Chinese Journal of Oceanology and Limnology
Vol.18, No.1, P.74 - 79, 2000

PHYTOPLANKTON DISTRIBUTION AND COMMUNITY STRUCTURE IN THE EAST CHINA SEA(ECS) CONTINENTAL SHELF*

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Received Jan. 5, 1999; revision accepted Aug. 12, 1999

Abstract This paper deals with the distribution and community structure of phytoplankton revealed by data obtained in a cruise in April and one in Oct. - Nov., 1994. Among 140 species of phytoplankton (including varieties and formas) identified, 104 species belonged to Bacillariophyta and 32 species belonged to Pyrrhophyta. In April, the biomass of phytoplankton was $0.09 \times 10^4 - 465 \times 10^6$ cells/m^3, and the dense area was located in the Zhejiang coastal zone and the estuary of the Changjiang River; the density of the studied area's west part was always higher than that of the east part. In October and November, the phytoplankton biomass was $0.42 \times 10^4 - 289.9 \times 10^4$ cells/m^3, and the dense area was located in the upwelling zone near the Zhejiang coast. In spring and autumn, biomass was very low in the outer part of the East China Sea continental shelf area, where phytoplankton was classifiable into two communities based on the phytoplankton's ecological characteristics and environmental parameters such as water temperature and salinity, i.e. neritic community environment characterized by warm temperature and low salinity and pelagic community environment characterized by high temperature and high salinity.

Key words: phytoplankton, ecology, community, East China Sea

INTRODUCTION

Phytoplakton has a key role in the marine ecosystem as the basic part in the food chain, which is important information for assessing productivity potential and fishery resources. Phytoplankton also has an important role in the carbon biogeochemical cycle, because it can absorb a large quantity of carbon dioxide during photosynthesis and transfer organic matter into the ecological cycle. Because of the rich species composition and dense biomass of phytoplankton and other feed organisms in the excellent natural environment of the East China Sea (ECS) area investigated, some important fishing grounds are located here (Jin et al.,1965). Previous ECS phytoplankton investigations (Our institute's 1958 - 1959 national comprehensive investigation in the ECS area west to 124°E, summer of 1976 phytoplankton ecology investigation in the ECS continental shelf, 1985 - 1986 phytoplankton ecology investigation in the Changjiang River estuary; spring of 1976 investigation by Xu et al. (1990) and Lu et al. (1990) on phytoplankton biomass and species composition in the Kuroshio area) did not yield fully complete information on the ecological state of ECS phytoplankton, so, to fill in the gaps, we carried out a cruise in April, and one in Nov. - Oct., 1994, to investigate phytoplankton ecology in the ECS area from 121°00'E to 129°00'E, 26°00'N to 32°00'N (Fig.1). Phytoplankton sampling nets (37 cm diameter, 280 cm length, 64 mesh) were used to collect sur-

* Contribution No. 3701 from the Institute of Oceanology, Chinese Academy of Sciences.
Project 49636210 supported by NSFC.

face to bottom samples for preservation for subsequent counting of cell number under microscope.

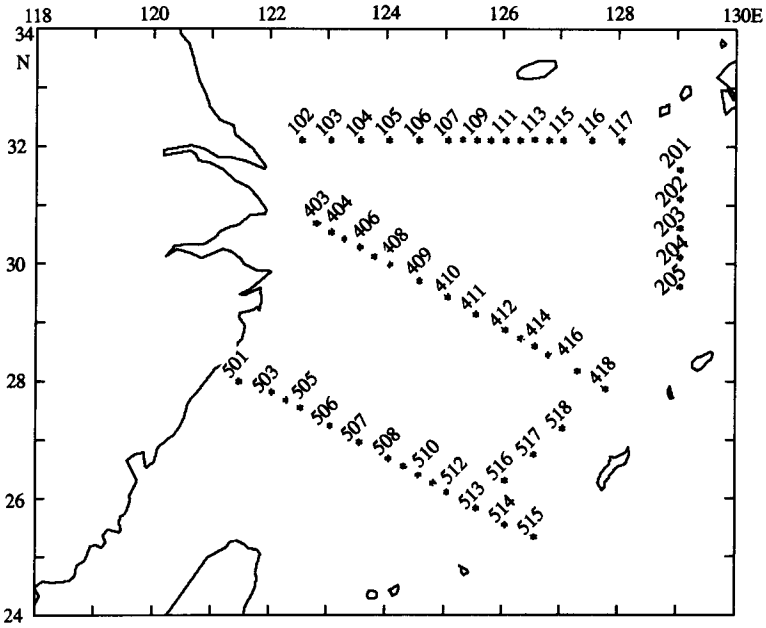

Fig.1 Location of sampling stations

HORIZONTAL DISTRIBUTION AND SEASONAL FLUCTUATION OF PHYTOPLANKTON BIOMASS

Horizontal distribution

Phytoplankton density in the ECS continental shelf area was $0.09 \times 10^4 - 465.47 \times 10^4$ cells/m^3, average of 46.34×10^4 cells/m^3, in April, 1994. One dense area was located in the Zhejiang coastal area south of Hangzhou Gulf. In the middle of this area, phytoplankton density exceeded 4.00×10^6 cells/m^3; *Chaetoceros curvisetum*, *Ch. compressus*, *Nitzschia pungens* were dominant species. For instance, *Ch. curvisetum* reached 1.96×10^6 cells/m^3 in Station 503, representing 42 percent of the total biomass. There was one small dense area centred at Station 102 near the north part of the Changjiang River estuary, where phytoplankton density reached 4.33×10^6 cells/m^3 and *Skeletonema costatum* was the dominant species, accounting for 99.7% of the total biomass. There was another high biomass area around Station 406, where *Ch. deblis* was the dominant species, reaching to 2.48×10^6 cells/m^3 (94.3% of the total biomass). The density near shore was higher than that offshore, and decreased gradually eastward (Fig.2).

In October and November, the phytoplankton density fluctuated from 0.42×10^4 cells/m^3 to 289.9×10^4 cells/m^3, averaging 56.37×10^4 cells/m^3; a large dense area was located from the Zhejiang coast to the middle of the investigation area, and centered near Stations 506 and 507 in the Zhejiang outer sea area where the phytoplankton density exceeded 2.89×10^6 cells/m^3, and *Thalassionema nitzschioide* was the dominant species, and accounted for 31.8% and 41.4% respectively

of each station's total biomass. Other large biomass species were *Skeletonema costatum*, *Ch. compressus*, *Ch. lorenzianus* and *Rhizosolenia styliformis*. The density near the Changjiang River estuary and Hangzhou Gulf was low, almost 10×10^4 cells/m^3. Similar to the investigation in April, the density in the outer area was also low, lower than 5×10^4 cells/m^3. The growth of phytoplankton in this sea area was inhibited by the low phosphate content of the Kuroshio water.

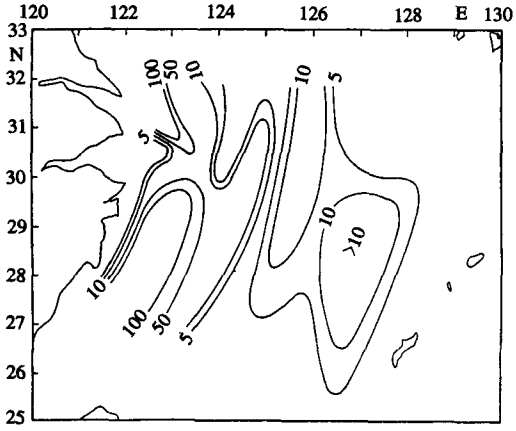

Fig.2 Distribution of phytoplankton ($\times 10^4$ cells/m^3) in April, 1994

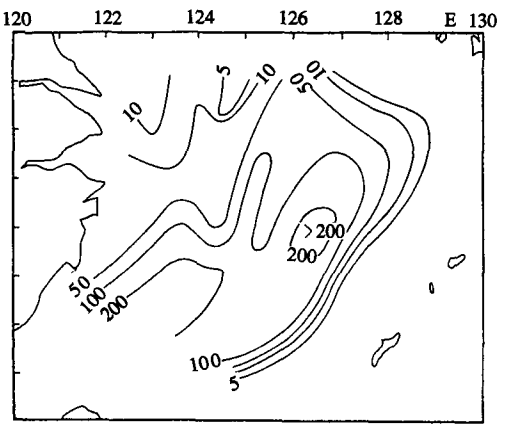

Fig.3 Distribution of phytolankton ($\times 10^4$ cells/m^3) in Oct. – Nov., 1994

Seasonal fluctuation

Data from these two cruises showed that phytoplankton biomass was dense in autumn, and distributed evenly; that in spring, density in most areas was lower than 5×10^5 cells/m^3, but that in two areas exceeded 4×10^6 cells/m^3. In April and October – November, the study area had high density of phytoplankton and other marine organisms feeding on the abundant supply of rich nutrients upwelled from the sea bottom. A famous fishing ground is located in this area because its abundant resources of nutrients and fish feed organisms attract fish to come here.

SPECIES COMPOSITION OF PHYTOPLANKTON AND DOMINANT SPECIES DISTRIBUTION

Species composition

Of 41 families and 140 species (including varieties and formas) identified in these two cruises, 32 families and 104 species belonged to Bacillariophyceae; 6 families and 32 species belonged to Pyrrhophyta; 2 families and 2 species belonged to Cyanophyta; 1 family and 1 species belonged to Chrysophyceae. Based on phytoplankton ecological characteristics, warm water species reached 56, accounting for 40.0%. Dominant species were *Ch. laevis*, *Ch. dibversus*, *Ch. denticulatus*, *Rh. clevei*, *Rh. robusta*, *Climacodium frauenfeldianum*, *Pyrocystis hamulus*, *P. robusta*, *Ceratium deflexum*, *C. gravidum*, *C. praelongum*, *Ornithocercus steinii*. Of 32 species of dinoflagellates, 25 were warm water species, accounting for 78%. Eurytopic species reached 70, accounting for

more than 50% of total species, among which diatom species reached 63, accounting for 91%. The common diatom species were *Skeletonema costatum*, *Coscinodiscus asteromphalis*, *Cos. radiatus*, *Rh. stolterforthii*, *Rh. setigera*, *Ch. affinis*, *Ch. compressus*, *Ch curvisetus*, *Ditylum brightwell*, *Eucampia zoodiacus*, *Thalassiothrix frauenfeldii*, and *Nitzschia pungens*. *Eurytopic dinoflagellate species* were *Ceratium tripos* and *C. fusus*.

Main species of phytoplankton in the ECS continental shelf

Skeletonema costatum This is a low salinity neritic species spread widely near the Changjiang River estuary. Its rapid reproduction can induce red tide. The dense area (4.3×10^5 cells/m^3) located in Station 102, accounted for 99.7% of total biomass in April. In November, the dense area (5.09×10^5 cells/m^3) moved to Station 505.

Chaetoceros affinis This is a low temperature and salinity neritic species occurring mainly in October – November when it was the dominant species. The dense area located in Stations 412 (2.78×10^5 cells/m^3) and 414 (59×10^5 cells/m^3). In April, its density was low, at most 1.6×10^4 cells/m^3.

Thalassionema nitzshiodes This is an eurythermic and euryhaline species spread widely in both spring and autumn. In April, the dense area located in Station 505 (1.49×10^5 cells/m^3). In November, the dense area located near the Zhejiang coastal area. Density reached 9.2×10^5 cells/m^3 in Station 505 and 1.2×10^5 cells/m^3 in Station 506. The biomass in Station 505 was 10 times that in April.

Nitzschia pungens This is a low salinity neritic species occurring mainly in April when it was the dominant species. The cell number of a dense area located in Station 503 reached 1.53×10^5 cells/m^3. The biomass of another dense area located at the central part of the investigation area reached 1.93×10^5 cells/m^3. In autumn, this species spread widely, but at density lower than 10^4 cells/m^3.

Chaetoceros compressus This is a low salinity neritic species occurring mainly in Station 503 where density reached 7.62×10^5 cells/m^3 in April. In November the dense area moved to Station 506 (2.18×10^5 cells/m^3) and 508 (3.3×10^5 cells/m^3).

Chaetoceros deblis This is a low temperature and salinity neritic species, occurring mainly in spring. Its dense area located in Station 406 near the Changjiang River estuary. Its biomass in Station 406 (2.48×10^5 cells/m^3) accounted for 94% of the total biomass. The phytoplankton density in Station 111 in the north of the investigation area reached 3.58×10^5 cells/m^3, accounting for 90% of the total biomass in this station. *Chaetoceros debli* was one of the most important dominant species in the investigated area in April.

Chaetoceros messanensis This is a tropic and pelagic species tolerant to high temperature and salinity. In April, this species occurred mainly in Stations 414 and 416, where the water temperature exceeded 20℃. The highest density (1.1×10^4 cells/m^3) located in Station 416. In October – November, this species spread widely at high density where the water temperature exceeded 23℃; the highest density in Station 414 reached 2.2×10^5 cells/m^3.

ANALYSIS ON PHYTOPLANKTON COMMUNITY IN THE ECS CONTINENTAL SHELF

Classification of community

The phytoplankton community in the ECS continental shelf area is classified into neritic com-

munity and pelagic community.

Neritic community The biotype of this community was affected mainly by inflow of freshwater from rivers and of Yellow Sea Water Mass. Surface salinity was lower than 33 (surface temperature was 12 – 20℃) in April, and 19 – 23 in October – November. The dominant species were wide temperature, low salinity, neritic types such as *Chaetoceros affinis*, *Ch. debilis*, *Ch. compressus*, *Ch. laciniosus*, *Nitzschia pungens*. *Dictylum brightwell*, *Coscinodiscus* spp. were also rich in biomass. *Skeletonema costatum* and *Noctiluca scintillans* were sometimes so dense in the neritic zone that they could form red tide. Other species in this community were *Ch. denticulatus*, *Ch. messanensis*, *Rh. clevei*, *Rh. robusta*, *Ceratium gibberum*. *Thalassionema nitzschiodes* was also dense, more in autumn than in spring, and sometimes could become dominant species in a limited area.

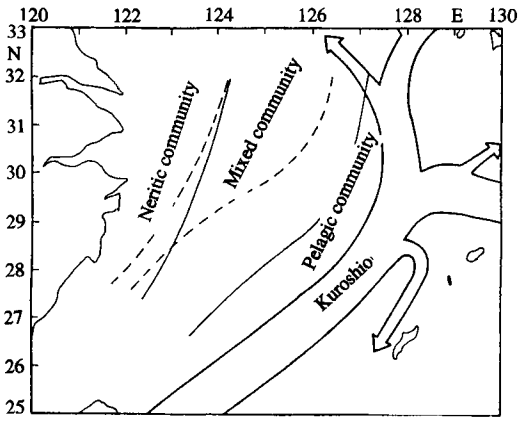

Fig.4 The distribution of different phytoplankton community in the ECS continental shelf area
————: 1994.4, ----: 1994.10 – 11
The water current model of Kuroshio based on Guan (1986)

Pelagic community The biotype of this community was affected mainly by the Taiwan Warm Current and the Kuroshio; water temperature (surface temperature was higher than 20℃ in April, and 23℃ in October – November) and salinity (> 33 psu at surface) were high but stable in this area. The tropic and pelagic species such as *Pyrocystis fusiformis*, *Ceratium contortum* var saltand, *C. gravidum*, *Ornithocercus steinii etc.* dominating here can be used as indicator organisms for the Kuroshio. Temperate species belonging to diatoms were *Ch. laevis*, *Ch. diversus*, *Rh. robusta*, *Climacodium frauenfeldianum*, *Ditylum sol*, and *Thalassiothrix longissima*. The tropic and pelagic species were *Ch. messanensis*, *Ch. coarctatus*.

There was a mixed neritic and pelagic community area (also called transient area). Guo and Zhang (1982) classified this area as a "central ECS mixed community" of psychrophilic and euryhaline species. But Chen (1980) argued that an independent community cannot be formed in this area.

Seasonal variation of community

Community area variation The Taiwan warm current and other factors changed greatly the community area. In autumn, the ECS shelf area was affected mainly by the Taiwan Warm Current and the Kuroshio; the > 34 salinity area widened more westward than that in April, when the center reached 124°E and surface water temperature exceeded 22℃; the pelagic community widened while the neritic community shrank in the west.

Variation in community structure The community structure was analyzed by using the biodiversity index (d) below:

$$d = (S - 1)/\log_2 N$$

where: S is the total number of phytoplankton species; N is the total number of phytoplankton.

In April, the biodiversity index d exceeded 2 for the pelagic community, but was lower than 2 for the neritic community. In October – November, many temperate species such as *Chaetoceros messanensis*, *Ch. denticulatus*, *Rh. clevei*, *Ceratium gibberum* intruded into the neritic community affected by the Taiwan Warm Current and the Kuroshio. The biodiversity index d was >2 in most stations, and there was no obvious difference between these communities.

The neritic community structure changed greatly. The dominant species were *Chaetoceros deblis*, *Ch. compressus*, *Ch. curvisetus*, *Nitzschia pungens* in April, and *Ch. affinis*, *Ch. laciniosus*, *Thalassionema nitzschiodes*, *Ch. lorenzianus* and *Rh. styliformis* in October – November. Temperate species in autumn were more than those in spring, but they were both small in individual number, and distributed mainly in the east part of this area.

The pelagic community structure was stable and without dominant species. In autumn, some euryhaline and eurythermic species such as *Chaetoceros messanensis*, *Thalassiothrix longissima* and *eurytopic* species such as *Thalassionema nitzschiodes*, and temperate, neritic species such as *Ch. compressus*, *Ch. denticulatus*, *Ch. affinis* spread densely (10^5 cells/m^3) in the west part of this area.

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