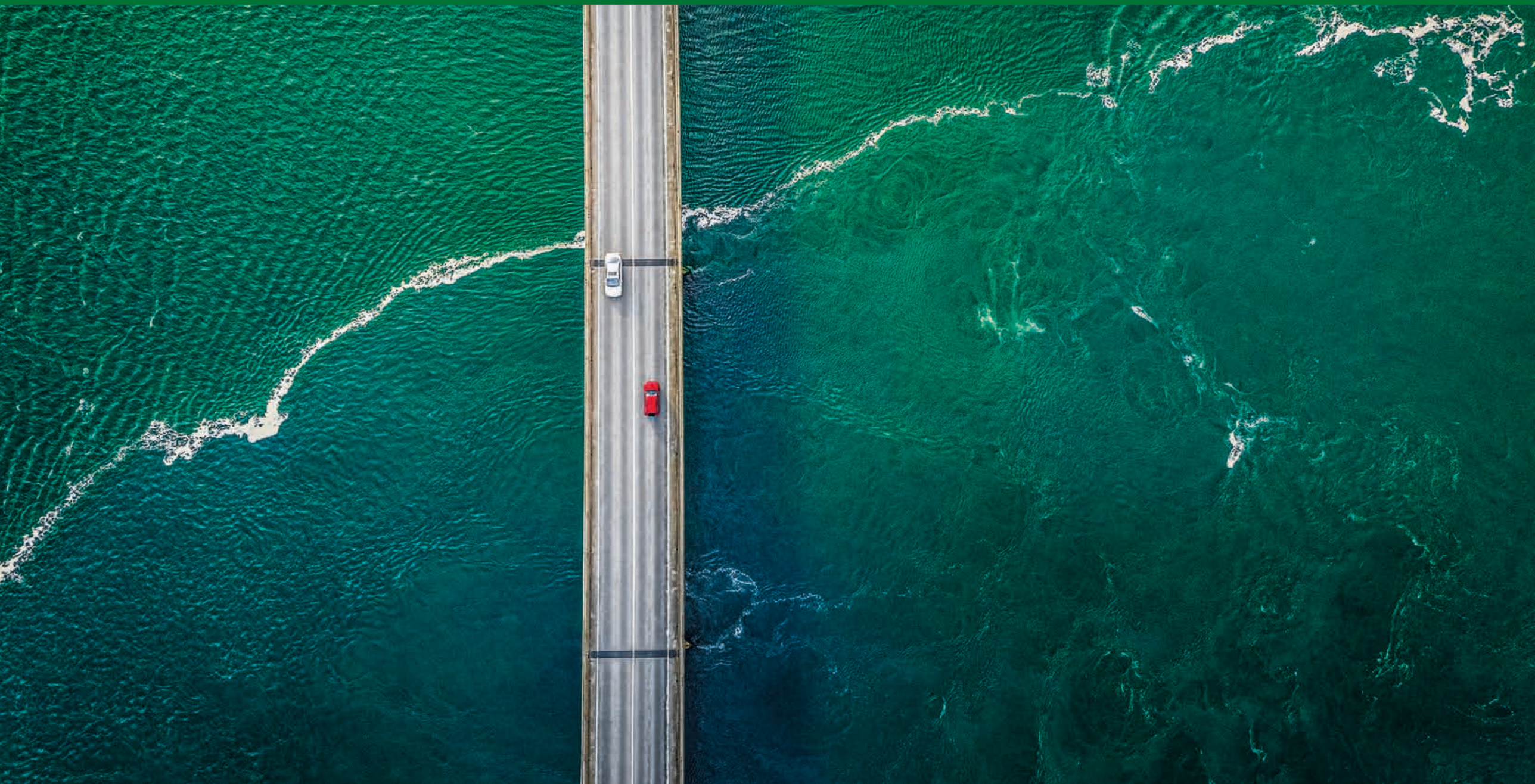
1 Our oceans – source of life

> The oceans and seas supply much of the oxygen we breathe and are a source of food for over a third of the world's population. They provide livelihoods for millions of people and have a place in the hearts of many more as a haven of dreams, a spiritual home, or as a playground for sports and adventure. The seas also regulate the weather and climate and curb anthropogenic warming of the Earth. For all these reasons, the future of humankind is directly connected to the fate of the oceans.



Vital yet finite seas

> For thousands of years, humankind lived with and from the ocean – all this time seeing it as infinite, boundless in its ability to provide food and resources, inviolable against every human encroachment. Today, the consequences of this human error are more visible than ever: reefs are dying, coasts collapsing, and in many places, fisherfolk are pulling in empty nets. This much is clear: if we wish to benefit from the ocean's bounty, we must treat it with respect and recognise that even the planet's largest habitat has its limits.

Water – the dominant elixir

Earth is the watery planet. Its oceans and seas extend for 362 million square kilometres, covering 71 per cent of the Earth's surface. Unimpressed by these figures? Then consider this: the Pacific Ocean alone is large enough to cover the entire landmass of all the world's continents and islands combined. And that's not all: the world's four major ocean basins have an average depth of approximately 3700 metres below sea level and together hold a total volume of 1.3 billion cubic kilometres of water – enough to fill the largest lake in Germany, Lake Constance (water volume: 48 cubic kilometres) to the brim more than 27 million times. Roughly 97 per cent of all the water on Earth circulates in the oceans.

These figures are almost beyond human comprehension. And yet if these 1.3 billion cubic kilometres are divided by 7.9 billion – the world's approximate population in 2021 – it works out at just one-sixth of a cubic kilometre of water, or 160 million cubic metres of seawater, for everyone. It is a vanishingly small amount if we consider that this must supply us with all the services we take from the sea. For example, the ocean produces half of the oxygen we breathe and provides a nursery and habitat for all the marine fish and shellfish we eat. Every drop of water we drink over the course of a lifetime comes from the world's seas, for it is here, on the ocean's surface, where most of our water evaporates before falling as rain or snow elsewhere.

The sea acts as a brake on climate change by absorbing heat and carbon dioxide (CO_2), a greenhouse gas, and locking it away in its watery depths for centuries. It provides sea routes for our freight and connects continents located thousands of miles apart. It is a repository of resources in or on the sea floor, some of which we are already using today or plan to use in future; it is a source of renewable energy – and besides all of this, it is a place where we can relax and recharge, if necessary even online. At the height of the coronavirus pandemic in 2020, for example, people all over the world were posting seascapes on social media – an expression of their desire to switch off for a moment and forget about the stress of the pandemic.

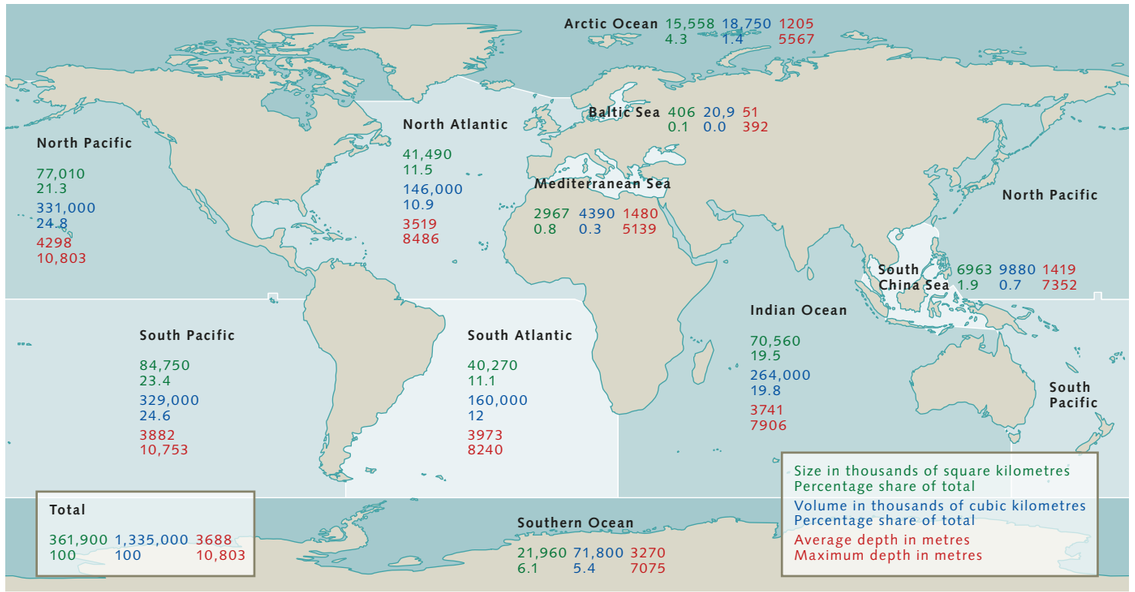
The oceans and seas are also our planet's largest continuous habitat, containing 99 per cent of habitable space for much of the great diversity of organisms that thrive on Earth – from microscopic single-cell algae and deep-sea microbes to the world's largest mammal, the gigantic blue whale *(Balaenoptera musculus)*, which can grow to 30 metres in length.

In some cases, human communities make direct use of these marine organisms. Others benefit us indirectly, such as phytoplankton: these single- or multi-cell algae not only absorb carbon dioxide and produce around half the oxygen in the Earth's atmosphere; they also serve as a forage base for many of the zooplankton and fish species that we ultimately consume as food.

As these few introductory examples show, the fate of humankind is bound up with the world's oceans in countless ways. They are the cradle and the engine of life on our planet and, as such, they gain in significance with the dawn of each new day and the birth of each new citizen of our Earth. It is projected that by 2050, the world's population will have swelled to around nine billion. This

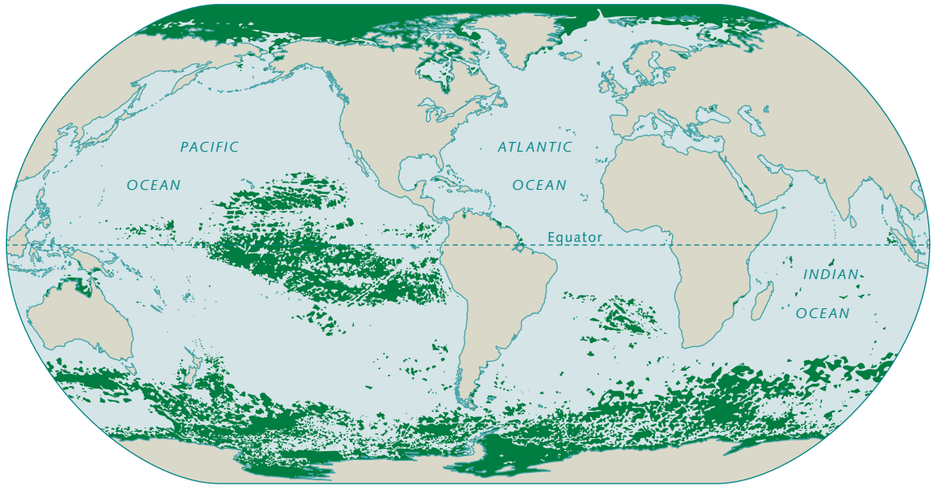
1.1 > A longing for the sea: People are often drawn to the sea to switch off for a moment, to forget their cares and concerns and let their thoughts and ideas roam free.

Ocean
The term "ocean" refers to the major bodies or volumes of saltwater which fill the Earth's huge deep-sea basins. These include the Arctic Ocean, the Atlantic Ocean, the Indian Ocean, the Pacific Ocean and the Southern Ocean.



1.2 > The ocean covers 71 per cent of the Earth's surface. It is divided into the ocean regions shown here. Areas and volumes are based on calculations by the US National Oceanic and Atmospheric Administration (NOAA).

1.3 > The giant of the deep: This blue whale, seen foraging off the Californian coast, has an estimated body length of 25 metres. Researchers recently discovered that the heart of a blue whale can slow to just four to eight beats per minute on a deep dive, when it is searching for food. Its heart rate then accelerates to as high as 37 beats per minute after it has returned to the surface to breathe.



1.4 > "Marine wilderness" means areas of water whose habitats and biotic communities are mostly undisturbed by humans. In 2017, the term applied to just 13.2 per cent of the global ocean. Most of these ecologically intact spaces are located in open ocean regions, remote from overexploited coastal areas.

means that by then, the per-capita share of the ocean and its services – oxygen, food and water, and many more – will have shrunk to around one-seventh of a cubic kilometre of seawater.

Growing demands on the ocean

It is already apparent that our demands on the ocean will increase at the same time, and this applies particularly to food production. The fact is that onshore, our scope to produce sufficient food by conventional means is limited. Competition for fertile land is intensifying; water and fertilizer are in short supply in many parts of the world, and extreme events – such as heatwaves, droughts, heavy rainfall or pest infestations – are occurring more frequently in many regions as a result of climate change, with negative impacts on crop yields.

In order to assuage the hunger of an ever-growing world population in the long term, we need new strategies for sustainable land use and resource-efficient food production, which must include a return to mainly plant-based foods. But according to some scientists, the ocean too should make an even greater contribution to our food supply – and has the capacity to do so, provided that this more intensive use is based on sustainable, near-natural expansion of marine aquaculture and improved conservation and management of natural stocks and habitats.

Other scientists doubt that the ocean can fulfil this ambition. They point out that according to statistics compiled by the FAO, 34.2 per cent of natural fish stocks in the world's marine fisheries in 2017 were overfished, and that maximally sustainably fished stocks accounted for a further 59.6 per cent. The experts are also critical of plans to expand aquaculture in coastal areas, seeing this as ecologically unsustainable in many instances.

Barely a place without a human trace

In truth, human activity has been impacting on the health and welfare of the seas and oceans for decades. In its *Global Assessment Report on Biodiversity and Ecosystem Services*, published in 2019, the **Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)** (also known as the World Bio-

Sea
The term "sea" has two meanings. Firstly, it is synonymous with "ocean" and means the expanse of water that surrounds the continents and covers most of the Earth's surface. But it also means bodies of water that are smaller than the oceans, are located on their periphery, or are separated from them by chains of islands, deep-sea trenches, ridges or straits.

1.5 > A sharp-edged stone tool discovered in a cave on the Portuguese coast. Other finds from the site – crab and clam shells, scraps of fish and the fossilized bones of seabirds – provide evidence that Neanderthals, in their day, assuaged their hunger with food from the sea.

diversity Council) concludes that marine ecosystems worldwide, from coastal to deep sea, now show the influence of human actions, with 66 per cent of marine habitats experiencing significant human impacts. In plain language, this means a proven deterioration in their condition. Coastal marine ecosystems are in a particularly poor state, with the majority showing rapid ongoing decline.

The researchers note that this decline in marine biodiversity and deterioration in habitat condition are driven mainly by the growth of fishing and intensive use of coastal land (including coastal construction, expansion of urban area, start of production at oil and gas installations, pollutant and nutrient inputs from rivers). These two main drivers account for more than 50 per cent of the observed changes over the past five decades. Climate change, marine pollution and the arrival of invasive alien species appear lower down in the ranking; however, the IPBES experts emphasize that the influence of these three drivers is steadily growing.

According to ocean researchers, genuinely unspoilt marine wilderness, meaning biologically and ecologically intact marine habitats mostly undisturbed by humans, still exist in some open ocean regions in the southern hemisphere and in the still largely inaccessible polar seas. These unspoilt ocean regions extend for approximately 55 million square kilometres in total – roughly three times the size of Russia, but just 13.2 per cent of the global ocean.

In physiographic regions that are heavily frequented by humans, the pressure on natural biotic communities (biocoenoses) has become so intense that some species are now showing more rapid biological evolution. This is happening in the ocean as well. Some commercial fish populations, for example, have evolved to reach maturity earlier under intensive harvesting. Rising air and water temperatures favour the evolution of seasonally earlier reproduction in some species and disrupt established patterns of life in the ocean. The impacts of this rapid evolution on species diversity and marine biotic communities may be positive or negative, according to the IPBES experts, and must certainly be considered in all relevant marine conservation and management planning.

Taken together, it is apparent from all the various changes observed and listed by the IPBES that humankind now poses the greatest threat to the ocean and that this often unchecked exploitation of the marine environment is steadily depriving humankind of its own future.

How do people profit from the sea?

There is only one way out of this downward spiral: through the sustainable management of the marine environment and protection of major ecosystems that perform key functions. The latter, however, presupposes that there is a clear definition of what the terms “valuable” or “worth protecting” mean. The scientific community has been discussing the value of nature and its services to humankind since the 1970s, when researchers were beginning to gain a better understanding of the functions of nature and its biocoenoses – ecosystems, in other words. It was also becoming increasingly apparent, at the same time, to what extent humankind was degrading nature and, in consequence, losing many of the services provided by the natural world.

In order to assess the benefits that nature provides to humankind and the harm caused by its degradation, economists and ecologists developed the concept of ecosystem services in the 1990s. This refers to the functions and processes within an ecosystem that contribute directly or indirectly to human wellbeing. Examples are the provision of drinking water, fresh air or food in the form of fish or crops.

Natural phenomena that have destructive or harmful impacts, such as storms, diseases, earthquakes, floods or droughts, are termed “disservices” and, for a long time, did not count as ecosystem services. Almost 20 years on, the IPBES, among others, took this conceptual weakness as an opportunity to rethink and expand the analytical approach. Guided by the recognition that humankind not only dominates but is also exposed to the dynamic forces of nature, its broader notion of “nature’s contributions to people” goes beyond the ecosystem services approach and takes the harmful aspects of dynamic nature into account, such as pest infestations, parasites and viral or bacterial diseases.

The ecosystem services concept was presented in a scientific paper for the first time in 1997 and was subsequently used by the United Nations as the basis for its *Millennium Ecosystem Assessment (MEA)*, published in 2005. According to this model, the ecosystem services provided by nature and hence by the marine environment are divided into four categories:

Provisioning services

Provisioning services include marine functions and processes which form the basis for human communities, using labour and technical aids, to provision themselves with products such as food and raw materials. These services also include the spaces and areas in the marine environment that can be used for shipping or generation of renewable energies, for example. The utility or profits yielded by provisioning services can often be measured directly and are traded in the marketplace. In other words, they generally have a market value which can be precisely quantified. For example, according to the FAO, the market value of all global fish production – edible fish, shellfish, crustaceans and aquatic plants – harvested from seas, lakes and rivers or produced in aquaculture is estimated to have reached USD 401 billion in 2018.

Fish and shellfish provide 3.3 billion people with around 20 per cent of their average per capita intake of animal proteins, albeit with regional variations in fish consumption. The ocean is an indispensable source of food and livelihoods for coastal communities in many developing countries. In countries such as Indonesia, Sri Lanka and many smaller island states, fish provides more than 50 per cent of the average per capita intake of animal proteins.

Regulating services

This category refers to the benefits and utility that humankind derives from the regulating effect of the sea. It thus comprises services such as climate regulation (heat transfer and exchange) by the sea; coastal protection by mangrove forests, dunes, seagrass beds and reefs; the production of oxygen by phytoplankton and other marine flora; and natural water purification through the breakdown of nutrient and pollutant inputs. Monetizing these services has proved to be extremely difficult: for many of them, a market, i.e. a trading place in the conventional sense, does not exist. In lieu of this, attempts have in some instances been made to capture their value using comparative cost accounting, for example by seeking to determine the level of investment that would be required if humankind were to provide these services itself using technological solutions. Scientists have also attempted to identify and analyse the economic or financial harm that would ensue without the protective functions of nature.

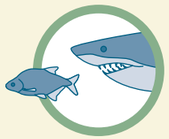
Overview of marine ecosystem services

The advantages and benefits that the oceans provide from the human perspective are referred to as ecosystem services. Ecosystem services can be both material and non-material, and are grouped into four categories.

SUPPORTING ECOSYSTEM SERVICES

can be regarded as the indispensable basis for the other categories of services

Maintenance of intact habitats (by supplying food, oxygen, clean water etc.)

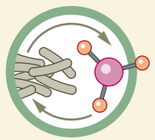


Maintenance of food web dynamics (functioning predator-prey relationships)

Water cycle (evaporation and rainfall; exchange between land, atmosphere and sea)

Safeguarding biodiversity

Primary production (production of biomass)



Nutrient cycles (formation of nutrients through primary production, degradation of nutrients by bacteria and biochemical conversion on the sea floor or in water)

Maintenance of the resilience of marine habitats

CULTURAL ECOSYSTEM SERVICES

comprise diverse functions which serve the non-material wellbeing of humankind

Contribution to science and to natural history education

Aesthetic value
beautiful marine landscapes

Religious and spiritual value of marine landscapes and places near and in the sea

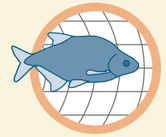
Inspiration for folklore, art, architecture etc.

Recreation and tourism

Cultural heritage (culturally significant landscapes and places near and in the sea, culturally significant sea creatures for traditional jewellery etc.)

PROVISIONING ECOSYSTEM SERVICES

encompass products and goods for direct human sustenance, on the one hand, and spaces and areas that the sea makes available, on the other

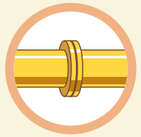


Fish and seafood from wild catch and aquaculture

Transportation routes

Renewable energies (tides, waves and wind)

Drinking water from seawater desalination plants



Areas for pipelines and sea cables

Pharmaceutical ingredients and other biochemical substances, e.g. for the food and cosmetics industry

Goods for jewellery or souvenirs

Areas suitable for military use

Non-renewable resources (natural gas, oil, gravel and sand)

Genetic resources from bacteria, sponges, and other organisms, e.g. for the development of new medicines

REGULATING ECOSYSTEM SERVICES

comprise the advantages and benefits that humankind gains from the regulating effect of the sea and its ecosystems

Climate regulation through the transportation of heat by ocean currents and heat exchange between water and atmosphere

Coastal protection by dunes, coral reefs and mangrove forests

Maintenance of water purity by breaking down nutrients from wastewater and agriculture which enter the sea

Maintenance of air quality through algal production of oxygen or ocean uptake of carbon dioxide

Maintenance of water purity by breaking down pollutants by means of dilution, chemical modification into harmless substances, or sinking and burial in the sediment

In a recent study, for example, researchers in the US showed that mangrove forests, salt marshes, seagrass beds and wetlands along the USA's Atlantic coast and the Gulf of Mexico avoided billions of dollars in storm and flood damage costs between 1996 and 2016. They found that one square kilometre of wetlands saves an average of USD 1.8 million per year in property damage caused by storms (wind and flooding). In densely populated coastal areas, the protective effect of coastal forests and wetlands is valued at nearly USD 100 million per square kilometre per year.

Cultural services

Cultural services comprise many diverse functions that serve human wellbeing in a non-material sense. They may have a particular social, religious or spiritual significance or form part of a nation's traditions. They include services such as the aesthetic appeal of a seascape, the marine environment's recreational function and leisure value, or the inspiration that artists, academics, architects and many other social groups draw from the sea.

The utility of the cultural services provided by the sea is also difficult to measure and almost impossible to monetize. What we do have available, however, are the turnover figures for the ocean tourism industry, whose business model is based to a large extent on the cultural services provided by the sea. With global direct value-added in marine and coastal tourism an estimated USD 390 billion and some seven million full-time equivalent jobs, it was the second most important branch of the ocean economy in 2010, surpassed only by the oil and gas industry, and is projected to become the leading marine industry by 2030. Whether this prediction from 2016 will come to fruition is debatable, however, given that the 2020/2021 coronavirus pandemic has led to the collapse of the travel industry.

Supporting services

This means the basic biological, chemical and physical processes which occur naturally in the environment and sustain life on our planet. In the marine environment, they include biomass production by algae and aquatic plants, nutrient cycles, the sea's contribution to the global water cycle, predator-prey relationships, and species and habitat diversity. Humankind generally benefits from all these supporting services indirectly, as they form the basis for the cultural, regulating and provisioning ecosystem services described above.

It is important to bear in mind that some services provided by the sea can be assigned to more than one category. With their abundant fish stocks, coral reefs, for example, often play a significant role in food production, which falls into the category of provisioning services. But they also provide regulating services – for example, by dissipating wave energy and thus protecting coastlines on their leeward side from erosion.

To this day, one of the great strengths of the ecosystem services concept is that it allows scientists to investigate and describe to what extent our human wellbeing hinges on nature. Some scientists note that the concept helps to strengthen the commitment to the environment by highlighting the vital role that ecosystems and species diversity play in sustaining human life. These services, they point out, are the foundation of life, contribute to our wellbeing and are a key pillar of our economy. Other experts extol the fact that the ecosystem services approach has helped to promote social dialogue on environmental and marine conservation and has thus enhanced communication between interest groups such as environmental campaigners, scientists, businesses and policy-makers.

There has been criticism as well – and not only of the failure to take account of harmful natural phenomena such as earthquakes. One point of criticism is that application of the concept is tantamount to putting a price tag on nature's bounty, turning it into products and services that can be traded or even privatized. Environmental ethicists also complain that it is often unclear who is performing this valuation of ecosystem goods and services and which criteria are being applied. In their view, this vital task should not be entrusted solely to scientists and policy-makers, for the value of nature is measured differently for each person and often cannot be quantified in monetary terms at all. This is the case, for example,

1.6 > A winter storm rages on France's Atlantic coast, demonstrating the terrifying power of the sea.

1.7 > The ocean has bestowed great wealth and power on coastal cities like Hong Kong. Port cities are important fishing and trading centres, but they are also at particular risk from global sea-level rise.

in relation to the aesthetic, cultural or symbolic value of nature to the individual or the personal value that a person assigns to a tree, a river or an ocean region to which they feel a special connection. An Indonesian spear-fisher who, every day since childhood, has dived on the coral reef along the coast near his village will have a very different connection to the reef and will value it very differently than a government official in Jakarta who decides on the allocation of funds for its conservation. Focusing solely on natural goods and services that can be quantified and given a price tag also diverts attention from the non-material ecosystem services, ethics experts say.

A Decade of Ocean Science for Sustainable Development

Despite all these justified criticisms, the ecosystem services concept has been widely applied by scientists in order to demonstrate the vital importance and value of natural physiographic regions such as the ocean and their need for protection. Reports such as the *World Ocean Assessment II* (2021) and the IPCC's *Special Report on the Ocean and Cryosphere in a Changing Climate*, published in September 2019, provide abundant evidence that the ocean is struggling under the weight of harmful human-induced impacts, that marine biodiversity is decreasing and the range of functions that it performs is shrinking and becoming more monotone. There is much to suggest that this downward trajectory will intensify, particularly against a backdrop of ongoing climate change and world population growth.

Based on this recognition, the United Nations came up with the idea of designating a Decade of Ocean Science for Sustainable Development, commencing in 2021 and ending in 2030. According to the project brief, the aim is to mobilize the scientific community and other social groups, during this period, in major efforts to connect the wealth of existing ocean-related scientific knowledge more effectively across disciplinary and national boundaries. This will make it possible, inter alia, to feed scientific knowledge about the seas and oceans more directly into decision-making processes and to improve forecasting, enabling potential policy impacts to be assessed more accurately.

The United Nations also sees it as the task of interdisciplinary ocean research to boost international cooperation and foster technological innovations that would, for example, enable polluted seawater to be purified, valuable habitats such as reefs and seagrass beds to be mapped and protected, and predicted changes in the ocean modelled with sufficient accuracy that humankind has time to adapt.

The Blue Economy – business and ocean in harmony

In a best-case scenario, researchers might even succeed in developing recommendations for action that would enable the world's oceans to be utilized in accordance with Blue Economy principles. This concept, often known by its synonym "ocean economy", was first introduced at the United Nations Conference on Sustainable Development in Rio de Janeiro in 2012. A precise and universally valid definition of what is meant by the term does not yet exist. Nevertheless, the broad objective is clear: the world's oceans should be used in a way which achieves maximum economic and social benefits without putting the health and sustainability of marine habitats and biotic communities at risk. In an ideal scenario, it would even be possible to restore degraded habitats such as seagrass beds, reefs and mangrove forests so that they regain the functions that they have already lost.

The ocean economy is now considered to encompass all the human activities that have a connection to the sea and generate revenue, provide employment or offer other benefits of a financial or non-financial nature. They thus include fishing and marine aquaculture, extraction of raw materials and resources, and the use of the seas as a source of renewable energies, as well as shipping and shipbuilding, marine tourism, safety technology and newly emerging business sectors such as marine biotech, large-scale marine protected area management, and CCS and blue carbon markets.

CCS stands for carbon capture and storage, a process whereby waste carbon dioxide – a greenhouse gas – from

1.8 > Unlike hard corals, soft corals do not form a hard, calcium-based skeleton, but they too provide many reef-dwellers with protection and food and are therefore essential for species diversity on coral reefs.

power plants or industry is captured before it reaches the atmosphere and then placed in underground storage or processed into synthetic fuels and other products. Blue carbon means the quantity of carbon dioxide that the world's coastal ecosystems, such as seagrass beds, mangrove forests, salt flats and salt marshes, capture naturally from the atmosphere and lock in their biomass or the substrate on which they grow.

In 2010, the ocean economy provided full-time jobs for around 31 million people, with industrial fishing and tourism the largest employers at that time. The value of the products and services generated annually by the ocean is an estimated USD 2.5 trillion. If the ocean were classified as a country, it would rank as the world's seventh largest economy. If non-marketed services – cultural or regulating services, for example – are included as well, the ocean would be right at the top of the leaderboard. Although there is much discussion among academics about the right way to value non-marketed ocean services, the experts are broadly in agreement: the total value of the ocean's regulating and cultural services exceeds the value of its marketed products and services many times over.

Gross domestic product
Gross domestic product (GDP) is a measure of a national economy's performance during a specific period. It is a monetary measure of the market value (value added) of all the final goods and services produced by the country during this period, excluding inputs used to produce other goods and services.

The Organisation for Economic Co-operation and Development (OECD), in its 2016 report *The Ocean Economy in 2030*, states that economic activity in the ocean will continue to expand to 2030 – and even has the potential to outperform the growth of the global economy as a whole. The economists also predict the emergence of new industries and greater use of the oceans.

The drivers that they identify include world population growth, increased trade, global resource consumption, new technological developments and climate change. At the same time, however, the OECD draws attention to the numerous complex risks associated with increased use. These risks, it says, must be minimized, as degradation of the marine environment also worsens the development prospects of the ocean economy.

In order to avert potential financial losses and guarantee a healthy, sustainable future not only for the ocean economy but also for the ocean itself, the OECD puts forward a number of recommendations, some of which also feature in the goals for the United Nations Decade of Ocean Science for Sustainable Development. They include the following tasks:

- Foster greater international cooperation in marine science and technology as a means to stimulate broad-scale innovation and the establishment of expert networks;
- Strengthen integrated ocean management, including improved governance structures, better economic and social stakeholder engagement, and more efficient management and decision-making processes;
- Improve the statistical and methodological base for measuring the scale and performance of oceanbased industries, with optimized methods for forecasting the future of this branch of the economy.

By applying this approach – analysing the multitude of services provided by the ocean and assessing their material or non-material value – there is now a growing recognition, not only among marine conservationists and affected communities, that the disappearance of individual ecosystem services constitutes a loss in real terms. It is also widely accepted nowadays that a change of mindset is needed in politics and the ocean industry itself in order to ensure that in future, human use or consumption of marine products and services is kept within the bounds of sustainability.

For that end – according to the pioneers of the ecosystem services concept – a new economic paradigm is needed, based on ecological principles: in other words, an economic model that is centred around nature. However, they also point out that achieving this is likely to be a long and arduous process, for political debate and decision-making in most countries are still dominated by traditional economic thinking. Nevertheless, the recognition that a nation's wealth and prosperity cannot be captured accurately using gross domestic product alone is a major step forward, say the experts. Instead, various indicators relating to the environment and the nation's health and social prosperity should be factored into the equation.

Proposals on how this new measure of prosperity might be applied successfully have been made by the

1.9 > Mangrove forests like the Sundarbans along the border between India and Bangladesh are a habitat and nursery for countless species of fish. They are of great benefit to local fishers, who put out their nets on the flats while the tide is out and wait for the incoming tide to bring in the bounty.

Changing perspective: one instead of five

How many oceans exist on Earth? Nowadays, there are two possible answers to this question. The first is five: this is the answer given in encyclopaedias and on knowledge platforms. It is usually accompanied by a world map of the type familiar to most of us from our school days, showing the continents as great land masses that separate four of the five oceans from each other. On the left- and right-hand margins of the map, there is the vast Pacific. The Atlantic takes pride of place in the centre, while the Indian Ocean is shown on Africa's eastern seaboard and the Southern Ocean encircles the Antarctic. That just leaves the Arctic Ocean, squeezed in right at the top.

But this is not the only way to think about the Earth's basic geography. There are other, very different options, such as that described by American geophysicist and oceanographer Athelstan F. Spilhaus in an article for *Smithsonian Magazine* in November 1979. In it, Spilhaus published a world map in the form of a square, with the five oceans and their respective seas depicted as one collective body of water, one ocean, in the centre, framed and delineated by the continental coastlines.

Spilhaus's world ocean map fell into oblivion for almost four decades after its publication, known only to a handful of ocean enthusiasts, who dusted it off whenever they wanted to show that a change of perspective and a new holistic understanding were required for effective marine conservation. Nowadays, however, Spilhaus's concept has the backing of ocean researchers and is steadily gaining in appeal. International organizations such as the United Nations increasingly refer, in their special reports, to one ocean whose water masses circulate in four ocean basins. Manufacturers of geographic information systems now offer the Spilhaus projection as a map template and the latest specialist publications on ocean management urge their readers, from the first chapter onwards, to think differently about the world, away from their preconceptions formed by life on land.

The rationale is as follows: the structure and functions of the ocean are so unique that attempts to manage the ocean with the same, often small-scale, methods and strategies that work on land are bound to fail. Unlike the land masses, the ocean has virtually no boundaries or barriers. When a tsunami inundated the Fukushima nuclear plant in Japan in March 2011, radioactive water escaped into the sea. Over the next three years, ocean currents carried this water from the coast of Japan all the way across the northern Pacific, with nothing – neither an army nor a deep-sea trench – to stand in their way. Likewise, plastic litter and other debris are transported freely around the world on the ocean currents. And of course, human-defined boundaries between areas pose no obstacles to shoals of fish or migrating whales.

As its name suggests, the *World Ocean Review* sees the world's oceans and seas as a single entity, the ocean. Nevertheless, as before, this latest edition uses a variety of terms – ocean, oceans and world's seas – interchangeably.

1.10 > The world map in the form of a square (left): Designed by American geophysicist and oceanographer Athelstan F. Spilhaus, this depicts the five oceans as one collective body of water, one ocean, with the Antarctic in the centre. Most people are more familiar with the conventional type of world map (right), which shows the continents as great land masses separating the Pacific, Atlantic and Indian Oceans.

World Bank, the United Nations and the OECD. However, academics have voiced criticism of these methodologies too, on the grounds that they fail to capture the extent to which economic processes impact on nature and society. Scientists are also calling for a shift away from the concept of limitless growth. A new common objective is required, they say: to safeguard adequate prosperity for all in such a way that the impending ecological crisis and the associated social crisis can be averted. To both these ends, the interests of the natural environment must become an integral component of global economic policy, with more frequent and more nuanced discussion of this topic across broader sectors of global society.

The need for such a transformation of our thinking and action towards sustainable development becomes ever more urgent with the onward march of climate change. As a result of anthropogenic greenhouse gas emissions and the consequent global warming, the basic pillars of life in the ocean are changing. But that's not all: the ocean itself is losing the ability to perform some of its key regulating functions to which we humans owe the – previously stable – conditions of life on our planet.

Conclusion

An end to the infinity illusion

The ocean covers 71 per cent of the Earth's surface and is more vital for human wellbeing than ever. It provides people and the global economy with goods and services, material and non-material, whose monetary value is often impossible to quantify. According to the ecosystem services concept, they can be assigned to four categories: researchers distinguish between provisioning, regulating, cultural and supporting services from the sea.

Although the ecosystem services approach has sparked controversy among scientists, it has, over the past 25 years, done much to reveal the major extent to which human wellbeing depends on the ocean, as well as the likely adverse impacts if the condition of the oceans and seas were to deteriorate. The state of the world's ocean is regularly investigated in international studies by bodies such as the IPCC (Intergovernmental Panel on Climate Change) and IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services). In its recent *Global Assessment Report*, the IPBES concludes that 66 per cent of marine habitats are experiencing significant human impacts and that the ocean's functional diversity is therefore decreasing. The world's largest habitat, once seen as vast and infinite, has long reached its limits.

International policy-makers and the ocean economy therefore face a challenge: to develop new and sustainable strategies for the use of the ocean. One possible solution is the blue economy model. The international ocean research community is also committed to more intensive cooperation and, during the United Nations Decade of Ocean Science (2021 to 2030), will help to build a shared information system, based on science-based data from all parts of the world's ocean. The aim is to be able to predict the possible impacts of political or economic decisions on the ocean more effectively and discuss them in advance. Campaigners against the reckless exploitation of the ocean, however, are calling for a total renunciation of conventional economic models and a shift towards ecological concepts that would enable the ocean, in future, to fulfil all the demands made of it by human communities.