# TEACHING MATERIALS AND WORKSHEETS FOR TEACHERS


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Funded by the European Union

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**Editorial concept development and execution**
Katrin Knickmeier[1], Katrin Kruse[1], Dennis Brennecke[1], Alice Nauendorf[1], Tim Kiessling[1, 2], Sinja Dittmann[1], Martin Thiel[2], Linda Mederake[3], Doris Knoblauch[3], Mandy Hinz-mann[3], Carla Lourenço[4], Mateja Grego[5]

[1] Kiel Science Factory, Germnay
[2] Universidad Católica del Norte, Chile
[3] Ecologic Institute, Germany
[4] Ciência Viva, Portugal
[5] National Institute of Biology, Slovenia

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# BACKGROUND INFO:
# PLASTIC PIRATES – GO EUROPE!

**Plastic Pirates - Go Europe!** is a European citizen science action in which school classes and youth groups collect plastic samples at streams and rivers and document their results. The collected data is then analysed by scientists. In this way, young European citizens make an important contribution to research on the state of European rivers and the degree and possible origins of plastic waste pollution. The action aims to strengthen scientific cooperation in Europe, to promote citizen science engagement and society's participation in the European Research Area, and to raise awareness for a conscious and considerate approach to the environment. The campaign was first developed as Plastic Pirates in Germany in 2016 by the Kiel Science Factory and partners with funding from the German Federal Ministry of Education and Research (BMBF) for the Science Year 2016*17 - Seas and Oceans and has been continued since 2018 as part of the research focus "Plastics in the Environment". During the German EU Presidency in 2020, the campaign was extended to the countries of the Trio Presidency and implemented as a joint action of the Ministries of Education, Science and Research of Germany, Portugal and Slovenia in the period from 2020 to 2021. Since January 2022, the action has been extended to other EU Member States with the support of the EU Commission.

More information on the Plastic Pirates can be found at **plastic-pirates.eu/en** .

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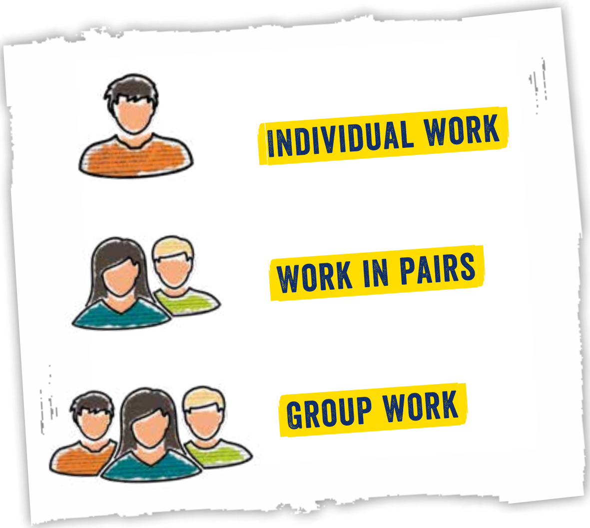
# USAGE




The citizen science action **Plastic Pirates - Go Europe!** deals with the topic of plastic waste in the environment and the influence of plastic waste transported into the oceans via inland waters. Over several counting periods, young people can use the action booklet to evaluate their results in and along running waters and make them available to science. In citizen science projects, people interested in science can get directly involved in the research process. In this case, it is an action-oriented invitation to young people to think further. The Plastic Pirates team informs about the current status of the scientific evaluations in the social media:
**plastic-pirates.eu/en/socialwall**

You can find more information at:
**plastic-pirates.eu/en**

# Contents

# THE MATERIALS: INTRODUCTORY REMARKS

A torn plastic bag on the riverbank or a yogurt pot floating in the water are symptoms of serious interference with the highly complex system of the ocean. The **Plastic Pirates – Go Europe!** project focuses on this plastic waste problem and our future handling of it, and aims to familiarise young people with the general topic of the ocean and water cycles in the process.

These teaching materials and worksheets have been designed for this purpose and are suitable for learners with different levels of prior knowledge thanks to their educational structure and content for different age groups. They can also be seamlessly integrated into the respective curriculum as needed.

# USING THE MATERIALS:

The exercises found in the teaching materials and worksheets are versatile and suitable for the classroom. As each chapter functions on a stand-alone basis, the chapters can be used individually or in a modified order. Depending on your thematic focus, the requirements of your pupils and the time available, you can also select individual exercises from the materials. The exercises come in various difficulty levels and therefore may have to be adapted to the levels of the pupils. On page 68, you will find an overview of all exercises along with an estimate of the time needed and complexity of the exercise. The teaching materials and worksheets have been designed for use in both standard lessons and project work. The areas of focus of the individual modules are particularly suitable for multidisciplinary learning, with the involvement of other subjects both intended and desirable.

## MASTER COPIES

The worksheets are available for you to download as free-to-use black-and-white master copies on the website **plastic-pirates.eu/en/material/download**

# THE STRUCTURE OF THE MATERIALS

These teaching materials and worksheets are divided into four chapters. The introductory chapter is all about discovery and brings to life the importance of seas, the ocean and rivers. The second chapter looks at how these bodies of water are used – and polluted – by people. We then move on to the third chapter, which focuses on the origin and impact of plastic waste in the sea. The final chapter provides answers to the question of what each and every one of us can do to help protect our seas.

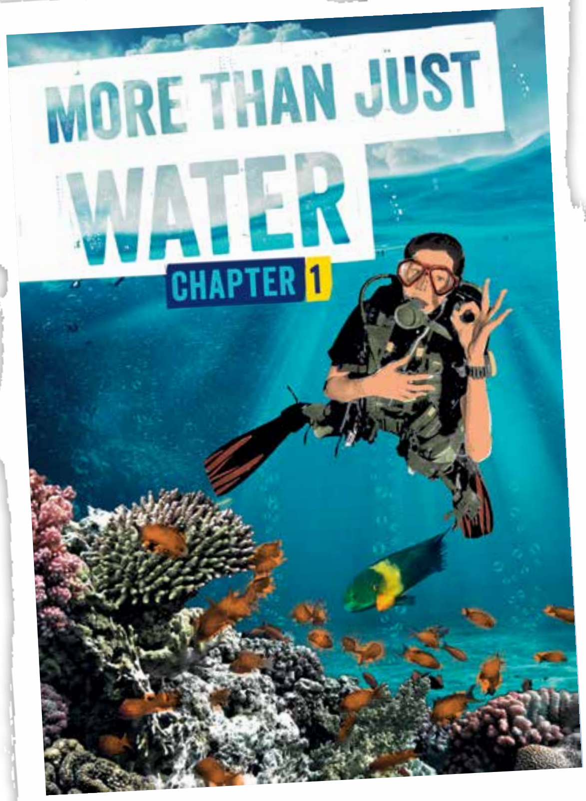
Each chapter comprises an introduction to the topic and a series of exercises, as well as notes and solutions for teachers. The introductory texts outline the key issues of the chapter concerned and illustrate the structure. First and foremost, they provide you as a teacher with a concise summary of the topic, while being written in such a way that they can be used as a classroom introduction.

The exercise sections have been designed as master copies and contain exercises tailored to the relevant topic. At the end of each chapter, you will find supplementary information, both on the concept behind the chapter and how to carry out the exercises in lessons.

**Introduction**

**Exercises**

**Notes and solutions for teachers**




## CHAPTER 1
# MORE THAN JUST WATER

Many people regard seas and the ocean as little more than somewhere to go on holiday and a place where you can take beautiful photos of the sunset. But the world's seas are so much more than that. They make up more than two-thirds of the earth's surface and are home to countless species of plants and animals. What would we do, for example, without the phytoplankton that forms the basis of the marine food web and that is the source of more than half of the oxygen in the atmosphere?

It is not possible to overestimate the importance of the sensitive ecosystems found in the ocean – even if you don't live by the sea, the sea still influences your every-day life. Do you wear a summer dress or winter coat? Your decision is made by the ocean, as it determines the climate. By the same token, however, inland regions influence the ocean as well since the sea begins here: rivers transport not only water to the ocean, but also sand and waste, such as plastic waste.

## CHAPTER 2
# FROM USING TO POLLUTING

The ocean is not just beautiful, but also exceptionally useful. We eat fish fingers that are made using pollack fished from the sea. We wear clothes that have been shipped across the ocean. We fill up our cars with petrol that has been made from deep-sea crude oil. We charge our mobile phones with electricity that has been generated at offshore wind farms. And in the future, the copper contained within our mobile phones may well be partly sourced from the ocean in the form of manga-nese nodules.

Fish represents the main source of protein for people in many countries. Furthermore, seawater is treated to make drinking water in many areas. This (over)use is sometimes a direct cause of pollution, such as the spill of oil or chemicals into the water. Most frequently, however, pollution makes its way into the ocean from land. Fertiliser, for example, causes a huge problem, as does plastic waste.

CHAPTER 3

## PLASTIC WASTE – A LASTING PROBLEM

There is no doubt about it: plastic is a practical material. It is easy to shape, resistant and lasts a long time. Perhaps too long? It may take centuries for a plastic bottle to decompose. Every single minute, enough plastic to fill a rubbish truck enters the ocean. Plastic waste patches the size of central Europe are already drifting around our ocean. And some researchers expect that, by the year 2050, the weight of the plastic waste in the ocean could exceed that of all the ocean's fish. The fish themselves eat the plastic, meaning that it can also reach us through our food web.

Very little research has been conducted into the effects of plastic on humans and animals. Additional studies on the distribution of the waste and sources of waste are also necessary to effectively combat the problem.



CHAPTER 4

## OVER TO YOU

Many people are shocked and saddened by the sight of seabirds or whales that have starved to death due to a stomach full of plastic. The good news is that something is already being done about it. Many organisations and initiatives campaign to protect the ocean, thus acting as inspirational examples.

Awareness of the problem is slowly but surely growing in society. This is extremely important. The United Nations has also set sustainability targets, but each and every one of us has to play a part in their implementation as well as rethink our actions. Is it really necessary to buy a new smartphone every year? Could I still do my shopping without that plastic bag? Who is responsible for the waste that I produce? These are questions we should all be asking ourselves. After all, we should never forget the good news about the plastic problem: it's a problem that can be solved. Let's do it!

# EDUCATION FOR SUSTAINABLE DEVELOPMENT – WHAT DOES IT MEAN?

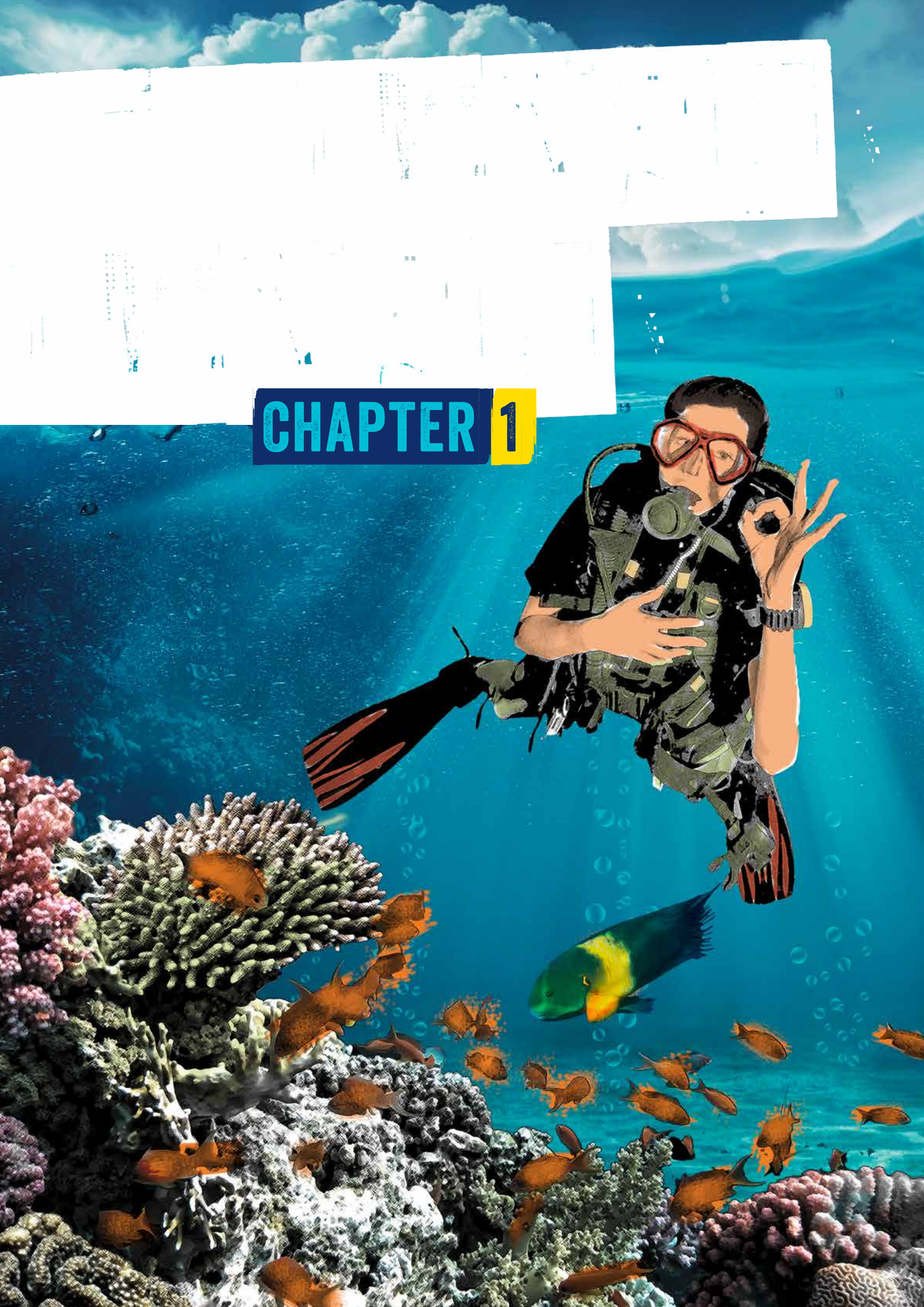
'My actions have consequences, not just for me and my environment but also for other people – both now and in the future. I can shape the present so that generations to come can also enjoy a good life on earth' – this is the core message that education for sustainable development (ESD) seeks to communicate and bring to life.

ESD offers insights into global issues and challenges such as climate change and international equality and the complex economic, environmental and social causes of these problems. In doing so, it always seeks to relate these issues to the personal circumstances of learners and to promote the experience of self-fulfilment when developing potential solutions.

The aim of education for sustainable development is to enable individuals to acquire the ability to shape events. This describes a capacity to put sustainable development insights into practice by means of actions and to help shape the future in a proactive manner that includes taking personal responsibility. This educational ethos involves a clear understanding that a multidisciplinary approach is required to promote knowledge and skills of this kind.

An overview of ESD can be found at:
en.unesco.org/themes/education-sustainable-development (English)

# CHAPTER 1



Introduction

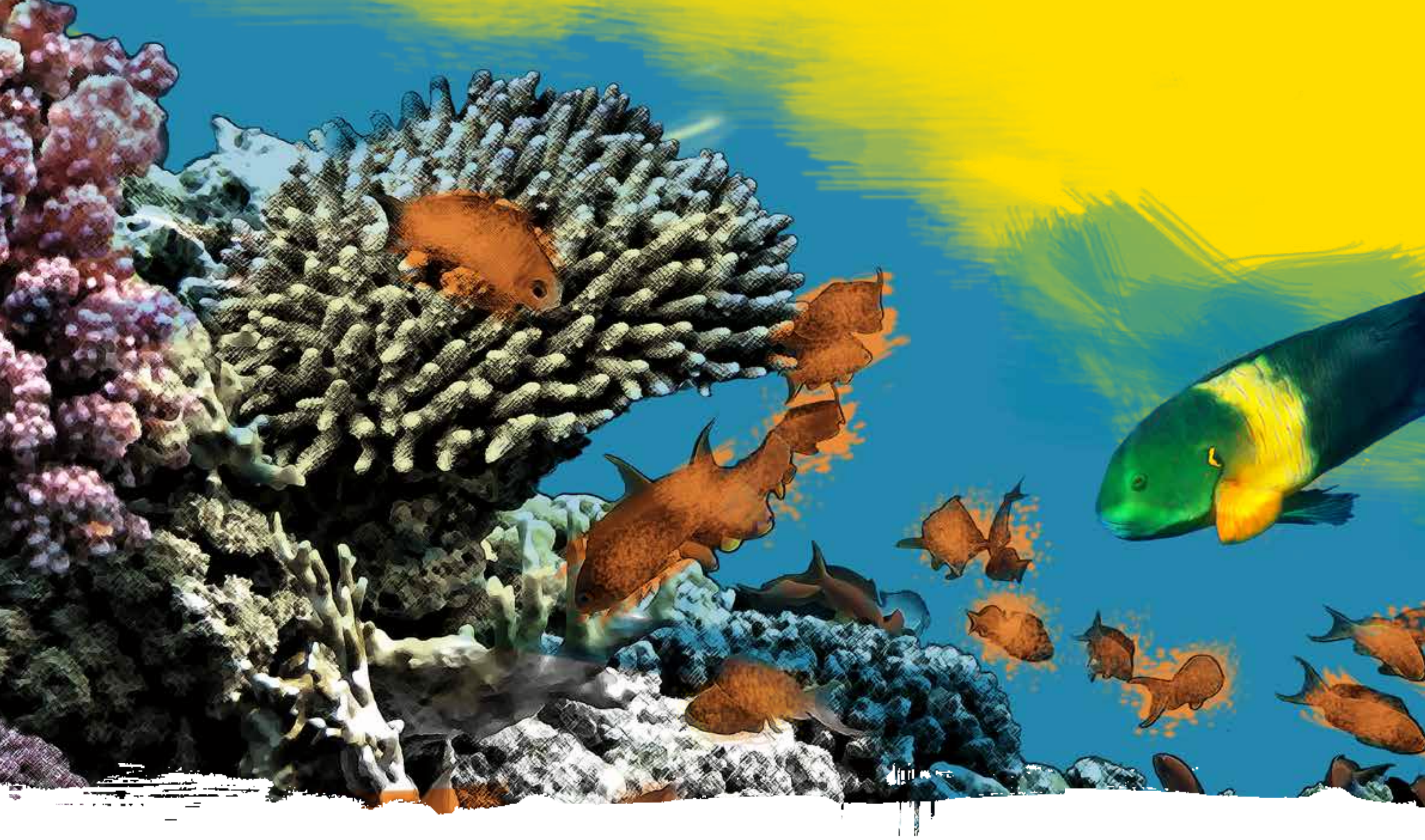
# IMPORTANCE OF THE OCEAN

## More than just water

**Seawater makes up two-thirds of the earth's surface, which is why earth is a blue planet when seen from space. The seas and ocean basins are the largest connected habitat on our planet. They are of vital importance for the climate and for life on earth.**

**They are a habitat and source of food for many organisms. People are also reliant on the intensive use of the world's seas. The sea provides humans with both food and natural resources. We also use it as a transport route. More than half of the world's population live in coastal areas. And, last but not least, the ocean gives us pleasure in the form of swimming and surfing, days at the beach and cruises. Whether living by the coast or inland – all humans are connected to the ocean.**

**At the same time, however, the ocean is under threat. One of these threats is pollution from plastic waste. Scientists want to research in more detail where the plastic waste comes from before it enters the ocean via rivers. For this reason, pupils will be taking part in an investigation of European rivers as part of the Plastic Pirates – Go Europe! campaign. All rivers eventually flow into the ocean.**



## A sea of knowledge: fascinating facts on the ocean

1. The average depth in the ocean is 3,800 metres. The deepest points are the oceanic trenches, which make up just two per cent of the seabed. With a depth of 11,034 metres, the deepest point in the ocean is the Mariana Trench in the Pacific. It is known as the Challenger Deep.

2. Most light can only penetrate to about 200 metres below the surface of the water. As a result, the ocean is largely submerged in complete darkness.

3. Less than five per cent of the ocean has been mapped in detail. There are better maps of Mars than of the seabed.

4. The world's longest mountain range is located in the sea. It is known as the mid-ocean ridge and runs down the middle of the Atlantic Ocean and through the Indian and Pacific ocean basins. It is more than 60,000 kilometres long.

5. A total of 97 per cent of earth's water is salt water. A mere three per cent is fresh water, and less than one per cent is available as drinking water.

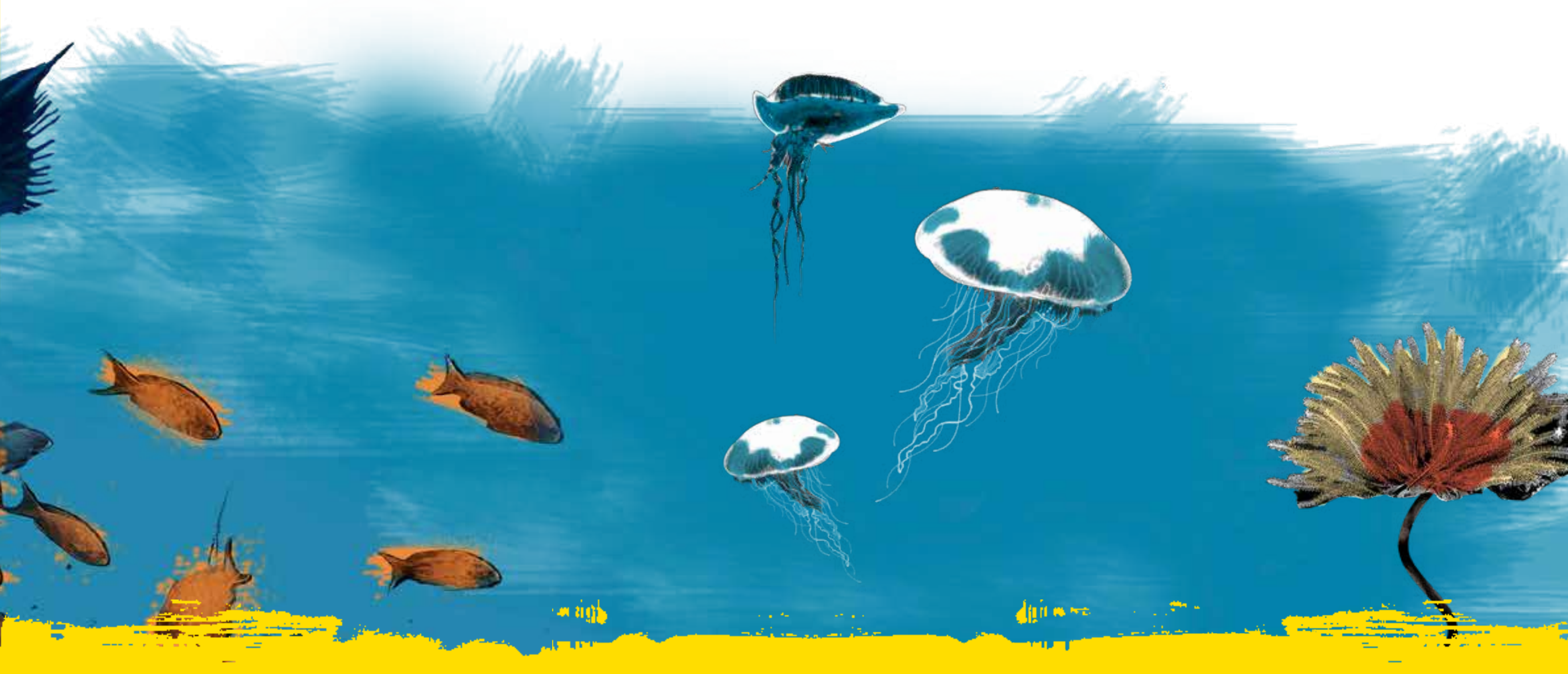
6. The blue whale is the largest living creature on earth. The largest specimen ever measured was 33 metres long. The heart of a blue whale is the size of a small car.

7. The Great Barrier Reef off the coast of Australia is the world's largest coral reef and is even visible from space.

8. Squids have three hearts. A central heart that pumps blood to the brain and body and two gill hearts that ensure that blood can be quickly channelled to the respiratory organs.

9. More than half of the oxygen in the earth's atmosphere is produced by plant plankton (phytoplankton) – the tiny algae drifting in the ocean.

10. One litre of seawater contains 35 grams of salt on average. That is enough salt to cover the entire landmass of earth in a pile of salt 40 storeys high.



Master copy

# IMPORTANCE OF THE OCEAN

**Perhaps you've been on holiday by the sea or ocean – or someone in your family or group of friends. Or maybe you even live near the coast. The following exercise is about reporting on it.**

## EXERCISE 1:

### Memories of the sea

**Add photos or images of your holidays by the sea and describe the time you spent there:**
What can you still remember?
What really impressed you?
What made you think?

**If you haven't yet visited the seaside yourself,** ask around to see if anyone in your family has been and has a photo of it. You can also search magazines and the internet for photos of the ocean and stick them in the spaces provided.

**Look for clues about the ocean on the photos,** e.g. clues about the water temperature.
What plants and animals typically live there?

**Compare your photos and findings as a group.** Look for similarities and differences between the different images of the sea.

COMPARISON:

Master copy

# OCEAN FACTS

**If you see the earth from space, you will immediately notice that there is more water than land. More than 70 per cent of the world's surface is made up of water, with less than 30 per cent covered by land masses. We live on a blue planet that should really be called 'water' rather than 'earth'.**

**When we talk about the ocean, we really mean the five large ocean basins of the world, which are all interconnected. The Pacific is the largest ocean basin and contains almost half of all water. In addition to the ocean basins, there are also smaller seas such as the Mediterranean Sea, Black Sea, North Sea and Baltic Sea.**

## EXERCISE 2:

### A visit to the Challenger Deep

Only four people have ever been to the deepest point in the world's ocean. Find the Challenger Deep on a globe or a map of the world. Research the names of these deep-sea explorers, their professions and the years of the expeditions in which they and their submersibles descended to the depths. Enter your findings in the table and compare them with the person sitting next to you.

| Name | Profession | Year of expedition |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

## EXERCISE 3:

### On the map

**Pick up an atlas and take a close look at the ocean. Enter the following information on the map of the world provided and in the table:**

- Name all five major ocean basins.
- Find out the surface area of the individual ocean basins (excluding the smaller seas) and how much water each one contains.
- Name three large rivers that flow into these ocean basins.
- Research how people use the ocean. What kinds of usage spring to mind? Come up with a symbol for each usage type and add it in the appropriate place on the world map, e.g. a fish symbol for fishing in the North Atlantic.

| Ocean basin | Surface area in million $km^2$ | Volume in million $km^3$ | Rivers |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |



**PLEASE NOTE**

The map of the world should be scaled to 200 per cent during copying.

Introduction

# EUROPE'S RIVERS – WHERE THE SEA BEGINS

## The beauty of rivers

**Rivers connect all of Europe – from small streams to major rivers. One of Europe's longest rivers is the Danube, which flows through a total of ten countries. The Danube stretches 2,850 kilometres from its source to the mouth of the river, where it flows into the Black Sea. Rivers offer habitat and food to a wide variety of flora and fauna. One example of a typical European species found near rivers is the kingfisher. This little brightly coloured bird eats small fish or larvae, grabbing them by diving into the river from its vantage point on the banks. Although the European population of the kingfisher is stable, the species is suffering from the loss of its habitat due to the straightening of river paths, for example.**

The appearance of a river changes several times between its source and its mouth. What starts as a noisy and fast-flowing stream gradually becomes a placid channel that eventually flows into the sea. The source of a river is often found in an upland region. As the terrain is extremely steep in these regions, the groundwater that emerges at the source flows downhill at a rapid pace. The flow speed is correspondingly high in the upper reaches of a river. As the fast-flowing water displays considerable force, small particles, sand and gravel are swept along. In the upper reaches, the riverbed is made primarily of large, heavy rocks.

The flow speed decreases continuously as the river flows from the upper to the lower reaches. In the lower reaches and the estuary, the river becomes wider. In extreme cases, a V-shaped delta is formed (see the diagram on page 16). Because the flow speed is very low in this section of the river, the stones and fine sand (sediment) transported this far are now deposited. But rivers also transport all kinds of waste into the ocean. Scientists want to find out where most waste enters the rivers, how the waste makes its way into rivers and how it changes in the process.

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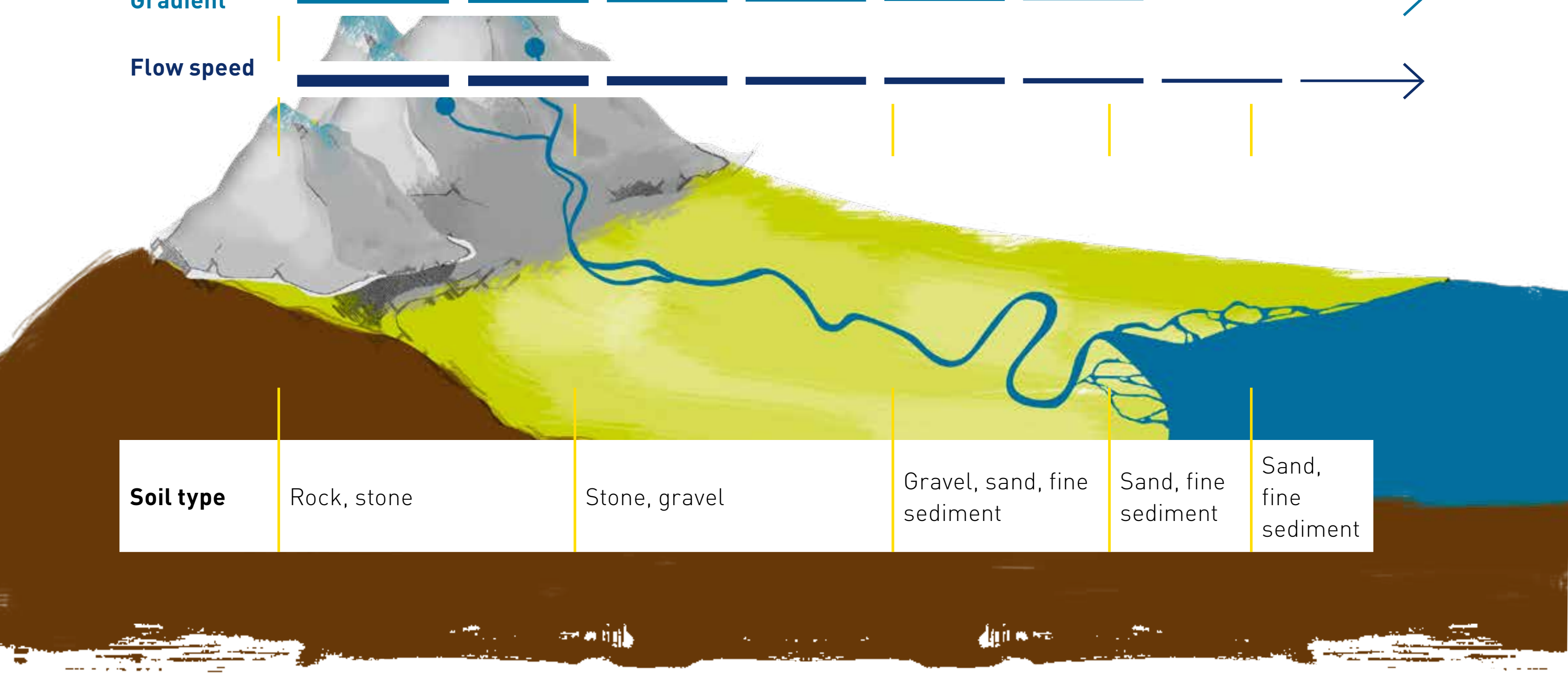
# RIVERS – EUROPE'S WHERE THE SEA BEGINS

**Not all of you will live by the sea. But your home town or city may be connected with the sea by rivers. These exercises will help you discover the rivers found in Europe.**

**All rivers progress in a similar way. We distinguish between the upper, middle and lower reaches.**



| | Upper reaches | Middle reaches | Lower reaches | Mouth | Lake and sea |
|---|---|---|---|---|---|
| **Gradient** | | | | | |
| **Flow speed** | | | | | |
| **Soil type** | Rock, stone | Stone, gravel | Gravel, sand, fine sediment | Sand, fine sediment | Sand, fine sediment |

## EXERCISE 4:

### The top three

**Draw up profiles of the three longest rivers in your country.**

Name of river:

Length:

Mouth:

Source:

Name of river:

Length:

Mouth:

Source:

## EXERCISE 5:

### Which river flows where?

Learn about more rivers in Europe by creating a quiz. Split up into groups of four and use an atlas to help you. Each group comes up with five questions – there are a few examples below to give you an idea. Each group asks their questions in turn, with points going to whoever gives the correct answer first.

1. **Which lake does the Rhine flow through?**

2. **Which of these countries does the Danube NOT flow through?**

| | | | |
|---|---|---|---|
| Hungary | ☐ | France | ☐ |
| Slovenia | ☐ | Germany | ☐ |
| Austria | ☐ | | |

3. **What is the name of the river that flows through Munich?**

4. **What is the name of the river that flows through Paris?**

5. **Which major rivers flow into the Baltic Sea?**

6. **What is the longest river on the Iberian peninsula?**

7. **Which river in Europe carries the most water?**

Name of river:

Length:

Mouth:

Source:

Introduction

# THE FOOD WEBS IN THE OCEAN, SEAS AND RIVERS

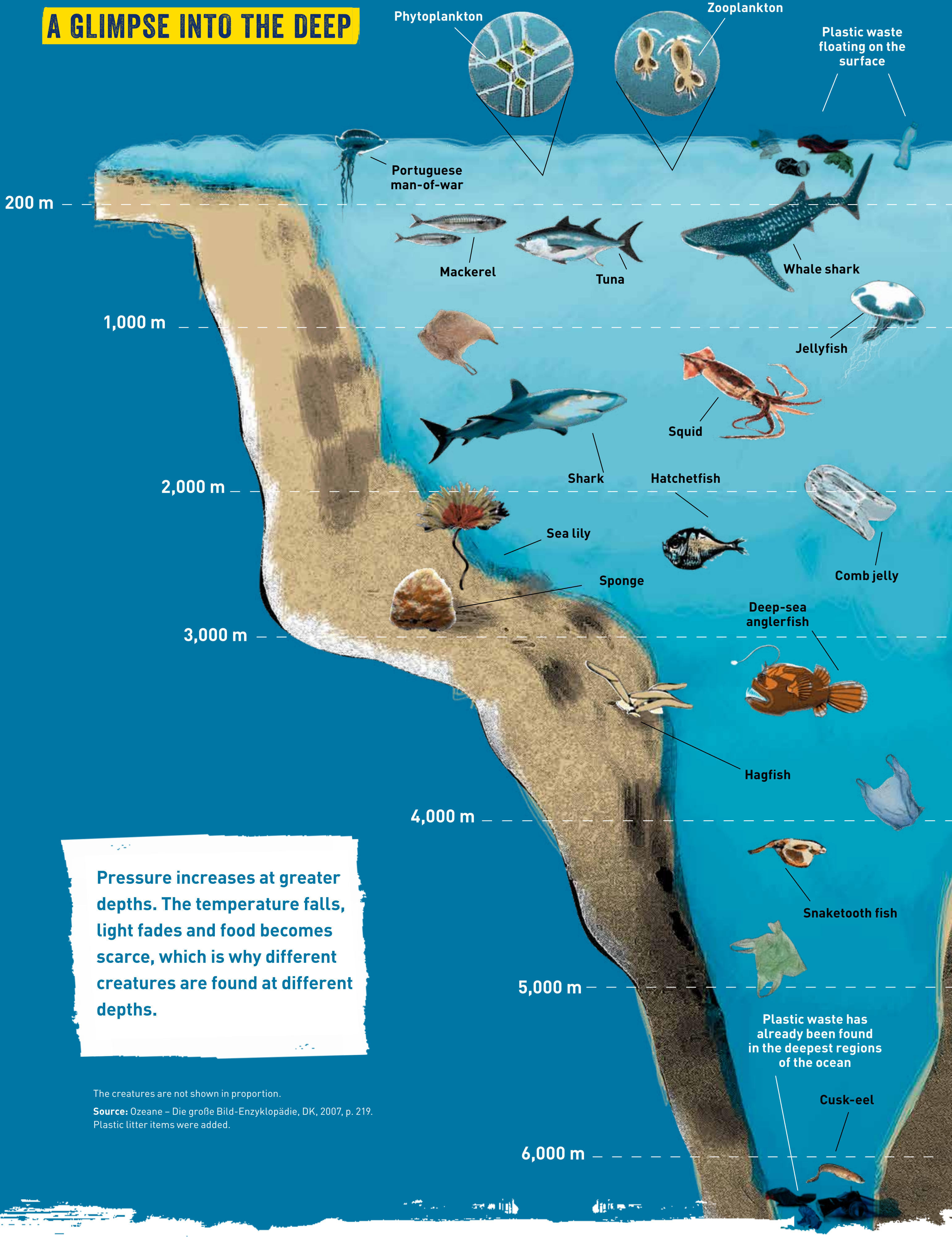
## The wildlife and living conditions in the ocean

The ocean forms one huge connected habitat. This habitat is home to a vast community of plant and animal organisms, as well as bacteria. The ocean can be broken down into many different ecoregions, all of which are very different in terms of living conditions. Alongside latitude, various factors such as light, pressure, temperature, currents and salt level all play a key role in determining where specific organisms can be found. For plants, sunlight is the most important factor, as both large algae (seaweeds) and microscopically small algae (phytoplankton) use the energy for photosynthesis. Photosynthesis produces sugar and oxygen. As the ocean is home to large numbers of phytoplankton, the amount of oxygen produced is correspondingly high. More than half of the oxygen in the atmosphere comes from phytoplankton.

Phytoplankton has a second important role to play. Because it produces its own energy, it serves as food for the animals found in the world's seas and therefore forms the foundation of the marine food web (see the food web diagram on page 21). The technical term is 'producer'. Producers are eaten by consumers. Phytoplankton is eaten by animal plankton (zooplankton), a category that includes small crustaceans swimming in the water, as well as the larvae of fish and mussels. The zooplankton, in turn, is eaten by smaller fish, who in turn are preyed upon by larger organisms, such as sharks and dolphins. Depending on the area of the sea concerned, there may be significant differences in these food webs with their many links between predators and prey. The living conditions that determine the make-up of ecosystems do not just change from one region to the next but also as the depth increases (see the diagram on page 19).

Living creatures are not just closely interdependent in the ocean, however. The ecosystems found in rivers can also be complex and made up differently depending on the environmental conditions.

# A GLIMPSE INTO THE DEEP




**Pressure increases at greater depths. The temperature falls, light fades and food becomes scarce, which is why different creatures are found at different depths.**

The creatures are not shown in proportion.

**Source:** Ozeane – Die große Bild-Enzyklopädie, DK, 2007, p. 219. Plastic litter items were added.

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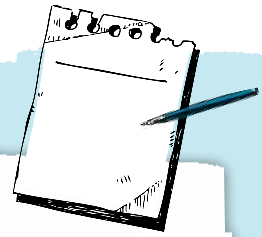
# THE FOOD WEB OF THE OCEAN

**The following exercise gives you a chance to explore the fascinating food web found in the ocean.**

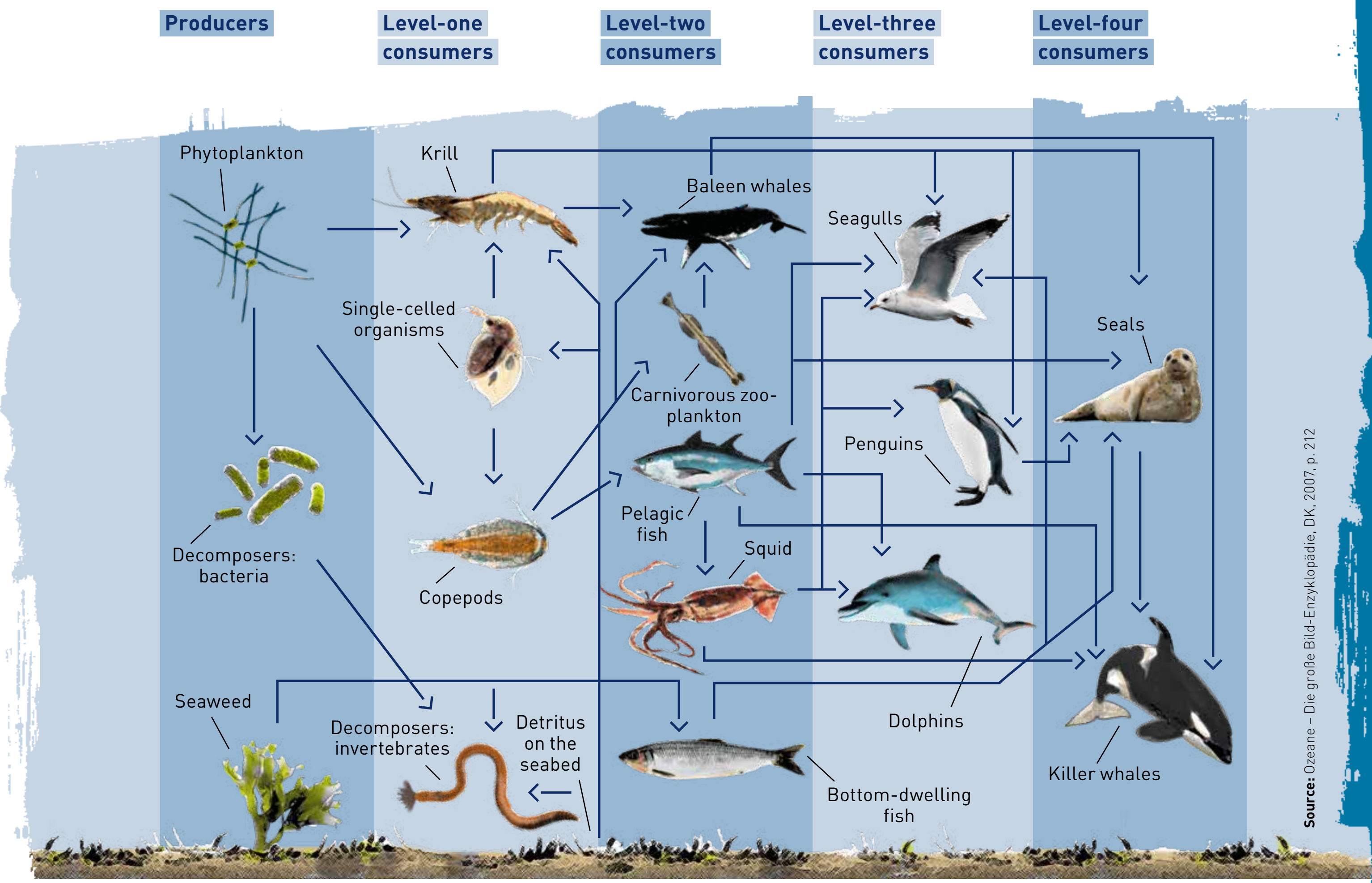
## EXERCISE 6:

### Plankton – small but mighty

1. Search for photos of phytoplankton and zooplankton (in a book or online). Draw one example in each of the spaces provided and label your drawing with the name of the organism concerned. **What can you find out about this organism?**



**2.** Take a look at the diagram below on the food web in the Antarctic. What role does the phytoplankton play in the food web? Why is this a food web and not a food chain?




The creatures are not shown in proportion.

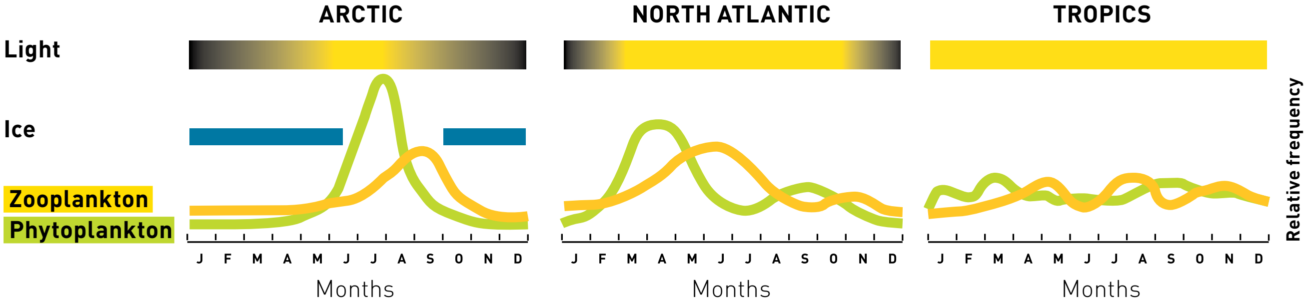
# EXERCISE 7:

## Year after year

The amount and composition of plankton in an area of the sea changes with the seasons. It is influenced by various factors.

**Use the diagram below to explain the annual cycle of plankton production in tropical seas, the temperate latitudes and the polar regions.**

### Seasonality




The seasonal distribution of phytoplankton and zooplankton at different latitudes.
**Source**: Faszination Meeresforschung, Hempel, Hempel and Schiel, Hauschild, 2006, p. 29

# EXERCISE 8:

## The food web game

**In order to experience the complex links in a food web for yourselves, you are now going to assume the roles of starfish, plankton and dolphin.**

Materials:
- Role play cards
- Different balls of wool (different colours if possible)

1. Everyone takes one role play card each, finds their prey and predators and stands next to them. The other players must be able to see the cards you have picked. What do you notice?

2. Now form a circle. Ideally, you should go onto the school playground or a large open space.

3. The person who has drawn the phytoplankton card stands in the middle of the circle and holds on to the start of the first ball of wool.

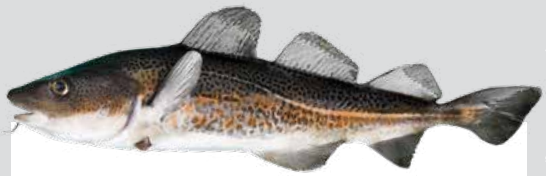
4. The ball of wool is now thrown over to another player whose card is linked to the plankton in the food web. That player holds on to one end of the thread and throws it to another organism that is linked in the food web. This continues until the apex predator, or final consumer, is reached. The procedure is repeated with another woollen thread.

5. Carry on with the same procedure until all players are holding at least one thread in their hands. What do you notice now?

### SHORE CRAB

**Eats:**
Mussels, snails, polychaetes, smaller crabs
**Eaten by:**
Shore crabs are eaten by a number of animals – larger fish and seabirds, for instance.

### COD



**Eats:**
Sand shrimps, starfish, common mussels
**Eaten by:**
Seals, dolphins

### COMMON MUSSEL

**Eats:**
Phytoplankton, zooplankton
**Eaten by:**
Starfish, black-headed gulls, crabs

### MACKEREL

**Eats:**
Zooplankton
**Eaten by:**
Dolphins, larger fish

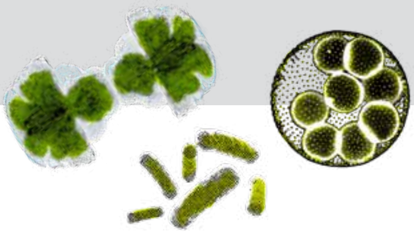
## SAND SHRIMP

**Eats:**
Zooplankton
**Eaten by:**
Seals, plaice

## PLAICE

**Eats:**
Common mussels, sand shrimps
**Eaten by:**
Predatory fish

## PHYTOPLANKTON



Phytoplankton produces its own food using sunlight and carbon dioxide.
**Eaten by:**
Zooplankton, barnacles, common mussels

## ZOOPLANKTON

**Eats:**
Phytoplankton
**Eaten by:**
Common mussels, barnacles, herring

## DOLPHIN

Dolphins are threatened by humans.
**Eats:**
Fish, octopus, squid, cuttlefish

## PLASTIC FRAGMENTS

Master copy

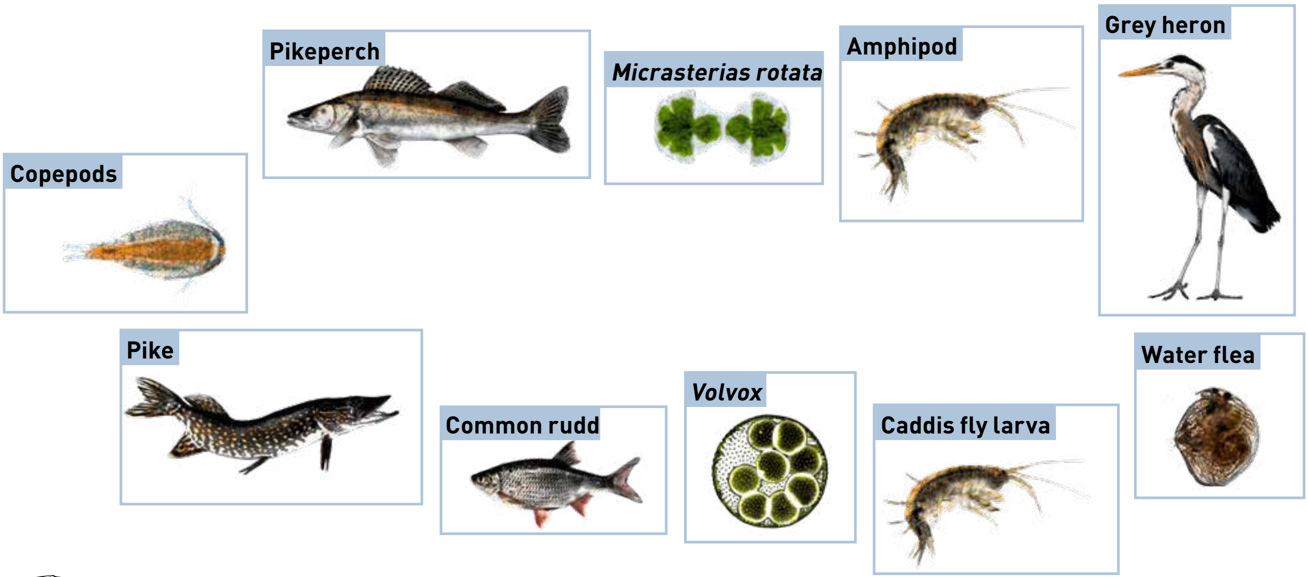
# RIVER WILDLIFE

**Living creatures are not just closely interdependent in the ocean, however. The ecosystems found in rivers can also be complex and made up differently depending on the environmental conditions.**

## EXERCISE 9:

### Who eats whom?

**Show how diverse a river food web can be by indicating who eats whom below. Draw arrows between the predators and their prey.**




## EXERCISE 10:

### The food web at your doorstep

**Research** which creatures are typically found in the rivers near you. Print out pictures of these species, or write their names on a sheet of paper. Now connect the species with arrows between the predators and prey (like in exercise 9).

**Make sure** to include species from every level of the food web, for example: primary producers such as phytoplankton, zooplankton, fish that eat plankton, birds that eat fish.

## EXERCISE 11:

### River wildlife card game

**Split up into groups of three.** On the cards provided, produce a profile of the species named along with a drawing on the reverse. Each player chooses four of these animals:

| | |
|---|---|
| Brown trout | Eurasian otter |
| Crayfish | Grey heron |
| Pike | Kingfisher |
| Fire salamander | Salmon |
| Beaver | Grass snake |
| Cormorant | Mute swan |

Cut out your profiles and mix them up with the profiles of the other players. Play the river wildlife card game. Decide for yourselves whether high or low values win in each of the five categories (size, diet, lifespan, age at which sexual maturity is reached and weight).

**For example:** The largest animal beats the smallest, meat eaters beat plant eaters or the animal with the shortest time to sexual maturity wins against the animal that takes longest to reach sexual maturity.

**Species:**

**Size:**

**Diet:**

**Lifespan:**

**Age at which sexual maturity is reached:**

**Weight:**

**Species:**

**Size:**

**Diet:**

**Lifespan:**

**Age at which sexual maturity is reached:**

**Weight:**

**Species:**

**Size:**

**Diet:**

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**Species:**

**Size:**

**Diet:**

**Lifespan:**

**Age at which sexual maturity is reached:**

**Weight:**

Introduction

# MARINE CURRENTS – EVERYTHING'S LINKED

## The ocean is on the move

**Seawater is always on the move. It is transported by the great currents that link all ocean basins. We distinguish between currents that transport water on the surface and currents that transport water in the depths. The many surface and deep-ocean currents come together like a conveyor belt to transport water around the world. We talk about the global conveyor belt (or, to use the technical term, 'thermohaline circulation'), which links four of the world's five ocean basins. A single water molecule that is carried on this global conveyor belt takes about 1,000 years to circumnavigate the globe.**

### Importance of the ocean for the global climate

The earth gets its energy from the sun. The amount of solar energy received in a particular region depends on the region's latitude, i.e. the distance from the equator. The tropics, for example, receive more sunlight than northern and southern regions. The North and South Poles get the least solar energy.

Many different factors such as temperature, salt level, wind and gravity form the motor that drives the global conveyor belt. The ocean stores the solar energy from sunlight and transports it by means of giant currents from the equator to the North and South Pole. The water cools again in the Arctic and Antarctic. It sinks to the depths (cold water is heavier than warm water), causing cold deep-ocean currents. These currents then transport the water back to the equator, where it then warms up again and rises.

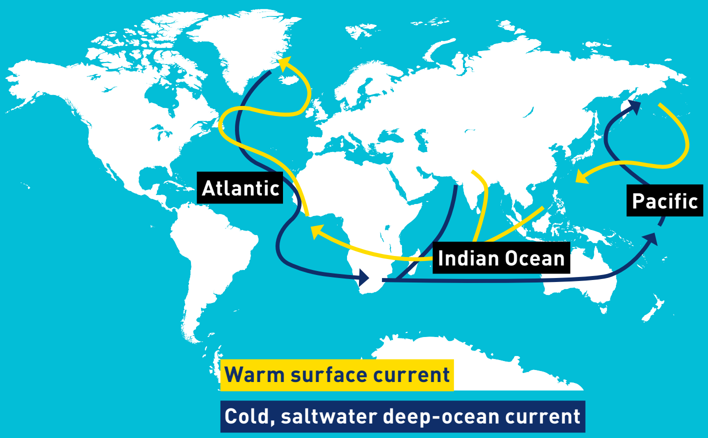
This global conveyor belt should not be viewed separately from the earth's atmosphere, as the atmosphere and the ocean currents influence each other. Storms move water around and can therefore also generate currents. Evaporation is also important. It causes water to rise up from the sea into the atmosphere. In the form of precipitation (rain and snow), it enters the sea somewhere else or comes back down on dry land.

The climate in Europe is also influenced by the interplay between the sea and the atmosphere. The warm Gulf Stream that flows up to us in Europe from the Gulf of Mexico is one of the most powerful currents in the world's seas. It transports warm water from the tropics to Europe and acts a bit like the continent's hot-water heating system.

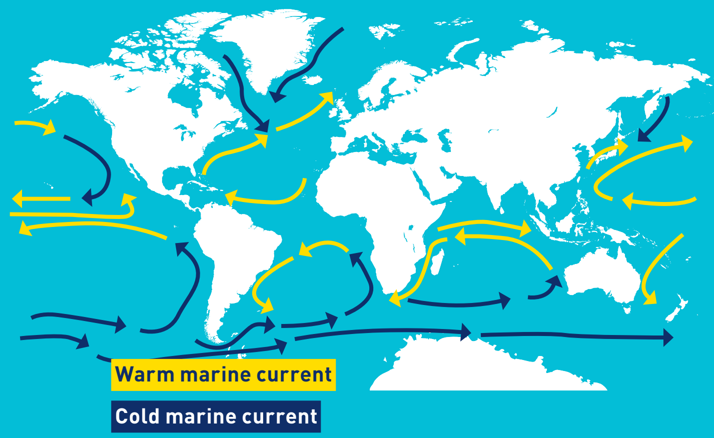
**Weather and climate? An important distinction!**

Weather refers to short-term changes in the atmosphere at a specific time in a specific place (e.g. heat, cloud coverage, aridity, sunshine, wind, rain). Weather can change within minutes, hours, days and weeks. Climate refers to long-term weather conditions and patterns at a location (over at least 30 years).

## The global conveyor belt



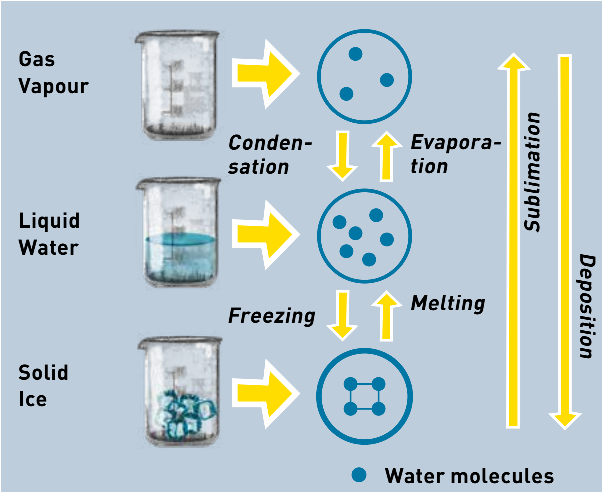

## Surface currents of the ocean



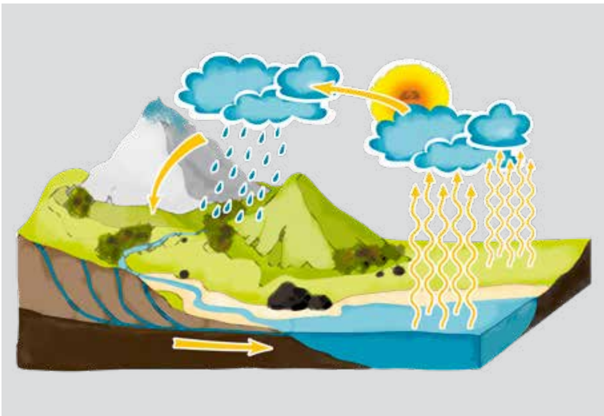

## It is not just seawater that is permanently on the move

Water molecules never stop moving either, whether in seas, rivers or as water vapour in our atmosphere. The ocean, rivers and lakes are not closed-off bodies of water, but are connected with each other via the water cycle.

This cycle begins with evaporation. As soon as sunlight hits the surface of the water, water molecules start moving. They repel each other, causing the water to evaporate and accumulate in the atmosphere as water vapour. This occurs on the surface of the ocean, seas, lakes and rivers. As the ocean makes up the lion's share of the earth's surface, most water evaporates here. The rising water vapour condenses as the atmosphere becomes colder and colder as the altitude increases.




States of matter for water



Water cycle

This condensation often takes place above continents and the slopes of mountain ranges. When the water condenses, precipitation that is formed normally falls as rain. When temperatures are low or pressure is high, however, the rain might freeze, which causes snow or hail.

The precipitation that falls on the ground seeps away and accumulates as groundwater in the soil. From here, the groundwater flows back into the sea below the surface. In some places, it comes to the surface as a spring that acts as the source of a river. The river eventually flows into the sea.

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# MARINE CURRENTS – EVERYTHING'S LINKED

**Seawater is always on the move. Large quantities of water are moved chiefly by ocean currents. Together, these ocean currents work like a conveyor belt that transports the water around the world. Heat and nutrients are also distributed across the world's seas in this way. But what drives this conveyor belt? The following experiments will help you find the answer.**

## EXERCISE 12:

### Always on the move

Carry out the following experiments to illustrate what drives the global conveyor belt. **Keep a log of the experiments.**

**EXPERIMENT 1:**

**Formation of marine currents I**

Required materials:

- Beaker (1,000 ml)
- Food colouring and water
- Conical flask (250 ml)
- Crucible tongs
- Thermometer
- Electric kettle

Method:

Pour 700 ml of water into the beaker. Now heat water to 50°C in a kettle and fill the conical flask to the rim. Take care not to scald yourselves. Colour the water in the conical flask with a few drops of food colouring and use the crucible tongs to place the flask in the beaker.

**Observe what happens.**

**EXPERIMENT 2:**

**Formation of marine currents II**

Required materials:

- Ice cube mould
- Beaker (1,000 ml)
- Electric kettle
- Thermometer
- Food colouring
- Water

Method:

Colour some water with a few drops of food colouring and leave it to freeze overnight in the ice cube mould. Then add one of the ice cubes to a beaker filled with warm water (approx. 40°C).

**Observe what happens.**

## ! PLEASE NOTE: EXPERIMENT LOG

**Scientists attempt to research and understand phenomena. To do so, they gather information, conduct experiments and evaluate them. In order to ensure that their findings don't get lost and are verifiable, they note down all information in an experiment log. The same method is used for scientific experiments all over the world:**

- **Problem:** What is the aim of the experiment?
- **Hypothesis:** What do I anticipate?
- **Method:** How do I proceed in order to verify my expectations?
- **Observation:** What do I notice? (What can I see, hear, feel or measure?) What data have I received?
- **Evaluation:** How can I use my observations and findings to support or contradict my hypotheses?

**EXPERIMENT 3:**

**Formation of marine currents III**

Required materials:

- Salt
- Crystallising dish or small aquarium
- Plasticine
- Food colouring
- Water
- Beaker (1,000 ml)

Method:

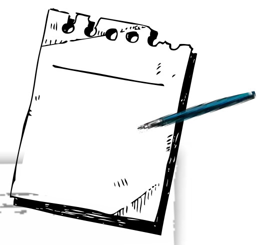
Use the plasticine to form a barrier in one of the crystallising dishes so that both sides are kept separate. Fill the dish with tap water. The water level should be approx. 1 cm above the barrier. Colour some water with a few drops of food colouring and dissolve some salt in the water to create a concentrated salt solution. Carefully add the coloured salt water to the dish on one side of the barrier until it flows over the barrier. **Observe what happens.**

## INFO BOX DENSITY

**Different substances that exhibit the same weight on the scales often take up different amounts of space. This is due to the fact that different substances have different densities. Density is a specific material property.**
**It is calculated by dividing the mass of an object by its volume.**
**The unit of measurement is $\rho$ (pronounced 'row').**

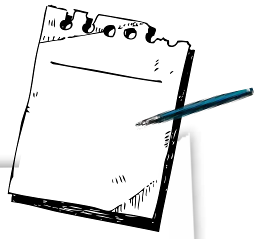
Observation:

Note down and describe your observations from all the experiments in the box below.



Evaluation:

Describe in your own words how ocean currents are generated.
If you find this difficult, you can use the terms in the help box.



HELP BOX

**Please note:** Each term should be used at least once. They can also be used several times.

warm water, cold water, density, heavier, lighter, salt water, fresh water

# Notes for teachers

**The first chapter, 'More than just water', serves as an introduction to the topic. It discusses the beauty and uniqueness of the world's seas and offers a first glimpse into their complexity so that the effects of marine waste can be understood in the following chapters.**

**In the introductory phase, pupils explore their own experiences of holidays by the sea to give them motivation as they start the topic. The diversity and unique characteristics of these fascinating habitats connect with the young people on an emotional level. They recognise the importance of the seas for humans and regard these ecosystems as worthy of protection.**

| | | | |
|---|---|---|---|
| **Exercise 1:** easy, 45 min. | **Exercise 4:** easy, 45 min. | **Exercise 7:** difficult, 15 min. | **Exercise 10:** moderate, 30 min. |
| **Exercise 2:** easy, 45 min. | **Exercise 5:** moderate, 45 min. | **Exercise 8:** moderate, 30 min. | **Exercise 11:** moderate, 30 min. |
| **Exercise 3:** moderate, 45 min. | **Exercise 6:** easy, 20 min. | **Exercise 9:** easy, 10 min. | **Exercise 12:** moderate, 45 min. |

**For exercise 12: the pupils have to wear safety goggles for experiment 1. Care should also be exercised when working with hot water. The ice cubes for experiment 2 should be prepared the day before.**

**Exercises 1–3** can be used for pupils aged approximately 11 to 16 years, and adapted to the appropriate level. As an introduction, you could show photo enlargements and link them to exercises 1–3. Here, it makes sense to select images that show different marine regions, e.g. polar seas and tropical seas, that are then discussed by the pupils.

**In exercises 4 and 5**, the beauty of the habitat comes to the fore. The ability to recognise the interdependency of a range of factors within the ecosystem is the basis for understanding the subsequent effects of plastic waste and the potential consequences for living creatures. The connection between rivers and seas is established to make the issue of marine waste more relevant for pupils who do not live near the coast. Exercises 4 and 5 can also be used for pupils of 11 to 16 years of age and adapted to the appropriate level. The introductory text may be copied to give older pupils more factual input.

**In exercises 6, 7 and 9**, plankton is shown in its natural role as a food source. First of all, the difference between animal and plant plankton is explained. The main message of these exercises is that all consumers higher up the food chain are dependent on the photosynthesis of phytoplankton. The complexity of the food web is presented in a way that the pupils can grasp. It also becomes clear which organisms are dependent on each other and how they are affected by external factors.

The food web game in **exercise 8** is particularly well suited to the school playground or other open space. For larger classes, it is worth copying two or three sets of role play cards to enable more groups of players. Once the food web has been formed as in the description, the teacher can take the exercise a step further by adding the microplastics card. The teacher holds up the microplastics card and explains that microplastic is about the same size as plankton. The teacher now asks the pupils where in the food web microplastics have an effect. The pupils affected take three steps back. The pupils can now think about how the interference of microplastics in the food web affects the ecosystems in our ocean. It becomes clear that altering one factor within an ecosystem can impact the entire biological community. Further human influences can then be discussed.

**Exercise 10** is designed to help the pupils get to know a food web in their area and to illustrate the fine balance of the ecosystem. The research work and gathering of information on the species (predators and prey) are carried out first, followed by the organisation and linking of the species on a board, table or the floor.

It is important to understand ocean currents in order to get to grips with the formation of so-called rubbish patches and the extent of the waste problem. The three experiments in **exercise 12** reveal the influence of temperature and salt content on the system of currents. This allows the conveyor belt to be explained clearly to younger pupils. Older pupils should be using specialist terminology here and talk about density.

# Solutions

**Exercise 2:**

| Name | Profession | Year of expedition |
|---|---|---|
| Jacques Piccard | Swiss oceanographer and engineer | 1960 |
| Don Walsh | US-American naval officer | 1960 |
| James Cameron | Canadian film director | 2012 |
| Victor Vescovo | US-American naval officer, retired | 2019 |

**Exercise 3:**

| Ocean basin | Surface area in million km² | Volume in million km³ | Rivers |
|---|---|---|---|
| Pacific | 166 | 696 | Amur, Yangtze, Mekong |
| Atlantic | 79 | 354 | Amazon, Congo, Niger, Orinoco |
| Indian | 74 | 291 | Irrawaddy, Ganges, Indus |
| Arctic (Arctic Sea) | 14 | 18 | Ob, Yenisei, Lena |
| Southern | 20 | 71 | Various meltwater rivers |

**Usage types:** fishing, oil, wind power, shipping, etc.

**Exercise 5:**
Answers
1 Lake Constance
2 France, Slovenia
3 Isar
4 Seine
5 Oder, Vistula, Neman, Daugava, Neva, Torne
6 Tagus
7 Volga, flow of approx. 8,000 $m^3$ per second

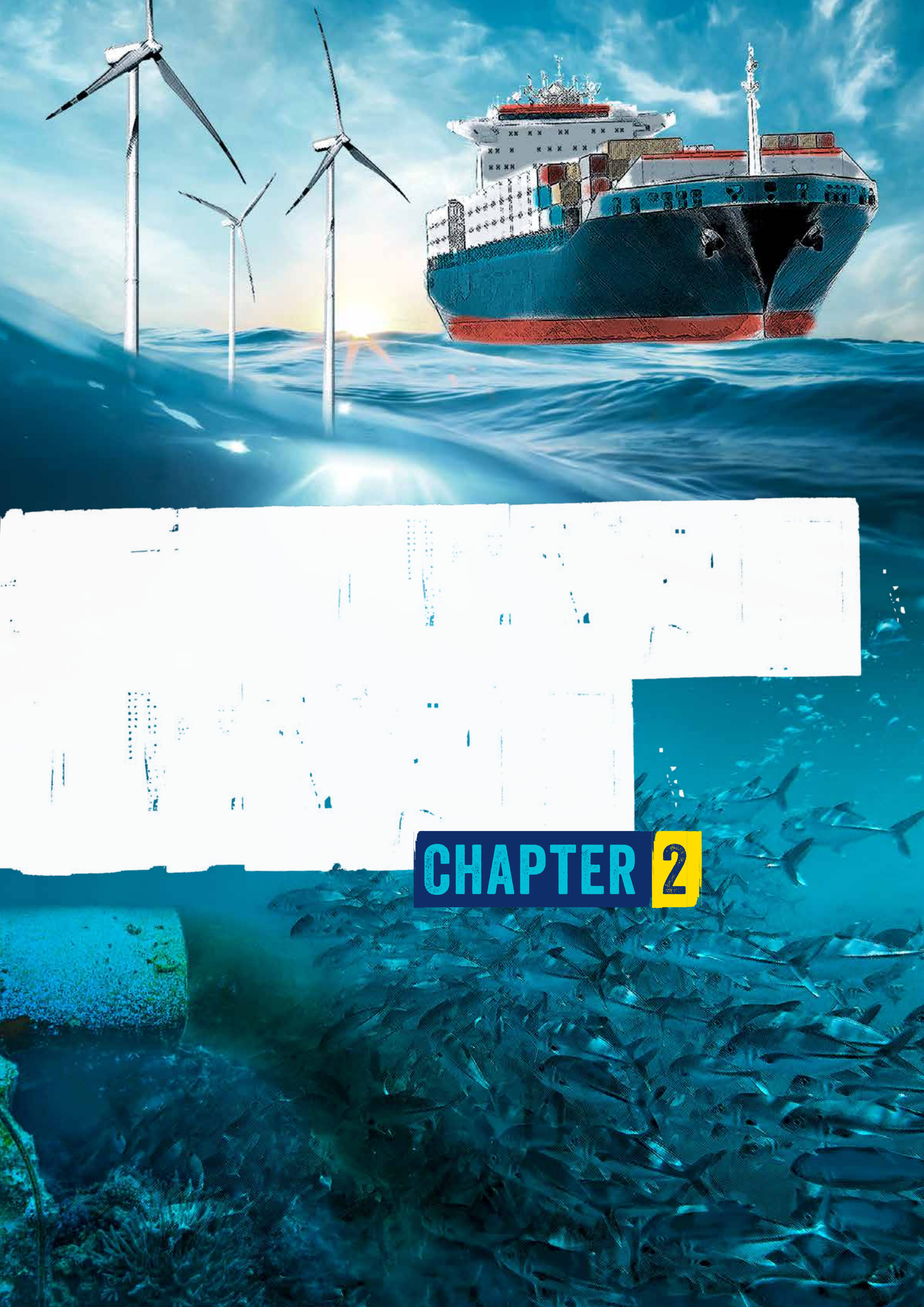
**Exercise 6:**
Phytoplankton forms the basis of the food web in the ocean and flowing bodies of water. It uses photosynthesis to generate its biomass from carbon dioxide and nutrients.

**Exercise 7:**
**Arctic:**
1. Phytoplankton occurs in summer as soon as the ice has melted and there is enough light for photosynthesis. The largest plankton blooms are found in the polar regions (which is why whales migrate there in the respective summer months).
2. Next comes animal plankton as a consumer.
3. In winter, there is no sunlight and lots of sea ice, which is why there are no significant quantities of plankton.

**North Atlantic**
1. Phytoplankton blooms are witnessed as soon as there is enough light in spring.
2. Next comes zooplankton.
3. In summer, all the nutrients have been exhausted, causing phytoplankton production – and, to an extent, zooplankton production – to decline again.
4. In autumn, the water is mixed up by storms, causing nutrients from the seabed to rise up to the surface. This creates a second surface plankton bloom, albeit one that is smaller than the spring bloom because there is less light and fewer nutrients. It is known as the 'autumn bloom'.
5. In winter, there is too little light, and the water is too cold.

**Tropics:**
There are only very minor seasonal fluctuations, as light is always present. But as there are fewer nutrients, the plankton blooms are less significant (which is why some whale species migrate away from the area).

**Exercise 9:**
**Producers:**
Volvox, Micrasterias rotata
**Level-one consumers:**
Caddisfly larva (feeds chiefly on algae), freshwater shrimp (feeds chiefly on algae/organic food particles), cyclops (feeds chiefly on small plant matter, microscopic animals and carrion), water flea (feeds chiefly on algae)
**Level-two consumers:**
Common rudd (feeds chiefly on algae and water plants)
**Level-three consumers:**
Pike (feeds on all kinds of fish), grey heron (feeds on smaller fish, frogs, newts, snakes and water insects), pikeperch (feeds on smaller fish)



# CHAPTER 2

Introduction

# RESOURCES FROM THE WATER

## Ways in which the ocean, seas and rivers are used

**The ocean is a place of unique diversity and is of untold importance to our planet. Many aspects are yet to be researched, however. This second chapter goes into greater detail about the importance of its habitats for humans. The world's seas play a vital role in the global climate system, which also greatly influences living conditions for human beings. The ocean is also a veritable treasure trove. It supplies food and resources and serves as an important transport route. This chapter also studies their importance for tourism. Rivers, on the other hand, are a key source of drinking water and, just like seas, are indispensable for the movement of goods.**

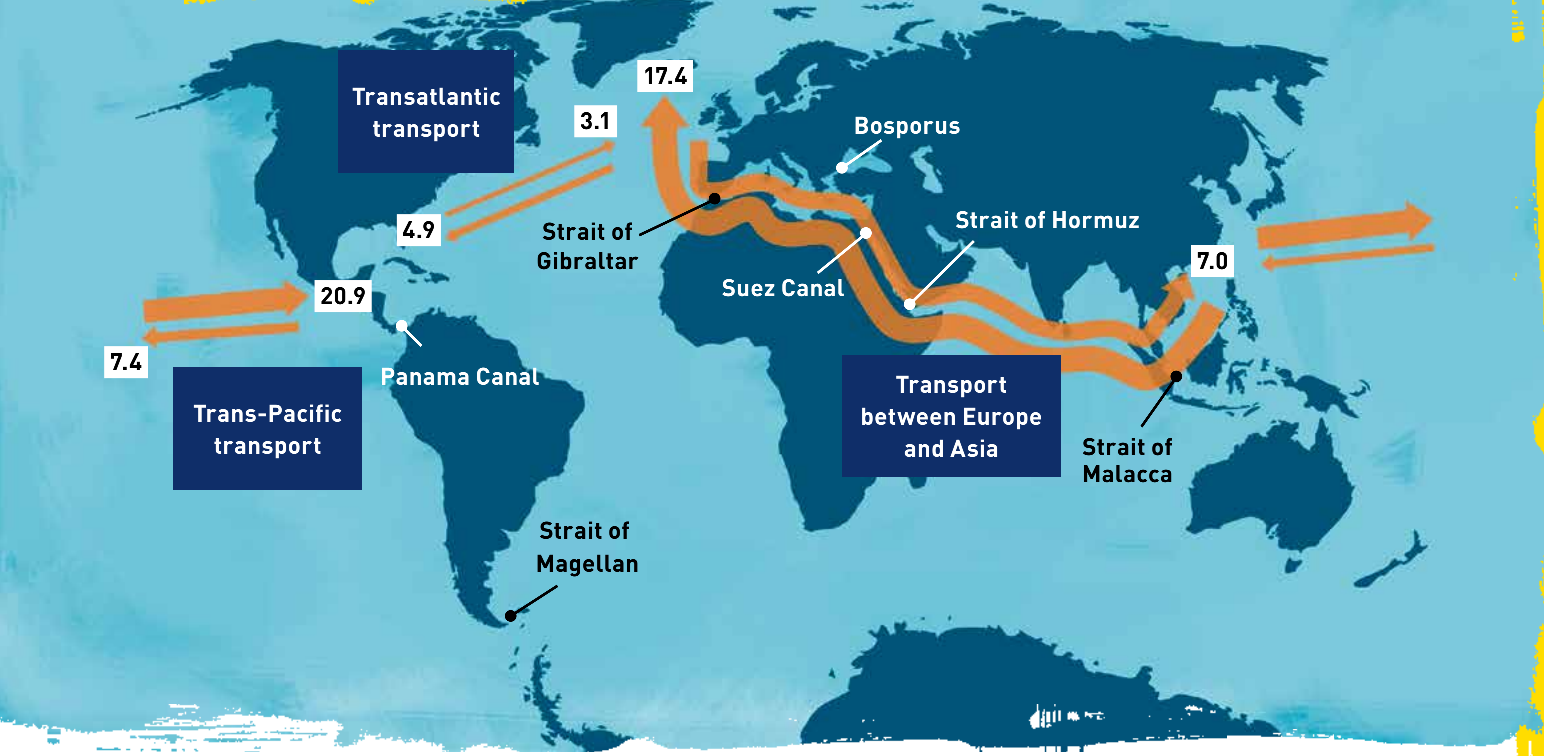
**People have been using the ocean for many millennia – initially as a source of food. Later, they discovered the importance of the various resources contained in the ocean and developed methods to use them. The global population currently stands at about seven billion people – and is rising all the time. This is resulting in rising demand for fish and other marine resources, primarily because resources on land are gradually dwindling. In addition, more and more technological goods such as cars and electrical appliances are being produced, which means that many resource deposits on land are being exhausted. Because demand is so high, there is an intensive search for new resource stocks. This search is extremely time-consuming and expensive. But resources, both on land and in the ocean, are limited. It is therefore important to use them sustainably and to develop new technologies that require fewer resources.**

### Contamination and pollution

Contamination means the presence of a substance which does not occur naturally, or the presence of a substance in a concentration that exceeds the natural level.

Pollution means that a substance has a harmful or toxic effect on organisms and/or the environment. All polluting substances also contaminate; however, not all contaminating substances have a polluting, or harmful, effect.

## Global trading routes




The principal shipping routes for global container transport. The figures indicate the number of standard containers (in millions) transported in 2018.
**Source:** United Nations Conference on Trade and Development – Review of Maritime Transport 2019, p. 13

# WAYS IN WHICH THE OCEAN, SEAS AND RIVERS ARE USED

**Trade, energy, raw materials and drinking water – examples from Europe**

## Shipping lanes and trading routes

As trade flourished, rivers and seas became important transport routes. People were moving large quantities of goods by water long before the advent of cars and roads. Even today, shipping accounts for some 80 per cent of global trade. Although the shipping trade is very economical and efficient, there is one major disadvantage: it releases gases which are harmful to the environment and human health (e.g. carbon dioxide, nitrogen oxide, sulphur oxide). They are often released on the high seas, but can then spread hundreds of kilometres, ultimately reaching land. They can thus harm not only creatures in the ocean, but human beings as well. The International Maritime Organization is responsible for regulating the harmful substances released by shipping (including through accidents).

The corresponding international agreement is called the International Convention for the Prevention of Pollution from Ships (MARPOL).

The Suez Canal is a very important waterway for world trade and a profitable shortcut to Europe. From the Persian Gulf to Europe, ships take about two weeks longer via the route around the Cape of Good Hope at the southern tip of Africa than through the Suez Canal. In spring 2021, however, there was a 6-day blockade of the Suez Canal by a 400-metre-long stuck container ship, which has room for 20,000 shipping containers. Many ships therefore had to take a forced break. Numerous companies, however, depend on sea transport. Inevitably, numerous supply chains in world trade have come to a standstill due to the obstruction. Economists have calculated that a blockade of the Suez Canal could lead to losses of 6 to 10 billion dollars per week for world trade.

## Source of energy

Considerable amounts of electricity are generated out at sea and in rivers. In light of this, as well as to reduce $CO_2$ emissions, the European Union is promoting the expansion of renewable energy. The objective is to gradually replace fossil fuel sources like coal, gas and petroleum, as well as nuclear energy. The construction of wind farms in European waters is a part of these measures and requires large areas and significant investment in the open sea. But this activity in the marine ecosystems is not without debate. For example, the piles used to construct the wind turbines are an impediment to and a source of harm for marine mammals in the vicinity.

The use of rivers for energy conversion has also been practised for centuries. There are more than 20,000 hydropower plants in the EU. More hydropower plants are to be added, mainly in the Alps and the Balkans. Of course, the construction of dams and power plants also has an impact on the environment and endangers local fish populations, for example.

## Resource stocks – oil, gas, manganese nodules and methane clathrate

Whether as fuel for cars, heating for homes or in the production of plastic products, oil is required for multiple applications. Oil is a truly versatile resource, which is why global consumption is so high and its demand is on the rise due to the global population's insatiable thirst for energy – which has risen by 70 per cent in the past 30 years alone. As with other raw materials, people are trying to meet the increasing demand for oil by using new resource stocks in the sea. In 2015, for example, 29 per cent of global oil production came from the ocean. This method of oil extraction is known as 'offshore production' as it takes place in coastal waters. In order to satisfy increasing demand for oil, researchers are constantly developing new methods with improved technologies that enable oil to be extracted from ever greater depths.

Alongside oil, the aim is to extract further resources such as manganese nodules with a high ore content and methane hydrates from the ocean. Manganese nodules contain metal and cover thousands of square kilometres of the deep-sea floor. Methane hydrates are made of water and methane gas. They are also known as 'fire ice' and are currently the subject of a controversial debate about whether or not they should be used as a future source of energy. As things stand, however, there are currently no suitable technologies for extracting either manganese nodules or methane hydrates.

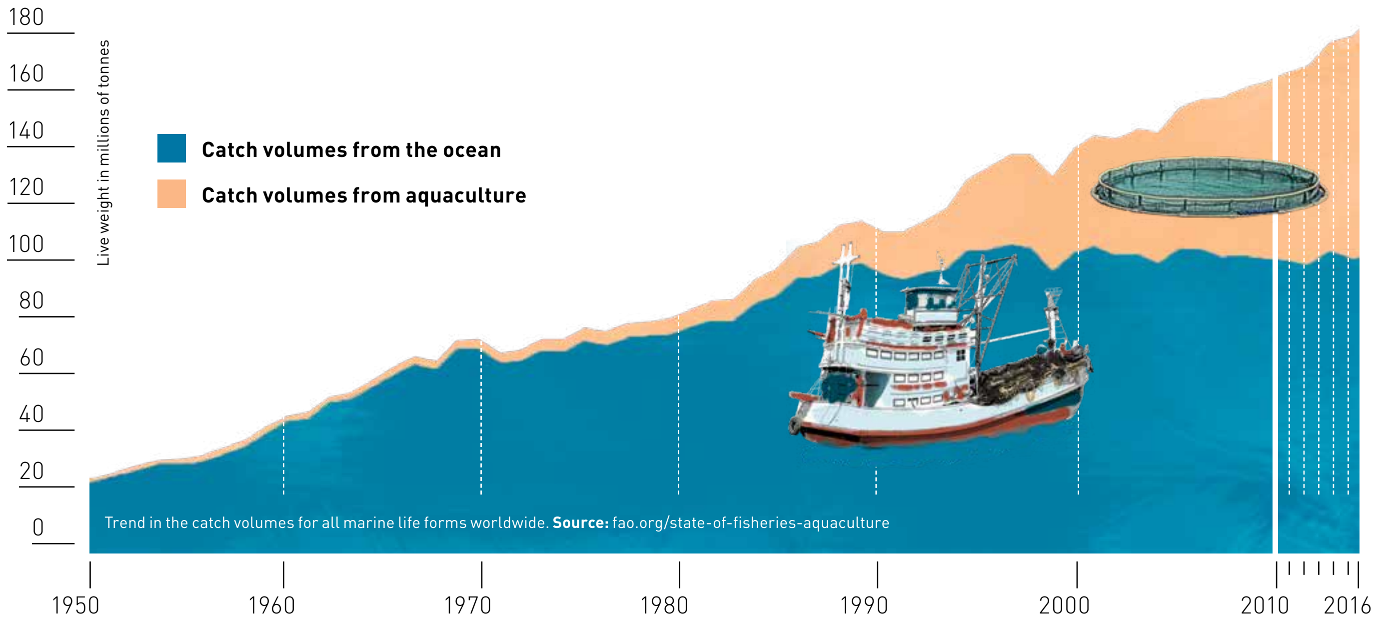
## The supply of drinking water

Water is essential to life, because humans can only survive for a few days without water. Drinking water is thus the most strictly controlled foodstuff in Europe and is generally available without much limitation. In many regions around the world, however, there is a shortage of water caused by various factors, such as the spread of deserts. This water shortage may worsen due to climate change and population growth. As a result, desalination plants – where seawater is converted into drinking water – may become more important in the future.

At present, however, the process of converting seawater into drinking water with desalination plants is still extremely energy-intensive and expensive.

In Central, Eastern and Northern Europe, there is sufficient drinking water and it is available in good quality in almost every household (it must be free of pathogens, clear and colourless and odourless). This is an exception for a large part of the world's population! In Europe, waterworks treat groundwater or surface water and test for possible pollutants such as lead, chloride and nitrate. Due to the high input of nitrate from industrial agriculture, this is a complex and expensive process. In southern Europe, much needs to be done to ensure access to drinking water in the future with regard to the consequences of climate change.

## Food source: fishing and aquaculture



Trend in the catch volumes for all marine life forms worldwide. **Source:** fao.org/state-of-fisheries-aquaculture

Fishing is a source of food, income and work for millions of people. At the same time, however, fishing constitutes one of the most extreme human impacts on the ocean. This is because strong demand for fish and the rapid development of fishing methods have led to global catch volumes increasing sharply within just a few decades. In 1990, for example, four times as many fish were caught as in 1950. Surprisingly, catch sizes remained stable after 1990 in spite of improved technology and larger fleets. This is because many fish stocks had been overfished. As the size of the fish caught continues to decrease and as fish stocks are rapidly dwindling, more and more fish are being sourced from fish farms (aquaculture) – the aim being to meet rising demand for fish products. About 47 per cent of fish consumed today have been reared at aquaculture facilities. The man-made breeding enclosures, however, pollute the water in many areas. Furthermore, important coastal habitats are often destroyed – such as mangrove forests to make way for the breeding of tropical prawns.

## Recreation areas and tourism

Rivers and seas are very much in demand as areas of recreation and relaxation. Coastal areas are amongst the world's top destinations for holidaymakers. Therefore, tourism is an important source of income, especially for countries with few natural resources. But mass tourism can also destroy the natural environment – for instance by building hotel resorts or through the increased production of waste – especially as tourists often travel to their destination by plane, causing air pollutants and greenhouse gases to be emitted directly into the upper layers of the atmosphere. Many regions are also suffering from increasing urbanisation and the associated environmental problems, such as air pollution. Problems can also be caused by cities growing too quickly and the resulting lack of infrastructure. There is often a shortage of treatment plants, for example, meaning that waste water and chemicals flow straight into the ocean.

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# PEOPLE AND THE SEA – A ONE-SIDED RELATIONSHIP

## EXERCISE 13:

### We depend on it

**The following questions will help you find out how dependent humans are on the ocean. Select a topic, read the corresponding text passage and answer the questions. You can also use the internet for research. Once you have finished, go up to your classmates, tell them about your topics and share your findings.**

#### SHIPPING LANES AND TRADING ROUTES

1. Follow the shipping route from Rotterdam, the largest European harbour, to Shanghai and then on to New York. Name the seas and shipping lanes that have to be navigated.

#### SOURCE OF ENERGY – WIND AND SEASONS

2. Find out where in European rivers dams and hydro-electric plants have been constructed. How much energy do they generate and how many people does this supply with energy? What arguments are used by advocates and opponents of hydroelectric power?

#### RESOURCE STOCKS – OIL, GAS, MANGANESE NODULES AND METHANE HYDRATES

3. Find out how oil and gas fields on the seabed are located. What are the consequences of these methods for whales?

#### THE SUPPLY OF DRINKING WATER

4. Not all water is alike. Some water is suitable for drinking, and some isn't. Find out the differences between seawater, fresh water, drinking water, spring water, mineral water, table water and distilled water. Where does your tap water come from?

#### FOOD SOURCE – FISHING AND AQUACULTURE

5. Which marine organisms do fishermen mostly catch? What methods are used? Which species are bred at aquaculture farms? What are the animals fed? What effects does this have?

#### RECREATION AREAS AND TOURISM

6. Role play: A company is planning to build a hotel directly at the beach. This will promote tourism, but habitats will be impacted. Split up into roles (e.g. hotel industry, environmental NGOs, residents). Make an argument for or against building the hotel. Can you make a compromise? Possible keywords: jobs, profit, destruction of habitats.

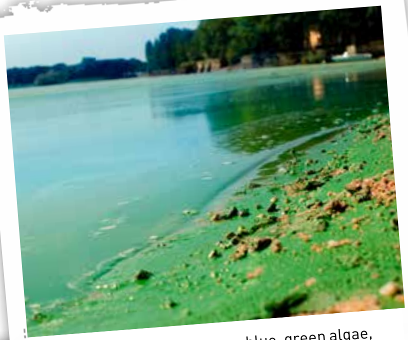
## Types of pollution

The beginning of the chapter explained how humans use rivers and the ocean. The following pages will study the pollution of these habitats, with the focus being on the issue of plastic. **In addition to plastic, there are other types of pollution:**

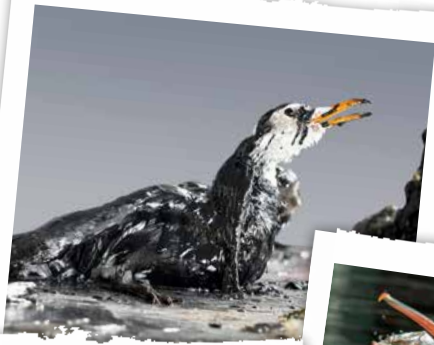
- The use of too much fertiliser in agriculture leads to excess fertiliser in groundwater and bodies of water
- Noise pollution from ship turbines and offshore industry
- Pollution caused by oil from shipping and the petroleum industry
- Pollution caused by harmful substances and toxins
- Household and industrial waste

## Plastic pollution

The waste that we humans leave lying around outside makes its way to the ocean in huge amounts via rivers, but also other pathways. Long-lasting and barely degradable plastic waste constitutes a particular danger to marine wildlife.



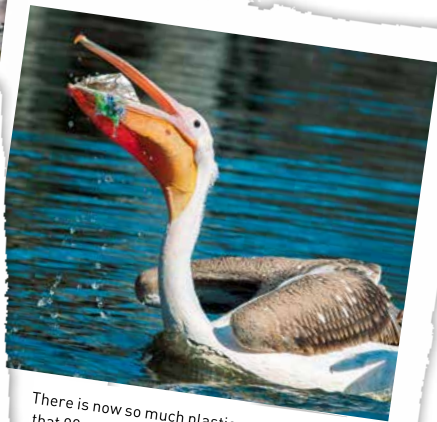
Cyanobacteria, also known as blue-green algae, are perfectly natural, but they are now unusually common due to over-fertilisation.



**Oil spills:** victim of an oil spill – a sea bird completely drenched in oil

According to an Australian study, balloons are the deadliest waste object for seabirds, as they can quickly block their digestive tracts.

Whales and other marine creatures produce their own sounds. But the noise caused by humans is much louder and interferes with the way many whales communicate.



There is now so much plastic waste in the ocean that 90 per cent of sea birds have eaten plastic according to the latest estimates. They often mistake plastic for food.

## ONCE IT ENTERS THE SEA, THE WASTE GOES ON A LONG JOURNEY.

# BUT WHERE DOES IT END UP?

16° 51' N, 99° 52' W

54° 17' N, 8° 35' E

## EXERCISE 14:

### Where the plastic waste ends up

**Use an atlas to help you or do some research on the internet.**

1. Look for the locations of the pictures using the coordinates and enter them into the world map on page 14.
2. Write the corresponding country and ocean basin and/or sea as well.
3. Consider ways in which the waste may have ended up at the places shown on the photos. You can use the map of ocean currents on page 27 to help.

27° 00' N, 33° 54' E

22° 54' S, 42° 01' W

62° 20' N, 5° 43' E

# Notes for teachers

**Exercise 13:** moderate, 30 min.
**Exercise 14:** easy, 30 min.

**Exercise 13** illustrates the ways in which humans use the ocean. The short text passages should be copied and handed out to the pupils. The pupils will split up to research the answers to specific questions and present their findings as short interviews in front of the class. They can move around the room and inform/ask questions to available pupils. Depending on their area of interest, the pupils may also select a particular aspect, study it in more depth and present their findings.

The exercise can be adapted to the attainment level of the pupils involved. Younger pupils will find the research work challenging and should therefore be provided with literature and appropriate internet links.

The last exercise on tourism allows the participants to assume specified roles and to discuss the issue amongst themselves and to come up with compromises. Role play cards can be prepared as an aid, providing more information and, if necessary, argumentations for the respective role.

**Exercise 14** uses the photos to illustrate that the problem of plastic waste in seas is a global issue. Huge quantities of waste can also be found on beaches in sparsely populated areas. It is made clear that everything is connected by ocean currents and that responsibility should be taken across the world. The research work with the coordinates emphasises importance of latitudes and longitudes.

# Solutions

**Exercise 13:**

**1.** Rotterdam to Shanghai:
North Sea, Atlantic, Strait of Gibraltar, Mediterranean Sea, Suez Canal, Red Sea, Indian Ocean, Strait of Malacca, South China Sea, East China Sea.
Shanghai to New York:
Pacific, Panama Canal, Caribbean Sea, Atlantic.

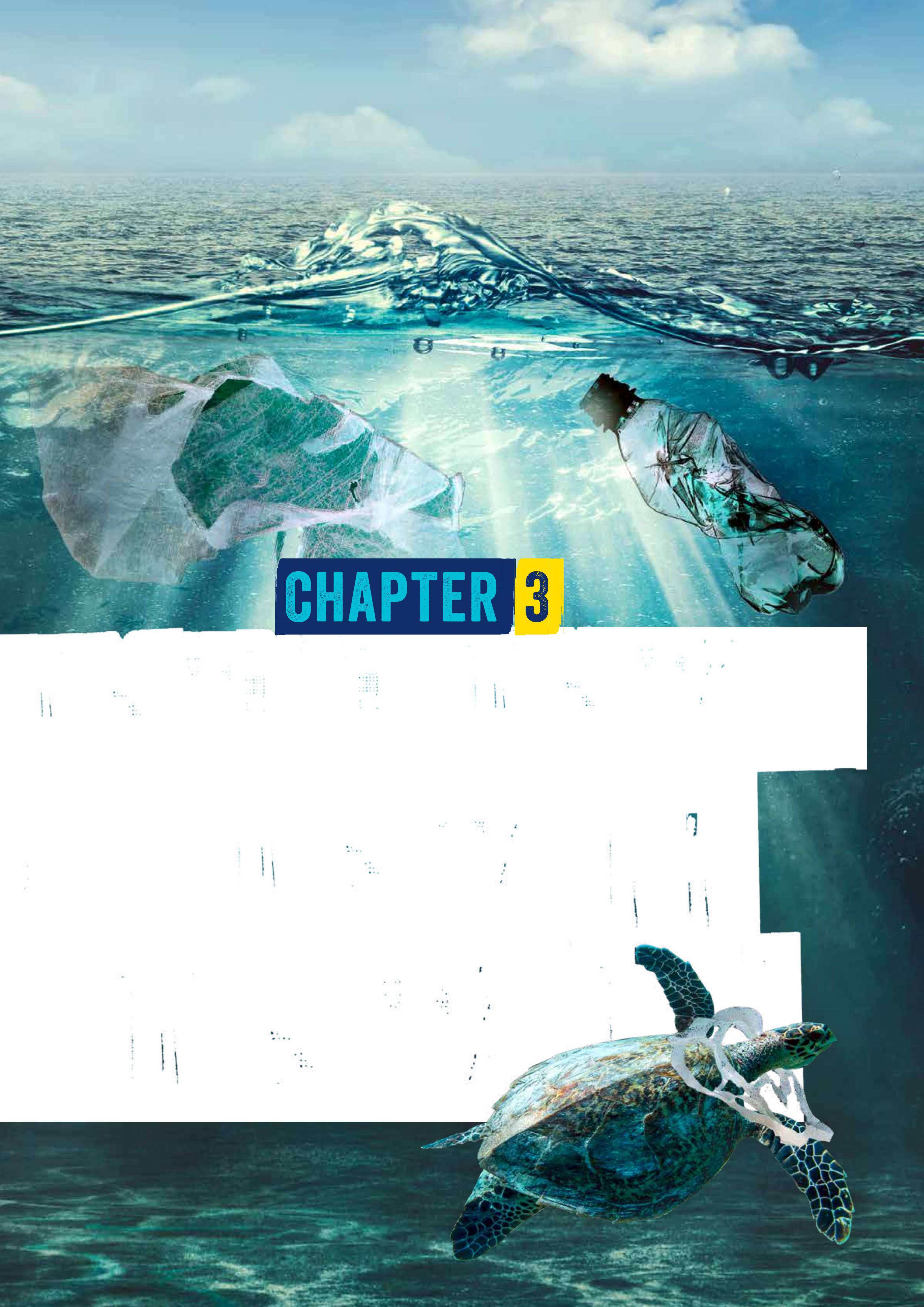
**2.** An introduction can be found using the search term 'Eurostat hydropower'.

**3.** Seismic methods: Special air guns fire acoustic waves into the water from research ships. These waves penetrate into the earth's surface. Depending on the rock type, they travel at different speeds. Other methods are gravimetric analysis, magnetism and electromagnetism.
Consequences of the air guns: They may damage the hearing of marine mammals and interfere with intra-species communication and the ability to perceive other environmental signals.

**4.** Seawater: Water with various kinds of salts, average salt content of 3.5 per cent.
Fresh water: Very small traces of salt.
Drinking water: Fresh water that has to meet a certain purity standard.
Spring water: Originates from a natural, subterranean reservoir protected from harmful substances and is filled at the site of the spring.
Mineral water: Natural water extracted from a spring and enriched with minerals.
Table water: 'Man-made' water that usually consists of drinking water with added ingredients.
Distilled water: Water that has been treated to remove the ions, trace elements and impurities found in normal spring or tap water.

**5.** Pollack, Peruvian anchoveta, skipjack tuna, sardines, Atlantic horse mackerel (as of 2018, source: FAO, The State of World Fisheries and Aquaculture, 2018).
Catching methods: Gill nets, seine nets, pelagic trawl nets, bottom trawl nets, beam trawls, longlines.
Species at aquaculture farms: Carp, trout, pikeperch, iridescent shark, shrimps/prawns, tilapia, temperate basses, sea bream, cod, salmon, common mussel, oysters, eels.
Feed: Natural feed that the animals source from their immediate environment. Artificial feed, usually grain pellets, fishmeal made from wild fish or fish offal, plant feed.

# CHAPTER 3



Introduction

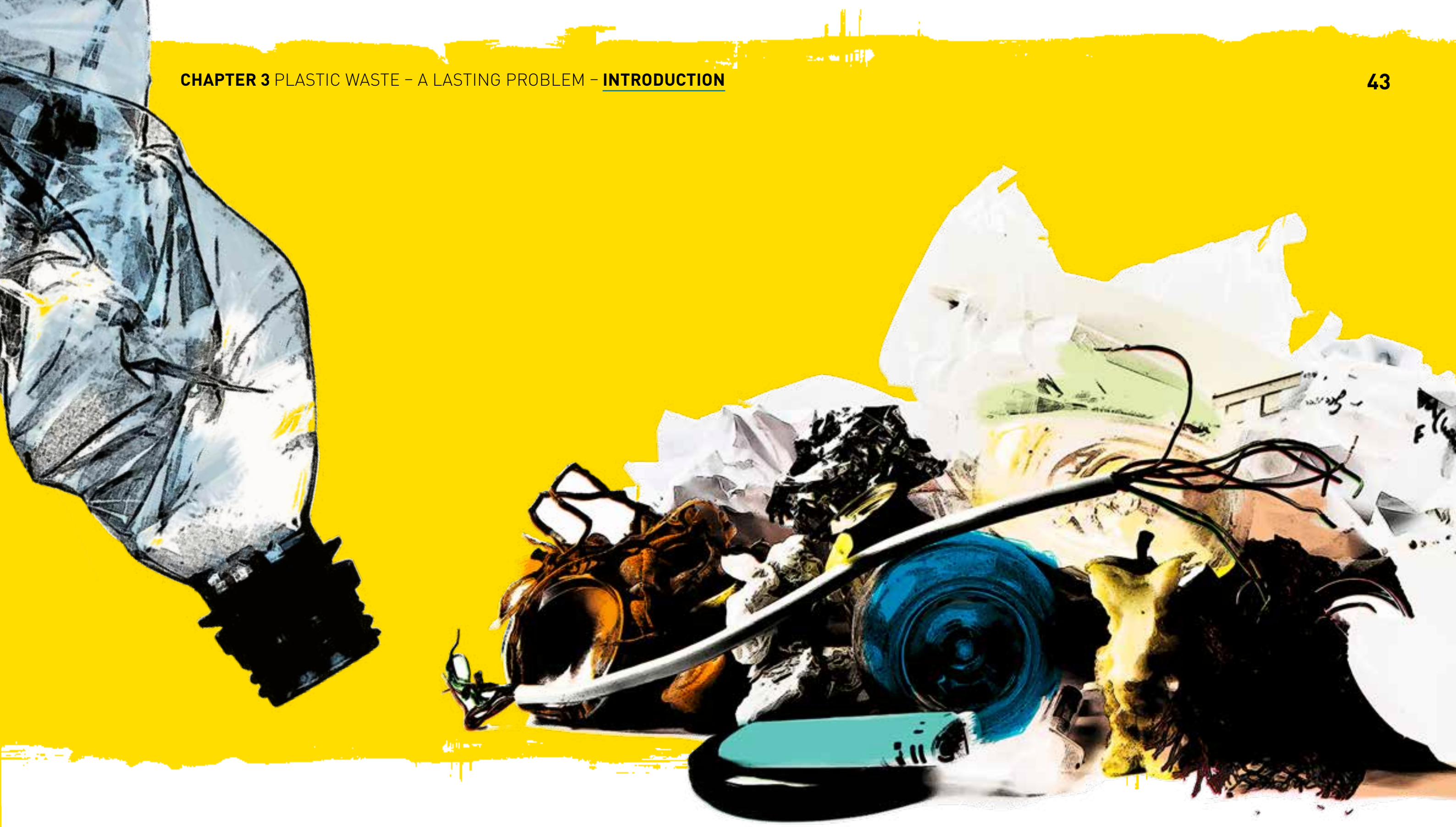
# PLASTIC WASTE'S JOURNEY TO THE SEA

**If you ever collect and take a look at the waste lying around when you go for a walk by the river or on the beach, you most often find cigarette filters, plastic lids, plastic bags, food packaging, beverage cans, fishing lines and fishing nets.**

But many of the plastic objects that end up in rivers or the ocean are not found on riverbanks or on the beach. It is assumed that the majority of plastic waste is no longer on the surface of the ocean, but rather has sunk down below. No one really knows how much waste that is. By contrast, recent estimates have been made about the waste floating on the surface of the sea. According to these estimates, more than five trillion pieces of plastic with a total weight of more than 268,000 tonnes are drifting in the world's seas. More than a third of these items are located in the North Pacific. Researchers arrived at these findings after they had evaluated the data from 24 expeditions conducted over a six-year period. Fishing equipment, for example, was also found in the researchers' nets. Buoys, lines and nets originate from ships, whereas other plastic items such as bottles, polystyrene and plastic bags often originate from land. The scientific study also shows that the majority of the plastic waste floating around the ocean is made up of small fragments measuring less than five millimetres. The technical term for these is 'microplastics'. These tiny plastic fragments are produced when larger pieces gradually disintegrate.

However, small plastic pellets are also produced by industry from which larger plastic objects are manufactured.

**So, how does the waste get into the sea? And, of course, how does the issue affect us and how can we help to improve the situation? The exercises in this chapter provide answers to these questions.**



## This problem has many different causes

**The ocean is a dumping ground for our waste. It gets there in different ways.**

**Via rivers:**
Whenever people carelessly drop litter, it can end up in rivers due to wind and rain. The waste then travels from smaller to larger rivers before it finally enters the sea.

**Via landfills:**
Many people around the world live near the sea. In many countries, waste is stored in landfills that are situated near the sea. The strong winds that are often found in these areas blow large quantities of waste (mostly plastic bags and film) into the sea.

**Via shipping:**
A lot of ocean waste can be generated when transporting goods. For instance, in 2019, the container ship MSC Zoe lost more than 300 containers in the North Sea, including two containers filled with hazardous goods. The waste produced on the ships is also sometimes disposed of in the ocean, despite this being prohibited.

**Via fishing:**
During fishing expeditions, items of equipment are often lost, with nets above all entering the sea. Broken nets are often just thrown straight into the sea instead of being disposed of at the next port. These floating 'ghost nets' then continue to kill marine creatures.

**Via catastrophes:**
During the devastating tsunami catastrophe in Japan in 2011, around five million tonnes of rubble from houses, boats and factories were washed into the ocean. In 2012, a 60-metre unmanned ship from Japan washed up on the Canadian coast.

**Via offshore industry:**
All over the world, there are more and more offshore gas and oil platforms right in the ocean near the coast. Here too, waste is sometimes carelessly thrown into the water.

**Via waste water:**
When washing laundry (e.g. fleece garments), thousands of synthetic fibres per wash cycle are released. When car tyres wear down, this also releases many plastic fragments which are so small that they cannot be completely filtered out at the waste water treatment facilities. Additionally, many places around the world do not have these treatment facilities, which enables these microplastics to make their way into the ocean via rivers.

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# PLASTIC WASTE AT HOME

**You are no doubt familiar with various plastic products. It is hard to imagine everyday life without them. An average European, for example, produces more than 100 kilograms of plastic waste a year. The global increase in the consumption of plastic materials has given rise to huge quantities of waste. Think about how much plastic you use and dispose of every day:**

## EXERCISE 15:

### Plastic waste diary

**Keep a plastic waste diary for a week. Note down the quantities of plastic waste that you personally generate each day. Make a list of all the plastic items that you throw away.**

What do you notice? Compare your results with those of your classmates and work out an average figure for your class.

Average number of plastic waste items:

-----------------------------

Now try to reduce your plastic waste for a whole week. Count it again.

What has changed? What can you do differently in the future to reduce your plastic waste further?

| Day of the week | Number of plastic waste items | Type of plastic waste items | |
|---|---|---|---|
| | | 1st week | 2nd week |
| Example day | 4 | PET bottle, toothpaste tube, cheese packaging, chocolate wrappers | |
| Monday | | | |
| Tuesday | | | |
| Wednesday | | | |
| Thursday | | | |
| Friday | | | |
| Saturday | | | |
| Sunday | | | |

Diary to determine your own use of plastic

## EXERCISE 16:

### How does the waste get into the sea?

**Produce a wall newspaper that describes the routes travelled by plastic waste into the ocean. Find out where the waste ends up and add this information to your wall newspaper. Use photos taken from magazines or draw your own sketches to illustrate your points.**


Global production:
359 million tonnes of plastic in 2018
Global discharge:
4.8–12.7 million
tonnes of plastic a year
Concentration of plastic in
major ocean currents
Mussels, barnacles
and copepods consume
microplastics
Plastic waste transports
non-native (invasive) species
and pathogens
Fish eat plastic
Marine creatures perish
in ghost nets
Plastic disintegrates into
microplastic and harmful
substances are deposited
Plastic sinks to the deep sea
PLASTIC WASTE IN THE OCEAN
Plastic is deposited in sediments
The creatures are not shown in proportion.
200 m
400 m
700 m
1,000 m
1,500 m
3,000 m
11,034 m

Introduction

# PLASTICS – MANY DIFFERENT FORMS AND USES

**We use plastic as a matter of course in our everyday lives. We encounter plastic products pretty much everywhere we go – whether as packaging on supermarket shelves, children's toys, clothing or the dashboard in the car.**

We hardly ever question the fact that we use plastic. Plastic is a synthetic material that nowadays comes in many different forms with all kinds of properties. Most plastics are made using crude oil. A small number of plastics are made from sustainable resources. Plastics have many practical properties. They are malleable, hard or elastic, resistant and long-lasting, and can be modified in almost any way by mixing them with additives. As they can also be produced relatively cheaply, they are found across the globe.

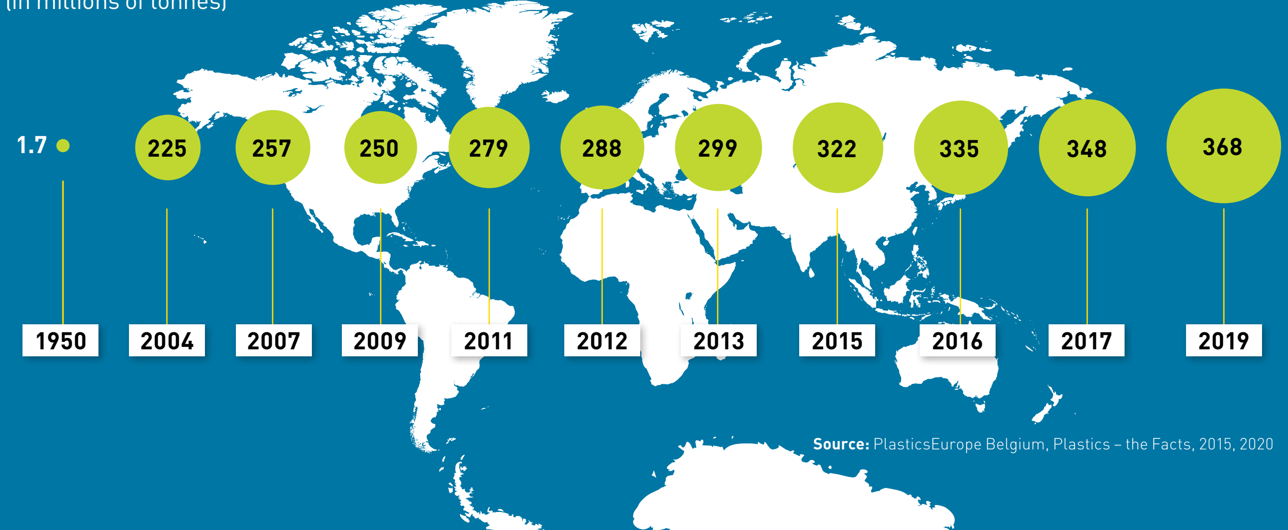
But there is also a dark side to this success story, as the generation of plastic waste has become a global environmental problem. In 2018 alone, nearly 360 million tonnes of plastic were produced, with huge quantities entering the ocean every single year. If there is no improvement in global waste disposal, this amount may rise even further.

Before we study the plastic waste problem more closely, it makes sense to get a better understanding of the large group of plastics and their properties.

An important underlying principle of plastics is that their properties are determined chiefly by their chemical structure. You will explore what is meant by this in the following experiment.

You can start by roughly dividing plastics into three groups: thermoplastics, thermosetting polymers and elastomers, although not all experts classify elastomers as plastics. Generally speaking, thermoplastics, thermosetting polymers and elastomers differ in terms of their physical and chemical properties. If you mix them with additives, these properties can be changed still further. Phthalates, which are used as plasticisers to improve the malleability of thermoplastics, are one example. Flame retardants, which stop plastics from burning easily, are another. Some of these additives are toxic for people and wildlife and could enter the body. Additives could be released by toys, for instance, when children put them in their mouths. They could then enter the body via saliva. It is also conceivable that harmful additives could enter the body via food and drink consumed from plastic packaging.

**Global plastic production**
(in millions of tonnes)




**Source:** PlasticsEurope Belgium, Plastics – the Facts, 2015, 2020

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# PROPERTIES OF PLASTIC

## EXERCISE 17:

### What is plastic made of?

**Use a chemistry textbook to help you or do some research online.**

1. Look online for information on plastic that will help you to answer the following questions: in which year was the first plastic developed?
   Why were plastics developed?

2. Bring three everyday plastic items to school so that they can be studied more closely in class. Choose items that you no longer need or that you find on your way to school, such as plastic waste. Determine the type of plastic used to make your items and enter this information in the table. Record the items of your classmates in the table. Can you find any information that indicates the type of plastic? Find out about the recycling codes used for plastics, how you should dispose of these plastics and what happens to them afterwards.

| Type of plastic | Abbreviation | Recycling number | Type of item (in my group) |
|---|---|---|---|
| Polyethylene terephthalate | | | |
| High-density polyethylene | | | |
| Polyvinyl chloride | | | |
| Polystyrene | | | |
| Polypropylene | | | |
| Others | | | |

3. Conduct the following experiment on your sample items.

**EXPERIMENT:**

**Properties of different plastics**

Material:

- 2 crystallising dishes (300 ml)
- 4 beakers (50 ml)
- Plastic samples
- Samples from cardboard boxes, plant-based materials, woollen socks, etc.
- Crucible tongs, Bunsen burner

Chemicals:

- Fresh water
- Butyl acetate or acetone (It is not recommended to use acetone with humans of childbearing age.)
- Ethanol
- Salt water
- Vinegar concentrate (20–25 per cent acetic acid)

Method:

1. Consider a method for studying the mechanical properties of the various samples (breaking strength, tensile strength, malleability, hardness). Note down your observations in the table on **page 48**.

2. Examine the floatability of the various plastic samples in both fresh water and concentrated common salt solution and note down your findings. Ensure that you use similar forms and volumes so that your test results can be compared with each other. To do so, cut out small pieces of equal size from the sample items.

3. **Please note:** This experiment must be conducted beneath an extractor fan. Working below the extractor fan, pour 20 ml butyl acetate/acetone in one beaker, 20 ml ethanol in the second beaker and 20 ml acetic acid in the third beaker. Now study the solubility behaviour of the different plastic samples by adding your small pieces to the various solutions. Note down your findings.

4. **Please note:** This experiment must be conducted beneath an extractor fan. Carry out the combustion experiment with your plastic items by holding your small piece of the sample (about the size of a five-euro-cent piece) in the roaring blue flame of the Bunsen burner. Enter your observations in the table on **page 48**. Compare your observations with the cardboard box, plant matter and woollen sock samples.

| Plastic (abbre-viation) | Mechanical properties | Combust-ibility | Resistance in various solutions | | | Floatability | |
|---|---|---|---|---|---|---|---|
| | | | Ethanol | Vinegar concentrate | Butyl acet-ate/acetone | Fresh water | Salt water |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

# COMPOSITION OF PLASTIC

**The various plastics can be divided into three main groups with different properties – thermoplastics, thermosetting polymers and elastomers.**

Thermoplastics slowly soften when heated, going from a solid to a viscous state. This viscous mass can then be reprocessed and moulded into a new form. This property is attributable to the long linear chains that form the basis of thermoplastics. There are little or no links between these chains. Thermosetting polymers, on the other hand, remain stable and hold their form at low temperatures and do not soften when slowly heated. Changes only occur at high temperatures, with the plastic charring. The kind of melting witnessed with thermoplastics is not possible here. The molecular chains of the thermosetting polymers are tightly linked, causing the resulting network to appear like a single molecule. Elastomers, on the other hand, can be compressed like a sponge before reverting to their original form. Just like thermosetting polymers, their long molecular chains are connected but the bonds between them are longer. The bonds between the chains are broken if the temperature becomes too high or the force too strong.
One thing that all three plastic groups have in common is that they are very durable due to their long molecular chains, making them barely degradable.

## EXERCISE 18:

### Plastic does a spot of modelling

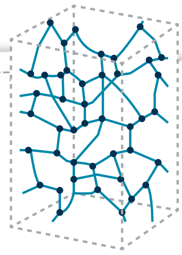
**Read the informational text on the chemical structures of different groups of plastics** and match up each of the diagrams with one of the three groups.

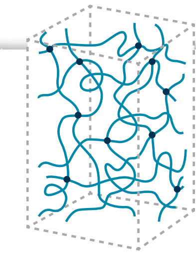
**Describe the chemical structure of the plastics** and enter the properties described in the informational text. Write in the space provided.

**Build one of the three plastic types as a 3D model** using household or handicraft materials.

**Please note:** All three plastic types should be built at least once within the class. Present your models to the rest of the class. Then think about what properties of each plastic type are illustrated by the models. What are the limits of your models? To what extent are they not true to life?

**Match up each diagram with a plastic type and describe its properties. Name one example product for each type of plastic.**





# PLASTIC AND THE SEA

**Researchers are now studying the behaviour of plastic waste in seawater. This knowledge is essential to find out what damage plastic waste causes in the sea.**

A key question in this regard is how plastic waste is transported and/or spread. Many experiments that seek to understand the behaviour of plastic waste start in the laboratory. Alongside the type of plastic, its form plays an important role too. This determines whether a plastic object floats on the surface, drifts within the water column or sinks to the seabed.

## EXERCISE 19:

### Floating plastic

Collect three items of plastic waste each. Choose the three plastic objects that you find most often in your household waste or recycling bin. Consider the factors that may determine the floatability of the plastic.

**Develop a series of experiments that you can use to study this property.**

You can use entire plastic objects or cut out small samples. If you don't have any ideas, you can examine the following question with the variations below it:

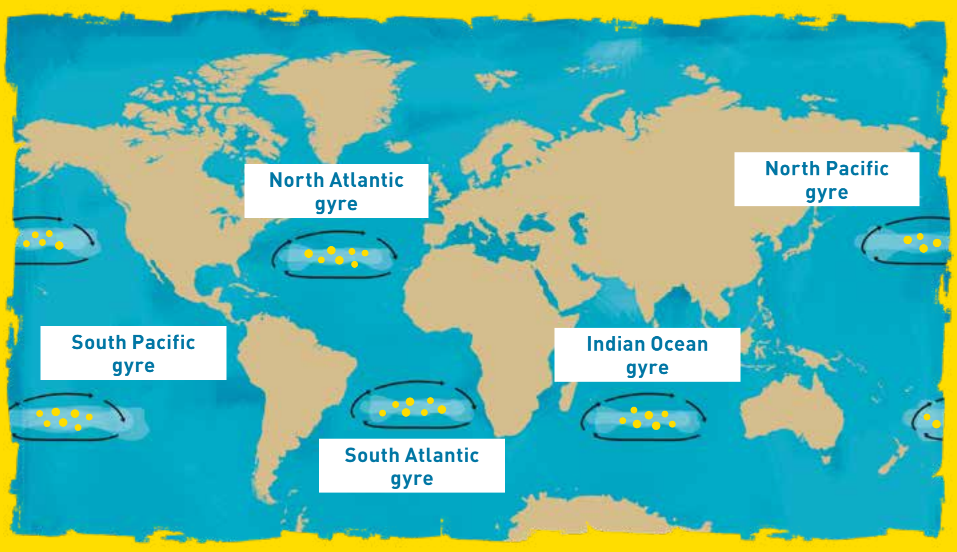
**What items float in the water and how do they behave in water?**

- Closed bottles with a lid and open bottles without a lid
- Closed and filled bottles
- Bottles with different volumes (e.g. 250 ml, 500 ml and 1,000 ml)
- Bottles colonised by species such as barnacles (the colonisation can, for instance, be simulated using plasticine)
- Bottles made from different types of plastic (e.g. drinks bottles and shampoo bottles)

Carry out the experiments with other plastic products (e.g. plastic bags or yogurt pots). Complete a log for your series of experiments.

Introduction

# HUNTING FOR EVIDENCE IN THE OCEAN – WHERE'S THE PLASTIC WASTE?




Enormous amounts of waste are circling around the gyres of the ocean. Many pieces of plastic drift across the sea for thousands of kilometres before congregating up in the gyre.

**The amount of waste in the ocean is increasing all the time. Although the plastic waste slowly breaks down into smaller pieces, we still don't know if and when it completely degrades – research is still being conducted in this area.**

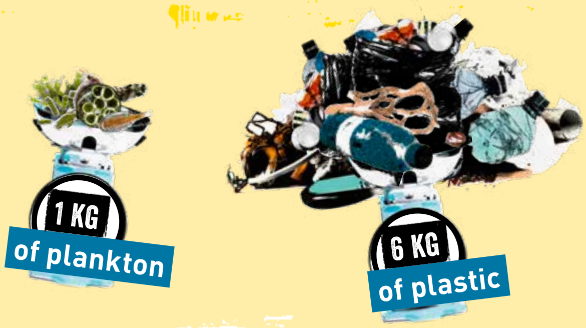
## Global currents and waste swirls

There are many currents in the ocean. Some of these currents form giant swirls (gyres) spanning several hundred kilometres. Waste also gathers in these swirls. In 1997, researchers discovered a particularly large swirl of waste in the North Pacific between Asia and North America: the Great Pacific garbage patch (aside from the gyres, there are also other regions with high concentrations of plastic waste, such as the Mediterranean Sea).

More and more plastic objects are accumulating in these areas of the ocean. Depending on the composition of the plastics, the items either sink to the seabed or float in the water. Many of the floating plastics may already be decades old and could be colonised by small organisms such as barnacles, mussels and even bacteria. Plastic bands from California, for instance, which are used to hold together the pincers of lobsters, can be found on the coast of Portugal. Time after time, the ocean currents 'introduce' the plastic and its inhabitants into other ecosystems. This can pose a huge problem for the habitat concerned, as the invasive species may breed rapidly in their new territory and drive out the native wildlife. In turn, this can interfere with existing food webs. Species introduced in this way are known as 'invasive species'.

**INFO BOX**

**In the regions with the highest concentrations of plastic in the Pacific, there are six kilograms of plastic waste for every kilogram of plankton.**



## The impact of plastic waste on marine life

**Plastic fragments can expose wildlife to danger: for example, seals and other animals become entangled in torn-off nets, known as 'ghost nets', get injured and are no longer able to swim. They usually drown.**

Another problem is that many creatures mistake plastic with food. Seabirds, which spend most of their lives out at sea, eat plastic fragments floating on the surface by mistake. They then have a full stomach but are unable to digest the plastic, ultimately causing the birds to starve to death. There are now also reports from Asia about marine mammals being found dead, some with more than 1,000 plastic fragments in their stomachs.

The plastic waste in the ocean is subjected to strong forces. Due to the force of the waves and currents, as well as sunlight, the material breaks into ever-smaller fragments. Therefore, the plastic does not disappear. It is simply no longer visible to the naked eye. Experts assign the tiny particles to categories according to their size (see the next page): plastic fragments that are smaller than five millimetres are referred to as 'microplastics'. Anything larger than that is termed 'macroplastics'.

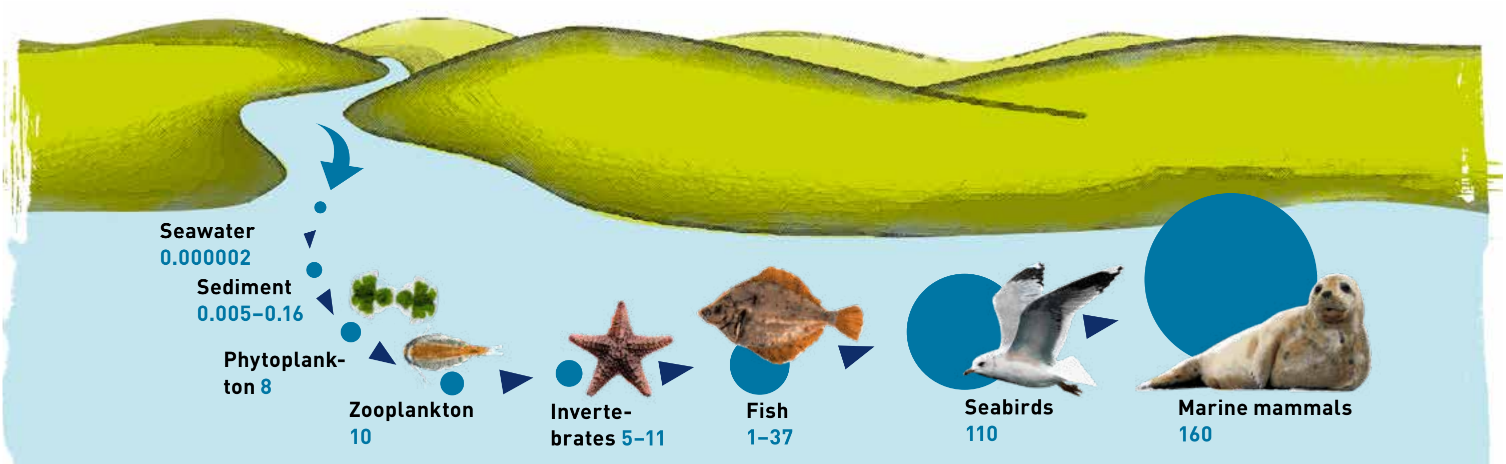
Microplastics do not just occur, however, when floating plastic disintegrates (secondary microplastics). It is also used in industry. Plastic objects such as bottles are manufactured using small microplastic pellets. Plastic microbeads are also added to individual cosmetic and personal hygiene products, the aim being to improve the cleansing effect. Additionally, plastic microbeads (primary microplastics) are sometimes used in sandblasting.

According to recent research, the source of most microplastics is the wearing down of car tyres. This material mixes with the grime on the road and forms small particles that contain plastic. Microplastics pose a threat to many animals. They have a particularly significant impact on animals that filter water, such as mussels. These creatures survive by filtering plankton from the seawater. In doing so, they consume microplastics. A portion of this is excreted, but some particles are stored in the body and thus make their way into the food web. An additional problem is that seawater contains many persistent organic pollutants (POPs) that enter the sea via rivers and coasts. Due to their similar chemical properties, these pollutants often form deposits on the surface of microplastics. As a result, microplastics become floating pollutant carriers.

Once the particles have been eaten by plankton-eaters such as mussels, the pollutants can enter the tissue. POPs are usually deposited in the fatty tissue. Moreover, the toxic substances can harm the creatures concerned, as they affect their hormone systems or can cause cancer. Further, the pollutants enter the food web when they are consumed by the plankton-eaters. Once they have been eaten by first-level consumers, the pollutants are then passed from one consumer level to the next within the food web, amplifying in the process bioamplification.

### Bioamplification of toxic organic substances in the marine food web

Bioamplification describes the increase in concentration of a material via the food web. Here's an example: seabirds eat fish which are contaminated with low concentrations of heavy metals. The heavy metals accumulate in the tissue of the seabirds, and the concentration is then higher than in the fish tissue.




**PCB content in milligrams per litre/milligrams per kilo of fat**
**Source:** World Ocean Review 1, Maribus, 2010, p. 83

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# HUNTING FOR EVIDENCE IN THE OCEAN – WHERE'S THE PLASTIC WASTE?

**Plastic waste pollution has increased dramatically in recent years. The consequences are already clear today. The photos are a stark reminder of what this pollution means for creatures that live in the water.**


## EXERCISE 20:

### Seas at risk

**Take a close look at the photos and find out the dangers posed to living creatures by plastic waste.**

# MACRO, MICRO OR NANO?

**Plastic does not just disappear, although plastic objects can get smaller. The power of the waves and currents (mechanical forces), coupled with sunlight, breaks down large pieces of plastic into ever smaller fragments. These small plastic fragments found in the water are known as 'microplastics', as they are sometimes microscopic in size. The plastic is still there. It is simply no longer visible to the naked eye.**

**The term 'microplastic' is used to refer to plastic fragments that are smaller than five millimetres. Scientists differentiate between large microplastics (1 to 5 mm) and small microplastics (1 µm to 1 mm). Nanoplastics are much smaller (<1 µm). Research in this regard is still in the early stages. All pieces larger than five millimetres are termed 'macroplastics'. Additionally, there is a distinction between primary microplastics, i.e. microplastics that were intentionally produced as microplastics (pellets, granulates, microbeads), and secondary microplastics (which result from the breakdown of macroplastics).**

## EXERCISE 21:

### Scouring the sand

**EXPERIMENT: Scouring sediment and sand samples for (larger) microplastics**

Material:

- Petri dishes
- Containers with sediment or sand samples (your own sediment samples from the bank of a river or lake/ sand from a play area will do fine)
- Tap water
- Dissecting microscope or magnifying glass
- Jam jars
- Salt

Method:

1. Use a spoon to add some sediment to a Petri dish. Label the sample with a waterproof pen. Study the sample under the dissecting microscope or the magnifying glass. Can you spot any larger micro-plastic particles? Note down your observations.
2. Use a spoon to add some sediment to a jam jar. Fill up a third of the jam jar with tap water and give the sample a good shake. Transfer some of the liquid above the solid residue into a Petri dish and study it with the binocular microscope or magnifying glass. Note down your observations.
3. Now use a spoon to add salt to the jam jar and shake it again. Transfer the rest of the liquid above the solid residue into a Petri dish and study it with the binocular microscope or magnifying glass. Can you spot any larger pieces of microplastic now? Note down your observations.

Explain why microplastics pose a danger on the beach and think about how you could free the beach from micro-plastics. If you have come up with a solution, rethink your approach by considering whether your ideas are financially viable. **What conclusion have you come to?**

| | Source of sample | Without water | With tap water | With concentrated common salt solution |
|---|---|---|---|---|
| Sample 1 | | | | |
| Sample 2 | | | | |
| Sample 3 | | | | |

# Notes for teachers

**Exercise 15:** easy, 5 min. per day, evaluation 45 min.
**Exercise 16:** moderate, 55 min.
**Exercise 17:** moderate, 45 min.
**Exercise 18:** moderate, 30 min.
**Exercise 19:** moderate, 30 min.
**Exercise 20:** easy, 20 min.
**Exercise 21:** moderate, 30 min.

**Exercise 15** can be planned to run for a week. When comparing results, the pupils should talk about how averages are calculated and their significance for scientific studies. To do this, they might consider the importance of a large data set to balance out any deviations. If, for example, there is a birthday party in the middle of the week, there will be much more waste on this day than on other days. This exercise aims to illustrate how much waste is generated and also gives pupils an opportunity to reflect on their own actions. It becomes clear how hard it is for us to change our actions.

Before getting started on **exercises 16** in this chapter, it makes sense to do exercise 14 from the chapter 'From using to polluting'. The photos of the beaches covered in waste are the pupils' first contact with the problem of marine waste, immediately encouraging them to explore the causes. The different routes to the sea taken by waste should be presented to the young people in a creative fashion by means of a wall newspaper. During the project period, this can be hung up in the room and repeatedly come to the fore.

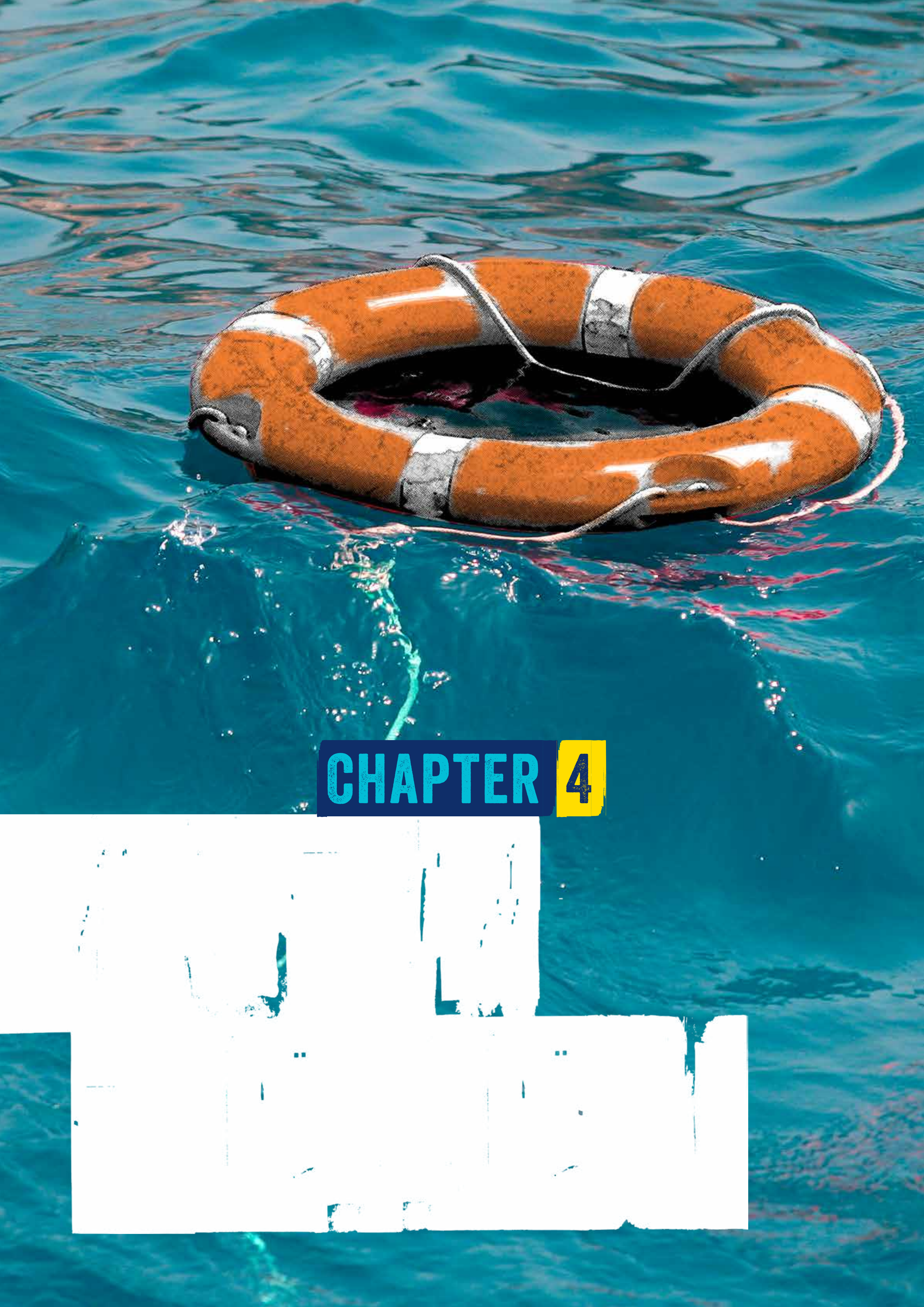
In **exercise 17**, the pupils learn about the plastics we encounter in everyday life and their prevalence. This is an important insight when it comes to recycling our waste. The majority of our plastic waste can be melted down and reused by means of thermal recycling. It is therefore necessary to dispose of the waste correctly in the first place. The subsequent experiment on the properties of plastics sheds light onto why plastics degrade so slowly and provides an insight into the behaviour of different plastics in seawater. Please note: An extractor fan is required for this experiment, as different solvents are used. Particularly well suited for use in this experiment are polystyrene, stockings (polyamide), fishing lines (nylon), yogurt pots (polystyrene) and plastic bottles (polyethylene terephthalate).

**Exercise 18** looks at the structure of plastics. The pupils should start by reading the informational text. The information will then be matched up with the three models. By building the model, the pupils will get to grips with the typical properties of thermoplastics, thermosetting polymers and elastomers.

**Exercise 19** shows the pupils what happens to the various plastic types when they enter a river or the ocean. Some plastic types are heavier than water and sink as a result; other types are colonised by various organisms and may plummet to the seabed. Other plastic objects, such as plastic bags, drift along rivers into the ocean. Here, they eventually disintegrate into microplastics as a result of mechanical forces and sunlight.

**Exercise 20** is the first exercise to look at the environmental consequences of not disposing of plastic waste properly. It focuses on wildlife and the dangers of plastic waste. The images aim to show the pupils these consequences and therefore illustrate the myriad dangers. Creatures become trapped in the plastic waste, sea creatures eat waste, and bacteria and algae grow on the plastic, which can also be harmful to human health under certain circumstances.

**Exercise 21** is another practical experiment. This time, the aim is to work out the microplastic content of various samples. The pupils can spot the plastic with a magnifying glass or with the naked eye (if available, we recommend using a dissecting microscope). Some plastics do not float in tap water. Adding salt increases water density. Due to the floatability characteristics of the plastics, the plastic fragments with a lower density than the salt water rise to the surface. This makes the plastics easier to spot. If additional help is needed to differentiate microplastics from other small particles, you can find instructions in the **Plastic Pirates – Go Europe!** project booklet (see pages of group C).



# CHAPTER 4

Introduction

# YOUR HELP IS NEEDED

**We humans have been exploiting rivers and our ocean since time immemorial. At the same time, we live in fear of storm floods and tsunamis. The ocean can pose a danger to us – but we also pose a danger to the ocean. We pollute and exploit it.**

Alongside the many bad news concerning the state of our ocean, we are now also witnessing positive examples of how marine protection and sustainable use of the sea can go hand in hand. This includes the decision of the International Maritime Organization (IMO) to tighten up the pollutant limits for ship exhaust gases.

Another success is the whaling moratorium (agreement to stop whaling) that came into force in 1986. It has played a significant role in putting a stop to the hunting of large whales in most countries. As a result, the number of animals killed has fallen considerably.

Another positive case is the disappearance of the hole in the ozone layer above the Antarctic. Just a few decades ago, people were using various products with gases that were destroying the ozone layer. The ozone layer, which is located high in the earth's atmosphere, filters out high-energy radiation (ultraviolet rays) from sunlight. This radiation can damage the skin and eyes and even cause severe sunburn and skin cancer. Due to these gases, a particularly large hole in the ozone layer had formed above the Antarctic, allowing the radiation to pass through almost unimpeded. At the time, the fear was that the hole in the ozone layer would continue to expand. A milestone in efforts to protect the ozone layer was the Montreal Protocol of 1987, which saw industrial nations declare their intention to stop producing gases such as CFCs that deplete the ozone layer. Experts now believe that the hole in the ozone layer is closing more quickly than expected. In addition, the Paris Agreement on climate change was concluded by 195 countries in 2016 in order to maintain average global warming below 2°C (compared to the pre-industrial temperatures). And there's more good news: in 2017, an agreement was concluded on the largest marine sanctuary to date near the Cook Islands in the South Pacific. Pollutant limits for ship exhaust fumes, the whaling moratorium, the protection of the ozone layer and the largest marine sanctuary are all examples of global treaties.

The issue of plastic waste in rivers, seas and the ocean is also a global problem, which is why efforts to combat the issue should not be put on hold. Legislation has already been enacted in some countries in this regard: in the United States, for example, microplastics are prohibited in certain cosmetic products. Plastic bags have also been outlawed in several countries such as Kenya, where their production, sale and use were prohibited and are punishable. The European Commission also passed a law in 2018 against single-use plastic items which enters into force from 2021. Some products (e.g. plastic cutlery and plastic cotton swabs) will be prohibited and other products need to be redesigned.

But laws are not everything; the actions of each and every individual matter. It does not take much. All we really have to do is modify our day-to-day routines and habits slightly. But this seems to be too much for many people. Some people argue that they can't make much difference on their own. But that's not right. After all, who says that you have to change your habits on your own? Young people in particular find it easy to change their habits and help raise awareness in a larger community, thus speeding up the transition to a cleaner planet. 'Thinking globally, acting locally' is an important ethos when it comes to combating threats to the environment.

The following chapter shows what young people can do to tackle the pollution of the ocean.

**INFO BOX**

**Taking responsibility also means not allowing other players – from the worlds of politics and business, for instance – to shirk their responsibility and to encourage them to become active.**

Master copy

# WHAT CAN I DO?

**We humans have been using rivers, seas and the ocean since time immemorial. These habitats give us a great deal of resources and ecosystem services. But instead of caring for them, we pollute and exploit them. Fortunately, there are also people and organisations who actively campaign to protect the planet. There are many ways of protecting the environment. Each and every one of us can change our behaviour and inform those around us.**

**It is, of course, also important that change is implemented at a political level. Strict environmental protection laws, for example, have been passed in many countries. These require industrial companies and others to keep the environment clean by purifying waste water, for example. It sometimes takes many years for new environmental protection regulations to come into force, as compromises have to be negotiated.**

## EXERCISE 22:

### Setting a good example – part 1

**Gather information on the good examples listed here in which global marine protection and behavioural changes led to an improvement in the state of the ocean. You may use the internet for research.**

The examples are:

- Pollutant limits for ships
- Whaling moratorium
- Hole in the ozone layer above the Antarctic
- Marine sanctuary in the Antarctic

You can also find an example on your own for how rivers, seas and the ocean have been protected by international treaties.

Research phase:

- Find information on a treaty for the protection of the ocean or rivers. Who initiated the treaty? Which countries are signatories? For how long is the treaty valid?
- Outline the problem that the treaty aims to combat.
- List pros and cons of the treaty. Has the law or treaty been successful? What has changed as a result? Were there any obstacles? Were different interest groups involved?

Interview phase:

Interview the other groups about the treaties that they have found. Start by drawing up a questionnaire. The questions from the research phase can be used as an interview guide.

## EXERCISE 23:

### Setting a good example – part 2

Find positive examples of how individuals or small groups have had a positive effect on marine protection or continue to have a positive effect. Don't look for examples that have a global impact but rather ones that have been implemented, say, at your school, at a club you attend, in your town/city or in your local region. You can also use the internet for research. Present your project, as well as its pros and cons, on a poster or as a 'gallery walk'.

Evaluate the projects presented using the following criteria:

- Can the project actually contribute to marine protection?
- Is the project a one-off event or a long-term initiative?

Give reasons for your evaluation. Select another example and evaluate it by researching the project in terms of social, environmental and economic factors.

Introduction

# THE MANY ASPECTS OF ENVIRONMENTAL PROTECTION

**There are currently numerous projects and organisations (e.g. conservation groups) that campaign to protect seas and the ocean. These activities form the basis of change and are therefore indispensable. Large-scale changes are particularly achievable when politicians pass new environmental protection laws. The highest political authority that seeks to achieve political goals and drive forward change is the United Nations.**

## What is the United Nations and what does it do?

The United Nations (UN) is a global organisation with 193 member states. The members of the United Nations pursue shared aims. The organisation's most important role is to safeguard world peace and human rights. In 2001, the United Nations was awarded the Nobel Peace Prize 'for its work for a better organised and more peaceful world'.

## The UN Sustainable Development Goals

In 2000, the members of the United Nations met in New York to set out eight key aims to make the world a better place. Two important aims were to combat global poverty and hunger by 2015. Some of these aims were achieved, others were not. Therefore, the UN agreed upon new shared goals in September 2015. The deadline for achieving these goals is 2030. Instead of the eight previous goals, 17 goals were laid down on this occasion: the **Sustainable Development Goals.**

They aim to allow everyone in the world to live in dignity and peace and promote a sustainable relationship with the world and its inhabitants. Goal 13 is concerned with climate change, and Goal 14 deals with seas and the ocean (see the information box).

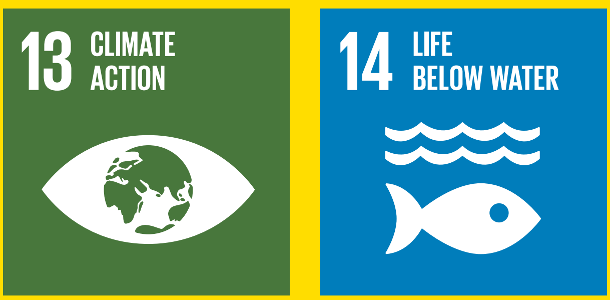
The individual global Sustainable Development Goals are aimed at all the nations of the global community, but each country decides for themselves how they plan to achieve the targets.

**INFO BOX**

### UN Sustainable Development Goal 14 for the protection of the ocean:

**The aim of Goal 14 is for humans to 'conserve and sustainably use the oceans, seas and marine resources'.**

**As this definition is quite vague, Goal 14 has been broken down into ten individual targets. One of these, for example, is to 'prevent and significantly reduce marine pollution of all kinds' by 2025. This refers primarily to the pollution originating on land, the waste drifting in the ocean and eutrophication. A further sub-target stipulates that 'at least ten per cent of coastal and marine areas' are to be conserved by 2020 (only around eight per cent were conserved at the beginning of 2022).**




**Source:** United Nations Sustainable Development Goals

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# THE MANY ASPECTS OF ENVIRONMENTAL PROTECTION

**Everyone can do something. In order to reduce plastic consumption, you can apply the rule of the Rs. The Rs stand for 'rethink', 'refuse', 'reduce', 'reuse', 'repurpose' and 'recycle'.**

### 1. RETHINK

It is often easier than we think to change our habits. All you have to do is plan a sensible course of action and stick to it. This applies to private individuals, but also to businesses, politicians and the research community. One example could be a future decision to stop making cosmetic products containing microplastics.

### 2. REFUSE

This means saying no whenever you are offered things that you don't need, such as advertising brochures or bags. Just think: do you need it or could you do without it? You can also plan ahead and use alternatives: keep a shopping bag in your handbag, cutlery in your rucksack, etc.

### 3. REDUCE

Here, the aim is to cut down on things that you don't actually need. Do you really need the latest smartphone or new shoes, even though you already have enough pairs?

If you are now thinking about throwing away everything that is surplus to requirements, then this is the wrong approach.

**INFO BOX**

**Not all single-use plastics are bad! It is logical to make certain products out of plastic and to only use them once. Some of these include items in hospitals which are contaminated after use. These items are very helpful, but it must be ensured that they are disposed of properly and that they do not end up as waste in the environment.**

You can get rid of superfluous items in other ways, such as by getting them to places where they will still be used. You can sell, give away, donate or swap your items instead.

### 4. REUSE

Before buying something new, why not use something that you already have and spend your money on things that you will use more often? One example would be shopping bags that can be reused many times. If you think carefully on a day-to-day basis, you will find all kinds of disposable items that can be replaced with long-lasting alternatives.

### 5. REPURPOSE AND REPAIR

Many products can easily be repurposed, i.e. used for something else. All it takes is some thought and creativity. There are plenty of examples these days (search for 'upcyling' on the internet, for instance). You can also just as easily repair broken items, which is especially important for electronics. Ideally, you would buy products that are made to last and are easy to repair, i.e. products for which replacement parts are available, or which have a modular design. In some cities, there are so-called repair cafes where experts will help you repair certain products.

### 6. RECYCLE

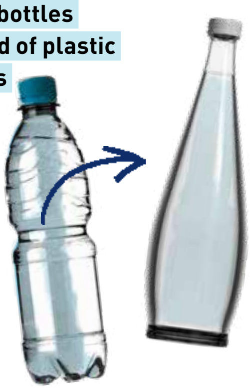
Separating waste is essential when it comes to recycling. Not all rubbish items can be recycled. In some countries, container deposit schemes, where the consumer pays a small deposit for items such as bottled drinks, which they then get back upon returning the bottles, are an example of where recycling works well.

## AVOID SINGLE-USE PLASTIC!

**Reusable bags instead of plastic bags**

**Lunchboxes instead of disposable plastic film**

**Glass bottles instead of plastic bottles**



**The more often you use things, the better it is for the environment.**

# EXERCISE 24: PROJECT WORK

## Rethinking plastic pollution

1. Choose one of the six project titles (1. Less is more, 2. As good as new, 3. How recycling works, 4. Rethinking and changing, 5. Giving away instead of throwing away, 6. Things used to be different) and work on it in your class or project group. Split up into groups.

2. Present your results to the other groups. It's up to you how you do so.

# PROJECT 1: LESS IS MORE

**Many of us would like to do something about the pollution of rivers, seas and beaches. The most important steps in this regard involve a change in our use of resources and adapting our own consumer behaviour. If we are to improve the current situation, it is important to avoid waste. Furthermore, many disposable items can be replaced by recyclable products.**

Exercises:

1. How could you change your everyday routine in order to produce less plastic waste? Note down your ideas.

2. Think about ways in which you could raise public awareness of the problem of plastic waste pollution in the ocean so that more people are informed. What initiatives could you carry out so that lots of people get involved? What can people who do not live in coastal areas do to help protect seas and the ocean?

   You may find the following questions useful:
   - Who produces a lot of waste in your area?
   - Who is still not aware of the waste problem?
   - How can we present the results?

3. Put the project into practice and document every step with photos.

4. Answer the following questions once you have completed the project:
   - What was difficult? What could you do better?
   - How can you make sure that your project becomes a long-term initiative rather than a one-off event?

# PROJECT 2: AS GOOD AS NEW

**Not all products can be easily recycled. Plastics, for example, often lose their original quality after being melted down. The value of the material is considerably reduced. This is known as 'downcycling'. Alongside downcycling, there is also upcycling, where waste products are transformed into products that are as good as new, but have a different function. Both processes are examples of how plastic waste can be repurposed.**



Upcycling of discarded shoes

**Upcycling:** Waste products are turned into items that are as good as new and that have a different function. The value and quality of the products increase. This is only sustainable, of course, if it replaces the use of other materials, thereby reducing consumption of products and resources.

**Downcycling:** The materials lose their initial value when they are reused. A well-known example of downcycling is waste paper recycling. The cellulose fibres become increasingly brittle each time the paper is used and therefore have a limited range of applications. In the case of plastic, it is often necessary to add lots of new materials and use energy during melting and reforming in order to be able to reuse the material at a later date.

Exercises:

1. What other products come to mind that can be upcycled and downcycled? Find out more online if you need some inspiration.
2. Collect everyday waste that you would otherwise just throw away. Get creative and develop your own idea for a product. Make a sketch and then produce the product.
3. Explain why people should buy your product.

Downcycling of plastic granules

Recycling symbol

## PROJECT 3: HOW RECYCLING WORKS

**Many valuable materials can be found in waste packaging such as packaging that is used for food. If the waste cannot be avoided ahead of time, it is important to separate your waste and throw it away in the designated container. At recycling facilities, the waste is sorted and treated so that it can be reused as raw materials for new products and packaging. In order to reuse the raw materials, the complex structures of the plastics are broken down into their constituent components. These can then be used for further chemical processes, such as the manufacture of other plastics. Burning waste in a waste incineration plant at the end recovers some energy.**

Exercises:

1. Write down and explain what happens to the waste produced at your home. Observe and research the paths taken by the different types of waste. You could maybe even take a tour of a recycling company, a landfill or a waste incineration plant. Make a presentation with photos.

2. Find out about recycling codes. What are these used for and what do they mean?

3. What are the similarities and differences between your country, a neighbouring country and a developing country?

## PROJECT 4: RETHINKING AND CHANGING

**You have now learned a lot about the pollution of rivers and seas and have even developed ideas about how to improve the situation. It is now important to think about making a few permanent changes in your environment. In doing so, you should always act as a role model and make changes to your own behaviour. It is also important to make other people aware of the problem. Rethinking our actions and changing our habits can be the first major step in the right direction.**

Exercises:

1. If you have found microplastics or macroplastics in the local environment or if you are simply interested in the topic, you could speak to the operators of a waste water treatment plant in your area. Ask questions that matter to you.

   **Sample questions:**
   How can microplastics be removed from the water? What equipment do the operators of waste water treatment plants need? Why is this equipment not available everywhere in Europe? Why don't consumers use alternative products?

2. Speak to the administration of your town/city or the local by-law enforcement agency. What can be done in your town to make our rivers – and therefore the ocean – cleaner? Do you have any other questions?

3. Visit a supermarket near you and look for products with unnecessary plastic packaging. Ask the operator of the supermarket why these products are packaged in plastic and whether alternative items are available.

   Organic products, for example, are often in plastic packaging on supermarket shelves. In dedicated organic stores, many products such as fruit and vegetables are often unpackaged. Why is this?

   Find the address of these companies and ask why they have chosen to package the products in this way.

# PROJECT 5: GIVING AWAY INSTEAD OF THROWING AWAY

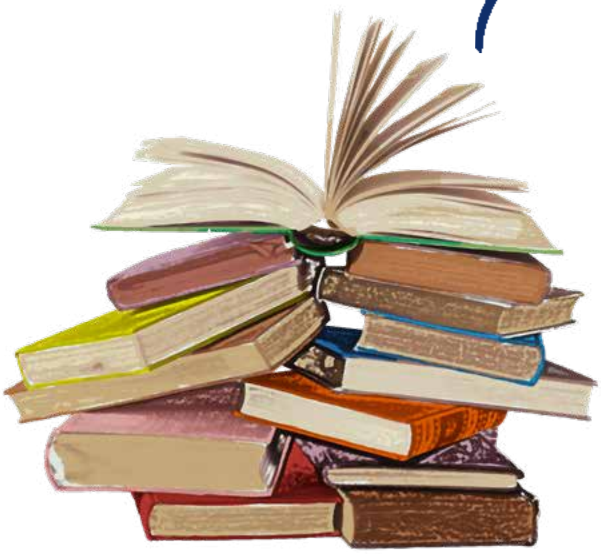
**Often, we use many things very rarely or sometimes not at all. Yet these items are often still in good condition and could be used by other people. Some examples are books that were only read once, clothes that no longer fit or that we don't like anymore and tools or kitchen appliances that we only use once a year. The result is shelves or boxes full of disused objects. Rather than throwing them away, you can donate them or give them to a second-hand shop. In this way, the products as well as the resources used to make them aren't wasted – and another person can get some use out of them.**

Exercises:

1. Write down a few items that you have at home and that you no longer or only rarely use. Could you live without these items?

2. Take pictures at home of three of these disused items and discuss in the group why you no longer or only rarely use them. What do the others in the group think?

3. Organise an event or create a space for second-hand items. For example, this could be a flea market at your school or in your organisation, a 'tool library' where power tools are stored and can be borrowed by everyone or a book box where people can place the books they have already read. In the process, also think about expensive items that could potentially be shared.



# PROJECT 6: THINGS USED TO BE DIFFERENT

**Plastic is still a relatively new material and, not that long ago, many products – foodstuffs in particular – were available without or with hardly any packaging. Single-use packaging was an exception due to the amount of resources consumed. It is high time to think back to those days and consider how packaging problems were solved before the days of single-use plastic.**

Exercises:

1. Make a list of the food items or everyday products that you have recently bought. How were they packaged? As a group, think about which alternative packaging would be possible for the product and whether packaging is necessary at all.

2. Now, using this list, talk about which items do not need single-use plastic packaging and for which items single-use plastic packaging makes sense. In the process, remember the following aspects: weight, shipping, origin of the products, protection of the products and hygiene.

3. Interview your parents, grandparents or another person who is a bit older: how were food items or other things used every day packaged when they were young? Make a short film or a poster about the interview and describe how packaging was dealt with in the past. Reflect upon whether it would be possible to use some of those methods today. What would have to happen to do so?

# Notes for teachers

**Exercise 22:** moderate, 30 min.
**Exercise 23:** easy, 45 min.
**Exercise 24:** moderate, at least 90 min.

**Exercises 22 and 23** provide a summary of the myriad environmental problems. The pupils will acknowledge the close links between social, ecological and economic aspects. The levels at which the problem needs to be dealt with will also become clear, as well as who can get actively involved. The pupils will learn that even small projects and their own actions can make a big difference when taken together.

**Exercise 24** gives the young people a chance to get active. This exercise also allows them to reflect on the content of the entire booklet and transfer their insights to their projects. The individual project topics each have a different focus, enabling you to provide tailored support to each pupil. Depending on their interests, the pupils can decide whether they want to be reporters and interview local stakeholders or whether they want to become product designers and make new things from old materials. You can tailor the project to the attainment level of the class in question. This work can also be done as part of a project week or in a working group, or even to a certain extent as homework, as it is worthwhile to have more time for the project than is normally available during school lessons.

# ARE YOU NOW A REAL PLASTIC PIRATE?

What have you experienced during the project?

Who would you like to tell about the problem of plastic waste, and why?

How have the Plastic Pirates changed your view of the issue of plastic waste?

What have you learned about yourself throughout the project?

What did you find particularly surprising during the programme?

What will you do to protect our seas and ocean in the future?

What was the biggest challenge you faced?

Are you prepared to change your habits and produce less waste? If so, welcome aboard! What exactly do you plan to do?

# Glossary

**Additives** = substances that are added in small quantities during plastic production in order to induce or enhance specific properties (e.g. plasticisers, flame retardants or dyes)
**Algae** = plants living in the water, of which there are numerous different species and which can have very different shapes and sizes.
**Bacteria** = microscopic, single-celled organisms
**Carrion** = dead and decaying animal flesh
**CFCs** = chlorofluorocarbons that are used as propellant gases, refrigerants or solvents. The releasing of CFCs into the atmosphere plays a significant role in the depletion of the ozone layer.
**Climate** = long-term weather conditions and patterns in a certain location over a long period (at least 30 years)
**Condensation** = the process by which gas turns into liquid
**Contamination** = the presence of a substance which does not occur naturally, or the presence of a substance in a concentration that exceeds the natural level
**Corals** = immobile cnidarians that form colonies. Stony corals form coral reefs.
**DDT** (dichlorodiphenyltrichloroethane) = chemical pesticide that has been used since the early 1940s as a poison with long-lasting effectiveness against insects and is now banned in many countries
**Delta** = the mouth of the river in a lake or sea that resembles a triangle and where the main channel diverges into several outlets
**Downcycling** = processing of waste where the recovered material is of lower quality and functionality than the original material
**Earth's atmosphere** = the envelope of gases surrounding the earth
**Ecology** = the relationships of organisms to each other and to their environment
**Ecosystem service** = the advantages from which humans can benefit through healthy ecosystems (e.g. availability of food, pollination by insects)
**Elastomers** = elastic plastics that can be compressed or pulled apart and subsequently return to their original shape
**Expedition** = research trip
**Fleece** = a plush, roughened fabric for clothing that provides good warmth. It is often made from polyester.
**Food web** = complex feeding relationships between organisms in an ecosystem
**Gills** = respiratory organs of many water-dwelling animals
**Invasive species** = non-native, introduced species that threaten the biodiversity of other animal and plant species and thus the native ecosystems through their spread.
**Macroplastics** = items of plastic that are larger than 5 mm
**Microplastics** = plastic particles that are between 5 mm and 1 µm in size.
**Monomers** = molecules that can join together to form long chains (called polymers)
**Mountain chain** = a series of high mountain summits, a linear sequence of interconnected or related mountains or a continuous ridge of mountains within a larger mountain range
**Nanoplastics** = tiny plastic particles in the nanometre range that are smaller than 1 µm
**Offshore industry** = industry located in coastal waters or the open sea
**Organic pollutants** = compounds that only biodegrade or change state very slowly in the environment and that are made up of carbon and water
**Organism** = an individual life form
**Ozone layer** = an area of the earth's atmosphere characterised by an increased concentration of the trace gas ozone ($O_3$). It is located at an altitude of 15 to 30 km and protects life on earth from the harmful effects of sunlight.
**PCB** = (polychlorinated biphenyls) = toxic and carcinogenic organic chlorine compounds that were used as plasticisers and flame retardants in plastics. They have been banned worldwide since 2001.
**Photosynthesis** = process by which plants (and some bacteria) use light, water and carbon dioxide to produce glucose and oxygen.
**Phthalates** = substances used as plasticisers for plastics such as PVC or rubber
**Plankton** = organisms that live in the water and are carried on the currents. The term includes both animals (zooplankton) and plant-like organisms (phytoplankton).
**Plankton bloom** = a mass reproduction of plankton
**Pollutant** = a substance has a harmful or toxic effect on organisms and/or the environment
**Polymers** = long molecular chains that are formed by placing several identical or different core components (monomers) next to each other in a row
**POPs** = persistent organic pollutants, i.e. long-lasting organic substances that only biodegrade or change state extremely slowly in the environment
**Population** = the total number of an animal or plant species living in a certain connected habitat at the same time
**Predators** = animals that hunt and catch other animals to eat them
**Prey** = animals that are caught, killed and eaten by predators
**Recycling** = reuse process by which waste is processed in order to use it for the production of new products.
**Reefs** = ridges of varying lengths that rise from the bed towards the surface of the water
**Resources** = natural raw materials such as oil or minerals
**Scrub** = a cosmetic treatment that exfoliates the skin
**Seasonal** = at a recurring time period of a year, e.g. summer
**Sediment** = deposition of natural substances on land and in the sea, such as from dead organisms, sands, limestones.
**Subtropical gyres** = circular surface currents formed from ocean currents. The Pacific and Atlantic oceans each have two such eddies, one north and one south of the equator.
**Spawn** = the eggs of snails, fish and amphibians laid in the water
**Thermohaline circulation** = combination of ocean currents driven by differences in temperature and salt concentration
**Thermoplastics** = plastics that change from a solid to a viscous state when heated and can then be formed
**Oceanic trenches** = elongated but relatively narrow depressions in the seabed
**Thermosetting polymers** = very hard and very stable plastics that do not melt even at high temperatures and retain their shape
**Tropics** = climate zone located between the Tropic of Cancer and the Tropic of Capricorn
**Upcycling** = the process of turning waste products or useless materials into products that are as good as new
**Urban agglomeration** = larger settlement area in which a very large number of people live
**Weather** = short-term changes in the atmosphere (e.g. heat, cloud coverage, aridity, sunshine, wind, rain). It can change in a matter of minutes, hours, days or weeks

# Overview of the exercises and master copies

Teachers and/or leaders of youth groups are required to adapt the exercises to the learning level of the participants. The difficulty column can help in this regard (easy = from 11 years of age, moderate = from 13 years of age, difficult = from 15 years of age). The symbols in the method column indicate individual work, work in pairs or group work.

| Chapter | Master copy | Exercises | Method | Time | Difficulty | Page |
|---|---|---|---|---|---|---|
| 1 | Importance of the ocean | **Exercise 1:** Memories of the sea | | 45 min. | Easy | 12 |
| | Ocean facts | **Exercise 2:** A visit to the Challenger Deep | | 45 min. | Easy | 13 |
| | | **Exercise 3:** On the map | | 45 min. | Moderate | 14 |
| | Europe's rivers – where the sea begins | **Exercise 4:** The top three | | 45 min. | Easy | 17 |
| | | **Exercise 5:** Which river flows where? | | 45 min. | Moderate | 17 |
| | The food webs in the ocean, seas and rivers | **Exercise 6:** Plankton – small but mighty | | 20 min. | Easy | 20 |
| | | **Exercise 7:** Year after year | | 15 min. | Difficult | 21 |
| | | **Exercise 8:** The food web game | | 30 min. | Moderate | 22 |
| | River wildlife | **Exercise 9:** Who eats whom? | | 10 min. | Easy | 24 |
| | | **Exercise 10:** The food web at your doorstep | | 30 min. | Moderate | 24 |
| | | **Exercise 11:** River wildlife card game | | 30 min. | Moderate | 24 |
| | Marine currents – everything's linked | **Exercise 12:** Always on the move | | 45 min. | Moderate | 28 |
| 2 | People and the sea – a one-sided relationship | **Exercise 13:** We depend on it | | 30 min. | Moderate | 38 |
| | | **Exercise 14:** Where the plastic waste ends up | | 30 min. | Easy | 39 |
| 3 | Plastic waste at home | **Exercise 15:** Plastic waste diary | | 5 min./ day, 45 min. evalu-ation | Easy | 44 |
| | | **Exercise 16:** How does the waste get into the sea? | | 55 min. | Moderate | 44 |
| | Properties of plastic | **Exercise 17:** What is plastic made of? | | 45 min. | Moderate | 47 |
| | Composition of plastic | **Exercise 18:** Plastic does a spot of modelling | | 30 min. | Moderate | 48 |
| | Plastic and the sea | **Exercise 19:** Floating plastic | | 30 min. | Moderate | 49 |
| | Hunting for evidence in the ocean – where's the plastic waste? | **Exercise 20:** Seas at risk | | 20 min. | Easy | 52 |
| | | **Exercise 21:** Scouring the sand | | 30 min. | Moderate | 53 |
| 4 | What can I do? | **Exercise 22:** Setting a good example – part 1 | | 30 min. | Moderate | 57 |
| | | **Exercise 23:** Setting a good example – part 2 | | 45 min. | Easy | 57 |
| | The many aspects of environmental protection | **Exercise 24:** Project work: Rethinking plastic pollution | | 90 min. | Moderate | 60 |
| | Are you now a real Plastic Pirate? | Reflection | | | | 66 |

# NOTES

**Plastic Pirates - Go Europe!** is a European citizen science campaign with the aim of strengthening scientific cooperation in Europe, promoting citizen science engagement and society's participation in the European Research Area, and raising awareness for a conscious and careful approach to the environment. During the German EU Presidency in 2020, the campaign was extended to the countries of the Trio Presidency and became a joint action of the Federal Ministry of Education and Research (BMBF) with the Portuguese Ministry of Science, Technology and Higher Education and the Slovenian Ministry of Education, Science and Sport for the period 2020 to 2021. Since January 2022, the action has been extended to other EU Member States with the support of the EU Commission.