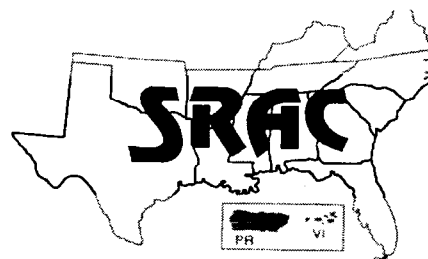


Southern Regional Aquaculture Center



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Harvesting Warmwater Fish

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Aquaculture is an established and viable commercial agricultural practice in many states. It includes a variety of native and exotic species grown for human consumption, fish bait, recreational fishing and hobby use. At some time in the production cycle from brood fish to marketing different live product forms, one or more life stages of fish must be harvested from the culture facility.

A successful fish farmer must know how to keep fish alive and healthy when they are moved. Different handling operations, like harvesting, can trigger stress-related conditions in fish. Stress from various handling practices weakens fish and makes them more susceptible to disease outbreaks and adverse physiological imbalances. The sensitivity of fish to stress associated with handling varies among species. Some are hardy, while others are extremely delicate and sensitive to the smallest of stressors. Eggs and young fish are more susceptible to sudden changes in their environment than are older, larger fish.

More care and precautions are required during harvesting if fish will be restocked into other facilities for further growout rather than sent to a nearby processing

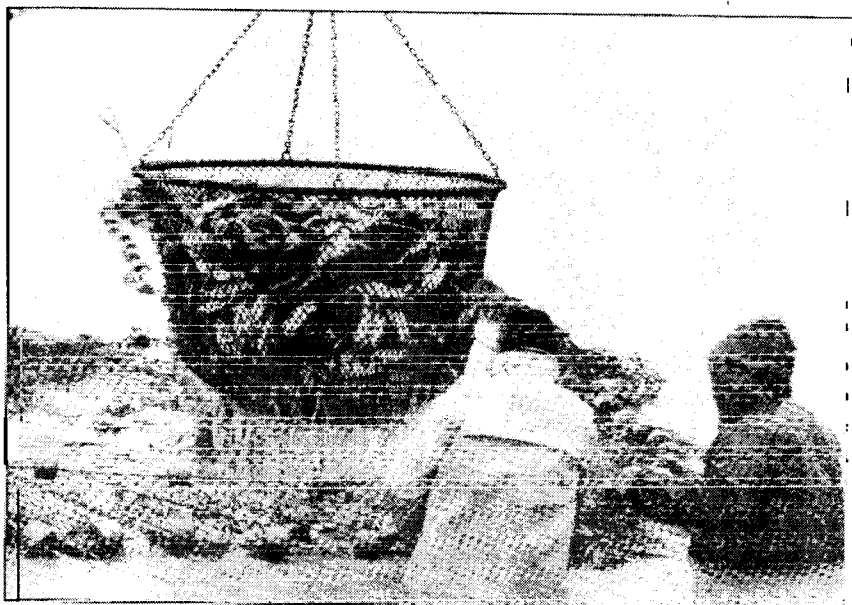
plant. However, recent problems in the catfish industry with red spots and blotches in fillets, called "red spot syndrome," are thought to be caused by stress incurred during harvest and transport to processing facilities. Therefore, it is wise to take every stress prevention measure possible any time fish are handled or harvested, regardless of their destination.

Several methods can be used to harvest fish efficiently and safely, but careful planning is required for a successful harvesting operation. Too often, ponds are seined and only a few fish are caught be-

cause of improper harvesting techniques, poor pond design or insufficient planning. Consequently, harvesting logistics should always be considered in the design and construction of aquaculture ponds. The approximate number and weight ranges of fish in ponds should also be known or projected so both the pond owner and buying customer are not disappointed with a shortage of fish for delivery.

Pre-harvesting guidelines

Plan easy removal. Before planning the harvest operation, make sure that fish can be removed eas-



Fish basket on boom truck for moving fish from pond to truck.

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ily from the production unit. If a cage or raceway is used to grow-out fish, then harvesting is somewhat simplified and fish numbers and weights should be known. However, when fish are in a large pond, several factors can delay or stop harvesting. Also, an inventory of fish stocks is more difficult to maintain when a pond has been in continuous production for several years. In such systems, larger fish are "topped" and smaller fish have been understocked, resulting in a wide diversity of sizes of fish in the pond.

Avoid debris and delays. First, check for debris on the pond bottom that will snag the seine or live-car. Aquatic plants may not be visible at the water surface, but may be growing at or near the pond bottom. These plants can cause the net to roll up at the bottom and may make seine dragging impossible. Fish can be killed if they are entrapped in aquatic weeds during harvest. Nuisance weeds should be controlled before harvesting is scheduled. During an unexpected delay in harvesting, fish prices may change, an off-flavor condition may develop, and the crop may have to be held into the next growing season, seriously impacting cash flows. So, avoid unnecessary delays that may be costly.

Take samples. It is important to know what's in your pond before harvest. Sample fish with a short seine, cast net, lift net or snag hooks, depending on species. Keep records of fish numbers and amounts of feed consumed. Ensure that the quantity of fish expected to be harvested can be marketed. Otherwise, you may have to release many fish after expending considerable time and labor. The harvesting operation may severely stress fish after they are trapped, crowded and held. Release of these fish back into the pond or culture facility can markedly affect their mortality risk.

Check fish health. It is essential that fish are healthy and in good condition before being harvested.

Signs of good condition include good feeding appetites, no mortalities and no obvious external problems. A sample of fish can be examined by a qualified fish health specialist to determine if any obvious health-related problems exist. This does not mean that fish are certified to be disease free, but it does provide more information to determine the condition of fish stocks. If sick fish are handled, the added stress can trigger a disease outbreak that can cause high mortalities.

Try to pick favorable conditions. You should have adequate labor, equipment and supplies available for harvesting. Weather and water quality conditions may also be important. On many farms, food-sized fish for processors are harvested regardless of the weather. Only thick ice on ponds may stop some harvesting operations. Movement of large trucks and harvesting equipment can rut and damage levee tops that are excessively wet and lack protective cover such as gravel. In severe cases, equipment may not even be able to reach ponds because of the poor condition of access roads or levee tops. Main levees should have a gravel cover that provides an all-weather surface.

Stop feeding. Take fish off feed before they are harvested. Withdrawal varies from one to two days during summer, to three or more days during winter. This is especially true if fish will be transported long distances. Undigested food can be regurgitated in the transport tank and foul the water quality. Fish are also hardier and less stress occurs when their stomachs are empty. If food fish have been fed medicated feed, be sure that the proper withdrawal time has passed before they are harvested for processing. A 21-day withdrawal period is required for Terramycin® medicated feeds and three days for feeds containing prescribed levels of Romet® for catfish. Water quality conditions should be good during harvest. Beware of possible low oxygen con-

centrations when fish are harvested at or shortly after sunrise.

Check for hydrogen sulfide. In deep water ponds, hydrogen sulfide can accumulate in oxygen-deficient bottom muds and may be released upon disturbance of the pond bottom. This gas is highly toxic to fish and can be detected by a smell similar to that of rotten eggs. If unsure about this condition, stir up the mud around the proposed harvesting site to determine if a potential problem exists. If a rotten egg smell is noticed, find another suitable site. Stir up the site to release the gas before harvesting or treat with potassium permanganate to oxidize the gas. This condition is seldom a problem in shallow, warmwater fish ponds.

Check temperatures. Harvest sensitive species during the early morning when water temperatures are lower and sunlight is less intense. Some fish, like golden shiners, striped bass and the striped bass hybrids, are harvested most successfully at water temperature less than 65°F to minimize stress and fish losses. They require special handling during harvest at higher temperatures. Fish should be moved quickly from ponds to buckets or transport tanks in freezing, windy weather. Exposure to sudden temperature changes can shock fish, especially small ones.

Investigate custom harvesting. In some areas, harvesting can be contracted. The custom harvester supplies the labor, equipment and expertise. Cost is based on the total pounds of fish harvested and possibly a distance factor. Producers may also cooperate in a local area by sharing labor and capital for harvesting purposes. Many farms have their own harvesting capability when harvesting is frequent or self-sufficiency is needed because of the unavailability of custom services. Purchase of specialized harvesting equipment should be cost beneficial, and adequate labor is essential.

Basic equipment

There is a variety of harvesting equipment used in the commercial fish farming industry. Various nets are available for harvesting, in addition to specialized equipment that includes livecars, boom trucks, loading baskets, fish pumps, boat with outboard motor, and other items. The choice of equipment depends on the size of the operation, available labor, frequency of use, available capital, preferred harvest method, volume and sizes of fish harvested, and species considerations.

Cast nets. These are inexpensive and useful for sampling. Cast nets are made of monofilament nylon, and the mesh size should be matched to the species harvested. Fish with spines entangle easily. With practice and patience, anybody can throw a cast net properly.

Lift nets. Bait minnow and tropical fish producers may use lift nets to capture small numbers of fish. These nets are made of soft, small mesh that minimizes injury. Fish are lured into the trapping area with feed, and the net is lifted quickly when fish are evident. The lift net and its assembly are portable.

Short seines. Short 10- to 20-foot long "Commonsense" minnow seines work well to harvest fry in tight schools. Seines can be pulled manually by two persons or can be shortened and used like a dip net from a boat. The water should be clear. Once fry break out of schools and scatter, a V-trap can be used for harvest of small, delicate fry.

Success depends upon knowing the habits of fish and locating the trap properly. The V-trap usually has glass or fine mesh sides that form a narrow vertical opening that fish enter. A lead panel may extend from one or both sides of the mouth to guide fish into the opening as they move along the pond bank. Set the trap so fry swim between it and the shore. The lead panel intercepts fry and leads them into the trap. Use a dip

net to harvest fish daily (or as often as necessary depending upon species) from the box-shaped trap.

Gill nets. These can be used in ponds to harvest large fish selectively or a few at a time. They are normally strung across a pond. They are made of clear, monofilament nylon that makes them difficult for fish to detect. Floats are used to mark their location, and each end is anchored. Nets can be totally submerged or extended from the surface to the pond bottom. Fish can be driven into the net by a boat to increase the catch. Gill nets work best at night when less visible, and should be checked frequently because fish caught usually die. They can also be eaten or damaged by turtles or other predators.

Large seines. The most common type of harvesting equipment is the seine or harvesting net. Seines work well in large regular-shaped ponds with relatively flat, unobstructed bottoms. Ponds that can be harvested without draining are called seine-through ponds. No water is drained for seining typical levee type ponds, but in some embankment ponds water levels are lowered to facilitate harvest.

Net features

Mesh size. Select the proper mesh size to harvest fish of the desired size. Fish shouldn't go through, be gilled or become entangled in the net. Raschel nylon mesh is available in various sizes and is recommended for fingerlings 4 inches or smaller.

Small mesh seines are harder to pull because of more resistance. Also, mud does not sift through them as readily. Seine length should be one and one-half times the widest part of the pond. This assures enough length to keep the weighted line on the pond bottom and levee toe as the seine is pulled. The depth of the seine should also be one and one-half times the maximum water depth. For large commercial catfish ponds, seines may be longer than 1,000 feet.

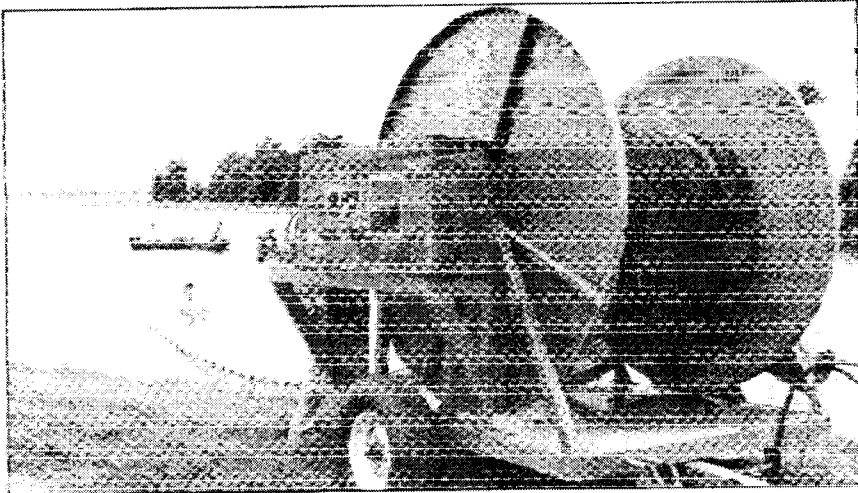
Because of such weight, tractors are used to pull them.

Texture. Net texture is determined by the material and how the mesh is formed, either with knots or woven. Nylon nets should be coated with a resin or asphalt-based net preservative to prevent catfish from getting caught by their spines. Polyethylene nets require no coating treatment. Knotted net is suitable for catfish, but most scaled fish require soft, uncoated knotless nets. These nets limit injuries from scale loss caused by abrasions. Carp or buffalo fish, however, can be harvested with knotted nets. Number 42 nylon twine is recommended for catfish and other large fish to provide adequate strength. Net manufacturers can recommend the proper size, number and distance interval between floats.

Bottom line. The bottom line, or mudline, of the seine can have a many-ends sisal mudline, 2-inch diameter mudline of knotless mesh nylon netting or hard rubber rollers. The design affects how deep the bottom line digs into the pond bottom and its ease of pulling. Evaluation studies of various mudline designs indicate that roller-mudline equipped seines are preferred when harvesting food-sized channel catfish from ponds with irregular bottoms consisting of deep, soft muds. The mesh-mudline is recommended when harvesting channel catfish from ponds with hard bottoms or harvesting fingerlings because of its lighter weight and tendency to clear mud.

Seine reels

A hydraulically operated seine reel is often used to transport, store and beach the seine. There are various models and sizes. Most are single reels, but some have two. The smaller second reel hauls in the loose end of the seine when fish are funneled into a sock or livecar. With the single reel, the loose end is landed manually. A standard 5-foot reel can store seines as long as 1,200 feet. The



Hydraulic seine reel used in seining large ponds.

reel is mounted on a trailer. Some have hydraulic controls that pivot the reel into various positions to line up with the seine as it is landed.

Basic harvesting operation

Seine crew. Five to seven persons form a seining crew for large ponds. Two to four persons inside the pond keep the weighted line on the bottom near each levee toe, two drive the tractors, and one operates a boat to dump mud from the bottom line. An experienced crew can seine a large pond and

concentrate fish in one to two hours.

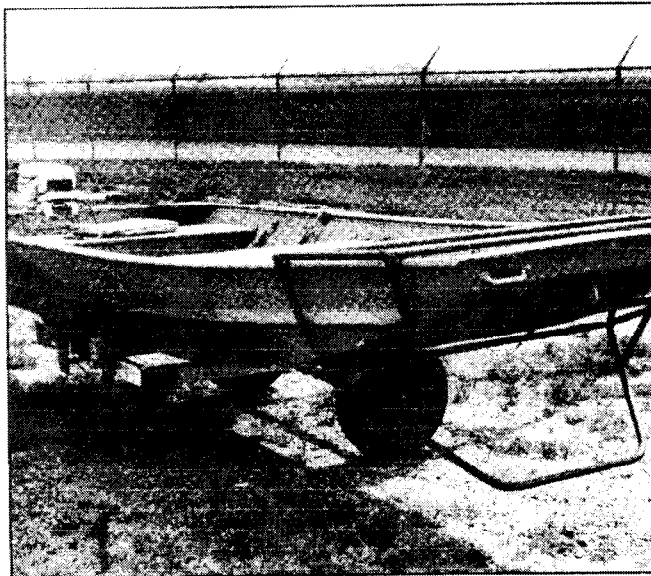
Seining technique. The shape of the pond determines how it should be seined. Usually the proper length of seine is stretched across the narrow end of the pond in front of the drain structure: A bracket on the bow of the boat, or the float line laid over the bow, helps push the seine as it collects mud. Watch the float line for indications that the net is "mudding up." The floats will be pulled underwater if this occurs. The seine boat should quickly move to roll

or dump the mud from the seine so that fish do not escape. A 14-foot boat with a 25-horsepower outboard motor is adequate. A chemical boat also works well and has ample space for carrying a livecar. Pull the seine slowly with a zig-zag motion at about 25 to 45 feet per minute to prevent the seine from lifting off the bottom. Seines will have to be pulled over or pushed under aerators, depending on how they are anchored.

Seines can be pulled manually or with small tractors, trucks or four-wheelers in small ponds less than several acres. A seine longer than several hundred feet, however, is difficult to pull manually in ponds with soft, muddy bottoms. A bag that is woven into the seine is a nice feature for small seines. It provides a good area to capture, hold and harvest fish.

Land the seine near a water supply or aerator where fresh, oxygenated water can be provided if needed. When fish are crowded, they can rapidly deplete the dissolved oxygen in a localized area, especially in warm weather.

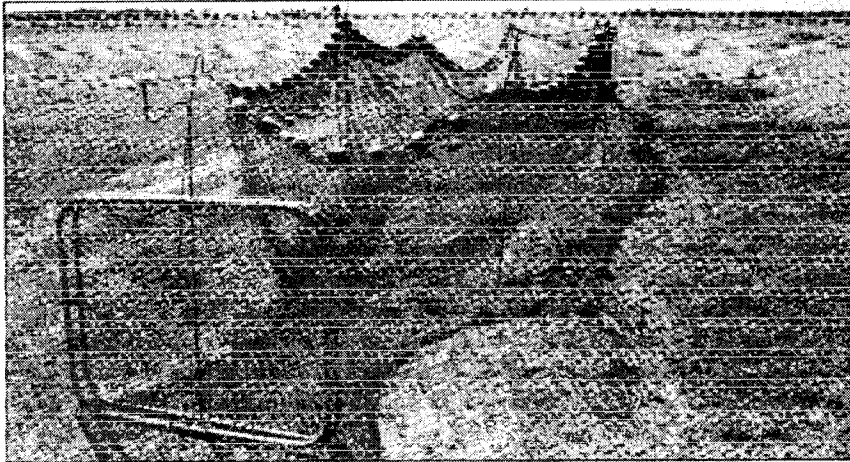
Holding fish. A device called a livecar, or sock, is used to crowd and hold fish. Attach it to the seine after fish are crowded with the har-



Seining boat for working large seines.



Boom truck used for loading fish from pond onto hauling truck



Livecar (sock) used for holding fish after seining.

vesting seine. This lessens the chance of the livecar hanging up on snags and decreases the pulling drag. A short piece of rope ties off the funnel end of the harvesting seine until the livecar is attached.

The livecar has a metal loading frame which attaches to the seine with drawstrings. The metal loading frame sets up a narrow chute to funnel fish into the livecar as the seine is beached. Without the chute, many fish can remain in the seine as it is landed. They will then be much harder to move into the livecar.

Water should be at least 2 ½ to 3 feet deep for easy fish transfer. If water temperatures are below 60°F, fish can be held many hours and overnight. However, if temperatures are in the low 80s or higher, fish should be held only for a short time and carefully monitored. Water temperatures affect fish activity and ease of grading in socks before harvesting. Use one mesh size larger than normal, and allow overnight grading before harvesting fish in winter. This will avoid harvesting many off-sized, unmarketable fish. The sock needs to be in good condition or fish will escape overnight. Hauling trucks can be scheduled with assurance when fish are held in livecars.

Minimize stress. When holding fish, move the sock to deeper water to provide more room and

clearer water. In warm or hot weather, it is helpful to cool fish before harvest by moving the sock near a flowing well but not under it or directly in the high current area. Fish in socks are usually so crowded that little water movement takes place within the sock, and the increased current probably stresses the fish on the exterior of the sock as they constantly swim against the current. Harvesting stakes can be used to secure the lead line into the pond bottom and hold the float line about 1 foot above the water surface. If the sock is not properly anchored, currents from a well or an aerator can roll up the livecar and kill fish. Also, beware of the possibility of theft when fish are held overnight. Livecars are more secure for holding catfish than seines because they have a solid mesh bottom and double float line that prevent fish from jumping out. Fish are good escape artists. Several livecars may be required if many fish are harvested. About 5,000 pounds of fish can be held in each 10-foot length of a standard-sized sock at temperatures below 80°F. The increasing frequency of "red fillet syndrome" in catfish is thought to be directly related to harvest and holding stressors.

If fish must be landed in shallow water, or a large number must be harvested, consider another harvest method. Harvest fish as before, but stake out the harvesting

seine. Do not use a livecar. Pull a short cutting seine of the desired mesh through the fish to roughly grade and concentrate them for loading. If fish require overnight holding, leave them in the larger area of the staked harvesting seine.

Watershed ponds. Harvesting is more difficult in watershed ponds because pond depths are usually more than 10 feet. Obstacles are common in bottoms and on banks. Fresh water is usually absent at the harvesting site. Watershed ponds usually have to be drained to a smaller area with a maximum depth of 6 to 8 feet. The height from the harvesting area to the levee top makes loading a transport truck difficult and time consuming without the use of mechanized equipment. Ideally, fish are harvested in colder months so stress on fish is less and ponds can refill with runoff water during late winter and early spring.

Most baitfish are harvested by seining because it is faster than using lift nets. Fish are crowded into the bag portion of the seine, then the bag is staked. Minnows are dip netted into floating holding boxes with nylon walls. Summer harvests are stressful because of warm surface waters. Pumping cool well water near the harvesting operation helps reduce stress and losses. Minnows are harvested frequently to keep up with customer orders.

When manually beaching a seine, pull it slowly and carefully to keep the lead line on the pond bottom. Too often there is an unnecessary rush to land the seine, and many fish escape under the lead line when it is accidentally lifted off the bottom. Four persons can beach a seine. Two pull in each of the loose ends. One keeps the lead line on the bottom, and the other helps pull and piles the seine on the bank. When the lead line is on shore, raise it and close off both ends by slipping your arm under the seine and lifting it out of the water. This forms a hammock shape that traps fish. Concentrate

fish into the middle, and move the seine to deeper water to stake it if desired. Harvesting stakes free up labor to move fish rather than just hold the seine.

Fish pumps

A fish pump can be used for harvesting. There are various models. They move fish rapidly and safely from tanks or ponds to hauling trucks. Crowding is required, then the pump intake is placed where it can move fish and water to a dewatering tower or box. The water returns to the ponds, and fish are loaded into the transport tank. Pumps can be portable units mounted on trailers or fixed units mounted on a transport truck. They are commonly used in the trout industry and are being evaluated for use with warmwater species.

The use of fish pumps often means fish weights are determined by water displacement rather than with scales. This weighing method is less stressful on fish than scale weighing and can be accomplished quickly. One pound of water is displaced by 1.02 pounds of fish, and 1 gallon of water weighs 8.35 pounds. To determine fish weights by water displacement, just determine the change in water volume in gallons in the transport tank after fish are loaded and use a simple formula.

For example, if loaded fish increase (displace) the water volume in a tank by 50 gallons, then the weight of fish is equal to 50 gallons x 8.35 pounds/gallon x 1.02 or 425.8 pounds. A water displacement tube on the outside of the tank, or a clear viewing plate in the tank wall, can be used to calculate the amount of water displaced. This is a new technique for most warmwater fish farmers but offers some real advantages and promise.

Harvesting eggs and fry

Besides food-sized and fingerling fish, there are situations when eggs and fry require harvesting. Catfish egg masses are usually re-

moved from spawning boxes and transported to hatcheries for incubation. To remove the eggs, use a wide blade scraper or putty knife to loosen the adhesive egg mass from the bottom of the spawning container. Gently raise the box toward the shallowest water along the bank so the eggs can be more easily retrieved if they fall out of the box.

Remove the eggs with your hand, and put them into a plastic fish basket that has mesh openings. The basket can be placed inside an inner tube for flotation. The openings allow water to pass freely through the basket as it is pulled from box to box. Tie a rope between the egg collection container and your belt or pants' belt loop to pull the container as you walk to check spawning boxes, and keep your hands free.

Tubs or ice chests can also be used, but they are less suitable. Water can warm more quickly and water quality can deteriorate faster unless eggs are emptied frequently and the water is replenished. Do not hold eggs in stagnant water during collection for more than 15 minutes without aeration or adding fresh, clean water. Make sure all pieces of the egg mass are removed from the spawning box so the male catfish can service another female, rather than care for a small fragment of eggs.

Yolk-sac fry can be harvested from incubation troughs by siphoning with a 1/2 inch-diameter clear plastic hose. Siphon fry into a dip net or strainer that is submerged in a bucket of clean water. The fry can now be quickly stocked into a rearing trough. To harvest older swim-up fry, use a fine mesh aquarium dip net to transfer them from the rearing trough to a bucket of clean water for stocking into a transport tank. Always move small fish in a cushion of water, and minimize their time out of water.

Harvesting situations and options

There are three harvesting situations to consider:

- **Partial harvesting** exists where only part of the fish are removed.
- The pond may also be **topped** where larger market-size fish are selectively harvested from ponds with mixed fish sizes.
- Finally, the pond maybe **clean cropped**, where all fish are harvested.

The only reliable way to harvest all fish from a pond is to drain it completely. This involves a combination of draining and seining. Avoid using a seine in very shallow water because it stirs up the mud and causes low dissolved oxygen and high toxic gas conditions which can be extremely stressful to fish. Shallow water can also warm quickly in hot weather.

Seine trapping relies on feed to attract fish into a trapping area. A seine at least 200 feet long works well. Locate the seine parallel to the pond bank or across a corner about 50 feet from shore. A pull rope attached to each end is staked on the bank for easy retrieval. The trapping area should have a firm bottom, be free of any debris and be less than 5 feet deep. Catfish and other species may be shy initially, but can be lured into the trapping area by feeding outside the open end of the corral seine and drawing them in with a trail of feed. Use floating feed to observe feeding activity. Feed routinely at the time you intend to harvest. Do not alter your feeding activity on harvest day, except for using less feed.

To harvest, simply pull the coiled seine ends to shore. Drag the seine carefully to shore to concentrate fish. Have enough labor available to keep the bottom line on the pond bottom while dragging the seine to shore. Trapping success in the same area requires a 7-to 14-day recovery time before fish lose their shyness and the operation

can be repeated. Because of the importance of baiting with feeds, this method is more effective during warm weather when fish are feeding actively.

Many catfish producers prefer to top their ponds by harvesting larger market-sized fish in a population of mixed fish sizes. This method works best in seine-through ponds that require no draining. The same pond may have fish harvested three or more times yearly. Fish are harvested when sufficient numbers reach market size. This may be 1,500 or more pounds per acre in large 10- to 20-acre commercial ponds. Harvesting efficiency in seine-through ponds should be about 70 percent to 90 percent of the harvestable sized fish, depending on species, size, experience of harvesters, and the condition of the pond and harvesting equipment. Catfish can create large craters in pond bottoms that can become extensive after continuous production of 4 or more years. These depressions probably reduce harvest rates. However, there is considerable controversy over how often a pond should be clean cropped and renovated to restore fish inventories and repair pond bottoms and levees.

Other trapping methods include large lift nets and drop nets, but they are usually not as effective. The lift net covers too small an area, and repeated use can reduce fish production. Catches with the drop net decrease considerably after the initial catch.

In ponds used for fingerling production, especially when raising delicate fish species, harvesting kettles or basins are common features. They are made of poured concrete and have several openings with vertical grooves for placement of wood tongue and groove boards to adjust water levels inside the basin. These areas are located in front of the drain structure, and their bottom is the same elevation as the bottom of the drainpipe. A water supply pipe is often located near the basin

to furnish fresh, oxygenated water as needed. Concrete steps from the basin to the levee top make it easier to carry tubs or buckets of fish and water. Before fish are concentrated, the basin should be cleaned with a broom or other device while the drain is open to remove any mud or sediment that can accumulate in the area. The harvest basin is usually found inside the pond, but outside kettles also exist. Fish are usually dip netted from the basin and placed in buckets of fresh water. These structures are common in government hatchery ponds that frequently harvest small fingerlings of game fish species.

Removal from ponds

When fish are moved from ponds, they are commonly lifted with a loading basket attached to a hydraulic boom. The fish are first crowded in a livecar or cutting seine. The boom can be mounted on a special truck. A front-end loader or backhoe will also work well with a few modifications, including an extension pipe. The loading basket is designed so fish drop through a trap door with an easy, safe release. The basket can move 500 pounds or more per load. Weights are determined with in-line, spring-loaded or electronic scales. The loading basket net should be treated with a coating if used for catfish. Do not overload the basket if fish will be restocked or hauled on a long trip. Make sure people are clear of the swinging basket as it moves and nobody is underneath it.

Another method of harvesting fish involves dip netting fish into buckets or tubs filled with clean water. Fish should be moved quickly and should not be overloaded. Water quality deteriorates rapidly when fish are concentrated, especially in warm weather. A bucket-brigade helps reduce the strain and work of heavy lifting. Remember, one gallon of water weighs 8.35 pounds! This method works well for small, delicate fish where special harvesting precautions are re-

quired, but it can be time consuming if many fish are harvested.

Seine maintenance

Seine storage and care are important to prolong the life of equipment. Uncoated nylon seines are damaged by direct sunlight. Remove dead fish that can attract rats, which damage seines. Short seines should be hung in a covered site and air-dried. Never store a damp and unclean seine in a heap. Some aquatic weeds, parasites and infectious diseases may be transferred from pond to pond by harvesting equipment. For this reason, remove any fish or nuisance aquatic weed fragments. Air-drying the seine can kill most parasites. Diseases such as bacterial ESC may remain alive in moist mud balls not cleaned from seines. Repair any holes in the seine as soon as they are detected in order to maintain the equipment in workable condition and ready for use.

Summary

Fish harvesting is an important step in getting fish out of production facilities in good condition so their survival and quality for other uses are assured. Experience and common sense will be valuable factors to assure success. Take time to plan properly before putting nets into the water. Do not forget that fish are sensitive to handling, and that harvesting is the first stress of more to come if fish will be graded, held, transported and restocked. It takes a higher quality fish to live after harvesting compared to one that will shortly be processed.

Additional information

For information on sorting and grading warmwater fish refer to SRAC Publication No. 391. Detailed information on transporting warmwater fish can be found in SRAC Publications 390, 392 and 393. For additional information or assistance on this subject, contact your local office of the Cooperative Extension Service.

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