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Biotic communities of the marine ecosystem in Meizhou Bay

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Abstract—The current situation of biotic communities in Meizhou Bay is presented in this paper. The species composition, seasonal variation, and distribution of phytoplankton, zooplankton, red tide organisms, fishes, and benthos in Meizhou Bay were investigated, and the content of chlorophyll a and primary production and their seasonal variation were also determined. The water quality of Meizhou Bay was monitored by measuring the density of *Escherichia coli*. Results reveal that there is a great variety of species in Meizhou Bay and the water in Meizhou Bay is oligotrophic. But the individual numbers of various organisms are very low, especially those of algae. Moreover, there are more than 40 species of red tide organisms and there exist opportunities of red tides between May and November. All these demand cautious be taken in the future development of this area although it has great environment capacity.

Keywords: biotic community; marine ecosystem; Meizhou Bay.

1 Introduction

Meizhou Bay (24°51′—25°45′N, 118°25′—119°45′E) is located at the middle of the coast of east Fujian Province, China. The recent development of industry and aquaculture of this area demands a thorough study on the biotic communities in order to obtain adequate information to forecast the trends of ecological changes, the opportunities of eutrophication, and thus to direct the future industry and aquaculture development.

2 Methods

2.1 Sampling stations and investigation transects

Samples were collected at twenty sampling stations, divided into two categories, category A and category B, according to not only the specificities of the ecosystems in Meizhou Bay in order to be typical in space but also the future layout of outlets, and eight investigation transects near the stations of category B(Fig. 1).

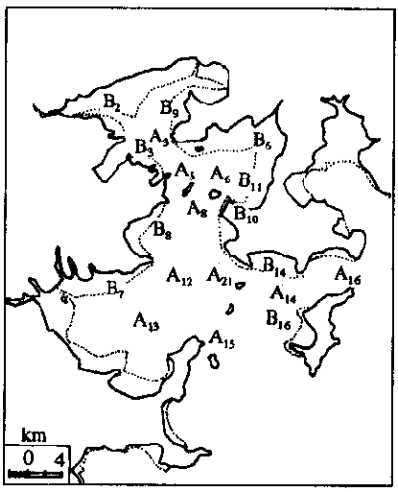

Fig. 1 Locations of the sampling stations in Meizhou Bay

In stations of category A, which were situated at the deep waters zones near the main channels, we sampled both at high tide and low tide at the depths of 0.5 and 5 meters below the surface while we collected samples only at high tide stations of category B, which were located at the intidal zones near the shore.

2.2 Time of sampling and investigation

Samples were collected in mid-May 1988, mid-July 1988, mid- November 1988 and January 1989 in the sea areas and in mid-July 1988 and mid-November 1988 in the intidal zones respectively.

2.3 Investigation

We monitored and investigated the water quality according to the methods developed by Stickland (Stickland, 1972), planktons (Brock, 1978; Bai, 1986), nekton, benthos, microorganisms, chlorophyll a (Holm-Hanxen, 1965), primary production, and the intidal organisms. At the same time, standard marine parameters such as temperature, dissolved oxygen and light were measured. General methods of monitoring and investigation were according to The Concise Technical Regulations of Comprehensive Investigation of the Resources Coasts and Shoals in China(Environmental Science Committee, 1986).

2.4 Closed marine ecosystem experiment

Enhanced nutrients(mainly N, P) were input in the ecosystem in order to study the dynamics of the changes of the biotic community compositions and the individual number of the

populations.

3 Results and discussion

3.1 Phytoplankton

3.1.1 Species composition

In the present study, 157 species of phytoplankton, belonging to 60 genera, were found in the marine ecosystem in Meizhou Bay. Of these, there are 138 species of diatoms(85%), 12 species of dinoflagellates, and 3 species of planktonic blue algae belonging to 51 genera, 7 genera, and 2 genera respectively.

3.1.2 Seasonal variations

Distinct seasonal variations in the phytoplankton densities, lowest in winter, increasing rapidly in spring, highest in summer, and declining obviously in autumn, have been recorded (Table 1). And there is highly significant difference between the densities of phytoplankton of two season's succession(Table 1).

Table 1 Seasonal variations of the total numbers of the cells of phytoplankton in Meizhou Bay

Time		No. of Samples	Density of algae, 1×10^4 cells/m^3 Mean±*SD*	Range
Mid-May	1988	8	96.2±41.1	36.2—148
Mid-July	1988	24	96.2±77.3*	45.0—308
Mid-Nov.	1988	25	22.6±29.9*	3.07—37.4
Jan.	1989	3	5.13±3.40*	2.50—10.0

* $P<0.01$

3.1.3 Distribution

The distribution of phytoplanktons is not stable in the marine ecosystem. Even at the same station, there is obvious difference between the densities of phytoplanktons of high tide and that of low tide. In mid-July 1988, for instance, at station A3, the density of phytoplanktons of high tide (5.45×10^4 cells/m^3), was one and a half times greater than that of low tide (3.07×10^4cells/m^3). Generally, the distribution of phytoplanktons of high tide is patchy or linear; the densities of phytoplanktons of the deep water zones near the main channels are somewhat low and those of the shallow water zones are relatively high.

3.1.4 Seasonal successions

Seasonal successions of the compositions of the phytoplanktons in Meizhou Bay are presented in Fig. 2, with the species of *Rhizosolenia*, *Nitzschia*, *Coscinodiscus*, *Biddulphia* and *Chaetoceros codominating* in May, the species of *Nitzschia* dominating obviously in July, and the species of Coscinodiscus dominating absolutely in November and January.

3.2 Zooplankton

3.2.1 Species composition

All together 12 species protozoans of 10 genera, 8 species coelenterates of 8 genera, 3

species ctenophores of 3 genera, 2 species planktonic colychaetes of 2 genera, 5 species chactognaths of 1 genus, and 26 species crustaceans of 23 genera were indentified in Meizhou Bay in the present study. Copepods, rich in species and individual numbers, are the dominant species.

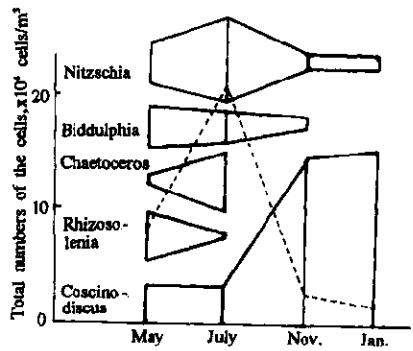

Fig. 2 Seasonal successions of the dominant species of the phytoplanktons in Meizhou Bay

3.2.2 Seasonal variations

There are distinct seasonal variations in the density of zooplankton in Meizhou Bay, highest in May with an average density of 1.95×10^4 individuals/m^3, and lowest in January with an average density of 1.48×10^2 individuals/m^3.

3.2.3 Distribution

The horizontal distribution and vertical distribution of zooplankton are parallel to those of phytoplankton; the densities of zooplanktons of shallow water zones are greater than those of deep water zones and those of the surface water are greater than those of deep layer water.

3.3 Red tide organisms

In the present study nearly 40 species of red tide organisms were found, including 22 species diatoms, 5 species of dinoflagellates, 3 species blue algae, and 1 species protozoon. Species which have caused red tide in East Sea, South Sea and the west coast of Taiwan Sound, such as the species of *Noctiluca*, *Skeletonema*, *Nitzschia*, *Rhizosolenia*, *Trichodesmium*, *Gymnodinium Stein*, and so on, also occur in certain quantity in Meizhou Bay.

3.3.1 *Noctiluca miliaris*

N. miliaris fluorishes from mid-April to mid-May in Meizhou Bay. Fig. 3 shows the distribution of *N. miliaris* in mid-May 1988, with an average density of 1.46×10^4 individuals/m^3. After May, the density of *N. miliaris* declines sharply. And there are only two individuals detected in the 90 samples in November.

3.3.2 *Skeletonema castatum*

Due to the increased light and temperature of the summer months, the individuals of Skeletonema castatum, 5-6μm in diameter, by way of sexual reproduction, form auxospores which lead to a bloom by the way of vegetative reproduction although the density of them is very low in May. The distribution of them in mid-July 1988 is presented in Fig. 4.

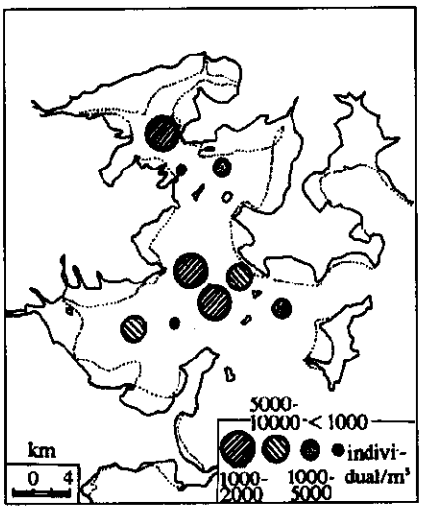

Fig. 3 Distribution of the *Nocliluca miliaris* in mid-May 1988 in Meizhou Bay

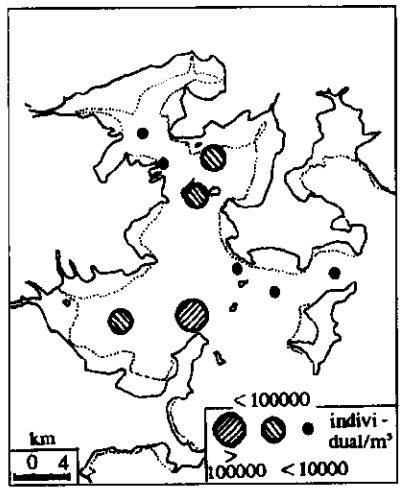

Fig. 4 Distribution of the *Skeletonma castatum* in mid-July 1988 in Meizhou Bay

3.3.3 *Opportunitic species*

Some opportunitic species, such as the species of *Gymnodinium Stein* and *Chlamytomonas*, will multiply rapidly and dominate under optimum condition in the waters polluted heavily by organic matters, although they rarely occur in the waters of oligotrophic and mesotrophic states. For example, the bloom of a species of *Chlamytomonas* occurred in the closed marine ecosystem experiment with enhanced nutrient inputs near Xiuyu Island.

3.4 Chlorophyll a

Chlorophyll a is the direct index of the density of the phytoplanktons and its changes. The investigation results of the densities of chlorophyll a of mid-May, mid-July, and mid-November 1988 are listed in Table 2.

Table 2 Seasonal variations of the contents of chlorophyll a in Meizhou Bay

Time		No. of Samples	Contents of chlorophll a, mg/m³ Mean±*SD*	Range
Mid-May	1988	10	1.68±0.55	0.96—2.82
Mid-July	1988	19	1.79±1.05	0.62—4.18
Mid-Nov.	1988	20	1.76±0.63	0.31—2.59

Chlorophyll a distributes evenly in May in Meizhou Bay, with the densities of all sampling stations less than 2 mg/m³ except three stations (Station A6, A13, A16). In July, the distribution of chlorophyll a is obviously patchy, with the densities of station A3 and station A13 greater than 3 mg/m³, those of main channels between 2 mg/m³ and 3 mg/m³, and those of the intidal zones and the shallow waters zones less than 2 mg/m³ due to a great number of algal feeders and their high amounts of predations.

3.5 Primary production

Table 3 shows the values of daily net primary production of the phytoplanktons in Meizhou Bay, indicating that there is marked variability in production. That of mid-May is the highest, with an average of 2.41 gC. m^{-2}. d^{-1}, and a maximum of 3.73 gC. m^{-2}. d^{-1}, and that of mid-November is the lowest (0.42 gC. m^{-2}. d^{-1}) although the chlorophyll a content of mid-November is greater than that of mid- May.

Table 3 The daily net primary production in Meizhou Bay

Time		No. of samples	Daily net primary production, gC/(m^2. d) Mean±*SD*	Range
Mid-May	1988	5	2.41±0.98	0.728—3.3
Mid-July	1988	2	0.77±0.27	0.43—0.97
Mid-Nov.	1988	3	0.42±0.40	0.05—0.97

This can be explained by the high photosynthetic efficiency of mid-May and low photosynthetic efficiency of mid-July and mid- November, with an assimilation coefficient of 13, 0.002, 0.002 mgC. mg chlorophyll a^{-1}. h^{-1}, respectively deduced using the data of chlorophyll a contents and the daily primary production.

3.6 Fishes

3.6.1 Species composition

Totally 141 species fishes, consisting 22.8% of the marine fishes of Fujian, belonging to 113 genera, 62 families, 150 orders, 3 classes are found in Meizhou Bay. Of these 1 species of Cephalochorda; 15 species of 11 genera, 10 families, 3 orders of Chondrichthyes and 125 species of 101 genera, 51 families, 11 orders of Osteichthyes, including 74 species of Perciformes, which is the largest group in Osteichthyes, were detected.

Meizhou Bay lies in the subtropical zone, affected by the warm currents of South Sea and the coastal waters of Zhejiang and Fujian. The interplay of these two current influences the fish species compositions of Meizhou Bay; there are 108 warm water species, consisting 77% of all the fishes of Meizhou Bay and the rest are warm temperature water species, without any cold temperature water species and cold water species.

3.6.2 Large yellow croakers fishing season

In the last ten day period of April, large yellow croakers' *Pseudlsciaena crocec* breeding migration from the wintering colonies of the open sea to the breeding colonies near Meizhou Bay creates the fishing season of large yellow croakers in spring. At the end of October, large yellow croakers migrate to the south from the fishery of East Fujian. And this leads to the autumn fishing season of large yellow croakers in November.

3.6.3 Distribution of the fish eggs and young fishes

In mid-May, the occurrence of fish eggs is 60 percent with the average density and maximum density of 0.98 eggs/m^3 and 2.55 eggs/m^3 respectively, and the density of young fish is 1.12 individuals/m^3 (Fig. 5).

The number of fish eggs decreases and the occurrence is only 26 percent in mid-July. In mid-November, there are only a few young fishes and no eggs detected.

3.7 Benthos

3.7.1 Benthos in the marine ecosystem

There are a great variety of benthos in the marine ecosystem in Meizhou Bay, with 87 species belonging to 15 groups detected. The often uncounted species include: *Glycera chirori*, *Lumbrineris heterpoda* and *Lumbriners latreilli* of Polychaeta; *Murex aduncospinosus Beck* of Gastropoda; *Gammarus gregroyi*, *Dorippe astuta*, *Chlorinoides aculeatus* of Crustaces; and *Crapidaster hesperus*, *Peronella lesueuri* of Echinoderms. In addition, various species of *Bugula* and corals were observed occasionally. In some sampling stations where the substratum are gravels and sands, lancelets *Branchio stomabelcheri* have been collected using the trawlnet in mid-May. The distribution of benthos is shown in Fig. 6.

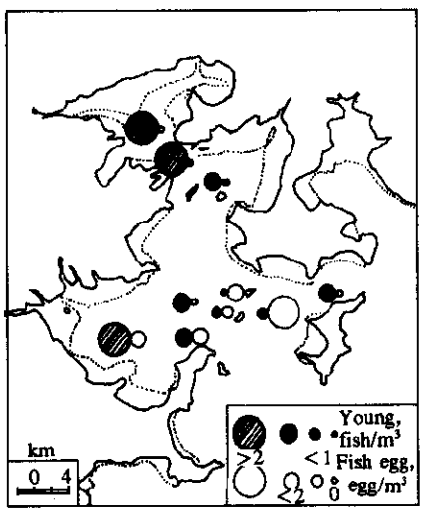

Fig. 5 Distribution of the fish eggs and young fishes in mid-May 1988 in Meizhou Bay

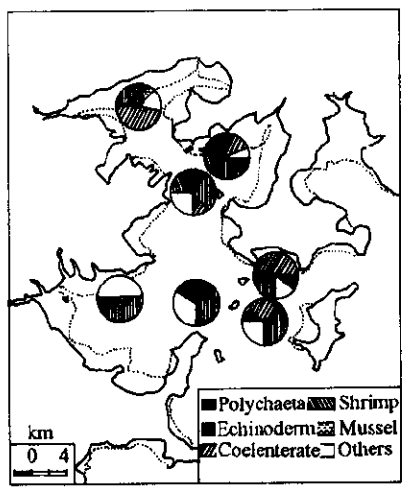

Fig. 6 Distribution of the benthos in mid-May 1988 in the marine ecosystem in Meizhou Bay

The presence of many sensitive benthos species such as *Peronella lesueuri*, *Asterine limboonkengi* and *Tethya aurantium* indicates high water quality and high concentration of dissolved oxygen in Meizhou Bay.

3.7.2 Benthos at the intidal zones

At the intidal zones, there exists a greater variety of macrobenthos in Meizhou Bay, with 316 species indentified (Table 4). Of these, there are 106 species of Crustanceans, comprising the greatest group (34 percent of the 316 species). The average density and biomass are 90.2 g. cm^{-2} and 73.89 g. cm^{-2}, respectively.

Crustaceans and *Molluscss* have high biomass due to their relative large sizes and Polychaeta have low biomass due to their small sizes although their density is the greatest. Polychaeta, which make up a portion of the intidal organisms, supply excellent preys for the

predators. The density of Polychaeta in Weijia and Puwei where are rich in *Lumbrineris heteropoda*, *Aglaophamas sinensis* and *Tylorthynchus heterochaetus* is 60.14 individuals/m^2 and that in Talin Sands where *Diopatra neplitana* and *Lumbrineris tetraura* are the dominant species, is 47.76 individuals/m^2.

Table 4 The major groups of organisms at intidal zones in Meizhou Bay

Group	No. of species	Density, individual/m^2	Biomass, g/m^2
Molluscs	73	19	15.29
Polychaeta	29	39	6.35
Crustaceans	106	20.9	18.10
Echinoderms	30	0.75	12.40
Other	78	10.5	21.75

There are varieties of crabs in the intidal zones of Meizhou Bay, with 39 species belonging to *Grapsidae*, *Xanthidae* and other families often uncounted.

There are many economic important mollusca, including *Ostrea denselamellosa*, *Sinonovacula constricata* and *Tapes variegata*. Macroalgae, such as lavers *Porphyra dentuta* and kelps *Laminaria japonica* also represent.

3.8 Microorganisms

The average density and the maximum density of *Escherichia coli* in Meizhou Bay are both less than 700 individuals/liter, as the results of investigation showed (Table 5), conforming to not only the water quality standard of the first-class marine water but also the water quality standard of cultivating molluscs for eating without cook due to none of its effluents carrying evident excrements and urines of human and animals to it.

Table 5 The density of Escherichia coli in Meizhou Bay

Time		No. of Samples	Density of *E. Coli*, individual/L	
			Mean±*SD*	Range
Mid-May	1988	9	85±76	20—230
Mid-Nov.	1988	10	12±22	2—79

4 Conclusion

There is a great variety of species in Meizhou Bay, with more than one hundred species of algae, many sensitive species of zooplanktons such as jellyfish and copepods, many benthos consisting mainly of *Crustaceas*, *Molluscs*, and *Echinoderms* and rare species such as lancelets and progies. The diversities of organisms in Meizhou Bay reveal the soundness of the current situation and the relatively great capacity of self-regulation of the ecosystem in Meizhou Bay. In addition, the water of Meizhou Bay is oligotrophic and it has great environ-

ment capacity. But the individual numbers of various organisms are very low, especially that of algae, the producers and they are affected evidently by the seasonal variations, suggesting those the rapid development of the harbor industry might affect the community compositions.

There are more than 40 species of red tide organisms. Of these, species of *Noctiluca*, *Skeletonema*, *Nitzschia*, *Rhizosolenia* are the main opportunistic species. Most of these species appear and breed rapidly in spring or summer. There exist opportunities of red tides between May and November due to various causes, especially the discharge of waste organic matters containing phosphorus(P) and nitrogen(N).

All these demand accepting the "controllment to the moderate degree" strategy to resolve the problems concerning the future development of the harbour and the protection of the ecological environment in Meizhou Bay.

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