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# Breakeven Analysis of Red Sea Bream Fingerling Production in Kagoshima, Japan

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## Abstract

Operating and facilities costs for fingerling production were provided by the Kagoshima Pre-fecture Marine Ranching Association and the Kagoshima Prefecture Mariculture Center.

Fifty cases were examined, assuming with and without depreciation in annual cost compu-tation. These cases were subjected to varying degrees of capital (opportunity cost) ranging from 0% to 8% of the present value of capital investment and to varying degrees of subsidy (0-100% of annual cost) to determine the corresponding effects on the breakeven price and production.

The breakeven point depended mainly on the amount of capital and subsidy invested in the fingerling production activity. Allowing depreciation, the breakeven price and production varied from 0 to ¥74/piece and 0 to 24 million fingerlings, respectively, while those without depreciation were 0 to ¥63/piece and 0 to 20 million, respectively. Even without allowing depreciation, the subsidy rate should be at least 25%.

# Introduction

The red sea bream (*Pagrus major*) is widely dispersed along the coasts of western Japan and is considered a prime fish because of its high demand and market value, which have resulted in the depletion of the resource. The government has encouraged the sea ranching of red sea bream as well as other primary species.

Red sea bream landings in 1988 amounted to 58,147 t of which 45,152 t or 78% were cultured. Landings of wild sea bream have been declining over the years while those of cultured bream have been increasing rapidly since their culture began in the late 1960s. Since 1980, landings of cultured red sea bream have exceeded those of wild caught sea bream (Matsuda 1992a).

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Coastal sea ranching activities in Japan have been initiated by the national government through the establishment of the Seto Inland Marine Ranching Centers. Red sea bream ranching in Japan started in Kanagawa Prefecture in 1962 and was followed by ventures in other prefectures (Matsuda 1992b). The predicted ratio of released red sea bream in the catches in the Seto Inland Sea is calculated at 8-15%, while the observed value in commercial catch is 5-10%. The gap between the two values suggests that the survival rate of fry up to the time of first capture is about 67% and the gap is due to the inferior quality of fry as well as capture of the fingerlings by fishers, for sale to culturists (Suda 1991).

At present, red sea bream ranching in Japan is in an experimental stage where the government is gradually transferring the responsibility to the private sector such as marine ranching associations and fisheries cooperative associations (FCAs).

In Kagoshima Prefecture, red sea bream ranching began in 1974 as a national government-subsidized project composed of two separate activities: fingerling production and fingerling release. The former consists of spawning red sea bream broodstock in tanks and growing the larvae to a size of about 3 cm. Only the fingerling production will be discussed in this paper.

Red sea bream fingerling production is done by the Kagoshima Prefecture Marine Ranching Association (KPMRA) using facilities of the Kagoshima Prefecture Mariculture Center (KPMC) for free. The KPMRA is a body designated by the prefecture, city/town, federation of fisheries cooperative associations, fisheries cooperative associations and private organizations to take charge of the administrative, technical and financial aspects of all sea ranching activities in Kagoshima. A revolving fund contributed by these organizations was time-deposited in a bank, using the interest to finance all sea ranching activities in the prefecture. The KPMRA is required to produce 2.5 million fingerlings per year for sea ranching. Any excess are sold to mariculturists. Price per fingerling differs due to government policy: ¥12/piece [¥140=US$1 in 1990] for sea ranching, a government-subsidized price, and ¥32/piece for mariculture (KPMRA 1991).

The goal of this paper is to determine the breakeven production and price of red sea bream fingerling production in Kagoshima.

The breakeven point (BEP) technique is generally used in the analysis of business performance. If the projected production volume or selling price per unit is higher than the BEP, the project is expected to gain. This situation also meets all qualifications for cost effectiveness and cost-benefit analyses commonly used by public investment decisionmakers.

The breakeven chart is a useful tool in portraying and understanding the effects of variations in fixed and variable costs on the profitability of an economic activity. Thus, it may be used to portray the effects of proposed changes in the operational policy.

The breakeven point may be determined using formula or a chart indicating the graphs of fixed cost, variable costs and total revenue as done in the study.

The accuracy of the breakeven chart depends on identifying all the cost components. Cost is defined as the total payment made by an enterprise, such as capital, land and labor including management expended in any economic activity. These are made in the form of interest, rent, wages and other direct or indirect payments. The total cost of an enterprise is frequently divided into variable and fixed costs.

Variable costs vary as the total volume of production increases or decreases like the cost of raw materials and labor (Muro 1989). Fixed costs remain constant regardless of the level of output; for example the purchase price or rent on a machine is the same regardless of production (Anderson 1986).

## Methodology

Data on revenue and operating and facilities costs of red sea bream fingerling production were provided by the KPMRA and KPMC, respectively.

The breakeven analysis was done using a breakeven chart and formula. In the computation of annual cost, economic factors such as depreciation, present value, opportunity cost and subsidy were assigned assuming equal percentages to both fixed and variable costs. Depreciation was estimated by prorating the original cost of an asset over its useful life.

The present value of capital investment is defined as today's value for an asset that yields a stream of income over time, to which a discount rate is applied.

Opportunity cost is the benefit foregone by using the money in the construction of hatchery facilities for fingerling production or the next best alternative use. In the analysis, opportunity costs were calculated assuming 0%, 3%, 6%, 7% and 8% of investment costs. The 0% opportunity cost of capital represents public investment or private investment with no borrowed capital, while the 3%, 6%, 7% and 8% opportunity costs represent hypothetical interest rates charged to the money used in the purchase of facilities, equipment and land had the money been borrowed.

Subsidies are financial assistance extended to the fingerling production activity. Average subsidy rates were assumed at 0%, 25%, 50%, 75% and 100%.

In the breakeven chart, x and y axes were plotted with total revenue values on all sides, forming a square. The fixed costs, variable costs and revenue were graphed as explained in Fig. 1. By representing the revenue and cost of

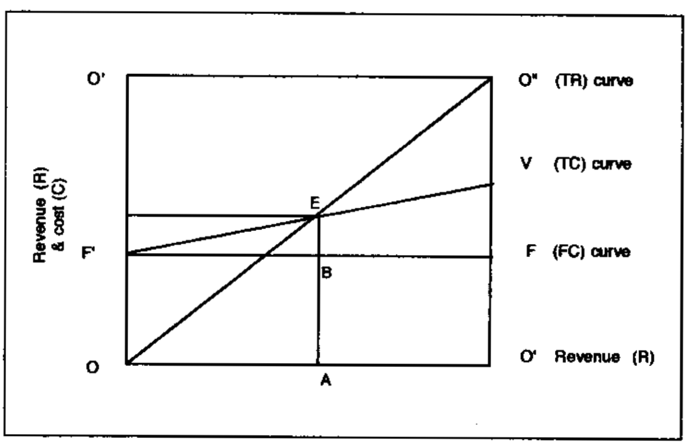



Fig. 1. Breakeven chart of a business enterprise, where: total revenue curve = OO' = O'O"; fixed cost curve = O'F = OF' = AB; total cost curve = FV; profit = VO"; breakeven point = E.

an economic activity in this manner, we can easily determine the possibility of profit for any level of production. The breakeven price and production using three different prices - ¥12, ¥18 and ¥32/piece - were also computed. The ¥12 and ¥32/piece are the prevailing prices of KPMRA, and ¥18/piece is the average price. The breakeven price was derived by dividing the total cost with the number of fingerling produced, and breakeven production by the annual cost with the designated price per fingerling.

## Results and Discussion

Total cost incurred in red sea bream fingerling production in 1990 amounted to about ¥48 million excluding depreciation and about ¥89 million including depreciation. Variable costs totalled about ¥27 million while fixed costs were about ¥62 million including depreciation. Total revenue derived from the sale of about four million fingerlings was about ¥71 million. Sale of fingerlings for sea ranching reached ¥32 million at ¥12/piece, while sale for mariculture was about ¥39 million at ¥32/piece (see Table 1). The price of ¥12/piece is a subsidized price which considers only the out of pocket expense (total cost excluding depreciation) in the production, while the ¥32/piece for mariculture was based on the prevailing price which is ¥1 for every mm size of the fingerling.

### *Breakeven Chart*

In Fig. 2, the effects of differing subsidy rates on fingerling production at 0% and 8% opportunity cost on both cases with and without depreciation are illustrated. Increasing the subsidy will decrease both fixed and variable costs at the same rate, thus increasing profit. Without subsidy, as illustrated in the first graph of Case a in Fig. 2, the revenue generated from the activity was not even enough to cover the total cost as shown by the dotted line, hence the activity is losing with no chance to breakeven. However, if the subsidy rate is increased to 25%, the activity gains a little profit. This is shown in the second graph where the breakeven point is located inside the square and a small profit triangle is exhibited. Increasing the subsidy lowers the breakeven point. Once the subsidy rate reaches 100%, total costs become zero; thus, all the revenue generated will be profit.

Case b in Fig. 2 illustrates the effects of charging 0-100% subsidy with depreciation at 3% opportunity cost. Results showed that only cases with 75% and 100% subsidy rates will break even; for the rest, revenue generated will not even be enough to pay for the fixed cost.

Cases c and d in Fig. 2 show the effects of subsidy on fingerling production without depreciation at 0% and 3% opportunity cost. Findings were the same as with depreciation. Nevertheless, the fixed cost was higher relative to the case of without depreciation, thus increasing the total cost of undertaking the activity. More profit is generated when opportunity cost is 0%. At 3% opportunity cost and subsidy rates at 0% and 25%, the venture is losing, but as the subsidy rates are increased from 50% to 100%, it becomes profitable.

Table 1. Annual cost of red sea bream fingerling production in Kagoshima, 1990 (unit: ¥1,000 unless specified).

| Capital cost | Useful life (years) | Investment cost | Salvage value | Annual dep. | Annual cost |
|---|---|---|---|---|---|
| A. Construction cost | | | | | |
| Pump building | 50 | 51,185 | 5,119 | 921 | 921 |
| Fish hatchery building | 50 | 130,110 | 13,011 | 2,342 | 2,342 |
| Chlorella, rotifers cultivation tanks | 50 | 92,315 | 9,232 | 1,662 | 1,662 |
| Chlorella purification facilities | 50 | 9,631 | 963 | 173 | 173 |
| Boiler room | 50 | 7,308 | 731 | 132 | 132 |
| Fence | 50 | 8,363 | 836 | 151 | 151 |
| Equipment | 15 | 599,129 | 59,913 | 35,948 | 35,948 |
| Artemia polycarbonate tank | 3 | 475 | 48 | 143 | 143 |
| Land | | 46,335 | | | |
| Sub-total | | 944,851 | 89,852 | 41,472 | 41,472 |
| B. Annual operating cost | | | | | |
| Variable cost | | | | | |
| Wages for part-timers | | | | | 5,172 |
| Welfare | | | | | 2,816 |
| Feeds | | | | | 6,341 |
| Office supplies | | | | | 5,816 |
| Rental | | | | | 263 |
| Water, electricity | | | | | 5,742 |
| Gasoline | | | | | 560 |
| Commission | | | | | 150 |
| Others | | | | | 488 |
| Sub-total | | | | | 27,348 |
| Fixed cost | | | | | |
| Board member fee | | | | | 800 |
| Salaries | | | | | 17,057 |
| Repairs | | | | | 500 |
| Insurance | | | | | 225 |
| Interest | | | | | 0 |
| Travel | | | | | 733 |
| Conference | | | | | 100 |
| Public relations | | | | | 600 |
| Communication | | | | | 189 |
| Publication | | | | | 157 |
| Depreciation | | | | | 41,472 |
| Sub-total | | | | | 61,833 |
| Total | | | | | 89,161 |

C. Gross revenue

| Purpose | Production (pieces) | Price (¥/piece) | Gross revenue (¥) |
|---|---|---|---|
| For sea ranching | 2,628,000 | 12 | 31,536 |
| For aquaculture | 1,229,000 | 32 | 39,328 |
| Total | 3,857,000 | 18 | 70,864 |

Source: Ungson, unpubl. data

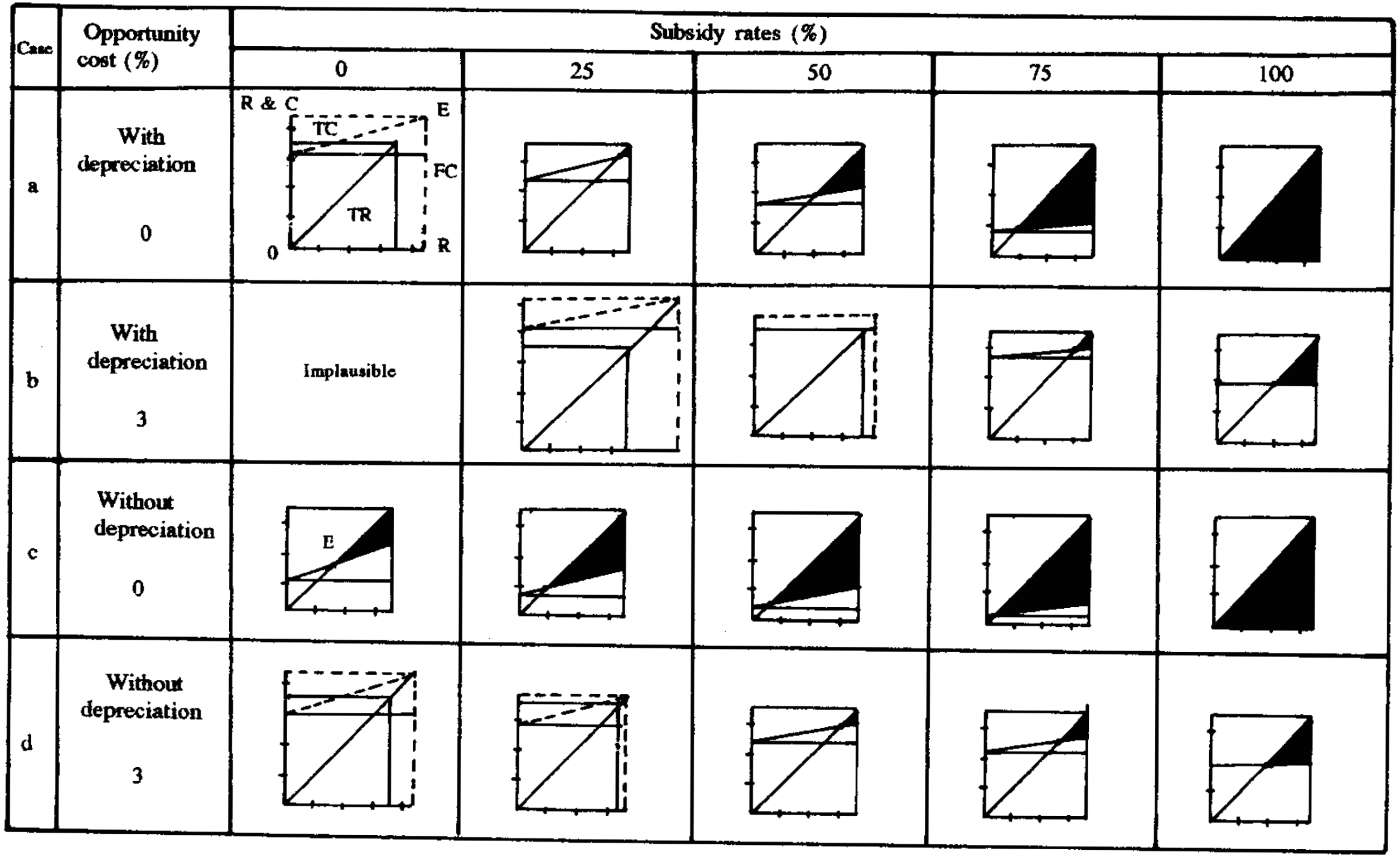



Fig. 2. Effects of subsidy (0-100%) on fingerling production (based on total revenue of ¥70,864,000). TR = total revenue; FC = fixed cost curve; TC = total cost curve; E = breakeven point; R = revenue; C = cost

Results further revealed that the activity is profitable only if depreciation of equipment and opportunity cost are not included in the total cost as depicted in Case c, Fig. 2. Otherwise, a subsidy of at least 25% should be pumped into the activity to make it viable.

The effects of 0-8% opportunity cost on fingerling production at 0% and 100% subsidy rates are illustrated in Fig. 3 under the conditions with and without depreciation.

Case a in Fig. 3, presents the effects of opportunity cost (0-8%) on fingerling production with depreciation and 0% subsidy. All the situations have a negative profit and as the opportunity cost is increased from 0% to 8%, cost also increases, incurring greater loss. The revenue generated is not enough to cover fixed costs.

Case b, Fig. 3, illustrates the effects of opportunity cost (0-8%) on fingerling production with depreciation at 100% subsidy. At 0-3% opportunity cost, the activity generates profit. However, at 6-8% opportunity cost, loss is sustained.

Case c, Fig. 3, shows the impacts of opportunity cost (0-8%) on fingerling production without depreciation or subsidy. Only where opportunity cost is 0% is positive profit realized, while the rest exhibited a negative profit. At 3% opportunity cost, the revenue generated is enough to cover the fixed cost but not the variable cost, hence loss is sustained. The rest of the situations demonstrate that revenue is not enough to cover the fixed cost.

Case d, Fig. 3, presents the effects of 0-8% opportunity cost on fingerling production, without depreciation but with 100% subsidy. Two situations, 0% and 3% opportunity cost, gave a positive profit, while 6-8% opportunity cost gave a negative profit.

The above analysis was based on the present production of 3,857,000 fingerlings at ¥12/piece for sea ranching and ¥32/piece for mariculture, though these vary according to changes in environmental and technical factors, and market demand.

### *Breakeven Formula*

The breakeven price and production of fingerlings are shown in Table 2. The breakeven prices range from 0 to ¥74/piece. The 0 price is a result of 0% opportunity cost with 100% subsidy, while the ¥74/piece is derived from 8% opportunity cost with 0% subsidy. The average price of ¥18/piece almost reaches the breakeven point at 0% opportunity cost with 25% subsidy rate. Nevertheless, at 0 depreciation, 8% opportunity cost, and 0% subsidy, the maximum breakeven price is ¥63/piece.

The breakeven price of ¥74/piece is not plausible with current market conditions. A move to increase the price of fingerlings to ¥74/piece is unattainable. This is due to the present trend of a decrease in demand for fingerlings produced in mariculture centers among aquaculturists who prefer fingerlings produced at hatcheries specializing in improved varieties intended for aquaculture; hence, mariculture centers tend to produce fingerlings intended for sea ranching.

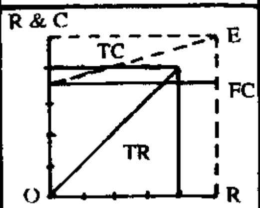
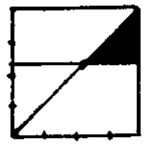
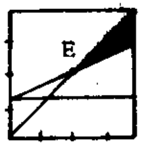
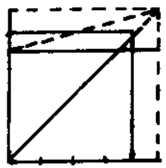
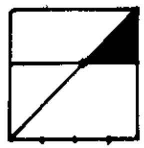
| Case | Subsidy rates (%) | Opportunity cost (% interest rates) | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 3 | 6 | 7 | 8 |
| a | With depreciation 0 |  | Implausible | Implausible | Implausible | Implausible |
| b | With depreciation 100 |  |  | Implausible | Implausible | Implausible |
| c | Without depreciation 0 |  |  | Implausible | Implausible | Implausible |
| d | Without depreciation 100 |  |  | Implausible | Implausible | Implausible |

Fig. 3. Effects of opportunity cost (0-8%) on fingerling production (based on total revenue of ¥70,864,000). TR = total revenue; FC = fixed cost curve; TC = total cost curve; E = breakeven point; R = revenue; C = cost

Table 2. Results of the breakeven analysis of the red sea bream fingerling production activity in Kagoshima, 1990 (unit ¥1,000 unless specified). Annual cost with depreciation at ¥89,181.

| Cases | Opportunity cost at varying interest rate* | | | | | Subsidy on annual cost at varying subsidy rate** | | | | | Adjusted annual cost | Breakeven price (¥/pc) | Breakeven production (¥12/pc) | Breakeven production (¥18/pc) | Breakeven production (¥32/pc) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0% | 3% | 6% | 7% | 8% | 0% | 25% | 50% | 75% | 100% | | | | | |
| 1 | 0 | | | | | 0 | | | | | 89,181 | 23 | 7,431,750 | 4,954,500 | 2,786,906 |
| 2 | 0 | | | | | | 22,295 | | | | 66,886 | 17 | 5,573,833 | 3,715,889 | 2,090,188 |
| 3 | 0 | | | | | | | 44,591 | | | 44,590 | 12 | 3,715,833 | 2,477,222 | 1,393,438 |
| 4 | 0 | | | | | | | | 66,886 | | 22,295 | 6 | 1,857,917 | 1,238,611 | 696,719 |
| 5 | 0 | | | | | | | | | 89,181 | 0 | 0 | 0 | 0 | 0 |
| 6 | | 40,775 | | | | 0 | | | | | 129,956 | 34 | 10,829,667 | 7,219,778 | 4,061,125 |
| 7 | | 40,775 | | | | | 22,295 | | | | 107,661 | 28 | 8,971,750 | 5,981,167 | 3,364,406 |
| 8 | | 40,775 | | | | | | 44,591 | | | 85,365 | 22 | 7,113,750 | 4,742,500 | 2,667,656 |
| 9 | | 40,775 | | | | | | | 66,886 | | 63,070 | 16 | 5,255,833 | 3,503,889 | 1,970,938 |
| 10 | | 40,775 | | | | | | | | 89,181 | 40,775 | 11 | 3,397,917 | 2,265,278 | 1,274,219 |
| 11 | | | 116,643 | | | 0 | | | | | 205,824 | 53 | 17,152,000 | 11,434,667 | 6,432,000 |
| 12 | | | 116,643 | | | | 22,295 | | | | 183,529 | 48 | 15,294,083 | 10,196,056 | 5,735,281 |
| 13 | | | 116,643 | | | | | 44,591 | | | 161,233 | 42 | 13,436,083 | 8,957,389 | 5,038,531 |
| 14 | | | 116,643 | | | | | | 66,886 | | 138,938 | 36 | 11,578,167 | 7,718,778 | 4,341,813 |
| 15 | | | 116,643 | | | | | | | 89,181 | 116,643 | 30 | 9,720,250 | 6,480,167 | 3,645,094 |
| 16 | | | | 153,019 | | 0 | | | | | 242,200 | 63 | 20,183,333 | 13,455,556 | 7,568,750 |
| 17 | | | | 153,019 | | | 22,295 | | | | 219,905 | 57 | 18,325,417 | 12,216,944 | 6,872,031 |
| 18 | | | | 153,019 | | | | 44,591 | | | 197,609 | 51 | 16,467,417 | 10,978,278 | 6,175,281 |
| 19 | | | | 153,019 | | | | | 66,886 | | 175,314 | 45 | 14,609,500 | 9,739,667 | 5,478,563 |
| 20 | | | | 153,019 | | | | | | 89,181 | 153,019 | 40 | 12,751,583 | 8,501,056 | 4,781,844 |
| 21 | | | | | 196,582 | 0 | | | | | 285,763 | 74 | 23,813,583 | 15,875,722 | 8,930,094 |
| 22 | | | | | 196,582 | | 22,295 | | | | 263,468 | 68 | 21,955,667 | 14,637,111 | 8,233,375 |
| 23 | | | | | 196,582 | | | 44,591 | | | 241,172 | 63 | 20,097,667 | 13,398,444 | 7,536,625 |
| 24 | | | | | 196,582 | | | | 66,886 | | 218,877 | 57 | 18,239,750 | 12,159,833 | 5,839,906 |
| 25 | | | | | 196,582 | | | | | 89,181 | 196,582 | 51 | 16,381,833 | 10,921,222 | 6,143,188 |

* Based on the present value of investment: $PV = Po(1+r)^n$; opportunity cost = PV x r, where Po = original cost of investment, r = rate of interest and n = number of years.

**Based on the annual cost which includes fixed and variable costs. Subsidy = annual cost x subsidy rate. Depreciation cost = (original cost - salvage value)/number of useful years.

References:

Cumulative investment cost (C) = ¥944,854,000
Gross revenue(R) = ¥70,864,000
Total production = 3,857,000 pcs.

Total present value of capital investment (PV):
3% = ¥1,359,174,000 7% = ¥2,185,980,000
6% = ¥1,944,044,000 8% = ¥2,457,277,000

Table 3. Results of the breakeven analysis of the red sea bream fingerling production activity in Kagoshima, 1990 (unit ¥1,000 unless specified). Annual cost without depreciation at ¥47,709.

| Cases | Opportunity cost at varying interest rate* | | | | | Subsidy on annual cost at varying subsidy rate** | | | | | Adjusted annual cost | Breakeven price (¥/pc) | Breakeven production (¥12/pc) | Breakeven production (¥18/pc) | Breakeven production (¥32/pc) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0% | 3% | 6% | 7% | 8% | 0% | 25% | 50% | 75% | 100% | | | | | |
| 1 | 0 | | | | | 0 | | | | | 47,709 | 12 | 3,975,750 | 2,650,500 | 1,490,906 |
| 2 | 0 | | | | | | 11,927 | | | | 35,782 | 9 | 2,981,833 | 1,987,889 | 1,118,188 |
| 3 | 0 | | | | | | | 23,854 | | | 23,855 | 6 | 1,987,917 | 1,325,278 | 745,469 |
| 4 | 0 | | | | | | | | 35,782 | | 11,927 | 3 | 993,917 | 662,611 | 372,719 |
| 5 | 0 | | | | | | | | | 47,709 | 0 | 0 | 0 | 0 | 0 |
| 6 | | 40,775 | | | | 0 | | | | | 88,484 | 23 | 7,373,667 | 4,915,778 | 2,765,125 |
| 7 | | 40,775 | | | | | 11,927 | | | | 76,557 | 20 | 6,379,750 | 4,253,167 | 2,392,406 |
| 8 | | 40,775 | | | | | | 23,854 | | | 64,630 | 17 | 5,385,833 | 3,590,556 | 2,019,688 |
| 9 | | 40,775 | | | | | | | 35,782 | | 52,702 | 14 | 4,391,833 | 2,927,889 | 1,646,938 |
| 10 | | 40,775 | | | | | | | | 47,709 | 40,775 | 11 | 3,397,917 | 2,265,278 | 1,274,219 |
| 11 | | | 116,643 | | | 0 | | | | | 164,352 | 43 | 13,696,000 | 9,130,667 | 5,136,000 |
| 12 | | | 116,643 | | | | 11,927 | | | | 152,425 | 40 | 12,702,083 | 8,468,056 | 4,763,281 |
| 13 | | | 116,643 | | | | | 23,854 | | | 140,498 | 36 | 11,708,167 | 7,805,444 | 4,390,563 |
| 14 | | | 116,643 | | | | | | 35,782 | | 128,570 | 33 | 10,714,167 | 7,142,778 | 4,017,813 |
| 15 | | | 116,643 | | | | | | | 47,709 | 116,643 | 30 | 9,720,250 | 6,480,167 | 3,645,094 |
| 16 | | | | 153,019 | | 0 | | | | | 200,728 | 52 | 16,727,333 | 11,151,556 | 6,272,750 |
| 17 | | | | 153,019 | | | 11,927 | | | | 188,801 | 49 | 15,733,417 | 10,488,944 | 5,900,031 |
| 18 | | | | 153,019 | | | | 23,854 | | | 176,874 | 46 | 14,739,500 | 9,826,333 | 5,527,313 |
| 19 | | | | 153,019 | | | | | 35,782 | | 164,946 | 43 | 13,745,500 | 9,163,667 | 5,154,563 |
| 20 | | | | 153,019 | | | | | | 47,709 | 153,019 | 40 | 12,751,583 | 8,501,056 | 4,781,844 |
| 21 | | | | | 196,582 | 0 | | | | | 244,291 | 63 | 20,357,583 | 13,571,722 | 7,634,094 |
| 22 | | | | | 196,582 | | 11,927 | | | | 232,364 | 60 | 19,363,667 | 12,909,111 | 7,261,375 |
| 23 | | | | | 196,582 | | | 23,854 | | | 220,437 | 57 | 18,369,750 | 12,246,500 | 6,888,656 |
| 24 | | | | | 196,582 | | | | 35,782 | | 208,509 | 54 | 17,375,750 | 11,583,833 | 6,515,906 |
| 25 | | | | | 196,582 | | | | | 47,709 | 196,582 | 51 | 16,381,833 | 10,921,222 | 6,143,188 |

* As in Table 2
**As in Table 2
References: as in Table 2

In order to lower the breakeven price of ¥74/piece, fingerling production should be increased. However, considering the limited production capacity of the facilities, such a move is unrealistic. As a matter of fact, the hatchery used for red sea bream production is now producing about 4 million fingerlings a year exceeding the stipulated capacity of 2.5 million fingerlings.

Options to decrease the breakeven price of ¥74/piece include decreasing a part of the cost like the opportunity cost or increasing the subsidy on annual cost, or both. These alternatives should be properly examined giving due consideration to the government's capacity of extending support to sea ranching.

The breakeven production was computed at the present KPMRA's pricing policy of ¥12/piece for sea ranching, ¥32/piece for mariculture purposes and ¥18/piece as the average price. With depreciation, production is 0-24 million pieces at ¥12/piece, 0-9 million pieces at ¥18/piece.

The breakeven production of 24 million, 16 million and 9 million fingerlings are the results of extreme cases of 8% opportunity cost with 0% subsidy and prices at ¥12/piece, ¥18/piece and ¥32/piece, respectively. These breakeven productions are, however, unachievable due to the limited production capacity of the facilities needed for such an activity. At ¥32/piece, breakeven production of 9 million fingerlings at ¥32/piece is two-fold higher than that of the present production of 4 million fingerlings; 16 million at ¥18/piece is four-fold higher and the highest, 24 million at ¥12/piece, is six-fold higher.

The present fingerling production is faced with the problem of disease due to overcrowding of fingerlings. Such a situation is evidence of going beyond the production capacity of the facilities.

Assuming maximum production of 5 million fingerlings, at 0% opportunity cost, 50% subsidy at ¥12/piece, and without subsidy at ¥18/piece or over, a profit can be realized.

This is also true if opportunity cost is charged at 3% with 100% subsidy, price at ¥12/piece or subsidy 50%; price at ¥18/piece; or without subsidy and price at ¥32/piece. If a 6% opportunity cost is counted, the profitable cases are those with over 75% subsidy and price at ¥32/piece. If a 7% opportunity cost is necessary, only the case with 100% subsidy is plausible.

Based on the above findings, subsidy is a vital factor in considering the continuity of operation, if an opportunity cost of at least 3% is charged to the activity. Moreover, if depreciation is to be excluded, it is necessary that subsidy be set at 50% or more at 3% opportunity cost as shown in Table 3.

The move of the government to transfer the financial burden of sea ranching to FCAs should be thoroughly studied. Considering the results presented in this paper, the government has to give at least 25% subsidy assuming a 0% opportunity cost of capital to make the activity viable. At present, fingerling production of red sea bream depends mainly on government subsidy with minimal contributions from the FCAs. Moreover, the national and prefectural governments further contribute 2/3 of the total fingerling costs aside from the subsidized price of ¥12/piece for sea ranching. Thus, the findings can be used as a basis for policymakers in the government as to the degree of financial assistance to be given to FCAs while gradually transferring the financial burden to the fishers.

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