded traditional fisheries in terms of volume of production. Policy makers will need to ensure that aquaculture can benefit from the opportunities that come with globalisation, while at the same time mitigating any potential risks. This means that governments will need to set certain criteria and rules that enterprise managers need to observe, including in environmental matters, use of land and ocean areas in land-based and sea-based aquaculture, in governance, food security, and research, to mention only a few areas of concern (Fig. 11.2).

Trade in fish and fish products is extensive in the developed countries, with species such as shrimp, prawns, lobster, and tuna tending to flow from the developing countries to the developed countries. But unlike in many other economic sectors, free trade in capture fisheries will not necessarily increase economic efficiency. According to a report from an OECD committee, proper management regimes have to be in place if the full benefits of market liberalisation are to be achieved without compromising sustainability.[b]

FIG. 11.2

Aquaculture in Si Lanna National Park, Thailand (Anna María Clausen).

The globalisation of fisheries and aquaculture can be looked at with differently tinted glasses. As regards harvesting from the sea, globalisation primarily involves securing access to fish and ensuring optimum profitability of the capital tied up in the vessels used in fishing at any time. In aquaculture, globalisation is of special importance, particularly in a time of urbanisation and increased population. The principal investments in aquaculture have the form of foreign direct investment (FDI) and outsourcing manufacturing processes to other countries. Rich theoretical and empirical literature on the determinants of FDI is widely available.[c] Aquaculture enterprises globalise in order to achieve economies of scale and gain control over inputs. For aquaculture enterprises, size is of crucial importance, as the sector is both knowledge and capital intensive.

The globalisation of the processing part of fisheries is mostly taking place by outsourcing part of the production to external parties by establishing (greenfield) or acquiring enterprises in other countries, or by globalising sourcing of raw material. Globalisation comes into play when corporate management is looking for increased profits, stability, quality, and a secure supply of raw material. For developing countries, it can be a difficult matter to meet technical standards because of the cost and shortage of know-how. To resolve this problem developing countries enter into management contracts in order to obtain access to the knowledge needed. With the presence of tariff peaks and tariff escalations for a number of products in OECD markets, developing countries may not find the trading environment enabling for their processing sector, meaning that they may not fully reap the benefits of globalisation.

In the retail section of fisheries, globalisation centres on securing a steady supply of fish for customers. Retailers are in direct contact with their customers, and it is important for them to maintain their reputations, including their reputation for reliability, by offering a steady supply of quality products. Retailers are increasingly held accountable for local and global needs and concerns, such as social responsibility, environmental impact, and sustainability, which affect the entire value chain. This is what underlies the demand for independent environmental labelling as well as fully recorded chains of custody, that is to say paper trails. This is particularly important in markets where retailers are highly concentrated and brands are an essential feature. Product globalisation and the growth of online sales are shifting supply chains in the seafood sector, just as they are in other consumer markets, where customers expect to receive the exact sustainable, fresh and healthy products that they want, preferably delivered to their doorstep, cheaply and efficiently. Many entrepreneurs in fisheries and aquaculture are responding to these new trends by selling fish directly to consumers and finding new ways of packaging and delivering that cut costs and boost quality. Some companies have even started delivery by drone in an attempt to meet some of these expectations. This is happening all over the world, and it is opening new high-value local market opportunities in countries that long have been net exporters of seafood.

Decision sets that managers face in the international business environment have changed radically, especially decisions on coordination and location. These changes, and managerial responses to them, have wrought notable changes in the organisation and configuration of international business. These are not incremental changes and they have radically changed corporate structures, management, and even business models.

From the point of view of managers, globalisation is promoting market growth, both for products and services, as well as for supplies. As a result, managers are able to take advantage of economies of scale in the production processes. Managers of major seafood companies want to secure access to reliable and environmentally sustainable supply chains. Globalisation contributes to the possibility of operating and investing in many places at the same time, which can help to spread risk. It is safe to say that globalisation contributes to productivity in the world, and in many cases it improves living standards.

When looking at the strategy of entering foreign markets, the question needs to be asked why an enterprise should be taking such a step. Operating across borders is risky; it involves more expenses and can create more problems than if the enterprise sticks to its domestic market. Management also needs to take account of a number of extra considerations when managing operations that are conducted in many countries; these include factors such as possible time differences, different laws and regulations, for instance regarding working hours and working conditions, wages, or even an entirely different legal environment altogether, transport costs may be high and employing expatriate personnel may entail extra expense. All of these matters need to be taken into consideration by management when deciding if their enterprise should stick to domestic operations or expand across borders. There must therefore be benefits to working in more than one country that exceed the attendant risk and expense; otherwise there would be no multinational enterprises (Fig. 11.3).

FIG. 11.3

Global Fishery Forum and Seafood Expo in Brussels (Ásta Dís Óladóttir).

When the decision has been made to expand into foreign markets many questions need to be answered. Questions like why to enter foreign markets—examining the motives for the decision. The second question would be where to go: which country, which city, etc. If the decision is to take the acquisition route, a decision needs to be made on which enterprise or enterprises to take over.

The third question faced by management is how. Should they employ an equity mode or a nonequity mode? The nonequity mode means avoiding foreign direct investment (FDI). Instead, exports are used, or licensing, giving the enterprise access to employees in the market into which the enterprise is expanding, who will intermediate in the conduct of business. The other approach is the equity mode, sometimes called the investment-related mode or hierarchical mode, which means entering foreign markets through foreign direct investment. This means either investing in a wholly owned subsidiary or a joint venture in collaboration with one or more participating undertakings. Management also needs to decide how much risk to take. How much capital is management prepared to invest, and how quickly do the enterprise or its products need to enter the foreign market?

The fourth and last question that management needs to ask is when to take action. Management may make the decision to become an early mover into the market in order to achieve a competitive advantage, or the preference may be to wait, observe market trends, and enter later. Different approaches at different times have both advantages and disadvantages that need to be weighed. There is no single correct approach.

11.2 Market entry strategies and motives

The 21st century has been characterised by a race between the world powers, both governments and investors, for access to resources, raw materials, shipping routes, and communications, all of which encourages and influences the globalisation of enterprises. A firm's decision to initiate global market involvement is multifaceted and may arise for a variety of reasons. For many organisations the primary motive is the search for new markets to ensure sustainable growth. Underlying reasons may be the demand for the products or services, the existence of attractive segments, or a generally huge market size or anticipated market growth. Other influential driving forces might be the avoidance of tariffs, trade barriers, or regulatory frameworks, or it might be achieving economies of scale or gains in efficiency, production, productivity, or sustainability. Many of these motivational factors have been identified in international models.[d]

Enterprises may be influenced in their internationalisation by more than one motive. Their motivational factors could arise from success in the domestic market, from a saturated domestic market, from a geographical location advantage, from technological improvements, or from any other motive. Initially, most firms invest outside their home countries to acquire natural resources or gain access to markets. As they become increasingly multinational, they use their activities abroad to improve their global market conditions by raising their efficiency or acquiring new sources of competitive advantage.[e]

Accessing lower-cost inputs, or resource seeking, is another motivation for FDI. This form of foreign investment is often characterised as vertical FDI, since it involves breaking up the vertical chain of production and relocating part of an enterprise's activities in a lower-cost location. Firms with labour-intensive operations, but based in advanced high-wage countries, may establish operations in lower-wage countries to cut costs. That is a business pattern that is highlighted by many multinational enterprises in the fisheries and aquaculture industry, from fishing and fish farming to sales and marketing.

Access to resources is a particular driving force for larger countries. Managers might be after resources that are unavailable in their home markets, such as raw materials; also, the resources available in their home markets may not be suitable for certain enterprises, whose managers may then venture into foreign markets that are able to meet their needs. These can be financial or technological needs, or a need for better trained and educated human resources. The motives can vary from enterprise to enterprise based on past experience, current market circumstances, and projected market trends. Population growth, rising food prices, and instability in the food and raw material markets of the world will lead to reduced food security, which is certain to become one of the most important issues faced by world governments in the coming years. For these reasons the need for access to raw material, such as fish, will be pressing, and land, water, and energy are key resources, possessed by some countries but lacking in others. Enterprises must have a clear strategy of what they want to achieve when entering a new market. In a strategic framework, objectives, goals, and targets are pinned down and the mission, purpose, and value are clearly outlined.

Looking at the size of markets, small states benefit from liberalisation in international trade, as they need to be able to do business with everyone on an equitable and transparent basis. The general rule is that small economies derive greater benefit from international trade than large economies for the simple reason that it is often easier in a large economy to bring about an efficient division of labour and achieve economy of scale without international trade. International trade makes it possible for small countries to concentrate on relatively few sectors, and perhaps excel in some sectors, to export part of their production and leave other industries to larger economies and buy their products and services from outside. Accordingly, it may be expected, generally speaking, that the smaller a country, the larger the proportion of its domestic product that will be either imported or exported.

According to OECD figures,[f] open economies underpin growth and improvements in material living standards, and the globalisation of fisheries and aquaculture supports this contention. With globalisation, consumers around the world have access to a far greater choice of fish species at a lower price, all other things being equal. At the same time, enterprises can utilise their resources in a more efficient way through globalisation by exploiting comparative advantage and scale effects.

Many small islands depend heavily on fishing. One of them is Kiritimati, a Pacific Ocean raised coral atoll in the northern Line Islands. Kiritimati is part of the Republic of Kiribati. Fishing is the key industry of Kiritimati Island, employing, directly or indirectly, about 90% of the people. The majority of the households on Kiritimati Island are engaged in fishery as a source of income. The construction of a storage and handling area in the fishing port on Kiritimati Island was funded in 2006 by a grant of about 7 million USD provided by the government of Japan under Japan's General Grant Aid Programme to Kiribati (Fig. 11.4).

Japan's aid followed a request from the Government of Kiribati for assistance in 2003. In response, a survey and detailed design exercise was conducted by Japan, after which the two governments agreed on the final project. The main objective of the project was to construct and improve receiving, handling, and storing facilities for fisheries products in the Ronton area, the only fishing port on Kiritimati Island, and to provide the relevant equipment and materials. The Government of Japan's assistance was aimed at assisting the Kiribati Government in creating the necessary infrastructure for the fisheries sector's growth.[g]

Multinational corporations in smaller economies have a higher propensity to internationalise than firms from larger home economies[h] and they tend to be competitive in a few niche sectors because of their limited resources and a preference to concentrate their activities on a few targeted sectors rather than spreading the

FIG. 11.4

A scene in Kiritimati in the Pacific Ocean (Anna María Clausen).

available resources thinly across several industries. At the same time, there is appreciable variation between countries, because small and open economies are by no means a homogenous group. There can be many factors that encourage a firm from a small economy to expand outside its home market. The limited domestic market size means that if such firms are to achieve economies of scale in production, they must seek additional markets outside their home location.[i]

A small market size constitutes a disadvantage in the development of processing technology, as economies of scale are not present, but may provide a competitive advantage in product innovation. Globalisation has also meant that firms increasingly need to maintain competences in several areas, as products become increasing multitechnological in nature. In this context, it is well documented in the international business literature that multinational corporations can generate and implement a wide range of global integration strategies that eventually fit into certain organisational structures. Globalisation has led to industry consolidation, with few large and vertically integrated transnational corporations operating across the entire supply chain from harvesting through to retail.[j]

Then there are all sorts of barriers to entry, such as tariffs and import quotas, and a number of enterprises will for those reasons elect foreign direct investment over exports in order to avoid these barriers. For all economies, and particularly small economies, freedom of export is of major importance. Barriers to international trade have been significantly reduced under the umbrellas of organisations and international agreements, including the World Trade Organization (WTO), the European Union (EU), and the North American Free Trade Agreement (NAFTA).

11.3 Nonequity mode

The simplest method of expanding into a foreign market is through exports; it is also the most common method. It is estimated that up to 90% of all manufacturing companies opt for exports as their international business. The advantage of exporting is that it carries relatively low risk, as the product is manufactured in the home country and then transported, directly or indirectly, to a merchant or distributor in the foreign market. This gives an opportunity for a number of approaches, and the approach chosen will depend on the number of intermediaries. Another advantage of exporting is that the enterprise does not need to have employees or agencies abroad, which is expensive; however, problems can arise for reasons of distance and, of course, shipping costs can be high. When shipping costs are added on top of the manufacturing cost it may be unprofitable to ship products over long distances. Then, of course, legal and other requirements may differ from one country to the next, there may be currency-exchange risk, and there will be cultural differences. The general understanding is that small and medium-sized enterprises will choose exports over other means of entering foreign markets, as the commitment needed is less than that of other means. About 80% of the enterprises that go international are small and medium-sized enterprises. Currently over 90% of traded goods and components are transported by sea.[k]

Exports can be divided into three categories: direct export, indirect export, and cooperative export. Direct exports are when a manufacturer, or exporter, sells directly to an importer or to a buyer located in a foreign market area. Indirect exports are when the enterprise manufacturing a product does not itself engage in the export, but rather a third party, usually an independent firm located in the producer's country. The sale is like a domestic sale, because in fact the firm is not really engaging in international marketing, as their products are carried abroad by others. Cooperative export involves collaborative agreements with other firms; export marketing groups of this kind are common among small and medium-sized enterprises that are exporting for the first time.[l]

Fig. 11.5. shows the leading exporting countries of fish and fishery products worldwide in 2018 in billion USD.[m] The chart shows that the European Union, then comprising 28 countries, was by some distance the leading exporter of fish and fish products in 2018, with 38.1 billion USD in export value. China came next with 25 billion USD, followed by Norway in third place with an export value of 12.1 billion USD. In terms of export and import of seafood in tons, the global seafood trade is expected to grow from 37 million tons in 2012 and reach 45 million tons by 2022.[n] China is expected to continue to be the primary international exporter, and the EU and the USA are likely to be the largest seafood importers to meet their growing seafood consumption demands (Fig. 11.6).

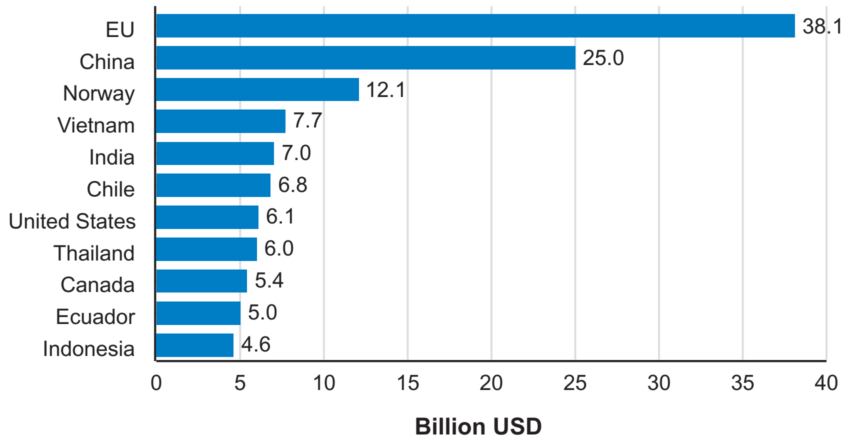

FIG. 11.5

Leading exporting countries of fish and fishery products in billion USD worldwide in 2018.

FIG. 11.6

London protest against climate change in October 2019 (Ásta Dís Óladóttir).

If managers are not willing to commit themselves by investing or taking significant risk, there is the possibility of taking the route of franchising, a nonequity mode. An agreement is then made with external entities on the production of a product in a specific market. The foreign entity then receives either a fixed commission or a percentage of sales in the market. This route can be suitable for enterprises that want to increase their revenue and spread expenses, as taking this route means that markets can be approached in a relatively short time.

In franchising, the franchisee, that is to say the entity that is granted a franchise, obtains the right to utilise the business idea, name, image, working procedures, capability, and knowledge of the franchiser in another country against payment of a consideration. Franchising agreements are normally long-term agreements, where the franchisee undertakes to observe the specifications and working procedures of the franchiser, that is to say the entity granting the franchise. In return for the franchise, the enterprise owning the franchise receives an advance payment of a percentage of sales. The advantage of the franchise approach is that less risk is involved than in other approaches. One of the reasons for this is that the franchisee will often have a better knowledge and understanding of the local market in question, the cost will be lower, and management will have greater control over the course of events. The principal disadvantage is that the franchiser has no control over the foreign market. This approach is not widespread among enterprises in fisheries and aquaculture, but could be an option for some enterprises.

Joint ventures, or strategic alliances, are partnerships where two or more entities enter into an agreement to enter a foreign market or foreign markets. One common approach to a joint venture is to enter into a partnership with local entities in the foreign market, a well known approach in fisheries and aquaculture. One benefit of this approach is that the best advantages can be cherry-picked from a range of enterprises, making the collaboration more efficient. Among the reasons that management might seek partnerships of this kind could be a shortage of some resource, for instance labour or capital. Also, the management or staff of an enterprise may lack necessary knowledge.[o] It should be borne in mind that the government of a country where the joint venture operates may require the entity wishing to enter its domestic market to work with a domestic enterprise. To give an example, both South Korea and China try to restrict foreign ownership in this and other ways.

Management contracts are contracts with outside enterprises on bringing management knowledge, capability, and experience into the enterprise. Shortages of management capabilities, where this approach could have advantages, are common in the developing countries, and this approach can also be advantageous if direct investment is considered too risky, for instance because of political conditions. Also, the managers entering foreign markets in this way may gain a great deal of experience. One disadvantage, however, is that these managers may be training their future competitors in the market, and another disadvantage is that this approach requires greater human resources for the enterprise in the home country.

11.4 Equity modes

Foreign direct investment (FDI) is defined as an investment by an enterprise in one country in a at least a 10% share in an enterprise in another country.[p] Management can enter foreign markets without cooperation with others using hierarchical modes or equity modes. With direct entry, management has full control over the business operation. However, this is a more expensive and riskier approach in comparison with other approaches. The arrangement can take a number of forms, for instance opening a subsidiary in a foreign country or acquiring a controlling interest in an existing foreign company by means of a merger or joint venture.

Interestingly, there has been a significant increase in FDI in recent years. There are various reasons for this trend. One is that pressure has increased from protectionists in the last 20–30 years, and corporate managers have seen FDI as a means of overcoming barriers. Another reason for increased FDI is the profound changes that have taken place in the developing countries with opening markets and increased liberalisation. Markets in Eastern Europe, Latin America, and Asia have become much more attractive options in the eyes of investors and management, as various barriers have been removed and a number of programmes set up which are designed to attract investors, and economic growth has picked up. But FDIs are expensive, as the investing enterprise must buy, or buy into, another enterprise or establish a new one, and FDI can also carry risk, as various unforeseen problems can arise in the foreign market. Nevertheless, this approach is widely used.

Opening a branch in a foreign market is an option if management does not possess a great deal of knowledge of the target market. This requires greater management commitment than having domestically based representatives. In such cases, management transfers all sales matters to the foreign market, but everything else remains in the home market, such as research and development (R&D) and actual production. This is a far simpler method than most other methods and offers greater flexibility. Also, exiting is easier if matters do not go as planned in the foreign market. Sometimes management will choose this approach to explore the foreign market and take stock of consumer behaviour and the environment in general before undertaking further investment in the market. Tax benefits may be another reason for management to take this approach, as tax regimes differ from one country to the next (Fig. 11.7).

Since marine products are generally delicate goods, it is important for the producers of such products to exercise control over their own end products and address matters such as traceability, hygiene, and quality. This will tend to increase the importance of establishing or acquiring processing companies and make them into a more attractive investment option. At the same time, retailers are steadily growing and increasing in strength, and concentration is increasing among distributors in fisheries and aquaculture, as distributors strengthen their positions by taking over companies that engage in fisheries, fish farming, and processing. Strengthening their position vertically improves distributors' competitiveness vis-à-vis retailers with plans to take over companies in their sector. Take-overs have long been used to

FIG. 11.7

Fish research in laboratory (Wladimir Bulgar).

achieve efficiency; one of the most common goals of mergers and take-overs is to achieve economies of scale and increased efficiency in order to reduce costs and increase revenue. The principal driving forces behind mergers and acquisitions in fisheries and aquaculture are the need for faster access to the market, and of course managers see an opportunity to achieve higher profits. The incentive that drives mergers and acquisitions will depend on the location of enterprises in the value chain. Producers perceive opportunities in mergers and acquisitions to strengthen their distribution networks and get their products faster into foreign markets. A merger or acquisition will provide management with immediate access to everything that the other enterprise has to offer, such as manufacturing equipment, human resources, access to markets and customers, and distribution channels.

So it can be said that in the short term management is looking to achieve synergies and thereby increase the profitability of the merged enterprise, but in the long term the value consists in obtaining greater knowledge and capability, and gaining access to products and markets that can provide a foundation for further growth, and thereby an increased value of the enterprise. In addition, mergers and take-overs can be a favourable route if there are high barriers to access or if competition is fierce.[q]

Mergers and acquisitions can be divided into three categories, depending on their nature: horizontal, vertical, and conglomerate. Horizontal mergers and acquisitions refer to mergers within the same sector. One reason for a horizontal merger may be that it is cheaper to buy another enterprise in the same sector than to renew existing assets. The value added may be in the form of increased income resulting from increased market power and market access. It may also be in the form of economies of scale and scope and opportunities for further growth.

A vertical merger and/or acquisition may take the form of a take-over by a manufacturer of a distributor, which brings the manufacturer closer to the customer base; conversely, a distributor may take over a supplier, bringing the distributor closer to the needed resources. Locations that have relatively abundant unskilled labour attract FDIs from multinational companies engaged in unskilled labour-intensive production.[r] Vertical integration in fisheries and aquaculture has increased significantly, as integration of this kind gives enterprises better control of their production costs; in addition, management is better positioned to serve customers and ensure the traceability of their products. A conglomerate merger is when enterprises in totally unrelated sectors are merged.[s] The rationale behind a conglomerate merger may be risk mitigation, better access to financial and management resources or more efficient allocation of resources.

The increasing requirements of traceability in fisheries and aquaculture have made it more important for enterprises to have control over their entire value chain. Having full control of the fishing or farming, processing, and distribution increases an enterprise's ability to trace all the products it sells and prove their origin and the sustainability of their source. Enterprises that control both their processing and distribution are therefore able to meet different needs, and even market their products in different ways and offer a more varied range of products under their own brand names. Large entities in a market will also seek to have their own distribution systems in order to secure their market position.

11.5 Largest companies in fisheries and aquaculture in the world

The market for fish products has changed profoundly in recent years and decades, as discussed earlier. These changes will continue, as stakeholders in both fisheries and aquaculture, processors, distributors, and retailers, will seek new opportunities to increase sales, reduce production costs, and uncover new and attractive investment opportunities in an environment that is becoming increasingly globalised.[t]

Aquaculture, which now accounts for the majority of the fish products consumed in the world, has become an attractive investment option in the context of mergers and acquisitions. There are also potentials for take-overs in the distribution section, on the customer side of the value chain, in some cases the most profitable section of fisheries and aquaculture. Large companies in Asia, including the largest fisheries and aquaculture companies in the world in 2020, Maruha Nichiro and Thai Union Frozen Products, have grown rapidly by aggressively pursuing overseas acquisitions in order to be able to market their products worldwide.

Driven by the growth of aquaculture, the fish feed segment has shown a corresponding growth and is becoming an increasingly popular segment for mergers and acquisitions. Fish feed is a major expenditure for fish producers in aquaculture, accounting for 40%–50% of the total fish production cost. As a result, access to fish feed is a key consideration for better economies of scale. The segment is dominated by a small number of large global producers and driven by growing global demand. Moreover, feed science is becoming ever more sophisticated, leading to ever more proprietary knowledge acquired by the feed companies. This knowledge is a key factor in reducing the cost of feeds, for instance by understanding the different nutritional needs of the fish at different stages of development. The price of fish feed is highly susceptible to fluctuations, as fish feed is largely dependent on small pelagics from commercial fishing. These price fluctuations have a major impact on the profitability of aquaculture companies. As a result, these firms are investing in fish feed companies to achieve synergies in feed procurement and reduce production costs.

China is by far the largest fisheries country in the world, with about 17% of the world catch, followed by Indonesia, the United States, Russia, and Perú, with about 5%–7% each. But which are the 100 largest seafood companies, or the largest enterprises in fisheries and aquaculture, in the world in 2020, and where are they?

Figs 11.8 and 11.9 show the 100 largest seafood companies in the world by country.[u] As Fig. 11.8 shows, Japan had by far the greatest number of the largest seafood companies in the world in 2019, or 22 out of the 100. Note that Japan is only the eighth largest fisheries country in the world, with just short of a 4% share of the world catch. Next after Japan on the list of the countries with the largest seafood companies

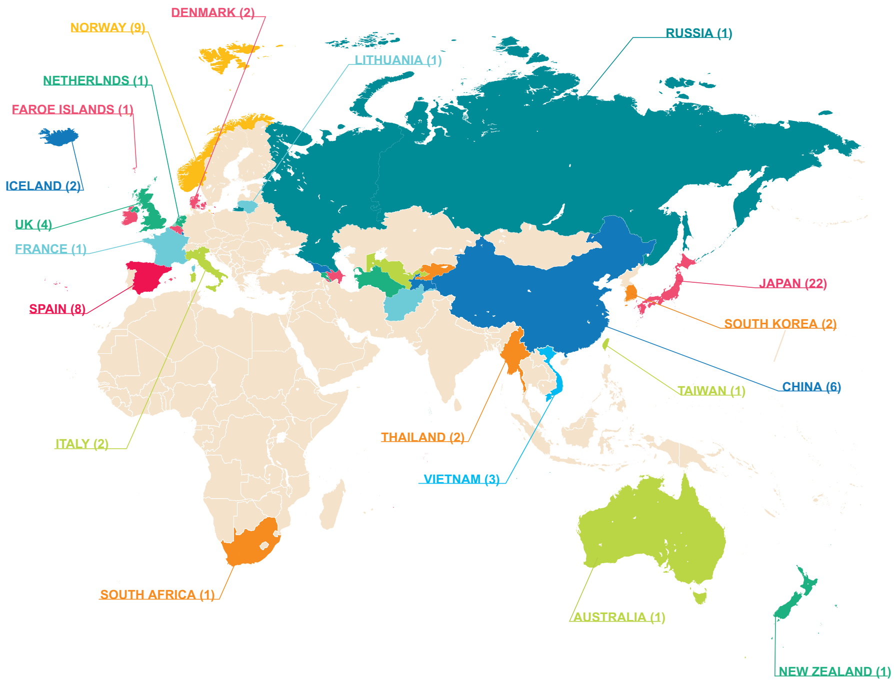

FIG. 11.8

World's largest seafood companies in Asia, Africa, Europe, and Oceania (Ólafur Kristjánsson).

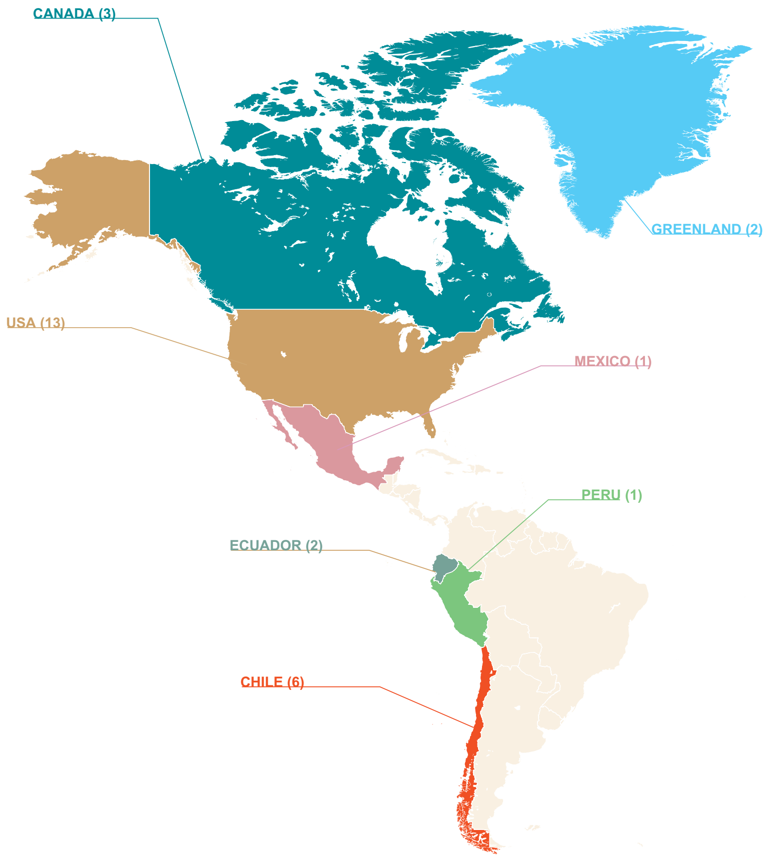

FIG. 11.9

World's largest seafood companies in North and South America (Ólafur Kristjánsson).

is the United States of America, with 13 out of the 100 largest seafood companies, as shown in Fig. 11.9.

Table 11.1 shows that the combined revenues in 2018 of the 100 largest seafood companies of the world amounted to 106.8 billion USD. Of the total number of companies, the 10 largest had revenues of 41.2 billion USD, which corresponds to just short of 40% of the combined revenues of the 100 largest companies. This illustrates their huge size, as the next 90 companies share only 65.6 billion USD in combined revenues, or just over 60% of the total revenues of the100 largest companies.

The annual revenues of the world's 100 largest seafood companies differ widely. Fig. 11.10 shows that 32 of the largest seafood companies in the world had revenues under 0.5 billion USD in 2018. Of the 100, 42 had revenues ranging from USD 0.5 billion to 1 billion USD. Twelve companies had revenues over 2 billion USD in 2018.

Table 11.1 Seafood's top 100: Combined revenues 2017 and 2018 in billion USD.

World's largest seafood companies	2017	2018	Change between years in %
Top 100	101.2	106.8	6
Top 10	40.0	41.2	3
Top 25	60.2	63.5	6
Top 50	78.9	83.3	6

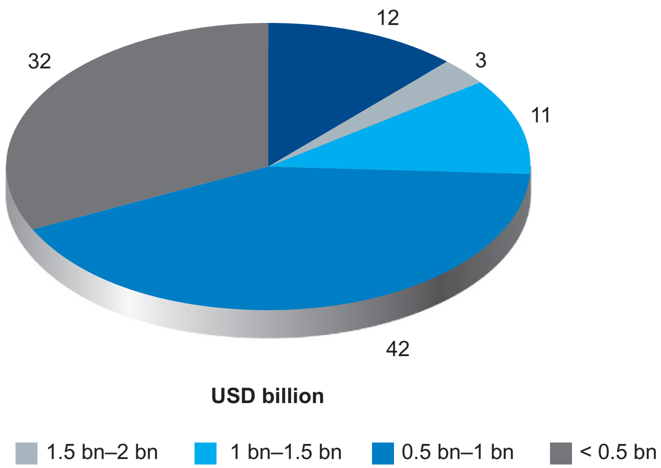

FIG. 11.10

Revenue distribution of the top 100 largest seafood enterprises in 2018.

Mergers in the fisheries and aquaculture sectors have had the effect that the large have become larger. The five largest companies in fisheries and aquaculture in the world are the Maruha Nichiro corporation (Japan), Nippon Suisan Kaisha (Japan), Dongwon Enterprise (South Korea), Mowi (Norway), and Thai Union Group (Thailand), with combined sales of fish products at the end of 2019 at 27 billion USD.[v] Mergers have also made the boundaries between fish farming, fisheries, processing, and feed companies less clear than before, and more companies now extend over the entire value chain, with no end in sight of the merger trend. The increased demand for products from fisheries and aquaculture, combined with the mergers of companies in the sector, contribute to the increasing size of enterprises. Of the 15 largest companies in fisheries and aquaculture in the world, almost a half, i.e., 7, are Japanese. Even though the Chinese fish more than any other country in the world, there is not a single Chinese company among the 15 largest companies; China makes its first appearance in 20th place with the Bright Food Group. That company is rooted in the Shanghai Fisheries Bureau, which was transformed into a state owned enterprise in 1992. Taiwan Province of China has one company on the list, FCF Co.

The following is an overview of the five largest seafood companies in the world; all are public companies, that is to say companies that are traded in stock markets, and all have sales over 4 billion USD. By far the biggest seafood company in the world is the Japanese vertically integrated producer, processor, and supplier Maruha Nichiro, based in Tokyo, Japan. The company was created in 2007 with the merger of two 100-year old Japanese enterprises, Maruha Group and Nichiro Corporation. The company's fisheries-related turnover is about 7.5 billion USD. Maruha Nichiro is a comprehensive food company, doing business in fisheries, aquaculture, reprocessing, canned food, ready meals, pharmaceuticals, animal meat, and international and domestic trading. Its total annual turnover is 8.4 billion USD. The company has operations in 65 countries.[w] The distribution of sales is 80% in Japan, 6% in the United States, 5% in the EU, 5% in Asia, and 5% elsewhere. The group has 11,276 employees in total and 153 group companies worldwide, half of them in Japan.[x] The company, commanding 15% of the Japanese shrimp market, is a huge buyer of shrimp in the world and bought over 34.000 metric tons of shrimp in 2016 (Fig. 11.11).

In addition to its business in Japan itself, the company has operations across the world. In Alaska, Maruha Nichiro owns the subsidiaries Peter Pan Seafoods, Alyeska Seafoods, and Westward Seafoods, which are salmon, pollock, and crab processors. It also owns Trans-Ocean Products and Premier Pacific Seafoods, which are surimi makers. In South America, Maruha Nichiro owns Sakana del Peru, which processes and supplies squid, eels, and other species. In Europe, the group's principal interest is Seafood Connection, a Dutch importer that opened a US office in 2014. Seafood

FIG. 11.11

Japanese seafood dish (Fahroni).

Connection expanded into Spain in 2019 with the purchase of a minority stake in Inlet Seafish. Maruha Nichiro owns a share in the Australian shrimp and toothfish harvester Austral Fisheries, and in New Zealand it owns a share in the fishing firm Sanford.

The growth of this largest seafood company in the world has been slow in recent years, which is in line with the growth of other Japanese companies. Unlike many other Japanese firms, Maruha Nichiro's strong portfolio of foreign harvesting, processing, and distributing assets means that it is better prepared to deal with the weakening demand from Japan's ageing population.

The next largest seafood company is the Japanese Nippon Suisan Kaisha (Nissui), based in Tokyo. Nippon's turnover is 6.2 billion USD. Like Maruha, Nippon concentrates on aquaculture, fishing, processing, import, export, trading, wholesale, and distribution. The company has extensive foreign operations, with over 100 establishments in 32 countries. The company's key products are tilapia, salmon (Pacific, Atlantic), vannamei shrimp, Japanese flying squid, Alaska pollock, jumbo flying squid, and surimi. It has more than 30 subsidiaries and partners in its home country, most operating in sourcing, processing, sales, and distribution of fish products, and its domestic aquaculture business in Japan is growing.

In South America, Nippon Suisan Kaisha owns Chilean farmer Salmones Antarctica and hake harvester Empedes. It also owns shares in the New Zealand fishing firm Sealord Group and a share in Seafarms Group, which is in the process of developing a major land-based shrimp farm in northeast Australia. In Europe, the company's reach extends to Danish harvester J.P. Klausen and distributor Nordic Seafood, as well as French processor Cité Marine and UK processors Caistor Seafood and Flatfish. The company also holds a strong position in procuring US seafood with major Alaska processor Unisea, pollock catcher/processor Glacier Fish Company, and distributor F.W. Bryce. Furthermore, the group is a big branded retailer in North America through US subsidiaries Gorton's, King & Prince Seafood, and, in Canada, through BlueWater Seafoods.

The third largest company in the world in fisheries and aquaculture is the South Korean giant Dongwon Enterprise, with a turnover of just short of 4.8 billion USD. The key activities of the company are fishing, processing, import, export, trading, and wholesale and distribution. The company is the parent company of the tuna-focused enterprises Dongwon F&B and Dongwon Industries. Dongwon Enterprise is one of the largest companies in South Korea and produces meat, dairy, and other foods, in addition to manufacturing electronics and providing logistics services. The company has 72 partners in 20 countries.

Dongwon Industries, the fisheries section of Dongwon Enterprise, was founded in 1969; it operates over 20 vessels, most of them in tuna fishing. The company is involved in joint venture partnerships with companies in New Zealand and China, among other things in connection with processing and export. The company is also in collaboration with enterprises in Senegal and has set up a processing plant in Papua New Guinea. It produces over 250 product types, although most of its fish products are in the form of canned tuna; in fact, the company owns the second largest tuna brand in the United States. It has also engaged in salmon fishing in Alaska since it invested in a large processing enterprise, which is mostly owned by Alaskan fishermen.

The fourth largest company is Mowi, previously Marine Harvest, in Norway. Mowi produces most of the farmed salmon in the world and also produces its own feed in a feed processing plant in Bjugn in Norway and another in Scotland. Mowi is vertically integrated up and down the value chain. It was founded in 1964, and in 2018 its turnover was 4.5 billion USD. It operates in 25 countries, with its largest plant in Poland. Mowi also has six plants in Asia, in Taiwan Province of China, South Korea, and Japan, and in North America the company has salmon plants in Texas, Maine, Florida, and British Columbia. Salmon farming companies are facing various challenges due to concerns that escaped salmon from sea pens can have a severe impact on wild salmon stocks, as can lice from farmed salmon, and Mowi has not been immune to these challenges.

The fifth largest seafood company in the world at the start of 2020 is Thai Union in Thailand, with a turnover of 4.1 billion USD. Thai Union is a vertically integrated giant in the market and produces more canned tuna in the world than any other company, in addition to producing mackerel and herring. Approximately 40% of the company's sales involve fresh and frozen fish products, such as salmon, lobster, crab, and shrimp. The company has significant market shares in Europe, North America, and Thailand. It focuses mostly on sales and production, with 17 production plants on four continents. It is also engaged in research and development in France and Thailand.

Looking at global fisheries by continent, Asia is in the lead by a considerable distance, with 53% of the world catch and 36 out of the 100 largest companies. America comes next, with 19% of the world catch and 27 out of the 100 largest companies. The European countries have 16% of the world catch and 32 of the world's largest companies, followed by Africa with 11% and one company out of the 100 largest fisheries companies. Oceania comes last with only 2% of the world catch. There is one Australian company on the list, and one from New Zealand. If the Nordic Countries are taken separately, they have 13 companies on the list. Norway has the most, with nine, and Iceland and Denmark have two each. In addition, there are two companies in Greenland and one in the Faroe Islands, but both those countries are a part of Denmark. It is interesting that notwithstanding Russia's share in the world capture, and the fact that Russia is the largest fisheries country in Europe, they only have one of the 100 largest fisheries companies in the world.

Of the 100 largest fisheries companies in the world, the majority are private companies, about 54%, as shown in Fig. 11.12. Of the 100, 44 are public companies, and 2 are state owned.[y] The state owned companies are Royal Greenland, which is the 34th largest fisheries company in the world, and Bright Food Group in China, which is the 20th largest fisheries company in the world. On the whole, Japan has 22 companies on the list of the world's largest fisheries companies, the majority of them public companies. There are eight Norwegian companies on the list, five of them public and three private.

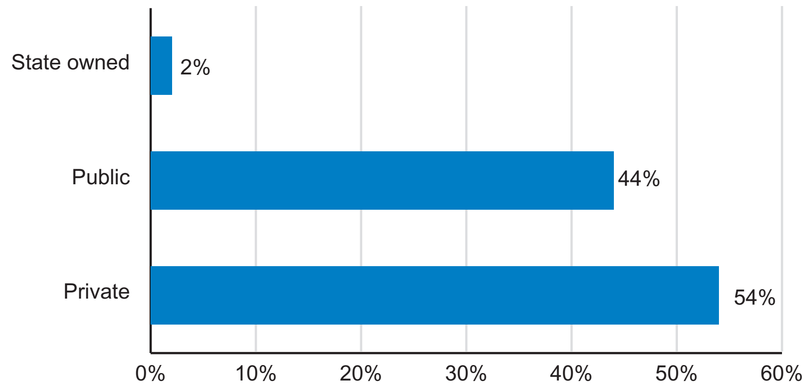

FIG. 11.12

Ownership of world's 100 largest seafood companies.

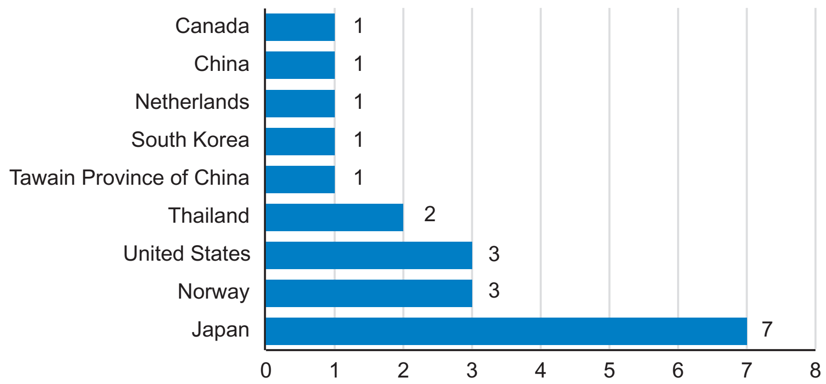

FIG. 11.13

Top 20 largest seafood companies in the world by country.

Looking only at the 20 largest fisheries companies in the world, the Japanese have complete dominance, with seven out of the 20 largest, as shown in Fig. 11.13. The integration of harvesting, processing, and distribution activities into a single diversified entity is viewed by the seafood industry as an optimal business model. This is reflected in the ongoing consolidation in the industry across the value chain.

Illustration of the merger of enterprises in fisheries and aquaculture

Founded in 1964, Norway's Mowi, the world's largest farmer and producer of value-added salmon, was until year-end 2018 known as Marine Harvest. Mowi ASA, headquartered in Bergen in Norway, is in 2020 the fourth largest seafood company in the world. In 2019 the company had 14,500 employees and operated in 25 countries, mainly in Europe and Asia, with revenues in 2018 at about 4.5 billion USD.

In 1980 the company went through several mergers and acquisitions, and Hydro took over 100% ownership of Mowi and changed its name to Marine Harvest. In 2006 Marine Harvest group was established out of three independent companies, Pan Fish, Marine Harvest, and Fjord Seafood. This new alliance created the world's largest salmon farming company, supplying 30%–40% of all farmed salmon in the world. From 2012 to 2019 the company acquired or established several companies for the purpose of strengthening its market position.

Mowi focuses on three principal types of production activities: salmon feed production in Norway; fish farming and primary processing of fish in Norway, Scotland, Canada, Chile, Ireland, and the Faroe Islands; and secondary processing of seafood in Norway, Chile, Ireland, the United States, the United Kingdom, France, Belgium, the Netherlands, Poland, the Czech Republic, Japan, Vietnam, Taiwan Province of China, and South Korea.

Since the 1980s Mowi (then Marine Harvest) has been largest producer of value-added salmon. The company entered into a series of acquisitions aimed at growing into a leading global integrated protein producer and diversifying throughout the salmon production chain. The company remains strictly salmon-focused on the production side, but has vertically integrated up and down the value chain. It sells its fish through its own brands. Mowi makes its own feed in its facility in Norway and operates another plant in Scotland.

On the downstream side, the company operates 28 plants worldwide. It has value-added processing plants across Europe, including in Belgium, the Netherlands, France, the United Kingdom, Spain, and Sweden, but the biggest facility is the 95,000-m^2 Morpol plant in Ustka in Poland. Mowi operates six plants in Asia. Three are in Japan, one is in South Korea, one in Taiwan Province of China, and the sixth, the company's first in the People's Republic of China, opened in Shanghai in 2018. In North America, the company operates salmon plants in Dallas, Texas; Belfast, Maine; Miami, Florida; and near the Canadian city of Vancouver, British Columbia.

The year 2018 was quite busy for the company. Marine Harvest opened a new plant in Shanghai, China, and inked a strategic cooperation agreement with Alibaba Group. China is the world's most advanced Internet trading market, which means that Alibaba and Win-Chain, Alibaba's supply chain management company, is working more closely with Marine Harvest to speed up the delivery of salmon in China. The same year the company acquired a processing facility in the Faroe Islands from Bakkafrost. At year-end, Marine Harvest changed its name and once again became Mowi and the brand was launched in 2019.

According to an Undercurrent news report in 2019 Mowi is moving full speed ahead as a branded producer of salmon worldwide. The company is investing both upstream and downstream to reach its goals and is investing in growth plans in Canada, a new feed factory in Kyleakin in Scotland, and an expansion of smolt facilities in Chile, Norway, and Canada. Additionally, Mowi is looking to the future with the creation of its 'Blue Revolution Centre' in Norway to develop new offshore salmon farming methods. The company is also automating its production facilities with self-driving forklifts, online grading technology to sort fish, and trimming solutions to optimise yield for modified atmospheric packaging.

Endnotes

a. For a forecast of international trade in marine products see, e.g., Statista (2019a).

b. For trends and recent development in foreign direct investments see, e.g., OECD (2006a).

c. For literature on foreign direct investment (FDI) see, e.g., Rugman (1980), Dunning (2000), Antràs and Yeaple (2014).

d. For motivational factors for internationalisation see, e.g., Albaum (1983), Bilkey and Tesar (1977), Malhotra, Agarwal, and Baalbaki (1998).

e. For competitive advantages see Dunning (1993).
f. For open economies see, e.g., OECD (2006a).
g. For more information on the grant aid from the people of Japan to Kiritimati in 2006 see, e.g., a press release from the Embassy of Japan in the Republic of the Fiji Islands https://www.fj.emb-japan.go.jp/pr_Japan_Provides_Grant_for_Coastal_Fisheries_Development.html.
h. For a discussion of open economies and internationalisation see, e.g., Benito, Larimo, Narula, and Pedersen (2002) and Hogenbirk and Narula (2001).
i. For a discussion of small economies and internationalisation see, e.g., Óladóttir, Hobdari, Papanastassiou, Pearce, and Sinani (2012).
j. For a discussion of industry consolidation see, e.g., Troell et al. (2014), IntraFish (2013), and Undercurrent News (2019).
k. For a discussion of international trade and shipping see, e.g., Hill and Hult (2019).
l. For discussion of export see, e.g., Hollensen (2017).
m. For a discussion of an estimation of the leading exporting countries of fish and fishery products worldwide in 2018 see, e.g., Statista (2019b).
n. For a discussion of exporting and importing regions of seafood in 2012 and outlooks for 2022 see, e.g., OECD and Food and Agriculture Organization of the United Nations (2013).
o. For a discussion of joint investments see, e.g., Kuo, Kao, Chang, and Chiu (2012).
p. The United Nations' definition differs, stating that FDI is an investment reflecting a lasting interest and control by a foreign direct investor, resident in one economy, in an enterprise resident in another economy (foreign affiliate) see, e.g., https://stats.unctad.org/handbook/EconomicTrends/Fdi.html.
q. For a discussion of the use of mergers and acquisitions where there are barriers to access see, e.g., Chang and Rosenzweig (2001) and Meyer and Estrin (2001).
r. For a discussion of why multinational firms may choose vertical FDIs see, e.g., Braconier, Norback, and Urba (2005) and Dunning (2005). Vertical FDI and horizontal FDI have been tested in number of empirical papers, including papers by Brainard and Riker (1997), Carr, Markusen, and Maskus (2001), and Yeaple (2003).
s. For more on the division of mergers into three categories see, e.g., Brigham and Daves (2009).
t. For a discussion of the globalisation of fisheries and aquaculture see, e.g., OECD (2010).
u. Figs 11.8 and 11.9 and Table 11.1 are based on Undercurrent News (2019).
v. More information on the world's largest seafood companies in 2019 may be found in a report from the Undercurrent News (2019).
w. For discussions of the largest fisheries companies in the world see, e.g., Bjarnason (2014) and Österblom et al. (2015).
x. For further information on the world's largest seafood company see Maruha Nichiro (2020).
y. For further discussion of the largest fisheries companies in the world in 2019 and Figs 11.12 and 11.13 see Undercurrent News (2019).

CHAPTER

Management 12

Following the technological advances made in recent decades the global economy is facing a number of changes, many of them bringing opportunities, but many also bringing challenges that need to be understood and addressed. Management, one of the key factors of the business environment of enterprises and institutions, relates, among other things, to human relationships and technical solutions. Changes that follow technological advances are nothing new; they have been a feature of the ascent of humans from the earliest times. It is an important matter for stakeholders, including politicians, public institutions, and the various sectors of the economy, to understand them and adopt appropriate policies and strategies. Questions need to be asked, such as how well the education system is prepared to address these changes, whether the labour market is ready for a revolution in automation and technology, and how a society can either maintain or attain a competitive advantage, especially when the advances are as rapid as they are. In this context it is useful to study the prevailing corporate forms of enterprises in the various sectors and their ownership, for instance whether a sector is characterised by listed companies or family firms, or other corporate forms, as corporate form will influence corporate governance, and corporate governance will determine the interaction of an enterprise with society and, importantly, it will influence the position of women in a sector.

12.1 Size, organisation, and management of enterprises

The international classification of enterprises by size normally takes account of number of employees, volume of turnover, and size of balance sheet. The general criteria are that small and medium-sized enterprises have fewer than 250 employees, an annual turnover under 55 million USD, and a balance sheet below 47 million USD. Over 99% of all enterprises in the European Union are small- or medium-sized enterprises.[a] Research has shown that the size of an enterprise, measured in terms of number of employees, has a significant impact on their organisation and structure. As enterprises grow, standardisation takes on more importance and communications become more formal. Generally speaking, as enterprises grow coordination problems increase, because employees do not know each other personally, apart from their close co-workers, and do not meet or interact on a daily basis. This calls for an array of formal coordination processes, like formalising job descriptions, establishing processes, documenting them, monitoring their results, and following up.[b]

Fisheries and Aquaculture. https://doi.org/10.1016/B978-0-12-821056-7.00020-2

It is also common in large workplaces that similar procedures need to be carried out repeatedly, like orienting new employees, calculating wages, sending out invoices, attending to customer complaints, etc., all of which calls for documented procedures. Standardising processes, documenting workflows, and publishing guidelines can contribute greatly to efficiency. This, however, has the consequence of a more rigid regime of rules. The number of management levels goes hand in hand with the number of employees. According to some studies, an enterprise with 1000 employees will have up to 4 levels of management, and the number of these levels will invariably increase when the number of employees is increased to 3000. Where there are few levels of management, in a flat organisational structure, this will facilitate communications between managers and employees, but at the same time this increases the strain on managers who will need to supervise a large number of employees.[c]

When an enterprise is small it can be enlarged by adding resources, and when that happens production may increase proportionally more than the increase in resources as a result of specialisation and division of labour. However, there is a ceiling, because with the growth of an enterprise some degree of oversight is lost, and management can become rigid, cumbersome, and sluggish. There is therefore a relationship between good management and the most efficient size of an enterprise; the better the management, the greater the scope for growth and expansion.

The organisation, or structure, of an enterprise is primarily an internal matter, defined by the form of interaction within the enterprise. Closely related to an enterprise's organisation is its legal, or corporate, form, which shapes the general outward features of the entity, as in the case of a limited company, where the liability of its owners is limited to the shares that they contribute, or a publicly listed company, where all decisions that may affect the price of the company's listed stock and securities are subject to the rules of the market where the company is listed.

The organisation of an enterprise partly answers the question of how the production of goods and services is carried out in fisheries and aquaculture enterprises. The organisation determines, among other things, how tasks, powers of decision, and responsibilities are allocated, including the details of how information is disseminated throughout the enterprise, what needs to be monitored, how and by whom, and then there is the plan detailing the arrangement of the production process itself. The organisation of an enterprise defines and assigns responsibilities, divides personnel into departments, and has the purpose of representing a usable system to link and coordinate different elements of the enterprise's entire business operation.

An organisation chart is used to show in a graphic manner the links between employees. Fig. 12.1 illustrates a simple organisation chart of a fish processing plant. It shows that the board of directors of the fish processing enterprise, which may have any corporate form, is placed above the managing director (the legal term) or chief executive officer. The managing director has two subordinates, or department managers, that is to say a chief financial officer and a foreman. The subordinates of the chief financial officer are an accountant and a bookkeeper, while the subordinates of the foreman are workers, all at the same level. The organisation chart shows who

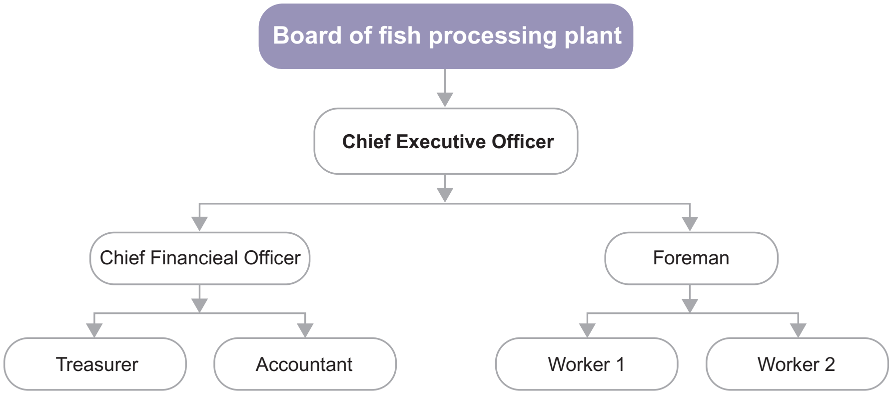

FIG. 12.1

Organisation chart for fish processing.

supervises whom and what the channels of communication are in the enterprise. The managing director does not concern himself/herself with the workers and leaves it to the foreman to communicate with them.

Fig. 12.2 shows an organisation chart aboard a fishing vessel.[d] It shows that the captain is the supreme commander on board, and his immediate subordinates are the first and second mate, the cook, and first engineer. The first mate is obviously placed above the second mate. The mates have the boatswain as their subordinate and the boatswain oversees three deckhands. Fig. 12.2 gives a typical example of the hierarchy of a vessel, although the hierarchy may differ from one vessel to the next, with size being an important factor. However, the captain, or ship's master, on board a vessel always wields the supreme authority, and the captain's word is law.

The organisation of enterprises has changed profoundly in recent decades as a result of globalisation and production diversity, even within local market areas.

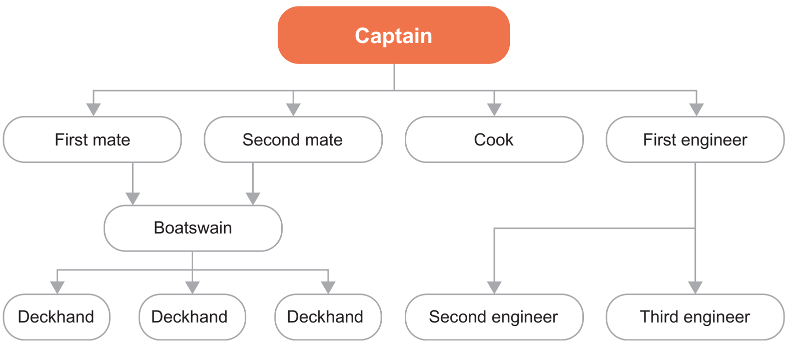

FIG. 12.2

Organisation chart aboard a fishing vessel.

Knowledge of these matters will increase the likelihood of success, especially in planning the management of an undertaking that operates in a multinational market and employs people from a variety of different cultural or ethnic backgrounds. The rapid changes in contemporary business operations impose even more demands for precise organisation. The organisation of an enterprise has to be so designed as to make it possible to respond to changed circumstances, for instance increased global competition or increased speed in both production and transport. Changes are a catalyst for progress, and standstills in business operations will usually lead to stagnation and, eventually, losses.

The current technological progress in many areas of fisheries and aquaculture will lead to a job shift from basic fisheries, fish farming, and fish processing jobs to high-tech jobs. The number of jobs requiring training and education is growing, while at the same time the need for unskilled labour in fisheries and aquaculture is shrinking. However, this is simplifying things a bit, as there will be continued need for labour to work with the technical solutions that are being developed. Workers will still need to be trained and educated to make use of new technology. This can have a positive impact on workers, even in the form of higher wages, as productivity will generally grow, and may grow significantly, with the introduction of new technology. These trends are also making research and development increasingly important, and with new technology and advances in fisheries and aquaculture it will become increasingly urgent for governments to attend to the education of the people who will be working in these sectors in the future and to devise plans based on the future vision of each government and on their strategies to attain a competitive advantage (Fig. 12.3).

All this said, it is entirely possible for an enterprise to have a very limited organisation, where everyone simply addresses a task that needs to be done and completes

FIG. 12.3

Technological changes in processing fish (Valka).

it. A typical example could be work on a farm, where all the employees will normally be capable of tending to all the chores that need to be done, and very often do. Another example is small-scale fisheries. Loose organisation of this kind is common in small enterprises, but if those enterprises start out on a path of growth they will soon face a need for discipline and organisation.

A number of plans are made within an undertaking, such as a financial plan, or budget, and a manufacturing plan. A business plan is one such plan, which encompasses most of the major aspects of an undertaking's operation; this is necessary if the intention is to attract attention from investors and credit undertakings and outline for them the potential benefit of investing in the undertaking. A business plan will include a description of the undertaking, its products and supplies. It will also describe the management system of the undertaking, its marketing strategy and financial structure.[e]

12.2 Strategy and SWOT analysis

A key aspect of corporate management, however, is strategic planning. In their strategic planning, owners and managers can begin by going through a series of four fundamental questions: what is the current situation, where do we want to go, when do we want to get there, and how do we intend to get there? A strategy takes account of the way in which fundamental factors have developed within an enterprise, and what the plan is for their development in the future, that is to say the objective of the strategy, what the owners and managers wish to achieve what resources are available, and how managers and owners will communicate in the environment in which the organisation operates. The core of a strategy is its sense of purpose at any given time and what means can be used to achieve the organisation's objectives through well considered plans and actions.[f]

It is important for any business organisation to have an awareness of where it stands in its competition with other businesses. Important factors in such a comparison are market size, production capacity, state of research and development, quality of raw material and/or products, and employee and management qualifications.

Leaders of a business organisation, whether a fish processing plant or seafood restaurant, need to examine various aspects of their environment in formulating their strategy. It is of special importance for them to understand where the business has a competitive advantage over other businesses with which it is competing and to use this advantage in the best possible way. A sound knowledge of the market is the most important means of achieving results. This knowledge has to be disseminated throughout the organisation. It is important to take stock of the current position of an enterprise and the challenges that the enterprise will face in the future. Four factors need to be taken into account in analysing circumstances: **S**trengths, **W**eaknesses, **T**hreats, and **O**pportunities. This methodology is abbreviated as 'SWOT' analysis (Fig. 12.4).

FIG. 12.4

Boats in Essaouira in Morocco (PeskyMonkey).

A SWOT analysis consists in assessing four elements of an enterprise's position; first, there is strengths, which, in the case of a fish processing enterprise, for instance, could be good access to raw material, advanced technological equipment, and strong cash reserves. An enterprise's strengths may also consist in qualified employees, sound financial management, or a good reputation, e.g., for selling quality products. The second element to analyse is weaknesses. These can include matters as varied as poor financial management, poor executive management, poor equipment in processing, or distance from markets. The third element to analyse is opportunities. These can consist in the introduction of a new type of processing line, location in an unpolluted environment, improved advertising, or entering new markets, for instance through partnerships with foreign enterprises. The fourth step is to analyse the threats that an enterprise may face. These can include competitors, potential legislative changes, technological advances, or environmental changes, such as climatic change, acidification of the oceans, and fish stock fluctuations.

SWOT analysis is used in various types of circumstances, and it is an important tool to analyse the position of an enterprise in an efficient and organised manner. However, the usefulness of a SWOT analysis should not be overestimated. The analysis can give a good picture of an enterprise's situation for the short term, but rapid changes in its environment can lead to its rapid obsolescence. SWOT analysis is therefore a good example of a methodology that needs to be continually reviewed to preserve its usefulness.

A SWOT analysis can be made of a sector of the economy, a single enterprise, or even an individual. In conducting a SWOT analysis of a country, region, or city with regard to fisheries or aquaculture, strengths and weaknesses could include proximity to fishing grounds or favourable natural conditions for aquaculture, such as access to clean water. Local knowledge of fisheries or aquaculture and fish processing are also important elements, and the infrastructure needed to engage in fisheries and aquaculture has to be in place in the proposed location. Other factors may also come into play, such as financial situation, a growing or shrinking population, the age composition of the population, education level, cost of communications, price of housing, and wage structure. With regard to threats and opportunities, it could be considered whether there is an ongoing brain drain from the sector, whether the number of jobs in fisheries and aquaculture is increasing or decreasing, what the situation is as regards transport to and from the area. It might also be considered whether there is a need to increase or enhance human resources in the area, whether investments in transport and communications are needed, whether research needs to be supported, or whether there will be need for teleprocessing or even distance teaching.

Table 12.1 shows a SWOT analysis of an entity in the fisheries value chain, that is to say a fishing operation, fish processing operation, a distributor, and a retailer. It shows a selection of imagined factors, which, of course, could be expanded and set out in greater detail. As the table shows, some of the opportunities, like new markets, can be the same for many entities. Financial situation may be a weakness for one entity and a strength for another, and the same element can entail both threats and opportunities for the same entity, as also shown in Table 12.1. The purpose of Table 12.1 is to illustrate the use of this convenient tool for management and planning.

Planning, for instance in marketing in fisheries and aquaculture, relies on organised work, which in fact also applies to other areas, as planning is an element of the management factors of production. Circumstances need to be analysed and a strategy formulated, laid down in detail, and monitored. Strategic planning in marketing and financial matters is based on the same basic principles as other planning. Various models are used in marketing for the analysis of factors such as market growth,

Table 12.1 SWOT analysis for an entity in the fisheries value chain.

	Strengths	Weaknesses	Threats	Opportunities
Fisheries operation	Good vessel, good planning	Difficult financial situation	Severe competition	New markets
Fish processing plant	Good staff, favourable location	Far from sea	High inflation	New production line
Distributor	Good financial situation	High distribution cost	High inflation	Mergers with other enterprises, new markets
Retailer	Favourable location	Poor organisation	Online sales	Online sales

market share, new products, and new markets. Management positions in fisheries and aquaculture nowadays are generally held by highly educated people, which in fact is true of most other sectors.

12.3 Porter's five forces model

The nature of competition among enterprises can be shown using Porter's five-force model.[g] To give an example, Fig. 12.5 illustrates this methodology in the fishing industry.

Fish processing is so diverse that a distinction needs to be made between individual enterprises and organisations for this approach to be useful. Nevertheless, there are many common features, such as buyers or consumers. Most of the activities within the fish processing industry focus on individuals as buyers, as shown in the box furthest to the right in Fig. 12.5. The bargaining power of buyers is strong, as fish is in competition with a number of other food products. Substitutive goods and services, like other foodstuffs, are shown at the bottom of Fig. 12.5; their position is often strong compared to fish products.

Suppliers in fish processing, shown in the box farthest to the right in Fig. 12.5, may be fisheries operators that supply the raw materials, or they may be fish markets where the raw material is purchased. The bargaining power of fisheries operators vis-à-vis fish processing enterprises is usually strong, as there are many enterprises competing for fish to process, with the supply of fish normally limited. The key element lies in the middle of the model, which shows the extent of the competition, or rivalry between enterprises, within the industry. Competition between enterprises is usually extensive in most fields of the fish processing industry.

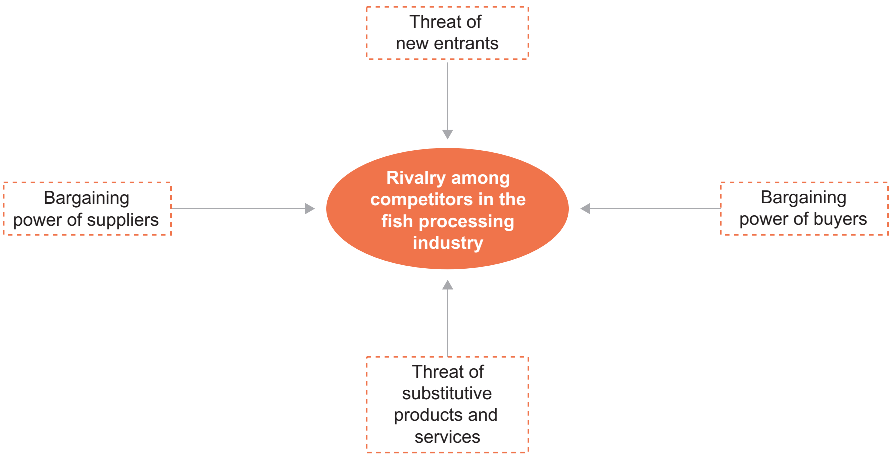

FIG. 12.5

Porter's five forces analysis in the fishing industry.

The top of the illustration shows the possible new entrants in fish processing. The barriers to entry are generally low, although starting up a fish processing plant will usually call for investment in premises and machinery, and there must be access to fish as raw material. However, formation expenses are generally not high in comparison with many other industries. The cost of investing in a fishing vessel is generally much higher, to give an example. Analysis using this model to uncover competitive advantages can result in building upon a weak foundation in some area which later, if decisive measures are taken, can prove to hold potentials for competitive advantage. The competitiveness enterprises in fisheries can be assessed based on a number of criteria.[h]

This idea, that is to say the concept of Porter's five forces model, can be transposed to the competitiveness of countries.[i] The model used for that purpose is known as Porter's diamond, which is illustrated in Fig. 12.6 for the fish processing sector in a single country. The factors of production, shown on the left side of Fig. 12.6, are labour, capital assets, natural resources, planning, organisation, management, and knowledge, as discussed earlier. For fish processing, access to raw material, qualified employees, and efficient capital assets are most important. Demand, which is shown to the right on Fig. 12.6, could be of a special nature if the domestic market for fish products is small in comparison with the quantity produced, and the products would then largely be exported. The performance of individual enterprises in sales of fish in the global market helps other enterprises, as does a good reputation abroad for fish products from a country or area. Related industries and support industries, shown at the bottom of Fig. 12.6, include repair services, fishing gear manufacturers, and the education system. Firm strategy, structure, and rivalry, shown at the top of Fig. 12.6, describe the general situation of enterprises in the fish processing industry.

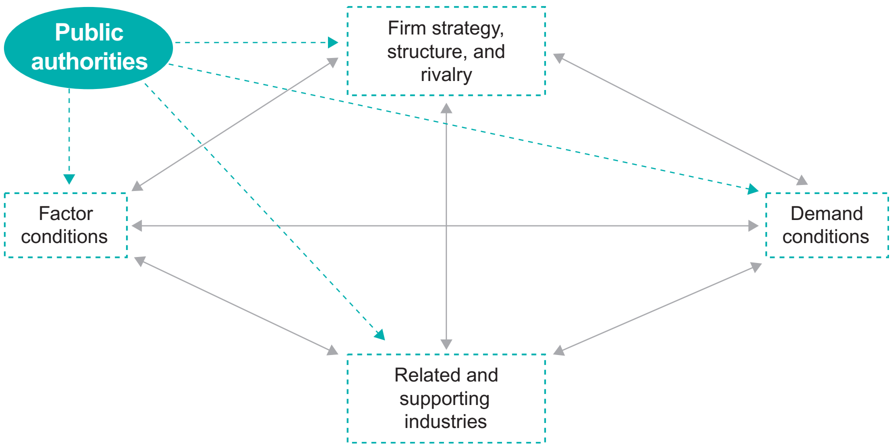

FIG. 12.6

Competitive advantage of a country in the fish processing industry.

Government, shown top left in Fig. 12.6, can do much to improve a country's competitiveness in fish processing, for instance through allocations to education in the sector, improved communications, and increased research. Relations with the government are shown by a dotted line in the illustration, signifying that the government can impact individual factors of the model directly.

A comparative study of competitiveness in Icelandic and Norwegian fisheries showed that, on the whole, Iceland's competitiveness was slightly better than that of Norway, but there were differences in individual areas. The Icelandic fisheries management system was considered more effective than that of Norway, but infrastructure and economic management was considered better in Norway, and exchange rate fluctuations were seen as a disadvantage for Iceland. As regards infrastructure, long transport distances, domestically and to foreign markets, were a disadvantage for Iceland. Fish processing in Iceland was seen as superior to Norwegian fish processing as regards competitiveness. Another study also revealed that fish processing was more profitable in Iceland than in Norway.[j] Having control of much of the value chain, which is common in Iceland, but not in Norway, ensures a comparative advantage, which is one reason that fish processing is more profitable in Iceland than in Norway. Norway has set a course for extensive improvements in their fisheries, and the Norwegian government has set a target of increasing income from Norwegian fisheries fivefold from 2010 to 2050, which is more than Iceland's entire domestic product over 4 years. This is an ambitious plan, and the first steps have been to allocate greatly increased funding to research.

Management theory is an extensive area of microeconomics. It is sometimes maintained that managers work mostly on decision making, relationships, and information, but the role of management can be broken down further.[k] Every manager of a fisheries company has to make decisions on things like what fisheries to emphasise and which markets to focus on. Relationships for the purposes of management involve things like appointing a captain or a foreman, and continuous work goes into discussing, gathering, assessing, and disseminating information relating to the operations, such as information on advice from marine biologists or government tax decisions.

With increased education and knowledge, modern methods of management have become increasingly prominent in fisheries in recent years. Among the most important aspects of management is human resource management, focusing on recruiting appropriate employees, keeping those employees, training them, and developing their skills; previously, this aspect of management dealt mostly with contract bargaining, calculating wages, and reviewing work reports. Those matters still need to be dealt with in any enterprise, but the emphasis on human resources as one of the most important factors of production has increased, although it could be increased still more, particularly as regards training, as in many enterprises in the fisheries and aquaculture sectors automation and the use of robot technology have increased and the trend has been steadily in the direction of streamlining, reducing the number of jobs and increasing productivity, which requires better trained employees.

The role of management has increasingly focused on encouraging employees and engaging them in working together towards the goals of the enterprise that employs them. This will frequently involve empowering employees and assigning to them tasks for which they are entirely responsible, as when a foreman is made responsible for quality management and the recruitment of the employees needed for the quality management system to work.

Managers in the fisheries sector will often protest, when certain management deficiencies are pointed out to them, that some things are difficult to deal with, that it is impossible to foresee catch figures, and that there are so many factors that influence fisheries operations that they cannot all be dealt with. Excuses of this kind are simply false and have no basis in reasoning, as contemporary management theory focuses precisely on these matters, and responses to all such influencing factors and all manner of methods have been developed to address problems of uncertainty and risk.

The traditional roles of management can be classified in a number of ways. For instance, they can be categorised by production, sales, finance, and human resources, with their primary focus on the future, making decisions in an environment which has become much more global in scope than just a few years or decades ago.

12.4 Knowledge management

Knowledge is one of the cornerstones of an enterprise; it is the resource that most matters as regards performance and competitiveness. One of the prerequisites of knowledge management is the ability to recycle and disseminate knowledge in an effective manner, which is also a key to the ability of enterprises to achieve their goals. Changes in the operating environment are becoming constantly more rapid, and it is safe to say that knowledge is giving management and employees a better overview of situations than was the case earlier, and knowledge is also the basis for effective decision making. Possessing knowledge shortens response times, which is particularly important today, as many organisations need to be able to review all their processes almost instantly when circumstances demand. For this reason, management has to be open to new opportunities and be ready to change and adapt (Fig. 12.7).

But not only is technology advancing at an unprecedented rate, customers are also becoming more and more demanding. In addition, returns on traditional resources, such as land, capital goods, and capital are steadily shrinking. The revolution in communications has also made its mark on business operations. Although disseminating knowledge relating to procedures and working methods is nothing new, knowledge management did not really become a fundamental concept of general management until the years towards the end of the last century. In our times, this work involves creating circumstances where tacit knowledge is useful to others in an enterprise; knowledge has become a valuable asset, and the ability of enterprise to learn faster than its competitors strengthens its position. Managers have therefore implemented

FIG. 12.7

Delta rivers in Iceland (Ozzo Photography).

knowledge management systems, or databases, to keep records of knowledge that has been acquired, and information is preserved so as to be accessible to all those in the enterprise who need it. In order for records of knowledge to return success, it is necessary to classify, organise, and present information in a systematic manner so that users can examine and assess search results and decide whether, and in what way, the information meets their needs.[1]

Organisations that that can be referred to as knowledge enterprises are those that have made advances in managing their knowledge environment. This environment includes factors such as culture, planning, technology, and measurements. The environment is both internal and external. The culture of knowledge enterprises is one of the most important factors in this context. The culture, criteria, and values of an enterprise need to have the effect of encouraging employees to gather knowledge, use the knowledge, and share it with others; the culture also needs to afford scope and incentives for innovation. Technology is also a vital factor of knowledge work, in particular in developing a knowledge base and means of disseminating the knowledge throughout the organisation. However, it must be borne in mind that the technology is only a tool to facilitate the work of knowledge enterprises and not a goal in itself. The organisation of the knowledge base has to be clear and accessible, and it must encourage dissemination and sharing of the information it embodies. A structure where only a single person at the top has possession of all the information is not a good structure. Information and knowledge have to be able to flow through the organisation to return any success. If an organisation relies too much on bureaucracy and red tape, this will create barriers to learning, and thereby barriers to the creation of new knowledge.

Technology and software play a key role, in particular for the purpose of building a knowledge base, ensuring the accessibility and user-friendliness of the information contained in the knowledge base and enabling dissemination of knowledge throughout the organisation. The technical equipment used for systematic information management is therefore an extension of the people themselves who possess the information, record it, organise it, and place it in the context of their own experience. It is therefore important for the software used to record information for the purpose of dissemination to encourage rather than discourage sharing knowledge. The accessibility to recorded knowledge and its usefulness is therefore dependent on the culture and trust already in place among the employees of an organisation.

The start of keeping records of this kind in fisheries can be traced to increased demands from the market, for instance regarding range of package sizes, fishing for species in appropriate proportions with regard to quotas, preventing overfishing, and increasing processing plant specialisation. With targeted accumulation, recording and dissemination of knowledge it becomes possible to control fisheries in a much more effective manner—even to the point of reducing the likelihood of fishermen wasting time in waters where there is no fish to be had, or at least not the desired fish.[m]

Targeted accumulation and use of information with interconnected systems between fishing operations and processing operations increases the likelihood of success. If an enterprise has the possibility of gathering information, for instance fishing data from vessels, information on departure, arrival, fish species, quantities, and fishing grounds, a great deal of information will accumulate in the long term. Keeping records of this kind can be extremely helpful in directing vessels to the areas that are most likely to yield the composition of species, sizes, or quality that the enterprise is after. It is important for management in fisheries to know when and where the best fish was caught and where deficient resources were harvested and processed. Information of this kind can enable an enterprise to meet the market demand for traceability.

An illustration of the use of knowledge in the fishing industry

For 20 years an annual ceremony has been held in Iceland to present an award to the knowledge enterprise of the year. Only once has a fisheries enterprise been selected, the family firm Vísir, operating on the south coast of Iceland. The conclusion of the jury was that Vísir had achieved notable results in its operations and increased productivity and efficiency with the introduction of digital solutions.[n] The use of technology thus opened the opportunity for Vísir to complete the production process from sea to consumer packaging, saving on intermediate transport and intermediate packaging, which represented a large step forward in reducing the company's carbon footprint.

Vísir is a family firm, currently under the control of the third and fourth generations of the same family. Vísir has a workforce of 320 people, of which 120 are seamen and 200 work on land. Vísir's principal products are fresh, frozen, and lightly salted products, as well as saltfish, all shipped throughout the world, although the firm's main markets for saltfish are Spain, Italy, and Greece. In recent years, Vísir has developed partnerships with Trackwell, Wise, and Marel to implement digital solutions and maximise value.

Among the main reasons Vísir was named as the knowledge company of 2018 was that the firm achieved greater operating efficiency through effective management of its fleet, improved utilisation, and a higher proportion of better paying products based on years of systematic record keeping and dissemination of information through the firm's databases. The firm's record keeping began in 1995, when all landed catches were recorded for each individual vessel; however, at that time records were not kept of where the vessels had been fishing, what species were being landed from each vessel, or what the value of each catch was. Looking at the traceability of Vísir's products, it can be asserted that the key to the targeted collection and utilisation of information by Vísir was the interconnection between the firm's data and systems.

Catch data are sent electrically from a Trackwell system to Wise, as shown in Fig. 12.8, including information on time of departure, arrival in port, fish species, quantity, fishing waters, weather, depth and temperature of the sea, quantity of bait used, and number of hooks. The records were useful in directing vessels to areas that were most likely to have a certain composition of species, sizes, or quality that Vísir was seeking. The system also fulfils the market demand for traceability. Explanations can be found for incidents that arise because of the detailed traceability. Access to the data and information enabled the firm to create value.

Also important is that the data was not only accessible, but also easy to understand. The management and employees of Vísir understood that knowledge is not the sacred possession of individuals, but the fruit of joint effort. The key to the firm's success has been its systematic collection and use of information, the interconnection between the data collected and the firm's fisheries data systems, and the resulting traceability.

FIG. 12.8

System collaboration.

12.5 Family-owned enterprises

Family firms are defined as being a corporate form where a family, or more than one family, exerts ownership over the firm and its strategic direction by leveraging control through management, ownership, or membership of the board of directors. According to several studies the family firm is the most common corporate form in the world, and it is estimated that up to 90% of all the firms in the world are family owned and family controlled firms.[o] Studies of family firms are a relatively new area of management theory, with the first studies published in the 1960s. Initially, the studies focused on what it was that prevented the growth of family firms, and factors were identified, such as nepotism, competition between generations, and unprofessional management.

Generally speaking, what distinguishes family firms from other enterprises is the participation of a family in the operation of the firm, which is a common arrangement among small enterprises, including in fisheries and fish farming and related business activities, such as processing, marketing and distribution. According to various studies, family firms differ from other firms not only as regards their ownership, but also as regards their management and recruitment of employees. Family firms therefore have a variety of opportunities, although at the same time they face threats, in that managers of family firms are at risk of mixing business relationships with personal relationships. For a business to be properly run, there have to be clear borders between business and personal affairs and interests. It has also been pointed out in studies that families running family firms are usually extended families rather than core households, where the extended family shares a workplace rather than a home. Also, family firms can run into more kinds of trouble than other firms, some of which may be characterised as financial crises, but perhaps more often as emotional crises (Fig. 12.9).[p]

As in other business operations, it is important for management to make decisions on business grounds with the interests of the firm at heart rather than personal interests. Decisions of this kind can relate to recruitment of employees, and in family firms there is a special risk of family members being appointed, even when they do not possess the knowledge and/or experience needed for the job to which they

FIG. 12.9

Ásta Dís Óladóttir, jr., 11 years of age, attempts to save a beached whale on the coast of Iceland, 2019 (Ozzo Photography).

are appointed. They may also relate to wage terms and remuneration; it is quite common for family members to be better paid than employees from outside the family.

One obstacle that family firms tend to face more often than other businesses is financing, and for this reason they tend to grow more slowly, and when growth does happen a family firm may often need to bring in unrelated parties from outside. Many family firms have had a tendency to hire children and relatives rather than appointing external staff, often because managers trust their family members better than outsiders. That way, responsibilities are kept within the family; however, this can also lead to disagreements and various other problems.

What makes a family firm different from other businesses is the influence of the family on the business. Family firms will often use different methods from other business in their strategic planning and have features that set them apart from other businesses. For instance, family influences will impact relations among the employees of the firm, and more direct communications can also facilitate and speed up decision making.[q]

In the context of family firms in fisheries and aquaculture, it is worth noting that while fish farming contributes to increased food security, both locally and globally, it also contributes to employment, both for the families themselves, many of which go on to establish large companies on the basis of their firms, and for their local communities. Examples include the development of fish farming in the European Union, which has mostly occurred in the form of small family-owned firms.[r]

12.6 Women in fisheries and aquaculture

Of the 100 largest seafood companies in the world, only one has a woman at the helm, the privately held Bolton Alimentari in Italy, where Marina Nissim is the CEO. The situation cannot be explained by any shortage of talent or knowledge among women, but only the invisible barriers, cultural and social, that have the effect that women can be excluded from top management positions, not only in fisheries, but in the economy in general. It has also been suggested that women simply are not as interested as men in working further up in a male-oriented competitive environment like the fisheries sector.[s]

Various jobs have through the ages been categorised either as men's or women's jobs, and it can prove difficult for both genders to look outside those job brackets, as various stereotypes and divisions of labour have become entrenched in the course of the centuries, with many of those ideas being shaped in early childhood. The genders select studies and jobs that are considered typical for their respective genders, and thereby the stereotypes become ingrained.[t] Ideas of this kind on division of labour and differentiation of jobs by gender have a deterring effect on individuals seeking jobs that are not typical for their gender. Caregiving jobs and teaching jobs are examples of jobs that have been earmarked as women's jobs, but stereotypes of this kind extend to a considerable number of job types. As noted earlier, women are less likely to occupy management posts in companies, as men have a head start in the race for management posts as a result of the reference standards that have been formed by tradition.

This is the case in most countries of the world, and the prediction is that it will take almost a century to reach full gender equality in the world. In 2019, 29% of senior management roles were held by women and 87% of global businesses had at least one woman in a senior management role.[u] Women are more likely to be CEOs of small enterprises with 1–10 employees, and in Iceland, for example, in the case of larger enterprises with 50 or more employees, women hold only 13% of the CEO positions. Even though Iceland has in 2020 topped the World Economic Forum gender equality list for 11 consecutive years and has succeeded in eliminating most of the imbalances that have dominated the job market, and even though Iceland is considered by many to be a gender equality paradise, the situation of women in top management positions remains far short of equal to that of men.[v] Out of the 50 largest companies in fisheries in Iceland only one has a woman as a CEO. Norway and Iceland rank high on all lists where gender equality is measured, and both countries have established gender quotas for company boards. Norway and Iceland also have in common the statistic of having the highest participation by women in the job markets of the OECD countries. Nevertheless, among Norway's 200 largest companies, only 1 in 10 chief executives is a woman. In the top executive committees of those companies, the share is 22%.[w]

The term 'gender segregation' in the labour markets is used in discussions of the different situations of the genders in the labour market, where the two genders occupy different jobs. The segregation is said to be horizontal when the genders do different work, and vertical when men are more prominent in managerial positions and positions of influence in enterprises and institutions, and therefore in better paid jobs than women.[x]

Profound changes have occurred in fisheries and aquaculture in recent decades, including extensive and rapid changes in technology, that have transformed both the sector itself and the jobs in the sector. Looking at the past, the roles of the genders in society were clear, in that women mostly took care of the home and children, while men put the food on the table (although not literally). This remains the case in many countries, though the situation has admittedly changed in the Western countries, most notably in the Nordic countries.

Industrial, or capital-intensive, fishing conveys the popular image of a massive boat, rough seas, and virile men on board. Going to sea in rowboats, a familiar image from the past, was physically demanding work, and so it was usually men who went out to sea. In many countries, however, such as Canada, France, and the United States, women work aboard industrial trawlers, although mostly on the processing floor.[y]

In most regions, women are less involved in offshore and long distance capture fishing. Women's participation in aquaculture, however, is extensive, particularly in processing. Looking at processing in aquaculture as a whole, the proportion of women is estimated at approximately 70% of the total workforce, although the proportion differs from one continent to the next, being by far the greatest in Asia and

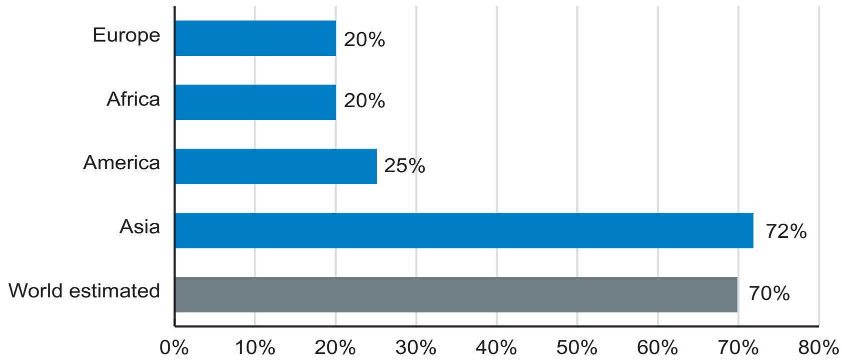

FIG. 12.10

Percentage of women employed in aquaculture.

smallest in Africa and Europe, as shown in Fig. 12.10. This figure is merely indicative, as it is only an estimate, where processing is sometimes included and sometimes not. Women work in the household concurrently with their work in small-scale aquaculture in many places in the world. Small-scale aquaculture is common in Asia, and women are 33% of the rural aquaculture workforce in China, and 42%–80% in freshwater and cage culture in Indonesia and Vietnam; women also participate in most activities related to aquaculture in Thailand. Some women are owners, co-owners, or managers of the businesses.[z]

Of the largest fisheries companies in the world, 84% have less than a 20% proportion of women in management. Norway is at the forefront, with the proportion of women in management of fisheries companies at 31%. In China this proportion is 20%, and in Iceland it is 17%. About 14% of fisheries enterprises in Denmark and Canada have women on their boards of directors. In the United States this proportion is 6%, in the United Kingdom it is 4%, and in Chile and Japan the proportion is a mere 2%.[aa]

In order to remedy the situation of boards of directors being composed entirely of men, many countries have resorted to introducing gender quotas. The implementation of gender quotas differs from country to country, and also by type of enterprise. The first country in the world to introduce quotas of this kind was Norway; the goal was to increase the number of women serving on the boards of directors of companies and institutions. Next to introduce quotas of this kind was Spain, followed by Iceland. Although many have welcomed the legislation on gender quotas in Iceland, not everyone is convinced. Following enactment of the legislation on gender quotas people began to speculate whether women were being selected to serve on boards of directors only because the quota system so required, and not because they were necessarily the best choices.[ab]

Looking at aquaculture in Norway, enterprises in the sector have developed in the course of a few years from localised family firms into modern, global, high-tech companies. With increased advances in technology in 1990–2010 the production of farmed salmon increased by 600%, but concurrently with the increased growth, the number of women in the sector declined, mostly because of the shift that occurred when the small family firms, where women were often key employees, disappeared, to be replaced by large international enterprises, where men held the reins. With increased production and globalisation, the number of women in aquaculture shrank from being 20% of the workforce in 1990 to about 9% of the workforce in 2010.[ac]

The fisheries sector in Norway, like in many other countries, is controlled by men. Almost all the fishing quotas in Norway are owned by men, and, like in other countries, they occupy the top management positions in the fisheries companies. The same applies to entrepreneurs and owners of aquaculture enterprises.[ad] Women in fisheries and aquaculture are mostly involved in the slaughtering and processing, office jobs, and cleaning. Where women are owners, they generally own a small share, and in most cases those are shares in family firms.

The fisheries sector, together with all the ancillary industries and side products that have been introduced in recent years, is growing at a fast pace in line with the growing consumer market. There is no doubt that in terms of intellectual ability, women are entirely on a par with men, and, obviously, enterprises will have twice the choice of applicants if both women and men are taken into consideration in selecting candidates for leadership positions. More women in positions of influence and power would, as role models, also attract further women into the sector.[ae] Clearly, change and progress is needed in both fisheries and aquaculture in this regard.

Endnotes

a. For a discussion of small and medium-sized enterprises in Europe see, e.g., Eurostat (2018, May).
b. For a discussion of the growth of enterprises and problems in relations see, e.g., Pugh and Hickson (1976).
c. For research on enterprise size and management structure see, e.g., Rutherford, McMullen, and Oswald (2001), Bolman and Deal (2003), Pugh (2007), and Jones (2013).
d. Further discussion of Fig. 12.2 showing the organisation chart of a fishing vessel can be found in Pétursson (2010, p. 84).
e. For a discussion of organisation and business plans see, e.g., Einarsson (2005), Lynggaard (2008), Daft (2010), and Wöhe, Döring, and Brösel (2016).
f. For a discussion of the fundamentals of strategic planning in organisations see, e.g., Lynch (2005).
g. For a discussion of the competitive position of enterprises and related models see Porter (1998c).
h. For a discussion of models used to assess the competitiveness of fisheries enterprises see Gudmundsson and Ottósson (2005).
i. For a discussion of the competitiveness of nations see Porter (1990).
j. For more on these studies of the competitiveness of Icelandic and Norwegian fisheries see Verdlagsstofa skiptiverds and Norges fiskerihøgskole (2005) and Einarsson (2016).

k. For a discussion of management, particularly in the context of fisheries see Chaston (1988a, 1988b) and Ragnarsson (2011).
l. For more on communications using new technology and the beginnings of knowledge management see, e.g., Nonaka (1994), Hansen, Nohria, and Tierney (1999), Skyrme (2011), Kankanhalli, Lee, and Lim (2011), and Leonardi and Meyer (2015).
m. For more on the use of technology and dissemination in knowledge management see, e.g., Oliver and Foscarini (2014), Hwang, Lin, and Shin (2018), and Haraldsdóttir and Gunnlaugsdóttir (2018).
n. For more on the award to Vísir see Óladóttir and Haraldsdóttir (2020).
o. For a discussion of family firms see, e.g., Aldrich and Cliff (2003), Pieper, Klein, and Jaskiewicz (2008), and Sluhan (2017).
p. For a further discussion of the special circumstances of family firms see, e.g., Tagiuri and Davis (1996), Habbershon, Williams, and MacMillan (2003), Jaffe (2005), Astrachan (2010), and Haag (2012).
q. For more on family firm performance see, e.g., Habbershon and Williams (1999), Steier (2001), and Dyer (2003).
r. For a discussion of fish farming family firms in the European Union see, e.g., Nielsen, Asche, and Nielsen (2016).
s. For more on women in management positions and the number of women managing the largest fisheries companies in the world see Monfort (2015), Undercurrent News (2016, December 1), and Óladóttir and Pétursdóttir (2018).
t. For a discussion of traditional men and women's jobs see, e.g., Kurtz-Cotes, Copping, Rowley, and Kinlaw (2014) and Spencer, Logel, and Davies (2016).
u. For a discussion of senior management see Thornton (2019, March).
v. For a discussion of global gender equality see Óladóttir, Adalsteinsson, and Christiansen (2019) and the World Economic Forum (2019).
w. For more on gender quotas in corporate boards see, e.g., Norwegian Ministry of Children and Equality and Norwegian Ministry of Trade, Industry and Fisheries (2019).
x. For more on gender segregated labour markets see, e.g., Massey (1994), Dahlström (1996), Walby (1997), and Andersen (2009).
y. For a discussion of specialised women's jobs in fisheries see, e.g., Framgoudes (2013) and Lentisco and Lee (2014).
z. For more on women in aquaculture in the world see, e.g., Hishamunda et al. (2014), De and Pandey (2014), Satapornvanit, Little, Satapornvanit, Sritha, and Murray (2014), Monfort (2015), and Food and Agriculture Organization of the United Nations (2020).
aa. For more information on women in the world's largest fisheries enterprises see Monfort (2015).
ab. For a discussion of gender quotas for boards of directors see, e.g., Rafnsdóttir, Einarsdóttir, Snorrason, De Vos, and Culliford (2014), Terjesen, Aguilera, and Lorenz (2015), Óladóttir et al. (2019).
ac. For more on the position of women in aquaculture in Norway see Pettersen and Alsos (2007), Monfort (2015), and Óladóttir and Pétursdóttir (2018).
ad. For more on women in top positions in fisheries see Pettersen and Alsos (2004), Sloan et al. (2004), Pettersen and Alsos (2007), Fischer (2015), and Gerard (2018).
ae. More women in leadership positions attract more women to the sector see, e.g., Briceño-Lagos and Monfort (2018) and Fischer (2017).

CHAPTER

Legal framework, research, and some peripheral issues

13

13.1 Governments and legislation that applies to fisheries and aquaculture

The framework within which fisheries and aquaculture operate is shaped by laws and regulations. Of course, this applies not only to fisheries and aquaculture but all economic sectors, and indeed all human relations. Limits are set not only by government regulation, but also by custom, which in fact largely dictates the way people interact with one another. Sources of law can therefore be both written and unwritten. Laws are passed in individual countries and on their basis a regulatory environment is created featuring various institutions, official supervision, and sanctions for violations.

The legal environment can be divided into three segments, as shown in Fig. 13.1; first, there are international laws and treaties, often tied to membership of various organisations, such as the United Nations (UN) and its various subordinate bodies like the Food and Agriculture Organization (FAO) and others. Then there are bilateral and multilateral agreements on various subjects, such as mutual fishing rights in territorial waters, distant water fishing, commerce and trade, tariffs, charges, and investment. Third, there are the domestic laws and regulatory frameworks of individual countries.

International laws are often based on complex treaties and organisations established on the basis of those treaties to ensure their enforcement, including tribunals like the International Tribunal for the Law of the Sea (see later) and the European Court of Human Rights. Sometimes international law is incorporated into domestic law, as in the case of the Geneva Convention, which, among other things, provides for the treatment of people in times of armed conflict. An example of international laws and treaties that carry great weight in fisheries and maritime navigation is the United Nations Convention on the Law of the Sea, often known as the constitution of the oceans, which entered into force in 1994.[a]

To this day, the United Nations Convention on the Law of the Sea remains one of the most significant of all legally binding international agreements. A total of 168 states are parties to the Convention, in addition to the European Union.[b] The United Nations Convention on the Law of the Sea establishes rules governing activities on the world's oceans and covering matters such as territorial waters, international straits, archipelagic states, exclusive economic zones, the high seas, protection and preservation of the marine environment, marine scientific research, marine

Fisheries and Aquaculture. https://doi.org/10.1016/B978-0-12-821056-7.00003-2

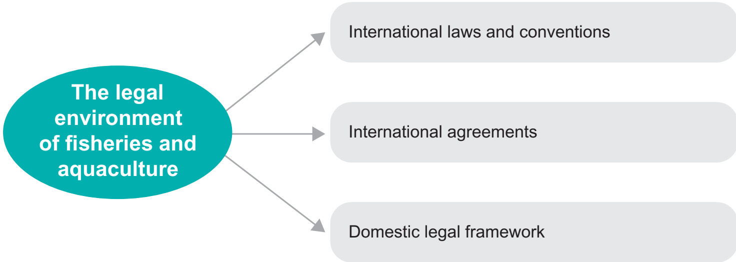

FIG. 13.1

The legal environment of fisheries and aquaculture.

technology, and settlement of disputes. The United Nations Convention on the Law of the Sea was the foundation for the establishment of the International Tribunal for the Law of the Sea in 1966, which handles disputes on the interpretation of the Convention and other related matters.[c]

The law of the sea covers the legal order of the sea under international law and the rights and obligations of states in that regard. The issues that arise are mostly of three kinds: the classification and demarcation of different areas and belts in the sea and on the seabed. There are specific international rules that govern each such area, and the rights and obligations of coastal states and other states within such areas need to be determined and codified. This includes the utilisation of any resources that may exist, or be discovered, in the areas. Issues can also arise regarding the appropriate means of resolving disputes that may come up in relations between states concerning the enforcement of the instruments of the law of the sea.[d]

The background of the modern law of the sea can be traced back to a dispute on ownership rights. Roman law provided for freedom of the seas and free utilisation by all. History has shown, however, that this has not always been the case. In the Middle Ages, powerful states declared their ownership of vast areas of ocean. In 1609 the book *Mare Liberum* appeared in print, written by the Dutch lawyer Hugo Grotius. He set out the argument of why the sea should be free to all, whether for fishing or navigation. No state should be able to declare its ownership of the sea, any more than ownership of the atmosphere or the Northern Lights. His writing attracted widespread attention and gave rise to many more works on similar subjects. The English lawyer John Selden was one of those who was commissioned by the English crown to write on the *Mare Clausum* (the closed sea). The objective was to establish proof that the English crown held the ownership rights to English waters. Selden's reasoning was grounded in a long tradition of state ownership of the world's ocean, but in the end it was the writings of Grotius on the freedom of the seas that prevailed and became a fundamental principle of the law of the sea into the 20th century.[e]

Sovereign rights to fisheries are now among the most significant elements of the rights of coastal states to their economic jurisdictions. Coastal states can now claim up to a 200-mile economic jurisdiction, measured from the baseline of their territorial sea. The coastal states hold exclusive rights to fisheries within their economic jurisdictions. Since most bountiful fishing waters are generally close to coasts, these sovereign rights can have great economic significance for coastal states.[f] Up to 90% of the catches of fish in the world are harvested within 200-mile jurisdictions.[g]

The agreement adopted by the United Nations in 1995 on straddling stocks and highly migratory fish stocks, normally shortened to the UN Fish Stocks Agreement, was intended to fill the gaps left by the United Nations Convention on the Law of the Sea. One of the big steps taken with the Convention on the Law of the Sea was to limit the number of states that could lay claim to each fish stock and empower the states to establish and enforce rules on harvests. However, this could not be applied to fish stocks that migrated outside 200-mile jurisdictions. No state has jurisdiction over the high seas, with the exception that states have jurisdiction over their own vessels. It became clear quite soon that even though 90% of all catches of fish were harvested in the economic jurisdictions of individual countries, the remaining 10% had considerable importance. However, the Fish Stocks Agreement did not take the route that in some ways would have been logical in light of the Convention on the Law of the Sea, that is to say to extend territorial waters still further in order to close various loopholes. Instead, the countries of the world were encouraged to join regional management fisheries organisations and resolve problems relating to the utilisation of fish stocks outside 200-mile jurisdictions. However, there is much that is unclear regarding the enforcement of this agreement, as these regional organisations have no powers to enforce their own decisions, although they have attempted, with some success, to convince countries to enforce bans on landing fish caught in contravention of their decisions.[h]

Coastal states are also responsible for the maintenance and growth of the fish stocks in their exclusive economic zones (EEZ). Previously, the norm was that the responsibilities of coastal states were confined to the boundaries of their territorial waters. The areas outside territorial waters were the high seas, where the principle of freedom of the sea applied and fisheries were unrestricted (Fig. 13.2).

Among the important agreements relating to fisheries is the FAO Code of Conduct for Responsible Fisheries, dating from 1995, which addresses, among other things, responsible fisheries, the United Nations Sustainable Development Goals of 2015 and the Paris Agreement of 2015 on the campaign against Climate Change.[i]

Other international organisations that concern themselves with global fisheries and aquaculture, in addition to the Food and Agriculture Organization of the United Nations, include the International Council for the Exploration of the Sea, International Hydrographic Organization, International Labour Organization, International Maritime Organization, International Monetary Fund, World Trade Organization, World Bank Group, World Conservation Union, and World Meteorological Organization. The names of these organisations describe their respective competences.

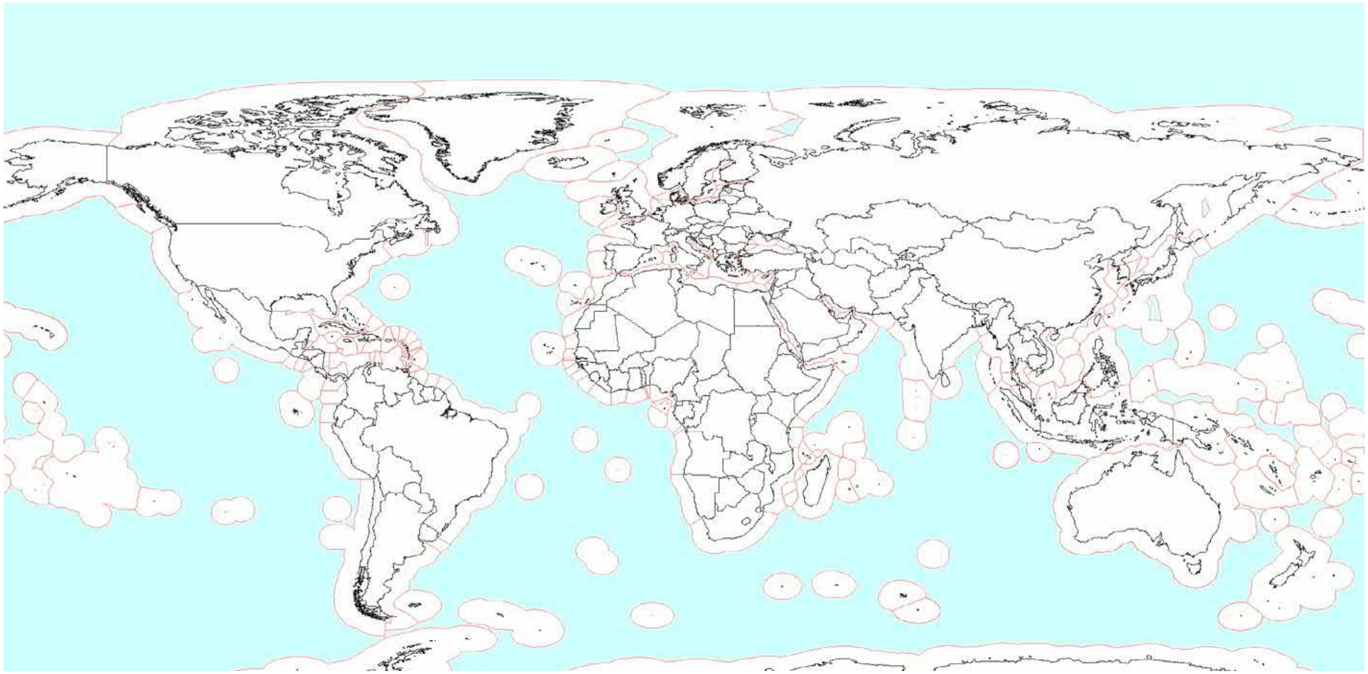

FIG. 13.2

The countries of the world and their exclusive economic zones (Wikimedia Commons—The Tom).

International agreements are not only agreements between two countries, but can involve a number of countries, examples being agreements on mutual fishing rights and on harvests of migratory fish stocks. Sometimes a number of countries may also be subject to common legislation, as in the case of the European Union, and agreements can also be made between international organisations. International agreements can be complex instruments, as in the case of some agreements between the countries of North and South America, Africa, and Asia, often including wide-ranging provisions on trade and tariffs.

The legal framework of economic sectors in individual countries is widely based on general principles regarding a free market featuring demand and supply, and price formation in the marketplace. As regards fisheries and aquaculture specifically, these are subject to an extensive legal framework. A number of laws, and regulations grounded in those laws, apply to ocean fishing, including laws and regulations on fisheries management in the exclusive economic zones of individual countries and supervision of fisheries. There are also laws on fisheries in rivers and lakes and the arrangement of such fishing, disease control, records of catches, and surveillance of fishing vessels. Fisheries and aquaculture are also subject to general rules on business practices, particularly in the food industry, on safety in the workplace, hygiene, pollution, staff facilities, statistical data, education and research, commerce and trade, and relations with other countries, as in the case of legislation on foreign trade and currency matters.

Although legislation, whether international or local, can be detailed with regard to various matters relating to fisheries and aquaculture, its enforcement is largely dependent on the regulatory institutions in the countries in question and their ability to intervene in the event of noncompliance. The financial situation of such institutions can differ vastly, as can access to human resources. Sometimes these institutions are effective and manned by well educated and capable staff, but that is far from being the case everywhere. Supervision of compliance with law is good in some countries and deficient in others. Corruption can play a role and severely undermine the usefulness of laws and regulations. One of the most urgent tasks regarding legislation and rules in some countries is therefore to reinforce institutional frameworks. Of course, this does not apply exclusively to fisheries and aquaculture, but to most economic sectors, particularly in the developing countries.

Closely linked to the legislative framework on fisheries and aquaculture is the work of various interest groups, ranging from seamen's unions and unions of workers in processing and marketing to associations of fisheries operators and processing plant enterprises. However, it should be noted that in many countries, including various developing countries, the activities of labour unions are restricted. Many interest groups of enterprises spend a great deal of effort on influencing the public discourse and swaying it for the benefit of their interests. Often, perhaps most often, these associations are protecting their own special interests, and frequently at the expense of others. It is an urgent matter to understand the work and objectives of interest groups, not only in fisheries and aquaculture, but also in other sectors (Fig. 13.3).

FIG. 13.3

Italian naval education barquentine *Palinuro*, moored at a pier in Odessa, Ukraine (A Lesik).

13.2 Education, research, and artistic creation

Formal education relating to fisheries and aquaculture was basically nonexistent for centuries, apart from the informal education of skills passing from one generation to the next. People learned from experience, for instance by going to sea, fishing, handling fish, navigating by the stars, absorbing local knowledge of fishing grounds, and reading weather signs. For centuries fishermen would row out to fish on inshore fishing grounds, so that positioning of vessels at sea was unimportant if vision was not obstructed by fog or weather in general. But of course there has always been a great deal of formal naval training for military purposes. Any navy, as an institution, will place great emphasis on training and education for its prospective seamen, and this knowledge has always seeped into nonmilitary seamanship on both fishing vessels and the merchant marine.

There are close links between various forms of vocational and technical training and fisheries and aquaculture. Many of the services to fisheries and aquaculture are based on vocational studies, as in ship and boat building, the manufacture of nets and other fishing gear, which requires a wide range of skilled workers, such as electricians, metal turners, construction workers, painters, and a variety of other trained workers.

Education in fisheries and aquaculture is similar in most countries, the principal difference being the level of advancement in specialised education rather than

FIG. 13.4

Masters students in Fisheries at the University of Iceland (Kristinn Ingvarsson).

any fundamental difference. As a result, it is generally quite easy for trained personnel to relocate in other countries to work in their fields of specialisation (Fig. 13.4).[j]

The Fisheries Training Programme in Iceland was established in 1998 as part of the United Nations University. Since 2020 it has been operated under the auspices of the United Nations Educational, Scientific and Cultural Organization (UNESCO).[k] The Fisheries Training Programme offers 6 months' advanced studies at university level for students from developing countries. About 400 students from 60 countries have graduated from the programme. The programme has been very successful, and over 1000 students have attended courses offered in partner countries.

Research relating to fisheries and aquaculture in universities and research institutions is largely the same in most countries. Biological research is an important field for various purposes, such as identifying the food chain for individual species of fish and calculating the size of fish stocks for fisheries management purposes, as is investigation of the sea bed, measuring ocean temperatures, currents, and so on. Most scientific research is by its nature international, and scientists disseminate their knowledge in conferences and seminars and by writing books and articles. Participation in multinational conferences is among the most significant aspect of the work of scientists, and research is also often conducted in parallel with teaching, a common feature of universities. But extensive research is also conducted in specialised institutions, where scientists engage exclusively in research, although many of those scientists might also teach in universities.

The oceans, both as a part of the environment and a place of work, have always been prominent in art, with fisheries at sea, in rivers and in lakes featuring in virtually all art forms, ranging from painting and sculpture, through literature, music, drama, and cinema.[1] To pick an example from music, Richard Wagner's 1843 opera *The Flying Dutchman* is based on a theme from folklore and literature and tells the story of a ghost ship that is doomed to sail forever on the oceans of the world. The best known ship in Western culture is no doubt Noah's biblical Ark, constructed to save the animals of the world, including humans, from obliteration by a wrathful God, although legends of floods caused by wrathful deities are common in eastern religious legends. Painters have created countless paintings of scenes of the sea, rivers, and waters, one famous example being Théodore Géricault's painting of the shipwrecked seamen of the French frigate *Méduse* in the early 19th century, see Fig. 13.5.

Other famous ships of legend and history are the *Argo*, sailed by Jason and his fellow Argonauts in their quest for the Golden Fleece, one of the best known stories of Greek mythology. Historic ships include the *Beagle*, the vessel that took Charles Darwin on his expedition of discovery in 1831–36, in which he gathered data that subsequently led to the formation of his theories on the origin of species. Other historic ships include the passenger vessel *Lusitania*, which was sunk in 1915, leading to the United States' participation in World War I. A number of ships feature in

FIG. 13.5

The Raft of the Medusa by the French painter Théodore Géricault, dated 1818–19 (Wikimedia Commons—Musée du Louvre).

works of fiction, such as the *Nautilus*, a submarine commanded by Captain Nemo in a popular 1870 novel, *Twenty Thousand Leagues Under the Sea*, by the French novelist Jules Verne.

Turning to the cinema, the *African Queen* featured in a 1951 Hollywood movie of the same name, directed by John Huston and featuring Humphrey Bogart and Katharine Hepburn in the starring roles. The movie *Titanic*, launched in 1997 and directed by James Cameron, is based on the disastrous sinking of the *Titanic* on her maiden voyage from Southampton in 1912, starring Leonardo DiCaprio and Kate Winslet. The film was awarded 11 Oscars, regarded as the most prestigious award in film; it is among the three films that have received the greatest number of Oscars in more than 90 years of the award's history. Other ships in films include the *Black Pearl*, Jack Sparrow's vessel. The story of the resourceful pirate dates from the 21st century, so that the sea features as prominently in artistic creation as it ever has.

13.3 Whaling

It could be argued that a discussion of whaling hardly belongs in a book devoted to the subject of fisheries and aquaculture, even though whaling, like fishing, involves hunting for marine animals.[m] Nevertheless, the subject merits a brief digression, if only for the reason that it is not so long since a clear distinction was made between fish and whales. This happened in a courtroom in New York in 1818, in a case that concerned control of 'fish oil', which came in different forms and was subject to different rules depending on whether it was processed from fish or other species. The product in this case was oil processed from whale blubber, and the task of the court was to determine whether a whale was indeed a mammal or a fish. A number of scientists appeared before the court and testified that the whale was a mammal. Nevertheless, the jury returned a verdict contending that a whale was a fish![n]

The practice of whaling began early in human history, as evidenced by a number of place names associated with whales.[o] The Basques hunted for whales as early as the 12th century, and their proficiency made them in great demand as crew on vessels from other countries, such as England and the Netherlands. In the 16th century there was extensive demand for whale blubber, which was refined into whale oil for lamps; this practice continued until the 19th century, when fossil fuels were introduced and whale oil was widely replaced by kerosene, a derivative of crude oil, and later by natural gas, which in turn has now been replaced by electricity. A number of products were made from whales; the skin, for example, was used to produce rope. Products made from whales were for a long time a vital necessity for humans, and for some communities they were even more important than fish products. Many communities owed their very existence to whaling, which formed the basis of large-scale industries. Stories of depleting whale stocks in the North Atlantic abound, from as early as the Viking Era.[p]

The most famous novel involving whales is no doubt *Moby-Dick; or, The Whale* by Herman Melville, which was first published in 1851. The novel describes the struggle of Captain Ahab with the white whale, Moby Dick; its subject, however, is not just whaling but the battle between good and evil. The novel has been translated into innumerable languages and has been read for over a century and a half around the world, including in schools.

Whaling has long been a subject of heated debate, and it is an undeniable fact that whales were hunted to excess in the North Atlantic around the turn of the century in the late nineteenth century, but the situation in the south seas was far worse. Some species of whale, such as the blue whale (*Balaenoptera musculus*), are now protected (Fig. 13.6).

The United Nations Convention on the Law of the Sea sets out special rules on whales and other marine mammals. The general principle is that if a coastal state cannot use its entire permitted harvest, it is required to provide access to the rest of the permitted harvest to other states. However, coastal states are always permitted to ban, restrict or set more stringent regulations regarding the utilisation of marine mammals. The provisions do not entail a ban on whaling or hunting for other marine mammals, or restrict such utilisation, but instead grant permission to coastal states and international organisations to do so. A number of states have, on the basis of these provisions, banned all whaling in their economic jurisdictions.

The Convention says that states should work together on protecting marine mammals and, as regards whaling, collaborate under the auspices of the competent international organisations on their protection, management, and research.

FIG. 13.6

Whales in the North Atlantic (Ozzo Photography).

The collaboration has mostly been conducted within the International Whaling Commission or between neighbouring states.[q] The International Whaling Commission was established in 1946 and is now entrusted with the management of whaling around the world. In 1982 the Commission approved a global ban on whaling, and since 1986 commercial whaling has been prohibited. However, some limited whaling by indigenous people for sustenance is still permitted. Denmark was granted an exemption from the whaling ban in Greenland, and both Russia and the United States were also granted exemptions for indigenous whaling. Also, certain limited exemptions have been granted for ‘scientific whaling’, which is a subject of periodic debate. Iceland, Japan, and Norway have all taken advantage of these exemptions, and increasing scientific whaling, especially by Japan, has been the subject of loud criticism.

Environmental organisations, such as Greenpeace, have been opposing whaling for almost half a century, since the mid-1980s of the last century. There are people who feel that humans simply should not hunt whales and seals; in their view these mammals are special animals. One prominent protester of sealing was the French actress Brigitte Bardot, who campaigned for a ban on seal hunting with considerable success. In the United States there is widespread opposition to whaling, although indigenous people in the United States, mainly in Alaska, do hunt whales on some scale, as noted earlier.

In the European Union (EU) whaling is expressly prohibited. As a matter of fact, whaling is economically insignificant, with Japan being the principal market for whale products, but the demand for whale products in Japan is shrinking. It is quite possible that whaling will be completely abandoned in the coming years as its importance is already limited, and it is difficult to bring the products to market in Japan because of the growing opposition. The Japanese have been one of the one of the most prominent whaling countries in the world, and in 2019 they withdrew from the International Whaling Commission and took up commercial whaling once more, that is to say they no longer hunt under the label of scientific research.

Sightseeing expeditions, seagoing safaris of a sort, to observe sea-dwellers in their natural habitats are growing in popularity. Whale watching expeditions have become an important tourist attraction in many coastal areas of the world. Boats are sailed into waters where there is an abundance of wildlife, birds, seals, whales, and attractive natural surroundings. While activities of this kind are not directly connected with either fishing or fish farming, and are usually associated with tourism, they do take place in the same environment as fisheries. The same can be said of aquariums around the world, where living fish and whales and other marine animals are on show for huge audiences, particularly the younger generations. One example is the Monterey Bay Aquarium in California in an area that provides the setting for a number of the novels of the American writer John Steinbeck, many of whose works relate to the sea and life by the sea.

Another example of the deep roots of the sea and associated activities in human culture is the huge number of maritime museums around the world. These

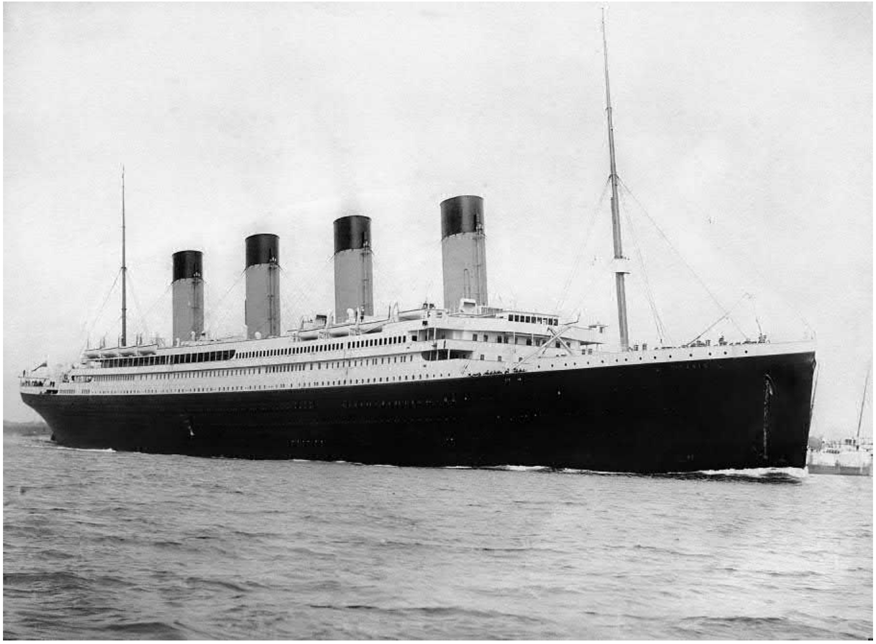

FIG. 13.7

The British passenger liner *Titanic* departing Southampton 1912 (Wikimedia Commons—F.G.O. Stuart).

museums are often the pride of countries that boast an illustrious maritime history. Also, marine animals and artefacts of all kinds relating to the sea, rivers, and lakes are prominent exhibits in museums of natural history all over the world (Fig. 13.7).

An illustration of disasters at sea

Inclement nature has been, and remains, one of the most difficult challenges for both fishing, freighting and passenger transport in the world, with great numbers of seamen having lost their lives at sea through the ages; although deaths may not be as common as they used to be, drowning remains a frequent cause of death among seamen.[r]

Fishermen often perished at sea in earlier times, and in all countries with traditions of fisheries there are countless stories of disasters at sea and losses of life. To give an example, on a single day of monstrous weather in the 18th century so many fishermen died in the waters around Iceland that if their number were adjusted to the population of the modern United States the figure would correspond to 165,000 deaths in one day, many times the number of people that perished in New York on 11 September 2001. One of the principal reasons that so many seamen perished at sea was that it was not common for people in general to know how to swim. It was not until late in the 20th century that the number of deaths by drowning decreased. However, stories of disasters at sea are often accompanied by stories of heroic rescue.

History also abounds with stories of disasters at sea that did not involve fishermen, and many of these stories are well known, like the loss of the *Titanic* in 1912 after a collision with an iceberg. The lives of 1600 people were lost out of total of 2200 crew and passengers. Investigation of the accident revealed a number of deficiencies in safety measures aboard: lifeboats were too few, and life jackets were inadequate.

However, this was not first such accident in modern history. In 1904 the ferry *General Slocum* set sail from New York on a day trip up the East River from Manhattan, an island lying between the East River and the Hudson River. The passengers were mostly women of German origin and their children, their husbands, immigrants from Germany, being at work. There was a fire aboard, and the ship was not run aground until it was too late. Over 1000 of the 1300 people aboard lost their lives. Investigations later revealed that there were far too few lifeboats aboard. Fire hoses were deficient, and life jackets were in such poor condition that they fell apart when passengers tried to put them on. Not many people were held to account for the disaster, and only the captain spent time in jail, but the accident brought the German colony in the Lower East Side in New York to an end. Not until 11 September 2001, with the terrorist attack on the Twin Towers, did New York suffer more deaths in a single day.

However, the *General Slocum* and *Titanic* incidents were far from the deadliest incident at sea in history. That dubious distinction goes to the sinking of the German military transport vessel *Wilhelm Gustloff* by a Soviet submarine in the Baltic Sea in 1945, when 9400 lives were lost, including those of 5000 children and a number of wounded veterans returning from the front.

[r] For a discussion of accidents at sea see, e.g., Hoehling (1999) and Blackmore (2004).

13.4 Angling and recreational fishing

Angling may be regarded as having too tenuous a connection with commercial fisheries, let alone aquaculture, to merit a section in a book on the latter two subjects. Nevertheless, angling does involve catching fish and no doubt began as a foraging activity rather than a recreational one, which eventually placed it within the sphere of cultural activities rather than fisheries. Fish may have been caught from the earliest time principally for food, but it is unlikely that hunger was always the sole reason for fishing; for those who are familiar with fishing in lakes and rivers there are few more pleasant experiences than landing a fish after a long battle.[s] Angling even has some connections with fish farming, both tangential, as fish farms are used to raise smolt to replenish salmon stocks in angling rivers, and controversial, as the practice of salmon farming in sea pens has given rise to concerns among anglers that farmed salmon escaping from pens create a risk of degeneration of wild salmon stocks.

Angling is known all around the world and practised by millions of people. In the earliest times, gorges, or gorge hooks, were used rather than the bent and barbed hooks that arrived later. A gorge is a bone, stone, or stick that is pointed at both ends. The first hooks probably date from about 3000 years ago, originating in southern Europe. They were simple, but similar to the hooks we know today. The earliest records of fishing with poles can be traced back to ancient Egyptian tomb paintings. Originally, however, no poles were used, the principal equipment probably being hand lines. The most efficient approach was to use hand lines from a boat, but the eventual trend was probably that the line was attached to a branch to extend the fisherman's reach. It was not until the fourth century that longer poles began to emerge, and fly fishing can be traced back to the 13th century in England. The fly was described as a hook tied with feathers and it was used in fishing for grayling and trout. It was not until the end of the 15th century that fly fishing became a sport indulged in by the upper classes of England. The earliest English poetical treatise on angling by John Dennys, said to have been a fishing companion of William Shakespeare, was published in 1613 under the title 'The Secrets of Angling'.

The demand for sports fishing is quite specialised, but it can be divided into two main categories. On the one hand there is demand for angling in lakes and rivers, mostly for salmon and trout. On the other hand, there is demand for saltwater fishing for various species, such as cod, haddock, saithe, etc., or gamefish, such as tuna and marlin. Saltwater fishing has two forms, that is to say fishing with poles from land in coastal areas, and deep-sea angling from boats (Fig. 13.8).

Although angling is a popular sport, or hobby, it is for many also a profession, not necessarily the angling itself, but various ancillary services. Angling is different from most other types of fishing, where the principal object is the profit from the effort; in angling it is the effort that gives the pleasure and provides the experience. In many places, fishing permits are the property of the landowners, often farmers, who own the land through which a river runs or where a lake is situated. A common

FIG. 13.8

Angling at Blanda river in Iceland (Ozzo Photography).

arrangement is for these landowners to form associations that sell fishing permits, or licences, which can be issued either for the short term or even for years at a time. These permits, in particular permits for salmon fishing, can be quite expensive.

In Japan, the traditional fly fishing is known as 'Tenkara', which has its roots in the mountains of Japan, where professional fishermen and innkeepers used long poles to catch aya, a local fish, trout, and char. The fish was used both as food for the guests of the inns and for sale to others. The only fishing method in Japan that is characterised by the use of a fly and a casting technique, where the line is being cast, is Tenkara.[t]

In Iceland, fishing in lakes and rivers has been known since the Age of the Settlement in the ninth century, and in an age of sustenance, farmlands that included access to fishing waters had significant added value. There are numerous accounts of fishing in the Icelandic sagas. For instance, there is an account of salmon fishing where an early settler, Ingimundur the Old, was killed in the ninth century when his sons were evicting troublemakers who were fishing illegally in a river using nets. There are also laws on fishing rights in Icelandic law codices dating from the 12th and 14th centuries, which remain a part of current legislation.

It is safe to say that angling is something of a national sport in Iceland. A significant number of people engage in sales of fishing permits for salmon, and services to anglers are increasing in scope from year to year. In the 19th century a number of wealthy Englishmen began to wander farther afield from the British Isles for their salmon fishing, and their destinations included Norway and Iceland. Prince Philip, Duke of Edinburgh, fished in Iceland in 1964, and a number of dignitaries and celebrities subsequently followed in his footsteps. Angling in lakes and rivers has a considerable economic impact in Iceland, where the utilisation of fisheries benefits of land is important to many rural areas. About a third of the Icelandic population engages in angling to some extent, which is evidence of its popularity. The progress that has been made in the profitability of fishing in rivers and lakes is quite remarkable, and there are few places in the world where the profit from each caught fish is greater. Utilisation of angling rights on an association basis has close connections with the growing tourist sector in the rural areas of Iceland.[u]

Kiribati is a state in the central Pacific Ocean. It comprises 32 atolls and one raised coral island, constituting a total land area of 800 km^2, dispersed over 3.5 million square kilometres. Kiritimati is an island in the Line Islands and part of Kiribati. It is a fisherman's paradise and popular among sports fishermen who thrive on saltwater fly fishing. Most fishermen are taken by boat to a coral atoll, where they are left to fish for bonefish, milkfish, trevally, triggerfish, or even Puffers like the one in Fig. 13.9.[v]

Another popular destination for fly fishermen is the Seychelles, an island state in the Indian Ocean, about 1500 km east of mainland Africa and north-east of Madagascar. The Seychelles have some of the richest fishing grounds in the world; around the Inner Islands species abound, such as marlin, sailfish, wahoo, greater barracuda, rainbow runner, milkfish, bonefish, trevally, and barracuda, as well as varieties of bonito and tuna. Bottom fishes like snappers, coral-trout, seabass, and groupers can also be found at Seychelles.

FIG. 13.9

A Pufferfish, caught off Kiritimati in 2017 (Ásta Dís Óladóttir).

Fishing for char in Greenland has also been much in demand, as many of Greenland's rivers have been considered among the best char fishing destinations in the world. The Umba salmon river on the Kola Peninsula in Russia is 123 km long, and in May each year anglers flock to the river. It is believed to have up to five salmon runs per year, making for an almost endless flow of fish. The Umba is isolated, the wading is tough going, and anglers have to share their space with the greatest fish fans of them all: bears. The giant black Marlin is one of the most coveted catches on the planet: weighing up to 750 kg and able to swim up to 130 km per hour, it has the ability to turn hardened game fishers (and, after several hours in battle, their wrists) to jelly at Cairns in Australia.

At the Taimen, Eg-Uur river basin in Mongolia, fisherfolk can try for the world's largest trout species, the taimen, known as river wolves. Taimen can grow up to 2 m long and weigh around 90 kg. The fish can live for up to 50 years, giving determined taimen trollers a lifetime to land the perfect beast. At the Congo River Basin fisherfolk can try for Goliath tigerfish, which grow up to 1.5 m and weigh in at 70 kg-plus. The mbenga (as it is known locally) is no easy catch. It can require dangerous day-long battles, making it one of the world's greatest sports fishing challenges (Fig. 13.10).

FIG. 13.10

Ásta Dís Óladóttir releasing a large salmon in a river in Iceland (Jakob Bjarnason).

Catch and release has been a growing practice among sports fishermen, the purpose being to try to preserve fish stocks, such as the salmon, char, and trout stocks. Specific directions have been issued on the best catch-and-release practices. In the United Kingdom, catch and release has been practised for decades by anglers to prevent target species from disappearing altogether in heavily fished waters. The same is true in many states in the United States, in Australia, Ireland, Iceland, Canada, Switzerland, Germany, and other countries. The idea of catch and release to prevent stock depletion from angling is not new, and probably has roots in Mediaeval Europe.[w]

13.5 Demand and supply of fish in the future and food security

The future of the demand for fish for human consumption is subject to some questions, as is the demand. Much will depend on environmental trends and the condition of the sea, both of which are difficult to predict. A starting point could be to look at fish consumption by continent[x] in 2 years, 1950 and 2020. Looking at the population sizes[y] and fish consumption per capita[z] gives us the demand for fish products and their consumption. This can be compared to the catches of these years and farmed fish for human consumption. Table 13.1 shows this comparison of 1950 and 2020. The figures for 2020 are estimated based on the trends of recent years.

Table 13.1 World demand and supply of fish for human consumption in 1950 and 2020.

	1950			2020		
	Population in billions	**Consumption (kg) per person**	**Consumption in million tons**	**Population in billions**	**Consumption (kg) per person**	**Consumption in million tons**
Africa	0.2	4	1	1.3	11	14
N-America	0.2	8	2	0.4	23	9
S-America	0.1	4	1	0.7	11	8
Asia	1.4	8	11	4.6	25	115
Europe	0.6	7	4	0.7	23	17
Oceania	0.0	8	0	0.1	24	2
Total	**2.5**	**7.6 (avg.)**	**19**	**7.8**	**21 (avg.)**	**165**
			Production in million tons			**Production in million tons**
Global capture			18			75
Aquaculture			1			90
Total			**19**			**165**

Table 13.1 reveals a number of interesting facts. The population of Africa and South America has grown more than sixfold in 70 years, from 1950 to 2020, but has doubled in North America, grown by a factor of 3.5 in Asia and grown threefold in Oceania, but remained much the same in Europe in comparison with the other continents. The consumption of fish per capita has increased threefold over the same span of time and increased almost ninefold in absolute terms. This is a huge change over this relatively short period. Fish farming grew from almost nothing to 90 million tons over the same period. The entire period can be said to have been the era of fisheries and aquaculture in the world, concurrently with the exponentially increasing global trade in fish, revolutionary technical progress in fisheries, fish farming, and fish processing, and generally increasing public health with the increasing modern trend towards more wholesome diets. As Table 13.1 shows, the consumption, or demand, in 1950 was 19 million tons, and the supply was the same. In 2020 the demand is 165 million tons and the supply is the same, divided into 75 million tons of capture and 90 million tons of farmed fish.

Based on the information in Table 13.1, the supply and demand for fish for human consumption is projected for the future in the following tables, that is to say for 2050, 2100 and 2150. The world population may be expected to grow by about 1.9 billion, counting from 2020, to about 9.7 billion in 2050, with the growth almost entirely in Africa and Asia. The estimate for 2050, that is to say 30 years into the future, is shown in Table 13.2. Two scenarios are projected regarding demand (Scenarios 1 and 2). On the one hand, it is assumed that fish consumption per person will remain the same in 2050 in the continents as in 2020 (Scenario 1); on the other hand, it is assumed that the consumption of fish will converge, increasing by just short of 100% in areas of limited fish consumption, but increasing much less where it is already substantial (Scenario 2).

As regards supply, two scenarios are projected (Scenarios A and B) in 2050; on the one hand that the harvested catch for human consumption will be 75 million tons, as in the preceding years (Scenario A), and on the other hand that the catch will be 85 million tons in 2050 (Scenario B), which assumes successful management based on the capacity of fish stocks and efficiency in effort. If this is successful, it is assumed that the catch for human consumption can be increased by 15% over the next 30 years, to 85 million tons, as shown in Table 13.2.

Aquaculture now supplies 90 million tons of fish for human consumption. Scenario A assumes a 1% annual growth, which is only a quarter of the annual growth over the past 5 years. This takes the quantity of farmed fish to 120 million tons in 2050. Scenario B assumes an annual growth of 1.5%, bringing the quantity of farmed fish to 140 million tons in 2050. The second scenario is based in particular on genetic modification in fish farming, which would increase quantity significantly, and most likely much more than assumed in Scenario B. Projections of population growth are pretty straightforward.[aa] Projections of increased fisheries and aquaculture assume, among other things, an increased focus on food from the oceans, rivers, and lakes of the world, and increased aquaculture, where such increase is feasible.

Table 13.2 World demand and supply of fish for human consumption in 2050.

	2050—Scenario 1 on fish consumption per person			**2050—Scenario 2 on fish consumption per person**		
	Population in billions	**Consumption (kg) per person**	**Consumption in million tons**	**Population in billions**	**Consumption (kg) per person**	**Consumption in million tons**
Africa	2.5	11	28	2.5	20	50
N-America	0.4	23	9	0.4	30	12
S-America	0.8	11	9	0.8	20	16
Asia	5.2	25	130	5.2	30	156
Europe	0.7	23	16	0.7	30	21
Oceania	0.1	24	2	0.1	30	3
Total	**9.7**	**18 (avg.)**	**194**	**9.7**	**25 (avg.)**	**258**
		Production in million tons—Scenario A	**Production in million tons—Scenario B**		**Production in million tons—Scenario A**	**Production in million tons—Scenario B**
Global capture		75	85		75	85
Aquaculture		120	140		120	140
Total		**195**	**225**		**195**	**225**

As Table 13.2 shows, the demand is 194 million tons in 2050 based on the current consumption of fish per capita, but 258 million tons assuming increased consumption. The supply is 195 million tons, assuming the same catch quantity and a slight increase in fish farming, but 225 million tons if the increase in fish farming is greater. Based on Scenario 1 in Table 13.2, it appears that an equilibrium could be achieved of supply and demand. It should be borne in mind that in a market economy prices will bring supply and demand into an equilibrium. According to the earlier discussion, however, the increase in the consumption of fish shown in Scenario 2 will hardly materialise with the production shown in Table 13.2 in Scenarios A and B. However, keep in mind that this scenario assumes much less growth in aquaculture than the growth of recent years.

Table 13.3 shows a projection for 2100. The population growth is about 1.2 billion from 2050; surprisingly, the population in Africa is shown to grow by 1.8 billion from 2050, but to fall in Asia by about half a billion people. Scenario A regarding supply in 2100 projects the catch of fish for human consumption at 75 million tons, like in recent years, while Scenario B projects 100 million tons in 2100. Based on Scenario B, it is assumed that the catch for human consumption can be increased by 33% over the next 80 years, to 100 million tons, as shown in Table 13.3.

As regards aquaculture, Scenario A assumes a 1% annual growth. This takes the quantity of farmed fish to 200 million tons in 2100. However, Scenario B assumes an annual growth of 1.5%, bringing the quantity of farmed fish to 300 million tons in 2100.

As Table 13.3 shows, the demand is 199 million tons in 2100 based on the current consumption of fish per capita (Scenario 1), but 276 million tons assuming increased consumption (Scenario 2). The supply is 275 million tons, assuming the same catch quantity and a slight increase in fish farming (Scenario A), but 340 million tons if the increase in fish farming is greater (Scenario B). Based on these scenarios in Table 13.3 it is easy to establish an equilibrium of supply and demand, and even increase the consumption of fish if Scenario B regarding supply materialises.

A projection can be made for 2150.[ab] The population shrinks by 700 million people from 2100, mainly in Africa and Asia. The supply of fish for human consumption in 2150 will be from 400 to 700 million tons, depending on the increase in the production of farmed fish. The demand will be 200 to 250 million tons, so the consumption of fish can be increased substantially. The consumption of fish in the future will mostly be in Africa and Asia, where a large part of the world population will live in the coming decades.

The estimates of demand and supply of fish for human consumption, as shown in Tables 13.2 and 13.3, clearly indicate that the supply of fish can be increased significantly with slow and steady growth. There are many who might say that aquaculture will show even faster growth, but this growth will be restricted by a number of factors, including environmental factors. The scenarios used here represent a cautious forecast for the future without assumptions of extensive changes in the supply and demand trends. It appears safe to say, however, that with increased consumption of fish, even more than assumed in previous estimates, the objective of ensuring the

Table 13.3 World demand and supply of fish for human consumption in 2100.

	2100—Scenario 1 on fish consumption per person			2100—Scenario 2 on fish consumption per person		
	Population in billions	**Consumption (kg) per person**	**Consumption in million tons**	**Population in billions**	**Consumption (kg) per person**	**Consumption in million tons**
Africa	4.3	11	47	4.3	20	86
N-America	0.4	23	9	0.4	30	12
S-America	0.8	11	9	0.8	20	16
Asia	4.7	25	118	4.7	30	141
Europe	0.6	23	14	0.6	30	18
Oceania	0.1	24	2	0.1	30	3
Total	**10.9**	**18 (avg.)**	**199**	**10.9**	**25 (avg.)**	**276**
		Production in million tons—Scenario A	**Production in million tons—Scenario B**		**Production in million tons—Scenario A**	**Production in million tons—Scenario B**
Global capture		75	100		75	100
Aquaculture		200	300		200	300
Total		**275**	**340**		**275**	**340**

food security of the world, while at the same time contributing to more wholesome diets, can be achieved. It is therefore clear that fish, and farmed fish in particular, will play an important role in the world's future food security. It is a matter of some urgency to establish global targets on strengthening fisheries and aquaculture, as both will be among the most important contributions to the food security of the future, while bearing in mind that any actions taken must take full account of the need to preserve the environment.

Endnotes

a. For more on the United Nations Convention on the Law of the Sea see, e.g., United Nations (n.d.-d) and Rothwell, Oude Elferink, Scott, and Stephens (2017).
b. For a chronological list of ratifications of, and accessions and successions to, the Convention and its related agreements see, as of March 22nd 2020: https:/www.un.org/depts/los/reference_files/chronological_lists_of_ratifications.htm.
c. For more information on the International Tribunal for the Law of the Sea see, e.g., Rao and Gautier (2018).
d. For a discussion of issues relating to the law of the sea see, e.g., Rothwell and Stephens (2016) and Thorarensen and Leifsson (2011).
e. For more on the background of the law of the sea see, e.g., Brown (1994), Selden (2004), Grotius (2013), and Rothwell and Stephens (2016).
f. For more information on the sovereign rights to fisheries see, e.g., Munro, Van Houtte, and Willmann (2004), Tanaka (2012), and Christie (1999).
g. For further discussion of fisheries outside 200-mile jurisdictions, see, e.g., Cutlip (2016) and United Nations (2020, 9. March).
h. For a discussion of UN Fish Stocks Agreement see, e.g., Hannesson (2004) and Division for Sustainable Development Goals (n.d.).
i. For further information on international law on fisheries and aquaculture see, e.g., Rothwell and Stephens (2016) and International Seabed Authority (2017).
j. For more on education in fisheries and aquaculture see, e.g., Lee, Burtle, and Newman (2005), Weintrit and Neumann (2013), and Einarsson (2016).
k. For information on the Fisheries Training Programme see UNESCO (n.d.).
l. For more on the arts and industries see, e.g., Throsby (2010), Towse (2010), and Einarsson (2015).
m. For more on whaling see, e.g., Sanderson (1993), Mawer (2000), and Newton (2013).
n. For a discussion of the whale case in New York see Greenberg (2010).
o. In earlier times, Icelanders utilised whales almost like domesticated animals, as the same pods of whales would approach the same waters around Iceland year after year. Care was taken to hunt only some of the calves and let others live. Some whales were so well known to coastal farmers, that they were given names.
p. For more on whaling in Viking times see Birgisson (2013).
q. For more information on the rules and provisions of the United Nations Convention on the Law of the Sea regarding whaling see Rothwell and Stephens (2016).
r. For a discussion of accidents at sea see, e.g., Hoehling (1999) and Blackmore (2004).

s. For more on angling see, e.g., Wulff (1988), Gilbery (2008), and Walton and Cotton (2015).
t. For a discussion of fly fishing in the United States and Japan see, e.g., Fly dreamers (n.d.).
u. For a discussion of angling in Iceland see, e.g., Einarsson (2016).
v. There are over 120 kinds of puffer fish in the world; what is special about puffers is that as the puffer fish gulps in water, its stomach inflates and the fish can grow up to 100 times its original size. It has been maintained that the puffer fish is the most poisonous creature on the planet, and the more colourful, the more poisonous.
w. For a discussion of catch and release see, e.g., Policansky (2002) and Tsuboi and Morita (2004).
x. The continents are either five, six, or seven. The five continents are Africa, the Americas, Asia, Europe, and Oceania, which is the general definition used in this book. The sixth continent is Antarctica, which is usually omitted in comparisons of this kind, as it is mostly unpopulated, apart from visiting scientists and explorers. The seventh continent is North or South America, when the Americas are seen as two continents; this is the division used in this section.
y. For information on population by continent in 1950 and 2020 see Statista (2020) and Worldometer (n.d.).
z. For a discussion of fish consumption and the production of fish for human consumption see, e.g., Food and Agriculture Organization of the United Nations (2018a).
aa. For more information on the future world population growth see, e.g., United Nations (2004), United Nations (n.d.-b), and Worldometer (n.d.).
ab. It is worth thinking about that even though a forecast extending to 2150, that is to say 130 years into the future, appears to cover an extraordinary long time, it is probable that some individuals born in 2020 will still be alive in 2150, having reached an age of 130 years. For a discussion of the likely age of individuals in the future see, e.g., Einarsson (2019). However, it should be noted that any projection reaching all the way to 2150 is subject to a great deal of uncertainty.

CHAPTER

Summary

14

Fishing, and also fish farming, are ancient practices with a long history and links to religion and legends of the distant past. Although fisheries were not extensive in scope into the 19th century in comparison with modern day fisheries, fish has always been a significant element of people's diets.

Overfishing, one of the most serious problems of our day was hardly known in the past; for one thing, the world population was much smaller in earlier times, especially before 1800; for another, technology remained largely unchanged for centuries. With increased capacity, efficiency, and effort, struggles over fisheries and territorial waters became an increasingly prominent feature of international relations in the 20th century. With the Industrial Revolution in the 18th century, and the huge population growth of the last two centuries, fisheries and aquaculture have grown significantly in importance and now play a sizeable role in the world's food security. Concurrently with this growth in population, the likelihood of armed conflict over control of fishing grounds has also grown.

Fisheries differ widely in scope between countries, with a huge number of species harvested and the oceans, covering 70% of the surface of the world, being an environment of extraordinary biodiversity; and bear in mind that fishing is conducted not only in the sea, but also in rivers and lakes. As regards aquaculture, that sector has grown exponentially over the course of just a few decades, and it now actually contributes more fish for human consumption than traditional fisheries. This is in part due to the fact that technology in aquaculture has advanced rapidly, with various contemporary methods, such as genetic modification, returning huge increases in yield; these methods are certain to see even greater advances in the future. It is also worth noting that progress in producing what has been known as 'biomeat', that is to say meat produced without the use of animal flesh, could in the future lead to production of biofish, or fish meat produced without the use of living fish.

Food consumption in the world has changed, with many people now eating less meat than before, and some people none at all. However, the consumption of fish has increased substantially, not least because fish has been shown to be wholesome and even to contribute to longevity. But the consumption of fish varies by continent, being extensive in Asia, Europe, and North America and less so in Africa and South America. Tens of millions of people are employed in fisheries and aquaculture and related jobs in the world, and many hundreds of millions of people are dependent on these sectors for their sustenance.

Fisheries and Aquaculture. https://doi.org/10.1016/B978-0-12-821056-7.00007-X

The importance of fisheries and aquaculture for individual countries is assessed on the basis of consumption of fish and the domestic economic importance of trade in fish. This method of assessment gives us the result that 45 countries, including a number of island states, out of the roughly 200 countries of the world, are dependent to a significant degree on fisheries and aquaculture. Increasing the emphasis on these sectors has proven an effective method for many countries to reinforce their food security and improve the welfare of their populations, measured, among other things, in income per capita and the criteria of the human development index.

A large part of the world's fishing fleet is nonmotorised, and in many countries much of the fishing is at a rudimentary, or artisanal, level, while other countries have moved to an advanced level of technology. The countries where fisheries and aquaculture are important sectors therefore fall into two distinct groups as regards level of technology, although the level of technology can also differ within countries.

The concepts of the social sciences, including economics, are useful in analysing fisheries and aquaculture and world food security, where enterprises and individuals, supply and demand, utility cost and income all play key roles in the human activities of catching, cultivating, processing, distributing, and selling fish across the world. The demand for fish is dependent on a number of factors, including the utility that consumers derive from fish as a part of their diets. Individuals and enterprises ensure the supply of fish through fishing and fish farming in diverse forms. Markets and market structures and ownership of factors of production are fundamental features, as without proper organisation production cannot take place in an effective and efficient manner. Productivity and capacity have increased both in fisheries and fish farming, and simple methods of measuring these elements are useful to compare trends between countries and enterprises over longer periods.

Environmental factors are hugely significant for any human activities, especially in our time, as there are limits to what the natural conditions of the Earth will tolerate, and these limits are both particularly visible in fisheries and aquaculture and particularly relevant to food security. Pollution, climatic change, and acidification of the oceans are the most serious problems faced by the human race in our times, and they have radically changed the living conditions of plants, people, and animals in recent decades. New approaches will need to be found to producing energy in order to halt, or at least slow down, global warming.

The world faces a number of threats, with severe consequences for marine life in the form of pollution from plastic and heavy metals and melting glaciers in both the Arctic and Antarctic regions, which, in combination with global warming, will cause rising sea levels, a particularly serious environmental problem for low-lying areas around the world. Concerted efforts by all the countries of the world, under the auspices of international organisations such as the United Nations, would enable us deal with these problems in an effective manner. The United Nations have set number of development goals for this purpose, and most have direct significance for fisheries, aquaculture, and food security (Fig. 14.1).

Fisheries management is a complex matter, but if fisheries are not managed sensibly the risk of overfishing and depletion of the renewable resources of the oceans is

FIG. 14.1

Inside Vatnajökull, the largest glacier in Europe (Ozzo Photography).

a serious one. In many countries, records of catches are deficient and discarding fish at sea is not uncommon. There are scientific methods that are useful in managing fisheries, but implementing them has proven problematic. However, the situation differs from one country to the next, and there are a number of successful methods in use in the world to manage fisheries. But although overfishing is a widespread problem, it is not enough simply to prevent overfishing; in addition to the simple matter of preventing overfishing, management must be designed also to maximise the yield from marine resources. To this end, models based on marine biology and fisheries economics are useful tools.

Even though only six of the world's 100 largest fisheries companies are Chinese, China is nonetheless the world's leading fisheries and aquaculture country; not only do the Chinese catch more fish than any other country, the volume of their aquaculture production is also greater than that of all the other countries of the world combined. China's long history of fishing and fish farming, in addition to its status as the most populous country in the world, has enabled China to harvest the resources of the sea extensively for the benefit of its people, contributing not only to healthier diets, but also higher living standards. The Chinese have improved their living standards vastly in recent decades, and China is now the world's largest economy and plays a more active role in world politics than before, placing it among the leading countries of the world. China is among the 45 countries in the world identified in this book where fisheries and aquaculture have a high level of significance.

The developing countries are numerous in the world. Fisheries and aquaculture have a high level of significance in many of these countries, and those sectors may in the future be the key to food security and improved living standards. Technology in fisheries and aquaculture is widely inadequate in these countries, many of which are highly dependent on development assistance. The developing countries face a number of problems with regard to their fisheries, including fishing by other countries in their jurisdictions, which is subject to limited management and little transparency. Distant water fishing also features a great deal of illegal, unreported, and unregulated fishing, which compounds the problems faced by these countries. Corruption, which costs a great deal of money and severely restricts efficiency, both social and economic, is also a problem in many of these countries.

The population growth in the world in the coming decades will be most rapid in Africa, the poorest continent, where the consumption of fish is relatively limited. It is important for that reason to support the development of fisheries and aquaculture in that region to the extent possible, if only to improve the food security of poor people. One of the problems of the developing countries is that gender equality is less advanced than in the developed countries, making it one of the most urgent tasks of the world today to improve this situation, as increased equality is one of the most effective means of improving general living standards.

Fish processing is a highly developed and technologically advanced industry in many places of the world, but not everywhere. Handling of fish, both in fishing and fish farming, is fundamental to the preservation of the quality and freshness of a very delicate raw material. Education, scientific research, and innovation have increased greatly in both fisheries and aquaculture in recent decades, within enterprises, academies, institutions, and clusters. Investment in knowledge and technology has also increased substantially, which has contributed significantly to the improved quality of raw material. An array of technological equipment is used in today's fisheries and aquaculture, much of which has made it possible to produce valuable side products from raw materials such as algae, and even offal and fish skin, which until recently was almost universally discarded. In fisheries and aquaculture, value is added at every level, from the actual fishing and farming through processing, distribution, and sales. Constant efforts are being made to increase the value added at each level.

Sales of fish products have increased in recent decades, both across and within borders. A variety of methods from marketing sciences are used in the sale of fish, with exports of fish and international trade in fish products increasing in importance, in particular for many developing countries. Technical progress and comparative advantage are among the factors that have led to increased international trade, which is reflected in increased exports and imports of seafood.

Like other industries, fisheries and aquaculture have been affected by increasing globalisation, leading to a growing number of large multinational corporations. Small domestic markets, combined with shortages of factors of production and specialisation will often lead to increased foreign trade. The size of an enterprise does not make any difference in this context, and corporate managers need to decide whether, why, where, and how they should expand into foreign markets. Various theories developed within the field of international studies are useful to describe the situation of enterprises and countries with regard to international fisheries and aquaculture, where cross-border partnerships of various kinds are common. Japanese enterprises are among the largest companies in the world in the fisheries and aquaculture sectors, and mergers of large companies in the two sectors are common. Many enterprises, large and small, will attempt to gain and maintain control over as many levels of their value chain as they can.

Enterprises in fisheries and aquaculture are subject to the laws of financial theory, like all other economic activity. The competitive advantage of both enterprises and countries is an important element in planning, and investments in technology and innovation are the key to successful operation. The methods of financial theory can be used to obtain a clear picture of the operation of individual enterprises in fisheries and aquaculture, as in other business operations, and there is great divergence in the performance of enterprises. However, state subsidies are extensive in fishing, and they distort the competitive position of enterprises (Fig. 14.2).

Management in fishing and aquaculture is subject to the same principles as management in other sectors, where strategic planning and knowledge management are key elements. Many models of modern management theory are useful in analysing the position of fisheries and aquaculture in different countries. Small-scale enterprises and family firms are common in fisheries and aquaculture in many countries, and women's participation in the workforce is extensive, although it remains an important challenge to increase women's role in the management of enterprises and organisations in fisheries and aquaculture.

World fisheries are subject to an independent legislative and regulatory environment that provides for exclusive economic zones. In other respects, enterprises in

FIG. 14.2

Harbour in the Faroe Islands (Ozzo Photography).

fisheries and aquaculture need to observe similar laws and regulations as other businesses. Most countries have experiences of disasters at sea. Whaling was an important economic activity in many countries in earlier times. Other activities relating to the sea and water, like angling and recreational marine fishing, have become major features of the tourist sector. There is much in art and artistic creation that can be traced to influences from the oceans, lakes, and rivers of the world.

Forecasts and scenarios of fish consumption and supply in the coming decades into the 22nd century show that there is a wide scope for increases in both fisheries and aquaculture in the world, and that the consumption of fish is likely to increase in the future. If fish consumption does in fact increase, as projected in these scenarios, fish could to some extent supplant or supplement the production of agricultural goods, and fish could become an increasing source of food and nutrition for the Earth's growing population.

But fisheries and aquaculture face a number of difficult challenges, as described in the earlier chapters of this book. To summarise these, the biggest challenge is that the natural resources of the world are limited, which will inhibit growth in these sectors. However, many countries have achieved good results, such as Iceland, where the fisheries management system has not only contributed to the improved prosperity of the country, but provided a model for other countries. The restricted access to fish stocks has in many places encouraged better utilisation of raw material, but it has also contributed to the rapid growth of fish farming to meet the increasing need for food.

Also, the hardening competition in international markets, combined with increased consumer demand for product quality and sustainable production, are challenges that the fisheries and aquaculture of most countries need to confront.

Many countries have emphasised automation in the fisheries sector. The future is all about quality and increased productivity. Laws and regulations on fisheries and fish processing are also challenges. The basis for increased innovation is knowledge. It needs to be ensured that a strong dialogue and collaboration takes place between enterprises in the sector and the knowledge society, universities, and research institutes in order to meet these challenges in an efficient manner and in harmony with nature in order to strengthen the competitive position of fisheries and aquaculture, and, last but not least, to support food security.

There are also many challenges in the spotlight already in 2020, as illustrated in Fig. 14.3. Many of those challenges will persist in the coming years and some will cause setbacks in globalisation with an increased tendency for countries to attempt to achieve self-sufficiency with regard to various aspects of their security, with food security as a priority. In that context there are numerous factors that will require consideration, such as the COVID-19 pandemic and its repercussions, the trade dispute between the United States and China and the United Kingdom's exit from the EU, to mention only a few.

A great many of the challenges faced by fisheries and aquaculture can be placed in the context of the United Nations Sustainable Development Goals, protection of the Earth and life in the oceans and on land, the elimination of poverty and hunger, improved health, improved equality, peace, and justice. The oceans of the world

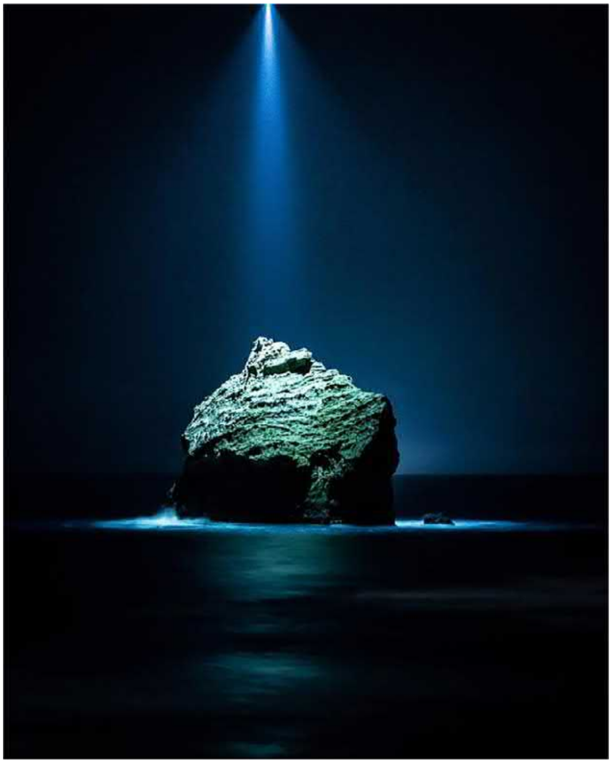

FIG. 14.3

In the spotlight (Ozzo Photography).

respect no borders and the difficulties facing fisheries and aquaculture will not be resolved in isolation by individual countries. The nature of these difficulties calls for holistic solutions and international collaboration on a previously unknown scale. With international collaboration based on the United Nations development goals, fisheries and aquaculture are set to play an important role in improving the standards of living of the world population, where environmental matters will be at the centre of all trade and human relations in general.

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Index of names

Note: Page numbers followed by *f* indicate figures and *np* indicate endnotes.

Index of terms

Note: Page numbers followed by *f* indicate figures, *t* indicate tables, *b* indicate boxes, and *np* indicate endnotes.

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Fisheries and Aquaculture
The Food Security of the Future

Ágúst Einarsson and Ásta Dís Óladóttir

Examines the operations and environment of fisheries and aquaculture from an economic perspective to improve production and sustainability

Fisheries and Aquaculture: The Food Security of the Future takes a multidisciplinary approach in evaluating the fisheries and aquaculture sectors from the scientific and practical perspectives of industry professionals. The authors recognize the importance of looking at the industry from a value chain viewpoint, not only for food security but also for a blue economy. The book takes a unique and innovative approach to show how fishery and aquaculture can achieve sustainability and how small fishery communities can become highly successful fishery and aquaculture communities and contribute to overall industry globalization. This is a practical and useful reference for a wide-ranging audience. It is for those who wish to make systematic efforts to develop their fisheries or aquaculture sectors, scientists and researchers, anyone in fisheries management or marine resource management, fish farmers, policy makers, leaders and regulators, operations researchers, as well as faculty and students.

- Presents potential solutions for more economical and sustainable fisheries development
- Provides an overview of the fishing industry's technology options, ranging from less-developed communities to modern high-tech communities
- Demonstrates market principles in the fisheries sector, particularly demand for seafood in various parts of the world, its availability and the importance of ownership rights

Ágúst Einarsson, professor emeritus at Bifröst University and former professor at the University of Iceland, served as Rector of Bifröst University and as a Member of the Icelandic Parliament. He has managed fish-processing and fisheries companies and has served on the boards of numerous enterprises. Dr. Einarsson was a member of the Export Prize Committee of the President of Iceland and served as Vice President of the European Council for Small Business and Entrepreneurship. He currently holds the position of chairman of the Advisory Committee of the National Marine and Freshwater Research Institute of Iceland. Dr. Einarsson is the author of 33 books on economics, culture and fisheries and has been a visiting scholar at the University of Siena, Stanford University, the Copenhagen Business School and New York University.

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"The authors benefit not only from their advanced scholarship but also from the inspiring history of their native country, the people of Iceland, who within the lifespan of a single generation successfully transformed themselves from a nation of poor fishermen into a global leader in modern, sustainable, high-tech and uniquely profitable fishing industries." - from the Foreword by Ólafur Ragnar Grímsson, former President of Iceland

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