

Less biomass, smaller algae and a bit earlier: the plankton spring bloom in warming waters

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Climate warming will affect the phytoplankton spring bloom. Experiments conducted at IFM-GEOMAR indicate, that bloom biomass of phytoplankton will become less, average cell size will become smaller, the biological carbon pump will be weakened and the timing of the bloom will be advanced a bit in a warming climate.

Warming of our climate is now beyond doubt while the extent of warming and mankind's ability to reduce emissions of green-house gasses is still a matter of debate. Global warming also affects our planet's water bodies, as shown for example by a 1.1°C increase over 40 years in sea surface temperatures in the Helgoland Roads time series. The more pessimistic scenarios of the IPCC predict a warming of up to 6°C for the end of the century. Geographic distributions of species and seasonal activity patterns have already begun to shift, with potential consequences for the structure and function of ecosystems and ecosystem goods and services for mankind. Those consequences of regional species shifts and seasonal activity shifts were the focus of the DFG-funded priority program AQUASHIFT ("The impact of climate variability on aquatic ecosystems: Match and mismatch resulting from shifts in seasonality and distribution") which started in 2005 and was coordinated by Ulrich Sommer from the IFM-GEOMAR. Funding of AQUASHIFT is now approaching its termination and the last AQUASHIFT-experiments at IFM-GEOMAR

have been terminated in early 2010.

At IFM-GEOMAR, the focus of AQUASHIFT activities was put on the spring bloom of plankton, an annually repeated burst of phytoplankton productivity at the beginning of the growth season which is of utmost importance for the nutrition of the pelagic food web reaching from phytoplankton over protozoa and crustacean zooplankton to fish. From 2005 on, 8 to 12 mesocosms were installed in four temperature controlled rooms (Fig. 1). Seawater with its natural plankton content of plankton was maintained under 4 different temperature patterns: the present long-term average of late winter/early spring sea surface temperature pattern ("business as usual") and 2, 4 and 6°C above that (mild to strong warming scenarios). During the first years, the four temperature scenarios were tested under different light regimes mimicking cloudy to sunny winter-spring transitions. During the last two years the coldest and the warmest temperature scenarios were combined with the experimental factors light and density of overwintering zooplankton.

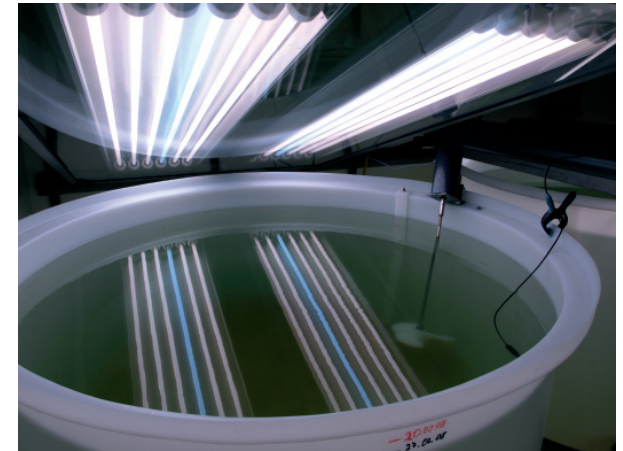


Figure 1: Mesocosm with opened light unit.

Despite considerable interannual variability, a number of patterns were consistent across all experiments and compare well to field observations:

1. The magnitude of the phytoplankton spring bloom (phytoplankton biomass) decreases with warming (Sommer and Lengfellner, 2008), while phytoplankton production rates did not show this trend in all experiments. The decreasing biomass could be explained by stronger grazing activities of the overwintering copepods, which was also supported by the observation that experimentally increasing the density of overwintering copepods has the same effect on phytoplankton as warming (Sommer and Lewandowska, 2011)
2. The mean body size of phytoplankton and to a lesser extent also of zooplankton decreased under warming conditions (Daufresne et al., 2009). The phytoplank-

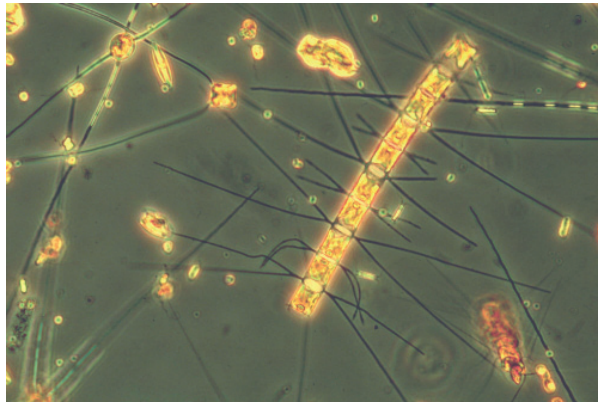


Figure 2a: Microscopic photograph of a spring bloom under business-as-usual temperature: high biomass dominated by medium sized diatoms, which are a good food for copepods.

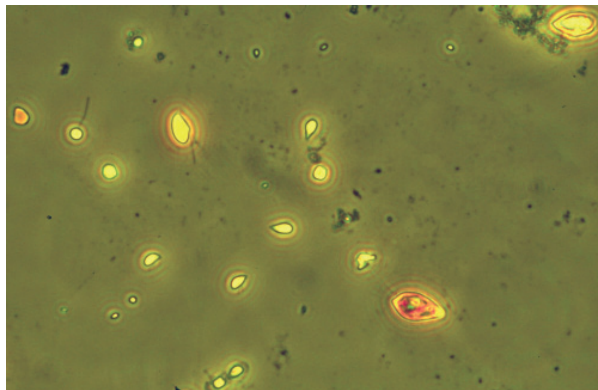


Figure 2b: Microscopic photograph of a spring bloom under 6°C warmed (+6°C) conditions: low biomass dominated by small flagellates, a poor food for copepods. dominance by medium sized diatoms, which are a good food for zooplankton.

ton size effect can be explained by preferential feeding of copepods on larger phytoplankton species and leaving the smaller ones (Fig. 2).

3. The higher respiration under warmer conditions led to a reduced amount of remaining POC available for downward export by sedimentation and thus to a potential weakening of the biological carbon pump (Wohler et al., 2009). This is a matter of serious concern, because it implies a positive feed back loop (“vicious cycle”) in the CO₂ effect on temperature: warmer oceans would be weakened in their ability to take up CO₂ from the atmosphere.
4. The onset of the spring bloom was almost independent of temperature but depended on passing a threshold daily light dose of ca. 1.3 E m⁻² d⁻¹ calculated for the mixed water layer (Sommer and Lengfellner, 2008). The peak of the phytoplankton spring bloom was slightly accelerated by warming (ca. 1 day earlier per °C), while release of nauplii from the eggs of overwintering copepods was strongly accelerated (ca. 9 d °C⁻¹). But only under the extreme combination of strong warming (+6°C) and low light (84% loss of sunlight by clouds and underwater shading) this led to a temporal mismatch between food supply and demand in the phytoplankton-copepod food chain: Nauplii starved before there was a sufficient supply of algal food (Sommer et al., 2007).

References

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