02

SEAWATER

The Mediterranean and its coastline education programme

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

02

SEAWATER

Without a doubt water is the planet's most abundant liquid and one which is essential for living creatures. Seas and oceans contain around 96.5% of the planet's water. This is seawater, which, apart from salt, has other properties, both physical and chemical which make it different from freshwater.

You already know seawater is salty but, do you know why?

2.1 SEAWATER:

WHAT IS IT MADE UP OF?

The water of the seas and oceans consists of an enormous quantity of known chemical elements, lots of minerals derived from the earth's crust and organic salts which come from animal and plant remains, in varying proportions, which give it its salty taste. It also contains dissolved gases, like hydrogen and oxygen, which make life possible.

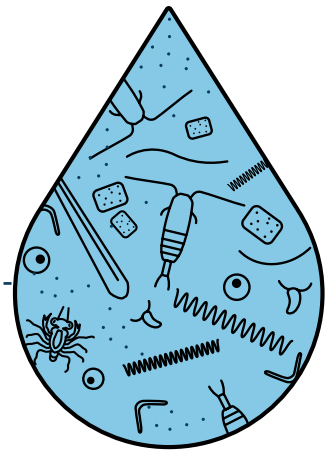
THE IMPORTANCE OF SEAWATER

The water of the seas and oceans is of vital importance for human development. Not only is it an ecosystem where species we eat live, it is also an important source of minerals used in industry.

The oceans also play a very important role in the planet's natural equilibrium since they influence the redistribution of hot and cold. They interact with the atmosphere in a constant interchange of gases between the air and water, and half of the oxygen present in the atmosphere is generated by marine **phytoplankton**. Likewise rainwater is water which has evaporated from the oceans.

GLOSSARY

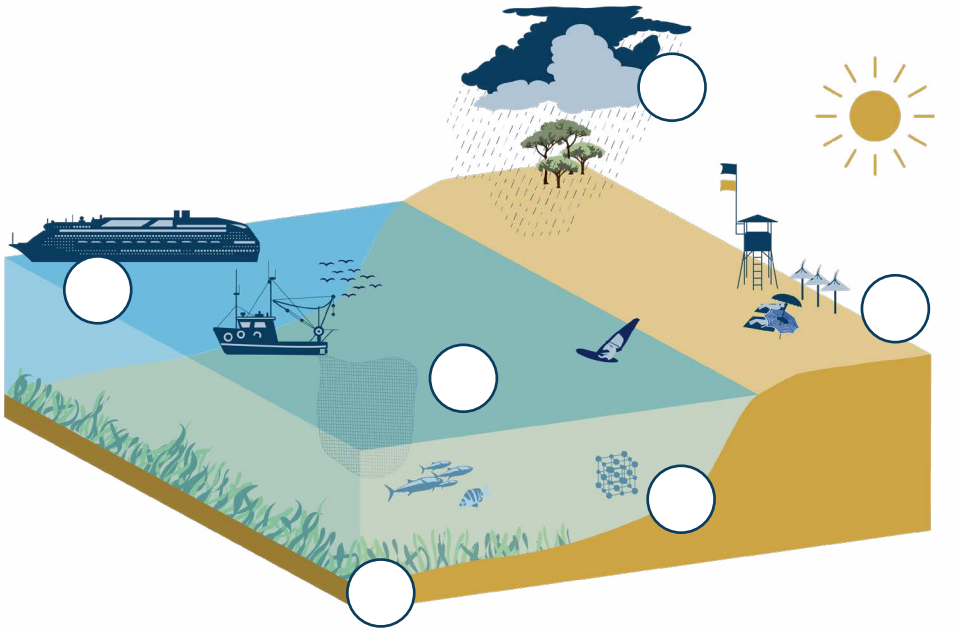
Get to know more about phytoplankton in the glossary at the end of this book.



A.2.1.

THE IMPORTANCE OF OUR OCEANS

Locate the aspects which make seas and oceans important for human development on the followinng picture:



Marine environments are fundamental for human beings for the following reasons:

a. *They are a food source (they maintain so called fishery stocks).*

b. *They are a source of raw materials and energy (salts and chemicals).*

c. *They are a resource for tourism (sun and beach tourism).*

d. *They are communication routes (shipping).*

e. *They act as thermal moderators (moderate temperatures).*

2.2 PHYSICAL AND CHEMICAL CHARACTERISTICS OF SEAWATER

The most notable physical property of seawater is, without a doubt, temperature, and the most relevant chemical property is salinity. Both these properties determine the density of water.

However, these aren't the only interesting properties of seawater. Understanding the propagation of light and sound in the ocean, how the colour of the water varies, the degree of acidity, the chlorine levels and the organic matter content are all of great biological interest.

SEAWATER TEMPERATURE

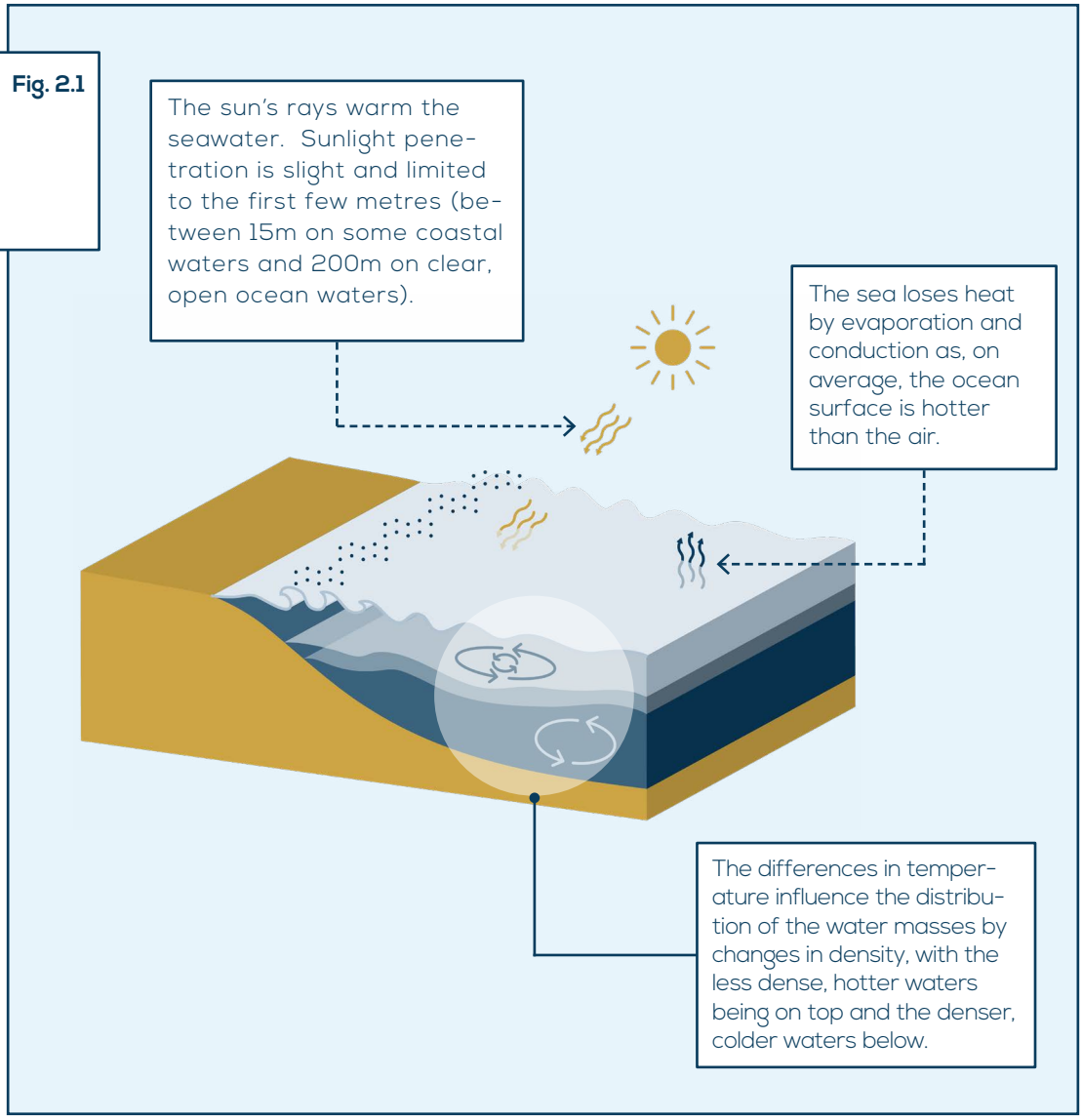
The thermal properties of seawater depend on the heat that is absorbed from solar radiation, and the amount of heat returning from the sea to the atmosphere.

The seawater temperature is between -2ºC (polar waters) and 37º (in the Red sea). The temperature range on land is far greater and ranges from -68ºC (in Siberia) up to 56ºC (reached in Death Valley, California).

Therefore, it is possible to appreciate the great thermal-stabilisation power of the sea, since in reality the air, land and rocky formations of the planet heat up much faster and more easily than water. The same occurs when cooling. Therefore, the oceans are great temperature moderators. In a coastal town, if you stand by the sea during the day, you will notice the thermal sensation is cool and pleasant, whilst further from the coast it is hotter. During the night exactly the opposite happens. All of this is due to the heating and cooling processes of seawater.

Another aspect relating to the temperature of seawater is that the dissolved salts lower its freezing point, preventing a large part of the planet's water from being solid ice.

Fig. 2.1



The temperature of water on the surface of the Mediterranean sea varies according the season of the year. It is between 21ºC and 30°C in summer and between 10ºC and 15 °C in winter. Between 100m and 200m deep the temperature remains constant at ± 13°C.

Before the development of satellites it was impossible to observe large-scale seasonal changes in temperature. Today, it is possible to know the marine surface temperature on a global scale with an accuracy of one tenth of a degree centigrade. However, the only way of getting information about the temperature at depth is still by means of in situ measurements.

Did you know...

Salt water has a much lower freezing point than freshwater.

Salt water with a salinity of 35 grams of salt per litre, which is the average salinity of the ocean, freezes at approximately -2ºC.

When seawater freezes, the salt concentrates in the water which remains unfrozen. Fresh water ice crystals form on the surface, leaving the salts in the surrounding water below the ice. **This is because the salt is expelled from the ice as the water freezes.**

A.2.2.

TRUE OR FALSE

Indicate whether each of the following statements is true (T) or false (F):

Ocean water cools down and heats up more slowly than land masses, so areas close to the sea tend to have milder temperatures: less hot in summer and less cold in winter. ○

The salinity and the temperature determine the density. ○

The surface water temperature of the Mediterranean remains constant at ± 13°C all year round. ○

Seawater composition includes dissolved materials from the land's surface and the remains and fluids released over millions of years by ocean organisms. ○

The influence of solar radiation reaches the whole of the water mass, heating it rapidly. ○

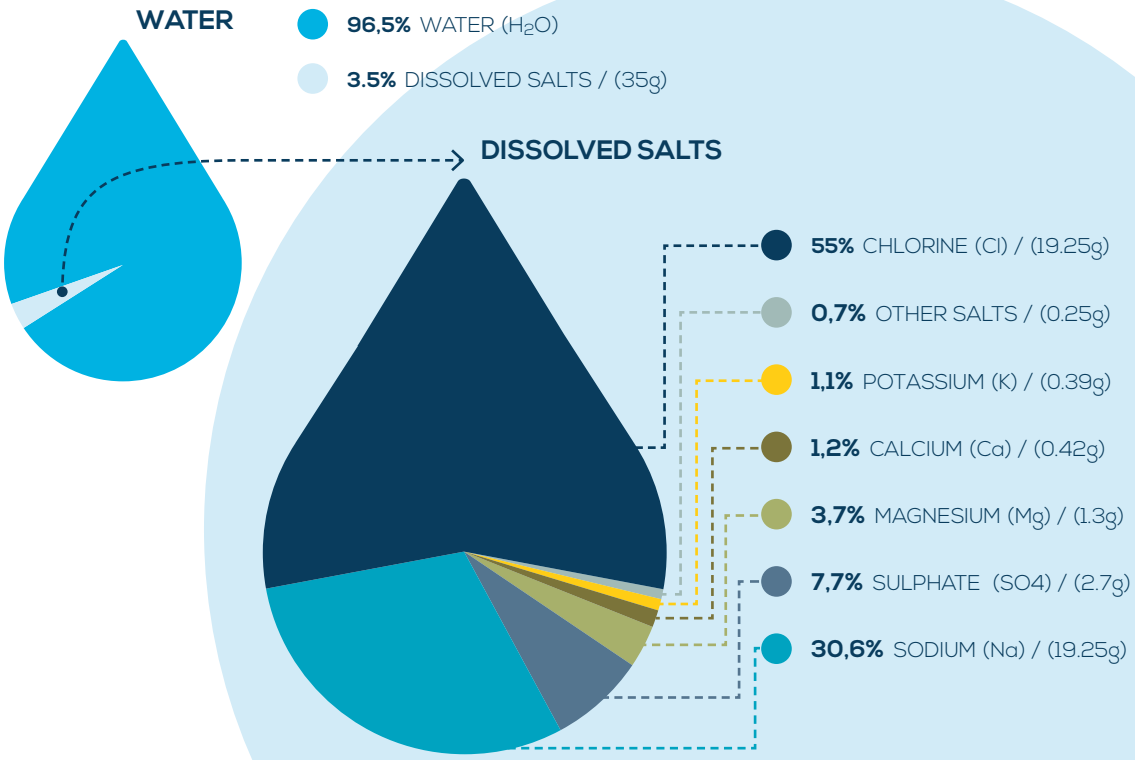
Water, regardlessof whether it is freshwater or saltwater has a freezing point of 0ºC . ○

SALINITY

Seawater is evidently salty and the salinity indicates the concentration of salt in the seawater. This property is the result of the combination of the different salts found in seawater, the main ones being chlorides, carbonates and sulphates.

Of these salts, the most abundant is sodium chloride, known as common salt, which constitutes 80% of the salts, the rest is made up of other components in varying ratios.

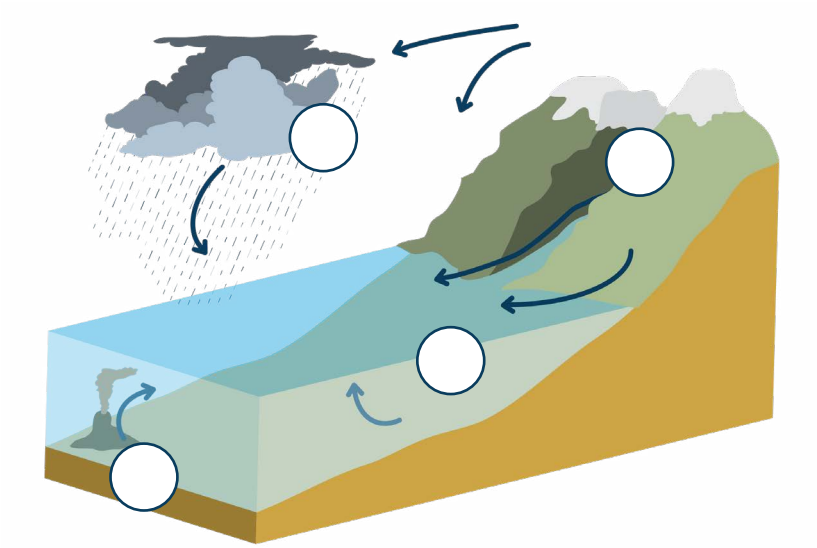
The salt and the rest of the minerals found in the seawater originate from river contributions, deep-sea hydrothermal vents and volcanic eruptions on the seabed. When water evaporates from the surface of the ocean, the salt is left behind. After millions of years the oceans have developed a noticeably salty taste.



A.2.3.

THE JOURNEY OF THE SEA SALTS

Indicate in each box the natural processes each stage refers to as shown in the image:



1 _____

Undersea volcanoes begin to erupt. Along with the lava and steam spouting under pressure from the centre of the Earth, large amounts of sodium chloride (NaCl), or common salt, and other chemical elements are emitted which are concentrated in the seawater.

2 _____

Rain falls over land masses and drags salt and other water-soluble chemical elements which are deposited between the rocks and the land surface with it, sending them towards the seas and oceans.

3 _____

Snow and ice thaws on the mountains and the salt deposited on the land surface is washed into the sea by the rivers.

4 _____

The water evaporates but the salts remain, concentrated in the seawater, increasing salinity.

Salinity and the different oceans

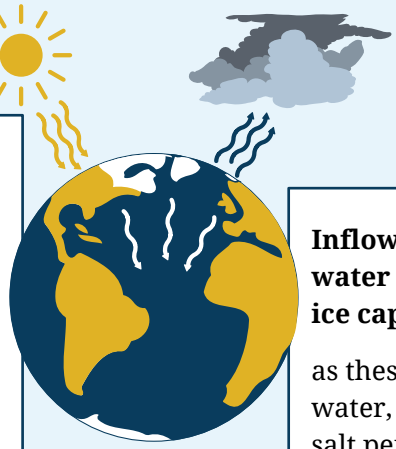
Salinity is measured in Practical Salinity Units (p.s.u.) which is **equivalent to one gram of salt dissolved in one litre of water**, and is usually expressed in parts per thousand.

After numerous water measurements were taken from different oceans, **the average salinity of seawater was calculated to be 35 parts per thousand**, (35 gr. of salt per kg. of water) and we say it has **35 p.s.u.**

The salinity of the Mediterranean sea fluctuates between 38.5 g/kg of water in the deep parts and slightly less nearer the surface. In the area of the strait of Gibraltar you find Atlantic waters and Mediterranean waters, together, and they have different salinities: the Mediterranean water which flows underneath, has 38 PSU, and the Atlantic water which flows above, has only 36 PSU. This is because **the greater salinity increases the density of water**: the water with a higher concentration of salt will have a greater mass and will be below the water with a lower mass, as in this case the Atlantic water flows over the Mediterranean water. The Ibiza channel is another important point where Atlantic and Mediterranean waters meet.

As you can see, the salinity of the seawater is not the same in all seas and oceans. In fact, salinity is so variable that a single point may be subject to variations over the year.

Factors which cause changes in salinity are **temperature** and **inflows of continental water and from polar ice caps**.



Temperature:

The higher the temperature (warmer waters) the more intense the evaporation. As water evaporates, the concentration of the salts remaining in the sea increases.

Inflows of continental water and from polar ice caps:

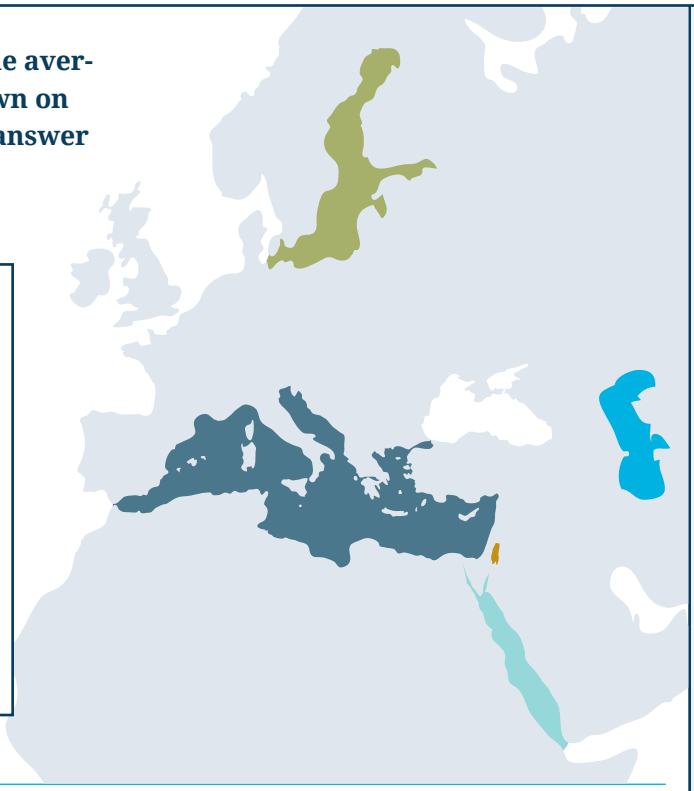
as these dilute the seawater, the quantity of salt per litre decreases.

A.2.4.

THE SALINITY OF DIFFERENT SEAS

The following table gives the average salinity of the seas shown on the map. Use these data to answer the questions:

	SALINITY (‰), (p.s.u)
Baltic Sea	6
Caspian Sea	12
Mediterranean Sea	38
Red Sea	40
Dead Sea	330



1 - *If the oceans' average is 35 p.s.u., which seas have a higher salinity than this average?*

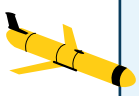
2 - *Which sea has a lower salinity? Do you think this is related to its location?*

3 - *Why does the Mediterranean sea have higher salinity than the oceans?*

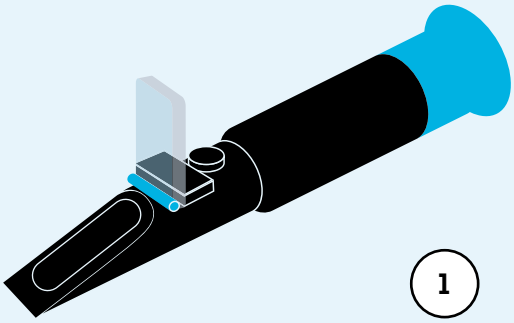
4 - *Which sea would have greater density? How do you think this might affect floating on the water?*

For researchers, knowing the salinity of seawater is a very important, so **on every ocean survey the temperature and salinity of the sea are recorded using different instruments**. This data is stored and is very useful for the study of different physical processes (currents) or important biological processes (such as Bluefin tuna spawning in the Mediterranean).

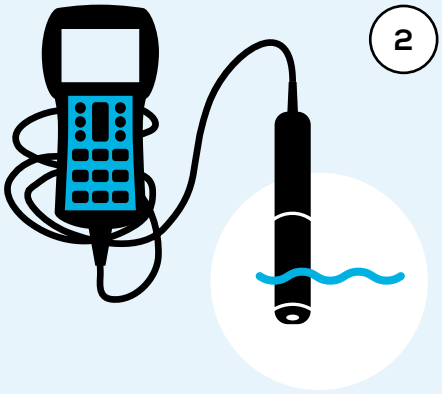
Fig. 2.2 Different methods are used to measure the salinity of seawater, either analysing the refractive index of light or by the conductivity of the seawater: refractometer (**1**), thermosalinometer (**2**) and oceanographic vessels (**3**), CTD (**4**), oceanographic rosette (**5**), APEX (**6**) and gliders (**7**).



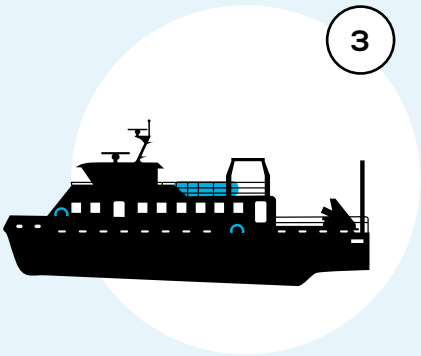
A **refractometer** (**1**) determines the concentration of salts by making calculations based on the refraction of light. **The refraction of light is the change of direction the light makes when it passes from one transparent substance to another**. Refractometers work on the principle that when the density of a substance increases (for example, when salt is dissolved in water), the refractive index increases proportionally. To do this the deviation of light in a sample of distilled water is compared with the deviation produced by a sample of seawater.



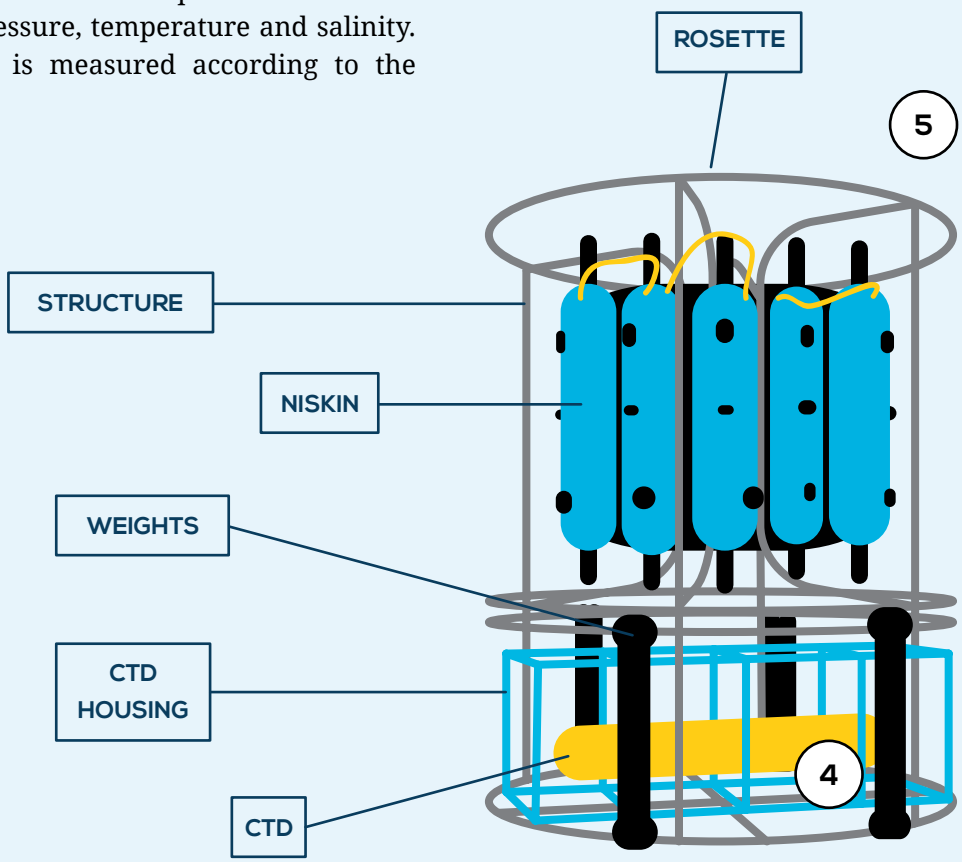
Other instruments, like the salinometer (**2**), measure the concentration of salt **by the conductivity of seawater**. The electrical conductivity of seawater is high. Conductivity varies with temperature and with salinity (greater salinity, greater conductivity), measuring conductivity whilst controlling temperature, provides a salinity measurement.



Ocean research vessels (**3**) are equipped with **thermosalinometers**, which are used to record the temperature and salinity of the waters the ship sails through. The data obtained by the **SOCIB oceanographic vessel**'s thermosalinometer is available on *www.socib.es* and from this it is possible to see how the salinity varies according to the vessel's location.



But salinity does not only vary in a horizontal direction as the vessel moves forward, it also varies vertically, that is to say, depending on depth. To measure temperature and salinity on the seabed, an instrument called a **CTD** (**4**) is used, which is an electronic probe which measures pressure, temperature and salinity. Salinity is measured according to the

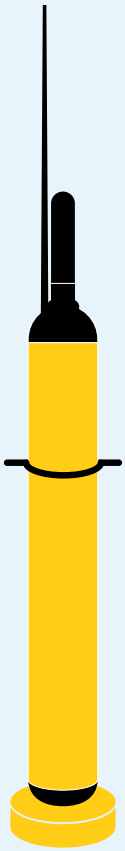


electric conductivity by sensors inside a metal casing, at depths of up to 10,000 metres. It is possible to incorporate other sensors to measure chemical or biological parameters, such as dissolved oxygen or the presence of phytoplankton.

If samples need to be taken at different depths they use a piece of equipment called an **oceanographic rosette** (**5**) which holds various bottles and a CTD. The water samples are collected in the so-called Niskin bottles. They are when they enter the water open and when they reach the desired depth they have a closing mechanism which takes, a water sample at the precise depth.

Another more advanced system for collecting data are the drifting floats called **APEX** (Autonomous Profiling Explorer) (**6**) which are used to measure currents and are equipped with temperature and salinity sensors. They transmit the data they obtain via satellite.

Other autonomous explorers which are revolutionising oceanography are the **autonomous underwater gliders** (**7**), which differ from APEX which simply drift, as the gliders follow a route defined by an operator and they transmit data in real time. If you would like to know more about the gliders go to *www.followtheglider.com*.



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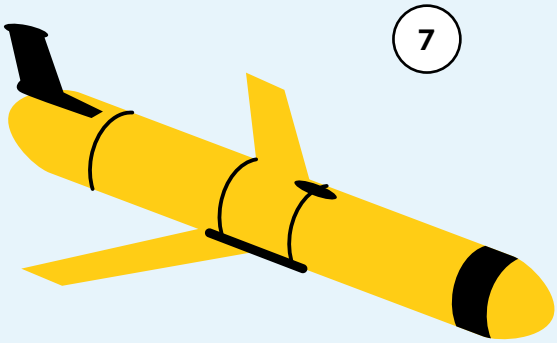

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A.2.5.

WORD SEARCH

In the following word search find the oceanographic instruments mentioned in the text which tell us about the salinity of seawater, among other things.

A	R	T	I	S	A	C	V	U	T	O	P	D	O	A	A
X	O	P	Ñ	V	G	B	W	S	H	K	N	D	Z	J	P
R	R	K	J	H	H	L	Y	O	E	N	Ñ	M	N	V	E
L	E	E	J	G	L	I	D	E	R	A	J	E	U	C	L
L	R	F	F	Z	L	G	Z	P	M	E	O	F	B	G	W
A	B	E	A	R	Z	M	R	A	O	H	C	I	F	L	R
I	M	V	F	C	A	O	R	O	S	E	T	T	E	U	O
M	Z	X	Q	R	T	C	Z	V	A	N	D	J	U	A	B
W	B	A	Y	F	A	O	T	F	L	I	L	C	Ñ	A	Ñ
V	Ñ	U	B	J	P	C	E	O	I	G	Y	J	W	D	A
X	J	W	Z	T	C	A	T	A	N	V	N	P	R	U	W
S	L	M	Y	U	Z	O	R	O	O	E	P	J	L	A	P
P	A	P	E	X	Z	U	V	O	M	S	T	E	Y	L	M
G	R	B	E	E	Ñ	X	U	C	E	E	W	R	E	Y	O
U	I	T	D	O	P	F	L	I	T	Ñ	T	P	O	E	N
A	C	X	I	J	D	T	Ñ	D	E	A	D	E	O	N	P
C	E	Ñ	K	Y	H	X	V	D	R	N	T	I	R	C	A

APEX

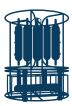
CTD

REFRACTOMETER

GLIDER

THERMOSALINOMETER

ROSETTE



A.2.6.

CAN THE SEA BECOME MUCH MORE SALTIER? WE WILL CONDUCT AN EXPERIMENT TO SEE IF IT IS POSSIBLE:

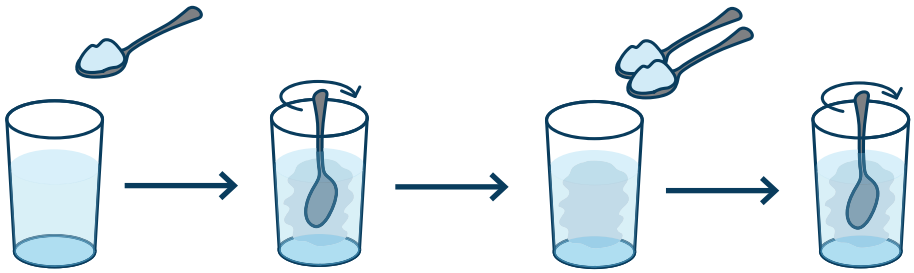
You already know that seawater is salty because it contains salts which come either from underwater sources or from the rivers. The evaporation of water helps increase the salinity insome areas of the ocean. So, if the sea receives minerals continuously, does the sea become even saltier?

No, the sea can't become more and more salty since water can't dissolve an unlimited quantity of salts. This is easy to see in the following experiment:

WHAT DO WE NEED?

A large glass | Water | Table salt | A spoon

TRY IT!



1. Fill the glass half full with water.
2. Add a little salt.
3. Stir the water with the spoon.
4. Add more salt.
5. Stir the water again
6. Repeat the procedure until no more salt will dissolve.

WAIT, WATCH AND THINK...

What do you see when no more salt will dissolve? What appears in the bottom of the glass?

A certain amount of water can only dissolve a certain amount of salt, the rest cannot be dissolved. At the point beyond which the solute no longer dissolves it starts to appear at the bottom of the container, this is called the saturation point. The solutions, which under these conditions have reached the maximum concentration of solute, are called **saturated solutions.** Solutions which have more solute (salt) than that held by a saturated solution (salt appears at the bottom) are called oversaturated solutions. Solutions which contain less solute than can be dissolved are called **dilute solutions**.

Besides even though the sea receives salts continuously it also rids itself of salt in many ways before becoming oversaturated, for example in salt marshes and salt pans.

Mediterranean salt marshes

Coastal salt marshes are wetlands of incalculable ecological and cultural value. They are located in low, flat coastal areas, at sea level or below, allowing water to enter freely. They appear to be divided into various connected reservoirs, which allow water to pass through floodgates. The structure of the salt marsh is closed so that the seawater collects, and, due to the sun and warm dry winds, the water evaporates and a salt deposit remains.

Coastal salt marshes have been exploited historically by the various civilizations which settling in the Mediterranean. Since the Phoenicians up until today the salt marshes have been used to obtain salt.

In the Balearics we find salt marshes on the east coast of Mallorca, in the municipalities of Ses Salines and Campos; and in Ibiza and Formentera the coastal lagoons of s'Estany d'es Peix and Estany Pudent are the most prominent.

A.2.7.

SEA SALT AT HOME

How to get our own sea salt at home with very few materials:

WE NEED

Two litres of seawater | A large bowl | Lots of sunshine hours

PROCESS

1. Collect the seawater from a clean place, it is better if the sea is calm so it is not carrying other materials, such as sand sediments in suspension.
2. Once at home put the water in a container, the bigger it is the more surface the water will have, which will facilitate evaporation. Choose a sunny spot.

WATCH AND WAIT...

It is a very slow process and at first you won't see anything, **only that the water level drops**. **As the water evaporates**, the remaining water **starts to become saturated** and you will see **small salt crystals**. **The salt molecules will group together following a pattern**: Table salt has a cubic structure.

You will see that after a few days the container will be full of these salt crystals. If, under this layer of salt, you find water which doesn't seem to want to evaporate, it is due to the salt absorbing moisture from the air.

Did you know...

Salt is not only used for food, it also plays an important role in the chemical industry, enabling the manufacture of cosmetics, medications, cold stores and electrical batteries.

2.3 DENSITY

Density is the quantity of mass an object contains. **The density of seawater depends on the quantity of mass of salts it contains, so it is related to salinity**. At higher salinities seawater becomes denser. Temperature also affects density, at higher temperatures density decreases.

Therefore, **the density of seawater varies according to temperature and salinity**. In the sea, the differences in salinity and temperature cause the water to distribute itself into layers and gives rise to density currents. It is possible to identify 3 main layers:

1. **On the surface** — There is a layer of warmer, less dense water.
2. **An area where water masses of different densities converge, called a thermocline** — The waters of different densities don't mix and they form a buffer zone, a barrier we call a thermocline, and in this layer the temperature declines sharply.
3. **In the deep water zone** — The water is colder and denser.

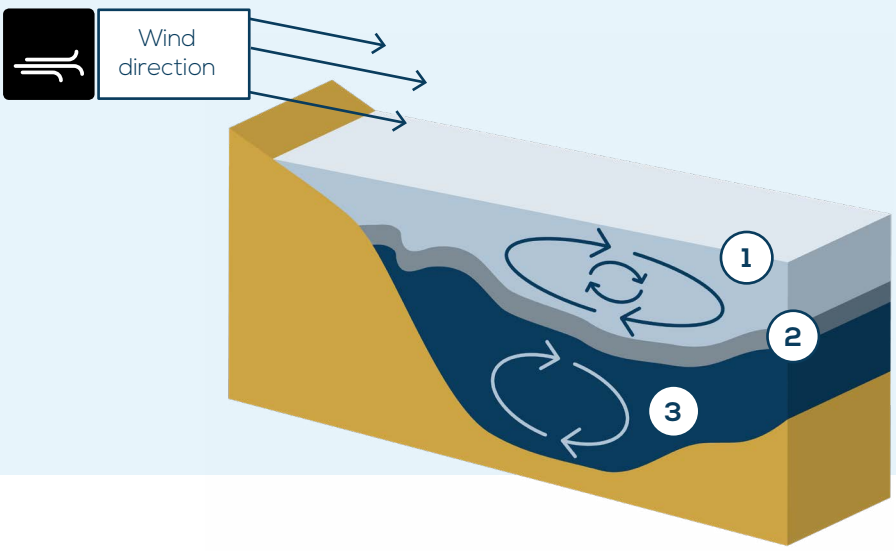


Fig. 2.2

A.2.8.

THE SAME SEA, DIFFERENT DENSITIES

Choose the correct option to complete the following sentences:

1- *The surface layer of the sea is ...*

a) *Colder and more dense.*

b) *Warmer and more dense.*

c) *Warmer and less dense.*

2- *The thermocline ...*

a) *Has the same temperature as the surface but is more dense.*

b) *The temperature declines sharply and it is slightly denser than the surface layer of water.*

c) *Is colder and less dense than the water in the deep water zone.*

3- *The deep layer ...*

a) *Is the most dense and therefore the saltiest.*

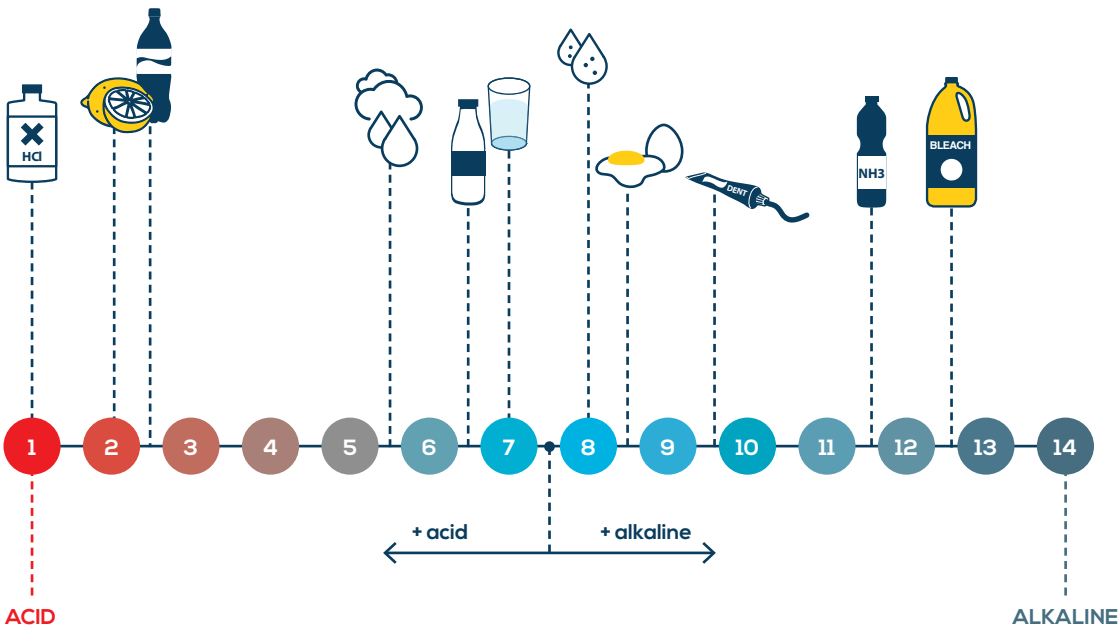
b) *Is the least dense and the saltiest.*

c) *It is the coldest and least dense.*

2.4 ACIDITY LEVEL OR pH

Acidity is one of the most important properties of water. **The pH level indicates the acidity of a substance**. The word pH is an abbreviation of "pondus Hydrogenium" (hydrogen weight, in Latin). **The pH is an indicator of the number of hydrogen ions in a substance**. A greater presence of hydrogen increases the acidity of a substance. pH is a very important factor since certain chemical processes can only occur at a certain pH level.

Scientists devised a way of understanding how acid or alkali a substance is by assigning it a number on a scale of pH. The acid alkali scale has fourteen levels. Substances with a pH of seven are neutral, that is to say, neither acid nor alkali. Distilled water is a neutral substance. Substances with a pH value of between one and seven (a low pH) are acid, whilst substances with a pH value between seven and fourteen (a high pH) are alkaline. **Seawater is slightly alkaline and it has a pH of 8**.



Data regarding pH are important for researchers since many organisms which inhabit our seas and oceans are affected by changes in acidity. In recent years there has been a lot of research in this area since it has been proven that the rise of carbon dioxide in the atmosphere has lowered the pH level of seawater, a process which has been called **ocean acidification**. If seawater becomes more acidic it could have significantly harmful effects on many marine species. Many organisms build the hardest parts of their bodies with calcium carbonate, the acidity dissolves the calcium carbonate contained in the shells or skeletons of organisms such as oysters, clams, sea urchins and calcareous plankton. Corals are also severely affected since they form their colonies out of calcium carbonate structures. The acidification of the ocean could not only harm important commercial species, such as lobsters, crabs and mussels, but also key species of the marine food chains, such as the primary producers.

A.2.9.

OCEAN ACIDIFICATION

Answer the following questions:

1- *If seawater becomes more acidic, what consequences could there be?*

2- *In addition to affecting live organisms, what other, for example economic, consequences could there be?*

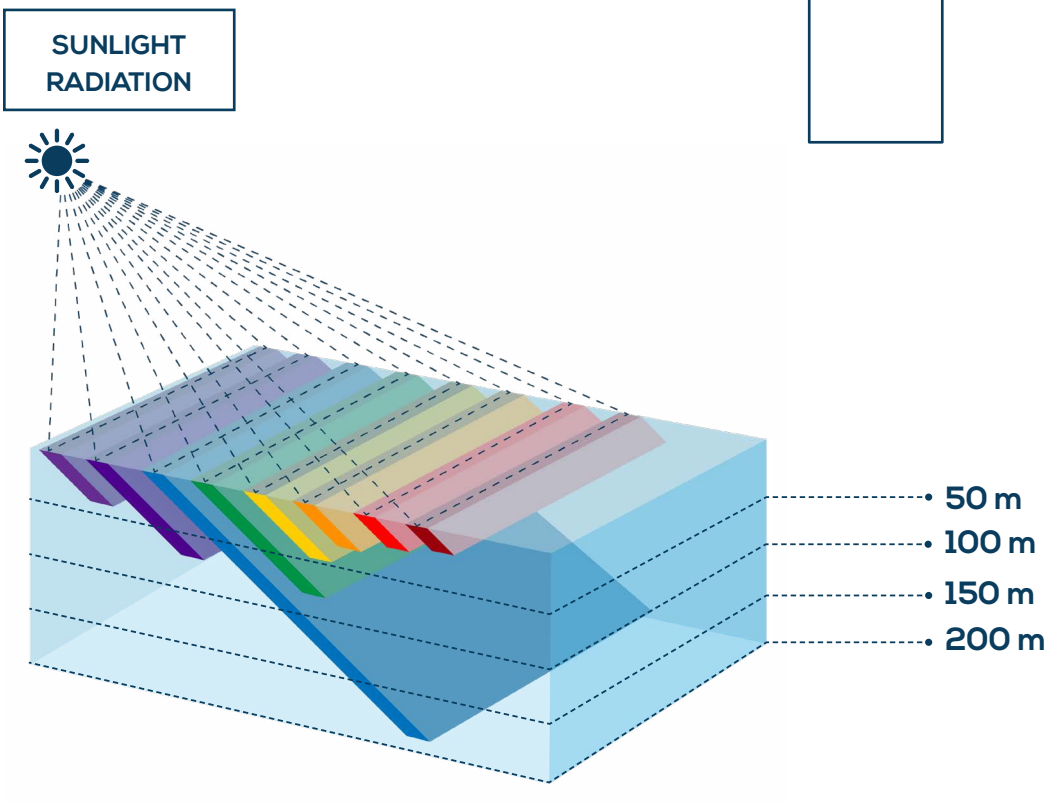
COLOUR

If you ask people what colour seawater is practically everybody will respond that the sea is blue.

Seawater has a certain transparency, which means it allows light to pass through it. Solar light radiations are absorbed by seawater selectively, so that NOT all the wavelengths (colours) that make up visible light reach the same depth. Blue light penetrates the deepest and this is why seawater turns blue at greater depths.

The choppiness of the water, the cloud cover, or the reflection of the sky colour can all influence the colour of seawater. There are times when the sea appears green because of the large quantity of algae in it. Other times it appears brown because it has lots of minerals in suspension. Even more spectacular are the colours produced in seawater when there is massive growth of certain organisms.

Fig. 2.3



When the transparency of water is affected by the different types of particles it contains, plants, animals, organic and inorganic matter, etc, it is referred to as turbidity. Turbidity is considered a good measure of water quality, the more turbid it is, the lower the water quality is.

Transparency is measured using a Secchi disk, which is a white disk (or black and white), which is launched from a vessel so that it sinks down in to the water until it can no longer be seen. When it reaches the point it can no longer be seen, the depth it has reached is noted. This indicates the turbidity of the water and the amount of suspended material it contains.

The average transparency of seawater fluctuates between 1 and 66 metres in depth. It is far greater in oceanic waters whilst in coastal areas the water is not so transparent, due to the abundance of organic and inorganic particles in suspension. The Mediterranean sea is poor in phytoplankton and therefore the waters are more transparent.

A.2.10.

GIVE YOUR OPINION

How do you think the transparency of water around beaches will affect tourism?

GLOSSARY

Phytoplankton:

Aquatic, autotrophic (self-feeding) organisms, part of the plankton community, which can photosynthesise and live scattered in the water. They are the foundation of the food chain in aquatic ecosystems as they are food for other, larger organisms. Plankton is also initially responsible for the presence of oxygen (O_2) in the atmosphere.

Thermocline:

A layer within a body of water where the seawater temperature drops rapidly, vertically, with very little increase in depth.

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..