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GPO Box 1040, Kasetsart University Post Office
Ladyao, Jatujak
Bangkok 10903
Thailand
www.enaca.org

The Asia-Pacific Marine Finfish Aquaculture Network (APMFAN) was established in 1998 at a meeting of regional grouper aquaculture specialists in Bangkok, Thailand. APMFAN seeks to promote collaborative research, development and extension activities in the field of tropical marine finfish aquaculture to support the development of sustainable marine finfish aquaculture in the Asia-Pacific region.

www.enaca.org/marinefish/

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# Author affiliation

**Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand**

*Sih-Yang Sim*

*Michael J. Phillips*

**Department of Primary Industries and Fisheries, Northern Fisheries Centre, Cairns, Queensland, Australia**

*Michael A. Rimmer*

**Southeast Asian Fisheries Development Center, Aquaculture Department, Iloilo, Philippines**

*Joebert D. Toledo*

**Department of Marine Affairs and Fisheries, Central Research Institute for Aquaculture, Jakarta, Indonesia**

*Ketut Sugama*

**Sam Ratulangi University, Manado, Sulawesi, Indonesia**

*Inneke Rumengan*

**Commonwealth Scientific and Industrial Research Organisation, Marine Research, Cleveland, Queensland, Australia**

*Kevin C. Williams*

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# Foreword

Recent improvements in hatchery production technology for high-value marine finfish species such as groupers have led to an increased interest in setting up hatcheries to produce fingerlings for aquaculture. Small-scale hatcheries make this technology available to poor people in developing countries. Capital costs for small-scale hatcheries are relatively low, and the profitability of these ventures ensures rapid payback of capital investment.

This guide provides an outline of the requirements to establish a small-scale marine finfish hatchery, particularly the economic aspects. It is intended to provide sufficient information for potential investors to decide whether investment in such ventures is appropriate for them. The guide provides some basic technical information in order to give an indication of the level of technical expertise necessary to operate a small-scale marine finfish hatchery. However, it is not intended as a detailed technical guide to the operation of small-scale hatcheries. Additional resources, such as training courses in marine finfish hatchery production, are available and these are listed in this document.

Development of small-scale hatcheries may be more appropriate where there are existing marine hatchery operations, e.g. for shrimp or milkfish. By definition, small-scale hatcheries do not have broodstock facilities, so a supply of fertilised eggs (usually from a larger hatchery) is essential. Access to fertilised eggs and experienced hatchery staff will limit the application of small-scale hatchery technology. Despite this, there is considerable potential for this technology to be widely adopted.

This guide has been written by a team of experts in marine finfish aquaculture who have been involved in a multinational collaborative research project since 1999.

This research project, funded by the Australian Centre for International Agricultural Research (ACIAR), has made an important contribution to improving the sustainability of marine finfish aquaculture by improving hatchery production of high-value species, particularly groupers.

Further details of research undertaken as part of project FIS/97/73 *Improved hatchery and grow-out technology for grouper aquaculture in the Asia-Pacific region* are available from the project website:

http://www.enaca.org/aciar/

# 1. Introduction

## What is a small-scale marine finfish hatchery?

We define 'small-scale' hatcheries as those where the capital costs and technologies are accessible at relatively low cost, and which focus on the hatchery (larval rearing) and nursery aspects of fingerling production. Small-scale hatcheries do not hold broodstock – instead they purchase fertilised eggs or newly hatched larvae from larger hatcheries.

Small-scale marine finfish hatcheries operate throughout Southeast Asia, including Indonesia, Malaysia, Thailand, the Philippines, Vietnam and China. One of the success stories of small-scale hatchery technology is the 'backyard' hatcheries that are found in northern Bali. This technology was developed by the Gondol Research Institute for Mariculture and was taken up rapidly by local farmers who wanted to diversify from more traditional agricultural crops such as coconuts. As of 2005, there were over 2,000 units (1 unit = 2 larval rearing tanks) of small-scale hatcheries in Bali, producing a range of marine finfish including milkfish and several grouper species.

One advantage of small-scale hatcheries is that they can be easily adapted to culture a range of different species. Some marine finfish species commonly produced in small-scale hatcheries are:

- milkfish *Chanos chanos*
- barramundi / Asian seabass *Lates calcarifer*
- humpback / polkadot grouper *Cromileptes altivelis*
- tiger grouper *Epinephelus fuscoguttatus*
- green / orange-spotted grouper *Epinephelus coioides*
- snappers *Lutjanus* spp.

A typical small-scale hatchery unit consists of the following features:

- 2 indoor larval rearing tanks with 10 $m^3$ capacity
- 1 sand filter (8–10 $m^3$)
- outdoor live food production tanks (2–3 units each of microalgae and zooplankton tanks, with 10$m^3$ and 5 $m^3$ capacity, respectively)
- flow-through water supply system with regular water exchange

'Backyard' hatchery in Bali, Indonesia, producing milkfish and grouper fingerlings.

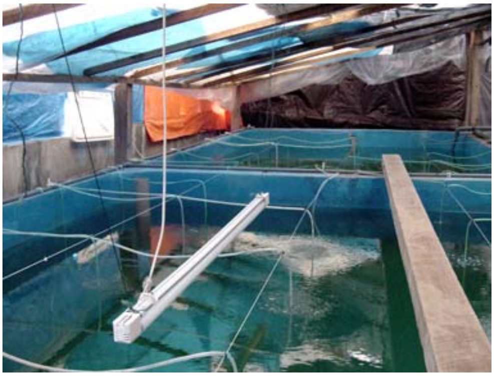
Prototype backyard hatchery developed at Research Institute for Mariculture, Gondol, Bali, Indonesia.

## Advantages of small-scale marine finfish hatcheries

The popularity of small-scale marine finfish hatcheries can be ascribed to the following advantages:

### Low capital inputs

The capital investment for a small-scale marine finfish hatchery is relatively low. For example, in Indonesia the capital cost for constructing a small-scale hatchery is around US$2,851 (refer to Section 7: Economic Assessment).



*Interior view of a small-scale hatchery showing larval rearing tanks.*

### Simple construction

Construction of a small-scale marine finfish hatchery is relatively simple and inexpensive. One unit consists of at least two larval culture tanks (6–10 $m^3$), one sand filter, two microalgae production tanks (10–20 $m^3$) and two zooplankton production tanks (5–10 $m^3$). There is no complicated mechanical set up, the only machines needed are air blowers, water pumps and a backup generator.

### Ease of operation and management

Because of the relatively simple construction of the small-scale hatchery, it is easy to manage and there is less requirement for sophisticated technical expertise for the workers or owner to operate the system.

### Flexibility

Small-scale hatchery operations are flexible, and can be used for a range of marine finfish. Many small-scale hatcheries in Indonesia switch between milkfish and grouper production as prices of these two commodities fluctuate.

*Concrete blocks being used to construct rearing tanks for a small hatchery in Bali, Indonesia.*

### Quick economic returns

Because capital and operating costs are low, the return on investment is rapid. An economic assessment of small-scale hatcheries in Indonesia indicated that 7 out of the 11 hatcheries surveyed had capital payback periods of less than one year. Section 7 of this guide *Economic Assessment* contains a simplified financial evaluation based on the economic analysis of the Indonesian 'backyard hatchery'.

## Licensing and permits

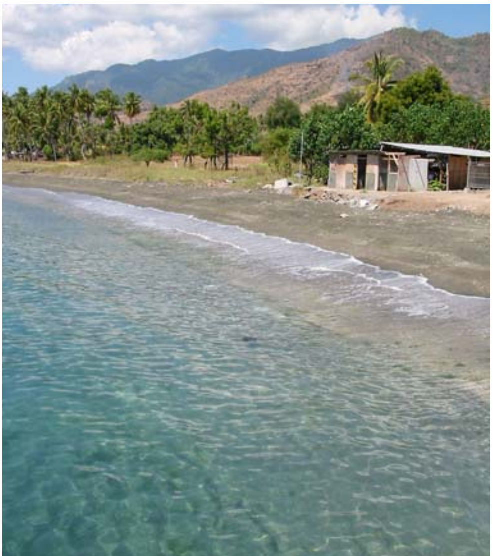
Different countries have different requirements for marine finfish hatchery operations. It is not the intention of this guide to provide details on licensing and permits for marine finfish hatchery. Intending hatchery operators should seek advice from the relevant licensing authorities with regard to these aspects.

# 2. Small-scale hatchery equipment, design and setup

## Site selection

A site suitable for a small-scale marine finfish hatchery should have the following characteristics:

- Good water source – both seawater and access to freshwater.
- Good infrastructure, such as roads, electricity and freshwater supply.
- Free from domestic, industrial, fisheries and agricultural pollution.
- Located in an area where technical support can be obtained from the government or academic research centres.
- Access to:
  - Good quality fertilized eggs.
  - Hatchery and live feed suppliers.
  - Fingerlings traders/exporters.



*Site selection is critical for marine finfish hatcheries. A clean source of seawater is vital.*

*A clean beach front such as this may provide a good water source for a marine finfish hatchery.*

*The turbid water at this location will require filtration before it is suitable for use in a marine finfish hatchery. The turbidity may be due to run-off and consequently this site may experience rapid changes in salinity.*

It is important to avoid the following when selecting a site for a small-scale hatchery:

- Poor quality or polluted seawater supply (high turbidity, high nutrient loads, variations in salinity due to freshwater runoff).

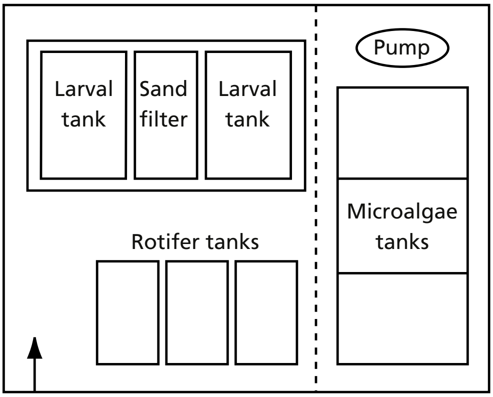
- Locating the hatchery close to other hatcheries, which may result in:
  - Local pollution – hatcheries may discharge nutrient-rich wastes.
  - Disease transmission from other hatcheries, either by direct contact or through hatchery discharges.
- Areas where conflict of interests may arise between communities or resources users.

*Polluted water sources are not suitable for marine finfish hatcheries.*

## Hatchery layout

The hatchery should be laid out in such a way that it provides for ease of operation and it should also be free from work hazards. The layout should take into account the need for the hatchery to expand in the future, so space should be left for future tank construction, water and air supplies, etc.

*Concrete sand filter tank for a small hatchery – approximately 10 m$^3$ capacity.*



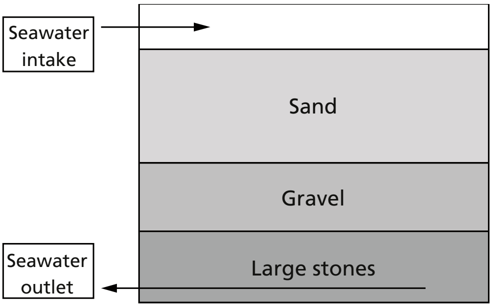

*Basic layout for a small-scale hatchery with 2 larval tanks, 1 sand filter, 3 rotifer tanks in indoor section, a pump house and 3 microalgae tanks at the outdoor section.*

## Tank design and description

This section describes the essential types of tanks required in small-scale hatcheries. These are the sand filter tank, larval rearing tanks and live food production tanks.

### Sand filter tank

Small-scale hatcheries may use a gravity sand filter to initially remove coarse particles and organisms from the source water. Such filter tanks are usually made of concrete and the filter medium comprises a layer of coarse material such as stones at the bottom and gravel and sand layers,




*Sand filter tank set up with layers of different filter media. Water is pumped in at the top of the tanks, flows through the various media, and out at the bottom of the tank.*

respectively. The water inlet to this filter is at the top of the tank, to allow water to filter from top down before going to the larval rearing tanks.

## Larval rearing tanks

Larval rearing tanks are generally concrete tanks, rectangular or square in shape. They range in size from 6 to 10 $m^3$ capacity. Usually larval rearing tanks are 1 metre in depth, but nursery tanks can range between 0.5–1 meter in depth. All concrete tanks used in hatcheries need to be finished internally with an epoxy paint to prevent the water coming in direct contact with the concrete. In marine finfish hatcheries, the tanks are often painted blue or yellow (for milkfish).

*Larval rearing tanks, about 10 $m^3$ capacity, in a larger hatchery facility.*

*Larval rearing tanks, about 6 $m^3$ capacity.*

## Live food production tanks

Microalgae production tanks normally make up about 30% of the total production volume of a small-scale hatchery. These tanks are usually located outside the hatchery building and are not roofed. Capacity varies from 10 $m^3$ to 20 $m^3$.

*Outdoor microalgal production tanks, about 10 $m^3$ capacity.*

Rotifer tanks are usually located close to the microalgal culture area, although in some hatcheries, rotifers may be cultured within the hatchery building itself. Generally, the rotifer culture area will take up about 10% of the total hatchery area. Rotifer tanks are usually 5–6 $m^3$.

Brine shrimp (*Artemia*) are hatched in fibreglass or plastic tanks. These tanks range from 20 to 500 litres. Larger hatcheries may use concrete tanks to meet higher production requirements.

*Indoor rotifer production tanks, about 5 $m^3$ capacity.*

*Small fiberglass tanks (1–2 m3 capacity) for rotifer enrichment.*

*Fibreglass brine shrimp hatching tank, about 50 litres capacity.*

*Circular concrete tanks for hatching brine shrimp, about 500 litres capacity.*

# Hatchery equipment and accessories

## Water pump – submersible pump and seawater pump

There are two types of water pumps required for small-scale hatchery operation. A pump of 5 horse power (hp) is required to pump seawater to the hatchery's sand filter tank. A separate submersible pump is required to distribute water within the hatchery system if needed, such as transferring microalgae for rotifer culture.

## Generator

A generator of 1 KVA is essential as a backup electricity supply for small-scale hatcheries. Even apparently reliable main electricity supplies can fail (e.g. during severe storms).

## Aeration system

Air blowers are generally used to provide aeration in hatcheries. In small-scale hatcheries these are usually 100-watt air blowers with at least one back up unit while the other is running.

*Small air blower used for aeration in small-scale hatchery.*

## Other hatchery equipment

A range of other items is required to successfully operate a small-scale hatchery, some of which are shown opposite.

*Microscope.*

*Nets.*

*Sorting cups.*

*Dipping buckets.*

Although a microscope is very useful equipment for the hatchery operator to observe the development of larvae and their health condition, it is rather expensive and may be difficult for a small-scale hatchery to afford one. If the hatchery is located close to a research facility, it may be possible to gain access to a microscope and utilise it as needed.

## Temperature

The optimum water temperature for marine finfish hatcheries in tropical regions is around 26–30°C. In most parts of Southeast Asia, marine finfish hatcheries do not use heaters to elevate water temperature. However, most small-scale hatcheries are enclosed to reduce temperature variation.

## Lighting

A 40-watt (or similar) fluorescent tube can be used for each larval rearing tank (6–10 $m^3$ capacity). The fluorescent light is normally installed above the tank and about 30-60cm above the water. Light is necessary for the larvae to visually hunt for live prey and the use of artificial lighting helps keep a consistent rearing environment in the tanks.

# 3. Live and compounded feeds

## Live food species

This section describes the live food types used in small-scale hatcheries including microalgae, zooplankton and mysids.

### Microalgae

The main microalga used in the hatchery is *Nannochloropsis*, which is used to culture rotifers. It is also introduced into the larval rearing tanks to provide a food source for rotifers, as well as to serve as a buffering medium for homogenous light intensity and water turbidity. Starter cultures of *Nannochloropsis* can often be obtained from local government hatcheries.

*Microalgae (Nannochloropsis) being slowly introduced into larval rearing tanks in a small-scale hatchery.*

### Rotifers

Two types of rotifer are used in marine finfish hatcheries. 'Super-small' or 'SS'-strain rotifers (*Brachionus rotundiformis*) are used for first feeding when larvae change from internal food source to external feed. Slightly larger ('small' or S-strain) rotifers are used after the first few days of larviculture. The nutritional composition of rotifers cultured on *Nannochloropsis* must be modified to increase the levels of highly unsaturated fatty acids (HUFA) in order to provide adequate nutrition for the fish larvae. This is done by maintaining the rotifers in tanks with commercial enrichment media for 12–24 hours.


*Super-small (SS) strain rotifer.*

### Brine shrimp

Brine shrimp (*Artemia*) nauplii are used during the later stages of larval rearing. Brine shrimp are purchased from commercial suppliers and hatched in the tanks described earlier in this guide. Like rotifers, brine shrimp must be enriched to increase their nutritional value before they are fed to the fish larvae.

*Artemia enrichment carried out in a 20 L tank.*

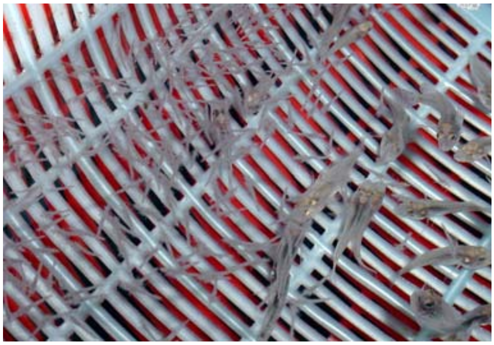
## Mysids

Mysids are very small white shrimp (*Palaemon* spp.) that can be found in shrimp ponds where they usually gather in large numbers and can be collected with a fine net. Mysids can be used as an alternative food source for grouper larvae during the later stages. This is generally from day 35 onwards.

*Small white shrimp (mysids) can be used as alternative live food source for groupers.*

## Compounded feeds

Most marine finfish require live food during most of the larval rearing period. However, live food can be supplemented by compounded or formulated feeds during the late larval period,

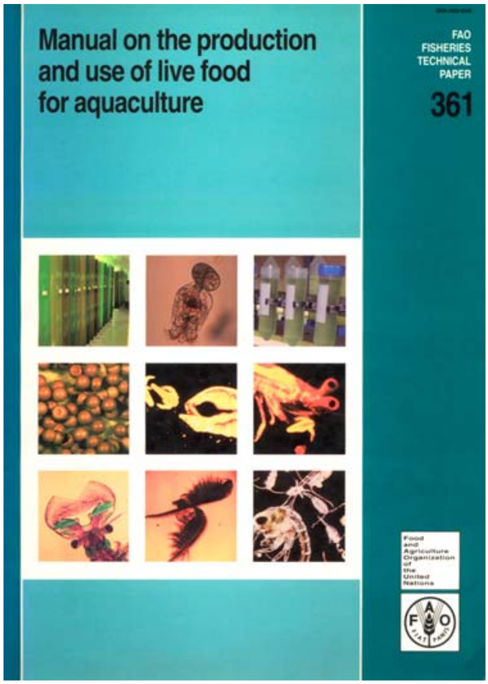


*Mysids are fed to tiger grouper fingerlings.*

particularly once the fish larvae are being fed brine shrimp. There are various commercially available larval fish feeds.

## Technical manual for live feed

For those who would like more details of live food production there is an FAO Fisheries Technical Paper (361) 'Manual on the Production and Use of Live Food for Aquaculture'. An electronic version is available from FAO website at http://www.fao.org/DOCREP/003/W3732E/W3732E00.htm.



# 4. Key points for hatchery operation

## Survival rates and production

### Survival rates

Survival rates at different stages vary between hatcheries and also vary between production 'runs'. The following are conservative survival rates for various stages of grouper larval rearing (Siar *et al*. 2002):

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

*Note: this table is a guideline only; survival rates vary considerably and different larval rearing 'runs' may range from 0% to as high as 50%.*

The basic feeding and water management schedule for grouper hatchery operations is shown in Figure 1 (p.11). This diagram is for reference only – different grouper species will have different requirements at various stages.

### Production per unit culture module

It is very common for small-scale hatcheries to calculate their production in terms of yield per culture tank rather then yield per $m^3$. The production per tank usually ranges from 3,000–5,000 larvae from a 6–10 $m^3$ tank, which is equivalent to 500 larvae per $m^3$.

## Hatchery staffing and manpower skills

### Number of staff

A small-scale hatchery with four or less larval rearing tanks will require a full-time technician and a part-time or casual worker to assist, particularly during the harvesting period. If there are more than four larval rearing tanks, two full-time staff (one technician and one worker) will be required.

*Hatchery worker cleaning a larval rearing tank after the fish have been harvested.*

### Level of skill

The skills required to operate a small-scale hatchery are very simple and basic. It does not require highly educated and/or trained staff. Basic training on technical aspects is needed for day-to-day hatchery operation. Daily routine work includes cleaning of larval tanks, harvesting microalgae, rotifers and *Artemia*, feeding larvae, etc. This type of basic training can be obtained at government extension or research centres. More information on training activities is listed in Section 5: *Training, Extension and Information Dissemination*.

*Routine tank cleaning: A hatchery worker siphons waste from the bottom of a larval rearing tank.*

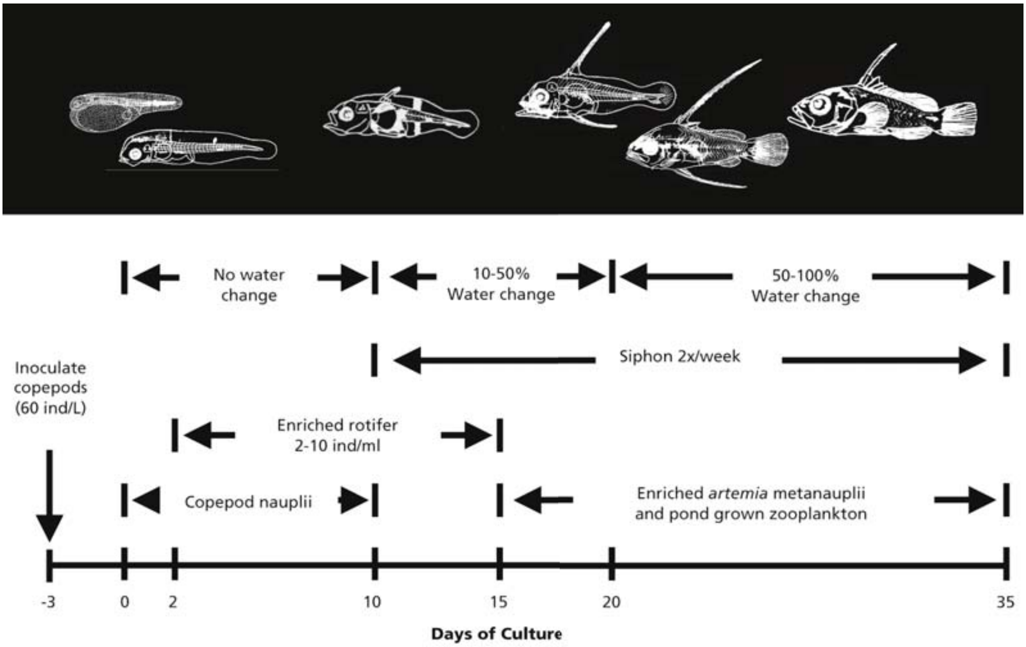



*Figure 1: Feeding and water management scheme for semi-intensive rearing of grouper larvae.*

# 5. Training, extension and information dissemination

## Training activities in the region

Training activities are available from various institutions in the Asia-Pacific Region. For details, see the Training section of the APMFAN website (www.enaca.org/marinefish/).

## Information dissemination

### Websites

Information on grouper and other marine finfish research and aquaculture is available from the following websites for free access and download:

- Asia-Pacific Marine Finfish Aquaculture Network (APMFAN) www.enaca.org/marinefish/
- ACIAR Grouper Project www.enaca.org/aciar/

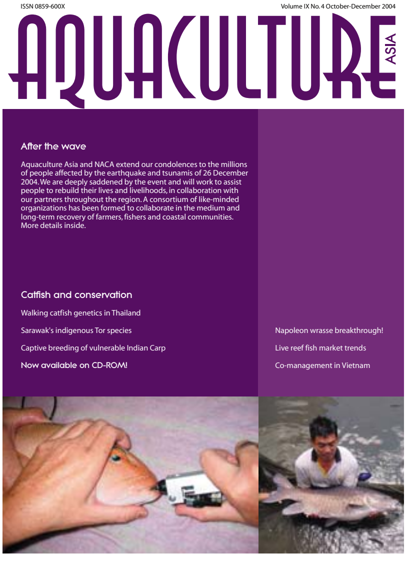
### Marine Finfish Aquaculture e-News and e-Magazine

APMFAN, through NACA, publishes an electronic e-News (fortnightly) and e-Magazine (quarterly) in cooperation with ACIAR, APEC, Queensland DPI&F, and SEAFDEC Aquaculture Department. The e-News provides the latest news on grouper and coral reef fish aquaculture research, development and commercial farming, while the e-Magazine provides more in-depth articles outlining recent developments in marine finfish aquaculture. These publications are circulated by e-mail, and are also available from the network website. For anyone interested in joining the mailing list for these publications, send your request to grouper@enaca.org.

### Magazines & other publications

Several regional magazines contain good information resources and materials on marine finfish and other aquaculture commodities:

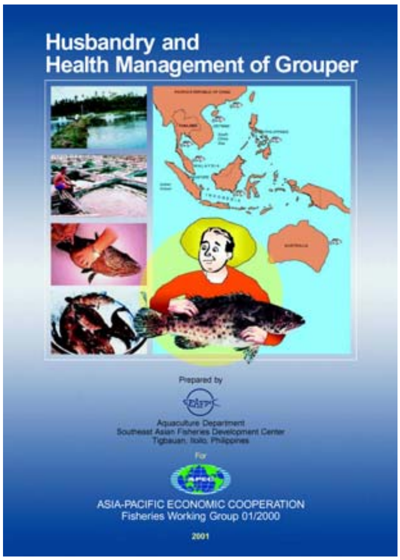
- Aquaculture Asia – published by NACA http://www.enaca.org/AquacultureAsia/index.htm
- SEAFDEC Asian Aquaculture – a magazine of SEAFDEC Aquaculture Department http://www.seafdec.org.ph/information/saa.html
- INFOFISH International – http://www.infofish.org/publications_infofishinternational.cfm
- Live Reef Fish Information Bulletin – an information bulletin of the Secretariat of the Pacific Community – Coastal Fisheries Program http://www.spc.org.nc/coastfish/News/lrf/lrf.htm
- Fishing Chimes – the fisheries journal of India http://www.fishingchimes.com/



# 6. Health management, disease diagnosis and treatment

Disease can cause substantial losses at marine finfish hatcheries. Disease problems can be reduced by maintaining rigorous quarantine procedures and treating infected fish in accordance with established guidelines such as good hatchery practices. This guide does not cover details of diseases of groupers and other marine finfish. For more details on their common diseases refer to:

- **Manual for Fish Diseases Diagnosis**
  *Zafran, Des Roza, Isti Koesharyani, Fris Johnny and Kei Yuasa*
  This publication is available from the Research Institute for Mariculture Gondol, Bali, Indonesia. Contact: grim@indosat.net.id.
- **Manual for Fish Disease Diagnosis – II**
  *Isti Koesharyani, Des Roza, Ketut Mahardika, Fris Johnny, Zafran and Kei Yuasa*
  This publication is available from the Research Institute for Mariculture Gondol, Bali, Indonesia. Contact: gondol_dkp@singaraja.wasantara.net.id.
- **Asia Diagnostic Guide to Aquatic Animal Diseases**
  *Melba G. Bondad-Reantaso, Sharon E. McGladdery, Iain East and Rohana P. Subasinghe*
  This publication is available in an electronic version and can be downloaded from the NACA website www.enaca.org.
- **Husbandry and Health Management of Grouper**
  *SEAFDEC AQD*
  This publication is available in English, Thai, Mandarin, Indonesian, Filipino and Vietnamese. Information on how to obtain a copy of each language version see Marine Finfish Network website at www.enaca.org/marinefish/.

# 7. Economic assessment

Small-scale marine finfish hatcheries require low capital investment and are relatively cheap to operate, so they suit many farmers or investors with limited capital. The following economic analysis is based on one provided for the Indonesian prototype 'backyard' hatchery system described in Section 1. The capital required for initial investment and annual operating costs are US$2,851 and US$2,016 (based on an exchange rate of US$1 = Rp 8,500), respectively for the first year's operation. Three production cycles per annum are possible for most grouper hatcheries. The following investment and return calculation is based on the financial statistics provided by RIM-Gondol for humpback / polka dot grouper (*Cromileptes altivelis*) with the following assumptions:

- 3 production cycles per annum (each culture cycle 65 days)
- two full time workers employed
- two larval rearing tanks
- depreciation rate is 20% per annum
- interest rate from the bank is 30% per year
- survival rate is 3%
- fingerling price is US$0.60 each
- stocking rate per tank is 50,000 fertilised eggs
- cash for capital investment is borrowed from the bank in full
- the standard lease fee for the hatchery land is 10% of net annual sales.

To more easily assess the various components of establishing and operating a small-scale marine finfish hatchery, this economic analysis has been split up into: Capital Investment, Operating Expenses, Non-operating Expenses, Profit and Loss.

## Capital investment

This component involves all the expenditure on the infrastructure and establishment of the hatchery. The items included in this component generally have a life span longer than one year, and they are used to generate the future income for the hatchery. The items include:

| Capital Investment Items | US$* |
|---|---|
| Roofed larval & rotifer tanks | 470 |
| Microalgae tanks | 353 |
| Submersible pump | 88 |
| Power installation | 59 |
| Emergency generator set | 353 |
| Air blowers – 100 watt | 764 |
| Seawater pump – 5 hp | 353 |
| PVC piping | 235 |
| Miscellaneous | 176 |
| **Total Costs** | **2,851** |

* Based on data from Indonesia: exchange rate: US$1 = Rp 8,500

## Operating expenses

This component is for the expenses that are generated during each production cycle and are essential for the routine operation of the hatchery. The items included in this component are:

- fertilised eggs (from a larger hatchery)
- feeds and nutritional supplements: brine shrimp, rotifer and brine shrimp enrichment products, artificial diets
- electricity
- workers salaries
- land lease costs
- miscellaneous (e.g. fertilisers, chemicals, accessories, etc., but excluding microscopes)

## Non-operational expenses

The expenses classified under this component do not directly relate to day-to-day operating expenses; rather they are related to the capital cost and investment write-off.

There are two items under this component for small-scale hatcheries:

- depreciation
- interest rate expenses

## Profit and loss

This component is straightforward and basically consists of the revenue generated from sales of grouper fingerlings minus all the operating and non-operating expenses. The Profit and Loss Financial Statement can be presented as per the table below. For basic calculation of the return on investment based on the financial calculation provided below we can use Payback Period to measure how rapidly the small-scale hatchery can provide a return to the farmers or investors.

Payback Period (PP):
= (CI / Profit) x 12 months
where CI = Capital Investment

For the example above:
PP = (2,851 / 2,013) x 12
= 1.28 x 12
= 15 months

Return on Investment (ROI) or Payback Period for small-scale hatchery based on the above calculations is 15 months, therefore it is apparent that the capital invested for a small-scale hatchery can be recovered fully within 16 months. This of course assumes that the hatchery operation is running smoothly and the price of the fingerlings and cost of expenses remain stable during this period. A more detailed assessment of the economic aspects for small-scale hatchery can be found in the report on *Study on Economics and Socio-economics of Small-scale Marine Fish Hatcheries and Nurseries, with Special Reference to Grouper Systems in Bali, Indonesia* by Siar, S. V., W. L. Johnston and S. Y. Sim. 2002. This report is available from www.enaca.org/marinefish/

| **Revenue** | **US$** | | |
|---|---|---|---|
| Sales of grouper fingerlings (production x price) | | | |
| = 9,000 fingerlings x US$0.60 each | | | 5,400 |
| **Operating Expenses** | | | |
| • Fertilised eggs (100,000 x 3 cycles) | 53 | | |
| • Rotifer and brine shrimp enrichment products | 118 | | |
| • Brine shrimp | 88 | | |
| • Artificial diets | 388 | | |
| • Electricity | 88 | | |
| • Workers salaries | 565 | | |
| • Land lease | 540 | | |
| • Miscellaneous | 176 | 2,016[1] | |
| **Non-operating Expenses** | | | |
| • Depreciation (US$2,581 x 20%) | 516[2] | | |
| • Interest rate expenses (US$2,581 x 30%) | 855[3] | 1,371[4] | |
| Total Expenses | | | 3,387[5] |
| **Profit (Loss)** | | | **2,013** |

[1] *This amount represents operating expenses as defined above.*
[2] *This amount represents 20% of the total capital investment.*
[3] *This amount represents 30% of the total capital investment.*
[4] *This amount represents total non-operating expenses.*
[5] *This amount represents total expenses, i.e. operating expenses plus non-operating expenses.*

# Glossary

**Aeration:** Air is pumped through small diffusers ('airstones') into the water to elevate oxygen levels.

**Brine shrimp:** Brine shrimp (*Artemia franciscana*) is a small aquatic organism generally used in hatcheries as food for fish or shrimp larvae. Brine shrimp are sold as cysts (resistant egg stage) and are hatched by placing the cysts in water in aerated tanks.

**Broodstock:** Adult fish kept in tanks or in sea cages to produce eggs for rearing in the hatchery.

**Grouper:** Fish belonging to the Subfamily Epinephelinae, Family Serranidae. Known as cod (estuary cod, flowery cod, etc.) in Australia.

**HUFA:** Highly unsaturated fatty acids. Larval fish have specific requirements for several HUFAs to provide adequate nutrition for growth and development – these are knows as essential fatty acids (EFAs). HUFAs are provided to the fish by adding commercially available enhancement products to the zooplankton (rotifer and brine shrimp) culture tanks.

**Larvae:** The early stages of the fish life cycle, after hatching from the egg. The larval stage of grouper lasts for 4–6 weeks in the hatchery. Fish then metamorphose to juvenile stage.

**Microalgae:** Microscopic aquatic plants that are commonly used as a food source for rotifers and other zooplankton. Also termed phytoplankton. *Nannochloropsis* is one microalga commonly used in hatcheries.

**Mysids:** Small white shrimp, ranging from 1–3 cm, generally transparent in colour. Used as a food source for advanced larvae or juveniles.

**Rotifer:** A small (about 0.15 mm in length) aquatic organism that is raised using microalgae. Rotifers are commonly used as the first food for many marine finfish species. Several different strains of rotifers are used in hatcheries: super-small (SS-) strain and small (S-) strain are *Brachionus rotundiformis*; large (L-) strain are *Brachionus plicatilis*.

**Salinity:** A measurement of the saltiness of the water, and usually expressed in part per thousand (ppt). For example, sea water is usually around 35 ppt; pure freshwater is 0 ppt.

**Sand filter:** A filter filled with grades of gravel and sand, used to remove particulate matter from the water before it enters the hatchery.

**Snapper:** Fish belonging to the family Lutjanidae.

**Zooplankton:** Microscopic aquatic animals which are commonly used as food sources for fish or shrimp larvae, including rotifers and brine shrimp.

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