Study on economics and socio-economics of small-scale marine fish hatcheries and nurseries, with special reference to grouper systems in Bali, Indonesia




Prepared by:

Susana V Siar, William Lee Johnston and Sih Yang Sim

Report prepared by:

Susana V Siar[1], William Lee Johnston[2] and Sih Yang Sim[3]

1 SEAFDEC Aquaculture Department
Tigbauan, 5021, Iloilo, Philippines
E-mail: siar@aqd.seafdec.org.ph

2 AFFS Fisheries and Aquaculture
Queensland Department of Primary Industries
PO Box 5165 SCMC
91-95 Howard Street Nambour
Qld 4560, Australia
E-mail: Bill.Johnston@dpi.qld.gov.au

3 Network of Aquaculture Centres in Asia-Pacific (NACA)
PO Box 1040, Kasetsart Post Office
Bangkok 10903, Thailand
E-mail: sim@enaca.org

Report prepared for:

Asia-Pacific Marine Finfish Aquaculture Network
c/o NACA Secretariat
Suraswadi Building
Department of Fisheries Compound
Kasetsart University Campus
Ladyao, Jatujak, Bangkok 10900
Thailand
Tel: 66-2-561 1728
Fax: 66-2-561 1727
E-mail: grouper@enaca.org
Website: http://www.enaca.org/grouper/

Reference:

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Table of Abbreviations and Acronyms

ACIAR	Australian Centre for International Agricultural Research
AFFA	Agriculture, Fisheries and Forestry – Australia
APEC	Asia-Pacific Economic Cooperation
BMHS	Backyard Multispecies Hatchery System
CH	Complete Hatchery
FCR	Feed Conversion Ratio
GRIM	Gondol Research Institute for Mariculture
CSIRO	Commonwealth Scientific and Industrial Research Organisation
IRR	Internal Rate of Return
JICA	Japan International Cooperation Agency
NACA	Network of Aquaculture Centres in Asia-Pacific
NFC	Northern Fisheries Centre
NPV	Net Present Value
QDPI	Queensland Department of Primary Industries
SEAFDEC AQD	Aquaculture Department, Southeast Asian Fisheries Development Centre

Table of Foreign Currency Exchanges

Currency	Australian Dollar	Indonesian Rupiah
US Dollar	2	10,000
Australian Dollar	1	5,000

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1 Executive Summary

The development and success of the Backyard Multispecies Hatchery System (BMHS) in Gondol Research Institute for Mariculture, Bali, Indonesia has attracted a lot of attention region wide for grouper fingerling production. As to date the survival rates for most grouper species in hatchery are very low, and for some species most countries are almost unable to get any hatchery produced fingerling at all. The systems developed in the Gondol research institute have been extended to the private sector and there are now a substantial number of private farmers involved in grouper hatching and nursing in Bali. This has led to this survey to be carried out under the staff exchange component of the APEC Grouper project, *FWG 01/99 Collaborative APEC Grouper Research and Development Network*, in cooperation with ACIAR Grouper project *FIS/97/73 Improved hatchery and grow-out techniques for grouper aquaculture in the Asia-Pacific region*.

The main objectives of the study were to describe the development of the small-scale hatcheries and their economic structure and benefits to the farmers and local community in Bali.

The social and economic impact of the BMHS has been analysed and details of the benefit of this system to the community have been described. Some of the negative impacts of the rapid development and success of the BMHS are also provided. The report also provides details of the development of the BMHS from the early system of milkfish hatchery, and the uptake of the new system by the hatchery operators and then being applied to grouper species.

The economic study component detailed the data collection methods and analysis. The results of the economic statistics were presented in details based on standard economic analysis tools such as NPV (Net Present Value), IRR (Internal Rate of Return), Benefit-Cost Ratio, and Payback period.

The strengths and weaknesses of the BMHS are also being described. Although the BMHS is very successful, the draw back for it is the demand for grouper fingerlings, as it is not recurrent, either locally or regionally. The key factors for further expansion on the BMHS lies on the development of grow-out technology for grouper. There is also a need to develop advanced nursery phase for grouper fingerlings as currently this section of the industry has not been taken up by the local hatchery and nursery operators.

2 Background

During the last three years, the Gondol Research Institute for Mariculture (GRIM) in Bali has successfully been producing grouper seed on a commercial scale for *Cromileptes altivelis* (see Figure 1, common names: barramundi cod, humpback grouper, mouse grouper, polka dot grouper or high-finned grouper). This has been achieved through collaborative research with the Japan International Cooperation Agency (JICA) Research and Development for the *Multispecies Hatchery Project* and more recently the ACIAR project (FIS/97/73) *Improved hatchery and grow-out techniques for grouper aquaculture in the Asia-Pacific region*. The seed production

techniques developed by GRIM have been widely adopted by farmers in the northern part of Bali. Several million seed, equivalent to around Rupiah 20 billion (AUD 4 million) has been marketed not only to the domestic market but also for export to neighbouring economies such as Malaysia, Singapore, Chinese Taipei, China and Hong Kong SAR. Research work on other species, including *Epinephelus fuscoguttatus* (see Figure 1, common names: tiger grouper, brown marbled grouper and flowery cod) and *E. coioides* (common names: orange-spotted grouper, greasy grouper, gold-spot cod and estuary cod), has demonstrated that the hatchery techniques developed by GRIM can be used to produce juveniles of other grouper species. The hatchery techniques developed at GRIM have now been transferred to the private sector, reportedly contributing to farmers' incomes, job opportunities and export earnings. The uptake of GRIM hatchery and nursing techniques by local small-scale farmers is a success story in the transfer of grouper hatchery technology to the private sector that is of interest to the other economies in the region. However, little is known at present about the social and economic aspects of small-scale hatcheries.

Consequently, the Network of Aqauaculture Centres in Asia-Pacific (NACA) in collaboration with the Queensland Department of Primary Industries (QDPI) and the Southeast Asian Fisheries Development Centre's Aquaculture Department (SEAFDEC AQD) assembled an expert team to evaluate the economic and socio-economic aspects of small-scale hatcheries in Bali. This research was funded by the Asia-Pacific Economic Cooperation (APEC) through project FWG 01/2001 *Collaborative APEC Grouper Research and Development Network*, administered by Agriculture, Fisheries and Forestry – Australia, and by ACIAR through project FIS/97/73.

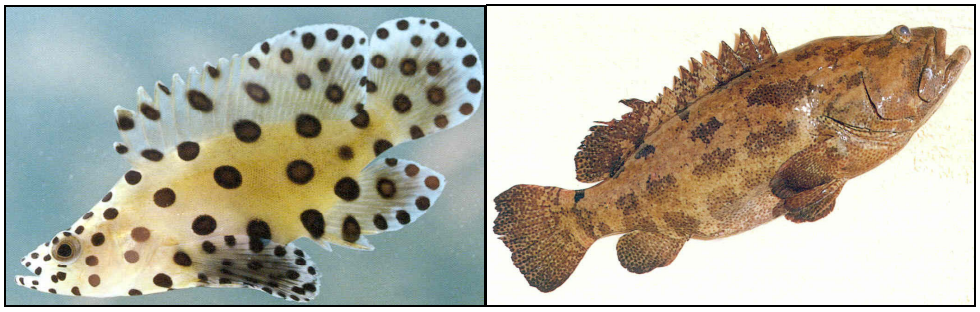

Figure 1. Juvenile *C. altivelis* (left) and an adult *E. fuscoguttatus* (right)

3 Objectives of the Study

The study was split into two main components: (a) hatchery and nursery economics and: (b) a socio-economic study.

The objectives of the economic study component were:

1. To understand and document the economic structure of small-scale grouper hatcheries in Indonesia, with particular application to the Asia-Pacific region. This includes initial capital investment, annual operating costs and income streams;

2. To develop a bio-economic model of a small-scale grouper hatchery using inputs from the hatchery survey in northern Bali and information supplied by researchers in Australia, Indonesia and the Philippines. The resulting model was used to examine how improvements in growth and survival affect the cost of production of grouper fingerlings. It also provides small-scale grouper hatcheries with a tool to assess the effects of changes in management and farming methods on business profitability;

3. Provide a basis for recommendations to the APEC grouper network on the potential for small-scale hatcheries to support the development of sustainable grouper aquaculture;

4. Provide a cost-benefit analysis tool to asses research and development options; and

5. Provide decision tools for researchers.

The objectives of the social study were:

1. To describe the development of the private grouper hatchery business in Bali, including participants, and key factors responsible for its development.

2. To assess the benefits of the grouper hatcheries to small-scale farmers/investors, and to the wider community. The study examined the participation of small-scale operators, their previous occupations, and benefits from participating in the grouper hatchery business.

3. To provide recommendations to the APEC grouper network on the potential for small-scale hatcheries to support the development of sustainable grouper aquaculture, and if appropriate how they might be promoted as part of the development activities of the network.

4 The Study Team and Methods

The team for the case study consisted of Dr. Susana V Siar of the Aquaculture Department, Southeast Asian Fisheries Development Centre (SEAFDEC AQD); Mr. William Lee Johnston of the Department of Primary Industries, Queensland, Australia and Mr. Sih Yang Sim of the Network of Aquaculture Centres in Asia-Pacific (NACA).

Dr. Susana V. Siar was supported by the Collaborative APEC Grouper Research and Development Network, Staff Technical Exchange Scheme under project FWG 01/2001. Dr Siar is the Head of the Socioeconomics Section of the SEAFDEC AQD, Tigbauan, Iloilo, Philippines.

Mr. William Lee Johnston was funded by ACIAR Project (FIS/97/73) to support the economics study of the proposal. Mr Johnston has experience in developing economic models for Australian aquaculture sectors, including finfish (barramundi, silver perch). He has been involved in the ACIAR grouper project in which he has developed sophisticated economic models for grouper hatchery, nursery and grow-out. The project is currently gathering baseline data from partner countries (Indonesia,

the Philippines) to establish economic parameters to evaluate the economic aspects of grouper aquaculture. Previews of the models at the Grouper Aquaculture Seminar held at SEAFDEC AQD, Tigbauan, the Philippines, in July 2001 provoked a great deal of interest from both researchers and industry representatives.

Mr. Sih Yang Sim of NACA was supported by the Asia-Pacific Marine Finfish Aquaculture Network to provide assistance and coordinate the activities with GRIM. He also assisted in interpretation of Indonesian and Chinese during the study. He is the editor of the 'Marine Finfish Aquaculture Newsletter' (formally Grouper Electronic Newsletter), and has been involved in supporting the R & D and extension activities for the Asia-Pacific Marine Finfish Aquaculture Network since 1999.

The study was carried out from 2–18 March 2002 in cooperation with GRIM researchers and the resident JICA Mariculture Expert, Mr Shogo Kawahara. In addition to GRIM staff, the study team undertook extensive interviews with owners and staff of the local small-scale hatcheries, nurseries and local brokers dealing in marine finfish fingerlings.

The team was based at GRIM, whose staff members facilitated the visit and interview of hatchery operators. The team visited and interviewed 17 hatcheries (15 in the Gondol area and three in Negara), two brokers, and one live fish trader in Denpasar. The team also visited the cage culture facility of GRIM.

A questionnaire was used for the face-to-face interview of hatchery operators, technicians, or managers (see Annex 1). The interview focused on technology adoption, labour allocation, socio-economic background of hatchery operators and workers, socio-economic impact of hatcheries, perceptions of sustainability, and the personal background of informants. The questionnaire was discussed with the GRIM staff prior to the conduct of the interviews. The hatcheries visited were recommended by the staff of GRIM.

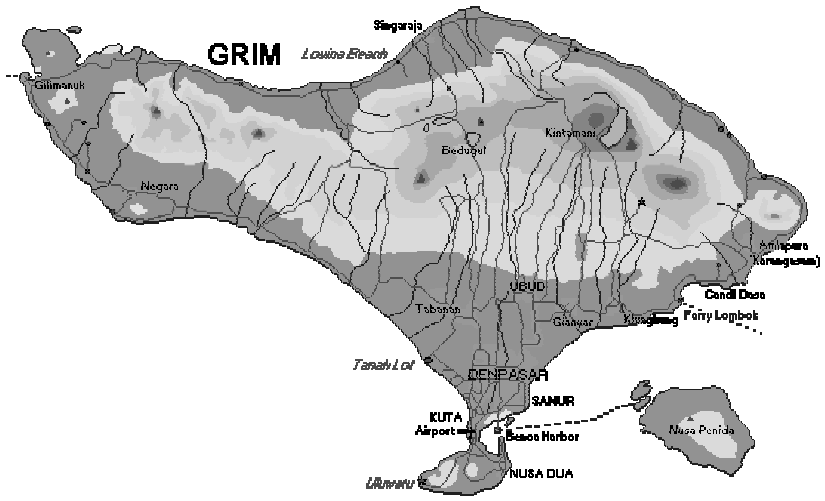

Figure 2: Map of Bali.

The information from this study of small-scale grouper hatcheries should be of widespread interest in APEC economies involved with marine finfish aquaculture, including grouper aquaculture. The information from the study is useful to economies in seeking to promote small and medium business enterprises involved with marine

finfish aquaculture. One of the objectives of the APEC Grouper Research and Development Network is to transfer research findings to the private sector, and the study findings provide an important base of information to support this transfer.

5 The Development of the Backyard Hatchery

The development of the backyard hatchery technology for milkfish, and subsequently, grouper, was a product of the collaboration between researchers of GRIM in Bali and experts from JICA. The collaboration dates back to 1988, when the hatchery technology for shrimp was developed. This was followed by the *Multispecies Hatchery Project* in 1994, with the goal of strengthening GRIM's capacity in 'fish seed production, shrimp seed production, disease control and extension planning' (Sugama *et al*. 2001). Humpback grouper, *Cromileptes altivelis*, was the target species of the highest priority for the development of mass seed production technology. Since 1999, the development of hatchery technology for grouper species has been assisted by GRIM's involvement in the ACIAR project FIS/97/73 *Improved hatchery and grow-out technology for grouper aquaculture in the Asia-Pacific region*.

There were about 10 to 20 units of milkfish hatcheries in the Gondol area during the time the Multispecies Hatchery Project started. The survival rate was 10–20% for milkfish hatchery and through the Multispecies Hatchery Project the survival rate was raised to 50%. Milkfish seed production became more stable, and the backyard hatchery system was picked up by small farmers around Gondol as the price of milkfish fry increased. During the peak of the backyard hatchery system in 1997–1998, the price of milkfish fry reached AUD 0.02 (Rp. 100) per fry. A survey conducted in 1997 by GRIM revealed that there were 779 units of milkfish hatcheries in the Gondol area at that time (Slamet *et al*. 1998; Ikenoue and Ono 1999).

GRIM was already developing the hatchery technology for grouper during the height of the milkfish backyard hatchery in 1997. For the first time in 1998, GRIM was able to produce 2,000 humpback grouper fingerlings. The aquaculture team tried to extend the technology to backyard hatcheries, but the price of milkfish fry was very high, and farmers did not pick up the grouper production technology. At this stage, the egg production technology was not yet developed, and humpback grouper eggs came from East Java. In the same year, GRIM tried the seed production technology at three hatcheries, and one succeeded in producing juveniles. This was short-lived, however, because the juveniles were infected by virus and died.

Efforts in seed production of humpback grouper continued in 1999, when the technology for *E. coioides*, originally developed in Kuwait, was introduced by Shogo Kawahara, the resident JICA Mariculture Expert. In November 1999, 54,000 fry were produced with an average total length of 2.5 cm (Kawahara *et al*. 2000). The following year, the technology was transferred to backyard hatcheries in the Gondol area, and GRIM started distributing eggs from GRIM broodstock. In September 2001, GRIM distributed humpback grouper eggs to 62 hatcheries in the Gondol area. These hatcheries were originally involved in milkfish fry production.

5.1 Backyard Hatchery for Milkfish: Precursor of Grouper Hatcheries in Bali

The backyard hatchery for milkfish was introduced in 1993, and initially picked up by the staff of GRIM in collaboration with small farmers. In the beginning, groups of four persons, usually comprising two staff from GRIM and two farmers, were organized, each member contributing a share of the capital investment to set up the backyard hatchery. Later on, additional tanks were added to the setup or some members of these groups established their own hatcheries when they were able to accumulate capital. A brochure issued by GRIM in 1995 showed that the total cost (investment, annual operating cost for 10 runs, depreciation, maintenance, and interest) for the backyard hatchery was AUD 3,540 (Rp. 17,686,500). The projected annual profit at that time was AUD 4,050 (Rp. 20,263,500).

There are two types of milkfish hatcheries in Bali: complete hatcheries and partial hatcheries. Backyard hatchery is a partial hatchery, designed to hatch and rear fertilized eggs until selling time (mainly a nursery function). Complete hatcheries (CH), on the other hand, perform broodstock maintenance, maturation, spawning, live feed culture, fry production, and marketing. Backyard hatchery buys fertilized eggs from CH. In the initial stage of the seed production technology dissemination, only GRIM had a complete hatchery, distributing eggs to small farmers for free until breakeven point. With the increase in the price of milkfish fry and the consequent investment boom, farmers organized themselves into groups of ten similar to the group of four described above, comprised of one CH and several partial hatcheries. In these groups of ten, the egg requirement of members are prioritized, after which surplus eggs are sold to non-members. In a group comprised of GRIM staff, members pay 10 per cent of net sale for the fertilized egg and another 10 per cent for rent of the land in which the CH is located. There are about 20 to 30 of these groups in Bali, with members ranging from 13 to 15, and maintaining from 100 to 1,000 milkfish broodstock. The production of milkfish fry is modelled after the core-satellite concept, whereby backyard hatcheries are organized around CHs and GRIM for the supply of fertilized eggs.

5.2 Technology Transfer from GRIM to Small-scale Hatchery Operators

5.2.1 Technology Transfer of Backyard Hatchery for Milkfish

In a period of four years between 1993 and 1997, milkfish hatcheries in the Gondol area increased from 10-20 to 214. The phenomenal adoption of the milkfish hatchery technology by farmers in the Gondol area, and later on by investors from outside Bali, may be attributed to three factors. The first factor was the willingness of the GRIM staff to invest in milkfish hatchery, thus shortening the period between technology verification/demonstration and adoption by target beneficiaries. The initiative of the GRIM staff to collaborate with small farmers and organize groups of four to establish backyard hatcheries created an investment climate conducive to the participation of those with little capital. In this setup, risk is shared among members of the group. The involvement of the GRIM staff who possess the technical know-how may also have engendered confidence among small farmers that the technology would work.

The second factor was GRIM's strategy of distributing fertilized eggs for free to backyard hatcheries until breakeven point. This was a reflection of GRIM's determination to disseminate the technology with a minimum amount of risk to small farmers should the first or succeeding attempts at rearing the milkfish larvae become unsuccessful. The arrangement enabled small farmers to try out the technology until their investment was recovered. This process of technology adoption paved the way for small farmers to experiment and make modifications and additions to the technology based on their own understanding, observations, and experiences.

The third factor was the availability of technical support from the GRIM staff who may be called upon for advice by small farmers. Many milkfish hatcheries were located near GRIM and this nearness facilitated the fast delivery of technical support. Moreover, GRIM has training and dormitory facilities for those who are interested to have practical experience in seed production technology. GRIM opened its door to farmers, students, and other interested parties who may come from Bali and other parts of Indonesia. All they had to do was pay their own way to GRIM, and they can use the facilities and get hands-on training from the staff. GRIM's dormitory was always full of students, farmers, and other interested persons. In addition to the face-to-face technology transfer through training activities, GRIM also published brochures and manuals for dissemination. These publications were written in the Indonesian language and English.

5.2.2 The Prototype of Backyard Hatchery for Milkfish

The prototype backyard hatchery as transferred to the small farmers consisted of two roofed 10 m^3 larval rearing tanks and its associated phytoplankton and rotifer culture tanks. The inside of the larval rearing tanks was usually painted yellow. This setup was modified as farmers get a handle on the technology and observe the conditions under which the milkfish larvae grow best. For example, better growth was observed when the roof was removed. Now, most larval rearing tanks for milkfish are open and distinguished by the yellow color inside. The prototype backyard hatchery also evolved into a medium-scale or even large-scale milkfish hatchery as farmers kept on adding larval rearing tanks when the price of milkfish fry increased (see Figure 3).

Figure 3: Prototype larval rearing facility at GRIM

5.3 Transfer of the Seed Production Technology for Humpback Grouper

Under the *Multispecies Hatchery Project,* GRIM developed seed production technology for humpback grouper in 1998. GRIM was able to produce 2,000 humpback grouper juveniles for the first time. The details of the seed production technology was published in a manual titled "A Method of Seed Production for Humpback Grouper, *Cromileptes altivelis*," by Matsuda et al. (1998).

In 1999, trial runs continued, and many larvae survived until day 25, and died. Virus was again identified as the cause of death. This prompted GRIM to stop operations until all facilities had been sterilized with chlorine and all humpback grouper broodstock were tested for virus using the PCR (Polymerase Chain Reaction) technique (Kawahara, personal communication). Broodstock that tested negative (<10 million virus in the sample) for the virus were selected to reduce the virus density, and activity started again in October 1999.

In November 1999, GRIM successfully produced 54,000 humpback grouper fry with an average length of 25 mm using two 10 m^3 tanks (Kawahara et al. 2000). Survival rates from hatching for the trials ranged from 45.5 to 53.9 per cent, with a production density of 3,000 fry per m^3. The larvae were reared for 43 days.

As in the transfer of milkfish backyard hatchery technology to small farmers in the Gondol area, the transfer of seed production technology for humpback grouper was done with the collaboration of staff from GRIM. In October 2000, three GRIM staff were selected to participate in the trial run, with the arrangement that they work full time in their hatcheries under the supervision of the JICA expert. They were selected based on their willingness to make two of the following modifications to their hatcheries from milkfish culture to humpback grouper fry. One was the addition of sand filter; the other was the frequency of water change and cleaning of the tank bottom to reduce viral density. Some production inputs were provided by GRIM, such as the fertilized eggs, and artificial feed. By November 2000, two hatcheries were able to produce juveniles but the other one failed. One hatchery produced 19,000 juveniles; the other had 3,000 juveniles. The fish were sold at AUD 2.00 (Rp. 10,000) per 5 cm, and were used for cage culture within Indonesia and the aquarium trade. A humpback grouper fry of 5cm has a 50-60 days rearing period.

The success of the seed production trial by the GRIM staff generated interest among hatchery operators in the Gondol area. By December 2000, GRIM started selling eggs to farmers at AUD 0.0005 (Rp. 2.5) per egg. GRIM staff, however, had first priority over the fertilized eggs, but limited to 100,000 eggs per staff. About 10 to 20 farmers bought eggs from GRIM. GRIM also played the role of retailing agent for the artificial feed imported from Japan because it was difficult and expensive for farmers to buy this on their own, as the quantities required by small scale farmers were very small. In addition, copies of a booklet "Successful mass fry production of humpback grouper, *Cromileptes altivelis*" written in Indonesian language were distributed to the farmers. By January 2001, 150,000 humpback grouper juveniles were produced from the hatcheries that used to rear milkfish fry. In September 2001, GRIM distributed humpback grouper eggs to 62 hatcheries in the Gondol area, an indication that many

milkfish hatchery operators have adopted the seed production technology for humpback grouper.

The highest production of humpback grouper juveniles was achieved in March 2001 with 200,000 juveniles (Kawahara 2001). During the year, a total of 1.05 million humpback grouper juveniles were produced in the Gondol area. The price of a 4 to 7 cm fingerling ranged from AUD 1.40 to AUD 2.00 (Rp. 7,000 to 10,000) in January-February; AUD 1.20 to AUD 1.60 (Rp. 6,000 to 8,000) in April-June; and AUD 0.80 to 1.20 (Rp. 4,000 to 6,000) in October-November (Kawahara 2001).

5.3.1 From Humpback Grouper to Tiger Grouper

Tiger grouper, on the other hand, started to be produced in April 2001 by some hatcheries in Gondol area, with an initial production of 25,000 juveniles. The highest production for the year was 400,000 juveniles in August, with a total production of 1.1 million. Tiger grouper fetched a lower price compared with humpback grouper. The price of a 2 to 3 cm tiger grouper ranged from AUD 0.40 to 0.60 (Rp. 2,000 to 3,000) in April-June, and AUD 0.10 to 0.16 (Rp. 500 to 800) in October-November (Kawahara 2001). For a 5 to 7 cm size, the price ranged from AUD 1.00 to 1.40 (Rp. 5,000 to 7,000) in April-June, and AUD 0.40 to 0.60 (Rp. 2,000 to 3,000) in October-November. Unlike humpback grouper which can be weaned off to artificial diets easily during larval rearing period, tiger grouper is fed mysid shrimp and trash fish in the hatchery. Tiger grouper is costly to keep in a hatchery for long culture periods as high stocking density is not favourable due to its cannibalistic nature.

By the end of 2001, hatcheries in the Gondol area were rearing milkfish, humpback grouper, and tiger grouper. In the landscape, it is easy to distinguish the concrete tanks with grouper larvae because these are roofed and surrounded by black plastic curtains to control natural light intensity. The inside of the concrete tanks are painted light blue and the top of the tanks is covered by transparent plastic sheets to control water temperature.

Like the technology extension for milkfish fry production, farmers, students, and other interested persons may come to GRIM to get practical training on the seed production technology for humpback and tiger grouper. In addition to this, GRIM published a manual titled “Manual for the Seed Production of Humpback Grouper, *Cromileptes altivelis*” by Sugama et al. (2001) in the Indonesian language and English.

6 ACIAR Project FIS/97/73

In 1999, Australian Centre for International Agricultural Research (ACIAR) funded a grouper project *FIS/97/73 Improved hatchery and grow-out technology for grouper aquaculture in the Asia-Pacific region*. The major bottlenecks to increased aquaculture production of groupers are the generally poor, and highly variable, survival in larviculture, and the limited sources of trash fish for grow-out. The ACIAR project is addressing these issues by collaborating with research and development organisations in the Asia-Pacific region to carry out priority grouper research to improve larviculture and to develop cost-effective grow-out diets of low fish content.

The overall objective of the ACIAR project is to increase grouper production in the Asia-Pacific region by developing improved hatchery and grow-out technology. The project has three major components:

- **Larval Rearing of Grouper** to improve growth and survival of groupers during the hatchery phase.
- **Diet Development for On-growing of Grouper** to develop compounded feeds for grouper grow-out that have low environmental impacts, have a low content of fishery resource, and are as cost-effective for the on-growing of grouper as the alternative of using trash fish.
- **Support for the Grouper Aquaculture Research and Development Program** to 'value add' existing grouper aquaculture R&D efforts in the Asia-Pacific region by improving communication and promoting collaborative research between regional laboratories and agencies.

The collaborating institutes for the ACIAR grouper project are listed below:

- Department of Primary Industries, Agency for Food and Fibre Sciences – Fisheries and Aquaculture, Northern Fisheries Centre, Cairns, Queensland, Australia
- Commonwealth Scientific and Industrial Research Organisation (CSIRO), Division of Marine Research, Marine Research Laboratories, Cleveland, Queensland, Australia
- Southeast Asian Fisheries Development Center (SEAFDEC), Aquaculture Department, Tigbauan, Iloilo, Philippines
- Gondol Research Institute for Mariculture, Bali, Indonesia
- Research Institute for Coastal Fisheries, Maros, Sulawesi, Indonesia
- Sam Ratulangi University, Manado, Sulawesi, Indonesia
- Network of Aquaculture Centres in Asia-Pacific (NACA), Bangkok, Thailand

The ACIAR project has also provided strong support for GRIM in that several scientists from Indonesia have been funded to be in Australia for specialized training in feed and nutritional aspects for marine finfish larviculture. Three workshops under the project were held, and one was conducted in GRIM in 1999. The workshops were serving as platform to disseminate research findings and technical exchanges from scientists in the region as well as to the private sector.

An ACIAR grouper project website (http://www.enaca.org/aciar/) was established in 1999 and this website is to serve as an information update and exchange tool for project members, and to provide information on the project to others interested in the development of grouper aquaculture. Information from GRIM has been disseminated using the web site and electronic newsletter.

7 Socio-economics of Backyard Hatcheries

This section of the report describes the results of the socioeconomic study of grouper hatcheries in Bali. However, the analysis is not restricted to grouper hatcheries only; it also covers milkfish hatcheries as most of the hatcheries visited were adopting the Backyard Multispecies Hatchery System (BMHS). The typical feature of this system is that the hatchery operator can switch from grouper to milkfish (or to other species) when the milkfish fry price is good and vice versa.

7.1 Socioeconomic Impacts of Milkfish Hatcheries in Bali

Although Bali is famous for its magnificent rice terraces, the staple food in the Gondol area in Northwest Bali is corn. Sometimes, rice is mixed with corn, with a ratio of 70 per cent corn and 30 per cent rice. In the market, rice sells for AUD 0.70 (Rp. 3,500) per kg whereas corn sells for AUD 0.24 (Rp. 1,200) per kg. Grape is a major agricultural crop and vineyards maybe found along the stretch from Singaraja to Gondol. About 25 to 30 per cent of the population in Northwest Bali are dependent on fishing for their livelihood. Tuna from Bali is exported to Japan and fetches a good price. Bali has a predominantly Hindu population, but there are Muslim populations along the coast who migrated to Bali to fish.

Ten years ago, before the development of the milkfish fry production technology, the collection of wild milkfish fry was a source of livelihood among Bali's coastal dwellers. In the Gondol area, there were about 100 fishers gathering wild milkfish fry. Today, the gathering of wild fry is not profitable anymore, as the cost of wild fry is AUD 0.0004 to 0.0006 (Rp. 2 to 3) higher than the hatchery-bred fry. Moreover, gatherers can only catch 100 to 200 pieces at a time.

According to Dr. Adi Hanafi, Director of GRIM, the Gondol area used to be one of the low income villages in Indonesia. With the introduction and adoption by small farmers of the backyard hatchery for milkfish, however, new sources of livelihood and employment opportunities were created. Seventy per cent (70%) of hatchery operators do not own land and rent land from Balinese landowners. Land that used to be planted to coconut, corn, and grape were converted to milkfish hatcheries. According to Bejo Slamet, staff of GRIM, coconut and grape are not so profitable compared with milkfish hatchery.

7.1.1 Employment in Milkfish Fry Industry

The different stages of seed production from egg production, fry production, and fry marketing are engaged in by different groups of people. In addition to jobs in the hatchery, the widespread adoption of milkfish fry production technology also spurred employment opportunities for short-term construction work, as backyard hatcheries continued to increase and owners kept on adding new larval rearing tanks.

Fishers who used to catch ornamental fish using destructive methods found employment as technicians and workers in milkfish hatcheries. A backyard hatchery usually employs one technician whose educational attainment ranges from elementary to junior and senior high school. It may even be possible for those without any education at all to be employed as technicians. Those who have no money to continue their education usually find work as hatchery technicians and workers. In the survey conducted by GRIM in 1997, there were an estimated 546 technicians working in 214 milkfish hatcheries surveyed (Slamet 1998).

Technicians are usually paid a percentage of net sales, ranging from 10 to 20 per cent. If production is very good they may even get a bonus payment. In some cases, technicians are paid a fixed monthly salary, usually AUD 100 (Rp. 500,000). The hatchery owner may also provide food and lodging for the technician and workers. A prototype backyard hatchery may be able to produce 150,000 fry in one run, or a total of 1.5 million for 10 runs in a year. According to Suko Ismi, a staff of GRIM, survival

rate for milkfish larvae is very high, and a 100 per cent survival rate is not uncommon. In 1995, the price of milkfish fry was AUD 0.008 (Rp. 40), which translates into a gross income of AUD 1,200 (Rp. 6,000,000) for a backyard hatchery for one run. At the time of this survey, gross income for one run ranged from AUD 390 (Rp. 1,950,000) to AUD 750 (Rp. 3,750,000).

7.1.2 Marketing Systems and Operation for Milkfish Fry

Whereas a backyard hatchery or a medium-scale hatchery may employ one or two workers, fry marketing provides livelihood opportunities for many people. In the Gondol area, there are about 20 brokers for milkfish fry, each employing from 10 to 20 workers, both part time and full time. A total of 10 million fry are traded in the Gondol area daily. Every morning, workers gather around the house of the broker, waiting for announcement of the day's buying price for milkfish fry. In the afternoon, these workers may be seen riding on motorcycles, carrying inflated used tires which carries oxygen that will be used for packing milkfish fry into small plastic bags (see Figure 4). The workers collect fry from the hatcheries and transport them to the house of the broker. A worker is paid AUD 0.20 (Rp. 1,000) per rean by the broker; one rean is equivalent to 5,000 pieces of fry. A hatchery operator may sell to any broker, and there is no standing hatchery operator-broker relationship that limits the selling of fry to only one broker. From the broker, the milkfish fry are shipped to nursery and grow-out farms in Batam, Padang, and other parts of Indonesia, or bought by exporters of milkfish fry to the Philippines. During the period of the conduct of this study, the buying price of milkfish fry by brokers fluctuated from AUD 0.0026 to 0.0044, and 0.005 (Rp. 13 to 22, and 25) a piece.

Figure 4: Motorbike carrying inflated used tire with oxygen (left) and motorbike carrying plastic bags with milkfish fries (right).

Suko Ismi, a staff of GRIM whose husband is an exporter of milkfish fry to the Philippines, stated that her husband exports one to four million milkfish fry, four times a week, to the Philippines. The price of milkfish fry is AUD 0.008 – 0.01 (Rp. 40 – 50) a piece. The peak season for exporting milkfish fry is from December to March. Exporters such as Suko Ismi's husband hires temporary workers to pack the fry in the early morning for transport to Denpasar airport. From there, the milkfish fry are transported by flight to Manila.

7.1.3 The Role of Women in Milkfish Fry Industry

Although hatchery owners, technicians, and workers are males, women find a niche in fry marketing as brokers and temporary workers. Hatchery operators and exporters hire women to count milkfish fry for packing into small plastic bags. Women living in the neighborhood of the hatchery are hired as a group, earning AUD 0.40 (Rp. 2,000) for every 5,000 pieces of fry counted. The earnings are pooled and divided after the work, and a group may earn AUD 20.00 (Rp. 100,000) in two days. Women are also hired by exporters to pack fry for export (see Figure 5).

Figure 5: Women counting milkfish fries for packing (left), and women packing milkfish fries for export (right).

7.1.4 Unintended Consequences: Migration and Overproduction

Once released for extension and adoption by farmers, a technology such as the milkfish seed production technology, will have a life of its own. As originally intended, the backyard hatchery was designed to alleviate poverty and diversify livelihood opportunities of fishers who are dependent on catching ornamental fish with poison for their livelihood. During the early stages of technology adoption, people around the Gondol area who were once fishers and fry gatherers found employment in the milkfish hatcheries. Staff from GRIM, in collaboration with small farmers from the Gondol area, benefited from the technology.

In 1993, milkfish fry sold for AUD 0.0044 – 0.005 (Rp. 22 - 25) per piece; in 1995, the price was AUD 0.008 (Rp. 40). The increase in the price of milkfish fry and short culture period attracted many people to invest in backyard hatchery, both small and big farmers from within and outside Bali.

In 1997–1998, the price of milkfish fry increased to AUD 0.02 (Rp. 100) a piece, a 250% increase from 1995 level. This created an investment boom for milkfish hatcheries in the Gondol area (Kawahara, pers. com.). Members of the Chinese community from Java moved to Bali to invest in milkfish hatcheries. Workers from Java and other parts of Indonesia also moved to Bali to seek employment in these hatcheries. During this time, milkfish fry production was 500 to 600 million per year, and one backyard hatchery can produce 100,000 to 200,000 milkfish fry in a month. One larval rearing tank was counted as 0.5 unit in the survey, with the prototype backyard hatchery counted as one unit with two larval rearing tanks. Table 1 shows that of the hatcheries surveyed, 36.4 per cent were the prototype backyard hatchery,

whereas 49.5 per cent had 1.5 to five units. Four hatcheries had between 31 to 60 units. In terms of number of units, the prototype backyard hatchery comprised 10 per cent; 1.5 to five units, 33.8 per cent; and 31 to 60 units, 21 per cent. This means that the medium to large hatcheries predominate in the Gondol area.

Table 1. Size distribution of milkfish hatcheries in Bali, Indonesia, 1997

Number of units	Frequency	Percent
1.0	78	36.4
1.5-5.0	106	49.5
5.5-10.0	20	9.3
10.5-20.0	6	2.8
20.5-60.0	4	1.8
Total	214	100.0

Note: One larval rearing tank was counted as 0.5 unit in the survey. The prototype backyard hatchery consists of two larval rearing tanks, and counted as 1.0 unit.

Source: Slamet *et al*. 1998.

After 1998, Chinese-Indonesian from Java and Chinese Taipei moved to Bali to build medium-scale hatcheries. More technicians and workers from Java also migrated to Bali to find employment in milkfish hatcheries. Today, if a milkfish hatchery is not owned or managed by a staff of GRIM, it is owned by a Javanese or somebody from outside Bali. People from Jakarta, Surabaya, and even Chinese Taipei moved to Bali to buy land and set up their hatchery in the Gondol area. The obvious reason for this is the increase in business opportunity in this area for various people from within Indonesia and in the region. One of the hatchery operators surveyed told that he was introduced to venture into milkfish hatchery business by a friend who is in milkfish hatchery business. After being successful in the hatchery business, he introduced the business opportunity to another three of his relatives.

The expansion of milkfish hatcheries in terms of number of units and the addition of new hatcheries resulted in overproduction and a decline in price. In 1996-97, a hatchery can reach breakeven point after three months of operation. Today, newcomers to the hatchery business may even lose money due to the low and unstable price of milkfish fry.

7.2 Socioeconomic Impacts of Grouper Hatcheries in Bali

Many hatcheries rearing humpback and tiger grouper in the Gondol area started with milkfish fry production. With the success of the mass seed production technology by GRIM in 2000, many hatchery operators switched to rearing grouper. Unlike milkfish fry production which has a rearing period of 21-25 days and may have 10 runs per year, grouper seed production takes 50-60 days with a maximum of three runs. Humpback grouper juveniles sell for AUD 0.20 (Rp. 1,000) per cm, whereas tiger grouper sells for a lower price at AUD 0.30 (Rp. 1,500) a piece for a 2-3 cm size, and AUD 1.60 (Rp. 8,000) a piece for 11-12 cm size.

The adoption of the seed production technology for grouper generated four distinct groups in the supply chain in the grouper fingerling industry in the Gondol area.

1 **Egg Supply** – At present, GRIM is the source of fertilized eggs for humpback grouper in Bali. For tiger grouper, there are three other hatcheries in addition to

GRIM that supply fertilized eggs to farmers. Two of these are located in the Gondol area and one in Negara, all owned by Taiwanese businessmen. GRIM sells eggs at AUD 0.0002 (Rp. 1) per egg for tiger grouper and AUD 0.0005 (Rp. 2.5) per egg for humpback grouper, with priority given to the staff at a maximum of 100,000 eggs per staff. There are also increasing number of private hatcheries beginning to establish themselves for eggs supply.

2 **Hatchery** – The hatcheries buy the fertilised eggs and rear the larvae to a size of around 3-5 cm in length (minimum of 2 cm) for 50-60 days. This size is good for transport but not suitable for stocking for grow-out culture, particularly floating cages. Most hatchery operators in the Gondol area belong to this category.

3 **Nursery** – A small network of nurseries on grow the fingerlings to a more marketable size of around 10 cm from 3-4 cm. There are very few of these in the Gondol area, maybe three to five farmers only, because it is costly to grow humpback and tiger grouper for longer period.

4 **Brokers** – The majority of product produced by the hatchery and nursery sectors are sold through local brokers. The major product sold through brokerage firms is the milkfish. The brokers have the export linkages and absorb some of the market risk.

It is very difficult to ascertain the total number of existing grouper hatcheries in the Gondol area. According to Dr. Adi Hanafi, Director of GRIM, there are about 100 to 200 small-scale hatcheries in the Gondol area. Many of these hatcheries are growing milkfish, tiger and humpback grouper, and started with milkfish. Hatcheries in Negara, however, were originally used for rearing shrimp fry.

7.2.1 Employment in Grouper Fry Industry

Most grouper hatcheries employ a minimum of two workers, who are usually paid 15 to 20 per cent of net sales. Some hatchery operators provide food and lodging for their workers. Some workers are paid a fixed monthly salary, from AUD 100 to 120 (Rp. 500,000 to 600,000). Workers usually have junior and senior high school education, and many of them come from outside Bali.

7.2.2 The Role of Women in Grouper Fry Industry

As in milkfish hatcheries, women are also involved in grouper hatcheries. They are being employed as temporary workers for size-grading of humpback and tiger grouper during hatchery production cycles. The women are paid AUD 8.00 (Rp. 40,000) a day for this job. According to a large-scale grouper hatchery owner, women are very good at size-grading grouper and counting milkfish fry, which are very hard work.

8 Economic Analysis of Backyard Hatchery

8.1 Introduction

The successful evolution of small-scale grouper hatcheries in the Gondol area of Bali is of great regional importance. The technology transfer of grouper hatchery

techniques to the private sector hatcheries of the region, primarily based on milkfish, is a template that can be applied in many regions of the Asia-Pacific.

The main focus of this section of the report is to develop an economic profile of the small-scale hatcheries undertaking grouper culture and determine their feasibility. The ability of these hatcheries to develop sustainable production of grouper seed is a key factor in creating employment opportunities for the local population, providing income streams to farmers and workers and create both domestic and international markets.

Aquaculture enterprises are usually capital intensive, requiring substantial investment with extended payback periods. The ability of aquaculture enterprises to source investment, establish capital infrastructure and weather financial and operating expenses during inception has, in the past, been a major stumbling block for sustainable aquaculture industries. Variability in market prices and income flows also pose major hazards to establishing early profits and ensuring viability in the long term. However, the relative success of small-scale grouper hatcheries in northern Bali will provide some insight into the operational, managerial and economic factors that give rise to such success.

The economic analysis will concentrate on the two most commonly produced species in the northern Bali region. The species are *Cromileptes altivelis* and *Epinephelus fuscoguttatus*. The predominant species to be cultured in Indonesia is *C. altivelis*.

In addition to this economic report a bio-economic model of grouper larviculture is provided in CD-Rom format[1]. The model has been developed using data collected from field surveys in northern Bali and additional information provided by the GRIM in Indonesia. The model will be used to examine how improvements in growth and survival affect the cost of production of grouper fingerlings, and to determine a 'break even' cost for grouper fingerling production. The model can also be used as a tool for:

- Assessing the real costs associated with grouper hatchery production;
- Providing small-scale grouper hatcheries with the tools to assess the effects of decision making, various management options, alternative farming methods, and changes in operational costs and market prices on business profitability;
- Providing a cost-benefit analysis tool to asses research and development options; and
- Providing a decision tools for researchers.

Discounted cash flow analysis was used in the bio-economic model to determine the annual cost structure and the likely profitability of the small-scale grouper hatchery.

8.2 Brief Economic Background on Backyard Hatchery

The predominant culture marine finfish species in Indonesia is the milkfish of which there are over 2,000 small-scale hatcheries currently producing the fry. The milkfish are relatively easy to culture, have developed markets and provide a good source of protein for economies such as Indonesia and the Philippines. Their survival rates are exceptionally high (up to 95 %) which is reflected in the 300 to 400 million fry that

[1] Bio-economic model in CD-Rom is available from the Asia-Pacific Marine Finfish Aquaculture Network (grouper@enaca.org) or from Mr. Bill Johnston (Bill.Johnston@dpi.qld.gov.au).

are produced each month. The basic industry structure revolves around cooperative hatcheries/private hatcheries supplying the multitude of hatcheries. The basic economic structure of milkfish hatcheries in northern Bali is outlined in Table 2.

Table 2. Economics of milkfish (*Chanos chanos*) as supplied by GRIM

Scale	10 hatchery runs of 150,000 viable eggs
Survival rate	50% (1,500,000 x 50%)
Income	AUD 6,000 (AUD 0.008 per pc)
Capital investment	AUD 1,590
Annual operating costs	AUD 1,200
Depreciation (20%)	AUD 318
Maintenance (3% of capital)	AUD 48
Financial costs (24% interest)	AUD 382
Total annual cost	AUD 1,948
Annual profit	**AUD 4,052**

(Source: JICA and Gondol Research Institute for Mariculture, 1995)

8.3 Problem Statement and Objectives

At present there is little nursery or grow out culture of grouper in northern Bali due to lengthy production times and the requirement of carrying the burden of operating costs over the nursery and grow out phase with minimal cash flow. The primary reason for the development of grouper hatcheries, rather than the follow-on nursery and grow out industries, is a quick turnover of product.

In most cases the decision to grow grouper seed is based on market demand and prices. As a result there is a significant fluctuation in the number of hatcheries prepared to stock grouper, preferring to stock milkfish because of high throughput, ease of culture, and market demand.

However, the primary motivator for the uptake of grouper larviculture is the relative high economic value of the product, particularly in the Asia-Pacific region. Increasing demand and relatively high prices for groupers in local and export markets are seen throughout the region, particularly in the live fish markets of Hong Kong and southern China.

The decline of wild stocks combined with increasing demand and high prices are key factors in the development of small-scale grouper hatcheries in the Asia-Pacific. With this in mind it is of key importance to identify the economic barriers to the development of operations that can develop economically sustainable grow out facilities. Primarily though, the focus of this section of the report is on the economic structure of current small-scale hatcheries and their flow on benefits to the community in terms of regional economic development.

8.4 Scope of the Economic Study

The economic component undertakes a microeconomic evaluation of the small-scale hatcheries producing grouper in the northern region of Bali. A total of 11 farms out of the 17 farms surveyed provided economic data. Due to time constraints and sensitivity

of the topic, detailed economic data was limited. However, sufficient data was collected to develop a discounted cash flow model for each of the 11 farms surveyed. The calculations were based on the following assumptions:

- The real value of land was maintained over the life of the project (20 years);
- Taxation was excluded from all calculations;
- The equivalent annual return was calculated net of owner/operator labour, capital and operating costs;
- The price used for grouper fingerlings was based on average market sales prices provided by GRIM, unless otherwise stated by the hatchery;
- The opportunity cost of time spent on setting up the enterprise was not included;
- An exchange rate of Rp 5,000 to AUD 1.00 was used; and
- All farms surveyed create the majority of their income through grouper culture.

GRIM has released extension materials to aid potential hatchery operators in identifying some of the key areas, including the economics of grouper hatchery. The following is a summary of the information released by the institute to potential grouper hatchery owners and operators:

Table 3. Economics of humpback grouper (*C. altivelis*) as supplied by GRIM.

Scale	3 hatchery runs of 100,000 viable eggs
Survival rate	5% (300,000 x 5%)
Income	AUD 12,000 (AUD 0.8 per fingerling)
Capital investment	AUD 8,850
Annual operating costs	AUD 6,330
Maintenance (3% of capital)	AUD 266
Financial costs (18% interest)	AUD 1,593
Total annual cost	AUD 8,189
Annual profit	**AUD 3,811**

(Source: JICA and Gondol Research Institute for Mariculture, 1995)

8.5 Methods for Economics Study

8.5.1 Data Collection

This economic study was based on information collected from established grouper hatcheries operating in northern Bali, Indonesia. A survey of these farms using personal interviews was carried out. Aquaculture extension officers at GRIM supplied additional production and technical information.

8.5.2 Data Analysis

Discounted cash flow analysis was used to determine the annual cost of production and the likely profitability of grouper hatchery culture in Indonesia. Discounting reduces a time stream of costs or benefits to an equivalent amount in today's dollars. The single amount calculated using the compound interest method is known as the

present value (PV) of the future stream of costs and benefits. The rate used to calculate present value is known as the discount rate (opportunity cost of funds).

The analysis of the small-scale grouper hatcheries assumed a project life of 20 years and used a real discount rate of 8 per cent to calculate the net present value (NPV). The budget incorporates the initial capital and establishment costs.

8.5.3 Profitability Measures

Three profitability measures, and a measure of financial risk, were used to evaluate the grouper hatcheries:

8.5.3.1 Equivalent Annual Return

The NPV is the difference between the present value of cash inflows and the present value of cash outflows over the life of the project. If the NPV is positive the project is likely to be profitable. When the NPV is converted to a yearly figure it becomes annualised. In this report the annualised return is called the equivalent annual return. It is a measure of annual profit after deducting capital, operating and labour costs generated over the life of the project expressed in today's dollars.

8.5.3.2 Internal Rate of Return (IRR)

The discount rate at which the project has an NPV of zero is called the internal rate of return. The IRR represents the maximum rate of interest that could be paid on all capital invested in the project. If all funds were borrowed, and interest charged at the IRR, the borrower would break even, that is, recover the capital invested in the project.

8.5.3.3 Benefit-Cost Ratio

The benefit-cost ratio measures the expected present value of project benefits to the expected present value of project costs. For example, a ratio of 1.5 to 1.0 indicates that for every dollar we spend on the project we expect to return AUD 1.50. Therefore a ratio of greater than one indicates a project is acceptable.

8.5.3.4 Payback Period

Payback period is a measure of the attractiveness of a project from the viewpoint of financial risk. Other things being equal, the project with the shortest payback period would be preferred. It is the period required for the cumulative NPV to become greater than zero and remain greater than zero over the life of the project.

8.6 Physical and Biological Structure of Small Scale Hatcheries

Before entering into the economic analysis an examination of the physical and biological structures of the small scale hatchery industry in Indonesia is necessary.

8.6.1 Rearing, Algal and Filter Components

The 11 farms surveyed all produced grouper, either *C. altivelis* or *E. fuscoguttatus*, or both. Of the eleven hatcheries, only six produced the humpback grouper, while the remaining five hatcheries produced a combination of both humpback and tiger grouper.

Table 4. Allocation of rearing tanks between humpback and tiger grouper.

	C. altivelis	***E. fuscoguttatus***	**Total**
Farm 1	4	0	**4**
Farm 2	4	2	**6**
Farm 3	6	6	**12**
Farm 4	10	0	**10**
Farm 5	4	0	**4**
Farm 6	3	2	**5**
Farm 7	1	1	**2**
Farm 8	7	0	**7**
Farm 9	8	8	**16**
Farm 10	8	0	**8**
Farm 11	3	0	**3**
Total	**58**	**19**	**77**

All hatcheries in the Gondol region had an average size larval rearing tank of approximately 10 metre^3. The format of the grouper hatcheries were quite standardised as they were modeled on the prototype hatchery developed on site at GRIM.

The other components of the hatchery structure included filter and live feed culture tanks. The ratio of filter tanks to rearing tanks is 1.5:1, and the ratio of live feed tanks to rearing tanks is 4:1. The associated volumes were as follows; filter tanks held 2.5 m^3 and algal tanks were of a standard 5 m^3. The aforementioned ratios and volumes were standard across all hatcheries due to the copying process that was based on the prototype facility.

8.6.2 Survival Rates

The survival rates of the groupers were set as a standard percentage across all hatcheries and was based on information supplied by the research staff at GRIM and the QDPI Northern Fisheries Centre in Cairns. Survivals prior to stocking out into the hatchery facilities are similar for both species. The fertilisation rate of eggs at Gondol is estimated at 70%, while the hatching rate of the fertilised eggs is also 70%. The following table represents the survival of larvae from their initial stocking into the hatchery through to the sale of fingerlings. The time period for the rearing of the fingerlings is assumed to be 60 days.

Table 5. Survival rates for both *C. altivelis* and *E. fuscoguttatus.*

	Day	**Survival (%)**
Initial stocking	1	100 %
First feed	4	40 %
After first feed	6	20 %
***Artemia* feeding**	10	15 %
Day 25 mortality	25	12 %
Weaning	35	10 %
Sale size	60	5 %

8.6.3 Rearing Densities

Of the 11 farms surveyed it was found that the majority of grouper hatcheries were operating a density of around 5,000 fingerlings per 10 m^3 tank. This equates to a density of around 0.5 fingerlings per litre of water.

The variation in rearing densities ranged from the lowest at 3,600 fingerlings per 10 m^3 tank, to the highest being 6,000 per 10 m^3 tank. An initial stocking density of fertilized eggs into larvae tanks was estimated at 10 per litre.

8.6.4 Size of Fingerlings at Harvest

For the majority of farms surveyed the average size of fingerlings harvested for sale was 5 cm. This included both *C. altivelis* and *E. fuscoguttatus*. The size of fingerlings sold by a hatchery was not so much driven by the market, but by the cost of production. The variation in size of turnoff was greatly affected by the ability of the hatchery owner to cover the basic operating costs, this being predominantly feed costs.

All hatcheries surveyed incorporated three production cycles of *C. altivelis* per year and where grown, four production cycles of *E. fuscoguttatus*.

With regard to *C. altivelis*, two of the hatcheries had a relatively quick turnover of fingerlings, having a sale size of 2 cm. Another hatchery had an average turnoff size of 3 cm. At the upper end of the scale two hatcheries produced 6 cm fingerlings, while one hatchery produced fingerlings anywhere from 2 to 10 cm depending on market conditions. The remainder of hatcheries surveyed produced predominantly 5 cm fingerlings.

The sale size of *E. fuscoguttatus* was similar to that of *C. altivelis* with one hatchery producing 2 cm fingerlings, another producing a size of 3 cm, two hatcheries producing a 6 cm product, and one hatchery producing a range of sizes from 2 to 10 cm. The remainder of *E. fuscoguttatus* hatcheries turned off 5 cm fingerlings.

8.7 Cost Structure Evaluation of Small Scale Hatcheries

The following section will evaluate the cost structure of the small-scale grouper hatcheries in northern Bali. Each component of the cost structure will look at, and evaluate, comparisons between the eleven farms surveyed. A full cost break down for each of the 11 farms is available in bio-economic model CD-ROM.

8.7.1 Capital Expenditure and Land

The purchase value of land varied greatly from hatchery to hatchery with the value of land increasing with better the access to seawater, but this increasing value of land in relation to coastal proximity is true almost anywhere. Land in northern Bali is commonly sold in 100 m^2 lots. Two of the hatcheries are renting the land from the owner at a rate of 10 percent of the hatcheries net sales each year.

In this analysis, 100 percent of the land value would be recovered at the end of the project life (20 years). Average land values per 100 m^2 in northern Bali were AUD 1,620.

Table 6. Land sizes and prices.

	Land Size (m^2)	Land Value (per 100m^2)	Total Land Cost
Farm 1	500	AUD 3,000	**AUD 15,000**
Farm 2	Rent	-	**-**
Farm 3	5,000	AUD 1,440	**AUD 72,000**
Farm 4	Rent	-	**-**
Farm 5	1,500	AUD 1,440	**AUD 21,600**
Farm 6	500	AUD 1,000	**AUD 5,000**
Farm 7	10,000	AUD 1,500	**AUD 150,000**
Farm 8	400	AUD 1,400	**AUD 5,600**
Farm 9	13,000	AUD 2,000	**AUD 260,000**
Farm 10	1,600	AUD 1,400	**AUD 22,400**
Farm 11	1,500	AUD 1,400	**AUD 21,000**

The remainder of the capital items have been broken down into the following categories:

- **Buildings** - sheds, hatchery, accommodation, cold rooms and site electricity connection;
- **Vehicles** - utilities and motorbikes;
- **Tanks and peripherals** - rearing tanks, algal tanks, filter tanks and blowers;
- **Other infrastructure and equipment** - generators, seawater intakes, pumps, monitoring equipment and tools.

Table 7. Capital expenditure and land values.

	Buildings	Vehicles	Tanks and Peripherals	Other Infrastructure & Equipment	Total
Farm 1	AUD 1,700	-	AUD 6,050	AUD 17,250	**AUD 25,000**
Farm 2	AUD 2,550	-	AUD 7,375	AUD 5,075	**AUD 15,000**
Farm 3	AUD 3,300	-	AUD 14,463	AUD 5,800	**AUD 23,563**
Farm 4	AUD 550	-	AUD 7,750	AUD 3,700	**AUD 12,000**
Farm 5	AUD 4,750	-	AUD 1,513	AUD 22,137	**AUD 28,400**
Farm 6	AUD 1,375	-	AUD 5,563	AUD 8,062	**AUD 15,000**
Farm 7	AUD 7,350	-	AUD 3,225	AUD 20,900	**AUD 31,475**
Farm 8	AUD 1,925	-	AUD 8,488	AUD 4,400	**AUD 20,413**
Farm 9	AUD 54,600	AUD 30,000	AUD 27,400	AUD 102,000	**AUD 214,000**
Farm 10	AUD 2,200	-	AUD 7,000	AUD 2,500	**AUD 11,700**
Farm 11	AUD 2,925	-	AUD 3,688	AUD 2,500	**AUD 9,113**

8.7.2 Purchase of Fertilised Eggs

The main supplier of fertilised eggs to the hatcheries surveyed was GRIM. During the inception of the small-scale grouper hatchery industry in the north of Bali the fertilised eggs were supplied free of charge. Gondol now charges a set fee for the eggs at the following rate:

C. altivelis	AUD 0.0005 (Rp. 2.5) per egg
E. fuscoguttatus	AUD 0.0002 (Rp. 1) per egg

At the time of the survey a small number of privately owned hatcheries were beginning to provide some fertilised eggs to the hatcheries. The eggs were predominantly *E. fuscoguttatus* at a cost of AUD 0.0003 (Rp. 1.5) per egg.

8.7.3 Feeds

A variety of feeds were encountered during the survey and all were utilised in a number of combinations. Primarily the feed components of the hatcheries could be broken down into the following categories:

8.7.3.1 Microalgae and Rotifers

This feed cost relates to the maintenance of rotifer cultures. The cost involved in maintaining algal cultures to support rotifer production involves initial purchase of starter algal cultures at AUD 10.00 (Rp. 50,000) per annum. To maintain algal volumes, a fertiliser is used at an average rate of 0.5 kg per m^3. Fertiliser costs are estimated at AUD 1.00 (Rp. 5,000) per kilogram.

8.7.3.2 *Artemia*

Artemia is used at a rate of two cans per tank per hatchery run with an average cost of AUD 70.00 (Rp. 350,000) per can.

8.7.3.3 Microdiet

Microdiet is used to rear the fingerlings during the initial stages of growth. It is an expensive product and is commonly imported from Japan. In the past GRIM has imported the products and sold the feeds to the hatchery owners. This practice has become less prevalent as more hatchery owners develop their businesses. Microdiet is used at a rate of five kilograms per larval rearing tank (10 m^3), given a final density of 5,000 larvae per tank. The diet itself costs around AUD 2.00 (Rp. 10,000) per kilogram.

8.7.3.4 Pellet Diet

Following the use of microdiets the feed size is increased to match the feeding capabilities of the larvae. The price of the commercial diet ranged from AUD 3.00 to AUD 5.00 (Rp. 15,000 to 25,000) per kilogram. The feed conversion ratio (FCR) for the commercial pellet diet was estimated at 2.5.

8.7.3.5 Alternatives

The grouper hatcheries growing *E. fuscoguttatus* commonly use trash fish as an alternative to the pellet diet, as the tiger grouper does not readily accept the pellet diet. The cost of trash fish ranged from AUD 0.80 to AUD 1.40 (Rp. 4,000 to 7,000) per kg and has an average FCR of 7.0. Mysid shrimp is also used prior to feeding the tiger grouper fry with trash fish. The mysid shrimp are caught from the shrimp farms 25 to 80 km away from Gondol and sold at around AUD 0.80 (Rp. 4,000) per bag to the hatcheries. Approximately 15 bags of mysid shrimp are fed to one larval rearing tank during the hatchery cycle. No FCR figures were available for mysid shrimp.

8.7.4 Labour

The labour cost of any aquaculture operation is always considerable. The employee payment structure for hatcheries in Indonesia falls in either one of two categories:

8.7.4.1 Performance Based Payment

The majority of hatcheries had an established performance based payment system whereby the workers share in 20 percent of the net farm income. The owner of the business would retain the remaining 80 percent of net income. Variations of this formula were found in two instances, one hatchery allocated 15 percent of the gross income to workers, while the other allocated 20 percent of gross income to workers.

8.7.4.2 Salary or Wage Structure

Only three of the hatcheries surveyed incorporated a salary or wage based structure. Wages for workers ranged from AUD 25.00 (Rp. 125,000) per week to AUD 67.00 (Rp. 335,000) per week depending on seniority. A manager at one hatchery visited was paid an allowance of only AUD 50.00 (Rp. 250,000) per week while another was paid AUD 300.00 (Rp. 1,500,000) per week. The variation in managerial salaries was based on qualifications and skills. The lesser managers' salary was based on his ability to train and succeed in the job, while the other held a degree qualification and had trained on prawn farms.

8.7.5 Operating Expenses

The analysis of operating expenditures in grouper hatcheries is broken down into three main categories. However the majority of hatcheries surveyed provided either a total operating expenditure per tank or per year and were unable to define the costs. These summary operating expenses will be discussed at the end of this section.

8.7.5.1 Fuels and Oils

The main use of fuels and oils in the hatcheries is on running vehicles (only one hatchery owned and operated a vehicle) and operating fuel based generators and seawater intake systems. A litre of diesel fuel costs around AUD 0.23 (Rp. 1150) to purchase locally. Only one farm of the eleven had a back up generator that is used to combat the inconsistent government electricity supply. Around 20 litres of diesel fuel is required each month to provide a consistent electricity supply to that hatchery.

One other hatchery operated a diesel powered seawater intake system that cost around AUD 30.00 (Rp. 150,000) in diesel per month to run.

8.7.5.2 Repairs and Maintenance

Repairs and maintenance costs for the various hatcheries is based on 3 percent of the total capital outlay for the hatchery. This figure was taken from calculations provided by researchers at GRIM. One farm did however provide a figure of AUD 2,000 (Rp. 10,000,000) per annum to repair and maintain his hatchery.

8.7.5.3 Electricity

Hatchery operators in the Gondol region are faced with an unstable electricity supply and an ever-increasing electricity cost. The Indonesian Government heavily indexes the cost of electricity each year. Those farms that were able to provide an electricity cost are listed below. A per tank comparison is also provided.

Table 8. Annual electricity costs for Indonesian hatcheries.

	Annual Electricity Cost	Electricity Cost per Tank
Farm 2	AUD 1,680	AUD 280
Farm 6	AUD 720	AUD 144
Farm 7	AUD 3,600	AUD 1,800
Farm 8	AUD 1,800	AUD 257
Farm 9	AUD 28,800	AUD 720
Farm 10	AUD 2,400	AUD 300

Note: Farm 9 had only 2 tanks operating at the time with 24 unused that are normally in production. This has been accounted for in the above table.

8.7.5.4 Aggregated Operating Expenses

In the majority of cases either managers or workers were only able to provide an estimate of annual operating expenses or per tank operating expenses (excluding labour). The following table illustrates the hatcheries that provided aggregated operating expenses exclusively, or in addition to the costs outlined above.

Table 9. Aggregate operating expenses.

	Operating per Tank	Annual Operating
Farm 3	-	AUD 120,000
Farm 5	AUD 960	-
Farm 6	AUD 2,400	-
Farm 7	AUD 3,000	-
Farm 8	AUD 1,000	-
Farm 9	AUD 1,000	-

8.7.6 Marketing Systems for Grouper Fry

Grouper culture is wide spread throughout the Indonesian Islands including Sumatra, Bangka, Bengkulu, Lampung, Kepulauan Seribu, Banten, Java, Lombok, Kalimantan, and Sulawesi. Grouper culture is also established in economies such as China, Hong Kong SAR, Chinese Taipei, Philippines, Singapore, Brunei Darussalam and Malaysia.

The majority of the grouper fingerlings reared in the Gondol area are sold domestically to a number of grow-out facilities or exported to other grow-out facilities in the Asia-Pacific region. Like in milkfish fry marketing, brokers are involved in buying and trading humpback and tiger grouper fingerlings. There are about four to five brokers of grouper fry, compared with about 20 for milkfish fry. An established network of hatcheries and brokerage companies exists in Bali and has adapted well to the distribution of grouper. The hatcheries deliver stock to the brokers on a regular basis, normally as the market demands. However, the supply of grouper fingerlings from the hatcheries tends to far outweigh the market demand for the fingerlings. The small-scale hatcheries have accelerated production of grouper fingerlings beyond the capacity of grow-out facilities in Indonesia. It is now the focus of GRIM to develop the downstream industries such as nursery and grow-out culture for groupers.

Based on figures provided by GRIM, production of *C. altivelis* can reach 400,000 per month, while numbers of *E. fuscoguttatus* can reach 1,000,000 per month. This is in comparison to the average production rates of milkfish fry at around 450 million per month.

8.7.7 Packaging

The majority of hatcheries we visited sold their product through local brokers that required no actual monetary outlay from the hatcheries. The brokers would pick up the grouper fry from the hatchery and market the product either locally or to other regional economies. Therefore, the brokers incur all freight and packaging costs. The brokers cover this cost by setting a price for the grouper fingerlings (payable to the hatcheries), less than the actual price available on the open market.

In some instances hatcheries undertake their own marketing programs. During the survey only two hatcheries were marketing product themselves to local and overseas buyers. The standard package used is a 20-litre styrofoam box, with plastic bags/liners used to contain the fingerlings. This type of live fish transport method for fingerlings is used world wide with bulk transport in bins the other option. The styrofoam box costs around AUD 4.00 (Rp. 20,000) and plastic liners around AUD 0.50 (Rp. 2,500) each (2 normally used in live transport of fingerlings for protection against spiking). Packing tape and rubber bands to seal the boxes and bags respectively cost around AUD 0.07 (Rp. 350) per box. Oxygen is estimated to cost around AUD 1.00 (Rp. 5,000) per box. Total packing costs for one box of fingerlings is approximately AUD 5.57 (Rp. 27,850), excluding labour.

The actual cost of packing fingerlings for market depends heavily on the size of fingerling that is produced for the market. Market demand is predominantly for larger specimens that can be transferred directly into grow-out facilities. As a benchmark, grouper of around 10 cm in length are sought after for introduction into the grow out sector. Fingerlings that are smaller in size normally require a nursery phase. As a rule of thumb, the following number of grouper fingerlings can be transported in a 20-litre styrofoam box:

- 3 to 4 cm fingerling – 500 per box
- 11 to 12 cm fingerling – 30 per box

The small-scale hatchery industry in Bali aims to sell the product at the smallest possible size, normally around 2 cm. This reduces production risk and alleviates ongoing operating expenses.

Due to the infant nature and limited capacity of grow-out facilities in Indonesia, the other major market for the 2 to 5 cm product is the aquarium (ornamental) fish trade. Without the existence of established nurseries, or willingness of hatcheries to undertake the role, the aquarium trade plays an important role in keeping the small-scale hatchery industry afloat.

8.7.8 Freight

In most instances, the freight costs were bore by the brokerage firms and passed onto buyers in the local region. These costs were not sought in the survey, but a number of farms were able to provide a freight cost to Jakarta of AUD 20.00 (Rp. 100,000) per

box, or around AUD 1.00 (Rp. 5,000) per kilogram. This freight price was indicative of freight costs to domestic locations throughout Indonesia. Brokerage firms indicated that export costs of around AUD 2.50 (Rp. 12,500) per kilogram were common when sending to other economies such as the Philippines and Malaysia.

8.8 Price Structures of Small Scale Hatcheries in Indonesia

One of the difficulties in estimating the revenues of each hatchery is the variability in the market for grouper fingerlings. The number of grouper supplied to the market, whether that be for grow-out or the aquarium trade, far exceeds demand. This means that the majority of hatcheries producing grouper in the Gondol area are price takers, accepting whatever the market offers to them.

Another added complexity to the stability of the market is the incentive for farmers to turnoff grouper fingerlings as quickly as possible. The majority of hatcheries surveyed did not have the resources, or the cash flow, to maintain the fingerlings for long periods, for example to culture up to 10 cm. The driver for this is the increase in feed costs over a longer period, and the packaging and freight costs required in sending larger fish increase rapidly as the fish size increases.

This creates another disparity between the suppliers and the market, because the market demands larger specimens for stocking into grow-out (5 to 15 cm) while the hatcheries aim to turnoff the smallest possible product (2 to 5 cm). However, the supply chain is being developed to increase the number of nurseries that can grow the fingerlings from the 4 to 5 cm range to a more marketable size of around 10 cm in length. The nursery industry is often attached to a more affluent hatchery operation or part of the grow-out industry, where fingerlings are reared in sea cages. Grouper hatchery culture is high risk and the time to turnoff is critical in the success of local hatchery operations.

As the supply chain develops further with the development of a local cage culture industry. GRIM is developing a 500 cubic metre nursery cage site linked to an experimental grow-out site. As the nursery and grow out industry develops the hatchery sector will stabilise as the demand for product increases.

Current information on the status of small-scale hatcheries in Indonesia suggests that there are between 100 and 200 productive hatcheries. In the Gondol area there were approximately 20 active grouper hatcheries. The estimated price structure for the sale of grouper fingerlings is as follows:

Table 10. Representative price structure for grouper fingerlings in Indonesia.

Size of Fingerling	*C. altivelis*	*E. fuscoguttatus*
4 to 5 cm	AUD 1.20 to 1.40	AUD0.60 to 0.80
10 to 12 cm	AUD 2.40 to 2.80	AUD1.60 to 2.00
16 to 18 cm	AUD 5.00 to 6.00	AUD3.00 to 4.00

The variation of size in grouper being produced by the hatcheries provided a range of prices for the survey. There were also differences in the markets supplied, domestic versus export. The following is a summary of prices received by the hatcheries that were able to state them. In a number of instances the manager or owner was not available to comment on the hatcheries revenue structure.

Table 11. Indicative farm gate prices for grouper.

	C. altivelis		*E. fuscoguttatus*	
	Price	**Size**	**Price**	**Size**
Farm 1	AUD 2.20 (E)	6 to 7 cm	-	-
	AUD 1.40 (D)	6 to 7 cm	-	-
Farm 2	AUD 0.40 (D)	2 cm	AUD 0.10 (D)	2 cm
Farm 3 (Nursery)	AUD 0.20 per cm (D)	6 to 10 cm	AUD 0.20 per cm (D)	6 to 10 cm
Farm 4	AUD 0.40 (D)	2 cm	AUD 0.40 (D)	2 cm
Farm 8	AUD 1.00 (D)	5 cm	-	-
Farm 9	AUD 0.20 per cm (D)	-	AUD 0.30 (D)	3 to 4 cm
	AUD 0.20 per cm (D)	-	AUD 1.20 (E)	6 cm
	AUD 0.20 per cm (D)	-	AUD 1.60 (D)	11 to 12 cm

(E – Export, D – Domestic)

8.9 Results of Economics Analysis

All results were assessed using the cost benefit analysis method, which utilises discounting to evaluate the project(s) over a length of time. In this case the analysis was carried out over a 20-year period using a discount rate of 8 per cent.

8.9.1 Cost Structure

The analysis of the farms over a 20 year period breaks the costs into the categories of egg purchases, feed, labour, repairs and maintenance, electricity, additional operating, packaging, freight and capital replacement. Although costs may vary from year to year, as do revenues, the discounting approach enables the presentation of the costs as an annuity.

Table 12. Break up of hatchery cost structures.

	Tank	**Eggs**	**Feed**	**Labour**	**R & M**
Farm 1	4	AUD 1,224	AUD 4,584	AUD 6,500	AUD 1,200
Farm 2	6	AUD 1,551	AUD 3,399	AUD 12,869	AUD 450
Farm 3	12	AUD 2,437	AUD 6,724	AUD 29,900	-
Farm 4	10	AUD 3,061	AUD 4,724	AUD 5,503	-
Farm 5	4	AUD 276	AUD 153	AUD 1,867	-
Farm 6	5	AUD 1,245	AUD 5,561	AUD 8,849	-
Farm 7	2	AUD 694	AUD 1,740	AUD 1,578	-
Farm 8	7	AUD 1,500	AUD 4,146	AUD 11,306	-
Farm 9	16	AUD 3,755	AUD 15,908	AUD 34,480	AUD 2,000
Farm 10	8	AUD 2,449	AUD 5,152	AUD 11,912	AUD 1,000
Farm 11	3	AUD 918	AUD 1,947	AUD 5,288	AUD 900

	Tank	**Electricity**	**Operating**	**Pack**	**Freight**	**Capital**
Farm 1	4	AUD 480	AUD 1,600	AUD 1,677	AUD 11,400	AUD 4,719
Farm 2	6	AUD 1,920	AUD 8,400	-	-	AUD 1,934
Farm 3	12	AUD 720	AUD 36,055	-	-	AUD 8,627
Farm 4	10	AUD 720	AUD 22,510	-	-	AUD 1,472
Farm 5	4	-	AUD 3,300	-	-	AUD 5,238
Farm 6	5	AUD 720	AUD 40,800	-	-	AUD 2,431
Farm 7	2	AUD 180	AUD 3,500	-	-	AUD 15,996
Farm 8	7	AUD 1,800	AUD 18,300	-	-	AUD 2,249
Farm 9	16	AUD 28,800	AUD 25,200	AUD 7,826	AUD 36,400	AUD 24,458
Farm 10	8	AUD 2,400	AUD 6,860	AUD 3,354	AUD 12,000	AUD 3,227
Farm 11	3	AUD 2,000	AUD 10,000	-	-	AUD 2,795

(Tank – scale reference for number of grouper rearing tanks)

8.9.2 Output Summary for Economics Analysis

The output summary shows the annual fingerling output for each of the farms surveyed, the expected annual gross revenue for the hatchery, the annual production cost of the hatchery (consisting of the costs outlined in Table 12), the actual cost to produce one grouper fingerling, and the revenue expected for one fingerling. Where both *C. altivelis* and *E. fuscoguttatus* are reared in one hatchery the figures below represent an average cost between the two species. The details breakdown of the costs is available from the bio-economic model in CD-Rom.

Table 13. Output summary for grouper hatcheries.

	Fingerling Output	Gross Revenue	Production Cost	Cost per Fingerling	Revenue per Fingerling
Farm 1	60,000	AUD 103,200	AUD 33,385	AUD 0.56	AUD 1.72
Farm 2	100,000	AUD 82,000	AUD 30,524	AUD 0.31	AUD 0.82
Farm 3	129,000	AUD 184,500	AUD 84,463	AUD 0.65	AUD 1.43
Farm 4	150,000	AUD 60,000	AUD 37,989	AUD 0.25	AUD 0.40
Farm 5	13,500	AUD 18,900	AUD 11,433	AUD 0.85	AUD 1.40
Farm 6	85,000	AUD 95,000	AUD 59,606	AUD 0.70	AUD 1.12
Farm 7	35,000	AUD 30,000	AUD 23,688	AUD 0.68	AUD 0.86
Farm 8	73,500	AUD 84,525	AUD 39,302	AUD 0.53	AUD 1.15
Farm 9	280,000	AUD 267,200	AUD 179,187	AUD 0.64	AUD 0.95
Farm 10	120,000	AUD 96,000	AUD 48,354	AUD 0.40	AUD 0.80
Farm 11	45,000	AUD 45,000	AUD 23,849	AUD 0.53	AUD 1.00

The sensitivity of a hatchery can be shown by the differential between the cost to produce one grouper fingerling (break-even) and the revenue received per fingerling. The cost per fingerling highlights the price floor below which the annual returns and the net present value of the project become negative. In most instances there is a significant differential between the cost and revenue per fingerling.

Given the ability of the market price to fluctuate dramatically (supply greater than demand) Farm 1 has the best buffer against price fluctuations. The price would have to fall by 67% for Farm 1 to start making a loss. At the other end of the scale, Farm 7 has the least buffer against price fluctuations. If the price for grouper fingerlings (on average) fell 21% then Farm 7 would make a loss.

8.9.3 Profitability

In any investment analysis it is necessary to estimate likely future project cash inflows and outflows. A key feature of investment analysis is the process of discounting future cash flows to present values. Discounting procedures are used to evaluate the profitability of a project whose life is more than one period. Discounting is also used when selecting among projects with differing lives and cash flow patterns.

People generally prefer to receive a given amount of money now rather than to receive the same amount in the future, because money has an opportunity cost. For example, if asked an amount of money they would just prefer to receive in 12 months' time in preference to AUD 100 now, most people would nominate a figure around the AUD 110 mark. In other words, to them, money has an opportunity cost of around 10 per cent.

Measurement of the likely profitability of each grouper hatchery was based on three measures of profitability, and a measure of financial risk (see Methods section). They were equivalent annual return, internal rate of return, benefit-cost ratio, and the measure of financial risk was the payback period.

The following table outlines the profitability measures and the measure of financial risk for each of the hatcheries surveyed.

Table 14. Summary of profitability results.

	Annual Return	Internal Rate of Return	Benefit-Cost Ratio	Payback Period (Years)
Farm 1	AUD 69,815	186%	3.09	1
Farm 2	AUD 51,476	356%	2.69	1
Farm 3	AUD 100,037	114%	2.18	1
Farm 4	AUD 22,011	196%	1.58	1
Farm 5	AUD 7,467	24%	1.65	6
Farm 6	AUD 35,394	189%	1.59	1
Farm 7	AUD 6,312	12%	1.27	16
Farm 8	AUD 45,223	233%	2.15	1
Farm 9	AUD 88,013	46%	1.49	3
Farm 10	AUD 47,646	149%	1.99	1
Farm 11	AUD 21,151	79%	1.89	2

Given that the average capital expenditure for a hatchery on the Indonesian Island of Bali is around AUD 36,000 (Rp. 180,000,000), the annual returns generated through the sales of grouper fingerlings are exceptionally good. Relatively low capital investment is required to produce a high value product. This coupled with a quick turnover (2 to 3 months) provides for a high rate of cash flow through the hatchery.

8.10 Strengths and Weaknesses of Grouper Hatcheries in Bali

The backyard multispecies hatchery system (BMHS) designed for milkfish and grouper species are revolving around the principle of "flexibility". The system is designed for culture of various marine finfish species and can be switched easily if one species is in favour to the other. In this case milkfish, tiger grouper and humpback grouper.

In the middle of 2001, the price of humpback grouper started going down. By November-December of 2001, farmers have stopped producing grouper fry because there were no buyers, and switched to milkfish. According to Dr. Adi Hanafi, Director of GRIM, 60 million grouper eggs were released to the sea in December 2001 because there were no buyers.

In 2001, the Gondol area produced 1.05 million humpback juveniles and 1.1 million tiger juveniles. This supply is more than enough for the grow-out requirements in Indonesia at the present time (Kawahara 2001). There is a wide gap between the seed production technology and the grow-out technology in Bali, as GRIM has not yet developed the cage culture technology for humpback and tiger grouper. In addition to Gondol, Lampung is also a major producer of tiger grouper eggs and seed. At present, humpback and tiger grouper fingerlings are sold to Batam, Padang, Lampung, Central and East Java, Nusa Tenggara, and Jakarta. Some of the fingerlings are also being exported to Malaysia and Singapore.

Not many farmers are interested to do nursery phase of humpback and tiger grouper, which also leaves a gap between the 3-4 cm size and the 10 cm size for grow-out culture. At present, only big hatcheries are able to rear humpback and tiger grouper which they can grow up to 10 cm. Small hatcheries, however, have decided to concentrate on milkfish fry production in the meantime, or closed down. The group comprised of GRIM staff which maintains their own milkfish broodstock decided to sell 200 of their milkfish broodstock in order to buy the humpback grouper juveniles (3 cm) of their participants. The complete hatchery is going to grow these juveniles until 10 cm, and if there are still no buyers, continue growing them up to 500 g.

At present, only GRIM is the source of humpback grouper eggs because the broodstock are very costly to maintain. If the grow-out culture technology is developed, however, a few groups may be encouraged to maintain their own broodstock, thereby diversifying the sources of eggs.

The prevention and control of virus is a weakness of grouper hatcheries that need to be responded to. Although there are no reports of decimation of stocks in hatcheries due to viral disease, ways of prevention and control have to be developed.

The sustainability of grouper hatcheries in Bali depends on the price and the availability of market. The latter, however, hinges on the development of grow-out technology for humpback and tiger grouper.

9 Conclusions

The development of the milkfish and grouper hatchery technology, and its widespread adoption in Bali, underscores the importance of aquaculture research and the need for establishing farmer-scientist linkages. Conducting research is expensive and small farmers and would-be farmers do not have the capability to shoulder the costs of research. Therefore, governments, international and regional research institutions, and funding agencies should work together to ensure that research needs of small farmers and resource-poor coastal dwellers are addressed. The experience of GRIM, JICA, and ACIAR serves as a reminder to researchers and funding sponsors that the development of appropriate technology is a realistic goal which should not stop there. The transfer of the science behind the technology, and working with farmers and target beneficiaries to improve the technology, is an equally important task that must be faced.

Hatcheries, nurseries, and grow-out of marine fish such as groupers provide potential sources for the diversification of rural livelihoods and poverty alleviation. These also provide a solution to the degradation of the environment attributed to destructive practices in the live reef food fish trade. However, research on the following areas are needed to support the sustainability of these systems:

- **Establishment of criteria to determine good quality seed**. The goal is to improve survival rates of grouper in the hatchery so that both production and income of farmers remain stable.

- **Development of price and market information systems to match supply with demand of grouper fry and fingerlings**. The Multi-species hatchery system

developed by GRIM is a good model for other countries. However, this should be supported by an information system that tells farmers the lean and peak seasons for the different species in the different parts of the region so they could take advantage of good prices and schedule their production activities.

- **Development and pilot-testing of models of farmer-scientist linkages that are appropriate to the socio-political context of each country**. This will ensure that needs, experiences, and knowledge of small farmers are addressed and taken into consideration in the development and transfer of technology in aquaculture.

- **Development of carrying capacity models of a coastline or body of water for hatchery and grow-out systems**. The sustainability of these systems depends both on the environmental and socioeconomic context within which they are located. Research work on carrying capacity will help prevent economic losses, pollution, disease outbreaks, cumulative impacts and over-concentration, and social displacement.

The small-scale hatchery industry in Bali was founded on the development of milkfish culture. Milkfish fry production still remains the staple product for the majority of hatcheries in Indonesia. More than 2,000 hatcheries producing milkfish exist in the Indonesian provinces and produce from 300 to 450 million fry per month. The demand for milkfish fry is high in some Southeast Asian economies, such as Indonesia and the Philippines as an important source of protein. As milkfish culture techniques developed (improved survival rates) and market prices reached AUD 0.02 (Rp. 100) per fry, heavy foreign investment from Chinese community of Indonesia and Chinese Taipei expanded the industry. Milkfish production in Indonesia is now at the point where supply commonly exceeds demand, causing prices to drop to a low of AUD 0.002 (Rp. 10) per fry. The price fall of 90% has lead to hatcheries seeking to produce a diversity of products. Hatcheries have diversified to grouper species for grow-out as well as the aquarium trade.

The development of grouper hatchery culture techniques at GRIM, supported by the JICA and ACIAR has seen a rapid uptake of grouper by the local hatcheries. GRIM assisted the development of the local industry by developing training programs, manuals, and setting up a prototype tank system. The leaders in the development of the hatchery industry are predominantly workers in the employ of GRIM who have set up hatcheries to produce grouper for private benefit. The extension of the techniques is direct toward the private industry. GRIM supplied the eggs in the initial stages for free and provided appropriate rearing diets.

At present the hatchery industry has developed to the point where the production of grouper fingerlings is greater than the demand. The grouper hatchery industry is very lucrative given the extremely high returns derived from a relatively low capital investment. Of the 11 farms surveyed, annual returns ranged from AUD 6,312 (2 tanks) to AUD 100,037 (12 tanks) (Rp. 31,560,000 to 500,185,000).

Internal rates of return for each of the hatcheries are also exceptionally high. The IRR represents the discount rate at which the annual return becomes zero, or the hatchery breaks even. In other words, the IRR represents the interest rate at which capital could be borrowed for the hatchery, or the interest that could be earned on capital

(opportunity cost). The internal rates of return ranged from 12% to 356% with the majority of IRR's exceeding 100%.

The benefit-cost ratio is the third profitability measure used and calculates the ratio of annual returns to capital investment. Of the farms, surveyed benefit-cost ratios ranged from 1.27 to 3.09. The following statement can explain these results: for every dollar spent in the production of grouper fingerlings, a return of between AUD 1.27 and AUD 3.09 is expected, depending on the hatchery. As a decision rule, a project (grouper hatchery) would be accepted if the benefit cost ratio is greater than 1.0, in this case all projects are deemed acceptable.

Payback period is used as a measure of financial risk. It simply estimates the time required (in years) to recover the initial investment out of the expected annual returns. It is not a measure of the profitability of the project, but is an indicator of the feasibility of the investment where the risks are relatively high. Given the relative high risk of grouper culture (survivals, high operating expenses and market variability) the payback period indicator is an appropriate measure. Seven of the eleven farms surveyed had a payback period of one year. Only one farm exceeded 10 years in paying back the capital investment. The results of the analysis indicate that production of grouper fingerlings by local hatcheries dramatically improves the ability of the hatcheries to recoup their investment in the face of over supply, variable market prices and relatively high production risk.

Although milkfish provides the backbone of the hatchery industry in Indonesia, grouper culture obviously provides a viable alternative. Groupers are high value finfish having a high demand in a range of Asian markets. Hong Kong and southern China are the main markets for live grouper because of the high prices paid for grouper products in these markets. The main blockers to future expansion of grouper hatchery culture are:

1. **Market Demand** – based on information gathered during the survey period the majority of hatchery owners had difficulty in selling the product on a regular basis. For that reason many had scaled back their grouper culture in favour of milkfish to reduce their exposure to risk. Due to the length of time it takes to grow out many of the grouper species demand volumes can be quite low for lengthy periods throughout the year.

2. **Minimising Size / Nursery Culture** – many of the hatcheries are not willing to hold onto the grouper fingerlings for longer than necessary, preferring to sell the fingerlings at smaller sizes to avoid ongoing operating expenses such as feed. Given the results of the economic report it would appear they have the capacity to sustain a longer production period, but in the decision to minimise time to sale is driven more by the uncertainty that the product will be sold at all. In some instances, the larger hatcheries have established nurseries to purchase the smaller fingerlings (2 cm), rear them to size for grow out (10 cm) and on sell the fingerlings to the grow out industry.

3. **Grow Out Culture** – The main driver of the hatchery industry is obviously the grow-out sector. In most examples of aquaculture supply chains the grow-out sector leads the development of the supply chain, however, in this instance the hatchery industry has expanded beyond the capacity of the grow out sector. This

causes supply to outstrip demand. Alternative markets exist for the grouper fingerlings with the aquarium trade able to absorb a portion of the excess supply. However, the grow-out industry needs to be developed. The development of downstream industries appears to be occurring with GRIM leading experimental trials of local nursery and grow-out facilities using floating cages.

4. **Supply of Operating Components** – There is a lack of local distribution networks for the high priced rearing feeds with the majority of product having to be imported by the hatcheries themselves or being supplied through GRIM. Supply of materials is also limited for hatchery maintenance and operation.

The development of the grouper aquaculture supply chain in Indonesia will increase the supply of grouper to local markets and increase their availability for export. Spin off benefits such as the development of associated processors, freight and transport industries, brokerage firms and feed millers will also improve the economic development of the region through increased employment opportunities. Given the impressive economic returns achieved by the hatcheries in the region and the opportunity to develop the grow-out industry the grouper supply chain will provide a sustainable and viable industry base.

10 References

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11 Annex 1: Survey Questionnaire

Socio-economic study of grouper hatcheries in Bali, Indonesia

Guide Questions for Informants (hatchery operators, managers, technicians):

A. Technology adoption

1. What is your role in this hatchery?

_____ owner _____ manager _____ worker
_____ owner-operator _____ technician

2. If owner or owner-operator, when did you put up your hatchery?

3. If manager, technician, or worker, how many years of experience do you have of working in a hatchery?

4. What kinds of fish do you rear in this hatchery?

5. What kind of fish did you first rear in this hatchery?

6. From whom did you learn how to operate a hatchery?

7. When did you start rearing grouper in this hatchery?

8. Why did you decide to rear grouper in this hatchery?

9. Would you encourage a friend or a relative to put up their own hatchery?

10. Of all the kinds of fish that you rear, or have experienced rearing, which one is the most difficult to rear in the hatchery?

11. Would you say that it is easy to learn how to operate a hatchery?

12. How long did it take you to learn hatchery operations?

B. Labor allocation

13. How many persons are needed to operate this hatchery?

14. I am interested in the participation of the members of your household in the operations of this hatchery. In the daily activities in this hatchery, could you tell me which of the tasks are done by you, by the members of your household, and by hired workers?

15. Would you recommend hatchery operation as a source of livelihood for women in your community?

C. Socio-economic background of hatchery operators

16. What was your source of livelihood before you started working in this hatchery/putting up this hatchery?

17. What percent of your income is derived from this hatchery?

18. What are your other sources of income? What % of your household income are derived from each?

19. Are you originally from this village? (Or How many years have you been living in this village?)

20. If not, why did you move to this village?

21. For manager, technician, or worker: from where is the owner of this hatchery and what is his/her primary source of livelihood?

D. Socioeconomic impact of hatcheries

22. Would you consider hatchery operation as a major source of livelihood in your community?

23. How many hatcheries are there in your community?

24. What other sources of livelihood in your community are connected with hatchery operation?

25. How many people are involved in these activities?

E. Perceptions of sustainability of grouper hatcheries

26. How many years do you think will you continue rearing grouper in this hatchery?

27. Do you think that this perception is typical of other hatchery operators in your community?

28. What are the things, experiences, or events that will encourage you to continue rearing grouper in this hatchery?

29. What are the things, experiences, or events that will discourage you to continue rearing grouper in this hatchery?

F. Personal background

30. Age
31. Educational attainment
32. Gender
33. Place of birth