Black Sea Bass in a Recirculating Aquaculture System (RAS): Sensitivity Analyses of Farm Input Costs and Genetically Induced Growth Increases and Alteration of Protein Sources in Aquafeeds

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Background

Black sea bass (*Centropristis striata*), (Figure 1) occupy shelf waters of the eastern US and are highly sought by commercial and sport fishermen. Genetic selection combined with more sustainable aquafeeds containing terrestrial protein sources such as cottonseed meal or soybean meal as main protein sources have great potential for improving growth performance and feed efficiency of black sea bass to reduce production costs and improve the profitability of Recirculating Aquaculture System (RAS) (Figure 2) facilities (Watanabe et al. 2021, 2015, Alam et al. 2018). The overall goal of this study is to decrease barriers to black sea bass production by conducting a detailed economic analysis of a land-based recirculating aquaculture system for production of black sea bass to help identify the critical biological constraints to production in the south-eastern US. A spreadsheet economic model will be developed to explore the profitability of different production scenarios via sensitivity analysis.

▲ **Fig 1.** Black sea bass *Centropristis striata*

Fig 2. UNCW-Pilot-Scale RAS ▶

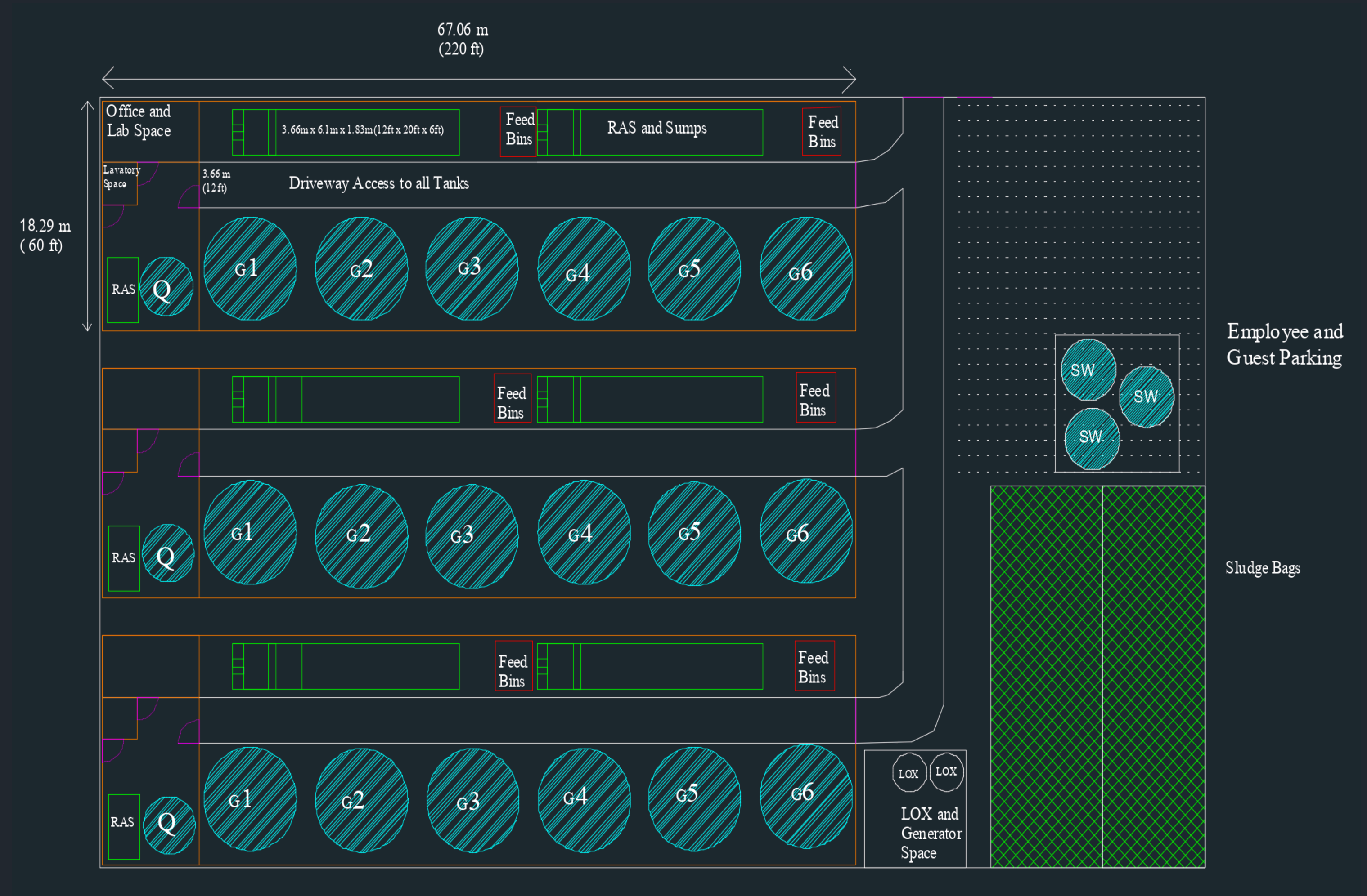

Fig 3. Base aquaculture three building facility equipped with 15 ft quarantine tanks (Q) and growout tanks (G1-G6). Each building includes laboratory and lavatory space. Mechanical and biological filtration are indicated in green.

Table 1. Commercial base case cumulative net present value (CNPV), Modified Internal Rate of Return (MIRR), Discounted Payback Period (DPP), and breakeven price (BE) for base case generation (F0) and two generations of selective breeding (F1 and F2).

Generation	15-year CNPV-$	MIRR - %	DPP (Years)	BE - $/lb
F0	$423.141.95	7.56	12	$8.236
F1	$2,253,800.08	11.66	7	$7.376
F2	$3,053,031.52	12.86	6	$7.048

Methods

Data for mortality rates at all culturing stages, feed costs, feed formulations, stocking densities dependent on size and age, biological and engineering parameters as well as all operational costs, was acquired the University of North Carolina Wilmington (UNCW) Center for Marine Science Aquaculture Facility (Wrightsville Beach, NC). Based on these parameters, a theoretical facility containing three buildings of six growout tanks and one quarantine tank was designed using AutoCAD (Figure 3).

Economic Modeling and Sensitivity Analysis

- A spreadsheet economic model was developed to explore the profitability of different production scenarios via sensitivity analysis. Alternative models were generated by implementing a **12.5%** increase in growth per generation during a 15-year time period over two generations.
- Financial performance under the various growth models was assessed by 15-year cumulative net present value (NPV), modified internal rate of return (MIRR), discounted payback period (DPP), and breakeven price (BE).
- Base case feed costs of $1.08/ lb (Europa feed line) were obtained from Skretting feeds. A UNCW formulated diet (Alam et. Al. 2018) containing only 10% fish meal was implemented in scenarios for alternative feeds, priced at $0.74/ lb (Zeigler Feeds, 2022).

Results

In comparison, with selective breeding the benchmark of 75% of the cohort at premium marketable size or larger is reached at 23.9 months for F0 and at 22.8 mos for the F1 generation and finally 21.7 mos for the F2 generation, at BE prices of $8.228, $7.376 and $7.084, respectively (Table 1). The greatest variation in the cumulative net present value of the facility was seen when loan rates and feed costs were altered to reflect changes in market value. When F2 generations were fed the UNCW formulated plant based aquafeed, break-even price drops to $6.842. The results of this study show that black sea bass can be grown using RAS methods at commercial scale and at competitive prices. Furthermore, implementing genetic selection for improved growth concurrently with plant-based aquafeeds has the potential to drastically improve the economic performance of a black sea bass RAS facility.

Future Work

Other aspects of design that could be considered, include the addition of purge tanks. Due to the high density of commercialized aquaculture, many fish species have "off" or "muddy" flavors which could reduce interest from buyers. A facility's ability to purge off flavors from fish cohorts before they are taken to market, could also allow higher stocking densities to be applied. For this study stocking density was capped at 60 kg/m^3, which is considered a conservative stocking density for black sea bass. A recent study (Watanabe et al. (UNCW, unpublished data, 2022) held black sea bass at 60 kg/m^3 without any decrease in growth rate, indicating that perhaps still higher stocking densities could be applied in future culture to further increase production. Site costs for black sea bass could also be lowered if RAS facilities were moved inland and managers utilized low salinity RAS. Alam et. al. (2020) found that black sea bass juveniles could be reared in pilot scale RAS at low salinity ranging from 10.1-12.3 g L^{-1} without no adverse effects on long term growth when compared to counterparts raised in 34 g L^{-1} RAS. Salt incorporated diets of up to 7.5% improved survival of these fish when challenged with an extremely low salinity of 4 g/L^{-1}.

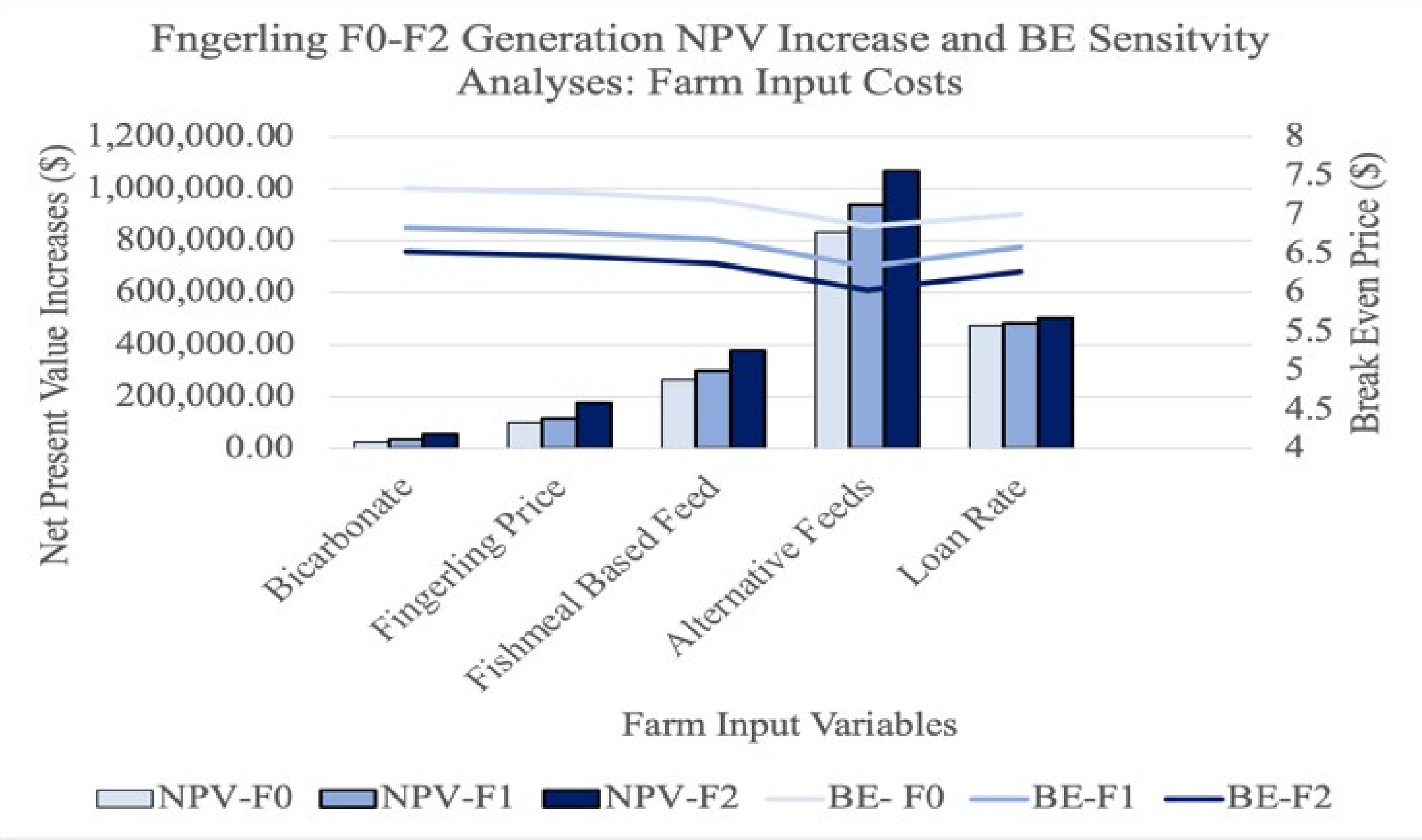

Figure 3. Each farm input cost was varied by 5 and 10 % above and below the base price while the loan rates were varied by 2, 4 and 6% above and 2% below the base loan rates. The net present value (left axis) and break-even cost (right axis) are shown for F0-F2 generations.

References

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