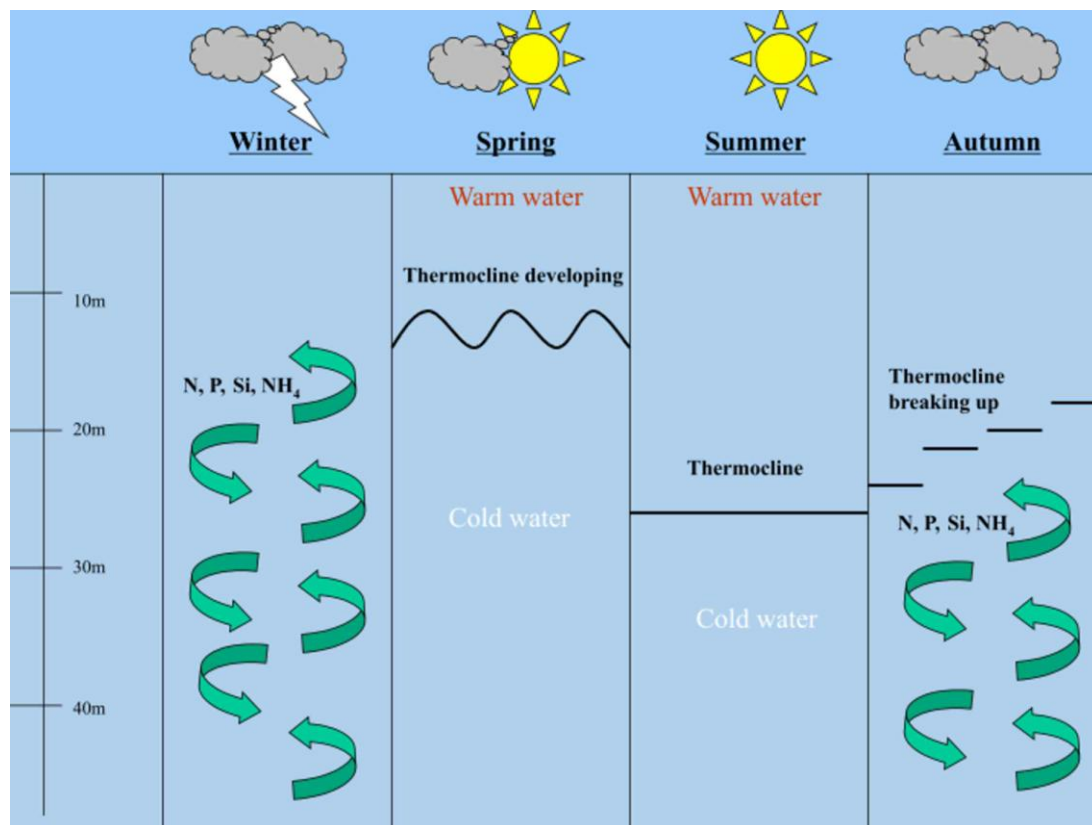


## Primary Production and Thermoclines

*Primary production* is defined as the rate in which biomass is produced by photosynthetic organisms. Gross primary production (GPP) is the total rate of biomass production, whilst net primary production (NPP) is the total biomass produced after some has been lost through plant respiration. Phytoplankton accounts for almost all the primary production in the oceans.

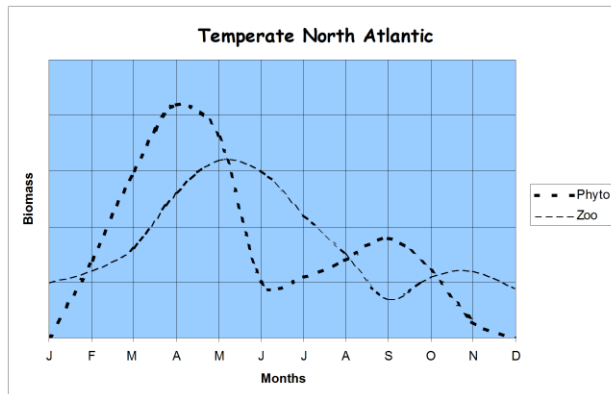
In the marine environment climate and weather patterns effect the rate of photosynthesis, and therefore the primary production in that area of the sea. There are distinct differences between the seasonal cycles in temperate Atlantic waters and tropical seas. This distinction is based on thermoclines.

*Thermoclines* are defined as an area in the ocean where warm water on the surface is separated from deep, colder water. In temperate seas, thermoclines develop in the spring months as daylight hours increase and surface waters warm. Cold water sinks (as it is denser) to the depths and the warm water overlies it. In the summer months the thermocline sinks deeper and deeper as the sea warms, until it eventually breaks up in the autumn (see diagram). As the thermocline breaks down, windy and stormy weather promotes mixing of the sea, which churns up nutrients from the depths. These nutrients include nitrogen, phosphorus, silicate and ammonia, all of which are used by phytoplankton. With the onset of spring the phytoplankton ‘bloom’ in large numbers until the nutrient availability becomes limiting.

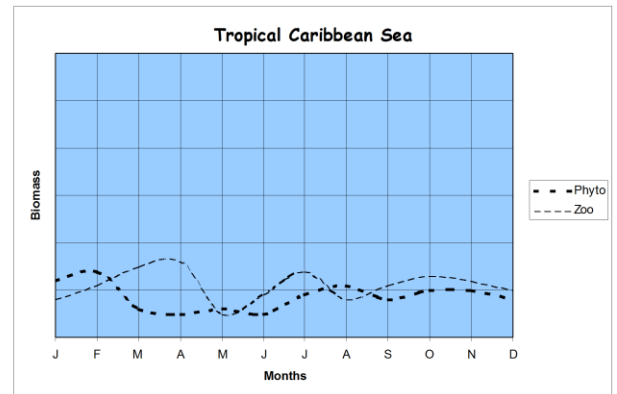


In the warm waters of the tropics, the seasons are less distinct and the weather is relatively constant throughout the year. This means that the thermocline is never broken up by winter storms and high winds. As a consequence there is a phytoplankton presence throughout the year, which is only limited by the abundance of nutrients.

These climatic patterns also promote distinct differences in the life cycles of marine copepods and other zooplankton, as many rely on the phytoplankton as their food source.



**Figure 1.** Monthly phytoplankton and zooplankton biomass in the temperate North Atlantic Ocean



**Figure 2.** Monthly phytoplankton and zooplankton biomass in the tropical Caribbean Sea

## Primary Production and Thermocline questions

1. How does primary production differ from photosynthesis?
2. Name two factors that limit primary production in the oceans.
3. Why is there such a marked difference in the biomass of temperate and tropical oceans?
4. Explain why there is a second phytoplankton 'bloom' in autumn in the temperate North Atlantic

