



## » WHY IS THIS IMPORTANT?

Humans have altered and will continue to alter their environment, while remaining dependent upon marine ecosystems as resources of food, water and materials. Human populations are both moving to, and growing in coastal areas globally. Consequently, there is an increased reliance on, and use of, these coastal resources, ranging from fishing and aquaculture activities to desalination for drinking water and recreational use of beaches and coastal areas.

Increasing our knowledge of the connections between human health and the ocean has many public health applications, ultimately allowing us to:

- improve our understanding of the potential public health benefits from marine and coastal ecosystems;
- reduce the burden of human disease linked with marine environmental causes; and
- anticipate new threats to public health before they become serious.

## » WHAT DO WE MEAN WHEN WE TALK ABOUT HUMAN HEALTH AND THE OCEAN?

There is increasing recognition that the health of the ocean is inextricably linked to human health and wellbeing in a number of ways. In other words, the marine environment impacts human health. These impacts are a complex mixture of negative influences (e.g. from extreme weather events such as cyclones to water-borne illnesses and pollution) and beneficial factors (e.g. from natural products including seafood to marine renewable energy and wellbeing from interactions with coastal environments).

Humans also impact the ocean in a number of ways. Through our activities, including pollution and overfishing, as well as global climate change, we are directly and indirectly affecting the health of the ocean. This in turn has significant implications for human health, particularly if future potential medicines from the seas, as well as important sources of protein in seafood, are lost due to contamination as a result of human activity and the effects of climate change.

Considering these factors together, the study of human health and the ocean is the study of all the ways in which the ocean influences our health and wellbeing, and in turn, how we influence the health of the ocean.

## » WHAT ARE THESE FACTSHEETS FOR?

With these factsheets, we want to communicate the idea that the marine environment, its structure and processes have a major bearing on current and future human health and wellbeing, and public health more broadly. We also want to spread the message that we all share the responsibility of looking after the ocean and it is in our own interests to do so. By taking small actions and changing our habits we can make a big difference.

With this in mind, each of these 5 factsheets explores a different topic and explains how human health and the ocean are connected. In addition, each factsheet suggests 'ocean-friendly' actions that you can take.

We now have an opportunity to mitigate and prevent further destruction of the ocean environment, and in turn, protect the health of current and future generations of humans and other organisms.

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Watch the animation and find out more at

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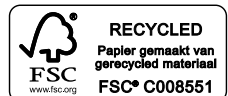
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# The Ocean is Planet Earth's Life Support System



The ocean plays a fundamental role in supporting life on Earth by regulating our climate. It does this by storing and transporting huge amounts of heat, water and greenhouse gases (such as carbon dioxide). By absorbing heat as well as large amounts of carbon dioxide, the ocean lessens the effects of climate change\* experienced on land. However, this comes at a cost to ocean health and therefore human health.

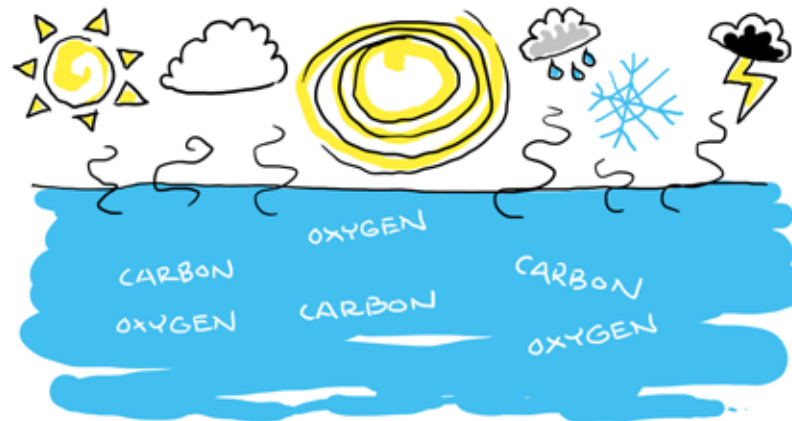
We can reduce the stress we put on the ocean and limit further climate change by decreasing our carbon footprint (a measure of environmental impact in units of carbon dioxide).

\*Climate change refers to long-term changes in the Earth's climate as a result of increased concentrations of atmospheric greenhouse gases through human activities, which is warming the planet. Current impacts of climate change include sea level rise, decreasing amounts of snow and ice and changes in rainfall patterns and growing seasons as well as increased occurrences of extreme weather events.



## » THE OCEAN AS CLIMATE REGULATOR & CLIMATE CHANGE BUFFER

- Ocean currents redistribute heat around the globe. For example, winters in Northwest Europe are 5°C warmer than they would otherwise be because of the Gulf Stream, an ocean current in the Atlantic that draws warm tropical water northwards. Without currents, regional temperatures would be more extreme, i.e. extremely hot at the equator and frigid toward the poles with the result that much less of Earth's land would be habitable.
- Almost all rain that falls on land comes from water evaporated from the ocean. This water helps support all life on land, and we store it to provide drinking water and irrigate crops.
- The ocean currently plays a critical role in reducing the effects of climate change by acting as a buffer. With a volume of 252 billion billion gallons of water, the ocean acts as a vast store of heat, absorbing about 90% of the additional heat as a result of global warming and about 30% of human emissions of carbon dioxide.



## » CLIMATE CHANGE IMPACTS ON THE OCEAN ALSO IMPACT HUMAN HEALTH

- Changes in the distribution of marine life mean that the fish and shellfish we eat could become more abundant in some parts of the world, and less so in others, with profound impacts to commercial fisheries.
- Warming sea temperatures can lead to an increase in the growth rate of marine pathogens (disease-causing microorganisms). Within Europe, there is concern that the bacteria *V. vulnificus* and *V. parahaemolyticus*, a leading cause of seafood-associated illness, may represent an increasing clinical problem as a result of increasing water temperatures.
- The impact of changing ocean conditions on weather patterns also has consequences for food crops grown on land through changes to rainfall patterns, growing seasons and the occurrence of extreme weather events such as drought. This can lead to food shortages and increased food prices.
- Other impacts of changing ocean conditions include changes in the frequency and severity of tropical storms, which have major consequences for human wellbeing. At the coast, increases in sea level, caused by thermal expansion of sea water, and melting ice caps, could have major consequences for coastal cities through increased risk of flooding.

## » CLIMATE CHANGE AFFECTS MARINE LIFE

- Increases in water temperature of just 1-2°C can cause coral reefs to become severely stressed, leading to death if thermal stress is prolonged, thereby endangering coral reef ecosystems.
- Marine species may respond to ocean warming by altering their geographic ranges. Temperature change has been linked to geographic range extension and contractions in diverse marine animal and plant species, such as seaweeds, invertebrates and fish. For example, in the Northeast Atlantic, some plankton are moving northwards at a rate of 200-250 km per decade. As a result, the distribution of fish and other animals that feed on them may also change.
- Carbon dioxide reacts with seawater to raise acidity (ocean acidification) and reduces the availability of calcium carbonate for plants and animals to make calcium-based shells, reefs and exoskeletons (outer body coverings). This could have severe consequences for many marine organisms such as coral, clams, mussels, sea urchins, barnacles, and some microscopic plankton.

## » REDUCE YOUR CARBON FOOTPRINT

**Travel:** Use public transport, walk or cycle instead of driving. When you do need to use a car, try to car share.

**At Home:** Turn down the heating, use energy efficient light bulbs and take shorter showers.

**At school or at work:** Turn off electrical items (e.g. lights and computers) before you go home.





Find out more about initiatives you can get involved in and the everyday actions you can take by visiting the Sea Change website.

Remember  
**OUR OCEAN  
OUR HEALTH**

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The warm North Atlantic current (red) transfers warm surface waters to Europe, creating a relatively mild climate in North-west Europe. This warm, salty water eventually cools, sinks and returns southwards via deep ocean currents.

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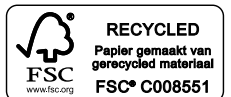
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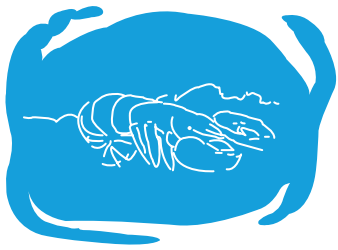
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# Seafood and Human Health

From ancient times, fisheries and aquaculture (the farming of fish, shellfish and aquatic plants) have been an important source of food. These activities also provide economic benefits to millions of people engaged in harvesting, culturing, processing and trading along the world's seashores and waterways. Today, we are facing the challenge of growing demand for seafood together with declining catches from the world's marine fisheries. Therefore, well-managed fisheries are essential to continue providing food into the future.

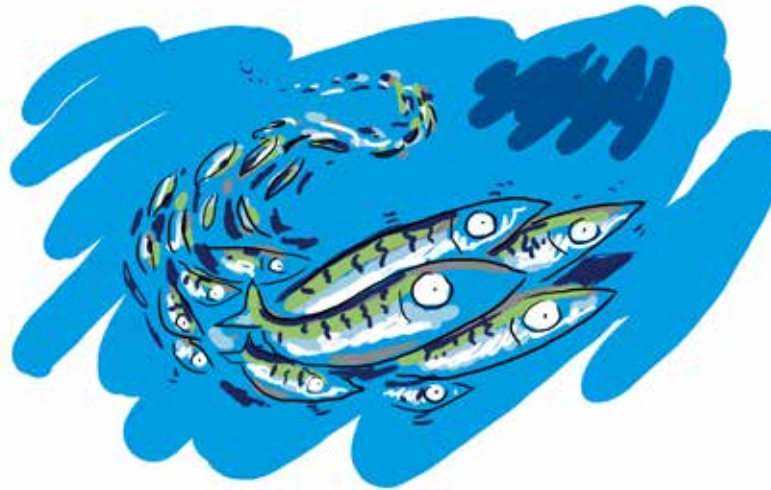
We can help to protect the ocean as a provider of food and health by supporting sustainable fishing practices when we buy seafood.

## » AN OCEAN OF FOOD

- Fish contributes about 17% to the world's animal protein intake. In some small developing island states populations rely on fish for up to 40% or more of their protein intake.
- Worldwide demand for seafood in 2010-2012 was 19kg per person. Currently, average seafood consumption in the EU is 23kg per person per year.
- Other types of seafood also serve as important sources of protein and micronutrients. For example, various types of seaweed contain protein, dietary fibre, vitamins, minerals and amino acids.
- Mussels, rainbow trout and Atlantic salmon are the top 3 species farmed in the EU by volume, followed by oysters, sea bream, common carp, clams and sea bass. Aquaculture accounts for about 20% of Europe's fish production.

## » THE FUTURE OF FISH

- Well-managed fisheries are very important to future food security. Given that current fisheries and aquaculture production is about 136 million tons and assuming an annual fish consumption of 19kg per person per year, it is estimated that 47.5 million additional tons of fish will be needed for food in 2050 to cope with a global population of 9.6 billion people.
- At the same time, the world's marine fisheries catches are declining and fishing is threatening a number of fish stocks. Recent assessments indicate that approximately 29% of fish stocks are overfished while 61% are sustainably (fully) exploited.
- Adoption of better management practices will contribute to sustainable fishing practices that avoid overfishing and support the recovery of fish stocks. These practices include the establishment of new marine protected areas and the promotion of environmentally friendly fishing techniques that minimize fish discards and avoid degradation of marine habitats.
- Aquaculture production is predicted to substantially exceed capture fisheries production in the next few years.



## » SUPPORT SUSTAINABLE FISHERIES

You can help to protect the ocean, the source of your future seafood, as well as the fishermen and communities that rely on it for their food and livelihoods by buying sustainable seafood.

**Get to know your seafood:** Ask your fishmonger about sustainable choices or alternatively, look up a seafood guide for your country.

**Become familiar with EU seafood labelling:** Fishery products sold in the EU must contain information such as the type of fishing gear used and where it was caught. This enables consumers to make informed choices.

**Try something new:** High demand for certain species of fish and seafood can lead to overfishing. Choosing lesser-known fish eases pressure on more vulnerable species and they are often more plentiful. Your fishmonger can advise on preparation.

## » THE COMMON FISHERIES POLICY— MANAGING EUROPE'S FISHERIES

The Common Fisheries Policy is a set of rules for managing European fishing fleets and for conserving fish stocks. The policy aims to ensure that fishing and aquaculture are environmentally, economically and socially sustainable and that they provide a source of healthy food for EU citizens.

## » SEAFOOD AND HUMAN HEALTH – THE GOOD AND THE BAD

- As well as being an important source of protein, vitamins and minerals, seafood has the highest concentrations of omega-3 fatty acids of any foods. Omega-3 fatty acids improve heart health, benefit brain health and development and protect against the development of certain cancers.
- Fish intake is also associated with health outcomes such as reduced depression symptoms in adults and fewer asthmatic and respiratory allergies in children.
- Environmental factors, such as pollution and poor ecosystem health threaten seafood quality and safety. For example, the contamination of bivalve shellfish such as mussels, clams and oysters with norovirus (a common cause of viral gastroenteritis in humans) from human faecal sources is an important human health risk.
- Long-term exposure to pollutants that accumulate in seafood also pose risks to human health. For example, methylmercury is a neurotoxin that can accumulate to high concentrations in predatory fish such as tunas and swordfish. It is recommended that seafood species with a high content of mercury in the daily diet should be limited.





Find out more about initiatives you can get involved in and the everyday actions you can take by visiting the Sea Change website.

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OUR HEALTH**

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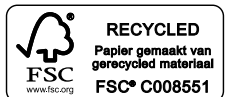
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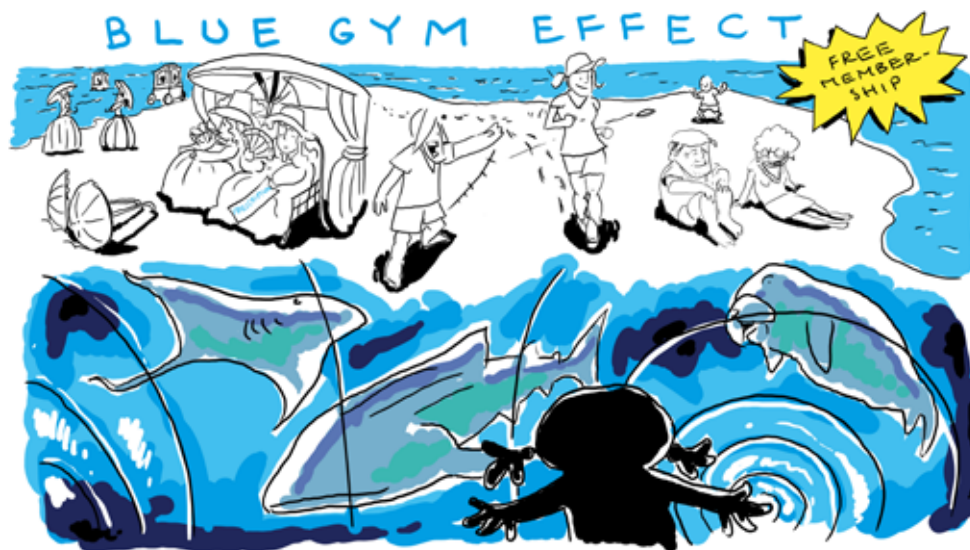
# The Sea and our Physical and Mental Wellbeing

Spending time by the sea has long been associated with health benefits and a sense of wellbeing. Acknowledging the importance of the sea's influence on our mental and physical health, the Blue Gym concept refers to using the coastal environment specifically to promote health and wellbeing by increasing physical activity, reducing stress and building stronger communities.

To continue benefitting from the Blue Gym effect for our own health, we must keep our marine environment clean and healthy.

## » UNRAVELLING THE BLUE GYM EFFECT

- More feelings of restoration (i.e. feeling calm, relaxed, revitalized and refreshed) are recalled by individuals after visits to coastal environments compared to rural/countryside environments and urban green/open spaces.
- Families in Southwest England emphasized that the key health benefits they experienced from living in coastal regions were psychological, including experiencing fun, stress relief and engagement with nature. Other benefits indicated were increased social and family interaction and encouragement to be physically active.
- Populations living near the English coast have higher levels of self-reported health than those living inland. The positive effects of coastal proximity were greater amongst more socio-economically deprived communities, indicating that access to 'good' environments may play a part in reducing health inequalities.
- A laboratory study found that higher restorativeness was associated with pristine rather than littered coastal scenes. This demonstrates that the presence of marine litter can undermine the psychological benefits that the coast provides and that as well as the environmental costs of marine litter, there are also costs to people.



## » EXPERIENCE THE BLUE GYM EFFECT FOR YOURSELF

**Walk by the sea:** Coastal walking is the single most popular activity which connects people to the sea.

**Visit an aquarium:** Spending time in aquariums has been shown to have positive effects on mood, heart rate and blood pressure.

**Leave only footprints:** Take your litter home with you when you visit the beach.

## » FUTURE BLUE GYM RESEARCH

- **Mechanisms of the Blue Gym effect:** Future research seeks to uncover the mechanisms by which positive health benefits are conferred. For example, could lower levels of air pollution in coastal areas be part of the explanation for the positive health effects observed?
- **Using Blue Gym for Healthcare:** The de-stressing properties of the Blue Gym effect are being investigated for use in healthcare through the use of virtual reality. In a study simulating dental experiences, people felt (and recalled) less pain when "at" the virtual beach (the virtual reality environment used is displayed on the back of this page).
- **Healthcare Savings:** The translation of the Blue Gym effect into healthcare savings is beginning to be investigated. Exercising outside offers benefits in treating or even avoiding the onset of obesity, depression and many other conditions currently on the rise. Taking the healthcare savings and societal benefits of physical activities in the marine environment into account alongside the need for local economic growth could influence marine spatial planning in terms of improving coastal access and water quality.

## » TOURISM IS INFLUENCED BY THE BLUE GYM EFFECT

- The positive effect of coastal environments on human health and wellbeing and the preference of many people to spend their leisure time at the coast has resulted in the coastal and maritime tourism sector representing over one third of Europe's maritime economy.
- 'Sea' and 'view' combined are considered to be the two most 'expensive' words in the English language, referring to the fact that people are willing to pay more for homes and hotel rooms with sea views.
- Coastal and maritime tourism is listed as one of the five focus areas for delivering sustainable growth and jobs as part of Europe's Blue Growth strategy. The strategy acknowledges that high quality bathing waters and pristine coastal and marine habitats have a high recreation value.





Find out more about initiatives you can get involved in and the everyday actions you can take by visiting the Sea Change website.



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A virtual reality environment used in a study simulating dental experiences and people's recollection of pain (Tanja-Dijkstra *et al.*, 2014).

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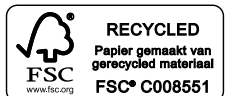
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The Blue Gym Initiative was created in 2009 and is run by a team of researchers working at the European Centre for Environment and Human Health at the University of Exeter, UK.



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# The Ocean – A Treasure Trove for Human Medicine



The ocean is home to a vast variety of organisms, diverse in their adaptations to the marine environment. Marine organisms produce an abundance of natural products to defend themselves against predators, to locate mates, to communicate and to compete for space and food. Many of these compounds have no terrestrial equivalents and are unique in terms of chemical structure and biological activity.

Studying the physiology of marine organisms (the study of how an organism and its body parts function) and their natural products has increased knowledge of how our own bodies function and uncovered new medicines to treat disease. These are compelling reasons why we need to protect marine biodiversity into the future. There is much more to discover.

## » THERE ARE 7 MARINE-DERIVED MEDICINES IN CLINICAL USE

Compound	Disease Area	Marine Organism	Species
Trabectedin	Cancer	tunicate	<i>Ecteinascidia turbinata</i>
Eribulin Mesylate	Cancer	sponge	<i>Halichondria okadai</i>
Cytarabine	Cancer	sponge	<i>Cryptotethya crypta</i>
Brentuximab vedotin	Cancer	mollusc	<i>Dolabella auricularia</i>
Ziconotide	Chronic pain	cone snail	<i>Conus magus</i>
Vidarabine	Antiviral	sponge	<i>Cryptotethya crypta</i>
Omega-3-acid ethyl esters	Hypertriglyceridemia	fish	Oily fish such as mackerel and anchovy

Many more compounds are currently going through clinical trials to treat conditions such as schizophrenia, Alzheimer's, chronic pain and cancer. Hundreds more compounds isolated from marine animals, algae, fungi and bacteria have been shown to have antibacterial, antifungal, antiprotozoal, antituberculosis, antidiabetic, anti-inflammatory and antiviral activities.



## » MARINE ORGANISMS TELL US A LOT ABOUT OURSELVES

- As well as being a source of medicines, studying marine organisms increases our knowledge of human physiology and disease. It is the specific adaptations of organisms to the marine environment that makes them so valuable as models.
- **Sharks and the immune system:** Sharks have an immune system with the same fundamental components found in humans. This makes them a good comparative model for studying features of the immune system including autoimmunity (the immune response of an organism against its own cells and tissues), which is the underlying cause of several human diseases such as lupus and rheumatoid arthritis. Sharks also have some extraordinary immune mechanisms which mammals lack, offering exciting new possibilities for immunotherapeutics (using the immune system to fight disease).
- **Sea urchins and the cell cycle:** Sea urchins produce huge quantities of large, clear eggs that lack external coatings, making them ideal for studying the cell cycle, the sequence of events in which a cell reproduces its genetic material and then divides. The discovery of cyclins (a group of proteins that regulate the cell cycle) in sea urchin eggs in 1982 revolutionized the study of the mammalian cell cycle and paved the way for new research into the diagnosis and treatment of cancer.
- **Squid and the nervous system:** The squid giant axon (a nerve fibre that transmits nerve impulses) is 1000-fold larger than vertebrate axons. Its discovery opened up new avenues for researching the nervous system. The concepts that emerged from this research formed the basis for diagnosis and treatment of disorders of conduction in nerves and other tissues such as heart and skeletal muscle.

## » HELP PROTECT MARINE BIODIVERSITY

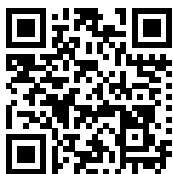
An estimated 91% of marine species still await description. Any one of these species could be holding the key to the next disease treatment.

**Leave only bubbles:** When diving or snorkeling, don't touch coral reefs or marine life, or take souvenirs.

**Select sea-friendly souvenirs:** Don't buy jewellery and products made from marine animals or animal parts, including shells, coral and turtle shell.

**Choose non-toxic cleaning products and low-phosphate detergents:** Products that go down the drain can eventually end up in the ocean and harm aquatic life. Many household chores can be done with simple ingredients like vinegar, baking soda, or lemon juice.





Find out more about initiatives you can get involved in and the everyday actions you can take by visiting the Sea Change website.

Remember  
**OUR OCEAN  
OUR HEALTH**

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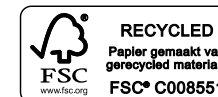
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A colony of *Ecteinascidia turbinata* which is the source of the anticancer agent trabectedin.

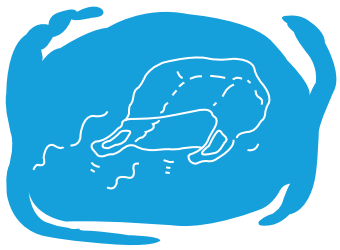


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The ascidian *Aplidium albicans* is the source of an anticancer agent called plitidepsin, which is currently going through clinical trials.







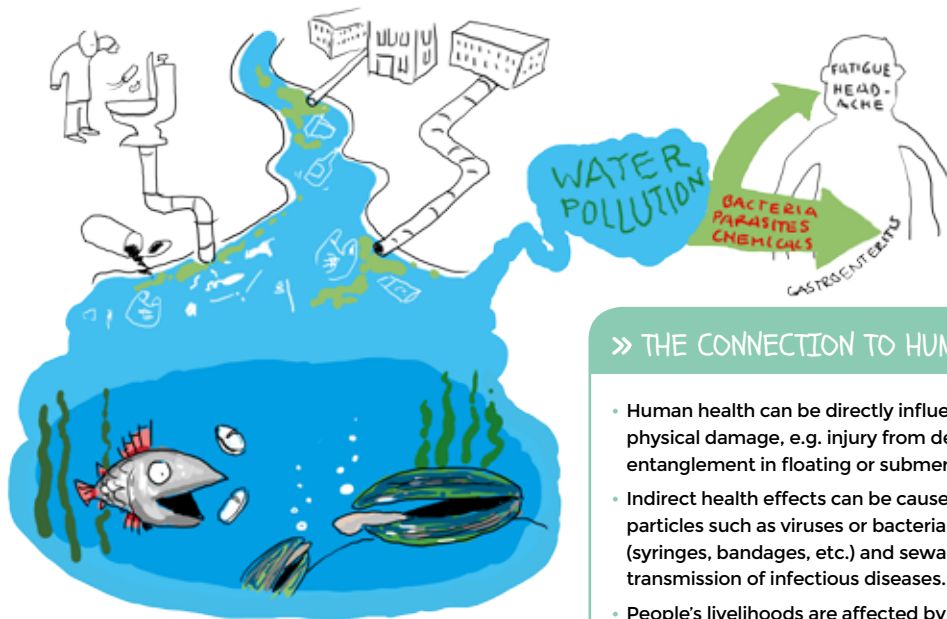
# Marine Pollution and Human Health

Many of our waste products end up in the sea. This includes visible litter as well as invisible waste such as chemicals from personal care products and pharmaceuticals that we flush down our toilets and drains. Once in the sea, these pollutants can move through the ocean, endangering marine life through entanglement, ingestion and intoxication.

When we visit coastal areas, engage in activities in the sea and eat seafood, we too can be exposed to marine pollution that harms our health. We can all help to reduce marine pollution by changing our consumption patterns and reducing, reusing and recycling our waste.

## » SOURCES OF MARINE POLLUTION

- The sea is the final resting place for much of our litter. Common items of marine litter include cigarette butts, crisp/sweet packets, cotton bud sticks, bags and bottles.
- Man-made items of debris are found in marine habitats throughout the world, from the poles to the equator, from shorelines and estuaries to remote areas of the high seas, and from the sea surface to the ocean floor.
- Approximately 80% of marine litter comes from land-based sources (eg. through drains, sewage outfalls, industrial outfalls, direct littering) while 20% comes from marine-based activities such as illegal dumping and shipping for transport, tourism and fishing.
- Plastics are estimated to represent between 60 and 80% of the total marine debris. Manufactured in abundance since the mid-20th century, most of the plastics that have been produced are still present in the environment.
- The cumulative amount of plastic produced since the mid-20th century is of the order of 5 billion tons, enough to wrap the Earth in a layer of plastic wrap. The amount projected by 2050, on current trends, is about 40 billion tons, which is enough to wrap 6 layers of plastic wrap around the planet.



## » THE CONNECTION TO HUMAN HEALTH

- Human health can be directly influenced by marine litter in the form of physical damage, e.g. injury from debris such as broken glass, medical waste or entanglement in floating or submerged debris.
- Indirect health effects can be caused by chemicals, toxins or other harmful particles such as viruses or bacteria in the water. For example, medical waste (syringes, bandages, etc.) and sewage pose a public health hazard through transmission of infectious diseases.
- People's livelihoods are affected by marine pollution. For example, littered beaches or polluted water does not attract tourists. Fewer tourists means less income for coastal communities.
- Plastic particles have been found in a wide variety of species including some that we eat, such as bivalves (e.g. mussels), crustaceans (e.g. crabs) and fish. The risk of chemicals adhered to plastics transferring through the food web from marine organisms to humans has not yet been conclusively established and represents an important knowledge gap.

## » A DANGER TO MARINE LIFE

- Observed effects in wildlife attributed to microcontaminant exposure (a diverse class of chemicals including pharmaceuticals, pesticides and industrial chemicals) include reproductive abnormalities and behavioural effects.
- All sea turtle species, 45% of all species of marine mammals, and 21% of all species of sea birds have been affected by ingestion of or entanglement in marine debris, with plastic items being the most frequently documented.
- Plastics can absorb toxins from surrounding seawater, such as pesticides and those in the class of chemicals known as Persistent Organic Pollutants (POPs). They can also release harmful constituents such as Bisphenol A (known to mimic the hormone estrogen), as they degrade.
- Because of their small size, microplastics (plastic fragments < 5mm) can be ingested by a wide range of organisms. This can cause physical damage from abrasions, blockages or accumulation of toxins in organisms.

## » SMALL ACTIONS MAKE A BIG DIFFERENCE

The best way we can all help is to minimize new litter entering the marine environment.

**Reduce:** Choose products with less packaging. Better still, choose shops where you can refill your own container.

**Reuse:** Use reusable coffee mugs, water bottles and shopping bags.

**Recycle:** Separate items that can be recycled (i.e. plastic, paper, cardboard).

## » THE MARINE STRATEGY FRAMEWORK DIRECTIVE – PROTECTING EUROPE'S MARINE ENVIRONMENT

Europe's Marine Strategy Framework Directive (MSFD) is the framework for Member States to achieve Good Environmental Status for their marine waters by 2020. Descriptor 10 of the MSFD focuses on marine litter. It states that Good Environmental Status is only achieved when "properties and quantities of marine litter do not cause harm to the coastal and marine environment".





Find out more about initiatives you can get involved in and the everyday actions you can take by visiting the Sea Change website.

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