Models for the assessment of sustainability and risk in shrimp aquaculture

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SHRIMP FARMING OBJECTIVES

MAXIMISING SHRIMP PRODUCTION

Shrimp production generally occurs in three stages: (1) hatchery, (2) nursery & (3) grow-out. Fertilised adult female shrimp produce eggs, which hatch into prawn larvae. The newly hatched larvae are usually kept in brackish water, needing protein rich feed such as zooplankton. The post-larvae are nursed for at least another 30 days, before the juveniles are ready to be stocked into ponds for grow-out to adult prawns.

Shrimp farmers face decisions regarding the production processes for farms. These decisions affect the natural mortality rate, profitability and sustainability of shrimp farms. The parameters of shrimp production include:

- Stocking density
- Age of seed at stocking
- Feeding or fertilisation rate
- Feed types
- Artificial substrates

OPTIMISING PROFIT IN SHRIMP FARMS

Stakeholders have a trade-off between short-term profitability and long-term sustainability. The implementation of best management practices (BMP's) can aid shrimp farmers to achieve profitability and facilitate the provision of mitigation strategies, such as aquaculture insurance. Shrimp farmers must determine resource requirements and the price of those resource requirements. Considerations such as land costs, yield/seed costs, aeration, staff costs, feed costs and disease control costs all influence the return on investment.

Levels of profitability are influenced by site selection and the equipment employed. Site selection is an important factor for shrimp farmers. Land costs can vary widely, as well as pond constructions. Sites can be newly constructed or adapted for shrimp farming purposes. Ponds built for shrimp production are easier to manage than typical farm ponds, and are in general terms easier to harvest and manage.

The appropriate equipment for shrimp farming also influences the profitability of shrimp farming. The equipment needed includes harvesting equipment, aerators, water pumps, artificial substrates, etc.

Harvesting and holding equipment typically includes baskets, tanks and feeding equipment. The variable costs faced by a farmer vary (e.g. according to geographical location) and will affect the profitability of a farm. These costs include the cost of seed, feed, legal permits, etc. The stocking cost depends on both the seed price and stocking density. The price of seed is dependent on juvenile age, as older juveniles have a higher survival rate.

ACCESS MARKETS

The level of profitability of a farm will also depend on the ability of shrimp farmers to sell their product.
The ability to target export markets is essential and is related to factors such as the quality of product, production costs, competition, transport issues and accessibility to distributors. Farms with a high level of concern for environmental issues, best management practices and traceability can achieve certification, increasing their chances of reaching export markets.

FACTORS OF CONCERN

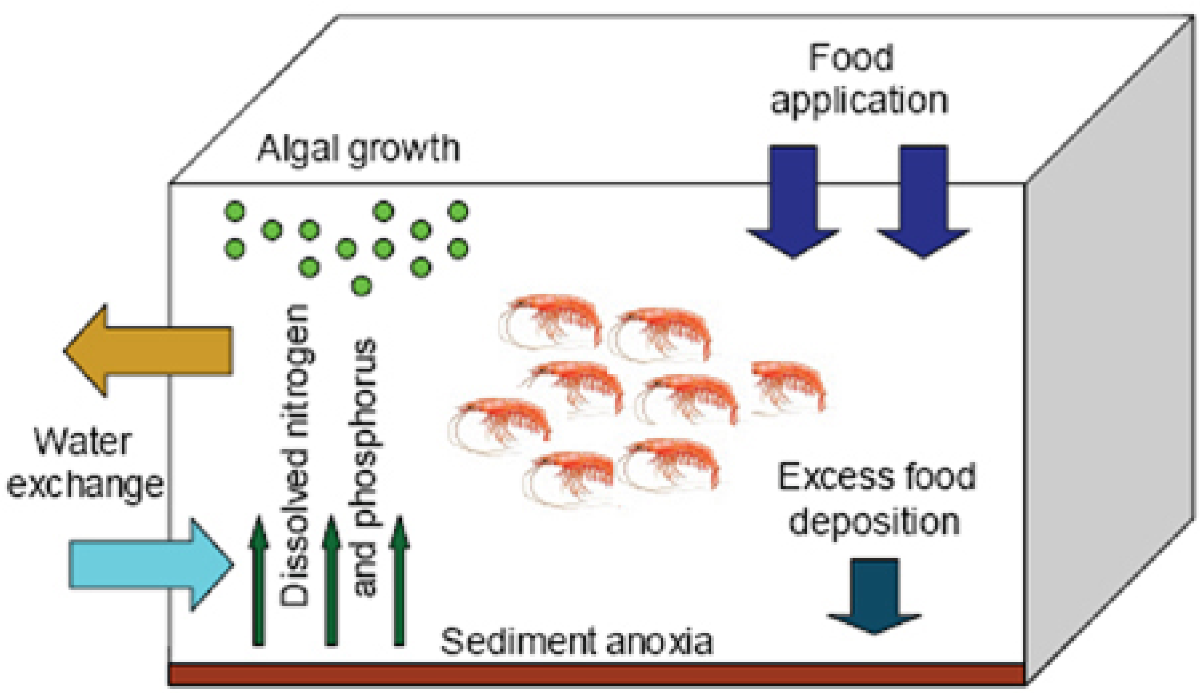
Objective	Issues	Factors
Production	Growth	Overstocking
		Feeding
	Mortality	Dissolved oxygen
		Disease
Profit	Costs	Seed
		Optimisation
Markets	Product quality	Seed
		Feed optimisation
Plant & Equipment	Physical damage	Storm, Floods

INSURANCE FACTORS FOR SHRIMP FARMS

Issue	Approach
Valuation of business	Simulate production using mathematical models.
Valuation of risk	Calculate eutrophication potential based on feeding stocking and physical (climate, water renewal, etc), predict dissolved oxygen and mortality risks.

SCIENCE

Shrimp ponds are (typically) enclosed cultivation systems, subject to periodic water renewal to compensate for volume changes (e.g. due to evaporation) and salinity changes (evaporation, precipitation), and to maintain water quality. In a similar way to agricultural systems on land, or to salmon or sea bass farms, food is typically applied in excess, to ensure maximal production. Consequently, unused organic material accumulates in the ponds, particularly in the benthic layer.

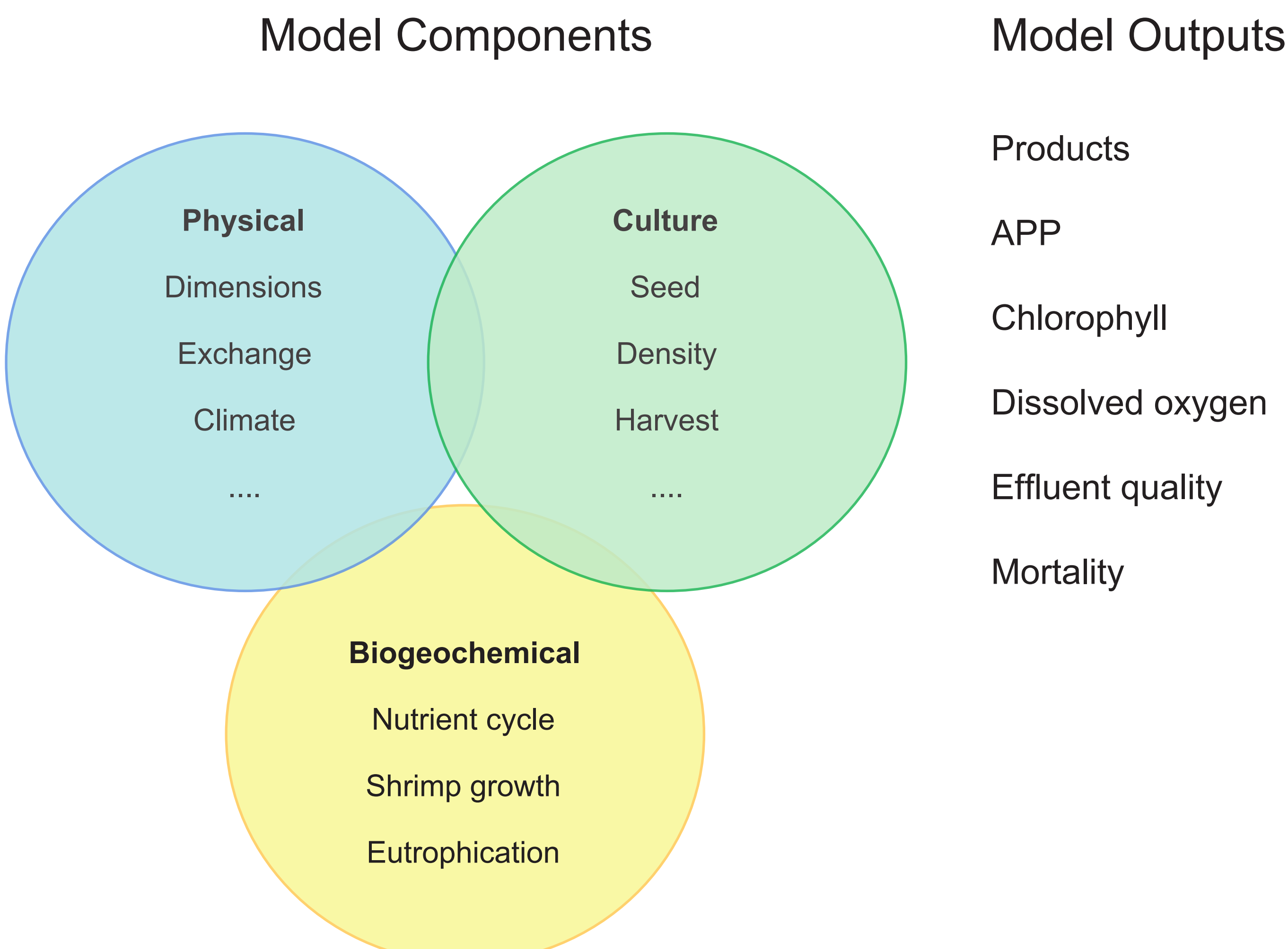


This may result in bacterial decomposition of organic matter in the sediment, and in the eutrophication of the surface layer, due to abnormal algal growth (eutrophication). Both processes result in oxygen depletion, potentially causing shrimp mortality. Additionally, the effluent from shrimp ponds is often a water quality hazard, due to the high organic loading.

These effects may be offset by the practice of Integrated Multi-trophic Aquaculture (IMTA), using e.g. detrital feeders such as tilapia or filter feeders such as oysters or razor clams. This approach of combined cultivation is common in Southeast Asia and elsewhere, and has the triple benefits of providing a second cash-crop, reducing shrimp mortality and improving water quality.

TECHNICAL MARKETS

The types of models developed by Longline Environment Ltd. focus on the production, and combine physical processes, cultivation practice and biogeochemical processes such as shrimp growth and eutrophication. These models take into account different weight classes, and provide outputs such as production and average physical product (APP).



Because growth is simulated based on the food supply, which determines the distribution of individuals into different weight classes, we are able to calculate the food loss, and simulate its effect both on water quality, through oxygen depletion and excessive algal growth, and on the profitability of the business, provided basic financial data are made available.

This type of model may be used as a risk assessment tool, and therefore is of value for actuarial purposes. In many ways it can be seen as a screening model for determining whether appropriate management practices are being applied. Like any model, the outputs are only as good as the input data used. The 'Model Components' diagram on page 6 illustrates the type of input data required. Typically, the results are validated by datasets of animal growth and water quality.

FURTHER INFORMATION

Due of the specificity of each site, a generic evaluation is challenging, and probably unsuited to the complexity of the problems at hand. Longline does not focus on the disease component, which is presently impossible to simulate for predictive purposes, but can contribute to assessment and valuation of risk with respect to other factors of production, such as growth rates and mortality due to low oxygen derived from eutrophication and other factors.

We can also assist in determining whether water quality standards in emission waters will be appropriate, thereby addressing other business risks such as non-compliance fines from regulatory authorities.

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