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GERMAN BIGHT ECOSYSTEM RESPONSES TO THE INVASION OF A SIPHONOPHORE

by

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Abstract

In July 1989 a population of *Muggiaea atlantica* invaded the German Bight from the West. The appearance of the population was monitored during a routine cruise. Subsequently the population abundance was monitored at the station Helgoland Roads in the centre of the German Bight. *Muggiaea atlantica*, new to the North Sea inhabited the waters of German Bight, reaching abundances up to 91 colonies * m^{-3}. As most plankton parameters have been monitored at Helgoland Roads for two decades, the impact of the siphonophore could be realized by comparing the 1989 population processes with the long-term mean. The siphonophore reduced the populations of small copepods to 10 % of their normal abundance. Consequently, the decrease in the grazing pressure on phytoplankton encouraged the growth of the algal populations. This again resulted in a reduction of phosphates, which usually increase via remineralization at this time of the year.

Introduction

Experiments commonly function on the conceptual basis that one parameter is artificially modified in order to realize the response of the other parts of a system to this change. Natural experiments sometimes are equally clear in their experimental design and thus render a closer understanding of the natural processes.

Experiments involving the introduction of new species usually have disastrous results and are thus unacceptable. If, however, the introduction of a new species happens in reality, the scientific means are commonly not flexible enough to investigate the event.

In 1989, the immigration, or invasion, of *Muggiaea atlantica* (Cunningham, 1892) into the German Bight occurred during the annual quasisynoptic survey aiming at a measure of the annual biocoenotic pattern formation. Thus, it was geographically documented, the station "Helgoland Roads" series serving for the documentation.

Material and methods

The plankton sampling with a 500-micron mesh CalCoFi net in the German Bight, also the measurements of other zooplankton-parameters of the pelagic ecosystem, have been described by Greve and Reiners (1988). Data on phytoplankton and phosphate were provided by Hickel (pers. comm.).

MABIS-computer graphics (Greve and Reiners, 1989) were used for the visualisation of data.

Results

During the cruise from July 10th to 14th 1989, a population of *Muggiaea atlantica* was measured in German Bight. The population reached abundances of up to 91 colonies * m^{-3}. The maximum abundance was measured at the westerly deep-water stations. The number of individuals decreased east- and southwards. The siphonophore colonies were accompanied by eudoxids, indicating the reproductive activity (Figure 1).

At the permanent plankton station "Helgoland Roads", the immigration, propagation and disappearance from the plankton of *Muggiaea atlantica* was monitored (Figure 2). The abundance of *Muggiaca atlantica* reached a level of 125 siphonophore colonies in August. It then decreased until the end of November.

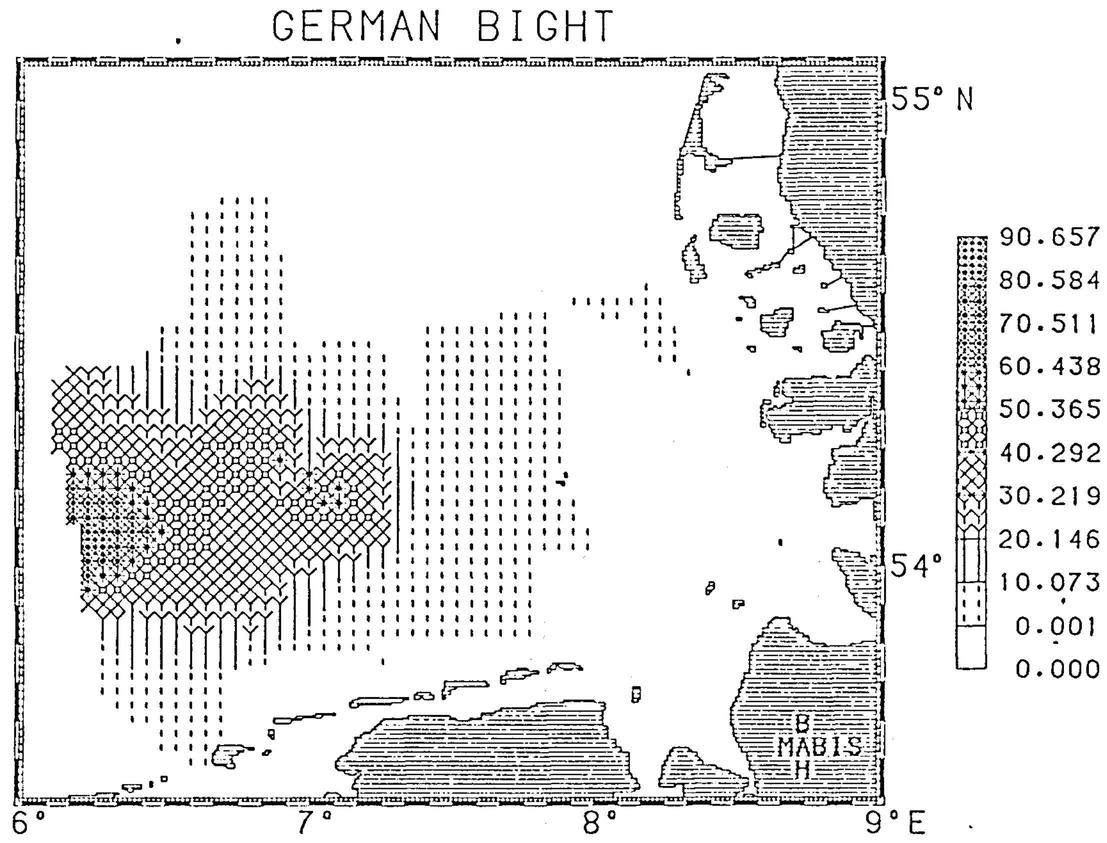

Figure 1: The distribution of *Muggiaea atlantica* when detected in the German Bight in July 1989 (individuals * m^{-3})

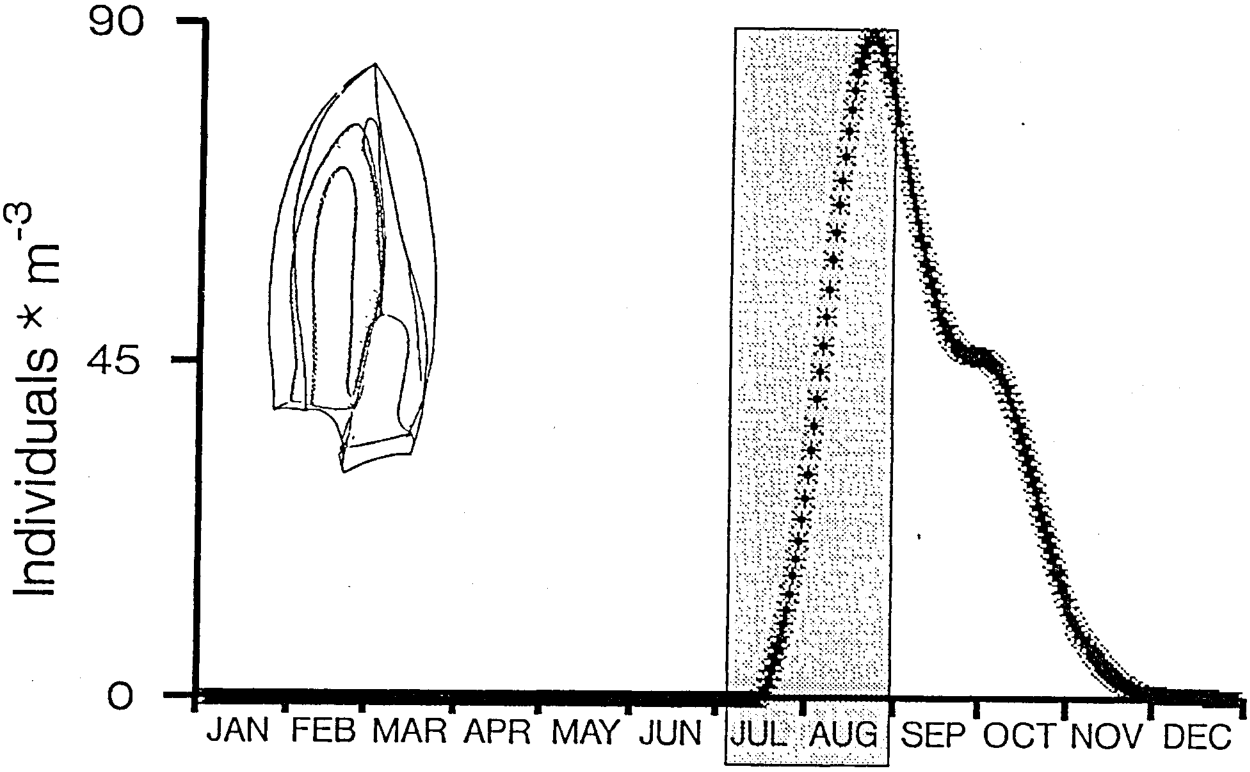

Figure 2: Abundance dynamics of *Muggiaea atlantica* in the German Bight, measured at the station "Helgoland Roads" (shaded area, see figure 3)

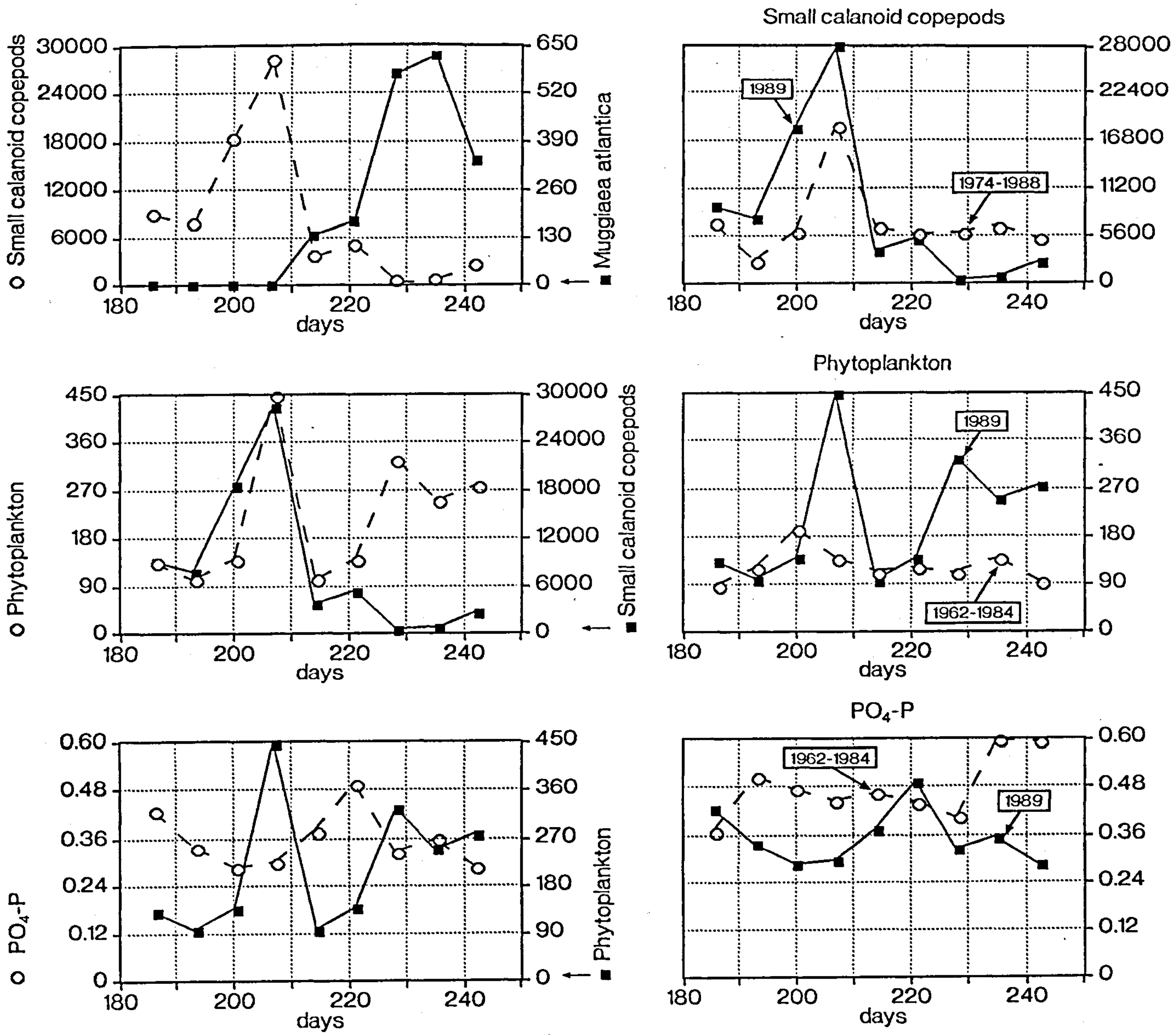

Figure 3: The July-August development of *Muggiaea atlantica* (individuals * m^{-3}), small calanoid copepods (individuals * m^{-3}), phytoplankton (µg C * L^{-1}), phosphate (µmol * L^{-1}) in 1989 and as a mean development of the years 1974 to 1988 as measured in the plankton time-series "Helgoland Roads". The zooplankton measurements were derived from an independent sampling programme, producing higher population estimates than the standard CalCoFi-net samples (Figure 1, 2)

Discussion

At the Biologische Anstalt Helgoland, plankton investigations have been carried out since the last century. From these investigations, it is known that siphonophores do not occur in German Bight (Totton and Fraser, 1955). On the other hand, *Muggiaea atlantica* is a regular member of the Lusitanian plankton biocoenoses in the western part of the English Channel (Russell, 1934). This makes the 1989 siphonophore invasion a centennial event, which had implications

- on the biocoenotic processes within the plankton of the German Bight in 1989,
- on the understanding of the regulatory processes functioning within the ecosystem,
- on the constancy of biocoenotic regimes in the southern North Sea, especially with respect to possible shifts in the climatic and succeeding advective pattern of the North Atlantic.

(1) Modifications in the plankton process pattern of German Bight

From Purcell's (1982) investigations it is known that *Muggiaea atlantica* is a voracious predator on copepods: a population of 100 colonies * m^{-3} require up to 2000 food items daily. As the mean copepod-abundance at Helgoland Roads is given as 8000 ind. * m^{-3} (Greve and Reiners, 1988), the effect of a population of up to 125 colonies of the siphonophore is easily estimated.

In 1989, the annual population dynamics pattern of copepods varied significantly from the long-term mean (Figure 3). The level of copepods only maintained 10 % of the usual value.

This induced a closer look into the secondary effects of the siphonophore invasion. At the time of the depressed copepod abundance the phytoplankton differed from the long-term mean, indicating the effect of a reduced grazing control (Figure 3). One step further the phytoplankton bloom obviously affected the autumnal-phosphate-remineralization, which was lower than normal.

These results are good evidence for the functioning of the ecosystem though they are not final proof of a dominant causal relationship.

The use of a mean population process representation would require the proof of the interannual synchronization of these processes.

(2) Improvements in the understanding of the regulatory processes

The "*Muggiaea atlantica*" event, seen as an experiment, shows that the pelagic ecosystem in summer is modified by an excess predator control beyond the chaetognaths and others that normally reduce the number of grazers to a lesser degree. This disturbance of the equilibrium of the ecosystem encourages a phytoplankton bloom in autumn, as nutrient and light conditions are not limiting. This backs the predator control theory discussed for the early summer period in this conference (Greve, 1993)

(3) Expected modifications of the biocoenotic constancy

Muggiaea atlantica entered the German Bight in the form of an accelerating plankton wave, as the growth conditions favouring the nutritionally sympatric species of *Pleurobrachia pileus* equally support the siphonophore. Is has been proven that *Muggiaea atlantica* can live in the German Bight biocoenosis in summer. It has not survived the winter conditions and no further comparable abundances have been registered in the following years. The reasons for its appearance and disappearance are not known but the ecological potential of the population must be acknowledged, especially in the light of the predicted climatic changes (Dickinson R.E., 1986). We have to face the possibility that *Muggiaea atlantica* replaces *Pleurobrachia pileus, the* dominant carnivore. Then, the control by *Beroe gracilis* would no longer support the biocoenotic equilibrium. Summer phytoplankton blooms and deep water oxygen depletions would be the consequence. But these are guesses only, as the pelagic ecosystem has not yet been fully analysed.

Outlook

The occurrence of novel species in biocoenoses, their population success and modification of the complete ecosystem regime have to be anticipated as a response to changes in the boundary conditions (e.g. global warming). The 1989 *Muggiaea atlantica* provides an excellent example of such a limited event. At the same time, it helps us understand the ecological potential of the siphonophore as well as the regular biocoenotic feed-back systems of the German Bight.

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