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Advances in fish harvest technologies for circular tanks

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ABSTRACT

Improved equipment and husbandry practices are required to effectively grade and harvest fish in large land-based culture tanks. The objective of our work was to develop and evaluate several types of relatively inexpensive, portable, and efficient fish handling equipment to reduce the labor requirement for grading and harvesting fish from large circular culture tanks. This equipment and husbandry practices also had to provide for worker safety and minimize the stress or damage to the fish. Two techniques were developed and evaluated to remove the entire population from a large and deep circular tank, i.e. (a) purse seine and (b) carbon dioxide avoidance response. Two other techniques were developed and evaluated to remove the fish from a large (150 m^3) and deep (2.44 m) circular culture tank after they had been top-graded *in situ* using a 3-panel clam-shell grader: (c) an airlift fish pump and hand sorting/dewatering box and (d) a sidewall drain box for hand sorting/dewatering. Some of these technologies are new, while others (such as the purse seine) have been used in other applications. Our commercial-scale evaluation of these technologies provided insight into the advantages and disadvantages of each option. With use of the clam-shell grader, the majority of the fish in the culture tank were never lifted from the water during the self-sorting process, which minimized stress, perhaps enhancing final product quality. In contrast, harvesting the tank using the purse seine and hand brailing was much more labor intensive and increased the stress on the fish, as indicated by a nearly 10-fold increase in fish mortality compared to the mortality observed when the clam-shell type crowder/grader system and an airlift fish pump or sidewall drain box were used during fish harvest. The combination of the clam-shell crowder/grader with the sidewall drain harvest box was our preferred harvest method, because of its low labor requirement, relatively low fish mortality, and rapid harvest rate. We also think that the carbon dioxide avoidance harvest technique can be used effectively, with little labor input and practically zero mortality when the entire fish population must be removed from a fish culture tank, but not during a selective harvest using *in situ* grading. Ultimately, the more effective technologies and practices should help fish farmers overcome scale-up issues and improve land-based fish farm profitability.

1. Introduction

Increasing the scale of intensive fish culture systems can significantly improve their economics by reducing both fixed and variable costs per unit of production. However, an increase in system scale requires working with much larger tanks and water flows. For example, as much as 75–150 ton of annual production can be supported in a 1000-m^3 culture tank, depending on the species and the flow through the culture tank. Providing this volume in large and deep circular tanks can improve floor space utilization sufficiently to reduce building costs by as much as 40% when compared with tanks only 15–20% as large (Freshwater Institute, unpublished data). Large tanks will also reduce the cumulative fixed cost of tank flow and level control structures, fish feeders, dissolved oxygen probes, and float switches. The time spent analyzing water quality, distributing feed, performing cleaning chores, and harvesting fish will also be reduced. A reduction in labor per unit of production is probably the largest savings in variable costs realized by moving to larger tanks (Wade et al., 1996).

When large and deep circular tanks are used, both equipment and husbandry practices require better management. In addition, the ability to effectively grade and harvest fish in a large culture tank allows the producer to use continuous stocking and harvesting strategies that can double production efficiency relative to batch stocking and harvesting (Hankins et al., 1995). Even when an 'all in—all out' fish stocking and harvesting approach is used to maximize biosecurity, large tank-based production systems could reduce production costs if relatively inexpensive, efficient, and portable fish handling equipment were available to reduce the

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labor requirement for grading and harvesting fish from large circular culture tanks. Unfortunately, there are few, if any, publications that describe harvest methods for fish stocks in large and deep circular tanks (Timmons et al., 1998). Therefore, researchers at the Conservation Fund Freshwater Institute have worked to develop and evaluate such equipment and practices. In addition to being cost effective, this equipment must also minimize the stress on fish and provide for worker safety. Two techniques were developed and evaluated to remove the entire population from a large and deep circular tank, i.e. (a) purse seine and (b) carbon dioxide avoidance response. Two other techniques were developed and evaluated to remove the fish from a culture tank after they had been top-graded *in situ* using a 3-panel clam-shell grader: an airlift fish pump and hand sorting/dewatering box (c) and (d) a sidewall drain box for hand sorting/dewatering. We hope that these technologies will help overcome scale-up issues and improve land-based fish farm production per unit investment. These technologies, as well as their advantages and disadvantages, are described below.

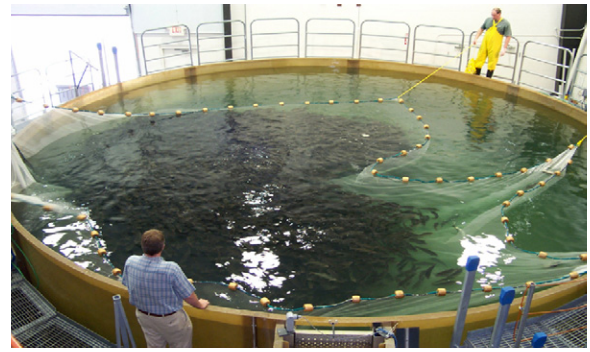

Fig. 1. The modified purse seine used to crowd fish in the growout tank is 3.66 m (12 ft) deep by 30.5 m (100 ft) long to stretch around the perimeter of the tank. Extra weights were added to the bottom lead line and ropes were secured to the float line at the top of the seine to keep it ballooned out and in a stable position, otherwise the water current created by the rotating flow and the pull of the pursing ropes at the bottom of the net tended to pull the seine out of shape or position.

2. Techniques to remove the entire population from the circular tank

A major challenge has been to find the best way to effectively harvest fish from large circular culture tanks, i.e., tanks that are too wide and deep to enter without swimming. Harvest of rainbow trout (*Oncorhynchus mykiss*) and Arctic char (*Salvelinus alpinus*) was studied in a 150-m^3 tank (9.1 m diameter by 2.4 m deep) and in several 10 m^3 tanks (3.7 m diameter by 1.1 m deep) at the Conservation Fund Freshwater Institute. During this research, staff never entered any of the tanks while they were filled with water and fish.

2.1. Purse seine

The combination of a purse seine (Fig. 1) and a hand sorting box (Fig. 2) was the first techniques developed and evaluated for selective harvest of Arctic char from the growout tank.

A customized purse seine (Fig. 1) was purchased from Memphis Net and Twine (Memphis, Tennessee) in 2000 for approximately $ 1000. The purse seine could be used in the 150 m^3 tank because the tank's center drain was located flush with the tank bottom. The net was 3.66 m (12 ft) deep by 30.5 m (100 ft) long and designed to stretch around the perimeter of the tank. By design, the seine was fabricated deeper than the tank to provide some extra stretch when crowding fish. The seine was made of a knotless, non-coated, nylon netting with 1.3 cm (1/2 in.) diamond shaped openings. Use of a soft net material was extremely important given the sensitive skin of Arctic char. Floats were positioned on the top of the net every 18 in. to keep the top of the net afloat and to prevent fish from swimming or jumping over the top of the net (Fig. 1). Plastic rings were sewn into the bottom of the net every 15 cm (0.5 ft) and a 36.6-m (120 ft) pulley string ran through the plastic rings to purse the seine. The string can be pulled from either ends of the net to tighten up the bottom lead line and to crowd the fish closer to the side of the tank (Fig. 1). The lead line at the bottom of the net is intended to keep the net on the bottom of the tank, which prevents fish from escaping under the net.

We used the seine for the first time to crowd the fish close enough to the side of the tank to obtain an accurate sample. The net was dropped into the tank around the perimeter and was tied off at each end. The water's strong rotational velocity forced the seine out of position and prevented the seine from enclosing all of the fish in the tank. However, the net still engulfed a large percentage of the fish and we were able to take an accurate sample of crowded fish using a dip net. Some mortality (about 20 dead fish) occurred during and after the use of the seine.

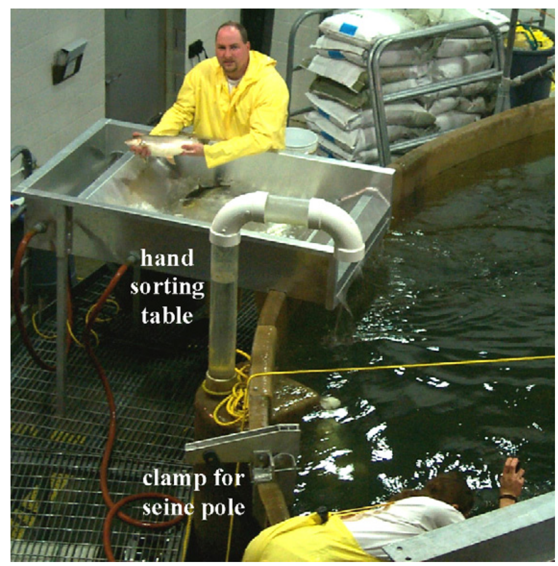

Fig. 2. 1–2 people hand-sorted the Arctic char for size and condition nearly as fast as another 1–2 people could hand brail the fish from the culture tank and onto the custom fabricated sorting table. Note the clamp to hold a seine pole in the picture (seine pole not shown). Trough end.

To improve the design, during the next effort we attached seine poles to each end of the net and more weight was added to the bottom lead line. The top of the net was secured using ropes to keep it ballooned out and in a stable position (Fig. 1). When employed, only one end of the pulley string was able to tighten the bottom of the net, while the other end most likely became entangled. Nonetheless, the seine worked well. Approximately 80–90% of the fish were captured in the net and were crowded close enough to the side of the tank to initiate a small harvest and collect a random sample. This process required 5–7 people at various times, including two people to hold the seine poles. Minimal mortality occurred afterwards.

In its third use, the seine was used to crowd the fish and to hand-sort and cull out runts and deformities from the population. Procedures were similar to the previous seine event. This time the pulley ropes worked perfectly and we estimated about 90% capture inside of the net. It took about 3.5 h to hand-sort close to 10,000 fish when using a specialized sorting table that we designed and