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Economics of Ocean Culture of Giant Clams: Internal Rate of Return Analysis for *Tridacna gigas*

ABSTRACT

Estimates the internal rate of return on costs of investment in a ‘standard’ giant clam farm involved in the ocean phase of giant clam mariculture as a function of the period of ocean growout of *Tridacna gigas* using Australian data obtained from trials at Orpheus Island Marine Research Station. The standard ocean 'farm is assumed each year to place 100,000 seed clams of approximately one year of age. The optimal length of time to hold them is estimated to be 10 years when they are sold for their meat at $5 per kg at the farm gate. This yields an estimated internal rate of return of 19.5% and maximises the net present value or capitalised value of the farm. The method used to estimate the optimal rotation or harvest cycle for giant clams is similar to that used in the forestry economics literature for determining forest rotation cycles.

Keywords: Tridacna gigas, giant clam farming, CBA,

JEL Codes: Q57, Q21, Q22

Economics of Ocean Culture of Giant Clams: Internal Rate of Return Analysis for *Tridacna gigas*

1. Introduction

The potential economic viability of farming giant clams (*Tridacna gigas*) in Australia has been demonstrated by Tisdell et al. (1991). They showed that a farm, acquiring 100,000 seed clams per year, can expect a real rate of return on funds used in excess of 10%; this holds even at a gate-price for clam meat as low as $3 per kg. The optimal harvesting age (from an economic point of view) was found to be 11 years of age, at an interest rate of 10% or 14 years of age at an interest rate of 5%.

Tisdell et al. (1991) noted that the harvesting model adopted did not fully account for interdependencies between periods and the results obtained were therefore an approximation to the economic profitability of growing giant clams (*T. gigas*).

The analysis was also limited to one set of clams and some arbitrary allocation of joint capital costs and operating costs had to be made.

When the objective of the farm is the maximisation of its discounted present value (Hicks, 1946), the stream of all expected costs and benefits has to be considered. This approach eliminates the need of the above mentioned arbitrary allocation of joint expenditures. It also allows one to determine the overall expected benefits from an investment project, expanding the previous analysis of Tisdell et al. (1991) which was limited to one set of clams only.

The maximum internal rate of return for a farm growing giant clams (*T. gigas*) is calculated using the extended method and found to be 19.5%. This occurs when the farm adopts a 10-year harvesting cycle.

2. The Hypothetical Farm

The hypothetical farm considered here is supposed to acquire 100,000 seed clams per year. In the first year the clams are kept in lines and moved to exclosures in the second year; in the third year the clams are ready to be transferred to the open ocean (Crawford et al., 1988).

For a farm operating according to the above method, long term capital costs, short-term capital costs and operating costs can be identified (see Table 1). Long term capital costs include worker accommodation, a tractor and a utility truck. As it is assumed that the depreciation rate for the tractor and the utility truck is 10% they have to be replaced in year 11 of operation. Short-term capital costs comprise ‘lines’ and ‘exclosures’ (Barker et al. 1988). Lines have to be replaced every three years and exclosures every second year. Operating costs include miscellaneous expenditures, wages (one worker is assumed to be sufficient to run the operation) and the expenses to purchase 100,000 seed clams per year (@ 75 cents per clam) (Tisdell et al., 1990; 1991).

Year	Capital Costs					Operating Costs	Total
	Long Term			Short Term			
	Worker House	Tractor	Utility Truck	Lines	Exclosures		
1.	80,000	20,000	15,000	15,000	-	115,000	245,000
2.			-	-	27,000	115,000	142,000
3.				15,000	-	115,000	130,000
4.				-	27,000	115,000	142,000
5.				-	-	115,000	115,000
6.				15,000	27,000	115,000	157,000
7.				-	-	115,000	115,000
8.				-	27,000	115,000	142,000
9.				15,000	-	115,000	130,000
10.				-	27,000	115,000	142,000
11.		20,000	15,000	-	-	115,000	150,000
12.				15,000	27,000	115,000	157,000

Annual Operating Costs

Miscellaneous Expenditures (eg. fuel and vehicles maintenance)	10,000
Wages (one worker)	30,000
Seed clams (100,000 x 75c)	75,000
TOTAL	115,000

3. Some Considerations on the Economic Analysis of Culture of Giant Clams

Given that clam mariculture is at an early stage, several assumptions have to be made in order to assess its economic viability. Tisdell et al. (1991) assumed that the output (about 180t/year) of a farm that acquires 100,000 seed clams a year would be absorbed by the market and this is a reasonable assumption given the findings of marketing studies undertaken (e.g. Tisdell and Wittenberg, 1990a; 1990b). Tisdell et al. (1991) noted that determining the optimal harvesting age of one set of clam (the first batch in this case) and its expected present value in the simple framework used has some drawbacks. One is the need to allocate (arbitrarily) capital and operating costs (jointly used for several sets of clams) to one batch of clams. The first set of clams has the ‘burden’ of being allocated the total operating costs for the first year; in subsequent years the joint operating costs are allocated according to the number of batches held. This initial burden for the first set of clams is compensated by the fact that future sets of clams will have the burden of capital costs compounded by interest; for example, the set of clams acquired in year 10 of operation will be allocated one-tenth of the purchasing cost of the tractor (it has a life of 10 years) plus compounded interest.

In order to further assess the economic viability of a clam farm, the net present value of each set of clams could be assessed but this would not eliminate the arbitrary allocation of joint costs.

Hicks (1946) notes that the objective of a firm is to maximise its present value or net capitalised value; this is equivalent to profit maximisation. In order to ascertain the net capitalised value, the stream over time of all expected costs and benefits has to be taken into account. The arbitrary allocation of joint costs is avoided.

The net present value (NPV) of an investment project is given by:

$$\text{NPV} = \sum_{t=0}^{n} \frac{(B_t - C_t)}{(1+r)^t} \quad (1)$$

where

B_t = benefits at time t

C_t = costs at time t

r = discount rate

A closely related measure to the NPV is the internal rate of return (IRR).

The IRR of return is the discount rate r that makes NPV equal to zero:

$$\text{NPV} = \sum_{t=0}^{n} \frac{(B_t - C_t)}{(1+r)^t} = 0 \quad (2)$$

In other words, the discounted benefits and discounted costs are equated. The IRR indicates the maximum return that can be earned from an investment that breaks even.

The maximisation of the IRR determines the economically optimal length of the rotation cycle for the farm. The economically optimal length of the rotation cycle is shorter than the biologically optimal cycle (Cf. Hartwick and Olewiler, 1986; Ch. 11; Bowes and Krutilla, 1985). The existence of positive interest rates determines an opportunity cost in holding clams.

Notice that in determining the optimal length of the rotation cycle, it is necessary not only to take account of reinvestment opportunities or returns available in the market (as indicated by the rate of interest) but also the returns available from reinvestment in the farming of clams (Cf. Mishan, 1971, Ch. 28). It will not, as a rule, pay to hold a batch until the marginal increase in its net value equals the rate of interest, if one can harvest a batch earlier and take advantage of the rapid growth in weight of clams in the earlier part of their life-cycle to earn a higher rate of return than the prevailing rate of interest. This seems to be the situation potentially in relation to the ocean culture of giant clams.

In Figure 1 a hypothetical possible relationship between the number of years clams are held in their ocean phase (equals the number of batches of various ages in place) is shown. In the case shown, the maximum internal rate of return is shown as OA and this suggests that the optimal policy is to establish a rotation cycle of x_1 years. If the rate of interest is less than OA and net present value is maximised without account being taken of the possibility for returns of reinvestment in clam farming, the computed rotation cycle will exceed x_1. But it will be too long in comparison to what is most economic (Cf. Tisdell, 1991 forthcoming), Observe that if the rate of interest exceeds OA, clam farming would be uneconomic - it would be better to invest any available funds at the going rate of interest.

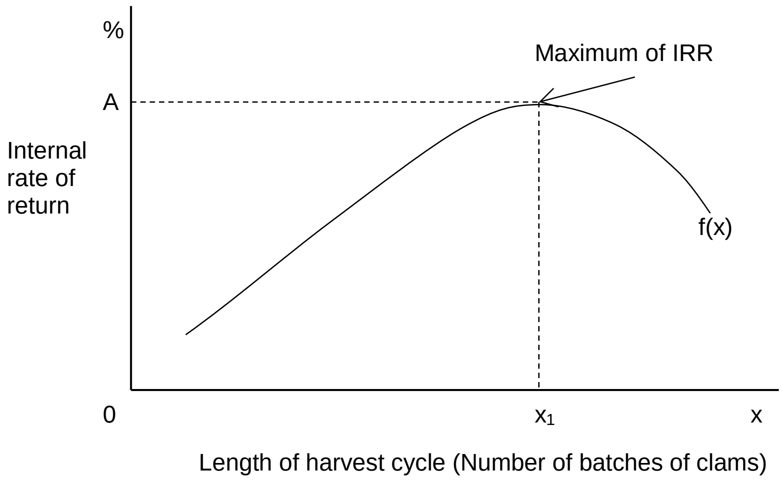

Figure 1: Internal rate of return as a function of the length of the harvest cycle – theoretical relationship.

Note that both maximisation of the internal rate of return, taking account fully of reinvestment opportunities, and net present value maximisation, not taking reinvestment opportunities in clam farming into account, will result in cycles of shorter length in comparison to their two biological counterparts. These biological counterparts are (a) the length of cycles required to maximise biological output (meat mass) on average per unit of time taking into account replacement cycles, and (b) that length needed to maximise biological mass (meat weight in this case) taking a single cycle in isolation into account.

The latter two concepts are illustrated in Figure 2. The function $h(x)$ shows biological mass (meat mass) as a function of time - number of batches put down. In this case the production function may only reach a maximum when constrained by the available space. Space may constrain the farm to x_3 batches for example and maximum production would then be achieved by using all the space and putting down x_3 batches. But in the case shown this will not maximise production per unit of time. This will occur for a cycle of length x_0 which corresponds to the maximum of the average function which has been dotted in.

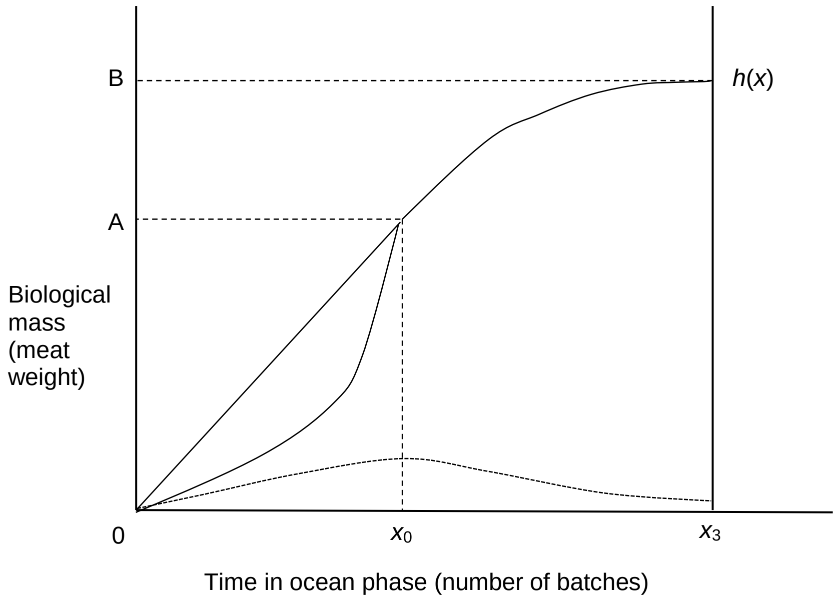

Figure 2: Time in ocean phase needed to result in two types of maxima for biological mass (meat weight in this case)

The maximisation process of the IRR is shown in Fig. 1; the maximum IRR occurs for x_1 number of batches of clams and is equal to OA. Given that one set of clams is put down every year, this is also the optimal length of the rotation cycle (x years). The 'hypothetical' farm examined here (See Figure 3) maximises its present discounted value by holding ten sets of clams of ages for each batch ranging from 1 to 11 years, or in other words, by holding each batch of clams for 10 years (clams are 11 years old when sold)(Table 2).

As there is not a direct way of determining r from equation (2), the IRR has to be determined in a recursive way by trial and error. In the present case to determine the maximum IRR for the project, the recursive procedure was repeated for several different years.

It was assumed that the value of the farm is given by the market value of the stock of clams held at the end of the year considered (e.g. 10) plus the value of all the assets that have a realisable market value, i.e. worker accommodation, tractor and utility truck. The market value of the clams was calculated using a gate-price for clam meat of $5/kg. Eventual sales of shells and clams as species for aquaria were not considered.

Also the price of meat is assumed insensitive to the age of clams (i.e. young clams are not harvested for the sushi and sashimi market but it could be a market in practice). The biological data (e.g. mortality rates and growth rates) are those reported in Tisdell et al.

(1991). The market value of the assets is assumed to be the purchasing cost less depreciation. Depreciation factors used are:

house	2.5%
tractor	10%
utility truck	10%

It should be noted that when discounting, it is assumed that expenditures occur at the beginning of the year. This implies that costs for year one are not discounted; costs in year two are discounted by a time factor of one. Benefits are instead assumed to accrue at the end of the year, therefore, in year 10, the time factor is 10.

The maximum .IRR accrues in year 10 when IRR is 19.5% (Table 2 and Figure 3). For the investor who wants to maximise returns to investment it would therefore be optimal to hold the clams for 10 years in the ocean phase.

Table 2: Internal rate of return and expected benefits

Year	IRR (%)	Cost* ($)	Net Profit (p.a. equivalent)
5	9.00	676,676	60,901
6	13.60	711,161	96,718
7	16.80	726,806	122,103
8	18.40	751,219	138,224
9	19.35	765,837	148,189
10	19.50	796,404	155,298
11	19.45	820,465	159,580
12	19.15	849,891	162,754

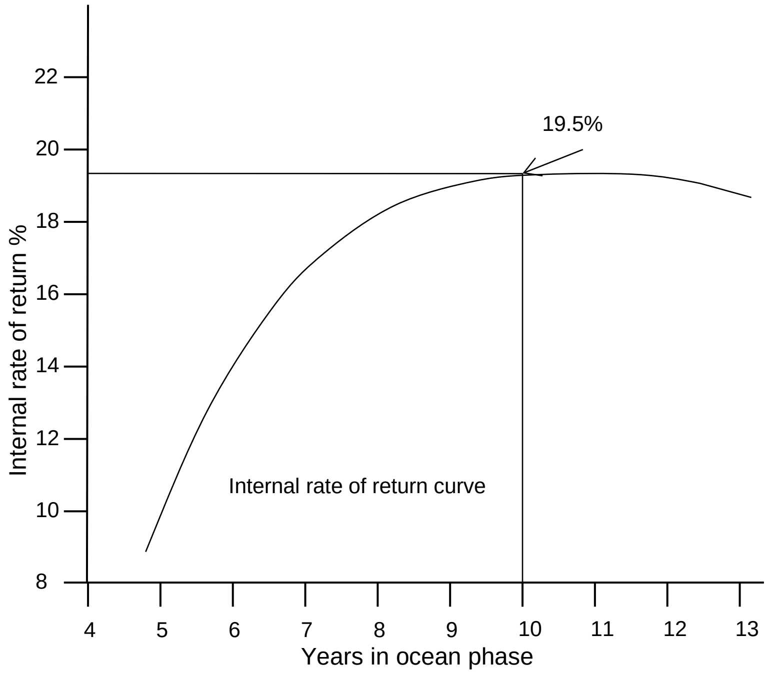

Figure 3: Internal rate of return from ocean farming (meat sold at $5/kg)

From Figure 3, it can be seen that the IRR curve is steep in the first few years (years 5 to 8). This reflects the fact that the growth rate of the clams (and therefore the value) is higher in the early stage of their life and then tapers off.

4. Conclusion

Giant clam farming appears to have economic potential in Australia. The present analysis has shown that a giant clam farm, facing the environmental and economic conditions assumed in the paper, could expect to reap a maximum return on capital investment of about 19.5%. At a prevalent market real rate of interest of 10%, this amounts to a substantial 9.5% profit above normal.

Some caution should however be taken in using this result. In fact, the present analysis does not take into account the risk of adverse weather conditions (e.g. cyclones) or potential diseases that could affect farm output.

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