Phaeocystis and foaming beaches

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Have you seen foam on the beach in spring and wondered what it is and where it is coming from? The foam is caused by a unicellular alga called *Phaeocystis globosa.* This is a small alga and it varies from 3 to 7 micrometer in diameter (a micrometer is 1 thousands of a millimeter). How can such a small algae form so much foam? This is because the cells organize themselves into large spherical colonies which can be several mm in diameter and which are easily visible by the naked eye. If you fill a bucket with seawater when the sea starts foaming, you can easily see them. These colonies often float near the surface and they can grow very fast, causing large “blooms” (i.e. a high biomass).

When the bloom is developing, the colonies of *Phaeocystis* are nicely spherical. Most of the cells are actually arranged at the periphery of the colony, which is a mucus-like watery ball. Because the colonies are so large, they are hardly eaten by “grazers” like copepods (small crustaceans) and unicellular grazers (“microzooplankton”). This is one of the reason why they can form such large blooms. However, when they have depleted the nutrients in the water, the colonies deform and start to disintegrate. At this point a part sinks to the bottom and another part is attacked by special viruses, causing the cells to fall apart (lysis). During this decaying phase, the foam is released and when the wind conditions are right, it can form huge quantities on the beach. Fortunately the foam is not toxic. Fishermen, however, do not like *Phaeocystis* as the colonies can clog their nets. Because of their unwanted effects, *Phaeocystis* is often included in the group of Harmfull Algal Blooms (HABs). As mentioned above, *Phaeocystis* is hardly eaten by copepods, which is preferred food for small fish, which are in themselves good food for larger fish. For this reason *Phaeocystis* does not contribute much to the fisheries industry.

There are 6 species of *Phaeocystis*, but only 3 species form large blooms. These species are *Phaeocystis antartica, Phaeocystis globosa* and *Phaeocysits pouchetti*. As the name suggests, *Phaeocystis antartica* is mainly found in the Antarctic southern ocean. *Phaeocystis pouchettii* is mainly observed in the cold Arctic waters whereas *Phaeocystis globosa* can be found in the temperate seas like the North Sea, the north Atlantic, but it has also been sighted in the warmer waters of the Arabian Sea and the Caribbean. *Phaeocystis* has a complex life cycle, with free living single cells and colonies, but only when it forms colonies can it bloom.

Phaeocystis and the global climate

Although rain forest are generally regarded as the “lungs of the world”, this is not entirely true. About 50% of all CO_2-fixation takes place on land; the other 50% takes place in the ocean. Hence, about 50% of the oxygen we breathe is produced in the ocean. This means that algae in the ocean (phytoplankton) play an import in the global carbon cycle. Because they take up CO_2 they have the potential to “dampen” the global rise in temperature. But this will only happen when the cells are not recycled in the upper well mixed layer (upper 30-100m depth layer) of the ocean and seas. However, when the cells sink and sediment to the ocean floor (or are being transported from the bottom of the shallow shelf seas to the deep ocean floor) the CO_2 taken up from the atmosphere by the alga is buried on the ocean floor and it then removed from the atmosphere for thousands of years. This process is called the biological pump. It is by plate tectonics and volcanism that part of it is transported back to the atmosphere.

Although the activity of the biological pump is not entirely understood, some algae are more important for the activity of the biological pump than other species. Carbon in algae (produced by taking up atmospheric CO_2) can reach the ocean floor in two ways: either by direct sedimentation or in the form of “faecal pellets” (“grazer excrements”). Many diatoms (a very important group of unicellular algae) are large and will sink quickly to the sediment floor. They are also preferred food for copepods, hence when diatoms are the main species in the phytoplankton the biological pump will be active. Diatoms are often the first species to bloom when the winter recedes and spring arrives. As long as they grow they often outcompete *Phaeocystis* for nutrients and *Phaeocystis* will not become a dominant species. However, diatoms are unique in that they require silicate for their cell wall. Hence, when silicate is taken up (and it is usually one of the first nutrients to become limiting), diatoms stop growing and *Phaeocystis* can continue to grow and develop a bloom, but the extent of the bloom will largely depend on the availability of other nutrients (mainly nitrate or ammonia and phosphate in the North Sea, but iron in the southern ocean). Because *Phaeocystis* is poorly eaten by copepods, part of its carbon will not end up in faecal pellets and this will decrease the efficiency of the biological pump. Also, after lysis a large fraction of the cell remains will be mineralized in the upper mixed layer and the CO_2 formed during this process will be given back to the atmosphere. The same holds for the foam on the beaches. Thus when *Phaeocystis* forms blooms, only a small fraction of the carbon fixed by this alga will be finally buried on the ocean floor.

Phaeocystis also influences the global climate in a different way as it is a major player in the global sulfur cycle. In order to keep its internal salt concentration at the right range (osmoregulation) it produces a substance called dimethylsulfoniopropionate (DMSP). When this is released in the environment (when the cells break apart) bacteria convert it to dimethylsufide (DMS). DMS is volatile and it escapes to the atmosphere. Here it acts as cloud condensation nuclei which promote the formation of clouds. The result of this is that it increases the reflection of solar radiation back into space. This dampens global warming.

Phaeocystis and eutrophication

Eutrophication is the "fertilization" of the environment. Most of the fertilization in the North Sea is caused by fertilizers used in agriculture. Not all nutrients in the fertilizers are taken up by the plants, and the remainder is transported via ground waters and rivers to the estuaries and coastal seas. Here they promote the growth of algae. Problems due to eutrophication are most visible in fresh water lakes. Often cyanobacteria ("blue green algae") develop large and toxic blooms, and when the blooms decay in autumn the dying cyanobacteria are recycled by bacteria and the oxygen demand for this is so large that all oxygen in the water is depleted, leading to anoxic waters and large fish kills. But the nutrients (nitrates and phosphates) can also affect the coastal waters adversely. In shallow lagoons or estuaries large quantities of "green flaps" of the green macroalgae *Ulva* (Sea Lettuce) can develop. When they are washed ashore they decompose and kill anything below it (due to anoxia). During the decomposition hydrogen sulphide gas (the smell of rotting eggs) will develop and this toxic gas can be harmful, as demonstrated recently when large quantities of Sea Lettuce were washed ashore on some of the northern beaches in Brittany, France. Whether eutrophication promotes the growth of *Phaeocystis* is still not sure, although several lines of evidence suggest this. As fertilizers do not contain silicate, a major macronutrient for diatoms, it is not unreasonable to assume that the nutrients from the fertilizers will sustain the development of *Phaeocystis* after the growth of diatoms has stopped because of silicate depletion. Large blooms of *Phaeocystis* are known to cause net clogging, and some cases have been documented that they settled on mussel beds, causing anoxia and killing the mussels.

To conclude, the occurrence of *Phaeocystis* and the foaming of the beaches is a natural phenomenon. However, due to eutrophication the occurrence and the intensity of the blooms and foam increased, causing adverse effects. For this reason eutrophication should be avoided in order to have a healthy ecosystem.

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