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TOOLKIT FOR OCEAN CONSERVATION



OSES

OCEAN SUSTAINABILITY THROUGH
EDUCATION AND SPORT

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Introduction

The **OSES Project** (“Ocean sustainability through education and sport”) focuses on the development of tools for federations and local sports actors to educate youth in eco-responsible actions and develop environmental awareness from an early age through water sports. It is built around **three main objectives**:

- Assess the experience and insight of active sports organizations on creating and implementing an awareness campaign and educational methodology towards ocean and seas preservation.
- Develop educational and environmental awareness methodology at local level to foster ocean protection through sport.
- Measure the social and environmental impact of the programme implemented to strengthen advocacy toward ocean protection.

The project is built around four pilot interventions, implemented by sports organisations at local level. Those pilot interventions will consist of integrating pedagogical methodology about ocean protection and environmental awareness into day-to-day sports activities. More than only implementing activities, one of the main objectives is to impact at different levels, in order to showcase the benefits and importance of educating the youth on environmental issues with particular, measurable and identifiable results. By defining the spectrum of analysis and the tools used with relevant stakeholders, the project will ensure that the results obtained are appropriated and translated into operational terms.

Objective

The aim of this document is to develop a methodology on training the youth and training the trainers, including contents, tools, methods, activities, accessible online through our website.

The materials will be sent to the partners. This methodology will further use the different projects and initiatives already implemented by the different partners to adapt it and to better integrate the question of environmental education through and during sports practice.

Also, this methodology will be developed to last in time, that is, the clubs will be able to use it to obtain scientific data as in citizen science, to be able to study these different parameters with practitioners in the future. This will allow the clubs to have enough data to understand how their surroundings change and teach and sensitize the public.

It will be based of the four topics addressed during this project which are the following:

- The impact of climate change on the ocean
- Protection of biodiversity
- Marine pollution
- Coastal protection and management

In order for sport organizations to create awareness programmes, this document will show different tools that they can use to create these programmes.

These tools will be divided into theoretical and practical ones. The first one is a compilation of information already created by some of the partners, the UNESCO and other sources, which is necessary to make a more complete document. This has been designed as a document for consultation for sports organizations so they can adapt it and make their own documents, presentations or even learn about the topics from scratch. The practical tools are a set of devices the organizations will be able to use once they decide which one is more suitable for their sports practice. They will be divided by topic.

Toolkit

The toolkit will consist on different sections: theoretical materials, practical materials and a methodology with four examples for the pilot interventions to be carried out during the duration of the project.

Theoretical tools

The tools that have been gathered in this document have been extracted from the UNESCO's Ocean Literacy platform, Surfrider Foundation Europe, Dan Europe, EMSEA and external sources. The complete versions of some of the tools will be added in the annex section.

The "Ocean knowledge unit" (Annex pages 6-26) was created to compile the most important definitions, topics and issues regarding the ocean. It also includes some sections related to the Mediterranean Sea in Malta, English Channel in France, Rias/Estuaries in Spain and the Atlantic Ocean in the coast of Portugal. We wanted to highlight the places where the pilot interventions will take part.

The document is organized as follows (this sums up the real table of contents of the document which can be found in page 6 of the Annex):

1. Ocean Literacy and its 7 principles
2. Marine pollution (water quality, marine litter and acoustic pollution)
3. Protection of biodiversity
4. The impact of climate change on the ocean
5. Coastal protection and management
6. Bibliography

For the topics in section 2, 3, 4 and 5 we tried to explain each of them by defining their name and what it refers to. Once this was done, we presented the current situation of each topic, some examples to make it easier to understand and some solutions to each of the issues so the readers could learn how individual and collective actions can be the key to change.

This unit could be modified, shortened, adapted, etc. by the organizations. Its purpose is to serve as a starting point and guidance tool to build their own materials.

As mentioned above the unit was built extracting content from different sources (internal of the project and external to it). We will mention some of them, the rest can be found in the unit's bibliography.

To create the Ocean literacy (from now on referred as OL) section, the content used was from the [UNESCO's Ocean Literacy Portal](#). This website uses many tools to learn about OL like articles, videos, etc. It also provides training courses for educators, media and government officials. It is a very complete site which has many possibilities to improve and expand knowledge.

This can be combined with the resources from our partner EMSEA which developed a [series of educational videos](#) regarding OL and its 7 principles. And also complemented with their [publications](#) (in different languages).

To create the sections 4 and 5 and the subsections of Marine litter and Water quality, the content used was the one from [Ocean Campus](#), an educational website from Surfrider Foundation Europe. This website contains various topics such as marine litter, water quality, climate, coastal development, sea shipping and wave protection. It aims to educate via videos, quizzes, articles, etc. for different levels (junior, intermediate, advanced). Besides, this platform can be found in 4 different languages: Spanish, French, English and German.

The rest of the topics addressed in the unit were extracted from different sources which are mentioned throughout the text using number as a reference to find them easily on the bibliography section on pages 25-26 of the Annex.

Along with the materials used to build the unit, there is also educational material developed by our partners DAN Europe and Ocean as Common which they use in their awareness activities. An example is DAN Europe, which has developed and [e-learning platform](#) where students, or any user, can choose from their course

catalogue and start learning about various topics such as OL, climate change, citizen science, plastic pollution, etc. The courses are in Italian and English.

Also, Ocean as Common's Aquasphere is a philosophical concept including the scientific notion of hydrosphere but also the interconnections between water and the living, and more specifically the relationship between man and water in all its forms. This educational content can be found in their [website](#). More content can be found in their [Youtube channel](#).

Practical tools

These tools have been chosen to be easy to use during the sport practice. They were thought for each of the topics and for different sports. They will be divided by topic and each of them will be added a category for “suggested sport” that could find useful to use it.

These devices have two purposes, to measure parameters and to engage the participants in data collection by interpreting the data gathered, enhancing ocean conservation.

Marine pollution

Although there are many different types of marine pollution, we have focused on the ones that are easy to measure by water sports practitioners as they, from time to time, may be affected by any of them. The ones chosen are water quality measurements, underwater noise pollution and marine litter.

Water quality

To measure water quality there a few utensils we have thought can be useful to estimate the good or bad quality of the waters where aquatic sports are being practised. They are the Forel Ule scale and the Secchi disk.

The Forel Ule scale is a device which allows the user to accurately determine and classify the colour of natural waters. (Reference 56 of the Ocean Knowledge Unit).



Figure 1. Forel Ule scale

The scale as seen in Figure 1, has a series of colours associated with a number, that is the FU number. Some natural phenomena can change water colour but it does not necessarily mean that the water has bad quality. The different colour numbers correspond mainly to these types of water bodies:

- Indigo blue to greenish blue with high light penetration (1-5 FU scale). These waters have often low nutrient levels and low production biomass. The colour is dominated by microscopic algae (phytoplankton).
- Greenish blue to bluish green (6-9 FU scale). The colour is still dominated by algae, but also increased dissolved matter and some sediment may be present. Typical for areas towards the open sea.
- Greenish (10-13 FU scale). Often coastal waters which usually display increased nutrient and phytoplankton levels, but also contain minerals and dissolved organic material.

- Greenish brown to brownish green (14-17 FU scale). Usually with high nutrient and phytoplankton concentrations, but also increased sediment and dissolved organic matter. Typical for near-shore areas and tidal flats.
- Brownish green to cola brown (18-21 PU scale). Waters with an extremely high concentration of humic acids, which are typical for rivers and estuaries.[1]

The Secchi disk (Figure 2) helps to measure turbidity or transparency of water masses. The disk is attached to a rope which has a colour mark every one metre.



Figure 2. Secchi disk with the rope

Additional

To measure the quality of the water by telling which substances are present and in which concentrations, there are a few lab kits that can be purchased. These kits are set for measuring: pH, KH, PO₄, NO₂, NO₃, NH₄ in Fresh or Sea Water.

As an example of this kind of portable kits, you can find the one in Figure 3, which is often used by our partner DAN Europe.



Figure 3. Compact lab water tester

How to use these tools?

Forel Ule and Secchi disk

1. First, slowly lower the disk into the water until it disappears from sight and note down the depth. If possible, this has to be done in the shaded area.
2. Slowly raise the disk until half of the Secchi dept.
3. Determine the colour of the water with the Forel Ule scale (in the shade).
4. Compare the colour observed on top of the Secchi disk, with the colours of the scale (over the white bars).
5. Record the FU number. [1]

Water sampling kit

This depends on the kit purchased but usually requires to get a sample of the water subject to analysis. Once the sample is taken, it is divided into smaller tubes and a few drops of different substances from the kit can be poured into each tube. It is important to read the instructions as these substances need time to react when in the water sample and may take a few minutes. Once the time is completed, the water in the tubes may have had a change in colour and now it is time to compare the colour in the tubes with the colour chart provided by the kit.

Recommended for: snorkel, diving, surf, kayak, sailing, etc.

Acoustic pollution

Noise pollution has been studied for decades so our aim with this tool is for the aquatic sports practitioners to be able to measure the noise and see if they are also affected by it or think on how it affects marine life in the area.

This hydrophone works as a microphone. It only needs to be plugged to an amplifier and a speaker and the user will be able to hear if there is any noise underwater. They can also plug it to a phone and record the sound.



Figure 4. Hydrophone and amplifier

How to use this tool?

The hydrophone is very easy to use, it just needs to be plugged into the amplifier and phone/speaker. Then, the side not plugged to anything needs to be introduced in the water to whatever depth the wire allows the user.

It is best to use while being in a boat because it provides more stability.

Recommended for: kayak, sailing, etc.

Marine litter

Marine litter has been an issue for the last decades and plenty of organisations are completely involved in understanding and stopping it. It can be found on beaches, rivers and oceans which is of great concern to scientists and citizens. That's why we have chosen a set of utensils to make the litter collection easier.

The tools can be used to collect microplastics, too (as there is a sieve in the kit). There are also some dynamometers (50 gr and 250 gr) and a scale (32 kg), to weigh the litter.



Figure 5. Different dynamometers and scale, on the left, and a sieve on the right.

Some of these materials can be provided by Surfrider (Figure 5) thanks to its Ocean Initiatives program which sends them for free.



Figure 6. Gloves, reusable bags and recycled plastic bags.

We have also included a couple of nets (Figure 7), one for underwater sports and the other one useful for sports that require any kind of vessel such as sailing or kayak. The first one on the left, is very convenient for underwater sports because it allows to collect litter while snorkeling or diving instead of using a plastic bag which can be uncomfortable for the user's mobility.



Figure 7. Nets.

How to use these tools?

The way to use these tools is first to decide where the litter collection is going to take place: beach, underwater or by boat.

If it is a beach collection, the material that can be used are the gloves, bags, sieve and dynamometers or scale. Here, we need to consider what do we want to collect and measure, microplastic, macroplastic or both.

Microplastic requires to follow a specific methodology to be able to collect robust data scientists can later use in their research. By using the sieve, sand can be separated from the microplastics.

Macroplastic sampling can also follow a methodology and use a protocol. The utensils most common used are gloves, reusable and recycled plastic bags. Of course, it is important to quantify the items following the protocol and after that, classify it by materials so they can be correctly disposed in bins.

If the collection is underwater, the gloves are still needed, and the nets are more useful than the bags. So, once again, following a specific protocol for underwater collections is the most adequate way to collect litter, quantify and classify it.

Some sports using boats such as kayak or sailing boats might find easier to use the telescopic nets. They allow them to reach floating litter that may be far to reach from inside the boat. So, this is a safe way to do it.

Once the litter is correctly quantified and classified by materials it can also be weighted with the different scales mentioned above.

At the end of this document, all the information about protocols, guides and databases to upload the data can be found.

Recommended for: snorkel, diving, surf, kayak, sailing, etc.

The impact of climate change on the ocean

Climate change is affecting the ocean in a local and global scale and in many different forms. In this project, we would like to show an easy way to study it a local level by measuring the temperature of the water with a thermometer (Figure 8). By measuring it often, the data collected will be able to show if the temperature was different from the previous years by being warmer or colder or just remaining the same.



Figure 8. Thermometer.

How to use this tool?

Thermometers just need to be introduced in the water and after a few seconds they will show the temperature. The example shown in Figure 8, is a floatable one with a rope in case it is used from a boat or when the water conditions aren't favorable.

Recommended for: snorkel, diving, surf, kayak, sailing, etc.

Coastal protection and management

Nowadays, with the increasing frequency of marine weather phenomena such as storms and the population growth in coastal areas, communities are rethinking the way which coastlines are developed.

By taking a photo of a reference place, and always from the same place, the users will be able to observe how these weather phenomena affect the coast throughout time. This photo can be taken with a phone and, for stability it is suggested to use a tripod like the one included in this toolkit (Figure 9).



Figure 9. Tripod.

The interesting thing about these time series photographs is that they can be taken every day, weekly, every two weeks, once a month, etc. It is important to have several photos of different times of the year to observe the change over time.

How to use these tools?

1. Choose a reference place you can photograph throughout the year. It can be a cliff, a beach, buildings close to the coast, etc.
2. Deploy the tripod, attach the phone and set it in a suitable place.
3. Take a picture and save it.
4. You can either upload it to a citizen science app or save it and create a time-lapse with all the photos taking in that period.

Recommended for: snorkel, diving, surf, kayak, sailing, etc.

How to use these tools?

- Gather information of your local marine species. These species can include invasive species and key species important for a healthy ecosystem.
- Then, you can build a table with pictures of the species and both their common and scientific names. There is an example in pages 27-28 of the Annex.
- It can have instructions for the users, and it is important to save enough space to note each of the observations made of each of the species.

Recommended for: snorkel, diving, surf, kayak, sailing, etc.

Additional material

Other utensils that can be useful are water resistant phone cases, pens or pencils, folders and a waterproof bag to store the materials in a safe place.



Figure 11. Example of a folder and phone cases.

Where to upload the data?

This toolkit will provide the user with the opportunity to collect data for different parameters. For each of the thematic and measurements, we will suggest a website/app/spreadsheet to upload the data so it can be added to the database of research projects. The participants will be asked to also fill in the documents created during the project so the partners will have the backup data to consult/use in the future. These documents will be added in pages 2-5 of the Annex.

Once the user starts collecting data it is very important to keep a register of the data collected. An example would be a table like the one shown in page 2 of the Annex. Simultaneously, data can be collected following the different protocols mentioned below (these are just some suggestions, for some categories there are plenty of protocols):

- Marine Litter
 - Macro litter
 - Diving and snorkeling → Information about the steps to follow, the requirements and the datasheet can be found in Dive Against Debris [website](#).

- For beaches, kayaking, sailing, etc. → Surfrider Foundation Europe developed a program called [Ocean Initiatives](#) where anyone can organize or join a waste collection. The protocol, guide and materials can be found in the website.
- Microplastics in beaches → Sea observers offer a variety of projects where data can be uploaded. In this case we have chosen the project [Microplastic watchers](#) which has plenty of documentation to learn how to sample and collect microplastics.
- Water quality
 - Forel-Ule and Secchi disk → OSES project Excel spreadsheet (pages 3-4 of the Annex)
 - Compaq lab kit → the protocol used by DAN Europe can be found in this [link](#) and the data can be uploaded through this [form](#).
- Acoustic pollution → the recorded files can be sent to Surfrider España to this email: ifuertes@surfrider.eu.
- Protection of biodiversity → OSES project Excel spreadsheet (page 5 of the Annex)
 - DAN Europe uses its own protocol for biodiversity which is called Visual Census. There is more information in their [website](#), with a video tutorial and also the possibility to download the protocol. Data can be uploaded in the Sea Observers website in the [Climate Fish section](#).
- Climate change → OSES project Excel spreadsheet (page 4 of the Annex)

- Coastal protection and management → Coastsnap is a global citizen science project to capture changing coastlines. Relies on repeat photos at the same location to track how the coast is changing over time due to processes such as storms, rising sea levels, human activities and other factors. It turns photos into valuable coastal data that is used by coastal scientists to understand and forecast how coastlines might change in the coming decades. It is a mobile phone app and more information can be found in their [website](#).

Methodology: examples

For each of the pilot interventions a customized methodology was designed taking into account the aquatic sport practised, the number and ages of participants and the time dedicated to the intervention.

Some of the interventions will last a few hours so it won't be feasible to measure all the parameters.

The following will be examples which can be used as a guide to build from scratch other methodologies more suitable for the readers.

First pilot intervention in Malta

- Number of participants → 11 (divided in 2 groups)
- Age → 16-17
- Duration → 1 day (4 hours each group, morning and afternoon sessions)
- Location: Cirkewwa Marine Park
- Sport → Snorkeling

D-day (This methodology will be the same for both groups)

- Before the field intervention, the participants will take a course on DAN EUROPE'S e-learning platform to get familiar with the topics related to the OSES project.
- When in the field, the participants will be welcomed and introduced to the pilot intervention and to a general overview of the OSES Project.
- After that, the practical approach will be explained by instructors. They will explain each topic with specific take home messages highlighted in the Ocean Knowledge Unit.

- Then the practical activities will start:
 - The participants will take a picture of the reference place to study coastal changes.
 - Once inside de water
 - They will study the biodiversity by using the visual census waterproof charts and measure the water temperature to study the climate change in the ocean.
 - To assess the water quality of the chosen location, a couple of samples will be taken following the protocol mentioned above.
 - Once outside the water
 - The water samples will be analysed with the test kit and the data obtain will be noted in the data collection form.
- When all the data are collected, they will be uploaded to the different platforms described above.
- Finally, the group and instructors will have the opportunity to share their experiences, opinions and debate about what they have observed.

Second pilot intervention in France

- Number of participants → 12
- Age → 8-14
- Duration → 1 day.
- Location: → Cherbourg-en-Cotentin, Normandie
- Sport → Sailing

D-day

- The participants will be welcomed and introduced to the pilot intervention and to a general overview of the OSES Project.
- Brief presentation about the topic by using the Ocean Knowledge unit.
- After that, the practical approach will be explained by instructors. They will explain each thematic with specific take home messages highlighted in the unit.
- Then the practical activities will start:
 - The participants will take a picture of the reference place to study coastal changes.
 - Once inside de water
 - They will study the biodiversity by using the biodiversity waterproof tables created with local species and measure the water temperature to study the climate change in the ocean.
 - To assess the water quality of the chosen location, the Forel-Ule and Secchi disk will be used.
 - Marine litter will be picked with the telescopic net using the gloves and bags provided.
 - Noise pollution will be assessed by using the hydrophone and recording the sounds on the phone.
 - Once outside the water
 - The participants will quantify and classify the litter and note the results in the Ocean Initiatives form.
- Once all the data is collected in the form provided (see page 2 of the Annex), it will be uploaded to the different platforms explained above.
- Finally, the group and instructors will have the opportunity to share their experiences, opinions and debate about what they have observed.

Third pilot intervention in Spain

- Number of participants → 15 each day
- Age → 15 (one group), adults above 18 (second group)
- Duration → 2 days
- Location: → Orrio, Gipuzkoa
- Sport → Kayaking

D-day

- Both days will follow the same methodology as the second pilot intervention.

Fourth pilot intervention in Portugal

- Number of participants → 15
- Age → 8-12
- Duration → 1 day
- Location: → Espinho
- Sport → Surfing

D-day

- The participants will be welcomed and introduced to the pilot intervention and to a general overview of the OSES Project.
- Brief presentation about the topics by using the Ocean Knowledge unit.
- After that, the practical approach will be explained by instructors. They will explain each thematic with specific take home messages highlighted in the unit.

- Then the practical activities will start:
 - Outside the water
 - The participants will take a picture of the reference place to study coastal changes.
 - Then they will study the biodiversity by using the tables created with local species while walking in the beach and looking in the surroundings.
 - Marine litter will be collected on the beach using the gloves and bags provided. The participants will quantify and classify the litter and note the results in the Ocean Initiatives form.
 - Inside the water
 - They will measure the water temperature to study the climate change in the ocean.
 - To assess the water quality of the chosen location the Forel-Ule and Secchi disk will be used.
 - If any animal or algae is spotted while surfing, they can note it after in the biodiversity chart.
- Once all the data is collected in the form provided, it will be uploaded to the different platforms explained above.
- Finally, the group and instructors will have the opportunity to share their experiences, opinions and debate about what they have observed.

Note: the contents of the Ocean Knowledge Unit will be adapted to the age of the participants by summarizing the most important content by the sports entities in charge of each pilot intervention.

Additional information

This methodology will serve as a guide being subject to the changes or customization for the needs of sports organizations who wish to consult this “Toolkit for ocean conservation”.

It is interesting to remember that this methodology can be gamified and the participants can be awarded with a diploma after completing the activities.

Besides, in our [Good practices handbook](#), there can be found up to 25 initiatives to protect the ocean by practicing different water sports.

Annex – Toolkit for ocean conservation

PILOT INTERVENTION DATA

First and second name:

Date:

Hour:

Location:

TYPE	DATA	COMMENTS
Forel – Ule scale		Coordinates:
Marine litter weight (gr o kg)		
Marine litter quantified?	YES/NO	
Temperature (°C)		Coordinates:
Secchi disk (metres)		Coordinates:
Hydrophone used?	YES/NO	Coordinates:
Coastsnap used?	YES/NO	Coordinates:
Biodiversity table used?	YES/NO	

COMMENTS:

EXCEL SPREADSHEET

EXCEL SPREADSHEET PART 1

GUIDE TO USE THE TOOLS	
FOREL - ULE SCALE	
How does it work?	Estimates the colour of bodies of water. Help us measure water quality. Slowly lower the Secchi disk until it disappears from sight. Needs to be done in a shaded area. We need to count the marks in the Secchi's rope to know the depth. Slowly raise the disk until half the Secchi depth. Determine the colour of the water with the Forel Ule scale. Compare the colour observed on top of the Secchi disk, with the colours of the scale (over the white bars). Record the FU number.
Forel-Ule and Secchi disk need to be used together	Colour guide
	FU 1-5 These waters have often low nutrient levels and low production of biomass. The colour is dominated by microscopic algae (phytoplankton).
	FU 6-9 The colour is still dominated by algae, but also increased dissolved matter and some sediment may be present. Typical for areas towards the open sea.
	FU 10-13 Often coastal waters which usually display increased nutrient and phytoplankton levels, but also contain minerals and dissolved organic matter. Typical for near-shore areas and tidal flats
	FU 14-17 Usually with high nutrient and phytoplankton concentrations, but also increased sediment and dissolved organic matter. Typical for near-shore areas and tidal flats.
	FU 18-21 Waters with an extremely high concentration of humic acids, which are typical for rivers and estuaries
SECCHI DISK	
How does it work?	Measures the water turbidity or transparency. Slowly lower the Secchi disk until it disappears from sight. Needs to be done in a shaded area. We need to count the marks in the Secchi's rope to know the depth.
THERMOMETER	
How does it work?	Measures the water temperature. Introduce the thermometer in the water while holding its rope. Wait one minute and note the temperature.
HYDROPHON	
How does it work?	Measures the noise underwater. Plug the hydrophon to the amplifier and the phone/speaker. Introduce the hydrophon in the water. Record on your phone the noise during one minute.
COASTSNAP	
How does it work?	Stores photos from coastal locations affected by climate change. Download the app and create an account. Choose a specific location where you can go frequently. By using the tripod, take a picture of the building, construction, beach, cliff, etc. And upload it to the app.
MARINE LITTER	
How does it work?	Using nets and gloves pick litter while sailing. Once the waste collection has been done and the items counted and noted in Surfrider's Ocean Initiative protocol, separate items by materials and weight the bags. Note the weight. The items data needs to be uploaded to the By creating an account and registering the waste collection you just did you will be able to upload the data and download a final report of the top items collected.

EXCEL SPREADSHEET PART 2

Data from the pilot intervention		
Name		
Date:		
Hour:		
Location:		
Type	Data	Comments
Forel-ULE scale		Coordinates:
Marine litter weight (gr or kg)		
Marine litter quantified?	YES/NO	
Temperature (°C)		Coordinates:
Secchi disk (metres)		Coordinates:
Hydrophon used	YES/NO	Coordinates:
Coastsnap used	YES/NO	
Biodiversity chart used	YES/NO	
Comments:		

EXCEL SPREADSHEET PART 3

BIODIVERSITY CHART

OBSERVER 1				
Name of the observer				
Ability in species recognition:	Low	Medium	Good	Very good
Name of the place:				
Protected area? If yes? What figure?				
Date:				
Hour:				

ID	Species	Scientific name	OBSERVER 1 + Comments
1	Great black-backed gull	<i>Larus marinus</i>	
2	European herring gull	<i>Larus argentatus</i>	
3	Black-headed gull	<i>Chroicocephalus ridibundus</i>	
4	Eurasian oystercatcher	<i>Haematopus ostralegus</i>	
5	Northern gannet	<i>Morus bassanus</i>	
6	Common bottlenose dolphin	<i>Tursiops truncatus</i>	
7	Oyster	<i>Ostrea edulis</i>	
8	Beadlet anemone	<i>Actinia equina</i>	
9	Small-spotted catshark	<i>Scyliorhinus canicula</i>	
10	Brown alga	<i>Sargassum muticum</i>	
11	Moon jellyfish	<i>Aurelia aurita</i>	
12	Lion's mane jellyfish	<i>Cyanea capillata</i>	
13	Compass jellyfish	<i>Chrysaora hysoscella</i>	
COMMENTS			

OCEAN KNOWLEDGE UNIT

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Introduction

This document has been created in the framework of the OSES project. It is intended as a basis for understanding the ocean and its current situation. Therefore, it will begin by explaining the 7 principles of Ocean Literacy, as well as some basic concepts and curiosities related to the ocean. It will also describe some of the threats that currently affect it and how there are individual and collective solutions to deal with them.

The Earth has one Ocean with many features. Approximately 70% of the Earth's surface is covered by water. About 97% of this water is contained in the global ocean. The Earth's highest peaks, deepest valleys, and flattest plains are all also in the ocean. [1]

For example, the highest volcano is the Mauna Kea (Hawaii) with 10,000 meters between the ocean floor and the summit of the volcano. [2] It is also important to mention that the largest mountain ridge is also in the ocean. This is the mid-ocean ridge with more than 64,937 kilometers long. This largest single volcanic feature on Earth is made up of thousands of individual volcanoes or volcanic ridge segments. This system of mountains and valleys runs throughout the ocean. Its crest averages 2286 meters below sea level, but it dives to - 3657,6 meters in the Cayman Trough and rises above sea level in Iceland.[3]

It also contains the largest cascade on Earth. This waterfall is beneath the Denmark strait. At the bottom of the strait are a series of cataracts that begin 609,6 meters under the strait's surface and plunge to a depth of 3,048 meters at the southern tip of Greenland—nearly 3219 meters drop. [4]

Ocean Literacy

What is ocean literacy?

Ocean literacy is defined as an understanding of the ocean's influence on you, and your influence on the ocean. Ocean literacy is a way not only to increase the awareness of the public about the ocean, but as an approach to encourage all citizens and stakeholders to have a more responsible and informed behavior towards the ocean and its resources. [1]

The 7 principles of Ocean Literacy

1. Earth has one big ocean with many features.

There is one ocean with many ocean basins, the North Pacific, South Pacific, North Atlantic, South Atlantic, Indian, Southern, Arctic, Mediterranean Sea, Gulf of Mexico, Hudson Bay, among others.

Ocean basins are composed of the seafloor and all of its geological features (such as islands, trenches, mid – ocean ridges and rift valleys) and vary in size, shape and features due to the movement of Earth's crust (lithosphere).

In this project we are going to study four different areas: Mediterranean Sea, Atlantic Ocean, La Manche/ English Channel and the Oria river which ends at sea as an estuary. They have different geological and physical conditions which will be mentioned below.

The Mediterranean Sea:

- The sea is made up of two large basins, the Western and the Eastern basins, connected by the strait of Sicily, that give rise to a sea with an average depth of 1,500 metres. However, the eastern basin contains the deepest areas, exceeding 5,000 metres below the surface.
- Its salinity is relatively high, with 38g salt/L, clearly above the average mean of the global ocean (35g/L) because, as it is an enclosed area, evaporation is higher than in other areas).
- Water's surface temperatures range between 21°C and 30°C in summer and 10°C and 15°C in Winter.
- The Mediterranean region contains 10% of the world's biodiversity (12,000 marine species have been recorded) . Amongst the endemic flora, on the sandy inshore seabed three species stand out: *Posidonia oceanica*, *Cymodocea nodosa* and *Zostera marina*, which provide habitats for a multitude of marine species.
- It is a major breeding ground for Atlantic bluefin tuna, which is the most sought-after marine species of fish in the world.
- *Posidonia* prairies are some the most important ecosystems of this sea, acting as relevant carbon sinks. Their long leaves buffer the waves and protect the coast from erosion and lessen

the impact of waves and currents on beaches. *Posidonia* prairies and coralligenous communities increase the spatial structure of the seabed and provide a habitat for more than 400 species of plants and 1,000 creatures.

- It has more than 200 islands, some of which are quite big. It is “crossed” by tectonic plate limits which make volcanoes arise and also give birth to a trench, experiencing 4 seasons during the year (seasonal sea). [5]

The English Channel (La Manche):

- Part of the Atlantic Ocean which divides England from northern France, and connects the North Sea to the Atlantic. The channel covers around 560 km length and the range of width is from 240 km to 34 km in the Strait of Dover (Pas de Calais).[6]
- It is comparatively shallow and covers an area of about 75,000 km² and the average depth varies from 120 m to the 45 m. [6] Smallest of the shallow seas covering the continental shelf of Europe. [7]
- The channel has been shaped by the effect upon its rock strata of such forces as weathering and erosion, sea-level changes, and contemporary erosion and deposition by marine currents.
- The floor of the western channel has alternations of clays and limestones give rise to an undulating terrain, with depths reaching almost twice the average. A continuation of the Seine River valley system north of the Cotentin Peninsula of Normandy complicates the relief forms.
- Tides in the English Channel generally are strong, especially in the Strait of Dover. The central portion experiences semidiurnal (twice-daily) tides (helpful to shipping movements at Southampton, which has a double, or prolonged, high tide), and the Gulf of Saint-Malo experiences the greatest tidal range, 28 feet or more.
- Surface temperatures range from 7 °C in February to 16 °C in September, although shallow coastal waters are warmer in summer. There is little temperature change with depth in the well-mixed eastern waters of the channel, but bottom-water temperatures fall to 5 °C in the west.
- Surface salinities decline eastward from slightly less than the Atlantic level of 35.5 parts per thousand; coastal salinity readings are further reduced by the influx of river water, especially from the larger French landmass. There is an overall water flow through the English Channel to the North Sea, with complete replacement taking about 500 days.
- Connecting the Atlantic Ocean and the North Sea, the respective waters of which are rich in warm- and cold-water plankton, the English Channel is favoured from the latter with cod, herring, and whiting and from the former with hake, pilchard, and mullet. The traditional fishing industry declined in the 20th century with the development of deep-sea fishing, the exhaustion of resources, and the advent of pollution problems, but coastal fishing remains important in Brittany.[7]
- The English Channel is the busiest channel in the world with over 500 ships per day passing through. Here commercial fishing is a crucial economic activity, but these commercial objectives need to be carefully balanced with conservation goals. [8]
- No cetacean species is abundant, the most frequently observed in nearshore waters being the bottlenose dolphin (*Tursiops truncatus*) and in offshore waters, the common dolphin (*Delphinus delphis*), whilst the harbor porpoise (*Phocoena phocoena*) is seen occasionally nearshore and the long-finned pilot whale (*Globicephala melas*) offshore.

- Of the two seal species resident in the British Isles, both the harbour seal (*Phoca vitulina*) and Atlantic grey seal (*Halichoerus grypus*) occur only casually in the region, their breeding grounds being some distance away.[9]
- Some of the birds that can be spotted are the following European herring gull (*Larus argentatus*), black-headed gull (*Chroicocephalus ridibundus*), common murre (*Uria aalge*), black-legged kittiwake (*Rissa tridactyla*), lesser black-backed gull (*Larus fuscus*), northern gannet (*Morus bassanus*), razorbill (*Alca torda*), great cormorant (*Phalacrocorax carbo*), common gull (*Larus canus*) and great black-backed gull (*Larus marinus*).[10]

The Oria Ria (Oria River in Spain):

- The structure of estuaries is largely determined by geomorphological and hydrographic factors. They are partially exposed to wave action and the hydrodynamic processes generated by tidal currents and fluvial discharges. [11]
- There are four main sub-types being one of them ria estuaries.[12]
- A 'ria' is a drowned mouth of a valley that forms on rocky coasts, characterized by steep slopes and often found in areas with high tidal ranges.[13]
- The vertical salinity and temperature gradients are minimal compared to the longitudinal gradients (Dias et al., 1999). [14]
- The mixture of seawater and fresh water in estuaries is called brackish water and its salinity can range from 0.5 to 35 ppt. The salinity of estuarine water varies from estuary to estuary, and can change from one day to the next depending on the tides, weather, or other factors.[15]
- The averaged values of surface temperature range between 13°C, from January to early May, and 18°C, during July and August. The bottom temperature ranges, on average, between 13°C, from the end of May to August, and c. 14°C, from the end of September to January. The highest averaged values, c. 15°C, occur in November. [16]
- Estuarine areas have a high species richness. Species richness increased towards the equator, and higher values were found in larger estuaries and with a wide mouth. All these trends showed a high variability. A larger estuary area probably reflects a higher diversity of habitats and/or productivity, which are key features for estuarine ecosystem functioning and biota. The mouth width effect is particularly notorious for marine and diadromous fish species, enhancing connectivity between marine and freshwater realms. [17]
- Some estuaries are protected areas due to their habitat and biodiversity richness. This is the case of the Oria ria (lower part of the Oria river), in Gipuzkoa, Spain. It is considered a SAC (Special Area of Conservation) because it conserves enclaves of functional marshland of great faunistic and floristic value and interest in which various habitats of great interest are found and between which there is a close relationship and interconnection. It also contributes to the connectivity with other estuaries on the Cantabrian coast, as it is an area of passage for numerous species of migratory birds.
- Some of the animal species include sedge warbler (*Acrocephalus schoenobaenus*), common kingfisher (*Alcedo atthis*), black-crowned night-heron (*Nycticorax nycticorax*), great cormorant (*Phalacrocorax carbo*), Atlantic salmon (*Salmo salar*), allis shad (*Alosa alosa*), and common frog (*Rana temporaria*) [18].

The Atlantic Ocean:

- The Atlantic Ocean is the second-largest ocean on Earth, accounting for one fifth of the Earth's surface and 29% of the Earth's water.[19] Separating the continents of Europe and Africa to the east from those of North and South America to the west.[20]
- The area of the Atlantic without its dependent seas is approximately 81,760,000 square km, and with them its area is about 85,133,000 square km. It has an average depth (with its seas) of 3,646 metres and a maximum depth of 8,380 metres in the Puerto Rico Trench, north of the island of Puerto Rico.
- The continents on both sides of the Atlantic tend to slope toward it, so that it receives the waters of a great proportion of the major rivers of the world.
- The outstanding feature of the Atlantic floor is the Mid-Atlantic Ridge, an immense median mountain range extending throughout the length of the Atlantic, claiming the centre third of the ocean bed, and reaching roughly 1,600 km in breadth.
- East and west of the ridge, about 3,700 to 5,500 metres below sea level, lie basins that seem to present parts of the basin floor as mountainous as the Mid-Atlantic Ridge, while other parts are extremely smooth. The former are rocky abyssal hills; the latter are the abyssal plains that form the upper surface of great ponds of mud that fill many of the broad depressions. Large ancient volcanoes are found singly or in rows in the basins; these rise to form seamounts and, occasionally, islands.
- Beneath the Atlantic basin slopes—in accumulations 3,000 to 15,000 metres thick—that some of the largest potential reserves on Earth of petroleum, natural gas, and coal are found.
- The North Atlantic Oscillation (NAO) is an irregular climate fluctuation, the phases of which may span months to decades. The phenomenon is measured by changes in a north-south atmospheric pressure gradient over the North Atlantic. In general, the steeper the gradient, the stronger the wind, and the more heat from the Atlantic's Gulf Stream is delivered to Europe, thereby ameliorating its climate.
- In its further course, the Gulf Stream colder water continues toward the European coast as the North Atlantic Current. Vestiges of the Gulf Stream can be traced as far north as Spitsbergen, above Norway at about latitude 78° N.
- The basic salinity value differs from one area of the Atlantic to another; it is highest for the North Atlantic, at 35.5 parts per thousand.[20]
- About the temperature, as an example, the warmest water temperature in Portugal is in August with an average around 21.7°C. The coldest month is March with an average water temperature of 16.1°C. [21]
- From the whole North Atlantic Ocean nearly 1100 species of fish are known.
- At the Azores 13 out of 14 breeding bird species have an unfavourable conservation status. Three of these little shearwaters (*Puffinus assimilis baroli*), the Madeiran storm-petrel (*Oceanodroma castro*) and Bulwer's petrel (*Bulweria bulwerii*) breed nowhere else in the Atlantic. In addition, more than 60 % of Europe's roseate terns (*Sterna dougallii*) breed in the Azores.
- The grey seal (*Halichoerus grypus*) is frequently found in rocky and wave-exposed areas, while the harbour seal (*Phoca vitulina*) prefers more sheltered areas. 32 different species of whales have been observed in the Atlantic Ocean. The most common whale is the harbour porpoise (*Phocoena phocoena*).[22]

On a global scale, ocean currents are generated by winds, tides, the Earth's rotation and water density differences. There is a surface circulation, but also a global deep circulation system which is mostly generated by density differences in water masses and is called "the great ocean conveyor belt". This

global ocean conveyor belt moves water throughout the ocean basins, transporting heat and energy around the world and thus serving as a key ingredient in the planet's climate system.

Changes in the ocean circulation have a large impact on the climate and cause changes in ecosystems.

Sea level is the average height of the ocean relative to the land, taking into account the differences caused by tides. Sea level changes due to changes in plate tectonics, for example, and cause the volume of ocean basins and the height of the land to change. It also changes as ice caps on land melt or grow. And it further changes as sea water expands and contracts when ocean water warms and cools.

Most of Earth's water (97%) is in the ocean. Seawater has unique properties: it is saline, its freezing point is slightly lower than fresh water, its density is slightly higher, its electrical conductivity is much higher, and it is slightly basic. The salt in seawater comes from eroding land, volcanic emissions, reactions at the seafloor, and atmospheric deposition.

The ocean is an integral part of the water cycle and is connected to all of the Earth's water reservoirs via evaporation, circulation and precipitation processes.

The ocean is connected to major lakes, watersheds and waterways because all major watershed on Earth drain to the ocean. Rivers and streams transport nutrients, salts, sediments and pollutants and life forms from watersheds to estuaries and to the ocean.

Although the ocean is large, it is finite, and its resources are limited.

2. The ocean and life in the ocean shape the features of the Earth.

Life on Earth first evolved around 3.8 billion years ago (3800 million years), as evidence of microfossils and ancient rock structures in South Africa and Australia suggests. [23] .

Many of Earth's materials and geochemical cycles originate in the ocean. Many of the sedimentary rocks now exposed on land were formed in the ocean. Ocean life laid down the vast volume of siliceous and carbonate rocks.

Sea level changes over time have expanded and contracted continental shelves, created and destroyed inland seas, and shaped the surface of land.

Erosion—the wearing away of rock, soil and other biotic and abiotic earth materials—occurs in coastal areas as wind, waves, and currents in rivers and the ocean move sediments.

Depending of its origin, sand consists of tiny bits of animals, plants, rocks and minerals. Most beach sand is eroded from land sources and carried to the coast by rivers, but sand is also eroded from coastal sources. Sand is redistributed by waves and coastal currents seasonally.

It is important to highlight that life also protects coastlines and gives them structure. For example, coral reefs provide tridimensional structures which are home to more than 25% of all marine species. Coastal ecosystems, like mangroves, seagrass prairies and coral reefs, help protect the coastlines from strong storms and provide nurseries for juvenile fish. Another important fact about these ecosystems

is that they help as carbon sinks and therefore their preservation and restoring is a priority for combating or mitigating climate change.[24]

Tectonic activity, sea level changes, and the force of waves influence the physical structure and landforms of the coast.

3. The ocean is a major influence on weather and climate.

The interaction of oceanic and atmospheric processes controls weather and climate by dominating the Earth's energy, water and carbon systems. Areas closer to the ocean have a smoother weather compared to landlocked ones.

The ocean moderates global weather and climate by absorbing most of the solar radiation reaching Earth. Heat exchange between the ocean and atmosphere drives the water cycle and oceanic and atmospheric circulation.

Heat exchange between the ocean and atmosphere can result in dramatic global and regional water phenomena, impacting patterns of rain and drought. Significant examples include the El Niño Southern Oscillation, which causes important changes in global weather patterns because they alter the sea surface temperature patterns in the Pacific.

Condensation of water that evaporated from warm seas provides the energy for hurricanes and cyclones. Most rain that falls on land originally evaporated from the tropical ocean.

The ocean dominates the Earth's carbon cycle. Half the primary productivity on Earth takes place in the sunlit layers of the ocean and the ocean absorbs roughly half of all carbon dioxide added to the atmosphere. This is possible thanks to the biological pump and the physical-chemical pump which are a set of processes by which inorganic carbon is fixed into organic matter via photosynthesis and then sequestered away from the atmosphere generally by transport into the deep ocean. [24]

Changes in the ocean's circulation have produced large, abrupt changes in climate during the last 50,000 years.

Changes in the ocean-atmosphere system can result in changes to the climate that in turn, cause further changes to the ocean and atmosphere. These interactions have dramatic physical, chemical, biological, economic, and social consequences.

4. The ocean makes Earth habitable.

Most of the oxygen in the atmosphere originally came from the activities of photosynthetic organisms in the ocean. This accumulation of oxygen in Earth's atmosphere was necessary for life to develop and be sustained on land.

The first life is thought to have started in the ocean. The earliest evidence of life is found in the ocean.

These first life forms most probably originated in the ocean or coastal lagoons. It is known that they didn't need oxygen to survive since oxygen wasn't present in the atmosphere. However, 2.7 billion years ago, this started to change thanks to a group of microbes called cyanobacteria which evolved starting to release oxygen steadily. These tiny forms were the first to use water and carbon dioxide and convert them into organic matter and oxygen thanks to the energy of light. Then, oxygen was accumulated over vast areas of the ocean and oxygenated the water. Gradually, the formed oxygen started escaping into the atmosphere becoming, in due time, one of the major components of the atmosphere (currently, 21%). This huge event, called "the oxygen revolution", had several consequences, not only on Earth's atmosphere, but also on the evolution of living organisms, as oxygen first caused a massive extinction of life forms but later allowed for the development of other life forms. [25]

The ocean provided and continues to provide water, oxygen and nutrients, and moderates the climate needed for life to exist on Earth (Essential Principles 1,3, and 5).

5. The ocean supports a great diversity of life an ecosystems.

Ocean life ranges in size from the smallest living things, viruses and microbes, to the largest animal that has lived on Earth, the blue whale.

Most of the organisms and biomass in the ocean are microbes, which are the basis of all ocean food webs. Microbes are the most important primary producers in the ocean. They have extremely fast growth rates and life cycles, and produce a huge amount of the organic carbon and oxygen on Earth.

It is also important to mention plankton, which is a group of marine and freshwater organisms that drift along ocean currents because they cannot swim against them. There are two types of plankton: phytoplankton and zooplankton. Phytoplankton includes dinoflagellates, diatoms, cyanobacteria and green algae. They contain chlorophyll and need sunlight and nutrients to grow. Zooplankton, on the other hand, includes all animals in the plankton, many of which stay in there their whole lives and many of which stay in the plankton only during certain life periods (e.g. as larvae or juveniles). [26]

Phytoplankton are also primary producers, meaning they convert water into oxygen and carbon dioxide into organic carbon, they turn inorganic into organic.

Photosynthesis in the ocean represents up to 50% of global oxygen production.

Unfortunately, plankton abundance has been decreasing. Changes in ocean temperature and ocean acidification threaten plankton health, which in turn has major implications for marine food webs and oxygen production. [26]

Some of the major groups of living forms that exist on Earth are found exclusively in the ocean and the diversity of major groups of organisms is much greater in the ocean than on land.

Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (symbiosis, predator-prey dynamics, and energy transfer) that do not occur on land.

The ocean provides a vast living space with diverse and unique ecosystems from the surface through the water column and down to, and below, the seafloor. Most of the living space on Earth is in the ocean.

Ocean ecosystems are defined by environmental factors and the community of organisms living there. Ocean life is not evenly distributed through time or space due to differences in abiotic factors such as oxygen, salinity, temperature, pH, light, nutrients, pressure, substrate and circulation. A few regions of the ocean support the most abundant life on Earth, while most of the ocean does not support much life.

There are deep ocean ecosystems that are independent of energy from sunlight and photosynthetic organisms. Hydrothermal vents, submarine hot springs, and methane cold seeps rely only on chemical energy and chemosynthetic organisms to support life.

Tides, waves, substrate, and/or other factors, such as predation, cause vertical zonation patterns along the coast: density, pressure, and light levels cause vertical zonation patterns in the open ocean. Zonation patterns influence organisms' distribution and diversity.

Estuaries provide important and productive nursery areas for many marine and aquatic species.

6. The ocean and humans are inextricably interconnected.

The ocean affects every human life. It supplies freshwater (most rain comes from the ocean) and nearly all Earth's oxygen. The ocean moderates the Earth's climate, influences our weather, and affects human health.

The ocean provides foods, medicines, and mineral and energy resources. It supports jobs and national economies, serves as a highway for transportation of goods and people, and plays a role in national security.

The ocean is a source of inspiration, recreation, rejuvenation and discovery. It is also an important element in the heritage of many cultures.

Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity lead to pollution (point source, non-point source, and noise pollution), changes to ocean chemistry (ocean acidification), physical modifications (changes to beaches, shores and rivers) and overexploitation of fishing resources. In addition, humans have removed most of the large vertebrates from the ocean.

Changes in the environment such as increasing water temperature and pH due to human activities cause biological stress in many organisms, affecting their survival rates and negatively impacting biodiversity. For example, coral bleaching due to increased temperature and inhibition of shell formation due to ocean acidification.

For instance, much of the world's population lives in coastal areas. Coastal regions are susceptible to natural hazards (tsunamis, hurricanes, cyclones, sea level change, and storm surges) some of which are currently increasing due to changes in climate.

Each human life affects the ocean independently on where this person is so that is why everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

7. The ocean is largely unexplored.

The ocean is the largest unexplored place on Earth.

Understanding the ocean is more than a matter of curiosity. Exploration, experimentation, and discovery are required to better understand ocean systems and processes.

Over the last 50 years, use of ocean resources has increased significantly, the future sustainability of ocean resources depends on our understanding of those resources and their potential and, most importantly, how their role affects the good functioning on the ocean.

New technologies, sensors and tools are expanding our ability to explore the ocean system together with scientific diving and sampling. Scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.

Use of mathematical models is an essential part of the ocean systems. Models help us understand the complexity of the ocean and of its interaction with Earth's interior, atmosphere, climate and land masses.

Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, physicists, animators and illustrators. And these interactions foster new ideas and new perspectives for inquiries.

(Note: the information about "The 7 principles of ocean literacy" has been mostly extracted from the reference 27, except the paragraphs indicated with a different reference number).

Marine pollution

Marine pollution comes in many forms. In the following pages we would explore different types such as: bacteriological pollution, chemical pollution, marine litter and acoustic pollution among others. And also, their consequences and the solutions to the impacts they produce.

Nowadays, with climate change globally affecting the ocean, we may start taking into consideration the higher temperatures of the water as another type of pollution, which affects ocean physics and chemistry and also many marine life forms by disrupting biological and ecological processes. It may also benefit the growth and the harmful effects of other types of pollution such as toxic algal blooms like *Ostreopsis* sp.

Water quality

Water pollution is considered as an alteration of 'good water quality' with a harmful effect on human consumption and use and also on aquatic life. In some countries, like the ones in the European Union, good water quality is defined by its good chemical and ecological status. This covers surface water, rivers, lakes and groundwater.

Good ecological status corresponds to a well-functioning environment and it is assessed through aquatic biodiversity (fauna and flora).

Good chemical status, on the other hand, takes into account the parameters of pollution by toxic substances.

These are three examples of contamination affecting water quality:

- Bacteriological pollution: these bacteria (*Escherichia coli* and *Enterococcus* sp.) originate mainly from (untreated) sewage waste containing faeces and organic waste.
- Chemical pollution: generally, originates from sewage discharges containing cleaning products, hydrocarbons and heavy metals.
- Aquatic debris pollution: is defined as 'Any manufactured material or object used for the benefit of mankind that is dumped or abandoned directly or indirectly into the sea'.

These types of pollution can have many origins, but there are four main ones:

1. Domestic pollution: in general, is due to wastewater discharges, which can be of two types:
 - a. Wastewater from daily water use (toilets, kitchen, shower...) containing organic waste or faeces. Houses that are poorly connected or not connected to the collective sewerage network can generate bacteriological contamination of the water.
 - b. The household products we use are loaded with chemical pollutants that are harmful to the environment. Mixed with water, they end up in our pipes or in the nature and

generate chemical pollution. Difficult to treat by sewage systems, the residues of these products add even more chemicals to the rivers.

2. Industrial pollution

- a. Industry generates different types of pollution depending on the sector of activity. Paper mills, for example, use large volumes of chemicals in their manufacturing processes. Although regulations impose treatment of their wastewater, some substances are still difficult to eliminate and end up in the environment.
- b. The agri-food industry (companies, cooperatives, etc.) deals with a large volume of organic matter, which adds nutrients to nature and contributes to the phenomenon of eutrophication.

3. Agricultural pollution

- a. Pesticides and fertilizers cause chemical pollution. The massive use of natural fertilizers, such as manure, can be a source of bacteriological pollution. These substances, through the natural water cycle, infiltrate or leach and end up polluting the aquatic environment.

4. Pollution related to maritime transport

- a. Maritime transport can be the source of chemical pollution, which is often caused by leaking hydrocarbons, whether consciously or not, these chemicals go directly into the ocean. Oil spills are a clear example.
- b. Maritime transport has facilitated the introduction of new species transported in ballast water such as the algae *Ostreopsis ovata*, present in the Mediterranean Sea and Cantabrian Sea. Which blooms and toxicity are dangerous in warm water conditions.

These types of pollution have negative consequences on the aquatic environment, on human beings and on the economy.

Solutions to water pollution

Public authorities have established several standards to combat water pollution.

- Against domestic pollution → To prevent sewage from ending up in our waterways, several types of actions are implemented in sewage treatment plants:
 - Restoration of facilities (reconstruction or modernisation)
 - Development of water treatment methods
- Against industrial pollution → Standards exist at the national level, penalising operators who directly discharge their wastewater into lakes or rivers. In addition, since 2006 they have had to declare their actions in a European register. National standards can be complemented by local regulations and inspections.
- Against agricultural pollution → In order to prevent the infiltration of chemical substances present in pesticides and fertilisers, farmers are obliged to plant vegetation on plots of land close to watercourses. This practice creates a natural plant filter, reducing the number of pollutants entering watercourses.
- At the individual level → It is also possible to limit water pollution at the individual level. When you have a septic tank, it is important that it is well maintained to avoid sewage leaking into the ground. Pollution from cleaning products can also be mitigated. In fact, using household products, cosmetics of natural origin and more environmentally friendly products reduces the

environmental impact. Today many labels have emerged (Ecocert, European Ecolabel, Nature and progress ...) and make it easier to find these products. [28,29]

Marine litter

Be it plastic, glass, fabric or metal, all litter is created by human activity. Marine litter is defined as: 'any object or material produced by man which, directly or indirectly, ends up in the ocean [30]. Marine debris is solid and resistant, be it floating, stranded or submerged. It's classified according to its size and can be 'macro-waste' (>5mm) or 'micro-waste' (<5mm) [31].

The debris mainly comes from inland regions. It's transported by wind, rain and waterways to the ocean. Between 1.15 and 2.41 million tons of plastic flow from rivers into the ocean every year [32]. During storms or heavy rains, water levels rise, sweeping away litter from the shore. As they travel through agricultural, industrial and urban areas, waterways pick up a multitude of litter (food packaging, tin cans, cigarette butts, etc...). Fish farming, fishing and maritime transport also contribute hugely to the waste abandoned on beaches or out at sea. [33]

Of all the marine debris present in our ocean, plastic is the most common [34]. Every year, eight million tons of plastic waste flow from land to the sea [35]. In certain parts of the globe, plastic represents up to 95% of the total marine debris [36]. This omnipresence of plastic in our ocean is due to constantly increasing industrial production. In 1950, world plastic production stood at 1.5 million tons. In 2015, it was 322 million [37].

What happens to litter once it's in the ocean?

Litter transported by wind, rain and waterways finds its way into the ocean. A tiny part of this waste drifts onto our beaches, but the majority of it sinks to the bottom of the ocean [38]. Floating debris can be carried by ocean currents across remarkable distances. Of all this debris, plastic is the most problematic for the environment. It becomes fragmented into micro particles by the UV effect and micro bacteria [39]. Today there are over 5000 billion plastic particles floating in our ocean [40]. Marine currents play a crucial role in the transport and distribution of ocean waste on a global scale. This is why certain waste products can be found in areas with little or no human activity. Large quantities of plastic debris can be found in the Arctic, for example. Ocean currents are essentially highways for litter. [33]

What is the impact on sea life?

Floating on the surface, lining the ocean floor or washed up on the beach, marine debris threatens aquatic ecosystems. It can injure many marine species by hindering their mobility. Marine debris can also transport invasive species or harbor numerous contaminants. This pollution of the ocean has a profound impact on all aquatic life. Today there are 693 marine species directly threatened by plastic pollution [41].

Marine debris can work as a lure for ocean fauna, who confuse it with their usual prey. Certain turtles, for example, mistake plastic bags for jellyfish and can choke on them if swallowed. Many sea birds confuse plastic with food. It is estimated that 90% of sea birds have plastic fragments in their stomachs. By 2050, this could reach 99% if effective measures are not taken to reduce the flow of plastic entering the ocean [42].

Solutions

There are many possible solutions to the issue. Acting directly at the source of the pollution is still the most effective method. Reducing our daily consumption of plastic is something everyone can do individually. There are some [guides](#) that can help the transition to a plastic free life. [33]

Acoustic pollution

What Is Ocean Noise?

Sound plays an essential role in critical activities for marine species, like breeding, foraging, maintaining social structure, and avoiding predators. For instance, cetaceans (whales, dolphins, and porpoises) send and receive complex sounds to communicate with each other, navigate the water, find food, and more. Fish and invertebrates also use sound for these basic life functions.

Since the beginning of the industrial age, humans have introduced increasing amounts of sound into the ocean. Wide-ranging activities, such as global shipping, oil and gas exploration, construction activity, and naval exercises, contribute to ocean noise. Potential effects of these human-made sounds may range over wide spatial and temporal scales because sound travels so well and much farther than light underwater. [43]

Why Is Ocean Noise Important?

There has been growing concern over the potential impacts of ocean noise on the efficiency of sound traveling underwater and the overall wellbeing of marine species. Depending on the sound source, duration, and location, human-caused sound can affect animals by:

- Causing temporary or permanent hearing loss
- Causing a stress response
- Forcing animals to move from their preferred habitat or divert from their migratory path
- Disrupting feeding, breeding/spawning, nursing, and communication behaviors

The impacts may be immediate and severe, or they may accumulate over time. [43]

What can we do to avoid this?

Some organizations like Ocean Conservancy have advocated for several years for the International Maritime Organization (IMO) to reduce underwater noise from ships. In January 2022, the IMO's Sub-Committee on Ship Design and Construction (SDC) began a new round of work to address the harmful impacts of underwater noise since previous work completed in 2014 resulted in the creation of voluntary guidelines didn't work, resulting in a continued increase in noise levels in the ocean due to its non-mandatory nature.

Thankfully, the subcommittee acknowledged that previous work to reduce underwater noise had not succeeded and approved a work plan to revise the 2014 guidelines and develop comprehensive next steps which will actually be effective in reducing underwater noise. To protect ocean animals from the harmful impacts of underwater noise, this new work must include mandatory measures to ensure industry-wide action. [44]

What measures can ships take to reduce underwater noise?

A combination of ship design, ship maintenance and policy solutions can decrease underwater noise and its harmful impacts. Quieter propellers, have already been developed and can be installed on new and existing ships. Vessels can also maintain polished, clean hulls and propellers, insulate engines, or easiest of all, just slow down to reduce noise.

Reducing speed is a particularly simple action that has the added benefit of decreasing fuel use and harmful emissions.

The IMO and its member countries must set policy to require ships to quiet down.[44]

Protection of biodiversity

What is biodiversity?

Biodiversity is the variety of different forms of life on earth, including the different plants, animals, micro-organisms, the genes they contain and the ecosystem they form. It refers to genetic variation, ecosystem variation, species variation (number of species) within an area, biome or planet. Relative to the range of habitats, biotic communities and ecological processes in the biosphere, biodiversity is vital in a number of ways including promoting the aesthetic value of the natural environment, contribution to our material well-being through utilitarian values by providing food, fodder, fuel, timber and medicine. Biodiversity is the life support system.[45]

Current situation in the ocean

Biodiversity loss is considered to be one of the most severe global environmental problems. In our ocean, this decline is heavily influenced by habitat degradation stemming from human activities including pollution, pH and water temperature changes, etc. [45]

Without action, more than half of the world's marine species could be on the brink of extinction by the year 2100, according to UNESCO [46].

Why is important to protect it?

Marine biodiversity loss hinders the ocean's ability to provide food for our growing population, with an estimated **three billion** people dependent on fish as their primary source of dietary protein. [45]

Solution

Knowledge of the species and their populations is key to understand biodiversity status in the ocean and allow its integral conservation.

There are projects all around the world that aim at biodiversity conservation. Some of them are working on habitat restoration to attract animal species from places where human activities and constructions such as gas pipelines, trawling for fish, drilling for oil, etc. have destroyed ecosystems. [45]

Another example the EU biodiversity strategy for 2030 sets out that 30% of the EU's seas should be protected by 2030 (+19% compared to 2020). And whereas only 1% of EU marine areas are strictly

protected today, at least one third of protected areas (or 10%) should be strictly protected in the future. [47]

Some of this strategy's goals are to reduce the impact of fishing on the seabed. Urgent protection and restoration of seabed habitats in MPAs is critical, given their significance as hotspots of EU marine biodiversity. The Commission, therefore, calls on Member States to propose joint recommendations and take national measures to phase out mobile bottom fishing in all MPAs by 2030 at the latest and not to allow it in any newly established MPAs. Also, healthy fish stocks are key to the long-term prosperity of fishermen and the health of our ocean and biodiversity. An ecosystem-based management approach will gradually reduce the adverse impacts of fishing, extraction and other human activities, especially on sensitive species and seabed habitats. [47]

The impact of climate change on the ocean

The ocean also regulates our climate and provides the air we breathe. It works both, as the lungs of the planet and as the world's largest carbon sink helping to combat the negative impacts of climate change. [48]

However, our precious ocean is fragile and is being severely affected by climate. Water temperatures are getting warmer, making it more acidic, and sea levels are rising. These changes have an impact on marine biodiversity, but they also affect humans. In fact, people are dependent on the ocean, as it provides a range of resources and a livable planet. The rising sea levels are therefore a cause for concern when we know that 10% of the global population live near the coasts within 10 meters above sea level.

Why do we call the ocean a 'carbon sink'?

A carbon sink is a natural or artificial tank that captures and stores carbon from the atmosphere. The ocean is the main carbon sink on Earth, storing about 13 times more CO₂ than the atmosphere, soil and continental plants combined.

This carbon storage is due to two major processes:

- Biological: just like terrestrial plants, phytoplankton (all plant micro-organisms that live in water) absorbs CO₂ and emits oxygen.
- Physicochemical: due to permanent exchanges that take place between the ocean surface and the atmosphere, some of the CO₂ is absorbed and dissolved in water.

Since it plays a fundamental role in regulating the climate and helps to store much of the carbon released into the atmosphere, particularly due to human activities, it is important to ensure the ocean stays in good health. However, within the scope of the current climate change, this immense mass of water so essential for life is under threat.

What is climate change exactly?

The evolution of the Earth's climates, defined as weather averages (temperatures, precipitation, sunshine, air humidity and wind, etc.) that affect a region for longer periods of time, is a natural phenomenon. For example, 15,000 years ago, the Sahara was not a desert. The climate experienced much more rain in that part of the world, and the landscape was made up of lakes and prairies.

However, climate change today differs from the past climate variations given how fast it is changing, unprecedented in the history of the Earth, and also due to its human origin. Indeed, we humans are

mainly responsible. Using fossil fuels (coal, oil and natural gas) for development, human societies have considerably raised the amount of greenhouse gases (GHG) in the atmosphere.

This change in the composition of the atmosphere is the main reason for the increase in temperatures. In fact, greenhouse gases retain a portion of the Earth's infra-red radiation within the atmosphere, causing it to heat up. Since the 19th Century, average temperatures have risen by one degree, and global warming is expected to result in an increase of 1.5°C between 2030 and 2052.

As climate change is caused by the rapid increase in GHG emissions of human origin, temperatures on Earth continue to increase.

What are the impacts of climate change on the ocean?

The ocean is an integral part of the climate system. If any element in this system is changed (in this case, rising temperatures), the ocean is also affected.

Rising sea levels

As there are constant exchanges between air and water, the warming of the atmosphere also influences the ocean.

The increase in the ocean's temperature causes, in turn, a rise in sea levels. During the 20th Century, the average increase in sea level is estimated at 4,4mm/year approx.

This increase can be traced back to two phenomena:

- Thermal expansion: the hotter the water becomes, the more volume an amount of water occupies since the particles under heat tend to vibrate more and move away from each other.
- Ice melting: the rising temperatures are causing ice to melt (glaciers and polar caps). This is added to the amount of water in the ocean, increasing its volume and therefore raising sea levels.

Ocean acidification

The increase in the amount of CO₂ absorbed by the ocean, due to emissions of human origin, causes a change in its chemical composition and, in particular, a decrease in pH. This is why we refer to it as acidification.

What are the main consequences for ocean life?

The warmer ocean leads to a disruption of marine ecosystems. Some species may become extinct, while others show signs of proliferation. In addition, many species are forced to migrate because of the changing characteristics of the water they usually inhabit. Their entire local ecosystem is threatened.

Example: coral reefs under threat

Coral reefs are complex ecosystems, made up of calcareous skeletons from marine organisms. They are extremely rich in biodiversity, since they are home to about a third of all marine species known to date. However, they are also a fragile environment, threatened by ocean acidification. In fact, as the water becomes more acidic, the organisms that make up the reef can no longer build their calcareous skeleton, which decreases the size of the reef. Coral reefs are also threatened by an increase in ocean temperatures. As the water becomes too warm, the corals lose their colour and eventually die. Worldwide, 19% of reefs have already been destroyed, and 15% are seriously damaged.

What are the main consequences for humans?

Increased risks in coastal areas

The rise in sea level increases risks in coastal areas:

- Risk of erosion: the more ocean encroaches land, the more likely it is that sand is removed (beach shorelines) or rocks become unstable, increasing the risk of collapse (rocky shorelines). This phenomenon of erosion is causing a decrease in coastlines in many parts of the world. Example: In Barcelona (Spain) the erosion is accelerating as a result of the climate crisis. Bogatell beach, at the north end of the city, has shrunk from 36,000 cubic metres in 2010 to 15,000 cubic metres today. Overall, Catalonia's beaches have lost 25% of their sand since 2015.[49]
- Risk of flooding: if the level of the ocean increases, areas at low altitudes will be flooded more regularly. For example: Venice (Italy) is already experiencing frequent flooding, which is expected to worsen with rising sea levels. To avoid this, they are already implementing some measures like the MOSE project. [50]

These areas are strongly exposed to rising waters due to their natural characteristics (located at sea level or below), and to the many assets exposed (population, large economic activities or elements with an important heritage...). The risk is increased even more when people have few possibilities to adapt, for instance on small islands where there are limited opportunities to retreat to higher altitudes inland. This is the case on Kiribati, an island state in the Pacific which is seriously threatened by rising sea levels. Its government has begun preparing the migration of certain residents.

Changes in local climates

As the ocean regulates the climate, any change to the ocean also has an impact on the climate. The increase in water temperatures disrupts major ocean currents, which changes local climates.

Disruption of human activity

Changes in marine biodiversity caused by the warming and acidification of the ocean also affect humans. In fact, this disrupts fishing activities, which is the initial supply of food for inhabitants of certain regions. However, it may also affect the tourism sector, by impacting activities like scuba diving, or even the pharmaceutical industry, since some marine species are used in the manufacture of drugs.

Solutions

No one person can directly influence the climate but by joining forces we definitely can. On the other hand, companies can work to reduce greenhouse gas emissions, and thus contribute to limit the warming of the atmosphere, by changing their production and consumption behavior. This requires political decisions (for example, encouraging the development of public transport or renewable energy) but also a commitment from companies to operate with more environmentally friendly practices. *Perhaps one may think that individually we cannot directly have an influence on climate; but joining the efforts and actions of many people we definitely can.* [51]

At the individual level, each of us can contribute to reduce our carbon footprint and greenhouse gases emissions by changing our habits. The [Sustainable Development Goals](#) spell out how we can protect our environment and slow climate change, from forests to the ocean to everywhere in between. The UN suggests some actions we can take into consideration to reduce your impact on the environment:

1. Save energy at home
2. Change your home's source of energy
3. Walk, bike or take public transport
4. Consider using a more sustainable transport instead of an airplane
5. Reduce, reuse, repair and recycle
6. Eating more vegetables results in fewer greenhouse gas emissions and requires less energy, land, and water.
7. Make your money count by choosing products from companies who use resources responsibly. [52]

(Note: the information about “The impact of climate change on the ocean” has been mostly extracted from the reference 51, except the paragraphs indicated with a different reference number).

Coastal protection and management

Coastlines are attractive spaces subject to a high population pressure. In UK, 36% of the people lived within 5 km from the sea and 94% within 50 km (in 2006).

They are varied territories with very different environments (beaches, cliffs, dunes, estuaries, etc.) and which are given over to a variety of uses (commercial and industrial activities; commercial and fishing ports, marinas; water sports, etc.). Also, thanks to their diversity, coastlines attract high numbers of tourists. For example, the town of Biarritz, in France, grows from 23 000 to 110 000 inhabitants during the summer season.

Nowadays, with the increasing frequency of marine weather phenomena such as storms and the population growth in coastal areas, communities are rethinking the way in which coastlines are developed.

Consequently, several strategies have been put in place in order to protect stakes on the European coast. There are four types of strategies: engineering solutions, the adaptation or support of natural processes, relocation or strategic retreat and passive monitoring.

Depending on the stakes to be protected (homes, infrastructure, natural habitats, etc.) different strategies will be favored.

In this document we will focus in supporting natural processes, relocation or strategic retreat and passive monitoring.

Supporting natural processes

Dunes and wetlands naturally protect the coastline. Their rehabilitation or reinforcement can slow down the phenomenon of erosion and thereby reduce the risk of flooding.

1. Dune restoration

For dune restoration, the natural processes are supported by the installation of wooden barriers (sand fences) and the planting of vegetation which traps the sand. This prevents the sand, carried by the wind, from advancing inland. The dune is stabilized and can even gain land on the sea.

This process is slow and requires patience and specific measures to prevent people walking over the protected areas. This forces users to make detours to access the beach, but this small effort is rewarded in the long term thanks to the preservation of a healthy beach enabling users to enjoy their coastal activities.

Disadvantages:

- Requires regular maintenance of the dunes and installation of essential protective structures
- Slows down the erosion process but does not stop it

- Only suitable for zones where a large dune system already exists

2. Restoration of wetlands

Many wetlands on the French coastline have been dried out over recent centuries to make way for farmland or building land, to fight against the invasion of mosquitoes (the Landes Forest, for example) or to facilitate access to the coast. Yet these areas act as “buffer” zones which can absorb significant quantities of water and which are capable of slowing down waves during storms. They thereby considerably reduce the risk of flooding and re-establish biodiversity.

Apart from its capacity to protect the coast, the rehabilitation of wetlands would favor the development of leisure activities such as fishing, nature observation, walks, etc. That can be a real advantage for a territory and its inhabitants, improving the living environment in keeping with a sustainable development approach.

3. Posidonia conservation and restoration

Posidonia is not only a highly effective carbon sink capable of absorbing 15 times more CO₂ from the atmosphere than the Amazon rainforest, but it is also home to an enormous range of organisms. The meadows also purify the waters around us, giving them their characteristic turquoise color, generate huge amounts of oxygen, capture plastic materials dumped into the sea and return them to dry land, and prevent erosion along the coastline by keeping the sand in place. [53]

4. Living shorelines

Research suggests that living shorelines may be a viable approach to conserving coastal habitats (marshes, beaches, shallows, seagrasses) along eroding shorelines. Living shorelines typically involve the use of coastal habitats, such as wetlands, that have a natural capacity to stabilize the shore, restore or conserve habitat, and maintain coastal processes. They provide stability while still being dynamic components of the ecosystem, but due to their dynamic nature, careful designs and some maintenance will be required if habitat conservation is a goal. Living shorelines may represent a singular opportunity for habitat conservation in urban and developing estuaries because of their value to society as a shoreline protection approach and resilience to sea level rise. [54]

Disadvantages:

- Large areas of coastline need to be left in a natural state
- Tourist development limited to “green tourism”

Relocation or strategic retreat

Relocation involves demolishing and moving seafront properties and activities inland. This solution is foreseen when maintaining the coastline becomes technically impossible or when the cost of doing so becomes too high.

In areas where the coastline is retreating fast, relocation can be foreseen when few properties are concerned and they can be easily moved (for example: a campsite).

This strategy requires accurate forecasting on the part of local authorities and a vast program of information and communication to convince stakeholders (inhabitants and businesses). While it seems to be the only long-term solution faced with the growing risk of erosion in certain areas, it is very complex to put in place, notably due to the thorny issue regarding the compensation of the people concerned as it can be difficult to find the necessary funding.

Disadvantages:

- Numerous regulatory, operational and financial obstacles to overcome
- Very slow to put in place, which often involves finding an expensive temporary protection solution
- A feasibility study needs to be carried out beforehand involving all local stakeholders
- Low social acceptability (difficult to convince the people concerned)

Passive monitoring

This involves letting nature take its course, without human intervention. The ecosystem is often able to regain normal functioning after having suffered an external disturbance (a storm for example). This is known as "resilience".

These natural areas are nevertheless monitored by the relevant authorities which study their evolution in order to anticipate any change.

Although relatively inexpensive, this solution is unfortunately suitable for very few places. These areas are shrinking as a result of tourism development and population growth.

For example, the designation of Natura 2000 protected areas is a measure which help to preserve untouched spaces which can thereby act as buffer zones.

Disadvantages:

- Suitable for only a few areas
- Requires in-depth knowledge of the territories

Often, local authorities apply several strategies to their territory, depending on the configuration of their coasts, the budget and the stakes to protect. These are difficult decisions to take and consultation among stakeholders (decision makers, managers, users, inhabitants, business owners, etc.) is essential.

(Note: the information about "Coastal protection and management" has been mostly extracted from the reference 55, except the paragraphs indicated with a different reference number).

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Biodiversity table

Instructions: Note down all the observations made on the species in the table during the outward journey and for about an hour.

Name of the observer: _____

Species recognition skills (round the correct one): **Low** **Medium** **Good** **Very good**

Location : _____

Is it a protected area? If so, what is its protection figure? _____

Date :

Hour:

Name of the species		Number of observations
	Great black-backed gull <i>Larus marinus</i>	
	European herring gull <i>Larus argentatus</i>	
	Black-headed gull <i>Chroicocephalus ridibundus</i>	
	European Oystercatcher <i>Haematopus ostralegus</i>	

 Northern gannet <i>Morus bassanus</i>	
 Bottlenose dolphin <i>Tursiops truncatus</i>	
Name of the species	Number of observations
 Native oyster <i>Ostrea edulis</i>	
 Beadlet anemone <i>Actinia equina</i>	
 Small Spotted Catshark <i>Scyliorhinus canicula</i>	
 Japanese wireweed <i>Sargassum muticum</i> INVASIVE	
 Common jellyfish <i>Aurelia aurita</i>	

	Lion's mane Jellyfish <i>Cyanea capillata</i>	
	Compass jellyfish <i>Chrysaora hysoscella</i>	

COMMENTS:



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