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NURSERY MANAGEMENT OF GROUPER:

a best-practice manual

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NURSERY MANAGEMENT OF GROUPER:

a best-practice manual

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Foreword

With continued expansion of grouper aquaculture throughout the Asia–Pacific region, there is growing demand for fingerlings to stock grow-out farms. In Indonesia, this demand has led to the development of a dedicated grouper nursing industry in several provinces including Aceh and East Java. The nursery phase is an intermediate step between hatchery production of seed and stocking of grow-out farms. It involves growing delicate juvenile fish of 2–3 cm long through to physically robust animals of 5–10 cm long.

The Australian Centre for International Agricultural Research (ACIAR) has funded research by Indonesian and Australian agencies that has shown how grouper nursing can provide a profitable alternative to shrimp farming. As marine finfish aquaculture continues to develop throughout the Asia–Pacific region, there is associated potential for specialised nursery culture in other countries.

This manual provides practical guidelines for those engaged in the nursery culture of groupers in Indonesia as well as elsewhere in the tropics. It provides information on husbandry of groupers in the nursery phase, to reduce losses due to disease and cannibalism, and thus to increase the profitability of grouper nursing. The guidelines are derived from outcomes of ACIAR-funded research as well as other published information on grouper nursery management.

Nick Austin
Chief Executive Officer, ACIAR

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Abbreviations

ACIAR	Australian Centre for International Agricultural Research
DO	dissolved oxygen
NACA	Network of Aquaculture Centres in Asia–Pacific
ppt	parts per thousand
Rp	Indonesian rupiah
TL	total length
US$	United States dollar

Introduction

Marine finfish aquaculture is developing rapidly in the Asia–Pacific region. One reason for this expansion is the high prices paid for live reef food fish, particularly groupers, in markets in Hong Kong and China. Consequently, demand for grouper juveniles for grow-out in sea cages is increasing.

Indonesia is a major producer of grouper seed stock, with hatcheries in northern Bali producing 200,000–1,000,000 tiger grouper (*Epinephelus fuscoguttatus*) (Figure 1a) per month, and smaller numbers of mouse grouper (*Cromileptes altivelis*) (Figure 1b) and coral trout (*Plectropomus leopardus*) (Figure 1c). The hatcheries generally grow fingerlings to around 2–3 cm total length (TL); whereas the sea-cage farms that grow the fish to market size require larger fingerlings, in the range 5–10 cm TL. To fill the size gap in between, a specialised grouper nursing subsector has developed to grow 2–3 cm fingerlings to 5–10 cm or larger, after which they are stocked in sea cages for grow-out.

Figure 1a Juvenile tiger grouper (*Epinephelus fuscoguttatus*) from an Indonesian hatchery (Photo: M. Rimmer)

Figure 1b Juvenile mouse or humpback grouper (*Cromileptes altivelis*) from an Indonesian hatchery (Photo: M. Rimmer)

Figure 1c Juvenile coral trout (*Plectropomus leopardus*) from an Australian hatchery (Photo: R. Knuckey)

Grouper nursing is undertaken either in shore-based tanks (tank culture) (Figure 2), or in cages in coastal brackish-water ponds (pond culture) (Figure 3). Generally, juvenile grouper that have been nursed in ponds are darker in colour than those nursed in tanks. However, pond-cultured grouper juveniles tend to have a better tolerance to variable environmental parameters (such as salinity) and are preferred for grow-out in sea cages because they are already adapted to living in cages to some extent.

Figure 2 Tank nursery for marine finfish at the Mariculture Development Centre, Batam, Indonesia—tank-based nurseries such as this are relatively expensive to set-up and operate (Photo: M. Rimmer)

Figure 3 Coastal ponds in Aceh province, Indonesia, used for nursery culture of grouper—tiger grouper sourced from hatcheries in Bali and green grouper captured locally from the wild are commonly nursed in these ponds for 30–45 days before being shipped to grow-out farms in South-East Asia (Photo: M. Rimmer)

Groupers found in estuarine environments, such as the green grouper (*Epinephelus coioides*) and the giant grouper (*Epinephelus lanceolatus*), are suitable for nursing in brackish-water ponds. Tiger grouper are also nursed in brackish-water ponds, but ponds used for tiger grouper should have reasonably high salinities (>20 ppt). Species of grouper more usually found in coral reef environments (such as coral trout and mouse grouper) should be nursed only in tank systems with provision of good-quality sea water of high salinity (Table 1).

Table 1 Recommended nursing systems for some grouper species commonly cultured in the Asia–Pacific region

Scientific name	Common (English) name	Common (Indonesian) name	Recommended nursing system
Epinephelus coioides	Green grouper	*Kerapu lumpur*, *kerapu bulat* (Aceh)	Pond
Epinephelus fuscoguttatus	Tiger grouper	*Kerapu macan*, *kerapu kodok* (Aceh)	Pond or tank
Epinephelus lanceolatus	Giant grouper	*Kerapu kertang*	Pond
Cromileptes altivelis	Mouse grouper, humpback grouper	*Kerapu tikus*, *kerapu bebek*	Tank
Plectropomus leopardus	Coral trout, leopard coral grouper	*Kerapu sunu*	Tank

Tank culture

Facilities and equipment

Facilities and equipment needed for tank culture of groupers are:

- tanks made from concrete or fibreglass—the tanks can be round, square or rectangular
- roofing over the tanks to reduce ambient light levels and prevent freshwater ingress during rain. Our research has shown that light levels up to about 600 lux provide optimal survival of groupers during the nursery phase
- seawater supply (pump and associated piping)—sea water should be available continuously (24 hours per day) and salinity should be between 15 and 35 ppt
- sand filter to filter the sea water before it enters the tanks
- low-pressure air blower to provide aeration
- plastic buckets and handling nets
- adjustable fish grader, or series of bar or mesh graders.

Water management

Water should be circulated continuously through the nursery tanks with a minimum of 300% water exchange per day. The water current in the tanks must be varied to match the size of the fish. Fish should not be made to swim excessively against, or to be pushed backwards by, the current. Too strong a current causes stress in the fish and contributes to disease outbreaks.

For tank culture systems, incoming sea water is pumped into a gravity sand filter to remove particles. The sand filter is constructed from layers of sand, gravel and stones inside a concrete or fibreglass tank (Figure 4). The outlet piping system is designed to collect filtered water from throughout the bottom of the sand filter and is made from polyvinyl chloride (PVC) piping drilled with numerous holes or with slots cut with a hacksaw. A layer of permeable membrane (such as geo-textile) or fine mesh screen over the outlet piping will help to prevent clogging of the outlet holes.

After passing through the sand filter, the water is distributed to the nursery tanks. If the filtered sea water is not clear because of suspended fine particles, then additional filtration using finer sand or cartridges may be required. Fingerlings can tolerate extended periods of salinity below the ideal levels (see later discussion of water-quality requirements). However, if this occurs when the water is turbid, the fish will probably stop feeding and are more likely to become diseased.

Figure 4 Cross-sectional diagram of a gravity sand filter showing arrangement of graded substrates and inlet and outlet configuration

Tanks should be provided with aeration throughout the tank to ensure mixing of the tank water and to maintain high dissolved oxygen levels. It is important to place airstones in the corners of rectangular tanks, firstly to ensure that water in the corner areas mixes properly, and secondly because grouper fingerlings will congregate in the corners, causing localised high densities that may deplete dissolved oxygen. Tanks should be drained to less than half capacity each morning, and the tank base siphoned to remove uneaten food, faeces and particulate matter. The tanks are then refilled with clean water.

Nursery design considerations

High stocking densities are possible in tanks if they are provided with a plentiful supply of good-quality sea water. However, at high densities, additional oxygen may be needed, using bottled oxygen provided through specialised diffusers. The advantage of a high stocking density is that feeding is quicker and much more efficient (giving lower feed conversion ratios—FCRs) than the lower densities typical of pond culture. However, disease outbreaks may be more common at higher stocking densities, so fish should be monitored and treated as soon as there is any sign of disease.

Tank culture facilities should be designed with sufficient tanks so that graded fish can be moved to a new, clean and disinfected tank (Box 1) immediately after grading. Nursery facilities should be designed with biosecurity in mind, particularly when they are integrated with hatchery (Sugama et al. 2012) or grow-out facilities. The nursery should be enclosed so that entry is limited to a single door. A footbath (Figure 5) and handwash should be provided to reduce the risk of introduction of pathogens. Recommended practices for nursery management of grouper are summarised in Box 2.

BOX 1

Disinfection for grouper nurseries

The most readily available and easiest to use disinfectant is hypochlorite. For nursery equipment and tank disinfection, use at 100–250 mg/L available chlorine, and treat for 3 hours. After chlorination, rinse thoroughly and allow to dry completely before use.

BOX 2

Best practice—nursery management for grouper

- Do not overstock cages or tanks
- Provide adequate aeration; if necessary, provide oxygen
- Water exchange rate should be at least 300% per day, preferably higher
- Measure and record water-quality parameters.

Figure 5 Access doors to nursery facilities should be fitted with a footbath and handwash—this footbath has been designed to prevent staff or visitors stepping over or around it (Photo: M. Rimmer)

Pond culture

Set-up

Ponds commonly used for grouper nursing were originally constructed as milkfish (*Chanos chanos*) or shrimp (family Penaeidae) ponds. Although many of these ponds are filled only by tidal water exchange, it is preferable to provide a seawater pumping system to allow water exchange at times other than high tide. Salinity should be between 15 and 35 ppt.

In Aceh, nursery ponds range from 500 to 8,000 m^2 in area. The fish are farmed in small net cages (known locally as *kelambu*) fixed to the substrate with wooden poles (Figure 6). Two types of *kelambu* are used: 'green' (1 mm mesh) which range in size from 1.8 × 1.0 × 0.6 m to 2.5 × 1.25 × 0.8 m; and 'black' (4 mm mesh) which range from 1.5 × 1.0 × 0.5 m to 2.5 × 1.25 × 0.8 m (Komarudin et al. 2010). To help to maintain adequate water quality, the area used for the nets should be less than one-third of the total pond area and the net cages should be separated by at least 1 m.

Figure 6 Green *kelambu*, with 1 mm mesh net, are used for the first phase of grouper nursing in ponds. Grouper are stocked at about 500–2,000 fish per net cage and nursed for 10–15 days before being transferred to the larger black *kelambu*. (Photo: M. Rimmer)

Rearing process

Nursery operations are divided into two phases: the initial phase utilises 'green' *kelambu* and takes 10–15 days. Grouper are stocked at 500–2,000 fish per cage (depending on cage size), and are fed mainly small wild shrimp and fish captured from the ponds. After 10–15 days, the fish are moved to the larger mesh 'black' cages and the stocking density reduced to 300–1,000 fish per cage. During the second phase, chopped 'trash' fish is used as feed (Komarudin et al. 2010).

Nets must be cleaned regularly to allow water movement into and out of the cages so as to maintain adequate water quality, and this is usually done in conjunction with grading.

The fish are harvested when they reach 7–10 cm TL which generally takes 30–50 days from initial stocking. The fish are graded every 3 days (Figure 7) to reduce mortality due to cannibalism. Farms undertake 7–8 production cycles per annum. Pond management in traditional ponds is relatively simple: the pond water is flushed twice each month on the highest tides (Komarudin et al. 2010). For a summary of best practices, see Box 2.

Figure 7 Grouper nursed in ponds are graded every 3 days—each *kelambu* is graded separately (a) and the different size classes are retained on floating plastic trays (b) until they can be returned to the cages (Photo: M. Rimmer)

Stocking grouper fingerlings

Grouper fingerlings are sourced either from hatcheries or collected from the wild (green grouper) and are transported to the nursery tanks or ponds. At stocking they are usually 2–3 cm TL. Fingerlings should be checked to ensure that they are healthy and free from parasites before they are stocked in the nursery. Fish should be of uniform size and free from abnormalities. Recommended stocking densities for tiger grouper in tank and pond culture are listed in Table 2. These densities can be increased if supplemental oxygen is provided, as noted above, but a higher incidence of disease outbreaks can be expected at higher stocking densities.

Table 2 Recommended density of tiger grouper (*Epinephelus fuscoguttatus*) fingerlings in nursery tanks and in nursery cages (1 × 2 m) in ponds.

Total length (cm)	Density (no. fish/m^3)	
	Tanks	Cages
2.5–4	1,000–1,500	1,500–2,000
4–5	750–1,000	1,000–1,500
5–7	500–750	750–1,000
7–9	400–500	500–750
9–11	300–400	300–500
11–13	250–300	250–300
13–15	150–200	150–200

The biomass (kg fish/m^3) of fish stocked per cage will vary between species at any given stocking density because of the different relationships between their length and weight (Figure 8). For a given fingerling length, coral trout are lighter than green grouper and both are lighter than tiger grouper. This can lead to substantial differences in stocking biomass: for equal numbers of coral trout and tiger grouper in cages, the tiger grouper cages will have 50% more biomass than the coral trout cages. It is important to consider the biomass stocking density of the cage when feeding fish to a daily percentage of their average body weight, and how this will vary depending on which species is being grown.

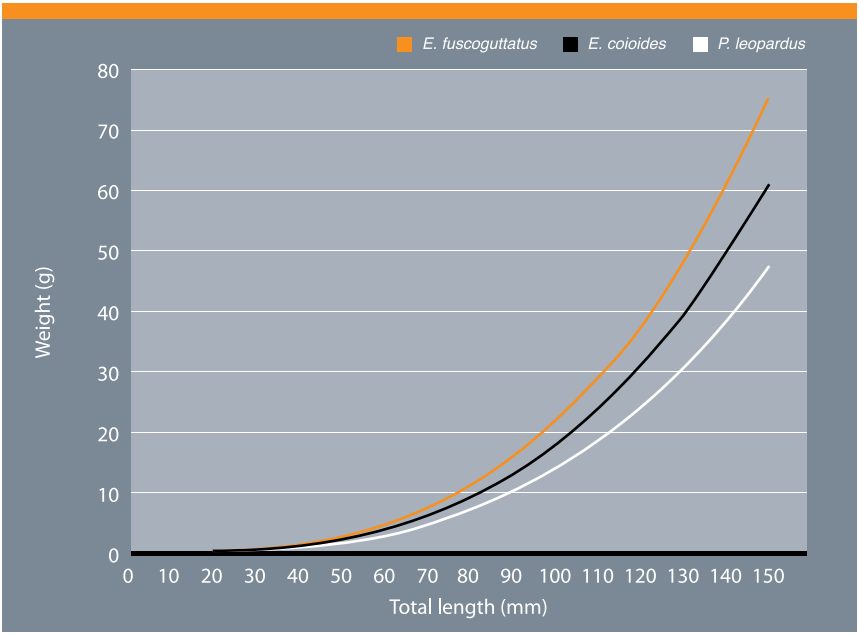

Figure 8 Relationships between fingerling length and weight for Australian hatchery-reared tiger grouper (*Epinephelus fuscoguttatus*), green grouper (*E. coioides*) and coral trout (*Plectropomus leopardus*) fed formulated pellet feed (Source: R. Knuckey, pers. comm. 2009)

Management of cannibalism

Cannibalism is a major cause of mortality in the nursery phase of many marine finfish species, including barramundi or Asian seabass (*Lates calcarifer*) and groupers. The main techniques used to reduce cannibalism are:

- grading to ensure that similar-size fish are held in each tank or net
- feed management to control appetite.

Grading

Grouper are regularly graded to reduce the variation in size in order to reduce cannibalism. Tiger grouper (*E. fuscoguttatus*), green grouper (*E. coioides*) and giant grouper (*E. lanceolatus*) should be graded so that there is less than 30% difference in total length (TL) between the grade sizes (Hseu et al. 2003, 2007b). For example, if fish are graded to about 50 mm TL, the size range for this grade should be 45–59 mm TL. While regular grading reduces the size distribution, it also causes stress due to handling and physical damage of the fish which can lead to disease outbreaks. Some nurseries grade as often as every 3–4 days; others prefer to leave longer periods (1 week or more) between gradings to reduce the possible adverse health impacts of grading. Recommended practices for grading grouper are provided in Box 3.

BOX 3

Best practice—grading grouper fingerlings

- Grade regularly to reduce cannibalism
- Use bar graders in preference to mesh graders for fish >1 cm total length (TL)
- Monitor fish health after grading.

Tiger grouper in particular will attempt to eat other fish very close to their own size. Because of the greater body depth of tiger grouper compared with green or giant grouper, such attempts often result in the cannibal fish suffocating on the prey fish because it cannot ingest the prey (Figure 9). Cannibalism attempts by tiger grouper are successful only when the prey is <50% of the TL of the cannibal fish (Hseu et al. 2007a). However, because attempts to ingest fish between 50% and 70% TL are generally fatal to the predator, we recommend reducing the size range of tiger grouper to less than 30% TL difference.

Unsuccessful attacks on smaller fish can cause damage to the prey fish, resulting in disease. Any fish showing signs of disease, swimming slowly or in an uncoordinated fashion, or with abnormal behaviour, should be removed from the tank or cage.

Figure 9 Cannibal tiger grouper (*Epinephelus fuscoguttatus*) after trying to ingest another tiger grouper of almost the same size—in this case, it is likely that the predator fish, as well as the prey fish, will die from suffocation (Photo: R. Knuckey)

Graders

Two types of graders are used: bar graders with a series of parallel bars (Figure 10); and mesh graders with square mesh netting (Figure 11). Mesh graders are preferred for very small fish (<1 cm TL), whereas bar graders are preferred for larger fish (and hence in grouper nursery culture) because they cause less damage to the skin of the fish during grading. The width of the bars, or the size of the mesh holes, limits the size of the fish passing through; larger fish are retained within the grader and moved to the next largest size group (Figure 12). The relationship between the bar width gap, or the mesh size, can be used to estimate the length of the graded fish.

Figure 10 Bar graders: grader (a) has the advantage of having 'walls' which allow the grouper to swim actively through the bars, instead of having to lift the grader out of the water to encourage the fish to move through the bars, but the bar width is not adjustable; while (b) has interchangeable panels with different bar widths—the square sections at the sides trap air and provide flotation, enabling the grader to float in the tank (Photos: M. Rimmer)

Figure 11 Mesh graders: (a) a simple mesh grader with floats, and a floating plastic tray used to retain the various grades of fish; (b) a nested set of mesh graders to allow multiple size grading of fish simultaneously—note that mesh graders are usually used only for small groupers (<1 cm total length) (Photos: M. Rimmer)

Figure 12 Juvenile (59 days after hatching) tiger grouper (*Epinephelus fuscoguttatus*) being graded using a bar grader, showing how larger fish are retained on the bars—note that the grader works by retaining fish that are wider than the gap between the bars; smaller fish pass through the gaps (Photo: R. Knuckey)

For bar graders, the relationship between bar width and fish size is approximately 1:10 for Asian seabass, 1:7.5 for tiger grouper and 1:8 for green grouper. For example, a bar grader setting of 4 mm will grade out Asian seabass around 40 mm TL, tiger grouper around 30 mm TL, and green grouper around 32 mm TL. Table 3 lists recommended bar grade sizes for green and tiger groupers, and the average length of fish for each grade size. For smaller fish, bar graders should be used in 0.5 or 1 mm increments to maintain the necessary size range (i.e. <30% TL) of fish (Table 3). Once the fish are larger than about 50 mm TL, size grades can be increased to 2 mm increments while still maintaining an optimal size range (Table 3).

Table 3 Average total length (TL) of two grouper (*Epinephelus*) species graded using different widths of bar graders; for example, green grouper that pass through a 2.5 mm bar grader but are retained on a 2 mm bar grader should be around 16 mm TL and less than 20 mm TL. This grade of fish should be less than 30% larger than the average grade size (for this example, <20.8 mm TL).

Grade width (mm)	Average TL (mm)	
	Green grouper *E. coioides*	Tiger grouper *E. fuscoguttatus*
2.0	16.0	15.0
2.5	20.0	18.8
3.0	24.0	22.5
3.5	28.0	26.3
4.0	32.0	30.0
5.0	40.0	37.5
6.0	48.0	45.0
8.0	64.0	60.0
10.0	80.0	75.0
12.0	96.0	90.0
14.0	112.0	105.0

As noted above, bar graders are preferred to mesh graders for fish >1 cm TL. However, if mesh graders are used for fish larger than this, Hseu (2004) and Hseu et al. (2007a) give equations to derive the relationship between body depth and total length.

Procedure

Grading should be undertaken in shallow plastic dishes, or in small tanks. A supply of clean sea water should be provided, and the containers aerated to ensure that dissolved oxygen levels remain high during grading. Grading should be done as quickly as possible with the smallest practical numbers of fish, because of the stress created by concentrating the fish at high densities. For grouper, the grading surface should extend to the 'walls' of the grader (Figures 10a and 11a) rather than being limited to the 'floor' only (Figures 10b and 11b) to allow the juvenile grouper to swim actively

out of the grader. Individual graders may have interchangeable sections of different bar widths to allow grading different-sized fish (Figure 10b). Alternatively, several different sizes of grader can be nested to hasten the grading process by grading several size groups at once (Figure 11b).

Larger nursery operations may invest in a mechanical grading system (Figure 13). These are relatively expensive but have a much higher rate of throughput and are economically viable for operations in countries with high labour costs, such as Australia, because they substantially reduce the labour requirement for grading large numbers of fish.

After grading, it is common to have small numbers of very small and very large fish. These can be kept in small floating cages in the tanks or in ponds (Figure 14).

Figure 13 Commercial finfish grader used in Australia to grade tiger grouper. The fingerlings travel down channels that gradually increase in gap width—the fish fall through the gap between the channels and the connecting hoses deliver the fish to separate tanks. Although relatively expensive, commercial graders such as this are capable of grading larger numbers of fish faster than hand-held graders. (Photos: R. Knuckey)

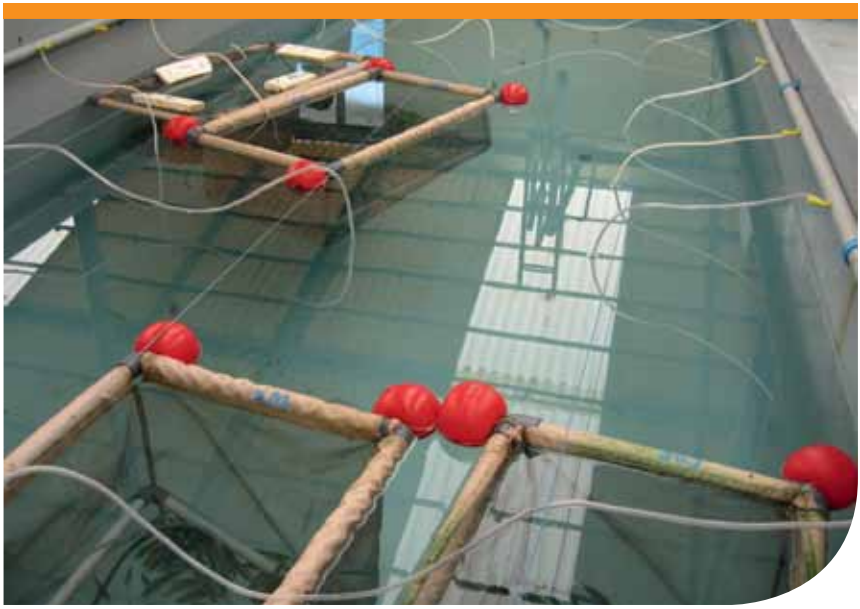

Figure 14 Small numbers of fish of various grade sizes can be kept isolated in small floating cages (Photo: M. Rimmer)

Feed management

Recommended practices for optimal feed management are provided in Box 4.

Types of feed

Various types of feed are used during the nursery phase, including dry (commercial) pellets, moist pellets, 'trash' fish, mysid shrimps, or combinations of these (Figure 15). However, the use of 'trash' fish is not recommended, unless there is no alternative (see further discussion below), because of the transmission of parasites from the feed fish to the cultured fish, resulting in increased mortality due to disease outbreaks (Rückert et al. 2009).

BOX 4

Best practice—feed management

- Provide good-quality, fresh feed
- Store feed in a cool, dry and vermin-proof room, with the feed elevated off the floor
- Use feed within 2 weeks (basic storage) or 3 months (ideal storage)
- Supplement, if necessary, with a vitamin and mineral mix
- Begin feeding at dawn each day, and continue until sunset
- Feed juvenile groupers frequently, at least 4–6 times daily
- Keep a record of feed used and feeding behaviour.

Figure 15 Types of feeds used in grouper nursing: (a) commercial pellet diet; (b) locally caught 'trash' fish prepared by removing the head and guts; (c) mysid shrimp in a brackish-water coastal pond (Photos: M. Rimmer)

If the juvenile grouper are destined for a grow-out farm that uses dry pellet feed (Figure 15a), they should be weaned to pellets before leaving the hatchery and maintained on a pellet diet during the nursery phase. Switching from a 'trash' fish diet to a dry pellet diet results in substantial growth differences among the fish because many fish will not readily accept the pellet diet. Consequently, cannibalism increases and many fish weaken due to poor nutrition, resulting in disease outbreaks. This is particularly problematic in nursery culture of tiger grouper.

The nutritional specifications of the feed used should match those for juvenile grouper (Table 4) as closely as possible. The size of pellets is increased as the fish grow. Most commercial pellet manufacturers provide feed tables based on the pellet sizes that they have available (Figure 16), but a general guide is given in Table 5. The feeding regimes (number of feeds per day and amount of food fed) for pellets and for 'trash' fish fed to groupers are shown in Tables 6 and 7, respectively.

Table 4 Dietary requirements for juvenile (<20 g) grouper (from Williams 2009)

Component	Recommended
Protein	50–52% dry matter basis
Lipid	<12–13% dry matter basis
Protein:energy ratio	30 g crude protein : 1 MJ gross energy
n-3 HUFA	>1%
DHA	>0.75%
Ascorbic acid	50 mg/kg ascorbic acid equivalent as a heat-stable product

HUFA = highly unsaturated fatty acids

DHA = docosahexaenoic acid

Figure 16 Example of a feed table on a bag of grouper/seabass commercial feed (Photo: M. Rimmer)

Table 5 Recommended pellet sizes for different sizes of grouper fingerlings during the nursery phase

Fish total length (mm)	Pellet size (mm)
25–30	1.2–2.0
30–35	2.0
35–45	2.5–3.0
45–55	3.0
55–75	4.0
75–100	5.0

Table 6 Feeding regime for feeding dry pellets to groupers (from Sim et al. 2005)—note that this is a guide only and requirements will vary between farms as well as seasons

Fish size (g)	Daily feeding rate (% ABW)	Number of feeds/day
1–5	4.0–10.0	3–5
5–20	2.0–4.0	2–3
20–100	1.5–2.0	2
100–200	1.2–1.5	1–2
200–300	1.0–1.2	1
>300	0.8–1.0	1

ABW = average body weight

Table 7 Feeding regime for feeding 'trash' fish to groupers (from Sim et al. 2005)—note that this is a guide only and requirements will vary between farms as well as seasonally

Fish size (g)	Daily feeding rate (%ABW)	Number of feeds/day
5–10	15–20	3–4
10–50	10–15	2–3
50–150	8–10	1–2
150–300	6–8	1
300–600	4–6	1

ABW = average body weight

Issues regarding the use of 'trash' fish (Figure 15b) to feed grouper are discussed in the related publication, 'A practical guide to feeds and feed management for cultured groupers' (Sim et al. 2005). In general, we recommend the use of dry pellet feed for all stages of grouper culture. However, where pellet feed is not available, is of poor quality or is prohibitively expensive, we recommend the use of moist pellets. These are particularly useful for grouper nursing and may provide a transitional diet from 'trash' fish to the use of dry pellets for grow-out. Semi-moist pellets can be made on site, using 'trash' fish in combination with other ingredients. The composition, manufacture and application of semi-moist feed is covered in detail in the publication mentioned above (Sim et al. 2005) which can be downloaded from the Network of Aquaculture Centres in Asia–Pacific (NACA) website (www.enaca.org).

In Indonesia, many nursery operations feed mysid shrimp harvested from brackish-water ponds (Figure 15c). For example, in East Java there is a thriving small-scale industry culturing mysid shrimp in operational or disused brackish-water shrimp ponds. The mysid shrimp are harvested daily, packed into oxygenated plastic bags and shipped live from East Java to Bali.

If mysid shrimp are used, numbers provided should be sufficient so that there are excess shrimp available early in the morning, to reduce cannibalism. After the groupers reach about 4 cm TL, they can be weaned to a 'moist' pellet diet and simultaneously the proportion of mysid shrimp fed to the groupers is gradually reduced.

If 'trash' fish is the only feed option, only good-quality 'trash' fish with the head and gut contents removed should be fed to groupers, as described in Sim et al. (2005). The 'trash' fish is cut to size appropriate to the mouth size of the juvenile grouper being fed. The 'trash' fish feed should be mixed with a vitamin and mineral supplement at the rate of 1–2% (i.e. 10–20 g supplement/kg of 'trash' fish). The juvenile grouper should be fed to satiation at each feeding. Any excess feed should be removed from the tanks or cages to prevent water-quality degradation.

Feed storage

If 'trash' fish is used as a feed source, it should be used within a few hours or frozen. Frozen 'trash' fish can be stored at –30 °C for up to 3 months.

Pellet feed should be stored under conditions that prevent contamination or degradation of the feed. Feed should be stored in enclosures that prevent access by vermin, including birds, insects and rodents. The feed must be stored in cool, dry and clean conditions, and elevated off the floor (e.g. placed on a wooden pallet). Ventilation space should be left between the feed bags and the walls for ventilation. A sealed and insulated room fitted with air-conditioning is the ideal storage facility (Figure 17). Feed can be kept for up to 1 year under these conditions, although it is better if the feed is used within a few months. If the feed cannot be kept under ideal conditions, it should be used within 2 weeks. Note the date of manufacture of each feed batch—this will also influence the effective shelf life of the feed. Batches of feed should be purchased so that they can be used up within the effective storage life of the product.

Figure 17 Pellet feed should be stored in an insulated and air-conditioned room to reduce temperature and humidity, and the feed bags elevated off the floor to improve ventilation. The room should be secure against rodents, birds and insects. (Photo: M. Rimmer)

Failure to store feed correctly can cause its nutritional degradation, including loss of vitamins and degradation of fatty acids leading to rancidity. Excessive moisture can cause moulds to grow on the feed, some of which produce mycotoxins that can adversely affect fish health and potentially cause mass mortality if fed to fish. Nutritional deficiencies in fish are difficult to diagnose; the best method for avoiding this problem is to ensure that only good-quality feed is used and that feed is stored and used properly.

Feeding frequency

Juvenile grouper should be fed as frequently as possible during the nursery phase: at least 4–6 times daily. Frequent feeding will reduce cannibalism.

Most importantly, our research has demonstrated that providing feed early in the morning (i.e. around dawn) significantly reduces cannibalism in tiger grouper compared with starting to feed later in the morning.

A belt feeder (Figure 18) can be used to reduce the labour requirements for feeding if dry pellets are used in the nursery. The belt feeder usually uses a clockwork mechanism to rotate a belt which slowly drops feed into the tank over several hours.

Amounts of feed used and the response of the fish should be recorded—see the Appendix for example data sheets.

Figure 18 Belt feeder used to feed pellets to juvenile grouper—a battery-operated mechanism drives the belt slowly, dropping feed into the tank. The amount of feed loaded on the belt, and its position, determine the feeding rate and pattern. (Photo: M. Rimmer)

Water-quality management

Maintaining good water quality is important for good fish health, and to maximise growth and survival. Recommended practices for optimising water quality are summarised in Box 5. Nurseries should have access to water-quality monitoring equipment to measure:

- temperature—an analog thermometer or a digital thermometer integrated with a salinity or dissolved oxygen meter
- salinity—a refractometer or, preferably, a salinity meter
- dissolved oxygen (DO)—a digital DO meter
- pH—a pH meter or pH test kit
- ammonia-nitrogen (NH_3-N)—an ammonia test kit.

BOX 5

Best practice—water-quality monitoring

- Purchase good-quality equipment
- Maintain meters and equipment in line with manufacturers' recommendations
- Maintain stocks of consumable items (e.g. dissolved oxygen (DO) probe membranes, calibration standards) and essential spare parts
- File original manuals and provide photocopies to staff
- Calibrate meters daily or weekly, according to the manufacturers' instructions
- Ensure that staff are adequately trained in equipment calibration, use and maintenance
- Monitor and record water quality regularly.

Technical staff should be trained in the use and maintenance of water-quality equipment. Instruction manuals should be photocopied and the originals filed for reference; copies of the manuals should be provided to staff and spare copies should be made available to replace those lost or damaged during use. Meters should be calibrated according to the manufacturers' instructions. pH and DO meters must be calibrated daily. All meters require regular maintenance; for example, pH meters need regular replacement of the electrode solution, and DO meters need regular replacement of the electrode membrane.

Although there is little information on the requirements of juvenile groupers for various water-quality parameters, Table 8 lists recommended values based on current knowledge and experience. It is important to record water-quality data, particularly to identify any changes that may cause disease problems. An example of a water-quality data sheet is included in the Appendix.

Table 8 Recommended values for physico-chemical parameters for nursery culture of groupers. Note that there is very little information available on the tolerances of grouper juveniles to various environmental parameters. The figures in this table are based on our own experience with a range of grouper species under different conditions and on limited published information (APEC/SEAFDEC 2001).

Parameter	Tiger grouper (*Epinephelus fuscoguttatus*), green grouper (*E. coioides*), giant grouper (*E. lanceolatus*)	Mouse grouper (*Cromileptes altivelis*), coral trout (*Plectropomus* spp.)
Temperature	25–32 °C	25–32 °C
Salinity	20–32 ppt	25–35 ppt
Dissolved oxygen	4–8 mg/L	6–8 mg/L
pH	7.5–8.3	7.8–8.3
Un-ionised ammonia (NH_3-N)	<0.02 mg/L	<0.02 mg/L

Health management

The main aspects of general health management of groupers are:

- minimise stress on the fish, particularly when grading
- provide good-quality feed in appropriate quantities to ensure adequate nutrition
- maintain good water quality
- detect and remove moribund and dead fish as quickly as possible
- practise good hygiene of facilities and equipment.

Recommended practices to optimise fish health are summarised in Box 6.

Tanks and nets should be kept clean to minimise the risk of disease outbreaks. They should be cleaned at least once daily to remove uneaten food and wastes as noted in the previous section.

Graded fish should be transferred to clean tanks and the vacated tank cleaned and disinfected. Likewise, fish cultured in ponds should be transferred to clean nets after grading. The frequency of cleaning nets will vary with the mesh size (smaller mesh sizes block more easily and thus need cleaning more frequently) and will also vary with local conditions. Equipment used for nursery culture (nets, graders, containers etc.) should be disinfected after use (see Box 1), and then dried to reduce the chance of transmission of disease organisms.

BOX 6

Best practice—health management

- Maintain good water quality
- Regularly clean and disinfect tanks, nets and equipment
- Monitor fish behaviour and feeding, and keep records
- Bathe the fish regularly in fresh water to dislodge external parasites
- If disease breaks out, isolate affected fish.

Regular freshwater baths are recommended to dislodge external parasites. Place the fish, in small batches, in fresh water for less than 15 minutes. While some species of grouper are tolerant to fresh water (e.g. giant grouper and green grouper, both of which are commonly found in estuarine environments), others are not (e.g. coral trout and mouse grouper). Some groupers, such as tiger grouper, are intermediate and are reasonably tolerant to freshwater exposure, although less so than the estuarine species. Exposure to fresh water should be varied depending on the tolerance of the species being treated.

If there is a disease outbreak, isolate affected fish by placing them in a tank or pond to separate them from healthy fish. Ensure that fish showing disease symptoms are not mixed with fish that appear healthy. Moribund fish (i.e. those close to death) should be euthanased, preferably by freezing. These fish often carry the greatest load of disease organisms, so their removal will reduce the number of pathogens that can infect other fish.

For specific information on diseases affecting groupers, refer to the following publications:

- 'Husbandry and health management of grouper' (APEC/SEAFDEC 2001), available by download from the NACA website (<www.enaca.org>)
- 'Diseases of cultured groupers' (Nagasawa and Cruz-Lacierda 2004), available from the Southeast Asian Fisheries Development Centre Aquaculture Department (<www.seafdec.org.ph>)
- 'Manual for fish diseases diagnosis' (Zafran et al. 2005) and 'Manual for fish disease diagnosis—II' (Koesharyani et al. 2005), available from the Centre for Aquaculture Research and Development, Pasar Minggu, Jakarta, Indonesia.

Economic evaluation

Grouper nursing is popular with small-scale farmers because it brings in regular income—the fish are harvested after 30–50 days. An economic evaluation of grouper nursing in Aceh found that a single cage stocked with 300–1,000 fish, and with 75% survival to harvest, can produce a profit of Indonesian rupiah (Rp) 280,000–900,000 (Komarudin et al. 2010).

Table 9 provides an example of a simple economic analysis for tiger grouper nursing for Indonesia. This assumes a 1 month rearing period from 3 cm TL fish purchased from a hatchery and grown to 7 cm TL. It also assumes a purchase cost of Rp1,000/fish for 3 cm TL seed stock. Costs for tiger grouper seed stock vary seasonally in response to demand, and can range from Rp700/fish to Rp1,200/fish. This simple analysis does not include depreciation of capital assets or other aspects that may influence overall profitability. These will depend on the size and nature of the business venture. Business models used in Indonesia for small-scale grouper nursery are discussed in Komarudin et al. (2010).

Table 9 Simple economic analysis of tiger grouper nursery culture in Indonesia—currency conversion is US$1 = Indonesian rupiah (Rp)10,000

Component	Rp	US$
Costs		
Grouper price (ex hatchery) 10,000 fish at Rp1,000/fish (3 cm)	10,000,000	1,000
Feed costs		
Mysid shrimp (*jembret*): 10 days at Rp200,000/day	2,000,000	
'Trash' fish: 20 days at Rp80,000/day	1,600,000	
Electricity: 1 month	500,000	
Labour: 2 staff at Rp600,000/month	1,200,000	
Miscellaneous expenses	200,000	
Total expenses	*15,500,000*	*1,550*
Income (60% survival to 7 cm total length)		
6,000 fish at Rp3,000/fish	*18,000,000*	*1,800*
Profit	**2,500,000**	**250**

Appendix

Sample data sheets for grouper nursery culture

Note: Collection and examination of production data are important aspects of 'best practice' in nurseries. These data sheets are provided as a guide to the type of information that should be collected routinely. However, they should be modified to the specific needs of each facility.

If a nursery has computer access, the data should be collected and maintained on 'hard copy' data sheets, and the data transferred to a spreadsheet program. This enables comparison of seasonal and annual data, and graphing data to visualise any trends.

Example data sheet for recording nursery tank or cage water quality

Pond: Date:

Tank/cage	Temperature (°C)		Salinity (ppt)		Dissolved oxygen (mg/L)		pH		Water exchange (%)	Notes
	am	pm	am	pm	am	pm	am	pm		

Example data sheet for recording feed management in grouper nurseries

Pond: Date:

Tank/cage	Feed 1		Feed 2		Feed 3		Feed 4		Feed 5		Feed 6		Pellet size	Notes
	Time	Feed (kg)	Time	Feed (kg)	Time	Feed (kg)	Time	Feed (kg)	Time	Feed (kg)	Time	Feed (kg)		

Example data sheet for fish health management in grouper nurseries

Tank / pond: Date:

Date	Mortalities						
	am	pm	Symptoms	Parasites	Lesions	Other	Notes

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