Case study

Development of a Tank Upweller System for Freshwater Pearl Mussel Propagation

Background

The Freshwater Biological Association (FBA) is based on the shores of Windermere and since 2007 has been running England's national freshwater pearl mussel (FPM, *Margaritifera margaritifera*) programme, having carried out successful FPM reinforcements in English rivers.

New methods are being developed on an annual basis and culture systems in use one year may be replaced the following. Every propagation facility is different, so a culture system that works well at one facility may be unsuitable at another. Each mussel species will have specific culture requirements too (i.e. food, flow, substrate etc.), therefore a rearing system that is successful for one species may not be applicable to others (Patterson 2018; Mair, 2013). The objective of this case study is to provide a review of a freshwater mussel culture technique currently in use at the FBA.

As juvenile mussels grow, they should be transferred to a secondary culture system. Many culture facilities have experienced excellent juvenile growth and survival in outdoor culture systems that use a wild-water source. Higher rates of survival have been observed when juveniles greater than five millimetres in length are deployed into outdoor culture systems. Outdoor culture systems can be deployed in ponds, lakes, impoundments, and even low-flow areas of rivers and streams (Patterson 2018).

Tank upweller systems can serve as secondary culture systems. First developed by the Marine Industry for Clam and Oyster Culture, the tank upweller has been adapted and tested for use in freshwater mussel culture (Patterson 2018; Mair, 2013). This relatively simple system is effective for culturing juvenile mussels greater than three millimetres in length and can be set up as recirculating (in a laboratory setting) or flow-through (beside or inside a pond).

What we did

A (flow through) tank upweller typically consists of a tank, juvenile culture chambers, and side drains for each chamber (Figure 1). Culture chambers (A) were constructed using a pair of nested 30 litre straight sided buckets with the base removed. A 40 mm hole was cut into the side of the culture chamber and nylon mesh (B) was secured between the nested buckets. Raw lake water is pumped from Windermere into the tank and exits through the side drain (C). The side drains are connected to the culture chamber, so the only way for the water to exit the system is to upwell through the culture chambers. The tank upweller systems at the FBA were constructed with fibreglass fish tanks (2 m diameter).

The system is utilised when propagated mussels reach five mm in length. At this size, they are not vulnerable to predation from organisms in raw Windermere water , and tolerant to environmental conditions such as natural temperate temperature regimes and higher suspended solid levels. To contain mussels of this size, the nylon mesh in the juvenile culture chambers is 1000 microns.

Mussels have been cultured in upwellers until they reach 15 mm in length. As long as growth rates remain consistent, mussels can remain in upwellers until tagging and release.

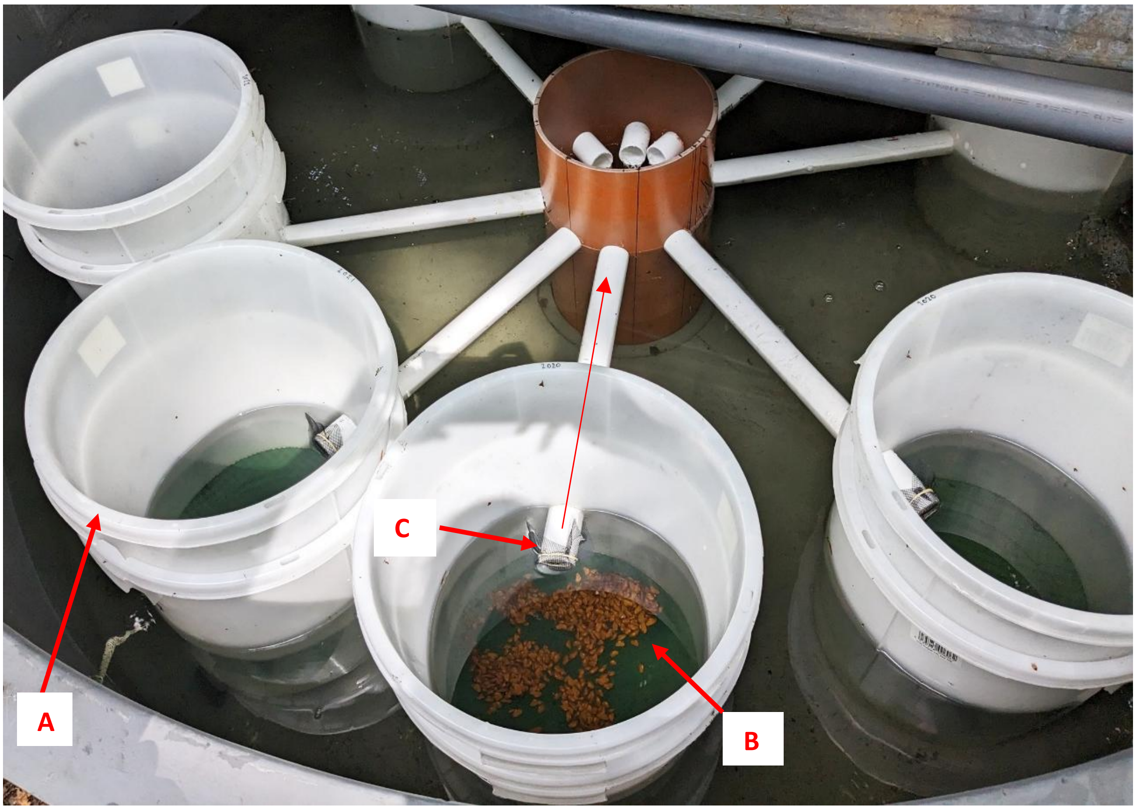

Figure 1 1. Annotated photo of an outdoor, flow-through tank upweller from above. Raw lake water is pumped from Windermere into the fibreglass fish tank (2 m diameter), then upwells through the mussel culture chambers (A). Culture chambers contain juvenile FPMs resting on the mesh screen (B). Water exits the culture chambers through the side drain (C).

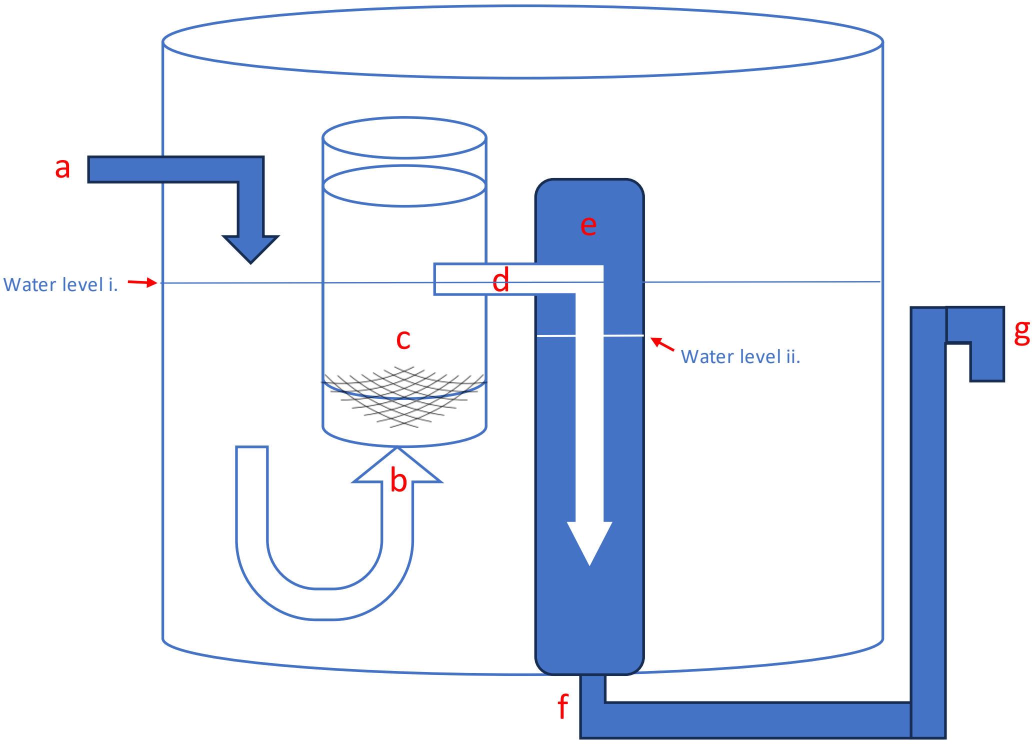

Figure 2. Water flows into the tank upweller system at (a) and upwells (b) into the nested buckets. Water flows through the mesh lining and over the juvenile mussels (c), then out the side drain at the top of the bucket (d). Water flows into a central drainage standpipe (e) and leaves the tank at the base (f). Water level i. is dictated by the side drain pipe level, and water level ii. is dictated by the height of the outflow elbow (g). Water level ii. is insurance that if water flow ceased (i.e. pump & backup power failure), then mussels would remain submerged.

Outcomes

This system is productive and efficient, with very low mortality of mussels and the highest growth rates of any system used at the FBA. It is also one of the lowest maintenance systems in the FBA, requiring cleaning monthly in winter and every two to three weeks in summer. It can also support a significant number of mussels; the FBA has held up to 2,000 juvenile mussels in each bucket, with a maximum 8 chambers per system. This tank upweller system is not heated and does not require feeding as the mussels receive a natural and complete diet from the raw lake water.

Learning

With this tank upweller system, the FBA demonstrates that mussel propagation systems do not require gravel substrate for juvenile freshwater pearl mussels once they are greater than five millimetres in length. Although gravel is a natural substrate, in a captive environment, gravel in culture chambers slow flows and more quickly clogs with debris, detrimental to the mussels and increasing maintenance frequency/duration. Whilst gravel and detritus substrates are evidenced to be beneficial for juvenile mussel growth and survival immediately post-excystment for freshwater pearl mussels (Zimmerman, 2003; Eybe et al., 2013; Lavictoire et al., 2020), sands and fine gravels can provide a surface for bacteria, fungi, and protozoa to proliferate. Any harboured pathogens can then cause disease in stressed mussel larvae (glochidia) or juveniles, and organic matter in the substrate encourages microbial growth, increasing the risk of infections (Barnhart, 2006).

Initially, FBA staff tried to glue nylon mesh to buckets with the bottoms cut off to create the culture chambers. However, a strong adhesion was found to be very difficult due to the relatively large diameter and thin sides of buckets with the flexible mesh. If the glue between mesh and bucket failed, the juvenile mussels could escape or fall to the base of the tank. This could have the possibility of mixing mussels between different culture chambers (e.g. for separation of year cohorts, research precision etc.) Taking inspiration from culture cups used in ‘Buckets of Muckets’ (Barnhart, 2006), it was found that nesting two cut buckets together held the mesh more securely. Additionally, cutting mesh to have a significant overlap provides greater strength to prevent the mesh slipping. Furthermore, when the hole is cut through nested buckets like this, a tight-fitting side drain prevents the buckets moving, also reducing the risk of the mesh slipping.

The hole cut in juvenile chambers was cut always cut at the same location for each system (essential to ensure chamber heights and thus flow rates are consistent across individual systems), however the location has been changed across systems to investigate impacts. Whilst flow rates are not impacted, cutting the hole as high as possible minimises juveniles becoming sucked against the side drain mesh.

The side drains must be covered with mesh of a size not greater than the culture chamber mesh. This can be simply secured with an elastic band around the pipe. This is necessary because juvenile FPMs can climb vertical surfaces, including the side of buckets, and so have the capability to exit out of the side drain. Additionally, when stressed (e.g. immediately after disturbance from maintenance), mussels can produce excess mucus. In flow, this mucus can carry light weight juvenile mussels and so can also be a route of escape if not prevented with netting. Furthermore, if multiple juveniles, along with other debris, clogs the side drain netting, the flow will be reduced in the bucket, impacting the whole culture chamber and potentially causing imbalances in flow in the system.

Initially, the FBA trialled this system using filtered (mechanically to 30 microns) Windermere water. After learning the system worked, the FBA trialled using raw Windermere water. Raw water increases growth rates further in this system. However, and unexpectedly adult broodstock mussels, which are believed to be able to handle greater levels of suspended solids and turbidity, filter less well when provided with raw opposed to filtered water. It is believed that this observation is due to the system design. Since the water upwells through the culture chambers, it is believed that some suspended solids, especially larger particles (potentially irritants such as hydra), settle on the tank base and do not interact with the juvenile mussels. Opposingly, the adult mussel's system has the water intake positioned with the flow directed across the adults, which could expose the adults to higher suspended solids & turbidity levels than juveniles in the upwellers.

The FBA also learned that by covering the system with a tarpaulin to block out sunlight, slowing formation of algae/biofilms, and preventing debris falling into culture chambers, the culture chamber mesh clogs significantly less frequently, reducing maintenance time.

Next steps

The next steps are to build an upweller system for each mussel population at the FBA. The upwellers are one of the easiest systems to setup and sample or to move juveniles and require little maintenance. The FBA will continue to develop and refine propagation systems and practices to improve the long-term success of the facility.

Future research opportunities to refine this system could evaluate system preferences of juvenile FPMs. Additionally, research could assist to identify optimal environmental parameters such as water flow, culture temperature, juvenile density/biomass. This could also include trialling this system as a recirculating system, allowing for further optimisations of parameters including diet and temperatures.

References

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