Chapter 11
Cage culture

Cage culture of fish
Cages are widely used around the world to culture fish in natural or artificial water bodies. The use of cages in aquaculture has several advantages which are summarized below. Cages have some disadvantages, such as not allowing the fish access to the substratum from which they can feed or seek refuge, with the ever-present risk of losing the entire stock within a cage should the fish be able to escape. Cages also suffer from fouling of the mesh in certain waterbodies; this prevents water free-flow through the cage, resulting in poor water quality at times within the cage. Cages may also pollute some waterbodies due to the accumulation of uneaten feed and fish waste below the cage. Another disadvantage is that the fish only receive the feed ration actually fed to them and little nutrition is derived from natural sources, especially in clear, sterile water situations. This means that the feed supplied has to fulfill all the nutritional requirements of the species cultured. Fish kept in cages are vulnerable to existing diseases in the waterbody, and they may introduce other diseases to wild fish in that waterbody, over which there is little control.

Types of cages

Small cages
Most people assume that fish cages are all very large and expensive. This is not true. In the Far East, many ornamental fish are cultured in small mesh cages called pen-nets or 'hapas' which are often set together in groups in fertilized ponds or small dams. Pen-nets are staked out using mesh for the sides and the natural pond bottom for the base. Sometimes these cages are made of locally available materials, such as bamboo, although today the wide availability of plastic mesh of various types makes for more secure cages. Some of these cages may be as small as 1 m x 1 m and only 0.5 m deep. They are either staked out in shallow ponds, or floated using bottles, inflated tubes, or closed-PVC piping for buoyancy. Hapas are strictly small cages whose mesh-base is on the bottom of the pond or dam, allowing the fish some access to benthic feeding. Often hapas have light mesh over their tops to prevent predatory birds from gaining access and eating the fish. Simple hapas can be made of plastic mosquito mesh, shade cloth or semi-rigid plastic mesh (such as oyster mesh). It is important to ensure that the cage is escape-proof, and that all seams and joins are robust and will not break open after prolonged use or when the cage is lifted up to remove the fish at harvesting. Needless to say, cages with weak or gaping seams and joins are useless, and the fish will be lost to the larger waterbody from where they cannot be harvested.

Small cages in ponds or small dams have the advantage that the waterbody can be enriched with manure or fertilizers to create a bloom of zooplankton or phytoplankton, which provides

The advantages of fish cages

- Cages are less expensive than building ponds, dams and other infrastructure.
- Cages can make use of existing water bodies (such as lakes, dams or the sea) that have good water quality.
- Cages do not require land-ownership and can be moved to the most suitable area.
- Cages protect fish from predators and theft.
- Cages are versatile in that they can be small and easily maintained for low volumes of fish such as ornamental species, where many different individual species are kept by one producer in groups of cages.
- Fish can easily be harvested from cages by simply pulling up the netting to crowd the fish, and then dip-netting out the required number.
- Cages can be kept in groups which facilitates the size-sorting of fish.
- Cages prevent unwanted reproduction of some species (such as tilapia) as the fish are unable to establish nesting territories in the confines of a cage.

a large proportion of the feed needed for the growth of the fish. This is widely done in the Far East where millions of gouramies, livebearers, cichlids and other fish species are reared in small cages in enriched ponds for the ornamental fish trade.

Large cages

Many people have seen pictures of the large marine sea-cages in the Northern Hemisphere (used to grow fish such as salmon, in Norway, the UK, Chile and Canada). These cages are built to withstand the storms and rough seas of their environment and are very expensive to construct. They are also very large, some being more than 20 m or more across. Some of these cages are circular, others are rectangular, and they may contain several tonnes of fish each. Stocking, feeding, monitoring and harvesting are all highly mechanized due to the heavy equipment and large volumes required. Such operations are run by large companies that usually have their own hatcheries to produce the juveniles, and their own factories to make the fish-feed and process the catch after harvest. A local example of such a fish farm is the Lake Harvest tilapia farm on Lake Kariba, Zimbabwe. Here, juvenile fish are produced in ponds on the lake side and then stocked into large cages in the main lake for growth up to marketable size. The tilapia are then harvested and processed in the farm's own factory, into value-added form (fillets, smoked fish, etc.) and then air-freighted to markets in Europe.

In South Africa, smaller-scale cage-culture enterprises that still use relatively large cages are found in the Western Cape. Here the many coolwater dams provide suitable habitat for culturing trout in cages. Often the water quality is very good, yet the use of the dams without cages would be difficult due to factors such as the impossibility of draining them, problems with harvesting the fish, loss through predation and theft, and conflict with other water-users such as anglers and farmers, etc. The use of cages to confine the trout into a manageable area, where they can be monitored, fed, and ultimately easily harvested, has proved to be a success.

The Western Cape cage culture of trout

This province's success with cage culture of trout over the last few years serves as an example of what potentially could be done in other regions of cooler water (temperatures <23˚C) such as the Mpumalanga escarpment, the KwaZulu-Natal Drakensberg region and the highland regions of the eastern and southern Cape. Trout are an established, highly marketable product and fetch a good price. However, the quality must be very high and there is no room for error in the cultivation of the fish. The essentials in achieving a successful cage-culture venture with trout are:

- Good water quality suitable for trout all year round.
- A ready and affordable source of fingerlings.
- Properly designed and built cages that are escape-proof and predator-proof, yet which can be managed efficiently and without difficulty.
- An installation that is easily accessible and can be monitored on a daily basis, which requires that someone check on and feed the fish usually twice daily.
- A source of suitable feed at an affordable price, with a place to store it nearby so that it retains good condition.
- Sufficient help at hand to assist with harvesting the fish.
- A pre-identified market to accept and process the fish, at an agreed price that makes the venture profitable.
- A business plan that details the responsibilities and potential rewards for all those involved in the project.

As with most fish-farming ventures, such a project should be run as a business that will incur capital costs, running expenditures and then income through sales of the product. This is then shared out between the members of the project according to a pre-agreed formula. Experience in the Western Cape has shown that each project should not involve too many participants, otherwise the rewards are too diluted and each member of the project will not receive enough cash at the end of the day to make him/her feel that it was worthwhile. Several established projects, each with one cage, have only two members, yet each partner receives a worthwhile income from the sale of the fish. Many of the workers on these projects are part-time in that they have fulltime jobs working on the farms where the cages are situated, and they feed and monitor the fish before and after work each day. Harvest usually takes place over a weekend or on a public holiday when other people are available to assist in the day's work and earn extra cash.

Technical aspects

Cage types

The design of the cage is a function of:

- The scale of the operation
- The fish species
- Environmental considerations such as aesthetics

A floating trout cage as used in the W. Cape, showing the raised blue-netting predator protection surrounded by the walk-ways. The cages are anchored away from the edge of the dam but can be pulled to the edge to stock with fish. Juvenile fish are transported to the dam in a tank and flushed into the cage through a pipe.

- The local availability of materials and skills to assemble suitable cages.

The cage bag has several requirements: it must hold the fish such that they cannot escape, even as juveniles, yet it must allow the maximum possible exchange of water to maintain water quality at a high standard inside the cage. Cage bags can be any shape, from rectangular to circular. Circular bags are cheaper to make, but harder to work with in terms of catching the fish, although some fish such as trout seem to prefer circular bags which allow them to shoal in a circular manner. The mesh should be rot-resistant, light yet non-abrasive, easily repaired, foul-resistant, and affordable. There are many materials available, from artificial fibre netting to semi-rigid extruded plastics. The cage bag should retain its shape by means of supports, weights or attachments, such that the fish are not crowded or crushed by collapse of the bag due to water currents or foul weather.

The cage frame must have several attributes built into its design. It should be durable and rigid such that its lifespan is in proportion to its cost. Wooden frames may last one or more years but will eventually rot under water. Metal frames are heavy and will rapidly corrode. Plastic components are best if sufficiently strong enough, and these have the advantage that they are usually lighter than other materials (a cage frame of 10m x 10m x 3m can be heavy and bulky to move!).

Access and ease of management

Clearly, large cages will hold large numbers of fish, which need to be fed, monitored and eventually harvested. Such cages need to be designed such that the persons doing these tasks can operate easily and safely. Large cages should have a stable walkway around them and should also project above the water surface by at least one meter to prevent the fish from jumping out. Supporting the cage, as well as the people working on them, requires floatation, and this should be sufficient to provide a stable working platform. Usually for larger cages in freshwater dams in South Africa, plastic drums are used. The entire structure needs to be rigid and should not partially sink or bend when being worked upon.

To prevent theft, and to increase water circulation through the cage body, cages are often moored offshore such that access is only by boat. These cages need to be securely anchored to resist strong winds and wave action in larger impoundments. If cages are grouped together then the grouping should take into account the prevailing winds and currents to ensure the best water exchange possible through the cages.

Where cages are installed in dams with deep water close to the shore, access can be by walkways or floating pontoons, but then consideration must be given to the equal ease of access by predators and the risk of theft.

Ancillary equipment needed

When cages hold fish at high densities, especially with high numbers of trout shortly prior to harvest, the oxygen content of the water may reach critically low levels at times of warm weather. To ensure that massive losses are not experienced, supplementary aeration may be necessary, and this can be done using mechanical surface agitators and air or water pumps. Alternatively, injection of either pure oxygen or compressed air to the cage may be a solution if electricity is not available.

In some situations the build-up of wastes under fish cages can reach a point where the proximate water oxygen content can decline to near lethal levels for the fish. The simplest solution is to then move the cage from site to site to disperse this build-up of wastes over a wider area.

Fish harvested from cages can be both individually quite large (250-500 g for trout) and also bulky in terms of overall mass. A range of dip-nets, screens, containers and other equipment is needed to efficiently harvest the fish. One successful method used by Western

Cape fish farmers is to use a floating rectangular keep-net of approximately 1m x 2m x 1m deep to place the caught fish into; this is then towed ashore, and the fish are emptied into large plastic tubs partially filled with crushed ice. These tubs are then sealed and taken by vehicle directly to the processing plant.