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# CONSIDERATIONS IN HATCHERY DESIGN FOR THE PREVENTION OF DISEASES

HARRY WESTERS
Michigan Department of Natural Resources
Fisheries Division Lansing, MI

Proper hatchery design and modes of operation can contribute significantly toward the prevention of fish diseases. Prevention techniques are aimed at maximizing the natural ability of the fish to resist disease as well as minimizing the risks of exposure to pathogens.

In the introduction to this manual, three elements were identified in fish health: the host (fish), the environment, and the pathogen. All three must also be considered in hatchery design.

Brown trout, for instance, should not be reared in water where furunculosis is endemic; brook trout should not be reared in IPN-infected water sources; etc. Although counter measures such as genetic disease resistance and fish immunization techniques are possible avenues to reduce disease problems, these techniques are not, as yet, available for most fish species and diseases.

Wedemeyer et al. (1976) consider stress to be one of the most important factors with respect to susceptibility to disease. Needham (1977) states that if a correctly designed and engineered environment is not provided for the fish, disease will strike. Since in intensive fish culture, fish are reared in very artificial situations, the hatchery design must be aimed at creating the best (least stressful) rearing conditions feasible.

The presence or absence of pathogens is a prime factor in whether or not a disease outbreak will occur, therefore design must aim at preventing the introduction of disease organisms, as well as reducing the pathogen load.

Hatchery design, in its broadest concept, includes site selection as well as providing options to apply sound hatchery management techniques and modes of operation.

## DESIGN CONSIDERATIONS — GENERAL

Maximum opportunity for fish health planning is available during the design stage of new culture facilities. That is the time to incorporate appropriate measures for disease control, rather than attempting to add them after the facility has been built and is in operation.

Unfortunately, such opportunities are often not available and a manager may have to work with established facilities after constraints are already in place, firmly embedded in concrete and steel and where water sources are fixed. Design of a new facility starts with site selection and should have water concerns as the number one criterion.

The ideal is to have a source of high quality water, free of fish, and, consequently, free of obligate pathogens. A hatchery built with this type of water source has the potential to be specific pathogen-free, provided that no infected stock is brought into the facility and that appropriate safeguards are taken against contamination.

Well and spring water sources are the most likely candidates. Such sources are difficult to find, are sometimes limited in flow, and often must be pumped. If the quality is high, such water can be used up to three times, as long as there is adequate re-aeration, unionized ammonia is kept below harmful levels, and most of the suspended solids are removed (Westers and Pratt 1977).

Another option to accomplish specific pathogen-free status is by treating the incoming water to destroy pathogens that may be in the source. The technology is available, such as ozone, UV irradation, and chlorination, but they are not without risk, since they can be toxic to the fish or may fail to destroy the pathogens. At this time, water sanitizing systems are not widely used, except possibly for UV irradiation. This technique poses no direct risk to the fish, but it requires rigorous quality control and maintenance in order to remain continuously effective. The system is expensive but merits consideration, especially in situations with relatively low flow requirements, such as egg incubation and early rearing.

Since specific pathogen-free rearing is just that, fish will still be exposed to ubiquitous opportunistic pathogens. Infections by these pathogens are best controlled by reducing stresses. The same approach, however, can also be applied for obligate pathogens whenever the option of specific pathogen-free rearing is not available.

In summary, these criteria must be considered in hatchery design:

1. Site Selection (water quality)
2. Water treatment
3. Pathogen control (sanitation, disinfection, quarantine)
4. Quality environment (reducing stress)
5. Hatchery management and operation (reducing stress)

## DESIGN CONSIDERATIONS — SPECIFIC

In site selection, water (quality and quantity) must be the first consideration. The guiding principle, as stated in the chapter on “Selection of Water Supplies”, is to select sources that minimize risk of disease exposure and provide an environment which maximizes fish health.

A source free of obligate pathogens is, of course, the most effective way to prevent certain diseases. Selection of this type of water should always be given priority, even if it involves some sacrifice in quantity. Such sources are scarce and of relatively low volume. However, they are usually of high quality, offer stable water temperatures and yield higher production per unit flow.

## WATER TREATMENT

It is likely that in the search for an ideal water source, one must accept a source that is less than ideal or even marginal. As a result, it may be necessary to pre-treat the water to improve chemical and physical characteristics and control pathogens.

Pre-treatment to improve the chemical and physical characteristics may involve oxygenation, degassing (nitrogen, hydrogen sulphide, carbon dioxide, etc.), iron removal, reduction in suspended and settleable solids, temperature control, and pH control (buffering).

For most of these, the needed technology is available in the form of aeration or de-gassing devices (packed columns, screen decks, various mechanical aerators, etc.), filtering systems (rapid sand filters) and temperature controls (well water, chillers, boilers, solar heating). Cost and economics of operation are a big factor in the selection of these systems.

## PATHOGEN CONTROL MEASURES

In addition to sanitizing and disinfecting the water supply, hatchery design must consider controlling contamination from outside sources and facility disinfection.

If eggs are routinely brought into the facility, the hatchery must be equipped with an egg disinfecting room. This should be a separate, isolated room that is easy to keep sanitized with an approved water (liquid) disposal system. Ideally, hatchery rearing facilities should be zoned into operational areas. Although physical barriers are not recommended, water intakes and outflows should be zoned. Zoning could be arranged in logical areas, such as those for incubation, early rearing, indoor rearing, outdoor rearing. It may be feasible to design indoor and outdoor rearing facilities at large hatcheries so that groups or even individual rearing units can be disinfected.

Specific pathogen-free hatcheries should have a quarantine facility, especially if the hatchery routinely receives fish from outside sources, even if they are from certified stocks (the only kind to be permitted into the facility!)

Successful pathogen control depends as much on the human element as on facility design. Expediency, lack of administrative support, lack of training and discipline, and improper procedures can destroy or negate pathogen control efforts even with the best designs. Although the facility design must allow for the most effective way to perform the needed work tasks, unless there is strict adherence to a sound plan, the disease control program is doomed. A chain is only as strong as its weakest link.

## QUALITY ENVIRONMENT

Quality concerns begin with the water supply. The poorer the quality, the fewer fish it can support. Incoming water must have a dissolved oxygen level at or near saturation (not less than 90%) and water temperatures should be stable. The maximum should not exceed the standard environmental temperature (SET) by one-third of its value. For example, if the SET for a species (rainbow trout) is 15°C, the maximum temperature should not exceed 15 + (⅓ x 15) or 20°C. Species with a SET of 24°C should not be exposed to temperatures over 32°C.

Toxic gases, such as hydrogen sulfide and methane, must be completely removed through a degassing device (packed column, screen decks, etc.) Nitrogen ($N_2$) gas should be kept at 100 % saturation or less. Supersaturation with $N_2$ gas can have subtle adverse effects without the classical signs of gas bubble disease. Nitrogen supersaturation can be a serious, insidious stressor and it is strongly recommended that any supersaturation be avoided.

The higher the water quality, the higher the production potential will be. As a consequence, water quality will greatly affect the design of rearing space. The objective is to obtain maximum production without seriously stressing the fish.

Two aspects of production must be considered. One is production in terms of flow, termed "loading", and expressed as weight of fish (kg) per litre per minute flow (kg/l/min); the second is expressed in terms of space, called density. Density is expressed as kg fish per cubic meter of rearing space ($kg/m^3$). Both are interdependent with the hourly exchange rate (R) as the only variable. This relationship has been expressed by Westers (1981) as

$$L = \frac{D \times .06}{R} \text{ and } D = \frac{L \times R}{0.06}$$

Where
L = Loading in kg/l/m
D = Density in $kg/m^3$
R = Hourly water exchange rate
and .06 = 1.0 l/min = 60 litres per hour = $.06 m^3$.

Water temperature is the most significant factor in loadings. Lower temperatures permit higher oxygen levels and lower oxygen consumption rates by the fish (lower metabolic rates).

If a decrease of 10°C reduces the metabolic rate by half, in theory, loading can be doubled. If the density must remain the same, twice as much rearing space must be available. The effect of density as a is probably the most controversial subject in the intensive culture of fish (Westers 1982). Opinions vary widely. Unless one knows what the optimum loading and density is for a particular species (optimum from both the biological and production point of view), one cannot properly determine the optimum rearing space. Further complications arise when water reuse is applied. Table 1 provides some insight into these relationships of water quality, maximum allowable loadings and densities, and optimum hourly water exchange rates in terms of hatchery design (rearing units). Water quality has been assigned values of 8, 6, 4 and 2, with the highest number representing highest quality.

According to Table 1, it is difficult, if not impossible, to have an ideal balance in hatchery design between loadings, densities, and exchange rates. The weakest area of knowledge concerns rearing density. Little is known about the point at which density becomes sufficiently stressful that it threatens the health or well-being of the fish. It seems important that the necessary research be done, since it is of such vital importance in hatchery design.

## HATCHERY MANAGEMENT AND OPERATION

How well a hatchery is managed and operated depends both on the skill, knowledge, and dedication of the staff and on what the physical design allows them to do.

Fish culturists must develop a strong consciousness for the welfare of the fish under their care. In time they should cultivate, as it were, a sixth sense that allows them to recognize any stressful condition the fish are exposed to. Certain design features can aid the fish culturist in reducing stresses on the fish.

Baffles, for instance, can be placed in rectangular, flow-through rearing units to provide effective and continuous cleaning action. Such baffles are usually spaced at distances approximately equal to the width of the tank or pond. The gap between baffles and the bottom of the unit varies from 3-8 cm. The objective is to create enough velocity along the bottom to move solids to the foot (clean-out section) of the raceway. A velocity of 20-40 cm/sec directly behind a baffle is recommended. To determine the velocity, the following formula can be used:

$V = L \times R$ where V equals velocity in meters per second (m/sec), R

is the hourly water exchange rate, L is the length of the rearing unit in meters, and 3600 is the number of seconds in one hour. This equation gives the velocity of the water through the rearing unit.

To determine the velocity behind the baffles, this equation is used:

$VB = \frac{D^1}{D^2} \times V$, where VB is the velocity in m/sec behind the baffle, and $D^1$ is the baffle gap (this ratio can be expressed in either cm or m). If $D_2$ is the unknown, we have: $D_2 = \frac{V^1}{VB} \times V$.

Baffles eliminate the need for frequent cleaning by drawdowns and broomsweeping, actions which excite and stress the fish. However, not all species can adapt to baffles. It has been our experience that lake trout and splake are stressed by baffles. Louvered baffles may provide the answer. Such baffles can be closed for a few hours each day to promote cleaning in the raceways. The design should be tailored, where applicable, to the species to be produced. Unfortunately, not enough is known about the specific requirements of most species. It is believed that requirements differ betwen Atlantic salmon and rainbow trout. Atlantic salmon must be provided more horizontal space (bottom area) (Peterson et al. 1972), while rainbow trout successfully occupy vertical space — in other words, rainbow trout can be “stacked”. Klontz et al. (1978) provide the following density-index recommendations: rainbow trout 0.5; coho

Table 1. Relationship of rearing to flow, loadings (kg/Lpm), densities ($kg/m^3$), and water exchange rates. The values are based on an available flow of 10,000 L/m and an individual raceway rearing volume of 60 $m^3$.

| Description of design parameters | Water Quality Ranking | | | |
|---|---|---|---|---|
| | 8 | 6 | 4 | 2 |
| 1. Maximum allowable loading (kg/l/min) | 3.00 | 2.25 | 1.50 | .75 |
| 2. Total maximum production in kg | 30,000 | 22,500 | 15,000 | 7,500 |
| 3. Rearing space ($m^3$) needed for a maximum allowable density of 32 $kg/m^3$ | 937 | 703 | 468 | 234 |
| 4. Number of raceways required | 15 | 12 | 8 | 4 |
| 5. Hourly exchange rate per raceway | 2.6 | 3.4 | 5.1 | 10.3 |
| 6. Resulting water velocity in cm/sec. | 2.4 | 3.2 | 4.8 | 9.7 |
| 7. Resulting density for R = 4; rearing space needed is 600 $m^3$ or 10 raceways | 50 | 38 | 25 | 13 |

salmon 0.4; chinook salmon and cutthroat trout 0.3. These reflect a relationship of 10:8:6. For design purposes, this means that chinook salmon and cutthrout trout require 1.66 times as much rearing space as rainbow trout, while coho salmon must be provided 1.25 times as much space as rainbows, providing loading requirements are the same. Such differences in requirements would drastically influence design of a particular facility.

Lake trout and splake require shade, but subdued lighting conditions appear to be beneficial to most species. It is recommended that serious consideration be given to the construction of roofs over raceways. In addition to shading out direct sunlight, roofs are effective in predator control, especially if the sides are screened as well. Predators not only destroy fish outright, but harassment by such predators is another stressor. Human activity can have a similar effect since public hatcheries, traditionally, are open to visitors. When designing such facilities, visitor control should be kept in mind. Design features should permit the public to observe operations without disturbing the fish. A visitor's center with a display pond can help to satisfy public interest.

Handling and harvesting, two necessary activities, are also stressful to the fish. Needham (1977) made the comment that most of the bacterial and fungal diseases he observed in fish were caused by physical damage. Proper design can help in easing the removal of fish from the rearing units. Fish should not have to be "chased around" and should be left out of water for as short a time as possible. Temporary holding facilities, where fish are concentrated for short periods of time, must be adequately supplied with oxygen to meet the increased oxygen demand of the fish. Metabolic rates may triple if fish become excited and frightened as they are handled. This stress is unavoidable, but the effects can be reduced through proper design and technique.

Specific design features aimed at reducing and countering stresses are not "off the shelf' items. As new hatcheries are planned, biologists, engineers, and bio-engineers are challenged to come up with the best design possible. Finally, it is important also to obtain input from the experienced, practical fish culturists whenever design for a new hatchery is started.

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