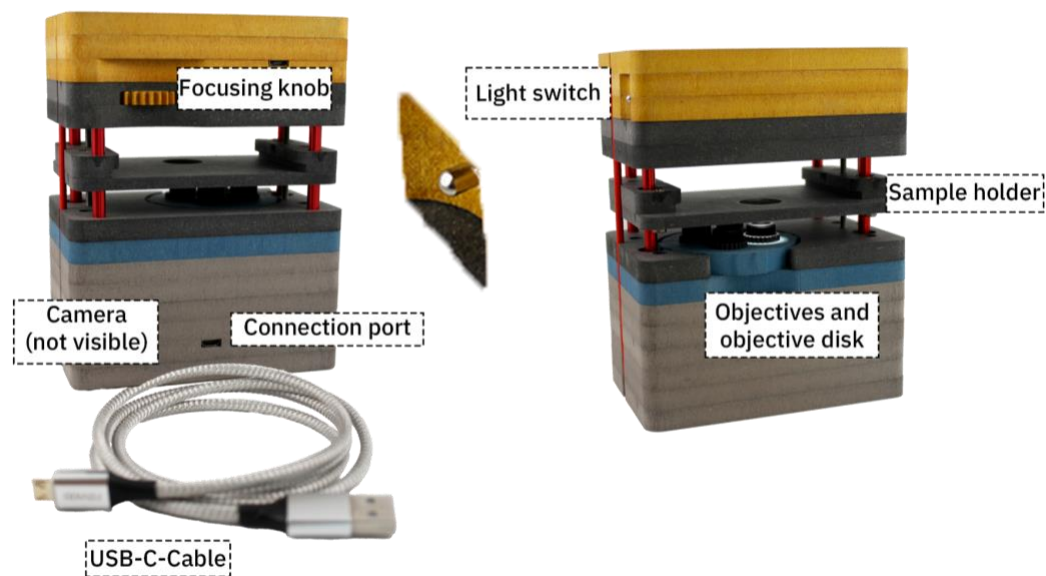


Diving into the world of plankton with the Curiosity Microscope

Answer sheet

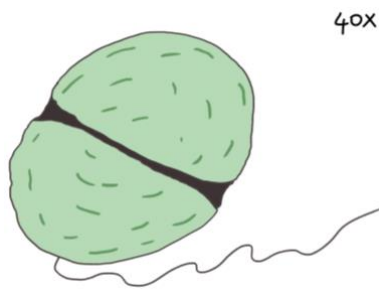
Visualisation under the microscope



Using the Curiosity microscopes and this educational material, we will explore and identify some of the planktonic organisms we can find in the water. After placing your sample on the sample holder, view it at different magnifications, starting at the lowest magnification and working up to the highest magnification (**40 minutes**). Use the available space below to insert an image of a plankton species taken with the microscope. Use the magnification at which you can best see the plankton and note the magnification used.

*You can also draw your observations instead of taking pictures.





1. **Outline** the general characteristics of the plankton you observe by answering the questions below.

- a. Look at your picture and think about whether your observed plankton lives alone or in colonies.

The plankton lives solitarily

- b. **State** the colour of the plankton you observe.

Light green

- c. Describe the shape of the plankton.

The plankton has an oval and asymmetrical shape. Two parts are separated by a groove that runs along the centre of the plankton. A flagellum can be seen at one end.

2. The word plankton means "drifter" and refers to the fact that they cannot swim against the currents. However, some plankton organisms have body parts that enable them to move in calm water. While some plankton organisms swim around using cilia and/or flagella, others use body parts such as legs to swim. Below are examples of planktonic organisms and the structures they use for swimming.^[2]

- a. Identify a moving plankton for observation and capture it in a picture with the microscope. Paste the picture below or draw the plankton in the box.

- b. Describe its movement and note the structure it uses to move OR include a picture of the structure that you took with the microscope (if visible).

Pupils may be able to observe a directional movement of the plankton. Their cilia or flagella are used for this, and the movement can be described as follows:

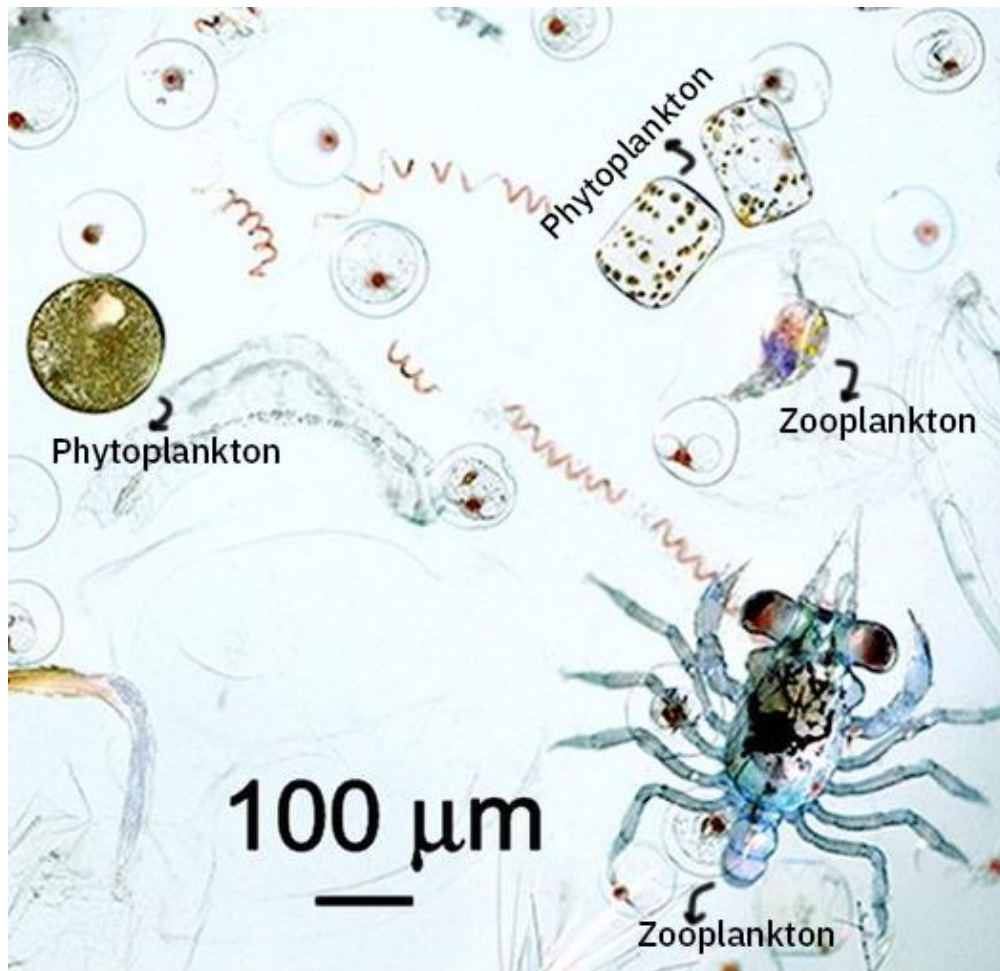


The plankton moves continuously in a certain direction until it encounters a barrier and changes direction. After changing direction, the plankton continues to swim uninterrupted.

Alternatively, the students can also record the movement of copepods, which show short jumps when swimming, whereby the description could be as follows:

The plankton moves through the water with jumps / periodic strokes using its legs. After each jump, the plankton stops and continues its movement by repeating the same motion.

3. While some plankton organisms in the water have an animal-like character (zooplankton), others are more plant-like (phytoplankton). Phytoplankton are the most common life forms in the ocean. Thanks to the green pigment chlorophyll, they utilise sunlight to produce food and grow. Chlorophyll is also found in plants and is the molecule that gives both plants and phytoplankton their green colour. Zooplankton, on the other hand, cannot capture sunlight and have no chlorophyll, so they are not normally green in colour. Zooplankton hunt other organisms like phytoplankton to feed, and therefore may also have small mouths, arms, claws, and in the case of jellyfish, even tentacles with which to capture prey. Below is a group of plankton organisms. Label one that you think is a phytoplankton. Label another one that you think is a zooplankton. Explain your reasoning below.

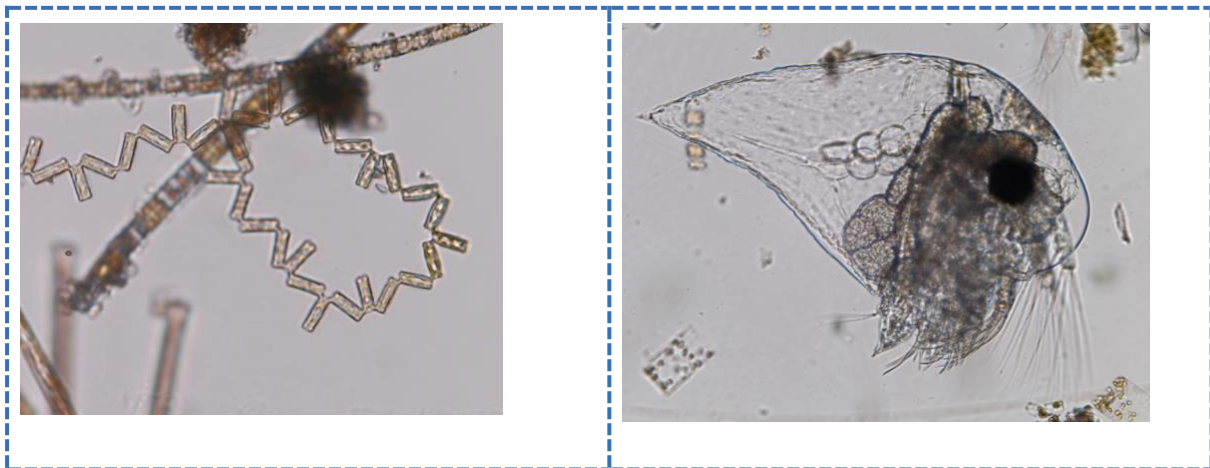


Phytoplankton are photosynthetic organisms that contain chlorophyll, which gives them their green colour. Therefore, organisms with green pigmentation could be phytoplankton. Zooplankton are organisms that feed on other organisms and do not contain chlorophyll. As they rely on hunting other organisms to feed, they may have eyes, claws and legs that can help them recognise and capture prey. The shrimp larva in the corner, for example, has claws, legs and eyes.

4. While looking at the water sample with your microscope, take a picture of a phytoplankton AND a zooplankton and paste them below. Answer the questions.







- a. **Indicate** whether they live alone (solitary) or in colonies.

Phytoplankton: Colony

Zooplankton: Alone

- b. **Describe** the general appearance of the plankton with reference to the characteristics below.
- Colour, shape, visible structures (grooves, symmetrical individual cells)
 - Presence of claws, spines, eyes, legs and/or mouth
 - Presence of flagellum/s

The phytoplankton colony has a pale yellow to greenish colour. The individual cells appear to be connected to each other at the corners, forming a chain-like structure. Individual cells are symmetrical and look like rectangles.

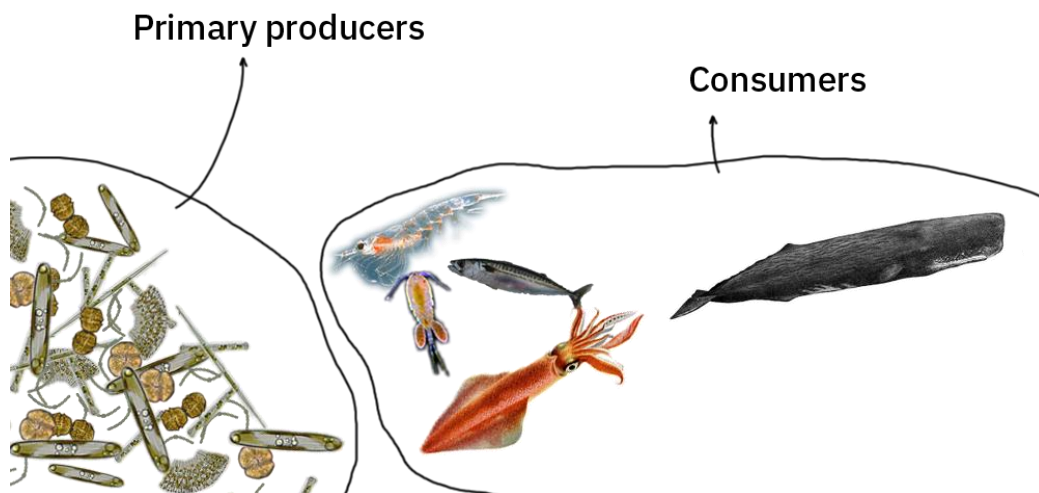
The zooplankton has a transparent and colourless body with visible outlines. There are legs and hair-like structures on the body. A dark black spot is also visible above the legs, which could represent an eye of the zooplankton.

5. Below is a scale comparison of individuals from three different groups of phytoplankton. The scale bar is 100 microns long and divided into 10 micron sections. Refer to the plankton fact sheet and **(5 minutes)**:
- Identify** the group to which each phytoplankton belongs and **label** them.
 - Estimate** the sizes of the individual cells in each group using the scale bar.

- c. Look at the three types of phytoplankton and **label** the visible parts of their cells that contain chlorophyll. **Explain** your reasoning.

The chlorophyll pigment has a green colour. The presence of chlorophyll in cells and tissues therefore also makes these structures appear green in colour. Similar to plants, phytoplankton also contain chlorophyll in their cells (especially in chloroplasts in eukaryotes), which appears green or various shades of green under the microscope. Therefore, parts of the cell that appear green may contain chlorophyll.

6. Similar to ecosystems on land, ocean ecosystems rely on primary producers such as phytoplankton to sustain other organisms. In the diagram below, identify and label the primary producers and consumers that depend on them (**5 minutes**).



7. Referring to Figure 5 of the "Plankton" information sheet, answer the following questions (**10 minutes**):

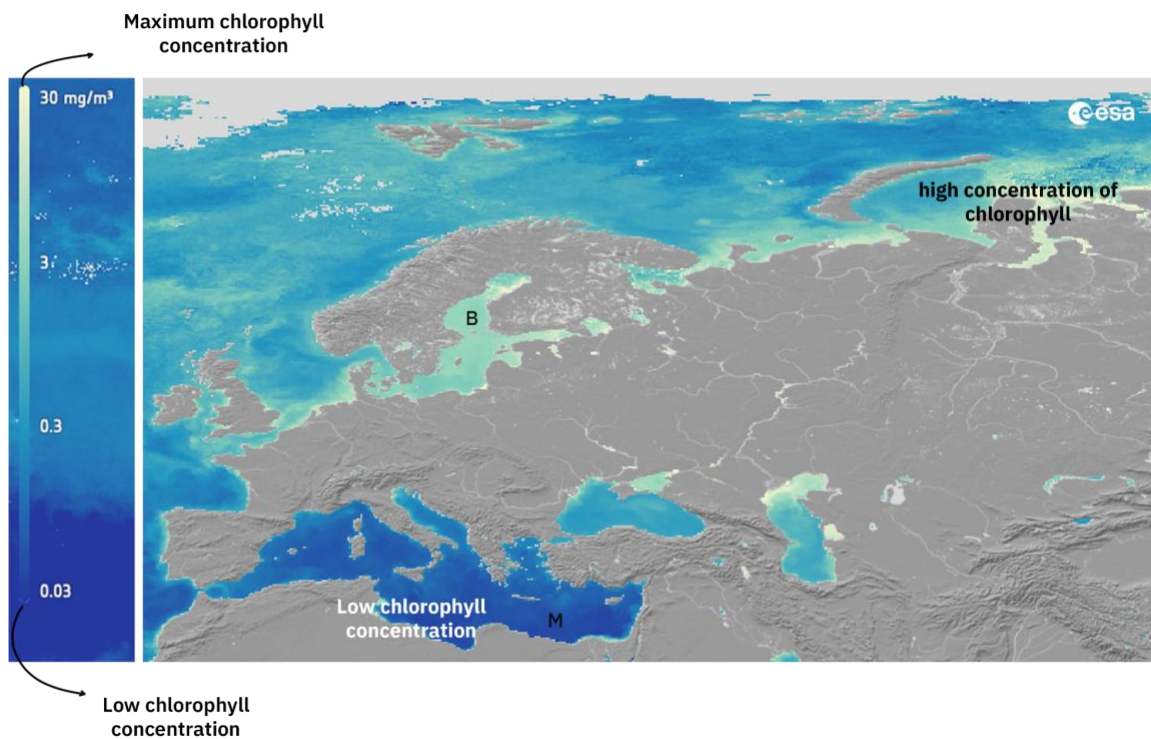
- a. How would the number of sperm whales change if the amount of phytoplankton in the region decreased?

A decline in phytoplankton numbers would lead to a decline in the total number of zooplankton that depend on them. A decline in zooplankton numbers would also lead to a decline in the number of organisms (such as whales) that feed on them.

- b. How would the number of phytoplankton and sperm whales change if the krill population decreased?

A decline in the number of krill would mean that there are fewer consumers who feed on phytoplankton. Unconsumed, the numbers of phytoplankton would increase. The same decline in the krill population would also lead to a decline in the number of whales.

8. Below is a satellite image showing the chlorophyll intensity in parts of the Atlantic Ocean due to plankton growth. Next to the image is a scale that assigns the corresponding chlorophyll intensity to the colours. Answer the following questions (10 minutes).
- Identify** the colour that shows the highest and lowest chlorophyll concentration in the ocean on the colour scale and **label** it accordingly.
 - Identify** a region of high and low chlorophyll concentration on the map below and **label** it "high chlorophyll concentration" or "low chlorophyll concentration".
 - Look at the chlorophyll intensity map and **predict** which area of the oceans (labelled B or M on the map) contains more plankton in the water.



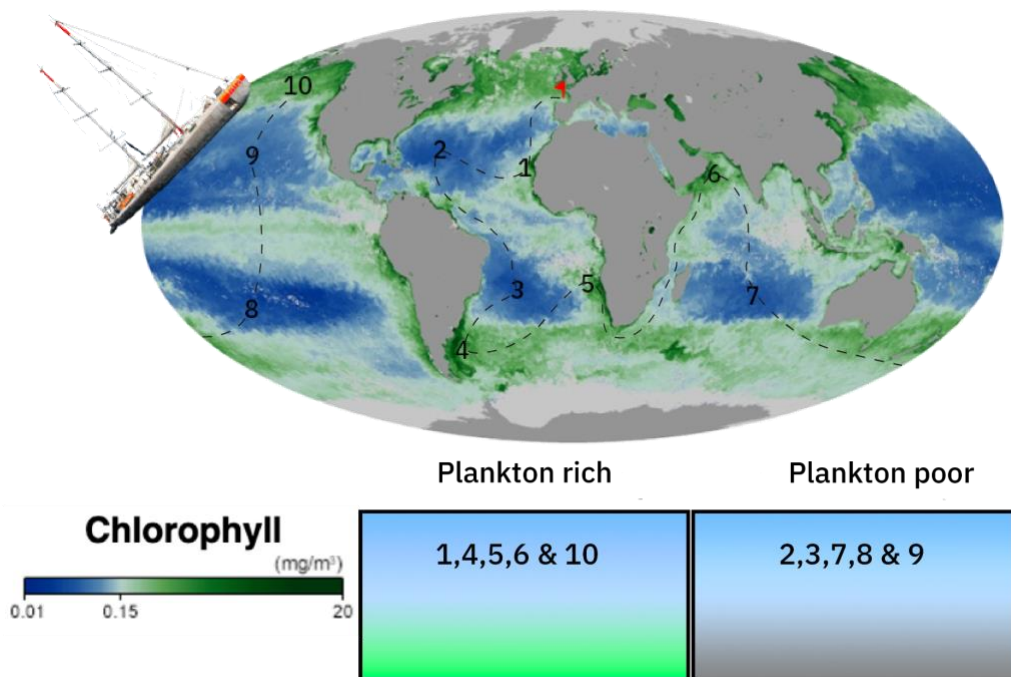
The greenish colouring on the map represents the amount of chlorophyll and therefore the abundance of phytoplankton in the region. When looking at the map, the Baltic Sea region labelled B has more phytoplankton in the sea, which can also feed other plankton species such as zooplankton. Therefore, the area of the ocean labelled B contains more plankton.

- d. **Explain** which of the two plankton groups (zoo- or phyto) is responsible for this colour change detected by satellites.

The colour detected by satellites comes from the chlorophyll pigment of the phytoplankton. The presence of large quantities of green phytoplankton colours the sea greenish. Phytoplankton organisms are therefore directly responsible for the colour change.

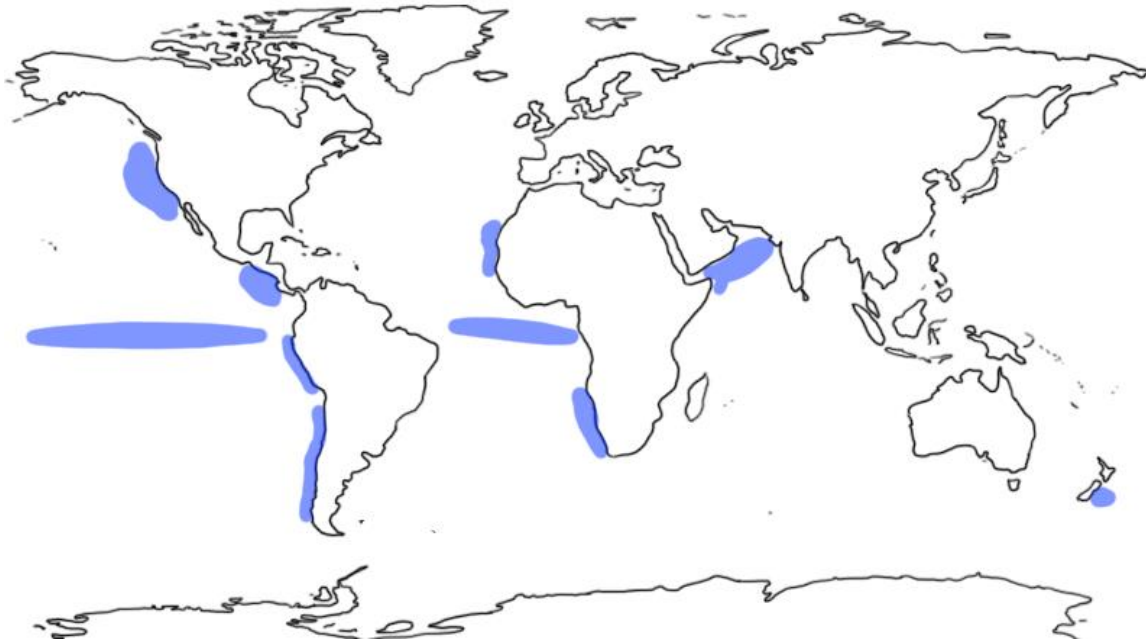
9. Phytoplankton shows an uneven distribution in the world's oceans. Therefore, certain areas of the oceans are rich in phytoplankton, while other areas lack it. Answer the following questions using the corresponding maps (10 minutes).

- a. The following world map of chlorophyll concentrations shows where phytoplankton is most abundant and the route of the Tara Ocean Foundation research vessel Tara along which samples were taken (marked by numbers on the map). The route starts at the coast of France (red flag) and ends at location 10. Look at the ocean colour at each location where samples were taken and identify the phytoplankton-rich and -poor parts of the ocean. Write them in the individual boxes you see in the diagram below.



- b. The growth of phytoplankton in the ocean depends on factors such as the availability of sunlight and nutrients. On the map below, the regions marked in blue indicate where nutrients rise from the deeper environment to the surface in a process called upwelling. Look at the map and indicate whether the

phytoplankton-rich regions you listed earlier correspond to the regions of nutrient upwelling.



Yes, the previously identified phytoplankton-rich regions correspond to the upwelling areas.

- c. Briefly **outline** how nutrients can contribute to the growth of phytoplankton.

Phytoplankton use sunlight, CO_2 and H_2O to produce organic molecules such as sugars ($\text{C}_6\text{H}_{12}\text{O}_6$).

CO_2 and H_2O do not contain elements such as N and P, which are also important for the development of organisms. Phytoplankton use the nutrient-rich compounds of N and P, which are brought to the surface by upwelling, to synthesise other organic compounds such as nucleic acids and amino acids. These in turn are used to synthesise DNA and proteins.

Once these organic compounds are synthesised, phytoplankton can reproduce.

10. The following map shows where the largest populations of sardines and anchovies live in the ocean. Look at the map and answer the questions **(10 minutes)**.

- a. Using the map, indicate whether the largest fish populations live in regions rich or poor in phytoplankton. Explain your reasoning **(5 minutes)**.

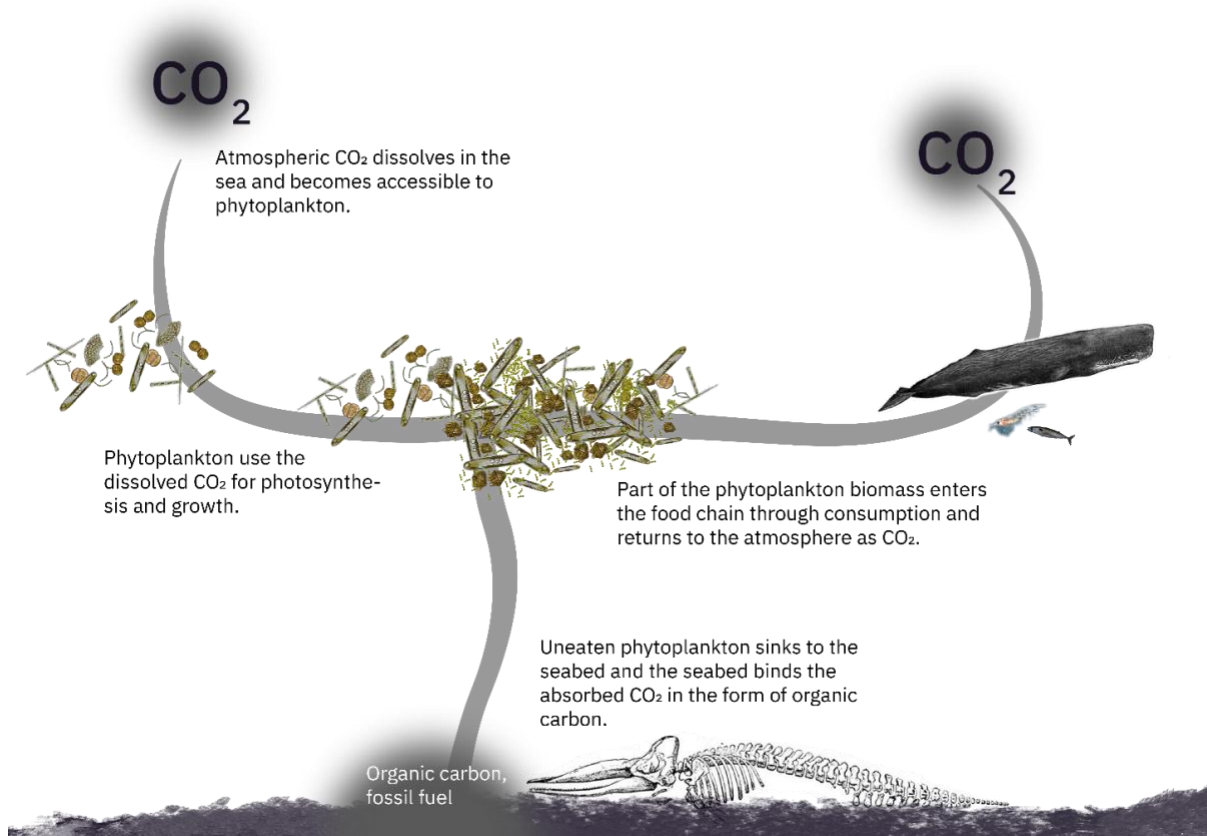
The largest fish populations overlap with the phytoplankton-rich regions. As producers in the ocean, phytoplankton forms the basis of the food web. Waters with abundant phytoplankton also support the growth of other types of plankton such as zooplankton, which feed on phytoplankton. The presence of zooplankton attracts larger animals such as fish, birds and marine mammals to the same areas to feed on them.

- b. Briefly **outline** the role of nutrients in the fish populations of upwelling systems (**5 minutes**).

Upwelled nutrients provide the necessary compounds that phytoplankton use to synthesise proteins and DNA molecules and help these organisms to reproduce. An increase in the number of phytoplankton leads to an increased presence of consumer organisms such as fish, which are dependent on them.

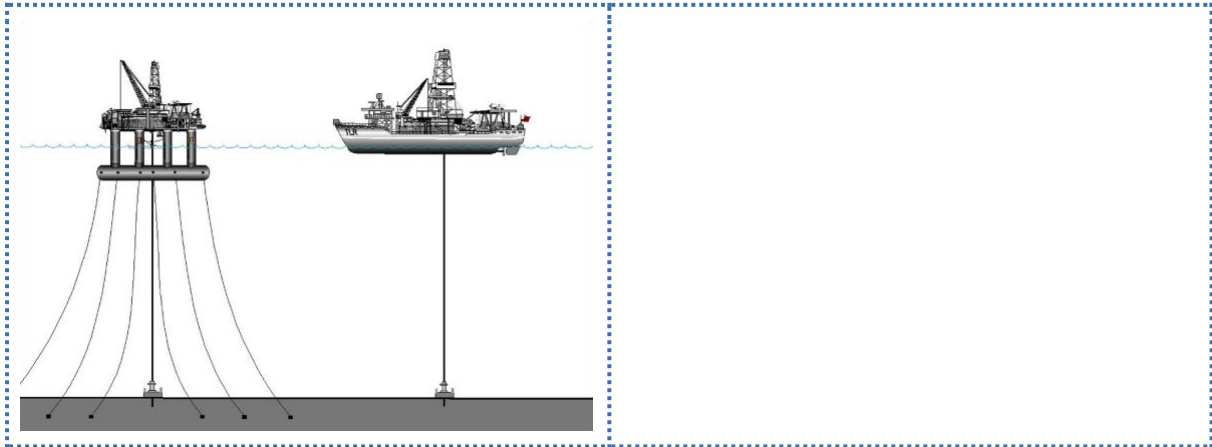
11. As phytoplankton photosynthesises and grows, it uses the CO_2 diffusing from the atmosphere into the ocean and converts it into organic carbon to produce mass, or in other words, to produce more phytoplankton. While most of this phytoplankton is eaten by marine organisms, the rest sinks to the bottom of the ocean, taking the captured CO_2 from the atmosphere with it. By absorbing CO_2 from the atmosphere with the help of phytoplankton and binding it in its depths, the ocean plays a crucial role in regulating our planet's climate. The extraction of sequestered carbon in the form of fossil fuels and its release into the atmosphere is a major cause of climate change^[1].





Using the above information, **explain** how offshore drilling as a human activity interferes with the different stages of the carbon cycle (10 minutes).

Human activity	Where it disrupts the carbon cycle
Offshore drilling: the process of drilling through the seabed to extract fossil fuels used in industry and transport.	Offshore drilling and fossil fuel extraction remove organic carbon from the seabed, which prevents the CO ₂ absorbed by phytoplankton from remaining in the depths of the ocean. The extracted organic carbon (fossil fuels) can then be utilised by humans.



References

1. Causes and Effects of Climate Change. (n.d.).
<https://www.un.org/en/climatechange/science/causes-effects-climate-change>
2. Kiørboe, T. (2016). Observing zooplankton with high speed video.
<https://www.tkboe.aqua.dtu.dk/research-areas/observing-zooplankton-with-high-speed-video>