A Guide to the Land Based Aquaculture Economics Models

The economic models provide the user with an indication of the likely costs of establishing and running a land based fish or shellfish farming operation in New Zealand. They have been formulated to allow the user to change a number of variables, particularly those relating to the scale of production, growth rates and market value in order to get a feel for the sensitivity of the model to those variables. Manipulating the variables allows the user to estimate of scale of production and level of investment required to achieve economic sustainability.

In order for any farmed organism to perform efficiently in culture its biological needs must be met. These include meeting their thermal, feed and oxygen requirements as well as ensuring that their waste products (CO_2, ammonia and faecal matter) are removed from the system (Figure 1). The model uses the best available scientific data on the optimum environmental parameters for growth for each species to calculate both the infrastructure requirements (capital costs) and operational costs of farming stock from fingerlings to market size.

Each model calculates the biomass of stock within the system from sub-models that predict individual growth over time. Separate growth curves have been derived for each species covering a range of growth rates that may be achieved in culture depending on environmental conditions and size at harvest. Stocking numbers, stocking frequency, variation in individual growth rate, and mortality rates are combined with the growth curves and harvest protocols to calculate the biomass of stock within the system at any given point in the production cycle. Knowing the biomass of stock present in the system allows the model to calculate the infrastructure and operational inputs (water pumping, feed, staff levels etc.) required to meet the biological needs of the stock.

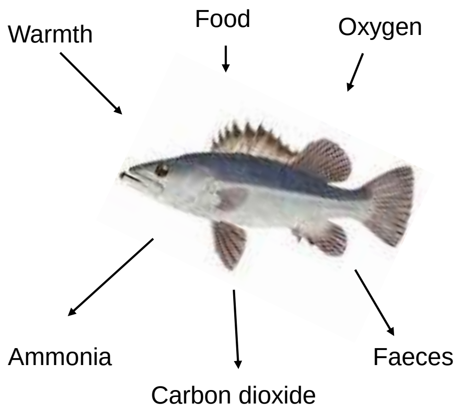


Figure 1. Key biological inputs and outputs from cultured organisms.

Each model has over 175 input variables that are used to calculate the costs involved in meeting the biological requirements of the stock. For ease of use, most of these have been fixed at values agreed by the model designers and industry reviewers as being a reasonable approximation of the real world values. However, variables such as growth rate, market size and survival, remain as inputs that the user can select to meet their individual situations. For many of these variables the values that can be selected have been limited to values that are within the expected ranges for each species.

Model outputs:

The model delivers four key outputs; an economic summary, and three simulations to illustrate the effects of changing scale, growth rate and price variables. The model provides these details in a highly simplified form to illustrate the likely costs associated with developing and operating a land based aquaculture system. For example the model does not calculate potential tax liabilities.

Economic Summary

The economic summary provides a cash flow forecast for 10, 25 and 30 years of production. It is divided into capital costs (buildings and equipment) and operational costs (feed, seed, staff, etc.). Additional capital costs are included after year 10 to allow for replacement of key infrastructure items in the medium to long term.

This summary also provides other useful information including:

Cost of Production (CoP): This represents the operational costs involved in producing one kilogram of product. For a business to remain in profit the sales costs must be higher than the expected cost of production. The model presents a total CoP and breaks the CoP down as a % of operational costs in Year 10 to illustrate the relative importance of each cost.

Investment: This represents the investment or equity required from an investor to establish the farm. In many cases this will include not only capital costs but also operational costs for the first few years of the business.

Finance: The level of investment shown only accounts for equity required and does not include bank debt incurred to meet capital or operational costs. The bank debt is shown, along with the interest payable on that debt. Debt repayments occur within the model once annual cash flows become positive. The ratio of debt to equity can be set within the model assumptions.

Internal Rate of Return (IRR): IRR is equivalent to the discount rate used in capital budgeting that would make the net present value of all cash flows from a particular project equal to zero. Generally speaking, the higher a project's internal rate of return, the more desirable it is to undertake the project. Within the model the IRR is calculated at 10, 25 and 30 years. .

Net Present Value (NPV): NPV is a method of calculating the expected net monetary gain or loss from a project by discounting all expected future cash inflows and outflows to the present point in time. In effect the analysis compares the value of a dollar today to the value of that same dollar in the future, taking inflation and returns into account. If the NPV of a prospective project is positive, it should be accepted. However, if NPV is negative, the project should probably be rejected because cash flows will also be negative. To establish the NPV the model estimates the net income generated by the farm over a 10, 25 and 30 year operational periods period and discounts that income each year by the NPV rate. The sum of the discounted cash flows gives the NPV for those years.

Scale Simulator

The scale simulator allows the user to test the effects of increasing farm scale at a predicted growth rate. It provides key output data, including investment required and CoP over a pre-determined range of farm scales.

Growth Rate Simulator

The growth rate simulator allows the user to test the effects of improving growth rate at a given farm scale. It provides key output data, including investment required and CoP over a pre-determined range of growth rates.

Sales Price Simulator

Sales price for the product can have a significant effect on profitability of a farming operation. There is often a tendency to over-estimate potential sales price or to fail to recognise that sales price may fall. A Sales Price Simulator has therefore been included to allow the sensitivity of sales price to be tested for a given set of production parameters.

Farm Design

The model is based on two simple designs for a fish farm or a paua farm that are illustrated below. The designs are intended to provide the user with an indication of the scale and layout of systems required to meet the nominated production output, rather than provide a detailed system design.

Fish farm

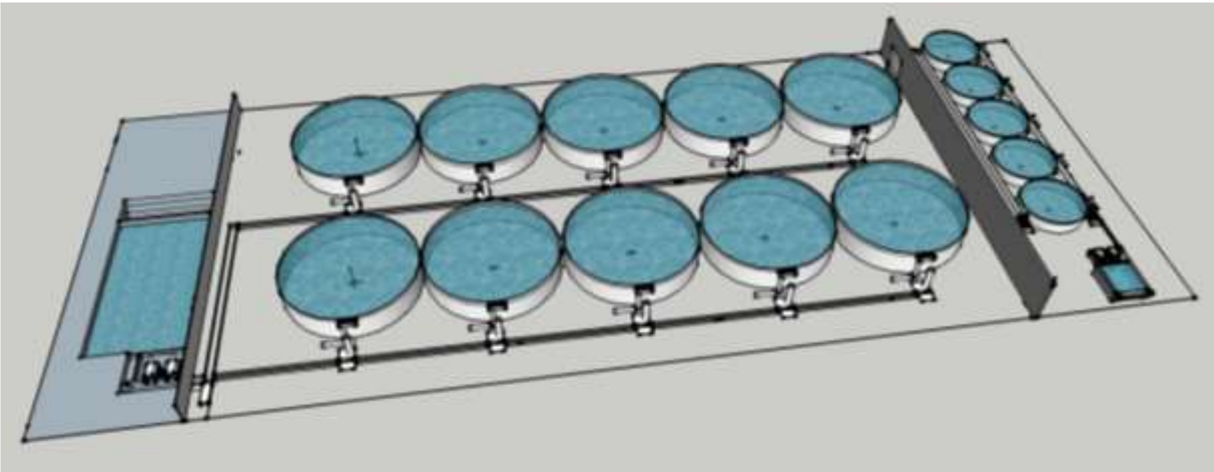
The fish farm design example shows a 500 t production unit consisting of 2 separate culture systems. The illustrated farm occupies an area of approximately 150 m x 65 m:

The reception/juvenile growing system consists of 1 unit of 5 x 10 m diameter x 2m deep circular tanks. This system will hold juvenile fish until they reach approximately 250 g. The juvenile system is supported by its own recirculation and reticulation system that effectively quarantines juvenile fish from fish in the on-growing system.

The on-growing system, used to grow fish from 250 g to 3.5 kg consists of 10 x 20m diameter x 3m deep circular tanks. This system is supported by a second water treatment system that includes; ozone treatment, drum filters and a biofilter. The water treatment system removes waste products and re-oxygenates the water before it is returned to the on-growing tanks.

Stock management within commercial farms is critical if biomass within the farm is to be optimised. For maximum efficiency farms should be stocked with juveniles on a monthly basis to enable a continuous and smooth supply of finished product. However, for some species, such as eels that have a seasonal recruitment, this may not be possible. The model allows for variable input of juveniles and shows a reduction in production efficiency under a seasonal stock input scenario. The model also assumes that harvests from the system occur on a continuous basis as stock reach a marketable size. The model accumulates harvested biomass on a monthly basis based on the proportion of fish expected to reach marketable size over that period. The systems operational requirements for the following month are the calculated assuming the harvested biomass is removed. The model does not allow for variable harvest rates. Failure to harvest stock regularly would cause a significant increase in system biomass that could compromise system operation and reduce production efficiency.

The optimum growth parameters for each species (temperature, pH and O_2 levels) have been identified as far as possible. The model includes algorithms to adjust production costs based on water quality requirements for each species.



500t Finfish unit

Paua Farm

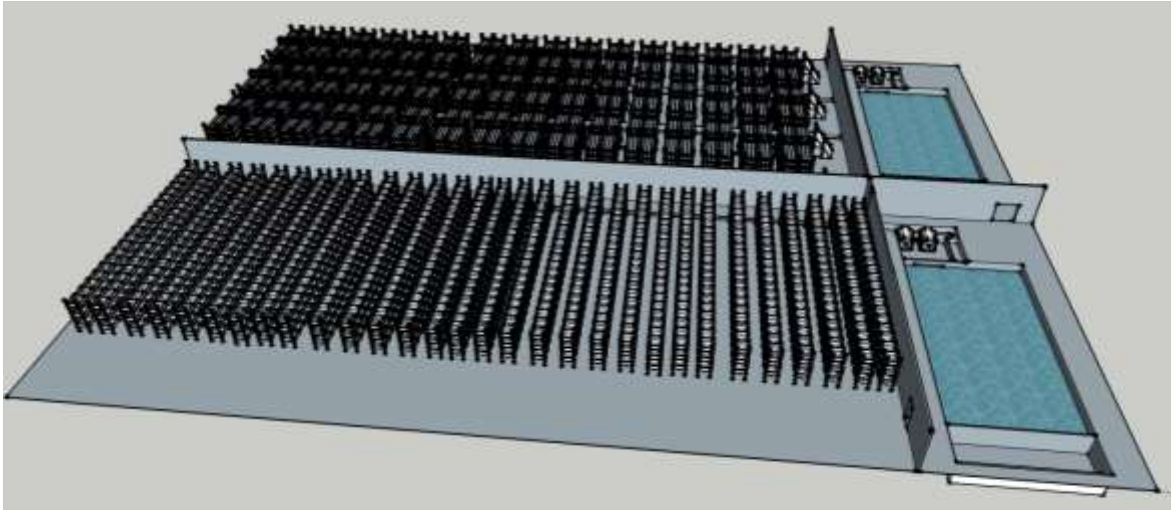
The paua farm example shows a 100 t production unit based on 2 tipper tray systems. The unit covers an area of approximately 70 m x 50 m.

The small tippers tanks are approximately 1 m x 1 m and are stacked 3 tanks high. The water enters each tank via a tipping bucket system to create a wave action. The wave action both provides water movement over the paua's gills and removes solid waste from the tank. The unit contains 2,000 of these tanks. The tipper tanks are used to grow juvenile paua from 10 mm to 40 mm in size.

The larger tipper trays are 1.2 m x 3 m and are stacked 6 trays high. Walkways are used to access the upper 3 layers of trays. These trays are also supplied by tipping bucket systems and on-grow paua from 40 mm to 80 mm.

Each system is supported by its own water treatment plant consisting of ozone treatment, drum filters and a biofilter. These systems clean and recirculate the water to the trays and tanks.

The model assumes that farm operation is optimised by using continuous harvesting and monthly stocking protocols, as outlined for the fish production model above.



100 t paua unit.