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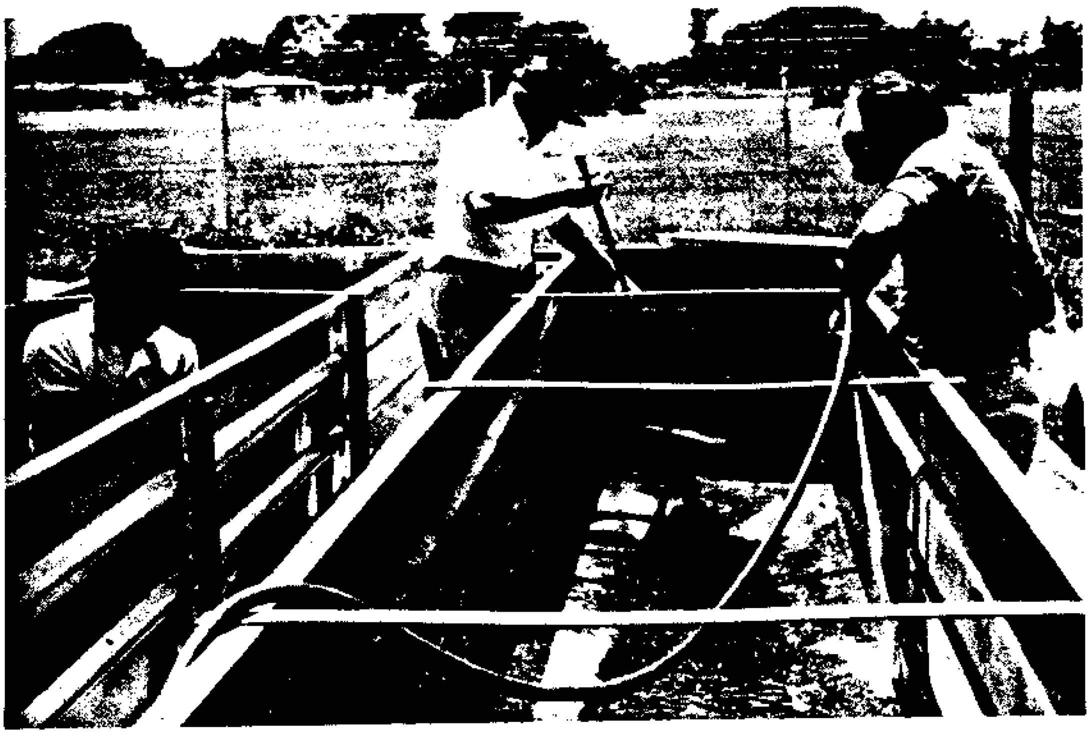
Guide to Backyard Aquaculture in Florida

Donald W. Pybas and Frank J. Lawlor



SEA GRANT

GUIDE TO BACKYARD AQUACULTURE IN FLORIDA

Donald W. Pybas, Marine Extension Agent
Sea Grant Extension Program, Dade County

and

Frank J. Lawlor, Marine Extension Agent
Sea Grant Extension Program, Southeast Florida

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INTRODUCTION

Florida seems to be ideally suited for commercial aquaculture enterprises. The mild sub-tropical climate, long shoreline and seemingly abundant water resources appear to offer great opportunities for commercial culturalists. However, with a few exceptions (see Appendix A) commercial aquaculture operations have not fared well in Florida. The reasons for this range from a lack of technical knowledge about certain species to environmental constraints, but the bottom line has been economics. If one cannot make a profit from farming operations, commercial operations are destined to fail.

Consider the following three distinct aquacultural alternatives - (1) hobby, (2) "backyard" operation, or (3) commercial system. The commercial system is of primary interest in Florida, but the backyard operation has enjoyed growing interest. Each of these alternatives suggest a given set of objectives and a specific level of interest in the economic feasibility of the culture process for the chosen species. For example, the hobbyist may decide that the goal of growing an exotic species for fun requires only an appreciation for the technical feasibility of the culture process, such as growing sport fish for "put and take" fishing in private farm ponds. Within certain bounds the economics of the hobby is of lesser importance than the recreational "value". On the other hand, the backyard operation (analogous to the home garden) is oriented toward the goal of offsetting a portion of home-food consumption expenses. In this case, the successful small-scale backyard aquaculturist may make the statement "I can grow it cheaper than I can buy it." Thus, the backyard operation must, given the prevailing price structure, be at least technically and economically with the goal of not only achieving, but maintaining profitability from one year to the next. The successful commercial operation must, therefore, be able to achieve not only technical and economic feasibility, but commercial feasibility as well.

Given the goals and objectives that have been established for aquacultural system, the potential aquaculturalist can understand whether economic and/or commercial feasibility is required. The possibility exists that neither of these levels of feasibility has been demonstrated for the species and location that you have selected. Just because you have heard that catfish can be grown in Florida does not necessarily mean that catfish can be grown profitably in your specific area. Given the nonuniform nature of Florida's natural resource base, utmost concern must be given to matching the culture requirements of a given species to the existing environmental conditions and other constraints of the selected location. Search the available literature (technical journals, trade magazines, university extension publications, etc.) and examine this question closely (from Aquaculture in Florida: Some General Economic Considerations, Adams, C.W., Florida Sea Grant Extension Program, University of Florida, Gainesville).

This guide presents a different perspective. Instead of examining the possibility of commercial applications, it will introduce the homeowner to backyard or hobbyist culture of food fish. With this type of culture, land and labor costs are not included in the economic analysis. From this perspective, backyard aquaculture can be compared to the home vegetable garden, and while it may not be profitable from a commercial perspective, the homeowner can grow fish at costs comparable to the retail purchase price and can be assured of a fresher product and the satisfaction derived from growing it himself.

Hobbyist or backyard culture of fish is not limited to small scale systems. However, as with any new activity it is better to start small to gain expertise and experience before committing large amounts of capital and labor that would be required of larger systems. Additionally, if the fish are being grown for home consumption, the use of small systems offers the advantage of adding additional capacity that can be stocked and harvested at different times throughout the year, thus offering fresh fish on a continuing basis and negating problems associated with harvesting and processing large quantities of fish from larger systems.

In the following chapters, this guide will examine water quality concerns, design and construction of several small scale systems, appropriate species for the hobbyist, regulations and permits required, operations and maintenance, harvesting and trouble shooting. In addition, informational sources are included.

Good luck and happy culturing!

CHAPTER 1

WATER QUALITY IN AQUACULTURE SYSTEMS

Much of the information in this chapter is adapted from: Management of Water Quality for Fish, R. W. Rottmann and J.V. Shireman, IFAS Extension Circular #715, Department of Fisheries and Aquaculture, University of Florida, Gainesville, 1987.

Aquaculture operations can be designed as either open or closed systems. Open systems provide for a regular exchange or flow through of water. These systems are often used when water is readily available and an outlet for the water is convenient. Conversely, closed systems provide for a minimal exchange of water and usually require some type of filtration system to maintain water quality. Since homeowners usually do not have access to unlimited water supplies and permits are required for disposal of water in Florida, closed systems are recommended for homeowner fish culture. Because closed systems do not dilute harmful agents in the water, water quality and regular monitoring of the water in these systems are critical.

Water quality in closed systems can change dramatically from day to day. Poor water quality can cause fish kills and is usually a significant factor contributing to fish diseases. In assessing water quality, the hobbyist must use chemical tests as well as observations to detect water quality problems. Several manufacturers sell water testing kits that are useful to the hobbyist (see Appendix B), and range from as little as a few dollars for a single parameter test kit to as high as $500 for a top of the line kit that can test most water quality parameters. Generally, water testing equipment that includes tests for the following are recommended.

1. Dissolved oxygen
2. pH
3. Total alkalinity
4. Ammonia
5. Nitrites
6. Temperature

A test kit that is capable of doing these tests would cost approximately $100-$300.

Dissolved Oxygen

This is the most important water quality factor for fish. Oxygen depletion results in more fish kills and stress that can cause disease problems than all other factors combined. The amount of oxygen dissolved in water after aeration is expressed in parts per million (PPM) by weight of milligrams per liter. The amount of oxygen that can be dissolved in water (saturation point) decreases as water temperature increases. At 68 degrees F. water can hold 8.8 PPM oxygen, while at 90 degrees F. the saturation point is 7.3 PPM.

Oxygen requirements for fish vary according to species, age, density of fish and other cultural conditions. Warm water fish usually require a minimum of 1 PPM to survive and more than 2 PPM for growth and good health. Early life stages usually require higher oxygen levels than adults. Additionally, chronic low levels of oxygen stress fish and increase disease.

Oxygen is dissolved in water at the air-water interface and by plant photosynthesis. Fish are not the only consumers of oxygen in a system. Insects, bacteria and aquatic plants also consume oxygen. Because of the photosynthetic action of plants, many times they are overlooked as oxygen consumers. During daylight hours aquatic plants produce oxygen. However, at night they become consumers of oxygen. Algae blooms, particularly during the hot summer months, can cause significant oxygen depletion problems and are the cause of many summer fish kills. Early morning hours are usually the most critical periods of oxygen depletion. Therefore, testing dissolved oxygen should be conducted during this time or late in the evening.

If a test kit is unavailable, the following observations and conditions can be used to anticipate oxygen depletion.

1. Fish swimming at or near the surface or gulping for air during late night or early morning.
2. Fish stop feeding.
3. Rapid change in the water color to brown, black or gray.
4. Putrid odor coming from the water.
5. Loss of algae bloom.
6. Extended periods of hot cloudy weather.
7. Heavy wind and rain storms.

Aeration should be used when first signs of oxygen depletion show. This can be accomplished by spraying or agitating the water, by using blowers to pump air through the water column, flushing with fresh water, or by certain chemical treatments with strong oxidizing chemicals (i.e. potassium permanganate). The most effective way to deal with dissolved oxygen is to ensure a minimum amount (i.e. 2-4 PPM) is available particularly at critical times (i.e. early morning and late night). This can be accomplished by proper maintenance of biological filters, mechanical movement of water, and supplemental aeration.

Ammonia

Ammonia is excreted into the water by fish as a result of protein metabolism. Some of the ammonia reacts with water to produce ammonium ions; the remainder is present as un-ionized ammonia. Un-ionized ammonia is much more toxic to fish than ammonium. Standard analytical methods do not distinguish between the two forms, and both are lumped as total ammonia. The fraction of total ammonia that is toxic ammonia varies with salinity, dissolved oxygen, and temperature, but is determined primarily by the pH of the solution.

For example, an increase of one pH unit from 8.0 to 9.0 increases the amount of un-ionized ammonia approximately 10-fold. These proportions have been calculated for a range of temperatures and pH values and are given in Table 1. Note that the amount of un-ionized ammonia increases as temperatures and pH increase. To calculate un-ionized ammonia, determine the percentage from the table by using the measured pH and temperature values. Un-ionized ammonia (PPM) = (PPM total ammonia X percent un-ionized ammonia)/100.

The amount of un-ionized ammonia that is detrimental to fish varies with species. Growth rate of trout declines and damage to gill, kidney, and liver tissue is evident at 0.0125 PPM un-ionized ammonia. Reduced growth and gill damage occur in channel catfish exposed to levels greater than 0.12 PPM un-ionized ammonia. Critical levels of un-ionized ammonia have not been determined for many of Florida's aquaculture species. Chronic exposure to low levels of un-ionized ammonia may stress fish, increasing the chance of infectious diseases.

TABLE 1: PERCENTAGE OF TOTAL AMMONIA THAT IS UN-IONIZED AT VARYING pH AND TEMPERATURES.

Temperatures in Degrees

	54F	62F	68F	75F	82F	90F
pH	12C	16C	20C	24C	28C	32C
7.0	0.21	0.30	0.40	0.52	0.70	0.95
7.2	0.34	0.47	0.63	0.82	1.10	1.50
7.4	0.54	0.74	0.99	1.30	1.73	2.36
7.6	0.85	1.17	1.56	2.05	2.72	3.69
7.8	1.35	1.84	2.45	3.21	4.24	5.72
8.0	2.12	2.88	3.83	4.99	6.55	8.77
8.2	3.32	4.49	5.94	7.68	10.00	13.22
8.4	5.15	6.93	9.09	11.65	14.98	19.46
8.6	7.93	10.56	13.68	17.28	21.83	27.68
8.8	12.01	15.76	20.08	24.88	30.68	37.76
9.0	17.78	22.87	28.47	34.42	41.23	49.02
9.2	25.53	31.97	38.69	45.41	52.65	60.38
9.4	35.20	42.68	50.00	56.86	53.79	70.72
9.6	46.27	54.14	61.31	67.63	73.63	79.29
9.8	57.72	65.17	71.53	76.81	81.57	85.85
10.0	68.40	74.78	79.92	84.00	87.52	90.58
10.2	77.42	82.45	86.32	89.27	91.75	93.84

Nitrites

Nitrite, the intermediate product of the oxidation of ammonia to nitrate, is also toxic to fish. Nitrite enters the blood of fish across the gill membranes and combines with the oxygen-carrying portion of red blood cells (hemoglobin) to form a compound called methemoglobin which cannot carry oxygen. Methemoglobin has a brown color, which it imparts to the blood of fish suffering from nitrite poisoning, hence the name "brown blood disease." Because nitrite interferes with oxygen uptake by the blood, the symptoms of nitrite poisoning are quite similar to those caused by oxygen depletion, except that the symptoms persist throughout the day.

The nitrite concentration that is toxic to fish depends on:

1. the species of fish
2. the amount of chlorides present in the water
3. the quantity of dissolved oxygen.

Rainbow trout are stressed at 0.15 PPM and killed by 0.55 PPM nitrite. Channel catfish are more resistant to nitrite, but 29 PPM can kill them. Nitrites are usually not a problem if there are three or more parts of chlorides present in the water for every part of nitrite. Chlorides do not affect the amount of nitrite in the water, but prevent the uptake of nitrite by the blood of the fish. Anytime there is 0.1 PPM or more nitrites present, the water should be checked for chlorides to see if salt should be added. The addition of 25 PPM salt for each PPM nitrite has proven to be an effective treatment. A freshwater flush is also recommended to reduce nitrites.

Ammonia And Nitrite Removal

Biological removal is accomplished with cultures of nitrifying bacteria that convert the ammonia first to nitrite and then to harmless nitrate. These bacteria of gerrera Nitrosomonas and Nitrobacter can be grown on almost any course medium such as rocks, plastic, netting, or oyster shells. Whole oyster shells are particularly well suited because they contain calcium carbonate, which contributes to chemical reactions and buffers pH changes. In addition, the size and shape of whole oyster shells results in considerable surface area for bacterial attachment and provides large void spaces which resist clogging. The latter aspect is of great importance because back-flushing of a clogged filter also removes considerable nitrifying bacteria which reduces the effectiveness of the filter. Filters of this material have been used for fish culture for many years at the University of Florida research laboratory.

Water should be pre-treated before it reaches the filter bed to insure adequate oxygen for bacteria and to reduce the load of particulate matter which could clog the filter. Aeration in the fish tank followed by a settling tank or clarifier are recommended for this purpose. In addition to providing oxygen, aeration also causes the formation of particulate aggregates that are easily removed by sedimentation. Panels of nylon netting have been shown to increase the effectiveness of settling tanks by reducing water current and also by providing additional surface for nitrifying bacteria.

Establishing a bacteria population in a biological filter is a slow process during which water quality undergoes several changes. Two weeks to 3 months may be required for the filter to stabilize. In the initial stage, high ammonia level predominates until nitrifying bacteria become established. There is also a time lag between the fall of ammonia levels and the oxidation of nitrite, because the growth of Nitrobacter is inhibited by the presence of ammonia. Efficient oxidation of nitrite to nitrate does not take place until most of the ammonia has been converted by Nitrosomonas.

Water should be circulated through the filters for several weeks before the fish or invertebrates are added to the system. Adding specimens a few at a time is always a good technique with a new filter system. If the species to be cultured are sensitive to ammonia and nitrite poisoning, the animal load should be gradually built up to maximum density. Seeding a new system with substrate from an established biological filter is one of the best methods to accelerate the conditioning process. Part of the detritus should also be included, since it contains substantial numbers of bacteria.

pH

The standard measure of acidity is pH. The pH scale ranges from 1 to 14, with a value of 7 being neutral. Values under 7 are considered acidic, over seven basic.

Fish can generally survive a pH range of from 3.5 to 10. However, most fish do better in a pH range from 6.5 to 9. Exceptions include some tropical fish that require acid water for breeding and larval development.

Alkalinity And Hardness

Fish grow over a wide range of alkalinity and hardness. Natural waters that contain 40 mg/l or more total alkalinity are considered more productive than waters of lower alkalinity. The greater productivity does not result directly from alkalinity, but rather from phosphorus and other nutrients that increase along with total alkalinity. In fish culture systems, total alkalinity values in the range of 20-120 mg/l have little effect on fish production. However, in systems containing less than 20 mg/l total alkalinity, fish production tends to increase with increasing alkalinity. At low alkalinity, water may lose much of its ability to buffer against changes in acidity, and PH may fluctuate. Even when alkalinity is zero, if weak acids such as tannic acid are present, they may accept hydrogen ions, thereby buffering changes in PH. Fish may also be more sensitive to some toxic substances such as copper at low alkalinity. Many tropical species, however, require low alkalinity and soft water for survival of the eggs and larva. Determination of water hardness and alkalinity can either be made on site with water test kits or by submitting a sample for analysis to a laboratory. Agricultural lime (dolomitic) is recommended for increasing alkalinity.

Hydrogen Sulfide

Hydrogen sulfide is a colorless, toxic gas with a distinctive odor similar to rotten eggs. When fish are exposed to hydrogen sulfide, they increase their respiration. Later respiration slows and finally ceases. Hydrogen sulfide is more toxic to fish at lower pH and higher temperatures.

Hydrogen sulfide can be a serious problem, especially if using well water. Well water containing hydrogen sulfide should be aerated before adding it to culture systems.

Temperature

Temperature has a direct effect on fish metabolism, feeding, and survival. No other physical factor affects the development and growth of fish as much as water temperature. Metabolic rates of fish increase rapidly as temperature goes up. Conversely, as temperature decreases, so do the fish's demands for oxygen and food. Many biological processes such as spawning and egg hatching are geared to annual changes in environmental temperature. Each species of fish has a temperature range that it can tolerate; within the range, there is an optimal temperature for growth and reproduction, which may change as the fish grows. Like fish, disease organisms also have an optimal temperature range for development, and outbreaks are more prevalent during these conditions. Most chemical substances dissolve more rapidly as temperature increases; in contrast, gases such as oxygen, nitrogen, and carbon dioxide become less soluble as temperature rises.

Large, rapid changes in temperatures are stressful to fish and may result in death. This problem is most important when fish are transported for stocking. Prior to stocking, water in the transport container should be tempered with the water in which the fish will be stocked. For small sensitive fish, a tempering rate of 3.6 degrees F./hour is suggested. Larger more hardy fish can withstand more than a 9 degrees F./hour change in temperature. Tropical fish species can generally tolerate an increase in water temperature better than a decrease. The opposite is true for temperate and cool-water species. Fish that initially survive a temperature shock may be sufficiently stressed to later succumb to infection.

Water Sources

The backyard culturalist will find differences in all these parameters of water depending on the source of water used for aquacultural operations.

If tap water is used it is important to remove chlorine form the water or by the addition of sodium thiosulfate. Particular care must be taken to remove chlorine from any water added once the system is operational. Additional copper, zinc or lead can have a toxic effect on fish. Thus, it is best to test for the presence of these metals when using surface or ground water. The alkalinity and hardness of the water can often be found in reference materials on aquifers and surface water in the general geographic area in which your site is located. Ground water from various aquifers and different depths can also have varying amounts of salt. It is best to have your water source tested by a lab to determine proper methods to condition it to use as a growth medium for fish.

CHAPTER 2

DESIGN AND CONSTRUCTION OF BACKYARD AQUACULTURE SYSTEMS

The backyard aquaculture systems described in this chapter were used during the Small Scale Aquaculture Demonstration Project, established in 1983 in cooperation with the Miami Agricultural School. These culture facilities are all closed-system recirculating systems. Each of these systems is designed to be relatively simple and inexpensive to construct from materials readily available from local sources. It is recommended to potential backyard aquaculturist that the systems presented here are only a guide and that the authors encourage interested individuals to consider their needs, space restrictions, and skill level before starting this type of project.

All backyard aquaculture recirculating systems, no matter of what design or configuration, consist of a culture tank(s), a filtering component, and a recirculating component. With the exception of the swimming pool/biodisc culture system and the trickle filter, the backyard systems were designed on site. The following system descriptions are provided as a guide to culture systems that can be constructed from almost any suitable container and in the configuration that available space allows. The primary concern for culturing fish is water quality, not the container. An additional consideration is system cost.

Depending on the level of expertise that the individual constructing a system possesses, some systems components may be more difficult to assemble than others. This factor may come into play when deciding on what system to utilize. Obtain and study as much literature and contact individuals and organizations that may have information and/or knowledge about backyard aquaculture. Once you have done this and determined the available space and necessary physical requirements to construct the desired culture system, then put everything down on paper. Lay out the system to fit in the allotted space. Make sure that adequate electricity and water are available to the site. Also list all required materials that would be necessary to complete the various components of the culture system. It is suggested that you shop around for materials, as prices may vary from one source to another. Many resourceful people may already have much of the necessary materials or are able to obtain them by visiting construction sites, etc., therefore reducing the cost of the culture system.

Fiberglass Tank System With Trickle Filter

This culture system has easily produced at least 100 fish per tank and perhaps is capable of higher stocking densities under optimum conditions.

The approximate cost of this system in 1983 was $430. This system consists of two five-foot diameter fiberglass tanks (approximately 450 gallons each) set in a six-inch concrete base, a biological trickle filter, recirculation system with a compost water heater, siphons and some miscellaneous materials and supplies. A complete materials list is shown in Table 2.

Each culture tank is constructed of a 16' X 40" piece of flat fiberglass sheeting and a 6' X 6' X 6" concrete base. The fiberglass sheeting strip should be fastened together with normal fiberglass resins following instructions on the container. The resin should be allowed sufficient time to bond the overlapped ends together. This operation will result in a five-foot cylinder. Once the cylinder is constructed, the concrete for the base can be mixed or brought in by truck and poured. As soon as the concrete's surface has been smoothed, the cylinder can be carefully set in the concrete while it is still wet. Being sure that the cylinder is in as near a circle as possible, press the fiberglass cylinder into the concrete approximately four inches in order to insure against leaks. When the bases have hardened, run a bead of silicone caulking with a caulking gun along the inside and outside joints where the concrete and fiberglass meet. This is an added protection from any small leaks. An article from Aquaculture Engineering (Journal), Volume 1, 1982 describes a template system to construct fiberglass tanks. See Appendix B for additional information concerning this article.

The two tanks should be placed so that a common biological filter can be used by both culture tanks. The filter used for this system was two 50 gallon steel drums with the bottom and top cut out of one and the other with the bottom cut out. Turn the drum with the top remaining upside down and place the drum with no ends on top of the other drum and weld them together. Construct the lath pallets (approximately 14" X 14") with two runners and nail lath strips across the runners leaving spaces between so that water can trickle down the stack of pallets. These pallets act as surface for bacteria to grow on and to break up as droplets for better oxygen uptake. Some type of bars or angle iron should be welded approximately 14 inches from the bottom to allow the lath pallets to rest above the settling basin.

Cut a hole in the side of the lower drum approximately 12" from the bottom large enough so that a 2" flange can be welded in place. This flange should be placed on the side opposite from from the large opening on the bottom of the drum.

TABLE 2

FIBERGLASS TANK SYSTEM
WITH TRICKLE FILTER

CULTURE SYSTEM

FLAT FIBERGLASS SHEETING 2 16'X 40"
(AVAILABLE IN ROLLS 52"X50')
CONCRETE BASES(6'X6'X6"[2/3 CU. YD.])

FILTER

2 BARRELS(50 GAL.)
2 GALVANIZED 11/4" 2"LONG NIPPLES
1 " " 3" " "
1 " " ELBOW
1 " REDUCER (11/4"X3/4")
1 " BUSHING (2"X11/4")
1 BRASS VALVE 11/4"
3/4" BRASS HOSE ADAPTER
6 CONCRETE BLOCKS

RECIRCULATION SYSTEM W/COMPOST HEATER

10' 1/2" PVC PIPE
3 " " BALL VALVES
2 " " " ELBOW
6 " MALE BRASS GARDEN HOSE ADAPTERS
2 " POLY HOSE MALE ADAPTERS
15' 5/8" GARDEN HOSE
2 SUBMERSIBLE PUMPS (1/12TH HP)
5' 2" PVC PIPE
2 " " ELBOWS
1 " " TEE
2 BUNDLES CYPRESS LATH 4'X11/4"X1/4")

SIPHON

10' 2" PVC PIPE
2 " " ELBOWS

MISCELLANEOUS

FIBERGLASS RESIN (1 QUART)
SILICONE CAULKING (2 TUBES)
PVC CLEANING SOLVENT (1 PINT)
" CEMENT (1 PINT)

APPROXIMATE SYSTEM COST $430.00

A bushing (2" X 11/4") is screwed into this large opening on the bottom of the drum and a two-inch galvanized 11/4" nipple screwed in it. Attach the elbow on this nipple and then screw the three-inch nipple into the elbow followed by the 11/4" brass valve, the other two-inch nipple, the reducer, and the 3/4" brass garden hose adapter. This assembly will allow drainage of the settling basin of the filter in order to remove unwanted sludge. The filter should be elevated on concrete blocks so that the water return outlet is above the tank tops. Two 1/12th HP submersible pumps rated at approximately 700 gallons per hour (GPH) each are used to recirculate water. The pump rating is based on a seven-foot head or height that water has to be lifted. Water volume in the tanks and the filter drum is approximately 900 gallons. Water will be completely exchanged 1.5 times every hour if all components are unobstructed and operating properly.

By reviewing the system diagram in Figure 1 an aquaculturist can set up the recirculating system by measuring the needed lengths of 1/2" pvc pipe to pump water from the culture tanks to the filter. Water is then returned to the tanks by gravity through the two inch flange welded in the side of the drum.

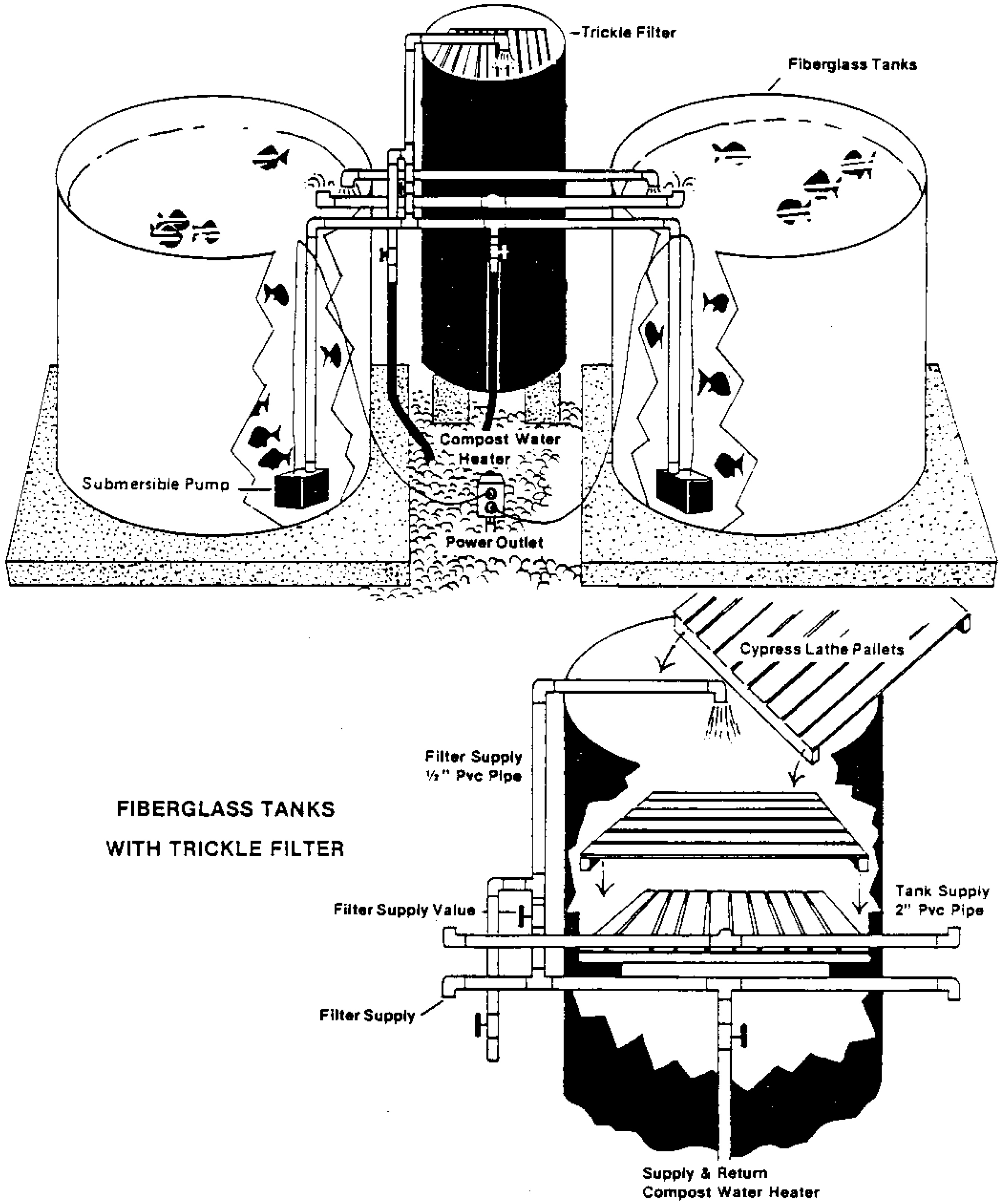
In colder months the compost water heater may be an option that should add several degrees to the water temperature, allowing the fish to continue feeding and growing. In extreme climates this option may not be adequate for maintaining water temperatures for warm water species such as tilapia. The compost heater is simply a coil of 100 feet of 1/2" poly pipe with associated hardware for connecting to the recirculation system. The coil is placed under a fresh pile of compost material that is kept active by adding plant material, manure, and other appropriate composting ingredients. The compost heater can be adapted to the available space.

A two-inch pvc pipe siphon should be constructed from a length of pipe adequate to fit from one tank to the other. All that is needed is two 2" pvc elbows and a down pipe for each end of at least 18" long. The siphon will insure equal levels in both tanks in the event of a pump failing in one tank thus preventing overflow.

Fiberglass Tank System

The Fiberglass Tank System is essentially the same as the previous culture system with two 440 gallon tanks. The exceptions are a different filter configuration and no compost water heater. The cost is approximately $100 less than the trickle filter system. Stocking densities are the same.

The filter consists of only a single 50 gallon drum filter with the same draining capability configuration. Table 3 lists



FIBERGLASS TANKS

WITH TRICKLE FILTER

FIGURE 1

TABLE 3

FIBERGLASS TANK SYSTEM

CULTURE SYSTEM

FLAT FIBERGLASS SHEETING 16'X 2
(AVAILABLE IN ROLLS 52"X50')
CONCRETE BASES(6'X6'X6"[2/3 CU. YD.])

FILTER

1 BARREL (50 GAL.)
2 GALVANIZED 11/4" 2" LONG NIPPLES
1 " " 3" " "
1 " " ELBOW
1 " REDUCER (11/4"X3/4")
1 " BUSHING (2"X11/4")
1 BRASS VALVE 11/4"
3/4" BRASS HOSE ADAPTER
2 CONCRETE BLOCKS
5 CORRUGATED FIBERGLASS SHEETS (26"X 8')

RECIRCULATION SYSTEM

10' 1/2" PVC PIPE
2 " " BALL VALVES
2 " " ELBOWS
1 " " TEE
1 " " MALE THREADED X SLIP ADAPTER
1 " BRASS MALE GARDEN HOSE ADAPTER
1 SUBMERSIBLE PUMP (1/12TH HP).

MISCELLANEOUS

FIBERGLASS RESIN (1 QUART)
SILICONE CAULKING (2 TUBES)
PVC CLEANING SOLVENT (1 PINT)
" CEMENT (1PINT)

APPROXIMATE SYSTEM COST $300.00

the necessary materials. Instead of lath pallets, corrugated fiberglass sections approximately 2'X 2' are placed on end and overlapped around the inside of the drum (See Figure 2). A single 1/12th HP submersible pump is suspended off the bottom by a 1/2" pvc pipe common manifold by an 18" piece of garden hose and brass hose adapters. This configuration will provide an exchange rate of 800 GPH or a complete exchange every 1.2 hours.

The manifold supplies filtered water back to the tanks while aerating. It is necessary to have two 2" pvc pipe siphons with each having the tank side downpipe 3' in length to remove solid materials from the tank bottoms into the filter's settling basin for easier removal from the system.

Pool System

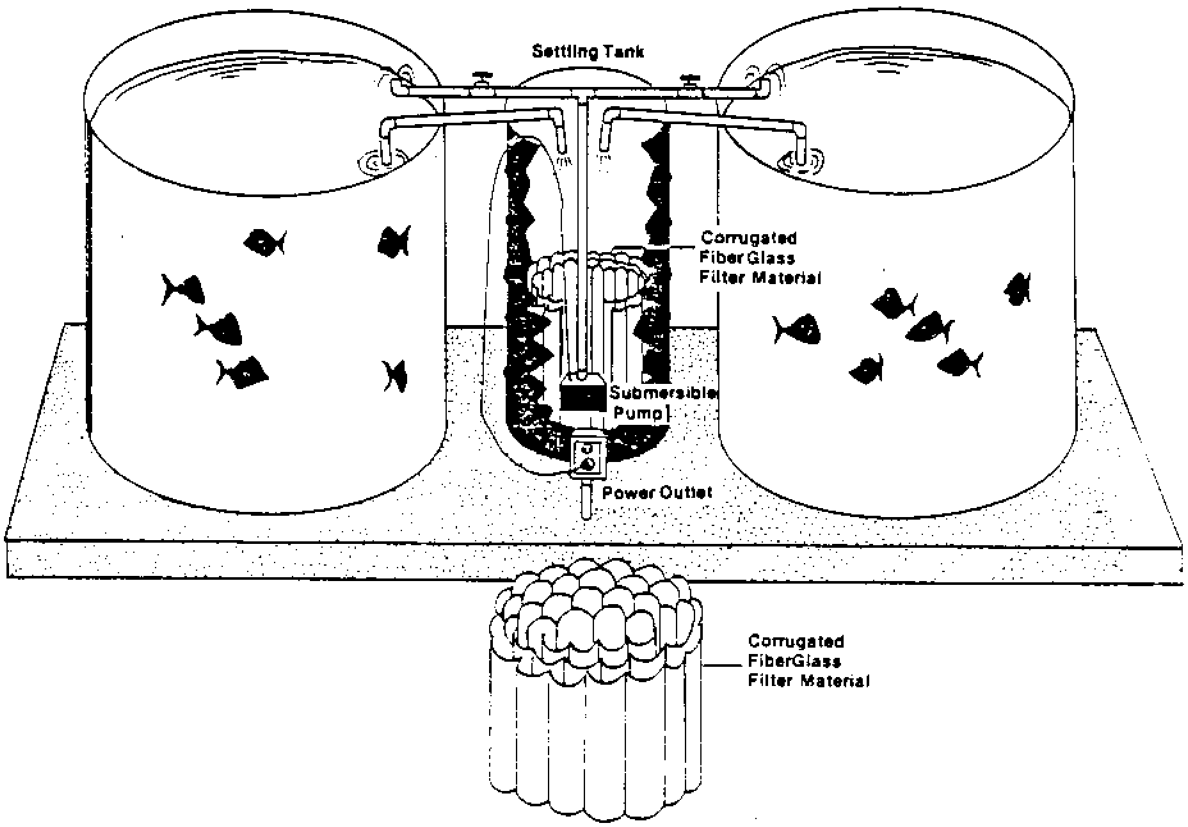
The Backyard Pool System was developed by the Rodale Aquaculture Research Center and is fully described with complete construction information in HOME AQUACULTURE - A GUIDE TO BACKYARD FISH FARMING (See Appendix B for further information on this publication).

The system consists of a 12'X 3' plastic lined swimming pool for fish culture, two clarifier drums or a second 12' pool which are used for settling basins or in the case of the second pool, as a means for growing aquatic and terrestrial vegetables, a rotating bio-disc biological filter/aerating water wheel and two 1.12th HP submersible pumps. Table 4 and Figure 3 give a materials list and a descriptive review, respectively.

The culture pool's is approximately 2538 gallons with a like amount in the settling pool for a system total of 5076 gallons. Pumping rate for the two submersible pumps is 1585 GPH with a two foot head. Water in the system will be exchanged every 3.2 hours or 7.5 times daily.

This system was stocked with 200 fish initially and later "pushed" by adding additional fish to approximately 300 fish to see what limits this system would allow without experiencing stress on the cultured fish. Blue tilapia were the selected fish in the system, which are very tolerant of poor water quality. It is recommended to start out with a lower number of stocked fish and work up to the limit of the system.

During colder months, an inexpensive solar dome can be constructed relatively easily to keep the water temperature in the culture system from dropping below a level where fish will stop eating. This can be done in conjunction with adding 1/2" foam insulation sheets on the outside of the pool sides to assist in prevention of heat loss. The dome is described in the Rodale publication and consists of several lengths of 1/2" pvc pipe and a 20'X 20' heavy duty clear drop cloth. This dome would be recommended for central and northern parts of Florida during the



FIBERGLASS TANKS WITH SETTLING FILTER

FIGURE 2

TABLE 4

POOL SYSTEM

CULTURE SYSTEM

12' VINYL LINED SWIMMING POOL (PRODUCTION)
12' " " " " (CLARIFIER)
SECOND POOL OPTIONAL, CAN USE 2 50 GALLON DRUMS AS FILTERS.

BIODISK FILTER

1' FOAM INSULATION		4' X 8' SHEET
SILICONE CAULKING	2 TUBES	
1.5" PVC PIPE		20' LENGTH
" " TEES	6	
" " ELBOWS	2	
" " 45 ELBOWS	3	
" " CAPS	2	
4" PVC PIPE		4' LENGTH
" " COUPLINGS	2	
" " FLANGES	2	
4" X 2" PVC BUSHINGS	2	
FLAT FIBERGLASS SHEETING	4 X 36" DIAMETER	

SIPHONS

2" PVC PIPE		20' LENGTH
	4, 36" LENGTHS	
	2, 20" "	
2" PVC ELBOWS		4

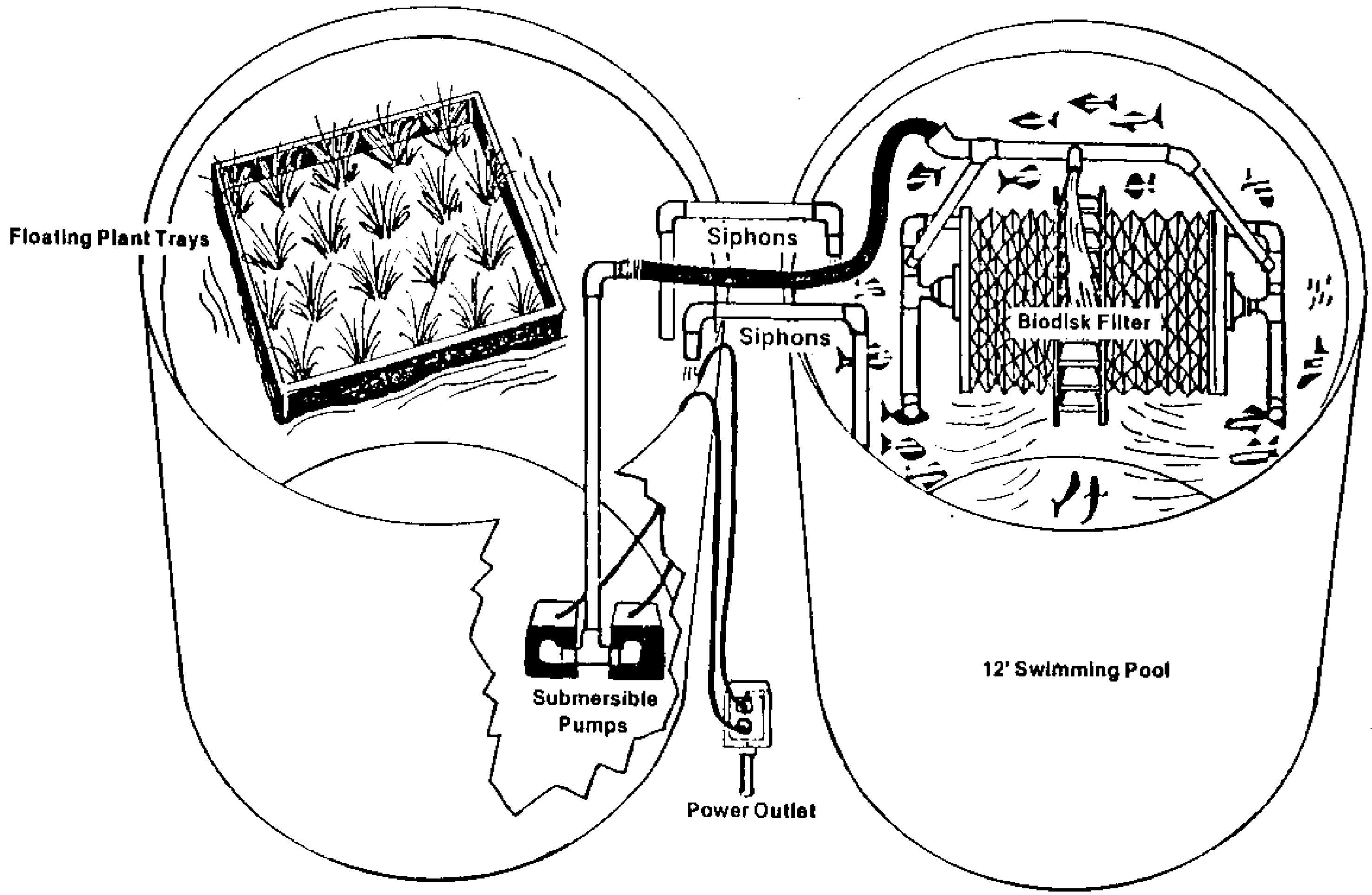
PUMPS

2 SUBMERSIBLE PUMPS (1/12TH HP)

MISCELLANEOUS

PVC CEMENT	1 PINT
PVC SOLVENT	" "
DROP CLOTHES	3
DUCT TAPE	1 ROLL

APPROXIMATE SYSTEM COST $500.00



12' PLASTIC LINED SWIMMING POOL SYSTEM

FIGURE 3

colder months.

Set-up of the pool will take some time. Follow the swimming pool manufacturer's instructions. The site should be as flat as possible or fill will have to be added to level the site. Care should be taken to remove all rocks and sharp objects, such as small rocks, to prevent puncture of the plastic liner. In addition, the pool site should have all grass removed and/or be sprayed with herbicide as certain grasses can grow through the liner bottom.

Concrete Vaults System

The Concrete Vault System consists of four concrete burial vaults with a common biological filter and two submersible pumps. The pumping rate for the pumps is approximately 810 GPH each. Each vault has a volume of 289 gallons thus totaling 1156 gallons for the four vaults and 30 in the filter for a system total of 1186 gallons. Water will be exchanged 1.4 times per hour.

Approximately 50 fish have been grown in each of the tanks for a total system stocking density of 200 fish. Cost for this system in 1983 was approximately $530. Table 5 lists the necessary materials for this system. Concrete vaults are readily available from vault manufacturers and in some cases, because of the demand for these vaults for fish culture, they are willing to install 2" threaded flanges in the bottom during construction. This feature allows for easier draining of the tank for cleaning, etc. System configuration shown in Figure 4 was utilized in order to incorporate the common biological filter.

Site planning and preparation should be completed prior to delivery of the vaults as they are heavy and will be difficult to move after they are placed on the ground. They should be set on concrete blocks to allow for attaching drain pipes to the tank flange if desired or so water can be drained from the tanks. To prevent inadvertent overflowing of the tanks, and possible loss of fish, due to heavy rain or improper recirculation, a 20" piece of 2" pvc pipe should be used as a standpipe with the male threaded adaptors attached to one end and screwed into the drain flanges.

The filter is a 30 gallon plastic trash can with a 10'X 10' piece of polypropylene bird netting used as filter medium. Two submersible pumps are attached to a common 1/2" pvc pipe manifold by means of two tees and brass hose adaptors. Short pieces of 5/8" garden hose are attached to the pumps with clamps and attached to the manifold. The pumps are suspended off the bottom of the filter so that solid waste materials in the filter basin will not be picked up and reintroduced into the tanks. The manifold has an outlet with a valve for each of the tanks. To complete the recirculation system, four 2" pvc siphons are placed with one end in the filter and the other in each of the four

TABLE 5

CONCRETE VAULTS SYSTEM

CULTURE SYSTEM

4 CONCRETE BURIAL VAULTS
2" PVC PIPE (4 20" STANDPIPES)
4 2" PVC MALE THREADED X FEMALE SLIP ADAPTER

FILTER & RECIRCULATION SYSTEM

1 PLASTIC GARBAGE CAN (30 GAL.)
BIRD NETTING 10'X10' (FILTER MEDIA)
20' 1/2" PVC PIPE
4 " " BALL VALVES
" " " ELBOWS
" " " TEES
2 " " MALE THREADED X SLIP ADAPTERS
2 BRASS MALE GARDEN HOSE ADAPTERS
2 FEMALE HOSE FITTINGS
2 SUBMERSIBLE PUMPS (1/12th HP)

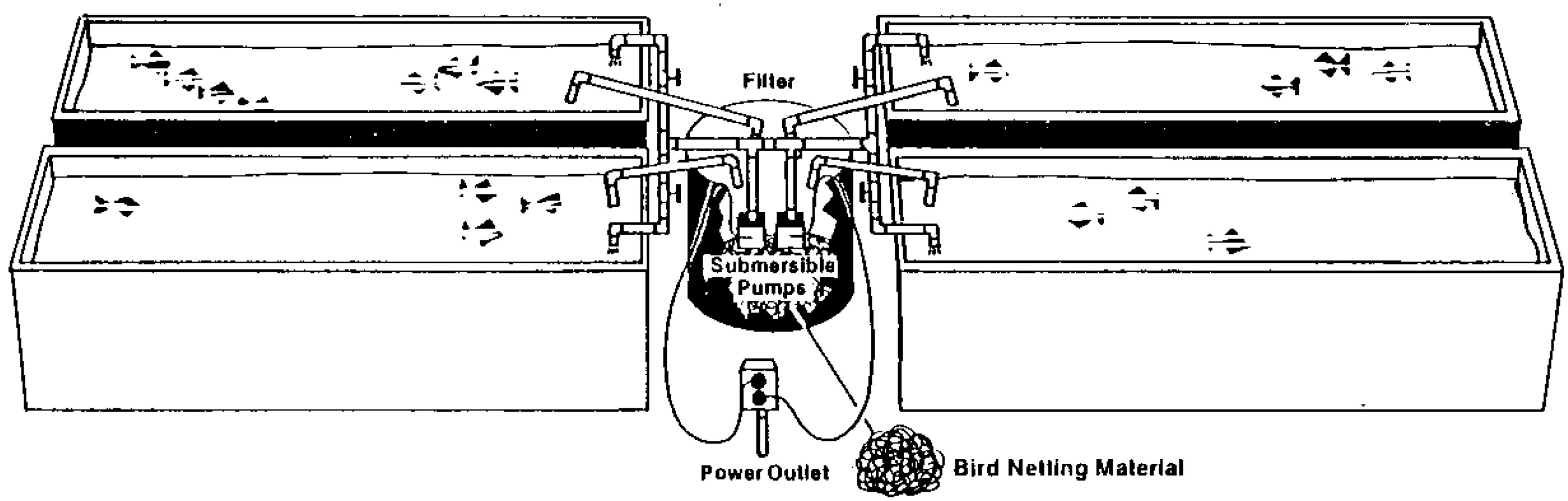
SIPHONS

20' 2" PVC PIPE
8 " " ELBOWS
1 " " CAP

MISCELLANEOUS

22 CONCRETE BLOCKS (5 PER TANK, 2 FOR FILTER)
PVC CLEANING SOLVENT (1 PINT)
PVC CEMENT (1 PINT)

APPROXIMATE SYSTEM COST $530.00



CONCRETE VAULT SYSTEM

FIGURE 4

tanks. These siphons should be of adequate length to reach from the filter to the tank. Two 2" pvc elbows are required for each siphon and the downpipe almost reaches the bottom of the culture tank. The downpipe in the filter should be approximately one half the height of the filter container so as not to break suction during operation of the system. The top of the filter should be level with the top of the culture tanks so as to maintain a balance of water levels throughout the system.

Of all the systems that were used at the Small Scale Aquaculture Demonstration Project, the vaults system was least difficult to maintain and keep in operation.

Trough System

The aluminum Trough System consists of two 25'X 3'X 28" troughs, one for fish culture and the other for a biological filter and culturing aquatic plants, a submersible pump and an air pump and manifold (Table 6). A pump removes solid waste from the bottom of the fish trough to the filter and the syphons return the filtered water back to the fish trough. Aeration was accomplished by the air pump through the submerged air manifold. Stocking density for this system ranged from 200 to 350 fish. The system cost is relatively expensive at between $575-$875. This consideration along with the required space to set up this system does not lend itself to most backyard situations (Figure 5). However, as the system was demonstrated during the project, it is included in this chapter.

The recirculation system described above is relatively simple as the 1/12th HP submersible pump is placed in the end of the culture trough on the bottom and the discharge hose placed in the filter trough. Two 2" pvc pipe siphons are constructed as the siphons in the previous culture systems were. The down pipes should be approximately one half the trough depth to prevent loss of suction. Pumping rate at three feet of head is 775 GPH, exchanging the 1300 gallons of water through the filter every 1.7 hours or approximately 14 times a day.

The supplemental aeration system is made up of a 1.5 cfm diaphragm air pump which supplies air to the 1" pvc manifold with 3' air diffusers on each end of the manifold. If this material is not available, 1" pvc with small holes drilled in it can replace the air diffuser material. The smaller the holes the better the oxygen is mixed into the water.

As the manifold will float, glass marbles or other inert material should be used to ballast the manifold to hold it on the trough bottom. If using marbles, be sure to place them in the manifold prior to cementing the pvc joints as it is difficult to get them in the pipe after construction is complete.

TABLE 6

TROUGH SYSTEM

<u>CULTURE SYSTEM</u>

1 25'X 3'X 28" ALUMINIUM TROUGH(PRODUCTION)
1 " " " " " (FILTER)

<u>SIPHONS</u>

2" PVC PIPE	12' LENGTH
	2 36" LENGTHS
	2 24" "
	2 12" "
2" PVC ELBOWS	4

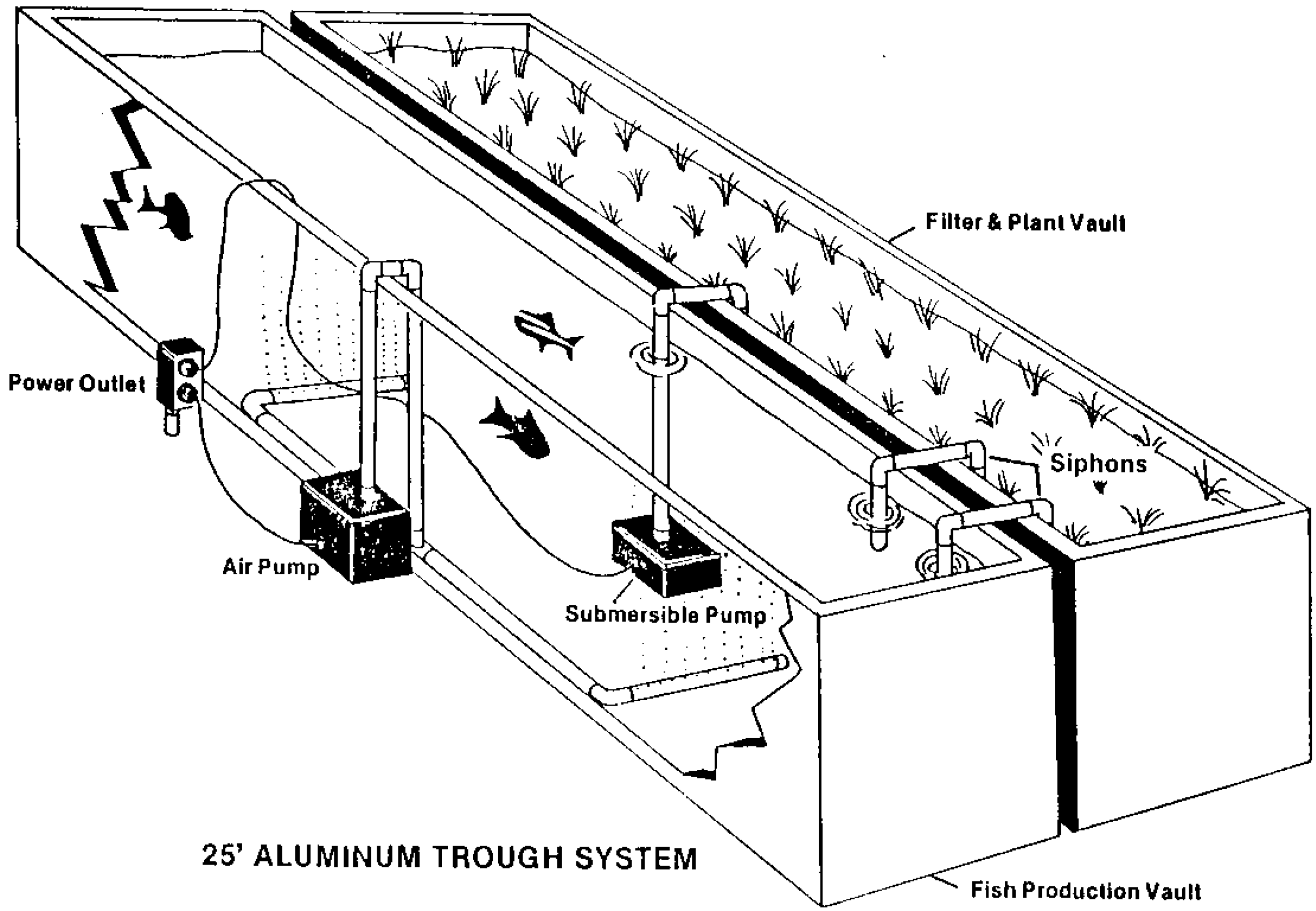
<u>PUMPS</u>

SUBMERSIBLE PUMP (1/12TH HP)	1
DIAPHRAGM AIR PUMP (1.5 CFM)	1
AERATION TUBING (1")	6' LENGTH
1" PVC PIPE	12' "
" " TEE	1
" " ELBOWS	2
" " CAPS	2

<u>MISCELLANEOUS</u>

PVC CEMENT	1 PINT
" CLEANING SOLVENT	" "
GLASS MARBLES	150

APPROXIMATE SYSTEM COST $575-$875



25' ALUMINUM TROUGH SYSTEM

FIGURE 5

Helpful Hints

Prior to starting any construction of a backyard aquaculture system, review thoroughly building and zoning regulations that may restrict the kind of activity planned in your residential jurisdiction. If permissible, you may be required to present plans for review by the agency staff for approval. This exercise may prevent the loss of money and time and potential fines for not obtaining any necessary permits.

When constructing pvc piping, be sure that all joints are a good fit and the dimensions are accurate, prior to cementing the joints together. Be sure to apply adequate amounts of pvc cement to all joints, especially on siphons, so that there are no leaks. If siphon joints are not sealed properly, suction will be broken and an overflow will occur. From time to time air bubbles may build up in the siphon and cause a loss of flow. It may be a good practice to break suction and restart the siphons to remove any trapped air.

When fingerling fish are first stocked in the culture tanks, care should be taken to place 1/2" hardware over the siphon ends in the culture tank. This will prevent the small fish from being pulled into the filter and clogging a pump and possibly causing a loss of fish due to a lack of oxygen or overflow of water due to imbalance in the recirculation system.

Have all materials needed on hand when starting construction so that delays can be kept to a minimum. If all necessary materials are not available locally, a very good reference to locate suppliers of equipment and materials is the AQUACULTURE MAGAZINE'S BUYERS GUIDE (see Appendix B).

CHAPTER 3

SOME APPROPRIATE SPECIES FOR BACKYARD AQUACULTURE

Susceptibility to rapid changes of environmental parameters, in backyard aquaculture systems described in this guide, will determine the type of fish that may be best suited for culture. A species has to meet several criteria to be a suitable candidate. As the culture systems and the Florida climate dictate, the fish would have to be a warm water species, tolerant to a wide range in water quality changes, hardy, disease resistant, and available.

Two families of fish that generally fit the above discription, as well as some others with potential, will be discussed in this chapter. By no means are these the only species available to aquaculture. By determining the motivation for culturing fish and the types of culture systems utilized several species would be practical to culture. No matter what species is selected for culture the potential aquaculturist should be aware that only a small number of fingerlings is needed to stock the backyard system, compared to thousands that a commercial fish farm would need. Private fish hatcheries normally do not sell in small lots, or if they do, the buyer will pay a premium price per fish.

The Tilapias

Tilapias are a family of fish exotic to Florida. They were introduced and, in the case of several species, established in Florida. The predominant species is the Blue tilapia, Oreochromis aurea, which has had reproducing populations in several central Florida lakes for many years. South Florida canals harbor several established species. Tilapias are native to the Near East and Africa's tropical and sub-tropical areas. They are well suited to the Florida climate. Several species and hybrids of these species have been promoted as a potentially high volume, inexpensive protein source. Tilapia have yet to be widely accepted by American consumers. As a food fish its table quality has been compared to largemouth bass and other desirable freshwater gamefish. The advantage of selecting tilapia is that they will readily reproduce in backyard culture systems, providing a supply of new fish for growout.

Culture characteristics: Feed low on food chain, eating algae and leafy plants, as well as prepared pellet foods; ability to survive low oxygen levels to 0.5 ppm, will gulp air at surface of water when low oxygen levels occur in system; do well in water temperatures 64-90 degrees(optimum 80-82 degrees); tolerate high levels of ammonia or nitrogen; highly resistant to both diseases and parasites; fingerlings available from a few commercial suppliers in Florida; growth rate of approximately 0.5 lbs. in 5-6 months under optimum conditions, can get to 5 lbs. or larger.

Due to regulation of tilapia in Florida, which will be discussed in a later section, the Blue tilapia is probably the lead candidate of this family for backyard culture.

The Catfish

Among the catfish family, the channel catfish, Ictalurus punctatus, is the most important commercially cultured food fish in the United States. Several other catfish species such as blue (Ictalurus furcatus), white (Ictalurus catus), brown (Ictalurus nebulosus), black (Ictalurus melas), and yellow bullhead (Ictalurus natalis) catfish are also candidates for culturing. Because of its qualities as a commercially cultured warm water fish and its general availability from suppliers, the channel catfish is highly suitable for backyard culture.

Culture characteristics: Feed well on prepared pellet feeds; grow well in water temperatures from 70-90 degrees; grow well at 4 ppm or higher oxygen levels; ammonia levels of less than 1 ppm, 2 ppm can be fatal; fingerlings can reach 1/2 pounds in 5-6 months under optimum conditions, market size of 3/4 to 1.5 pounds in 1.5 years.

Other Species

The sunshine bass is a hybrid resulting from the cross of the striped bass, Morone saxatilis, and the white bass, Morone chrysops. It has demonstrated hybrid vigor growth rates, disease resistance, improved survival rates and better overall hardiness. It would seem that this hybrid fish would lend itself to small--scale backyard culture. Previously a major drawback was the lack of availabe fingerlings. This situation changed as commercial hatcheries are producing fingerlings.

The carp family has several species that are potential candidates for backyard culture. Carp are more difficult to culture as they seem not to do well in small culture systems. They tend to cause problems in certain systems, such as plastic lined pools when they hit the sides and cause damage and/or injure themselves. The common carp or mirror carp (Cyprinus carpio), bighead carp (Aristichthys nobilis), and the grass carp (Ctenopharyngodon idella) all may be considered. Again, due to state regulations, the common or mirror carp, grass carp, and silver carp (Hypopthalmichthys molitrix) are restricted species and the culturist must have a permit from the state to possess these fish.

Regulations and Permits

The Florida Game and Freshwater Fish Commission(GFC) establishes and enforces rules concerning freshwater aquaculture and non-native fish species in Florida. The agency's rules are written to address regulations such as permitting of fish possession or licenses to sell fish. Table 7 summarizes regulations that impact aquaculture in Florida.

In the case of exotic or non-native fish species such as tilapia and carp, an aquaculturist is required to obtain a permit prior to possessing these fish. Game and Freshwater Fish Commission biologists will inspect a facility to ascertain that the site meets the criteria determined by the rules established for the restricted species the permit is being sought for. This process assists in the prevention of escapement of non-native species into an open water system allowing the establishment of a breeding population that may threaten native fish populations by habitat destruction, crowding out of native species or predation.

Of the tilapia species, the blue tilapia, Oreochromis aurea, permitting criteria are less strict than for hybrid tilapia. Criteria for issuing a permit include banning discharge of culture water off the property to an open body of water and requirement for an anti-personnel fence surrounding the property to provide for security. A permit is issued on an annual basis and must be applied for each year. The permit will stipulate what can and cannot be done with the species. Primarily, the fish can not be given, traded or sold to anyone without an existing permit to possess the same species. If the owner is selling these fish, he must have a Game and Fish Commission exotic fish license to do so.

As rules and regulations pertaining to aquaculture and possession of restricted species may change, current information can be obtained from the Game and Freshwater Fish Commission, Aquaculture Project, 3900 Drane Field Road, Lakeland, FL 33803. (813)644-9269 or (800)282-8002.

TABLE 7

REGULATIONS IMPACTING AQUACULTURE

AGENCY*	STATUTE OR RULE	DESCRIPTION	LICENSE/ PERMIT/ LEASE
GFC	372.0225 FS	Regulate aquaculture facilities	Yes
	372.76 FS	Search, inspection, seizure	
	372.83 FS	Penalties for violations	
	39-23.09 FAC	Sale and transportation of fish	Yes
	39-12.09 FS	Killing depredating birds	Yes
	372.65 FS	Fish farm, wholesale and exotic dealers	Yes
	372.26 FS	Import fish	Yes
	39-405 FAC	Non-native fish	Yes
	370.112 FS	Striped bass possession	Yes
	39-23.08-12 FAC	Non-native protection devices	Yes
	39-4.05 FAC	Diseased fish	
	39-23.08 FAC	Diseased fish	
	39-25.04 FAC	Alligator farm operation	Yes
	39-25.05 FAC	Harvest and sale of alligators	Yes
	39-25.07 FAC	Sale of alligator products	Yes
	39-25.051 FAC	Sale of alligator meat	Yes
DNR	370.16 FS	Shellfish leases	Yes
	253.67 FS	Water column leases	Yes
	161 FS	Beach and shore preservation	Yes
	16B-28 FAC	Shellfish sanitation	

(Table 7 continued)

	16C-52 FAC	Aquatic plants	Yes	
US	PL95-217	NPDES discharge		
EPA	40CFR 121-125		Yes	
DER	403 FS	Water quality discharges	Yes	
	17-4, 17-12 17-45 FAC	Dredge and fill		Yes
	PL92-583, 380 FS	Coastal zone management		
WMD	373 FS	Comsumptive use water	Yes	
	373 FS	Storage and management surface water	Yes	
	373 FS	Wells	Yes	

*Abbreviations for agencies:

GFC - Florida Game and Fresh Water Fish Commission
DNR - Florida Department of Natural Resources
USEPA - U.S. Environmental Protection Agency
DER - Florida Department of Environmental Regulations
WMD - Water Management District

CHAPTER 4

OPERATION AND MAINTENANCE

Since water quality is the major concern for all fish cultural operations, the addition and conditioning of the water in these systems are of paramount importance.

Before water is added to the cultural systems described in the preceding chapter, all components should be washed with a mild detergent and flushed with copious amounts of fresh water. This will remove any chemical contaminants and foreign materials. Allow all components to air dry after washing, before water is added to the system. Swimming pool liners should be washed prior to installation into the supporting frame, as removal of soapy water will be impossible after construction.

The source of the water used will determine the method used to treat and condition it for use in the cultural system. Tap water should be tested for the presence of chlorine and ammonia and treated as necessary, while well water and surface water need to be treated to remove any unwanted gaseous components. In either case, after initial treatment, the water should be aerated from a minimum of 24 hours to several days to ensure the removal of harmful gases.

Conditioning of the biological filter can be time consuming (2-6 weeks) and your stocking schedule needs to include this lag time to minimize ammonia and nitrite problems. Some of the best ways to condition the biological filter include: adding material from properly functioning biological filters already in existence, adding the culture organisms a few at a time over several weeks, adding algae and food products gradually over several weeks. Before adding the culture organisms, water quality testing on a frequent basis (twice a day, early morning and late evening is recommended) should be accomplished. Look for an initial increase in ammonia followed by a decrease as nitrifying bacteria increase in numbers. It is important to note that when cleaning or backflushing biological filters, large amounts of these bacteria can be lost to the systems. Therefore, care should be taken not to agitate the filter material too much while cleaning or problems with elevated ammonia levels could result.

The size of the fish at the initial stocking will affect the time required to grow the fish to edible size. The smaller the fingerlings, the longer it will take to grow them to minimum harvestable size. If your growing season is short, larger fish should be used for the initial stocking. With some tropical varieties, lower temperatures in the winter, while usually decreasing growth rates, could be fatal to the fish.

When fingerling fish are first stocked in the culture tanks, care should be taken to place 1/2" hardware cloth over the syphon ends that are placed in the culture tank. This will prevent the small fish from being pulled into the filter and clogging a pump and possibly causing a loss of fish due to a lack of oxygen or overflow of water due to imbalance in the recirculation system. Additionally, the tops of the culture tanks should be screened to prevent fish from jumping out. This problem can be critical to the success of the operation. In our trials fish loss was as high as 50% from this source. While this made neighboring cats happy it certainly decreases your chance of successful backyard aquaculture. It is strongly recommended if stocking tilapia because they tend to jump out as they are skittish. Also, the permitting agency requires that culture tanks be covered when rearing tilapia to prevent escape into open bodies of water.

Care and feeding operations are relatively simple, and do not require large amounts of time. Depending on the number of units and fish being cultured, anywhere from 1/2 hour to 1 hour twice a day will usually provide enough time for these operations. Care should be taken to provide enough observation time to assess any problems the fish may be having, especially when starting the system up. Required time will be reduced as the system is established and the incorporation of demand feeders into the culture system.

Feeding

The type of food to use is an important consideration since it will affect growth rates and could affect water quality. Generally, formulated foods are recommended with a relatively high protein content (over 40%). Foods with a lower protein analysis or the use of other forage items usually will not provide sufficient nutrition for growth rates needed to produce an annual crop. When feeding to saturation (i.e. when the fish will not accept additional food) floating rations are recommended because the culturist can visually determine if all food has been consumed. Manufacturers of fish food are constantly upgrading their rations as field experience and research in fish nutrition progress. Additions of vitamins, fats and oils to fish foods seem to play a significant part in growth rates and overall health of cultured fish. Most major manufacturers will provide the culturist with samples and analysis of the rations they make. Check with several companies before deciding on the rations to use in your operation.

Overfeeding can cause an increase in ammonia and nitrite levels that could harm the culture animal. Feeding rates depend on the species, age, temperature, and availability of other forage in the system. Generally, the rule of thumb is to feed 3 to 5% of body weight per day. 5% is usually fed to fry as they grow at a much faster rate than larger fish. Fingerling fish of three to four inches generally can be fed 3% of their body weight. Feeding schedules should be recalculated weekly to allow for body weight increases. The aquaculturist needs to know the initial total weight of the fish stocked to determine 3% of fish weight. The following formula can be used to assist in calculating increased fish weight.

$$\text{Fish Weight} \times 3\%(.03) = \text{Feed Weight}$$

$$\text{Feed Weight} \times 6 \text{ days} = \text{Weekly Feed Weight}$$

$$\frac{\text{Weekly Feed Weight}}{1.5^*} = \text{Net Fish Production}$$

Net Fish Production + Previous Weeks' Fish Weight =

New Fish Weight

* food conversion ratio

Feeding several times a day is more advantageous than a single feeding. Also most fish can be trained to use a demand feeder. Demand feeders can be purchased or constructed from a variety of locally available materials (see Appendix C). When food ages, there can be problems of spoilage and a breakdown of volatile components (i.e. vitamins, fats, oil, etc.). Also, contamination by beetles or "flour bugs" can cause problems for fish. Because of the small amounts of food used on a daily basis, proper storage of food is important. Store food in a cool dry place, and if a storage time of over 3 months is anticipated, frozen storage should be considered.

Filters should be cleaned weekly or more frequently if water quality problems arise. Remember that biological filters will lose their effectiveness if cleaned too vigorously. Additionally, daily checks on syphon systems and pump intakes will forestall problems with overflow or reduced water flow that could affect water quality. Screens on syphon pipes and pumps should be cleaned of any extraneous materials (including fish). Also, check PVC joints to ensure they have not failed, causing them to lose suction.

Water quality should be checked daily with special attention given to oxygen and ammonia levels. Charting water quality on a daily basis allows the operator to more quickly discover causes for water quality problems. Reducing stress on the fish is important and by monitoring water quality daily, operators can correct problems before they cause damage to the fish.

Diseases and Parasites

Much of the information in this section is taken from Introduction to Fish Parasites and Diseases and Their Treatment, --Aldridge, R.W. and Shireman, J.W., IFAS Extension Circular #716, Department of Fisheries and Aquaculture, Univeristy of Florida, Gainesville.

Before one can recognize a fish health problem it is necessary to know the fish when they are healthy. Observe their feeding habits; voracious?, timid?, selective?, piggish?. Are they active in the day? Passive? Know what a healthy fish looks like. Look at the gills and observe the healthy red color and texture of the gill tissue. Look at the skin, the scales, and feel the slickness of the slime layer. Make a mental note of how these things are on healthy fish and use this as a future reference for identifying problems. When the normal behavior and appearance are known then abnormalities can be recognized as an indication of a fish health problem. Some common behavioral indications of a fish health problems are:

- Failure to feed
- Swimming weakly, lazily, erratically or in spirals
- Scratching, flashing, or rubbing against objects in the water
- Twitching, darting, convulsions
- Failure to flee when exposed to fright stimuli
- Crowding or gathering in vegetation, shallow water or at a water inflow
- Gasping at the water surface or floating head up, tail up or belly up

When abnormal behavior is observed, it is necessary to capture some of the suspect fish for closer examination. Look at live fish when examining for a health problem. Dead fish decompose quickly obscuring physical clues of the cause of death. Some problems will be very obvious such as open sores on fish body, missing scales and/or lack of slime, and strange growths on body, head or fins. Other problems are not so obvious and are difficult to diagnose without a microscope or sophisticated procedures. There is no single treatment that will cure all fish diseases and parasite problems so it is necessary to diagnose the problem by treatment category. There are several philosophies of treatment:

1. No treatment at all.
2. Best guess method-choose a treatment based on the symptoms and hope you are right.
3. Broad spectrum approach where two or more treatments are used to cover all possible problems. (This approach is common of the "cure-all" remedies for aquarium fish diseases sold in pet shops).

3. Broad spectrum approach where two or more treatments are used to cover all possible problems. (This approach is common of the "cure-all" remedies for aquarium fish diseases sold in pet shops).
4. Contact a private or government fish disease specialist to diagnose and recommend treatment.

Any decision to treat for a fish health problem should be based on the extent of the problem and the economics of the situation. Some fish mortality or weak fish in a population are common and should be expected. It is only when the incidence of mortality or sickness increases to an unacceptable level that thepossibility of treatment should be considered. This unacceptable level of occurrence might vary from one infected fish to an entire population, and is dependent upon the fish culturist's perspective. For a hobbyist the cost of treatment might be more than the fish is worth, in which case the best treatment would be to optimize water quality and replace the fish. In cases where the value of the fish justifies treatment, the question is how to accurately diagnose the problem for the proper selection of treatment.

Selecting the wrong treatment because of misdiagnosis is a waste of time and money and is possibly more detrimental to the fish than no treatment at all. The majority of fish diseases and parasites can only be identified by the use of a microscope. If a microscope is unavailable or the person using it has no previous experience with one, the diagnosis is difficult and questionable. Successful fish culturists learn by experience and short-training courses how to use a microscope and make dependable diagnosis. Newcomers to the field need to begin learning the fundamentals of diagnostic procedures, but should not depend on their own inexperienced diagnosis for the first few encounters with fish health problems.

Culturalists having disease problems can obtain diagnostic help by contacting the IFAS Aquaculture Specialist at the Department of Fisheries and Aquaculture, University of Florida (see Appendix B).

Harvest

The most effective way to harvest small systems is to pump the down system to ensure complete harvest; however, if several different sizes of fish are in the same system, use a seine or net that will cover water column from top to bottom to assure harvest of all "keeper size" fish. When harvested, fish should be processed in whatever form desired and iced immediately. This will prevent spoilage and provide a better quality product.

To prevent an off flavor (caused by algae?), sample fish before harvest. If an off flavor is present, change water and hold fish for 2-3 additional weeks before harvest.

Other Helpful Hints

Keep it simple and keep it small. Plastic liners deteriorate with exposure to sunlight. Two to three years probably is the life expectancy in South Florida, less if there is direct exposure to sunlight.

Remember that it will take several weeks for a biological filter to establish the nitrifying bacteria necessary to remove unwanted ammonia and nitrites. In order to establish a population of bacteria to remove ammonia it is necessary to add an ammonia source to the culture system. Some aquaculturists put small amounts of bottom material from ponds in cheesecloth bags in the tank to assist in establishing the bacteria. Plan to construct the system early and operate the system without fish for several weeks or until nitrites are within tolerance levels of the selected fish to be cultured. Testing the water to determine parameter levels will be required to determine when the system is ready for stocking. This should include ammonia nitrites, dissolved oxygen, temperature, and pH at a minimum.

When stress is apparent, change some, not all, water. If all water is changed, the biological filter could be damaged (i.e. loss of bacteria). If high nitrate or ammonia levels cause stress, stop feeding for a couple of days, as well as the water changes. Some caution is necessary in the use of brass or galvanized metal in culture systems. Over time the water ages, metal ions accumulate and alkalinity declines due to the acidic reaction of nitrification. This situation could result in metal toxicity in fish. The reality of this happening in a backyard system is highly unlikely as regular replacement of water through filter cleaning and evaporation should maintain alkalinity as central and southern Florida water supplies are alkaline. A precaution of testing the pH on a routine basis monthly would be desirable.

Use of greenhouse bird netting or nylon window screening attached to a frame will prevent birds from "poaching" fish and the fish from jumping out of the tanks.

Drain filters of solid waste material and water replaced as needed. Check intake screens on submersible pumps regularly as bugs and other matter will collect on them and reduce circulation. Every few months, especially in hotter months, all pipes should be cleaned as algae and other matter will build up on the inside and reduce the efficiency of the recirculation system. Special brushes are available for this purpose or a piece of cloth and a long wire may be used to clean most pipes.

APPENDIX A

SUMMARY OF THE STATUS OF AQUACULTURE IN FLORIDA

Species or product	Use	Problems
A. Established large-scale (>$10 m) commercial operations		
Freshwater tropical fish and aquatic plants	Ornamental industry	Competition from abroad and lack of technology
B. Promising small-scale (<$1 m) commercial operations		
Alligators	Food, hides	Legal constraints, marketing (new industry)
Channel catfish	Food, fingerlings for sale to out-of-state growers	Competition from commercial fishery, unsuitable climate and/or soil type, economics of production
Tilapia	Export hatchery technology	Competition from commercial fishery, low value, economics of production
Watercress	Food	Unknown
C. Commercial operations in start-up or R and D phase		
Marine tropical fish	Ornamental	Ind.lack of technology
Marine (penaeid) shrimp	Export maturation/ hatchery technology and/or juveniles	Growing lack of need
Eels	Food (export)	Economics, marketing
Dolphin (fish)	Food or techology export	Unknown (new effort)
Freshwater centrarchids	Juveniles for sports fishery intro or rehab.	Marketing, economics

(Appendix A continued)

Species of product	**Use**	**Problems**
Little-neck clams	Food	Lack of capital, security, economics, legal constraints
D. Unsuccessful commercial operations		
Penaeid shrimp	Food	Economics, competition from commercia fishery
Freshwater shrimp (Macrobrachium)	Food	Economics, unsuitable climate
Pompano	Food	Economics, lack of technology
Striped bass	Food	Economics, lack of technology
Spiny lobster	Food	Lack of technology
Oyster	Food	Economics, competition from commercial fishery
Freshwater bait fish	Sports fishing	Lack of technology, marketing

Source: Florida Agriculture in the 80's: Marine Resources. University of Florida, IFAS, Gainesville, 1983.

APPENDIX B

SMALL-SCALE AQUACULTURE ORGANIZATIONS, AGENCIES AND LITERATURE

Organizations And Agencies

THE NEW ALCHEMY INSTITUTE
237 HATCHVILLE ROAD
EAST FALMOUTH, MA 02536

PIONEERED SMALL-SCALE, APPROPRIATE TECHNOLOGY AQUACULTURE IN NORTH AMERICA. A RESEACH ORGANIZATION WITH PUBLIC WORKSHOPS.

RODALE AQUACULTURE PROJECT
RODALE RESEARCH CENTER
RD NO. 1, BOX 323
KUTZTOWN, PA 19530

PURPOSE OF THEIR AQUACULTURE PROJECT WAS TO STIMULATE FISH PRODUCTION METHODS WHICH USE AS LITTLE WATER AND ENERGY AS POSSIBLE; ALSO, TO PROVIDE FAMILIES WITH ALL THAT THEY MIGHT NEED TO KNOW TO RAISE FISH IN THE SIMPLEST POSSIBLE WAY. HAS NUMEROUS PUBLICATIONS ON SMALL-SCALE AQUACULTURE. PROGRAM WAS PHASED OUT AS OF JANUARY, 1985. PUBLICATIONS AND BOOKS STILL AVAILABLE WHILE SUPPLY LASTS.

AMITY FOUNDATION
P.O.BOX 11048
EUGENE, OR 97440

AN ORGANIZATION FOR PROVIDING COMMUNITY MEMBERS WITH TECHNOLOGY THEY NEED TO LIVE MORE SELF-RELIANT AND LESS ENERGY-DEPENDENT LIVES. SOLAR GREENHOUSE FISH FARMING PROJECT.

DEPARTMENT OF FISHERIES AND APPLIED
AQUACULTURES
AUBURN UNIVERSITY
AUBURN, ALABAMA 36830

EXTENSIVE AQUACULTURE RESEARCH ON CATFISH AND TILAPIA.SOME EMPHASIS ON SMALL SCALE AQUACULTURE BY STUDENTS.

FLORIDA GAME AND FRESHWATER FISH COMMISSION
AQUACULTURE PROJECT
3900 DRANE FIELD ROAD
LAKELAND, FL 33803
(813)644-9269 OR (800)282-8002

STATE AGENCY THAT ISSUES PERMITS FOR NON-NATIVE RESTRICTED SPECIES OF FRESHWATER FISH AND LICENSES FOR SELLING TROPICAL FISH, ETC. ALSO, THEY MAINTAIN LISTS OF INFORMATION ON CHANNEL CATFISH; TILAPIA; ORNAMENTAL FISH; MACROBRACHIUM(FRESHWATER SHRIMP); BAITFISH; FROGS; RULES AND REGULATIONS; FISH DISEASES; FLORIDA CATFISH GROWERS LIST; AND FLORIDA GAME FISH GROWERS LIST.

FARALLONES INSTITUTE
INTREGAL URBAN HOUSE
1516 5TH STREET
BERKELEY, CA 94710

HAS DONE WORK IN SMALL SCALE APPROPRIATE TECHNOLOGY AQUACULTURE.

ALTERNATIVE AQUACULTURE ASSOCIATION
P.O. BOX 109
BREINIGSVILLE, PA 18031
(215)395-5854

FORMED TO CONTINUE SMALL-SCALE AQUACULTURE NEWSLETTER "NETWORK" PUBLISHED BY RODALE RESEARCH CENTER. MEMBERSHIP $10 ANNUALLY.

AQUACULTURE DEVELOPMENT REPRESENTATIVE
FLORIDA DEPARTMENT OF AGRICULTURE AND
CONSUMER SERVICES
425 MAYO BLDG.
TALLAHASSEE, FL 36301
(904)487-3867

GENERAL INFORMATION ON FLORIDA AQUACULTURE IS AVAILABLE, PARTICULARLY REGARDING MECHANISMS OF GOVERNMENT REGULATION OR REQUIRED PERMITS, AND MARKETING OF AQUACULTURE PRODUCTS.

AQUACULTURE EXTENSION SPECIALIST
DEPARTMENT OF FISHERIES AND AQUACULTURE
INSTITUTE OF FOOD & AGRICULTURAL SCIENCES
UNIVERSITY OF FLORIDA
7922 N.W. 71ST STREET
GAINESVILLE, FL 32606
(904)392-9613

GENERAL INFORMATION ON MOST ASPECTS OF AQUACULTURE IS AVAILABLE TO EDUCATE THE NOVICE.MORE TECHNICAL INQUIRIES ARE HANDLED CASE-BY-CASE, OR THROUGH SMALL-GROUP WORKSHOPS.

EXPERIMENTAL MARICULTURE PROJECT LEADER
FLORIDA DEPARTMENT OF NATURAL RESOURCES
BUREAU OF MARINE RESEARCH
100 8TH AVENUE, S.E.
ST. PETERSBURG, FL 33701
(813)896-8626

TECHNICAL INFORMATION ON SALTWATER FISH CULTURE AND RECIRCULATING SEAWATER SYSTEMS IS AVAILABLE, GENERALLY ON A CASE-BY CASE BASIS.

FLORIDA AQUACULTURE ASSOCIATION
P.O BOX 7537
WINTER HAVEN, FL 33883

STATEWIDE AQUACULTURE ORGANIZATION INVOLVED PRIMARILY IN COMMERCIAL AQUACULTURE BUSINESSES.

Literature

COMMERCIAL FISH FARMER MAGAZINE
VOL. 3, NO. 6 - SEPT. 1977 "AQUACULTURE ON A REDUCED SCALE."
VOL. 4, NO. 6 - SEPT. 1978 ENTIRE ISSUE - SMALL SCALE AQUACULTURE AND APPROPRIATE TECHNOLOGIES.

AQUACULTURE MAGAZINE (FORMERLY COMMERCIAL FISH FARMER)
SUBSCRIPTION DEPT., P.O. BOX 2329, ASHEVILLE, N.C., 28802. $15/YEAR(INCLUDES BUYERS GUIDE) EXAMPLES: VOL. 6, NO. 6 - SEPT. 1980 "THE POTENTIAL OF TILAPIA IN THE UNITED STATES AQUACULTURE," ALSO VOL. 8, NO. 1 - NOV.-DEC. 1981 "RODALE-DEVELOPING AND REFINING SYSTEMS FOR SMALL SCALE AQUACULTURE."

AQUACULTURE MAGAZINE BUYERS GUIDE
P.O. BOX 2329, ASHEVILLE, N.C., 28802. VERY GOOD REFERENCE GUIDE TO MANUFACTURERS, SUPPLIERS, TECHNICAL ASSISTANCE,AND EXTENSION SPECIALISTS IN THE AQUACULTURE FIELD.$8 OR INCLUDED WITH SUBSCRIPTION TO AQUACULTURE MAGAZINE.

JOURNAL OF NEW ALCHEMISTS
AVAILABLE FROM NEW ALCHEMY INSTITUTE. ADDRESS ABOVE.

BOOK OF NEW ALCHEMISTS
EDITED BY N.J. TODD, E.P. DUTTON PUBLISHERS, NEW YORK.

AQUACULTURE
J.E. BARLACK, J.H. RYTHER, AND WILLIAM O. McLARNEY. JOHN WILEY AND SONS, NEW YORK.

FISH FARMING HANDBOOK
E.E. BROWN, J.B. GRATZEK, AVI PUBLISHING CO., INC., WESTPORT, CT.

FISH FARMING IN YOUR SOLAR GREENHOUSE
AMITY FOUNDATION, P.O. BOX 11048, EUGENE, OR 97440 $5.

F.I.T. GUIDE TO BACKYARD AQUACULTURE
AQUACULTURE SERIES NO. 1. DR. MICHAEL HARTMAN, FLORIDA INSTITUTE OF TECHNOLOGY, JENSEN BEACH, FL.

HOME AQUACULTURE - A GUIDE TO BACKYARD FISH FARMING
RODALE AQUACULTURE PROJECT, RODALE RESEARCH CENTER, RT NO. 1, BOX 323, KUTZTOWN, PA 19530 $16.

THE FRESHWATER AQUACULTURE BOOK: A HANDBOOK FOR SMALL SCALE FISH CULTURE IN NORTH AMERICA
WILLIAM McLARNEY, 1984, HARTLEY AND MARKS, PUBLISHERS, POINT ROBERTS, WASH., 98281. $39.95. EXCELLENT BIBLIOGRAPHY OF AQUACULTURE LITERATURE AND OVERVIEW OF SMALL SCALE AQUACULTURE.

THIRD REPORT TO THE FISH FARMERS
SUPERINTENDENT OF DOCUMENTS, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C. 20402. STK # 024-010-00654-4. $8.

TANK CULTURE OF STRIPED BASS PROUCTION MANUAL
ILLINOIS STRIPED BASS IDC F-26-R. WILLIAM LEWIS AND R.C. HEIDINGER. FISHERIES RESEARCH LABORATORY, SOUTHERN ILLINOIS UNIVERSITY AT CARBONDALE, CARBONDALE, IL 62901. FREE.

AQUACULTURE (JOURNAL)
ELSEVIER SCIENCE PUBLISHERS B.V., AMSTERDAM, NETHERLANDS. TECHNICAL PUBLICATION WITH OCCASIONAL ARTICLES SUITABLE FOR SMALL SCALE AQUACULTURE. EXPENSIVE.

AQUACULTURE ENGINEERING (JOURNAL)
ELSEVIER APPLIED SCIENCE PUBLISHERS LTD. ENGLAND. MANY ARTICLES PERTAINING TO CULTURE SYSTEMS AND THEIR COMPONENTS. EXPENSIVE. EXAMPLE: 1. "CONSTRUCTION AND USE OF FREE-STANDING SOLAR SILOS AS COMBINED MASS ALGAL/FISH CULTURE UNITS," VOL.1, 1982. 2. "AN INTEGRATED SYSTEM OF AQUACULTURE, VEGETABLE PRODUCTION AND SOLAR HEATING IN AN URBAN ENVIRONMENT," VOL.3, 1984.

FLORIDA GAME AND FRESHWATER FISH COMMISSION RULES AND FLORIDA STATUTES RELATING TO AQUACULTURE - 1984-85
AVAILABLE FROM FL GAME & FRESH WATER FISH COMMISSION ADDRESS ABOVE.

FLORIDA AGRICULTURE IN THE 80'S: MARINE RESOURCES
AQUACULTURE COMMITTEE REPORT. IFAS, UNIVERSITY OF FLORIDA, GAINESVILLE 32611, MARCH, 1983.

A FIRST LOOK AT FLORIDA AQUACULTURE
SHIREMAN, J.V. AND LINDBERG, W.J., IFAS EXTENSION CIRCULAR 702, DEPARTMENT OF FISHERIES AND AQUACULTURE, UNIVERSITY OF FLORIDA, GAINESVILLE. 1986.

INTRODUCTION TO FISH PARASITES AND DISEASES AND THEIR TREATMENT
ALDRIDGE, F.J. AND SHIREMAN, J.V., IFAS EXTENSION CIRCULAR 716, DEPARTMENT OF FISHERIES AND AQUACULTURE, UNIVERSITY OF FLORIDA, GAINESVILLE. 1986.

MANAGEMENT OF WATER QUALITY FOR FISH
ROTTMANN, R.W. AND SHIREMAN, J.V., IFAS EXTENSION BULLETIN, DEPARTMENT OF FISHERIES AND AQUACULTURE, UNIVERSITY OF FLORIDA, GAINESVILLE. 1986.

FLORIDA CATFISH FARMING
WALSH, S.J. AND LINDBERG, W.J., IFAS EXTENSION CIRCULAR NO. 710, DEPARTMENT OF FISHERIES AND AQUACULTURE, UNIVERSITY OF FLORIDA, GAINESVILLE. 1986.

AQUACULTURE IN FLORIDA: SOME GENERAL ECONOMIC CONSIDERATIONS
ADAMS, C.M., SGEB 9, FLORIDA SEA GRANT EXTENSION PROGRAM, G022 McCARTY HALL, UNIVERSITY OF FLORIDA, GAINESVILLE 32611. 1986.

WATER FARMING JOURNAL
3400 NEYREY DRIVE, METAIRIE, LOUISANA 70002. MONTHLY AQUACULTURE TABLOID. $15/YEAR. (504)454-8934.

THE CATFISH JOURNAL
P.O. BOX 1700, CLINTON, MISSISSIPPI 39056. $20/YEAR OR WITH ANNUAL CATFISH FARMERS OF AMERICA DUES. (601)924-4407.

APPENDIX C

HOME BUILT DEMAND FEEDERS

The optimum feeding schedule for cultured fish requires the aquaculturists to feed the fish at least twice a day or more, especially fry or fingerlings. As most people do not have the opportunity to be home to feed their fish several times a day the use of demand feeders would alleviate this problem. The feeder would also reduce the amount of time that a person would spend on maintaining the culture system and provide more efficient growth rates by the fish.

A demand feeder is simply a container with the appropriate feed in it that is placed over the culture system with a rod or chain suspended down into the water. The fish quickly learn to bump or pull on the feed device in order to receive a portion of food. The only necessary work is to refill the feeder on a regular basis and to insure that the feeder opening is not clogged so as not to allow feed to pass through to the fish.

Two simple demand feeders that can be constructed by the home aquaculturist are presented in this appendix.

Bottle Feeder

The first feeder (Figure 6) is constructed from a five gallon plastic drinking water bottle. Once completed the bottle feeder is inverted with the small opening down and hung from above the culture tank. The bottom is cut off so that feed can be poured in. Save the bottom for a lid to prevent rain from wetting the feed. When cutting the bottom cut at the beginning of the lowest indention. The base of the bottle is the cut at the beginning of the next indention so to allow the bottom(lid) to fit onto the feeder top.

Drill a hole on each side of the container below the indention edge to allow heavy wire for a feeder hanger to be fitted. Drill a hole on each side of the bottle neck to place the cross wire piece through.Bend the cross wire as shown in Figure 11. The main wire should be at least 30 inches long and 1/8 inch in diameter. Adjust the level so that from 8-18 inches of the wire is in the water. The main wire is looped around the cross wire.

Place a metal or plastic disk-plate on the main wire and a large laboratory rubber stopper under the plate to hold it in place. The disk-plate will prevent water from entering the bottle opening from fish splashing water during feeding and clogging the feeder.The space between the plate and the jug opening can be adjusted by adjusting the loop on the cross wire.

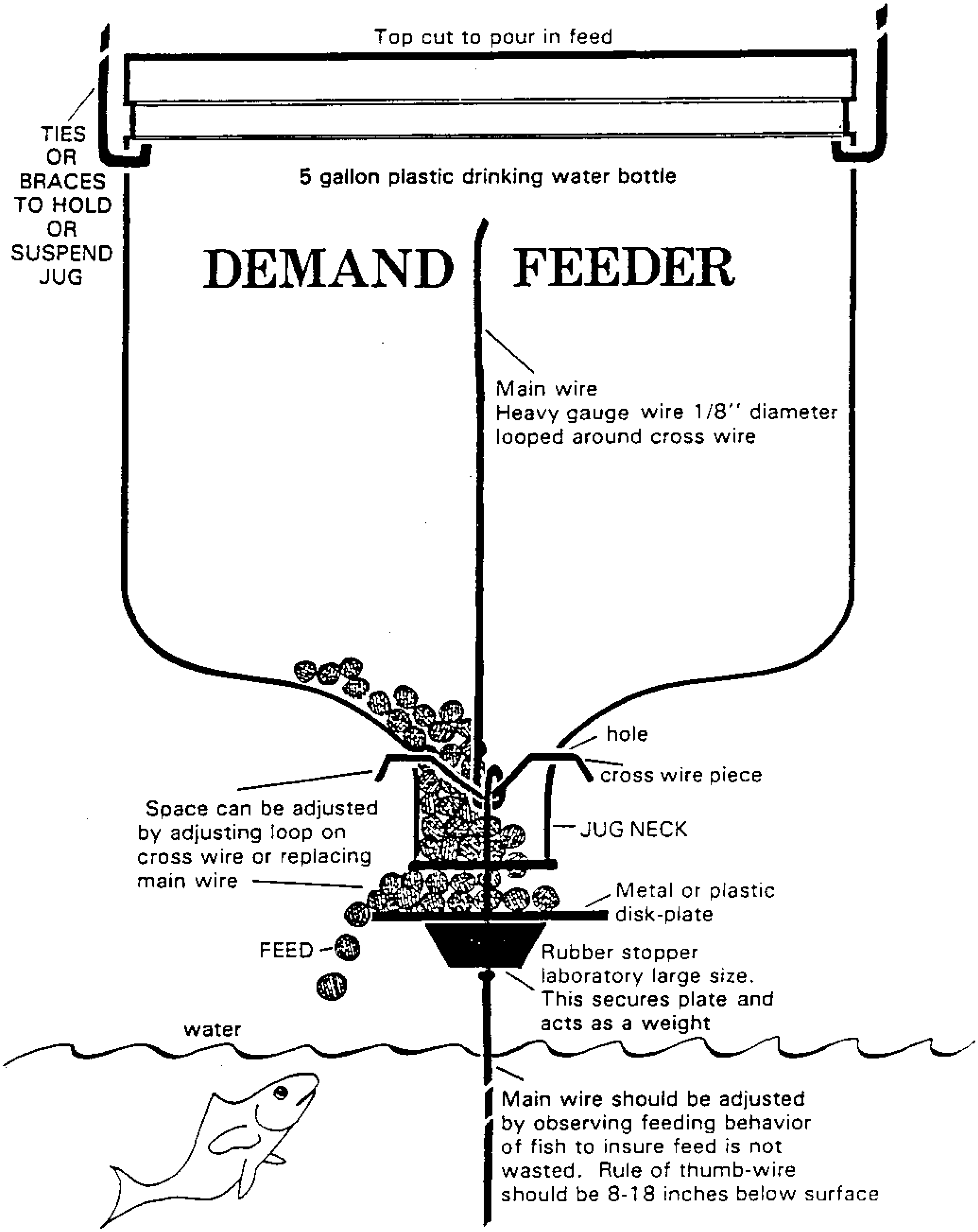


FIGURE 6

Source: Mike Ednoff

opening can be adjusted by adjusting the loop on the cross wire. This same feeder can be made from two or three liter plastic soft drink bottles for lower density culture systems with multiple tanks. The culturist should remember that the smaller the container the more often the need for refilling.

Bucket Feeder

The demand feeder shown in Figure 7 works on the same principle as the bottle feeder. This feeder is constructed from a five gallon plastic bucket available from fast food restaurants. Be sure that the bucket is thoroughly washed and rinsed before using.

Cut a 2 1/2 inch hole in the bottom of the bucket in the center. Use the pipe saddle to measure where the holes will be drilled in order to fasten the saddle to the bucket as shown in Figure 12. Next drill a 1/4 inch hole in the top center of the pipe saddle.Bolt the saddle in place in the bucket.

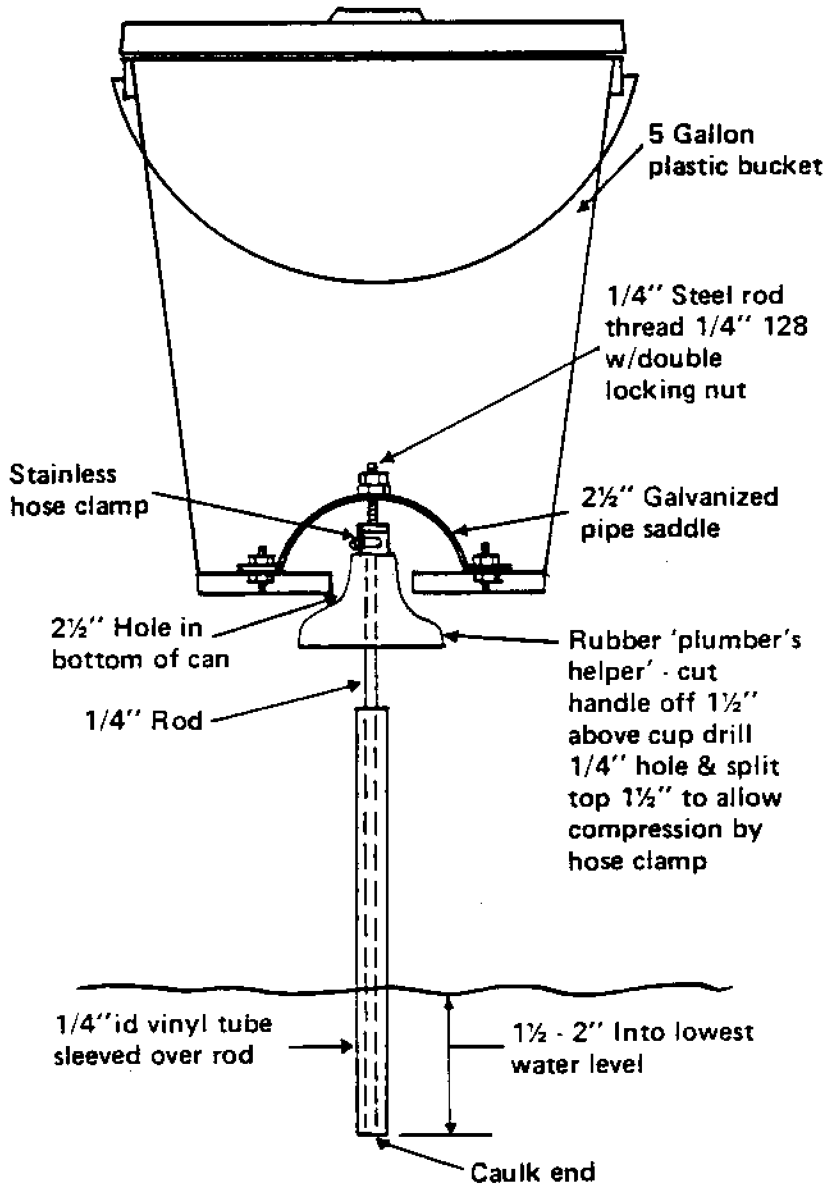
Cut the handle of the "plumber's helper" off at the top of the rubber plunger. Drill a 1/4 inch through the top of the remaining wooden handle and into the rubber plunger in order for the steel rod to pass through. Split rubber top at the handle 1 1/2 inches to allow compression by the hose clamp around the steel rod. Adjust the plunger on the rod for desired opening in the bottom of bucket and tighten clamp. Place clear vinyl tubing over rod and seal lower end with silicone caulking so rod will not rust. Attach rod to the pipe saddle with two 1/4 inch nuts and tighten to lock in place.

The feeder should be placed over the culture tank so that at least 1 1/2 to 2 inches of the rod are in the water at its lowest level.

This design was adapted from a 30 gallon trash can demand feeder illustration in Rodale's newsletter "Network".

Demand feeders can be constructed from many suitable containers. For example, soft drink two or three liter plastic bottles make good feeders for small culture systems. However, the aquaculturist must remember that the smaller the container the more often it must be refilled. The soft drink bottle may be good when first stocking fry or fingerlings.

Demand Fish Feeder



DRAWING NOT TO SCALE

FIGURE 7

Source: Rodale's Network newsletter

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