

PB1) First report of blooms of *Gonyaulax polygramma* (Gonyaulacales, Dinophyceae) in the Yeosu waters of the South Sea of Korea

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1. Abstract

The aim of this study was to determine the first outbreaks of nontoxic *Gonyaulax polygramma* Stein in Yeosu waters in place of harmful *Cochlodinium polykrikoides* Margalef, which has occurred annually in the same coastal region since 1995. The observation of cellular arrangement and structure by electron microscopy showed that *G. polygramma* isolated from Yeosu waters had a few spines connecting with membranes and prominent longitudinal ridges on the cell surface, with a circular displacement 1.5 times their cell width. Furthermore, the location of the nucleus was posterior of large oval formation according to electron microscopy. On 6 August, 2004, the first bloom of *G. polygramma* occurred, the date of its disappearance was with a maximum cell density of 8,000 cells ml⁻¹ on 21 August, 2004. During the period of this study, the horizontal distribution of sea water temperature and salinity showed a strong coastal front, whereas the front of DIN (Dissolved Inorganic Nitrogen) was significantly different between the occurrence and disappearance of *G. polygramma* blooms. These results suggested that the process of the breakdown of stratification by wind and a low level of inorganic nitrogen play important roles in the rapid growth of *G. polygramma*, which is associated with a greater robustness in growth against DIN than that of *C. polykrikoides* in nature.

2. Introduction

Interestingly, blooms of *Gonyaulax polygramma* Stein, instead of *C. polykrikoides*, in early August, 2004, first occurred in the coastal waters of Yeosu, which occurrence was the first for Korea as well. It is known that this species is an armored, marine planktonic dinoflagellate, and is of wide geographic distribution, in cold temperate to even tropical waters. In addition, this species is regarded as nontoxic fish kills, although fish and shellfish kills due to oxygen depletion in relation to cell mineralization have

been reported. So far, blooms of *G. polygramma* have been reported in several countries (<http://www.nmnh.si.edu/botany/projects/dinoflage/taxa>). The present study aimed to provide clues as to why the first blooms arose in Yeosu, based on an examination of fluctuations in water quality, nutrients, and weather conditions.

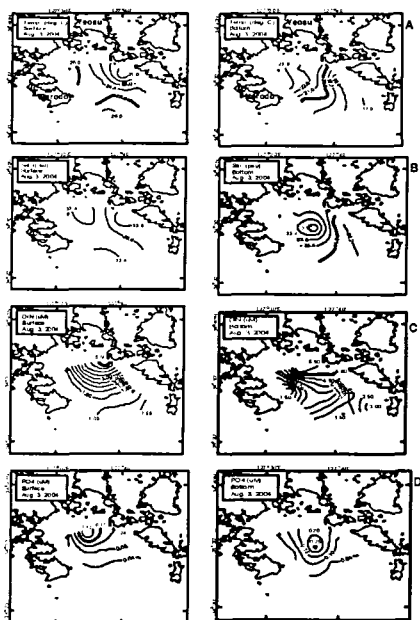
3. Materials and Methods

For the scanning electron microscope (SEM) observation, the field samples were fixed with 2.5% glutaraldehyde and filtered through a 5 µm pore size polycarbonate membrane filter under no pressure. The filter was dehydrated by a graded ethanol series to 100% ethanol. The samples on the filter paper were air dried, transferred to aluminum stub to be coated with deionized gold and then examined under a HITACHI SEM (S-3000N, Japan prod.). For the transmission electron microscope (TEM), the fixed samples were washed with 0.1M phosphate buffer (pH 7.2) and dehydrated according to SEM. The filter was placed overnight into two changes of propylene oxide and in a 1:1 mixture of Epon resin and propylene oxide for 8 h in fresh Epon resin. Sections were cut with a glass knife approaching the particles on the membrane filter parallel to the membrane surface. The ultra-thin sections (60–90 nm) were cut with a diamond knife, stained with uranyl acetate followed by lead citrate and observed at 80 kV with JEOL TEM (JEM 1200 EX-II, Japan prod.).

4. Results and Discussion

A high DIN concentration of $5.0 \mu\text{mol l}^{-1}$ was found in both surface and bottom waters, whereas a high phosphorus concentration was not. While water temperature and salinity at the surface and the bottom during the period of *G. polygramma* blooming were similar to characteristic magnitudes shown on 3 August, 2004, strong horizontal distributions of DIN and phosphorus were not found. Although the abundance of *G. polygramma* sharply declined, strong fronts of water temperature, salinity, DIN, and phosphorus were shown on 21 August, 2004. In summer, nutrient concentrations at the surface of the ocean are usually insufficient to support the production of phytoplankton assemblages, which are associated with stratified and nutrient-depleted conditions. On the basis of hydrographic properties, the Yeosu waters are influenced by different minor systems (the Kuroshio current; the Tsushima warm current; and the Korean coastal waters), which can often cause changes in water temperature and contribute to an abundance of nutrients. In this sense, the coastal regions of the South Sea of Korea are the most vulnerable to the influence of offshore water currents among the other waters in Korea. Consequently, the establishment of a strong front of high concentrations of DIN in the Yeosu waters on 3 August, 2004 are associated with a greater intrusion

of the nutrient-enriched offshore current than other nutrient sources including upwelling, freshwater input, and rainfall systems. According to weather conditions (data not shown), there was a shortage of precipitation during the period of this study, indicating that rainfall was not sufficient to supply nutrients to surface waters. However, among weather conditions, wind directly effected the demographic and spatial distribution of high concentrations of DIN after on 3 August, 2004. It is thought that a strong front of high concentrations of DIN on 21 August, 2004 was associated with the influx from enriched offshore water. In summer, freshwater input from rivers reduces surface water temperature and salinities over the study area. Choi has suggested that the influx of low-salinity water induces the promotion of blooms caused by *C. polykrikoides* in the Yeosu region. However, this study showed that freshwater did not play an important role in the progressive growth of *G. polygramma*. Overall, the combined results of the breakdown of the stratification of DIN by wind and a low concentration of organic nitrogen provide support for the outbreaks of *G. polygramma* in the Yeosu waters.



References

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