Trout Farming

Habitat Extension Bulletin No. 19

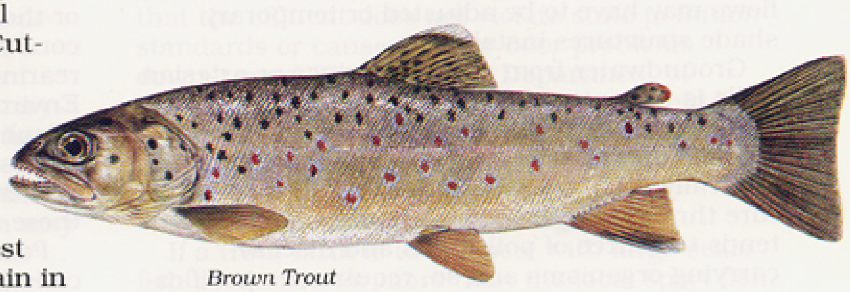
Trout culture in Wyoming represents an opportunity for landowners to yield monetary and recreational benefits from presently unused property. Given the basic inputs of water supply, land, and time, an individual may establish a trout farm ranging in scale from a small fish-out pond for personal use or fee use to an intensive fish culture operation. Throughout much of Wyoming, climatic conditions and water quality are such that trout farming is technically feasible. And provided that a farm's production strategies correspond to local demands, the practice can be economically profitable.

An operator beginning a trout farm should first decide what kind of operation he or she hopes to develop (fish farming for personal use, stocking in private ponds, fee-fishing, or selling to local markets and restaurants), since the set-up and daily operation strategies for the farm will depend on how the final product is to be utilized. Presently, stocking of private ponds is the primary market for farm-reared trout in Wyoming. This bulletin focuses on the practices required for a semi-intensive trout farm; these practices may be scaled up or down depending on plans for a specific trout farming operation.

Brook Trout

Rainbow Trout

Cutthroat Trout



Brown Trout

Selecting Fish Species

Rainbow trout, brook trout, brown trout, and cutthroat trout are the primary species recommended for trout farming. Raising rainbow trout is generally the best option, due to this species' propensity for pond–rearing, tolerance of repeated handling, and general resistance to common bacterial diseases. Cutthroat and brook trout tend to have higher market value than do rainbows, but require a slightly cooler and continuous water supply for culture, lower rearing densities, and more food per pound of trout. Brown trout do not tolerate crowding well and may be more difficult to harvest than rainbows; unharvested fish may remain in

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Table: Optimal trout–rearing water chemistry parameters

Parameter	Optimal Range
pH	6.5 to 8.5
Dissolved Oxygen	80 to 100 percent of saturation[1]
Turbidity/Suspended Solids	2000 ppm
Total Dissolved Solids	2000 ppm
Hardness	120 to 400 ppm[2]

[1] Typically 7 to 9 parts per million (ppm) at 54° F. The saturated dissolved oxygen concentration depends on altitude and temperature, and a book of chemical standards should be consulted for a particular pond site.

[2] At very low hardness values, water loses its ability to buffer against changes in acidity. The productivity of water generally increases with hardness through the optimal range.

the culture pond and consume fingerlings stocked in subsequent seasons. Both brook trout and brown trout tend to be more susceptible to disease when held under confined conditions, increasing the financial risk of their cultivation. The choice of species for culture will depend on the availability of each from local fingerling suppliers as well as the relative demands in a particular market area.

Water Supply

Water supply is the principle factor determining whether a trout farming operation succeeds in a given location. Trout require a large supply of cold, clean, well-oxygenated water. Sites where water must be pumped, treated, or temperature–controlled will not likely support a profitable operation.

The ideal water temperature for trout-rearing is 54° F, with an optimal range of 50 to 60° F. Extremely cold water will result in slower fish growth and lower flesh yields, while warmer temperatures lead to increased stress and disease. Temperatures above 74 to 77° F may be lethal. Water temperature should be measured daily using an accurate and sensitive thermometer. If culture water becomes too warm, water flows may have to be adjusted or temporary shade structures installed.

Groundwater from natural springs or artesian wells is the optimal water source for trout farming and critical if a semi-intensive trout farming operation is to succeed. This water is generally cold and has stable flow and temperature throughout the year. Groundwater also tends to be free of pollutants and disease-carrying organisms and so, requires no purification. If water can be obtained from a natural spring or artesian well, pumping costs should be negligible.

Spring-fed streams are also suitable water sources, though temperatures are more likely to fluctuate and diseases may be spread to cultured trout from resident stream fish. Larger streams, lakes, and reservoirs tend to vary in water quality and temperature and may be sources of disease for cultured fish. They are not recommended as trout culture water supplies since the required supplemental water treatment or temperature control will probably not be cost effective.

Culture water need not derive from a dedicated supply; some fraction of water presently used by a landowner for irrigation or stock watering, if flowing from a clean and cold source, can be easily and cheaply diverted to a series of trout-rearing ponds. Although not suitable for drinking, the pond outflow, rich in nutrients, can then be routed back into an existing irrigation system with minimal evaporative loss.

Water Quality

Before investing time and money in a trout farming operation, the water supply should be tested (Table) for its fish-rearing suitability. Dissolved solids, pH, hardness, concentration of dissolved gasses (oxygen, nitrogen, carbon dioxide), and perhaps metals and pesticide concentrations should be measured. Short-term toxicity tests (using sensitive-indicator species or the species to be raised) should also be conducted to guarantee safe conditions for fish-rearing. Commercial laboratories (look under Environmental Services or Water Analysis in the telephone book) will conduct such measurements and tests for a nominal fee; state or university laboratories may be able to provide these services as well.

Pond water pH should be measured periodically (the pH of a stable water supply is unlikely to change over the short term). If the pH of the source or pond water is below the optimal range, it may be altered by adding lime to the pond water. However, this process may become costly if waters are overly acidic, and more frequent pH measurements will be required. In this case, the operator should invest in a portable pH meter. Excessively high pH cannot practically be controlled and may be indicative of other water quality problems.

Dissolved oxygen at high concentrations is essential for trout culture, and an incoming water supply should be nearly 100 percent saturated in oxygen. The lowest safe level of dissolved oxygen for trout is five parts per million (ppm), although pond and raceway waters should contain concentrations well in excess of this value. Dissolved oxygen should be measured periodically (more often when the weather is hot), since low levels will reduce fish growth and may be lethal if too severe. Portable dissolved oxygen meters or field oxygen test kits are critical for operations with limited water flow and high concentrations of fish. Overcrowding of fish, high temperatures, and excessive degradation of organic matter will deplete dissolved oxygen, while photosynthesis by aquatic plants and algae, high water flow, and mechanically aerating the water will restore it. Aeration is fairly simple and inexpensive and probably will be required for any trout farming operation (aerators also are useful for preventing freeze-over of ponds during winter). Aeration involves physically introducing air into the pond, thereby increasing the amount of dissolved oxygen. Mechanical aerators are commercially available and typically involve either an air pump or paddle system. Pond size, water temperature, and stocking rates will determine the extent of the aeration system required.

Trout-rearing waters should not be overly turbid; high turbidity diminishes light penetration, reducing photosynthetic activity of plankton and slowing natural food productivity of a pond. Fish in muddy waters may also have difficulty locating food items, suffer respiratory stress, and their flesh may become tainted in taste and color.

Concentrations of dissolved hydrogen sulfide, hydrogen cyanide, and heavy metals (which may be toxic both to fish and to their human consumers) should be measured if their presence is suspected. Hydrogen sulfide, a by-product of anaerobic sediment decomposition, is lethal to fish at just a few parts per billion. Hydrogen cyanide, a contaminant from industrial activity, is also quite toxic. Copper, lead, mercury, zinc, and cadmium are all highly toxic metals that may be introduced into waters from metal pipes, fittings, or screens as well as from stream drainage of nearby abandoned mines. Galvanized steel and copper hardware should be avoided (especially if water pH is below seven), and water contaminated by mine drainage must not be used for fish culture. Pesticide and herbicide spraying in the vicinity of trout-rearing waters must be avoided, since minimal concentrations of these chemicals may be toxic to fish and to naturally occurring pond food organisms. Trout farming may not be feasible, in fact, in areas where pesticide spraying is common and watersheds are contaminated.

Basic water quality monitoring test kits, designed specifically for fish farming, are available from Hach Company (P.O. Box 389, Loveland, CO 80539, 1-800-227-4224). Kits allow for measuring up to 10 water quality parameters (pH, alkalinity, dissolved oxygen, hardness, nitrite, chloride, temperature, ammonia, carbon dioxide) by comparing the color of test solutions against reference color disks and contain supplies sufficient for 100 to 300 water tests.

A final water quality issue concerns the outfall, or effluent, derived from the trout-rearing operation. Depending upon the location of the ponds and the body of water into which the effluent is discharged, the operator may be required to limit the amount of nutrients (nitrogen) and ammonia being released from his rearing ponds. Effluent water quality measurements and periodic monitoring by a professional testing laboratory may be required of the operator under federal and state guidelines to ensure that the effluent does not violate state pollution standards or cause taste or odor problems downstream. The Wyoming Department of Environmental Quality in Cheyenne should be contacted to determine whether effluent permitting is required for a given site.

Trout Pond Design

If a trout farm is to compete with large-scale fish producers for more than the local sport fish, restaurant, and grocery store markets, most likely an elaborate system of raceways (rectangular pools receiving high volumes of flowing water) will be required. However, trout culture in standing ponds or in a limited number of raceways is feasible and may produce crops of fish suitable for local trade and sport fishing.

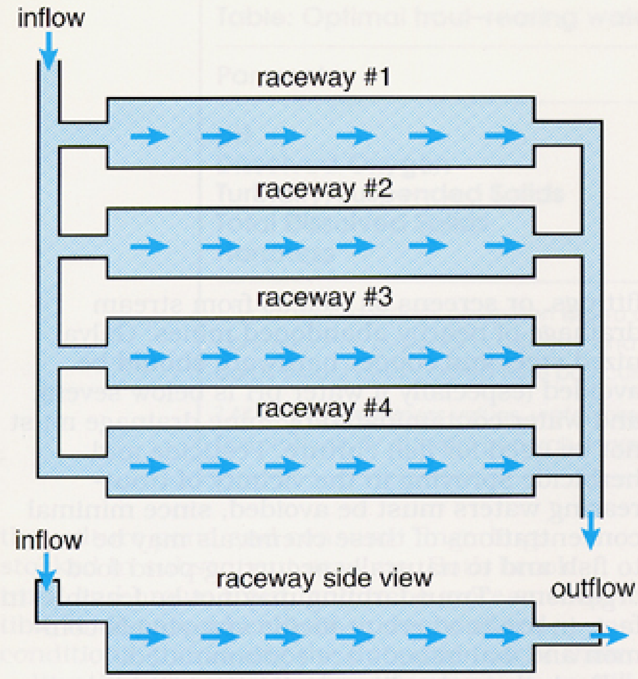

Figure 1. Parrell raceway design recommended for semi-intensive trout culture (after Wheaton 1977).

Ideally, the pond design should allow for deep water and limited current during normal operation while facilitating conversion to a shallow swift pond when necessary (e.g., at harvest time). Whereas raceway construction is a money-intensive operation, and raceway management may require full-time dedication, use and/or modification of pre-existing farm ponds or construction of new ones should not require gross investments of time or capital. Types of trout-rearing ponds include:

- Impoundment ponds, employing a dam built into an existing stream drainage,
- Dugout ponds, excavated to a desired depth,
- Levee ponds, for which banks are built up to create a basin.

The size of a trout-rearing pond depends primarily on the number and size of fish to be stocked. A private fish production pond may be as small as one-tenth of an acre or as large as 100 acres (by Wyoming law). As the size of the pond increases, so does its capacity for fish-rearing. The complexity of managing water and harvesting fish also increases with pond size. Given a patch of land, a prospective fish farmer may choose to build either one large pond or several smaller ones. A large pond will have lower construction costs, will require a less complicated water delivery system, and will be biologically more stable. Several smaller ponds will be easier to fill, drain, and harvest. Having several ponds receiving independent water supplies makes it more likely that, if fish in any one pond are lost or diseased, those in the other ponds will be unaffected.

A group (figure 1) of rectangular ponds (raceways four to eight feet deep, approximately five to 15 feet across, and 50 to 100 feet long) with regular banks is recommended for semi-intensive trout culture to ensure adequate space, uniform food distribution, and easy seining at harvest-time. Pond banks should be planted with low grasses to guard against erosion. To ensure efficient harvesting, trout pond bottoms should be uniform and slope towards the outlet pipe (although bottom irregularities may be desired in ponds designated for personal use and fee-fishing). In ponds where the entire crop of fish is to be harvested annually, a harvest basin should surround the outlet pipe, one to two feet deeper than the pond bottom and about one-tenth of the total pond area, to concentrate fish as the pond is drained. This harvest basin should safely hold one-third of the final standing crop of the pond.

Trout pond depth will depend on water flow, stocking rates, and harvesting techniques. Raceways receiving high continuous water flows need only be three to four feet deep. Standing ponds must be deeper (eight to 12 feet) to provide fish refuge from warm temperatures in summer and, if fish are to over-winter in the pond, from freezing during colder months. If fish are to over-winter in a standing pond, at least 25 percent of the pond must be deeper than 10 feet to prevent winterkill. Ponds from which 100 percent of the fish are harvested each fall may be more shallow, provided water temperatures remain within recommended levels during summer.

The pond dam (figures 2-5) should be constructed of impervious, moist material compacted in continuous horizontal layers as it is installed. It is important that the dam be keyed in to the soil in the pond foundation to minimize leakage around or under the dam. The steepness of the slope of the pond side of the dam should not exceed three feet horizontally to one foot vertically; the slope of the dry side of the dam should not exceed two- and one-half feet horizontally to one foot vertically. A dam less than 20 feet in height should be at least 10 feet

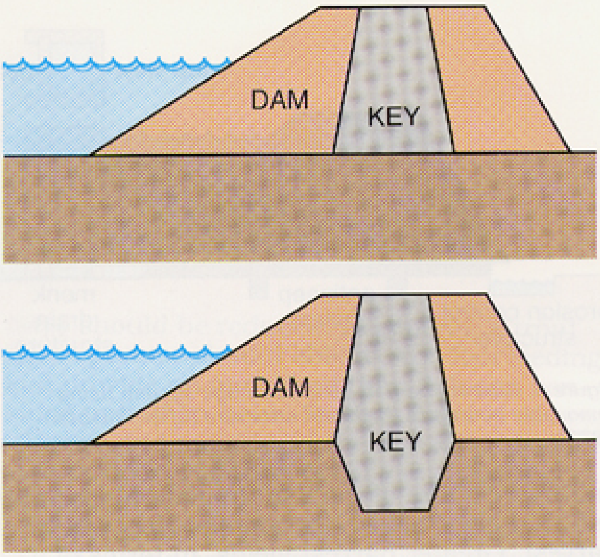

Figure 2. Dam design using an impermeable soil key for reducing seepage (after Wheaton 1977).

across and increased in width an extra two feet for each additional five feet of height. All dams should have a minimum freeboard of one foot above the peak height of water in the emergency spillway (discussed below) or three feet above the non-flowing elevation of the spillway. Again, specific guidelines for reservoir construction, as well as permit requirements, are available from the State Engineer's office in Cheyenne.

Drainage is best achieved with a sluice gate built into the lower wall of the pond (figures 4 & 5). The drainage system should incorporate both a stand-pipe and a drain that takes water from the bottom of the pond, where water quality tends to be lowest. Paving an area of the bottom surrounding the outlet pipe with gravel is recommended. The system should be equipped with mechanisms for regulating each outflow and for draining the pond completely and easily, as needed. A drain pipe which runs through the dam should meet loading pressures and be equipped with anti-seepage collars (figures 4 & 5).

An emergency spillway at the lower end of the pond should also be constructed and may either be lined with gravel or vegetation. Technical advice on the design of the pond and spillway should be obtained from the Natural Resource Conservation Service (NRCS), formerly the Soil Conservation Service, in Cheyenne. Some general guidelines on spillway construction are that the spillway should have a three–foot drop along its length, should be 15 percent as wide as the dam is long, and should be wide and shallow and free of obstructions. Though some fish may be lost through the spillway during periods of heavy runoff, the spillway will protect the pond from erosive flooding.

An additional consideration when designing a pond is ease of access to the fish by predators. Gulls, herons, ospreys, kingfishers, mink, and cats all have the potential to use trout ponds as food sources. Depending upon the geographical location and extent of cover around a pond, netting and/or fences may be required to restrict predator access.

Pond Site Selection

If ponds are to be constructed, considerations of soil properties, slope, and depth are important. And pre-existing ponds may require structural modifications to depth and outflow if efficient trout culture is to occur. The NRCS can provide valuable information on the water table and soil type in an area; and the NRCS office, as well as university extension services and nearby pond owners, should be consulted before beginning construction of a trout pond. The State Engineer's office should also be contacted for clarification of specific reservoir construction guidelines, permit requirements, and water rights issues.

A pond site should be selected which does not interfere with normal farm or ranch operations, but which allows access corresponding to the production intentions for the pond. Unless the

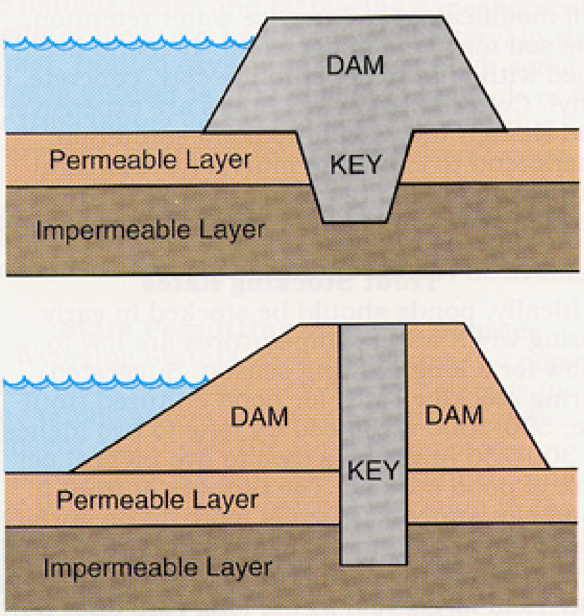

Figure 3. Dam design (above) when there is impermeable soil under the dam, or (below) when impermeable soil is not available (after Wheaton 1977).

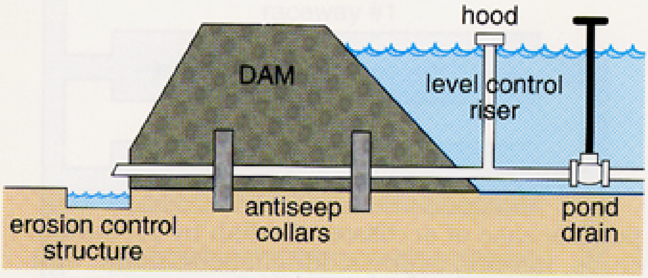

Figure 4. Fish pond dam with valve to control pond drainage (after Wheaton 1977).

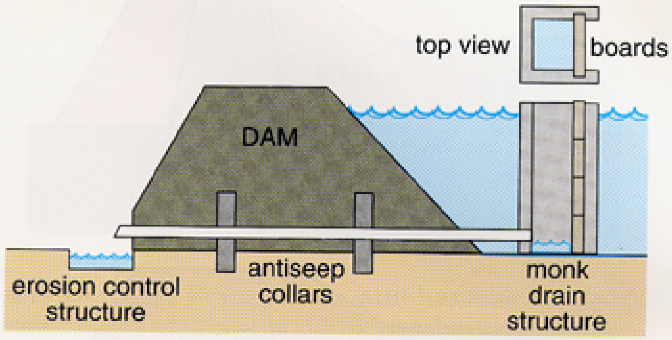

Figure 5. Alternative fish pond drainage system using removable boards in the drain structure (after Wheaton 1977).

pond is to be used only for personal fishing, truck access for stocking and harvesting is important. Where fee-fishing is planned, adequate access to a passing thoroughfare and room for parking are required. Ponds in which fish are being reared for resale should be concealed, with public access restricted to prevent poaching. The pond site should be developed on as steep a grade as the soil will allow (suggested horizontal to vertical range of 1:1 to 3:1), and should have higher ground on three sides and lower ground on the outlet side. If the pond is to be an impoundment type, the dam should not be built above any structures, roads, or cultivated fields. Most importantly, the pond site should have an easily accessible water source.

Soils rich in clay make the best pond beds due to their high water retention capacity and resistance to bank erosion. Water retention can easily be determined by digging a test hole to pond depth and noting whether it holds water. Pond beds that are too permeable will require soil modification to increase water retention. The soil may be compacted or the pond bed lined with a layer of bentonite clay, concrete, or vinyl. Concrete and vinyl liners are expensive, and though they facilitate pond sanitation, liners tend to eliminate much of the natural fertility and food organisms that occur in an earthen pond, at least for the first few seasons.

Trout Stocking Rates

Ideally, ponds should be stocked in early spring when water temperatures are low to allow for a long growing season. Suggested spring stocking rates for pond cultured trout are: 500-1000 advanced fry (one to two inches) or 300-750 fingerlings (two to five inches) per acre of pond surface. The number of trout a pond can support depends more on its surface area than its volume. Fall stocking rates should be about half the spring rates, but fall stocking may yield larger fish in the long run. Just how many fish to stock will depend on water quality, fertility, and temperature in the pond, and on the operator's plans for supplemental feeding and harvest size of the fish. In general, the more fish that are stocked, the smaller they will be at harvest. Greater harvest yields, in terms of increased size and number of harvested fish, may be achieved, however, through increased supplemental feeding. A few years of trout–rearing may be required before the optimal stocking rates for a given operation are determined.

Of the two stocking/production strategy extremes available to a small-scale trout farmer — stocking high numbers and harvesting smaller fish or stocking low numbers and harvesting large fish — the local market will likely determine which is more profitable. It should be noted, however, that high population densities of fish are often associated with disease and other water quality problems, so overcrowding of ponds should be avoided. Finally, two- to four-inch stocked fingerlings will more likely survive to pan size than will one- to two-inch fish.

Supplemental Trout Feeding

Though earthen farm ponds will usually contain populations of naturally occurring food organisms adequate for trout culture, rearing a commercially valuable crop of fish will likely require supplemental feeding to facilitate higher stocking and growth rates of fish. Stocking rates described above may be increased significantly if commercial feeds and/or cultured food organisms are added to trout waters.

Of the commercial feeds available, floating pellets are recommended for trout pond culture, since feeding activity can easily be observed by the operator and uneaten food is less likely to pollute the pond. Pellet size should increase as fish grow; numerous commercial feeds are available in various particle sizes (larger pellets may also be crushed to any desired size). Given average pond fertility, commercial dry feeds are usually fed at daily rates of two to three percent of the weight of the standing crop of fish. If natural food is especially abundant in the pond, or if fish show reduced feeding activity, feeding rates should be reduced. In general, a trout farm operator should observe the fish feeding, and provide no more food than fish can consume in half an hour. Feeding more is not cost effective and may cause the spread of disease and/or deoxygenation of the pond, leading to trout death.

Supplementing fish diets with cultured or collected food organisms, including adult and larval insects, earthworms, and zooplankton may be combined with a commercial feeding strategy to provide higher quality fish flesh, although insect and worm culture/collection tends to be a labor-intensive endeavor. Numerous techniques and animal species are available to the small-scale trout farmer for fish food culture.

Feeding once daily in the morning, six days a week, is recommended for trout ponds. However, young fry should be fed several times a day. Food pellets should be scattered over the feeding area of the pond, either thrown by hand or distributed by an automatic feeding device. It is best to feed in a shallow area (about four feet deep), over a clean, hard portion of the bottom (graveled if necessary). Doing so will result in maximum food consumption, and the operator may observe whether fish are feeding vigorously. Poor feeding may be an indication of low dissolved oxygen or disease and should be observed and managed.

Automatic feeders are commercially available and a big time-saver. Use of automatic feeders also will facilitate making incremental changes to the feeding rate and quantifying the amount fed over time. Drop/blade, fan, and blower type feeders are some of the types available.

Trout Harvesting

Appropriate fish harvesting strategies will be determined by the type of trout-rearing operation being run. Trout are unlikely to reproduce successfully in rearing ponds or raceways, so all fish removed from the operation must eventually be replaced if an adequate population is to be maintained. Ponds containing trout for market or sport fish trade will generally be stocked with a single age-class of fish, raised to a desired size, and then harvested, usually prior to the onset of winter. Harvest strategies should involve gathering the entire fish population, so that successive fish crops may be stocked and reared. Leaving fish behind will diminish profits and may lead to potential problems, as residual fish grow large and consume subsequently stocked fish.

At harvest time, the pond or raceway should be partially drained, concentrating the fish at the low end of the enclosure or in the harvest basin incorporated into the pond bottom. If pond drainage is not possible, a net or seine may be used to gather the fish into a confined area where they may be collected. When seining fish, several passes through the pond with the seine should be made to ensure that all fish are gathered. The seine must extend all the way to the pond bottom and should stretch across the entire pond width.

Once concentrated, fish can be removed from the pond using large nets. Fish harvested for human consumption should be placed on ice as soon as possible, dressed, and either refrigerated or frozen, depending on shipping constraints. Fish which are to be transported to other ponds for sport fishing must be handled carefully. Once concentrated, fish must be moved quickly to suitable transport tanks containing cold, aerated water. Operators can safely move trout short distances by adding ice to hauling tanks and by placing a mechanical agitator (powered by the vehicle battery) in the water. Bottled oxygen bubbled through some type of diffuser is a must with large loads of fish or trips taking longer than an hour. During transport, temperature and dissolved oxygen should be checked often to ensure that levels are kept consistent with those of the rearing pond. Fish must not be overcrowded, and galvanized and copper tanks should be avoided.

State Permitting and Fish Sources

Wyoming Statute 23-4-101 states "no person shall plant or release any fish or fish eggs in any public waters of Wyoming without the consent and under the supervision of the department or its authorized personnel." Anyone planning a trout-rearing operation in the state must obtain a commercial fish hatchery license. The licensee may operate one fish-out pond (not to exceed 10 acres) for which fishermen need not have a license. Additional ponds or ponds not in association with a commercial hatchery operation require the owner to obtain a fishing preserve license or else fishermen must obtain a Wyoming fishing license and abide by state fishing regulations.

Fish hatchery operators must submit monthly reports describing all sales and exchanges of fish, and must obtain approval from the Wyoming Game and Fish Department's Chief of Fisheries prior to each importation of fish or eggs to the hatchery.

Fishing preserve licenses may be obtained for bodies of water not exceeding 100 acres in size and lying completely within the boundaries of privately owned land. The owner is permitted to provide fishing facilities to fishermen and may charge fees as he or she chooses. Fishing licenses are not required, although all fish leaving the preserve must be documented with a receipt. Finally, operators must obtain approval from the chief of fisheries prior to any importation of fish to the preserve.

Suppliers of fish and eggs to hatcheries, fishing preserves, and other private waters must have their facilities certified disease-free annually before approval for importation may be obtained. A fish purchaser should request that a copy of the supplier's disease certification accompany any batch of fish received. A list of disease-free fish producers in the Rocky Mountain region is available from the Wyoming Game and Fish Department.

Additional information and application forms for the commercial hatchery and preserve licenses may be obtained from the Chief of Fisheries, Wyoming Game and Fish Department, 5400 Bishop Boulevard, Cheyenne, Wyoming 82006. The chief of fisheries can also provide information regarding routine disease inspections of culture fish. Inspection of fish flesh to be sold to grocery stores and restaurants is handled by the Department of Health. Further details regarding fish farm and stocking permits are available in the Wyoming Game and Fish Department habitat extension bulletin #44, "Fish Farm and Stocking Permit Requirements."

Points to Remember

The following points were taken from the NRCS Farmer's Bulletin Trout Ponds for Recreation and should serve as guidance for a successful trout-rearing operation:

- Build a pond that fits your needs and that is right for your soil, water supply, and climate.
- A good small pond gives more satisfaction than an inferior large pond.
- Have as little water as possible less than three feet deep (does not apply to raceways).
- Prevent or control water weeds.
- Run no more water through the pond than is necessary to maintain correct water level, proper temperature, and adequate oxygen.
- Be sure your pond is free of other fish before stocking trout.
- Restock in the fall at least every second year for maximum production.
- Keep the bank and shore free of tall weeds and brush.
- Avoid using insecticides on the watershed or near the pond.
- Improve management by keeping a record of stocking rate, growth, harvest, and survival.
- Add fresh water or increase aeration immediately if you see many fish swimming near the pond's surface. It is usually a sign they need oxygen.
- Plan for a drain pipe in your pond. It permits easy draining for fish removal and water quality control.
- Provide some inflow of water during winter, if possible. This is the surest way to prevent winterkill.

Fish illustrations by Michelle LaGory

Illustrations drawn after Wheaton, F. W. 1977. Aquacultural Engineering. John Wiley and Sons, New York.

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This publication is one in a series of habitat extension bulletins produced by the Wyoming Game and Fish Department. Call 1-800-842-1934 for additional information or assistance.