04

WAVES

The Mediterranean and its coastline education programme

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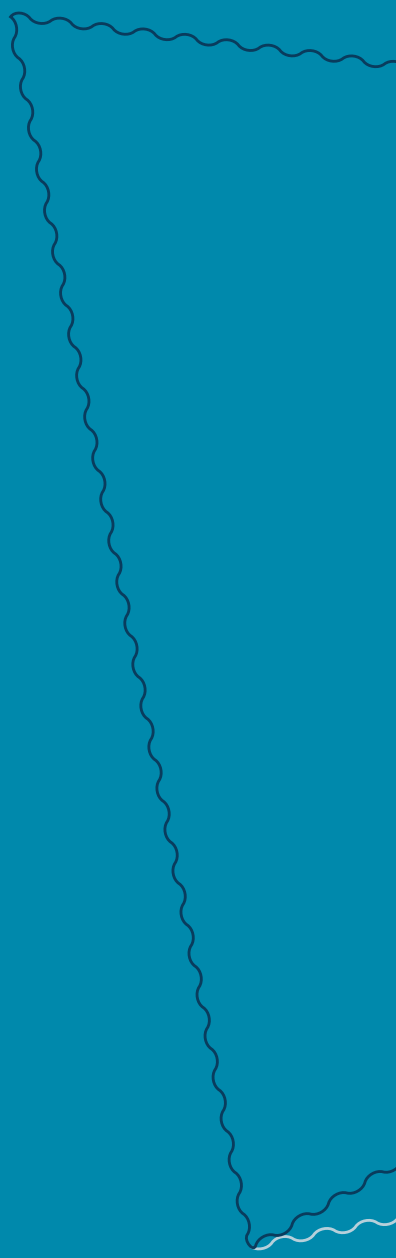
Fundación "la Caixa"

SOCIB Balearic Islands Coastal Observing and Forecasting System



04

WAVES

The surface of the sea is not really flat at all, when the wind blows on the sea's surface it generates waves. Even though it seems like waves form on the beach, they actually form on all of the earth's water surfaces, even if we only notice them when they break on the beach.

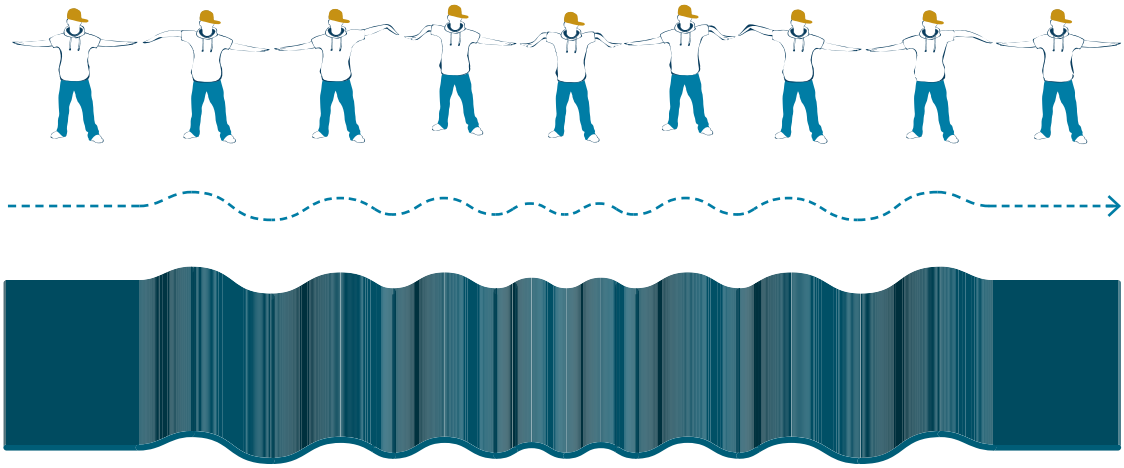
Do you know why the sea has waves?

4.1 WHAT ARE WAVES?

When the wind blows constantly over the surface of the sea it generates undulations we call waves.

HOW ARE THEY CREATED?

A wave is actually energy which moves through the surface of the ocean, created by the force of the wind on the sea. As the wind impacts on the surface of the water it produces a disturbance which is transferred to all the particles in the area, causing them to perform a circular motion. This movement spreads through the water as a wave, like the waves formed on a rope when it is shaken repeatedly at high speed, or in a football stadium when spectators do a Mexican wave that travels through the crowd. At that moment we only see the waves, transferring energy but without displacing particles.



The water in a wave moves from the top to the bottom.

Try it!

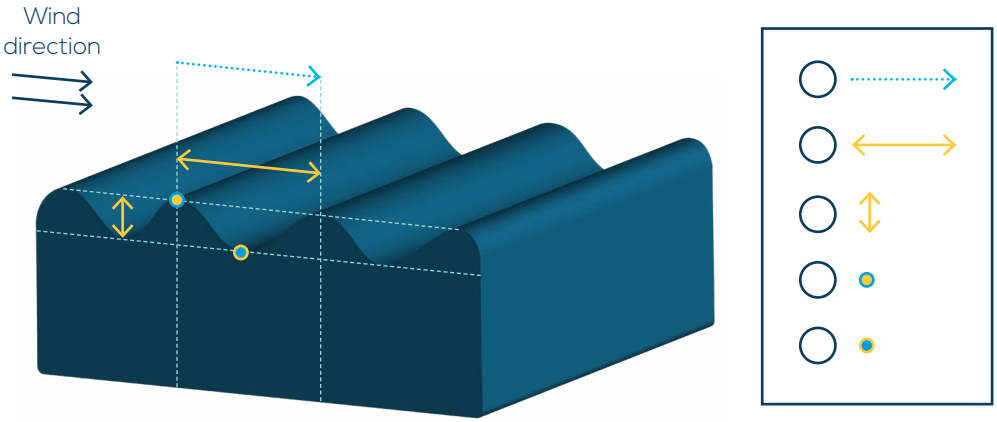
Make a wave with the people around you.

A.4.1.

ROLLING WAVES

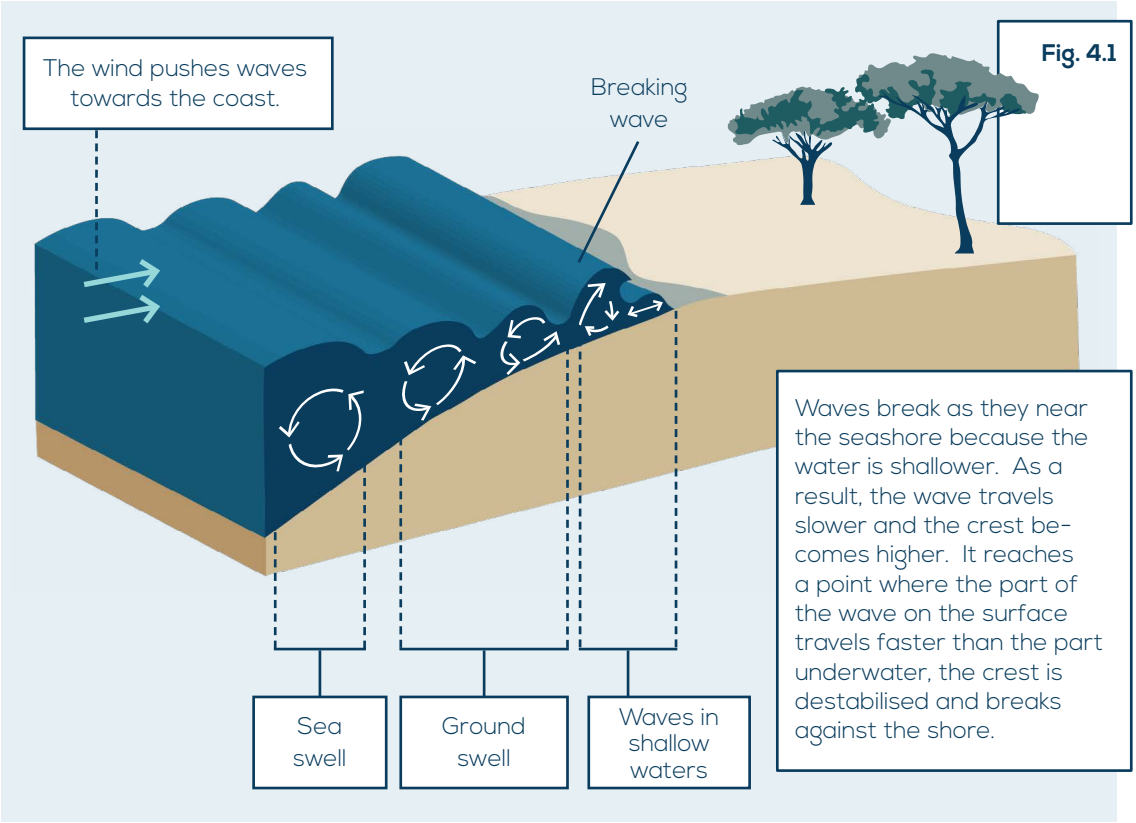
Read the text and indicate the different parts of a wave on the following diagram:

When you observe waves it is possible to identify the **crest** (a), which is the highest part of the wave, and the **trough,** or lowest part of the wave (b). Waves are defined by their **height** (c), which is the vertical distance between the crest and the trough of a wave; their **length** (d), which is the distance between two successive crests; and the **period** (e), which is the time it takes for two successive crests to pass a specified point.



4.2 WAVE FORMATION

In general, the stronger the wind, the higher the wave that will be formed. However, it is not always this simple, there are other factors which affect the height of a wave, like the wind speed, its duration and the area of the sea surface on which the wind blows (figure 4.1 page 4). The stretch of sea where the wind blows in a single direction and at a constant speed, generating waves, is called a **fetch** (figure 4.2 page 5). The fetch is measured in miles and the bigger the fetch, the higher the waves.

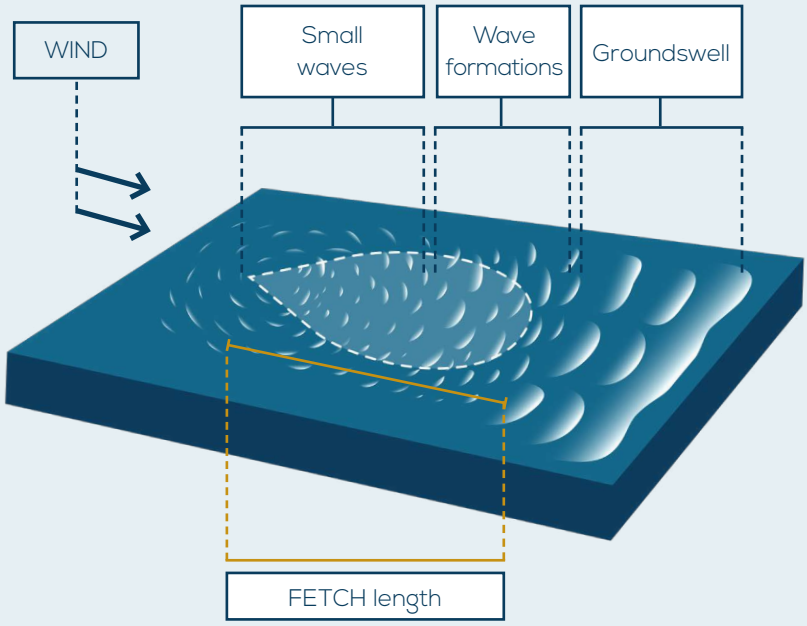


Usually there is distinction between wind seas and ocean swells. **Wind seas** are typified by waves generated locally by winds close to their point of origin. These waves appear in a irregular and disorderly manner, characterised by random wave period, height and direction of propagation.

When a wave is generated in the middle of the ocean, or in deep waters, the wave does not meet any resistance and it can travel hundreds of miles, huge distances from the area of wind it was generated in. It can only lose its force if it comes into contact with the sea floor as it approaches the coast, or if it meets opposing winds. If they don't meet any resistance, these small, irregular waves which were formed in the fetch, or wind area, disappear as they leave this area, leaving only the bigger waves which make up the ocean swell.

The waves that make up the **ocean swell** are not related to local wind. Swell is produced by distant storms far from the coast and swell waves have travelled out of the zone they were generated in with a minimum loss of energy. This type of wave has a regular, orderly appearance, characterised by a regular wave period, aligned crests and fast speed of travel in a uniform direction.

Fig. 4.2



4.3 THE SEA STATE

By simply observing the sea state we can classify it using the **Beaufort scale** and the **Douglas Sea Scale**.

Recap on the **Beaufort Scale** in the **WIND** unit

The **Douglas Sea Scale** is divided into ten degrees, which refer to the size of the waves, ranging from insignificant wave size (calm sea) to wave heights of more than 14 metres (very high seas) such conditions are recorded relatively frequently in the North Atlantic. It was created by a British man, Sir Henry Percy Douglas, who, in 1907, was at the forefront of the Naval Meteorology service and established a scale to describe the sea state based on the height of the waves.

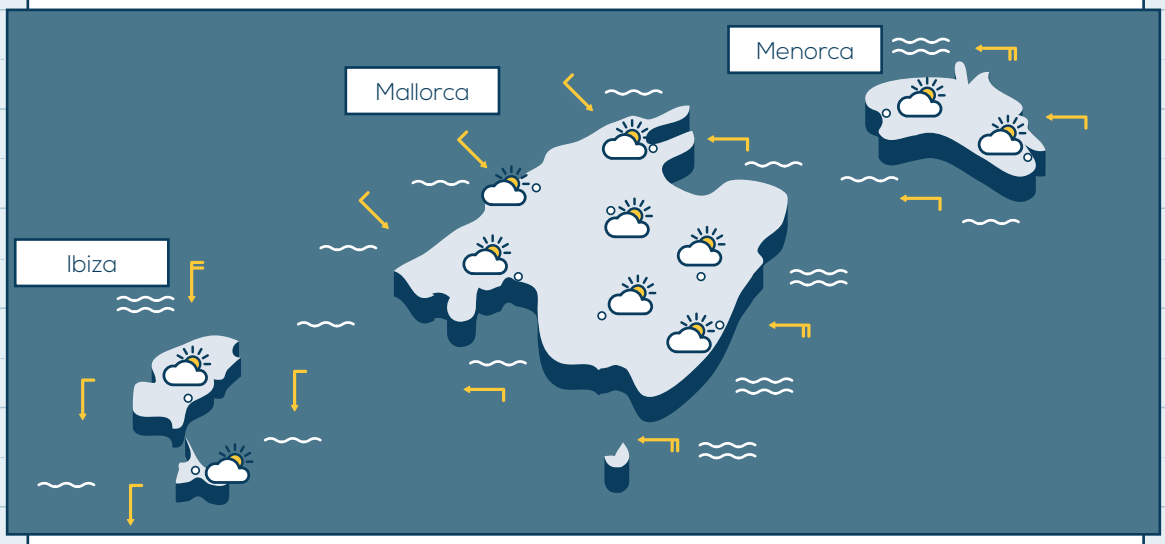
DOUGLAS SEA SCALE

degree	height (m)	symbol	name	description
degree 0	0		Calm sea	Perfectly flat sea.
degree 1	0-0.1		Rippled sea	Small waves are formed which do not break.
degree 2	0.1-0.5		Smooth	Waves become a little more pronounced without breaking and are no problem for small boats.
degree 3	0.5-1.25		Slight	The waves increase enough to make sailing in small boats more difficult.
degree 4	1.25-2.5		Moderate	The size of the waves makes it impossible to sail small boats.
degree 5	2.5-4		Rough	The size of the waves increases still further making it dangerous to sail small boats. The white foam on the breaking crests starts to be dragged in the direction of the wind. Increased sea spray.
degree 6	4-6		Very rough	Degree 5 conditions worsen with larger waves. Sea spray reduces visibility.
degree 7	6 -9		High	Degree 6 conditions worsen. Foam forms large banks which are dragged thickly in the direction of the wind.
degree 8	9 -14		Very high	Exceptionally large waves moving in no particular direction, such as may be seen in the vortex of a hurricane. Small and medium tonnage boats are lost sight of.
degree 9	más de 14		Phenomenal	The air is full of foam and sea spray, the sea is white and visibility is practically zero.

A.4.2.

CALM SEA, SLIGHT SEA OR SMOOTH SEA?

Interpret the weather map and answer the following questions:



1 - *What is the sea state be in the Portocolom area? And how about the Bahía de Palma?*

2 - *If we want to go out sailing in Menorca, which area will we have better conditions in, to the North or to the South?*

3 - *Look at the wind symbols:*

Where can we find light winds? What is the sea state in that area?

Where can we find strong winds? What is the sea state in that area?

What relationship is there between these two phenomena?

4.4 STUDYING THE SEA STATE

Today it is no longer necessary to observe the sea directly to obtain data about the waves since there are instruments that provide continuous data about its state.

Oceanographic buoys are one of these instruments. These buoys record the elevations of the sea's surface and analyse the height, the wave period and the direction. The buoys regularly transmit the information they obtain, via satellite, to a data centre which stores and analyses it.

ICTS SOCIB has a network of buoys which provide reliable data about waves at different points in the Balearic Sea. This network provides important information which means improved monitoring and forecasting of oceanic conditions (currents, waves, etc) which are essential for maritime activities, both economic and recreational. They also help water quality monitoring and detecting acidification in the sea.

You can check the sea state via the network of fixed infrastructures, whose data are available on *www.socib.es*

To be able to interpret the data about waves that the buoys provide, we have to look out for the direction they are coming from, and differentiate it from the data relating to the current, which will always indicate where they are going. We can also get information about the wind direction and intensity.

A.4.3.

LET'S INVESTIGATE

Look at the different variables on the next page and answer:

1- *Where are the waves coming from?*

2 - *Where is the wind blowing from?*

3 - *How strong is the wind? What number is it on the Beaufort scale?*

4 - *What is the wave height? What number is it on the Douglas sea scale?*

5 - *Explain the relationship between the wind and the waves in your own words.*

Air temperature 18.4 °C — Atmosphere Dynamic	Wind speed 5.0 m/s — Atmosphere Dynamic	Wind direction SSE — Atmosphere Dynamic
Atmospheric pressure 1022.99 — Atmosphere Dynamic	Water temperature 15.75 °C at 1 m — Hydrology	Water temperature 15.89 °C at 1 m — Hydrology
Wave height 0.25 m — Surface	Wave direction SSW — Surface	Current speed 9.77 cm/s at 1 m — Ocean Dynamics
Current direction NNE at 1 m — Ocean Dynamics	Current speed 2.2 cm/s at 2 m — Ocean Dynamics	Current direction NE at 2 m — Ocean Dynamics
Salinity 37.705 psu at 1 m — Hydrology		

4.5 WAVE ENERGY

As we have seen waves are an inexhaustible source of clean energy, which in some circumstances could be channelled for everyday uses, like the energy from the sun.

Wave power enables electricity to be obtained from the energy in the waves. Different methods of transforming the kinetic energy from waves into electrical energy are currently being developed.

In the last 25 years there has been huge progress in the designs of the devices for tapping into wave energy, even though they are still in the developmental stages and alternative methods are being researched, since the devices which are already installed at sea have very high maintenance costs.

A.4.4.

ADVANTAGE OR DISADVANTAGE?

Read the following statements carefully and indicate if they are an advantage (A) or a disadvantage (D):

1 -	*It is a way of obtaining inexhaustible energy.*	◯
2 -	*The process can be quite expensive, as there is a lack of research into this type of renewable energy.*	◯
3 -	*It could be very helpful in avoiding problems with contamination and shortage of energy resources.*	◯
4 -	*The maintenance cost of tidal power plants is high.*	◯
5 -	*This type of renewable energy is exploitable because its main feature is that the waves move over great distances with barely any energy loss.*	◯
6 -	*Seas and oceans cover three quarters of the earth's surface and, therefore, they represent an enormous energy reservoir in constant motion.*	◯
7 -	*Generation of energy from waves does not produce greenhouse gases.*	◯
8 -	*The initial investment required to build a tidal power plant is considerable.*	◯

A.4.5.

WRITE A STORY SUMMARIZING EVERYTHING YOU'VE LEARNED ABOUT WAVES

GLOSSARY

Sea spray:

Violent, abundant splashes of seawater caused when waves hit an obstacle.

All aspects of this unit have shown the Mediterranean to be a physically confined space, with characteristics which make it unique: its waters, its climate, its biological wealth and its historical legacy. The future of the Mediterranean sea depends on our knowledge of it, and on how much love and care we invest in it from now onwards.