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研究论文

粤东柘林湾中肋骨条藻（*Skeletonema costatum*）种群生态学

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摘要 于2000年5月~2004年12月对粤东大规模养殖区柘林湾的赤潮藻中肋骨条藻（*Skeletonema costatum*）种群的时空分布进行了长达5a的调查。结果表明，中肋骨条藻种群密度的周年变动模式基本为双峰型，平面分布没有显著的空间差异。调查期间，中肋骨条藻种群密度的站位实测值为0~1.4×10^7 cells/dm^3，总均值为3.3×10^5 cells/dm^3，占浮游植物总细胞数的67.1%，为调查海区第1优势种。在总共1045份样品中，有中肋骨条藻出现的样品数为1020份。其中，种群密度大于10^6 cells/dm3的样品有65份，大于10^7 cells/dm^3则有4份。以大于10^6 cells/dm^3为中肋骨条藻的赤潮密度标准，在调查期间至少于2000年、2003年发生4次赤潮。运用灰关联理论对中肋骨条藻种群密度与13个环境因子的关系进行排序分析发现，水温、pH值和浮游动物是影响柘林湾中肋骨条藻种群时空分布的关键因子。水温还与中肋骨条藻种群密度的对数值具极显著意义的线性关系，而达到赤潮密度的样品均落在24.5~32.0℃区间，即每年的5~9月份高温季节。由于柘林湾浮游动物的年高峰期也出现在高温季节，说明浮游动物摄食压力的存在可能是柘林湾中肋骨条藻赤潮发生的重要抑制因子。2004年调查海区中肋骨条藻种群密度和在浮游植物群落中的优势度骤然降低，可能与水体营养盐结构和Fe含量的变化有关。因此，长期调查与监测对于研究海湾生态学和赤潮发生机制是极为重要的。

关键词 柘林湾 _ 中肋骨条藻 _ 种群动力学 _ 赤潮

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Population dynamics of *Skeletonema costatum* in Zhelin Bay of Eastern Guangdong

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Abstract Zhelin Bay is characterized by intensive aquaculture along the coast of Southeast China, with approximately half of the water area occupied by either cultured oysters or caged-fish farms. As one of the most important bays for large-scale mariculture in Guangdong Province, aquaculture production in Zhelin Bay has made significant contributions to the local economy. However, development of intensified caged-fish farms during the last decade has accelerated eutrophication process of the bay, and massive fish kills due to harmful algal blooms such as Phaeocystis pouchetii were reported in 1997 and 1999. Diatom blooms such as *Skeletonema costatum* and *Thalassiosira diporocyclus have* also been reported in the recent years. Since May 2000, our research group has initiated an ecological investigation around Zhelin Bay, where samples were collected monthly or quarterly for analysis of phytoplankton, zooplankton, microorganism, water temperature, salinity, nutrients and other environmental parameters. In the present study, we described the population dynamics of *S. costatum* in 9 sampling stations from May 2000 to November 2004.

Samples were collected at high tide (1.5 h) weekly (March to November) or biweekly (December to February) at eight stations (except for S_3) between May 2000 and June 2001, and monthly at all nine stations between July 2001 and December 2003, and quarterly at all stations in 200

4. For quantitative phytoplankton analysis, one liter of water samples were collected with 5L HQM-1 sampling bottles 0.5 m under the surface and 0.5 m above the bottom at each station. Immediately after collection, the water samples were fixed with Lugol's iodine solution with a final concentration of 15‰. Water samples were then transferred to graduated glass cylinders and concentrated to 30-100 ml gradually through sedimentation over a period of 3 days. Species identification and density counting was performed with an inverted microscope (Zeiss Axiovert25, magnification 400) using a 1ml Sedgewick-Rafte counting frame, and a minimum of 400 cells were counted for each sample. Water temperature, salinity, turbidity, pH value, dissolved oxygen (DO) and water depth were determined in *situ* with a portable instrument for water quality analysis (YSI6600-02, USA). Additional water samples (250ml) were collected (filtered in situ) for nutrient and chlorophyll a analysis, and they were measured with an injection water quality analyzer (SKALAR, Netherlands) and a spectrophotometer (UV-2501PC, Japan) respectively.

A total of 1045 phytoplankton samples were collected in the present study, and among which S. costatum was found to be present in 1020 samples, with its population density ranged from 0 to 1.4×10^7 cells/dm3 and an overall average of 3.3×10^5 cells/dm^3. In relation to the algal bloom density, 65 samples were found with *S. costatum* density larger than 10^6 cells/dm^3 and 4 samples were larger than 10^7 cells/dm^3. The percentage of *S. costatum* accounting for the total phytoplankton ranged from 0% to 99% with an overall average of 67.1％.

Spatially, total averages of *S. costatum* density at each station ranged from 1.9×10^5 to 6.5×10^5 cells/dm3, and there were no significant differences among the sampling stations. Temporally, monthly averages of *S. costatum* density in the whole bay ranged from 0.03×10^5 to 67.42×10^5 cells/dm^3, and was characterized by a typical bimodal annual pattern with the first peak observed in May or July and second peak in August or September. Percent monthly averages of *S. costatum* accounting for the total phytoplankton density ranged from 6.5% to 94.5%.

The grey incidence-regression analysis ($\rho=0.1$) placed the importance (with the decreasing order) of effect of 13 environmental factors on *S. costatum* population dynamics as follows: water temperature > pH > zooplankton > salinity > DO > NH_4-N > DIP > DIN > NO_2-N > Turbidity > NO_3-N > Fe > SiO_3-Si. Thus, water temperature appeared to be the most important factor on *S. costatum* population dynamics. In addition, significant linear correlation was found between logarithmic values of *S. costatum* density and water temperature. Samples with *S. costatum* at high density (>10^6 cells/dm3) showed a range of water temperature of 24.5~32.0℃, corresponding to the warm seasons (May to September). Since the peak of zooplankton population also occurred in warm seasons, it seems reasonable to deduce that zooplankton placed a predation pressure on S. costatum population. The population density of *S. costatum* and its dominance in total phytoplankton were found to decrease rapidly in 2004, which were suspected to relate to the variation of nutrients structure and Fe content. Results in the present study indicated that long-term investigation are necessary for a comprehensive evaluation of estuary ecology, and also will facilitate the understanding of the mechanism of algal bloom formation.

Key words Zhelin Bay _ *Skeletonema* *costatum* _ population dynamics _ algal bloom

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