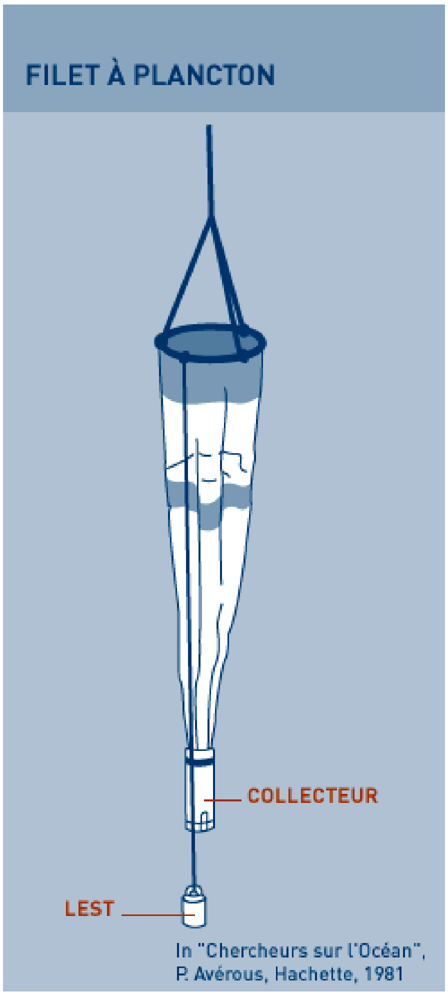
## ARCTIC PLANKTON

The term plankton is used to describe a group of organisms that live in water and are carried along by ocean currents without the means to swim against them. Plankton can be flora (phytoplankton, made up on uni-cellular algae) or fauna (zooplankton: eggs, larvae, small animals, gelatinous creatures, etc.).

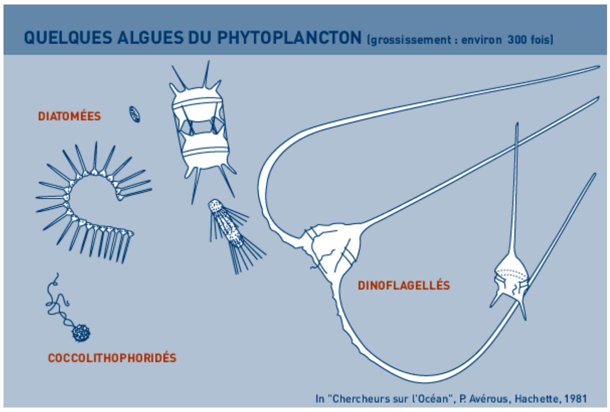
## PHYTOPLANKTON: THE FIRST STAGE IN MARINE LIFE

The algae component of plankton grows in the surface water, down to a depth of a few dozen metres, where the sunlight is still strong enough to allow photosynthesis to take place. Like land-based plants, phytoplankton needs both mineral elements and sunlight to be able to grow. There are thousands of different species of planktonic algae, all of them microscopic. They comprise the lowest link in the marine food chain.



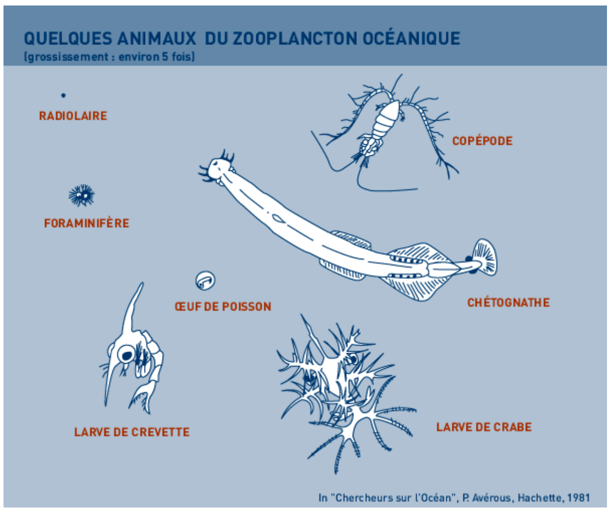

## ZOOPLANKTON

Zooplankton includes representative of most groups of marine fauna, from unicellular animals to jellyfish with “umbrellas” more than 2 metres across. But the stars of the zooplankton world are crustaceans: minute copepods that are among the most numerous creatures on Earth. And of course the “phony prawns” more properly called polar krill.



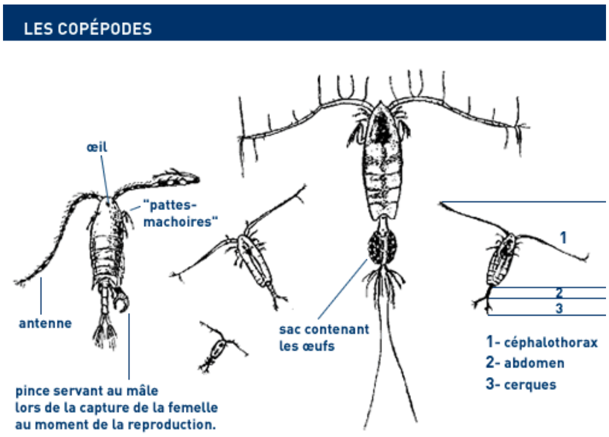

## PLANKTONIC LIFE IN THE ARCTIC OCEAN

During the polar night, planktonic algae stop growing for lack of light. When the thaw begins, the nutritious elements in the water are enriched by the addition of seawater and various organisms that were trapped in the sea ice, and by input brought by the currents and coastal run-off. When the sun returns, marine life reawakens and the food chain starts to function once more. By the time summer arrives, microalgae are even growing underneath and inside the sea ice.



## PHYTOPLANKTON FLOWERING

The growth of marine plants is never limited by a lack of CO2 or water. But if they are to build up their living matter they also need light and nutriments – nutritious elements such as phosphates, nitrates, oligo-elements, etc. Unfortunately, the only zone where there is enough light is the surface layer, even though there is nutriment much further down. Nutriment is not just found in coastal waters that are fertilized by input from run-off and rivers, there is also an abundant supply of food in deeper waters because organic matter falls from the surface layers to be recycled by bacteria. Ocean zones where phytoplankton (diatoms, flagellates, etc.) will proliferate are usually the zones where the nutriments are found close to the surface where light can penetrate (shallow waters or else deep waters where upwellings bring the nutriments to the surface).




## PRIMARY PRODUCTION IN THE OCEANS

Oceanographers estimate the amount of vegetal plankton (biomass) present at any given moment in an oceanic region by measuring the chlorophyll content of the seawater. The amount of vegetal biomass in the ocean, almost totally made up of microscopic algae, is a thousand times less than terrestrial biomass. On the other hand, phytoplankton multiplies very rapidly: just one diatom, with two cellular divisions every 24 hours, can generate a million descendants over a period of 10 days. Just compare this to a tree in a forest, which can sometimes take 100 years to reach maturity... Because of the rate at which planktonic algae multiply, primary production in the world's oceans – calculated by measuring the carbon 14 absorbed by photosynthesis – can be similar to terrestrial biomass production: a hectare of ocean produces anything from 200 kg to nearly 2 metric tons of carbon each year, depending on the region, while a field of corn (maize) produces 2 metric tons of carbon per year.

## SATELLITE OBSERVATION

There are still a lot of gaps in scientific knowledge of the productivity of the oceans; certain zones have still to be explored and we still do not fully understand the growth processes involved (deficiencies, water agitation, etc.). Satellite monitoring, which provides data on wind strength, current speeds, sea conditions (roughness...), water temperature, chlorophyll content, etc.) is an invaluable aid to gaining a better understanding of oceanic plankton "flowerings".

## KINGS OF THE ZOOPLANKTON WORLD: CRUSTACEAN COPEPODS

It is estimated that every litre of seawater contains between 1 and 10 copepods. These minute crustaceans have a body like a grain of rice, legs shaped like oars, sometimes a fairly well developed eye (more like a telescope that a human eye) and outsize feelers. There are about 2,000 species of planktonic copepods, ranging in size from less than a millimetre to several centimetres, depending on the species. They can be blue or red, colourless or luminescent, benthic or pelagic, polar or tropical. As they are so important to ocean life, they are the focus of numerous biological studies: species identification, studies of stomach content, estimation of daily food intake, determination of growth factors, oxygen consumption, fertility, etc.

## KRILL, OR "PHONY PRAWNS"

Krill is the Norwegian word used to describe large concentrations of euphasia, small crustaceans that look rather like prawns (and were for a long time classed as prawns) but that retain numerous characteristics of primitive crustaceans. World krill stocks have been estimated at some 500 million metric tons. Krill are not planktonic, in the strict sense of the word, because they can swim. They move along at 0.5 kph in a school and even faster than 2 kph on their own. Because of this, some specialists classify them as macroplankton while others regard them as microplankton (from the Greek nektos, creatures that swim like fish and cephalopods, etc). In addition, krill migrate vertically within the top 100 metres of the water column, sometimes going even lower in search of nutriments that they filter from the water using a very fine comb-like organ.

## BIO-POVERTY OF THE CENTRAL ARCTIC OCEAN

In the central part of the Polar Basin, production of phytoplankton is very low: less than 100 mgC/m2/day. Production in the surrounding strip (the continental shelf) is not much higher, at 150 mgC/m2/day. The zones that open onto the Atlantic and the Pacific (Scandinavian Basin, Baffin and Labrador Seas, vicinity of Bering and the Aleutians) are much richer (200-500 mgC/m2/day) and the coastal waters produce more than 500 mgC/m2/day. However, it should be borne in mind that these are average values that mask local, seasonal and even annual variations. Nevertheless, the central part of the Polar Basin is always one of the poorer zones. By comparison, primary production in the Western Mediterranean is 100 mgC/m2/day (ça devrait être 1,000?) and 10,000 mgC/m2/day in the exceptionally rich strip along the coast of Peru.

## THE LIFE OF ARCTIC PLANKTON IN SUMMER

Biologists have put forward several hypotheses to explain the life of Arctic plankton. In spring, the melting ice produces a desalinated and stable layer of water on the surface of an ocean rich in nutritious salts. This phenomenon allows micro-algae to start to multiply. The growth and recycling as waste of certain species subsisting in the ice underneath the pack provides some of the "ingredients" needed for this.

In the Barents and Norwegian Seas, the life cycle of the first "generation" or wave of the dominant copepod species (Calanus finmarchicus and C. glacialis) shows that the beginning and end of hibernation (more properly diapause in deep water) of the copepods, the growth of their genital organs and the moment of egg-laying seem to be determined by the need for the first (herbivorous) stages of the life cycle to be synchronised with the growth of surface phytoplankton in the surface layer. In the Greenland Sea, the water coming out of the Arctic Ocean contains little zooplankton. In this zone, only the waters mixed with Atlantic water, carrying copepods and probably other species (microphagous species such as salp) can introduce herbivorous grazers. So phytoplankton is very abundant there.

## WHAT HAPPENS IN WINTER ?

Scientists shave little information about the distribution, evolution and impact of plankton on the overall balance of matter (and CO2 in particular) during the Arctic winter. The hypothesis most often put forward is that the absence of light inhibits the mechanisms that govern the production of organic matter. In that case the biological absorption of CO2 by photosynthesis – on the part of autotrophic planktonic algae – is zero. On the other hand, the production of CO2 via the breathing of heterotrophic organisms (zooplankton) continues. Furthermore, the conditions in winter certainly have a decisive impact on the biological cycle of numerous planktonic species, and consequently on the build-up of a stock of nourishment for the larvae of several species of fish. Certain copepods in particular go through hibernation stages at great depth during which they are passively carried along by the currents. These animals would not be able to produce a new generation during the spring unless the individuals were transported towards zones where they is high production of spring phytoplankton – zones where they could continue to grow or, if already adult, reproduce. Other species survive and grow despite the extremely low temperatures.
The results published after an expedition around the Svalbard Archipelago show that during the warm season most of the zoological groups that play a part in the production or destruction of sedimentable particles are present there: crustaceans (copepods, amphipods, ostracods); molluscs (pteropods, chaetognaths, appendicularians, coelentrates, siphonophora and jellyfish).

## THE GREENLAND SEA

To what extent is zooplankton "inoculated" by the currents in the Greenland Sea? The Arctic waters bring with them only small quantities of living organisms, but the branch of the North Atlantic Current that flows up the eastern side of the strait that provides an exit for polar waters brings zooplanktonic species. But which are the dominant groups that subsist there in winter? And what role does the zooplankton play in the overall balance of matter (particularly $CO_2$) in the region? Firstly phytoplankton. Seawater samples taken in February and May in a fjord on the western coast contain only flagellates (between 0.1 and 37 million cells per litre). It is only in April that scientists will observe diatoms and a marked surge in production of vegetal biomass. Strong growth of a flagellate species can trigger a sudden influx of vegetal matter towards the zooplankton. The concentrations of chlorophyll that have been measured correspond to annual primary production of 150 mg of carbon per $m^2$ (between April and September), which is comparable to the Norwegian fjords. However, it should be noted that there is a relatively low concentration of nutritious salts in the upper layer of the sea, roughly equivalent to the concentration in the deeper waters of the Mediterranean and 2 or 3 times less than the concentrations recorded across upwelling zones in inter-tropical coastal waters. Zooplankton, on the other hand, subsists in winter at depths between 300 and 400 metres. The most abundant species are probably copepods. Calanus hyperboreus is a "resident" species and the dominant one in the Greenland Sea, while Calanus finmarchus (finmarchicus plus haut) is imported by deep currents and its numbers diminish in autumn. The species reappears in April at depths of 200-300 metres and by June it occupies the surface water. Pteropods such as Limacia sp., which subsists at the end of the autumn, as well as the chaetognath Eukrohnia sp. also add to the overall biomass. Ostracods such as Boroecia borealis have also been observed during this period. The microbial network (bacteria, etc.) must also remain quite active, even during the winter, because scientists have observed one of the ten most abundant species of appendicularians, which indicates the existence of small-sized prey.

## LIFE IN AMONG THE SEA ICE

On occasions, the sea ice can turn brown and give off a marked odour due to the presence of a multitude of diatoms growing on the underside of the sea ice. But within the mass of ice itself, life forms subsist among the crystals of fresh-water ice and in the thin seawater channels. A complete food chain can be found here, including planktonic algae and their decomposers (bacteria). Some of these organisms spend their whole life cycle inside the sea ice and others only part of their cycle, but all of them have adapted to a wide range of salinity and sunlight strength. This means that even during the Arctic winter, some algae can continue to photosynthesise using the very weak light of the polar night. Some of these organisms originate in the sea and others are washed down to the sea by rivers. In autumn, when the sea starts to freeze over once more, they remain there, clinging to the ice. At first, both their diversity and the quantities present are quite low, but as soon as spring arrives numbers and diversity skyrocket, along with those of their predators. In sections of ice that have built up over several years, and thus several life cycles, the ice displays several strips or layers of microscopic communities that allow scientists to date successive spring "flowerings".

## BIOLOGIST'S CORNER

> The $CO_2$ in the atmosphere is partially dissolved in the ocean water, and the lower the water temperature, the more is dissolved. It is then transported by ocean currents. For example, $CO_2$ absorbed in the Antarctic can "reappear" in the tropical zone after being carried along by deep currents for several decades. The $CO_2$ is also actively used by phytoplankton during its flowering or when it is building its shell (this is known as the **"biological pump"**), but some of it is also released back into the atmosphere by the breathing process.

> In the top 100 metres of the water column, between November and February, **zooplankton biomass** diminishes from 20 mg to 4 mg (dry weight) per $m^3$. It is as late as June before the surface biomass reaches 60 mg per $m^3$. In the Arctic Ocean as a whole, the biomass of the layer from 0 to 1,000 metres is quite low (0.2 mg per $m^3$) compared to biomass in the Greenland and Norwegian Seas (12-13 mg per $m^3$).

> Marine animals able to adapt to widely **diverging salinity levels** have an advantage in regions where life follows the freeze-melt cycle of the sea ice. For example, during the month of June, when ice is melting, salt water can become fresh water in less than an hour, later stabilising at 32% a few days later.

> **Low temperatures** restrict the number of species (although those that are present display a very large number of individuals) and slow the metabolism of living beings. In warm oceans, certain copepods can accomplish their full life cycle in just 15 days, but in polar regions some copepods can take nearly two years to reach sexual maturity.

## SOME USEFUL VOCABULARY

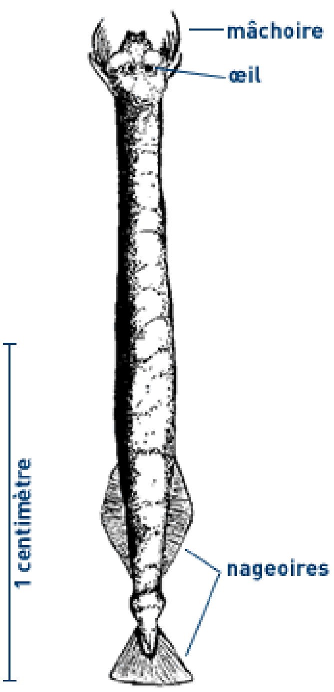
### PLANKTONIC ORGANISMS CAN BE CLASSIFIED :

| | |
|---|---|
| Nanoplankton | roughly a billionth of a metre, or 0,000,000,001 metres |
| Microplankton | a millionth of a metre, or 0,000,001 metres |
| Mesoplankton | a thousandth of a metre |
| Macroplankton | a few millimetres |
| Megaloplankton | several centimetres |

> By their position in the water column. Organisms on the surface are called **epiplankton**. This is where most of the better-known organisms live (copepods, small prawns, etc.). Organisms that live in the depths are known as **bathyplankton**. These are large transparent animals, filter-feeders like jellyfish, that can best adapt to the bio-poverty of this environment.

> By their adult form. When an organism spends only the larval phase of its life cycle floating in the water (e.g. the larvae of sea urchins, benthic fish, worms, etc.) they are called **meroplankton**. The other type is **holoplankton**, or animals that spend their whole life cycle in a planktonic state (foraminifera, radiolarians, copepods, chaetognaths, etc.).

CHÉTOGNATHE




## TO FIND OUT MORE ...

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