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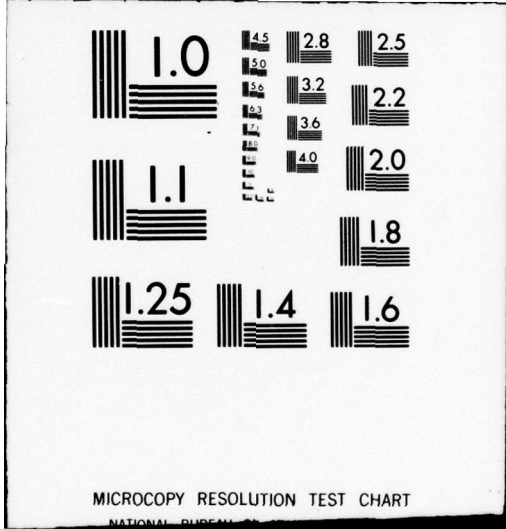
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The development of pond fish culture in China involves the utilization of small water bodies for rearing fish. These small bodies of water consist of artificial fish ponds and semi-artificial ponds, such as dams, or natural ponds.

Pond fish culture provides both fish fingerlings and food fish to the freshwater fishing industry. In order to meet these demands, it requires

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high density rearing, mixed species rearing, large scale feeding and frequent harvesting

The major species raised by pond culture are grass carp, Chinese black roach, bigheads, and common carp.

There are 3 major means of improving conditions for fish pond culturing: (1) increasing natural fish food by fish pond fertilization or other methods; (2) increasing the waters that are beneficial to fishery activities by building dams to reduce water flow thereby reducing nutrient loss; (3) controlling fish enemies, such as Elopichthys bambusa, Chinese perch, snakehead, pike, and catfish.

Complete elimination of predatory fish is not always necessary because many of these fish have high economic value. Also, it must be recognized that many non-predatory small fish are considered fish enemies because they have no economic value and they compete with other species for food.

To minimize fish escape from the ponds, several types of bamboo or wire fish blocking devices are used. These devices should be constructed to minimize interference with spawning and migrating fish, flood control, irrigation, and navigation.

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CHINESE FISH POND CULTURE AND FISH REARING

Chinese Fresh water fish culture has developed as a by-product of Chinese agriculture. Before 1950 Chinese farmers did not undertake large scale fish production as a business. Chinese fresh water fish culture experience before 1950 was centered on the small ponds.

The best criterion to measure the fish rearing technique is the production of fish per unit area. For instance in 1952 one farmer in Wusih District first broke the barrier of 50 kg/ha. This experience in turn stimulated other farmers for greater production. In 1957, one farmer in Hupeh province produced over 100 kg/ha. Under the encouragement of the Government, the fish pond culture venture in China was greatly increased.

The Kinds of Fish Rearing Ponds

In the development of pond fish culture in China, the important feature lies in the utilization of small water bodies for rearing fish. These small bodies of water consist of artificial fish ponds or semi-artificial ponds and the naturally formed ponds about 1/2 hectare in size. To rear fish in these small bodies of water manpower is available, and heavy density rearing is possible.

The so called semi-artificial ponds refer to those that are made by blocking the river or creek or confining fish in the lake or at the confluence of rivers, by making a dam or a dike. Often the purpose is irrigation; and fishery is

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only secondary. Natural ponds are those that are formed in nature such as pools, ponds, river bays, and so on. Generally speaking, the pond fish culture industry in China has been developed from small water bodies for high density rearing.

Characteristics of Pond Fish Culture

To rear fish from fish fingerlings to food fish is the last stage in fish culture. It involves a process of fattening and has unique characteristics such as: to rear fish fingerlings into adult fish demands a variety of species of food fish which are large and tender and flavorful. It also demands a fast going gross rate and it supplies the the fresh fish year around. In order to fulfill these demands, it requires high density rearing, mixed species rearing, large scale feeding and frequent harvesting. All the problems and the necessary techniques which are connected with pond fish culture are due to these unique characteristics.

Freshwater Fish Culture Industry

Pond fish culture aside from providing fish fingerlings to the freshwater fishing industry, has the major purpose of providing food fish. The rearing of food fish is more easily controlled by man. It does not depend upon the weather or environmental conditions as much as in the case of fish fry culture. As long as it is carefully planned and carefully executed results are usually satisfactory. Besides, the rearing of adult fish requires only small bodies of

water. These small bodies of water are found everywhere, therefore, it is practical to answer the demand of big cities. The cost of the pond culture accounts for a very major portion of freshwater fishing industry in China. According to statistics in 1957 the pond culture of adult food fish contributes 83% of the total freshwater fishing industry in China.

Rearing Period in Pond Culture

In most of China the time required to rear fish from the fry stage to the adult stage generally requires 2 to 3 years. Among the major species for instance, the bigheads require 2 years. The grass carp and Chinese black roach require 3 years. In this period, the first year is the period from fish fry to fish seedlings. The second and third are for the period of growing into adult fish. According to the experience of the people the bigheads put on greatest gross weight during their second year. If the conditions are right, the spring fingerlings, 25-50 grams, can grow from two to three kg in the second year. The grass carp and the Chinese black roach increase their weight the greatest during the third year. They can grow from 25-50 grams in the second year, to more than 10 kg in the third year. Therefore, in the provinces of Kaingsu and Chekiang, the rearing period in pond culture is usually two to three years.

In the provinces of Kwantung and Kwangsi where the weather is warmer and the grain period^{for} the rearing period of

fish is also shorter. Generally the growing period lasts only one to two years. In the case of bigheads, generally the rearing density is small and early rearing through the year can result in food fish within the same year. Late year rearing of the bigheads usually brings to adult stage by the next summer,. In the case of grass carp, Chinese black roach and in the common carp, two to three years are required.

Aquatic Vascular Plants. Because the lakes and rivers which are used for fish culturing purposes are generally shallow and less than 5 meters in depth and also are relatively flat, the growth of aquatic vegetation is very thick. The major species of the aquatic plants are Vallisneria, Hydrilla and several species of Potamogeton. The production of these plants are usually pretty high. For instance in 1957, one determination of the eastern lake in Wechung found that average production per hectare was 170 kilograms green weight. There are many lakes and small rivers which are similar and these waters provide beneficial conditions for the culture of herbivorous fish species.

Generally speaking, natural foods are suitable for the mixed species culture of grass carp, black roach, white bighead, striped bighead, carp and goldfish. This is because not only are the species of plants that these fish like to eat all present but they

are also very rich. If we can utilize this kind of condition and promote fish culture it is not too difficult to achieve the high production of fishery products.

Species Composition of Fish According to Geographical Zones

Lakes are usually stillwater bodies and are rich in natural foods for fishes, and those that are connected with the rivers serve as nursery grounds for semi-anadromous species. Therefore, the fish species that reside in the lakes consist of a small number of fish that are adapted to stillwater life (several species of Erythroculter) and several species of river type. Those species that are adapted to current are seldom seen in lakes.

The lakes along the fluvial plain of the middle and the lower Yansun River are generally rich in aquatic vegetation and therefore fish species that are mainly herbivorous such as the Parabramis, Megalobrama, Squaliobarbus, etc. Omnivorous species such as the carp and goldfish are very common. They deposit their eggs on aquatic vegetation, and usually become the dominant species in this habitat. The grass carp, even though a species that spawns in flowing water, also migrates into the lakes and uses them as a nursery area. They may remain in the lakes for long periods of time during their immature stages. Eutrophic lakes where molluscs such as snails and clams are rich provide excellent living conditions for the black roach and the

carp. Several small species of fish such as the Gobia often school along the shores among thick vegetation in the lakes and are seldom seen in rivers.

Because the lakes are rich in small miscellaneous fishes and because also there are plenty of shrimp, they become ideal for predatory fishes. The most commonly seen predators in the lakes are the snakehead, Chinese perch (Sinaperca) and catfishes. Their mode of feeding is not chasing after their prey, but rather they adopt a method of ambush. They are therefore suitable for stillwater life. There are also several species of Erythroculter that are common in the lakes. These fishes are not as voracious but they are carnivorous. Another fish, Elopichthys, often migrate into the lakes when they are chasing after small prey. Several species of Hemiculter are also very common in the lakes and often become dominant species.

The white bighead and the striped bighead depend upon planktonic organisms as food and they depend upon flowing water for spawning and ~~they~~ are therefore most adapted to river life. However, during flooding time they often migrate into the lakes and if they do not migrate out when the water recedes then they become landlocked in the lakes. In such conditions, they can live a normal life in the lakes only where production would be affected.

~~Some~~ ^{Some} species due to feeding and spawning demands frequently migrate into lakes during certain times of the year.

Examples are Salanx, Coilia, Ochetopius, Elpichthys, etc. Not found in the lakes are those genuine anadromous species which migrate from the ocean into freshwater to spawn. Only occasionally are the young stages of this species found in large lakes which are connected with the rivers. Generally speaking, not many species of fish are adapted only to lake life. Species that are residents of rivers and that have wide adaptability are usually the major components of fishes that are found in the lakes which are connected with rivers. Because riverine species have special demands for spawning purpose, they are usually restricted in the lakes and therefore the number of species of fish that are found in the lakes are usually about 1/3 to 1/2 of those that are found in the rivers.

The species make up of fishes in the lakes varies according to climatic conditions in different localities. In the northeastern area for instance where the climate is cold there are some northern species which are present in the lakes such as pike and Elophchthys.

At the present the rivers which are utilized for fish culture are mostly large sized water bodies or small tributaries to the lakes or even artificial canals. Generally these rivers are relatively narrow and have a slow flow. They are rich in vascular plants and have environmental conditions similar to those in the lakes. Therefore the fish species composition is similar to that of neighboring lakes.

Improvement of Natural Conditions

Natural water bodies that are used for fish rearing, *whether* ~~the~~ lakes or small rivers, vary greatly in the natural conditions.

Many of these water bodies due to their poorer natural conditions must be improved by man in order to increase their productivity. Also, those water bodies that have superior natural conditions can be made to produce more after appropriate improvement measures. Therefore the question of improving natural conditions has a great significance in increasing the productivity of lakes and rivers.


There are three major means of improving natural conditions: (1) increasing natural food of fish; (2) increasing the waters that are beneficial to fishery activities; and (3) control of elimination of fish enemies.

Increasing natural food: To increase the production of planktonic organisms proper fertilization measures must be taken, ~~(for details see Chapter 5).~~ To increase the production of benthic animals and underwater vegetation transportation, introduction of various species that are easily propagated should be done.

Increasing the water areas that are beneficial to fish activities: The major activity in this respect is to join *in the* effort with other culture work by building dams and by dredging the bottom mud from the lakes, in order to increase the depths of the water ~~to~~ to

between 3 and 5 meters. Sometimes, in the case of bays, dams or dikes can be built in order to increase the surface area. so that this improved water area can be used for intensive culturing of adult fish and siblings. The utilization rate and production rate of these water bodies can ^{then} be greatly increased.

The elimination of fish enemies: The control of predators and enemies of fish can be carried out according to the size of the water bodies and according to the scale of fish culture. It must be borne in mind that in China the species composition of lake fish is such that the predacious fishes usually account for a large proportion and many of these fishes have high economic value and also must be recognized that a lot of miscellaneous small fishes do not have economic value but also act as competitor for food.

In improving the natural conditions of small rivers it is important that as far as possible the velocity of the water flow should be reduced, by so doing the loss of nutrient material in the water can be reduced and that should be beneficial to the growth and reproduction of natural food. After the slowing down of the water velocity in the rivers, the other methods of improvement of the natural conditions for the lakes can be  also adapted for these rivers.

Fish Blocking Devices

In fish rearing in the lakes and the rivers the success or failure depends first of all on whether there is a good fish

blocking device. If the blocking equipment is poor, then the fish will escape no matter how good the other phases of fish culture are. Experience from various places tells us that of those rivers and lakes where the fish rearing has yielded good results, the fish blocking device has been generally good.

Lakes and rivers are used not only for fish rearing, they are used for many other purposes. Therefore, in constructing fish blocking devices attention must be paid not to interfere with the other uses such as flood control, irrigation, and navigation.

Kinds and Construction of Fish Blocking Devices

The fish blocking device that is most commonly used in China is built with bamboo or wire. The use of bamboo for fish blocking devices has had a long history in China. The use of wire is of relatively recent origin.

Bamboo fence. The use of bamboo to construct fish blocking fence has many advantages. First of all, it is cheap, secondly, it is common. The material can be obtained from many local places. Thirdly, it is easy to construct.

There are many kinds of bamboo fences: complete fence, straight-through fence, V-shaped fence, two-way v-shaped fence, bridge fence, bow-shaped fence, triangle fence, etc. Different shaped fences have different functions. They are built according to the shape of the

rivers, the water velocity, the winged velocity, and boat traffic and so on. The various kinds of fences are described below:

Complete fence. This kind of fence is used rather seldom. It can be used only where there is no boat traffic and ⁱⁿ narrow rivers where the flow is slow. It is made into a straight fence across the river without any doors and it completely blocks the river. The water pressure on this kind of fence is the greatest of all fences. (Figure 121, p. 375 - Caption: Complete Fence).

Straight-through fence. Like the complete fence the straight through fence is a fence directly across the river, the only difference is there is a gate installed to pass boats. This kind of fence can be built only on rivers which have a slow flow. This is the kind of fence that is most commonly seen in Chichown province where they account for 80% of all the fish fences (Figure 122 - Caption: Straight-through fence).

Small v-shaped fence. In rivers with a high velocity a complete fence or straight-through fence will not work well because of higher pressure of the water on the fence so that a different kind of fence has to be used. The v-shaped fence is built so that the cross-sectional surface of the fence is increased and thereby to reduce the pressure on each unit of fence surface. This kind of fence is to be used in rivers where the velocity is high. . Some

fishermen lengthen the v part of the fence in order to increase the surface of the fence, To achieve the maximum efficiency sometimes a double v or triple v-shaped fence is constructed for even more rapid water.

Large V-shaped fence. This kind of fence is similar to the small v-shaped fence except at the end of the v ^{where} a gate is installed which opens into a square box. This kind of fence is used in rivers ^{where} the velocities ^{are} especially great. The gate is usually closed in normal times when there is no flood but it is opened when there is a flood.

Two-way v-shaped fence. In some rivers where there is a tide during which the current is reversed, a two-way v-shaped fence is most suitable. (Two-way v-shaped fence.)

The v-shaped fence is the most common type of fence that is used in lakes and rivers where fish are reared. The important thing in the construction of this kind of fence is to locate where the ~~channel~~ ^{channel} is. The v should be located directly in the channel because this is where the velocity is the highest. Another important point is that the bottom of the v should be directly at the center of the current.

Bridge fence. This kind of fence is built near bridge either above or below where the current is rapid. The shape of the fence is more like a U. The gate of the fence is placed right in the middle.

Bow-shaped fence. This kind of fence is built at the confluence of the two branches to a main river. It is also called

moon shaped fence. The purpose, of course, is to divert water flow.

Irregular shaped fence. This kind of fence is built in a narrow river where the boat traffic is frequent, the water velocity is rapid, and it is not practical to build v-shaped fences. The shape of this fence depends upon the condition of the flow. (Figure 128. p. 379 -

Caption - Irregular Shaped Fence).

Triangular Fence. This kind of fence is built where the bottom near the shore is hard or rocky, where the bamboo fence cannot be planted solidly, then between the shore and the bamboo fence there is built a small bamboo fence to form a triangle. The space of the triangle is filled with dirt so that fish will not escape.

The Selection of Site for Fish Fence

The selection of fish fence must be based on (1) the fence should be built solidly and (2) the fence should not interfere with navigation. Therefore, the following points must be taken into consideration:

Straight stretch of the river. In Chinese rivers especially in Chikousou there are quite often many wooden vessels navigating in tandem in long series and if the fish fence is built on a winding course of river they will be damaged easily by the long series of vessels.

Narrow stretch of the river. The fish fence should be built at a site where the river is narrow. This would not

only save materials but would also make it easier to inspect and to take care of the fence. However, if the velocity is great and if the boat traffic is heavy then the fence should be built in a relatively wide location of the river because here the water flow will be slower. A good example is found in a fish rearing river in Chican province. In 1953, there was one fish fence which was originally built on the river at the place where it is 100 meters wide. For the sake of saving material this fish fence was moved to a location where it is only 43 meters wide. The result was when the flood came this fence was wrecked causing the fish to escape. After it was moved back to the original place, *this did not* happened again.

Appropriate depths. If the water is too deep it will be too wasteful to build the fence, but if it is too shallow then it is not convenient for the boats to pass. Therefore, a proper location must be selected where the water depths should be about 3 meters.

Low velocity. When the fence is built at the place where the water flow is slow it will last longer. Also, in these places the river is generally wider.

Flat bottom. For the convenience of planting the coast posts, a flat bottom will be much easier to deal with.

High shores and proper texture of bottom. When the fence is built at the place where both shores are high it serves as a safeguard against fish escaping during high tide or flood

stages. The texture of the bottom is also important because if its too hard then it is too difficult to plant the fence but if it is too soft then the posts will not hold.

The Construction of Bamboo Fence

The construction includes the planting of gate posts, the determination of water depths and the weaving of bamboo screens. As soon as the site has been selected and the water velocity determined, the construction can proceed.

The planting of posts. The bamboo posts are the major support for the fish fence and therefore the most important part of the fence. Only those bamboos that are large, strong and straight should be used. The planting of posts is best done during high water. A rope should be lined across the river where the fence is to be built near water surface so that the fence can be built ~~along this line~~ in a straight line. The planting of posts can be started at the gate and proceed toward both shores. The interspace between posts and that part of the post above the surface water should vary according to water velocity. Generally, the interspace between posts is from 1 to 2.5 feet and the exposed part should be 4 to 6 feet above the water level depending upon the nature of the bottom, ~~the~~ the water velocity, ~~the~~ wind conditions, and so on. The posts are generally planted in the bottom for 4 to 10 feet.

Main posts. These posts are erected on the downstream side of the fence. They are the main supports of the bamboo posts. Either end can be planted into the bottom but using the base or end on the bottom generally gives stronger support.

Coupling posts. Facing each main post is a coupling post which is placed on the upstream side of the fence. The distance between the main posts and the coupling posts is generally about 3 inches to 1 foot.

Gate posts. At each side of the gate, four posts are planted in places where the water velocity is great and boat traffic is heavy. The number of posts can be further increased.

Supporting posts. The supporting posts are installed between the upper and lower horizontal posts and can be planted on one side or both sides. Generally, they are planted only on the lea side or the downstream side.

Insurance posts. These are also called protection posts. They are installed where there is heavy boat traffic and these consist of vertical and horizontal posts only without any bamboo screens. The only function of these posts is to prevent the boat traffic from hitting the fence proper.

Termination of the water depths. After the posts are planted, the water depths along the whole cross section of the river where the fence is to be built

should be surveyed and measured so that the construction of the fence can be made accordingly.

Horizontal posts. In order to reinforce the bamboo fence some horizontal posts should be installed between the main and coupling posts. Generally, two rows of horizontal posts should be installed above the water surface and one to three rows of horizontal posts should be installed below the water surface depending on the water depths.

Bamboo splitting and fence weaving. fish fence is made of split bamboo. Splitting of the bamboo requires high skill. The bamboo must be split evenly and with uniform thickness. The characteristics of the bamboo fence are such that the bamboo is resilient so it is especially suitable for making gates. When the boat goes through the gate the bamboo will bend but will bounce back after the boat has passed.

The split bamboo is weaved into fish fence with pond twine. The thickness or diameter of the twine regulates with mesh sizes of the fence. In the case of rearing 2-year-old fish siblings and where the water is rapid and water velocity is high, coarser pond twine should be used. On the other hand, where the water velocity is low and the river is used to rear spring siblings then one should use finer twine.

The installation of fish fence. Installing the fish fence can be done one of two ways. One is by installing the fish fence first and then install^{ing} the fish gate, and two

is by tying the gate and fence together before they are installed in the river.

Wire fence. Wire fence is generally used in southern China. There are generally two kinds, one is automatically adjustable fence and the other is artificially controlled fence.

Other kinds of fish blocking devices. The two types of fish fences that are described above are the most commonly used in China. There are some other kinds of fish fences which are constructed in various local places utilizing local materials, such as in northern China ^{where} some fish fences are built with willow branches. Other places like in some parts of Canton, fish intestine materials are used. Fish bladder material is ^{also} used for fish fence building.

Fish Rearing

There has been great improvement in the method of rearing in fish culturing in the lakes and rivers in China. The smaller area water bodies which were used in the past for gross rearing have been used lately for intensive culture. Large water areas have also been utilized for gross rearing, and still larger bodies in which harvest only was carried out in the past have been utilized in recent years for conservation rearing purposes.

Intensive Culture. As mentioned earlier, rivers and lakes which are used for intensive culture must fulfill the

following requirements: 1) they must have facilities to prevent fish escape; 2) fish enemies and predators must be removed; 3) the problem of supply of fish siblings and feed **must** be solved; and 4) harvest conditions ^{must be} good. This is to say that in intensive culture lakes or rivers, one is conducting a high intensity mixed species method of rearing.

In other words a large number of fish siblings are planted and the main food source of the fish comes from an artificial source. However, this type of culture is not entirely the same as high intensity rearing in ponds where the intensive culture is based on the 100 percent artificial food and fertilization. Examples of intensive culture in large water bodies which have shown some relative success are a lake [redacted] and a river in Chican, and a lake in Kansee.

Aside from the aforementioned small type lakes and rivers that can be used for intensive culture there are some larger type lakes and rivers in which the bays are utilized for localized intensive culture, provided fish fences are constructed. In Hoopai province, for instance, the bays of a large lake are partitioned off to become small water bodies where intensive fish culture has been carried out. This is an efficient method for increasing the fish production.

Gross culture. Lakes and rivers that are utilized for the purpose of gross culture are relatively of large size. The required conditions for such kind of culture are that

fish fences are present to prevent fish escape, that basically it is possible to remove predators, and that there is no problem in the supply of fish siblings. Lakes and rivers that answer the above conditions can be used for fish culture. The main source of fish siblings will come from artificial planting in order to supplement the naturally present fish fry and siblings and also artificial food should be used as a supplement to natural food.

Conservation Culture. Generally speaking, this type of culture involves the protection of spawning and propagation of the fish. Depending upon local conditions several measures can be taken to increase the original fish species that are present in the lake. These consist of "river linking" and transportation of desirable species. At the same time regulations must be established to create closed areas for fishing and the limitations as to the fishing gear and fish methods. In addition, favorable spawning grounds could be created in order to encourage a large scale reproduction of existing species. On the other hand, fish species that either do not have economic value or that are predacious should be reduced to a relatively insignificant proportion.

River linking is a measure for lakes which has gates that link with rivers under appropriate conditions. These gates can be opened to let fish fry and adult fish to move into the lake following the flow of water.

There are ~~two~~ types of river linking. One is the in-current linking and the other ex-current linking. The former method usually occurs during a period from late April to August when fish fry are produced and when the water level in the river is higher than that in the lake. During such a period when the gate is opened the water will flow from the river into the lake. fish that come into the lake during this in-current linking are generally various species of fry. Ex-current linking is done in the succeeding year when the lake water level is higher than the river water level so that when the gates are opened the lake water will flow out into the river during which time the adult fish in the river will migrate up against the water current into the lake. These kinds of fish are adult species.

In-current linking is best done in the night, especially appropriate on nights before storms.

Intensive and Gross Culture Lakes

Fish fences must be carefully constructed before river linking and during in-current linking. In conservation culture lakes during in-current linking the gate can be wide open without having to have any fish fence.

The ex-current linking usually takes place in the spring. This method can be applied also to conservation culture lakes because this can attract parent fish in the lake to spawn.

River linking is a relatively new adventure and in many ways the techniques have to be perfected. The measure is closely related to agriculture and careful planning is required before it is done.

Fish Enemy Control

First of all it must be made clear that when we talk about enemy control we are referring to those lakes and rivers in which intensive culture is carried out. In such cases the predacious fishes and miscellaneous small species of fishes should be eliminated as much as possible. In the case of rivers and lakes where any gross culture is carried out it is necessary that comparatively larger predacious species be eliminated as far as possible and at the same time the size of fish plantings should be increased so as to reduce the danger of falling prey to predator species. As far as conservation culture lakes are concerned, generally no predator control is conducted. The only measure here is to get rid of those fish species that have relatively little economic value so that the proportion of food fishes is increased.

Fish enemies in the lakes and rivers refer to those that are predators and those that do not have much economic value but serve as competitors to the economic species and also those animals and birds that prey upon fish. Enemy control is a very important measure in fish rearing.

Major species of predators include Elopichthys, Bambusa, Chinese perch, snakehead, pike, and catfish . The principal food items of these fishes are various species of fishes and other animals such as shrimps and molluscs. Therefore, these species of fishes are enemies not only of intensive cultured lakes but also of gross culture lakes. They must be eliminated or there reproduction must be controlled.