05

OCEAN CURRENTS

The Mediterranean and its coastline education programme

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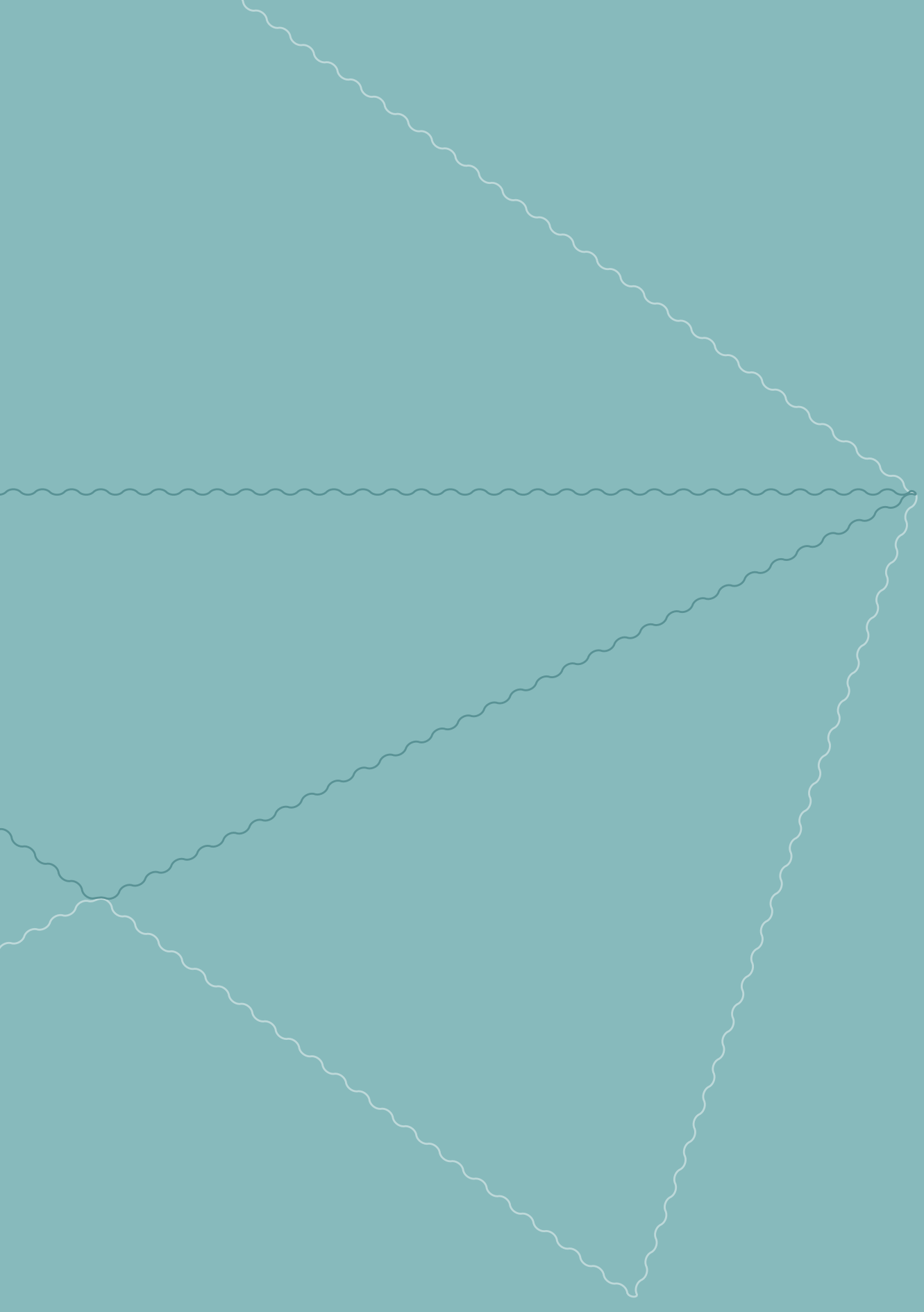
EL MEDITERRÁNEO A UN CLIC
Fundación "la Caixa"
SOCIB Balearic Islands Coastal Observing and Forecasting System



05

OCEAN CURRENTS

The water masses which make up our seas and oceans are in continuous movement, known as the ocean currents.

It is thanks to this continuous movement of water which generates a continuous transport of not only hot and cold, but also of the nutrients necessary to sustain marine organisms.

Ocean currents are responsible for the movement of the water masses which make up the oceans but,

do you know how they are produced?

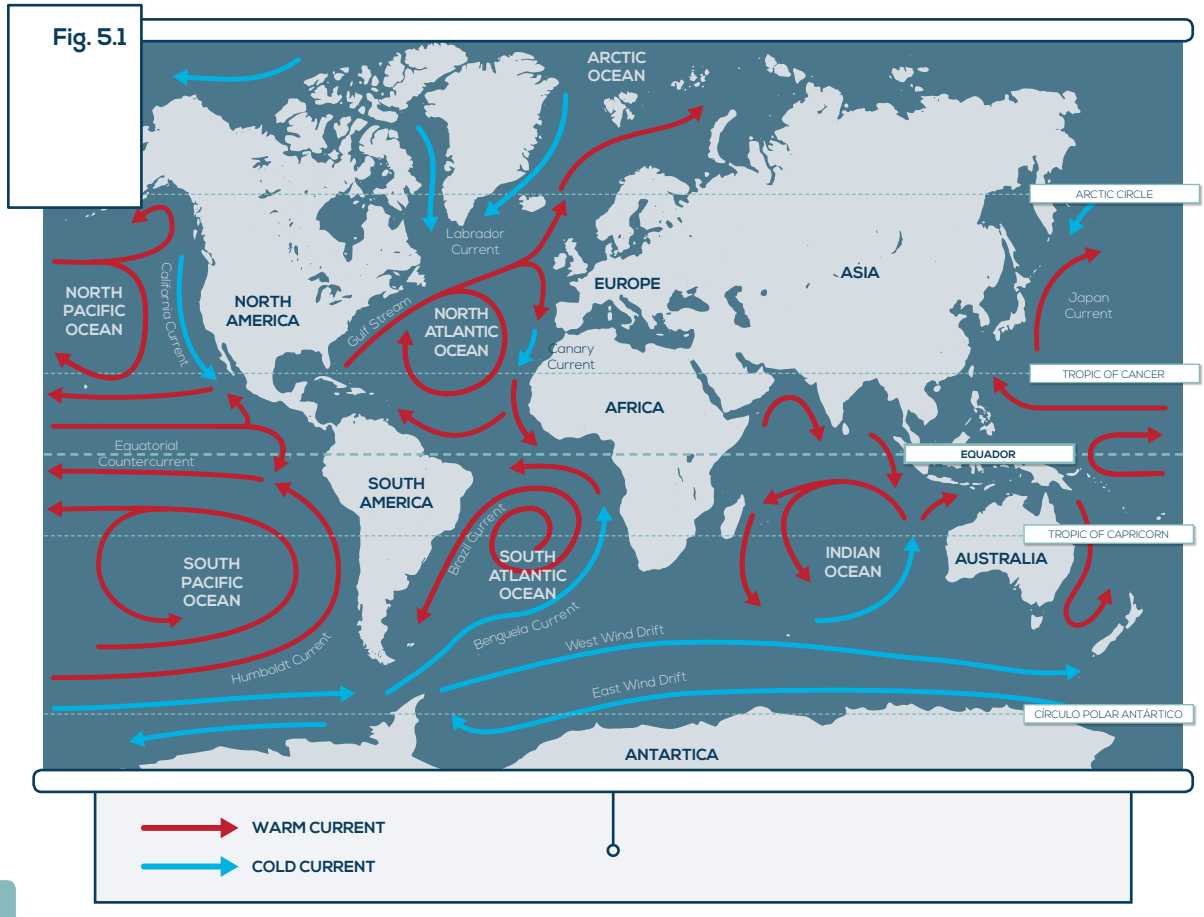
5.1 WHAT ARE CURRENTS?

Ocean currents are the movements of water masses from one location on the planet to another.

These currents can have very different spatial and temporal scales, from local currents which are only generated at certain beaches and bays, to the great ocean currents which move across the whole planet.

Along their route water masses transport both energy (in the form of heat) and matter (solids, dissolved substances and gases), helping to achieve a global energy balance between the cooling of the water in polar areas and the heating of the sea in the equatorial zone.

Fig. 5.1



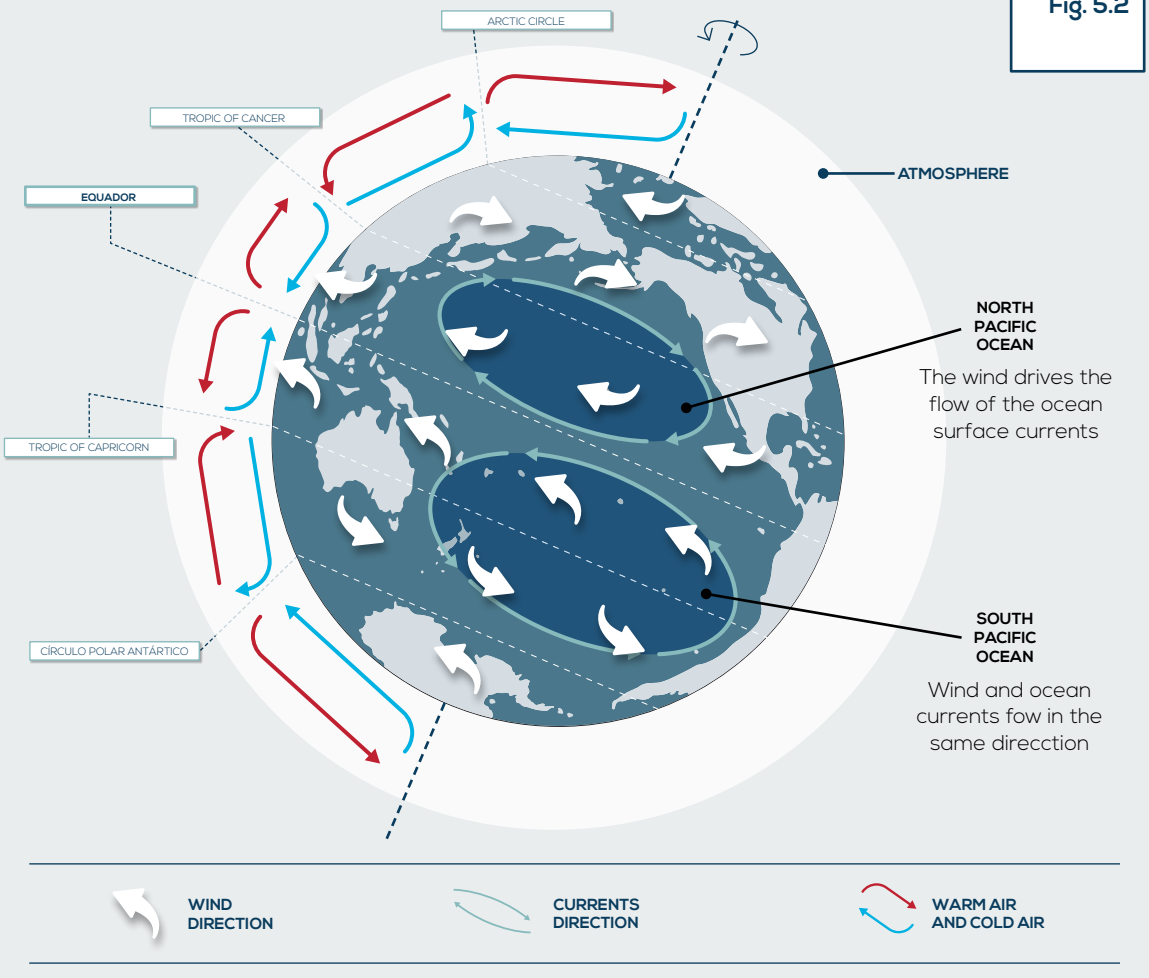
5.2 WHAT GENERATES CURRENTS?

Ocean currents are generated in various ways which can be classified according to the force which generates them, the three main factors are:

1 Currents generated by wind

As well as making waves, the force of the wind on the surface of the ocean also causes surface water layers to move in the direction the wind is blowing. In the ocean these winds can generate currents which move over thousands of kilometres, such as the Equatorial currents or the Gulf Stream.

Fig. 5.2



2 Thermohaline circulation

These currents are generated due to the differences in density of water masses with varying temperature and salinity, located at different points on the planet or at different depths. **Thermohaline** (figure 5.3) is derived from the words *thermo-* referring to temperature and *-haline* which refers to the salinity, these factors together determine the density of seawater.

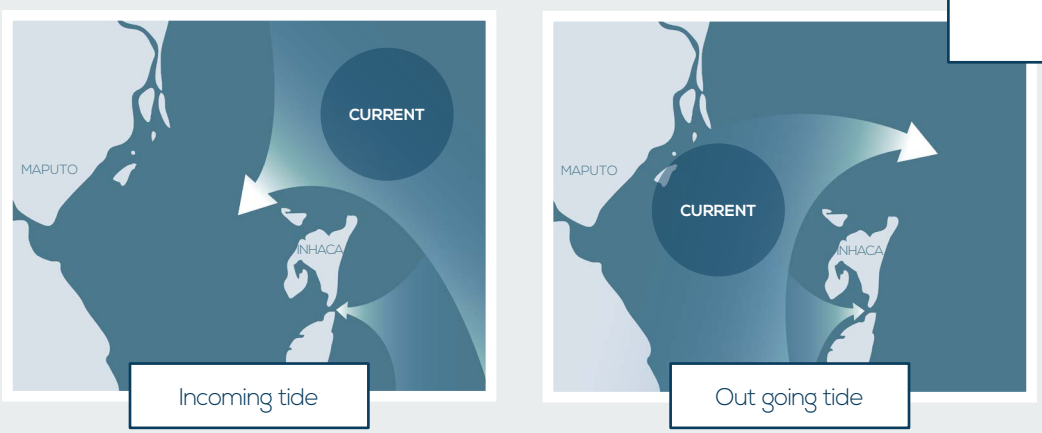
This type of current is generated by gravity and together with the others, they make up what is known as "**the Great Ocean Conveyor Belt**". This conveyor belt is largely responsible for transferring the warm waters of tropical regions towards the polar waters where they begin to sink as they cool and then circulate all around the planet, on a journey which can take up to 1000 years before returning to their point of origin.

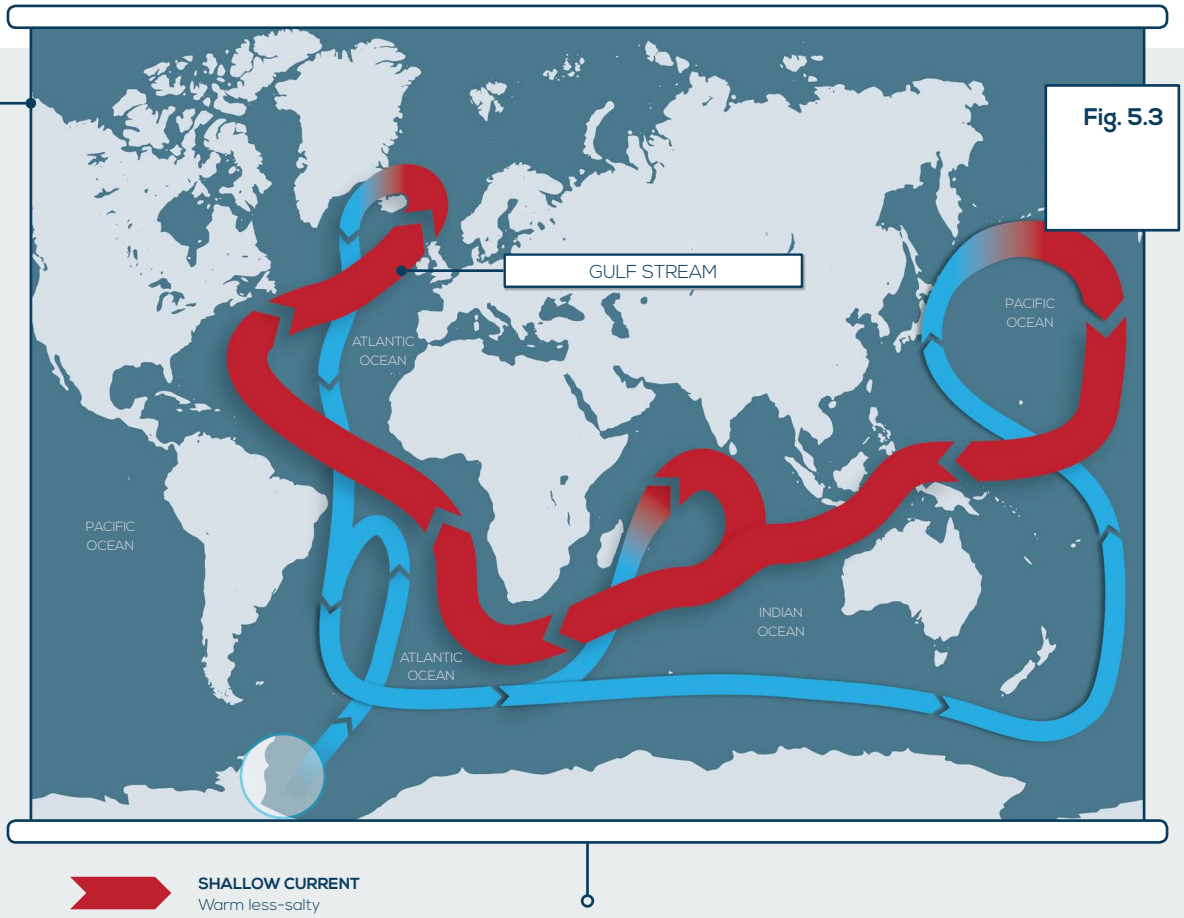
3 Tidal currents

The rise and fall motion of the tides generates currents in the oceans, which are strongest in coastal areas, bays or estuaries.

In the Mediterranean tidal effects are hard to appreciate. Tidal currents (have a very regular and predictable pattern, due to the motion of the Earth's rotation relative to the Sun and the Moon.

Fig. 5.4





THE EPIC JOURNEY OF THE RUBBER DUCKS

Ocean currents affect deep ocean waters, far from the coast, which are not so much influenced by the wind but by the **thermohaline** circulation which produces currents due to differences in density, created by variations in salinity and temperature.

For a better understanding of these processes, read carefully the story you will find on the following page about a shipwreck and rubber ducks:

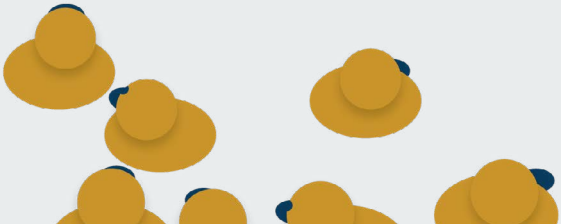
Stories of major shipwrecks always start on stormy nights, like the one experienced by a cargo ship travelling from Hong Kong to the United States on the night of the 10th of January 1992. In the middle of the Pacific Ocean, near the 45th parallel and the International Date Line, some of the containers it was transporting fell in to the sea releasing their contents: 29.000 plastic bath toys. The yellow ducks, blue turtles, red beavers and green frogs were set to sail on the ocean, propelled by the wind and the ocean currents. Even though their original destiny was the bathtub, they set off on an epic journey which became one of the longest scientific experiments in the history of oceanography. Ten months after they were washed overboard, the "*Friendly Floatees*" (the brand name of these toys) started to appear on the coast of Alaska and the West coast of the United States. After that some appeared much further South, on the coast of Hawaii, whilst others were moving around the cold waters of the North Pole, continuing their journey, until reaching Japan and returning through the Pacific Ocean to Alaska.

Dr. Curtis Ebbesmeyer, an American oceanographer, collated data about the locations where the adventurous ducks had appeared.

Thanks to the collaboration of other scientists a simulation program called OSCUR (Ocean Surface Current Simulator) was developed, which calculated the direction ocean currents would move in. With each sighting of the ducks the Ebbesmeyer oceanographic model´s predictions were confirmed.

Thanks to this research, scientists confirmed that currents move in large circles called ocean gyres, which are related to the terrestrial rotation motion.

Ducks continued to appear for over more than 15 years. Their epic journey became famous and hundreds of articles have been published about it, children's books have been written about these toys which have become collector's items fetching surprisingly high prices.



A.5.1.

THE DUCKS' JOURNEY

Draw on the map the route followed by the rubber ducks and indicate, according to the following clues, the places where they were found:

10th of January 1992: The container dumped the 29.000 plastic animals near to the 45th parallel.

1. End of 1992: The vast majority of the ducks went south and were found in Indonesia, Australia and South America.
2. 1992, 1994, 1998, 2001, 2004: Found on the beaches of Stika (Alaska).
3. 1995: They were found in Hawaii.
4. 1995-2000: Some ducks crossed the Bering Strait and sailed on through the cold waters of the Arctic ocean, towards the East, slowly navigating the polar ice.
5. 2003: More ducks were found in the state of Maine (United States).
6. 2003: Others were found on the Scottish and British coasts.

Answer the following questions:

1- *How do you think the ducks travelled to beaches thousands of kilometres from the site the incident occurred?*

2- *What relationship do you see between the route the ducks took and the ocean currents?*

3- *Considering the existence of these marine gyres which manage to trap floating waste in the sea, what environmental effects might they have?*

Did you know...

Donovan Hohn wrote the book "MobyDuck". One of the objectives of the book is to highlight the problem of over 10.000 objects which fall to sea every year, filling the ocean with litter or so called marine debris, which poisons, asphyxiates, entraps or kills marine animals.

5.3 THE MEDITERRANEAN CURRENTS

The Mediterranean currents arise mainly in two ways, partly from the circulation created by the differences in temperature and salinity (**thermohaline circulation**) and in part by the currents arising from **local winds**. In addition to this the Mediterranean climate directly affects the behaviour of these currents as it modifies the temperature and salinity of the water masses, due to our clearly defined seasons with high temperatures in summer causing lots of evaporation, and then during the winter there are lower temperatures with strong local storms which cause the waters to mix.

One of the main currents we see in the Mediterranean sea is the current caused by the entry of Atlantic waters via the Strait of Gibraltar (figure 5.5).

This constant flow of water causes a surface current of Atlantic water which is less dense than the warm Mediterranean waters, flowing towards the most eastern area, and a deep current of more dense water which flows in the opposite direction to the surface current, that is from the Mediterranean sea towards the Atlantic.

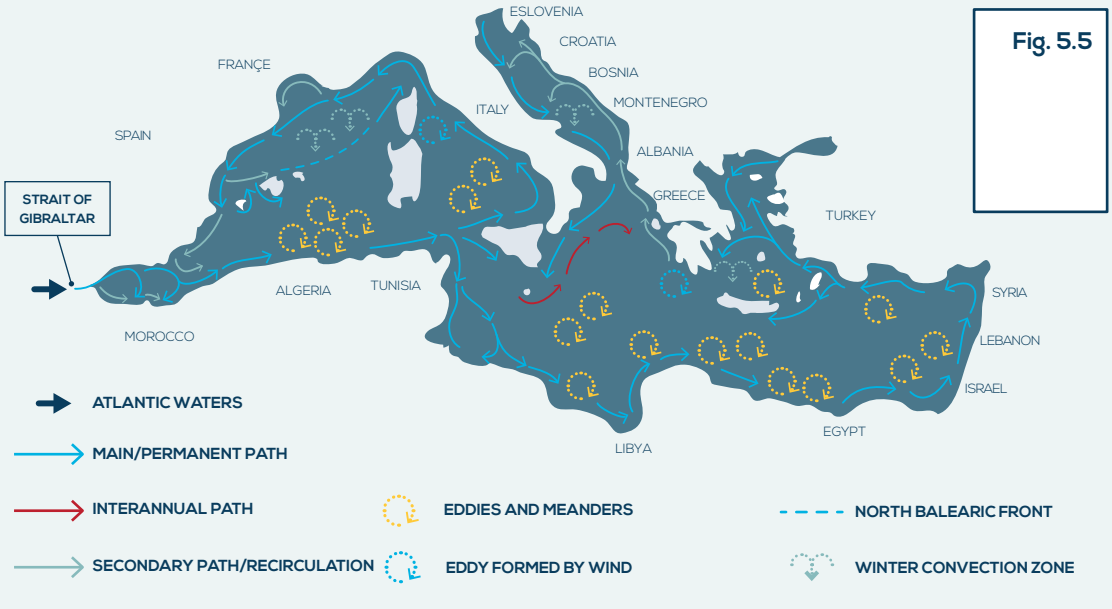


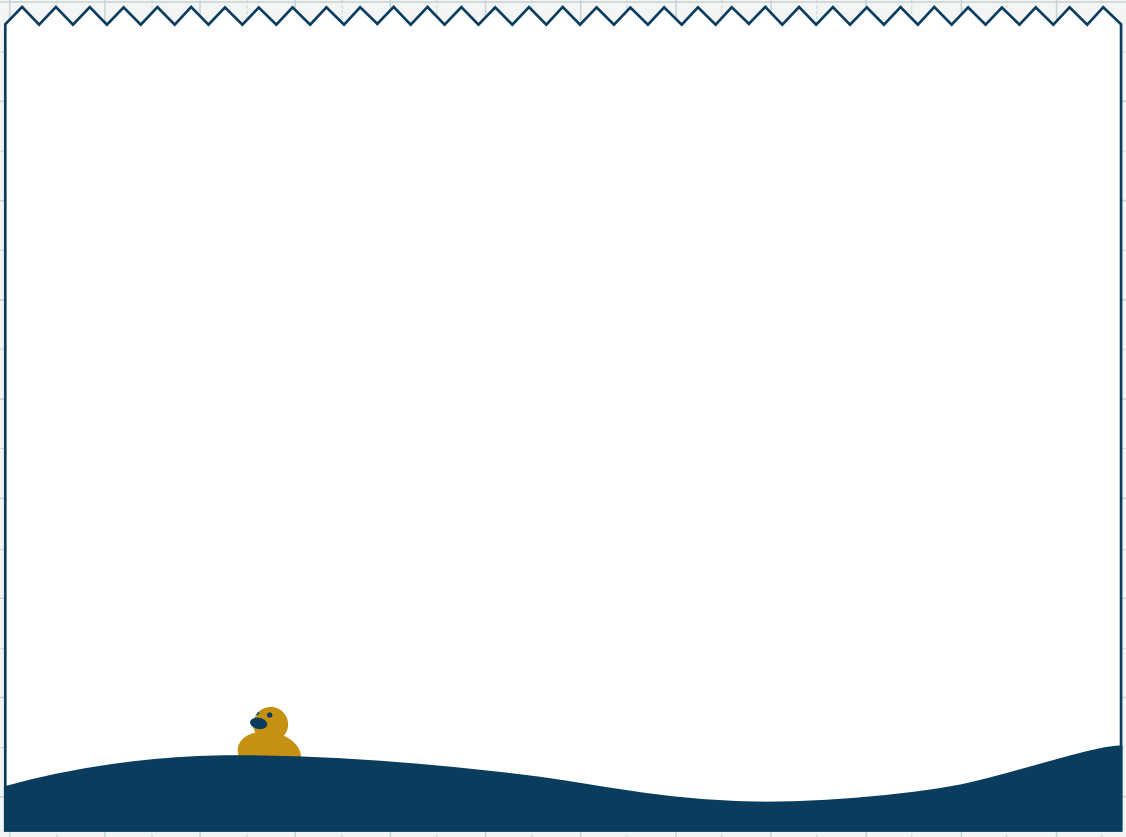
Fig. 5.5

These relatively cool waters of Atlantic origin which flow through the Strait in to the Mediterranean undergo and increase in density due to the rate of evaporation being greater than the precipitation levels in this area. These Atlantic waters, as they travel across the different Mediterranean basins, can form new deep water masses, sinking due to the cooling of the surface during the winter storms. Scientists have determined different areas were the cooling and sinking of water masses occurs in the Mediterranean, specifically in the Gulf of Lion, in the southern Adriatic Sea and off the coast of Egypt.

Fig. 5.6

A.5.2.

Imagine you are a rubber duck which accidentally falls from a boat in to the Mediterranean Sea. Describe your journey, explaining which countries the marine currents take you to or the beaches you discover.



THE STUDY OF CURRENTS

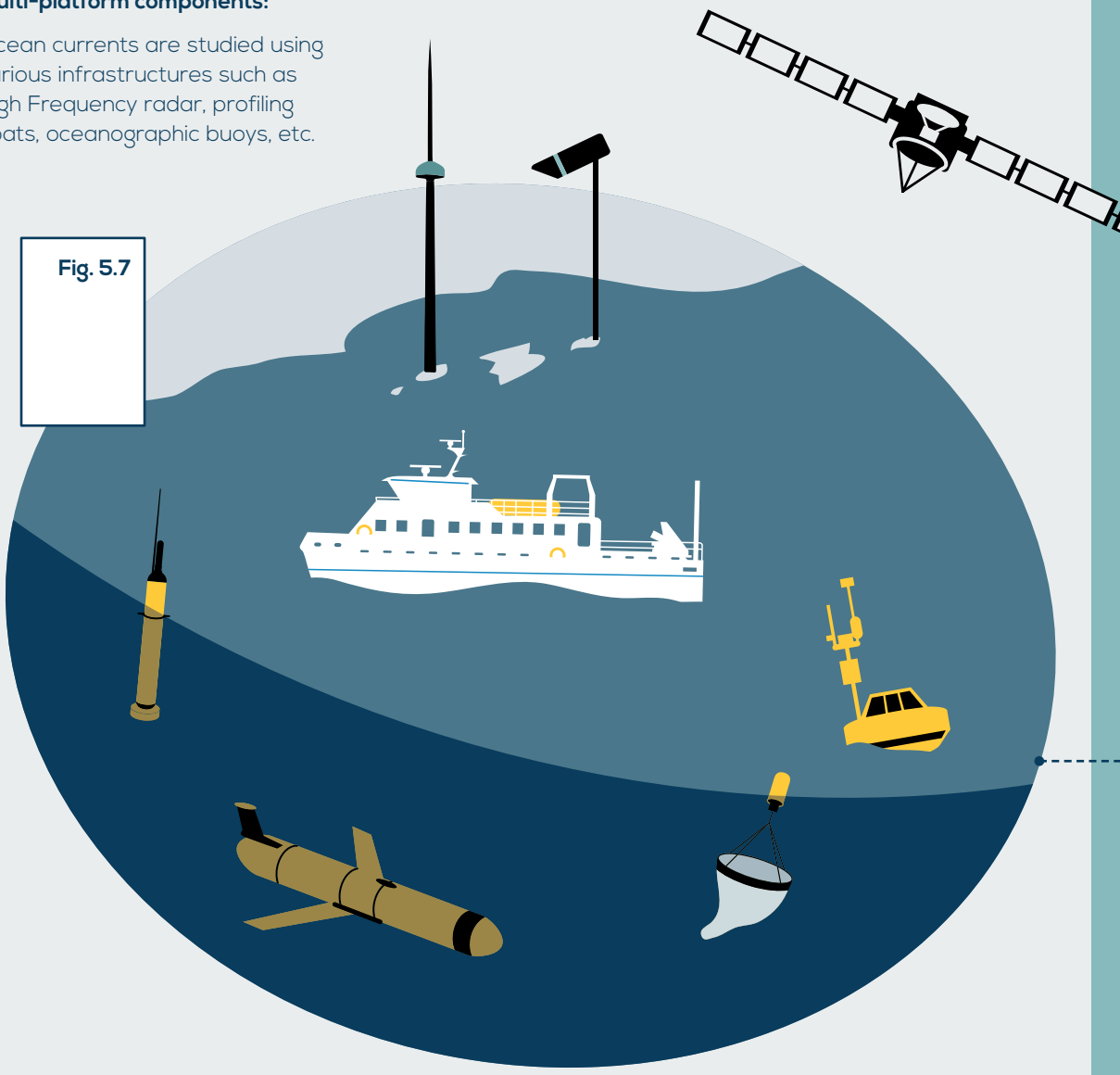
5.4

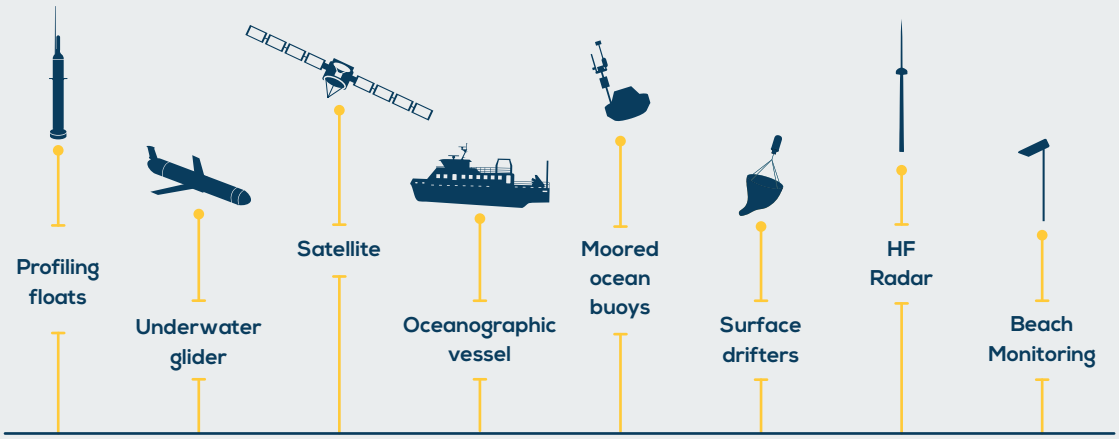
As we have seen, the study of marine currents provides significant data which enables us to understand and even predict the evolution of such important variables as the ocean's temperature and salinity. Since marine currents play a fundamental role in the distribution of heat and of greenhouse gases absorbed from the atmosphere, the study of currents can provide us with the data necessary to advance our knowledge in key topics for society, such as climate change.

Multi-platform components:

Ocean currents are studied using various infrastructures such as High Frequency radar, profiling floats, oceanographic buoys, etc.

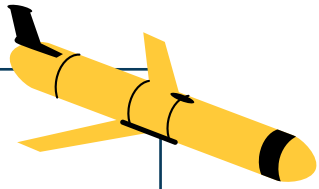
Fig. 5.7





Oceanographic research is very similar to the study of the atmosphere since both, air and water, are fluids subject to the same physical laws. Nevertheless, today there is far greater knowledge about the atmosphere and we are able to make pretty precise weather forecasts thanks to the satellite imagery and the abundance of data from weather stations around the world.

However, it is much more complicated and costly to take measurements from the ocean. In order to study marine currents scientists use different instruments such as floating ocean buoys launched at sea, fixed buoys, underwater gliders, oceanographic satellites and radars (figure 5.7).



+info about the instruments on the ***MEDCLIC web***

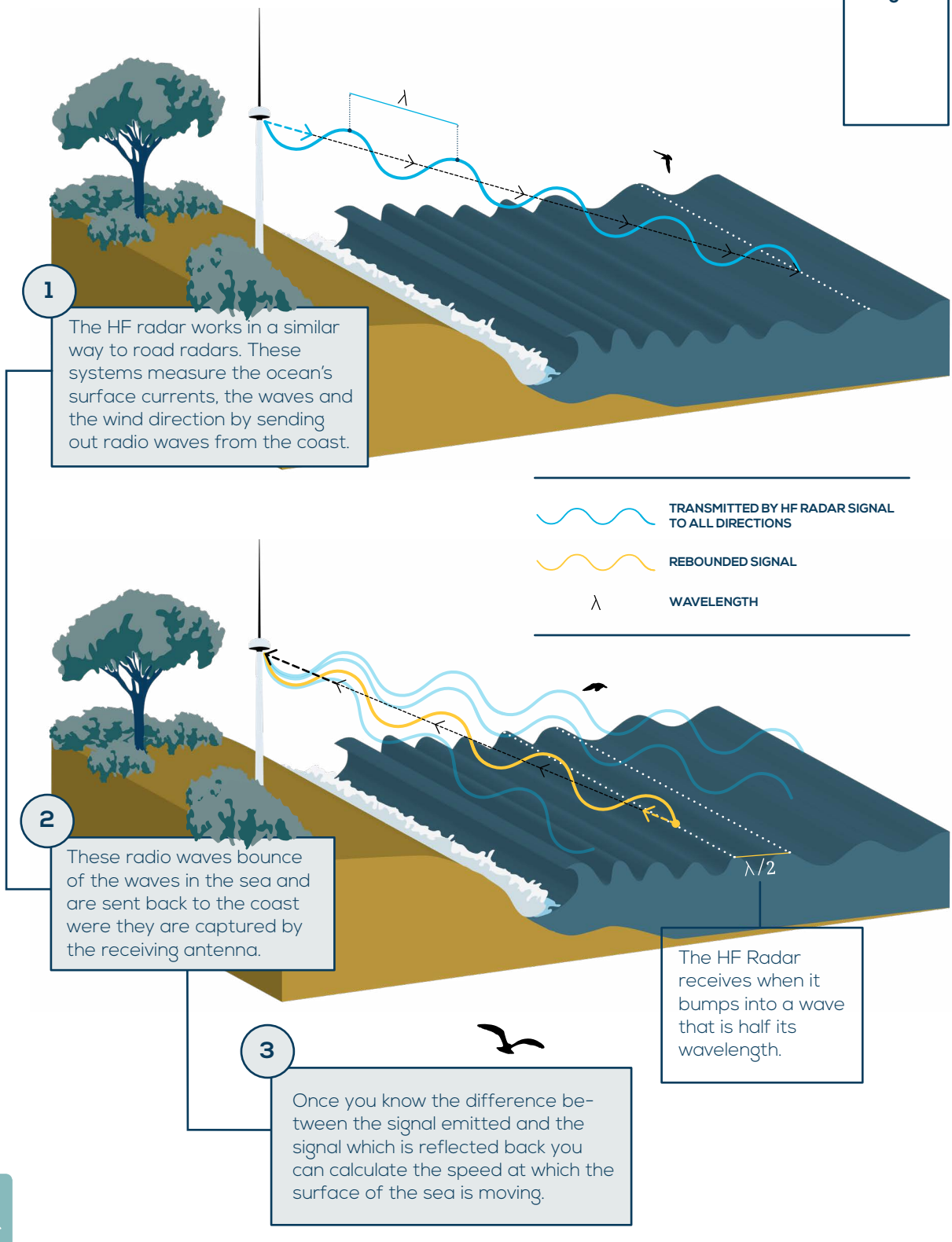
You will also find more details about any of these instruments in ***THE SEA WATER*** unit (pages 12 and 13).

ICTS SOCIB currently relies on one of the leading technologies for the study of surface currents, the High Frequency radar (HF radar). This ocean observing system is made up of two antennas, one in Ibiza and another in Formentera. The High Frequency radar takes very precise measurements of the currents and eddies which form on the surface of the waters flowing through the Ibiza channel, providing measurements of currents with a spatial resolution of 3 Km and a range of up to 70 Km.

The advantage of this over other instruments which must be launched at sea or over measurements taken during oceanographic surveys, is that the radar enables continuous observation in real time, and is not subject to weather conditions. Also, the signal doesn't penetrate the surface of the sea because it is a low power signal and therefore is not a threat to the environment.

The HF Radar (figure 5.8) works similar to road radars:

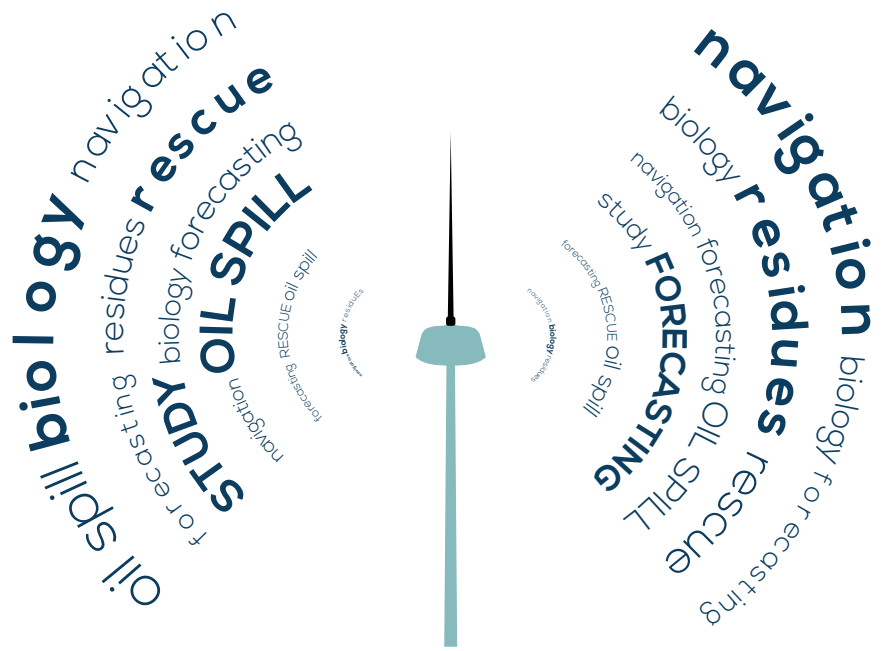
Fig. 5.8



A.5.3.

DISCOVER THE APPLICATIONS OF HF RADAR

Complete the text below with the key words you will find in the radar's signal:



1

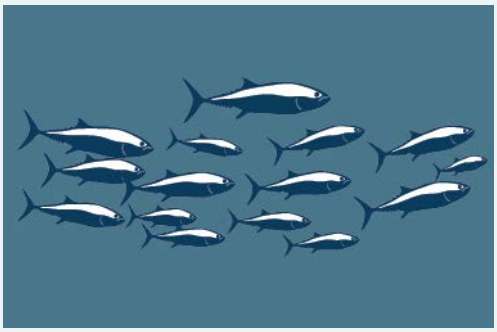
Marine rescue:

Knowledge about the trajectory of sea currents facilitates the _____ *of persons or boats adrift.*

2

Studies in _____ ***and fisheries:***

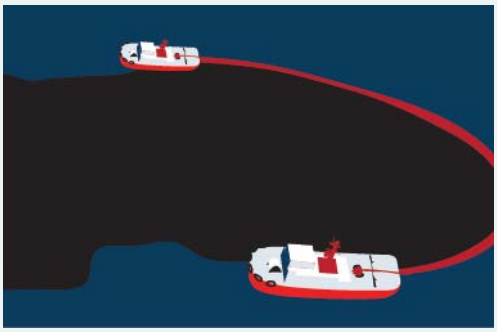
The study of currents enables us to track the movement of jellyfish or the transport of bluefin tuna larvae.



3

Action in critical situations or environmental accidents:

Enables plans of action to be put in place in the case of an _____ *as it is possible to predict the trajectory the hydrocarbons will follow.*



4

Aids for* _____ *and coastal management:

The statistical knowledge of areas at risk from wave action has applications when it comes to building sea walls or understanding the sea conditions in ports.

5

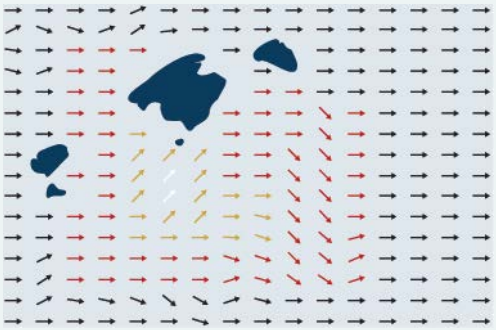
Contamination of the marine environment:

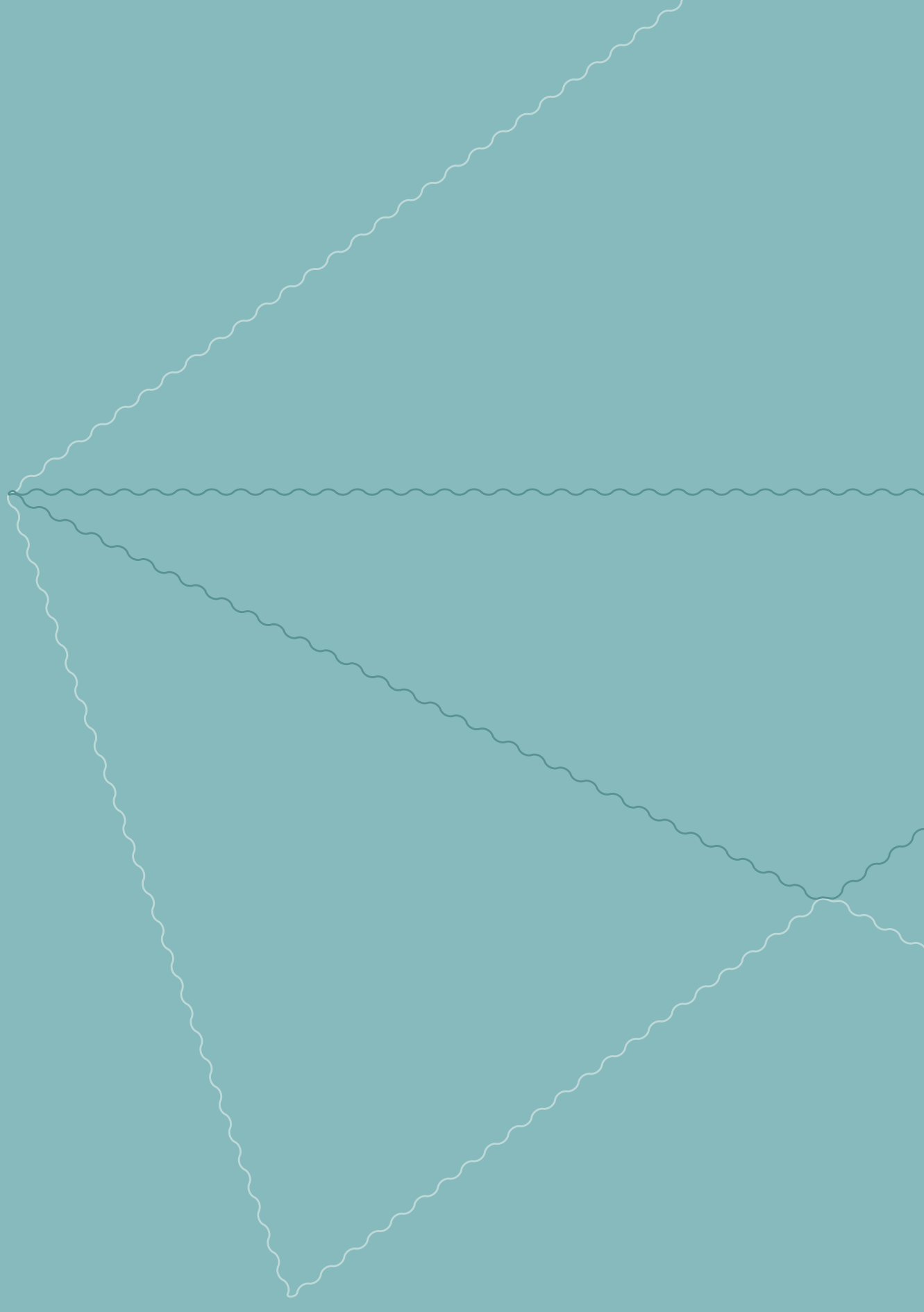
Knowledge about the trajectories of floating _____ *enables the detection of unlawful and deliberate contamination.*

6

Constant data collection:

Aids the _____ *of marine currents and is useful in the development of* _____ *models for ocean currents.*





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.