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Optimal production schedule in commercial shrimp culture

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Abstract

Using an extended version of the optimal scheduling model developed by [Yu, R., Leung, P.S., 2005. Optimal harvesting strategies for a multi-cycle and multi-pond shrimp operation: a practical network model. Math. Comput. Simulation. 68, 339-354.], this study attempts to demonstrate the impact on the optimal production schedule and its resulting economic performance of shrimp farming from variability in survival rate, growth rate, price seasonality and labor force constraints. The influence of these factors is described quantitatively within the context of a commercial shrimp farm operating in Hawaii. The managerial objective being expressed is to project a scheduling scenario that maximizes the net revenue from a 40 pond farm during a two year planning horizon, subject to a set of biological and economic conditions. These inherently practical results indicate that these factors can be managed to substantially improve the profitability of such a shrimp farm. It is apparent that continued development and application of this capability can have profound implications to the profitability of many multi-pond, multi-cycle farming operations.

Keywords: Optimal harvest; Shrimp culture; Scheduling

1. Introduction

A practical model for optimizing scheduling in commercial aquaculture has been demonstrated to be capable of improving the productivity (total production volume) of a commercial shrimp farm in Hawaii (Yu and Leung, 2005). However, the ultimate measure of economic viability of a commercial operation is its profit. Profitability is part from productivity, but it is also subjected to economic factors such as production costs and market price. The purpose of this study is to extend Yu and Leung's model to identify the most profitable, instead of highest productivity, production schedule of a multi-pond and multi-cycle commercial shrimp farm operating in Hawaii. The other major extension of their model has to do with the replacement of the constant growth chart with an artificial neural network growth model. This extended model is also used to elucidate the impact of major biological and economic factors (e.g., survival, growth, price seasonality and labor force constraints) on the production schedule that optimizes profitability based on possible scenarios expected by this farm.

2. Problem descriptions and methods

For a commercial shrimp operation which can produce shrimp year-round, harvesting and stocking

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decisions are not straight-forward. Clearly, a new crop cannot be stocked until the previous one has been harvested; but to maximize the overall returns from several production cycles, the manager has to balance the returns from retaining an existing crop with potential returns from a cycling new crop after harvesting the current one. Such decisions, although common for managers, involve several types of disparate information which are not easily/optimally processed. In addition, farm settings where multi production units have to be scheduled to smooth temporal production to satisfy the labor and market demand constraints, synchronization of harvesting decisions among production units also needs to be considered. Therefore, determination of the optimal harvest schedule to maximize the overall return for a multi-pond and multi-cycle setting is an extremely complex decision process. While many previous models have been built to tackle the optimal harvest problem in aquaculture (Paessun and Allison, 1984; Hannesson, 1986; Lillestol, 1986; Karp et al., 1986; Bjorndal, 1988; Leung and Shang, 1989; Shaftel and Wilson, 1990; Hochman et al., 1990; Arnason, 1992; Springborn et al., 1992; Watten, 1992; Summerfelt et al., 1993; Tian et al., 1993, 2000; Heaps, 1993, 1995; Hean, 1994; Forsberg, 1996, 1999; Spaargaren, 1999; Pascoe et al., 2002), the model by Yu and Leung (2005) is the only one to date that incorporates the multi-cycle and multi-pond nature typical of commercial shrimp farms operating on a year-round basis.

Because the structure and technical details of Yu and Leung's model have been detailed elsewhere, we here provide only a brief description of its principal components. The model takes into consideration of biological factors (e.g., size distribution at harvest, temperature and weight-dependent growth), economic factors (e.g., price, seasonality of price), and labor force and market demand constraints. The concept behind this model is a view of the production schedule of multi-pond and multi-cycle farming entity as a myriad of possible single pond and single cycle production schedules, each subject to the biological and economic constraints. Hence, the model incorporates every possible production scenario for a single production cycle for every growout pond during the whole planning duration. This is in fact the formidable challenge addressed by any farm production manager. Fig. 1 describes the structure of this scheduling decision model. The model is implemented on Microsoft Excel and utilizes an extended version of the Excel Solver to derive harvesting and restocking

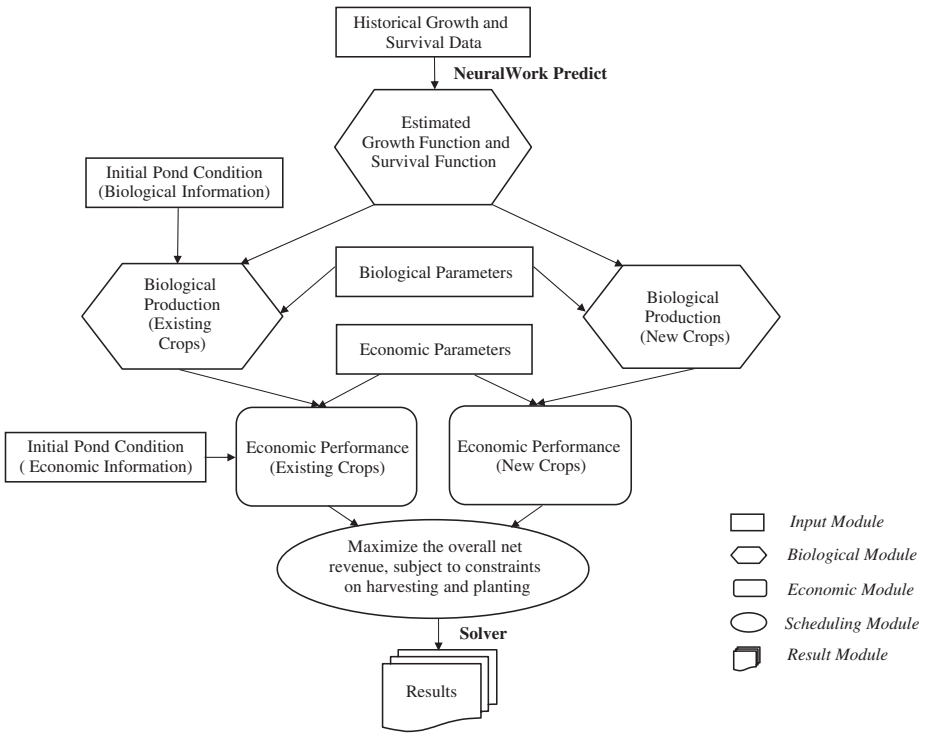

Fig. 1. The structure of optimal scheduling model (Yu and Leung, 2005).