



Theoretical note

1. OCEAN PLANET

In geography, we define an ocean as an **immense expanse of salt water**. The seas differ from the oceans by their size (seas are smaller), by the fact they are partly enclosed within a continent and by a **dominant continental shelf**. In geology, an ocean is an ocean floor delimited by water. In reality, the Earth has a single uninterrupted mass of ocean water which surrounds all of the land that juts out of the water. Having said that, the single world ocean is divided into five separate oceans:

- The Southern Ocean,
- The Atlantic Ocean
- The Arctic Ocean
- The Indian Ocean
- The Pacific Ocean



The oceans cover almost 71% of the Earth's surface and contain approximately 97% of the total volume of water on the planet. The average ocean depth is 3800 metres but it can reach as much as 11800 m (Mariana Trench).

Credits: earthobservatory.gov



On a human scale, the ocean is absolutely gigantic. However, on a planetary scale, the thickness of the ocean layer in relation to the Earth's diameter is in the same proportion as the thickness of an apple's skin to the apple itself. Described as such, the ocean suddenly becomes insignificant and fragile. Yet the oceans represent an essential part of the biosphere and play an essential role in our planet's functions.

Let's take a dive into this blue world....





WHERE DO THE OCEANS COME FROM?

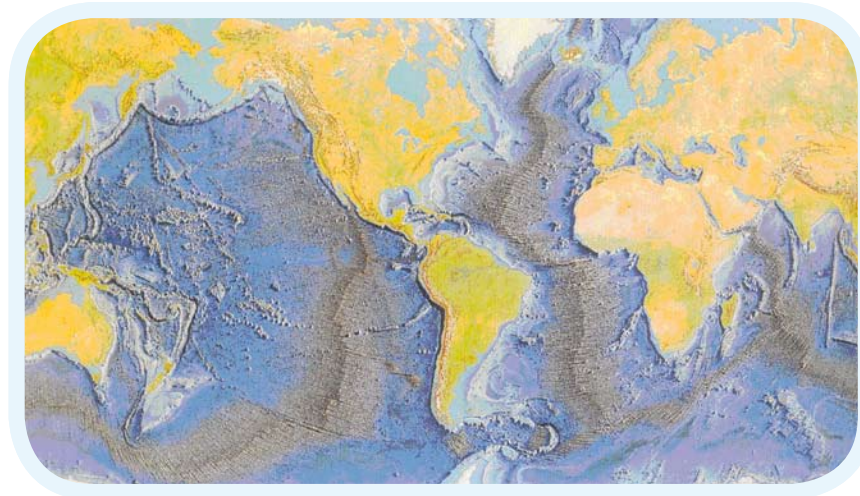
Studies conducted so far indicate that when it was formed 4.6 billion years ago, the primitive Earth was a burning mass of molten rock. Quite quickly, the heavy metals such as iron and nickel condensed in the centre of the Earth in order to form its core. The silicates rose to the surface and created the mantle.

The lighter materials formed a fine crust on the Earth's surface. Intense volcanic activity brought volatile elements to the surface, such as steam and carbon dioxide, forming a type of primitive atmosphere.

Little by little, the Earth cooled down. The water contained in the atmosphere condensed and fell upon the Earth in the form of torrential rain. About 4 billion years ago, the accumulation of this rain in lower-lying areas started to form lakes, then seas and **primitive oceans**.

The volume of water in these primitive oceans was the same as today. But the chemical composition of the water evolved over time, and came to contain the concentration of dissolved salt that we have today (average: 35g/l).

Since these first oceans were formed, the way in which land emerges from the water and that in which oceanic basins are distributed have changed. Convection movements in the Earth's mantle caused the creation of an oceanic crust in [mid-oceanic ridges](#) and its disappearance in [subduction zones](#).



200 million years ago, there was only one continent, surrounded by a single ocean; it was only about sixty million years ago that the continents and oceans moved into their current positions. Currently, Europe and Africa are moving away from America at an average speed of 3.5 cm per year (minimum speed: 2 mm, maximum speed: 15 cm).

THE OCEANS

a source and environment for life

The origins of life on Earth still remain shrouded in mystery. Various theories have been put forward in recent years. For example, the first bacteria might have appeared as a result of the growing complexity in combinations between the carbon compounds swimming within the "organic soup". Another theory suggests that life began at great depths, close to hydrothermal sources where,





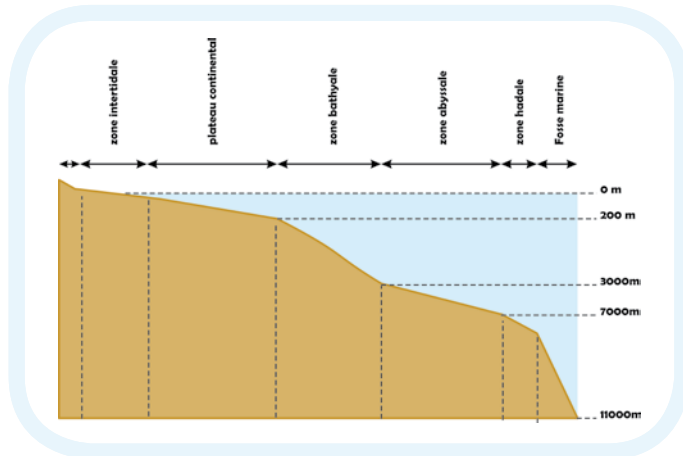
in the absence of photosynthesis, the energy required for living organisms was provided by chemical reactions. Finally, the presence of amino acids in very old meteorites found on Earth raises the theory that life on our planet may have come from space.



However, scientists do agree on the fact that life on Earth resulted from the presence of liquid water. They also agree that the first forms of life began in the oceans about 3.8 billion years ago as bacteria. This hypothesis is based on the discovery in Greenland of rocks containing traces of biological activity dating back approximately 3.85 billion years.

Ever since then, life has never left the oceans and, in fact, has diversified enormously. Scientists estimate that the oceans represent a pool of biodiversity that is equivalent to – or even greater than – what is found in the tropical forests. 274 000 marine species have already been catalogued in the oceans, and the pace at which new species are being described does not seem to be slowing down. In fact, some experts believe that there may be as many as 10 million species of marine life, if not more (source: www.ifremer.fr).

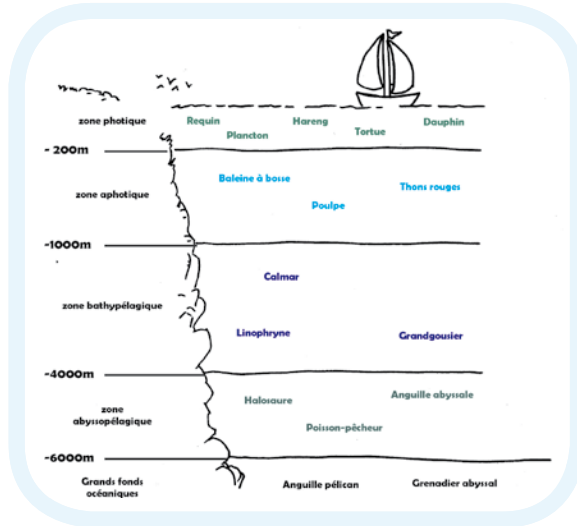
There is life at every level of the oceans' depths. However, 90% of the known marine biomass lives along the coastlines in an area 0 to 350 km from land and at a depth of less than 200 metres. This zone corresponds to the area affected by the tides and to the continental shelf ([intertidale](#) and [neritic zones](#)).



The way in which the various species are distributed throughout the oceans depends on ecological criteria and on the sources of food (or “nutrients”). A distinction is made between benthic species which live on the seabed (crabs, mussels, sea urchins) and pelagic species (jellyfish, fish, whales) which live in open water.

The temperature of the water and the amount of light that penetrates into the water are also essential parameters for determining the way in which species are distributed. Based on these parameters, there are five separate levels in the pelagic zone.





The maximum level of oceanic production is in what is known as the photic zone, the area into which sunlight penetrates. Production is at its peak in the areas in which there are abundant nutrients, such as river estuaries, zones in which currents converge, [upwelling zones](#) and the cold waters of the polar regions.

As is the case on land, marine life depends first and foremost on plants as primary producers. In the oceans, these are seaweed and especially plant plankton or **phytoplankton**. These micro-organisms use solar energy and the mineral salts present in the water to grow and reproduce (photosynthesis). The plant plankton

is at the bottom of the food chain and is eaten by zooplankton (animal plankton) as well as by a multitude of marine organisms. These are then preyed on by small predators, which themselves are hunted by large predators. Some marine mammals, such as baleen whales and certain types of fish, like the basking shark, feed directly on zooplankton: krill.

Phytoplankton plays another major role in the existence of life in the oceans and on Earth in general, by absorbing carbon dioxide. Carbon dioxide is found naturally in the atmosphere. But over the past 150 years, production of CO₂ was increased by the Industrial Revolution and the extensive consumption of fossil fuels (automotive traffic, industry, etc.), thereby increasing the greenhouse effect on the planet. The oceans absorb a large proportion of natural carbon dioxide, as well as part of that which is emitted by man.

THE OCEANS : A MASS ON THE MOVE

The oceans are by no means placid environments. Whether it be close to the coast, out in the open sea, on its surface or in its depths, our oceans' water is constantly moving. This movement can be caused by wind, waves or by heavy swelling; it may be the result of a gravitational pull, as is the case with tides; it might be the effect of the sun's rays like with surface currents; or it can be due to density variations, as with the thermohaline circulation.

Oceanic movements can be subdivided into two main categories: undulatory (wave) movement, and horizontal or vertical movement.

Undulatory movement

When the wind blows on the surface of the water, **waves** are formed. When waves continue as the wind has dropped, or if waves persist beyond the action of the wind, we call this a **swell**.

The waves and swell are known as the undulatory movements of the water, because the particles of water in motion rise and fall in a column, without moving horizontally. Waves and swell only affect the upper part of the water column in open water. It is only closer to the coast, when there is friction with the seabed, that the water particles are propelled forward by the waves.

The other undulatory movement visible in the oceans is the **tide**. The movement of the tide is





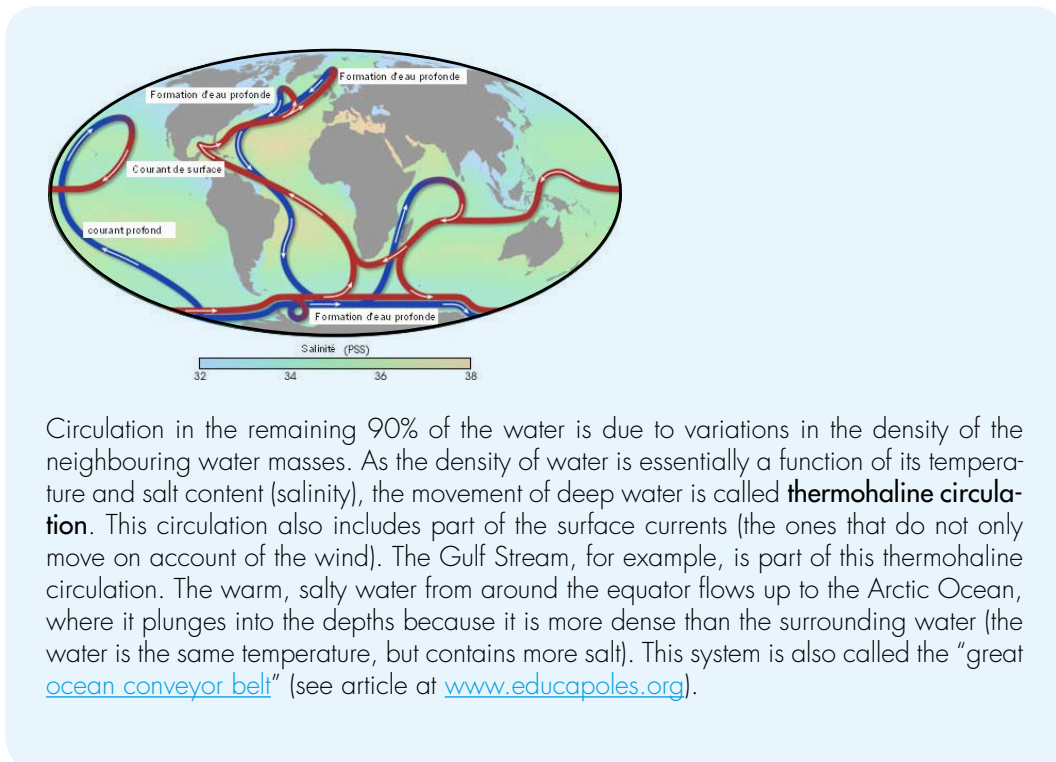
induced by a combination of two forces, the gravity exerted by the sun and the moon and the centrifugal motion generated by the Earth's rotation. There are several tide types, differing in accordance to the geographical position and the shape of the basin in which the tide occurs. The tides are characterised by the number of low tides and high tides that occur each day. The difference in the height of the water between high tide and low tide is called the **tidal range**. This range is important for sailors, fishermen and people out walking because it changes every day and enables us to know what level the water will be at in the port or along the beach. In some countries, tide coefficients are used to show this variation.

Tsunamis are also undulatory movements of the mass of water. Fortunately, they do not occur very often and are generally associated with some sort of natural disaster, such as an earthquake, volcanic eruption under the sea or a landslide. An event of this kind causes a huge mass of water to be displaced. This displacement grows and creates a giant wave that is imperceptible in the open sea (low amplitude, very long wave length), but as it approaches the coast, it gathers up an enormous quantity of water and hurls it on to the land.

Horizontal and vertical movements

The horizontal and vertical movements that take place in the column of water are driven by the currents. On the surface, they are produced by a combination of wind and mass of surface water being heated by the sun. Surface currents have an effect on the upper 10% of the water column. Some surface currents are fast-moving and well defined, like rivers in the middle of the ocean. Others are slow and diffuse. Surface currents tend to flow horizontally, but they can also move vertically in response to a wind blowing towards the coast, which then acts as an obstruction, making the current dip or rise. Surface currents redistribute heat or cold, depending on the case, thereby influencing the weather and climate and distributing nutrients and plankton.

Credits: earthobservatory.gov



Circulation in the remaining 90% of the water is due to variations in the density of the neighbouring water masses. As the density of water is essentially a function of its temperature and salt content (salinity), the movement of deep water is called **thermohaline circulation**. This circulation also includes part of the surface currents (the ones that do not only move on account of the wind). The Gulf Stream, for example, is part of this thermohaline circulation. The warm, salty water from around the equator flows up to the Arctic Ocean, where it plunges into the depths because it is more dense than the surrounding water (the water is the same temperature, but contains more salt). This system is also called the "great [ocean conveyor belt](http://www.educapoles.org)" (see article at www.educapoles.org).





On the scale of geological time, there is another movement in the oceans: **variations in sea levels**. As we have already seen, the amount of water on Earth has been the same since it was created. Water occurs either in liquid form, as a solid (snow or ice) or as a gas (steam). During the various ice ages that have marked our Earth's history, the level of the oceans has fallen. Water was thereby trapped inside continental icecaps (at the poles and elsewhere). Between ice ages, as the planet warmed up again, part of the icecaps melted and the trapped water was released back into the oceans, raising sea levels once again. In more recent times, the climate warming associated with human activity and the subsequent melting of the polar icecaps and mountain glaciers has increased average sea levels by an estimated 17 cm during the 20th century (IPPC WGI, 2007). This rise has accelerated in recent years and is currently 3.1 mm per year (IPPC WGI, 2007).

THE OCEAN AND MAN

The interaction between man and the ocean is, of course, of great importance, in particular because more than half of the people living on our planet are located less than 100 km from the coast. At the present time, the coasts are very important regions in economic terms and continue to attract increasing numbers of people.

Sea-based resources (fishing, aquaculture, mineral extraction, the production of energy, waste storage, tourism) have become essential for our livelihood and make a major economic contribution to world GDP. Although these resources are governed by a host of national and international laws, marine resources are struggling to meet world demand. The long-term management of these resources is currently rather catastrophic.

Currently, marine protein (fishing and aquaculture) corresponds to less than 20% of the consumption of animal protein for half of the population on the planet (FAO, 2006). To meet this demand, fishermen have put new fishing techniques in place and have extended their fishing grounds to include the great depths of the ocean. This has resulted in **massive over-fishing**. The Food and Agriculture Organisation¹ estimates that 75% of the studied marine species are either exploited to their full extent, over-fished or have died out. This means that the maximum potential for using the resources from our oceans has already been reached. The situation appears to be identical for aquaculture. Demand is so great that some areas of aquaculture have been extended into protected zones, disrupting entire ecosystems (such as mangroves in the case of prawns).

(Shrimp farms replacing mangroves in Gulf of Fonseca, Honduras crédits : UNEP – <http://www.na.unep.net/OnePlanet/ManyPeople/index.php>)



¹ The FAO is the United Nations organisation for food and agriculture. Part of its tasks involves assessing the situation of the world's fishing and aquaculture stocks each year (www.fao.org).



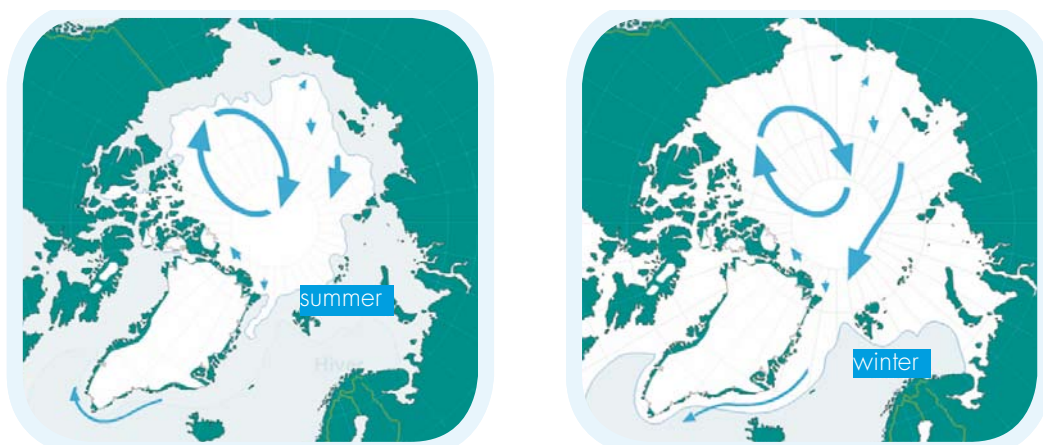


2. THE POLAR OCEANS

The Arctic: a frozen ocean surrounded by land

Almost completely hemmed in by land, the Arctic Ocean is the smallest of the Earth's oceans. Covered to a large extent all year round by pack-ice (sea ice), the Arctic Ocean encompasses all of the seas located between the geographic North Pole and the northern coastlines of Europe, Russia and Canada. In all, it covers an area of 14,090,000 km². The Arctic Ocean connects with the Atlantic Ocean via the Barents Sea and with the Pacific Ocean through the Bering Straits.

Although the sea ice extent varies according to the seasons, compact, permanent pack-ice covers 75% of the Arctic Ocean. This pack-ice is made up of "old" sea ice that may be several years old and up to 4 metres thick. This impressive thickness is due to the way sheets of ice slide on top of one another. This overlapping of the ice can create ridges anything up to 10 or even 20 metres thick. Driven by currents and winds, the pack-ice drifts and may move several kilometres a day. The direction taken by the **ice drift** is mainly controlled by the permanent anticyclone located at all times above the Arctic Ocean and by the Coriolis force.



However, climate warming has meant that the pack-ice has diminished significantly in recent years. Scientific observations have shown that in the summer, the area over which the pack-ice extends has been reduced by 15 to 20% over the past 30 years. Specialists believe that this reduction will accelerate over the coming decades, allowing commercial shipping to pass through the Arctic Ocean at all times. (See Educational File: The impact of climate change on mankind, www.educapoles.org)

Underneath its layer of ice, the Arctic Ocean is not very deep on account of the great width of the continental shelf. The average depth of the deep-sea shelf is 4,000 metres. It is separated by a range of mountains, the Lomonosov Ridge, which runs from the Siberian continental shelf, via the geographic North pole, almost as far as Greenland.

Water temperatures in the Arctic range between plus 2°C and minus 2°C, which is the temperature at which seawater freezes. (The salt contained in the water lowers its freezing point). The level of salinity in the waters of the Arctic Ocean is lower than the world average because the Arctic rivers flow into the ocean all around its basin, bringing freshwater from ice and snow.



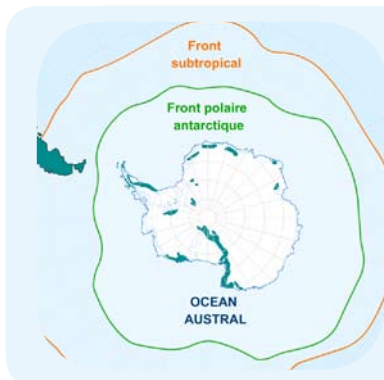


Most Arctic waters are rich in nutrients. This means that there is abundant phytoplankton in the water, even under the pack-ice, constituting the basis for the Arctic food chain. On the edges of the pack-ice is an area where life is very active, ranging from phytoplankton to the polar bear, capelin (fish), Brunnich's guillemots (seabirds), belugas, narwhals and Greenland whales. Numerous species of seal (phocides) also live in this environment, with one species (ringed seal) even spending the winter under the ice, using small holes in the ice to breathe. The walrus is an inhabitant specific to the Arctic Ocean, where it can be found on icebergs, islands and the pack-ice.

The Arctic Ocean plays a vital role in the stability of the Earth's climate. The mass of ocean water interacts with the atmosphere above it, exchanging heat, radiation and gas. Water retains heat more easily than air. As a result, when a warm current of water moves, it also heats up the surrounding air. If that air then passes over a landmass, it provides warmth for the local climate. This is the case, for example, of the Gulf Stream, which brings warmth to the north of Europe. The future of this warm current could be decided in the Arctic Ocean in the years to come. Some researchers believe that the way the planet is warming up has a direct effect on the salinity of our oceans. This, in turn, could modify the thermohaline circulation of the oceans (temperature – salinity). Warm, salty water from the region around the equator flows up to the Arctic Ocean, where it plunges into the depths because it has a greater density than the surrounding water (the water is at the same temperature, but is more salty). A greater supply of freshwater due to a higher level of precipitation could slow the Gulf Stream down, which would in turn disrupt the entire “[great ocean conveyor belt](#)” (article at www.educapoles.org).

The Antarctic (Southern) Ocean: an ocean surrounding a frozen continent

Unlike its smaller brother to the north, the Southern Ocean is not surrounded by continents. Instead, it surrounds a continent itself – Antarctica – which it separates from the rest of the world.



The Southern Ocean is bounded in the north by the **Antarctic Convergence**, which winds its way through 60 and 50 degrees latitude south. This hydrological barrier was defined by the International Hydrographic Organisation in 2000. From an oceanographic point of view, the Southern Ocean is defined as the ocean through which the **Antarctic circumpolar current** flows, which also weaves its way through 60 and 50 degrees latitude south.



Between the coastline of Antarctica and 60 degrees latitude south, the prevailing winds blow from the east, pushing the surface water towards the west. The Coriolis force is then added to this occurrence, diverting the ocean currents created by the wind to their left, thereby forming the Antarctic circumpolar current.

Variations in the density of the water (variations in salinity and temperature) create the Antarctic Convergence. All along this imaginary line, the cold, salty waters of the Southern Ocean dip beneath the warmer, less salty waters which come from the lower latitudes of the southern hemisphere. This vertical current causes the deep water from the other oceans to rise to the surface. It is a complex zone, characterised by whirlpools and depressions. The temperature of the surface water in the region ranges from minus 1°C to plus 3.5°C in the summer and minus 1.8°C to plus 0.5°C in winter.

The total surface area of the Southern Ocean is approximately 28 million km². This includes the small seas close to the continent, such as the Weddell Sea and the Ross Sea. Most of the ocean bed is somewhere between 3,000 and 5,000 metres in depth, with few areas of shallow water.

In winter, the Southern Ocean is covered with sea-ice, forming a gigantic icecap that extends to as much as 20 million km². This prevents most ships (with the exception of the most powerful icebreakers) from reaching the coast during the winter. In summer, only a narrow ring of coastal ice remains, like a broken belt



The winds that blow over the Antarctic, free of obstructions, generate a powerful ocean current that flows right around the continent: the Circumpolar Antarctic Current. This marine current ranges from 200 and 1000 km in width, travelling 24,000 km and carrying at an average speed of 2 km/h between 130 and 180 million m³ of water per second (approximately 1000 times the flow of the Amazon). It is the greatest marine current on the planet.

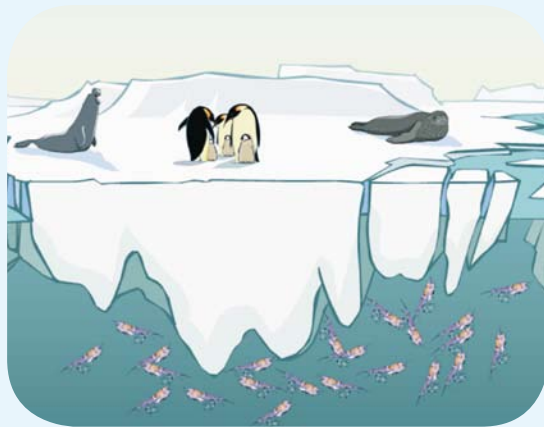
Despite this current, which could completely cut off Antarctica, the Southern Ocean is home to major exchanges between the cold waters of the coast and the warmer waters of further latitudes north. These exchanges have an important effect on biological productivity in the Antarctic. In addition, the formation of sea-ice in the winter makes the Antarctic the other significant producer of deep cold water for the thermohaline circulation.

The marine ecosystem of the Antarctic has long been thought to be a "short food chain of the giants", with three main levels: phytoplankton -> krill -> whales. But research in recent decades has shown that the Antarctic food chain is much more complex than that. The primary source of food is phytoplankton. Although it slows down in winter, phytoplankton begins to grow again the instant





spring reappears. Photosynthesis relies on nutrients found in abundance in the Southern Ocean, particularly in the upwelling zones along the Antarctic Convergence. This is true to such an extent that many researchers believe that the Southern Ocean is the most productive ocean on Earth. Zooplankton is represented mainly by krill. It also provides a good source of food for benthic species (i.e. living on the seabed), as well as for fish, squid, numerous species of marine mammals and birds. Alongside krill, the other major "grazers" of phytoplankton are copepods (microscopic crustaceans), as well as salpa, gelatinous organisms (like jellyfish).



The marine flora and fauna in the Antarctic is characterised by a high endemic level (i.e. when a species belongs exclusively to a specific region that may be more or less extensive). As for birds and mammals, there are fewer species, but their population numbers can be enormous.

Of the 38 species of birds, seven are penguins and twenty-four belong to the group which includes albatross and petrels, etc. There are also six species of seal, four of which are closely suited to living on the icecap.

There are 120 species of fish, 90% of which are endemic. Three-quarters of the fish types are benthic, meaning they live in close to the seabed. Some species are particularly well suited to the cold: they either do not have any haemoglobin or they are capable of producing a sort of antifreeze.

Finally, of the various species of whales and dolphins that live in Antarctic waters, some are only present in the area when the water is free of ice during the summer, while others make do by moving from one ice-free zone to the next (polynyas, fissures), even during the winter.



EDUCATIONAL NOTE

Teaching note

Many schoolchildren tend to know a little about a lot when it comes to the seas and oceans of our planet. Yet this knowledge is usually full of gaps and very fragmented. Also, there are many aspects of physics, chemistry, geology or biology that are virtually unknown to primary and secondary school pupils. As a result, the authors of this file have decided to place the emphasis on exploring a few major issues in terms of the dynamics of the oceans, as well as giving preference to a systematic approach that enables them to make links between the concepts being studied and the complexity of the oceans.

Also, children of school age frequently have misplaced ideas about the oceans. For example: the oceans we know today have always existed; the ocean bed is flat and covered with sand; the water temperature of the oceans is the same at all depths; the chemical composition of the oceans (especially their salinity) is the same wherever the oceans are in the world.

In addition, gaining some fundamental knowledge about the oceans is frequently set aside in favour of purely “geographic” study of the oceans, which mainly takes a simplistic approach.

As a result, for example, little is usually known about the ocean currents and their importance is under-estimated. Mention is rarely made of the interaction between the hydrosphere and the other ‘compartments’ that make up the Earth (atmosphere, biosphere, cryosphere, lithosphere). Details about the characteristics of water and the Earth’s seas and oceans are skimmed over. Yet water takes up particles and dissolves certain types of matter. It plays a part in erosion and plays a major role in heat exchanges and in the absorption of CO₂. Water is also a source of life and the main constituent of all living beings.

So, when it comes to understanding the oceans, the scope of knowledge that can be taken in is virtually limitless. This implies making necessary choices. The activities suggested in this dossier emphasise a structured approach allowing to build a number of scientific tools and concepts. But, above all, they make it possible to be systematic in establishing links between natural occurrences and the dynamics of oceans.





Proposed activities

To understand and retain facts about:

- The number of oceans in the world, their differences (warm oceans, cold oceans) and similarities
- Certain events in the geological history of your particular region
- The contribution of science to popular beliefs

To be able to:

- Carry out documentary research
- Search for information that is relevant for a specific topic and use that information for a particular purpose
- Apply reasoned logic based on questions
- Perform experiments to understand and identify various phenomena associated with the oceans
- Communicate to a group the results of the research carried out



file : ["Experiments in Earth Sciences"](#)

- The water cycle
- The formation of icebergs



file : ["Ice drift"](#)

- Proposed activity in class

Research questions and directions to be taken in work

What are the world's oceans?

How many oceans are there on Earth? Which ones are warm and which ones are cold? Are there more animals in certain oceans than there are in others? Are all the oceans of the same depth?

- Ask these questions to the pupils. Try to define the limits of the oceans based on the children's answers, then determine which oceans are warm and which ones are cold in the same way. Suggest to the children that they ask the same questions to their parents. On a different map, draw the limit of the oceans and indicate whether they are warm or cold, based on the answers from their parents.
- Then ask the children to conduct some brief research on each ocean and their specific features, either using the Internet or with books. The pupils can then produce a poster or small summary sheet





An ocean? What? Here?

Do you think that there might once have been a sea or ocean where our school stands today (or our town or region)? How can we find out? What do we need to look for to be certain?

There are various possible ways of going about this in order to answer these questions with the children.

- Scenario 1: A pupil mentions the existence of fossils or traces of ancient shorelines in the region. This makes it possible to work on what a fossil is, on how it is formed, on how palaeontologists use them to retrace the history of an area, etc. A day out might be arranged to go and look for fossils or other clues on the past existence of oceans. Some fossils can be easily analysed to determine whether they were deposited in deep water or more towards the shore. It might also be of value to invite a palaeontologist or geologist to visit the classroom and discuss with the children what they have found.
- Scenario 2: The pupils have to begin by deciding what type of clue might help them answer the question. The children can opt to contact the scientists from a university or museum in the area, or to conduct a survey with people outside the school (in which case it will be of interest to see how many people can actually realise this type of variation in landscape over the ages). Then, once the type of clue has been identified, the research can be continued along the lines of scenario 1.

How can we protect the aquatic environment around here?

- Think with the children about the various sources of pollution affecting the aquatic environment in your area. Make a list of them on a sheet of paper.
- Contact the local council (or agency that is responsible for the environment in your area) and ask them what measures are being taken to protect this environment. Link what they tell you with your list.
- Visit the edge of a lake, river or marsh and spend a day collecting rubbish.
- Organise one or two days devoted to awareness for this environment. Why is it important to protect it? What does the environment contain? What has already been done – and still needs to be done – to protect it? What else can be done?

Monsters or not?

Do you think that the old tales of sea monsters (or sirens on the rocks.) that used to frighten (or delight) people in the past can still frighten (or delight) them today? Why (not)?

- Choose a story about the sea that involves a monster, an imaginary beast of some kind or a siren (e.g. [The Little Mermaid](#), [Sinbad the Sailor](#)). Read the story with the children in class.
- Suggest that the children think about the image of the “monster”. No doubt the story was written before much was known about what exists in the depths of the oceans. At the time, this “monster” frightened people, because it may have been part of their beliefs. Is that still the case today? (You could also use the old Greeks’ representation of a flat Earth).
- Discuss the modern views about these “monsters” with the children. Why has our view changed? Scientific discoveries and marine explorations have enabled us to visit unknown places, to gain a better understanding of the world around us and to know more about some of the marine species that used to frighten people (such as the octopus).





TEACHING/LEARNING SEQUENCE: "EXPLORING THE MYSTERIES OF THE OCEAN"

To understand and retain the fact that :

- The ocean is a dynamic environment
- There are different natural processes in the oceans (biological, physical, anthropogenic)

To be able to :

- Ask oneself questions and ask others questions
- Establish a scientific method
- Make links between experiments and reality

This teaching/learning sequence is designed to discover more about the marine environment and its processes through a number of scientific research activities and experiments.

The aim is to understand that the ocean is dynamic in different ways (biological activity, physical processes, human dynamic) throughout the entire column of water, but that most activity takes place close to the coast.

To do this, we suggest making models of the ocean on paper and complete these diagrams after each activity which will enable us to end up with a fairly comprehensive picture of the dynamics of the oceans.

Starting point (10 minutes)

Show the children a map of the world and ask them to say what they see the most of on the map. The aim is to highlight the area of the world covered by the oceans. The map will remain in view throughout the teaching/learning sequence so that the various topics covered can be added to it.

Discussion (30 minutes)

Based on their response, ask them to indicate or name the various oceans. Try to identify which oceans are warm and which are cold by using their personal experiences on holiday. Develop the discussion based on their perception of the ocean: What is it? What happens there? What's in it? Is it important? Why? Make a list with their answers. This list will be used again at the end to check the ideas they come up with and as the basis for discussing what they have learned.

Set-up (45 minutes)

Working with the whole class, make a model of an imaginary ocean on a strip of paper, keeping the proportions as accurate as possible. Also make a model of the bathymetric profile (map of the seabed) of an ocean (horizontal profile, from the coast to the depths). Display these two profiles on a wall in the classroom and complete them after each activity conducted in class.

Give the children labels with the various terms to place on the profiles. Ask them to find out the





meaning of the terms so that they can place the labels in their correct locations. (See material at the end of the file.)

Specialisation 1: biology (90 minutes or 2 x 45 minutes)

Discuss the presence of life in the oceans with the children. What do we know about it? What form does this life take? Is there similar life in all oceans? At what depth? Why? How do we know?

Find 20 photos of marine organisms on the Internet and create "animal cards" for the pupils. Ask the children to position some of the different species on the map of the world; then on the model of the ocean depths and finally on the map of the seabed. The aim here is to demonstrate that some species need specific conditions to be able to live and that there is life even in places where you would expect least to find it.

(You can use the animation on [polar fauna](http://www.educapoles.org) at www.educapoles.org as an aid.)

Discussion (30 minutes)

Use the new aspect of the diagram as a basis for discussion. Make the children aware that there is life everywhere in the oceans, that certain species are endemic to certain areas (such as the polar bear) and cannot live anywhere else than where they are, whereas others (such as the whale), need to migrate.

You can use images of bathyscaphe if you would like to broach the topic of "how do we know that?".

Specialisation 2: the dynamics of the oceans (15 minutes + the time for each experiment)

Discuss with the children the physical processes they are able to see in the water (salinity, waves, currents, buoyancy, warm and cold currents, etc.):

Show the children the experiment protocols provided below which highlight the circulation of water in the oceans:

; **Is the temperature of the ocean the same at every depth?**

Starter question:

do you think that the water temperature is the same at all depths in a pond, lake or ocean?

Equipment:

A transparent container with sufficient depth (50 cm), two alcohol thermometers, some string, sticky tape, a watch, enough water to fill the container $\frac{3}{4}$ full. Note: it is important to have half of the water very cold and half of the water very hot.

Fill the container with water. Start by pouring in the very cold water, then the very hot water. Wait for 5 minutes. Measure the temperature of the water on the surface and at the bottom. To do this, press one thermometer against the wall of the container. Tie the thermometer that will go to the bottom of the container with string so that it can be lowered into the water without you having to put your hand into it, thereby avoiding to swirl the water.





Show the measures made to the pupils. Calculate an average and draw the obvious conclusions.

Observation :

The temperature is higher at the surface than on the bottom.

Scientific explanation:

The water is stratified² due to the difference in density between the hot water and the cold water. The molecules in hot water are more spaced out and agitated than in cold water. So there are fewer molecules in the same space. The weight/volume ratio (density) of the hot water is lower than for cold water. We call this water less dense. So, the 'lighter' hot water floats on top of the colder water.

Application in reality:

In the oceans, the water on the surface is heated by the sun. The column of water is so tall that from a certain depth on, the light – and hence the heat – of the sun can no longer penetrate (photic zone). So, the warm water remains on the surface.

After this experiment, you can show a depth profile with temperatures taken at a fixed point in the column of water, at different seasons, in a lake or the ocean.

; Is the surface water at the poles heavier than the surface water in a tropical ocean (not taking the salt into account)?

Starter question:

Do hot water and cold water have the same density?

Equipment:

Two plastic containers, two small glass containers (with neck), two transparent glass bowls, some food dye (red and blue), some hot water (that has just boiled), some cold water (straight from the fridge), two ice cubes made with water coloured blue.

1) Fill one of the containers with the cold water to represent the Arctic Ocean. Place some hot water with some food dye (red) in the small glass container. Place the bottle of hot water gently on the bottom of the container of cold water. Ask the children to watch, then draw what happens.

2) Fill the other container with hot water, representing tropical water. Place the cold water with some food dye (blue) in the small glass container. Pour the cold water gently into the container of hot water. Ask the children to watch, then draw what happens.

3) Fill one of the two bowls with hot water, then put one of the two ice cubes into it. Fill the other bowl with cold water and place the other ice cube in it. Ask the children to watch, then draw what happens.

Observation:

- 1) The hot water will come to the surface
- 2) The cold water will sink and remain in the lower part of the container

2 Stratified: made up of layers





- 3) In the bowl containing the hot water, the melted water from the ice cube will go directly to the bottom of the bowl. In the bowl containing cold water, the melted water from the ice cube remains on the surface (provided the temperature of the water is sufficiently close to the temperature of the ice cube)

Scientific explanation:

The water becomes 'stratified' due to the difference in density between the hot water and the cold water. The molecules in the hot water are more spaced out and agitated than the molecules in the cold water. So there are fewer molecules in the same space. The weight/volume ratio (density) of hot water is lower than that of cold water. This water is said to be less dense.

When hot water is poured into cold water, it moves vertically until it finds a layer of water having a density lower than its own (hotter). If it doesn't find any, it will go to the top. When cold water is poured into hot water, the mass of cold water will sink until it finds a layer of water having a density greater than its own. If it doesn't find any, it will go to the bottom.

Application in reality:

In the ocean, the warm currents are generally on the surface. When the water reaches the poles and cools down sufficiently, it dives down into the depths. This natural phenomenon also applies to lakes that are sufficiently large, such as Lake Geneva or the Great Lakes (USA/Canada)
NB: In the case of ocean currents, do not forget that salinity also plays a major role.

After this experiment, you can show a depth profile of water temperatures in the Atlantic Ocean and indicate the relative temperatures on the diagram of the column of water.

; **Would we float better in the Dead Sea or the Arctic Ocean?**

Question de départ :

Un objet flotte-t-il mieux dans l'eau douce, à salinité inférieure à la moyenne ou à salinité supérieure à la moyenne?

Equipment:

Little plastic boats, three balls of plasticine of identical weight, several transparent containers, an indelible pen, salt (2.5 kg), water, some scales, food dye (two distinct colours).

Prepare a solution of salty water that is more or less equivalent to the water in the Arctic Ocean: dissolve 30 g of salt in 1 litre of water. Prepare a solution of salty water that is more or less equivalent to the water in the Dead Sea: dissolve 300 g of salt in 1 litre of water. Pour the two preparations into different containers. Fill a third container with tap/fresh water.

- 1) Try to get the balls of plasticine to float in the three containers. Float the little plastic boats in the tap water, and indicate the water level along the hull using the indelible pen. Then float them in the "Arctic Ocean water", indicating the flotation line. Next float them in the "Dead Sea water", again indicating the flotation line. Compare the three flotation lines.





- 2) Weigh 1 litre of tap water, then a litre of "Arctic Ocean water", then a litre of "Dead Sea water".
- 3) Colour the tap water and the "Dead Sea water" with different dyes. Pour them gently into the "Arctic Ocean water". Have the children draw what happens.

Observation :

- 1) The saltier the water is, the higher objects float in the water.
- 2) The saltier the water is, the heavier it is.
- 3) The tap water stays on the surface, whereas the heavily salted water sinks to the bottom of the container.

Scientific explanation:

The density of the water increases as the salinity increases (i.e. the quantity of salt dissolved in the water). The saltier the water is, the denser it is. A small difference between the density of the water and the density of the object allows the object to float better.

The density of tap water (fresh water) is lower than seawater. So, the tap water will remain on the surface. By contrast water with greater salinity is more dense and will therefore sink beneath the less salty water.

Application in reality:

In the oceans, marine currents are also regulated by their level of salinity.

A complete ocean system

Discuss the various experiments with the children and ask them what they have learned and understood. Note their observations on the blackboard and see whether they think that these occurrences are related to one another in the ocean. Show them a final experiment that combines all the experiments we have seen so far.

Equipment:

A large container (such as an aquarium), water, some food dye, sea salt, a jug, bottle of frozen water.

Fill the container with warm, slightly salty water (30 g for 1 litre). In the jug, prepare a solution of very salty cold water using the food dye (50 g for 1 litre). (NB: the salt will be hard to dissolve if it is rock salt. Either dissolve it in advance in some hot water or stir it in well). Place the bottle of frozen water at one end of the container. Pour the cold, coloured water gently over the bottle a little at a time. Ask the children to take notes about what happens.

Observations:

The cold and saltiest water sinks, then moves slowly to the other end of the large container, although it remains underneath the rest of the body of water. It gradually warms up and mixes with the warm water above it. As it does this, it begins to rise.

Application in reality:

In the oceans, there is something called thermohaline circulation, which combines the effect of





temperature and salinity. It is this circulation that is being highlighted here. At the poles, the denser water sinks and comes back to the surface when it finds water of the same density.

After this experiment, you will be able to complete the map of the world's oceans, highlighting the thermohaline circulation. On the diagrams, show the surface currents generated by the winds and the deeper return currents.

Discussion (20 minutes)

Ask the children to look at the diagrams and to highlight the elements they have been able to add after the various thinking sessions and experiments. Discuss the spatial distribution of the various elements with the pupils and note them on the blackboard.

Research (45 minutes)

Based on the elements highlighted above, ask the children to think about the technical methods they have used to gain this new knowledge. Ask them to carry out research to confirm their ideas. Then have them present the results of their research to their friends.

Final discussion (30 minutes)

Discuss with the children the ocean system as a whole, using the diagrams again, as well as the new knowledge they have gained. Come to the conclusion that the oceans are part of a totally dynamic system (both in the depths and in the open sea), but one that is very fragile and that can easily be disrupted by man.





POSSIBLE EXTENSIONS

The polar oceans

- Discovering icebergs (30 minutes)

Look at [photos of icebergs](#) and ask the children where they come from and how it is they are able to float on water. Show them the following experiment:

Equipment:

A plastic bag, a transparent container.

Pour some water into the plastic bag. Seal it and put it in the freezer overnight.

The next day, fill the container with water. Take the "iceberg" out of the bag. Put it in the water and observe. Ask the children to draw what happens. Ask them to estimate the proportion of the iceberg that is under the water and the proportion above.

Observation:

Most of the volume of the iceberg is underwater, which does not prevent it from floating or from moving about in the water.

Scientific explanation and application :

Most icebergs break off from glaciers in the polar regions. Icebergs are immense blocks of ice that drift wherever the currents take them. We only see 20% of the total volume of the iceberg above the water. Even though the majority of the iceberg is above the water, it still floats because the density of the ice is less than the density of the water. You can also look at the [animation about icebergs](#) (www.educapoles.org).

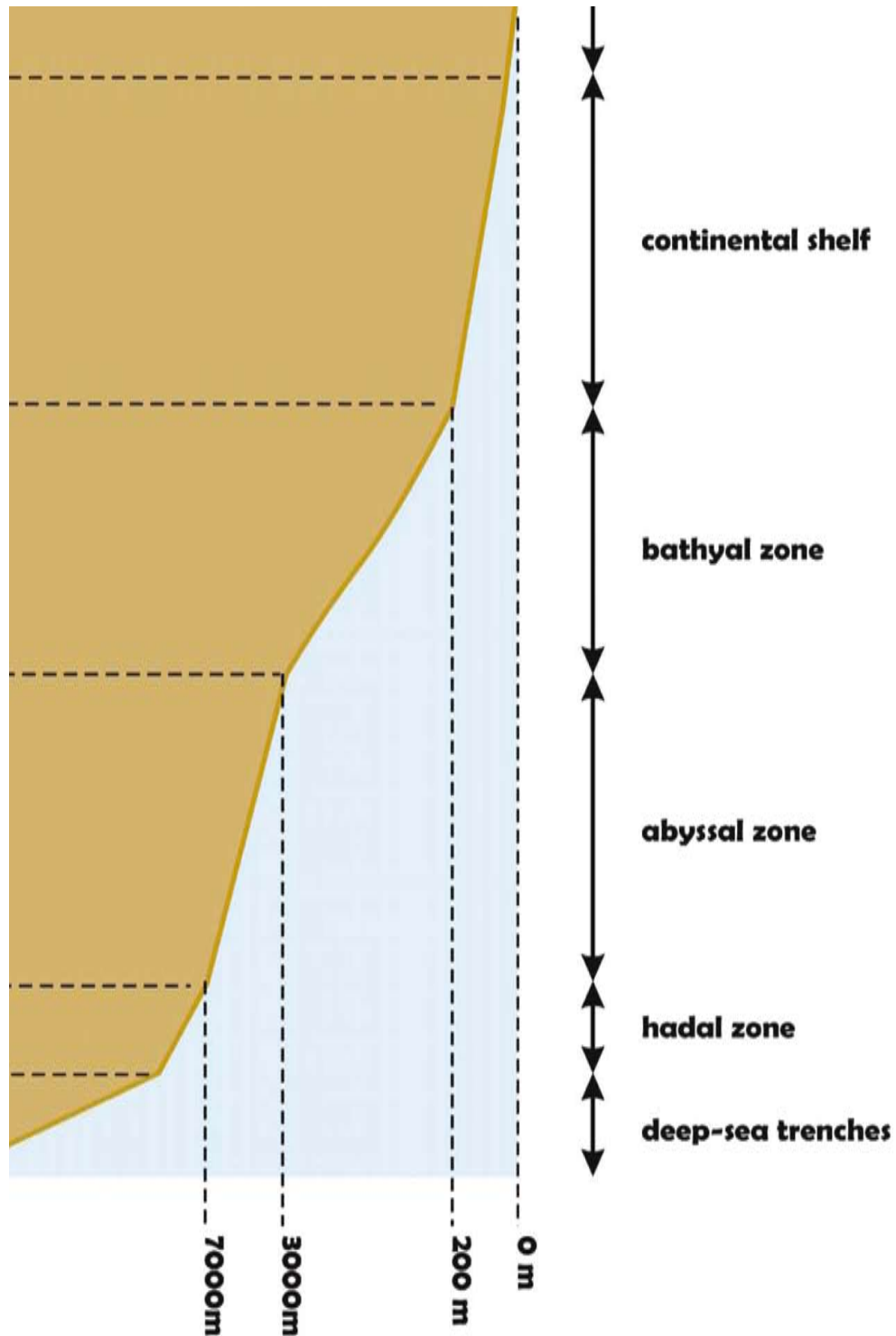
Spend some time thinking about the dangers icebergs can present with the children and tell them [the story of the Titanic](#), for example.





TEACHER SHEET

2. Bathymetric profil





PUPIL SHEET

1. Oceanic stage

zone photique	zone aphotique
zone néritique	zone bathypélagique
zone abyssopélagique	grands fonds océaniques

2. Profil bathymétrique

zone intertidale	plateau continental
zone bathyale	zone abyssale
zone hadale	Fosses océaniques





RESOURCES

WEB site

- www.educapoles.org Educapoles, the educational website of the International Polar Foundation provides learning activities about the Polar Regions and climate warming.
- http://www.dfo-mpo.gc.ca/canwaters-eauxcan/bbb-lgb/index_f.asp the young section of "Fisheries and oceans Canada" website
- <http://oceancolor.gsfc.nasa.gov/SeaWiFS/TEACHERS/> Educational section about oceans of the NASA (National aeronautics and space administration)
- <http://www.oceanexplorer.noaa.gov/> Section of the NOAA (National oceanic and atmospheric administration) dedicate to the oceans

References

Tell me about the Oceans, Patricia Chairopoulos, UNESCO publishing, 2003. (Also available in Spanish and Arabic)

The changing ocean Its Effects on Climate and Living Resources, Bruno Voituriez, IOC Ocean Forum series, UNESCO publishing,

Oceanography, Tom Garrison, Brooks Cole 6th edition, 2007 (seulement en anglais).

