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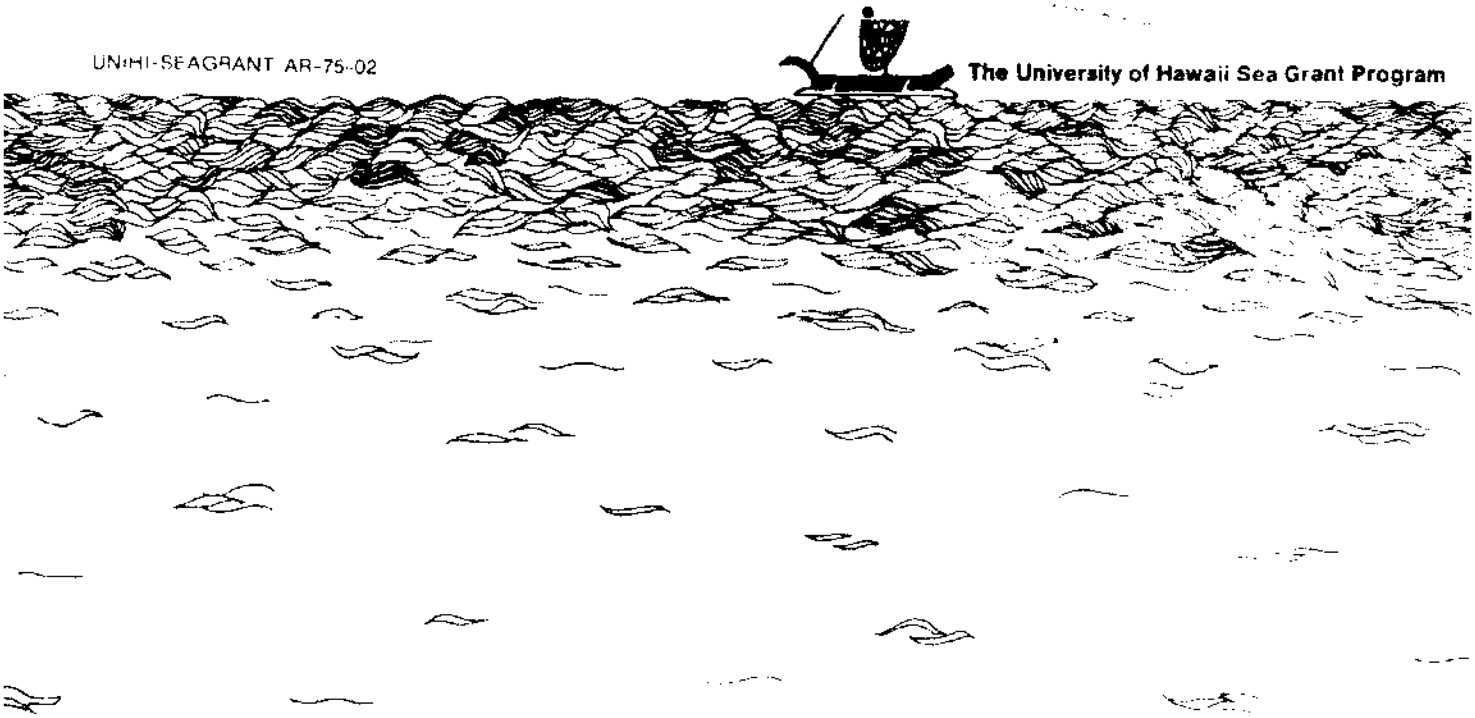

The University of Hawaii Sea Grant Program

The Commercial Production of Topminnows

A Preliminary Economic Analysis

Samuel F. Herrick, Jr. and Wayne J. Baldwin

January 1975

THE COMMERCIAL PRODUCTION OF TOPMINNOWS
A Preliminary Economic Analysis

by

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ABSTRACT

In an effort to provide alternative supplies of live baitfish suitable for use in the skipjack tuna (**Katsuwonus pelamis**) *fishery, researchers at the Hawaii Institute of Marine Biology have been investigating the feasibility of rearing the topminnow* (**Poecilia vittata**) *using high-density cultural techniques.*

Preliminary results from experiments using a prototype breeding and rearing system indicate that topminnows thrive and reproduce under a variety of environmental conditions. Broods produced by females kept in the prototype breeding pond contained on the average significantly larger numbers than those produced by their counterparts in the wild. Newly released young were removed from the breeding pond on a regular schedule and, after being placed in rearing ponds, grew to baitfish size within three months. Mortalities were exceptionally low.

Since the amount of time required to catch the nehu and the high mortality rate of the nehu limit the frequency and duration of fishing trips, the ease of handling and greater resistence to mortality of the topminnow may outweigh the tuna-attracting ability of the nehu.

The costs of producing topminnows are substantially lower than the costs of capturing live bait. Therefore, the production of topminnows on a commercial level using the techniques developed at the Hawaii Institute of Marine Biology appears economically feasible. The topminnows may be sold to the skipjack tuna fishermen at a price low enough to assure the fishermen of a profit after expenses.

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INTRODUCTION

The skipjack tuna (*Katsuwonus pelamis*) fishery is the most important commercial fishery in the state of Hawaii. Skipjack are caught using the traditional pole-and-line fishing method which requires the use of large quantities of live bait to attract the schools to the vessel. At present nehu (*Stolephorus purpureus*) is the major species of live bait utilized in the fishery (Shang and Iversen, 1971).

Nehu are caught by the fishermen before proceeding to the fishing grounds. This method of obtaining bait may consume as much as 50 percent of the fishing time, clearly limiting the amount of time that can be spent in pursuit of the skipjack. Furthermore, the nehu is a very delicate fish and has a high mortality rate both during capture and after it is placed aboard the fishing vessel. These two factors--the amount of time required to catch the nehu and its high mortality rate--limit the frequency and duration of fishing trips.

A number of attempts has been made to provide an alternate source of baitfish in Hawaii. Research with the topminnow (*Poecilia vittata*[1]) (Figure 1) supported by the University of Hawaii Sea Grant Program from September 1970 through August 1972 and conducted at the Hawaii Institute of Marine Biology (HIMB) has indicated that this species has a potential as a substitute live baitfish. It is hardy and easy to handle and readily adjusts to a variety of environmental conditions. Consequently, the rearing of topminnows at HIMB by intensive cultural methods has been reasonably successful (Baldwin, 1972, 1974).

A PRELIMINARY DESCRIPTION

The topminnow belongs to the new world family of fishes, the Poeciliidae (Rosen and Bailey, 1963). Recent studies suggest that this family contains close to 140 recognizable species which are more generally known as mosquitofishes or livebearers and, because of their popularity as aquarium fishes, the biology of many forms such as the common guppy (*Poecilia reticulata*) is reasonably well known.

Like other members of the Poeciliidae, *P. vittata* is viviparous, that is, it gives birth to well-developed young periodically during the year. Although many topminnows have been known to eat their young, no evidence of cannibalism has been detected in captive and wild *P. vittata* in Hawaii. The frequency and size of successive broods are dependent upon a number of environmental and biological factors such as salinity, water temperature, quantity and quality of food, size of female, and population density. Adult females were observed to release a brood of young mollies every 28 to 30 days in water temperatures from 25° to 30°C. The mean brood size recorded

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[1]The species previously reported by Baldwin (1972, 1974) as *P. sphenops* has been identified as *P. vittata* by Bill Fink, Systematics Laboratory, National Museum of Natural History, Washington, D.C.

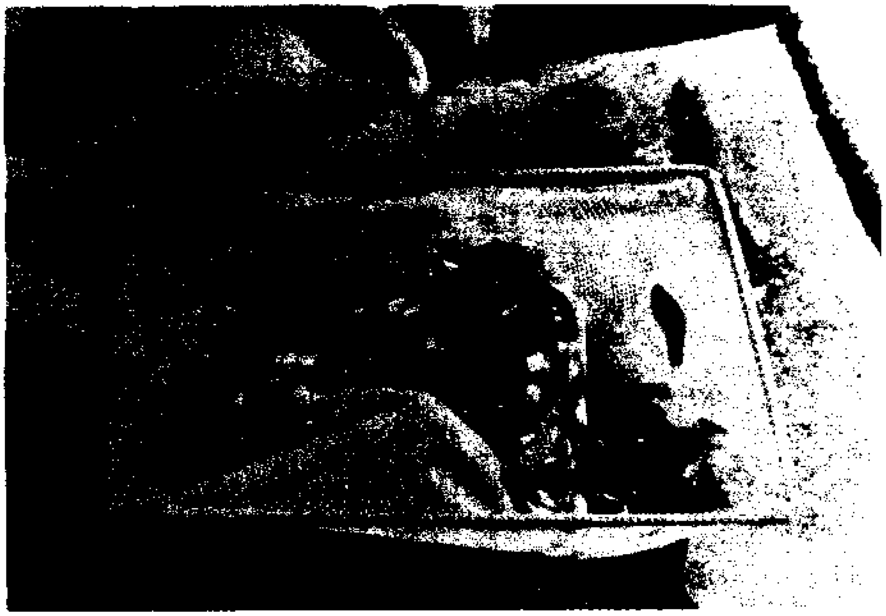

Figure 1. Adult topminnows (*Poecilia vittata*) used during tests at sea were reared in captivity at HIMB. The largest fishes are 7.5 cm (3 in) in length.

for a group of 25 select adult female topminnows raised in captivity under optimal conditions at HIMB was 137 young with a range of from 105 to 174 young. The standard length of the adult females ranged from 52 to 60 mm. The largest brood recorded to date contained 281 developing embryos; it was removed from a 72-mm (standard length) female. In comparison, the mean brood size recorded for a series collected from a mangrove habitat in Kaneohe Bay, Oahu was 14 with a range of from 9 to 33 young per female. The standard length of 20 adult females was 25 to 39 mm.

A mean brood size of 50 young topminnows per adult female released every 30 days over a 12-month period is used in the economic analysis. Observations of topminnows have shown that not all young are born alive; however, no tests were conducted to determine the exact mortality rate during the gestation period under different situations. In addition to mortalities during the three-month period,[2] precautions should be taken against the effects of occasional outbreaks of disease, equipment failures, bird predation, adverse weather conditions, and human error which would no doubt reduce annual production of bait-sized topminnows.

Following a series of tests with topminnows at HIMB under a variety of conditions over a two-year period, it was possible to delineate a number of factors relative to their biology, handling, and facility design that can

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[2]Tests at HIMB indicate that bait-sized topminnows (3.8 to 5.7 cm in total length) require a 10 to 12-week growing period.

be applied on a practical basis. Those factors considered important relative to the production of bait-sized topminnows on a commercial level are briefly outlined on the following pages, followed by a description of the recommended facility design.

Water Quality Parameters Conducive to Optimum Production of Topminnows

Water temperature

The optimal temperature range is from 28° to 30°C. Successful growth and reproduction were attained in a range of from 23° to 34°C.

Water salinity

The recommended range is from 3.5 ppt to 17.5 ppt (10 percent to 50 percent seawater.) Topminnows are able to complete their life cycle in a range of salinities from pure fresh water to pure seawater (35°/₀₀); however, consistently good results were obtained in the recommended salinity range.

Water exchange rate

The flow rate of gallons per minute (gpm) is quite variable and is dependent upon a number of factors including density of topminnows, aeration, water quality, and facility design. One complete exchange per day coupled with good aeration at a density of 4 adults per gallon in the brood ponds are recommended for maximum production of young. Densities of as high as 81 adult topminnows (mean weight of 1.31 gm) per gallon were confined in a 100-gal bait tank at HIMB under simulated shipboard conditions for ten days. With a flow rate of 2 gpm plus aeration, the topminnows were successfully held with a maximum mortality of less than 0.1 percent. Maximum flow rates for brood and rearing ponds are given in Table 1 for different levels of production. Good growth and reproduction can be attained with an exchange rate considerably less; however, the exact flow of water required must be determined *in situ*. With an exchange of water at the rate of once per 24-hour period, the flow rate per day would be equal to the total volume of the pond.

Dissolved oxygen

The recommended range is from 3.0 ppm to saturation at prevailing temperature. The lethal dissolved oxygen level is suspected to be between 0.9 and 1.1 ppm.

Hydrogen ion concentration (pH)

The recommended pH range is from 7.8 to 8.3. Ranges of from 7.6 to 9.3 were recorded during tests. No short-term effects or unexplained mortalities not caused by other factors were observed.

TABLE 1. PRODUCTION SCHEDULE OF TOPMINNOWS (*POECILIA VITTATA*) BY NUMBERS OF BUCKETS PER YEAR INCLUDING BASIC REQUIREMENTS FOR A COMMERCIAL ENTERPRISE

	Production Level in Thousands of Buckets per Year*										
	3	6	12	18	24	30	36	42	48	54	60
BROOD PONDS†											
Number of brood ponds	1	2	4	6	8	10	12	14	16	18	20
Total water volume in thousands of gallons§	8	16	32	48	64	80	96	112	128	144	160
Volume of compressed air in cubic feet per minute	0.6	1.2	2.4	3.6	4.8	6.0	7.2	8.4	9.6	10.8	12.0
Pounds of dry food mixture required per day**	21	42	84	126	168	210	252	294	336	378	420
Thousands of adult topminnows (1:1 sex ratio)	32	64	128	192	256	320	384	448	512	576	640
Thousands of breeding female topminnows	16	32	64	96	128	160	192	224	256	288	320
REARING PONDS††											
Number of rearing ponds	1	2	4	6	8	10	12	14	16	18	20
Total water volume in thousands of gallons	81	163	326	489	652*	815	978	1140	1303	1466	1629
Volume of compressed air in cubic feet per minute	4.8	9.6	19.2	28.8	38.4	48.0	57.6	67.4	77.0	86.6	96.4
Pounds of dry food mixture required per day§§	8.5	17	34	51	68	85	102	119	136	153	170

*One bucket of topminnows is equivalent to approximately 6 pounds of 3,000 individuals at 3 months of age.

†Pond size 16.5 m x 5 m x .5 m (50 ft x 15 ft x 18 in) deep.

§This volume is equivalent to the flow rate per day required for one complete exchange as recommended.

**The pounds of dry food required is based upon 3 percent of the body weight of the fish per day.

††Pond size used in these calculations is equivalent to 1/8 acre with a mean depth of .75 m (24 in) or 1/4 acre with a mean depth of .3 m (13 in).

§§The pounds of dry food (finely powdered) required for young topminnows on a daily basis is estimated at 15 grams per bucket or per 3,000 individuals. This figure will gradually increase with growth.

Lighting

For production and growth, direct sunlight appears necessary. Best results were obtained in outside ponds having full sun or with partial shade. In tropical localities where extremes in temperature are common, partial shade should be included in facility design.

Biological Parameters for Maximum Production of Topminnows

Density of topminnows

Brood pond density for maximum production of young should not exceed 6 adults per gallon; 4 adults per gallon is recommended. Rearing pond density should not exceed 10 to 15 young per gallon; 10 young per gallon is recommended for maximum growth. Density in bait wells or holding ponds will depend upon facility design and the volume and quality of water. (For recommended design of live-bait wells, see Baldwin, 1973.) Tests at HIMB indicated that densities of from 30 to 81 adult topminnows per gallon can be confined for periods of 30 days or more with mortalities not exceeding 1 or 2 percent.

Sex ratio of adult topminnows

For maximum production of young the recommended sex ratio for adult topminnows in the brood ponds is a 1:1 male to female ratio. Tests in aquaria having sex ratios of 1 male to 1 female, 3 males to 7 females, and 1 male to 9 females demonstrated that brood size is influenced by sex ratio. The higher the number of adult females per male topminnow, the smaller the broods (fertilized eggs to fully developed unborn young), all other factors being equal. Additional studies are required to determine growth and reproduction limiting factors related to population density and sex ratio.

Food and feeding

Topminnows are omnivorous and thrive on a large variety of natural and prepared foods. All prepared foods offered were consumed but no studies were conducted to determine diet preference. Because both items were easily accessible, a dry food mixture consisting of 50 percent tuna fish meal (54 percent to 58 percent crude protein) and 50 percent chick mash (20 percent crude protein) mixed together was used successfully as the primary food. The quantity fed was based upon the rate of 3 percent of the body weight per day. Most, if not all, of the food was consumed since topminnows feed at the surface, in midwater, and at the bottom. It is important that food particle size correspond to the size of the topminnows. Newly released young require finely powdered or sifted food while adults will eat food particles of 0.5 mm or more, depending on the type of food.

Facility Design to Optimize Production

Brood ponds

These are shallow ponds with a mean water depth of 18 inches, length of 50 feet, and width of 15 feet. The volume of water is slightly over 8,000 gal. At least three air stones down the center of the pond and one or two water inlets at one end with a discharge pipe at the opposite end are desirable for aeration and circulation. The bottom is angled down at 10 degrees towards the center to concentrate solid wastes that are easily removed by siphon or pump periodically at the center. The water level may be controlled by an adjustable standpipe at one end.

Observations on the behavior of juvenile topminnows show that they tend to concentrate at the pond edges for several days following birth, especially if shade, cover, or both are provided. This behavior makes it possible to include in the brood pond design a simple means for removing the young on a daily basis. This feature is the addition of a shallow, screened trough approximately 4 to 6 inches deep around the inside perimeter (Figure 2)--similar to a swimming pool trough. The lip of the trough would be 8 to 12 inches below the top of the pond with the water level normally 1 inch above the trough lip. By adding a strip of 1/4-inch mesh metal screen 5 to 6 inches high to the edge, young topminnows can enter the trough by passing through the screen while the adults are confined within the pond proper. To remove the young, a lift gate installed at one end (Figure 3) is removed, allowing the water level to drop below the lip of the trough. With the aid of a water hose, the young are gently flushed from the trough. The gate is then closed and the pond water level allowed to return to normal. A hinged shade cover (Figure 4) was added to the trough; it improved the brood pond efficiency.

Rearing ponds

The specific shape and size of the rearing pond are not as critical as for the brood pond. Past experience indicates that a pond size of 1/8 to 1/4 acre with a mean water depth of 12 to 24 inches and having a rectangular or circular shape is suitable. The water volume would be from 41,000 to 163,000 gal depending upon pond size. The number of ponds will depend upon the production level of bait-sized topminnows. Simple outdoor ponds excavated by a bulldozer and provided with the recommended water flow (see Table 1) may be all that is required, provided there is a suitable substrate and provided water level can be controlled. In porous soils it may be feasible to seal the ponds against excess water loss by the addition of a synthetic liner; however, costs will increase. Ideally, reasonably level shoreline areas adjacent to the ocean and protected from the effects of adverse weather and with a constant supply of good quality brackish water are desirable. Pond construction will depend upon geographical location and the prevailing topography. In suitable areas that have subsurface water levels near ground level, pond construction may be feasible by simple excavation. A water-saturated substrate near the surface would hopefully reduce or perhaps prevent water loss by percolation. A sufficient inflow of water and adequate aeration are required to reduce

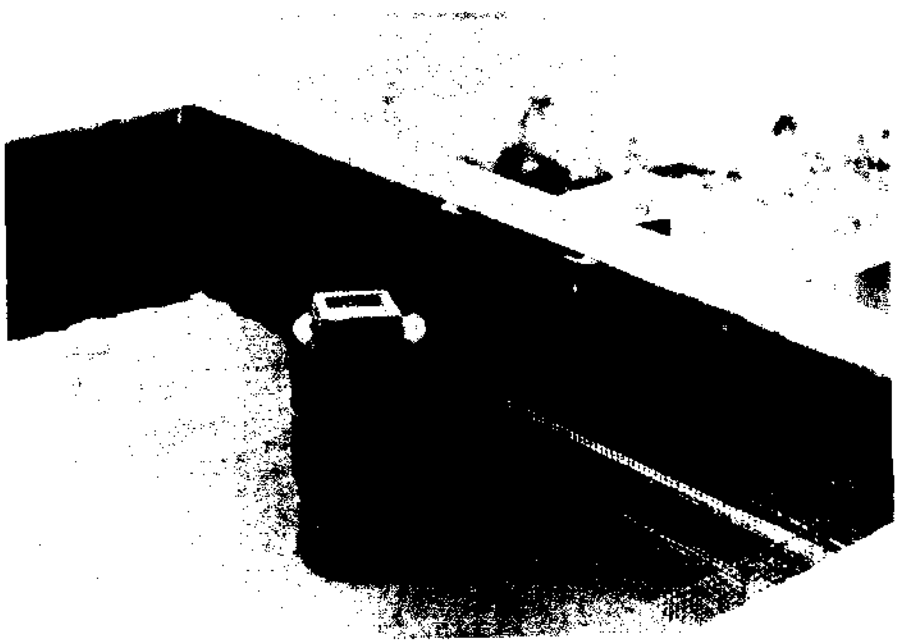

Figure 2. Inside corner of an experimental 2.6 m x 1.3 m (8 ft x 4 ft) brood tank constructed of plywood and fiberglass used for tests at HIMB. The inside perimeter trough with the 7.0-mm (1/4-inch) mesh screen is shown with the lift gate removed. The screened standpipe (at left center) controls the water level.

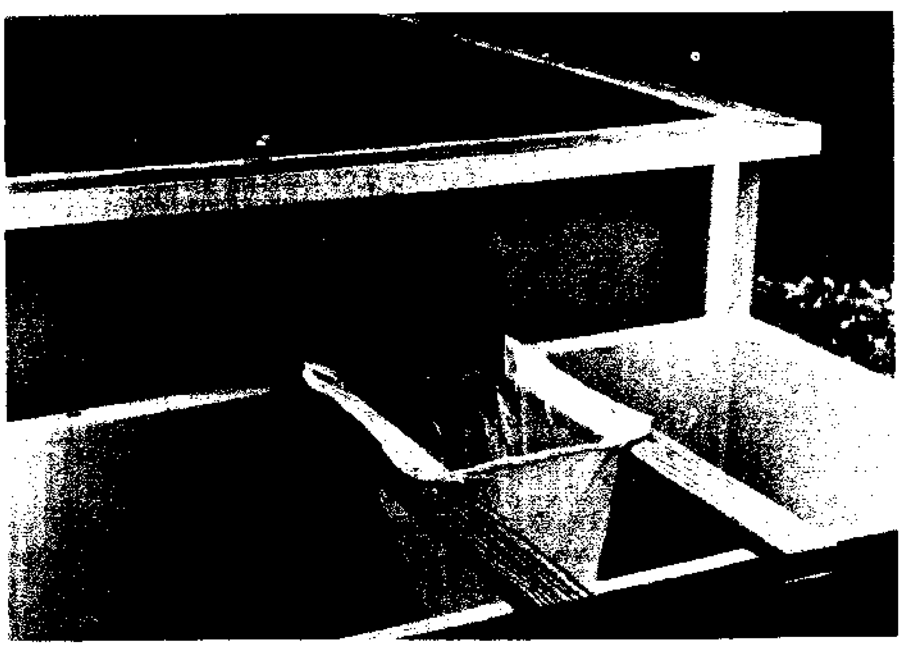

Figure 3. The 2.6 m x 1.3 m (8 ft x 4 ft) experimental brood tank at HIMB showing the lift gate raised for removing new born *P. vittata* from the screened trough inside. After the young topminnows are removed, the gate is pushed down into position and the inside water level allowed to return to normal--about 1-inch above the lip of the trough.

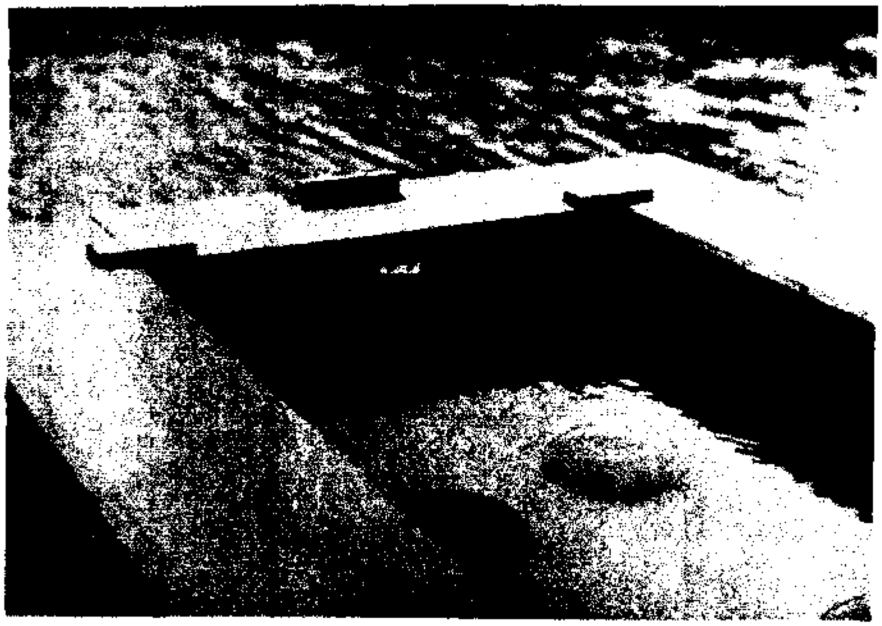

Figure 4. One end of the 2.6 m x 1.3 m (8 ft x 4 ft) experimental brood tank set up at HIMB. The hinged 1 inch x 12 inches wood shade cover is shown in position with the screened trough beneath. At left center the lift gate is pushed down into position and the screened standpipe controlling the tank water level is shown.

hydrogen sulfide accumulation that is highly toxic to fishes. In tropical localities where extremes in temperature frequently occur, some protection from the effects of too much sun should be included in the pond design.

ECONOMIC ANALYSIS

Cost-Revenue Analysis of a Topminnow Baitfish Enterprise: Present Value Technique

Together with the preliminary biological and technological considerations, the economics relative to the commercial production of topminnows for live bait must also be considered. Determining the economic feasibility of commercial topminnow production requires information regarding project outlays,[3] production, and price.

[3]Project outlays include captial investment, the expenditure necessary to establish the enterprise, and operational costs--costs of inputs, equipment maintenance, etc.--that are incurred during the production process.

Capital investment represents the funding initially committed to a project which is expected to return the investment plus a profit during future periods. However, to make a meaningful comparison between the initial investment and expected future returns, the time value of money must be considered since a sum of money today will not be equivalent to the same sum of money at a future point in time unless interest is at the unrealistic rate of zero. This discrepancy, the timing of associated expenditure and returns, can be overcome by discounting[4] the expected future returns by the appropriate discount rate over the life of the project. The resulting present value (value today) of future returns can then be compared directly with the initial investment. Thus, the present value technique, by taking into account the timing of expenditures and earnings, allows one to make a realistic comparison of future returns with initial expenditures.

To determine the profitability of the project using this method, one need only take the difference between the present value of the future returns and the value of the initial investment. If this difference were greater than zero, the project would be profitable from an economic standpoint. On the other hand, if the difference were less than zero, investment in the project would result in a loss. The difference between present value of future returns and the value of the initial investment can be expressed mathematically as:

$$NPV = \sum_{i=1}^{n} \frac{(Q_m \cdot P_m) - C_i}{(1+r)^i} - C_o \qquad (1)$$

where:

NPV - net present value

Q_m = annual quantity of topminnows produced

P_m = average price of topminnows

C_o = initial investment

C_i = annual operational costs

r = discount rate

i = 1...n number of years

[4]With an interest rate greater than zero, a sum of money increases as a function of time--a process known as compounding. Thus under the same circumstances, when bringing a future sum back to an earlier period of time, the sum decreases. This process is called discounting.

Enumeration of Costs and Revenues

Initial costs

Initial costs include the investment in ponds, wells, water storage tanks, equipment, and the land upon which these facilities will be located.[5] (See Tables 2, 3, and 4.) Costs of establishing an adult brood stock are not included in the initial costs. The full amount of these costs is treated as initial costs as of time zero and there is no charge for interest or annual depreciation.

Operating and replacement costs

Operating costs refer to the costs of operating the system; it includes the costs of maintaining equipment. Replacement costs refer to the costs of replacing worn out equipment. Those costs related to the replacement of adult brood stock loss due to natural mortalities however are not included. Operating costs will vary with the level of production while costs related to the replacement of equipment will vary yearly, depending upon the physical life of the equipment. (See Table 5.)

Discount rate

The discount rate normally reflects the rate of return which can reasonably be expected from alternative investments. If allowances for risk and uncertainty were to be included in the cost and revenue estimates, a discount rate corresponding to a "riskless" investment (5 to 7 percent currently offered by most financial institutions) may then be used. If, however, cost and revenue estimates were not adjusted for risk and uncertainty, as is the case in this study, an allowance could be incorporated in the discount rate.

Because risk and uncertainty associated with any baitfish enterprise may be rather high due to changes in fishing technology, discovery of additional or alternative natural bait stocks, or overexploitation leading to depletion of the skipjack stock, interest rates of 10, 20, and 30 percent will be used to determine present value.[6]

Annual production

Each breeding unit will produce 250 buckets[7] of topminnows per month or at an equivalent level in thousands of buckets per year (Table 1). In

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[5]Initial costs could be substantially reduced by leasing the needed land. Under such an arrangement lease rental becomes an annual expense.

[6]As can be seen in Equation 1, raising the discount rate will decrease the NPV.

[7]One bucket of topminnows weighs approximately 6 pounds and is estimated to contain 3,000 fish.

TABLE 2. PROJECT OUTLAYS FOR A 3,000 BUCKETS/YEAR BAITFISH PRODUCTION SYSTEM

CAPITAL INVESTMENT		
COSTS OF CONSTRUCTION		
1 Brood pond		
Design*	$ 147	
Excavation and construction	1,474	
1 Rearing pond		
Design	732	
Excavation and construction	7,322	
2 Wells (25-ft deep)	3,600	
2 Water storage tanks (53,000 gal each)	14,263	
Subtotal		$27,538
COSTS OF EQUIPMENT†		
2 Pumps (450 gpm) and 2 motors (7.5 hp)	5,000	
Plumbing, etc. (3" PVC)	1,000	
100-cfm air compressor (25-hp motor)	3,975	
1 one-ton utility truck	10,000	
Portable fish pump and transfer hoses	3,775	
Water analysis kit	250	
Experiment, work, and storage shed	2,930	
Refrigeration and food preparation	3,360	
40-amp generator (120/240 volts)	2,400	
Miscellaneous	1,500	
Subtotal		$34,190
TOTAL		$61,728
OPERATIONAL COSTS		
COSTS OF INPUT AND EQUIPMENT MAINTENANCE		
Electricity	$ 1,200	
Food (38,900 lb)	1,000	
Labor (1 technician, 1 laborer)	19,000	
Maintenance	1,500	
TOTAL		$22,700
OTHER COST		
COST OF LAND		
1 acre§ (total real estate required)	$13,000	
TOTAL		$13,000

*10 percent of cost of excavation and construction.

†Equipment costs vary year to year depending upon the physical life of the equipment (see Table 5).

§The value of agricultural land ranged from $4,000 to $30,000 an acre. In this study an acre valued at $13,000 is used.

TABLE 3. PROJECT OUTLAYS FOR A 30,000 BUCKETS/YEAR BAITFISH PRODUCTION SYSTEM

CAPITAL INVESTMENT		
COSTS OF CONSTRUCTION		
10 Brood ponds		
Design*	$ 147	
Excavation and construction	11,792	
10 Rearing ponds		
Design	732	
Excavation and construction	58,576	
2 Wells (25-ft deep)	3,600	
2 Water storage tanks (53,000 gal each)	14,263	
Subtotal		$ 89,110
COSTS OF EQUIPMENT†		
2 Pumps (450 gpm) and 2 motors (7.5 hp)	5,000	
Plumbing, etc. (3" PVC)	2,000	
100-cfm air compressor (25-hp motor)	3,975	
1 one-ton utility truck	10,000	
Portable fish pump and transfer hoses	3,775	
Water analysis kit	250	
Experiment, work, and storage shed	4,392	
Refrigeration and food preparation	4,000	
40-amp generator (120/240 volts)	2,400	
Miscellaneous (includes automatic fish feeders)	7,500	
Subtotal		$ 43,292
TOTAL.		$132,402
OPERATIONAL COSTS		
COSTS OF INPUT AND EQUIPMENT MAINTENANCE		
Electricity	1,200	
Food	9,956	
Labor (1 technician, 2 laborers)	25,000	
Maintenance	3,000	
TOTAL.		$ 39,156
OTHER COST		
COST OF LAND		
7 acres§ (total real estate required)	91,000	
TOTAL.		$ 91,000

*10 percent of cost of excavation and construction

†Equipment costs vary year to year depending upon the physical life of the equipment (see Table 5).

§The value of agricultural land ranged from $4,000 to $30,000 an acre. In this study an acre valued at $13,000 is used.

TABLE 4. PROJECT OUTLAYS FOR A 60,000 BUCKETS/YEAR BAITFISH PRODUCTION SYSTEM

CAPITAL INVESTMENT		
COSTS OF CONSTRUCTION		
20 Brood ponds		
Design*	147	
Excavation and construction	23,584	
20 Rearing ponds		
Design	732	
Excavation and construction	117,152	
2 Wells (25-ft deep)	3,600	
2 Water storage tanks (100,000 gal each)	25,673	
Subtotal		$170,888
COSTS OF EQUIPMENT†		
2 Pumps (450 gpm) and 2 motors (7.5 hp)	5,000	
Plumbing, etc. (3" PVC)	3,000	
150-cfm air compressor (40-hp motor)	5,960	
2 one-ton utility trucks	20,000	
Portable fish pump and transfer hoses	7,550	
Water analysis kit	250	
Experiment, work and storage area	4,392	
Refrigeration and food preparation	5,000	
2 40-amp generator (120/240 volts)	4,800	
Miscellaneous (includes automatic fish feeders)	8,500	
Subtotal		$ 62,467
TOTAL.		$233,355
OPERATIONAL COSTS		
COSTS OF INPUT AND EQUIPMENT MAINTENANCE		
Electricity	1,800	
Food	19,984	
Labor (1 technician, 3 laborers)	31,000	
Maintenance	6,000	
TOTAL.		$ 58,784
OTHER COST		
COST OF LAND		
14 acres§ (total real estate required)	182,000	
TOTAL.		$182,000

*10 percent of cost of excavation and construction

†Equipment costs vary year to year depending upon the physical life of the equipment (see Table 5).

§The value of agricultural land ranged from $4,000 to $30,000 an acre. In this study an acre valued at $13,000 is used.

TABLE 5. ESTIMATES OF THE PHYSICAL LIFE OF EQUIPMENT ASSOCIATED WITH RAISING TOPMINNOWS IN PONDS

Item	Physical Life Years
Ponds	40
Wells	25
Pumps	18
Plumbing	30
Air Compressor	15
Vehicle	5
Portable Fish Pump and Transfer Hoses	10
Water Analysis Kit	5
Experimental Work and Storage Shed	15
Refrigeration and Food Preparation	15
Storage Tanks	40
Generator	10

this study, for simplicity, it is assumed that optimal conditions prevail, i.e., there is a continuous monthly production of topminnows with all newborn surviving to marketable size. In addition, the entire output will be taken off the market at a constant price per bucket.

Shang and Iversen (1971) estimated the year-round breakeven price for a bucket of nehu in Hawaii to be $12.70. This breakeven price represents the cost of capturing a bucket of nehu and consequently the maximum amount fishermen would be willing to pay for a bucket of bait. If nehu were available through the market at a price below the breakeven price, it would be more profitable for fishermen to purchase bait. Since the breakeven price for nehu has been estimated, the breakeven price for topminnows can be determined by comparing its tuna attracting ability and mortality rate with that of nehu.

In this study, it is assumed that the tuna attracting ability of topminnows--the capacity of the bait, when chummed, to attract and hold skipjack tuna during fishing--is 70 percent that of nehu.[8] Based upon this characteristic, the relative price of topminnows should be 70 percent that of nehu. Traditionally, the majority of nehu may be held in vessel bait wells for periods up to 24 hours following capture and before use. Between

[8]See Baldwin (1974). Observations at sea by the authors and information received from Hawaiian fishermen also indicate that the 70 percent level is realistic.

capture and use, nehu mortalities at times average up to 25 percent per day. In comparison, tests with topminnows by HIMB personnel indicate that shipboard mortalities will usually be insignificant over the same 24-hour period. Tests with topminnows under simulated shipboard conditions indicate that they can be held for periods of from one week to several months with insignificant mortalities. Thus, upon reaching the fishing grounds fishermen using topminnows would have approximately 25 percent more bait for the first day or so than fishermen using nehu. If the additional bait on the fishing grounds were to result in a proportionally greater catch of skipjack tuna, the fishermen could profitably pay up to 25 percent more for topminnows than for nehu. Therefore, the net effect of live bait mortality and tuna attractability characteristics would cause the breakeven price of topminnows to be 95 percent that of nehu, or $12.07 per bucket.

$$P_m = .95\ P_n$$

where: P_m = price of topminnows per bucket

and P_n = price of nehu per bucket.

Revenue

Revenue is the income generated from producing the baitfish and is found by multiplying the total number of buckets sold by the price per bucket. Usually one of the objectives of the enterprise is to produce at full capacity and to sell the entire output at the current market price, thus maximizing revenue.

Result of Present Value Calculations

Net present values were calculated for three different levels of annual output.[9] Results of the calculations are shown in Table 6.

Since the net present values for the 30,000 and 60,000 (equivalent to an output of 2,500 and 5,000 buckets per month) bucket annual production levels are positive, investment in these enterprises would be profitable under the conditions described herein. For an annual output of 3,000 (equivalent to 250 buckets per month) buckets, investment in the enterprise would be profitable at the 10 percent discount rate, but unprofitable at the 20 percent and 30 percent rates.

[9]An annual output of 3,000 buckets is that which is estimated for a system composed of one each of the brood and rearing ponds described under "Facility Design to Optimize Production" (see Table 1). An annual production of 30,000 buckets represents a tenfold increase in annual production and approximates the average annual requirement of nehu of the traditional skipjack fishery. An annual production of 60,000 buckets represents the potential baitfish requirement should topminnows become a viable substitute for nehu, consequently allowing the fishermen to spend more time in pursuit of the skipjack.

TABLE 6. NET PRESENT VALUE FOR A TOPMINNOW BAITFISH ENTERPRISE

Years of Operation*	Annual Output (Buckets)	Discount Rate (%)	Present Value (PV) Revenues ($)	PV ($) Costs	Net Present Value (NPV) PV Revenues-PV Costs ($)
20	3,000	10	275,359	264,175	11,184
20	3,000	20	146,152	173,260	(27,108)
20	3,000	30	92,211	135,917	(43,706)
20	30,000	10	2,753,584	538,446	2,215,138
20	30,000	20	1,461,521	388,468	1,073,053
20	30,000	30	922,113	326,529	595,584
20	60,000	10	5,507,175	856,785	4,650,390
20	60,000	20	2,923,045	628,858	2,294,187
20	60,000	30	1,844,219	534,621	1,309,598

*A 20 year rather than 40 year period (physical life of ponds and wells) is used in the NPV calculations since uncertainties related to changes in fishing technology and therefore baitfish demand could substantially reduce the useful life of these assets.

The Breakeven Price of a Topminnow Baitfish Enterprise

The breakeven price used in the present value calculations is the estimated maximum price fishermem would be willing to pay for a bucket of topminnows. If the initial costs, operating costs, level of production, and discount rate were known, it would be possible to determine a selling price for a bucket of topminnows which would result in a zero net present value for the baitfish operation. This price is the producer's breakeven price.[10] By assuming a NPV equal to 0, equation (1) can be rewritten as:

$$\sum_{i=1}^{n} \frac{(Q_m \cdot P_m)}{(1+r)^i} = C_o + \sum_{i=1}^{n} \frac{C_i}{(1+r)^i} \qquad (2)$$

By maintaining a constant level of output over time, equation (2) becomes:

$$(Q_m \cdot P_m) \cdot \left[\frac{1 - (1+r)^{-n}}{r}\right] = C_o + \sum_{i=1}^{n} \frac{C}{(1+r)^i}$$

[10]This price is essentially what it costs to produce a bucket of topminnows, including the producer's expected rate of return. Thus a bucket of topminnows purchased at a price in excess of this price will produce a profit for the enterprise.

and

$$P_m = \left(\frac{C_o + \sum_{i=1}^{n} \frac{C_i}{(1+r)^i}}{\left[\frac{1-(1+r)^{-n}}{r}\right]} \right) \cdot \frac{1}{Q_m} \qquad (3)$$

where P_m is the price resulting in zero net present value or the producer's breakeven price for the topminnow baitfish enterprise. The results of the breakeven price calculations for the topminnow baitfish enterprise are summarized in Table 7.

TABLE 7. PRODUCER'S BREAKEVEN PRICE FOR A TOPMINNOW BAITFISH ENTERPRISE

		Breakeven Price per Bucket (P_m)		
Years of Operation	Discount Rate (%)	3,000 buckets/yr*	30,000 buckets/yr	60,000 buckets/yr
20	10	10.34	2.11	1.68
20	20		2.66	2.15
20	30		3.28	2.69

*The producer's breakeven price is not calculated for the 3,000 bucket annual production level at the 20 percent and 30 percent discount rates. This is because the NPV's are negative for these two discount rates. Therefore, the resulting producer's breakeven prices would be greater than the price fishermen would be willing to pay for a bucket of topminnows.

SUMMARY AND CONCLUSIONS

The present value method is used to evaluate the economic feasibility of a topminnow baitfish enterprise herein described. Investment in the enterprise is profitable if the calculated net present value is positive. Conversely, if the net present value is negative, investment in the enterprise would not be economically justified.

The price per bucket of topminnows used in the present value calculations is derived from the opportunity costs of a bucket of nehu by comparing the tuna-attracting abilities and mortality rates of topminnows and nehu.

Present value calculations were made using three levels of annual production: 3,000, 30,000, and 60,000 buckets. Discount rates of 10, 20, and 30 percent were employed over a 20-year period of operation. Results of the present value calculations indicate that the topminnow operation would be profitable for the 30,000 and 60,000 levels of production at all three discount rates, while the 3,000 bucket annual production enterprise would only be profitable at the 10 percent discount rate.

The calculated producer's breakeven price for a bucket of topminnows showed that, for those operations experiencing a positive net present value, a net return from the enterprise could still be realized at a selling price below the derived price for topminnows used in the present value calculations.

Since most of the data used in this study is based upon preliminary findings, it is recommended that further investigation be conducted to determine: (1) the tuna-attracting ability of topminnows; (2) the actual mortality rate of topminnows at different densities in the bait wells; (3) the effects of reproduction and growth limiting factors; and (4) the genetic makeup and variability of topminnows.

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