杭州市环境保护科学研究院

学术论文集

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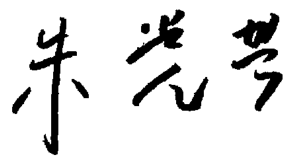
序 言

杭州市环境保护科学研究院（以下简称杭州市环科院）前身是杭州市环境保护科学研究所，创建于 1976 年 4 月，原与杭州市环境监测中心站合一，1998 年 10 月经杭州市编委批复单独设置，并于 2003 年 7 月更名为“杭州市环境保护科学研究院”，是杭州市环保局直属的多学科、综合性的专业环保科研机构。杭州市环科院自建院以来，结合环保科研实际，以“团结合作、爱岗敬业、求真务实、开拓创新”为总体要求，以“科研出成果、管理出成效、服务出效益”为目标，以加强能力建设为根本，以培养科技人才为关键，以提高环保科研水平为重点，紧紧围绕杭州市生态建设与环境保护中心任务和市环保局中心工作，大力开展环保科学研究、重点环境政策调研、环保和生态规划编制、环境影响评价、清洁生产审核、生态工程治理等工作，为杭州市的环境管理提供了强有力的技术支撑。

为庆祝杭州市环科院单独设置 10 周年，特总结建院以来的科技成果和管理经验，编辑出版了《杭州市环境保护科学研究院论文集》，以进一步推动科研、规划、环评业务开展，提高综合管理水平。该论文集所收录的文章是杭州市环科院全体科技工作者多年来努力探索、潜心研究的结晶，反映出他们求真务实、不懈求索、奋进创新的科学精神，其中新颖的观点和精辟的论述必将为相关环境科研工作者提供有益的参考。

21 世纪的今天，可持续发展战略已经成为世界各国在环境与发展问题上的共识和必由之路，杭州市环科院的广大科技工作者任重而道远，期盼在杭州市环保局的正确领导下积极进取、开拓创新、抢抓机遇、迎接挑战，在全力提升环境科技支撑能力的同时，实现自身的跨越式发展，为浙江省及杭州地方环保事业作出更大的贡献！

杭州市环境保护局局长 

2009 年 12 月 1 日

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第一部分

英文论文

Studies on the Changes of West Lake's Zoobenthic Communities after Qiantang River Water was Pumped into It①

YU Zuoming（虞左明） YAN Lijiao（严力蛟） WU Jie（吴洁）

Abstract: During Jan.1995 to Dec.1996, monthly investigations on the zoobenthic communities of West Lake, samples were collected from six sampling stations. A total of 26 species of macrozoobenthos were identified. The seasonal changes in density and biomass of zoobenthos in this lake were analyzed. The annual mean densities were 980～2751ind/m^2 and mean biomass was 19.69～122.80g/m^2. The densities in winter and early spring were higher than those in summer and autumn. Comparative study of the previous data（1982 to 1983）collected by the authors, showed that the succession of zoobenthic communities, dominated by *Procludius choreus* in density and *Bellamya purificata* in biomass, had been occurred in Xiaonan sub-lake after Qiantang River water was drawn into it; and that the species and biomass of zoobenthos were then increased and the density was decreased. In other sub-lakes, the dominant species were *Limnodrilus hoffmeisteri* and *Tokunagayusurika akamusi* in density and *Branchiura sowerbyi* and *Tokunagayusurika akamusi* in biomass. The water quality was bad in these sub-lakes because these dominant species are indicators of eutrophication. According to the Margalef index and Goodnight index, West Lake is still an eutrophic lake. Only the water quality of Xiaonan sub-lake was improved after water drawn from the Qiantang River was introduced into it.

Key words: Zoobenthos; Eutrophication; Water pumped; West Lake; Environmental engineering

1 INTRODUCTION

West Lake is a famous scenic spot for tourists in China, is a small shallow eutrophic lake. However, the lake has been suffering from eutrophication from year to year and its beauty is marred by the low transparency of the water. The eutro-phication of West Lake was studied in the 1970s by many scientists. In order to improve the water quality, wastewater from households was greatly reduced and Qiantang River fresh water was pumped into the lake during 1980s. It was the first time in China that the river water was pumped into the eutrophic lake in order to improve the water quality. So, many scientists were interested in the ecological effect of pupming Qiangtang River water into West Lake.

Because the habitats of zoobenthos are limited, they are good indicators of the lake

① 本文发表于：Journal of Zhejiang University Science, 2002, 3（1）: 118-124.

environment. The zoobenthic fauna of West Lake was investigated during 1982 to 1983 (Yu, et al., 1991) before Qiantang River water was pumped into the lake. This Jan. 1995 to Dec.1996 study was aimed to identify and compare to determine the communities of zoobenthos then with those in 1982 to 1983; to determine the ecological effect of drawing Qiantang River water into the lake; and to evaluate the lake's present trophic state.

2 STUDY SITES AND METHODS

West Lake (120°16′E, 30°15′N; surface area 5.6 km^2; mean depth 1.8 m) is divided into five sub-lakes, i.e, Outer lake (4.40 km^2), Xiaonan sub-lake (0.09 km^2), Xili sub-lake (0.76 km^2), Yue sub-lake (0.07 km^2), Beili sub-lake (0.34 km^2) Fig.1 shows the distribution of six sampling stations. Large scale dredging at stations E and F during the investigation, the complete quantitative data had been really yielded from stations A, B, C and D. Three replicate sediment samples were taken monthly from Jan. 1995 to Nov. 1996 with a Peterson Grab (1/16 m^2) at each sampling site. Each sediment sample was washed in laboratory with a stainless bolting net (0.45 mm opening), therefore zoobenthos were picked up in the laboratory. After that the water on individual surface was absorbed with the papers, the wet-weight of each species was obtained with electronic balance (0.1mg accuracy) and they were preserved in 70% ethanol solution.

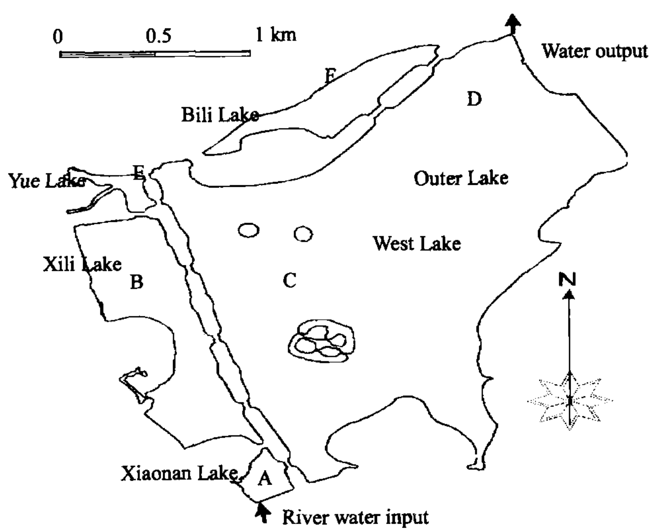


Fig.1 Sampling stations in West Lake

3 RESULTS AND DISCUSSION

3.1 Species composition and distribution

Table1 shows the 26 zoobenthos taxa have been recorded during the Jan.1995 to

Nov.1996, consisting of six Oligochaeta, seven Chironomidae, six Mollusca, two Odonata, one of Ceratopogonidae, Poly-chaeta, Hirudinea, Turbellaria and Nematoda. Among these taxa, *Branchiura sowerbyi* and *Limnodrilus hoffmeisteri* are the species surviving in heavy organic pollution (Brinkhurst, 1974). *Chironomus plumosus* and *Tokunagayusurika akamusi* are indicators of eutrophic lake (Iwakwma, T., 1988).

Table 1 Zoobenthos found in West Lake during the January 1995 to November 1996 Survey

Species	Outer lake	Beili lake	Yue lake	Xili lake	Xiaonan lake
Oligochaeta					
Branchiura sowerbyi	*+	*+	*+	*+	*+
Limnodrilus hoffmeisteri	*+	*+	*+	*+	*+
L. grandisetosus	*		+	*+	*+
L. udekemianus	*	*	*	*	*
Aulodrilus pluriseta	*+	*+	*+	*+	*+
A.prothecatus	*	*	*	*	*
Tubifex sp.	*+	*+	*+	*+	*+
Dero digitata	*				+
Specaria josinae				*	
Stephensoniana trivandrana	*		*	*	
Amphichaeta asiatica				*	
Chironomidae					
Tanypus punctipennis	*+	*+	*+	*+	*+
Procladius choreus	*+	*+	*+	*+	*+
Tokunagayusurika akamusi	*+	*+	*+	*+	+
Chironomus plumosus	*+	+	*+	*+	*+
Microchironomus sp.	+		+	+	+
Cryptochironomus conjugens	*			*	*
Einfeldia sp.					+
Tanytarsus sp.				*	
Orthocladius sp.					+
Other Insecta					
Ceratopogonidae			*+	*+	+
Epitheca sp.					+
Mollusca					
Bellamya purificata					+
Bellamya sp.	*+	*+	*+	*+	*+
Gyraulus sp.					+
Radix swinhoei	*+	*+	*+	*+	*+
Semisulcospira sp.	+	+	+	+	+
Parafossarulus striatulus			*		
Hyriopsis cumingii				+	+
Mytilus sp.					+
Polychaeta					

Species	Outer lake	Beili lake	Yue lake	Xili lake	Xiaonan lake
Nephthys oligobranchia southern					+
Hirudinea					
Helobdella nuda			+	+	+
Turbellaria					
Probescis worme					+
Other groups					
Nematoda				+	

Note: * Species that appeared before the drawing of Qiantang River water into West Lake (1982 to 1983).
+ Species that appeared after the drawing of Qiantang River water into West Lake (1995 to 1996).
Gastropoda appeared in stone which lie in the bank of the lakes except Xiaonan lake.

It was related to the drawing water from the Qiantang River that the euryhaline species (*Nephthys oligobranchia Southern. Mytilus* sp.) found existing in Xiaonan sub-lake because two taxa were also found ed in the sediment samples from the Qiantang River at one time.

The species composition of five sub-lakes was different. Table 1 shows that there were 25 taxa in Xiaonan sub-lake, 17 taxa in Xili sub-lake, 15 taxa in Yue sub-lake, 12 taxa in the Outer lake subarea and 11 taxa in Beili sub-lake. Mullusca distributed in all the lakes, but only in Xiaonan sub-lake did it appear in quantitative samples.

The zoobenthos of the lake relatively longer generation time, some of them had several generations in a year and appeared in all seasons, except *T. akamusi*, a 2-year life cycle univoltine species, that emerges once in autumn during Oct. to Dec of every year. Two generations were overlapped in winter and disappeared in May to Oct. because the species burrowed to the depths of 40～80 cm in the sediment (Iwakuma, T., 1987).

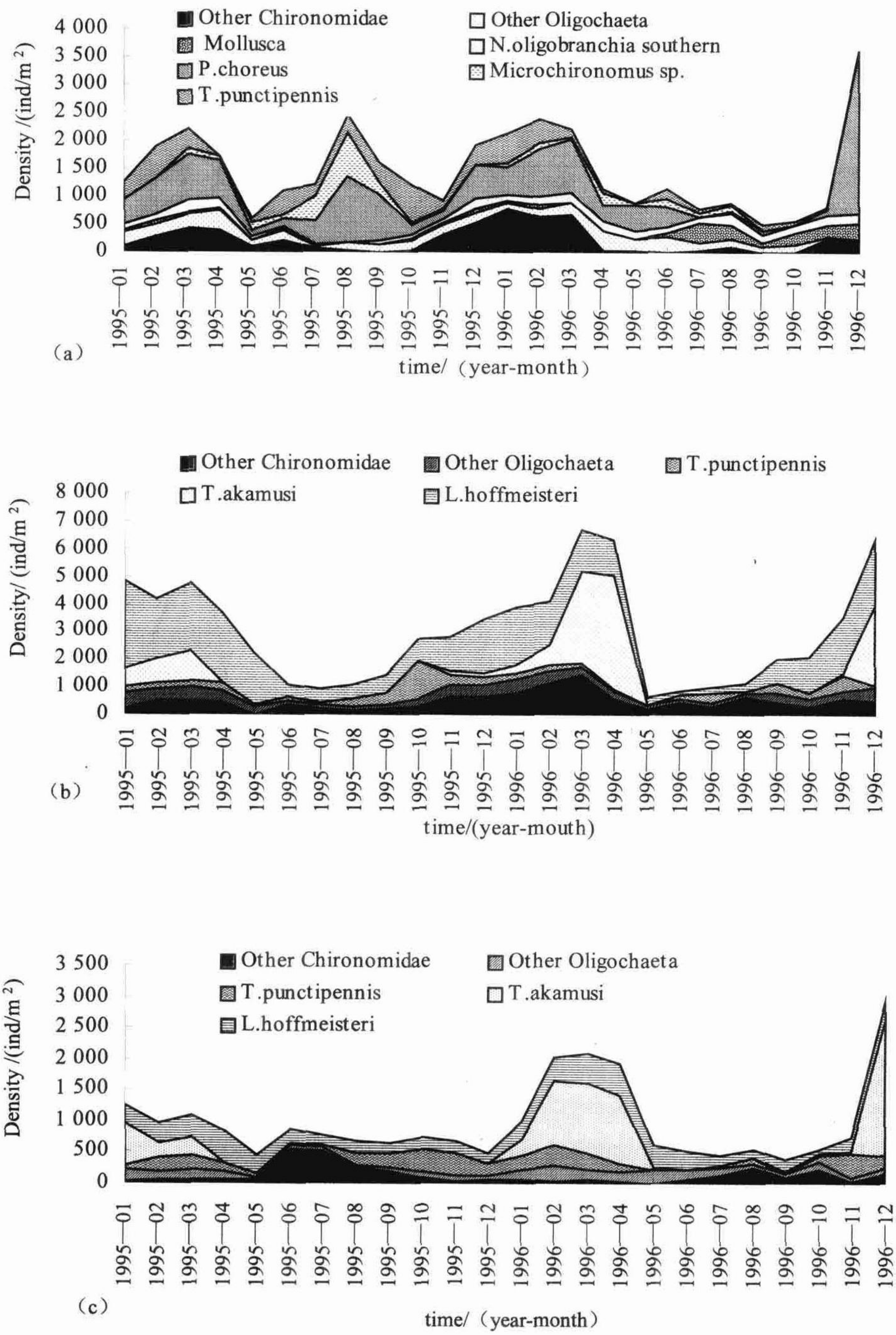
Compared with our 1982 to 1983 results, the species number of zoobenthos were increased from 12 taxa to 25 taxa in Xiaonan sub-lake, but in other sub-lakes were decreased from 18 taxa to 13 taxa. The increasing diversity of species indicated that the zoobenthic community had a qualitative change in Xiaonan sub-lake.

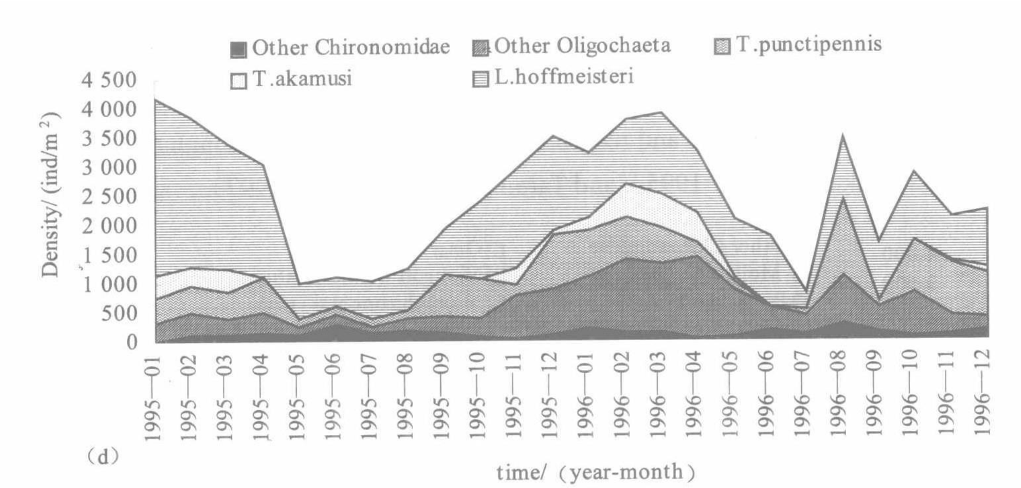
3.2 The standing crop of zoobenthos

The range of the average density in four stations was 2 751 ind/m^2 at Station B (Xili sub-lake), >2 514 ind/m^2 at Station D (Outer lake), >1 376 ind/m^2 at Station A (Xiaonan sub-lake), >980 ind/m^2 at Station C (Outer lake).

The seasonal density fluctuations in four stations of West Lake are shown in Fig. 2. The peaks of density occurred in the winter and the early-spring and lower density emerged in summer. This phenomenon was closely related to the lower predatory pressure of fish and to the life history of the dominant populations in fauna, and especially related to the life history of Chironomidae. In winter, there was higher density in the over-wintering generation of *T. punctipennis*, *P. choreus* and *C. plumosus* .The population of *T. akamusi* emerged once in autumn during Oct. to Dec.; its reproduction and growth occurred in Oct. to Apr. of next year. Two generations overlapped in winter, when there was a higher density of Oligochaeta. The lowest density of Oligochaeta in summer was related to the following reasons: first, Chironomidae emergence; second, *T. akamusi* burrowed deep into the sediment; third, the predatory pressure in summer from fish was higher than that in winter.

The seasonal trend of zoobenthic density in West Lake corresponded roughly with trend in previous results (1982 to 1983), and respectively with the trend in of Donghu Lake (Cheng, 1990), Honghu Lake (Wang, 1995) and Taipinghu Lake (Lui, 1997).

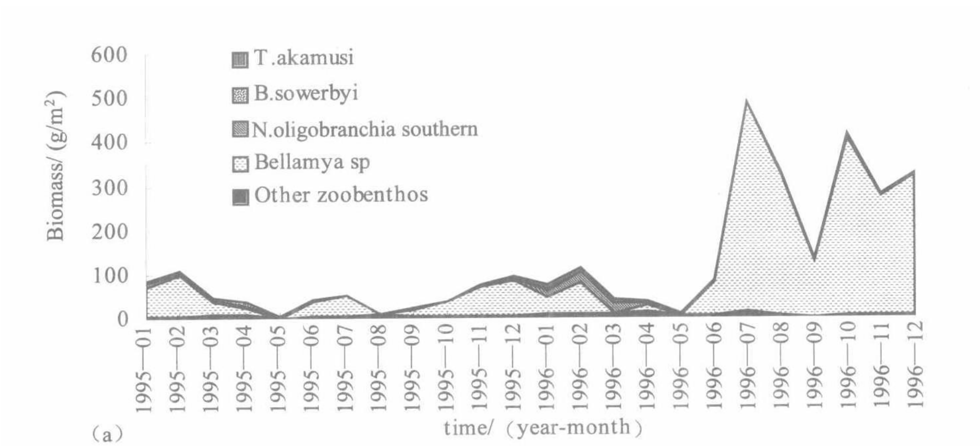


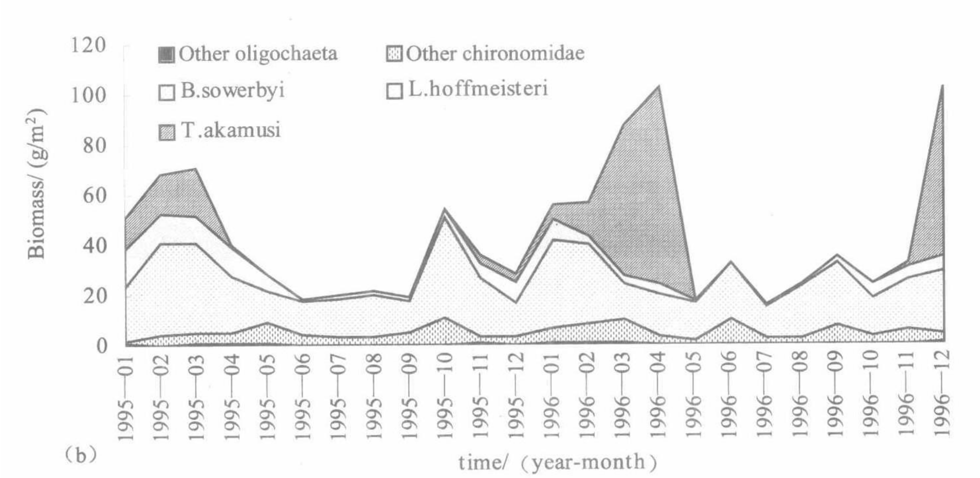


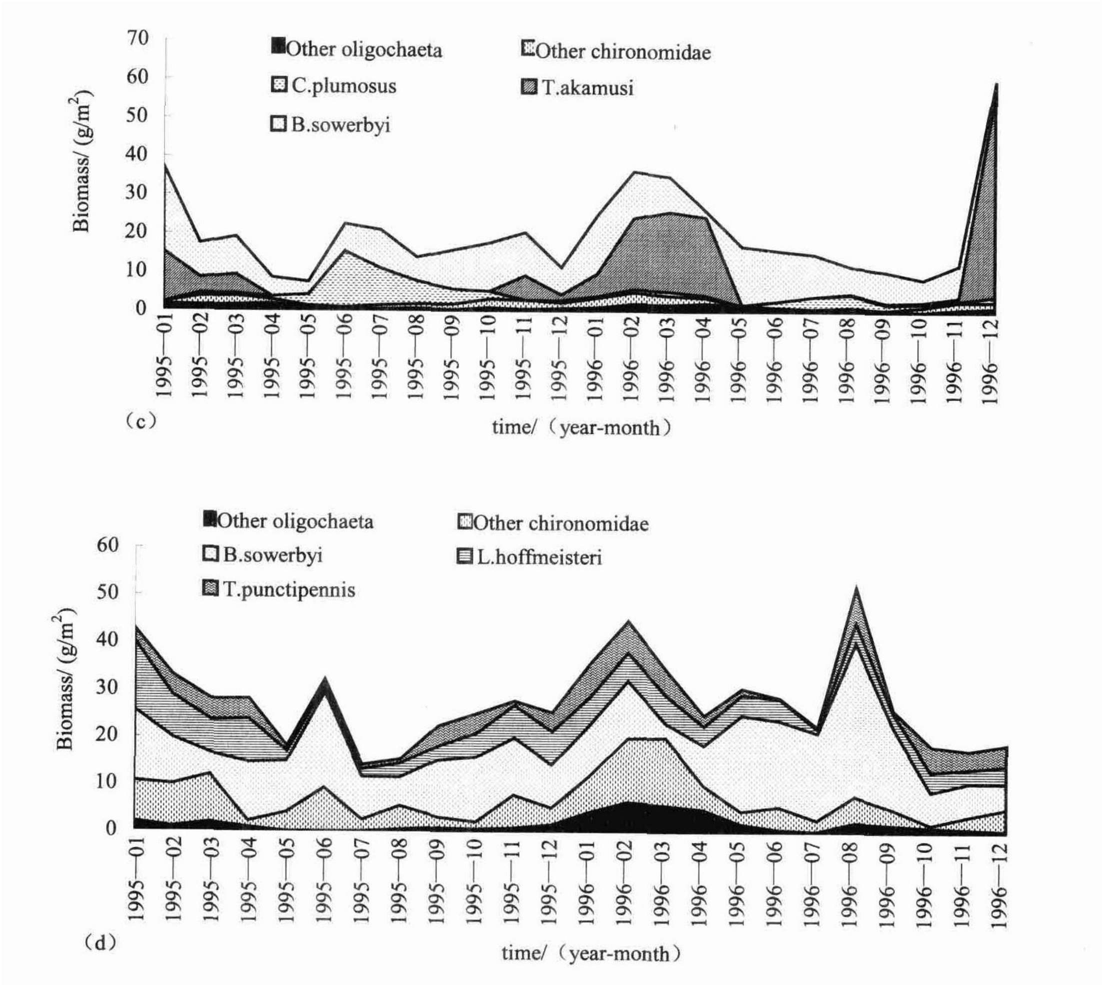
（a）StationA in Xiaonan sub-lake；（b）StationB in Xili sub-lake；

（c）StationC in Outer lake；（d）StationD in Outer lake；

Fig. 2　The seasonal density fluctuations at 4 stations







(a) StationA in Xiaonan sub-lake; (b) StationB in Xili sub-lake;

(c) StationC in Outer lake; (d) StationD in Outer lake;

Fig. 3 The seasonal biomass fluctuations at 4 stations

Fig.3 shows the seasonal fluctuations of the biomass in four stations. Because the zoobenthos were much different in size and weight, the variations of the biomass did not correspond with the density. Except at Station A (Xiaonan sub-lake), where the peaks of the biomass were related to the dominant Chironomidae. *T. punctipennis*, *P. choreus* and *C. plumosus* were important populations in biomass. *T. akamusi* made specially contributed to the biomass in winter because of its overlapping generations then. *Bellamya purificate*'s appearance in Xiaonan sub-lake, caused the biomass at Station A to be the highest among the four stations. The ranges of the average biomass in four stations were: 122.80g/m^2 at Station A (Xiaonan sub-lake); >41.05g/m^2 at Station B (Xili sub-lake); >27.09g/m^2 at Station D (Outer lake); >19.69g/m^2 at Station C (Outer lake) The biomass in Xiaonan lake was dominated by Mollusca, biomass at Station B (Xili sub-lake) and Station D (Outer lake) was dominated by Oligochaeta; and the biomass of Oligochaeta and of Chironomidae were equal at Station C

(Outer lake).

1982 to 1983 data collected by the authors, showed that the annual mean density and biomass were respectively 322 ind/m^2, 1.08 g/m^2 in Outer lake; 1 121 ind/m^2, 3.80 g/m^2 in Xili sub-lake; 1757 ind/m^2, 3.59 g/m^2 in Xiaonan sub-lake. Compared with the above data, the density and biomass of Outer lake and Xili sub-lake had increased, but the density was decreased and the biomass was increased in Xiaonan sub-lake. The reasons for the above results were as follows. The weight of individuals was increased because the dominant species changed and the succession of zoobenthic fauna occurred in Xiaonan sub-lake after the drawing of Qiantang River water into it. But the water of Qiantang Rive into the other sub lakes did not decrease their eutrophication, which is still progressing.

3.3 Dominant population

Table 2 shows the dominant populations in the density. *Limnodrilus hoffmeisteri*, *Tanypus punctipennis*, *Tokunagayusurika akamusi* were dominant species at Station. B (Xili sub-lake), Station C and Station D (Outer lake). If *Tokunagayusurika akamusi* burrowed deep into sediment in summer, its position in the dominant species should be go up. The dominant populations in Xiaonan sub-lake were different from those in other sub-lakes. Oligochaeta disappeared while Polychaeta became dominant.

Table 2 Dominant populations in density (ind/m^2)

Sampling station	Years	Dominant populations		
		First	Second	Third
Station A	1995	*P.choreus* 512	*T.punctipennis* 283	*Microchironomus sp.* 160
	1996	*P.choreus* 329	*N.oligobranchia southern* 153	*T.punctipennis* 140
Station B	1995	*L.hoffmeisteri* 1516	*T.punctipennis* 349	*T.akamusi* 241
	1996	*L.hoffmeisteri* 1175	*T.akamusi* 946	*T.punctipennis* 196
Station C	1995	*L.hoffmeisteri* 248	*T.punctipennis* 192	*T.akamusi* 127
	1996	*T.akamusi* 483	*L.hoffmeisteri* 283	*T.punctipennis* 146
Station D	1995	*L.hoffmeisteri* 1458	*T.punctipennis* 452	*T.akamusi* 125
	1996	*L.hoffmeisteri* 1013	*T.punctipennis* 532	*T.akamusi* 148

Because the zoobenthos were much different in size and weight, the dominant populations in the density differed from the dominant species in biomass. Table 3 shows the dominant populations in biomass. In Xiaonan sub-lake, *Bellamya purificata* and *Nephthys oligobranchia southern* became the dominant species in biomass, and because their individual weight was more than that of other taxa, their biomass was the highest in the sub-lakes.