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The Financial Feasibility of Small-Scale Marine Ornamental Aquaculture in the Philippines

R.S. POMEROY and C. BALBOA

Department of Agricultural and Resource Economics and Connecticut Sea Grant Program
University of Connecticut-Avery Point
1080 Shennecossett Road
Groton, CT 06340 USA

World Resources Institute
Ten G Street Northeast
Washington, DC 20002, USA

Abstract

Aquaculture is being increasingly cited as a priority solution for reducing the pressures on coral reefs arising from over- and destructive fishing associated with the trade in wild-caught live reef organisms. This paper presents a financial feasibility analysis for the culture of common clownfish (*Amphiprion ocellaris)* as a representative species for the culture of marine ornamentals by small-scale fishers in the Philippines. The analysis focuses on an integrated, full-cycle aquaculture system of broodstock, hatchery, larval rearing/nursery, and grow-out. The financial analysis shows that the production of clownfish in the Philippines can be profitable. However, the capital investment costs and operating costs are too high for clownfish culture to be an alternative or supplemental livelihood for small-scale fishers, unless loans and/or subsidies and technical assistance are provided.

Introduction

Like other reefs around the world, those in the Indo-Pacific are subject to pressures from human activities, that include coastal development, onshore pollution and erosion, marine-based pollution, overexploitation, the use of destructive fishing practices such as cyanide, explosives, and other poisons, and other causes (Burke, Selig and Spalding 2001; Moore and Best 2001). Among these threats, the live reef fish trade (LRFT), which involves the capture of living reef organisms (fish, coral) from the Indo-Pacific region, is currently the most destructive and unsustainable. It has been estimated that over 64% of the region's reefs are threatened by overfishing. Destructive fishing techniques put an estimated 56% of the region's reefs in peril (Burke, Selig and Spalding 2001). The sedentary nature of many coral reef species make them easy prey for fishers using cyanide, as does the habit of some larger reef fish species to aggregate in larger numbers at certain sites during spawning. Cumulatively, these pressures have had two results: 1) the degradation and/or net loss of reef habitat to sustain reef organisms, and 2) the loss of biomass through the removal of organisms.

Two destructive target reef fisheries for the LRFT are the live food fish trade and nonfood reef products for the curios and marine ornamental trade (Barber and Pratt 1997). A recent global assessment of some 200 fisheries around the world concluded that the live reef fisheries of Southeast Asia and the Western Pacific represent some of the most threatened fisheries on the planet, due in large part to the growing and lucrative live reef fish and ornamental fish trades and their association with the use of cyanide to capture these fish (Weber 1998).

Related to the live reef fish trade is the unsustainable and often illegal trade in coral reef products, including a variety of fish, corals, sea horses, mollusks and sponges, as well as sea turtles and dugongs. This has led to the endangerment of several species through the economic and biological extinction of local populations (Baquero 1999; Biffar 1997; Bruckner 2000, 2001; Cresswell 2001; Johannes and Riepen 1995; South Pacific Commission Secretariat 1999; USCRTF 2000).

Farming the reef

Aquaculture is being increasingly cited as a priority solution for reducing the pressures on coral reefs arising from over- and destructive fishing associated with the trade in wild-caught live reef organisms (Graham 2001). If technologically and economically viable, aquaculture could provide an alternative or supplemental livelihood for fishers using destructive fishing practices; thus reducing or eliminating destructive fishing.

The argument for the application of aquaculture in developing country tropical nearshore waters as a solution to over- and destructive fishing in the trade in wild-caught live reef organisms is premised on four assumptions (Bell and Gervis; Hopkins 1996):

1) Availability. Technologies exist to culture major species in trade from egg to adult, a “closed cycle”.

2) Feasibility. These technologies are economically feasible in the sense that sufficient quantities can be produced to have a significant impact on demand, and at a cost that is competitive with prices for the same species captured in the wild. Techniques are socially and culturally appropriate within a developing country context.

3) Incentive driven. The firms and fishers who capture and sell live reef fish and ornamental fish from the wild would have the means and incentive to enter the aquaculture business and trade and therefore reduce their reliance on the capture of wild fish.

4) Low impact. The aquaculture technology employed will have minimum or no impact on the coral reef environments.

If aquaculture is to be taken seriously as a solution for reducing the pressures on coral reefs arising from over- and destructive fishing in the trade in wild-caught live reef organisms, there is a need to comprehensively and objectively assess the biology, technology, economics and socio-cultural feasibility of aquaculture. This involves critically evaluating the production and marketing of live reef fish for food and aquariums and selected invertebrates in coral reef environments prior to the broad scale prescription of this intervention.

To address this issue, a team of researchers undertook a research study called “Farming the Reef”. The purpose of the project was to provide information and policy recommendations for the application of aquaculture for live reef organisms in developing country tropical nearshore waters as a priority solution for reducing the pressures on coral reefs arising from over- and destructive fishing associated with the trade in wild-caught live reef organisms (Pomeroy, Parks and Balboa 2003). The project focused on the biology, economics and markets for several live reef organisms including live reef food fish (grouper: *Epinephelus sp.* and *Cromileptes sp.*), ornamental fish (clownfish), and marine invertebrates (live rock and live coral: *Scleractinia* and *Alcyonacea*).

Study focus

The focus of this paper is on one output of the Farming the Reef project, that is, a financial feasibility analysis for small-scale culture of common clownfish (*Amphiprion ocellaris)* in the Philippines. We have focused on the clownfish as a representative species for the culture of marine ornamentals since it is reasonably well-known and there are currently available culture technologies. Several other marine ornamentals, such as orchid dottybacks (*Pseudochromis fridmani*), will utilize a similar culture system.

This analysis will provide information to determine if the culture of clownfish has an economic potential as an alternative or supplemental livelihood for fishers and their families in rural fishing communities in the Philippines. The economic analysis provides basic operational and financial information for making investment decisions concerning marine ornamental aquaculture enterprises.

The study focus is on a small-scale culture technology/system level that would be suitable for rural fishing communities in the Philippines. This was the project’s target audience as fishers from these communities are the individuals primarily engaged in the marine ornamental trade and those who would undertake aquaculture as an alternative to overfishing and destructive fishing. While this study has a geographic focus on the Philippines, it is felt that the conclusions may be applicable to other countries in the Indo Pacific region.

Methods

A mix of primary and secondary data was used for this analysis. A substantial amount of biological and technological research and industry development has been completed and is ongoing on clownfish. As such, the analysis relied on information from operating clownfish culture operations and secondary information provided by scientists and industry specialists currently working on these species around the world. Contact and visits were made with scientists and industry in the United States (Hawaii, Florida, Texas), Philippines, Taiwan, and Fiji. The analysis will focus on culture techniques, from broodstock to spawning to hatchery to nursery to grow out, felt by the scientists and industry specialists to be the most technologically feasible for transfer to the Philippines and other developing countries.

The financial analysis includes initial capital investment requirements, capital asset addition schedule, fixed costs, and annual operating costs. An enterprise budget and a cash flow statement (5 year) are presented for the integrated culture system.

Life history and technology of culture production

Common clownfish or anemone fish (*Amphiprion ocellaris)* are the most commonly kept clownfish in aquariums. They have an origin in the Indo-Pacific region and reach a maximum size of 8 cm in the wild and 5 cm in aquarium. The common clownfish is omnivorous and is compatible with invertebrate. The common clownfish has a symbiotic relationship with the anemone, living among its tentacles. However, both the clownfish and the anemone can survive without the other in an aquarium. Clownfish are territorial by nature, and should be kept alone or as a mated pair in an aquarium (Pettigrew and Brown 1999; King 1999; Ogawa and Brown 2001). Clownfish can be long lived (in excess of 18 years), however anemone can be difficult to keep alive for any length of time. More than one anemone should be kept per pair of clownfish.

Clownfish are relatively easy to breed in captivity (Animal World 2002). Clownfish possess the ability to change sex. The sex change is protanderous, from male to female, and it apparently occurs by changes in the social structure of the group (Moe 1992, 1999, 2001). The dominant fish will become the female and the largest one.

Clownfish spend the first two to three weeks of their life as pelagic larvae. Once hatched, the larvae migrate upwards to the plankton layers to feed and develop. The larvae are 4 mm in size at hatching. In 10 days they grow to 6-7 mm. The larvae are fed microalgae and rotifers after hatching. After 5 to 7 days when the larvae are large enough, brine shrimp or *artemia* becomes the main food source. As the larvae develop, a mix of shrimp or scallop and pulverized dry flake food is introduced and the fish are gradually weaned onto this diet (Moe 1992; Spotts 1997).

As the free swimming larvae develop, they start crowding in the tank and form a dense shoal. The beginning of adult behavior is seen when fish settle on the bottom in association with an anemone. When the young clownfish are fully colored and about 0.635 to 1.27 cm long, they are moved to a tank with a sponge filter (Moe 1992). Clownfish are fed a varied diet of finely chopped seafoods, planktonic foods, small live sea creatures, frozen preparations and well-balanced flake food, preferably one containing algae and vitamin C (Moe 1992). When properly fed, the clownfish develop to a length of 5 cm in four months.

Technical assumptions for production

The analysis will focus on an integrated culture system of broodstock, hatchery, larval rearing/nursery and grow-out. This is assumed to be an indoor system located in a coastal area with access to both salt and fresh water and transportation to markets (Tellock 1996). A centralized system provides both UV filtered water and air to the tanks.

There are 15 broodstock pairs. At any one time there are 10 active spawning pairs. Each pair spawns an average of 2.3 times per month or every 12-18 days. An average of 750 larvae are produced during each spawn. The survival rate of the larvae to transfer to the grow-out phase is 50 percent. The period from larvae to transfer to grow-out is 30 days.

The system provides 8,625 juveniles for stocking per month. There is a 70% survival rate for juveniles to market size. Seventy percent of the market size fish are saleable. The period from nursery to market size fish of 5 cm is 120 days. The sale price per fish is US$ 2.25.

The system utilizes 114 liter tanks. There are 15 broodstock tanks, 8 nursery tanks, and 25 grow-out tanks. Artificial light is supplied to the tanks.

The first six months of the operation will be construction and set-up of building and equipment. The first production period will begin in month seven of the first year. A production run is six months. There will be 12 production runs per year beginning in year two. The first harvest and sale will occur at the end of month twelve.

Baseline assumptions for the financial analysis

The financial analysis was conducted using a specific set of descriptive, operational and financial baseline assumptions. Costs and prices were for 2001 and for conditions present in the Philippines at that time. More specific technical assumptions are presented below for the culture system.

- All loans (i.e. capital and operating) are at 18% per year.
- Initial start-up capital expenses assumes that 50% of cost is financed (i.e. 50% is owner financed).
- Initial start-up operating expenses assumes that 50% of cost is financed (i.e. 50% is owner financed). An operating loan covers all cash shortfall.
- Each system is managed by the owner-operator, whose cost of management skills is not included. Therefore, final returns are to owner-operator's management and risk. Additional labor requirements for each system are presented in the analysis.
- Returns are before taxes.
- General overhead of 3% of total variable costs is included. These are "catch-all" costs including telephone, fax, e-mail, and contingencies.
- Repair and maintenance costs are 3% of total capital investment costs.

- Miscellaneous costs are 3% of variable costs. These include general expenses for operating the system but which were unexpected during the production period.
- Land is purchased.
- Insurance is not included. The purchase of insurance, except for vehicles, is not common practice in the Philippines.
- Harvest volumes, revenues and operational expenses are assumed to be constant across the years.
- Capital assets are depreciated using the straight-line method. Salvage value is zero for all capital assets.
- The cost of land is assumed to be the same in all locations.
- Construction will take six months. Production will begin in month seven.
- One US dollar equals 50 Philippine pesos.
- All costs and prices are in US dollars.

Results

The results of the economic analysis are presented in tables 1 to 9. Tables 1 to 6 contain the capital investment analysis for the building and equipment, broodstock, nursery, grow-out, and microalgae and rotifer culture system, respectively. Total capital investment cost for year one is US$ 20,212.00 (Table 6). Yearly capital assets additions are presented in table 6. Year seven has the largest cost for capital asset additions as equipment is replaced. Fixed costs, including annual interest on investment and annual depreciation, are presented in table 7. Table 8 contains the enterprise budget for the integrated system. Table 9 contains the cash flow statement for the integrated system.

The financial analysis shows that production of clownfish in the Philippines can be profitable. The total cost of production per clownfish is $0.53 with a farm gate price of $2.25 per fish (Table 8). Gross receipts for a full production year are $114,108.00 (Table 8). While there is a negative cash flow in year one, due to the start-up costs, year two and beyond provide a positive cash flow (Table 9).

While the operation provides a positive cash flow after year two, the capital investment costs and operating costs in year one are probably too high to be an alternative or supplemental livelihood for small-scale fishers, who are often poor and lack investment capital. A small-scale fisher would need to invest $15,371.00 of their own money (since a baseline financial assumption is that the owner will finance 50% of the initial capital investment and operating expenses) in the first year.

In addition, the level of management skills and technology to culture marine ornamental fish may be beyond the capacity of most small-scale fishers without training and extension services. As with any aquaculture operation, the financial figures presented here may change due to price changes, changes in survival rate, changes in grow-out period length and improper management. A culturist will need to have consistent production of market-

Table 1. Capital Investment: Building and Equipment

Equipment	#	Year of Life	Unit cost	Total Investment Year 1	2	3	4	5	6	7	8	9	10
Land			6m2	1200	-	-	-	-	-	-	-	-	-
Site Prep			0.5m2	100	-	-	-	-	-	-	-	-	-
Fencing		5	30	30	-	-	-	-	-	-	-	-	-
Building	1	10	700	700	-	-	-	-	-	-	-	-	-
Electrical		10	225	225	-	-	-	-	-	-	-	-	-
Plumbing		10	250	250	-	-	-	-	-	-	-	-	-
Saltwater pump/pipe/ filter	1	5	400	400	-	-	-	-	400	-	-	-	-
Freshwater well/pump/ pipe	1	5	400	400	-	-	-	-	400	-	-	-	-
UV filtration	1	5	400	400	-	-	-	-	400	-	-	-	-
Header tank	1	10	200	200	-	-	-	-	-	-	-	-	-
Blower/aeration	1	5	500	500	-	-	-	-	500	-	-	-	-
Quarantine/ treatment tanks	4	7	60	240	-	-	-	-	-	-	240		
Lab/Misc. Equipment		3	700	700	-	-	700	-	-	-	700	-	-
Shelving/ drawers		10	120	120	-	-	-	-	-	-	-	-	-
Generator	1	10	450	450	-	-	-	-	-	-	-	-	-
Total				5915	-	-	700	-	1700	-	940	-	-

Note:
(1) Land: 200m^2
(2) Building: 95m^2, hollow block, cement floor, roof, production/office/lab areas
(3) Generator: 2 KVA
(4) Laboratory/Miscellaneous equipment: phone, fax, furniture, microscope, refrigerator
(5) Blower/aerator: 2/3 hp with plumbing

Table 2. Capital Investment: Broodstock

Equipment	#	Year of Life	Unit cost	Total Investment Year 1	2	3	4	5	6	7	8	9	10
Tanks	15	7	60	900	-	-	-	-	-	-	900	-	-
Anemones	30	1	10	300	300	300	300	300	300	300	300	300	300
Lights	15	5	70	1,050	-	-	-	-	1050	-	-	-	-
Live rock	75lb	3	0.50	38	-	-	38	-	-	-	38	-	-
Live sand	15	3	25	375	-	-	375	-	-	-	375	-	-
Air stone	15	3	1.50	23	-	-	23	-	-	-	23	-	-
Broodstock pair	15	10	25	375	-	-	-	-	-	-	-	-	-
Water heater	15	3	17.50	263	-	-	17.50	-	-	-	17.50	-	-
Protein skimmer	1	4	1,000	1,000	-	-	-	1,000	-	-	-	-	1,000
Pump	1	3	100	100	-	-	100	-	-	100	-	-	100
Filter/sump	1	4	450	450	-	-	-	450	-	-	-	-	450
Tables	5	10	50	250	-	-	-	-	-	-	-	-	-
Pipes/tubing		10	60	60	-	-	-	-	-	-	-	-	-
Clay pots	30	2	0.25	7.50	-	7.50	-	-	7.50	-	-	7.50	-
Total				5,192	300	308	854	1750	1358	400	1654	308	1850

Note:
(1) Tanks: glass, 30 gallon, screened overflow, bulk head, standpipe
(2) Lights: fluorescent with metal halide bulbs, 250W and timer
(3) Live sand bed and live rock
(4) Water heater: 150W
(5) Protein skimmer: 2500 gph with beckett injectors

able fish and meet market requirements in terms of quality of fish and sales volume. Feed costs are not a major factor affecting economic returns,

Table 3. Capital Investment: Nursery

Equipment	#	Year of Life	Unit cost	Total Investment Year 1	2	3	4	5	6	7	8	9	10
Tanks	8	7	90	720	-	-	-	-	-	-	720	-	-
Lights	8	5	25	200	-	-	-	-	200	-	-	-	-
Mesh screens	1	3	125	125	-	-	125	-	-	-	125	-	-
Tables	3	10	50	150	-	-	-	-	-	-	-	-	-
Water heater	8	3	17.50	140	-	-	140	-	-	-	140	-	-
PVC shelter	1	10	20	20	-	-	-	-	-	-	-	-	-
Siphon hose		5	10	10	-	-	-	-	10	-	-	-	-
Total				1365	-	-	265	-	210	-	985	-	-

Note:
(1) Tanks: glass, 30 gallons, airstones, PVC sheet on three sides
(2) Lights: fluorescent with daylight bulbs
(3) Screens: 10 from 60 to 500 microns

Table 4. Capital Investment: Grow-out

Equipment	#	Year of Life	Unit cost	Total Investment Year 1	2	3	4	5	6	7	8	9	10
Tanks	25	7	110	2750	-	-	-	-	-	-	2750	-	-
Standpipe/ mesh screen	25	10	10	250	-	-	-	-	-	-	-	-	-
Water filter	1	5	500	500	-	-	-	-	500	-	-	-	-
Water recirculation pump	25	4	40	1000	-	-	-	1000	-	-	-	-	1000
Airstone/tubing	25	3	2	50	-	-	50	-	-	-	50	-	-
Lights	25	5	25	625	-	-	-	-	625	-	-	-	-
Total				5175	-	-	50	1000	1125	-	2800	-	1000

Note:
(1) Tanks: self-cleaning, circular, fiberglass, 27 gallon (100l)
(2) Water filter: UV with protein skimmer
(3) Lights: fluorescent with daylight bulbs

Table 5. Capital Investment: Microalgae and Rotifer Culture System

Equipment	#	Year of Life	Unit cost	Total Investment Year 1	2	3	4	5	6	7	8	9	10
Algae culture photoreactors	3	7	250	750	-	-	-	-	-	-	750	-	-
Airlines/valves/ air pump	1	5	250	250	-	-	-	-	250	-	-	-	-
Lights	3	5	150	450	-	-	-	-	450	-	-	-	-
Rotifer culture tanks	2	7	150	300	-	-	-	-	-	-	300	-	-
Valved harvest tubes	3	7	20	60	-	-	-	-	-	-	60	-	-
Wastewater container	1	7	100	100	-	-	-	-	-	-	100	-	-
Ozonators	2	2	65	130	-	130	-	130	-	130	-	130	-
Screens	1	4	125	125	-	-	-	125	-	-	-	-	125
Lab/Misc. Equip	1	3	400	400	-	-	400	-	-	-	400	-	-
Total				2565	-	130	400	255	830	130	1610	130	125

Note:
(1) Algae culture photoreactors: 100 gallon, transparent
(2) Lights: fluorescent with VHO bulbs
(3) Rotifer culture tanks: 200 gallon
(4) Waste water container: floor drains into sand filter
(5) Screens: 25 to 50 microns

although the unit cost of feed for marine ornamental fish is higher than commercial diets for foodfish, such as grouper.

Table 6. Total Capital Investment Costs per Year

Cost category	Year 1	2	3	4	5	6	7	8	9	10
Building/ equipment	5915	-	-	700	-	1700	-	940	-	-
Broodstock	5192	300	308	854	1750	1358	400	1654	308	1850
Nursery	1365	-	-	265	-	210	-	985	-	-
Grow-out	5175	-	-	50	1000	1125	-	2800	-	1000
Microalgae/rotifer culture	2565	-	130	400	255	830	130	1610	130	125
Total	20212	300	438	2269	3005	5,223	530	7989	438	2975

Table 7. Annual Fixed Costs

Cost Category	Interest on investment	Annual depreciation	Annual fixed cost
Building/equipment	450	808	1258
Broodstock	468	1343	1811
Nursery	123	251	374
Grow-out	466	910	1376
Microalgae/rotifer culture	222	542	764

Table 8. Enterprise Budget for the Integrated System (month)

Item	Unit	Price or cost/unit	Quantity	Total
Gross receipts: sale of fish	Market size fish	2.25	4226	9509
Variable Costs:				
Feed	Mixed feeds			350
Electricity				125
Medication				50
Labor-technician		200	1	200
Labor-aide		125	2	250
Supplies-microalgae/rotifer				120
Supplies-production				100
Marketing/packing				100
Repair/maintenance		421	1	421
Misc. expenses		39	1	39
Total VC				1755
Income above VC				7754
Fixed Costs				466
Total of above costs				2221
Net returns				7289
General overhead				53
Total costs				2274
Net returns to land, management and risk				7235

Note:
(1) Total cost per clownfish: 0.53
(2) Variable costs for one year: 27,060
(3) Gross receipts for one year: 114,108

Discussion

Under current conditions, the aquaculture of clownfish by small-scale fishers as a solution to relieve fishing pressures on the wild-harvest marine ornamental trade is not feasible. Several recommendations are presented

Table 9. Cash Flow for Integrated System (annual) (five years)

	1	2	3	4	5
Beginning bank balance	33742	(7058)	78420	165030	249809
Cash receipts/income	9509	114108	114108	114108	114108
Cash outflows/costs:					
operating expenses	13530	27060	27060	27060	27060
Net cash income	(4021)	87048	87048	87048	87048
Capital equipment purchase	20212	300	438	2269	3005
Long term/capital loan payment	11925	-	-	-	-
Operating loan	6765	7058	-	-	-
Operating loan payment	7983	8328	-	-	-
Ending cash balance	(7058)	78420	165030	249809	333852

which will create the conditions under which aquaculture of these fish could substantially relieve fishing pressure on coral reefs:

Policy recommendations

- Effective extension must be provided to transfer the technology to these communities;
- Research programs must be supported to make current technologies more accessible to small-scale "backyard" culture operations and to investigate aquaculture of other high-demand ornamental fish species;
- Institute national legal framework for best practices in ornamental fish aquaculture to foster economically and environmentally sustainable operations;

Economic recommendations

- Subsidies should be available to mitigate high capital investment costs and operating costs;
- Make market systems amenable to regulation for aquaculture to become viable (e.g. wild stock export/import controls, certification)
- Facilitate the choice of appropriate aquaculture technology given financial risk tolerances, profit margins, technical capacity, and operational management challenges;
- Establish price structure that allows cultured products to compete with wild harvest products
- Information on consumer preference and outreach for consumer education must be in place to develop consumer demand for certified products;

Conclusion

Aquaculture still offers the best alternative to wild-harvest fish for the ornamental fish trade. However, substantial work must be done to make ornamental fish aquaculture feasible and sustainable for fishing communities in developing countries. With financial subsidies for culture operations, appropriate technology transfer, a constant demand for cultured ornamental fish, and a research agenda which works to make current technologies more simple and seeks to apply current technologies to other, high-demand species, aquaculture of marine ornamental fish has the potential to be a financially sustainable solution to relieve fishing pressures on this coral reef fishery.

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