Stock Management Issues

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Fish farm production can also be increased (approximately doubled) through the use of a continuous production strategy, rather than a batch production strategy. The maximum economic productivity of the culture system can be obtained with year round fish stocking and harvesting because continuous production maintains the culture system at or just below its carrying capacity. Also, harvesting at a given size increases product value by providing more uniformly sized fish for the market. In a full-scale production experiment, Heinen et al. (1996A) showed that rainbow trout stocked every 8 weeks and harvested weekly could achieve a steady-state annual production (P), (kg/yr) to maximum system biomass (B), (kg) ratio (P:B) of 4.65:1 per year. Many commercial farms operate at P:B ratios of 3:1 per year or less. Adopting stock management strategies that increase the P:B ratio on a commercial farm would significantly reduce production costs.
Stock Management Issues

- Batch strategy
  - P/B = 1.74/yr,
  - \( t_s = t_h = 224 \text{ days} \quad N_0 = 1965 \)

In a batch strategy, all the fish are stocked and harvested from each tank and the maximum biomass is only achieved near the end of the production cycle. This approach for Rainbow trout yields a Production to Biomass ratio of only 1.74/yr. In this scenario, the tank is harvested every 224 day.
In a production strategy that simultaneously stocks and harvest fish from the same tank, the tank carries a higher biomass loading and operates near to its design capacity. The tank is stocked and harvested every 56 days. The production to biomass ratio increases over batch stocking to 3.14/yr.
Stock Management Issues

- Concurrent mixed-stocking and graded harvesting
  - \( P/B = 3.48/\text{yr} \)
  - \( t_s = 56 \text{ days} \)  \( t_h = 14 \text{ days} \)  \( N_0 = 1438 \)

In a concurrent mixed-stocking and graded harvest, the tank is stocked every 56 days as before, but harvested every 14 days using graders. The tank is maintained close to its design maximum biomass loading at all times and the production to biomass ratio is at its highest of 3.48/yr.
Stock Management Issues

- For > 5 years, Freshwater Institute produced rainbow trout:
  - 4.6 MTON annual production
  - 1.0 MTON maximum biomass

  - stocked every 8 weeks at 30 to 40 g
  - harvested weekly at 340 g
  - 1 mm/day growth

- vs. 2:1 to 4:1 annually for many commercial farms

This technique of concurrent mixed-stocking and graded harvest was used at the Freshwater Institute to raise rainbow trout with an annual production of 4.6 metric tons per year with a maximum carrying capacity of 1.0 metric tons. This was accomplished by stocking every 8 weeks with 30 to 40 gram fingerlings and harvesting 340 g animals weekly.

Continuous stocking and harvesting strategies requires culturing several size groups at the same time, handling the fish frequently, and improving inventory accounting techniques. This can stress the fish and increase labor costs if automated equipment is not used. To keep the cost of handling and grading fish to a minimum, and the stress on the fish to a minimum, a convenient mechanism for size sorting the fish, counting them, and moving them to other locations should be incorporated into the culture tank and facility design.
Stock Management Issues

• Harvesting and grading:
  • IMPORTANT!
  • can add considerably to labor cost!
  • mechanism/strategy must be incorporated with culture tank design.

• Automated fish grading/pumping equipment:
  • reduces labor costs
  • can reduce fish stress and damage

Few, if any, aquaculture facilities are designed to optimize handling of any materials used or produced in the facility. Harvesting usually consists of manually dipping the fish out of the tanks. Manual systems work well if there are only a few thousand pounds of fish produced per year. However, if production is measured in tons per year, handling of the fish becomes a major time and labor consideration, and, thereby, a major cost factor. It is also backbreaking work. Adequate planning during facilities design can save much grief later when handling fish. Equipment must be provided where automated handling is to be used. Unfortunately, little research has been done on how best to move fish from one tank to another, when reducing stocking densities. Pumps can be used and they often cause less stress on the fish than do standard dipping methods. How fish handling systems are designed can determine the labor needed for this operation and can determine how much stress the fish will experience.
Harvesting and Grading

Small box graders work well at small scale.

Grading is generally accepted as a way to improve growth rates by eliminating negative interactions between fish of different sizes. Grading also allows for a more accurate feeding regimen, feeding the proper feed particle sizes, and it makes harvesting easier to plan and to carry out. The less variability in fish sizes across the cohort, the less grading that will have to be done. Generally, the less deviation in sizes, the more marketable the fish will be to a growout facility and to the processor, although some processors may want different sizes or a mix of sizes from time to time, to meet their market needs.

The box grader is often used to grade fingerlings. It consists of a floating box that contains an adjustable or replaceable set of grader bars. In most cases, the appropriate bar width will be determined by trial and error. After grading a few times, grader size may be correlated with condition factors estimated from weight and length samples, and grading can be planned more accurately. The production notebook should contain records of fish size and grader bar width so that benchmarks relating fish size and weight or condition factor to grader width can be established.

Fish to be graded are placed in the top of the grader while it floats in the tank. The small fish pass through, and the larger fish that are trapped inside are emptied into a separate tank. Gently raising and lowering the grader up and down in the water can facilitate the grading process. Grading of fish into two size groups is most easily done using three tanks, but can be done with two. When three tanks are used, the source tank is gradually emptied as the other two tanks are filled with small or large fish.
Harvesting and Grading

Clam-shell graders reduce labor and are easy on fish!

When two tanks are used, fish are crowded to one side of the tank using a partition, such as a hinged screen. A portion of the fish are then netted and placed into a grader floating on the other side of the partition. The small fish fall through the grader into the empty half of the first tank. The grader is then lifted from the water and the large fish remaining in the grader are placed into the second tank. The empty grader is then returned to the first tank and the process continues until all fish are removed from the crowded side of the first tank. Ideally, all grading and sampling for growth estimates should be finished in one or two days so that fish growth during the days of grading does not negatively affect data quality.
Harvesting and Grading

Clam-shell graders reduce labor and are easy on fish!

Some Norwegian salmon farmers use grading to cull the smallest, least efficient feeders and might remove as much as 50% of the population. Maintaining inefficient feeders can create a 30–50% increase in production costs; therefore, these fish should be removed as early as possible. Culling decisions will need to be made by the manager, based on experience with the facility’s production. If it is not clear how well various size ranges of fish are converting feed, a small percentage of the smallest fish from a single tank can be removed. Feed conversion or other parameters can then be monitored to determine whether the initial cull improved production efficiencies.

There are many fish graders commercially available. Whatever the system used, facilities, and/or equipment are needed for grading. The type of grading equipment needed depends on the system design, species, management methods, and other factors.
At larger farms, labor and fish stress can be reduced with the wise use of automated grading and inventory tracking equipment. Commonly used automatic graders include mechanically driven belt graders and roller graders. These mechanical graders usually require removing the fish from water for a brief period as they pass through the sizing mechanism (see Chapter 11). Although mechanical graders produce some stress and trauma, many of the established commercial mechanical grading machines are considered safe, reliable, and fast methods to size sort and count large numbers of fish.
Sampling is used to estimate growth by measuring the weight and/or length of a subset of the entire population. Tracking fish growth accurately is necessary for rationing feed, calculating tank densities, and for projecting the time when fish will be ready for sale. By collecting some of the fish from the tank in question, and comparing the information over multiple sampling intervals, growth rates for the entire population can be estimated.

By analyzing growth rates for different cohorts of fish in conjunction with other production data, e.g., feeding information and water quality conditions, the manager can determine how production efficiencies change from cohort to cohort and how production parameters will affect the fish, and make adjustments to optimize fish production.
Harvesting and Grading

- Moving fish is hard work!
- Fish moving equipment:
  - fork lift a palletized tank
  - fish pumps
    - heli-arc
    - vacuum
    - pescalator
  - swim fish through channels and raceways

Remember: moving fish is hard work and whenever possible labor saving devices need to used including simple fork lifting palletized tanks or fish pumps.
Access to the aquaculture site is necessary for employees, feed supply trucks, oxygen supply trucks, fish haulers, and other functions. This implies that there is a road or some method of getting people and vehicle traffic in and out of the site. There must be available access in all weather conditions and there must be space enough to maneuvers trucks and other vehicles. These areas may be gravel covered or hard surfaced. The physical size of these areas will depend on the type of truck expected and the frequency of truck traffic. The turning radius of a tractor trailer is about 65 feet (20 m), which means that the smallest radius on any driveway should also be no less than 65 feet (20 m). Plan for efficient ingress and egress from the farm site for all large trucks. Loading docks may also be necessary. These facilities can be expensive, particularly if not properly planned into the overall facilities design.