NRAC Fact Sheet No. 120-1992

Northeastern Regional Aquaculture Center

University of Massachusetts
Dartmouth
North Dartmouth
Massachusetts 02747

Aquaculture Systems for the Northeast

Joe Buttner, SUNY College at Brockport
Gef Flimlin, New Jersey Sea Grant Marine Advisory Service
Don Webster, Cooperative Extension Service University of Maryland System

Introduction

Many systems are used to culture aquatic animals commercially in the northeastern United States. No single system is appropriate for all situations. Information on systems that are applicable to your area may be obtained from your university extension agents and specialists. They can also identify contacts to assist with design and construction of your operation, and regulatory agencies that must be consulted.

Culture Systems

Traditionally, aquaculture has been practiced extensively and intensively. Extensive culture involves production at densities not greatly exceeding those found in nature, such as an unfed pond or unmanaged bottom culture. The culturist expends relatively little energy and effort on system maintenance. At the start of the culture cycle, fingerlings or shellfish seed me stocked and minimal management is practiced. At the end of the growing period, fish or shellfish are harvested and sold. Extensive culture is generally restricted to some forms of shellfish culture and, occasionally, farm ponds.

Intensive culture involves production at densities that greatly exceed those found in nature. Examples include a fed pond, cage culture, recirculating systems and managed bottom culture. High densities are maintained through energy inputs and sophisticated culture methods such as the use of high quality feeds, fertilizer, monitoring and control programs, pumping, aeration or oxygenation. Intensive culture can maximize the biological return from a given water resource. It also increases the cost of production, chances for a catastrophic loss, and waste generated from the operation. Most Aquaculturists today practice some form of intensive culture. The culturists resources, time, and willingness to take calculated risks determine "how intensively" an operation is run.

Many successful culturists started with small operations and expanded with experience. Personal experience, site considerations, available resources, species cultured, and regulatory constraints all influence the system selection.

Water Source and Supply

Regardless of the system used or species cultured, good water quality and quantity are essential. Water source and supply must be a primary consideration from the planning stage.

Groundwater can be obtained from aquifers. Useful information on groundwater is usually available from well drillers in the area or the state geological survey. Frequently, states have aquifer maps as well as other important information on water quantity and quality. Test wells may be necessary to ensure that an adequate flow is available, especially for large operations where rapid filling or flushing is required. Well water is usually deficient in oxygen and saturated with nitrogen. Often it must be aerated before it is introduced into the system. Chemical analyses of well water for ammonia, contaminants, dissolved oxygen, etc. are essential before they are developed for aquaculture.

Surface waters represent an alternative water supply. They are frequently less expensive to develop and pump than ground water, but have restrictions that present problems for the farmer. Surface waters may be more variable with regard to flow, temperature, and quality. Chemical and biological contaminants may also be present. Water must be filtered or screened to eliminate unwanted fish and insect larvae. Other treatments such as aeration or filtration to remove particulate may be necessary.

In some areas, geothermal or natural hot water aquifers may be available. These are typically deep and require careful review of technical, chemical, and economic factors before being used. Water from municipal systems may be used, but it is expensive and usually requires dechlorination. Use of municipal water is usually limited to recirculating systems that reduce quantities needed and produce high value products.

In marine operations, proper salinity is important. Inflows of fresh water may stress or kill cultured animals. Both point and non-point runoff should be surveyed. Presence of disease, fouling organisms, and predators must be determined. Potential problems should be addressed during site selection.

Finfish Culture Systems

1. **Pond Culture:** Today, most commercial fish and crawfish production in the United States is in ponds (figure 1). In some areas, coastal or ocean water may be used, but regulations and quality must be considered. Most aquaculture ponds are less than 20 acres in size and have a maximum depth of 6-8 feet. Culture ponds north of the mid-At] antic region require water depths of 6-8 feet or more so fish can over-winter safely. During the planning stage, it is advisable to incorporate electrical access to each pond for aeration, pumping, etc.

Pond construction is expensive in the Northeast with earth movement costing $1.00-$2.00 or more per cubic yard. Before construction, a soil profile must be taken. It is wise to analyze for contaminants, especially if the land had been used for agriculture and if you plan to work with early life stages of fish or grow fish for human consumption. While rectangular ponds are easier to harvest, other shapes can be used. The primary concerns are that ponds conform to existing topography, available area, and anticipated use. The pond bottom should be smooth and without depressions to facilitate maintenance and harvest. Pond liners, clay, and other materials can be used if soil conditions are a problem at an otherwise attractive site, but they substantially increase construction costs. Control of water is highly desirable. Ponds should be designed to fill and drain easily. It is cheaper to build fewer large ponds, but easier to manage smaller ponds.

Experienced culturists grow species appropriate for their regions, growing season, and markets. They use high quality feeds, provide continuous or supplemental aeration, and may practice topping (the selective removal of large, marketable fish and their replacement with smaller fingerlings). Yields from culture ponds can range from a few hundred to several thousand pounds per acre, depending upon fish density, feeding rate, and skill of management.

Figure 1. Aquaculture ponds should be fillable, drainable, harvestable. and accessible as needed.

2. **Flow Through or Single-Pass Systems;** Raceways and tanks have been used to rear fish for over a century (figure 2). High quality water continuously flows into the holding unit. It passes through the heavily stocked unit and is discharged when quality is no longer suitable for good survival and growth. Federal, state, and local (zoning) laws increasingly require that the effluent from these operations meet quality standards before being returned to public waters. Treatment of discharge waters should be incorporated into a flow-through system. Yields are dependent upon water flow, aeration, and water temperature. Annual yields can range from 10 to over 100 pounds per gallon per minute of water flow to the raceway. High yields require large volumes of high quality water, stable temperatures, supplemental aeration and/or oxygenation, high quality feeds, and good management.

Figure 2 Raceways and tanks utilize a continuous inflow of high quality water to culture fish at high densities.

3. **Reuse Systems:** Some culturists now use all or part of their water several times before discharge in order to maximize fish production (figure 3). If suitable elevation differences are available, a series of flow through systems cart be linked together, Each raceway receives the discharge water from the preceding unit, The water is passively and/or actively re-aerated between raceways. Part of the water may be passed through a biological filter, where waste products are detoxified by bacteria before the water flows to the next rearing unit. Because the systems "recycle" part of their water, more fish are produced in a given volume and flow of water. Reuse systems must be designed and operated carefully to function effectively. Also, care must be taken not to transfer disease problems between units. Reuse technology in the Northeast is most commonly used to culture trout in raceways linked in series, Laws that regulate effluents of flow through systems also apply to discharges from reuse systems.

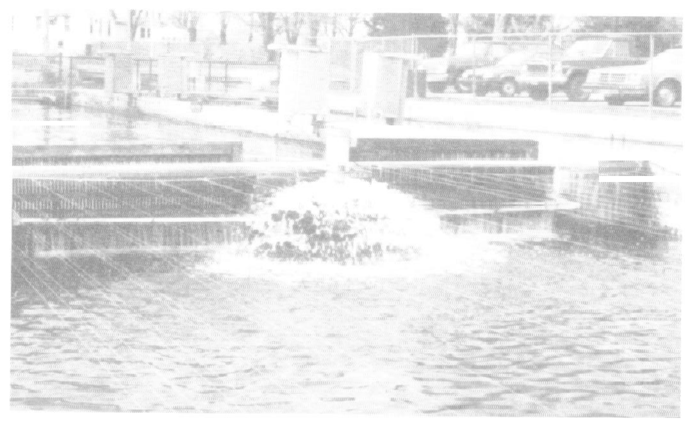

Figure 3, With sufficient drop in elevation, water can be passively re-acrated as it cascades from) one raceway to another; active aeration can be used in areas with less slope.

4. **Recirculating or Closed Systems:** These systems support fish in a totally or partially enclosed environment (figure 4), Fish are normally raised in tanks where they live, eat, respire, and excrete. Particulate wastes are removed by a primary filter. The water then passes through a biological filter

where excretory wastes (mainly ammonia=NH_3) are detoxified by bacteria. Toxic ammonia and nitrites (NO_2^-) are converted to nitrates (NO_3^-), which are considered non-toxic. The water is then returned to the fish holding unit.

Since most water is "recirculated," the systems require relatively small additions of new water. Water is added to replace that lost by evaporation and discharged to remove settled solids. These systems require continuous aeration or oxygenation of both the fish culture tanks and biological filter to function properly. Water quality must be monitored closely and emergency back-up systems are essential.

Recirculating systems are potentially appropriate when water quality and quantity are insufficient, for example if water must be cooled or warmed, or if discharge standards are strict. While the culture of fish in recirculating systems is biologically possible, the economics must be very carefully studied. These systems require high value species and experienced operators for commercial success.

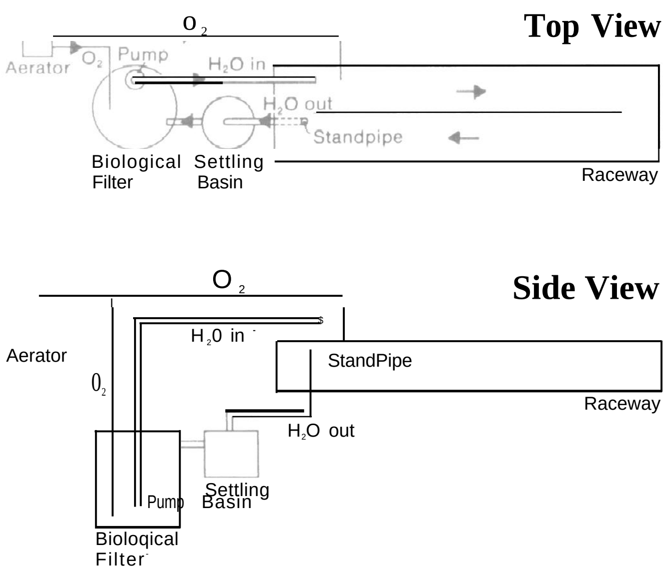

Figure 4. A variety of recirculating systems exist; most include a fish holding unit, biological filter, removal mechanisms for particulates, and aeration systems.

5. **Cage and Net Pen Culture:** Many natural bodies of water can be unsuitable for aquaculture. They may be too deep, too large, or have irregular bottoms or obstructions. Many can be used, however, to culture fish confined in cages or net pens (figure 5). Cages are relatively small, rigid structures usually between one and approximately 20 cubic yards. Net pens arc usually large mesh enclosures up to several hundred cubic yards. Both cages and net pens should be anchored securely in an area where water flow and depth are sufficient to provide aeration and waste removal.

Many successful aquaculture businesses use cage or net pen culture. One or two cages placed into an existing pond can provide an excellent and relatively inexpensive introduction to aquaculture as well as a source of high quality fish for the owner. Annual yields can exceed 400 pounds per cubic yard of cage or net pen, depending upon the skill of the fish farmer and quality of water. Use of public waters for cage or net pen culture requires careful investigation of social, regulatory, and technical issues.

Figure 5. Net pen culture of Atlantic salmon is an important industry in Maine.

Shellfish Culture

1. In or On Bottom: If the substratum or ocean bottom will support oysters or is of a consistency that allows clams to burrow, then shellfish seed can be stocked directly on the bottom (Figure 6). Clam and oyster seed are routinely planted at 20 to 100 per square foot, depending on the site, One mussel culture technique involves the harvest of small seed from dense beds and relocation to a bottom site at a lower density. At harvest, the mussels are purged of sand and other grit before sale.

Proper and frequent maintenance is essential for commercial success of a bottom culture system. No predator control is used in mussel culture. However, light plastic or nylon netting is commonly installed when clams are planted to control predation by crabs, drills, or rays. Nets used to control predators are monitored and cleaned on a regular basis to eliminate entrapped predators, repair holes, and remove fouling organisms.

Figure 6. Softshell clams are grown in wooden boxes covered with screens in coastal waters of Maine.

2. **Near Bottom Culture:** Cages and boxes of plastic mesh are used to culture clams and oysters just off the bottom (figure 7). These enclosures may be purchased from commercial suppliers or built by the culturist. Shellfish seed is put in the mesh bags or plastic boxes and sometimes placed on a rack. As the seed grows, it is transferred to enclosures with increasingly larger mesh. A larger mesh provides better water flow, which delivers more food and oxygen, while removing wastes.

Most pre-fabricated units are about five square feet, but units over 30 square feet have been used. Units can be used in the nursery phase for both clams and oysters. However, clams must be transferred to the bottom after 20 millimeters for growout to market size. Oysters will grow in cages until harvest.

Figure 7. Shellfish can be grown in plastic boxes lined with window screen and set close to the bottom

3. Water Column Culture: Clam and oyster seed maybe raised in containers suspended in the water column (figure 8). This technique is also used to culture bay scallops and mussels. Lantern nets, cylindrical containers made of nylon netting that are divided into sections and hung from floats, are also used to culture scallops and oysters. Mussels are cultured in long, plastic mesh sleeves. They are grown in deep areas with good, but not extreme, water flow. Rope culture, long lines, and other methods are also used to culture shellfish in the water column.

Water column culture is common in the northern states, but ice damage can be a problem. A boat is needed for access and a good anchoring system is essential.

Figure 8. Lantern nets are used to culture shellfish in the water column.

4. **Surface Systems:** At some locations, small mesh containers have been used to float shellfish seed near the warmer, surface waters (figure 9). Phytoplankton, microscopic plants that float in the water and are eaten by shellfish, are more abundant in shallow waters and water flow is usually greater, Surface culture is normally used in the nursery phase of shellfish culture and is occasionally used for final growout.

figure 9. In Maine softshell clams are grown in floating wooden boxes covered with plastic to discourage bird predation

5. **Land-based Systems:** Land-based systems are used to culture early stages of shellfish. Upwellers, downwellers and raceways are used to grow seed to 6-8 millimeters before planting (figure 10). Economic success in using land-based systems for growout has not been demonstrated, largely because of high energy costs. one exception is shedding units used to hold hard crabs until they molt and become soft shell crabs. These are special cases as shedding takes only a few days, does not require feeding, and the finished product has a high value.

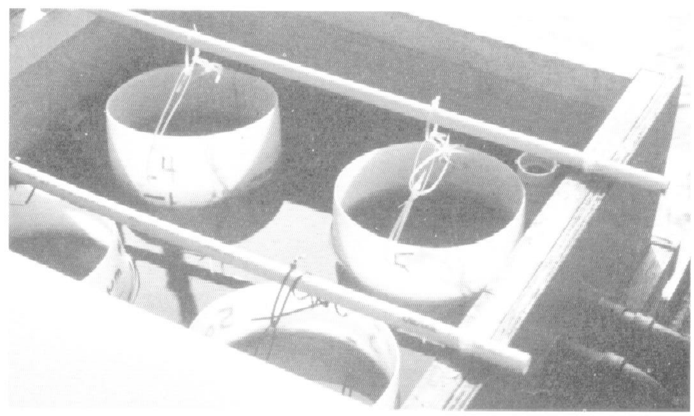

Figure 10. Larval bivalves are grown in land-based systems such as upwellers fabricated from five gallon buckets.

Additional Information

Extension specialists, university personnel, and your state aquaculture association can provide more information on the systems described and their application. The Aquaculture Information Center (National Agricultural Library, Rm, 111, Beltsville, MD 20705) has several up-to-date bibliographies available on the culture of different fishes.

Acknowledgments

This work was supported by the Northeastern Regional Aquaculture Center through grants number 89-38500-4356 and 90-3$500-5211 from the Cooperative State Research Service, U.S. Department of Agriculture. Any opinions, findings, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the U.S. Department of Agriculture.