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The ecological environment and fishery administration of Chaohu Lake

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Abstract— Chaohu Lake is a good base for fishery production, yet the pollution, construction of watergates and other improper actions have greatly impaired the potential of fishery productivity. It is necessary to strengthen the administrative functions of the organizations, to set a good management of the watershed and to use the ecological-economic water level line to improve the water environment as well as the fishery production.

Keywords: aquatic resources; fishery productivity; ecological-economic water level line.

INTRODUCTION

Chaohu Lake is one of the most famous large-scale freshwater lakes in China and the largest in Anhui Province. However because of the substantial population and intense human activity, the eco-environment of the lake has changed significantly resulting in many negative effect. This has drawn serious concern from the local government.

After the founding of the Chaohu Lake Management Committee and the Chaohu Lake Development Company in 1979, a series of fishery management policies were formulated. Their effective policies have led to economical, social and ecological benefits.

AQUATIC RESOURCE AND FISHERY

The aquatic resource of Chaohu Lake is similar to other lakes in the middle and lower reaches of the Yangtze River. According to recent investigations, there are 72 species of phytoplankton which cover 6 phylums and 56 genera, and their annual avarage biomass is 1.36 million per liter. The blue-green are the dominant algae, which contribute 95.9% of the species of the total annual biomass production. There are 35 genera and 46 species of zooplankton in the lake. The annual mean biomass is 477 cell per liter, in which protozoan covers 90.3%. Benthonic fauna covers 63 species, 23 families and 30 genera, and its biomass is 105 g/L in which *Corbicula fluminea* is the dominant species. Macrophyte includes 29 families, 44 genera and 54 species. The plant covers 3.65% of the lake surface and the plant production is 77.1 kg/ha, which are mainly reed, potamogeton and crispus. It has been noted that there are 94 species of

fish covering 11 orders and 20 families of which silverfish, *E. ilishaeformis* (*Bleeker*), and another 20 species have high economic and production value. There are 8 species of shrimps such as *Palaemon modestus* and *Macrobrachium nipponensis*.

According to calculations, the fish production potential of Chaohu Lake is 305 kg/ha. Fishes which feed on phytoplankton, zooplankton, benthonic fauna, macrophyte and bacterium fillings, contribute 70.4 kg/ha, 70.8 kg/ha, 58.2 kg/ha, 0.5 kg/ha and 70.35 kg/ha, respectively.

FISHERY PRODUCTION

In Chaohu Lake, there are a number of professional fishing teams. In recent years industrial developments have resulted in fishing losing its pre-eminent economic position(Table 1).

Table 1 Fishing capacity development in Chaohu Lake

Years	Number of boats	Tonnage of boats	Horse power of boats	Number of pot-boat	Number of staff
1979	156	5081	880		1086
1984	573	8719	8036		2122
1988	815	1345	14496	1684	4606

Fishery in Chaohu Lake has a long history. Production was very low before the 1949. The first recorded figure was 4000 tons in 1952. Production subsequently decreased to 2000 tons in the 1960s and kept at that level until the mid 1970s. Improved management, coupled with fish propagation led to an upturn in fish production post 1978. The changing production quotas are shown in Table 2.

Table 2 Fish production in different years in Chaohu Lake

Years	1952	1957	1962	1967	1972	1977	1979	1983	1988
Production, ton	4000	3000	1400	3800	1600	2100	2690	4900	6250

Table 2 shows that the increased total production has solely resulted from the increase of small fish production. Compared with previous periods the production of big fish actually decreased. Therefore, the composition of the fish population in Chaohu Lake is unusual.

Premium fish production requires several favorable eco-environmental factors. Climatic

conditions include enough sunshine, fairly high accumulated temperature, enough runoff and favorable wind intensity and direction. Topography factors include a winded bank line, natural harbors, sufficient water depth and appropriate slope grade of lake bed. Vegetation around the lake is very important for preventing bank erosion and sediment resuspension.

Effects should be made to reduce lake pollution. The physical and chemical quality of the lake water should meet the National Water Quality Standards. The structure of the fish community should be rational, with a high percentage of primary carnivores while harmful fishes with low economic values should be controlled. The increase of fishing capacity should be in harmony with the increase of natural resources in order to utilize the resources fully in the lake. Leaders of fishery departments should have sound management strategies and rules.

A combination of the above factors is necessary for the optimum development of fisheries in Chaohu Lake. Although the geography and climate cannot be altered, some environmental conditions could be improved by human intervention.

EFFECTS OF WATERGATES OF CHAOHU LAKE ON FISHERY

The watergates were built in 1960 at the egress of Chaohu Lake, on the Yuxi River. By use of the watergate, the water level has been artificially controlled. The watergate has played a positive role in drought-relief, water storage and flood control, and promoted the economic development of the region. But for the fishery in Chaohu Lake, they have their negative aspects. Firstly, the watergates keep water level high in the dry season and more than 8000 hectares of littoral zone which used to appear, are now submerged for a long time. Lack of sunshine for the littoral zone means that the essential conditions for germination of seed and underground-stem are lost (Fig. 1).

Secondly, construction of the watergates prevent fish returning from the Yangtze River, so fries and young fish cannot mature. Every year from May to June when fish breeding reached its peak, water from the Yangtze River used to flow into Chaohu Lake and brought its large amounts of fries. This was called "accepting fries from the Yangtze River". In bumper harvest years, there were 100 fish in every cubic liter of water, and it was estimated that every year, 0.4 billion fish were washed into Chaohu Lake from the Yangtze River. Since the watergates were built, large quantities of fries and large-scale fish are unable to enter Chaohu Lake at the season of "accepting fries from the Yangtze River". The production of those fish decreased dramatically and some species such as *Macrura reevsii* are now missing from the lake (Fig. 2).

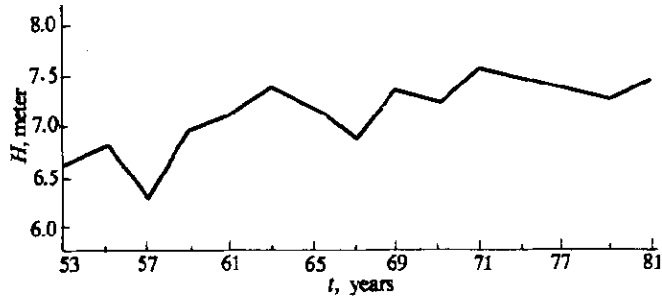

Fig. 1 The lowest water levels of Chaohu Lake in the years of 1953–1981

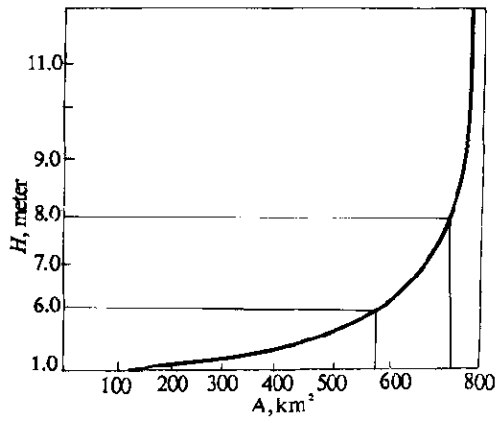

Fig. 2 The relationship between water level above sea (H) and the lake surface area (A)

EFFECTS OF POLLUTION

The accumulation of pollutants leads to high concentrations in sediment, macrophytes and fish. Below are the results of accumulation of Pb, Cu, Zn and Hg in the sediment.

Pb	29.78mg/kg	Cu	19.36 mg/kg
Zn	60.27mg/kg	Hg	0.042 mg/kg

As an example in macrophytes, the pollutants contained in reed were measured by ionic chromatography and gas chromatography (Table 3).

Table 3 Pollutants content in reed

Unit: ppm

Sample location	BHC	DDT	Total Organo-chlorine	Cu	Pb	Zn	Cd	Mn
Sanjiao River mouth	0.317	0.148	0.462	1.9	3.2	4.1	0.23	144
Mawei River mouth	0.207	0.351	0.351	2.6	3.3	4.1	0.24	310
Shiwuli River mouth	0.208	0.386	0.386	3.9	3.3	4.9	0.26	118

Table 4 and Table 5 show that many kinds of pollutants can be found in fish samples and their concentrations are far greater than in the lake water.

Table 4 Toxic residues in fish

Unit: mg/kg

Name of fish	Total BHC	Total DDT	Total organochl.	Cu	Pb	Zn	Cd	Mn
Hypophthalm	38.9	134	173	0.5	0.7	4.6	0.06	0.4
Ichthysmolitrix	56.3	200.8	257.1	0.3	0.53	4.2	0.045	0.4
Arist	68.1	157.1	225.2	0.5	0.55	4.2	0.050	0.4
Chthys nobilis	50.7	298.7	349.4	0.4	0.48	3.9	0.038	0.2
E. ilishaeforis	72.12	183.6	255.7	0.2	0.60	3.7	0.045	0.2
E. mongolicus	93.08	262.72	355.8	0.3	0.63	5.8	0.048	0.2
E. dabryi	108.8	171.03	279.8	0.3	0.50	3.9	0.045	0.2
Cyprinus	100.57	160.10	260.7	0.4	0.40	6.4	0.085	0.3
Carpio L.	48.20	81.92	130.1	0.4	0.40	4.6	0.083	0.3
Carassius auratus	95.27	548.57	644.0	0.5	0.45	7.4	0.075	0.3

Pollution in Chaohu Lake has brought many unfavorable effects. Since 1982, there have been several incidents resulting in fish fatalities. In 1990, the economical losses were near 0.3 million RMB Yuan.

Eutrophication in Chaohu Lake is a serious problem. The over use of detergents and fertilizers, and waste water discharge are believed to be the reasons for the high concentration of nutrients in the lake water. The blue-green algae *Microcystis* is the dominant species of phytoplankton. Every year in September and October, it reaches peak levels with a long algal bloom stretching in length over 10 km, in which width over several hundreds meters and with a depth over 30 cm. This produces unsightly effects as well as unpleasant odors.

Table 5 Accumulation of pollutants in fish

Unit: mg/L

Name of pollutant	Pollutant concentration in lake water	Pollutant concentration in fish	Concentration ratio
Total BHC	0.00027 – 0.00123	0.03894 – 0.1088	88 – 144
Total DDT	not found	0.08192 – 0.5488	
Cu	0.035 – 0.044	0.2 – 0.5	5.7 – 11.4
Pb	0.009 – 0.018	0.4 – 0.7	38 – 44
Zn	0.060 – 0.122	3.7 – 7.4	60 – 61
Cd	0.0007 – 0.0014	0.045 – 0.085	60 – 64
Mn	0.03 – 0.43	0.2 – 0.4	0.9 – 7

FISHERY MANAGEMENT STRATEGIES

1. Strengthening the administrative functions of the management organizations

It is important to establish an administrative organization with authority, efficiency and offering comprehensive services. The present administrative organization is an "Administration Office of Chaohu Lake of Anhui Province". The lake bank belongs to 4 countries and Hefei City. Administrative sections and groups in 23 districts and 115 villages were set up and an administrative network has been in operation with a job responsibility system. This system has brought beneficial results in the utilization of aquatic resources in Chaohu Lake and led to economic benefits for the local fishermen.

2. Improving the water environment through a comprehensive management policy

(1) To control soil erosion through adjusting the agricultural structure

In moderate erosion areas and gentle erosion areas, the tops of mounds where crops

cannot grow well should be reforested for soil and water conservation.

Trees should be planted in line with local site conditions, in mixed types, offering predictions as soon as possible. In addition, subwatershed management should be carried out, including engineering and biological methods for controlling slope and gully erosion.

(2) Use of the ecological-economic water level line to improve the water environment

The "Eco-Economic Water Line" can satisfy not only the demands of industry, agriculture, fishery and shipping without negative effects but also maintain the water environment at maximum ecological value.

In Chaohu Lake, industry, agriculture, fishery and shipping have different demands for water level (Table 6). On the other hand the water level has its own alternating patterns which often conflict with the demands of the items in Table 6. The operation of the eco-economic water line will solve the above problems and bring great economic, social and ecological benefits.

(3) To built dikes and dams for the prevention of bank erosion and collapse

At present, collapse can be observed along 64 km of the 184 km long shore line. It mainly results from the natural force of water, wind, gravity and daily freezing in winter. To date, several engineering methods have been used in locations around Chaohu Lake, including Zhongmiao, Jinkuang and Wangding. One method is to built preventive walls with cement bricks, which deter bank collapse. Unfortunately, the wall has only reached a length of 4.7 km, which is only 7.3% of total eroded bank. More wall needs to be constructed in the future.

Biological methods have also been used for the prevention of bank collapse. They are as follows: firstly, planting water-resisting and moisture-resisting trees to form trees zones on the lake edge; secondly, changing the tree-planting methods from being vertical to slope, to being parallel to contour line; thirdly, inter cropping crops with grasses and threes, which can improve the soil

Table 6 Different demands of different users for lake water level above the sea

User	Demands for water level, m	Notes
Industry	7.0 – 10.5	For water supply and flood control
Agriculture	7.5 (in winter and spring)	For crops in spring
Shipping	7.5 – 10.5	For motor sailboat and safety of dikes and dams
Flood control	10.5	Warning water level for flood control
	7.5 (from September to March)	Beach shining
	8.0 (April to June)	Accepting fry
	< 10.5	Avoiding submerging of macrophyte

quality and increase the crop production.

(4) To strengthen management control of the watershed

Management control should be strengthened in the major polluted rivers, especially in the Nanfei River. Their priority is to control pollution sources and reduce the pollution load to Chaohu Lake. In addition, engineering and biological methods should be taken to increase the output of nutrients from the lake ecosystem.

3. To carry out fishery regulations and strengthen the lake management policy

(1) To popularize regulations

For the purpose of rational management and development of Chaohu Lake and for aquatic resources conservation, many measures have been taken to popularize the fishery regulations. One of them is to print brochures of regulations and to provide them to the farmers and fishermen. Up to now, 6500 copies have been printed for distribution, including "Regulations for Aquatic Resource Conservation", issued by the State Council, "Fishery Acts of the People's Republic of China" and the "Methods of Management on Chaohu Lake". Another measure is to organize fishery officials to go to the countryside to educate farmers and fishermen by means of lectures, distributing communication cassettes and using radio broadcasts. All this activities have greatly promoted the understanding and accepting of the regulations.

(2) To set up non- fishing reserve periods and zones

Since 1982, about 10 non-fishing reserve zones have been set up in the fish-breeding area and in the area with luxuriant aquatic plants. The total area for reserves is approximately 80 km, 10 km of which is the perennial breeding reserves for aquatic plants, benthos and fish. In these areas, there are year round restriction on activities such as water-grass cutting and fishing. The reserve period was 50 days before 1985, when it increased to 120 days. In 1986, the time increased to half a year on the basis of investigations of fishery resources. Moreover, various fishing periods were set for different fish species. For instance, the fishing time for *Hemisalranx prognathus* is from the middle of May to early June. For shrimp, it is from Junly 24 to the end of February of the following year. For all kinds of big fish, it is from early December to spring of the next year. The non-fishing area and the non-fishing period both guarantee substantial fish reproduction and rational fish utilization.

(3) Regulations to control the licensing and intensity of fishing

With the development of commercialism in the countryside, the number and power of ships has increased rapidly. Fishing techniques have also improved. These lead to a greater intensity of fishing, which often exceeds the carrying capacity of the fishery resources. Therefore, it is necessary to license the fishing industry and rigorously adhere to the regulations. One such rule is to set a standard for fishing net meshes. For example, the net meshes must be less than 8000 mm in diameter for big fishes, 6.6 mm for *Coilia ectense* and 3 mm for *Hemisalranx prognathus*. All nets fail-

ing to meet this standard will be prohibited, whilst offenders will be liable to prosecution.

(4) Scientific research for enlarging fishery resources

a. To carry out an interdisplinary study on fishery

Since 1980, scientists from many universities and institutions have been invited to carry out research in the fields of the primary production of aquatic bodies, aquatic plants, fishery resources, benthos, water quality and watersheds. There are more than 20 universities and institutions which have participated in these research, projects including Nanjing Institute of Geography and Limnology of Chinese Academy of Sciences, Anhui University, Anhui Agriculture University, Anhui Normal University, Anhui Institute of Environmental Sciences. They haye obtained a large amount of data and written approximately twenty papers. Many of the results and recommendations have been applied with considerable benefit.

b. To grow macrophytes for setting up a rational ecosystem

In Chaohu Lake, few macrophyte species currently exist and their coverage is very low. Their primary productivity is also low. If this could be changed, the channels for energy and matter flow in the ecosystem will certainly be enlarged. The community structure will become more rational, function will be better coordinated, and fishery productivity will be increased. For these reasons, it is vital to take action. One important step has been to artificially grow aquatic plants in the littoral zone. During recent years, a large number of macrophytes have been planted and the area of plants has been increased from 300 hectares in 1978 to 3000 hectares today. These efforts considerably improve the environment of the lake area.

c. To enlarge fishery and lake resources

Fig. 3 shows that the percentage of zooplankton- feeding fish biomass is very lager, being about 70% of the fish population. However, the percentage of plant-feeding fish is only 20%. This kind of ecological structure is irrational, according to the law of ecological efficiency. It is known that the production output would increased five times if the average trophic level in an ecosystem could decrease by 50%. Therefore, more plant- feeding fish, debris- feeding fish and omnivorous fish should be cultivated in the lake which would increase the efficiency of energy transfer and benefit the economy.

Since 1980, 14 million fry have been introduced to the lake. 77% of them are plant- feeding fish and debris- feeding fish. Millions of young crabs have also been introduced to the lake. These measures clearly improve the community structure of Chaohu Lake, enlarge the aquatic resources and increase the fishery potential.

d. To exchange information

With the rapid development of technology, it is necessary to exchange scientific information with other organizations and research institutions. In this way management techniques can improve, keeping in step with scientific development.

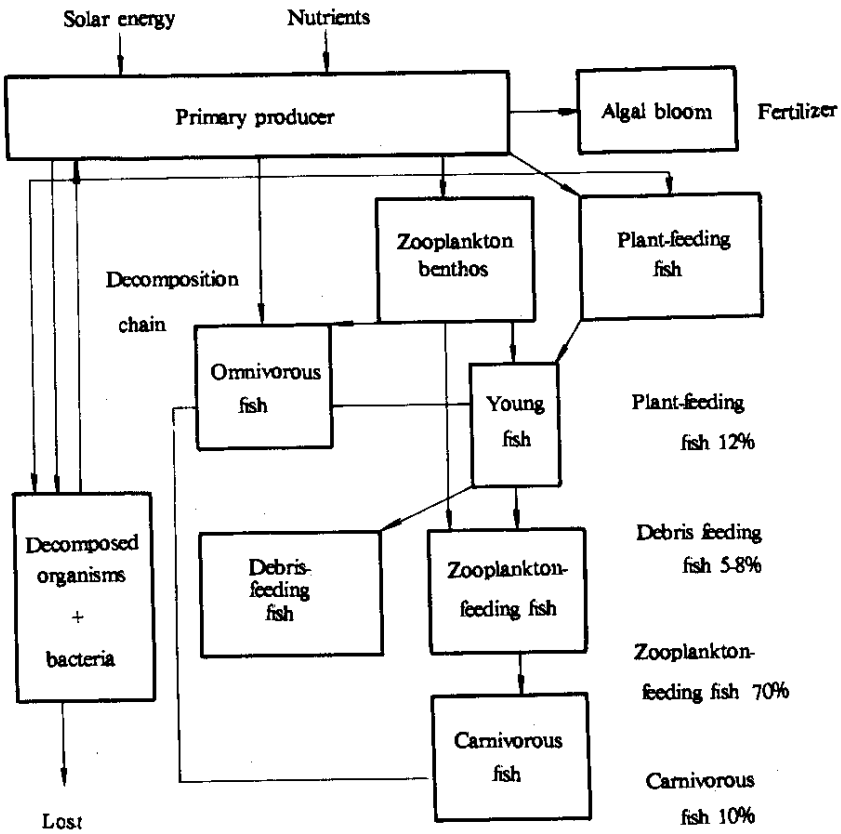

Fig. 3 The nutrient cycle in Chaohu Lake
(The black boxes represent the aquatic lake)

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