

Degradation and Restoration of Lake Ecosystem in the Changjiang (Yangtze) River Basin

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INTRODUCTION

Lakes in the Changjiang River Basin form a large amount of water areas in the plain of the middle and lower reaches of the Changjiang (Yangtze) River. There are more than 1,000 large or small lakes sized over 1 km² and distributing in the provinces of Hubei, Hunan, Jiangxi, Anhui, Jiangsu and Zhejiang, etc. The total area of lakes is 20,842 km² and the water storage amount is 7 billion m³. The Yangtze River Basin is one of the most developed regions in economy in China. They are lakes of multiple functions: water supply, agricultural irrigation, commercial fishery, navigation and sightseeing. Coordination of these functions is directly related to the life of 300 million people and the development of local economy in this region. Therefore, great attention must be paid to the maintenance of the change and function of this particular ecosystem structure.

FORMATION AND SUCCESSION REGULARITY OF THE LAKES IN THE YANGTZE RIVER BASIN

1. Formation of geomorphologic features

In the early Tertiary period, the present areas in the middle and lower reaches of the Changjiang River were at the status of quasi-plain. In the early period of the Himalayan Movement, the local subsidence occurred in this region which was connected with sea for a very short period. Therefore, numerous lakes existed, without any unified river systems. Up to the early Pleistocene, the Changjiang River course was divided into several sections. There was the connection of the river course between the Sichuan Basin and the Yichang ancient lake Basin, but no distinct river course in the ancient Dongting Lake was found to flow eastward. Up to the middle of Pleistocene, Jingshajiang River in the upper reach of the Changjiang River then cut through the Hutiao Gorge, converged with the water systems of Sichuan Basin, again cut through the Three Gorges and entered into the eastern plain. River water from Qinghai-Xizang (Tibet) Plateau traversed among ancient lakes in the plain and connected them to form the Yangtze River course at last, it entered into the sea at Chongmin in the late of Pleistocene. So, in the Yangtze River sections, there are no distinct limits between river and lakes. This is because the particularity of complex ecosystem of the river and lakes was formed at very beginning

2. Climate factor

The upheaval of the Qinghai-Xizang Plateau not only changed the setup of the geomorphologic feature in Asia, but also formed the situation of monsoon current and replaced original current situation of planetary system of winds. The Yangtze River Basin in the Latitude is controlled by

subtropical high-pressure and influenced by strong southeast monsoon current. Therefore, it was characterized with obvious subtropical monsoon climate. Rainfall is abundant in this region, but with uneven distribution. From March to August every year, influenced by southeast monsoon and southwest monsoon, precipitation and runoff are greatly increased, causing river overflowed. Flood in the plain region caused river flow traversing among lakes to reverse its direction. Along with washing and blocking, new lakes were formed one after another and, at the same time, old lakes disappeared one after another because of obstruction and deposition. Therefore, in this region, besides few lakes of depressed structure such as Poyanghu Lake, Dongtinghu Lake and Chaohu Lake, most of them are shallow lakes with water depth not exceeding 5 m. Moreover, their relative lifetime is short, only about several hundred years or over one thousand years.

3. Proper natural succession of lakes

Everything has a process from the birth to the death. We take the natural process of lake from formation to disappearance as the proper succession. The Yangtze River Basin is in the subtropical region and annual cumulative temperature is about 5,000 °C. Shallow lake has good illumination conditions and the runoff offers it with import of sufficient nutrition salt. Therefore, shallow lakes in the Yangtze River Basin have relatively high bioproductivity of water bodies, when the standing water environment appears in the new barrier lake or alluvial lake formed by flood and alteration, aquatic vegetation begins to grow. Submergent plants such as Hydrocharitaceae, Najadaceae, Potamogetonaceae, Ceratophyllaceae and Haloragidaceae appear firstly in these lakes. They form the different community groups along with the different hydrologic conditions. There are a few floating plants and pleustons growing along both banks of lake, such as *Nelumbo*, *Euryole*, *Trapa* and *Lemna*. However, there are a great number of emergent plants and wetland plants such as Gramineae, Cyperaceae and Polygonaceae growing in disappearing areas of lake. As the vegetation are the important compositions of the ecosystem structure of these lakes, we call them as shallow grass-type lakes. High aquatic plants utilize a great amount of nutrition salts such as N and P in water bodies. A small part is transferred along with the food chain but a great part is deposited with organisms withering and falling which causes lake basin becoming shallow. Especially for the wetland plants and floating plants, their trunk and root have strong action of sand-soil-fixation and extent toward lake center along with sand and soil. In 1980s, extension speed of *Zizania latifolia* in Honghu lake is about 5 m annually. Vegetation has developed from submergent plants, floating plants, emergent plants to wetland plants and lake is gradually becoming marshy and disappears at last. This is the natural process of proper succession of lakes in the Yangtze River Basin.

4. Lake disappearance quickened by human activity

Human activity, first of all, controls free-flood of the Changjiang River. Dikes are continuously strengthened so that it is difficult to form new barrier lakes or alluvial lakes again in the Yangtze River Basin, but the original lakes have been disappeared continuously during the natural succession. In recent decades and because of the great increase of human population, more cultivated land is needed day by day. People continuously build up sluice gates in mouths of lakes to control the lake water level and reclaim land from lakes. From 1954 up to now and according to incomplete statistic, reclaimed area from lakes in this region is about 12,000 km² which is about half of the present lake

area (see Tab.1).

Figure 1 shows the change of Dongtinghu Lake in recent 300 years. Its area in 1984 was only 2,691 km² and reduced 32% as compared with that in 1950 and 42.7% as compared with 6,300 km² in 1862. Human activity speeds up the proper succession of the shallow lakes, promotes the disappearance of lakes and, at the same time, limits the formation of new lakes. Therefore, to protect the existed lake ecosystem is especially urgent.

CONCEPT AND REASON OF DEGRADATION OF SHALLOW LAKE ECOSYSTEM

Concept of degradation of shallow lake ecosystem

Due to the particularity of shallow lakes, it is true that lake disappearance caused by proper succession is one of the important expression of degradation. However, this paper will put the stress on the discussion about the change process of damage of structure and function of ecosystem due to the disturbance of human activity during the process of succession. Here, structure degradation mainly means that biocommunity in the lake ecosystem is damaged. For example, damage or even disappearance of aquatic grass community followed by secondary extinction of a series of species causes results that species diversity in community is declined, life history is shortened, small-sized species with simple structure is dominant, food chain is shortened, structure of food net is simplified and system stability is declined. The function degradation mainly means that the self-purification ability of lakes is weakened, expressing that speed of material cycle in ecosystem is quickened, the system has sensitive reaction to the disturbance, primary productivity in water body is turned to the productivity of algae in the main and eutrophication is sharpened. As the damage of aquatic vegetation in shallow grass-type lake may slow down lake marshy and prolong the lifetime of lake. Therefore, we call this process of degradation as counter succession.

2. Status and reason of degradation of shallow lake ecosystem

2.1 One of the important characteristics of lakes in the Yangtze River Basin is that river and lakes are connected each other. A number of migratory fishes is formed during the evolution, such as *Mylopharyngodon*, *Ctenopharyngodon*, *Hypophthalmichthys* and *Aristichthys*. These fishes spawn in the river and young fishes swim into lakes and grow up there. They are the main consumers in the ecosystem and are the main objectives of fishery. Obstruction between river and lakes by water conservancy construction cuts off migratory route of these fishes, resulting that fish resources in lakes can not be replenished and fish fauna is changed. By the increase of fishing intensity, large-sized fishes with delay sexual maturity are reduced gradually and the population number of small-sized fishes of one year old with sexual maturity is increased steadily. In Hubei Province, Honghu Lake had its area 760 km² and there were 133 species of fishes before the obstruction of the river and lake. In 1980, its water area was only 350 km² and species number of fishes was only 31. In fishery production, *Carassius auratus*, *Pelteobagrus fuluvidraco* and *Culter erythropterus* which are small-sized fishes and their body weight is less than 100 g counter for 87%. So the fishery value is obviously reduced. We call this phenomenon as the fish miniaturization.

2.2. High development of aquatic vegetation is another important characteristic of shallow lake ecosystem. In some small-sized lakes in the Yangtze River Basin, the main measure to raise fish

production is to stock herbivorous fishes. Overstocking of grass carp (*Cteropharyngodon*) usually causes the reduction and extinction of aquatic grass. In Donghu Lake which covers 12 km² and is in the suburb of Wuhan City, the biomass of aquatic plants was 1,779.8 kg/m² in 1963. In 1973, massive stocking of grass carp was carried out and the biomass of aquatic grass was only 5.8 kg/m² in 1975. Now, aquatic grass is extincted in the main lake. Reduction and extinction of biomass of submergent plants can cause effects in two respects: 1) The nutritious substances such as N and P which were originally absorbed or covered in mud by aquatic grass were greatly released into water body, leading to the rapid increase of plankton biomass. The massive reproduction of algae reduced transparency of lake water and inhibited recovery of aquatic grass. Therefore, the counter succession that grass-type lake turned to algae-type lake occurred. 2) The extinction of aquatic grass enabled epiphytic organisms or some benthos to lose their basic living conditions and also enabled a great number of fishes to lose their living places and spawning grounds. In short, the damage of aquatic vegetation caused the loss of the lake biodiversity and the great change of the structure of the shallow lake ecosystem. Algae-type lake is not provided with self-purification ability that grass lake has and, it causes aggravation of eutrophication. Moreover, some secondary metabolic products of algae can directly affect the human health.

2.3. A great amount of untreated industrial waste water and sewage is directly discharged into lakes. Modernization agriculture brings about more and more pollution by agricultural fertilizers, pesticides and wastes. Followed by the damage of aquatic vegetation and the reduction of self-purification ability of water body, lake eutrophication is becoming serious day by day. Many lakes lose their ability of supplying drinking water.

PROTECTION OF SHALLOW LAKE ECOSYSTEM AND RESTORATION OF ITS STRUCTURE AND FUNCTION

1. Fishery - countermeasure of environmental optimization

Reduction of fish resources caused by obstruction of river and lake enabled irrational utilization of aquatic vegetation resources, which could speed up the process of swampiness of shallow lakes. Therefore, appreciate fishery exploitation in grass-type lake may be the important measure for protecting shallow lake ecosystem. From 1986 to 1990, we carried out the test of fishery environmental optimization in Donghu Lake in Hubei Province (its area about 350 km²)(See Figure 2). Fish crop was increased from 3,000 t to 8,000 t and swampiness was obviously controlled. Similar studies have been carried out in Gehu Lake and Taihu Lake in Jiangsu Province and Baoshan Lake in Hubei Province. The main method of such study is to make enclosing culture of herbivorous fishes and, thus, people may rationally utilize aquatic grass resources in a planned way so that swampiness of lake can be controlled and eutrophication of water body may be prevented. However, equilibrium relationship of growth and decline between fish and grass is still in study.

2. Recovery of aquatic vegetation

In algae-type lake of counter succession, to recover aquatic vegetation is the key technique of

restoring degraded ecosystem of shallow lake. *Elodea nuttalli* introduced into Taihu Lake has formed large community, covering 20 km² in the center area and distributing 60 km² in the lake. However, in water body where eutrophication is serious, mutual restraint between algae and submergent plants is very obvious and, it is difficult to recover the aquatic vegetation. In Donghu Lake in Wuhan City and in other water bodies, floating plants such as *Eichhonia crassipes* have been used to absorb N and P, inhibit algae growth and offer conditions for the recovery of aquatic vegetation. Some progress has been made.

3. Eutrophication controlled by biomanipulation

By epipelagic organisms in food chain, effects are occurred on sub layer organisms in food chain and physic-chemical factor of water bodies. This is called top-down effects and, in controlling lake eutrophication we call it as biomanipulation. In Donghu Lake in Wuhan City, we observed that filter feeder such as silver carp and bighead carp can feed on large planktons such as *Daphnia* and *Microcystis* so that planktons become small-sized and occurrence of blue-green algal bloom is decreased. Such study is carried out at present.

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Table 1 Statistics of reclaimed land from lakes in the Yangtze River

Name of province or lake	Reclaimed area (km ²)
Hubei	6,000
Anhui	1,363
Jiangsu	1,129
Poyanghu Lake	1,840
Dongtinghu Lake	1,659
Total	11,991

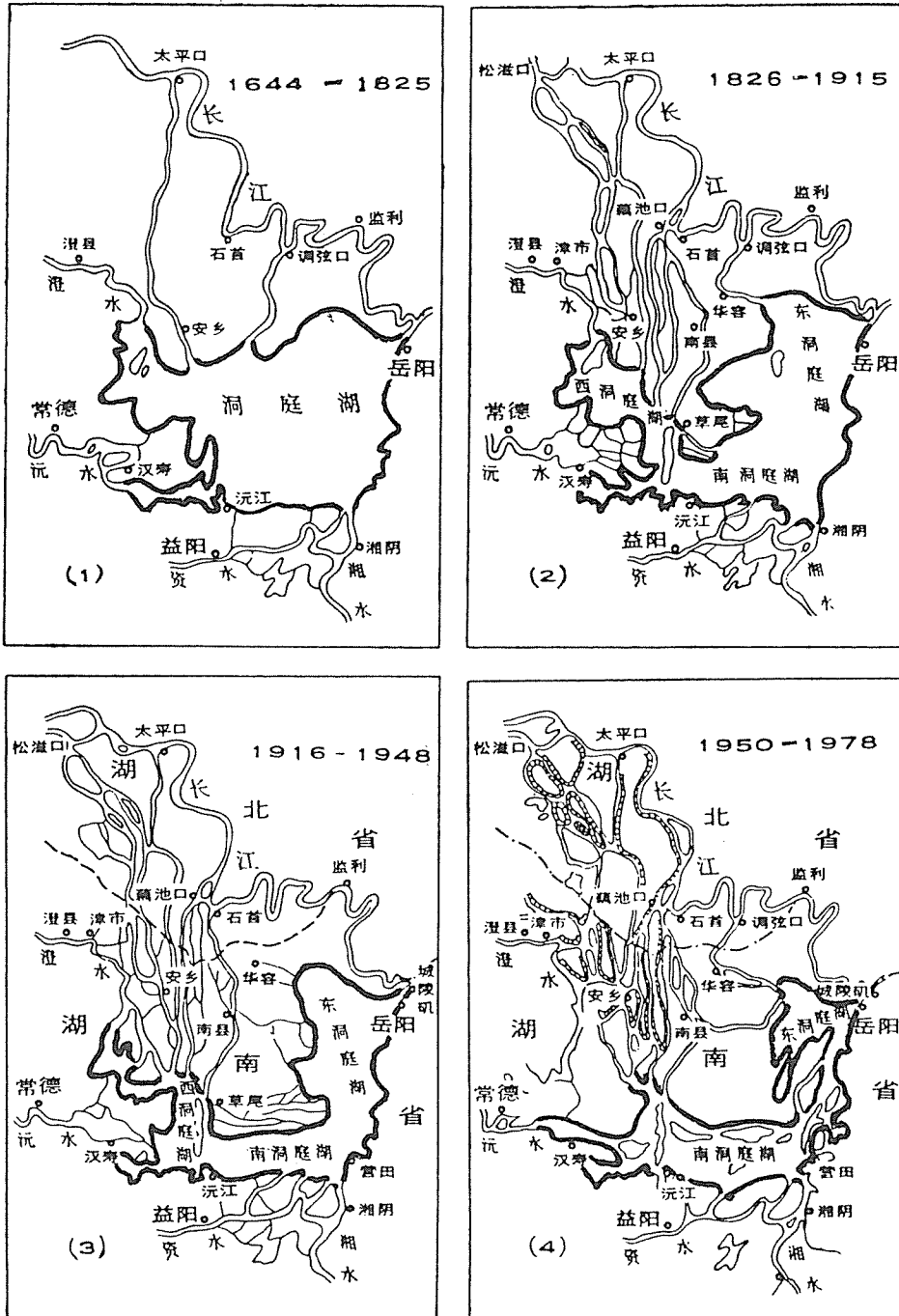


Figure 1. Changes of Dongtinghu Lake in different historical stages.

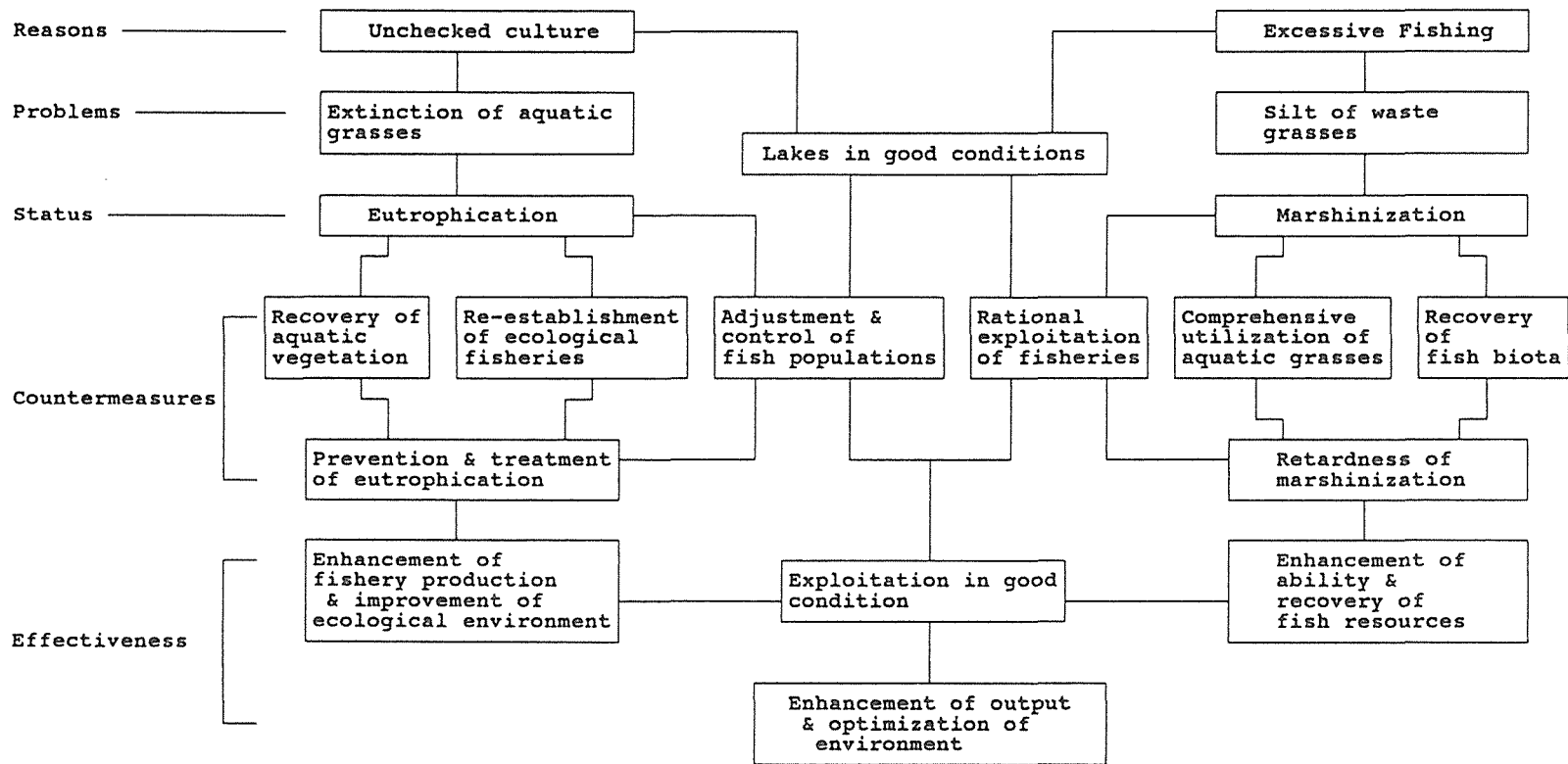


Figure 2. Schematic Diagram of Lake Fisheries and Environmental Optimization