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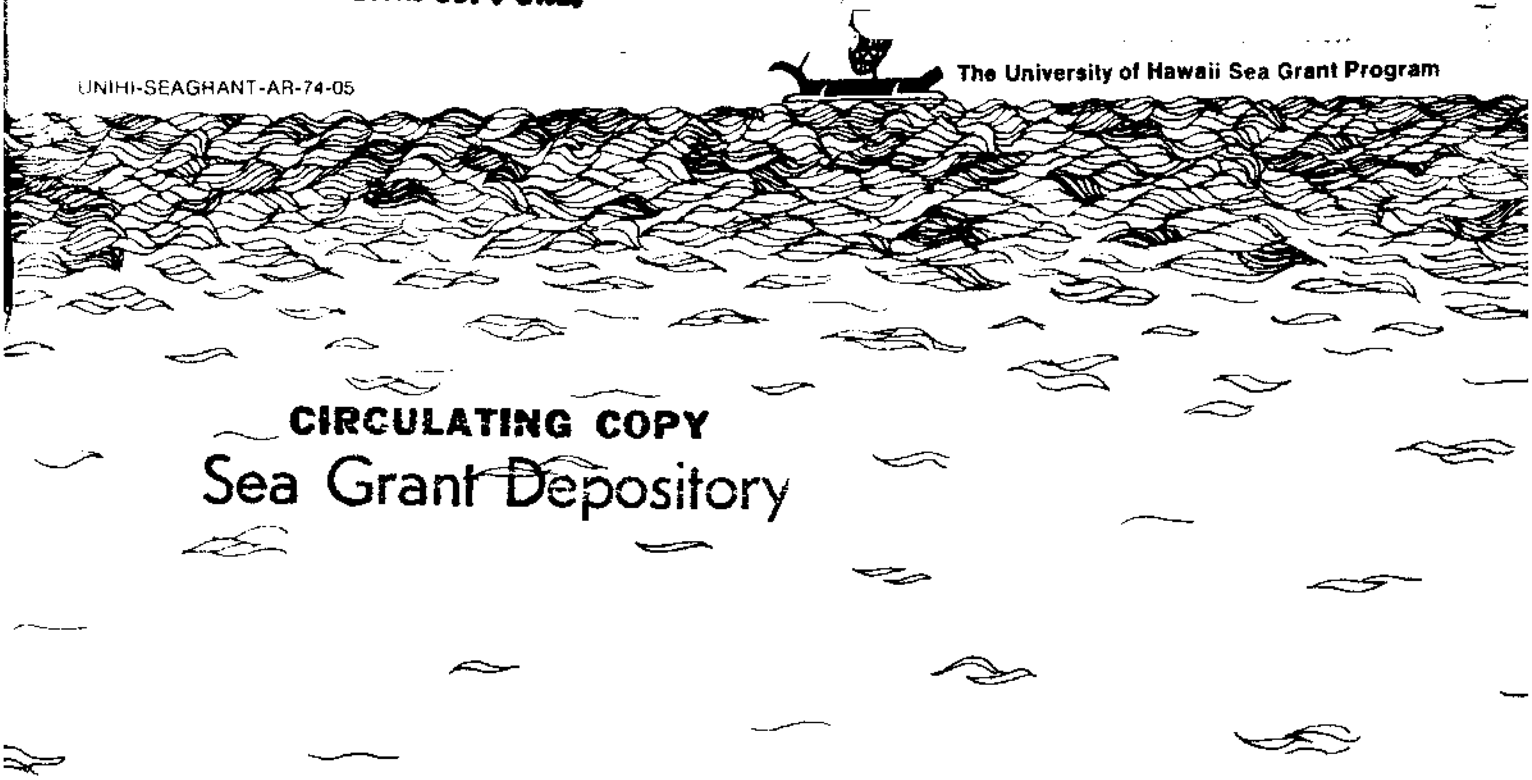

Economic Feasibility of Fresh Water Prawn Farming in Hawaii

Yung Cheng Shang

June 1974

ECONOMIC FEASIBILITY OF
FRESH WATER PRAWN FARMING IN HAWAII

by

Yung Cheng Shang

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Economic Feasibility of Fresh Water Prawn Farming in Hawaii

by

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Economic Research Center
University of Hawaii
Honolulu, Hawaii

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Yung C. Shang

June 1972

Honolulu, Hawaii

The Fishery Research Center tanks in the foreground are being utilized to test the efficiencies of various food mixtures for increasing prawn production.

A fistful of 2-month old juvenile prawns. These few are a part of the estimated one and a half million reared at the State Anuenue Fisheries Research Center this year for eventual distribution to cooperative pond owners.

State Fishery personnel harvest a net full of prawns at Ota's Pond in Punaluu.

It takes approximately one year to rear market-sized prawns weighing one half pound in operating ponds.

State Fish and Game Division personnel sampling prawns (above) and collecting data (below) at Punaluu pilot pond.

Participants and instructors of the aquaculture training program which took place during the summer of 1972. Kneeling from left to right are Takuji Fijimura (State Fish and Game Division), Philippe Siu (Tahiti), Prak Tha (Cambodia), and Gary Oura (Marine Option Program); standing in the first row are Bin Jaafar Mahmood (West Malaysia), Beejayechundre Jugnarain (Mauritius), Prasit Kessunchai (Thailand), Kenneth Kato (Pacific Aquaculture Corporation), and Songchai Sahavacharin (Thailand); and standing in the back row are Colin Nash (Oceanic Institute), Tin Taing Heang (Cambodia), Howard Deese (Marine Option Program), Nicolaas Luykx (East-West Food Institute), and J. Thomas Stuart (State Office of the Marine Affairs Coordinator).

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I. INTRODUCTION

The increasing pressure of world population expansion and the shortage of animal protein in many parts of the world have led to more intensive exploitation of the fishery resources of the world's oceans. However, the world ocean fishery resources are not only relatively limited but are common-property in nature. These have resulted in overfishing for some species. It is estimated that the major species presently being fished will reach the point of maximum sustainable supply in the 1985-2000 period.[1] The need for a substantial increase in the world supply of animal protein and the rapid increase in price of some of the fishery products have stimulated interest in aquaculture in recent years.

Fish farming is usually done by collection of fry or baby fish from the sea and feeding them in protected enclosures until they are ready for marketing. This catching and rearing of juveniles have proved an effective method of producing marketable fish and shellfish but is only a modest improvement over hunting adult fish at sea. During the 1950s some success was achieved in cultivating marine species from captive parent stock. Since these successes, the intensive cultivation of aquatic animals has been the object of a great deal of laboratory research throughout the world. One of the most successful researches was that done by the Fish and Game Division of the State of Hawaii with Malaysian prawn culture.

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[1]Frederick W. Bell and associates, <u>The Future of the World's Fishery Resources</u>, Division of Economic Research, National Marine Fisheries Service, Working Paper 71-1, 1970.

The Fish and Game Division of the State of Hawaii imported 36 giant freshwater prawns (Macrobrachium rosenbergii) from Malaysia in 1965.[2] After a thorough investigation of the physical and biological characteristics and after numerous rearing trials, a mass rearing technique was developed. The state scientists can now hatch eggs and rear them through the life cycle. To date, more than 2 million prawns, comprising five generations, have been produced from the 36 originally imported prawns. The advantages of this particular species over many other crustaceans are: (1) It readily adapts to a wide range of salinity, (2) it is amenable to culture techniques, (3) it breeds throughout the year under natural conditions, (4) a large female can produce as many as 80,000 eggs, (5) the female carries and cares for eggs thus resulting in relatively high hatching success, (6) it has a relatively short larval life, (7) it is a fast growing omnivore, feeding on both animal and plant materials, and (8) taste test done by an independent laboratory in New York indicated that the frozen freshwater prawn was more delectable than frozen salt water shrimp.

Although it is technically feasible to produce prawns in Hawaii, the economic feasibility of this production has yet to be determined. The major objective of this study is to evaluate the economic feasibility of freshwater prawn production in Hawaii. It is hoped that this study will serve as the first attempt to analyze the economic problems of the industry.

The study is divided into six sections. The method of evaluating investment worth is presented in Section II. Section III estimates the cost of

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[2] T. Fujimura and H. Okamoto, Notes on Progress Made in Developing a Mass Culturing Technique for Macrobrachium Rosenbergii in Hawaii, Division of Fish and Game, State of Hawaii, 1970.

juvenile prawns while section IV measures the economic worth of the investment in prawn farming. The prospects of the industry and a summary and conclusions are presented in Sections V and VI.

II. METHOD OF EVALUATING INVESTMENT WORTH

In most investment processes a large amount of capital outlay is necessary at the initial stage of investment with returns accruing to the investor over a period of time. A dollar in hand today is more valuable than a dollar to be gained sometime in the future. Therefore, the profitability of investment in prawn farming is measured by the present value method in this study. This method measures the excess of the discounted net cash inflow over the capital cost of the farm. There are four major steps involved in this method.

(1) Determination of an appropriate discount rate. The discount rate should reflect the rate of return that might reasonably be expected in an alternative investment. Decision makers use different discount rates for different classes of expenditures to reflect differences in the degree of risk involved. The discount rate chosen by the decision maker represents the "cut-off criterion" in judging whether or not an investment is desirable.

(2) Computing the present value of the net cash inflows that is expected to result if the capital expenditure is made. The net cash inflow in a particular year is the difference between total revenue and total cost. The total cost includes actual sums expended on equipment, labor, materials, taxes, etc. The summation of the discounted annual net cash inflow is the present value of the net cash inflow. It is also possible to discount independently the stream of annual receipts and costs and to calculate the present net cash inflow by simply subtracting the sum of the latter from that of the former. The present value of the net cash inflows represents

the maximum amount that a firm could afford to pay for the investment opportunity without being financially worse off.

(3) Computing the present value of the cash outlays required by the investment. Most of the capital outlays associated with investment occur immediately. In this case, the present value of the outlays is merely the net amount of capital needed when the investment is made (since the present value of a dollar expended today is $1.00). If the facilities constructed (or purchased) have salvage value at the end of the analysis period, the capital cost would be the difference between the construction cost and the discounted salvage value.

(4) The present value of the capital outlays, as determined in step 3, is subtracted from the present value of the net cash inflows, as determined in step 2. The difference is referred to as the net present value of the investment. These statements can be expressed mathematically as:

$$NPV = \sum_{i=1}^{n} \frac{Q_i \cdot P_i}{(1+r)^i} - \left[\sum_{i=o}^{n} \frac{C_i}{(1+r)^i} \right] + \frac{S}{(1+r)^n} \qquad (1)$$

where

NPV = net present value of investment

Q = annual production

P = price

C = production cost

S = salvage value of the assets in year n

r = discount rate

i = 1...n, number of years in operation

Since production cost (C) consists of (1) initial construction costs (C_o), (2) equipment costs (C_e), and annual operating costs (C_a), equation (1) can be rewritten as

$$NPV = \sum_{i=1}^{n} \frac{Q_i \cdot P_i}{(1+r)^i} - \left[C_o + \sum_{i=1}^{n} \frac{C_{ei}}{(1+r)^i} + \sum_{i=1}^{n} \frac{C_{ai}}{(1+r)^i} \right] + \frac{S}{(1+r)^n} \qquad (2)$$

By assuming annual revenue and operating costs to be constant, equation (2) can be again rewritten as

$$NPV = Q \cdot P \left[\frac{1-(1+r)^n}{r} \right] - \left\{ C_o + \sum_{i=1}^{n} \frac{C_{ei}}{(1+r)^i} + \left[C_a \cdot \frac{1-(1+r)^n}{r} \right] \right\} + \frac{S}{(1+r)^n} \qquad (3)$$

The criterion of this measurement is that if the calculated net present value is positive, investment in this industry would be profitable.

Given the production cost, the level of production and the discount rate, it is possible to calculate the break-even price by using the present value formula. The break-even price is the minimum price resulting a zero net present value. By assuming NPV = 0, equation (3) can be rewritten as

$$Q \cdot P \frac{1-(1+r)^n}{r} = C_o + \sum_{i=1}^{n} \frac{C_{ei}}{(1+r)^i} + \left[C_a \cdot \frac{1-(1+r)^n}{r} \right] - \frac{S}{(1+r)^n} \qquad (4)$$

$$P = \left\{ \frac{C_o + \sum_{i=1}^{n} \frac{C_{ei}}{(1+r)^i} + \left[C_a \cdot \frac{1-(1+r)^n}{r} \right] - \frac{S}{(1+r)^n}}{\frac{1-(1+r)^n}{r}} \right\} \frac{1}{Q} \qquad (5)$$

The criterion of this measurement is that if the expected farm price is higher than the calculated minimum price, investment in this industry would be profitable.

III. THE COST OF JUVENILE PRAWNS

There are two major steps involved in prawn production on a commercial scale: (1) producing juvenile prawns (eggs to stockable size) in a hatchery and (2) rearing stockable juvenile prawns in ponds to market-size. Prawn farmers have to either produce juvenile prawns from their own hatchery or buy it from a commercially operated hatchery.

The purpose of this section is to estimate how much it will cost the farmers to produce (or to pay for) juvenile prawns. The production of juvenile prawns involves the construction of tanks, a laboratory, and purchasing various kinds of equipment. There are also annual costs to operate the hatchery. By giving all of these costs and production levels, the minimum price of juvenile prawns can be calculated by using equation (5).

Enumeration of Cost and Production

Initial capital cost. The initial capital cost here refers to the construction costs of plankton culture tanks, larval rearing tanks, wells[3] and laboratory-hatchery building (including an office, laboratory, workshop, storage and hatchery) as shown in Table 1. The full amount of these expenses is treated as the initial cost as of time 0. Since the full amount has already been counted, any allowance for annual depreciation and any charge for annual interest would be double counting.

Equipment costs. Hatchery equipment include various kinds of pumps,

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[3] If domestic water is not available at the location wells are necessary to provide potable water. (This is in addition to the salt water well.)

TABLE 1

ESTIMATED INITIAL CAPITAL COSTS
OF HATCHERY FACILITIES

Items	Cost
Laboratory - hatchery building (11,200 sq. ft. at $10 per sq. ft.)	$112,000
6 plankton culture tanks (18' dia. x 8' depth, 10,000 gal. capacity)	18,000
16 larval rearing tanks (6' wide x 30' long x 3' deep)	24,000
Water transmission system	5,000
Salt water well	5,000
Freshwater well	5,000
Total -- without freshwater well	$164,000
-- with freshwater well	169,000

freezer, laboratory equipment,[4] tools, trucks, etc., as shown in Table 2. The useful life of all of these equipment is estimated at about 10 years, except the truck, which has a useful life of 5 years. At the 11th year (every five years for the truck), new equipment have to be purchased, at a higher cost, to replace the old ones if the operation is to last for 20 years.

Annual production. At present, the annual production of such a hatchery is estimated to be 16 million juvenile prawns after a 50 percent mortality rate which has been the current experience. Observations made during the experiments suggest that four important factors affect the mortality rate of juveniles: (1) The water temperature--the larvae must have a certain temperature range for survival. Ideal temperature is 84 degrees F, with a range from 77 to 87 degrees. One degree beyond that range in either direction will result in mortalities. (2) The salinity of the water--this species of prawns is basically a fresh water creature. However, the larvae require brackish water ranging in salinity from 6 to 21 parts per thousand (the salinity recommended for rearing larvae in a hatchery is 17 o/oo). (3) The amount of food--decomposition of excess food causes water pollution and increases the mortality rate. (4) The amount of shade--overexposure to direct sunlight causes the larvae to eat less than usual and slows down growth. With more experience and improved techniques, the mortality rate may be lowered to 40 percent with an annual production of 19.2 million juvenile prawns.

Another possible improvement in production is to reduce the length of the production cycle. At the present, 10 production cycles a year are

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[4] Such as saline meter, ph meter, water testing equipment, etc.

TABLE 2

ESTIMATED COSTS OF HATCHERY EQUIPMENT

Year of Operation	2 Salt Water Pumps (250 gpm)	Fresh-Water Pump (300 gpm)	Transfer Pump (200 gpm)	Air Pump (100 cfm, 6 psi.)	Walk-in Freezer (2 hp)	Laboratory Equipment	Truck	Heating Devices	Tools and Miscel.	Total: Without Fresh-Water Pump	Total: With Fresh-Water Pump
1	$1,600	$800	$800	$1,000	$5,000	$1,500	$3,000	$5,000	$2,000	$19,000	$20,700
2											
3											
4											
5											
6							3,000			3,000	3,000
7											
8											
9											
10											
11	2,000	1,000	1,000	1,200	6,000	1,600	3,000	5,000	2,000	22,000	22,800
12											
13											
14											
15											
16							3,000			3,000	3,000
17											
18											
19											
20											

possible. Each cycle lasts for about 35 days. With the proper amount and kind of food and the proper water temperature the growth rate will be increased and the juveniles may reach stockable size within 30 days. In this case, 12 production cycles yielding annual production of 19.2 million juvenile prawns are possible. If both mortality and length of production cycle can be reduced, the annual production would be about 23.0 million. In this study the production level of 16, 19.2 and 23.0 million are used.

Annual operating costs. Labor is the highest operating cost followed by electricity, food, water, maintenance and repair. Labor cost is estimated at 3,993 man hours annually at $4 per hour plus a manager's salary of about $20,000 annually.[5] The cost of electricity for equipment used in rearing larval prawn is calculated by multiplying the operating time (hours) by the horsepower and the rate paid (3.83¢ per kilowatt-hour). The cost of water is estimated on 50 percent potable water and 50 percent salt water,[6] and at 35¢ per 1,000 gallons of potable water. Plankton (natural culture), artemia nauplii, and prepared fish flesh (skipjack tuna) are the food items used for larval rearing. Food costs about $0.54 per thousand post-larvae. The hatchery site should be close to the beach where salt water is available. Lease rent is estimated about $100 per acre per year. Most of these costs are estimated based on the results of the actual operation of the hatchery owned by the state.

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[5] A hatchery can be either an independent operation selling of juvenile prawns only, or a combined hatchery-farm operation. In the case of a combined hatchery-farm operation, one capable manager can take care of both of these functions. There is a savings by sharing the manager's salary between hatchery and farm.

[6] The cost of salt water is the cost of electricity for the pump.

TABLE 3

ESTIMATED ANNUAL OPERATING COSTS OF HATCHERY

	Production Level in Millions of Juveniles		
	16.0	19.2	23.0
Labor	$35,974	$35,974	$35,974
Food	8,640	9,792	11,730
Water			
Using domestic water	3,680	4,416	5,290
Using well water	180	180	180
Electricity			
Using domestic water	12,160	14,592	17,480
Using well water	13,600	16,320	19,550
Maintenance and repair	1,000	1,000	1,000
Fuel or electricity for heating	3,000	3,000	3,000
Rental (one-half acre)	50	50	50
Miscellaneous (insurance, license permits, office supplies, etc.)	5,000	5,000	5,000
Total			
Using domestic water	69,504	73,824	79,524
Using well water	67,444	71,316	76,484

Discount rate. The choice of a proper discount rate is subject to considerable debate. The appropriate rate of discount is the rate of return that might reasonably be expected in an alternate investment as mentioned earlier. If explicit allowance for risk and uncertainty is made in the estimates of cost and revenue, the rate of return in a riskless investment can be used for discounting. This rate is estimated to be in the 5-6 percent range. If specific allowance for risk and uncertainty is not made in the cost and revenue estimates, an average allowance can be incorporated in the base discount rate. This rate is estimated in the 8-10 percent range. The risk and uncertainty of investment in prawn farming is assumed to be higher at present than in other well developed industries. In this study, a 6-14 percent range is used to test the sensitivity of the calculation.

Salvage value. The normal physical life of tanks and wells is estimated to be about 20 years. However, the loss of value of these facilities due to changes in farming technology is far less predictable than their physical life. In this study we consider only the physical depreciation. It is assumed that there is no salvage value at the end of the physical life.

The Results of Calculation

The estimated costs and production in Tables 1 - 3 were substituted into equation (5). The calcuations were done for two sources of water supply: domestic water and well water; three levels of production: 16, 19.2, and 23.0 million of juvenile prawns; and five levels of discount rate: 6, 8, 10, 12, 14. The results are summarized in Tables 4 and 5 and Figure 1.

The choice of varying discount rates makes a difference in the calculation. The higher the rate of discount used, the higher the minimum

TABLE 4

ESTIMATED MINIMUM PRICE OF JUVENILE PRAWNS[a]
USING DOMESTIC WATER

Production Level	Discount Rate				
	6%	8%	10%	12%	14%
16.0 million	$5.42	$5.58	$5.76	$5.94	$6.12
19.2 "	4.74	4.88	5.02	5.17	5.33
23.0 "	4.21	4.32	4.44	4.56	4.69

[a]Per thousand.

TABLE 5

ESTIMATED MINIMUM PRICE OF JUVENILE PRAWNS[a]
USING WELL WATER

Production Level	Discount Rate				
	6%	8%	10%	12%	14%
16.0 million	$5.33	$5.49	$5.67	$5.86	$6.05
19.2 "	4.64	4.78	4.93	5.08	5.24
23.0 "	4.10	4.22	4.34	4.67	4.60

[a]Per thousand.

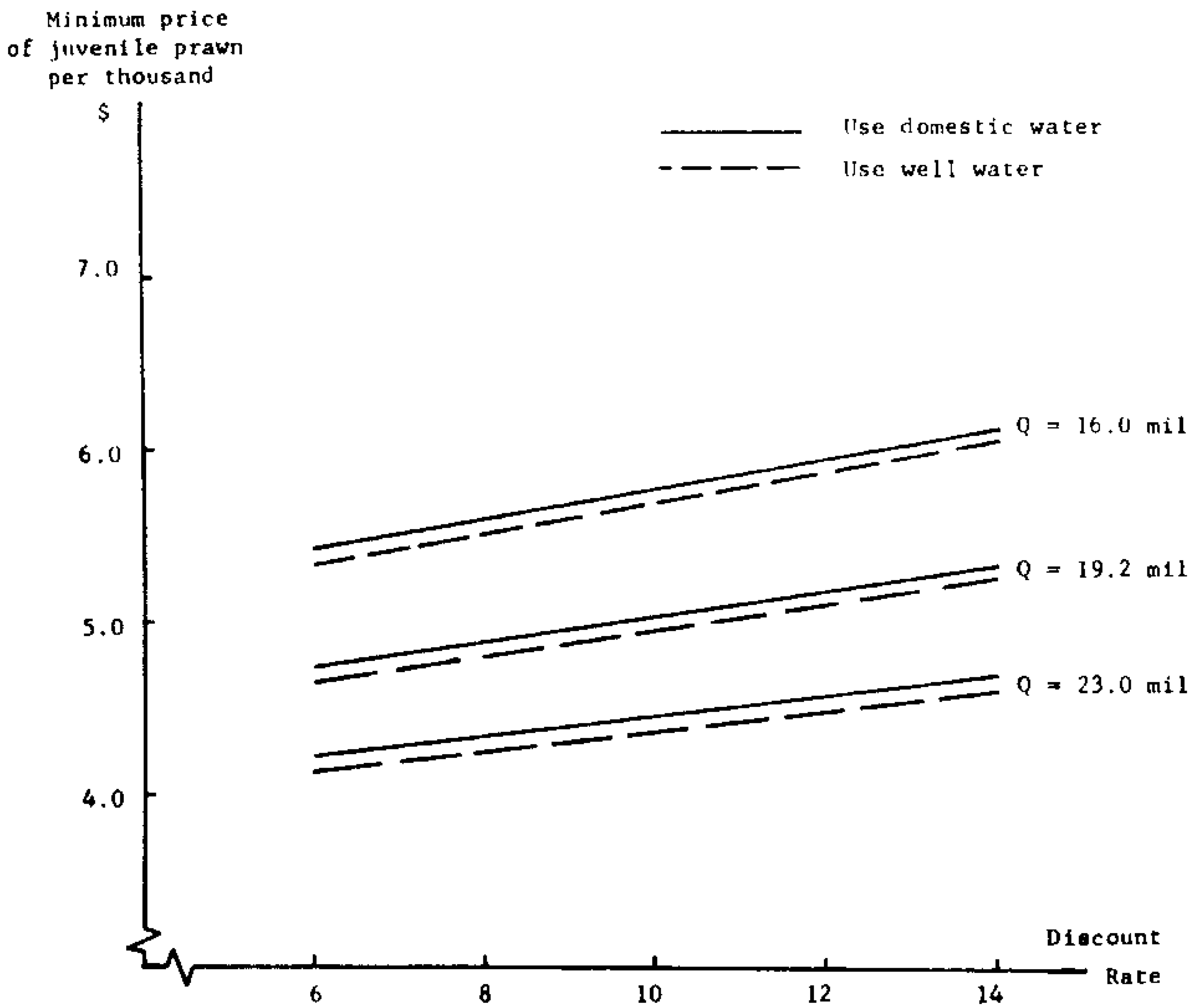

FIGURE 1

RELATIONSHIP AMONG MINIMUM PRICE OF JUVENILE PRAWN,
PRODUCTION LEVEL AND DISCOUNT RATE

price resulted. The minimum price of juvenile prawns ranged from $4.21 to $6.12 per thousand for domestic water and $4.10 to $6.05 for well water between the discount rate of 6-14 percent. The minimum price is lower by using well water instead of domestic water. However, this difference is rather small, less than $0.10 per thousand. The level of production makes a significant difference in the results of the calculation. The difference in calculated minimum price is over $1.20 per thousand of juvenile prawns between the production levels of 16 and 23.0 million.

IV. MEASUREMENT OF THE ECONOMIC WORTH OF INVESTMENT IN PRAWN FARMING

In this section we appraise the economic worth of investment in prawn farming by calculating the net present value and the minimum price of prawns under various cost and production conditions.

Enumeration of Cost and Production

Initial capital cost. Initial capital cost here refers to the construction costs of fish ponds, wells, workshed and storage as shown in Table 6. The full amount of these expenses is again treated as the initial cost as of time 0. There is no allowance for annual depreciation and no charge for interest.

The present harvesting techniques require the pond size to be about 110 feet wide and about 400 feet long with bottom sloped from 2.5 to 4.5 feet deep. The construction cost varies with the slope, type of soil and the amount of clearing work (trees, cover grass, etc.). On the average, it is estimated that the cost of construction is in the range of $3,000-$3,500 per acre (including engineering design, access road and drainage system).

The number of wells needed is based on the volume of water required. It is estimated that about 36.5 million gallons of water are required per acre per year. It is also estimated that a well with a pump of 700 gpm (gallons per minute) with 10 hp. can supply 10 acres and a pump of 1,500 gpm with 20 hp. can supply about 25 acres.

Equipment costs. Equipment on the farm level include pumps, net, truck, etc. All of the cost of equipment for the different farm sizes are estimated

TABLE 6

ESTIMATED INITIAL CAPITAL COST OF FISH PONDS AND FACILITIES

Total Acreage	Construction Cost of Ponds [a]	Well	Workshed-Storage House	Total
10	$ 35,000	$ 5,000 (1 well 8" dia., 110' deep)	$1,000	$ 41,000
50	175,000	20,000 (2 wells 12" dia., 150' deep)	4,000	199,000
100	300,000	40,000 (4 wells 12" dia., 150'deep)	5,000	345,000
150	450,000	60,000 (6 wells 12" dia., 150' deep)	6,000	516,000

[a] Construction cost is estimated about $3,500 per acre for 10-acre farm and $3,000 for the rest of the farm size, including engineering design, access road and drainage system.

and listed in Appendix Tables 1-4. The number of pumps required corresponds to the number of wells. The capacity of pumps is based on the volume of water required. New equipment will have to be purchased to replace the old ones if the operation is to last for 20 years.

Operating cost. Labor, feed, juvenile and electricity are the most important operating costs as shown in Table 7. It is estimated that one man can take care of 10 acres. However, in large scale operations, the efficiency of labor is expected to increase and one man is assumed to take care of more than 10 acres. Labor cost is estimated at 40 hours per man per week at \$4 per hour.

The estimation of the cost of feed (C_f) is based on the levels of production (Y), the conversion ratio of feed to prawn (R) and the price of feed (P_f) as follows:

$$C_f = Y \cdot R \cdot P_f \tag{6}$$

Two levels of production are used: 3,000 lbs. per acre and 4,000 lbs. per acre. The average conversion ratio of feed to prawn is estimated about 3.3:1. The estimated price of feed ranges from 6-8 cents per pound depending on volume purchased.

The estimation of the cost of electricity (C_e) is based on the volume of water required per acre (G), the number of hours operated (T), the horsepower of the pump (H) and the rate of electricity per kilowatt-hour (P_e).

$$C_e = G \cdot T \cdot H \cdot P_e \tag{7}$$

$$T = \frac{G}{gpm} \div 60 \tag{8}$$

TABLE 7

ESTIMATED ANNUAL OPERATING COSTS OF FISH PONDS

Acreage	Labor	Manager	Feed[a/]	Electricity	Juveniles[b/]	Water	Lease	Maintenance and Repair	Gasoline and Oil	Miscel. (includ. adminis.)
10	8,320 (one man)	10,000	7,920 10,560	3,302	5,242	180	320	1,250	1,200	5,000
50	41,600 (5 men)	15,000	34,650 46,200	15,411	26,208	360	700	5,625	2,400	15,000
100	66,560 (8 men)	20,000	59,400 79,200	30,822	52,416	360	3,200	10,000	3,000	20,000
150	83,200 (10 men)	20,000	89,100 118,800	46,233	78,624	360	4,800	15,000	3,500	20,000

[a/] The first estimate is based on the production of 3,000 lbs. per acre and the second estimate is based on 4,000 lbs. per acre.

[b/] Based on the cost of present level of production (16 million juveniles) in Table 5 under 10 percent discount rate.

where

gpm (gallons per minute) is the capacity of pumps.

It is estimated that about 36.5 million gallons of water are required per acre per year. The rate for electricity is about 3.83 cents per kilowatt-hour. This rate varies by islands and by amount used.

The cost of juveniles is obtained from Table 5. It is assumed that prawn farms have to buy juvenile prawns from commercially operated hatcheries at a price 30 percent higher than the calculated minimum price. It is estimated about 70,000 juvenile prawns are needed per acre per year.

Land is very expensive in Hawaii. The value of agricultural land ranges from \$4,000 to \$25,000 per acre. It is assumed in this study that land is leased from the state. The lease of state agricultural land is about \$25.6 per acre per year. A one-acre pond with access road requires 1.25 acres of land.

Three kinds of taxes are involved: (1) gross income tax (G.I.T.), (2) property tax (P.T.) and (3) corporate tax (C.T.) or individual income tax. They are estimated as follows:

$$\text{G.I.T.} = (\text{Gross Income})\ 0.5\% \tag{9}$$

where

0.5% = gross income tax rate

$$\text{P.T. on land} = [(\$25.6 \div 6\%)\ 70\%]\ 1.92\% \tag{10}$$

where

\$25.6 = annual rent of land

6% = percentage used to capitalize the market value of land by the State Taxation office

70% = percentage of assessment value to market value

1.92 = property tax rate on Oahu. It is 1.50% on Kauai and Maui and 1.79% on Hawaii

P.T. on improvements = (Replacement cost of improvements - Depreciation) + property tax rate (same with that of land property tax) (11)

C.T. = Net annual income x 50% (12)

where

50% = approximate corporate income tax rate.

The estimated taxes are summarized in Appendix Table 5.

Annual production and revenue. In demonstration ponds, juvenile prawns have been reared to marketable sizes in a period of seven months. Under a cycling system, 3,000 pounds of marketable prawns per acre per year have been attained. The mortality rate of prawns during the pond rearing period is again about 50 percent. Observations made during the experiments suggest that six important factors affect the mortality rate of prawns:[7] (1) amount of shade and shelter available to the prawns, (2) amount of predation by dragonfly nymphs and birds, (3) temperature of water, (4) food supply, (5) stocking density, and (6) disease. With more experience and research, the mortality rate may be reduced and an annual production of 4,000 pounds per acre may be possible.

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[7]For detail see Fujimura, op. cit.

Annual revenue is estimated by multiplying the total amount of production by the farm price of prawns. The farm price of live prawns from demonstration ponds is about $3.00 per pound. The price of prawns is expected to drop as a result of large scale production. The wholesale price of imported frozen prawns is about $2.00 per pound with heads-on and the import price of shrimp of comparable size is about $2.40 per pound with heads-off, which is equivalent to about $1.20 per pound with heads-on. In this study, figures of $1.20, $1.60 and $2.00 per pound with heads-on are used.

Again, a 6-14 percent discount rate is used to test the sensitivity of the calculation. The normal physical life of the ponds and wells is also estimated to be about 20 years. It is assumed that there is no salvage value at the end of the physical life.

The Results of the Calculation

Net present value. The estimated costs and revenues are substituted in equation (3). The calculations were done for three levels of price: $1.20, $1.60 and $2.00 per pound in live weight; two levels of annual production: 3,000 pounds and 4,000 pounds per acre; five levels of discount rate; and four farm sizes: 10-acre, 50-acre, 100-acre and 150-acre. The results are summarized in Tables 8 - 11 and Figures 2 - 5.

The levels of price make a significant difference in the calculation. The calculated net present values are negative at the price levels of $1.20 and $1.60 per pound for a 10-acre farm, and at the price level of $1.20 per pound for a 50-acre farm at the present level of production. The net present values are all positive for a 100 and 150-acre farm at all price levels.

TABLE 8

ESTIMATED NET PRESENT VALUE OF INVESTMENT IN A 10-ACRE PRAWN FARM UNDER SELECTED CONDITIONS

Price Level	Level of Production Per Acre	Discount Rate				
		6%	8%	10%	12%	14%
	(lbs.)			($1,000)		
$1.20	3,000	-136	-123	-113	-104	-98
	4,000	- 30	- 32	- 34	- 35	-36
$1.60	3,000	- 9	- 14	- 18	- 21	-24
	4,000	62	46	34	25	17
$2.00	3,000	59	44	32	23	15
	4,000	158	129	106	87	72

TABLE 9

ESTIMATED NET PRESENT VALUE OF INVESTMENT IN A 50-ACRE PRAWN FARM UNDER SELECTED CONDITIONS

Price Level	Level of Production Per Acre	Discount Rate				
		6%	8%	10%	12%	14%
	(lbs.)			($1,000)		
$1.20	3,000	13	- 19	- 45	- 65	- 81
	4,000	339	174	123	82	49
$1.60	3,000	362	280	215	163	120
	4,000	695	565	462	379	313
$2.00	3,000	705	572	469	386	318
	4,000	1,178	978	820	694	591

TABLE 10

ESTIMATED NET PRESENT VALUE OF INVESTMENT IN A 100-ACRE PRAWN FARM UNDER SELECTED CONDITIONS

Price Level	Level of Production Per Acre	Discount Rate				
		6%	8%	10%	12%	14%
	(lbs.)			($1,000)		
$1.20	3,000	238	154	82	27	18
	4,000	809	639	506	399	312
$1.60	3,000	909	725	580	464	369
	4,000	1,734	1,431	1,192	1,001	846
$2.00	3,000	1,607	1,323	1,098	919	773
	4,000	2,638	2,205	1,863	1,590	1,368

TABLE 11

ESTIMATED NET PRESENT VALUE OF INVESTMENT IN A 150-ACRE PRAWN FARM UNDER SELECTED CONDITIONS

Price Level	Level of Production Per Acre	Discount rate				
		6%	8%	10%	12%	14%
	(lbs.)	($1000)				
$1.20	3,000	584	421	292	190	107
	4,000	1,509	1,213	980	793	641
$1.60	3,000	1,610	1,300	1,055	859	700
	4,000	2,821	2,336	2,053	1,647	1,399
$2.00	3,000	2,637	2,179	1,817	1,528	1,293
	4,000	4,179	3,499	2,961	2,531	2,183

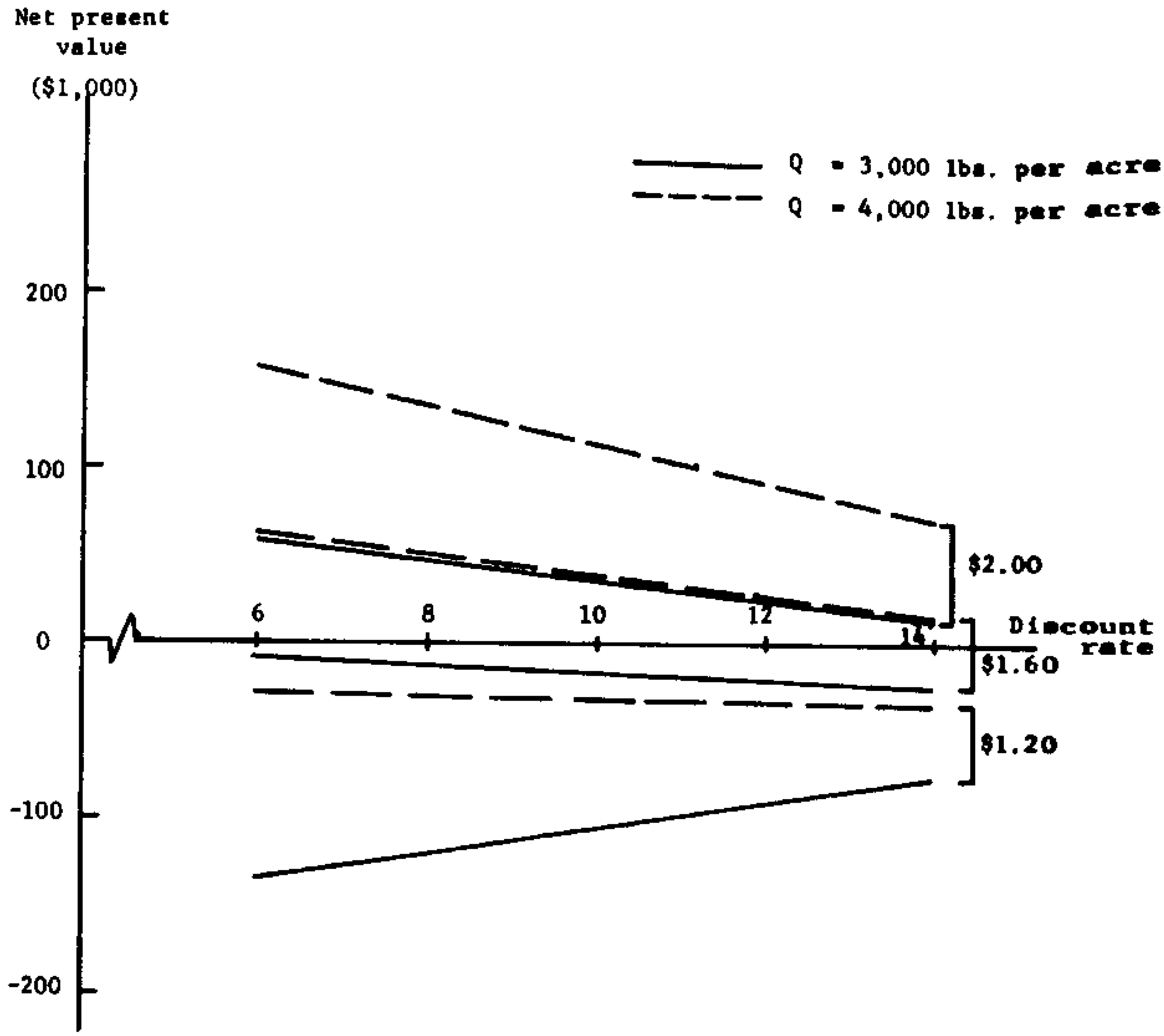

FIGURE 2

RELATIONSHIP AMONG NET PRESENT VALUE, PRODUCTION LEVEL AND DISCOUNT RATE FOR A 10-ACRE FARM

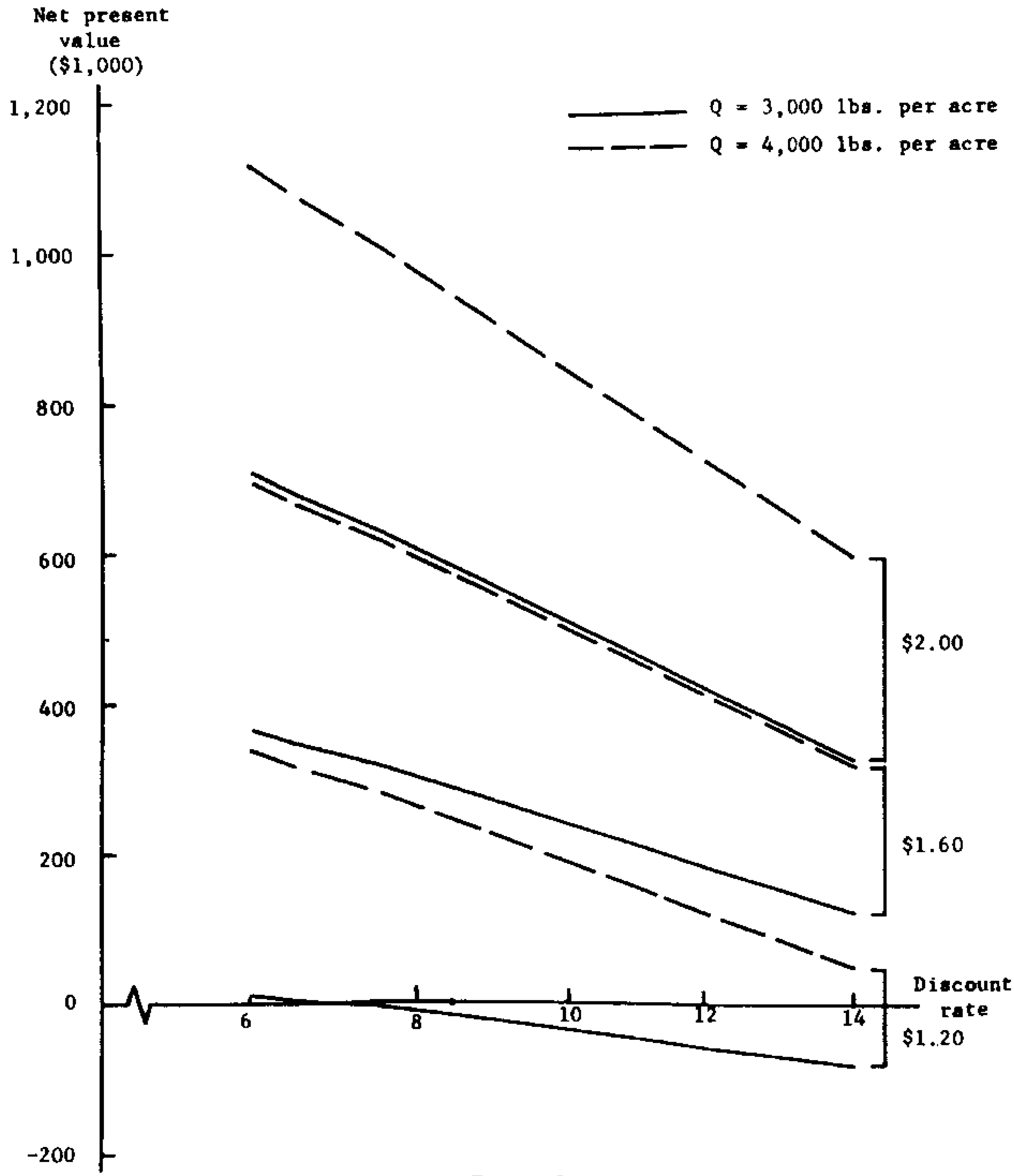

FIGURE 3

RELATIONSHIP AMONG NET PRESENT VALUE, PRODUCTION LEVEL AND DISCOUNT RATE FOR A 50-ACRE FARM

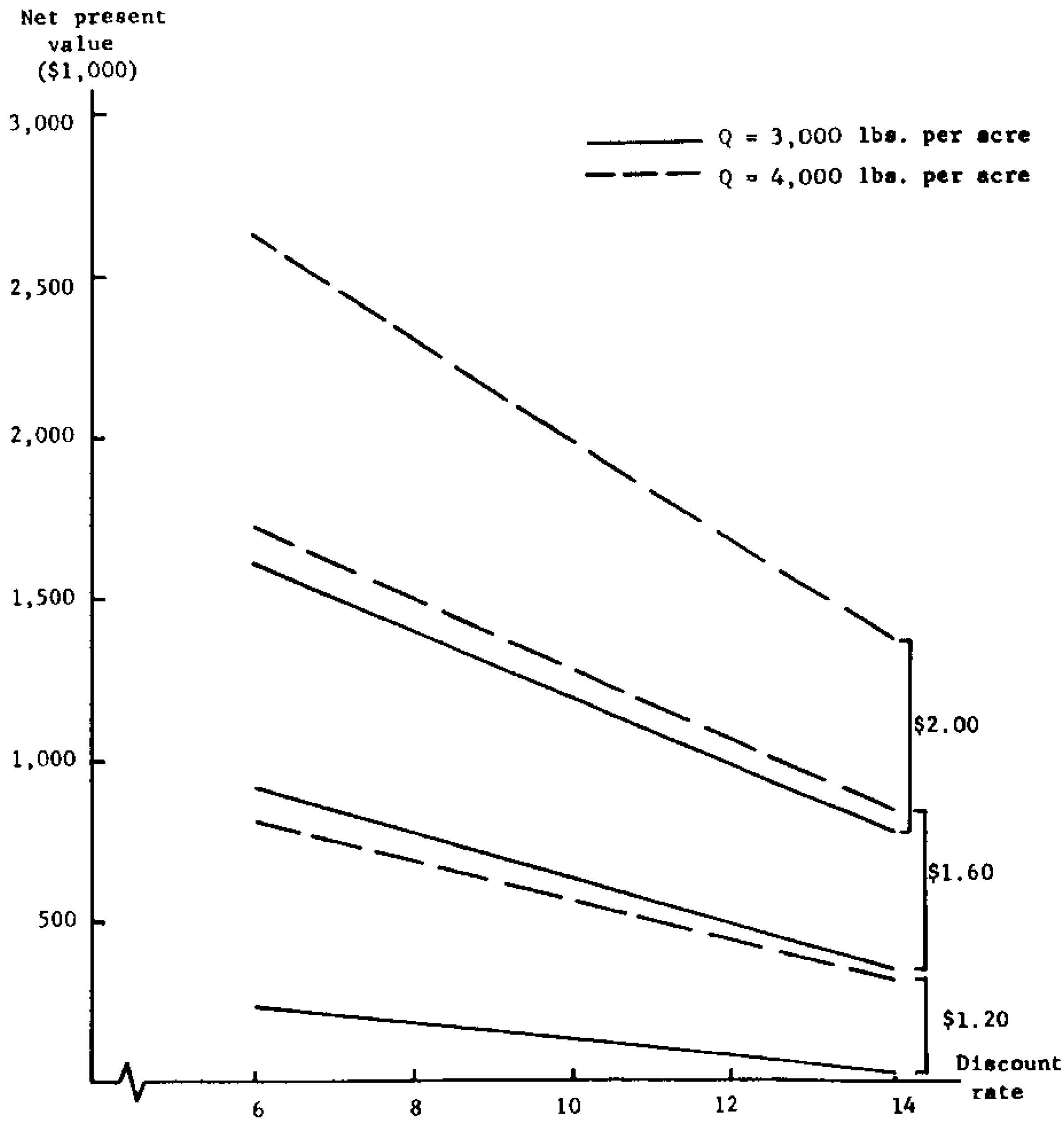

FIGURE 4

RELATIONSHIP AMONG NET PRESENT VALUE, PRODUCTION LEVEL AND DISCOUNT RATE FOR A 100-ACRE FARM

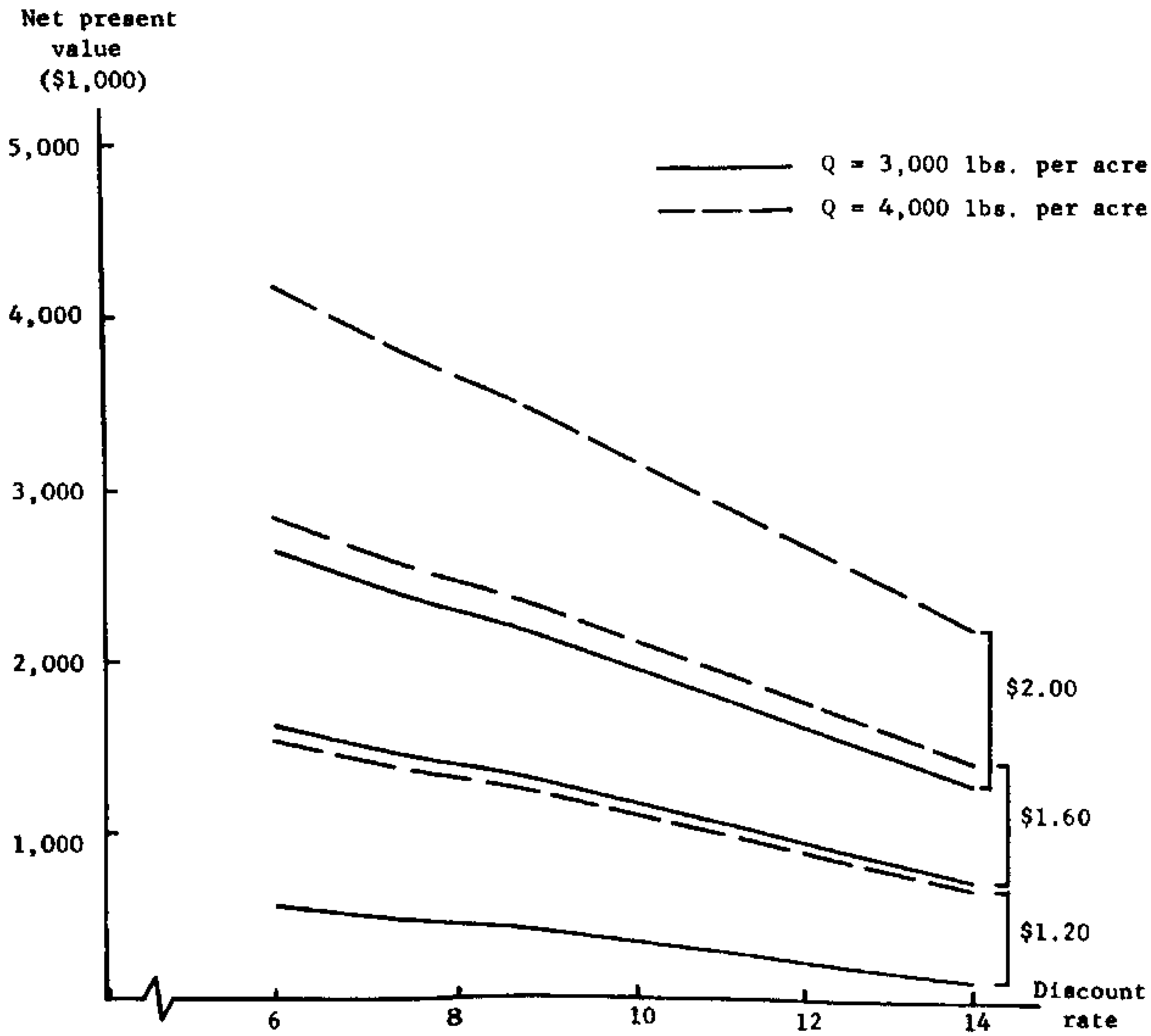

FIGURE 5

RELATIONSHIP AMONG NET PRESENT VALUE, PRODUCTION LEVEL AND DISCOUNT RATE FOR A 150-ACRE FARM

The higher the discount rate used, the lower the net present value result. The levels of production also make a significant difference in the calculation. A higher level of production results in a higher net present value. The large scale operation is more profitable than a small scale.

Minimum price of prawns. The estimated costs and production are substituted in equation (5). The calculations were done for two levels of production: 3,000 and 4,000 pounds of prawn per acre; four farm sizes: 10, 50, 100 and 150 acres; and five levels of discount rate. The results are summarized in Table 12 and Figure 6.

The higher level of production and larger farm size reduce the minimum price significantly. The break-even price of prawn is about $1.81 per pound for a 10-acre farm compared with $1.13 per pound for a 150-acre farm at a discount rate of 10 percent at the production rate of 3,000 pounds per acre. When production increases from 3,000 to 4,000 pounds per acre, the break-even price of prawn will reduce to $1.44 and $0.93 per pound respectively for 10-acre and 150-acre farms at the same discount rate. The discount rate does not make a significant difference in the calculation. The difference in the calculated minimum price is less than 9 cents per pound between the 6 and 14 percent discount rate used.

The results of the calculation suggest that in order to increase the net present value or to reduce the minimum price of prawn, the level of production should be increased by reducing the mortality rate.

TABLE 12

ESTIMATED MINIMUM (BREAK-EVEN) PRICE OF PRAWN BY FARM SIZE, LEVEL OF PRODUCTION AND DISCOUNT RATE

Farm Size	Level of Production Per Acre	Discount Rate				
		6%	8%	10%	12%	14%
	(lbs.)	(dollars per lb.)				
10-acre	3,000	1.76	1.78	1.81	1.83	1.86
	4,000	1.41	1.43	1.44	1.46	1.48
50-acre	3,000	1.39	1.41	1.43	1.45	1.48
	4,000	1.10	1.12	1.13	1.15	1.17
100-acre	3,000	1.17	1.19	1.21	1.23	1.25
	4,000	.96	.97	.98	1.00	1.01
150-acre	3,000	1.09	1.11	1.13	1.15	1.17
	4,000	.90	.91	.93	.94	.96

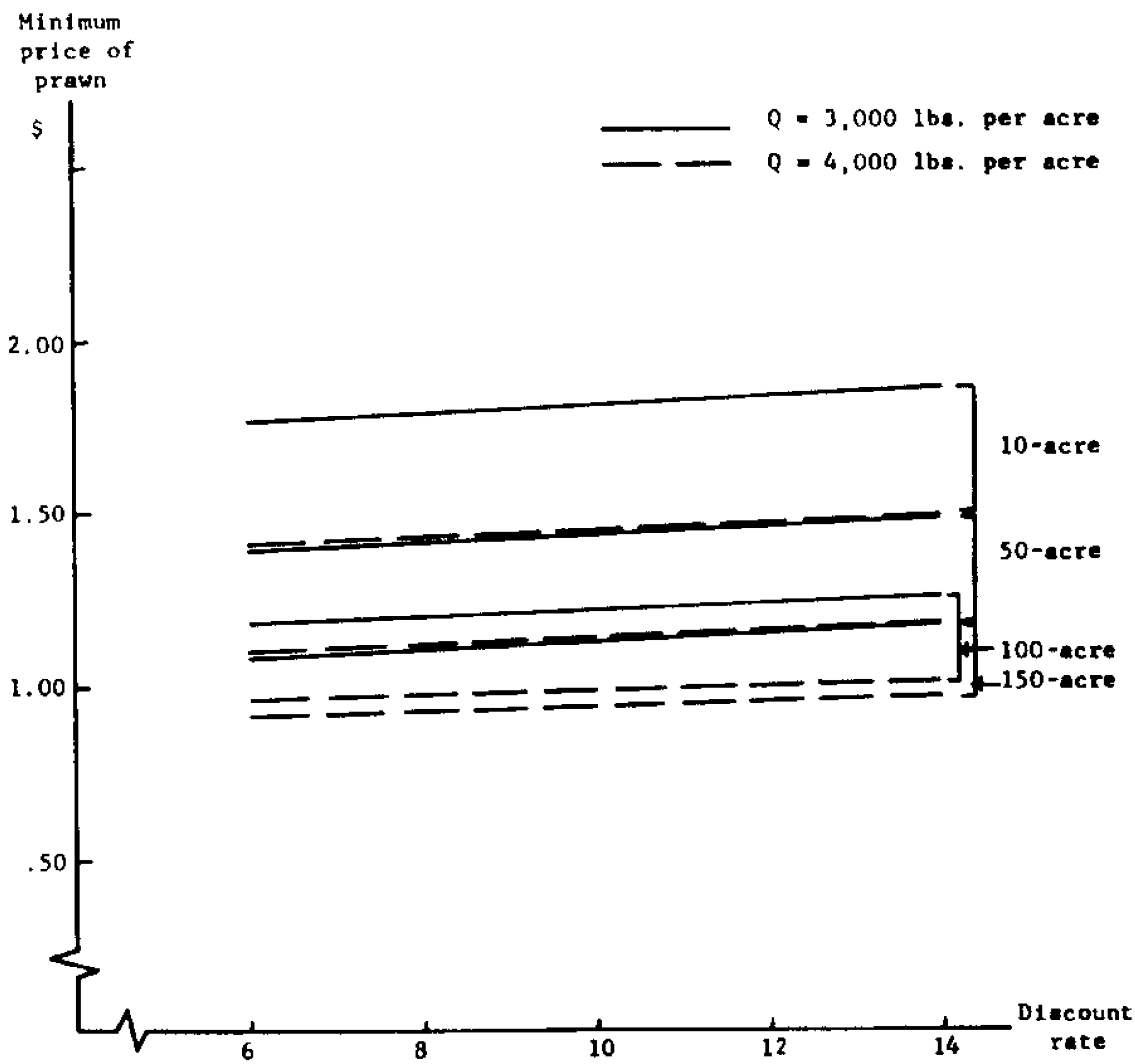

FIGURE 6

RELATIONSHIP AMONG MINIMUM PRICE OF PRAWN, PRODUCTION LEVEL, FARM SIZE AND DISCOUNT RATE

V. PROSPECTS OF THE PRAWN INDUSTRY IN HAWAII

The calculations in the previous section indicate that prawn farming in Hawaii would be profitable for a farm size of 50-150 acres at the farm price of $1.60-2.00 per pound. However, the prospects of this industry depend on the market demand of prawns.

It is estimated that over 2.2 million pounds (live weight equivalent) of shrimp and prawns were consumed in Hawaii in 1971.[8] It is also estimated that over one million pounds of raw shrimp and prawns (live weight equivalent) were imported from foreign countries and the rest imported from the U.S. mainland. The wholesale price of raw prawns from foreign countries is about $2.00 per pound with heads-on which is equivalent to about $4.00 per pound with heads-off. Since locally produced prawns are of better quality (fresh), they should be able to compete with those imports at comparable prices. However, when compared with the import price of shrimp of comparable size (10-15 count) which is in the range of $2.30-2.50 per pound with heads-off, prawns are a luxury food item and would be purchased mainly by restaurants and hotels. It is estimated that the local demand for prawns at the price range of $1.60-2.00 per pound in live weight would not be over one-fourth of the total shrimp consumption which is about half a million pounds. It requires less than 170 or 125 acres with an annual production of 3,000 or 4,000 pounds per acre respectively. If the price of prawns is about the same with that of shrimp

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[8] Estimated by using the national per capita consumption data which was about 2.8 pounds in round weight in 1970.

of comparable size, which is equivalent to about $1.20 per pound in live weight, the local consumption may be over 0.5 million pounds under an adequate market promotion program.

There is a potential market for prawns on the U.S. mainland. The income elasticity of demand for shrimp in the United States is about 1.70. Due to the rapid increase in income and population, total consumption climbed from approximately 400 million pounds in 1961 to about 700 million pounds (round weight) in 1971. It is projected that total consumption will reach 1,000 million pounds by 1980.[9] Over 50 percent of the U.S. supply is imported. Imports to the U.S. decreased sharply since 1971 due mainly to the fact that Japan has been aggressively buying shrimp in the world market to satisfy its growing demand. In order for Hawaii to share in the mainland market, the following necessary conditions must be met by the local prawn industry.

$$P_L + C \leq P_W \quad \text{or}$$
$$P_L \leq P_W - C \qquad (13)$$

where

P_L = local farm price of prawns

C = marketing and transportation costs from Hawaii to the mainland

P_W = West Coast farm price on ex-vessel price of shrimp of comparable size

The average ex-vessel price of shrimp of 10-15 count, which is comparable to prawns, on the U.S. mainland is estimated about $1.50 per pound with

[9] Basic Economic Indicators: Shrimp, Division of Economic Research, Bureau of Commercial Fisheries, 1970.

heads-off between 1969 and 1971. The transportation cost of frozen prawns from Hawaii to the West Coast alone is about five cents per pound.[10] Therefore, in order to compete with mainland produced shrimp of comparable size, the farm price of locally produced prawns should be less than \$0.70 per pound with heads-on.[11] When compared with minimum prices calculated in the previous section, it appears unlikely locally produced prawns can be exported to mainland markets unless production costs are reduced significantly.

Besides domestic markets, there is also a potential market for prawns in Japan. The wholesale price of 16-20 count imported frozen shrimp at Tokyo increased from \$1.78 per pound in 1970 to about \$2.50 per pound (heads-off) in 1971.[12] The freight cost of frozen prawns from Hawaii to Japan is about 5.3 cents per pound. If the price of shrimp maintains its increasing trend there in the future, and if the production cost can be reduced, it may be possible to ship locally produced prawns to Japan.

The market potential of prawns in the local and outside markets mentioned above was estimated under the assumption that fresh water prawns are closely competitive with shrimp of comparable size. However, these two products are not strictly comparable. The taste test indicated, as mentioned earlier,

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[10] Matson Navigation Company, Honolulu, Hawaii.

[11] One may argue that wholesale price, rather than ex-vessel price, on the mainland should be compared. The wholesale price of shrimp of 10-15 count on the mainland is estimated about \$1.10 per pound in live weight. At the present level of production it is still unlikely that locally produced prawns can compete with shrimp of comparable size at the mainland markets. However, if production of 4,000 per acre per year can be achieved, the cost of production would be reduced and there is a good chance for the large scale farms to export their prawns to the mainland markets.

[12] Shellfish Situation and Outlook, Annual Review, 1971. National Marine Fisheries Service, U.S. Department of Commerce.

that freshwater prawns are more delectable than salt water shrimp and may command a higher price. The market potential of prawns in the local as well as outside markets should be investigated more closely in the future.

The world supply and demand for shrimp appear to hold some promise for prawn farming in the future. Shrimp prices on all levels have been increasing during the past few years in the United States as well as in the world market. Much of the rise relates to increased demand and relatively stable supply. The shrimp population in the world's fishing grounds is relatively fixed. Though one female shrimp lays up to a million eggs, only about 0.5 percent survive predators and other hazards to become adult shrimp. In addition, the world shrimp resource is common property in nature. With demand for shrimp outpacing supply and boosting price, more and more fishing boats are competing for the available supply. This will eventually lead to overfishing and reduce the shrimp stock. Preliminary reports indicate that the world catch of shrimp may have been off somewhat since 1970.[13] All of these factors are favorable to prawn farming.

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[13] Ibid.

VI. SUMMARY AND CONCLUSIONS

Two major steps are involved in prawn production on a commercial scale: (1) producing juvenile prawns (eggs to stockable size) in a hatchery and (2) rearing stockable juvenile prawns in ponds to market size.

Juvenile prawns are an important input to the industry. The costs of producing juvenile prawns are estimated and the break-even price of juvenile prawns is calculated. The calculation is done by using the present value formula under various conditions. The level of production is the only variable that makes a significant difference in the results of the calculation. The calculated break-even price of juvenile prawns ranges from $5.33-6.12 per thousand based on an annual production of 16 million and from $4.10-4.69 on an annual production of 23 million. Production could be increased by reducing the mortality rate and the length of the production cycle.

The economic worth of investment in prawn farming is also measured by the present value method. The net present value and the break-even price of prawn farming are calculated. The criteria are that (1) if the calculated net present value is positive, investment in prawn farming would be profitable, and (2) if the calculated break-even price is lower than the expected farm price of prawn, investment in prawn farming would also be profitable. The calculations are done by two levels of production: 3,000 and 4,000 pounds per acre per year; four sizes of farm: 10-acre, 50-acre, 100-acre, 150-acre; five levels of discount rate: 6, 8, 10, 12, 14; and three levels of farm price (present value calculations only): $1.20, $1.60, $2.00 per pound. Except for the 10-acre farm at the price of $1.20 and $2.00 per pound and the 50 and 100-acre farms at \$1.20 per pound, the calculated net present values are all positive. The calculated break-even price of prawn varies with the farm size and the discount rate used. It is in the range of \$1.09-1.86 per pound when the annual production is 3,000 pounds per acre, and in the range of \$0.90-1.48 per pound if the annual production is 4,000 pounds per acre. As one would expect from the cost data, there are economies of scale. The large scale operation is more profitable than the small ones. The minimum price of prawns for a 150-acre farm is about 50 percent lower than those for a 10-acre farm.

The prospects of this industry depend on the market potential of prawns. It is estimated that the local market potential is less than half a million pounds at the price range of \$1.60-2.00 per pound with heads-on. It requires less than 170 or 125 acres with an annual production of 3,000 or 4,000 pounds per acre respectively. If the price of prawns is about the same with that of shrimp of comparable size, which is equivalent to about \$1.20 per pound in live weight, the local consumption may be over 0.5 million pounds under an adequate market promotion program.

There is a potential market on the U.S. mainland and in Japan. However, it is unlikely that locally produced prawns can compete with shrimp of comparable size in those markets at the present unless production cost is reduced and/or the price of shrimp is still increasing there. With demand for shrimp outpacing supply, shrimp prices have been increasing rapidly during the past few years in the United States as well as in the world markets. This appears to hold some promise for prawn farming in the future.

Since there are no commercially operated prawn farms in existence here, most of the data used in this study are based on preliminary estimates. The estimates of the production costs of juvenile prawns are based largely on the actual data of the hatchery owned by the state, while the estimates of prawn farming are based on several sources. The former estimates are considered more reliable than the latter.

The value of agricultural land ranges from $4,000 to $25,000 an acre. It is assumed in this study that land is leased from the state. The rent of state agricultural land is relatively low, about $25.6 per acre per year. Such an assumption would bias the estimation on the high side (on the low side for break-even price estimates) in the case of land purchased or leased from other sources.

Freshwater prawn is a new product. Little information is available at the present concerning the price and demand for prawns. It is assumed in this study that prawns are closely competitive with shrimp of comparable size. However, these two products are not strictly comparable. The taste test indicated that frozen freshwater prawns were more delectable than frozen salt water shrimp, and may command a higher price. The market potential of prawn in the local as well as outside markets should be investigated closely in the future.

The farming method described in this study is a labor intensive operation. Harvesting and feeding are all done manually. The cost of production would be reduced significantly if the farm could be mechanized and if a better and cheaper commercial feed could be developed. Since labor and feed are the most important cost items further research to cut these costs seems necessary.

Fish farming generally requires a higher level of management than conventional agriculture in the sense that the technology as yet lies mainly in the realm of art rather than science. For any individual or firm embarking on a commercial prawn rearing venture, it is essential that the operation be headed by or closely advised and supervised by a person specifically trained in the culture of prawns. At present, only a few persons have this competence within the state. Training of management personnel seems necessary before a commercial prawn industry is started.

A P P E N D I X   T A B L E S

APPENDIX TABLE 1

ESTIMATED EQUIPMENT COSTS FOR 10-ACRE FARM

Year	1 Pump (700 gmp 10 hp.)	Fence	Net	Truck	Miscel.	Total
1	2,000	1,000	345	3,000	600	6,945
2						
3						
4			345			345
5						
6				3,000	600	3,600
7			345			345
8						
9						
10			345			345
11	2,500	1,200		3,000	600	7,300
12						
13			345			345
14						
15						
16			345	3,000	600	3,945
17						
18						
19						
20						

APPENDIX TABLE 2

ESTIMATED EQUIPMENT COSTS FOR 50-ACRE FARM

Year	2 Pumps (1500 gmp 20 hp.)	Fence	Net	Truck	Miscel.	Total
1	8,600	4,000	1,725	3,000	2,000	19,325
2						
3						
4			1,725			1,725
5						
6				3,000	2,000	5,000
7			1,725			1,725
8						
9						
10			1,725			1,725
11	10,000	4,500		3,000	2,000	19,500
12						
13			1,725			1,725
14						
15						
16			1,725	3,000	2,000	6,725
17						
18						
19						
20						

APPENDIX TABLE 3

ESTIMATED EQUIPMENT COSTS FOR 100-ACRE FARM

Year	4 Pumps (1500 gmp 20 hp.)	Fence	Net	2 Trucks	Miscel.	Total
1	17,200	8,000	2,600	6,000	3,000	36,800
2						
3						
4			2,600			2,600
5						
6				6,000	3,000	9,000
7			2,600			2,600
8						
9						
10			2,600			2,600
11	20,000	9,000		6,000	3,000	38,000
12						
13			2,600			2,600
14						
15						
16			2,600	6,000	3,000	11,600
17						
18						
19						
20						

APPENDIX TABLE 4

ESTIMATED EQUIPMENT COSTS FOR 150-ACRE FARM

Year	6 Pumps (1500 gmp 20 hp.)	Fence	Net	2 Trucks	Miscel.	Total
1	25,800	10,000	3,450	6,000	4,000	49,250
2						
3						
4			3,450			3,450
5						
6				6,000	4,000	10,000
7			3,450			3,450
8						
9						
10			3,450			3,450
11	30,000	11,000		6,000	4,000	51,000
12						
13			3,450			3,450
14						
15						
16			3,450	6,000	4,000	13,450
17						
18						
19						
20						

APPENDIX TABLE 5

ESTIMATED ANNUAL TAXES BY LEVELS OF PRODUCTION AND FARM PRICE

Price Level	Type of Tax	10-acre Q_1 a/	10-acre Q_2 a/	50-acre Q_1	50-acre Q_2	100-acre Q_1	100-acre Q_2	150-acre Q_1	150-acre Q_2
	Gross Income	$ 180	$ 240	$ 900	$ 1,200	$ 1,800	$ 2,400	$ 2,700	$ 3,600
$1.20	Corporate	--	--	--	28,451	34,599	84,399	71,410	140,110
	Property	56		284		705		989	
	Total	236	296	1,184	29,935	37,104	87,504	75,099	144,699
	Gross Income	240	320	1,200	1,600	2,400	3,200	3,600	4,800
$1.60	Corporate	852	7,492	29,226	68,251	95,507	163,999	160,960	265,510
	Property	56		284		705		989	
	Total	1,148	7,868	30,710	70,135	98,612	167,904	165,549	271,299
	Gross Income	300	400	1,500	2,000	3,000	4,000	4,500	6,000
$2.00	Corporate	6,822	15,452	59,076	108,069	153,999	243,599	250,510	384,910
	Property	56		284		705		989	
	Total	7,178	15,908	60,860	110,353	157,704	248,304	255,999	391,899

a/ Q_1 = 3,000 lbs. per acre per year.
Q_2 = 4,000 lbs. " " " ".