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Economic feasibility of producing oysters using a small-scale Hawaiian fishpond model

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ABSTRACT

Traditional fishpond aquaculture in Hawaiʻi has declined since global trade provided access to cheaper, imported food. Farming non-native species like the Pacific oyster may prove more profitable than traditional species, and may help maintain the practice of fishpond aquaculture. Little literature exists on the economics of Hawaiʻi's oyster culture or the unique practices involved in fishpond-based production. Based on information supplied by a currently operating farm, we developed an enterprise budget for a model farm in order to 1) assess profitability, 2) determine sensitive input parameters, and 3) use stochastic modeling to determine the likelihood of different economic outcomes. The budget returned a marginally negative profit, with the bulk of operating costs from labor. Decision reversal analysis showed the model farm can be profitable with an increase in market price from US $1.25 to US $1.35 per oyster or a decrease in mortality rate from 50% to 45.9% – both are within reasonable reach in the near future.

1. Introduction

The people of Hawaiʻi were food self-sufficient centuries before contact with western civilization created a system of trade with the rest of the world. In addition to farming, hunting, and fishing, Hawaiians practiced aquaculture using fishponds. One type of pond, the loko kuapā, was built with a seawall of coral or lava rock around a portion of the shoreline. Sluice gates built into the wall restricted movement of fish into and out of the pond, allowing the overseer to control stocking and harvesting. Fishponds produced up to 900,000 kg (2 million pounds) of food annually, prior to the arrival of Captain James Cook in 1778 (Keala et al., 2007). Competition from cheaper imports, however, shifted food sourcing away from aquaculture, contributing to a historical decline in fishpond productivity. By 1975–1976, fishponds produced only 9000 kg (20,000 pounds) of food. Recent attempts to grow historically significant species like moi (Pacific threadfin), milkfish and mullet have also had little economic success, and only six structures are used actively for aquaculture today.

Raising species novel to Hawaiian fishponds may prove more profitable than farming traditional species. Hawaiʻi's waters are particularly well-suited for growing the Pacific oyster, *Crassostrea gigas*. In 2014, fishpond aquaculturists on the east coast of Oʻahu began selling the first locally-grown oyster available in decades. Triploid oysters, like those raised on the farm, have been shown to grow faster than diploid counterparts in warm climates (Nell, 2002). Hawaiʻi-grown oysters are reared from 6 mm spat to 75–100 mm (3–4 inch) market size products in as few as 6 months. Conspecifics from the northwest coast of the U.S. can take 2–3 years to reach the same size (Haws and Howerton n.d.). Fishponds also provide a constant source of natural algal feed for oysters. This allows farmers to avoid the high cost of growing feed, which is characteristic of raceway aquaculture.

High operational costs continue to challenge the aquaculture industry in Hawaiʻi. The state's labor cost share is 42%, nearly 3.5 times higher than that of mainland operations (Naomasa et al., 2013). Unpredictable environmental stressors can also create additional financial burdens for fishpond aquaculture. Loko kuapā are particularly susceptible to runoff and pollution because of their shoreline locations. Oysters grown in waters that are not classified as "approved" by the State of Hawaiʻi Department of Health must be depurated at a land-based facility. This activity removes any potential contaminants sequestered from pond water. Literature

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on potentially costly depuration dates back the 1980s (Yamauchi et al., 1983) and no recent characterizations of costs exists. Oysters grown in fishponds are also susceptible to natural disasters, unlike their counterparts that are grown in carefully controlled, indoor raceways. The former are likely to face higher mortality rates and less predictable yield on a year-to-year basis. The state government is interested in developing an oyster industry despite the challenges, and has collaborated with multiple stakeholder agencies to streamline the aquaculture permitting process. Before more efforts are made to advance the industry, however, it is necessary to address the economic unknowns of oyster farming in Hawai'i.

Several useful budgeting tools have been developed for bivalve producers in the last 15 years (Adams et al., 2001; North Carolina Department of Agriculture and Consumer Services 2001; Hudson et al., 2012a,b). The spreadsheet-based enterprise budget created by the Virginia Institute of Marine Sciences (Hudson et al., 2012a,b) is a comprehensive guideline for cultchless,[1] single-seed oyster production. The budget closely resembles the model case used in this study. Researchers identified labor and oyster seed as the highest operational costs, comprising 64.1% and 10.9% of the overall budget, respectively. They also identified market price and oyster mortality rate as two of the parameters having "the most impact" (on the budget). These figures provide insight on the cost structure of an outdoor farm resembling our model case.

In this study we investigate the economic feasibility of a small-scale oyster farm based at a traditional Hawaiian fishpond in terms of production costs and current market prices. The breakeven price to achieve the desired return and the most limiting factor to production was determined. The profitability, sensitivity of input parameters, and the probability of different outcomes were also investigated.

2. Methods

2.1. Experimental design

To conduct this study, we collected economic and operational (e.g. annual seed plantings) data for the last three years from an active oyster farm. We interviewed employees to create a comprehensive list of activities and equipment involved in the initial construction and daily operation of the facility. The site is located at a traditional Hawaiian fishpond that currently farms the Pacific oyster, *Crassostrea gigas*. Oysters are grown as single-seed individuals and sold as shell stock (i.e. in-shell) products. Depuration is mandatory for this farm due to its low water quality. Output is currently limited by use of a single depuration tank.

To protect confidential information,[2] a model farm case was developed. The model case derives real costs obtained from the current farm, when appropriate. Cost estimates are also based on expert testimony, as well as state and federal government statistics. The model farm uses three depuration tanks and will operate at three times the capacity of the existing farm. It projects a sales volume of 156,000 shell stock oysters a year, assuming a 50% mortality rate.[3] This requires a planting of 312,000 individual seed oysters, known collectively as spat, a year. Spat is planted in cohorts on a staggered schedule. This produces more even temporal distribution of harvest, sales, and labor hours. The model will operate for 10 years on the island of O'ahu, where the existing farm is currently located. As a small-scale farm, it will be run by an owner-operator who actively participates in aquaculture activities, and therefore receives an hourly wage in addition to profits.

2.2. Financial calculations

An enterprise budget (Tables 1 and 2) was specifically designed for a small-scale oyster producer, defined as 50,000–250,000 market size oysters sold per year (Hudson et al., 2012a,b). Annual pre-tax return was calculated by taking the difference between income from oyster sales and cost. It is important to note that the study is a pre-tax analysis. Annualized costs (using a straight-line depreciation scheme) on normally depreciable items, therefore, were used in lieu of depreciation schedules (MACRS) allowed by the Internal Revenue Service (IRS) of the United States. A cash flow was constructed for years zero through ten of operation. Annual net cash flows (cash inflows – cash outflows) were used to calculate modified internal rate of return (MIRR) at a 6% reinvestment rate and a 6% finance rate.[4] Internal rate of return (IRR) was also calculated for comparative purposes, though MIRR is the focus of analysis in this study.[5] Net present value (NPV) was also determined with a 6% discount rate. All monetary values are in USD ($).

A sensitivity analysis was conducted in order to calculate MIRR as a function of percent changes in parameter values. We chose to address seven specific parameters based on the high potential for impacting the economic outcome of the farm. Wage,[6] electricity, and water rates were examined because high costs of labor and energy have been, historically, impediments to the development of the aquaculture industry (Naomasa et al., 2013). We also chose to address the inputs representing high percentage costs of the budget, i.e. oyster seed and rent. Finally, we examined mortality rate and market price because these variables directly affect harvest quantity and income earned, respectively.

2.3. Stochastic model of a small-scale oyster farm

Stochastic modeling was used to address possible outcomes of the operation. Specifically, we used Monte Carlo simulation available through Risk Solver Version 9.6.3.0 (Frontline Systems Inc., Incline Village, Nevada, USA) analytical software to project a range of net present values for the 10-year operation. Three separate simulations were run under the premise that mortality rate and market price are random variables. The first included mortality as a triangularly distributed variable having a minimum value of 30% and a

[1] Cultchless oysters are individuals unattached to hard substrate, in contrast to reef oysters, for example. These are typically intended for half shell consumption.

[2] The currently operating farm is owned by a well-known agri-tourism business; this is atypical of the majority of Hawaiian fishponds. The farm's circumstances represent a unique case, and therefore our study uses a model case that better reflects more general conditions. Scaling up the model to three times the output capacity of the current farm is advantageous for the following reasons: (1) costs are based on real estimates, yet proprietary financial information related to the specific operating structure of the farm is protected, and (2) new farms are expected to operate at a similar capacity.

[3] Mortality in this study is equivalent to total production loss. This includes not only naturally occurring death, but oysters that have been culled, and those infected beyond salability with *Polydora* spp.

[4] The State of Hawai'i provides a 6% interest rate on farm operating loans for new farmers (State of Hawai'i Agricultural Loan Division n.d.) A 6% reinvestment rate was used recently in a similar economic feasibility study on aquaponics operations in Hawai'i (Tokunaga et al., 2015).

[5] MIRR, or modified internal rate of return, is used in lieu of traditional IRR methods. Sullivan et al. (2006) discuss the weaknesses of the latter. MIRR, unlike IRR, is advantageous in several regards by: 1) allowing the user to define the reinvestment rate, 2) avoiding guesswork, and is therefore easier to solve for in a direct manner, and 3) avoiding the potential of generating multiple IRR values.

[6] The study examines the part-time wage rate, as the owner-operator's full-time pay is not likely to change. Other cases may utilize non-owner, full-time employees as well as part-time employees, and thus may choose to address these rates accordingly.