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40 years of Pelagic Time Series at the Biologische Anstalt Helgoland: Evaluation and New Concepts

Since Victor Hensen in 1887 sought to answer the question of what the fish production level was in the ocean and how this was related to organic matter via primary production,relatively little has changed. We still pose similar questions, albeit maybe in a less linear fashion: related more to food web structures and organism interactions.

Hensen applied agricultural paradigms to the study of fisheries and presented us with his concepts in the field of quantitative marine ecology. He introduced the term plankton to describe all living or dead matter floating in the water column („was im Wasser treibt, ob hoch, ob tief, ob todt oder lebendig“). Other scientists at the time such as Haeckel, Schütt, or Dohrn were more interested in the functional and organism diversity. Ernst Haeckel coined the term “ecology” from the metaphorical Greek base Oikos and logos and implemented his holistic ideas on the island of Helgoland (Figure 1).

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The work of such scientists and the emergence of an increased interest in marine biology worldwide facilitated the foundation of the “Königliche Biologische Anstalt” on Helgoland in 1892. Thus, an era of intensive investigations began in the German Bight/ North Sea. Even before the formal foundation of the Institute, from 1873 onwards salinity and temperature measurements of the water column were carried out on a daily basis. This can be seen as one of the historically most important long-term marine data bases. However, unlike the present, where our interests lie in determining the effects of global warming, the original interests resulting in this time series were based more on curiosity regarding natural history.

Although the long-term investigations were interrupted briefly by war and the evacuation of the island, the Helgoland time series were restarted and are still continuing. Since 1962 long-term monitoring of biological, chemical and physical parameters has continuously been carried out at Helgoland Roads. Samples are taken each working day for water temperature, salinity, nutrient concentration and phytoplankton biomass at the cable buoy (Kabeltonne) station (Figure 2).

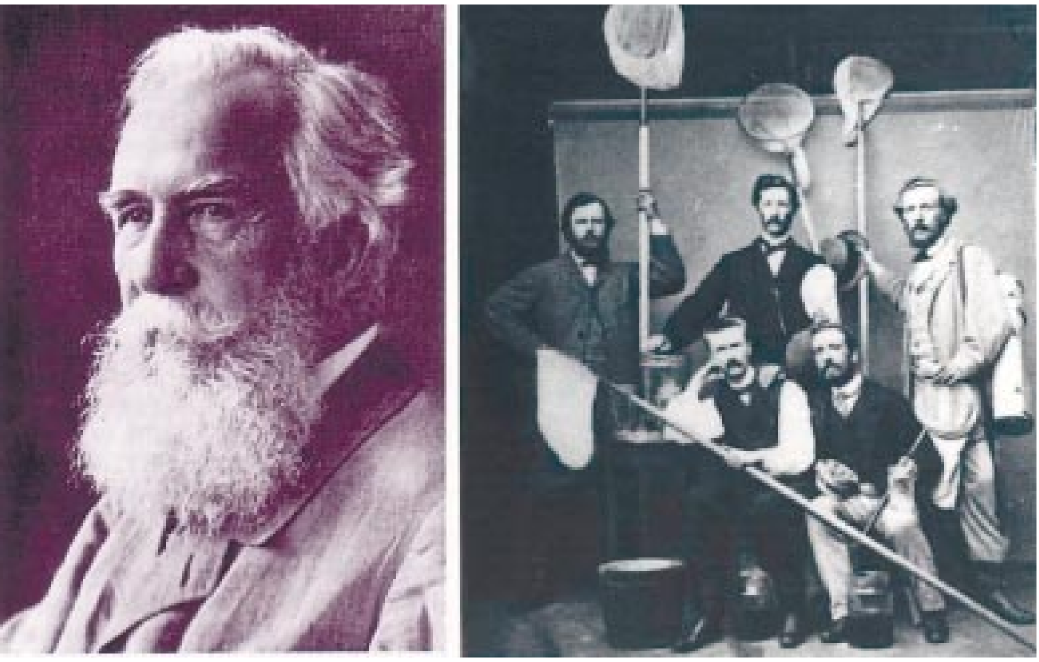

Figure 1: Ernst Haeckel left, and right with various colleagues and the then "newly invented" plankton nets in September 1885 on Helgoland (Archiv der Biologischen Anstalt Helgoland).

In the nineteen seventies the main worry in the German Bight was related to the problems associated with pollution and more specifically eutrophication. Indeed, the time series did show steady increases in nutrient loading at Helgoland which then levelled off in the eighties and nineties. However, a concurrent change in the phytoplankton biomass which was postulated has never been shown conclusively.

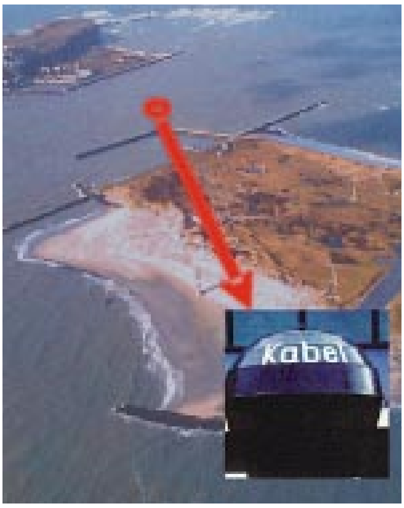

Figure 2: The cable buoy and the long-term sampling site at Helgoland.
Photo P. Mangelsdorf

In the meantime, the main interest in using the Helgoland data set has moved to global warming investigations.

The fingerprints of global warming on terrestrial animals and plants have been well documented. In contrast, for aquatic systems, we have little information on how the warming trends of the last 10–20 years have affected them. However, knowledge of how climate warming affects phytoplankton, in its important position at the base of the aquatic food chain, is vital. Hence, we analysed the temperature and phytoplankton data from Helgoland Roads time series, showing that a variable temperature trend over the past 125 years has culminated in a warming trend of 1.1°C since 1962. Very cold winters (with a minimum of -1°C or less) occurred about every 10 years up to 1944, but notably only once since 1960 (Figure 3).

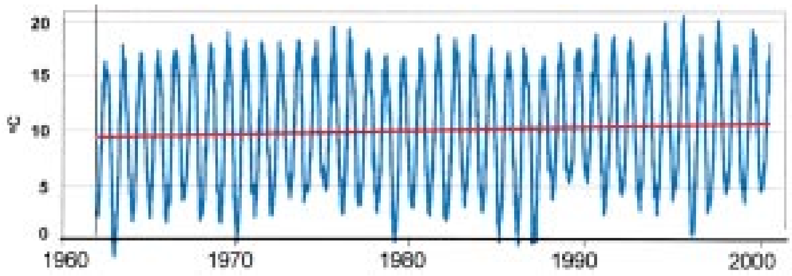

Figure 3: The water temperatures at Helgoland Roads 1962–2001

These data were combined with our phytoplankton counts to show a warming-related shift in phytoplankton succession thus making life cycle/food resource mismatches likely. As a result of this evidence we have at the BAH established a new project to investigate the interactions of pelagic organisms in more detail: the Helgoland Foodweb Project. With this we have established a new approach to dealing with marine food webs. A group of biologists including the disciplines of ecology, biochemistry, ichthyology, microbiology and physiology are working together to investigate the interactive role of microalgae, zooplankton, bacteria, larval fish in their chemical and, to a lesser degree, physical environment.

In this project we are following a three-pronged approach:

1. we monitor phytoplankton, zooplankton and physical parameters on a daily basis at Helgoland Roads and use this data for understanding trends and patterns.
2. we isolate key organisms from the water column during driving events such as algal blooms and in the laboratory try to understand interactions between organisms and to verify observations made in the field.
3. we try to re-apply the knowledge we have gained in the laboratory to further our understanding of our systems.

Ultimately we wish to understand our pelagic system better. We hope to be able to evaluate the patterns and occurrences of plankton. We need to know for example how our spring bloom of microalgae functions as this

Figure 4: Examples of automated measurement technology augmenting the Helgoland Roads Long Term data set: automated sensors, buoys and Ferryboxes.

drives much of our early year ecology. This means that certain finely tuned timings of organism co-occurrence and sequential occurrence will be disrupted.

Long term data sets were subject to a lot of criticism about 10–15 years ago. As a result, many were discontinued. The BAH managed to weather this storm and now the Helgoland Roads Time Series is one of the most used series. It is being augmented with new and more efficient technologies such as automated sensors, buoys and Ferryboxes (Figure 4). This introduction of new technologies and rigorous quality control of Long Term Data series is vital to providing a continuum and a useful heritage to the next generation. Only in such a manner can our global fragility be assessed and monitored successfully.