VIRGINIA FISHERY RESOURCE GRANT (FRG) PROGRAM
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Assessing the feasibility of integrating RFID technology into shellfish aquaculture to improve farm management

Final Report

Submitted by

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To

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Introduction

Inventory management in shellfish aquaculture is a struggle. Unlike other goods-producing businesses where inventory is easily accessible and can be readily counted; an inventory management system for aquaculture is constrained by reasonable measuring techniques, access to product, and time. It is further complicated by issues such as anticipated and unexplained mortality. Nonetheless, inventory management is critical to the success of any goods-producing business and shellfish growers are increasingly interested in seeking cost-effective methods to help achieve a system to allow them to set and evaluate company goals and objectives.

The 2018 Virginia Shellfish Aquaculture Crop Reporting Survey reported 103.9 million oysters planted in Virginia by 53 commercial farms for an average of approximately 2 million oysters per farm (Hudson and VSGMAP 2019). In container-based aquaculture, shellfish farmers process oysters multiple times during grow-out. During any husbandry activity throughout the grow-out period when farmers clean, grade, and split oysters, the developmental stage and health of the oysters may be revealed. An indication of mortality may be presented. Keeping track of this information is key to yielding accurate inventory numbers to project targets for marketing as well as growth and expansion needs. How to keep track of this information is the challenge since through husbandry, 10 bags become 40 bags, and 40 bags become 120 bags, and so on.

The other challenge is to maintain this inventory through a system that is easy to employ, cost effective, accurate and efficient. A comparison of common methods used is beyond the scope of this review. However, most farmers do record their inventory using some method; many failing to yield a permanent record. White boards, pen and paper, and smart device apps are a few. They may utilize some color-coded technique that tracks, at a minimum, when cages or floats have been tended to last.

The status of the inventory is typically revealed during husbandry. The method must be designed to remain as quick as possible in hopes of maximizing efficiency. The idea of spending extensive time on tracking inventory with available time-consuming methods is unrealistic and immeasurable, yet without a tracking system, a farmer is left without an accurate idea of how much product they are holding on the farm. Inherently, this causes a farmer to remain apprehensive about crucial business decisions such as replenishing stock, satisfying demands, and remaining flexible during times of uncertainty.

In this study we partnered with scientists at the Virginia Institute of Marine Science who wished to evaluate the feasibility, benefits, and drawbacks of implementing Radio Frequency Identification (RFID) technology into Chesapeake Bay shellfish aquaculture farms to track inventory. RFID is a common method for tracking inventory in real-time. For the reasons discussed above, inventory tracking at the Cappahosic Oyster Company that includes more than 2,500 double stacked grow out cages and additional floats is difficult and there is a desire to explore the efficacy of implementing another system.

We hypothesized the technology had advanced in hardware durability and automation to stand up to the demanding environment of shellfish farming. In this study, we integrated RFID technology into the farm to qualitatively evaluate the functionality and practicality of the system, and quantitatively assess the advantages and disadvantages of this technology in both a financial and operational sense.

Radio Frequency Identification Device (RFID) System

RFID is a common method for tracking inventory in real-time. It relies on radio frequency waves emitted from a powered reading device to identify serialized tags attached to products. It is prominent in retail, healthcare, courier, and airline industries which all require countless items to be accurately tracked and accounted for. The use of RFID in aquaculture has been spearheaded and successfully applied in finfish aquaculture.

The TROVAN RFID tagging system was selected for trial in this study. This RFID system was presented at a National Aquaculture Conference where VIMS partners first entertained the use of the system on a farm in Virginia. Trovan is a world leader in inventory management systems for finfish aquaculture. Based in the United Kingdom, the company has a demonstrated history of product development and success in marine environments. This made them a unique candidate for product selection ahead of other RFID developers more focused on land-based operations.

The project, as designed, set out to evaluate two inter-related systems which could connect with company's proprietary software. The first was a RFID tagging system that used and RFID reader, RFID Passive Integrated Transponder (PIT) tags with unique identifiers, and RFID Data Information Cards to link each cage on the farm with specific metrics of interest for the farm inventory. In practice the PIT tags, when affixed to a cage, gave that cage a unique identifier in the inventory database. The tags were permanently attached to the cage throughout the life of the cage. Each time a cage was processed the following information was collected using the RFID Data Information Cards: date, mesh size, type of apparatus (floating, bag, bottom), seed year class, seed size, grow-out line (red line, blue line, etc.), and whether the cage was being moved onto the farm or off the farm. This captured important information about the frequency that a cage was handled, the year class being addressed, and where the cage was located. For day-to-day operations, it provided critical guidance for where husbandry activities were needed most and where market ready oysters were being stored.

This part of the system included the three hardware components mentioned above and one software component. All were procured with funding from this grant. Several RFID PIT tag types were initially acquired and tested before settling on one type that proved to be the most durable and able to tolerate the marine conditions. The three images below in Figure 1 illustrate the three hardware components: the RFID Reader (left), the RFID Passive Integrated Transponder Tags (PIT) (center), and the RFID Data Cards (right), respectively.

Figure 1.

The second part of the system included a stationary reader interfaced remotely with a waterproof scale that could compute and integrate weights and measures to calculate growth and mortality of the bags as they came in. The interest in this component of the inventory management system was its capacity to estimate mortality and growth rates. Equipment for this was purchased through a separate grant funding agency, but was mentioned in the proposal to present the full picture of what the desired inventory management system would look like. Unfortunately, this element of the total inventory system did not work. The interoperability of the equipment was inadequate and was not functional at remote distances required. The research team; inclusive of the farm members, determined that the time and cost to implement this into the inventory management system was not feasible.

Finally, the system software that accompanies all these devices is proprietary to Trovan, and while it utilizes an excel platform for its framework, it is licensed by Trovan and unique. Data entering the system via the handheld aquapocket reader shown above in Figure 1 is downloaded into the software where a series of tables are generated following significant manipulation. The company provided initial onsite training followed by general technical client support in order to help with data manipulation issues. Licensing issues ensued early in the project and reoccurred periodically. Since only a single license was issued, this presented limitations on working through data and data problems. The company's reliability in technical customer support was not sufficient to keep the project on track.

Farm Application

The Cappahosic Oyster Company raises more than 3 million seed annually in a combination of floating and cage-based apparatus. Long line arrays and anchored floating lines are arranged within a 57 acre plot of leased bottom on the York River. The farm has developed a color-coded "home grown" version of a white board/pen and ink system to track the location, inventory, husbandry, and grow-out of oysters from seed to market. At any one time the farm could have more than 2,500 double stacked cages in the water and more than 100 floating gear. The company has grown exponentially over the past 8 years under this system, but entered into this project with the interest to test the efficiency, affordability, and utilization of an automated system that could generate past and projected statistics based on data that would be gathered on the farm directly.

Farm laborers were trained in the use of the aqua pocket RFID readers. Collectively, the team selected the suite of data that would be programmed to the data cards. A minimal of onsite training provided by the manufacturer, Trovan, occurred at project inception. Following a period trial and error, the team selected an RFID PIT tag that was durable. At this point the study moved into inventory collection mode. Every cage or float that was handled during either market or husbandry was tagged with an identifier and read using the aqua pocket reader (Figure 2). Data cards with the appropriately selected attributes were also read into the cage inventory (Figure 3). Data entry was rapid and of minimal disturbance to the operation.

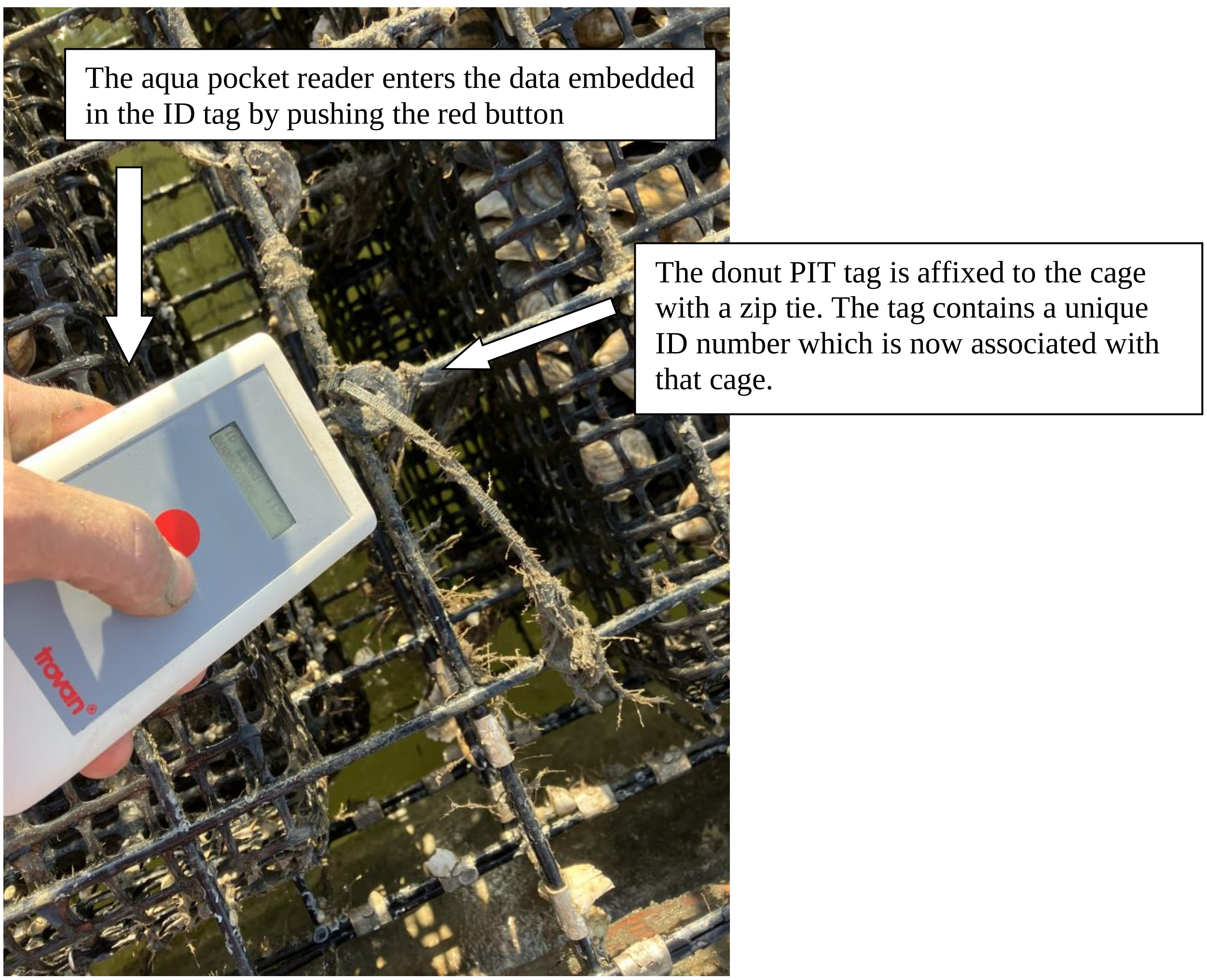

Figure 2. Reader captures id from the donut tag on the cage

Figure 3. The aqua pocket reader scans the data cards to attribute the cage (s)

This process continues today as more cages and floats are added to the farm inventory. More than 1000 cages have been tagged.

When a sufficient amount of data is collected, the readers are uploaded via a USB port to the computer holding the proprietary software license. Throughout the 12 months of data collection, there were significant failures in the aqua pocket units. Corrosion along the charging plate at the back of the units occurred which prevented the units from charging. Ultimately Trovan replaced the units with more rugged units that used a USBC charger rather than a charging cradle. Data stored on the units were recovered with technical assistance from Trovan. While this took a significant amount of time, and loss of new data collection, the replacement units appear to function reasonably well at the time this report was prepared.

The most critical part of the inventory management system is the database which extracts, manipulates and analyzes the information collected on the farm. This is where the Trovan system did not meet expectations. The software was difficult to manipulate and did not report out usable statistics quickly or easily. While relatively inexpensive, the user license was not web-based, and therefore limited to a single machine or user. This again was not efficient; particularly during the learning phases.

Too much time and effort were required to learn and understand the basic steps to transpose the data from the reader to proprietary tables, and then to a usable spreadsheet format. While useful data has been captured and can now be accessed, the system as packaged, lacks a final user-friendly interface to output data to the end-user. The farmer is basically left with thousands of lines of data that cannot deliver answers to basic inventory management questions needed for critical decision-making.

Summary of Findings

The aim of this project was to understand the value of RFID integration and data capture for both on-farm employees processing oysters daily as well as owners who make business decisions based on how many oysters they are actively growing, their sales demand, and their anticipated or planned growth in the coming years.

We could address 5 basic questions key to evaluating RFID success: 1) was the equipment easy to operate; 2) did the integration of the system disrupt normal operations; 3) was it durable in the working marine environment; 4) was it cost prohibitive to maintain; 5) did it yield data that was useful.

The equipment associated with the system provided to be very easy to operate and data collection took seconds; therefore, normal day to day operations of the farm were not disrupted. Throughout the course of the grant, thousands of data entries were made. The overall cost of the equipment and system had an initial start-up cost of approximately $6,500 for this farm but would vary depending on farm size. This farm required 2 readers at nearly $1,000/ea along with $3,000 worth of PIT tags, for example. Continuing expenses include the annual licensing fee for the software ($300.00/yr) and the cost for additional PIT tags ($3.00/each) needed as more cage-based gear is added. Two major equipment failures occurred throughout the course of the pilot study. The company was able to replace the units, but significant time lost meant a disruption in data inventory collection. The impact of this data loss has not been fully assessed. The replacement units appear to have been re-engineered to resolve some of these equipment failures, and we have resumed data collection with a focus on our 2023 year-class. All in all, the cost investment for hardware and software for the system is considered justifiable.

All members of the project team agreed that the data management software licensed by Trovan was the weak link in the overall management system, as it failed to generate a readily exportable data product that would allow the farmer to make business or farm management decisions easily or with confidence. This was recognized early on in the pilot, and efforts were made to overcome some of the data obstacles throughout the study period. At this time, the team believes all steps available to them with current resources have been made to export useful data products.

That being said; the team also agrees that the automation from this system has the capacity to aid or replace the time-consuming, manual data entry methods used previously. It has the capacity to answer questions related to location, oysters ready for market, and available space on the farm for new crop. On an operational level, the scanning of a fixed tag was easy and quick, and therefore the collection of the data could be considered easy, accurate, and reliable.

In consult with software engineers with experience in data handling and manipulation, the team believes additional effort to work through the data development problem is worthwhile. It is with this purpose in mind, that the team will follow-up with a phase II study proposal to seek minimal funds to work directly with a software specialist to develop a dashboard interface that can accept and continually generate use-friendly output from the field data.

Conclusion

This pilot study provided funds to test whether RFID technology is a suitable technology for tracking and managing farm inventory. The study concludes that, yes, RFID has the durability to withstand an oyster farm environment, and the capacity to collect and store large amounts of data critical for an inventory management system. However, the packaged system (i.e. Trovan) adapted in this pilot failed to produce a final product that would ultimately be useful. Given that no other RFID hardware/software package exists for the marine environment, the team is interested in moving forward to expand work on the data production end if additional funds can be found to assist with the cost. The intension is to work with a software professional who has the capacity to work directly with the Trovan data collected to produce a user interface that will become the inventory management system. This additional step would compliment the positive elements of the currently funded project and deem this pilot study not only a success for this farm, but a viable, cost-effective inventory management alternative for other farms to consider in Virginia and elsewhere.

References

Hudson, K., & Virginia Sea Grant Marine Advisory Program. (2019) Virginia Shellfish Aquaculture Situation and Outlook Report: Results of the 2018 Virginia Shellfish Aquaculture Crop Reporting Survey. Marine Resource Report No. 2019-8; Virginia Sea Grant VSG-19-03. Virginia Institute of Marine Science, William & Mary. https://doi.org/10.25773/jc19-y847.