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The major producers of fish fry in China are the Yangtze and Pearl River valleys. Together they account for over 75 percent of the nation's fish crop. The major species of fish caught are grass and common carp, striped and white bighead, black Chinese roach, Cirrhina molitorella, and half a dozen others. The Yangtze watershed produces fry from Hupeh to Kiangsu. Total number of fry taken number into the billions. The Pearl River produces slightly smaller numbers of fry.

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All collecting of fry in China is done with nets. Careful selection of netting sites is crucial to success. The types of nets used are many and varied. They all have different advantages and disadvantages that suit them to special water types. The collection of the fry occur during the annual fry "bloom." This period lasts approximately from mid-April to August. Besides fry, fish eggs are also collected at this time. Places and methods of collecting eggs are well developed and fairly successful. Identification of all species of fish fry is also well developed and accurate.

Counting the number of fry gathered raises some problems. The methods most commonly used are estimation, counting by aliquot, volumetric, and partition methods. Of the above methods, only the partition method is accurate. Separation of pest species and desired species of fish can also be a problem. The primary control methods are the sieve method and the squeeze method. Both are fairly effective.

FISH PRODUCTION IN CHINA

Fish Fry Producing Areas

The major fry producing areas in China are located in the Yangtze and Pearl valleys. In recent years, other producing areas have been discovered, but they are all of minor importance. In five provinces along the Yangtze, 1957's production was 13 billion fry or 56.3% of the total production in the entire country. The Pearl River is second only to the Yangtze River in importance, but the principal species here is Cirrhina molitorella. Its production in 1958 was 10 billion fry, accounting for 42% of nation's total. See Figure 1.

Yangtze River System

1. The main Yangtze. Fry are produced from Hupeh to Kiangsu along a 1,600 km stretch.

In Hupeh, the principal species harvested is the white bighead, and the next are black Chinese roach and grass carp. In 1957, the production was 4.5 billion, 19.2% of nation's total. In 1958, the production increased to 12 billion, taking the No. 1 position in the country.

In Kiangsu Province, the production in 1957 was 970 million.

In Anhui Province, the production in 1957 was 4,367 million, accounting for 18% of nation's total, second only to Hupeh. The white bighead accounts for 50%, the striped bighead, 20-30%, grass carp and black Chinese roach combined, around 20%.

In Kiangsu Province, the 1958 production was 1.9 billion, consisting of grass carp and roach, 70-75%, and the bigheads, 25-30%.

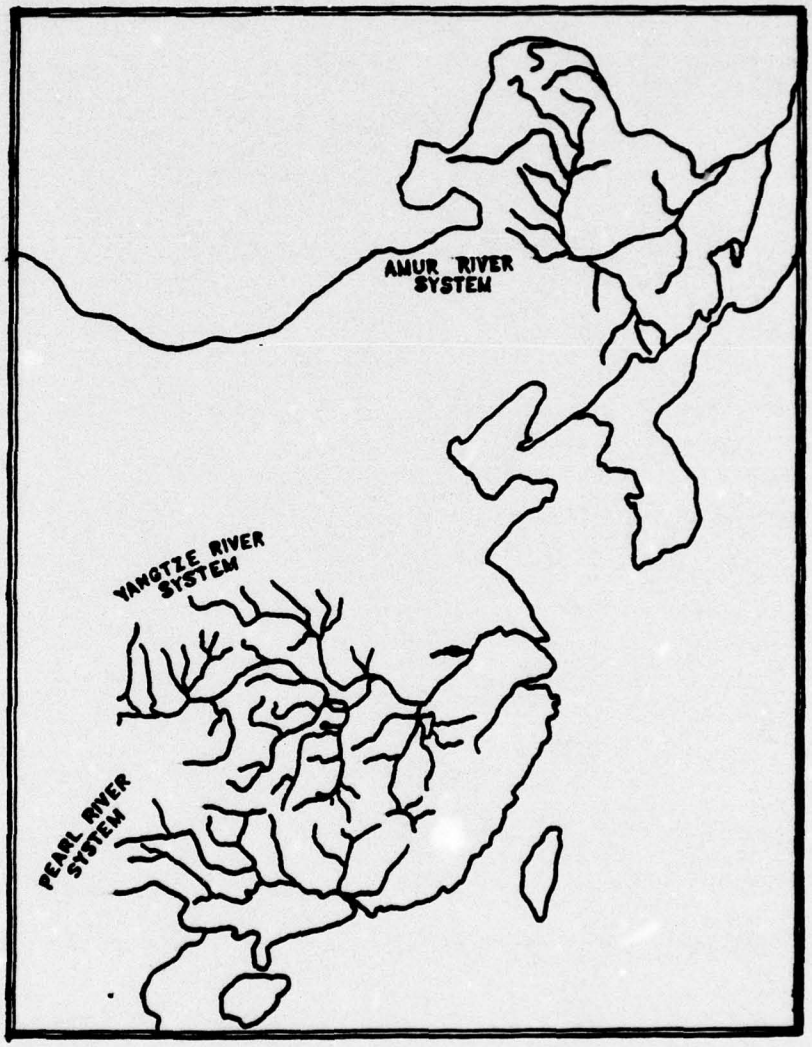

Figure 1 - Fish fry producing areas in China

2. Tributaries of Yangtze. Three major tributaries to the Yangtze River also produce large numbers of fry. These are the Han, Hsaing, and Kan rivers.

The Pearl River System

The Pearl River is made up of three main branches: West, North, and East Rivers. The West River is the most important contributor to fry production. The major species produced in this area is Cirrhina molitorella, which accounts for 80% of the total. Grass carp is next, accounting for 18%, and the white bighead accounts for 2%.

Other River Systems

Four other river systems in China also produce fish fry, but they are relatively minor in importance. These river systems are the Hwai, Amur, Great Canal, and Chientang.

Collection of Fry

Fry "bloom"

Fry "bloom" is a term applied to the phenomenon of mass appearance of fry in a river, and this is the time for fry collection. Fry bloom coincides with the spawning of the fish. The timing and duration of the bloom vary geographically. In the Yangtze River, the fry producing period lasts from mid April to early July. In the Pearl River, it lasts from mid April to the end of August.

1. Prediction of fry bloom

(1) Prediction of initial spawning date. Spawning season depends a great deal upon climatic and water conditions; and so does fry bloom. It therefore varies from year to year; and the difference may be as much as 20 days.

The most important factor is the temperature during the spring. The warmer the spring, the earlier the spawning and blooming. It has been estimated that if the weather stays warm after the beginning of Spring, fry will appear in 80 days; if the weather is cold after that date (February 15-18), fry will appear in 100 days.

(2) Forecast of fry bloom. Based on experience, fishermen forecast the onset of fry bloom on the basis of rain. This is because during the late spring to early summer, a heavy rain induces fish spawning.

(3) Phenomena accompanying fry bloom. The coming of fry bloom can be usually recognized by some phenomena that appear with the rise of river water. The water is usually turbid, full of debris, foam, and sometimes caddis fly larvae.

2. Periods of fry bloom. Fish fry are collected in five periods as follows:

(1) Mid-to late April. These are the earliest fry. They are relatively few in number, and consist of a large portion of undesirable small species. They account for about 10% of the yearly total.

(2) Around May 6. Fry produced in this period are larger and healthier, and are more fit for transport.

(3) Around May 22. During this period, water temperature rises above 20 C. Peak spawning takes place resulting in the largest production of fry. These fry are the most sought after by buyers.

(4) Around June 6. This is the height of summer, and it is very hot. Fry mortality is high during transportation. Fry are therefore mostly used locally.

(5) Around June 22. Fry production is small, and is used locally.

The above periods apply to Yangtze River. In the Pearl River, there are 8 or 9 blooms annually, and some of these may overlap each other.

Selection of Collecting Site

Most of the collecting gear used in China are setnets. Therefore, the collecting site is a determining factor of success or failure. All shoreline areas are not suitable for net setting. A lot depends upon the topography, current velocity, and current direction. Some of the more important points are the following:

(1) Current velocity. Fish fry are swept into the collecting net. Current velocity therefore becomes the primary factor in selecting the collecting site. If the current is too rapid, it will kill the fry that are collected in the net. A nearby river bank may collapse resulting in the loss of the net. On the other hand, if the current is too slow, the net may not extend fully, and not many fry will enter into the net. The most suitable velocity is about 0.67 miles/hour.

(2) Topography. Desirable conditions are relatively level bottom with a gradual slope and a depth of 5 to 8 feet. The two banks should be relatively straight, and parallel with the current flow.

An ideal spot for net setting would be at the confluence of two opposing currents, one flowing in from midstream toward the bank and the other flowing out from shore toward midstream.

A back eddy sometimes serves as a good place for setting the net if there is enough current flow.

(3) Nature of bottom. Avoid rocky, uneven bottoms. New delta area where there is a lot of new sedimentation should also be avoided.

Collecting Gear

The most prevalent gear used in the Yangtze River is the trap. There are two major kinds: the floating trap and the fixed trap. Both kinds are similar in structure. The only difference is that the floating trap is attached to a log or a bamboo stem, which can move up and down with the rise and fall of water level, while the fixed trap is affixed to stakes and is not movable.

1. Floating trap. Figure 2. This is the most popular gear used in Yangtze and Pearl rivers. There are many variations, but they are generally composed of three parts:

(1) Body. This is shaped like a half funnel, composed of a floor, a wall, and a sleeve. The sleeve leads into the tail box. The net is about 4 m long. The diameter of the mouth is 3-4 m. The sleeve is 0.9 m long and has a rear diameter of 10-13 cm.

(2) Tail box. This is the collecting box, usually 45x30x30 cm. It is mounted on a wooden support so that the net is above water surface.

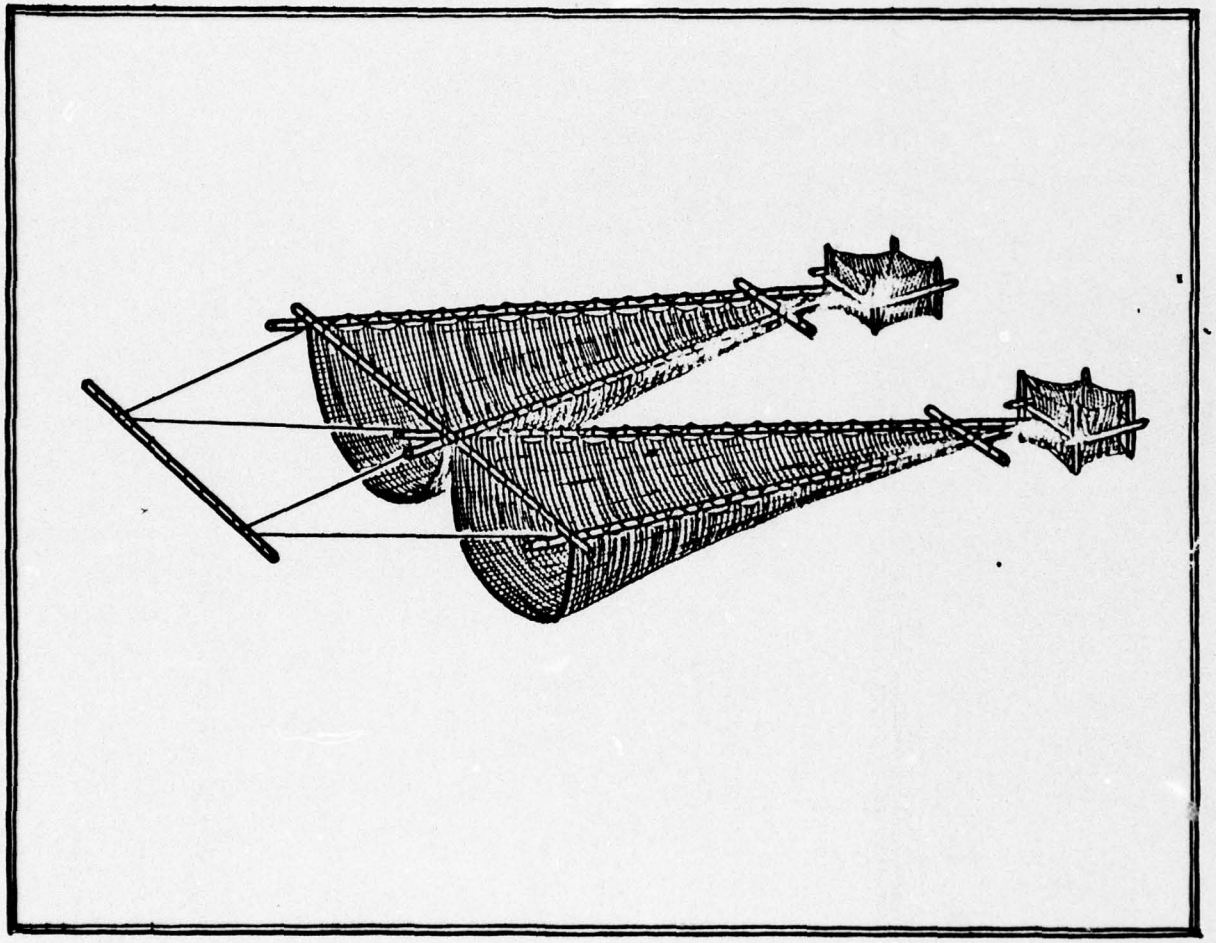

Figure 2 - Floating trap which rises and falls within the water level

(3) Frame. The frame is made of bamboo or log. It is V-shaped. It is used to fasten the net as well as to provide floatation.

2. Fixed trap. Figure 3. - The use of the fixed trap is limited to a few localities in Hupeh, Anhei, and Kiangsu.

The trap is made in the same way as the floating type. It is affixed to stakes that are planted into the river.

3. Bamboo trap. Figure 4. The shape of the bamboo trap is similar to that of the floating trap. It is also made of three parts: the body, neck (sleeve), and box.

(1) Body. This is constructed of split bamboo which is about 1 cm in width. Length of body, 3.4 m; width at mouth 1.3 m; diameter at tail end, 15 cm. Mesh size in front, 4 cm; mesh size at tail end, 1 cm.

(2) Neck. This is equivalent to the sleeve of the floating trap. Length, 70 cm diameter, 20 cm. It is made of cloth.

(3) Box. This is also made of cloth or silk material. It is rectangular, 105x36x36 cm.

The trap is attached to a floating log or bamboo, just as in the floating trap.

4. Cloth trap. Figure 5. This trap is used mostly in the Pearl River area. It is four-sided and tapers off toward the tail end.

The trap is made of cloth. The mouth of the trap is a rigid rectangle, 2 m long and 1 m high. A bamboo is attached to the top of the net. The sleeve is cylindrical, having a diameter of 25 cm at the mouth. The tail box is similar to that of the bamboo trap.

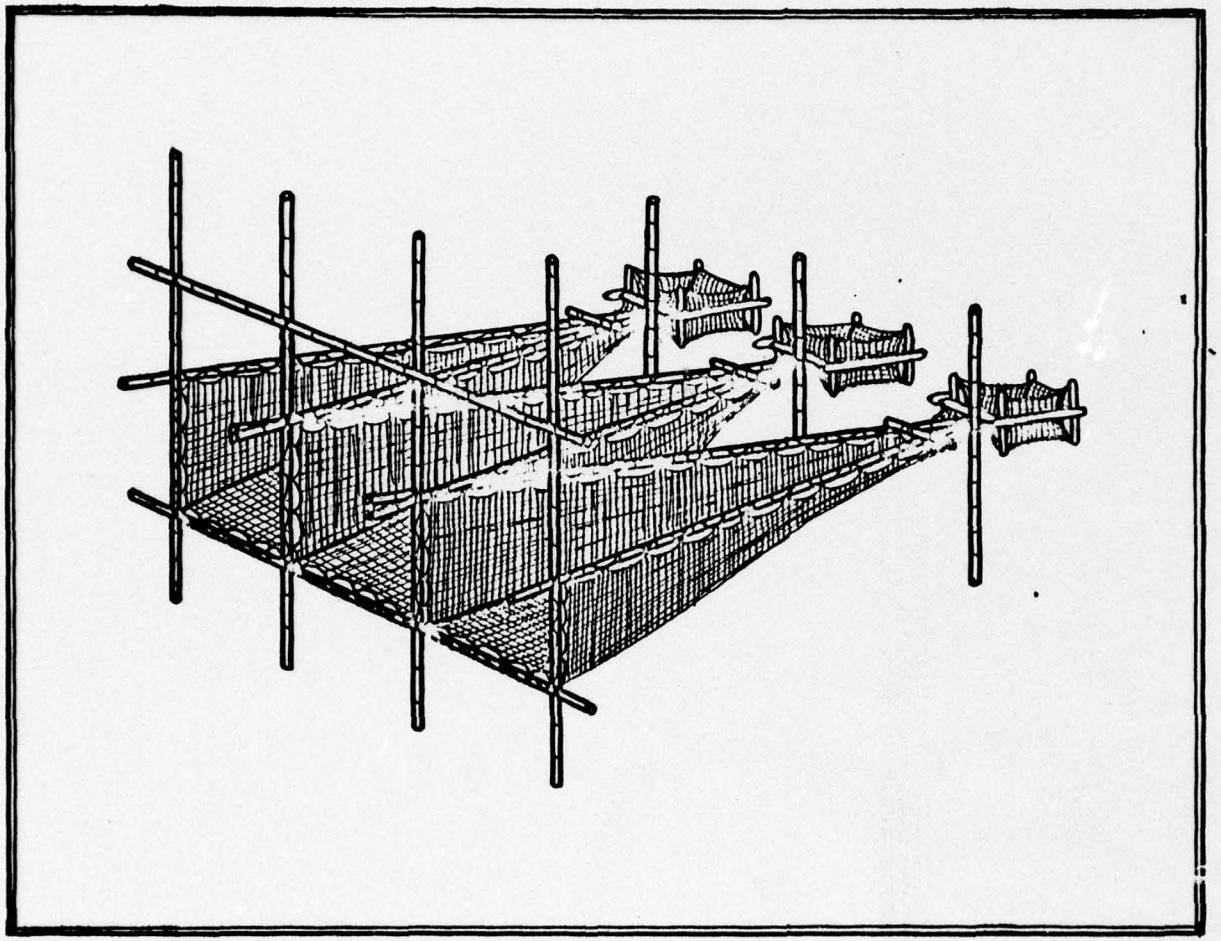

Figure 3 - Fixed trap, planted with stakes in the river

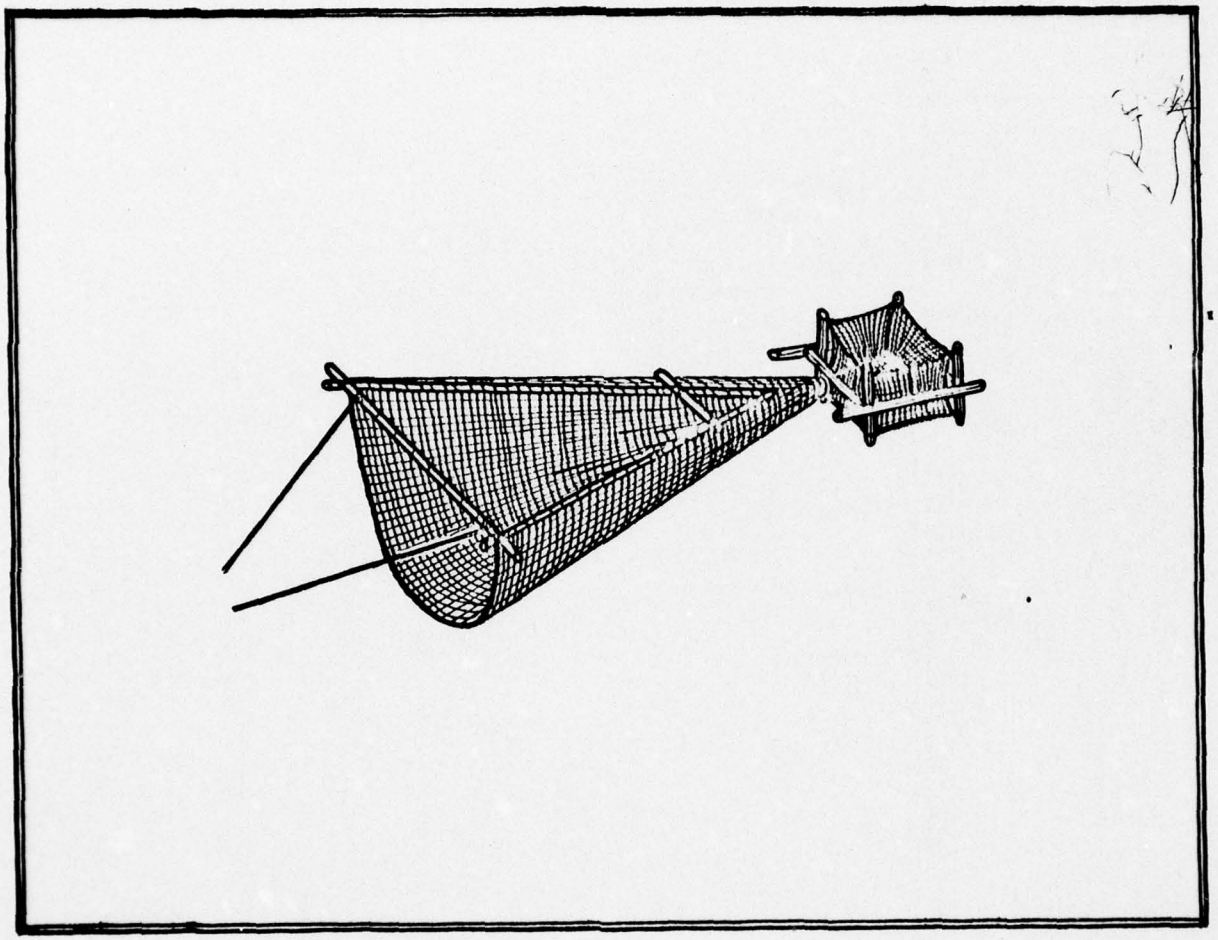

Figure 4 - Bamboo trap attached to a floating log

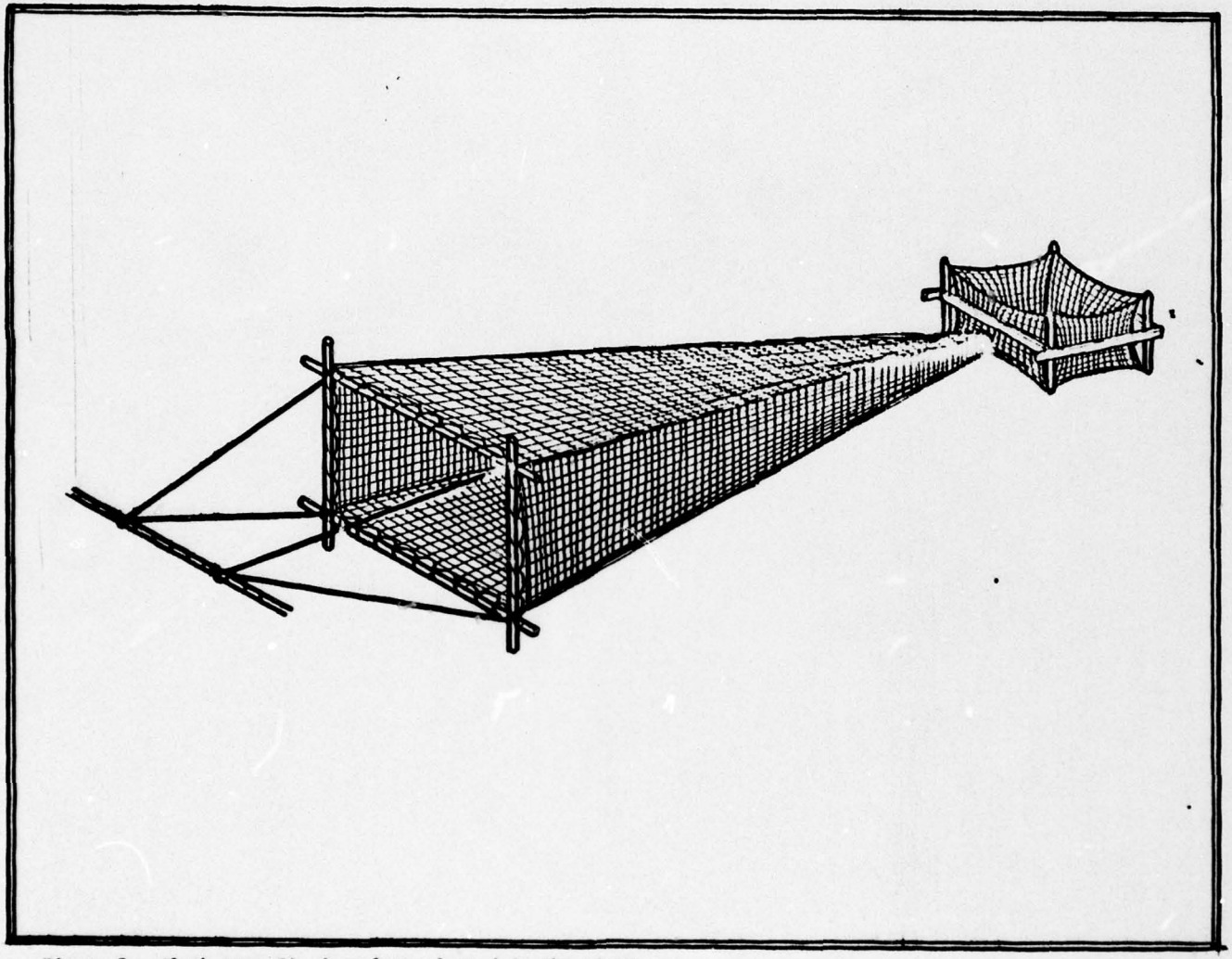

Figure 5 - Cloth trap-fixed to logs planted in the river

The cloth trap is affixed to logs in the same way as the fixed trap.

5. Merits and demerits of various gear.

(1) Floating trap. Merits are: low cost, easy to set, can rise and fall with the water level, and can fish continuously. Demerits are: easily affected by winds and waves; it must be tended and fished from a boat.

(2) Fixed trap. Merits are: resistant to moderate winds and waves; can operate from the net frame. Demerits are: more costly to install; cannot move up and down; extremely difficult to move from one place to another.

(3) Bamboo trap. Merits: cheapest to make; easy to operate and move; does not deteriorate easily; easy to clean; can rise and fall with the water level; adapts better in more rapid water. Demerits: not too productive; easily affected by wind and wave; structurally weak, can last only a year or two.

(4) Cloth trap. More productive than the bamboo trap but also more expensive. It can be used only in relatively slow-moving current.

6. Improvement on traps and fishing methods. In recent years many innovations have been added to the fishing traps described above. Some of the more important ones are as follows:

(1) Large-mouth trap. Figure 6. The opening of the trap is increased so as to filter more water, and do it more efficiently.

(2) Multisleeved trap. Figure 7. Increase the no. of sleeves to 5 - 7.

(3) Winged trap. Install two wings anterior and lateral to the mouth of the trap.

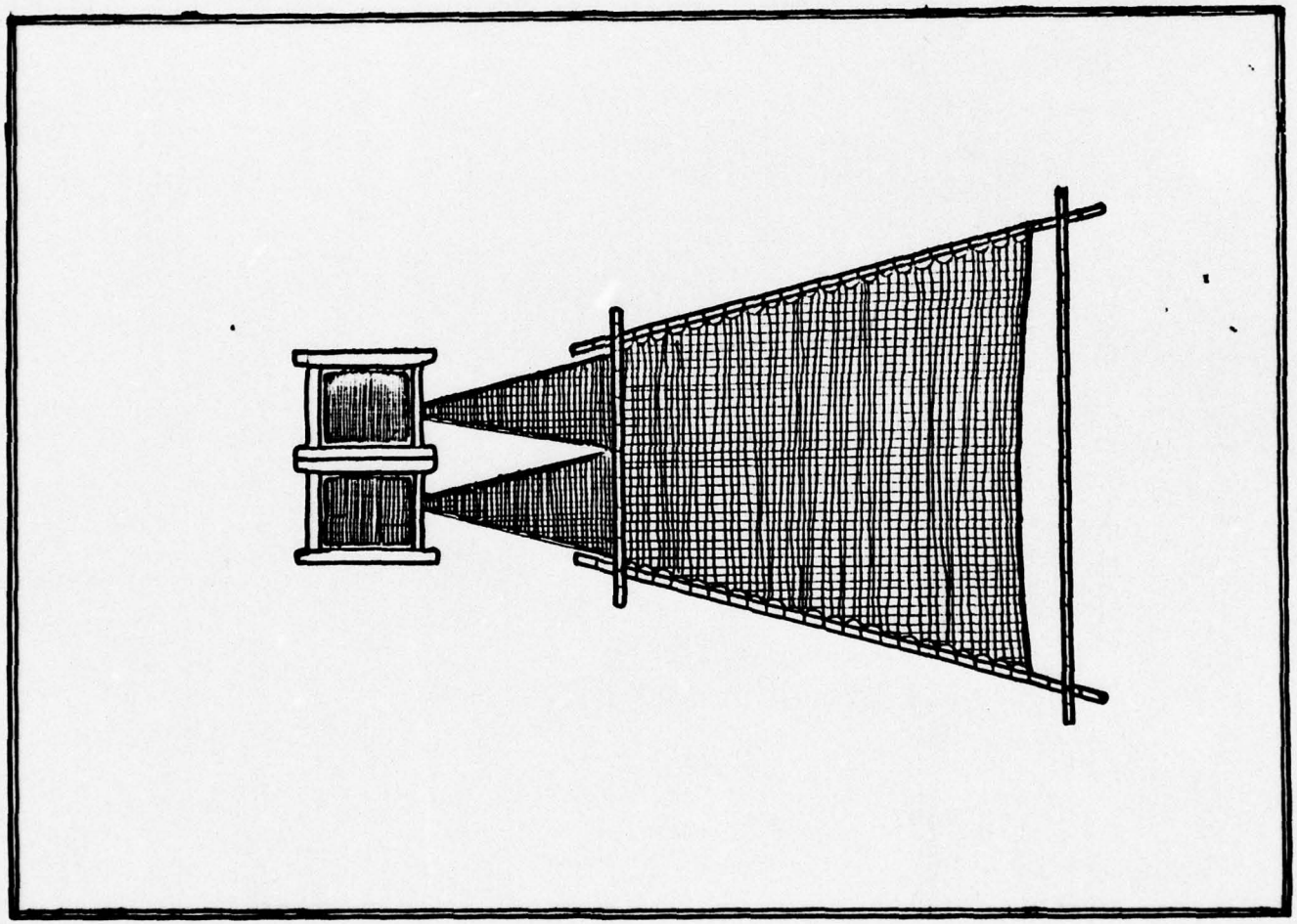

Figure 6 - Large mouth trap

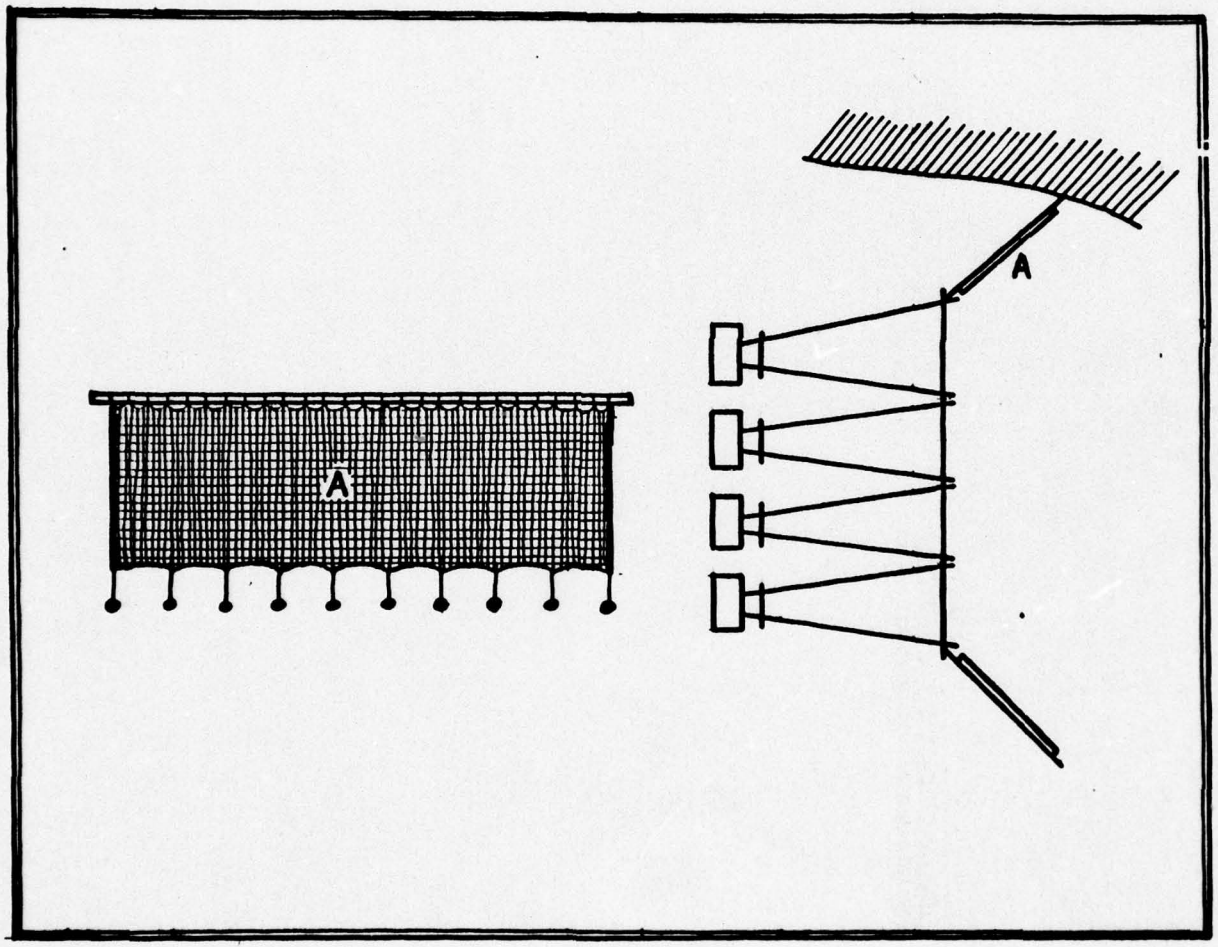

Figure 7 - Multi-sleaved trap and winged trap

(4) Large meshed floor. By using large meshed netting on the floor of the trap, the trap can be used in swifter waters and can be handled more easily. It does not, however, catch more fry.

(5) Increase the depth of net opening to 1.6-2.0 m. This can be accomplished by merely turning the trap 90 degrees.

Aside from the above improvements, there are also various devices which help to stabilize the trap so that it can fish during windy storms. These devices include connecting the tail boxes together, affixing the tail boxes to posts, and increasing the weight of sinkers.

Fish fry in the river are stratified in various depths. Domestic species of fry are present from 1 to 4 m. In one experiment that was conducted in Nanking, 43.5% of fry were caught in the upper layer, 27.6% in the middle layer, and 28.9% in the lower layer. According to the results by the Hainan Fisheries Institute the upper layer caught 27.73%, middle layer caught 32.35%, and lower layer caught 39.92%.

Fry Trapping

Based on prediction of fry bloom, fishermen usually put out a test trap first. When large amounts of fry are discovered, then full scale fishing is started. Testing fishing is undertaken every time before a bloom.

During fishing, the catch in the tail box must be emptied at definite intervals into larger containers. A large amount of debris and aquatic insects and larger pest fish species are often collected in the box. These must be removed by the use of a sieve.

In order to increase the production of fry, fishermen follow five "frequents." (1) Frequent testing. (Change the location as necessary). (2) Frequent emptying. (Fry in the box should be removed every 30 minutes, or at least once every hour or two when fishing is slack). (3) Frequent cleaning of the net. (Debris in the net is injurious to fry). (4) Frequent moving of net. (Fry occurrence depends upon water level, velocity, wind direction, light intensity, etc.; the net must therefore be moved accordingly). (5) Frequent study. (Study methods of improving the gear and adjust as necessary).

Names of Fish Fry and Their Identification

Names of Fish Fry

Fish fry are also called various different names by people from different localities. Generally there are two main kinds of fry: culturing fry and pest fry. The former include grass carp, roach, bigheads, carp, goldfish, bream, etc. that are used in commercial protection, and are cultured to some extent.

Identification of Fry

Many fish species spawn more or less at the same time in the river. The trap catch usually contains a mixture of species. To recognize the species is a very important skill. However, because fry are so small, identification is a difficult task. Fishermen can usually tell species by naked eye, a skill gained through long experience.

Fry are recognized by three methods: (1) Examined in water. Identification is based on the movement of the fry and the morphology of the back. (2) Examined out of water. Identification is based on characteristics viewed from the side. (3) Combined method.

Characters that are used to identify fish fry are as follows: (1) body shape and size, (2) size and position of the eyes, (3) shape, size, and position of air bladder, (4) shape of caudal finfold, (5) body color and distribution of pigments.

In production work, field identification with a naked eye is very useful, but it requires long experience. More reliable, of course, is by the use of a magnifying lens.

1. Grass carp fry. Trap caught grass carp fry usually measure 7.0 - 8.5 cm long. In fry, the dorsal side of the head is light orange in color, and has relatively large starshaped black pigments (not as dense as those in bigheads but denser than those in roach). There is a series of relatively large star-shaped pigments on the dorsal side extending from the head to the tail. There is also a band of pigments each along the dorsal and ventral side of the notochord, and near the caudal end of the ventral band there is a network of red blood vessels, giving rise to the name of "red tail". The ventral finfold in broader than that of roach; anal finfold is short and narrow; both finfolds are devoid of pigments. Caudal finfold is fan shaped, with a network of pigments on the lower lobe. Air bladder is oval; its longer axis is twice as long as its shorter axis, and is 1.5 times the diameter of the eye. There are 28-32 myomeres in the trunk and 12-16 myomeres post-anal.

2. Black Chinese roach fry. Length, 0.37 m fry, the head is light yellow with some light green shade. Pigments prominent, large, but scattered. The row of pigments along the back is scattered. Ventral

finfold is narrower than that of grass carp, and bigheads. Anal finfold is narrow and long. Both finfolds are devoid of pigments. Dorsal lobe of caudal finfold has a pigment mass, and the ventral lobe has a network of pigments. Air bladder is oval, has a blunt front end and a pointed rear end. Its longer axis is 1-1.5 times the shorter axis, and is 2 times the eye diameter. Trunk has 22-24 myomeres; post-anal myomeres, 15.

3. Fry of white bighead. Length, 0.29-0.37 m. In 0.37 m fry, head is light yellow, heavily dotted with granular and star-shaped pigment cells. Posterior to the eye and below the ossicle, there is a row of pigments, which extend along the air bladder and intestine to the tail. There are also 3 or 4 rows of irregular star-shaped pigments dorsal to the notochord. Ventral finfold is broad and has star-shaped pigments. Anal finfold is broader than that of grass carp and roach but narrower than that of striped bighead. Both dorsal and ventral lobes of the caudal finfold have a network of pigments. Air bladder is oval, its longer axis is 1.5 times the shorter axis and is 2 times eye diameter. Trunk myomeres, 24-26; post-anal myomeres, 14-17.

4. Fry of striped bighead. In fry, head is light yellow, with scattered star-shaped pigment cells. Body is also light yellow. In addition to the row of pigments along the intestine, there are also five rows of pigments on the dorsal and lateral sides of the body. Ventral finfold is broad with pigments; anal finfold has a row of pigments. The dorsal lobe of caudal finfold has some indistinct pigments, but the

ventral lobe has a network of pigments. Caudal end of notochord is curved upwards. Air bladder oval, its longer axis is 1.5-2.0 times the shorter axis and is 2-3 times the eye diameter. Trunk myomeres, 22-23; post-anal myomeres, 16-17.

5. Carp fry. Head compressed, triangular in shape. Length usually 7-10 mm. In fry, there are many irregularly laced round pigments. There are also two rows of round pigments along the back, extending from the head to tail. Air bladder is oval, slightly more pointed toward the posterior end. Dorsal and anal finfolds have a network of many blood vessels. When the fry is above 10 mm long, air bladder is partitioned into two lobes; pigments are greatly increased, and the body becomes dull green. Trunk myomeres, 17-20; post-anal myomeres, 11-14.

6. Goldfish fry. Eyes at fry 6-7 mm length are orange red with a light green shade. Head is short and squarish. Air bladder is oval and near the head. Irregular small pigments are distributed on dorsal and lateral sides of body. Caudal finfold rounded, with irregular pigments on the lower lobe. Dorsal finfold broad, with netlike blood vessels in posterior half. Trunk myomeres, 22; post-anal, 14.

7. Bream fry. In 0.28 mm fry, head is elongated; eyes are extremely black dotted with some fine golden yellow spots. Area around the pupil is pinkish. Distance between eyes larger than eye diameter. There are two black pigments on the snout. There is a large flower-like pigment on the ossicle. An even larger flower-like pigment is present

on the heart. Air bladder is somewhat oval, longer than high. Ventral finfold is broader than dorsal finfold. Caudal finfold is truncated. Body is covered with sensory hair. Myomeres 25 in the trunk, and 14 post-anal.

8. Fry of Cirrhina molitorella. In 7 mm fry, the body is pinkish, with many small round black dots. Air bladder conical, with the pointed end toward the posterior end. There are a few star-shaped pigments on the dorsal side of bladder. Caudal fin rounded. Myomeres, 24 in the trunk region; 9 in post-anal region. In fry 10 mm or longer, a network of star shaped pigments appear on the basal part of caudal finfold.

9. Fry of Squaliobarbus curriculus. In 6 mm fry, the head is oval as viewed from the top. Front the rim of the eyes, golden, showing a few black spots. The bladder is large, oblong, with its anterior end close to the base of pectoral fin. From the lateral view there is a row of black pigments extending from below the ossicle to caudal end. The ventral finfold is broad. Myomeres are, 25 in trunk, 12 in tail.

10. Fry of Siniperca chautsi. In 6 mm fry, fin rays are not developed on pectoral fins; other fins are undifferentiated. When 11 mm long, tip of notochord is curved upward slightly, and lower lobe of caudal fin shows bony fin rays. Intestine short. When long, body compressed, head large, more than 1/4 the body length. Snout pointed, mouth large. Mandibles bear fine, sharp teeth. Preopercle bears 4-5 sharp spines along posterior edge; opercle has two. Abdominal cavity triangular in shape, covered with several extremely large star shaped pigment cells. Anus situated in mid-length of body. A row of star

shaped pigments occurs post anus on ventral finfold. Bladder small, indistinct, and is constricted in the middle. Tail rounded. Body myomeres, 9, tail myomeres, 19.

11. Fry of Elopichthys bambusa. In 7-8 mm fry, from lateral view, oral slit extends to mid-eye. Rim of eyes pinkish except lower rim, which is slightly greenish. Ossicles larger than eyes. Fins undifferentiated. Posterior edge of caudal fin truncated. When viewed from the dorsal side, the snout is rounded, and short. Distance between eyes twice eyes is twice the eye diameter. The body is light yellow. When 10 mm long, the yolk sac is completely absorbed, the bladder is oval, twice as long as high. Body myomeres, 38-41; and tail myomeres, 15-19.

12. Fry of Parasilurus asotus. The body is light brown, both head and body are densely covered with round or patched black pigements. The intestine is short and straight. The anus located in the anterior half of body. In 8.6 mm fry, anal finfold and caudal finfold are contiguous. When the fry is 10 mm long, these two finfolds become separated and finrays appear also. Pectoral fin feather like; caudal fin truncated. Three pairs of barbels present. Body myomeres, 12; tail myomeres, 25.

13. Fry of Hemiculter leucisculus. In 0.24 mm fry, the eyes are large, and protruded, ossicles are distinct, the gill arch is present, the snout is blunt and the anus posteriorly situated. The intestine is fine and straight. The anal finfold is short and narrow. The dorsal finfold is narrow and long. In 8 mm fry, the bladder is present, and similar to the eyes in size. In 0.36 in fry, pigments are extend the whole body length and light yellow. Body myomeres, 32; tail myomeres, 11.

Deterimination of Species Composition and Quality of Fry

To determine species composition of fry in a catch, a sample is placed in a white tray, and the composition is estimated by visual examination. The composition is either in terms of percentage of culture species of the entire catch including undesirable species, or in terms of percentage of each culture species.

There are several ways of assessing the quality of fry. (1) Place fry in a white container, blow at the surface and watch for the reaction of the fry. If fry swim against the blow, they are strong; if they are blown to the side of container, they are weak. (2) Drain the container, if fry struggle hard and curl up head to tail, they are strong. If they stay flat against the bottom and struggle little, they are weak. (3) Stir the water to form a whirlpool, if fry swim against the current along the periphery of the whirlpool, they are strong. If they drift passively, they are weak.

Quantitative Measurement of Fry

There are many factors that make the counting of fry a very difficult task. At best it is an estimate. These are factors that affect quantitative measurement: fry are minute; they often occur in great quantities; species are mixed; fry are not uniform in size, and they are fragile and die readily once out of water.

Chinese fishermen use the following methods in estimating the quantity of fry:

1. Estimation. This depends entirely on experience. First, place an appropriate amount of water in the fish basket. Stir thoroughly to make fry uniformly distributed. Take a sample out on a white dish and estimate the species number and composition. Repeat several times. The total quantity of fry is estimated, based on the composition of species and volume of water.

2. Counting by aliquot. Use the smallest, practical container as an aliquot unit. Count fry in this aliquot, and calculate the total number of fry by the proper factor. Several aliquots of samples are counted to arrive at a mean.

3. Volumetric method. Before measuring, the seller and buyer must be agreed on the species composition. Concentrate the fry in the center of a net by lifting the net bottom to near the surface, then measure the fry by a standard sized container, usually a bowl. Generally, each bowl is regarded to contain 10,000 fry. In Kiangsi, where a tin cup is used, calculation is based on 80,000 fry per cup.

4. Partition method. This method is adopted in Kwangtung and Kwangsi. Fry are gathered into a cloth container. They are divided into two, then four, then eight, and so on portions, until a small enough unit is obtained when fry can be counted. The one unit is picked by lot for counting, and the number is multiplied by the proper factor to give the total.

Of the above methods, only the partition method is most accurate.

Pest Control

Fish fry that are caught in the river contain not only the culture species, but also many other nonculture species. Some of the latter are predators, such as catfish and Chinese perch; others are competitors, competing for food, oxygen, and space. Control of these nonculture species is a very important undertaking in fish culture business.

There are many methods of pest control, the best of which are sieve method and squeeze method.

The Sieve Method

This method includes sieving, selection, and separation.

1. Sieving. Fry of the same age and caught during the same bloom are of three basic sizes: One is the smallest, long, transparent, with only two eyes and the bladder dark. This group consists primarily of pest fry. The second group is slightly longer, being long and the body is light yellow in color. This group comprise generally culture species, plus some pest fish. The third group consists of the largest fish, and are mostly pest species. By using different mesh sized sieves pest fish are mechanically separated out.

Fish sieves are made of finely split bamboo. (See Figure 8). They are half spherical, with a diameter of 23.6 m and a depth of 11.8 m. Meshes are long and narrow. There are usually 24 sieves in a complete series, each sieve is designated by a number to indicate the width of the mesh.

The procedures of sieving consists of first, prepare a cloth container and place in an water area where work can be easily accomplished. Second, get rid of all debris and dead fry and leave only live fry in the container. Third, use a No. 2.5 to No. 3 sieve (mesh size 1.2-1.4 mm) to separate out the larger, pest species.

2. Selection. Oxygen consumption rate differs in different species of fry. Therefore, the tolerance toward oxygen depletion also differs. Selection of culture species is based on this principle. In a thick concentration of fry in a container, fish will surface for oxygen. The timing of surfacing differs according to species. Therefore different species of fish become stratified in the container, which is the basis for separation.

The selection procedure consists of:

(1) Place the fish fry that passed through the No. 2.5 to 3 sieve in a selection basket (diameter, depth), and fill the bast with water to the rim. Fry will generally stratify themselves in three layers. The uppermost layer generally consists of white bighead, striped bighead, black Chinese roach, and some pest species. The middle layer consists predominantly of grass carp fry. The bottom layer consists mainly of Cirrhina molitrella. In order to effect a higher percentage separation by species, it usually requires secondary separation, and much depends upon skill and experience.

(2) Sieving out pest fish. Fish fry that are separated out from each layer always contain a certain portion of pest species. To get rid

of pest species as much as possible, use appropriate sieves. By so doing, 95% purity can be achieved.

3. Separation. This is the procedure by which white bighead and striped bighead are separated. Also, the remaining pest species are removed. This is a complicated and difficult technique, and a lot of effort is required for preparatory work.

The white bighead fry occurs on the top layer and striped bighead on the lower layer. Also, because of the density of fry in the separation container, oxygen becomes very low and any pest fish that are mixed in it will die off rather rapidly.

The pond selected for separation work should be conveniently located. It should be rectangular, about half acre in size, and 0.8 m deep, and have a flat bottom.

During the first week of April, the pond should be drained and sterlized with lime. Leave it exposed for 7-10 days, then fill in with water up to 0.6 m deep.

Several days before fry are introduced, put in the pond wilted grass. After 4 or 5 days when large amounts of plankton are present and when the water turns from clear to dull red, introduce about 4,000 to the acre long striped bighead. The purposes are two-fold. One is to test the fertility of water. If these fish surface every morning, it means that fertility is just right for species separation. If the fish surface too much, it means that the water is over-fertilized and must be diluted. If the fish do not surface, then more grass should

be added. The second purpose is to eliminate larger sized zooplankton (such as copepods and cyclops), which are too large to be used as fry food, but will compete with fry for food and oxygen.

Before introducing fry into the pond, the pond should be partitioned into two series of compartmental ponds of unequal sizes with a communicating channel wide between the two series of ponds. Each compartmental pond is about wide by long and may contain 2 million to 2.4 million fry.

First of all, transfer all the striped bigheads into the communicating channel and shut all the doors. Then place the selected fry into the compartmental pond. This is done at noon when the weather is clear. Wilted grass is added to the pond at this time. Then at 3 P.M. all the grass is removed, and fry separation can be started at 4 P.M. A few hours after introduction of fry, pest species will largely die off due to oxygen depletion.

The separation depth is generally at, 6-9 cm, but it should be determined by sampling. Fry taken off from the upper layer usually consist of 90% of white bighead during the first separation, and about 50% during the fourth separation. After separation, white bighead and striped bighead are reared in separate ponds. One final separation should be made the next day. If there are still some pest fry, they can be removed by the use of sieves.

The Squeeze Method

The squeeze method is based entirely on the principle that tolerance of low oxygen level is much smaller in pest species than in culture species. The procedure is as follows:

Half fill a fish basket with clean water. Add to it a few hundred thousand fry. Create a whirlpool by stirring so that dead fish and debris will gather at the center of the bottom. Remove dead fish and debris with a pipette. At first, fry will swim in schools along the wall of the basket. After a while, due to depletion of oxygen, they will scatter and surface. Pest species will be the first to faint and rapidly die off. Culture species will soon also become much disturbed and finally will ball up. At this time fresh water must be added immediately. Stir the water to create a whirlpool and add mud paste into the basket so that mud will stick to dead fry and make them sink. Transfer live fry into a new basket and let them rest for a while. If pest species are still present, the process can be repeated once more. After pest fry are squeezed out, 2-3 cooked egg yolks, the culture fry are feed. They can be transported within a few hours.

The death of pest species is due to suffocation from the lack of oxygen. It has nothing to do with the increase of carbon dioxide. This is proven by the result of suffocation experiments with cultured carps. When carbon dioxide reaches 100 mg/l in water fry of four domestic carps will gradually lose their balance and start to die. If it is over 150 mg/l, then most, if not all, of the fry will die. However, in the squeeze method, carbon dioxide content only rises to 11.74 mg/l (Table 1), far below the lethal concentration. Besides, experiments with the four domestic carps show that the critical DO content is below 1 mg/l. In the squeezing process, DO approaches or even goes below 1 mg/l. Among the culture species, the white bighead, which has the

highest oxygen consumption rate, starts to be knocked out. At the same time, pest species, which has an even higher consumption rate, has already died out. It is clear, therefore, that the squeeze method kills pest fry by the depletion of oxygen, and that using the white bighead as a signal to stop squeezing is a reasonable means.

Table 1. Water contents of DO and CO_2 before and after squeeze.

No. Fry (bowls)	Air T. C	Water T. C	DO (mg/l) Before	DO (mg/l) After	CO_2 (mg/l) Before	CO_2 (mg/l) After
48	26.5	22.8	4.22	0.75	5.4	7.8
46	30.5	26.7	7.85	1.75	---	---
50	---	21.5	6.67	0.73	8.2	11.74
25	---	21.5	6.54	0.75	---	---
54	---	20.8	8.05	0.70	8.1	11.24
30	22.5	21.8	7.93	0.86	5.0	10.20

Advantages and disadvantages of squeeze and sieve methods

The advantages of the sieve method are that tools are of fine quality and are least injurious to fry during processing; that the technique is simple; that most of the pest fry are returned to the river to maintain fishery resource; and that the four domestic species are separated for separate rearing. The disadvantage is that pest species are only partly removed.

The advantages of the squeeze method are that the success rate is very high; that survival rate is high during transportation; and that tools are simple. The disadvantage is that all the pest fry and some

fragile culture species are killed. Also, the method is species and under-squeeze will not get rid of pest species.

Combining the merits of sieve and squeeze methods, a composite method should be practiced. The procedures of the composite method are as follows:

1. Cleaning of pond.

2. Get rid of pest species by sieving.

3. Separation of species by swimming behavior. Gather fry at one end of the pond, release water from the other end, creating current flow. Fry will swim against the current. Fry of the bigheads, being strong swimmers, will be in front, while the black roach and grass carp are slow swimmers and will lag behind. These two groups of fry can therefore be separated.

4. Separation of species by differential oxygen tolerances. Further separation of species can be achieved by subjecting fry to oxygen depletion.

5. Get rid of pest species.

Fry collected from the river usually comprise some 50 species, most of which are of economic importance. In numbers, the culture species constitute about one-fourth of the total. It is clear, therefore, that he great majority of collected fry are yet to be utilized.

Collection of Fish Eggs

A. Collection of eggs of grass carp, black roach, white bighead, and striped bighead.

Although there are many rivers in which spawning of culture carps takes place, only in Hsiang River, Hunan province, is the taking of spawn a well known practice. Here, there are more than 60 collecting places, extending in length. Among the species of eggs collected, the majority of eggs belong to grass carp and white bighead.

1. Prediction of egg bloom. In the Hsiang River, spawn taking is usually done from the latter third of April to the latter third of June. Prediction of egg bloom is based on weather and water conditions.

2. Selection of egg collecting sites. A good collecting site is essential to a good harvest of eggs. The following factors must be taken into consideration in the selection of a suitable site: water depth, topography, and water velocity.

3. Collecting gear. A fixed trap (Figure 9) is used as the collecting gear of eggs. The trap can rise and fall with the water. A typical trap consists of two supports made of bamboo rafts, which are set up in a V. At the end is built a little hut to be used by the watchman.

The trap consists of the body, funnel, and cod-end. The body is wide at the mouth, long, and has a mesh size of 3 mm. The diameter of the funnel is 4.4 cm. The cod-end is 1.5 m long, 80 cm wide, and 30 cm high. During fishing the net is held open by the current.

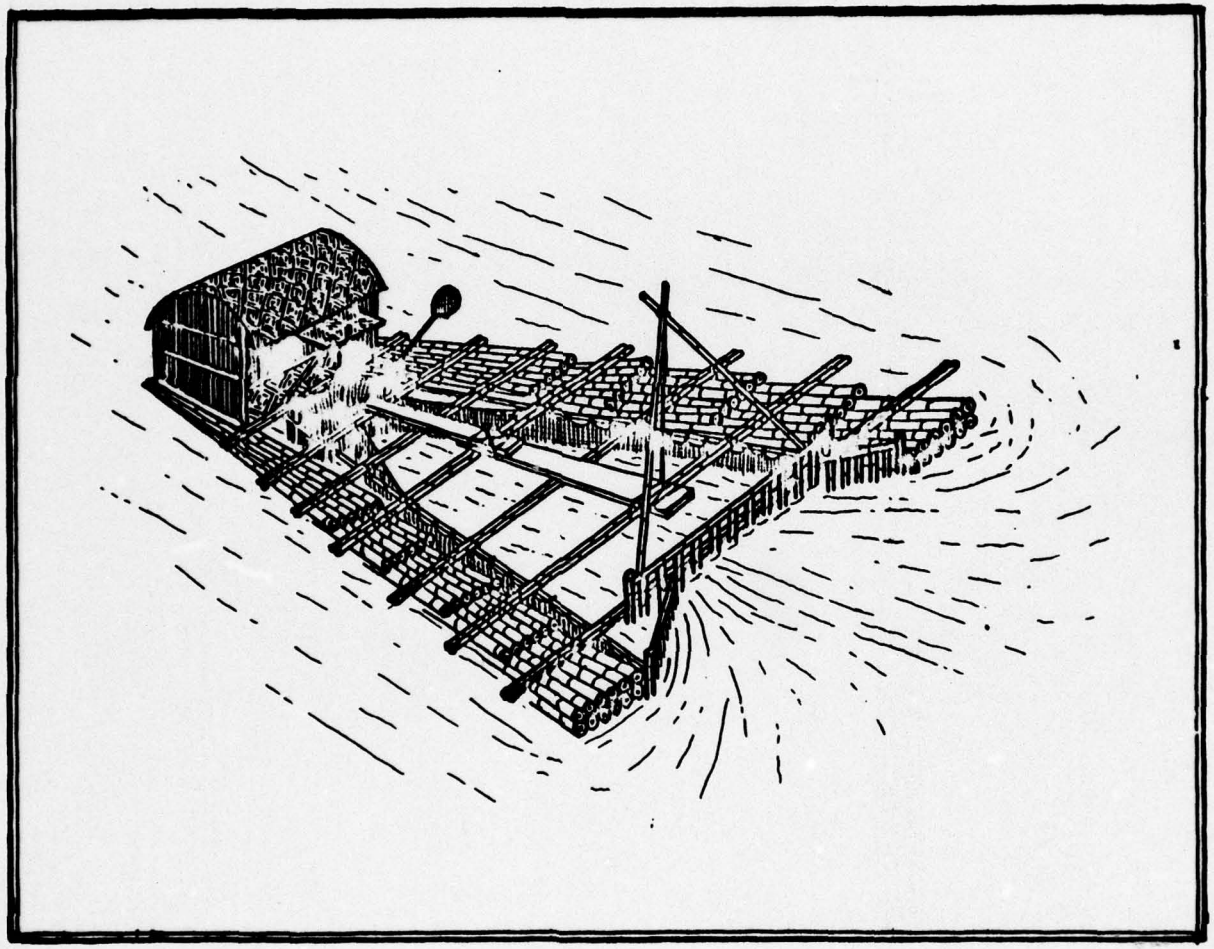

Figure 9 - Fixed trap for collecting fish eggs

The dip net has a diameter of 44 cm and is 3 cm high, and the meshes are 3 mm.

The grate is divided into the front and side parts. Its chief function is to prevent debris from entering into the trap.

A pair of fork posts are planted at the mouth of the trap to keep the mouth open and also to adjust the depth of the net.

Aside from the trap, there must be also a hatching box to hatch the eggs. The hatching box is rectangular in shape, and made of hemp or cotton webbing. It is 1.5 m x 0.8 m x 0.3 m.

4. Method of collecting eggs. Prior to egg bloom, test collecting should be conducted. Once the bloom is discovered to have started, the trap is then put in operation immediately.

The eggs are collected in the cod-end. They are dipped out and placed in a container and transferred into a hatching box to hatch. When the eggs are in large quantity, they can be dipped 30-40 times a day; when they are in low abundance, they can be dipped 8-10 times a day.

5. Identification of fish eggs and determination of their quality. Fish eggs that are collected in the river are nonadhesive, demersal. Because of their minute size, they are difficult to identify. Generally, identification is based on size, embryo size, shape, and color.

The eggs of culture species are generally larger than those of pest species. In the culture species, the eggs have a slightly yellowish vegetative pole and a light bluish animal pole. The color of pest species eggs is varied: yellow, red, black, or white, and they are non-uniform in size.

To judge the quality of eggs, one has to observe the embryo. When it has reached a stage of movement within the egg shell, the embryo is regarded as strong if it wriggles back and forth frequently. On the other hand, if the embryo merely moves occasionally, the fry after hatching is likely to be weak, slow growing, and have a high mortality rate.

The hatching boxes should be located in small bays with clean water and good circulation to prevent accumulation of mud. After hatching, it takes 2-3 days before absorption of yolk. At that time, the fry should be fed well cooked egg yolk. In a couple of days, they can be transferred into the pond for rearing.

The Collection of Carp Eggs

The common carp is a tenacious species. It can withstand both cold and hot temperatures. It is prolific, and requires an environment far different than that of grass carp, black roach, and bigheads. It can spawn not only in shallow areas among the grass in slow flowing rivers, but also in still waters, like reservoirs, lakes, and ponds.

To collect carp eggs, it is necessary to select the spawning ground, then place artificial nests. Carp eggs will adhere to the nests, which are then collected and placed in pond for hatching.

1. Time for collecting eggs. The common carp spawns when water temperature is between 17 and 21 C. The date varies according to geographical locality. In the Yangtze River, spawning starts in March or April; in Amur River, June; in Pearl River, December.

Spawning takes place usually just before or right after a thunder storm, or when the weather turns clear after a long rainy spell. Spawning is most active between midnight and dawn.

2. Spawning location. Locations that are conducive to carp spawning are (1) shallow bays in rivers where the flow is slow and grass abounds; (2) near shore areas in lakes where there is grass but not too thick to allow free movement; (3) slow flowing bays in lakes where water is clean and grass grows.

3. Method of collecting eggs. Carp eggs are adhesive. A proper number of nests should be placed in spawning areas. Nests should be examined frequently between midnight and dawn. They should be removed as soon as they are full of eggs and new nests can be replaced.

The Collection of Mullet Fry

The mullets (Mugil cephalus and Mugil soiuy are marine species. They can live not only in salt water or freshwater along the sea coast, but also in freshwater bodies inland. Therefore, they have become the favorable objects of freshwater culture species.

Mullets are quite abundant along the Chinese coast. Mugil soiuy predominates in the north, and M. cephalus predominates in the south.

The culture of mullets along the sea coasts in China has had a long historical record. However, the mullets do not reproduce in freshwater. Therefore, much effort must be expended each year in collecting natural spawns on the coast.

Spawning Season

Mullets grow in littoral sea. Their fry, when 10-15 mm long, migrate to estuaries to feed and grow. This is where they can be collected.

The appearance of mullet fry in estuaries varies according to geographical locations. In general, it is earlier in the south than in the north, and Mugil cephalus is earlier than M. soiuy. In southern China, from early February to April is the best time for the collection of M. cephalus. In mid-Eastern China Sea, M. cephalus appears as early as mid-February and persists until May. In northern China, the collecting time is from late May to July. For M. soiuy, the collecting time is usually later.

Habitat and Fishing Grounds of Fry

1. Fry habitat. When 10-15 mm long, the mullets migrate upriver, and congregate in inshore areas and river mouths where the salinity is relatively low. They prefer warm waters. In spring and summer they migrate into shallow shores to feed. In winter when water temperature drops below 5 C, the mullets migrate into the deeper parts of the ocean to winter. These fish are very active, often leap out of water, and therefore require a lot of oxygen. The young love light and frequent sand bottoms rich in organic detrites. Their food consists mainly of plankton. During the ebb tide, they school together, but on the flood tide, they scatter around in depth of 30-60 mm. Fry are more plentiful during calm, clear days with a big tide than on rainy, small tide days.

2. Fishing grounds. The following locations are where the mullets are often found gathered: (1) estuaries near the mouth of rivers; (2) Deep holes in bays where water is retained after the tides goes out; (3) in harbors where there are a lot of shelters.

Fishing Gears and Methods

Basically there are two kinds of fishing gears and methods:

1. Portable fishing gears and methods.

(1) Tow net. This net is made of two wings and a bag. On the tow line are tied shells, feather, etc. so as to make noise to scare the fish into the net. Set the net around a school of fry and have two men tow the net toward the shore. The fry are collected in the bag. They suffer some injury, and the survival rate is 70-80%.

(2) Seine. This is adapted to waters not deeper than. The net is rectangular, generally, and is made of cotton thread. In one tide (around three hours) over 10,000 fry can be collected.

(3) Push net. Figure 10. This is also made of cotton thread. The net is triangular in shape, supported by two bamboo poles on the sides. The bottom end of each pole is affixed to a wooden shoe to prevent the net from sinking into the mud. The bottom line of the net is lined with a row of 8-10 leads. This net is more suitable for smaller creeks.

(4) Bag net. Figure 11. This net is made of silk or linen thread of fine meshes. It can collect smaller fry. It is operated by two men.

2. Fixed fishing gears and methods. These devices save labor. They utilize light and food to attract fry so that they are very effective.

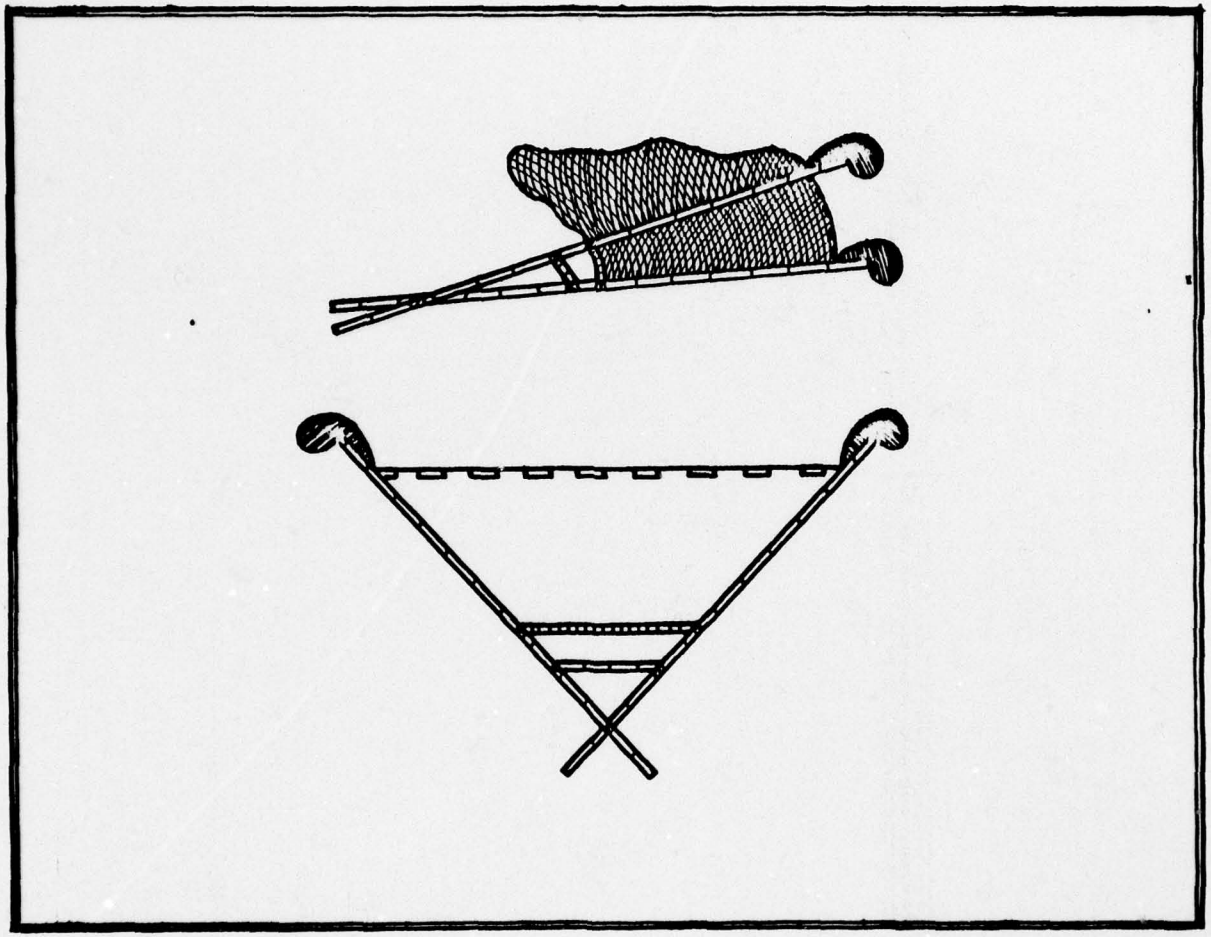

Figure 10 - Push net made of cotton thread

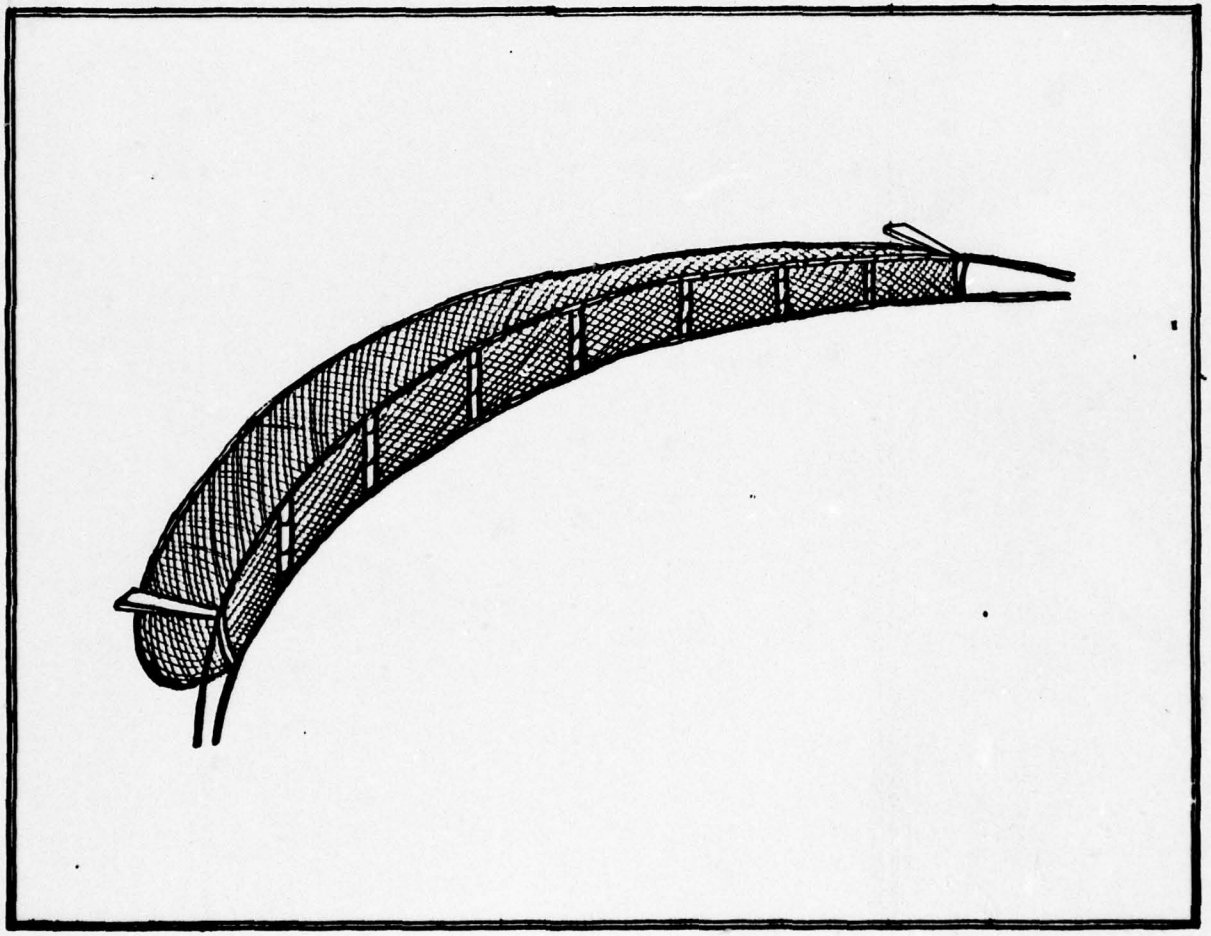

Figure 11 - Bag net made of silk or linen thread

(1) Balloon net. This net is used in tidal river mouth. It is made of silk or cotton thread. The total length is 2 m, the width at opening is 5.6 m and the height is 1.8 m. Net tapers toward the tail end, where it is 14-20 cm in diameter. The tail end is connected with an open box 50x50x40 cm, which is supported by a wooden frame.

(2) Collection by bait. During flood tide, use a sieve as the collecting gear. Place bits and pieces of fresh crab meat in the sieve and lower the sieve 8-10 cm below the surface. When fry gather to feed on the crab, lift the sieve to collect the fry. This method is not very productive.

(3) Light attraction method. This is for night fishing. Place a series of 6-12 W light bulbs under-water at intervals of 3m. At first, all lights are turned on. After 90 minutes, fry will gather near the lights. Turn off the lights one after the other as fry follow the lights until the last light is left lighted. At this time, a preset seine is hauled up to collect the fry. This method is best used during the ebb tide.

Identification of Mullet Species

Mugil cephalus, when 10-15 mm long, is laterally compressed; head rounded and large; mouth rounded, not protruded; a square red pigment on the head. Back greenish blue with a yellowish tinge; a small, insignificant red spot near the basal part of dorsal fin. Body silvery white. Pectoral fins large, situated high, with black pigments on the sides. They are strong swimmers, often schooled and form uninterrupted waves on the surface. On warm days, they prefer shallow waters.

Mugil soiuy, commonly called "pointed head", are easily mixed with M. cephalus. They are characterized by an elevated ridge in front of the dorsal fin. Body more compressed. Head pointed. From the same hatch, they are smaller, usually about 10 mm long. They are weaker swimmers; often swim and stop, therefore forming discontinuous surface waves.

References

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