NUTS & BOLTS

Noise: How much is too much?

By Stephen K. Piggott & KC Hosler

The theme of this month's Nuts and Bolts article is noise. Normally, Nuts and Bolts articles provide a perspective on the more common best management fish culture practices or design considerations. When the theme is a little more obscure, our archive of technical journals or contacts with friendly experts will supply the latest information on the topic at hand.

When selecting pumps and blowers, refer to the motor specifications and select those with low dB noise levels. Also, all pumps and blowers should be installed using vibration-isolating motor mounts, and vibration transmission from pumps or regenerative blowers to connecting plumbing may be lessened through the use of expansion couplings.

Studies specific to aquaculture facility noise generation and its effects on the fish are very limited. Much of the recent research on the reactions of fish to noise has been to determine the effect of sonar systems or of marine construction such as pile driving or underwater blasting on aquatic life, with a large percentage of the work devoted to the study of marine mammals. It is necessary to glean tidbits of information from studies devoted to a wide variety of interests and pursuits to find anything that could be related to fish or aquaculture facilities. Interpretation of the results, relating them to aquaculture facilities for a species that has never been studied is extremely problematic.

The study of sound within an aquaculture facility must evaluate the detection range and sensitivity of the fish being reared. To be effective, studies must measure the frequency, the intensity and the duration of the noise. Impact assessments include behavioural challenges, stress levels, changes in immunity, and temporary or permanent loss of hearing. Damage to body tissues, and mortality (from shock waves) are frequently within the scope of noise researchers but are rarely of significance to fish culturists. Some studies suggest that sensitivity to noise also changes as fish mature, owing to changes in their physiology (i.e. swim bladder development) and environment.

Most fish have the same basic acoustic capabilities as other vertebrates. They appear to use this capability, combined with sound generating abilities, to communicate for purposes of aggression, defense, reproduction, and detection of hazards and predators. Most fish are described as "hearing generalists", but some become "hearing specialists" with a broader range in detectable frequencies and the ability to detect sounds at lower dB levels. Specialists and generalists can be found within most orders, which prohibits drawing conclusions about one species from studies on different species even from the same family or genus.

Typically, fish detect sound frequencies between 50 and 500 Hz, although some species can detect sounds at greater than 3000 Hz or even down to 35 Hz. Threshold levels (level at which hearing begins) normally range from 80 to 145 decibels (dB) although some species such as Atlantic cod can detect sounds at intensity levels as low as 20 dB. There is evidence that fish that can withstand a single sharp noise event, but can be damaged if the noise is sustained. In humans, we know that we can tolerate noise levels of about 144 dB for one second, 126 dB for one minute, 112 dB for 20 minutes, and 100 dB for 8 hours. This type of information is not readily available for most fish species.

The information least available to us identifies the lower levels at which noise adversely impacts the fish, and the magnitude of the impact. Fish culturists know from observing behaviour that fish react to noises. However, measuring the cost in terms of increased stress, reduced growth rates or reduced immunity to disease has not been quantified. Similarly, little research has been performed to determine the sound intensity and duration at which measurable damage begins to occur. We know that physical damage to *Astronotus ocellatus* (Oscars) begins at 180 dB in the 60 to 300 Hz range. Other research with Atlantic cod (*Gadus morhua*) has also suggested that 180 dB at frequencies below 400 Hz is an important threshold. These intensities are noise levels for short duration sounds. However, no research appears to be available which quantifies behavioral impact thresholds, which may be useful to aquaculture facility operators. Studies are needed which compare reproductive performance, disease susceptibility, growth rates or mortalities which can be related to chronic noise before we will have commonly recognized criteria that can be used to design facilities.

Water flow, pumps and machinery are most likely to generate sound in the range below 400 Hz. Higher frequency sounds are generated mostly by aeration, collapsing air bubbles, and electric motors. It has been shown that sound transmission at some frequencies is slightly greater in FRP vessels than in concrete. In general, it appears that sound (especially the higher frequencies) attenuates rather quickly through water, so that most sound is transmitted through hard materials such as piping and tank walls. At the Freshwater Institute, scientists explored sound transmission pathways. Measurable improvement (reduction of transmission) was observed by isolating influent and effluent piping from contact with culture tanks, and by supporting culture tanks on insulating pads. Influent piping was suspended so that it discharged into the tank without contacting the tank walls or top flange, and the overflow standpipes were designed so that the water was discharged in free-fall from the standpipe into the recirculation return piping. Sound levels dropped by 10-15 dB from a high of 121 dB. Since the dB scale is logarithmic, this reduction in amplitude is significant. A 6 dB change represents a 50% reduction in noise. However, they did not indicate whether fish health was improved by these changes.

Whether or not the literature indicates effects of noise on fish, good hatchery design principles should include vibration and noise reduction measures to help protect both the fish and the operators. When selecting pumps and blowers, refer to the motor specifications and select those with low

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production of 10,000t/yr would require 100 separate systems of the sizes currently available.

The alternative is to design and build much larger individual components. I'm confident that some aquacultural engineers have the skill and experience to accomplish this unit process scale-up. However, would-be users must understand that specialized management and production regimes are as important as engineering in maximizing production from industrial-scale recirculating systems.

Aerial view of the ODAS systems at Solar Aquafarms Inc., which produces up to 2,300 MT of tilapia annually. Photo courtesy Steven Serfling, Sunwater Technologies, Sarasota, Florida.

To improve floor space utilization, some large-scale fish farms use rectangular (occasionally octagonal) tanks that share common walls. Others are using deep circular tanks holding 200-1000 m^3 of water. As much as 75-150 tonnes of annual production can be supported in a 1000 m^3 culture tank, depending on the species and the flow through the culture tank. Using large tanks can reduce building costs by as much as 40%, when compared with tanks only 15-20% as large.

Large tanks will also reduce the cumulative 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.

Experimental large scale culture tank at the Conservation Fund Fresh Water Institute. The fish are rainbow trout.

Even if very large tanks are used to lower production costs, both equipment and husbandry practices must be improved to better control the flow hydraulics and manage the fish within the tanks. In my opinion, these are a greater constraint to the adoption of industrial-scale recirculating systems than is the increase in system size.

At the Conservation Fund Freshwater Institute, we have been developing practices and equipment to overcome these scale-up issues and improve production per unit investment. We have focused on developing technologies that exploit the opportunities offered by very large tanks; improving fish handling techniques; designing more energy-efficient and integrated systems; and enhancing biosecurity. We are developing methods for controlling water velocity profiles within large tanks so that safe swimming speeds are not exceeded, and the self-cleaning properties are retained. We have developed two mechanical flushing systems that allow simple and rapid removal of dead fish from the center drain and require only 1-2 minutes of daily staff time. We have also developed a clam-shell grader that can be used with airlift- or other pumps to grade and harvest fish without anyone having to enter the tank.

Finally, a non-invasive 'herding' technique was developed that takes advantage of the fishes natural response to high concentrations of CO_2. Fish passively congregate in a distinct location in the tanks from where they can be readily harvested or directed into a separate tank. This new technique provides an efficient, inexpensive, safe, and humane process for transferring fish. We believe that this work, together with technologies being developed by the industry, will significantly improve production efficiency in land-based fish farms, and pave the way for major expansions in overall production.

Conclusion

A continuity in research funding over the past 10-15 yrs, along with the hard-earned experience of just a few dozen industry leaders, has truly benefited our understanding of the design and management of industrial-scale recirculating systems. This long-term investment must continue if we are to develop more environmentally friendly and cost effective recirculating system technologies that can produce the thousands of tonnes of fish that will be required. Meeting this challenge will require a long-term investment analogous to that now being made in broodstock development programs.

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dB noise levels. All pumps and blowers should be installed using vibration isolating motor mounts. Although spring-style mounts are commercially available, it is often more practical and less expensive to use a resilient rubber pad to isolate the pump and blower bases from the surface on which they are mounted. Mounting to a solid, high mass surface such as a concrete slab to dampen vibration is also desirable. It should also be noted that when installed pumps are making excessive noise, it may be an indication of problems such as bearing failure or cavitation, and servicing may be in order.

Vibration transmission from pumps or regenerative blowers to connecting plumbing may be lessened through the use of expansion couplings. Similarly, ducting connections on low-pressure fans may include couplings made from rubber, canvas, or another flexible material. Flexible rubber couplings secured with band clamps, such as those made by Furnco, may be used for piping connections to treatment vessels to lessen vibration transference. For process vessels, those that produce great amounts of noise may be insulated, using sprayed foam or foam pads similar to those used to insulate pipes, to dampen the sound. Although expensive, insulation of vessels may be worthwhile if noise becomes an issue.

In terms of overall facility layout, designers may reduce noise impacts by using walls or enclosures to isolate water treatment equipment and motors from the culture system. However such sound barriers may affect the operability of the system since they are also barriers to the movement of facility staff. Some operators prefer to see and hear treatment systems from the culture areas so that adjustments may be made while monitoring reactions of the treatment equipment. If treatment systems are not to be isolated physically, then it is important to locate the greatest noise generators, such as cascade aeration columns (which are loud due to the falling water) furthest from the fish to reduce noise effects. Especially noisy equipment such as electrical generators, vacuum pumps, and compressors may often be located remotely, in isolated, insulated rooms, or placed outside of culture buildings but within integral enclosures provided by the equipment supplier.

Because quantifiable targets have not been identified for every species and life stage, owners and operators must rely on personal observation and experience to determine the impact of noise on their facility. This must also include identification of other sources of stress and an evaluation of the relative impact of noise on the fish. In new facility designs, it is prudent to incorporate basic noise containment and reduction strategies. If noise is perceived to be an issue in existing facilities, identifying the sources of the noises and taking steps to mitigate the problems often only requires minor facility upgrades.

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