江苏省环境科学研究院

科技论文集

JIANGSUSHENG HUANJING KEXUE YANJIUYUAN KEJI LUNWENJI

张利民◎主编

河海大学出版社

江苏省环境科学研究院
科技论文集

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河海大学出版社

图书在版编目(CIP)数据

江苏省环境科学研究院科技论文集/张利民主编.
南京:河海大学出版社,2005.11
ISBN 7-5630-2186-8

Ⅰ.江... Ⅱ.张... Ⅲ.环境科学—科学技术—
文集 Ⅳ.X-53

中国版本图书馆 CIP 数据核字(2005)第 127481 号

书　　名　江苏省环境科学研究院科技论文集
书　　号　ISBN 7-5630-2186-8/X·2
责任编辑　毛积孝　李元松
责任校对　朱　庆　尹国胜
封面设计　杭永鸿
出　　版　河海大学出版社
地　　址　南京市西康路 1 号(邮编:210098)
电　　话　(025)83737852(总编室)　(025)83722833(发行部)
经　　销　江苏省新华书店
印　　刷　南京捷迅印务有限公司
开　　本　787 毫米×1092 毫米　1/16　38.25 印张　955 千字
版　　次　2005 年 11 月第 1 版　2005 年 11 月第 1 次印刷
定　　价　36.00 元

序

江苏省环境科学研究院自1985年成立以来，紧密结合我省环境保护的中心工作，积极开展科技创新，经过二十年的发展，逐步由弱到强，发展壮大，至今已跻身省内外一流的环保科研院所行列。省环科院在当前环境保护的多个领域取得了骄人的科研成果，培养和造就了一支有较强实力的科研队伍，构建了促进我省环境保护工作争创全国一流的科研平台，为我省环境保护工作提供了强有力的技术支撑。

省环科院总结二十年来的科研成果，特别是近五年来的学术论文，编辑出版了《江苏省环境科学研究院科技论文集》。该论文集既能充分反映全院职工的环境科研成绩，又能为今后的科研工作提供高水平的平台，起到继往开来、抛砖引玉的作用，有利于年轻一代在环境保护重点领域科研的不断深化和创新。

“十一五”是我国国民经济建设和改革发展的关键时期。在刚刚闭幕的中共中央十六届五中全会上，党中央明确提出了要在“十一五”时期，全国的“环境条件有较大的改善”的奋斗目标，特别强调了“要加快建设资源节约型、环境友好型社会，大力发展循环经济，加大环境保护力度，切实保护好自然生态，认真解决影响经济社会发展特别是严重危害人民健康的突出环境问题，在全社会形成资源节约的增长方式和健康文明的消费模式”的科学发展思路，这必将给下一阶段我省的环境保护工作带来新的发展机遇。为此，希望省环科院全体同志，紧密跟踪当前国内外环境保护新动态，结合我省环境保护的工作重点，锐意创新，开拓进取，努力拼搏，争取创造更多的科研成就，为我省环保事业和环境科学研究作出更大的贡献。

江苏省环境保护厅厅长 史根华

二〇〇五年十月十五日

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一、国内外外文刊物论文

Distribution of Environmental Factors in Lake Biwa in Low Precipitation Condition

Limin Zhang[1], Chunmeng Jiao [2]

(1. Jiangsu Province Academy of Environmental Sciences; 2. Lake Biwa Research Institute)

Abstract: Regular measurements across the north-south profile of Lake Biwa were performed by a fine scale profiler monthly from April 1994 to March 1995. In the period of extremely low precipitation, when strong stratification appeared peak value of chlorophyll-a didn't appear in the epilimnion as usual, rather than, a very sharp chlorophyll peak emerged uniformly in the upper metalimnion of the whole lake. A low dissolved oxygen and high turbidity bottom boundary layer was also observed in the deepest area during summer and autumn. The coincidence between the peaks of Chlorophyll-a and dissolved oxygen shows that the metalimnion is a photosynthesis active region.

Key words: Chlorophyll; Temperature; Turbidity; Dissolved Oxygen; Extreme Low Precipitation; F-probe; Lake Biwa

1 Introduction

Lake Biwa is the largest, monomictic lake in Japan with a topography characteristics of a deep oligo-mesotrophic central basin (the North Basin) and an adjacent shallow eutrophic embayment (the South Basin). During periods of stratification when strong winds sweep across the surface of the lake, the baroclinic response may be described by an initiation of internal Kelvin and Poincare waves which propagate around the lake (Kelvin waves) and oscillate the isopycnal surface in the centre of the lake (Poincare waves). Vertical transport will be most active in the surface and benthic layers, and patchy in the hypolimnion except in case when nolinear internal waves appear (Jiao and Kumagai, 1995).

Due to heavy development pressures, the lake has suffered a deterioration of water quality since the 1960s. The freshwater red tide in the North Basin since 1977 and Cyanobacteria blooms in the South Basin since 1983 are typical symbol of eutrophication process in the lake.

In Lake Biwa, chlorophyll-a or phytoplankton is abundant in the epilimnion during stratification period in most years (Nakanishi, 1976; Tezuka, 1984). It is observed in the epilimnion of the lake that there are two peaks of phytoplankton standing crop annually, one in spring which is caused by freshwater red tide, the other in autumn resulting from stimulation of primary production by addition of hypolimnetic nutrient (Tezuka, 1984).

In summer of 1994 when precipitation was extremely low, the peak of chlorophyll-a or phytoplankton appeared within the thermocline. This phenomenon is unusual in Lake Biwa (Nakanishi, 1995).

A deep chlorophyll peaks (DCP) have been observed in various aquatic environments. Although the dominant biological processes in the formation and maintenance of the DCP vary from environment to environment (Cullen and Eppley 1981; Culle 1982), it is clear that the DCP never appears in very turbid waters or where a thermocline is absent (Anderson, 1969). This strongly imply that radiation penetration and water stratification are very important factors for the formation and maintenance of the DCP.

Recently, blooms of algae in the North Basin have caused a marked increase in oxygen demand which has lead to a depletion of oxygen in the deep parts of the lake (Naka, 1973). If the decrease in oxygen continues, the store of phosphorus locked up in the sediment may be release, leading to accelerated eutrophication in the North Basin.

Several observation works have been carried out about spatial distribution of biochemical factors, with profile data acquired in several points or some area in the lake (Nakanishi, 1976; Tezuka, 1984). Our study was focused on the monthly routing observation of temperature, turbidity, pH, conductivity, chlorophyll-a, dissolved oxygen across north-south transect in a special case that river input was extremely low in summer of 1994 when the lake reached its new record of low water levels. This observation with a fine scale probe (F-probe) give us a great deal more insight into detailed spatial distributions in whole lake.

2 Methods and study area

Observations were conducted on a profile from the northern side in Shiozu Bay to the southern side under the Seta Bridge. Locations and water depths of the 10 survey stations are showed in Figure 1 and Table 1, respectively.

Table 1 Water depths (meters) of the 10 survey stations

St. 1	St. 2	St. 3	St. 4	St. 5	St. 6	St. 7	St. 8	St. 9	St. 10
30	72	86	87	72	75	50	6	4	3

The observations was carried out once a month from April of 1994 to March of 1995 using a fast research vessel, Hakken owned by Lake Biwa Research Institute. Each observation has to be finished within 4 hours in order to acquire simultaneous data. The locations of the stations were decided by differential Global Position System (GPS).

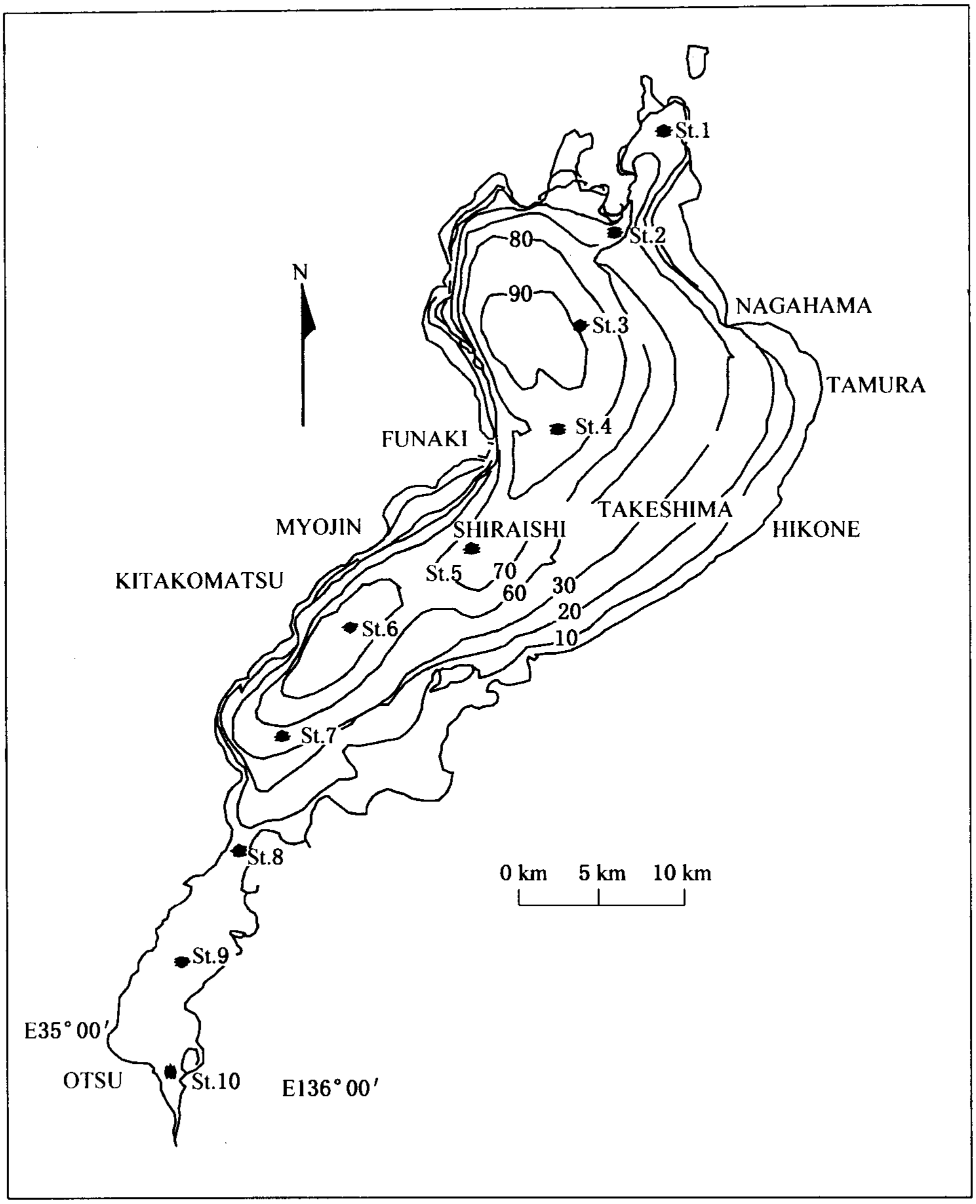


Fig. 1 Station locations on a bathymetric map of Lake Biwa.

Vertical profiles were obtained by a fine scale profiler, which is equipped by temperature, turbidity, PH, conductivity, chlorophyll-a, dissolved oxygen sensors. The conductivity in-situ instrument is made up by a SEA-BIRD sensor with accuracy of ±0.000 3 Siemens/meter, resolution 0.000 04 s/m and time response 0.07 seconds. The temperature sensor is SEA - BIRD one with accuracy of ±0.004 ℃, resolution 0.000 3 ℃ and response time 0.072 seconds. The dissolved oxygen sensor is a SEA - BIRD one with accuracy of 0.1 ml/L, resolution 0.01 ml/L and response time 2 seconds. The PH sensor is a SEA - BIRD one with accuracy of 0.1 PH and response time 1 second. Turbidity in-situ instrument is made up by SEA TECH transmissometer with accuracy of ±0.5%. Chloropyll-a in-situ instrument is made up by SEA TECH fluorometer with accuracy of 0.1 μg/L. All the sensors were calibrated by Center for Water Research, University of Western Australia.

Principally the data were acquired once a month, but the time interval between two observations is not exactly one month. Spline interpolation technique for raw data treatment was used for seasonal variation analyses. Because spatial distances among observation points are unequal, the same method was also used.

The profiles were acquired at a spatial of 10 cm from the surface to the bottom. The 7 profiles from the stations in the North Basin were averaged to get a normal vertical profiles. This averaged profiles were used to get seasonal distributions.

3 Results

3.1 The monthly variation of meteorology and transparency

The air temperature tended to increase from April, and got its maximum in July and August, then decrease until it reached its minimum in February (Fig. 2a). The variation of solar radiation showed that it was relatively low in June, which is a raining season, and got its maximum in July and August, and then seems to decrease until December. The distribution of precipitation showed an unusual partern, i.e., the rainfall is not so high in the raining season (June), but extremely high in September.

Comparison shows that air temperature was 1 to 2 ℃ higher than the standard values (annually averaged values) except that in June, especially in July it is 3 ℃ higher than usual (Fig. 2b). The solar radiation shows a big positive deviation in July and August. Attention should be focus on the big negative deviation of precipitation in June, July and August, which make the water level of Lake Biwa reach its historical low water level records. Therefore, the summer of this year is extremely dry and hot.

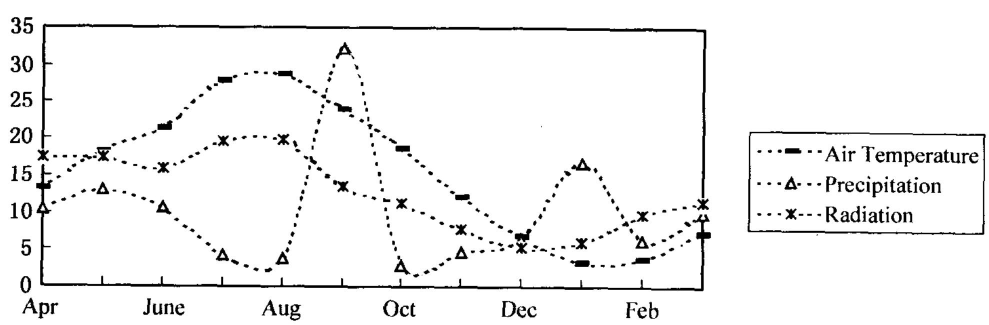


Fig. 2a The monthly averaged values of air temperature(℃) and average daily solar radiation (MJ/m²) and monthly total precipitation(mm×10) at Hikone Meteorological Station from April 1994 to March 1995.

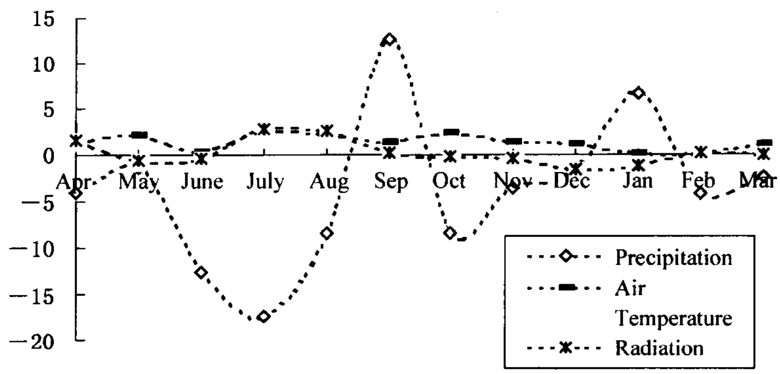


Fig. 2b **The deviation to annually averaged values of average air temperature(℃), total precipitation(mm×10) and average daily solar radiation(MJ/m^2) at Hikone Meteorological Station from April 1994 to March 1995.**

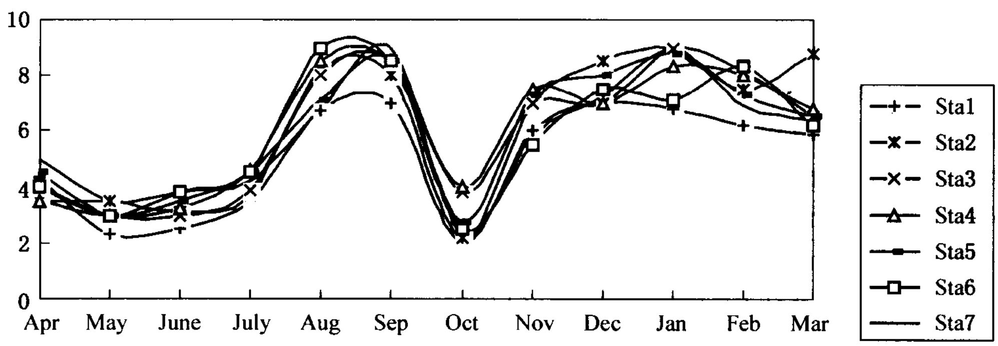


Fig. 3a **Water transparency(Secchi disc depth in meters) recorded once a month at 7 survey points in the North Basin of Lake Biwa from April 1994 to March 1995.**

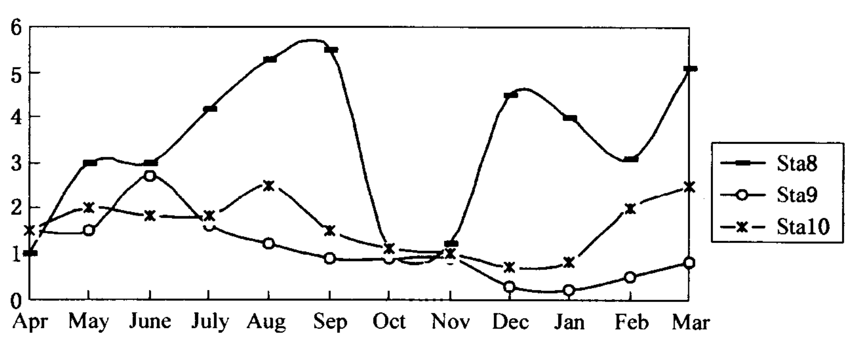


Fig. 3b **Water transparency (Secchi disc depth in meters) recorded once a month at 3 survey points in South Basin of Lake Biwa from April 1994 to March 1995.**

In the North Basin, Secchi disc depth (transparency) got its minimum in May when fresh water "red tide" bloomed, then increase until it reached it maximum in July and August, which corresponds to the extremely dry and hot season (Fig. 2a) when phytoplankton standing crop in the surface layer was very low. The transparency decreased gradually from September to October, which was caused by heavy rain in the mid and late September(Fig. 2a). The lowest transparency in October was due to the intense rainfall and turbid river water input which occurred 4 days before our sampling, rather than heavy phytoplankton standing crop. Compared in the meantime among the 7 stations in the North Basin, the lowest transparency values were always found at Station 1, near the Shiozuokawa river mouth and Yiwura habour, which seems to be caused mainly by the turbid river water input.

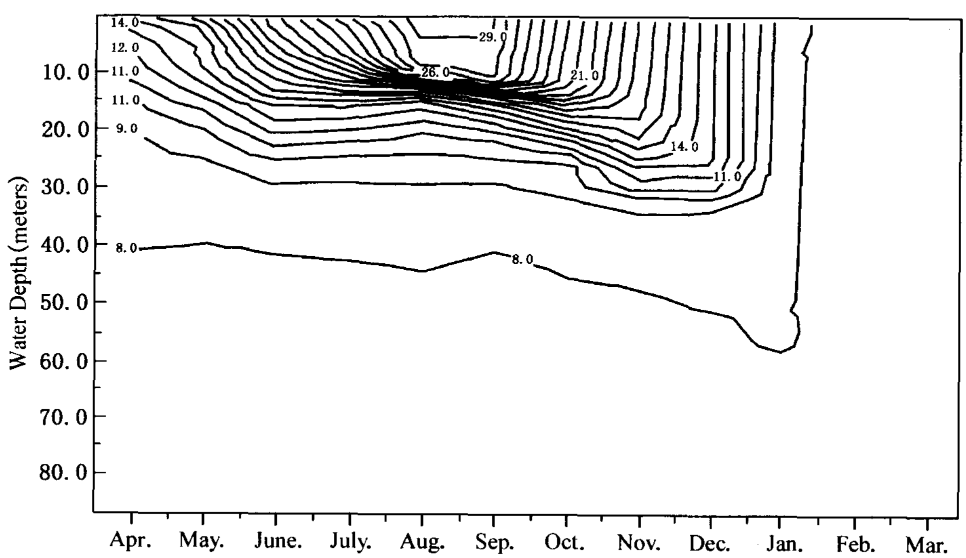
In the South Basin, the Station 8 with a depth of 6 meters is located at the conjunction, the Biwako bridge, with the North Basin, so that there was similar characteristics in transparencies to those obtained in the North Basin. The shallow South Basin is well-mixed by wind normally and there is no water stratification. Therefore, the transparency is irregular and random without any statistically reliable differences between stations

3.2 The seasonal variation of water temperature, chlorophyll-a, dissolved oxygen, and turbidity

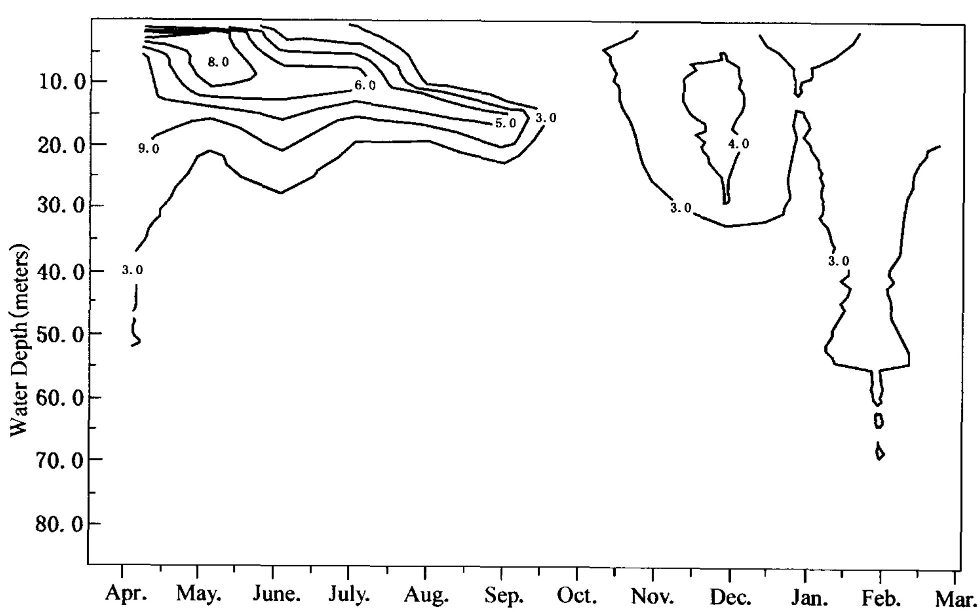
The seasonal variation of water temperature is well revealed in Fig. 4a. The water stratification started in April 1994 by gradually strengthened solar radiation. Under the strong solar radiation in July and August (Fig. 2). The stratification developed to reach a summer pattern in August and September, i.e., an uniform warm surface layer (epilimnion) with a maximum water temperature 29 ℃ (3 ℃ higher than usual), a deep layer (hypolimnion) with a uniform water temperature of 8 to 9 ℃, and a layer between them (thermocline) with a sharp temperature gradient. The surface of the thermocline in the meantime arrived at its shallowest depth of 10 meters, which continued for two months. From September, the epilimnion begun to cool and to deepen gradually and the stratification started to be weakened and disappeared in January. The lake became isothermal completely from January to March.

It is evident from Fig. 4b that chlorophyll-a concentration begun to increase from April in the middle of epilimnion, and got its peak in May, which is correspond to spring water bloom of the fresh water "red tide". The chlorophyll-a peak area deepened gradually and reached its deepest point (10 to 15 meters) in August and September when the phytoplaktopn species was dominated by picophytoplankton (Nakanishi, 1995). The characteristics of phytoplankton distribution is that they concentrated in a very narrow range in the upper metalimnion. Correspondingly, the Secchi disc depth transparency became larger and larger. It is coincided with the unusual arid and hot meteorological condition. Therefore, the record-making good transparency in the summer seems to be caused by the concentration of phytoplankton into the thermocline under the extreme climate. It is clear to be seen that there is valley between spring and autumn peaks, which is similar with the observation of Tezuka (1984).

The seasonal variation of oxygen (Fig. 4c) in the North Basin provide a great deal of information about the nature of the lake. The concentration of oxygen in an aquatic environment is a function of biological processes such as photosynthesis or respiration and physical processes. In the upper epilimnion, the O_2% decreased from April and reached its minimum in August, there exist no phytoplanktons there, then started to increase until December, remained the same values from January to March, which showed a opposite tendency with water temperature distributions. Oxygen saturation is determined by temperature and phytoplankton distribution. In spring when the stratification was weak



(a)



(b)