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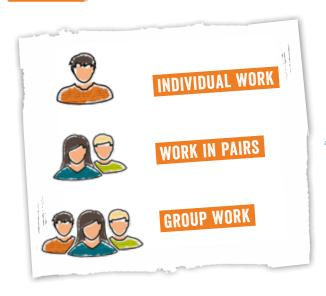
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The citizen science programme 'Plastic Pirates – the sea starts here!' explores the issue of microplastic and macroplastic in the environment and the impact of plastic waste that is carried into the seas via inland waterways. Using the programme booklet as a guide, young people have until mid November 2016 to take samples of microplastic and macroplastic in and around flowing waterways all over Germany, evaluate them and submit their results to the scientific community. Citizen science projects give people interested in science an opportunity to play a hands-on role in the research process. In this instance, the project is a practical invitation for young people to think more closely about an issue.

You can find more information at: www.plasticpirates.scienceyear.de

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BACKGROUND INFO:

THE SCIENCE YEAR

The German Federal Ministry of Education and Research (BMBF) has been organising Science Years in conjunction with Wissenschaft im Dialog (WiD) since 2000. Each Science Year focuses on a socially relevant and forward-looking issue from the field of science and research. The Science Year 2016*17 – Seas and Oceans is supported by the German Marine Research Consortium (KDM) as a specialist partner.

Seas and oceans account for about 70 per cent of the earth's surface. They are climate regulators, a source of food and a place of business – and they are also home to scores of plants and animals. Researchers have been

exploring the oceans for many years, but they remain mysterious, with large sections still uncharted. The Science Year 2016*17 is all about discovering seas and oceans, protecting them and promoting their sustainable use.

One aim of the Science Year – Seas and Oceans is to raise awareness of the complex issues of marine protection and sustainability amongst children and young people in particular and to show that personal initiatives can make a positive difference.

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 seas and oceans. The 'Plastic Pirates' project focuses on this plastic waste problem and our future handling of it, but aims to familiarise the young people with the general topic of oceans and water cycles in the process.

These learning 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. It is therefore guided by the educational standards of the Standing Conference of the Ministers of Education and Cultural Affairs and can, if necessary, be seamlessly incorporated into any curriculum.

USING THE MATERIALS

The exercises found in the learning 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 learning 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.

EDUCATION FOR SUSTAINABLE DEVELOPMENT — WHAT DOES IT MEAN?

My actions have consequences, not just for me and my environment but 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 (FSD) 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 personal responsibility. This educational ethos involves a clear understanding that a multidisciplinary approach is required to promote knowledge and skills of this kind.

You can find a comprehensive introduction to ESD – including theoretical background information for beginners, teachers and other parties as well as publications, learning materials and worksheets – by going to www.bne-portal.de

THE STRUCTURE OF THE MATERIALS

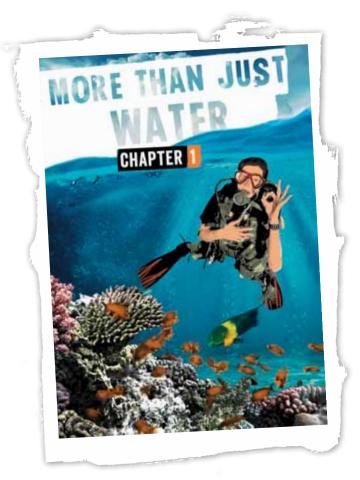
These learning materials and worksheets are divided into four chapters. The introductory chapter is all about discovery and brings to life the importance of seas, oceans and rivers. The second chapter looks at how these bodies of water are used – and polluted – by people. We then move on to the third 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, but are 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 oceans 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 chain and that is the source of half of the oxygen in the atmosphere?

It is not possible to overestimate the importance of the sensitive ecosystems found in seas and oceans. Because even if you don't live by the sea (as many Germans do not), the sea still influences your everyday life. Summer dress or winter coat? This decision is shaped by the world's seas and oceans, as they determine the climate. By the same token, however, inland regions influence the seas and oceans. This is where the sea starts. Rivers do not just transport water into the sea, but also sand and waste, such as plastic waste.

CHAPTER 2

USING

OR POLLUTING

The seas and oceans are 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 oceans. 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 oceans in the form of manganese nodules.

Unlike in Germany, 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 into the water. But pollution can also travel from the land into the sea. Fertiliser, for example, causes a huge problem. Just like plastic waste.



INTRODUCTION 5

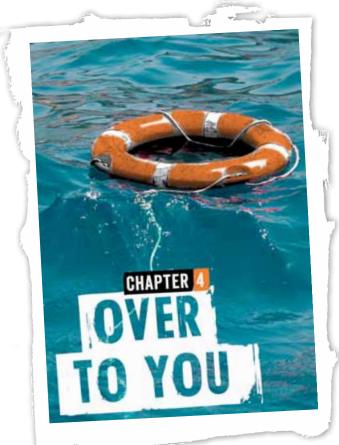
CHAPTER 3

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 takes several centuries for a plastic bottle to decompose. But this does not show the true scale of the problem. Every single minute, enough plastic to fill a rubbish truck enters the oceans. Plastic waste patches the size of central Europe are already drifting around our oceans. If this development carries on unchecked, the total weight of the plastic waste may exceed the weight of all the fish in the sea by 2050. The fish themselves eat the plastic, meaning that it can enter our food chain.

Very little research has been conducted into the effects of plastic on humans and animals. There are also not enough in-depth scientific insights into the nature and specifics of plastic waste distribution in seas and rivers to tackle the problem effectively.





CHAPTER 4 OVER TO YOU

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Many people are shocked and saddened by the sight of seabirds 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 seas and oceans, thus acting as inspirational examples.

Awareness of the problem is slowly but surely growing amongst society. This is extremely important. Because even though the United Nations has set sustainability targets, each and every one of us has to rethink our actions. Is it really necessary to buy a new smartphone every year? Could you still do your supermarket shopping without that plastic bag? Does that go in general waste or in the recycling bin? 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!

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Partners

The youth programme 'Plastic Pirates – the sea starts here' is part of the Science Year 2016*17 - Seas and Oceans of the German Federal Ministry of Education and Research (BMBF) and is carried out in cooperation with ozean:labor at Kieler Forschungswerkstatt and the marine biology work group of Universidad Católica del Norte in Coquimbo, Chile. The Plastic Pirates are based on the joint international project 'Dem Plastikmüll auf der Spur/Cientificos de la Basura' ('On the hunt for plastic waste'). The project is carried out and supported by the German Federal Ministry of Education and Research, the cluster of excellence 'The Future Ocean', the Lighthouse Foundation, the Leibniz Institute for Science and Mathematics Education (IPN) and the Ministry of School and Professional Education of the state of Schleswig-Holstein. On the Chilean side, the project is supported by Universidad Católica del Norte, the Center for Advanced Studies in Arid Zones (CEAZA) and the Chilean scientific association Explora Conicyt.

The **Kieler Forschungswerkstatt**, the school laboratory of Kiel University and the Leibniz Institute for Science and Mathematics Education (IPN), is an out-of-school place of learning that focuses on various topics, such as energy, life on earth and nanotechnology. Its key functions are to support grass-roots and elite science,

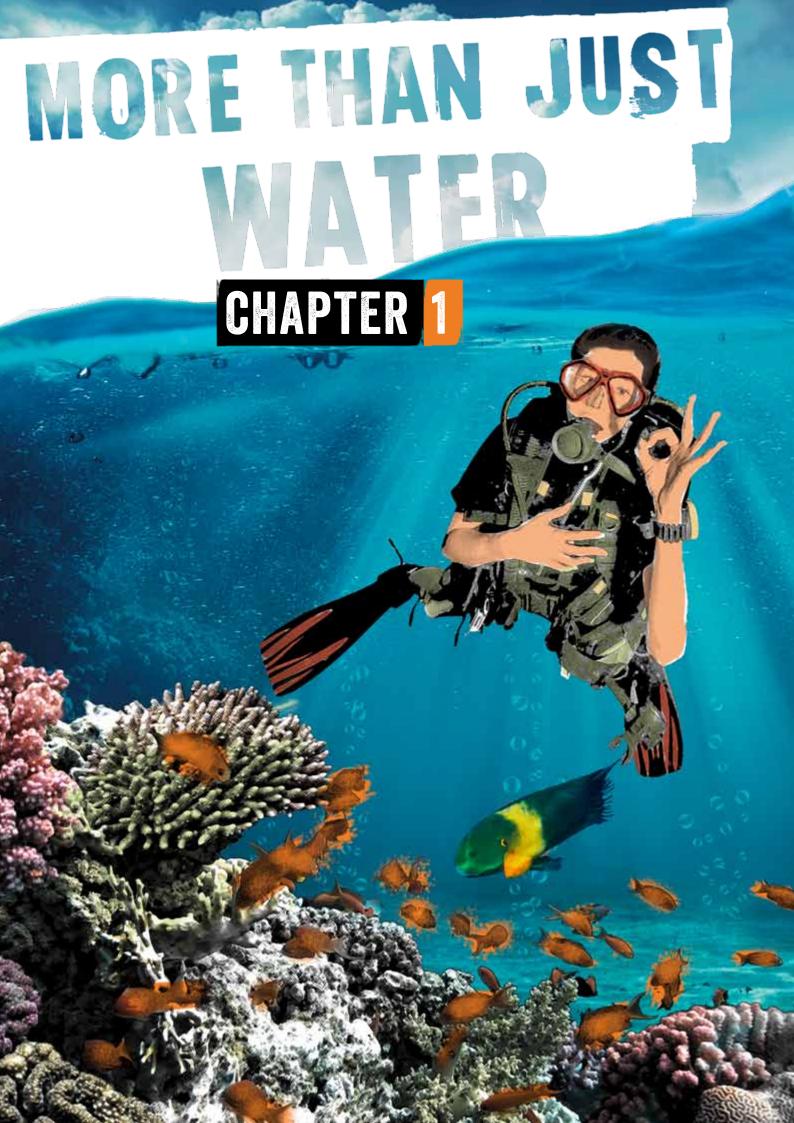
as well as teacher training and development. At the ozean:labor laboratory, school pupils explore the habitat of seas and oceans and get to grips with current issues in the field of marine research. The laboratory looks at the influence of people on the ocean ecosystem, using examples such as eutrophication and overfishing, and undertakes projects and activities connected with the issue of plastic waste in oceans:

www.forschungs-werkstatt.de

The **Leibniz Institute for Science and Mathematics Education** (IPN) is a nationwide research institute that studies and develops educational programmes and processes in the fields of science and mathematics.

The Kiel cluster of excellence 'The Future Ocean' has a globally unique approach to researching changes in the oceans – past, present and future: Experts from the fields of marine science, geography, economics, medicine, mathematics, information technology, law and social sciences pool their specialist knowledge. Their research findings are incorporated into sustainable usage concepts and potential courses of action for global ocean management. The research cluster supports ozean:labor at Kieler Forschungswerkstatt.





Introduction

MORE THAN JUST WATER

Importance of seas and oceans

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 oceans 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 oceans give us pleasure in the form of swimming and surfing, days at the beach and cruises. Even people who do not live on the coast are also connected to the sea via rivers.

At the same time, our seas and oceans are 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 seas and oceans via rivers. In the Science Year 2016*17 – Seas and Oceans, school pupils are therefore getting involved in a study of German rivers. All rivers eventually flow into the sea.



A sea of knowledge: Ten fascinating facts on seas and oceans

1. The average depth of water in the world's seas 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 world's oceans is the Mariana Trench in the Pacific. It is known as the Challenger Deep.

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- 2. Light can only penetrate to about 200 metres below the surface of the water. As a result, the world's seas and oceans are largely submerged in complete darkness.
- 3. Less than five per cent of the world's seas have been explored. 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 Oceans. It is more than 60,000 kilometres long.
- **5.** Less than two per cent of the water on the earth's surface is fresh water. The rest is salt 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 vegetable plankton (phytoplankton) the tiny algae drifting in the ocean.
- 10. Germany's research fleet comprises 16 vessels.

 They help us carry out scientific research into seas and oceans so that they can be used sustainably and protected more effectively.



Master copy



Perhaps you've been on holiday by the sea or ocean or someone in your family or group of friends. The following exercise is about reporting on it.







Memories of the sea Add photos or images of your holidays by the sea and describe the time you spent there:

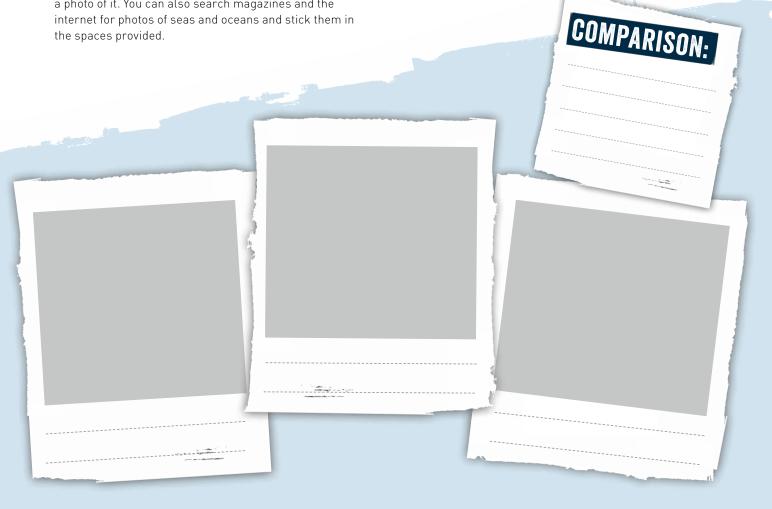
What can you still remember? What really impressed you? What made you think?

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

Look for clues about seas and oceans 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.



Master copy

ABOUT THE WORLD'S SEAS

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

When we talk about 'oceans', we mean the five largest seas in the world, all of which are connected. The largest ocean of all is the Pacific, which contains almost half of all water found on earth. Alongside oceans, there are also smaller seas such as the Mediterranean and the two seas that have a coastline in Germany - the North and Baltic Seas. These smaller seas are also connected with the oceans.

EXERCISE 2: 2





A visit to the Challenger Deep

Only three people have ever been to the deepest point in the world's oceans. Find the Challenger Deep on a globe or a map of the world. Research the names of these three 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



On the map

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

- Name all five major oceans.
- Name three large rivers that flow into these oceans.
- Find out the surface area of the individual oceans (excluding the smaller seas) and how much water each one contains.
- Research the ways in which humans use the seas and oceans. 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.



Introduction

THE BEAUTY OF RIVERS



Germany's rivers - where the sea starts

There are more than 1,000 flowing waterways in Germany, ranging from small brooks to large rivers. The most important river in Germany is the Rhine. It is the country's most important shipping route. With a length of 865 kilometres, it flows through three federal states. Rivers provide a habitat and source of food for many animals. Beavers build their lodges on the riverbank. Birds such as the kingfisher use rivers to hunt for fish. And fish such as salmon navigate the rivers in search of suitable spawning grounds.

Some species that were once a common sight on German rivers are now rare. For example, there are only about 20,000 or so kingfishers in Germany. Construction measures, such as the straightening of river channels, have led to a decline in many species. But we are now witnessing a turnaround. Thanks to comprehensive environmental protection measures, the populations of rare species are stabilising. The beaver is returning to more and more areas, whilst trout, salmon and grayling a particularly sensitive group of fish are also repopulating their native habitats.

The appearance of a river changes several times between its source and 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 in this section of the river displays considerable force,

small particles, sand and gravel are swept along. In the upper reaches, the riverbed is made primarily of large,

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 14] 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 from all over Germany into the sea. Scientists want to find out where the most waste enters the rivers. They are also interested in finding out how the waste makes its way into the rivers and





Name of river:

The top 3

जन मार्ग

Draw up profiles of the three longest rivers in Germany. Enter their flow directions on the map on page 14. What do you notice?

Length:
Mouth:
Source:
Federal states:
Name of river:
Length:
Mouth:
Source:
Federal states:

EXERCISE 5:

Which river flows where?

Learn about more rivers in Germany by completing the following quiz. Split up into groups of four and use an atlas to help you. Each group sets five questions, with 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.

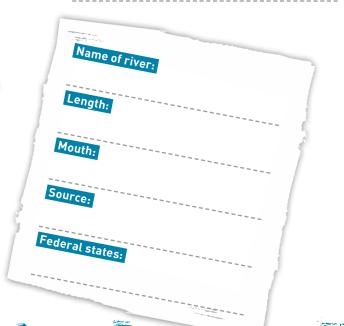
- 1. Which lake is situated on the Rhine?
- 2. Which of these German states does the Elbe NOT flow through?

Hamburg Schleswig-Holstein
Thuringia Lower Saxony
Saxony

- 3. What is the name of the river that flows through Munich?
- **4.** What is the name of the river that flows through Bremen?
- **5.** What is the name of the river that flows through Heidelberg?
- **6.** Which of these cities is NOT on the Danube?

Passau Heidelberg
Regensburg Ulm
Ingolstadt

7. A curved section of the Rhine forms the natural border between which two German states?



Introduction

THE FOOD CHAINS IN OCEANS, SEAS AND RIVERS

The wildlife and living conditions in seas and oceans

The world's seas form one huge connected habitat. This habitat is home to a vast community of plant and animal organisms, including bacteria. The oceans can be broken down into many different categories, all of which are very different in terms of living conditions. Alongside latitude, various factors such as light, pressure, temperature, current 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 and microscopically small algae classed as vegetable plankton (phytoplankton) use the energy for photosynthesis. Photosynthesis produces sugar and oxygen. As the oceans are home to large numbers of phytoplankton, the amount of oxygen produced is correspondingly high. About half of the oxygen in the atmosphere comes from phytoplankton.

But phytoplankton has a second important role to play. It serves as food for the animals found in the world's seas and therefore forms the basis of the marine food chain (see the food chain diagram on page 19). 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 plankton is eaten by smaller fish, who in turn are preyed upon by larger fish. These fall prey to predators such as sharks and dolphins. Depending on the area of the sea concerned, there may be significant differences in these food chains 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 (latitude) but also as the depth increases (see the diagram on page 17).

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



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E FOOD CHAIN OF SEAS AND OCEANS

The following exercise gives you a chance to explore the fascinating food chain found in seas and oceans.

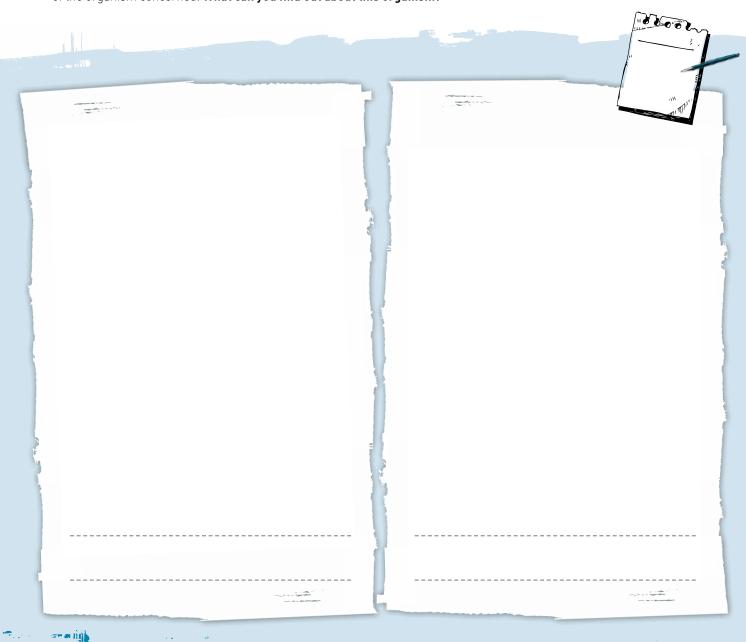






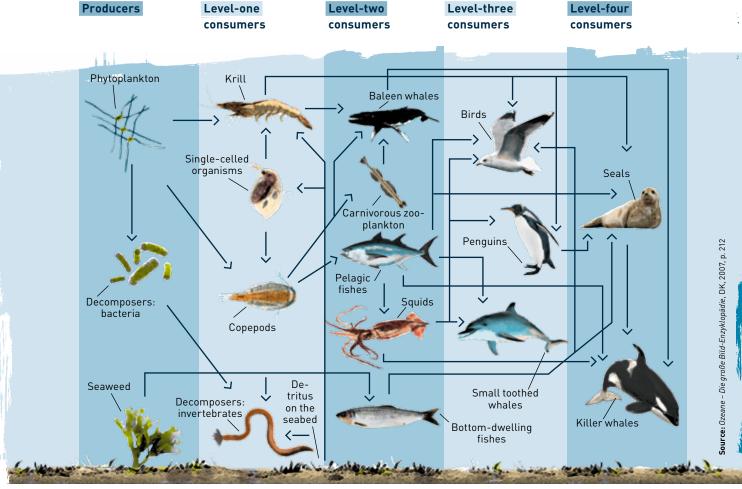
Plankton - small but mighty

1. Find a book or do some online research for photos of phytoplankton and zooplankton. 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 chain in the Antarctic.

Where is the phytoplankton and what role does it play in the food chain?



The creatures are not shown in proportion.

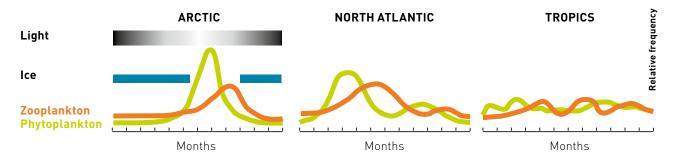


Year after year

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

Using the diagram below to help you, 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 chain game

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

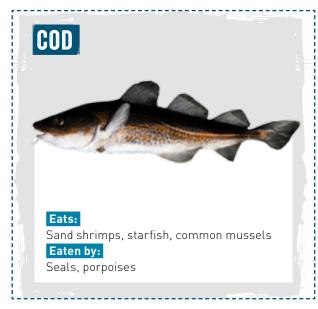
Materials:

- 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 sits 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. Whoever has drawn the phytoplankton card stands in the middle of the circle in their role as producer 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 chain. That player holds on to one end of the thread and throws it to the next player whose card is linked in the food chain. 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?





















Master copy



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





Who eats whom?

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























A plastic bag's-eye view

Creative writing workshop:

Write a story from the perspective of a plastic bag that ends up in your local river. How did the bag end up in the river? What places did it pass on its way? What animals did it come into contact with? And which people?



EXERCISE 11: 202



River wildlife card game Split up into groups of three.

On the cards provided, produce a profile of the species named. Please ensure that each member of your group picks four of the following creatures:

Brown trout Eurasian otter Crayfish Grey heron Pike Kingfisher Fire salamander Salmon Grass snake Beaver 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:	Species:	Species:	Species:
Size:	Size:	Size:	Size:
Diet:	Diet:	Diet:	Diet:
Lifespan:	Lifespan:	Lifespan:	Lifespan:
Age at which sexual maturity is reached:			
Weight:	Weight:	Weight:	Weight:
		<u> </u>	i
Species:	Species:	Species:	Species:
Size:	Size:	Size:	Size:
Diet:	Diet:	Diet:	Diet:
Lifespan:	Lifespan:	Lifespan:	Lifespan:
Age at which sexual maturity is reached:			
Weight:	Weight:	Weight:	Weight:
Species:	Species:	Species:	Species:
Size:	Size:	Size:	Size:
Diet:	Diet:	Diet:	Diet:
Lifespan:	Lifespan:	Lifespan:	Lifespan:
Age at which sexual			
maturity is reached:	maturity is reached:	maturity is reached:	maturity is reached:
Weight:	Weight:	Weight:	Weight:

Introduction

MARINE CURRENTS — EVERYTHING'S LINKED

Seas and oceans in flux

Seawater is always on the move. It is transported by the great currents that link all oceans. 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 oceans. A single water molecule that is carried on this global conveyor belt takes about 1,000 years to circumnavigate the globe.

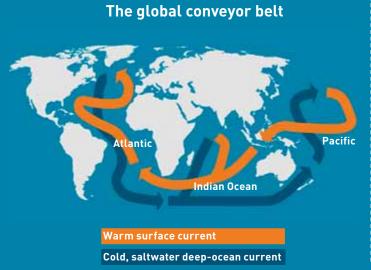
Importance of seas and oceans for the global climate

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. whether or not it is close to the equator. The tropics, for example, receive more sunlight than northern and southern regions. The cold North and South Poles get the least solar energy.

Many different factors such as temperature, salt level, wind, gravity, etc. form the motor that drives the global conveyor belt. The oceans store the solar energy found in sunlight and transport 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.

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 and Germany 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.

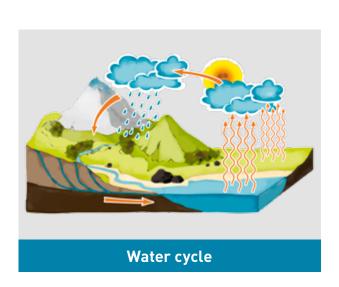




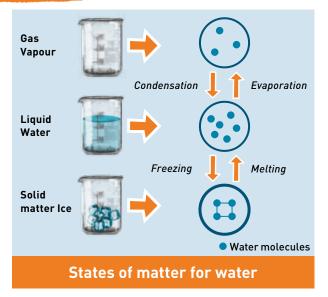
It is not just seawater that is permanently on the move

Water molecules never stop moving either, whether in seas, rivers or as water vapour in our atmosphere. Oceans, 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 seas, oceans, lakes and rivers. As seas and oceans make 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.



we an right



This condensation often takes place above continents and the slopes of mountain ranges. When the water condenses, precipitation is formed that 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.

MILITAN TO

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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.



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
- Kettle

Method:

Pour 700 ml of water into the beaker. Now heat more 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)
- 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.



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 new 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)

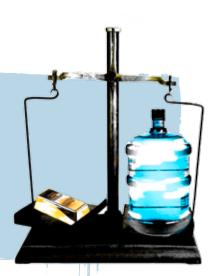
Method:

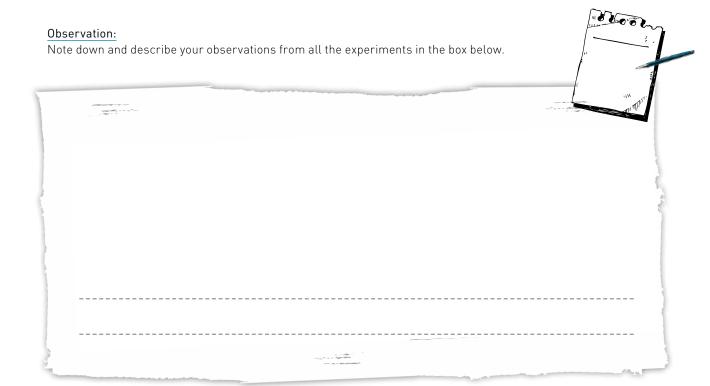
Use the plasticine to form a barrier in one of the crystallising dishes so that both sides are kept separate. Fill the dish with tap water. The water level should be approx. 1 cm above the barrier. Colour some water with a few drops of food colouring and dissolve some salt in the water to create a concentrated 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.



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 chemical property. It is calculated by dividing the mass of an object by its volume. The unit of measurement is ρ (pronounced 'rho').





1000

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.

-1

HELP BOX

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

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, the 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 2: easy, 45 min. Exercise 3: moderate, 45 min. Exercise 4: easy, 45 min. Exercise 5: moderate, 45 min. Exercise 6: easy, 20 min. Exercise 7: hard, 15 min. Exercise 8: moderate, 30 min. Exercise 9: easy, 10 min. Exercise 10: moderate, 15 min. Exercise 11: moderate, 30 min. Exercise 12: moderate, 45 min.

Exercises 1 to 3 can be used for years 5–10 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, tropical seas, etc. that are then discussed by the pupils.

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.

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 be used for years 5–10 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 vegetable 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 chain 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 chain game in **exercise 8** is particularly well suited to the school playground or other open space.

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

The river wildlife card game from **exercise 11** should be played in groups of three. Firstly, the group members divide the species amongst themselves and, working individually, enter the information about the river wildlife onto the cards. In the second part of the exercise, the group plays the card game. The rules of the river wildlife card game are based on those of Top Trumps (https://en.wikipedia.org/wiki/Top_Trumps). The pupils should decide for themselves which values win and which values lose. This ensures that they study the individual species in greater detail.

It is important to understand ocean currents in order to get to grips with the formation of 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 talking about 'density'.

Solutions

Exercise 2:

Name	Profession	Year of expedition
Jacques Piccard	Swiss oceanographer and engineer	1960
Don Walsh	American naval officer	1960
James Cameron	Canadian film director	2012

Exercise 3:

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

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

Exercise 4:

- 1. Name of river: Danube Length: 2,857 km
 - Source: Furtwangen (in the

Black Forest)

Mouth: Black Sea

German states: Baden-Würt-

temberg, Bavaria

2. Name of river: Rhine Length: 1,233 km Source: Swiss Alps

Mouth: North Sea near Rot-

terdam

German states: Baden-Württemberg, Rhineland-Palatinate, North Rhine-Westphalia

3. Name of river: Elbe Length: 1,091 km

Source: Špindlerův Mlýn, Giant Mountains, Czech Republic Mouth: North Sea, Cuxhaven German states: Saxony, Brandenburg, Saxony-Anhalt, Lower Saxony, Mecklenburg-Western Pomerania,

Schleswig-Holstein, Hamburg

Exercise 5:

Rivers and German states

- 1. Lake Constance 2. Thuringia
- 3. Isar 4. Weser
- 5. Neckar 6. Heidelberg
- 7. Rhineland-Palatinate, Hesse

Exercise 6, 2:

Phytoplankton forms the basis of the food chain in oceans 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 zooplankton 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 many whales 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), pike-perch (feeds on smaller fish)



Introduction

USING OR POLLUTING

Seas and oceans are places of unique diversity and are of untold importance to our planet. Many aspects are yet to be researched, however. The first chapter of these learning materials and worksheets explored the connections between the habitats of rivers, seas and oceans more closely. This second chapter goes into greater detail about the importance of these 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. What's more, the oceans are a veritable treasure chest. They supply food and resources and serve 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 seas and oceans 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 for mining 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, with a corresponding increase in the need for resources. 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 out at sea, are limited. It is therefore important to use them sustainably and to develop new technologies that require fewer resources.

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The principal shipping routes for global container transport. The figures indicate the number of standard containers (in millions) transported in 2007. **Source:** World Ocean Review 1, Maribus, 2010, p. 173

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Ways in which rivers, seas and oceans are used

Shipping lanes and trading routes

Rivers and seas became important transport routes as trade flourished. People were moving large quantities of goods by water long before the advent of cars and roads. Almost all German rivers were dramatically affected by this use, however, with the consequences for the environment sometimes devastating. Dams were built across the rivers, their channels were straightened and their banks were paved to facilitate commercial shipping.

Nowadays, the sea is primarily used for the transport of goods. Only very few people still use ships to get to their destination, as planes tend to be used for long-distance travel. By contrast, 90 per cent of goods are transported by ship. There are many busy shipping routes that take commercial ships such as container vessels, tankers and bulk carriers from A to B by the quickest and shortest route. In order to shorten these routes still further, canals such as the Suez and Panama Canals have been built over the years. Interestingly, these principal commercial shipping routes are located within a very small section of the world's seas (see the map above).

Source of energy – wind and tides

For several years, considerable amounts of electricity have been generated out at sea. In European waters, particularly the North Sea, wind farms have become a fast-growing source of energy. The aim is for wind energy to gradually replace nuclear power and the fossil fuels of coal, natural gas and petroleum. With this in mind, many wind farms and large sections of sea are required. The wind farms, however, damage the habitats

of many marine organisms, with the erection of wind turbines a particular problem for porpoises. The foundations of the turbines are pile-driven into the ground, causing noise that can interfere with the porpoises' hearing. The first German wind farm, alpha ventus, has 12 turbines and has been operating off the North Sea coast of Lower Saxony since 2010. Many more are being built or planned.

I III MATE

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 demand for oil 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 2007, for example, 37 per cent of global oil production came from seas and oceans. 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, scientists 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 clathrates from the sea. Manganese nodules are nodules that contain metal and cover thousands of square kilometres of the deep-sea floor. Methane clathrates 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 clathrates.

The supply of drinking water

Water is essential for life Humans can only survive for a few days without water. Every day, our bodies lose about 2.5 litres of water, which is why we have to drink fluids

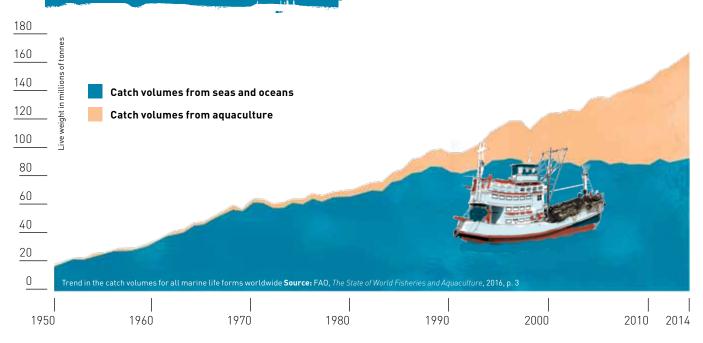


regularly. Drinking water is the most tightly controlled foodstuff in Germany. It is primarily sourced from groundwater. In central Germany, the population is also supplied with drinking water from reservoirs that are formed by building dams in river valleys. In large urban areas, surface water and bank filtration are also taken from rivers such as the Rhine. This has to be purified more thoroughly as it contains more pollution and therefore does not meet the stringent legal requirements for drinking water. At water treatment plants, the water is decontaminated for use as drinking water in several stages. First of all, it is filtered. Bacteria and pathogens are then killed off. Drinking water must always be free from pathogens, transparent and clear, colourless and odourless and have a neutral taste. In Germany, there is no shortage of drinking water. 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 at desalination plants is still extremely energy-intensive and expensive.



Food source: fishing and 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 oceans. 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 43 per cent of fish consumed today have been reared at aquaculture facilities. The manmade 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, 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 sea.

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We depend on it

The following questions will help you find out how dependent humans are on seas and oceans. 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 Hamburg to Shanghai and then on to New York. Name the seas and shipping lanes that have to be navigated.

Source of energy - wind and tides

2. Find out the areas of the German North Sea where wind farms are planned. How many are there currently? What arguments do their opponents put forward? And what about those in favour?

Resource stocks - oil, gas, manganese nodules and methane clathrate

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, 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. What are the consequences of tourism for the ecosystem and local economy? Which regions are particularly popular amongst tourists?

Types of pollution

The opening texts of this chapter explained how people use rivers, seas and oceans. The following pages will study the pollution of these habitats, with the learning materials and worksheets focusing on the issue of plastic. Alongside plastic, other types of pollution include:

Plastic pollution

The waste that people throw into rivers eventually makes its way into seas and oceans. Huge quantities are added every year via rivers and other means. Long-last-

- 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

ing and barely biodegradable 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. Whenever there are favourable conditions for phytoplankton, algae blooms appear in the sea.



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



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 oceans 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.

T WHERE DOES IT



Mexico: Pacific



Germany: North Sea

EXERCISE 14: 🏖

Where the plastic waste gets to

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

- 1 Look at the images carefully and use a coloured pen or pencil to mark the location of the sites on the world map on page 12.
- 2. Write down what you notice.
- 3. Consider ways in which the waste may have ended up at the places shown on the photos.







Notes for teachers

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

Exercise 13 illustrates the ways in which humans use seas and oceans. 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 of free 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.

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.

Solutions

Exercise 13:

- 1. Hamburg -> Shanghai:
 North Sea, Atlantic Ocean, Strait
 of Gibraltar, Mediterranean Sea,
 Suez Canal, Red Sea, Indian
 Ocean, Strait of Malacca, South
 China Sea, East China Sea
 Shanghai -> New York:
 Pacific Ocean, Panama Canal,
 Caribbean Sea, Atlantic Ocean
- Caribbean Sea, Atlantic Ocean **2.** See the maps provided by the
- Federal Maritime and Hydrographic Agency of Germany (BSH), currently in operation: 11 wind farms (As of 12 July 2016).
- 3. Seismic methods: Specialist 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: It is feared that 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.
 - <u>Drinking water:</u> Fresh water that has to meet a certain purity standard.
 - <u>Spring water:</u> 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, Atlantic herring, carangids (as of 2010, source: www.seaaroundus.org) Catching methods: Gill nets, seine nets, pelagic trawl nets, bottom trawl nets, beam trawls, longlines Species at aquaculture farms: Carp, trout, pike-perch, iridescent shark, shrimps/prawns, tilapia, temperate basses, plaice, 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.
- **6.** Urbanisation, water scarcity, overfishing, waste water, invasive species

<u>consequences for the local</u> <u>economy:</u> Considerable dependency on tourism, overuse of natural resources and the destruction of social and cultural structures.

Example of a region:

Mediterranean



Introduction

PLASTIC WASTE — A LASTING PROBLEM

If you ever collect and take a look at the rubbish lying around when you go for a walk by the river or on the beach, you will notice that the following items are particularly common: cigarette filters, plastic lids, plastic bottles, plastic bags, food packaging, glass bottles, straws, plastic cutlery, drinks cans and fishing lines. On beaches, you will also often find the remnants of fishing nets.

Over time, many of the items of plastic sink to the bottom of the sea. No one really knows how much waste is involved. 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. The scientific study shows that the majority of the plastic waste floating around the oceans takes the form of small fragments measuring less than five millimetres. The technical term for these is 'microplastic'. These tiny fragments are produced when larger

pieces gradually disintegrate. Fishing equipment was also found in the researchers' nets. These buoys, lines and nets go straight from ships into the sea, whereas other plastic items such as buckets, bottles, polysty-rene and plastic bags originate from dry land.

But how does the waste enter the sea in the first place and how long does it take for plastic bags or fishing lines to biodegrade? 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

It is quite clear that seas and oceans serve as 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 water then transports it from smaller to larger rivers before it finally enters the sea.

Via rubbish dumps:

All over the world, many people live on the coast. In many countries, the resulting waste is stored in large rubbish dumps that are also situated in direct proximity to 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:

Thousands of ships and boats navigate seas and rivers and – although it is now strictly prohibited – rubbish is still often thrown overboard.

Via fishing:

During fishing expeditions, items of equipment are often lost, with rubber boots, work gloves and, most of all, nets entering the sea. Broken nets are often just thrown straight into the sea instead of being disposed of with the rest of the waste at the next port.

Via offshore industry:

All over the world, more and more offshore gas and oil platforms are being built straight into the sea. Here too, waste is carelessly thrown into the water.

Via waste water:

When washing laundry (e.g. fleece garments), up to 2,000 synthetic fibres per wash cycle are released. These are too small to be filtered out of waste water at treatment facilities and therefore make their way to the ocean.

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You are no doubt familiar with various plastic products. It is hard to imagine everyday life without them. An average European, for example, uses more than 100 kilograms of plastic 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 day. 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
Sample 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



How does the waste get into the sea?

Produce a wall newspaper that describes the routes travelled by plastic waste into the sea. Do research to 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.

You've got a long wait

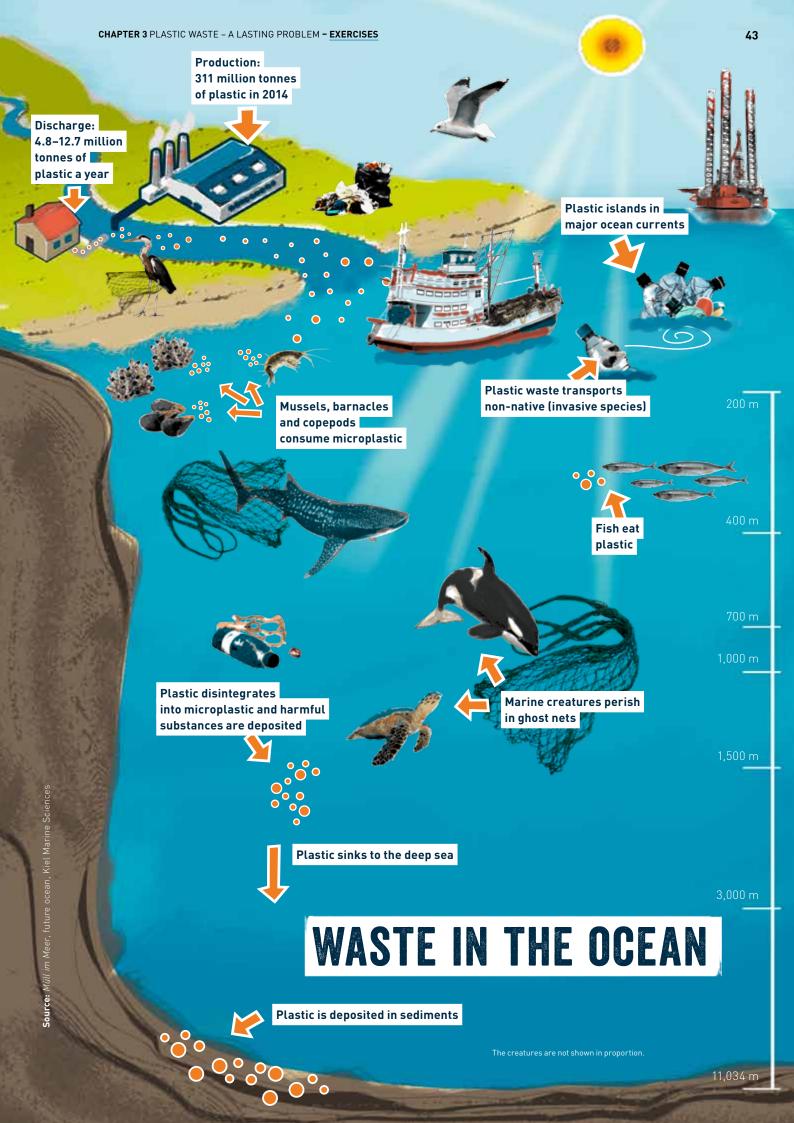
In the table below, enter your estimates of how many years it takes for the following items to biodegrade in the ocean.

Then compare your estimates with the diagram below and enter the correct figures in the final column. Once you're done, think about where the waste ends up in the ocean.

Type of waste	Estimated biodegradation period	Actual biodegradation period
PET bottles		
Polystyrene cups		
Cardboard boxes		
Fishing lines		
Newspapers		
Tin cans		
Nappies		

Biodegradation periods of different types of waste





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.

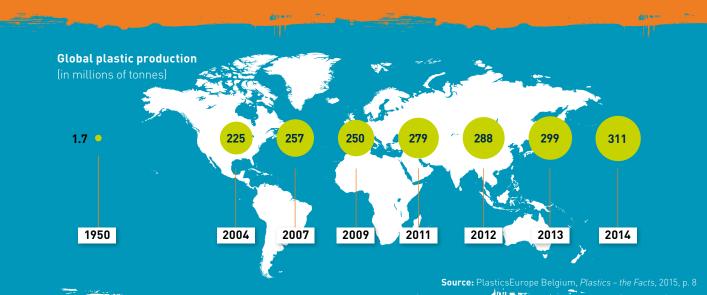
We hardly ever question the fact that we use plastic. Plastic is a synthetic material that nowadays comes in many different forms with all kinds of properties. What all plastics have in common is that they are made primarily using crude oil and that they are not biodegradable. A small number of plastics are made from sustainable resources. Plastics have many practical properties. They are malleable, hard, elastic, unbreakable, long-lasting and can be changed in almost any way, such as by mixing 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 plastic has become a global environmental problem. In 2014 alone, 311 million tonnes of plastic were produced globally, with huge quantities entering the oceans 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, are another. Experts fear that some of these additives may be 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.







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

Type of plastic	Abbre- viation	Recycling code	Type of item (in my group)
Polyethylene terephthalate			
High-density polyethylene			
Polyvinyl chloride			
Polystyrene			
Others			

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.

3. Conduct the following experiment on your sample items.

EXPERIMENT:

Properties of different plastics

Materials:

- 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
- Acetone
- 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 46.

- 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

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-eurocent piece) in in the roaring blue flame of the Bunsen burner. Enter your observations in the table on page 46. Compare your observations with the cardboard box, plant matter and woollen sock samples.

Plastic Mechanical		Combusti-	Resistance in various solutions			Floatability	
(abbre- viation) properties	properties	bility	Ethanol	Vinegar concentrate	Acetone	Fresh water	Salt water



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, do not soften when slowly heated. They remain stable and hold their form at low temperatures. 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 barely biodegradable due to their long molecular chains and that they will remain in the ocean for many centuries if incorrectly disposed of.

EXERCISE 19: 🙉

Plastic does a spot of modelling

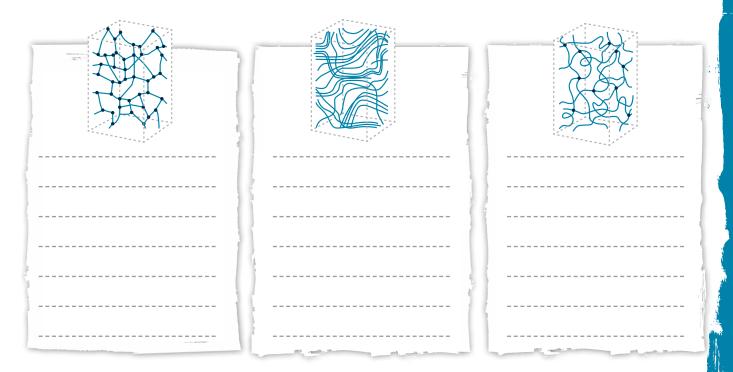
Read the informational text on the chemical structures of different groups of plastics and match up each of the diagrams with one of the three groups.

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.





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/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.





Floating plastic

To prepare, 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 questions:

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 types (e.g. plastic bags or yogurt pots). Complete a log for your series of experiments.

Introduction

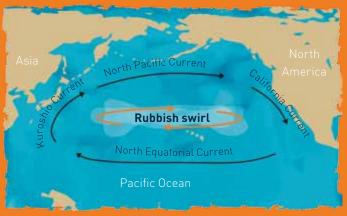
HUNTING FOR EVIDENCE IN THE OCEAN — WHERE'S THE PLASTIC WASTE?

The amount of waste in the oceans is increasing all the time. Much of this refuse only biodegrades very slowly. Plastic bottles and nylon fishing nets have particularly long lifespans. Although many plastic items break into smaller fragments, many decades or even centuries can go by before these disappear completely. The rate at which different plastics biodegrade has not been definitively established – and research is still ongoing in this area. The figures stated are therefore based on scientific estimates.

Global currents and rubbish swirls

There are many currents in the ocean. Some of these currents form giant swirls (gyres) spanning several hundred kilometres. Rubbish also gathers in these swirls. In 1997, researchers discovered a particularly large rubbish swirl in the North Pacific between Asia and North America: the Great Pacific garbage patch.

As it can take up to 600 years for the plastic to biodegrade, more and more plastic objects are accumulating in this area 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. 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 chains. Species introduced in this way are known as 'invasive species'.



Huge quantities of waste circulate in the North Pacific Gyre between Hawaii and North America. Many pieces of plastic drift across the sea for thousands of kilometres before becoming sweet up in the vortex

Source: World Ocean Review 1, Maribus, 2010, p. 89



The impact of plastic waste on sea life

Plastic fragments can expose wildlife to various risks. Turtles, seals and other animals, for instance, become entangled in torn-off nets, known as 'ghost nets', get injured or trapped and are no longer able to swim. They usually drown.

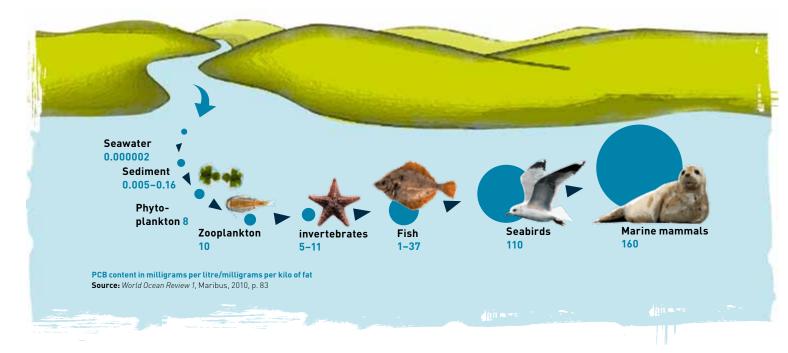
Another problem is that many creatures mistake plastic fragments with food. Seabirds such as albatrosses, which spend most of their lives out at sea, confuse plastic fragments floating on the surface with food and eat them by mistake. The seabirds then have a full stomach but are unable to digest anything. Despite their stomachs being full, the birds starve to death.

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 becomes brittle and breaks into ever smaller fragments. Therefore, the plastic doesn't disappear. It is simply no longer visible to the naked eye. These small plastic particles include fine synthetic fibres that break away from fishing nets drifting in the sea. Experts assign these tiny particles to different categories according to their size: plastic fragments that are smaller than five millimetres are referred to as 'microplastic'. Anything larger than five millimetres is termed 'macroplastic'. Microplastic does not just occur, however, when floating plastic disintegrates. It is also used in industry. Plastic microbeads are added to many cosmetic and personal hygiene products, the aim being to improve the cleansing effect of items such as facial scrubs.

This microplastic poses a threat to many animals. They have a particularly significant impact on animals that filter water, such as mussels. These creatures survive by filtering minute plankton from the seawater. In doing so, they consume microplastic. As they are unable to digest it, it forms deposits in their bodies and therefore enters the food chain. An additional problem is that seawater contains many persistent organic pollutants (*POPs*) such as DDT and PCB that enter the sea via rivers and coasts. As they share similar chemical properties, these pollutants often form deposits on the surface of microplastic fragments. As a result, microplastic fragments 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 of the organism. On the one hand, these toxic substances can cause great harm to the creatures concerned, as they affect their hormone systems or can even cause cancer. On the other hand, the pollutants enter the food chain as soon as they are consumed by the plankton-eaters. Once they have been eaten by first-level consumers, the pollutants are then passed up the food chain from one level of consumers to the next, accumulating in the process.

Accumulation of toxic organic substances in the marine food chain



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HUNTING FOR EVIDENCE IN THE OCEAN -WHERE DOES THE PLASTIC WASTE END UP?

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.





Seas at risk

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



Plastic doesn't 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 'microplastic', as they are sometimes microscopic in size. The plastic is still there. It is simply no longer visible to the naked eye.

'Microplastic' is used to refer to plastic fragments that are smaller than five millimetres. All pieces larger than five millimetres are termed 'macroplastic'.

EXERCISE 22:



On the hunt for microplastic

EXPERIMENT: Searching for microplastic in everyday products

Materials:

- Petri dishes
- Waterproof felt-tip pens
- Water tanks (plastic aquariums)
- Body scrub
- · Shower gel
- Fleece
- Scales
- Binocular microscope or magnifying glass

- 3 microsieves (100-300 micrometres) or filters (e. g. coffee filters)
- Wash bottle with distilled water
- Microscope
- Microscope slide
- Cover slip





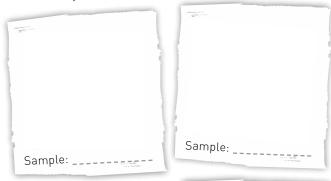
Method:

Weigh out two grams of each cosmetic product. To do so, place a Petri dish on the scales and add the sample. Use a wash bottle to transfer the sample to a microsieve or a filter. Rinse the sample in the microsieve or filter under the tap or in a water tank. Be careful with the water pressure so that none of the sample is lost. It should be rinsed until the sample no longer foams up. Using the wash bottle, transfer the rinsed samples to clean Petri dishes. Observe the samples with the binocular microscope.

Repeat the process with various cosmetic products and with fleece. Now take a little filter residue, add a drop of water and place it on a microscope slide. Cover your slide with a cover slip. Small air bubbles may appear in the slide. Study your slide with the microscope, starting at the smallest zoom, and make a sketch of at least three different samples.

Observation:

Draw your observations in the space provided and label your sketch!



Evaluation:

Plan an experiment designed to find out the plastic content of different cosmetic products. Select a cosmetic product and filter the entire sample.







Scouring the sand

EXPERIMENT: Scouring sediment and sand samples for microplastic

Materials:

- Petri dishes
- · Jam jars
- Tap water
- Salt
- Binocular microscope or magnifying glass
- 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)

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 binocular microscope or the magnifying glass. Can you spot any microplastic 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 microplastic now? Note down your observations.

Explain why microplastic poses a danger on the beach and think about how you could free the beach from microplastic. 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, 45 min./evaluation

Exercise 16: moderate, 55 min. Exercise 17: moderate, 10 min. Exercise 18: moderate, 45 min. Exercise 19: 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 waste diary week, there will be much more rubbish 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 and 17** in this chapter, it makes sense to do **exercise 2** from the chapter 'Using or polluting'. The photos of the beaches covered in rubbish 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. The fact that plastic waste does not biodegrade quickly is illustrated to the pupils when they classify different types of waste according to their biodegradation rates.

In exercise 18, 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 biodegrade 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, nylon stockings (polyamide), fishing lines (polyamide), yogurt pots (polystyrene) and plastic bottles (polyethylene terephthalate).

Exercise 19 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 20: moderate, 30 min. Exercise 21: easy, 20 min. Exercise 22: easy, 30 min. Exercise 23: moderate, 30 min.

Exercise 20 shows the pupils what happens to the various plastic types when they enter flowing bodies of water 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 microplastic as a result of mechanical forces and sunlight. They then sink.

Exercise 21 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.

Exercise 22 is a simple experiment that nevertheless makes a big impact. It illustrates another big problem: microplastic enters the environment due to many people's ignorance. The small plastic particles in various cosmetic products enter the sewer system and then the treatment plants. These plants, however, do not have the right equipment to filter out this plastic, meaning that the particles enter the water cycle. Many of the cosmetic products studied will be used by the pupils at home. The experiment offers an insight into the amount of microplastic in cosmetic products. The introductory text can be used to make the pupils more aware of the consequences. It is also an opportunity to introduce alternatives to the cosmetic products concerned, such as facial scrubs with sea sand. Scrubs are also easy to make at home with olive oil and sugar. The second part of the experiment reveals how much microplastic is contained in each product.

The ingredients list makes it relatively easy to see whether a product contains plastic. The most common plastics used are polypropylene (PP), polyethylene (PE) and acrylates copolymer (AC). There is also a wealth of online information on products that contain microplastic.

Exercise 23 is another practical experiment. This time, the aim is to work out the microplastic content of various samples. The pupils can spot the plastic using a magnifying glass or with the naked eye. 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.



Introduction

OVER TO YOU

We humans have been using rivers, seas and oceans since time immemorial. We try to avoid natural hazards such as storm surges and tsunamis. The sea poses a danger to us – but we also pose a danger to the sea. We pollute and exploit it.

But alongside the many items of bad news concerning the state of our seas and oceans, 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 doing something) that came into force in 1986. It has played a significant role in putting a stop to the hunting of large whales in almost all 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 powering 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.

Pollutant limits for ship exhaust fumes, the whaling moratorium and the protection of the ozone layer are all examples of global treaties.

The issue of plastic waste in rivers, seas and oceans is also a global problem, which is why efforts to fight the issue should not be put on hold. Laws will no doubt be passed in the near future that, for example, prohibit the use of microplastic in cosmetic products. In fact, this has already happened in some countries. But laws are not everything; the actions of each and every individual matter.

It doesn't 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 seas and oceans.

CHAPTER 4 OVER TO YOU - EXERCISES

Master copy WHAT CAN DO?

We humans have been using rivers, seas and oceans since time immemorial. These habitats give us a great deal of resources. 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 behaviours and inform those around us.

It is, of course, also important that change is pushed through 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.





Setting a good example - part 1

Gather information on the good examples listed here in which global marine protection and changes to behaviour have led to an improvement in the state of the seas. You may use the Internet for research.

The examples are:

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

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

Research phase:

- Find information on a treaty for the protection of seas, oceans 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 25: 25

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 and go on 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 oceans. 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 in the world 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'.



Goal 14:

The aim of Goal 14 is 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 target stipulates that 'at least 10 per cent of coastal and marine areas' should be conserved by 2020.

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. Target 13 is concerned with climate change, whereas target 14 deals with seas and oceans (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. In Germany, plans for achieving the targets are currently being devised by the Federal Chancellery and the other Federal Ministries and are due to be finalised in autumn/winter 2016.





Source: United Nations

CHAPTER 4 OVER TO YOU - EXERCISES

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THE MANY ASPECTS OF ENVIRONMENTAL PROTECTION

Each and every one of us can do our bit. In order to reduce plastic consumption, you can apply the 'three R's' rule. The three R's are 'reduce', 'reuse' and 'recycle' – and further R's – such as 'refuse', 'repurpose' and 'rethink' – can be added.

1. REDUCE

Here, the aim is to cut down on things that you don't actually need. Do you really need the latest smartphone or yet another pair of shoes? If you are now thinking about throwing away everything that is surplus to requirements, then this would be the wrong approach. You can get rid of superfluous items in other ways, such as by getting them to places where they can still be used. Therefore, you should sell, give away, donate or swap your items instead.

2. 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 alternatives.

3. 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.

4. REFUSE

This means saying no whenever you are offered things that you don't need. Classic examples include advertising brochures, straws and free plastic bags. In many cases, there are eco-friendly alternatives to these products that you can either buy or make yourself at home, e.g. scrubs.

5. REPURPOSE

Many products can be repurposed, i.e. used for something else. All it takes is a little bit of thought and creativity. There are plenty of examples these days.

6. 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 not only to private individuals, but to businesses, politicians and the research community. One example could be a future decision to stop making cosmetic products and toothpaste containing microplastic.







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

Master copy

PROJECT WORK

Working together against the flood of plastic

- 1. Choose one of the four project titles (1. Less is more, 2. As good as new, 3. How recycling works, 4. Rethinking and changing) and work on it in your class or project group. Split up into at least four groups. Each group should work on one project.
- 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 oceans 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 oceans?
- 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 an one-off event?

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?

UPCYCLE

PROJECT 2: AS GOOD AS NEW

Not all products can be easily recycled. Plastics, for example, do not retain their original quality after melting. 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 with different function. Both processes are examples of how plastic waste can be repurposed.



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.

Resources can be saved in this way.

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 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.



RECYCLE

PROJECT 3: HOW RECYCLING WORKS



Many valuable materials can be found in waste packaging such as that used for food. It is therefore 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. In order to reuse the energy, it is extracted in various ways, such as by burning waste.

Exercises:

- 1. Write down and explain what happens to the waste produced at your home and research the paths taken by the different types of waste. 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 Germany, a neighbouring country and a developing country?



PROJECT 4: RETHINKING AND CHANGING

You have now learnt 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 and to make other people aware of the problem.

Exercises:

er an Hill

I. If you have found microplastic or macroplastic in the local environment or if you are simply interested in the topic, you could speak to the operators of a treatment plant in your area. Ask questions that matter to you.

Sample questions:

How can microplastic – such as particles from cosmetic products that enter waste water – be removed from the water? What equipment do the operators of treatment plants need? Why is this equipment not available everywhere in Germany?

Why do consumers not use alternative products?

- 2. Speak to the mayor of your town/city or the local bylaw enforcement agency. What can be done in your town to make our rivers and therefore seas and oceans cleaner? Do you have any other questions?
- 3. Visit a supermarket near you and look for products with unnecessary plastic packaging. Ask the supermarket company 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 addresses of the firms that make the products in plastic packaging. Write to these companies and ask why they have chosen to package the products in this way.

Notes for teachers

Exercise 24: moderate, 30 min. Exercise 25: easy, 45 min. Exercise 26: moderate, 90 min.

Exercises 24 and 25 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 26 gives the young people a chance to get active. This exercise also allows them to reflect on the content of the entire module 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.



ARE YOU NOW A REAL PLASTIC PIRATE?



What have you experienced during the module?	Who would you like to tell about the problem of plastic waste, and why?
How has the project changed your view	What have you learnt about yourself
of the issue of plastic waste?	throughout the project?
What did you find particularly surprising	What will you do to protect our
What did you find particularly surprising during the programme?	What will you do to protect our seas and oceans in future?
	seas and oceans in future?
What was the biggest challenge	Are you ready to change your habits and
during the programme?	Are you ready to change your habits and produce less waste? If so, what exactly
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What was the biggest challenge	Are you ready to change your habits and produce less waste? If so, what exactly
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GLOSSARY 63

Glossary

Additives = substances that are added in small quantities during plastic production in order to induce or enhance specific properties

Algae = a group of non-vascular plants comprising many species and forms that live in the water and practise photosynthesis

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 = weather conditions in one place over the course of a year

Condensation = the process by which gas turns into liquid
Corals = immobile cnidarians that form colonies (stony corals)
DDT = dichlorodiphenyltrichloroethane, a long-lasting insecticide that has been used to poison insects since the 1940s and that 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 = conversion of a product into a lower-quality end product

Earth's atmosphere = the envelope of gases surrounding the earth

Ecology = describes the relationships between organisms, as well as between the organisms and their environment

Elastomers = less tightly branched plastics with elastic properties

Expedition = research trip

Fleece = artificial fabric used for clothing, often made with polyester

Food chain = complex feeding relationships between organisms in an ecosystem

Gills = the respiratory organs of aquatic wildlife

Invasive species = non-native, introduced species

Macroplastic = items of plastic that are larger than 5 mm

Microplastic = fragments of plastic that are smaller than 5 mm

Monomers = molecules that may bind together to form 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

Oceanic trenches = elongated but relatively narrow depressions in the seabed

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 (0₃).

It is located at an altitude of 15 to 30 km and protects life on earth from the harmful effects of high-energy sunlight

PCBs = polychlorinated biphenyls – toxic and carcinogenic organic chlorine compounds that were previously used as plasticisers and flame retardants for plastics. They have been

Photosynthesis = the natural production of high-energy organic compounds from low-energy inorganic substances using light energy

banned globally since 2001.

Phthalates = substances used as plasticisers for plastics such as PVC and for rubber

Plankton and plankton blooms = organisms that live in the water and are carried on the currents. The term includes both animals (zooplankton) and plants (phytoplankton). A plankton bloom describes the mass reproduction of plankton

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 animals and plants **Predators** = living creatures that kill and eat other living creatures

Prey = animals that are caught, killed and eaten by predators
Recycling = the process of enabling waste products to be
reused

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 = refers to a recurring period of the year, such as

summer

ar ar right

Sediment = natural substances that have been deposited on land and at sea, such as the remains of organisms, sand, chalk Spawn = the eggs of snails, fish and amphibians laid in the water Specimen population = total number of individual specimens of a single species that inhabit a specific connected habitat Subtropical gyres = circular surface currents in the oceans. Both the Pacific and Atlantic are home to two such gyres, one above the equator and one below the equator

Thermohaline circulation = combination of ocean currents driven by differences in temperature and salt concentration **Thermoplastics** = unbranched plastics that lose their form when exposed to a particular temperature range

Thermosetting polymers = tightly branched plastics that can no longer be deformed once they have set

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 areas = larger settlements with a high population density

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