Blue Economy Impact Investment East Asia

BUSINESS MODEL & FINANCIAL PLAN

GROUPER FARMING INDONESIA

Impact Investment for a Grouper Aquaculture Project in Areas of Intense Grouper Fishing in Indonesia

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IMPACT INVESTMENT FOR A GROUPER AQUACULTURE PROJECT IN AREAS OF INTENSE GROUPER FISHING IN INDONESIA

In 2015/2016, the COREMAP-CTI project worked to identify sustainable business opportunities on Selayar Island in southwestern Sulawesi, Indonesia. Grouper farming was identified as one of the potential business opportunities, given the importance of grouper fisheries in the area. This proposal develops a business concept and underlying impact and financial model for delivering an impact investment case for sustainable grouper farming on Selayar Island, within the framework of a contract agreement between PEMSEA and BLUEYOU CONSULTING LTD.

1 EXECUTIVE SUMMARY ... 3

2 INTRODUCTION ... 5

2.1 GROUPER MARKETS ... 5
2.2 GROUPER FISHERIES ... 5
2.3 GROUPER SPECIES AND STATUS ... 6
2.4 GROUPER FARMING ... 9
2.4.1 Indonesia ... 10
2.5 INDONESIAN GROUPER MARKETS AND VALUE CHAINS ... 10
2.6 SELAYAR ISLANDS ... 11
2.6.1 Selayar status quo fisheries and farming ... 12
2.7 SCOPE FOR IMPACT INVESTMENT ... 14

3 **BUSINESS STRATEGY AND CONCEPT** **15**

3.1 BUSINESS CONCEPT AND KEY OBJECTIVES 15
3.2 INVESTMENT MODEL / INVESTIBLE ENTITY 17
3.3 MARKETING AND SALES 17
3.3.1 Markets and sales strategy *17*
3.3.2 Products *17*
3.3.3 Projected sales volumes *18*
3.4 ASSUMPTIONS ON GROUPER BIOLOGY 19
3.4.1 Farming cycle *19*
3.4.1 Growth *19*
3.4.2 Survival *21*
3.4.3 Stocking density *22*
3.4.4 Economic Feed Conversion Ratio (eFCR) *23*
3.4.5 Feasibility & site selection *24*
3.4.6 Scalability *24*

4 **FINANCIAL PROJECTIONS** **25**

4.1 ASSUMPTIONS 25
4.1.1 Hatchery *25*
4.1.2 Grow-out *26*
4.2 EBIT PROJECTIONS 26
4.2.1 Cost Analysis for independent profit centres vs. integrated operation under scenario 1 or 2 .... *26*
4.2.2 5-year plan: Hatchery as independent profit center *28*
4.2.3 5-year plan: Grow-out as independent profit center (for 30 t grown out under scenario 1) *29*
4.2.4 5-year plan: Integrated hatchery and farm operation under scenario 1 .... *30*
4.3 INVESTMENT PLAN (CAPEX) 30
4.3.1 Hatchery *30*
4.3.2 Grow-out (scenario 1 or 2) *31*
4.4 WORKING CAPITAL AND CASH FLOW 32

5 **EXPECTED IMPACTS AND BENEFITS** **33**

5.1 IMPACT ON WILD GROUPER STOCKS 33
5.2 IMPACT ON COMMUNITY 33
5.3 SOCIO-ECONOMIC IMPACT FOR FISHERMEN TURNED GROUPER FARMERS 33

6 **PROJECT IMPLEMENTATION** **33**

7 **RISKS AND MITIGATION** **34**

7.1 RISKS 34
7.2 MITIGATION AND RISK MANAGEMENT 35

8 **REFERENCES** **37**

9 **ANNEX** **38**

9.1 DOCUMENTS 38
9.2 REPRESENTATIVE GROUPER SPECIES: COMMERCIAL RELEVANCE, LIFE HISTORY AND STOCK STATUS 38
9.3 SHRIMP FARMING ON SELAYAR ISLAND 43
9.4 GROWTH AND FCR FITTING 45

1 Executive summary

The demand for grouper is high in the entire East Asian region. Grouper products are among the most popular fisheries products on local markets of South East Asia, in particular the live fish market. In China, groupers are the most popular fish displayed in aquariums of restaurants, ready for the customer to select and consume. As a consequence of this demand, grouper prices are high and the fishing pressure on groupers is substantial. However, groupers represent a family of finfish (Epinephelinae) that is particularly vulnerable to fishing pressure: they grow rather slowly, mature late and are protogynous hermaphrodites (i.e. they mature as females and turn into males at larger sizes). From this life history, it cannot be expected that grouper stocks will withstand strong fishing pressure. Unfortunately, fishing pressure can be assumed high. There are no stock assessments available, as the main source for groupers are small-scale reef-associated fisheries. However, from observation of the sizes caught at landing sites in South East Asia, it can be concluded that grouper stocks are generally overfished: the landed sizes mostly represent juveniles and fishermen commonly share the opinion that larger groupers could be caught in the past. As it is highly complex to organize these small-scale reef fisheries, there is no prospect to sustainably manage such fisheries on a regional scale in the intermediate future. Furthermore, fishing for grouper is often the key driver for illegal fishing methods that employ, for instance, cyanide or dynamite. Despite the national regulation against these methods, they may represent the most important component of grouper fisheries, and hence the most important source in the international grouper trade. The cyanide-fished groupers could be detected and avoided by authorities, since some cyanide always remains in the fish. However, since it is a good business, in which local politicians are often entrapped, there are no clear incentives to stop such practices.

Since there is currently no alternative for sustainably caught grouper from wild capture fisheries, hatchery-based farmed grouper currently represents the only sustainable source of grouper supply. There are challenges to build up grouper farming due to the rather slow growth, scarcity in disease-free broodstock and fry, and its requirement for high quality feed. Farmed grouper competes on the market with wild caught grouper, and the pricing of the wild caught grouper thus sets the benchmark on the pricing. Furthermore, there can be political complexity and obstacles, particularly if politicians are involved in the local grouper business. Nevertheless, the positive impact of a commercial hatchery-based grouper farm would outweigh the possible difficulties: by sourcing hatchery-based farmed grouper instead of grouper caught from the wild, the small-scale producers are offered a more stable income than can be obtained through fishing, and parts of the wild stocks would be allowed to recover. If market actors commit to sourcing hatchery-based farmed grouper instead of wild caught grouper, the incentives for illegal fishing operations such as cyanide and dynamite, for which grouper is often the main driver, and the respective illegal trade, could be reduced.

The proposed business plan lays out the case for a grouper hatchery and grow-out farm on Selayar Island in southern Sulawesi, Indonesia, where fishing and trading of live groupers is prevalent. The main target of the fishery is the bright red colored leopard coral grouper ('suno'). The local government has offered fish cages to raise the wild caught juvenile groupers. These cages were, however, used in a way so far that is not commercially viable, and furthermore, the raising of wild caught groupers doesn't solve the sustainability problem, as incentives to catch undersized juvenile groupers are still present. Since there are currently no farmers on the island with the proper training, the farm must be initially run by the project, but fishermen could be integrated in a later step in this operation by offering infrastructure and training. These community farmers would then buy grouper fingerlings and sell the commercial-size groupers on the local live market or sell them back to the hatchery company, which already runs the supply chain logistics for the product. The business plan proposes an integrated hatchery and farming approach, where one half of the hatchery-reared groupers are raised to marketable size by the project-integrated grow-out operation, while the other half is available for independent farmers.

Currently, there are only successful farming protocols for two grouper species: green grouper (*Epinephelus coioides*) and tiger grouper (*Epinephelus fuscoguttatus*). The majority of groupers grown and marketed in Indonesia are tiger groupers, while the local market for green grouper is not yet developed – there would however be a profitable market for green grouper in Hong Kong or in the Middle East. It is therefore recommended to start the grouper hatchery and grow-out exclusively with tiger grouper, and possibly integrate green grouper in a later stage of the project. For any grouper species, the harvest and selling sizes are either 600-800g or 1.3kg up. Due to restaurant portion issues, there is no demand for grouper of 800g to 1.3 kg. However, during Chinese New Year, buyers will usually take any size of fish. Due to the economics of the farm and the market demand, the harvestable size will be set at 600 – 800g. The production cost of the farm will exceed the pricing of fresh grouper (vs. live grouper), therefore the farm is constrained to exclusively work with live grouper supply chains, for which China is the ultimate market. If volumes are sufficiently high, buy boats will come to collect the marketable size groupers at the farm.

The hatchery and the farm are considered independent profit centres with a (minimum) target EBIT of 15% for the hatchery and 20% for the farms. The investable entity, called here "Kerupa Co.", will in practice also integrate the grow-out of part of the produced fingerlings, and hence combine the EBITs for hatchery and farm at around 20-25%. But since the ultimate objective is to integrate community fishermen as grouper farmers, who would buy seedlings from the hatchery and sell the commercial size groupers, the projections in this proposal are also given separately for the hatchery and farming operation. To attain an EBIT of 15%, the hatchery must sell about 106'000 fingerlings annually, which would result in 60 t of marketable size groupers. We consider a 50%-scenario, where 50% of the produced fingerlings are raised in the integrated grow-out, and compare it to 0%-scenarios and 100%-scenarios, where 0% (i.e. no integrated grow-out) or 100% of the produced fingerlings are raised in the integrated grow-out. The 0%-scenario is too risky because there are no educated farmers in the region and it cannot be assumed that the fingerlings would be profitably raised by independent farmer, hence some integrated grow-out assures profitable raising of fingerlings to marketable size, and this knowledge can be transferred to independent farmers. In the 100%-scenario, there are no fingerlings left to be raised by independent farmer, there is thus no option that independent farmers can develop and the environmental and socio-economic impact of the project would become marginal. We therefore recommend a 50%-scenario where 30 t of marketable size groupers are raised in the integrated grow-out, with room for independent farmers to raise the other 30 t of marketable size. To optimize the survival during grow-out, the hatchery rears the groupers to a size of 4-5 inches (or 15 g), which is larger than the commonly marketed fingerling size of 5 cm, and sells the 15 g- fingerlings for 12'000 IDR/pc. The marketable size groupers will be sold at the current market price of 150'000 IDR/kg. Since the grouper output won't reach its targeted scale during the first two years, the profitability during this initial phase will be negative, for which, in addition to the 4.545 billion IDR of CAPEX, working capital of 3.322 billion IDR is needed, for a total capital need of 7.867 billion IDR (606'000 USD). To pay back the total investment of 7.867 billion IDR, the project, generating a positive account balance of 3.620 billion IDR per year from year 3 onwards, has therefore to be planned on a 10-year time horizon.

The project is expected to create jobs on and around Selayar Island and provide alternative livelihoods that generate more regular income than can be obtained through the highly irregular supply from fisheries. By saturating the local market on the islands with hatchery-reared grouper, it can be expected that fishing pressure on wild stocks will decrease and these stocks will be consequently allowed to recover. Furthermore, illegal fishing activities can be expected to decrease. Although there are several grouper hatcheries in Indonesia, disease-free fry resulting in good survival is rare. Applying adequate best practices in the hatchery can result in high quality fry, creating a potential for the hatchery to represent a best-case example on a regional scale.

2 Introduction

2.1 Grouper markets

Grouper are an important species on all local markets in Southeast Asia and customers are generally ready to pay higher prices for groupers than for other fish. China has an especially high demand for live groupers, typically ending up in restaurant aquariums. Eating an expensive fish from the aquarium in a restaurant is a demonstration of status in China, and the groupers somehow became the symbol for this. Groupers have a particular shape, coloration and meat taste, which indeed make them an enjoyable seafood experience. But ironically, the grouper demand and high pricing is, to a certain degree, also fuelled by the fact that groupers get quickly overfished (see below) and thus become shorter in supply. There is hardly any constant grouper supply, and the irregularity of this supply drives the high grouper prices. Not only in China, but also on the local Southeast Asian markets, groupers are important. The Lapu-Lapu in the Philippines and the Kerapu in Indonesia are always offered on menus – although the item might not always be available. In terms of pricing, China is by far the most attractive market and if the fish can be kept live, supply chain operators would mostly seek to sell the groupers live to China, or to Chinese restaurants in the local markets. The highest value species are the leopard Coral grouper (*Plectropomus leopardus*), also called "suno" in Asia, famous for its deep red coloration with blue dots, and the humpback grouper (*Cromileptes altivelis*), also called "mouse grouper" in Asia, which has a particular shape and white coloration with black dots (see Fig. 3), reaching prices in the range of 30-60 USD/kg. There is also a growing grouper market in the Middle East with similar pricing as in China.

2.2 Grouper fisheries

Because groupers are reef associated, they are mainly caught in the tropical island archipelagos by lining and netting gear, mainly on or around coral reefs. Very common for grouper are, however, illegal methods such as cyanide or dynamite fishing. Cyanide is probably the most common method to catch groupers and the main target of cyanide fisheries are the groupers. Cyanide is a nervous-system poison that stuns the fish where it is dispersed. The stunned fish can be easily collected by hand and subsequently recover and survive in a tank, remaining thus physically intact and in optimal condition for the live market. Residues of cyanide remain in the flesh and affect the fish's life expectation. This effect is, however, not sufficiently investigated and since it represents illegal practice there is no data available, but one might assume that if the grouper doesn't end up on a plate soon, it might die anyway due to the consequence of the cyanide exposure. The residues in the meat can be detected after capture. An effective measure against illegal fishing and trade would therefore simply be to test the traded groupers for cyanide. This doesn't practically happen as local politicians often benefit from the illegal grouper trade.

Data on grouper catch volumes is not reliable. Because the fisheries are mainly represented by small-scale fisheries that are not subject to any kind of management system, and often are mostly illegal fisheries that use cyanide or dynamite methods. It cannot be expected that grouper catches are accurately represented anywhere. According to official information, the globally declared grouper catches are 272 kt, of which China and Southeast Asia represents 181 kt (66%). China alone declares about 100 kt of "groupers nei" landings ("nei" standing for the FAO category "not elsewhere included"), i.e. 36% of the global grouper catches, but without differentiating the species. It also remains unclear if these are landed in China or if this number rather represents a trade estimate. Indonesia declares 47 kt of grouper catches, i.e. 17% of the global grouper production, differentiated by a few main species, and would thus be the second largest grouper producer from fisheries after China. Indonesia started to declare grouper landings in the early 2000s and the declared volumes have increased since then. The tendency of increasing volumes (Fig. 1) in Indonesia might be partly because the live grouper trade to China kept increasing during this period, but it is likely also just a consequence of including more sources of information on grouper trade over time (given that the data is most likely derived from trade estimates). If fishing effort had increased, one might expect the volumes to decrease because groupers are vulnerable to fishing and cannot withstand high fishing pressures. The Philippines has declared substantial grouper landings since the 1960s, representing 7% (20 kt) of global grouper landings, Malaysia 4% (12 kt) and Thailand 2% (4-5 kt).

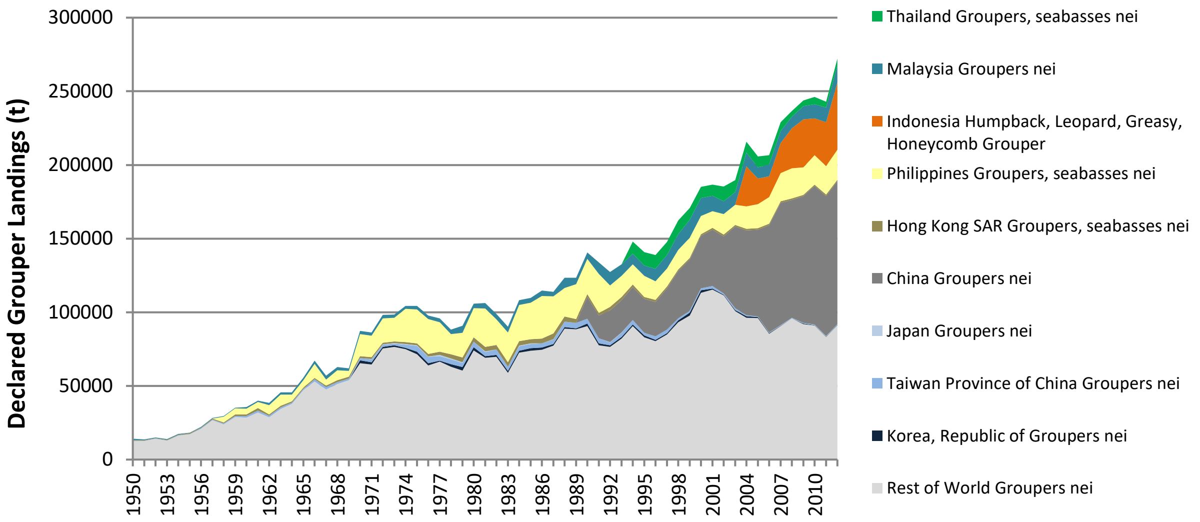


Figure 1: Time series of global grouper catches declared in official statistics by country and grouper species (FAO 2016).

It's unlikely that grouper catch data represents catches or landings, but is rather derived by authorities from trade documentation that indicates grouper as a commodity. Although the data is thus not reliable or representative for catches in terms of species and volumes, it might indicate which species are important for trade, e.g. in Indonesia (Fig. 2): leopard Coral grouper (40%), humpback grouper (24%), greasy grouper (21%), and honeycomb grouper (15%). It might be true that fishermen would target the leopard Coral grouper and humpback grouper due to their high values, but it is also obvious that declaring only 4 species in the landings of Indonesia as an oversimplification of the facts and certainly subject to species misclassification due to their phenotypic similarities: the catch would be composed of many other (grouper) species that are not easily correctly classified. See section 2.3. below and Annex 9.2 for examples of common grouper species that might show up in catches. It is unclear why declared catches in Indonesia are obviously falsely classified into only 4 species – the 4 species might, in fact, represent less than 20% of the grouper catches. A more accurate declaration of Indonesian grouper catches would therefore be "groupers nei, 46 kt".

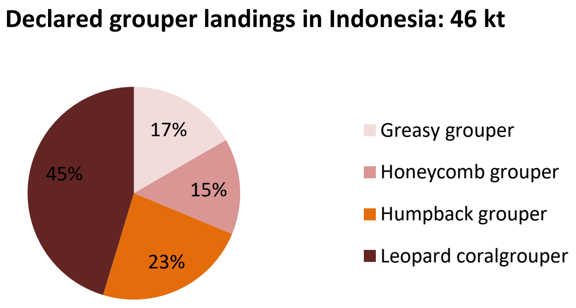


Figure 2: Species composition in the declared grouper catches from Indonesia (FAO, 2016).

2.3 Grouper species and status

Groupers are a versatile and colourful group of species classified in the subfamily Epinephelinae, mainly represented by the two large genera Epinephelus and Mycteroperca. In addition, the species classified in the small genera *Anyperidon*, *Cromileptes*, *Dermatolepis*, *Gracila*, *Saloptia*, and *Triso* are also called groupers. Fish in the genus *Plectropomus* are referred to as coral groupers. Groupers are demersal reef-associated species of typically rather long-lived life history attributes: slow growth, late maturation and medium fertility. Most groupers are protogynous hermaphrodites, meaning that they mature as females, and then convert to males at a larger size depending on the sizes in the surrounding grouper spawning group: the largest individual is a male and when this male disappears, the second largest individual transforms from a female to a male. Since fishing is usually size-selective, it can be expected that fishing affects the sex-specific sizes and, hence fertility, which increases disproportionally with female body size. Due to the rather slow growth, late maturation and hermaphroditism, groupers are particularly impacted by overfishing. Reliable data on stock status is not available, but given the high demand, the small sizes observed at landings, the irregular supplies and the vulnerable life history, it can be assumed that currently most grouper stocks are decreasing or overfished. Based on this assumption, the IUCN red list of species classifies many grouper species as near threatened (NT) or vulnerable (VU)[1]. See Annex 9.2 for examples of grouper species and their respective stock status.

Important grouper species reported to be collected as fry/fingerlings in Indonesia in terms of numbers are *E. coiodes*, *E. malabaricus* and *E. bleekeri* (Sadovy 2000), and occasionally small individuals of *Plectropomus* sp. and *E. fuscoguttatus* are also caught. The most consistently abundant species captured wild for culture and also reared in hatcheries (synonyms commonly used in the aquaculture literature included) were *E. coioides*, while *E. fuscoguttatus* has received most attention in farming in the past decade, e.g. in Indonesia. *E. malabaricus* and *E. tauvina* also commonly appear in aquaculture literature, but *E. tauvina* is most likely a misidentification of *E. coioides* (or *E. malabaricus*) as it has not been confirmed in most economies in the region. The highest value species are *Cromileptes altivelis*, *Plectropomus leopardus* (or *P. maculatus*), therefore these usually appear on catch and trade reports from fisheries, even if their contribution to the catch is only marginal. Species like the humpack grouper (*C. altivelis*, Fig. 3) or the coral groupers such as *P. leopardus* (Fig. 3), *P. maculatus*, or *P. areolatus* (see Annex 9.2) are usually main target species of reef fisheries due to their high value on the live fish market, and the stocks of both species are assumed to be declining. Orange-spotted grouper (*E. coioides*, Fig. 3) and brown-marbled grouper (*E. fuscoguttatus*, Fig. 3) are currently the most famous representatives for farming operations.

Leopard coral grouper (*P. leopardus*, Fig. 3), also called suno grouper matures at a length of 20–36 cm at an age of 2-4 years and grows to an age of around 20 years and sizes of 20 kg[2]. Spawning aggregations occur in line with the lunar cycle, which make them particularly vulnerable to overfishing. In some areas the species forms a single species fishery for the live reef fish export market, average fish size has declined, catch rates appear low, and mortality estimates are high (Padilla et al. 2003). Populations of leopard coral grouper are generally assumed to be decreasing1 due to the lack of management and the fact that juveniles are now caught and grown out in farming operations (Padilla et al. 2003). It is currently classified as Near Threatened (NT), but due to the declining trend in populations it will likely be reclassified as Vulnerable (VU) with more data. There have been many attempts to hatchery-raise leopard coral grouper, but survival rates have been so low these projects usually went bankrupt. Furthermore, an important quality attribute of the fish resulting in high pricing is its deep red coloration, which can only be reached if the fish is raised at 20-50 m depth. To operate floating cages at these depths becomes highly complex and uneconomical.

Humpback grouper (*Cromileptes altivelis,* Fig. 3), also called mouse grouper, matures at a length of 40 cm, while maximum size might be around 70cm, growth rate is very slow and age at maturation or maximum age are not known2. Spawning aggregations are not known, although spawning activities were observed in captivity. Humpback groupers might be the highest value grouper species. It is heavily fished, stock status is

[1] http://www.iucnredlist.org/

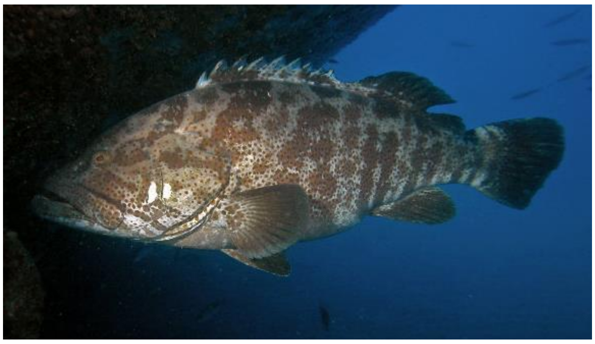
[2] http://www.fishbase.org

generally classified as Vulnerable (VU) and stocks are thought to be at risk in many areas. This species can be hatchery-raised (Sadovy et al. 2003), but its slow growth renders the farming a possibly unprofitable undertaking, despite its high value. Therefore, there is no commercial farming operation to serve the live fish market, but it is used for aquarium trade, and hatchery production does consequently not relieve fishing pressure on wild populations.

Leopard (*Plectropomus leopardus*) - NT

Humpback grouper (*Cromileptes altivelis*) - VU

Orange-spotted Grouper OR Green Grouper (*Epinephelus coioides*) - NT



Brown-marbled grouper OR Tiger grouper (*Epinephelus fuscoguttatus*) – NT

Figure 3: Some representatives of the subfamily of Epinephelinae (groupers) with corresponding IUCN status

Orange-spotted Grouper (*Epinephelus coioides*, Fig. 3), also called green grouper, is one of the most common groupers taken by fisheries. It matures at a length of 25–30 cm (2–4 years old), and sexual transition occurs at a length of 55–75 cm. Maximum observed size was 1.2 m, and it's heavily fished during spawning1. It is one of the species that is most successfully hatchery-raised in several countries, however, since supply of grouper seed is limited, grouper mariculture still partly relies on the supply of wild-caught grouper seed (Sadovy 2000). Its exploitation is unlikely sustainable in the long term and wild populations are likely being depleted. *E. coioides* is assessed as being Near Threatened due to the overall decline of imports of plate-sized fish from SE Asia into Hong Kong (a major import center for live fish), extensive take of juveniles for the unregulated and undocumented international juvenile trade for mariculture grow-out, and large mangroves losses in some of the largest countries in SE Asia, key habitat for young *E. coioides*.

Alongside the orange-spotted grouper, the brown-marbled grouper (*Epinephelus fuscoguttatus*, Fig.3), also called tiger grouper, is the most successful hatchery-raised species. *E. fuscoguttatus* matures at a size of around 50 cm, grows to a maximum size of 1.2 m and might have a lifespan of about 40 years[3]. The species is,

[3] http://www.iucnredlist.org/details/44673/0

therefore, inherently more vulnerable to impacts of overfishing, while always in high demand for the live reef food fish trade. It is still extensively taken from the wild (and marketed as adults or large juveniles or removed from the wild as small juveniles and grown out to market size in captivity), including from spawning aggregations in many cases. Little is known on the status of wild stocks, but it is assigned Vulnerable (VU) status due to its inherent vulnerability, being a large species that aggregates to spawn.

There are many other representative grouper species that appear in catches or play some role in farming. See Annex 9.2 for an overview of additional species. Some display life histories that make them even more vulnerable to impacts from overfishing. Others look very similar, complicating their correct classification and management.

Orange-spotted grouper ("green grouper", *Epinephelus coioides*) and brown-marbled grouper ("tiger grouper", *Epinephelus fuscoguttatus*) are the two grouper species that have been most successfully reared in hatchery operations. Since successful farming protocols are only available for these two species, the operation in this proposal will, at first, work exclusively with these species. For simplicity, the two species will be referred to as "green grouper" (*E. coioides*) and "tiger grouper" (*E. fuscoguttatus*) in this report.

2.4 Grouper farming

The globally declared grouper farming volume is 136 kt, with 99.9% coming from East Asian countries, predominantly China, Taiwan and Indonesia (Fig. 4). China declares 82 kt of "groupers nei" (60%) and Taiwan declares 26 t of "groupers nei" (19%), followed by Indonesia with 19 kt of "goupers nei" (14%). Besides these big players, Malaysia also has some significant grouper production with 5-6 t (4%) of "greasy grouper" (which is most likely misclassified as orange-spotted grouper, see Annex). The remaining 1% is negligible and split among all other countries. The farmed grouper volume represents about half of the global grouper volume from wild capture, but within East Asia, the declared farmed volume (136 t) represents about 75% of the declared capture volume (181 kt). Both farmed and capture volumes seem to be steadily increasing.

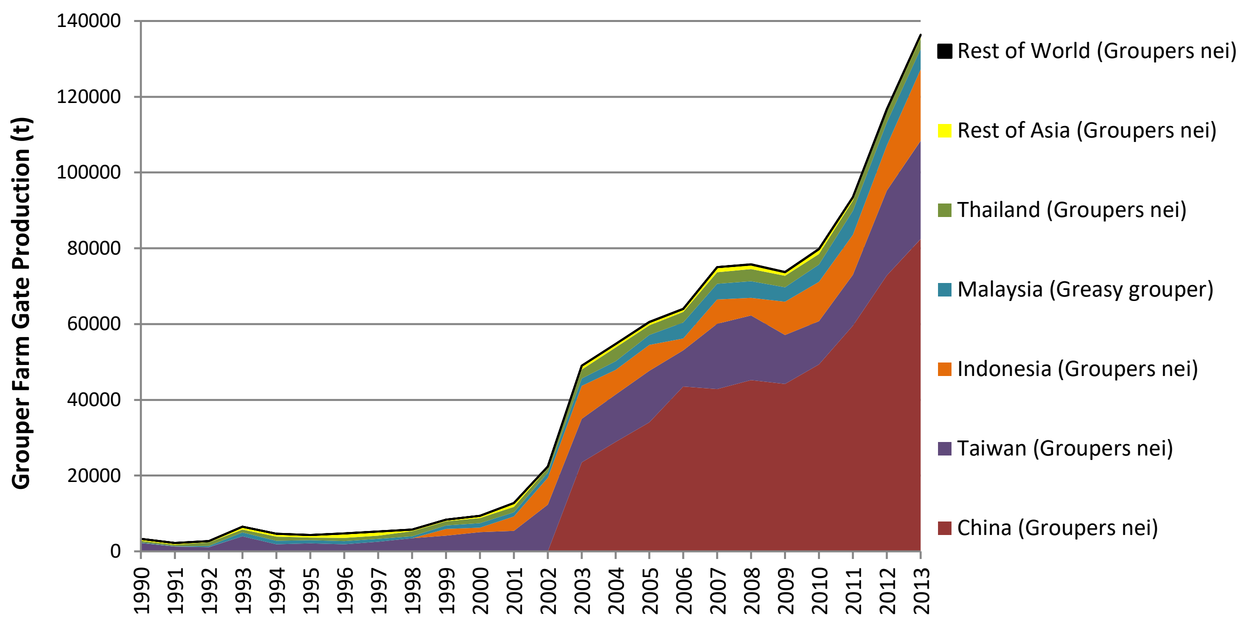


Figure 4: Official statistics on grouper farm gate production from aquaculture operations (FAO, 2016).

These absolute numbers should be interpreted with caution. Grow-out cages might be used to raise undersized groupers from capture fisheries. Since the live market is most attractive, the marketable grouper sizes from fisheries will be kept in cages or tanks, which might be interpreted as farmed grouper. Furthermore, the output volume might be based on false extrapolations by assuming some constant output by farming area, for instance when government has funded grow-out cages to support communities. These may not produce any relevant commercial output, and in most cases these numbers might simply be derived from the declared trade. Farms with a commercial output volume will always rely on hatchery-based fingerlings for a regular supply, as supply from fisheries would be too irregular. Official numbers are correct in the sense that in general, there are only three players in grouper farming: China, producing the vast majority, Taiwan and Indonesia. Furthermore, Malaysia and Thailand also have some grouper farming, but there is basically no other significant producer.

2.4.1 Indonesia

In Indonesia, grouper production is scattered, represented mostly by small-scale farms, while the largest farms might produce around 20 t per year (Rob Garrison, *pers. comm.*). There are several hatchery operations in the country, although usually not optimally managed. The broodstock is rarely disease-free and the survival of fry is often lower than it must be to exceed the breakeven of the farming operation (Rob Garrison, *pers. comm.*). Hatcheries in Indonesia mainly produce tiger grouper (*Epinephelus fuscoguttatus*), and some humpback (or mouse) grouper (*Cromileptes altivelis*). Humpback grouper has very slow growth and therefore is a high-risk species for farming. Nevertheless, farmers often still consider farming this species due to its high market price. There is no significant market for green grouper (*Epinephelus coioides*) within Indonesia. However, green grouper is the main grouper species in the Philippines and there is a significant green grouper market in Hong Kong and in the Middle East.

2.5 Indonesian grouper markets and value chains

Grouper fisheries are driven by the Chinese demand for live groupers, as the market value is much higher for live than for dead grouper. Furthermore, the market value can vary substantially by species (Table 1). The option to sell Gilled and Gutted (G&G) grouper at farm gate does not actually exists, as a farmer would always keep the fish alive given the high difference in market value.

	G&G landed [IDR/kg]	G&G local market [IDR/kg]	Live farm gate / landed [IDR/kg]	Live local market [IDR/kg]
Humpback Grouper	100'000-120'000	100'000-200'000	400'000-600'000	500'000-700'000
Leopard Coral grouper	80'000-100'000	100'000-150'000	300'000 - 400'000	400'000-600'000
Tiger Grouper	40'000-50'000	60'000-70'000	120'000-180'000	180'000-240'000
Green / Greasy / Honeycomb / Malabar / Duskytail Grouper	30'000-40'000	40'000-60'000	60'000-120'000	100'000-180'000

Table 1: Approximate prices of different grouper species in Indonesia at the level of the fishery and of the farm

The transportation cost of G&G grouper from the landing site or farm to the local market can be assumed at 6'000 - 10'000 IDR/kg including ice, depending on location. Live groupers are transported in oxygenated plastic bags, resulting in a transportation cost around 12'000 – 20'000 IDR/kg, depending on the location. The grouper trade in Indonesia is handled by Chinese operators that are directly or indirectly connected to the ultimate buyers on the Chinese market. If farms produce significant volumes of several tons per week or month, the Chinese grouper traders come with buy boats to the farms to get the groupers.

The sizes demanded by the market are either 600-800g or 1.3 kg up. The yield of the grouper fillet is around 30-35%, therefore a 600-800g grouper yields a fillet portion of 200-300g which is good for one person. Buyers are not interested in sizes of 800g-1.3 kg, as this is a portion that is too much for one person but too little for two people.

2.6 Selayar Islands

The Selayar Islands are a group of 73 islands in the Flores sea, covering an area of 10'509 km² with a population of about 120,000 (Fig. 5). The population, mainly a mixture of Makasars, Bugis and the natives of Luvu and Buton, is estimated at 57'000 on the main island, Selayar, and 24'000 on the nearby islands. The main island is inhabited on its west coast and the majority live around its capital, Benteng, from where there is a daily flight to and from the city of Makassar (Fig. 5). The governing Selayar Islands Regency is divided into eleven districts (kecamatan), tabulated below with their 2010 Census populations (Table 2) and their administrative centres ('capitals')[4].

Name	Population Census 2010	Capital
Pasimarannu	8'959	Bonerate
Pasilambena	6'786	Kalaotoa
Pasimassunggu	7'625	Kembang Ragi
Takabonerate	12'296	Batang
Pasimassunggu Timur (East)	7'307	Bontobulaeng
Bontosikuyu	14'332	Harapan
Bontoharu	12'484	Bontobangun
Benteng	21'344	Benteng
Bontomanai	12'226	Polebungin
Bontomatene	12'571	Batangmata
Buki	6'125	Buki

Table 2: Population census 2010, Selayar Islands populations.

Locals speak the Macassar language and are, for the most part, nominally Muslims (though many non-Muslim customs survive). They support themselves by agriculture, fishing, seafaring, trade, the preparation of salt (on the south coast) and weaving. Raw and prepared cotton, tobacco, trepang (sea cucumbers), tortoise-shell, coconuts and coconut oil, and salt are exported. There is frequent movement of goods between the area and other parts of Sulawesi as well as to other parts Indonesia.[5]

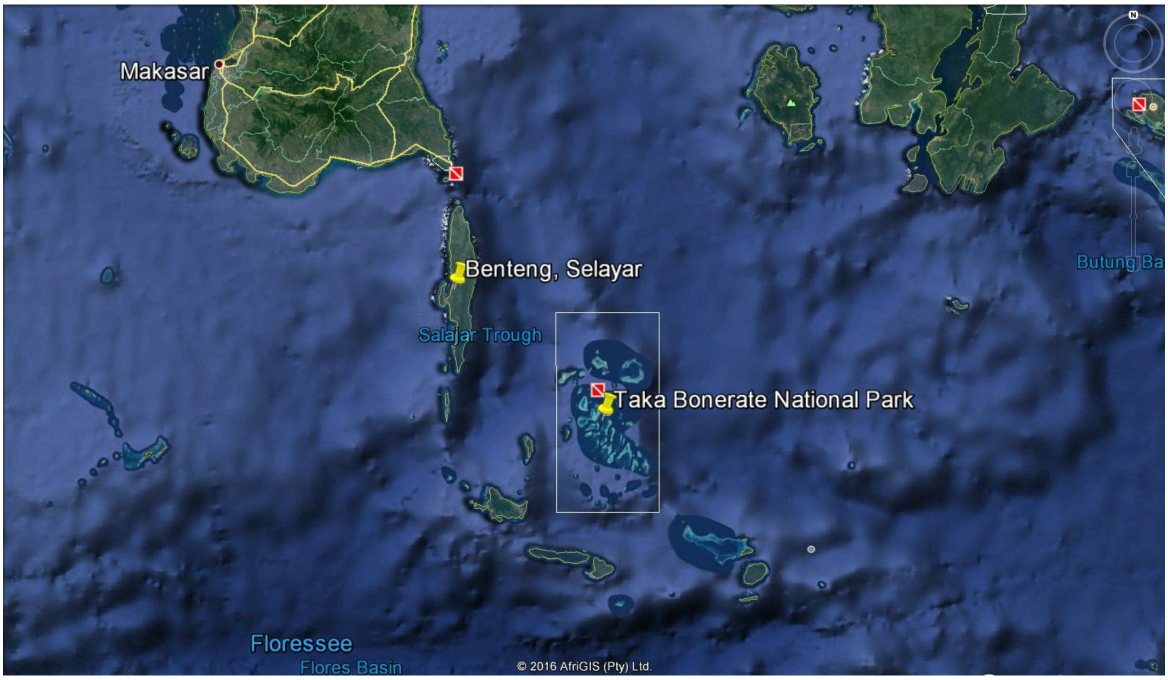


Figure: 5: Selayar Islands Regency and Taka Bonerate National Park in southwestern Sulwawesi.

[4] https://en.wikipedia.org/wiki/Selayar_Islands_Regency
[5] https://en.wikipedia.org/wiki/Selayar_Islands

To the east of the main island is Taka Bonerate National Park, a marine park that includes the Takabonerate atoll islands (Fig. 5). The area, which consists of the atoll islands and surrounding marine area, was granted national park protection status in 1992. In 2015, an area of 5'307 km^2 the Taka Bone Rate National Park was included in the UNESCO World Network of Biosphere Reserves. It can be assumed that fishing with illegal gear is prevalent around these islands.

Selayar is a focal area for both the "Coral Reef Rehabilitation and Management Program - Coral Triangle Initiative" (COREMAP-CTI) and "Capturing Coral Reef & Related Ecosystem Services" (CCRES) projects being implemented by the World Bank. CCRES has developed an assessment to determine alternative livelihood opportunities for sustainable development (Hine and Phelan 2016).

2.6.1 Selayar status quo fisheries and farming

2.6.1.1 Fisheries

Selayar grouper fisheries and farming represents the common status quo operation with respect to grouper fishing in SE Asia: the landed groupers are mostly undersized, which is an indicator of overfishing. As anywhere, the fishery targets mainly the highest value species -- the coral leopard grouper and humpback grouper. Marketable sizes are directly sold to (typically Chinese) traders, who bring them to Makassar in oxygenated plastic bags by boat and truck. In Makassar, the groupers are typically sold on the local market or shipped to Hong Kong. The undersized fish might be partly sold whole round on the local market at a much lower per-kg price than the marketable size live grouper (see Table 1), or they might be raised in cages until marketable size. The local government in Selayar has provided some cages of 3x3x3m in units of 4 cages, and these cages are partly used by the local fishermen. The "operators" of these cages are typically the fisherman themselves, who throw in the undersized groupers from their catch, or they might buy undersized groupers from other fishermen at a price of around 1000 IDR/cm. "Trash fish" (i.e. small fish that is caught in untargeted fishing operations) is used to feed the caged grouper, which they might also catch themselves or buy from other fishermen at 5000 IDR/kg. Feeding is not subject to any plan, but based on availability and intuition. There is no control of stocking density, growth, mortality, feed conversion, or the like. It is also not known how many of the cages are actually operated or what the production is from these grouper cages. Based on interviews with local stakeholders, it may be at most a few hundred kilograms (the local government might report a different number, which is not representative). The fishermen have already made attempts to buy fingerlings from a hatchery based in southeast Sulawesi (Kendari) at a price of 1'200 IDR/cm, but they had a bad experience and claimed the fingerlings had a poor survival rate, and therefore they don't much believe in farming hatchery-based fingerlings. They also claim that the buyers prefer wild caught fish over farm-raised fish. It remains to be evaluated whether the buyers retain some kind of superstition for farmed vs. wild caught fish. In the case of leopard grouper, any bias has to do with coloration, one of the leopard grouper's most important quality indicators. The red coloration can be maintained if the fish stays in a depth range of 20-50m. If it is kept in surface waters, as would usually be the case for the available cages, the coloration is lost.

The number of fishing vessels is unclear, as most of the vessels are small-scale (below 5 gross tons) and are not legally required to register. There are, however, some larger vessels of 5-10 gross tons. The Ministry of Maritime Affairs and Fisheries (MMAF) estimates that there are 9'000 fishermen on Selayar Island (of which 7'300 are registered as such), hence the number of vessels could be assumed to be a few thousands. Only 39 vessels are registered. Estimates on catch volumes are obtained by sampling and extrapolation and are probably not representative: 700 -1'000 t of coral leopard grouper and 1'000 – 1'500 t of other grouper species.

2.6.1.2 Fish farming

In an assessment of alternative livelihoods for communities on Selayar, grouper farming was presented among other alternatives as an option, since the grouper fisheries are a prevailing activity and the government has provided cages for fish grow out, mainly intended for groupers, as this is the predominant fishery (Hine and

Phelan 2016). The assessment takes the current status quo of grouper farming in its evaluation as a basis: fingerlings are caught from the wild and transferred to cages where they are fed with trash fish. Grouper farming, in this sense, has a negative environmental impact, since incentives are given to remove juvenile groupers from the wild, incentives are given for uncontrolled fishing operations (juveniles and trash fish), and the trash fish furthermore is prone to disease and generates bio-security issues. This form of grouper farming has, arguably, an even more detrimental effect than usual capture fisheries, which are not subject to incentives for catching of undersized fish, and would typically target larger fish. Furthermore, since there is no stable supply of fingerlings or a planned farming schedule, the current grouper farming can hardly be profitable. Supporting the status quo grouper farming operation therefore has a negative environmental impact and no or low economic (value creation) potential (Fig. 6).

The assessment would, however, turn out quite differently if a hatchery-based grouper farm using pellets as feed is assumed (Fig. 6). A hatchery-based operation has the potential to reduce fishing pressures – at least it removes the incentive for catching juvenile fish. Pellets, as the origin of the feed, can be controlled, and there would be better food security and opportunity to maximize growth efficiency. With stable fingerling supply and a professional farming operation that optimally stocks and feeds the species with health and disease control, the operation could also be economically profitable. The evaluation of such a farm would therefore have to place its performance in the upper right instead of the lower left quarter in Figure 6.

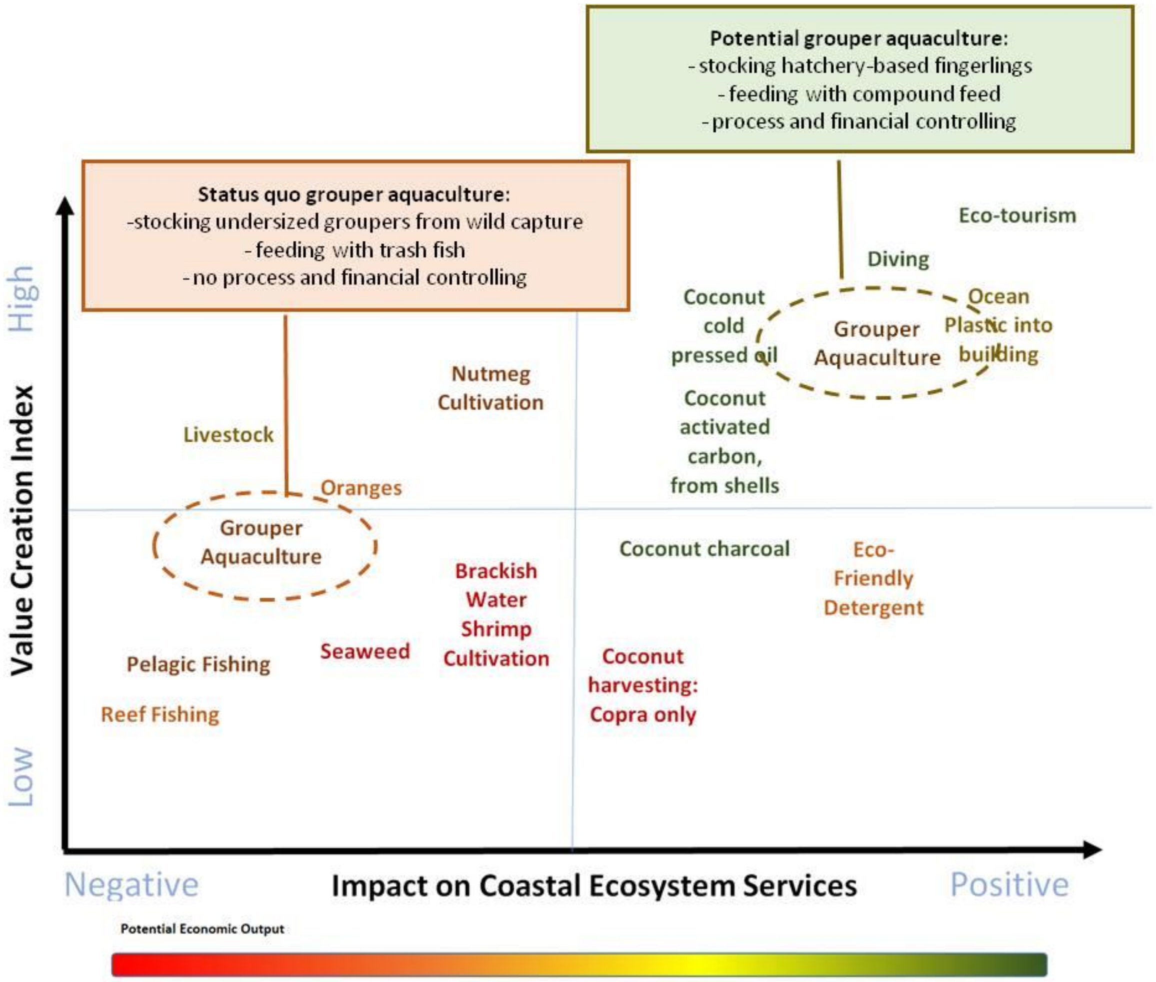


Figure 6: Environmental and economic rapid impact assessment of different alternative livelihoods including grouper farming, adapted from Hine and Phelan (2016).

Most farming activity on Selayar Island is around shrimp farming in ponds near the shore. According to MMAF, there are around 1600 ponds with an area of about 800 ha, where each farmer on average cultivates 1 ha. A hectare produces an output of 3-6 t of shrimp, generating on average revenue of around 500 million IDR in each farming cycle of 3 months with an average EBITDA of 20% (100 million IDR in 3 months, see Annex 9.3). Profitability might be improved to around 30-40% if the operation is optimized (and hence income could be twice as high during some farming cycles), but in such small-scale intense farming systems, it is typical that a complete break-down occurs every 3 years, e.g. due to diseases (see Annex 9.3 for more details on the profitability of shrimp farming on Selayar). Shrimp farming can generate decent incomes and the recruiting for grouper farmers would have to compete with this existing shrimp farming system. In terms of environmental impact, however, intensive shrimp farming performs rather poorly, generating significant effluents and often converting mangrove forests.

2.7 Scope for impact investment

Given the fragile state of fisheries targeting the vulnerable grouper species, alternative livelihoods for fishermen are desirable – on one side, to provide the fisher folk a more stable and predictable income, on the other side to reduce fishing pressure on grouper stocks. Instead of fishing groupers, the groupers can be farmed. Grouper farming is attractive because i) demand for, and value of, groupers is high, ii) supply from fisheries is irregular, while farming could guarantee regular supply, and iii) overfishing of groupers is a conservation problem and pressures from fisheries could be relaxed if the market was supplied by farmed groupers. There are, however, different ways of farming groupers, and the environmental and social impact will only be positive under certain conditions. Under the status quo grouper farming on Selayar, the environmental and social impacts cannot be deemed positive (Fig. 6). The following three components are indispensable for sustainable grouper farming, resulting in a positive environmental impact:

1) **Hatchery-reared fingerling supply:** In non-commercial grouper grow-outs, as is the case on Selayar,, undersized groupers are often sourced from capture fisheries. To avoid creating incentives for catching undersized grouper, the grouper farm must be exclusively supplied by hatchery reared grouper.

2) **Compound feed:** In most parts of Indonesia, groupers are fed by trash fish, or by a mix of trash fish and compound feed. Trash fish, however, introduce a bio-security risk, might be less efficient for grouper growth than optimized compound feed, and furthermore again provide incentives for unsustainable fishing practices.

3) **Environmental impact assessment and farm setup:** An environmental impact assessment (EIA) evaluates how the farm will affect its environment. For a marine cage system, the EIA should mainly assess how the farm debris will distribute in space, and what the expected consequences in the adjacent marine ecosystem will be.

There have been many attempts at hatchery-based grouper farming in Indonesia, but only a few of these have been successful on a larger commercial scale. First, it is difficult to obtain disease-free broodstocks and fry (Rob Garrison, *pers. comm.*), and, as a consequence, the survival rate of hatchery-reared fry and profitability in the grow-out is low. Second, the rather slow growth and low possible stocking density of groupers poses a profitability risk in the grow-out operation. The existing hatcheries sell their fry to many small-scale farms, while the cost control and profitability often remains unclear. In a professional setup, however, groupers could be profitably reared and grown out on a larger scale.

Due to its high value, many attempts have focused on leopard coral grouper (*P. leopardus*) and humpback grouper (*C. altivelis*). Survival rates for leopard coral grouper have been too low to make a hatchery and grow-out economically viable. Humpback grouper, with its slow growth, represents a high investment risk. Rearing of humpback grouper might pay off in some cases with decent survival due to its high market value, but it is a high-risk operation. The grouper farming operation should focus on species that minimize the risk of the operation with decent growth and survival rates, as the risk of not having a reliable production schedule outweighs the potential higher market values. Successful protocols for hatchery-based grouper rearing are currently only available for two species: orange-spotted grouper ("green grouper", *Epinephelus coioides*) and brown-marbled grouper ("tiger grouper", *Epinephelus fuscoguttatus*). It is therefore highly recommended to build up the production around these two species.

3 Business Strategy and Concept

3.1 Business concept and key objectives

This proposal presents a business plan for a grouper hatchery and grow-out operation on Selayar Island with the objectives of job creation, providing alternative livelihoods, and reducing fishing pressure on wild grouper stocks. There is strong emphasis on a professional hatchery setup to produce disease-free grouper fingerlings, resulting in high survival rates for farmers. The business concept is built around the main components of 1) creating alternative livelihoods, 2) building a strong hatchery case that produces high quality fingerlings for a local integrated grow-out, but also for independent farmers in the region, and 3) optimization of profitability by good farming practices, with the ultimate goal of 4) reducing fishing pressure on wild grouper stocks (Table 3).

Dimension	Component and key activities of the business concept
Alternative livelihood through fish farming	• Establish fish farming as an alternative for stable incomes: 106'000 pcs of 15 g fingerlings and a total of 60 t of marketable size groupers of 600 – 800 g • Training of local staff to commercially run a hatchery and fish farm • Training of independent community-based fishers households to commercially run a fish farming unit • Impact assessment to assure that other community activities or locally important political objectives are not affected by the grouper farm
High-quality fingerlings for integrated grow-out and independent farmers	• Good practices (e.g. water treatment) for disease prevention to produce high quality fry • Provide high quality fingerlings to the integrated grow-out of 30 t marketable size groupers of 600 – 800 g • Provide independent farmers with good quality fingerlings resulting in higher survival and yields
Optimization of profitability	• Good practices in the hatchery for maximal survival • Apply strictly documented farming schedules to optimize profitability by adapting size sorting, stocking density and feed choice (optimal feed conversion)
Reduction of fishing pressure on wild stocks	• Provide a stable supply of farmed grouper to compete with the supply from capture fisheries • Motivate community fishermen households to engage in grouper farming

Table 3: Overview of the main components of the business concept for a grouper hatchery and grow-out operation

Since there is currently no expertise on Selayar for fish farming, it is proposed that a portion of the grouper fingerlings produced (50%) are grown to marketable size in a grow-out operation that is integrated with the hatchery (scenario 1, Fig. 7). The company that would run the hatchery and the integrated grow-out is henceforward called "Kerupa Co." ("kerupa" is grouper in the Indonesian language). The remaining portion of fingerlings (50%) can be available for sale to independent grouper farms in the area, whereas the knowledge of how to run the grow-out would have to be transferred from the hatchery-integrated grouper grow-out to the farmers. The hatchery and the grouper grow-out farms are considered independent profit centres, allowing them to be evaluated on the potential profitability of their independent operations. For the integrated operation, the profitability of a hatchery and grow-out farm is combined in practice, and the fingerlings are transferred from hatchery to farm without a purchasing event. For the sake of comparison, we will present both, separated and combined EBITs for the hatchery and the farm.

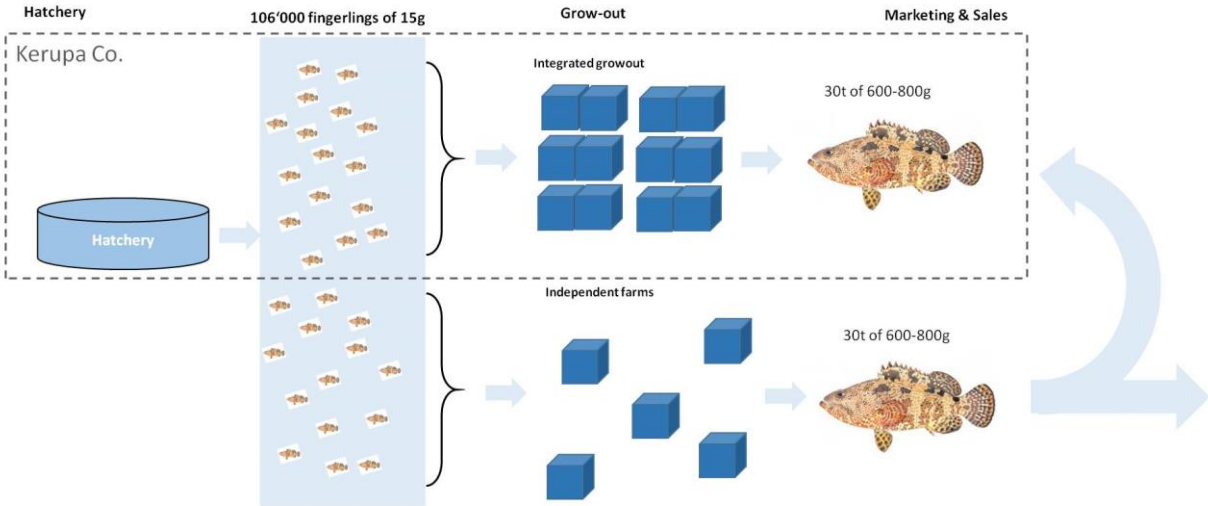


Figure 7: Business model scenario 1 with a hatchery producing 50% fingerlings for an integrated grow-out operation and 50% fingerlings for independent farmers.

For comparison, a scenario 2 can be considered where the entire fingerling production of the hatchery is raised to marketable size as part of the integrated grow-out operation. This would mean doubling the CAPEX for the farm investment, as twice as many farming installations would be needed, and proportionally doubling the farming costs, as twice as much feed would be needed. In this scenario, there would be no cost for the acquisition of fingerlings. The farm revenue would be doubled, but revenue generated by sales of fingerling would thus fall out. In the following, the two scenarios will be referred to for comparison:

Scenario 1: Integrated grow-out for half of the hatchery production: This is the recommended model, as it would allow independent farmers to develop in the region through the hatchery supply of good quality fingerlings, and would thus have positive socio-economic impacts.

Scenario 2: Integrated grow-out for entire hatchery production: From a business perspective, this approach is preferable, as it results in better profitability. However, there is no socio-economic benefit for farmers in the region.

Scenario 2 will result in higher profitability, however, there is no socio-economic impact for farmers to develop independently, as the entire fingerling production would be used by the grow-out farm. Likewise, an option where the entire fingerling production would be sold to independent farmers is too risky because 1) there are currently no knowledgeable farmers in the area and it therefore can't be assumed that the fingerlings would be successfully raised to marketable size in a profitable manner, and 2) the profitability of an operation without integrated grow-out would be too limited to make it an interesting case to an impact investor. Such a scenario is therefore not considered here.

The two species, green and tiger grouper, are in the mid-range of values among the grouper species and have acceptable larval survival of 1-2%. They grow relatively fast, reaching harvestable sizes of 600 - 800g in about 1 year. Tiger grouper grows a bit slower than green grouper, but usually has a slightly higher market value, and in Indonesia in particular, the market value of tiger grouper is significantly higher than green grouper (150'000 IDR/kg vs. 65'000 IDR/kg farm gate, see below). Green grouper has a market in most parts of SE Asia and the

Middle East, in Indonesia however it seems that this market has not yet been developed. Therefore, most of the hatcheries in Indonesia produce tiger grouper and not green grouper. As a matter of risk avoidance, it is recommended to start with tiger grouper when setting up a new hatchery in Indonesia. Green grouper could be included at a later stage, once the market for this species has been developed.

3.2 Investment model / Investible entity

The investable entity in this case is the "Kerupa Co." that must be formed to run the hatchery, which also includes the grow-out operation of at least half of the produced fingerlings. The Kerupa Co. will be managed by two managers, one for the hatchery and one for the grow-out. Some budget is allocated to training, knowledge transfer and building up of resources, but it is essential that the two managers have adequate qualifications and are thus appropriately compensated with a corresponding salary. The main seat of the Kerupa Co. will be the office of the hatchery building and the CAPEX for hatchery and farm is transferred to this company, who will pay back the investment. The hatchery reaches its scale and profitability in the second year and the farm grow-out in the third year, meaning that profitability of the integrated farm and grow-out operation will be negative during the first two years. With the projected profitability, it is suggested to plan the investment timeline over 10 years.

3.3 Marketing and Sales

3.3.1 Markets and sales strategy

Based on the current market value of grouper products, it appears that any grouper farm must serve the live fish market. Prices of live fish are at least twice as high as for dead fish, and transportation costs can be assumed at around 10% of the product value in both cases. In any case, the production costs of farmed grouper are already higher than the market value of the corresponding dead fish, therefore a farming operation would have no other choice than to serve the live fish market.

According to current grouper farming best practices, only green grouper (*E. coioides*) and tiger grouper (*E. fuscoguttatus*) are eligible for producing a reliable output volume. Since the market for green grouper does not seem to be developed in Indonesia, it is recommended that the hatchery project should base its production exclusively on tiger grouper at first. While there would be an attractive market for green grouper in Hong Kong, the market links would first need to be established before green grouper can be included in the operation.

In Indonesia, live groupers are sold directly at the farm to buy boats that are typically operated by Chinese grouper traders. However, for a buy boat to stop by, the farm must have several tons ready for harvest. Smaller farms will typically sell to a consolidator, or transportation to the next live fish trade hub is organized independently. Since the integrated operation is projected to produce 30 t per year, the average output per month is 2.5 t, which should suffice for a buy boat to pass by once per month. The project thus should not require a strong marketing function. As long as tiger grouper can be produced and offered at the current farm gate market price in sufficient volumes, it can be assumed that buy boats will come to get the fish at farm gate for the current market price. The independent farms can either sell the groupers independently or they might sell it back to the Kerupa Co., in which case the Kerupa Co. should obtain a handling fee and a small margin. For the independent farms, it depends on their location if buyers will directly source from the hatchery or not. For remote farms, it might be preferable for them to sell their marketable sized groupers back to the hatchery.

3.3.2 Products

The profitability of the integrated operation will be generated by the sale of 53'000 tiger grouper fingerlings of 15 g, and the sales of 30 t of marketable size tiger grouper:

Fingerlings: Tiger grouper fry sells for 1'200 IDR per cm. To reach higher survival rates in the grow-out, the hatchery will rear the groupers for 135 days to a size of about 4-5 inches or 15 g. The price of the hatchery output is projected at 12'000 IDR/pc, which would correspond to a 10 cm fingerling. This assumption is conservative since a grouper raised until day 135 (see below) would typically be a bit longer than 10 cm.

Marketable size grouper: For any grouper species, the harvest and selling sizes are either 600-800 g or 1.3kg and up. Due to restaurant portion issues, there is no demand for grouper of 800g to 1.3 kg. The yield of grouper meat is about 30-35%, hence the 600 – 800 g groupers would result in fillet sizes of 180 – 280 g, which is a good portion for one person. 1.3 kg and up is a good portion for two or more persons, but 800 g to 1.3 kg is too much for one person and too little for two. However, during Chinese New Year, buyers will usually take any size of fish. The economics of farming impose a decreasing profitability with increasing fish size, due to increasing eFCRs (economic feed conversion ratios) over time (see below). As a consequence, it is most profitable to harvest the fish at the smallest possible marketable size – unless the unit prices would significantly increase with size (i.e. if the price per kg would be higher for 1.3 kg up grouper than for 600 – 800 g grouper). As unit prices are not known to significantly increase with size, the harvestable size will be set at 600 – 800 g. The live tiger grouper of 600 – 800 g currently sells at 150'000 IDR/kg (11.1 USD/kg) farm gate and it can be assumed that this pricing level will persist in the future.

3.3.3 Projected sales volumes

Under scenario 1, half of the produced fingerlings (i.e. 53'000 pieces) will be sold at a value of 12'000 IDR, resulting in sales of 639 million IDR (49'000 USD) per year (Table 4). The hatchery won't produce at full scale during the first year, since the first product to be ready takes 4.5 month, but it is operational at its full scale after the first year. The other half of the fingerlings are used as a basis for the integrated grow-out operation, which will result in an output of 30 t of groupers of about 700 g size. At the current farm gate value, this will result in sales of 4.5 billion IDR (332'700 USD/kg). The farm, however, won't have any product ready in the first year. The first products will be obtained only in the second quarter of the second year, and the farm will furthermore be increased by 60 new cages during this year. Hence, the farm will only operate at its full scale in the third year. The combined revenue of hatchery and farm is thus of 5.14 billion IDR (378'000 USD) by the third year.

EBIT PROJECTION - HATCHERY & FARM	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
REVENUES FROM SALES					
HATCHERY: Fingerling sales 53'000 fingerlings of 15g	479'033'829	638'711'772	638'711'772	638'711'772	638'711'772
FARM: Grouper farm gate sales (30 t of groupers)	0	2'109'375'652	4'500'001'391	4'500'001'391	4'500'001'391
TOTAL	**479'033'829**	**2'748'087'424**	**5'138'713'162**	**5'138'713'162**	**5'138'713'162**

Table 4: Revenues from 30 t of groupers grown in the integrated grow-out and 53'000 fingerlings of 15 g (scenario 1).

If deemed feasible or necessary (e.g. because independent farmers in the region are not interested in buying the hatchery's fry), the integrated grow-out operation could be scaled up to grow-out the entire hatchery-produced fingerlings (scenario 2, Table 5).

EBIT PROJECTIONHATCHERY & FARM	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
A. REVENUES FROM SALES					
HATCHERY: no sales of fingerlings	0	0	0	0	0
FARM: Grouper farm gate Sales (60 t of groupers)	0	4'218'751'304	9'000'002'780	9'000'002'780	9'000'002'780
TOTAL	**0**	**4'218'751'304**	**9'000'002'780**	**9'000'002'780**	**9'000'002'780**

Table 5: Revenues from 60 t of groupers grown in the integrated grow-out (scenario 2).

In this case, the revenue from the farm would double to 9 billion IDR (692'000 USD) per year, but the revenue of 639 million IDR (49'000 USD) from selling fingerlings would fall out (Table 5).

3.4 Assumptions on grouper biology

For any hatchery and grow-out operation, the assumptions on farming cycle, growth, survival, stocking density, and eFCR are essential. The farming cycle and growth determine the duration of each phase of production and thus the turnover rate of production. Growth and survival determine what biomass can be obtained in what timeframe and thus how much revenue can be generated. Stocking density determines how the farm must be set up. Since feed is the major cost component in a farming operation, the eFCR will determine the cost of the farming operation. Labor is another major cost component and will be treated in section 4.

These assumptions are applied in the following section for the two proposed grouper species, green grouper (*E. coioides*) and tiger grouper (*E. fuscoguttatus*). The planning and financial projection tool (Annex 9.1) is given for both species, but the output of green grouper will be initially set at 0%, as this market would first have to be developed (see above).

3.4.1 Farming cycle

The farming cycles for green and tiger grouper in the hatchery are identical, and the differences between the two species become manifest only during the grow-out. The farming cycle starts with spawning of adult females following the lunar cycle (hence approximately every 2 weeks, Fig. 8). As a rule of thumb, an adult female larger than 6kg will spawn about 100'000 – 130'000 eggs per kg of body weight. The larvae hatch within 1-2 days and are transferred to the larval rearing tanks. They can be stocked at high densities , with mortality usually in the range of 1-2%, and the stay in these tanks for 1.5 months (until day 45 after hatching). At 45 D the fingerlings have grown to 2-3 cm and are transferred to the nursery tanks, where they are reared to the size considered optimal for the transfer to the farms. It is suggested here to make the transfer later than usual, at a size of 15 g and about 5 inches, to increase survival probability in the grow-out operation. From 15 g fingerling to marketable size, it can be expected to take about 8 – 10 months for green grouper and 10 – 12 months for tiger grouper.

3.4.1 Growth

Different grouper species can have quite different growth rates. Green and tiger grouper can be considered among the fast growers, probably one of the main reasons why their hatchery-based farming has been successful. Green grouper will take about 4 months to grow from 15 g to 100 g, and from there on grow about 100-120 g per month. Tiger grouper takes about 5 months to grow from 15 g to 100 g and from there on grow 80-100 g per month (Al Gonzales, *pers. comm.*). For the projections, an ontogenetic growth model based on energy allocation (West et al. 2001) has been used:

$$\frac{\partial w}{\partial t} = aw^{3/4} - bw - cw \qquad \text{(eq.1)}$$

where $aw^{3/4}$ is the energy acquisition rate, bw the maintenance rate and cw the rate of reproductive investment. Since the fish are harvested before reaching maturity, the term cw can be ignored. Growth as a function of time is given by integration of ∂w:

$$\int_0^t (aw^{3/4} - bw)\partial t = \left(\frac{a}{b} - \left(\frac{a}{b} - w_0^{1/4} \right) \mathrm{e}^{-bt/4} \right)^4 \qquad \text{(eq.2)}$$

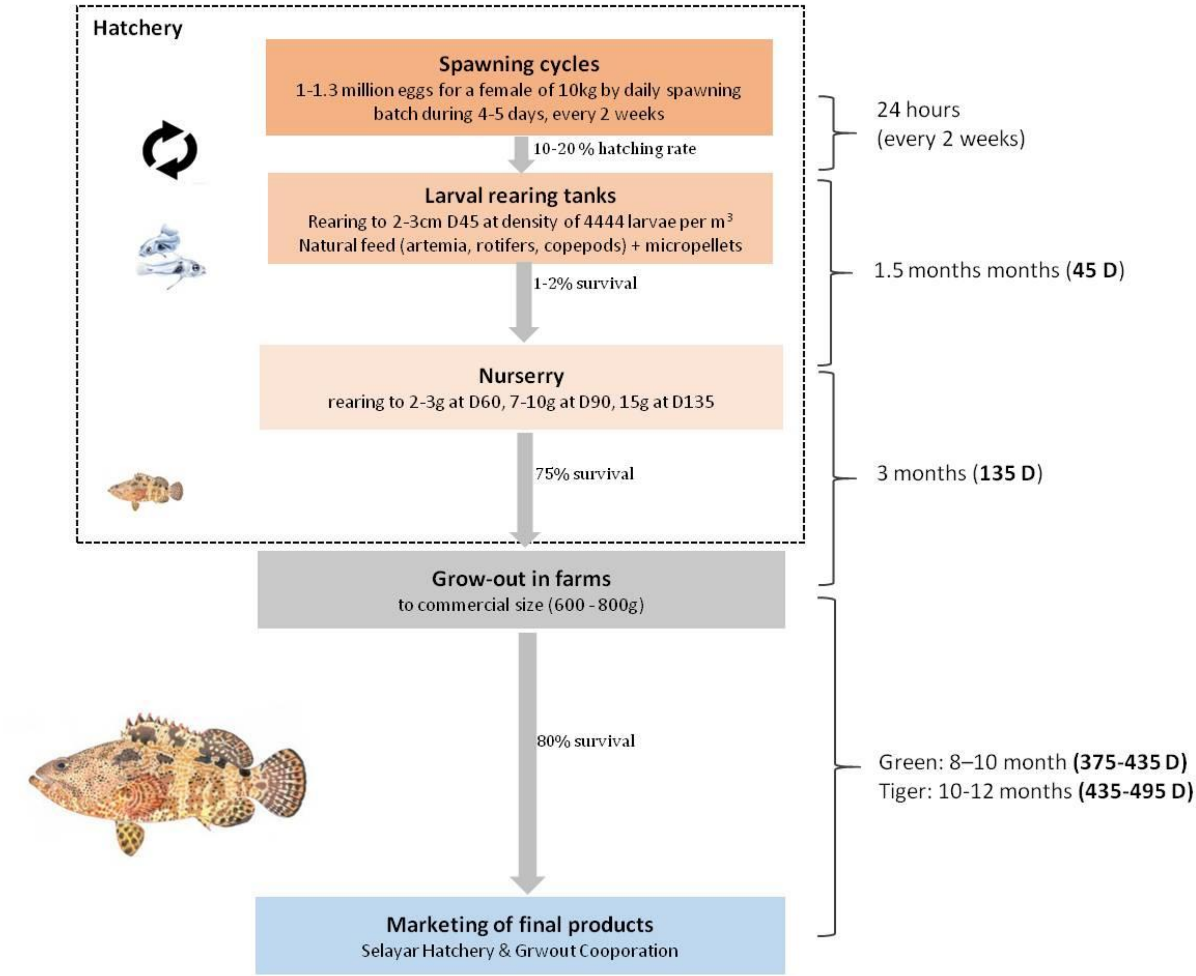


Figure 8: farming cycles from hatchery to growout for green and tiger grouper

Growth can thus be predicted at any time or for any time interval. Since reliable empirical data is not available, the function was fitted to the growth patterns as described above, resulting in the respective a and b parameters for each species in Table 6.

	a	b
Green grouper	0.067110	0.006282
Tiger grouper	0.05224	0.004568

Table 6: Parameters used in the energy allocation model for green and tiger grouper (used for growth and eFCR)

To have a rather conservative expectation on growth, it was assumed that tiger groupers grow from 15 g to 700 g in 12 months, while green grouper would exceed 700 g during less than 10 months (Fig. 9).

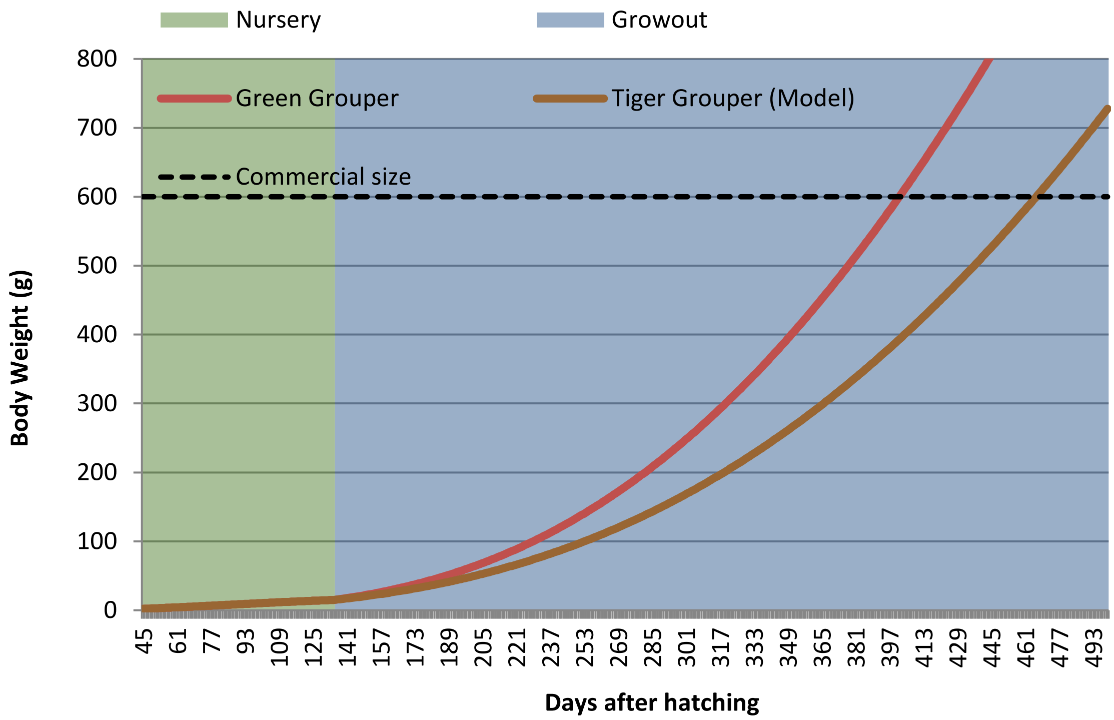


Figure 9: Growth functions under farming conditions with specialized pellet feed assumed for tiger and green grouper.

To obtain a better fit during the hatchery phase, a separate curve was fitted for the hatchery phase, but the different parameters had only a very marginal effect on financial projections (section 4). Furthermore, for each increment of weight increase, the necessary energy acquired can be given in terms of somatic body weight from which the FCR can be derived at any time (see Annex 9.4).

3.4.2 Survival

Survival is essential for the profitability of the operation, and the hatchery must apply adequate procedures to maximize survival. Survival can be managed by strict health and disease control, appropriately clean working procedures, water treatment, etc. In the grow-out phase, survival is more difficult to control and mainly dependent on the surrounding marine environment.

For the most part, current hatchery operations don't follow best practices, resulting in fry of suboptimal survival of around 50%. The break-even of the grow-out can, however, be expected at a survival of 70%. Besides producing lower revenues through lower outputs, low survival rates will also produce relatively higher costs through their effect on eFCR: low survival rates result in higher eFCRs, as the biomass for which feed has been used, will be lost. We assume that a total cumulative survival of at least 50% can be achieved from stocking in the nursery at 45D until harvesting at 495 D for tiger grouper. Although the hatchery will use best practice health procedures, survival was conservatively assumed at 67% during the nursery phase. For the grow-out phase, a survival of 80% was assumed, resulting in a combined survival ratio from nursery to harvestable size of about 54% (0.67*0.80=0.54). Since the stocked fingerlings will have a size of 4-5 inches and 15 g already, which is larger than the currently stocked sizes, the assumed survival can be considered conservative. Survival has been modelled using an integrated survival function accounting for these assumptions during the nursery and grow-out phase (Fig. 10):

$$S(t) = s_0 + (1 - s_0)e^{-\varphi(t-t_0)} \qquad \text{(eq.3)}$$

where s_0 is the minimal cumulative survival probability, and φ is daily mortality rate relative to s_0, and t_0 is the relative start of counting survival at day 45 after hatching.

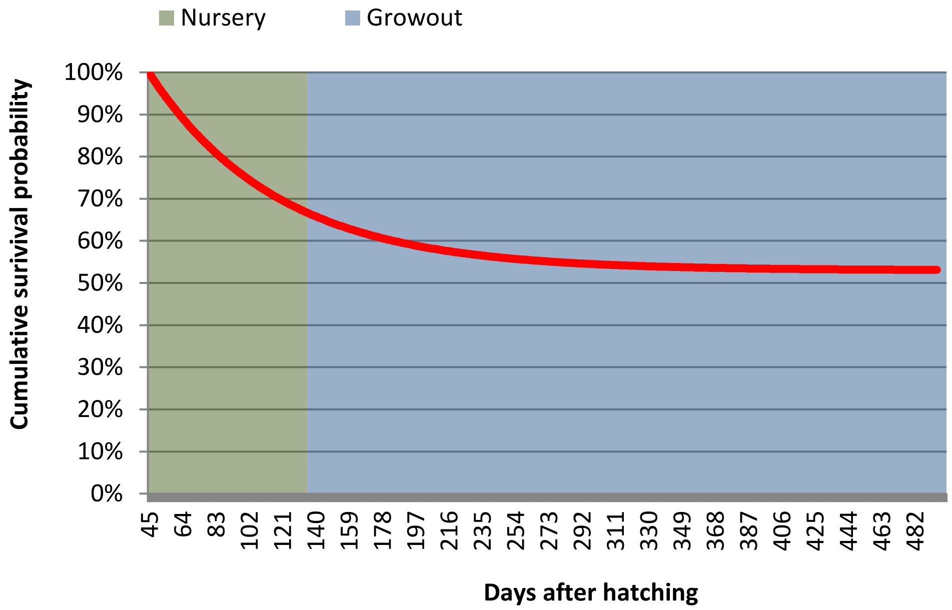


Figure 10: Cumulative survival function assumed over the nursery and grow-out phase used for tiger and green grouper.

3.4.3 Stocking density

Stocking density of groupers is generally rather low. Compared to other species that can be stocked in the entire water column, groupers are demersal species that sit on the bottom and don't use the entire water column. Therefore, it is recommended to stock grouper by square meter rather than by cube meter. There are however conflicting views on this. Experience in the Philippines has shown that stocking of smaller groupers can be in the range of 20-25 pcs/m^3 for groupers below 300g, and 15-20 pcs/m^3 for groupers above 300g (Al Gonzales, *pers. comm.*).

Fish size [g]	Cage volume [m^3]	# fish per cage	Density [#/m^3]	Density [g/m^3]
15	25	450	18.0	270
25	25	350	14.0	350
50	25	300	12.0	600
80	25	200	8.0	640
100	50	450	9.0	900
150	50	400	8.0	1200
170	50	400	8.0	1360
200	50	370	7.4	1480
250	50	370	7.4	1850
310	50	370	7.4	2294
370	50	350	7.0	2590
440	50	320	6.4	2816
500	50	300	6.0	3000
750	50	200	4.0	3000
1000	50	150	3.0	3000

Table 7: Current practice of stocking density in Indonesia.

Common practice in Indonesia is, however, to stock groupers at much lower stocking densities (Table 7), and without any clear evidence we can currently not fully discard the possibility that there might be some good reason for this. As a matter of precaution, we therefore assume the lower stocking densities according to common practice in Indonesia, bearing in mind the potential that these densities could be increased in practice.

The stocking densities over the grow-out phase gives an average stocking density of 4.44 pcs/m^3 and thus determines the number of cages necessary to produce 50 t of marketable size grouper (600 – 800 g): 240 cages.

3.4.4 Economic Feed Conversion Ratio (eFCR)

The eFCR gives the biomass obtained over the feed mass used over a certain time span and is of economic importance because the obtained biomass is directly proportional to the generated revenue and the feed is directly proportional to the most important cost component. There is controversial information on the eFCR that can be obtained in grouper grow-outs. Indonesian farmers give an eFCR of 3-4 as a general measure, however, feeding is rarely optimal and never relies on pellet feed exclusively – most of the farmers mix pellets and trash fish as feed. Experience in the Philippines using pellet feed exclusively has shown an eFCR in the range 2.4-2.6 for tiger grouper, and 2.0-2.4 for green grouper, assuming average survival. Therefore, it appears likely that the eFCR can be kept below eFCR=3 in an optimal farm setup and operation, and we assume an eFCR of 2.6 for tiger grouper and 2.4 for green grouper throughout this proposal, which is already considered a conservative assumption according to Filipino producers (Al Gonzales, *pers. comm.*). More reliable information on the eFCR could possibly be obtained from specialized grouper feed manufacturers, e.g. Grobest in Taiwan, although they would likely provide eFCRs at the upper end for their interest to sell as much feed as possible. For tiger grouper, the eFCR is assumed at a minimum of around 2.5 when the groupers are at a size of 100-200g, but from there onwards the eFCR increases to 2.6 at the harvestable size of around 700 g (at day 495), and it would keep increasing to beyond 3 for sizes above 1 kg (Fig. 11).

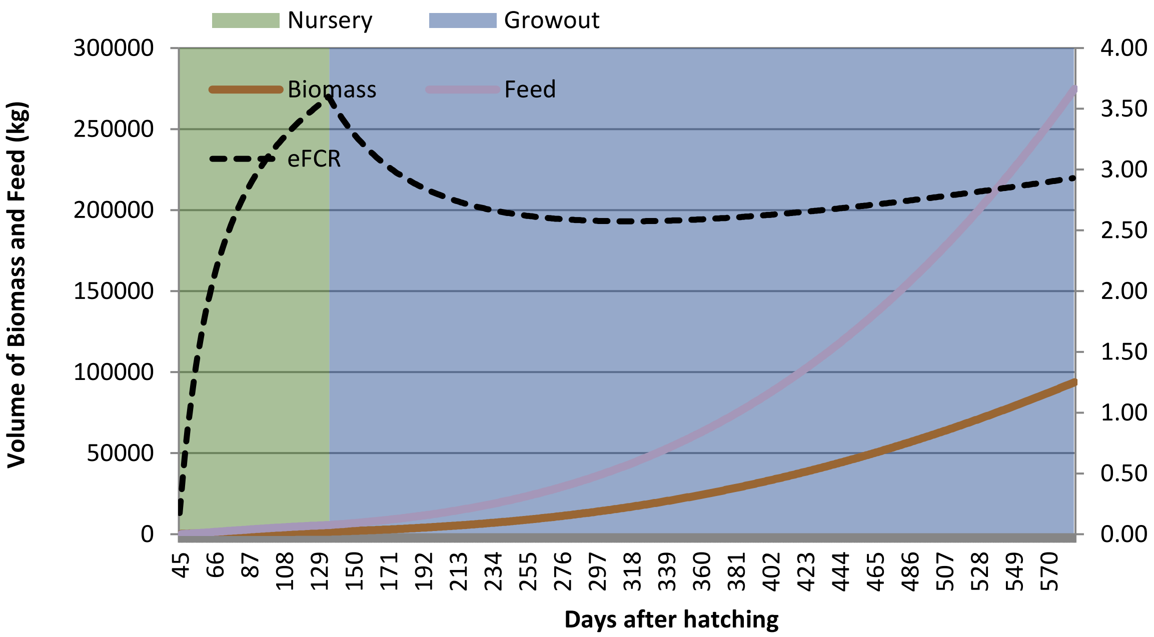


Figure 11 : Total biomass and feed volume used and evolution of corresponding eFCR over the nursery and grow-out phases for tiger grouper.

The increasing eFCR means that the larger the fish gets, the higher the cost is relative to the obtained biomass (and corresponding revenue), i.e. the operation becomes less and less profitable the larger the fish gets, assuming that the sales price per kg won't increase in the same manner. This is the basis for setting the harvestable size at the minimum possible harvestable size of 600-800 g.

3.4.5 Feasibility & site selection

The grouper hatchery is ideally placed near the grouper farm, though it is not mandatory as the grouper fry must be transported from the hatchery to farm anyway and a few kilometres difference would have a marginal impact on survival. More important for the feasibility of the hatchery are i) power supply and ii) water quality (Table 8). For the farm operation, the following two main factors are important: i) exposure and likelihood of rough weather conditions, and ii) water quality (Table 8).

Criteria	Condition
Hatchery	
Electricity	Reliability of and direct access to power supply
Water quality	Clean water, no contamination, no biosecurity (disease risk)
Farm	
Protected from wave & wind	Exposure to typhoons storms, waves and winds
Water quality	Clean water, no contamination, no biosecurity (disease risk)
Political | Social	
Peace	Terrorism, people army, violent social disruptions

Table 8: Feasibility criteria for grouper hatchery and farm

The feasibility criteria for the hatchery and farm thus overlap around water quality, i.e. hatchery and farm should both be placed where water quality is good, but if water quality doesn't coincide with available power supply or protection from rough weather, a hatchery and farm might not be placed in the same site. For both operations, some political stability is required, as would be required for any other business. Terrorist groups are however not known to be active in the area.

On Selayar Island, power supply is only available on the west coast. Water quality would have to be studied in more detail, but major pollutants are not known in the area, the next largest city being Makassar, located 150 km away to the northeast, on another island. It appears likely that water quality is sufficiently good on the entire island, hence the entire west coast of Selayar Island would appear feasible for the hatchery and the grow-out. Typhoons or strong storms are not known in southern Sulawesi. The major challenge in environmental conditions might be changes in salinity due to heavy rain falls. For the reason of accessibility of workers (and also power supply) it might be practical to have the operation in the vicinity of Benteng, i.e. somewhere in the Benteng Bay. For site selection, however, the water quality should be evaluated and an Environmental Impact Assessment (EIA) conducted. The key issue examined by an EIA should be the projected distribution of farming debris in the bay, and possible ecological consequences. To strengthen ecosystem capacity with respect to farming debris, it is recommended that the 240 cages are split up into 4 units of 60 cages each, and the 4 units could thus be placed to mitigate expected ecosystem impacts.

3.4.6 Scalability

For the hatchery to be profitable, a certain scale is needed (Fig. 12). The major cost component of a hatchery is operational expense for labour, which represents a fixed cost regardless of size. Hence, the hatchery must produce a certain minimum output to cover the assumed overhead cost. Furthermore, a smaller hatchery would still require a significant CAPEX investment, which is disproportional to the hatchery scale. The hatchery profitability can be given as a function of the assumed annual fingerling output (Fig. 12).

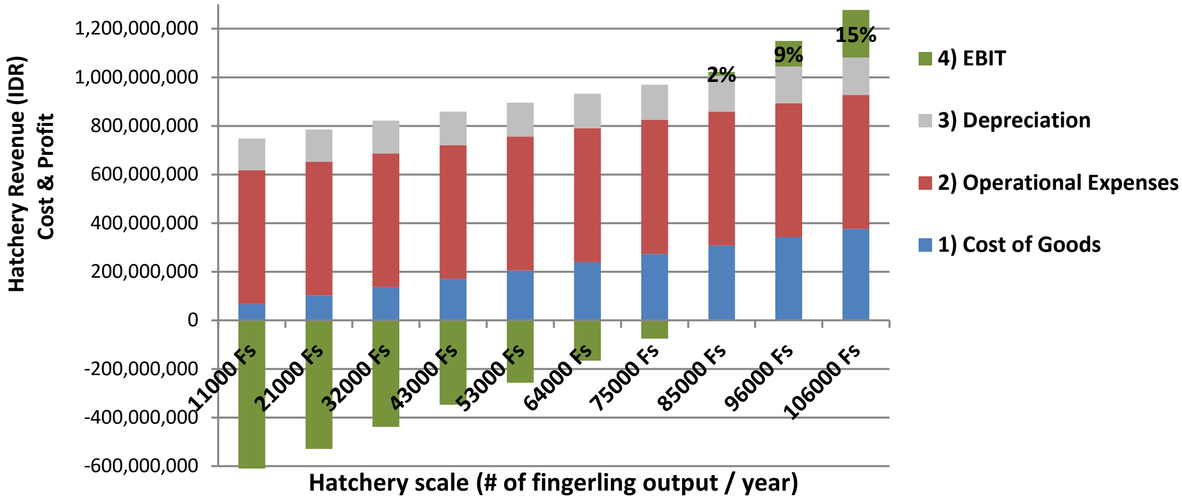


Figure 12: Feasibility criteria and scale for grouper hatchery and farm.

Under the costing and scaling assumptions, the break-even of a hatchery is at fingerling output of 83'400 fingerlings per year. We have defined 15% EBIT as minimum hatchery profitability for the conservative case, which requires an annual fingerling output of 106'400 fingerlings.

Rearing the 106'400 fingerlings to a marketable size of 600 – 800 g (or 700 g on average) results in a total harvestable biomass of 60 t. The integrated grow-out operation will, however, only absorb about half of this production (see above). The farm operation could also be scaled up more or less. As for the farming operation, the costs are more proportional to the produced output: a certain number of people are needed to handle a certain number of cages, and the major cost items, namely the feed (and the fingerlings), behave proportionately to the produced volume and CAPEX investment. The same relative profitability for the grow-out can therefore be assumed for all possible scenarios, irrespectively of the scale, i.e. profitability for producing 30 t is predicted at 22% (see below), but it would be the same for 15 t or 60 t annual output.

4 Financial Projections

4.1 Assumptions

4.1.1 Hatchery

The hatchery consists of a building of about 1'500 m² including office and toilets. It has enclosed tanks for intense plankton production, 16 larval rearing tanks of 3x3x1 m, and around 100 small nursery tanks of 500 l volume. Due to feed competition of groupers, experience has shown that smaller nursery tanks result in better outcomes (Al Gonzales, *pers. comm.*). Furthermore, a water reservoir tank of about 200 m³ is required.

The hatchery is managed by a qualified manager, who is assisted by a live feed technician, a health and disease technician, and a mechanic (who can be shared with the grow-out operation). Furthermore, 4 assistants are required to perform the daily work of feeding, sorting and cleaning etc., based on instruction of the manager. The manager should have a competitive salary, while the assistants get remunerated based on the minimal wage of 1.7 million IDR per month, which is common practice in Indonesia (Table 9). Furthermore, two staff members are appointed for security to work in rotational shifts.

		YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Functions	**Salary [IDR/month]**			**# of 100% workloads**		
Hatchery manager	8'000'000	1	1	1	1	1
Live feed technician	4'000'000	1	1	1	1	1
Health Disease	4'000'000	1	1	1	1	1
Mechanic	3'000'000	0.5	0.5	0.5	0.5	0.5
Manpower/ Assistants	1'700'000	2	4	4	4	4
Security	1'700'000	2	2	2	2	2

Table 9: Hatchery staff and labor costs.

4.1.2 Grow-out

The number of required cages is given by the projected stocking densities. Standard cages used in Indonesia are of 2.5m x 5m x 4m (W x L x D). This allows two smaller nets of 2.5m x 2.5m x 4m to fit in one cage for the nursery part of the farm, which is not needed in this proposed setup. Cage volume would thus generally be 50 m^3, and the resulting average stocking density over the entire farming cycle would be4.44 pcs/m^3, or 22.18 pcs/m^2 (see Table 6). At these densities, 240 cages are required to farm 30 t of groupers at 600 – 800 g (or 700 g on average). Since the farm will produce some debris (which will be subject to the EIA), it is recommended to split up the farm in 4 units of 60 cages each, that can be placed in space as to minimize potential negative ecological effects of the farm. For the first year, 3 units (180) should be ready to be stocked, the 4th unit can be built and stocked in the second year.

A farm manager is responsible for the entire grow-out production. Each of the 4 units has 2 staff responsible for feeding, 2 for net replacement, 2 for cleaning and repair and 2 for security, and the mechanic would be shared with the hatchery. The 4 units thus employ 32 workers that are paid at the standard minimal wage of 1.7 million IDR per month (Table 10).

		YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Functions	**Salary [IDR/month]**			**# of 100% workloads**		
Growout manager	8'000'000	1	1	1	1	1
Mechanic	3'000'000	0.5	0.5	0.5	0.5	0.5
Feeding	1'700'000	6	8	8	8	8
Net replacement	1'700'000	6	8	8	8	8
Cleaning & repair	1'700'000	6	8	8	8	8
Security	1'700'000	6	8	8	8	8

Table 10: Farm staff and labor costs.

4.2 EBIT Projections

4.2.1 Cost Analysis for independent profit centres vs. integrated operation under scenario 1 or 2

The profitability can be given either for the farm and hatchery as independent profit centres or for the integrated operation under scenario 1 or scenario 2 (Fig. 13, Table 11). The main difference between the integrated EBIT projections and the projections considering hatchery and farm as independent profit centres is that the fingerlings used in the integrated grow-out are not sold from the hatchery to farm, hence this Cost of Good (CoG) for the fingerlings is omitted, while the EBIT of both operations is then combined in the sales of marketable size groupers. Therefore, the resulting EBIT relative to the total revenue is higher for the integrated operation than if hatchery and farm are operated as independent profit centres (Fig. 13): The EBIT is 15% for the hatchery and 22% for the farm, if operated as independent profit centres, while for the integrated operation it is 23-25%, depending on the scenario. The difference between scenario 1 and 2 is that under scenario 1 only 50% of fingerlings are used in the integrated grow-out, and additional revenue is generated by selling the other 50% to independent farmers, while under scenario 2 the entire fingerling production is used in the integrated grow-out. The revenue under scenario 1 is given by 53'000 fingerling sales and 30 t marketable size grouper sales, whereas under scenario 2 it is given by 60 t marketable size grouper sales (see tables 4 & 5). Since the profitability of the farming operation is higher than for the hatchery, the profitability of the integrated operation increases with the volume used in the grow-out. Therefore, the profitability is higher under scenario 2 (25%) than under scenario 1 (23%). This is mainly a consequence that the operational expenses relative to the generated revenue decrease.

The revenue of the separated farm operation, broken down to kg of harvested grouper gives a farm gate price of 150'000 IDR/kg. In this breakdown, the hatchery revenue from independently selling fingerlings reflects the 14% fingerling cost of the independent grow-out operation (Fig. 13).

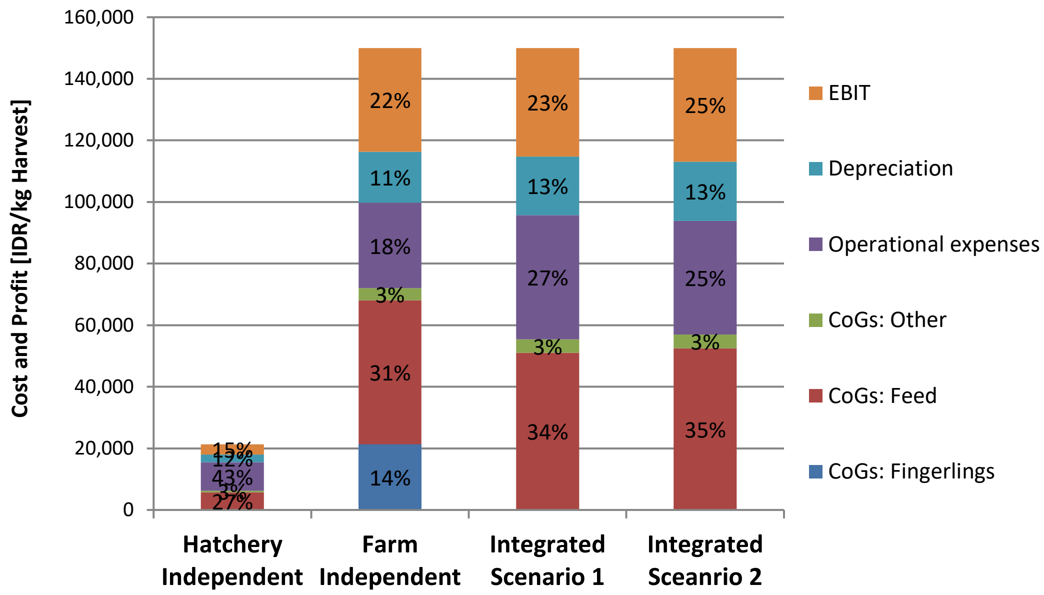


Figure 13: Cost analysis of separated hatchery and farm operations, as well as the integrated operation under scenario 1 and 2. Costs and profits are given per kg of harvested (marketable size) biomass.

Scenario 2 would require a higher CAPEX investment, but would generate a higher absolute profit, i.e. 25% EBIT or 2.25 billion IDR from the total revenue of 9 billion IDR resulting from 60 t of marketable size grouper sales (Table 11). Under scenario 1, the sales from 30 t marketable size grouper and 50% of the fingerling production (53'000 pieces) result in a revenue of 5.14 billon IDR with profit of 23% (1.18 billion IDR).

From a business perspective, scenario 2 is preferable due to the higher relative and absolute profitability, but its socio-economic impact on sustainable development might be marginal. The project would seek to develop independent farmers and transfer the knowledge on how to efficiently farm groupers from the integrated grow-out, and for this it will be necessary that a significant portion of the produced fingerlings are sold to independent farmers (scenario 1). From an impact perspective, scenario 1 is therefore the recommended model in this proposal. In the following, 5-year plans are given for the hatchery and farm if operated as independent profit centers, and for the integrated operation under scenario 1.

	Independent profit centres		Integrated Hatchery and Farm
	Hatchery	Farm	Hatchery & Farm
Scenario 1 50% of fingerlings are grown out in the integrated grow-out, 50% are sold to independent farmers	CAPEX: 2'229'072'444 Revenue: 1'277'423'543 EBIT: 15%	CAPEX: 2'315'999'294 Revenue: 4'500'001'391 EBIT: 22%	CAPEX: 4'545'071'738 Revenue: 5'138'713'162 EBIT: 23%
Scenario 2 100% of fingerlings are grown out in the integrated grow-out, there are no sales of fingerlings to independent farmers	CAPEX: 2'229'072'444 Revenue: 1'277'423'543 EBIT: 15%	CAPEX: 4'631'998'587 Revenue: 9'000'002'780 EBIT: 22%	CAPEX: 6'861'071'031 Revenue: 9'000'002'780 EBIT: 25%

Table 11: CAPEX, Revenue and EBIT after the third year, illustrated for the hatchery and farm as independent profit centres as well as for the integrated operation of hatchery and grow-out under scenario 1 and 2.

4.2.2 5-year plan: Hatchery as independent profit center

The EBIT projection of the hatchery is characterized by 30% cost of goods, 43% operational expenses, 12% depreciation and 15% EBIT. If all 106'000 fingerlings were sold at 12'000 IDR/pc, the total revenue of the hatchery would be 1.28 billion IDR, and hence the net profit would represent around 200 million IDR (Fig. 13).

The cost of goods consists mainly (90%) of feed costs for the pellets fed during the long nursery phase (D45 – D135), pellets to be fed to the broodstock, and Artemia (a species of brine shrimp) to be fed to the larvae. Broodstock is commonly fed a mix of pellets and trash fish (30'000 IDR/kg) and every fifteen days before each new moon spawning event 50% squid (45,000 IDR/kg). Additionally, vitamin mixes are used several times a month.

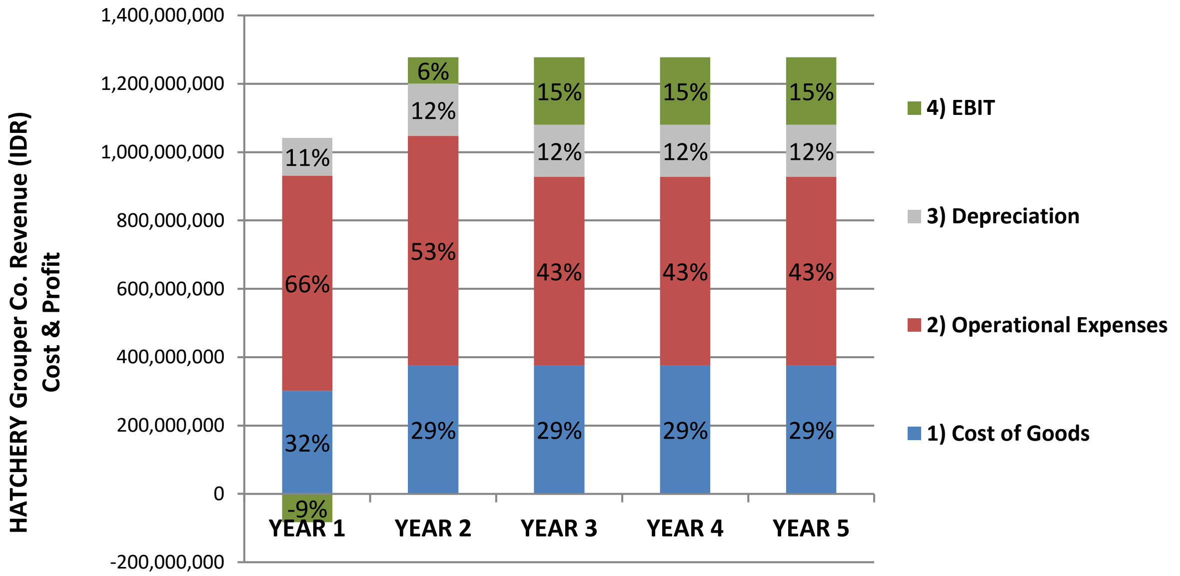


Figure 14: Projection of hatchery EBIT over 5 years for the hatchery as independent profit center

The operational costs are mainly labour costs (Table 8), resulting in a fixed cost of 332 million IDR per year (27.7 million IDR per month). Furthermore, electricity, including the use of generators, is assumed to cost 12 million

IDR per month. 180 million IDR are allocated to engineering, technical planning, monitoring and supervision of the hatchery by external experts, while this cost can be decreased over time.

The EBIT of 15% is reached in the third year, while in the first-year profitability is negative (-9%), and limited during the second year (6%) due to the supervision cost (Fig. 14).

4.2.3 5-year plan: Grow-out as independent profit center (for 30 t grown out under scenario 1)

The EBIT projection of the grow-out operation is characterized by 48% cost of goods, 18% operational expenses, 11% depreciation and 22% EBIT. If all 30 t of 600 – 800 g groupers are sold at 150'000 IDR/kg, the total revenue of the hatchery would be 4.5 million IDR for 30 t grown out, and hence the net profit represents 1 billion IDR (Fig. 15).

If the 53'000 fingerlings under scenario 1 would have to be purchased at 12'000 IDR/pc, the cost would be of 639 million IDR (14% of the revenue). Two-thirds of the Cost of Goods (CoG) consist of feed costs, assuming that good quality pellets can be purchased at an average price of 18'000 IDR/kg. With an eFCR of 2.6, the 30 t of groupers under scenario 1 require an annual feed volume of about 78 t of feed that would thus cost 1.4 billion IDR (31% of the revenue). Some marginal costs also result from diverse farm materials and fuel for the vessels to move feed, fish and workers between the farm units.

The operational costs are mainly the labor costs (Table 9), resulting in a fixed cost of 767 million IDR per year (63.9 million IDR per month) for the grow-out of 30 t marketable size groupers (scenario 1). Furthermore, 260 million IDR are allocated to engineering, technical planning, training, monitoring and supervision of the farm by external experts, while this cost can be decreased over time.

The EBIT of 22% is reached only in the third year. In the first year, no revenue is generated and in the second year profitability is still negative (-57%), as in this year the 30 t output is not yet possible (Fig. 15).

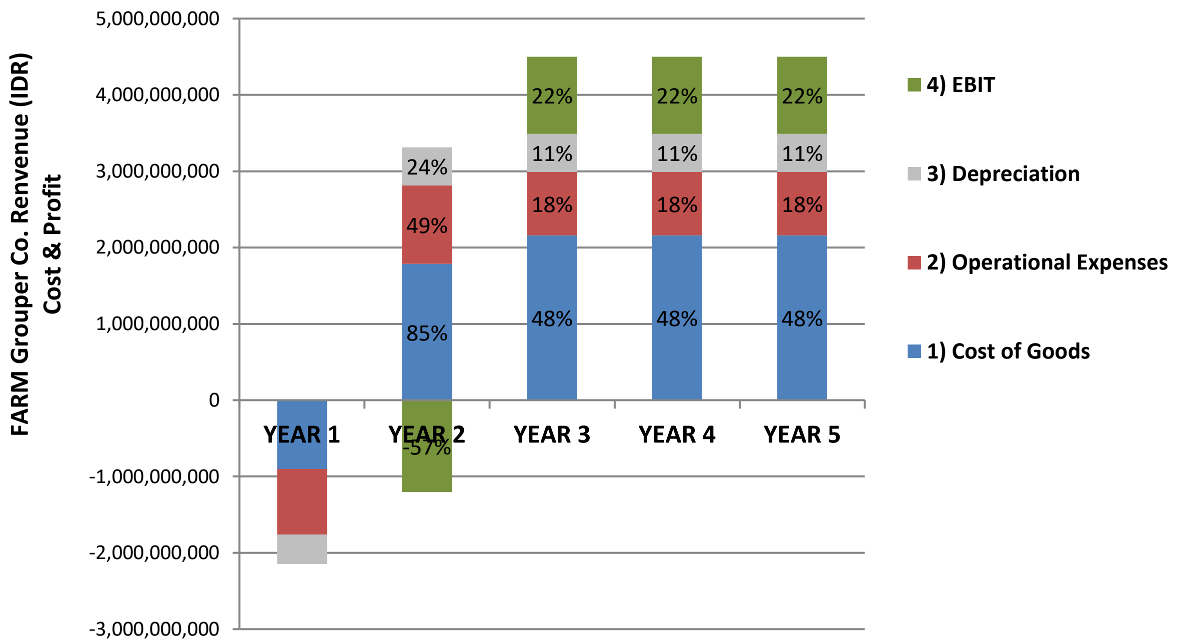


Figure 15: Projection farm EBIT over 5 years for the farm as independent profit center producing 30t of marketable size grouper (scenario 1).

4.2.4 5-year plan: Integrated hatchery and farm operation under scenario 1

The EBIT projection for scenario 1 of the grow-out operation (using half of the fingerling production of the hatchery) is characterized by 37% cost of goods, 27% operational expenses, 13% depreciation and 23% EBIT (by year 3). The combined revenue consists of 53'000 fingerling sales and 30 t of marketable grouper, totalling 5.14 billion IDR, and hence the net profit represents around 1.2 billion IDR (Fig. 16).

Since only the hatchery generates some income during the first year by selling 50% of its production, the costs still exceed the revenue by about 4 times, and therefore the EBIT is negative by 466% in the first year. In the second year it is still negative and only in the third year the operation is running at its full scale.

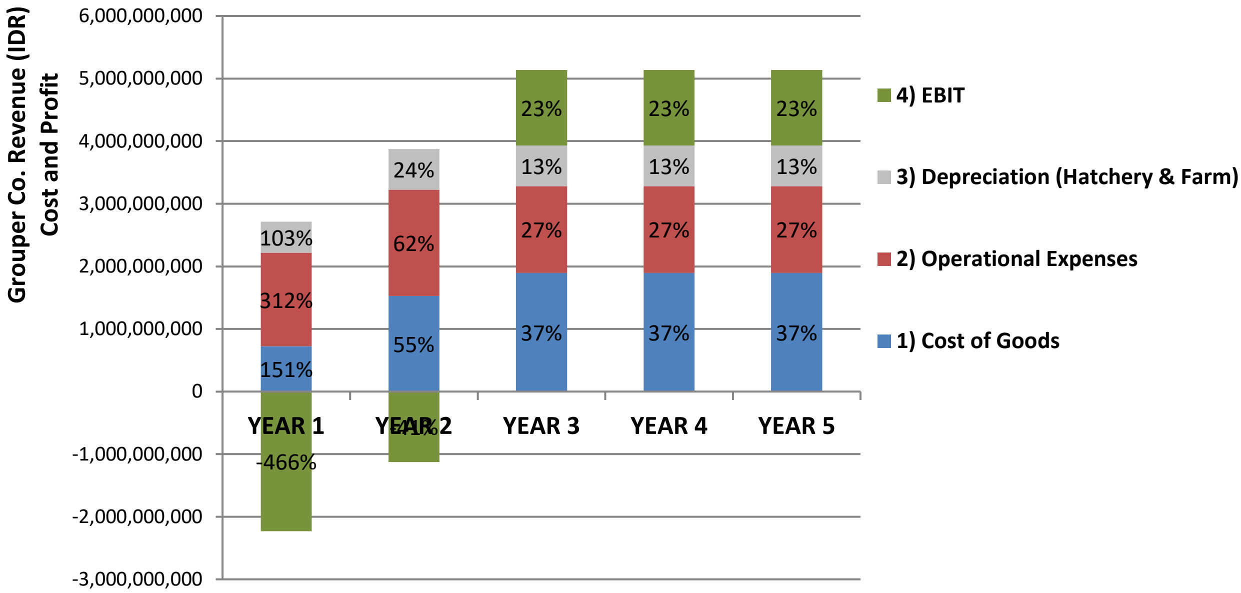


Figure 16: Projection of combined EBIT for the integrated hatchery and farm grow-out operation under scenario 1.

4.3 Investment Plan (CAPEX)

The following sections describe the CAPEX separately for hatchery and farm. Depreciation of each item is separately accounted for by taking its amortization time, i.e. the number of years until the item would have to be replaced, and depreciation is then based on the item value over the assumed amortization time, each year.

4.3.1 Hatchery

The total hatchery investment is projected at 2.2 billion IDR (171 kUSD, Fig. 17). The main costs are allocated to the hatchery building (67%), while the installations (i.e. tanks and piping systems for seawater and fresh water in the hatchery) can be constructed at relatively low costs (22%). Furthermore, generators, a pick-up truck, pumps and air blowers, represent 10% (machinery and vehicles).

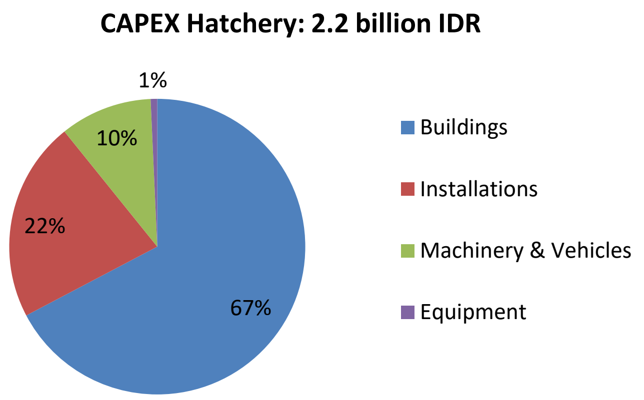


Figure 17: CAPEX for the hatchery.

4.3.2 Grow-out (scenario 1 or 2)

The total CAPEX investment under scenario 1 is 2.3 billion IDR (Fig. 18). The 30 t of groupers to be farmed require 240 grouper cages (installations). Since one cage costs approximately 4.5 million IDR including the mooring system with buoys and reeling, the total cost of farming cages come to 1.08 billion IDR, representing 55% of the total investment in the grow-out operation. Some extra cages are required for broodstock, grading and harvesting. A floating house of 50 million IDR is included for each of the 4 units. Two boats are needed to serve the 4 farming units of 60 cages each, preferably fiberglass boats with outboards at a cost of 130 million IDR per boat. The farm operation furthermore includes an onshore feed storage building, an area of offloading, and a pickup truck. The nets, counted as equipment, represent 30% of the investment cost. Each net costs about 1.8 million IDR and, for replacement of nets, it is required that another 1/3 the number of nets are available in addition to the nets in use. The 240 cages would thus require 320 nets for a total cost of 575 million IDR.

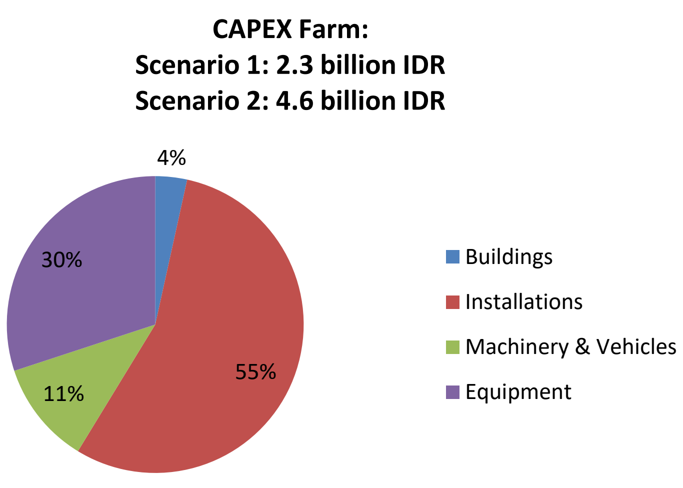


Figure 18: CAPEX for the farm under scenario 1. Under scenario 2 the CAPEX would double, while the relative contributions of the different cost positions would remain equal.

The CAPEX can also be considered for scenario 2 where 60 t of groupers are raised to marketable size. The CAPEX under scenario 2 would simply be double the investment in scenario 1, hence 4.6 billion IDR.

4.4 Working Capital and Cash Flow

Since the hatchery doesn't operate at its full capacity and generates more costs than revenue during the first year, and the farm doesn't work at its full scale until the third year, generating more costs than revenue during the first two years, the project has to dispose of some working capital to cover the negative account balance during the first two years (Table 12). The hatchery produces a loss of 83 million IDR during the first year and the farm a loss of 3.238 billion IDR during the first two years. Capital for the total loss of 3.322 billion IDR must be made available during this phase (Table 10).

		Year 1	Year 2	Year 3	Year 4	Year 5	Total
Account balance negative	Hatchery	-83'384'788					-83'384'788
	Farm	-2'148'471'305	-1'089'857'389				-3'238'328'693
	Total	*-2'231'856'093*	*-1'089'857'389*				***-3'321'713'482***
Account balance positive	Hatchery		76'944'342	196'944'342	196'944'342	196'944'342	590'833'025
	Farm			1'009'674'054	1'009'674'054	1'009'674'054	3'029'022'161
	Total			*1'206'618'395*	*1'206'618'395*	*1'206'618'395*	***3'619'855'186***

Table 12: Phases of positive and negative account balances during the first 5 years under scenario 1, separately for hatchery and farm.

The total capital requirement for scenario 1 would thus be 7.867 billion IDR, i.e. the hatchery CAPEX of 2.29 billion IDR, the farm CAPEX of 2.316 billion IDR, and the working capital of 3.321 billion. During years 3-5 the hatchery and farm then produce a positive income of 3.619 billion total during the years 3-5. This is, however, not even half of the required investment and hence, a 5-year time horizon is not enough to pay back the investment.

To pay back the investment, the project therefore must be considered over a longer time-span. After 10 years, for instance, the positive account balance would be 9.653 billion IDR, which would thus be enough to pay back the investment of 7.867 billion IDR. The full investment could be paid back after year 9 of the operation.

Under scenario 2, the situation would not be much different: under this scenario, the accumulated negative account balance would almost double, as a farm twice the size produces costs without sufficient revenue, but also the positive account balance would be almost twice as much each year from the third year onwards (Table 13). The total capital for scenario 2 would thus be 13.421 billion IDR, i.e. the hatchery CAPEX of 2.29 billion IDR, the farm CAPEX of 4.631 billion IDR, and the working capital of 6.560 billion. After 10 years, the project would have accumulated a positive account balance of 17.730 billion IDR, which would thus be sufficient to pay back the total investment of 13.421 billion IDR (likewise, the investment could be paid back by year 9).

		Year 1	Year 2	Year 3	Year 4	Year 5	Total
Account balance negative	Hatchery	-83'384'788					-83'384'788
	Farm	-4'296'942'609	-2'179'714'778				-6'476'657'387
	Total	*-4'380'327'398*	*-2'179'714'778*				***-6'560'042'175***
Account balance positive	Hatchery		76'944'342	196'944'342	196'944'342	196'944'342	590'833'025
	Farm			2'019'348'108	2'019'348'108	2'019'348'108	6'058'044'323
	Total			*2'216'292'449*	*2'216'292'449*	*2'216'292'449*	***6'648'877'348***

Table 13: Phases of positive and negative account balances during the first 5 years under scenario 2, separately for hatchery and farm.

5 Expected Impacts and Benefits

5.1 Impact on wild grouper stocks

The problem of grouper overfishing could be solved through grouper farming – if the grouper fishers convert to grouper farmers (see section 7). If fishers households generate income through farming groupers and the local market can be saturated by the supply of farmed grouper, there will be less demand and pressure on the fishermen to fish, and hence less fishing pressure on wild grouper stocks. With a significant effect on fishing pressure, the overfished grouper stocks would be allowed to recover, the age and size distribution would shift towards higher ages and larger sizes, and grouper fishing would become more efficient and profitable due to higher numbers and larger average sizes.

5.2 Impact on community

As fishing pressure on wild stocks decreases (see above) and wild populations recover, fishing can again become a more profitable activity. This should, however, be accompanied by a more stringent fishing documentation and monitoring program, as there is a chance that as fishing becomes more attractive, more people would engage in fishing, leading again to a depletion of stocks.

The project would also establish a successful business in the community as a model case for future entrepreneurs, giving full employment for 41 (scenario 1) to 74 (scenario 2) people. Under scenario 1, there is the potential that independent farmers are offered an alternative livelihood through grouper farming, which would provide a more regular income for households than the current fishing activity.

5.3 Socio-economic impact for fishermen turned grouper farmers

If fishermen or other community members convert to farmers, their success will depend on their organization and the size of the farm. If an independent farmer can handle an entire unit of 60 cages with 8 employees, according to the setup of the integrated grow-out operation, the farm unit would produce 7.5 t of marketable size grouper per year, resulting in a revenue of 1.125 billion IDR. With the projected profitability of the farming operation of 22% (see Fig. 14), the farmer's income would be 252 million IDR per year or 21 million IDR per month, which is a high salary for a community member on Selayar island.

6 Project Implementation

The project must be implemented by a supervising entity to assure that the production runs according to the plan and the investment is paid back to the investor. One year (year 0) would be required for preparation to set up the Kerupa Co., to select the site and to have legal agreements with the local government. In the same year, the hatchery and the farm units must be purchased and built up (Fig. 19). In year 1, implementation starts, the first fry is produced, and the first farm units are stocked with groupers during the second semester. During year 2, once the integrated farm is fully operational, independent farmers could be trained and built up (Fig. 19). From then onwards, the integrated hatchery and farm operation, as well as the grow-out by independent farmers in the area run in parallel, while the independent farmers might collaborate with the Kerupa Co. on the sales of marketable size groupers.

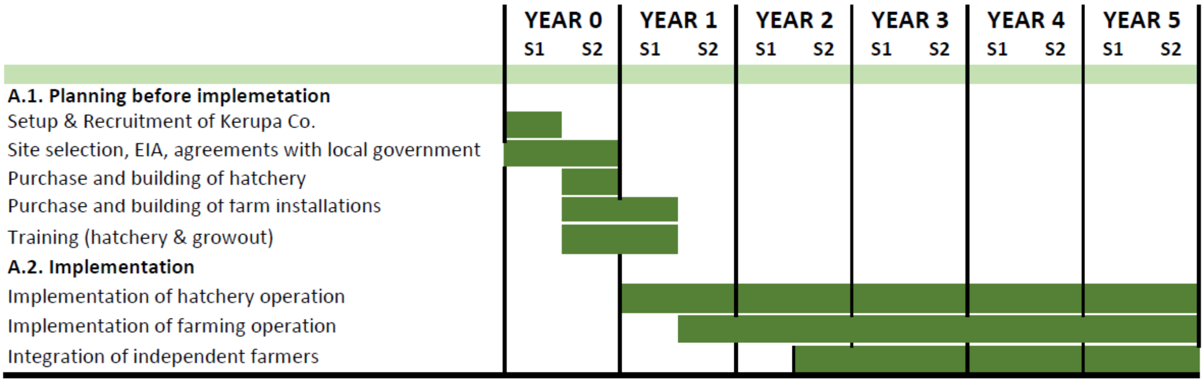


Figure 19: Overview of project timeline with a year of preparation and 5 years of implementation.

7 Risks and mitigation

7.1 Risks

The main risk is that the hatchery and the farm units are not professionally managed. The project will only be successful if the hatchery produces disease-free fingerlings. For this, it needs disease-free broodstock. Furthermore it has to apply best hygienic practices and react immediately if there are signs of disease. Experience in Indonesia has shown that hatchery-reared fingerlings are almost never disease-free and therefore the survival in grow-outs is low (Rob Garrison, *pers. comm.*). Also, the grow-out has to be conducted in an efficient fashion, fish must be size-sorted every few weeks, the farm must track number and biomass by cage to feed according to the plan, the right feed must be sourced and the nets must be replaced every 2 weeks. All these tasks require knowledge that currently nobody has on Selayar Island. The risk of inefficient implementation is thus mainly a management risk, or in other words, recruitment to find competent people for the projected salaries to efficiently implement the plan. There is further risk related to delivery of efficient training and monitoring.

For scenario 1, there is a risk that few or no independent farmers in the area will be interested to buy the 53'000 hatchery-reared fingerlings, for instance, because they don't trust the hatchery-reared fingerlings and believe that wild fish is healthier and will survive better. Since hatcheries in Indonesia are usually not disease-free, this might actually be true and the belief is simply based on negative experiences in the past where they've lost almost entire batches of hatchery-sourced fingerlings. The trust in hatchery-reared fingerlings can only be established by producing disease-free fingerlings and demonstrating in the integrated grow-out operation that the system actually works. Hence, producing disease-free fingerlings is of high importance from an impact perspective. If independent farmers in the area can be convinced to buy the hatchery-reared fingerlings in due time, i.e. after the integrated grow-out has been fully stocked, there might be a risk of selling the 5 inch (15 g) fingerlings elsewhere on the Indonesian market. Currently, the usual practice is for the hatchery to sell fingerlings of 5 cm and not 10 cm and more. We have opted for a transition from hatchery to farm here to assure even higher survival for the farmers, and this argument should be valid for any other farmer, but it is just not common practice. Hence, it will be a matter of successful marketing to sell the 5 inch fingerlings.

The impact is optimal if fishermen stop fishing and start farming instead – this is, however, a problematic assumption. Many project proposals have played with this idea to convert fishermen into farmers, but successful examples where fishermen actually become farmers are rare. Fishermen and farmers have different mindsets: a fisherman is a hunter without much daily or weekly structure, going to hunt when needed and then spending the resulting revenue until it is needed again; a farmer, in contrast, is of a character that plans ahead over the long term and lives his daily, weekly and monthly structure according to his plan. Changing people's mindsets is difficult, and it might, therefore, be deemed naïve to believe that the fishermen would suddenly change their mindset and become farmers. Furthermore, if the fishers continue fishing, their produce will compete with the farm output and have an impact on local pricing. Nevertheless, there is a chance that a grouper farm can relax fishing pressure on groupers. Communities are organized in households, and as long as a part of the household has a more stable and better income through farming, there is less pressure on fishers belonging to the same household to generate income through fishing. Furthermore, if the local market demand for groupers gets covered by farmed groupers, the demand for fished grouper will decrease.

If the fishing pressure decreases and stocks are allowed to recover, it will be more interesting to fish again, because there will be more groupers at larger sizes. There is thus a risk, that at this point too many people engage in fishing again and increase fishing pressure beyond the sustainable threshold. Furthermore, it won't be known what the sustainable threshold is if fishing catch and landing are not collected reliably.

7.2 Mitigation and Risk management

The best mitigation against inefficient practices in hatchery and farm operations is to have a stringent management and supervision system. First of all, the recruitment of competent managers of the hatchery and farm is crucial. Furthermore, the managers must be assisted by international experts. If it is not possible to recruit competent people at the projected salaries, the salary of the managers might have to be increased.

For the hatchery, it is most crucial to produce disease-free fingerlings, and for this the sourcing of broodstock and best practices in the hatchery are relevant. As a matter of risk avoidance, for instance, the hatchery water should be treated, which is not common practice in Indonesia. The incubation tanks for larvae feed should be separated to avoid contamination, which is currently also not common practice. And furthermore, best hygienic practices must be applied to avoid contamination anywhere in the hatchery. For all of these tasks, a strong health and disease team is necessary. This team shall be monitored, supported and supervised by international experts.

The plan to raise the fingerlings to 5 inches (15 g) can also already be considered a risk mitigation measure. The highest mortality risk is always in the first few weeks including the transition, which causes stress for the small fish. The more this risk is assumed on the hatchery side, the less it will have to be carried by the grow-out operation. If the fish make it to 5 inches in the hatchery, there is a good chance that they are fit to survive the rest of the grow-out and at the transition they are already at a size that can tolerate more stress, and the mortality risk during grow-out is significantly reduced by the lower mortality rate at a larger size and the reduced grow-out time.

Furthermore, the integrated grow-out and the option to increase the grow-out in the direction of scenario 2 is a further measure to mitigate against the risk that the fingerlings are not efficiently grown out by independent farmers, or that independent farmers are not interested to buy the hatchery-reared fingerlings. If it becomes obvious that the fingerlings are not raised efficiently by independent farmers, generating more losses than profits, or that independent farmers are not interested to collaborate, it is recommended to switch towards scenario 2. This would mean that more cages are purchased in the second and third year and that more people are trained and employed in the grow-out. At a later stage, these additional cages could then still be provided and operated by independent farmers, once these farmers have built up the corresponding knowledge, skills and motivation.

The impact of reducing fishing pressure can only be recognized if fisheries are effectively monitored. Monitoring will also be important to recognize a sudden increase in fishing effort, once stocks have recovered and fishing becomes more interesting again. To capture these effects, it is recommended that a consistent fishing monitoring system is built up, documenting on one side the catches, and on the other the fishing efforts (e.g. number of vessels, fishermen, and days at sea). Currently, catches are estimated by interviewing a few fishermen (probably <2% of the total population of fishermen) every 3 months, and then by extrapolating the findings from the interviews to the entire fleet and to the whole year. It is obvious that reliable estimates cannot be obtained with this method and that much more effort would be needed to estimate catches and fishing effort representatively. For instance, it would be necessary to register and license vessels and estimate the number of days at sea of each of these. Furthermore, catch estimates should be based on effectively measured weights by species at landing, and the data should be collected on a daily basis in certain landing stations. The information from landing stations could then still be extrapolated to other parts of the fleet, if there is reason to assume that others behave similarly. These efforts would obviously require funding, which is not represented in this business proposal. Ideally, the implementation of this proposal would run in parallel with a grant application for implementing a fisheries monitoring system that reliably documents catches and fishing efforts.

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9 Annex

9.1 Documents

N°	Document Name	Details
1	Grouper Farm Selayar – 5 year plan	Assumptions on biology, hatchery and farm setup and financial projections

9.2 Representative grouper species: commercial relevance, life history and stock status

This section provides an overview of some representative grouper species that might be encountered in literature or in catch report (Fig. 20). The description gives a quick review of life history, stock status and fisheries. The selection species only provides a small snapshot of the family of Epinephelinae, but gives an idea on the diversity of this family and generally critical stock status of groupers and critical fishing practices targeting these species. For the sake of illustration, the description of the leopard grouper, humpback grouper, and the two proposed farming species, green and tiger grouper, which were given in the main text, are partly repeated here.

The coral groupers are sought by fishermen due to their high market value, their most famous representative being the leopard coral grouper, *Plectropomus leopardus*, in local markets often referred to as suno grouper or coral trout. Landings of *P. leopardus* are generally in decline, implying that populations may be decreasing1. This trend observed in the Philippines and Indonesia may be due to the lack of management and the fact that that juveniles are now caught and grown out; where heavily taken, the capture of *P. leopardus* is considered to be unsustainable (Padilla et al. 2003). Leopard coral grouper is currently classified as Near Threatened (NT), but due to the declining trend of populations it will likely be reclassified as Vulnerable (VU) with more data. Estimates for average size at first reproduction of the fish ranges from 20–25 cm Fork Length (FL, Samoilys 2000) to 32–36 cm FL depending on differing histological criteria (Ferreira 1995), at an age of 2-4 years. Growth reaches a maximum age and size of around 20 years and 20 kg, respectively[6]. Spawning aggregations occur around new moon (Samoilys 1997) or the full moon, depending on location. In some areas in the Philippines, the species forms a single species fishery for the live reef fish export market. Catch and export figures reveal a fishery that was once large but has declined rapidly (43% over four years): average fish size has declined, catch rates appear low, and mortality estimates are high (Padilla et al. 2003). Conservation action is mainly taken in the Great Barrier Reef, wherethe minimum legal size limit of 38 cm TL is implemented (QFMA 2003) to prevent recruitment overfishing.

P. leopardus might be confused with *P. maculatus* or *Plectropomus oligacanthus* (Fig. 3), but also the roving (*P. pessuliferus*) or the sixbar grouper (*Epinephelus sexfasciatus*) have similar appearances, though they might be less common. These species might consequently also be marketed as suno groupers. *P. maculatus* is heavily fished in the Southeast Asian part of its range, but there is very little information, and overall, the global population is unlikely to be declining at a rate close to 30%. Therefore, the species is currently listed as Least Concern (LC). *Plectropomus oligacanthus* on the other hand is listed as Near Threatened because throughout its range it is overfished for subsistence and for export in the Live Reef Fish Trade1. It occurs in low numbers in the wild and is susceptible to degradation of shallow coral reefs (primary habitat) and is probably in decline close to 30%. When more data become available, it may be proven to be a threatened species. *Plectropomus oligacanthus* is rare in most areas, but is well known in the Philippines.

[6] http://www.fishbase.org

The squaretail Coral grouper *Plectropomus areolatus* is not red but possibly the most abundant *Plectropomus* species in the central Western Pacific (Fig. 3). Although this species has a wide range, it is heavily fished and is hence declining at a rate of at least 30% over the last 20 to 30 years, and this decline in the number of mature individuals is predicted to continue in the future1. There have been severe declines regionally, probably due in part to targeting spawning aggregations by local and foreign commercial fishers and the species being highly valued in the international live reef fish trade centred in Hong Kong (Sadovy et al. 2003). During the 5-year monitoring program (1995-2000) at two sites within a national park, mean size declined by 8 cm, with heavy fishing continuing even following protection of the sites in 2001 (Pet et al. 2005); fish numbers at aggregations were low, less than 100 per aggregation site and period.

The blacksaddled *Plectropomus laevis* is another illustrious representative of s (Fig. 3). Although this species is widespread, it is listed as Vulnerable (VU) because of its natural rarity, the heavy fishing pressure being experienced throughout its range, particularly the targeting of juveniles, and because it has shown declines in abundance of at least 30% (mature individuals). The primary issue with *P. laevis* is the rarity of this large roving serranid over most of its range. *P. laevis* is exploited over much of its range through line fisheries and is an important part of the live reef food fish trade. Catch records are difficult to interpret as several species may be aggregated under the term "coral trout" or "leopard grouper". *P. laevis* appears to be a relatively fast-growing species and reaches 50 cm in less than four years; females achieve maturity in under three years (Davies et al. 2006). *P. laevis* attains 100 cm SL (about 125 cm TL) and a weight of 18 kg.

Humpback grouper *Cromileptis altivelis*, also called mouse grouper, is probably the highest value grouper species, reaching prices of 40-60 USD/kg, even on local markets (see Fig. 3). Due to its high market value this species is heavily exploited, while at the same time its habitat is being degraded, leading to classification of Vulnerable (VU). *C. altivelis* is thought to be at risk in many areas, but this species can be hatchery-raised (Sadovy et al. 2003). However, slow growth rates mean that hatchery-produced fish are used for the aquarium trade and not the live reef food fish trade. Therefore, hatchery production is not thought to relieve fishing pressure on wild populations. Humpback groupers are among the more important (by volume) species imported into the major live food fish centre (Hong Kong) and come principally from Indonesia, China and the Philippines. Humpback Grouper has been successfully produced from three Fisheries Marine Culture Research Centres in Gondol (Bali), Situbondo and Tanjung Putus (Lampung) in Indonesia. In 2003, 2 government, 7 commercial and more than 100 farmer backyard hatcheries were actively producing juveniles (Sugama et al. 2003). Hatchery-produced fish are used exclusively for the grow-out industry and aquarium trade. *Cromileptes altivelis* is a protogynous hermaphrodite and matures at 40 cm TL, while maximum size might be around 70cm, but at maturation or maximum age are not known[7]. Spawning aggregations are not known, although spawning activities were observed in captivity.

The malabar grouper *E. malabaricus* is often reported in catch statistics (see Fig. 3) and is targeted at all life history stages throughout its range, including for the live reef food fish trade, and it is undoubtedly heavily fished and probably overfished in some countries. It is therefore classified as Near Threatened (NT). Available information from New Caledonia and from the fry fisheries in the Philippines demonstrate that fishing can greatly reduce populations. This is not surprising as this animal shows characteristics of large maximum size and late age of sexual maturity, at least in males, which probably equates to > 5yrs, sex change, and correspondingly low resilience to fishing (see under Habitat and Ecology). Fry/fingerlings of *E. malabaricus* are caught from the wild for mariculture in Indonesia, Malaysia, Thailand, Vietnam, the Philippines, Sri Lanka and China. *E. malabaricus* is the most commonly taken species after *E. coioides* in many areas. Small individuals of both of these species are primarily taken from brackish water or mangroves (Sadovy 2000). There has been taxonomic confusion and misidentification with *E. coioides*, *E. tauvina* and *E. malabaricus* at least in Australia

[7] http://www.fishbase.org/summary/6457

and probably elsewhere, and it may take some time to sort out the correct information for *E. malabaricus*. There is a lack of confidence that all the information currently available applies to *malabaricus*.

The duskytail grouper (*Epinephelus bleekeri)* is another often-mentioned widespread species (Fig. 3), locally abundant in some areas. It is highly sought after as fully grown adults for food and as fingerlings/juveniles for grow-out, and unrestricted exploitation has led to widespread local declines in the availability of fingerlings/juveniles for grow-out, leading to a classification as Near Threatened (NT). In southern China, fingerlings were nearly extirpated in 2'000 (Sadovy 2000). Within the live reef food fish trade, there is a capture fishery of wild caught fingerlings and juveniles (fingerlings, hereafter) for grow-out in sea cages and pens. Juveniles are commonly taken in estuaries in the Philippines (Padilla et al. 2003) and Thailand, Malaysia, southern China, Vietnam and Indonesia. Fingerlings are either locally grown out or sold to Taiwan or Hong Kong (Sadovy 2000). These numbers can be substantial. For example, in one year, 10 million fry were exported from Thailand to Hong Kong (Sadovy 2000). These fingerlings are grown out in open sea cages and large pens in Malaysia. *Epinephelus bleekeri* was widely cultured in Hong Kong in the early 1990s when green groupers experienced disease problems that could not be overcome. *Epinephelus bleekeri* was not affected by the same disease, so fish farmers gave up farming green grouper and changed to this species. *Epinephelus bleekeri* adapted very well to the new environment but grew much slower than green groupers. Disease problems with *Epinephelus bleekeri* began about three years ago. The diseased fish would consume excessive food one day, then stop feeding the following day. By then an infection was noticeable on the fish's body. Its condition would worsen very quickly and within three days most of the fish would die. Treatments with antibiotics, freshwater bath, malachite green, methylene blue and formalin have had no success with this problem. The situation was uncontrollable in 2001 with an almost 95% mortality rate for imported *Epinephelus bleekeri*. Researchers found that the disease was caused by a new vibrio (SPC Live Reef Fish Information Bulletin #9).

Camouflage grouper *E. polyphekadion* is one of the most commonly consumed live reef food fish in Hong Kong, while the main countries of origin are the Philippines and Indonesia (see Fig. 3). Although *E. polyphekadion* is widely distributed, it may be particularly susceptible to overfishing, especially spearfishing, as it is easy to approach underwater. Also, it is easy to target in its spawning aggregations, which are particularly easy to find in their outer reef channel pass habitat. Declines from aggregation-fishing have been reported in fisher interviews from a range of countries. Habitat degradation of coral reefs also has the potential to affect its numbers and a high proportion of coral reefs have been degraded in a significant part of its range in SE Asia. On the other hand, it remains one of the more common species of live fish imported into the Hong Kong restaurant market, although the ever shifting sources of these fish could obscure any localized depletions (Sadovy et al. 2003). Of the eight spawning aggregations identified during fishery surveys by the Society for the Conservation of Reef Fish Aggregations (SCRFA), one is stable and the rest are in decline according to falling Catch Per Unit Effort (CPUE, ee SCRFA database on www.scrfa.org). The first maturity might occur after 58cm and common length is 90cm. Age at maturation or maximum age are not known[8].

Greasy grouper (*E. tauvina*), Honeycomb grouper (*E. merra*), Areolate grouper (*E. areolatus*), and Highfin grouper (*E. maculatus*) are also often mentioned in catch statistics. However, due their similar phenotypic appearance (see Fig. 3), taxonomic confusion between these species is very likely, including also duskytail grouper *E. bleekeri*, malabar grouper *E. malabaricus* and orange-spotted or green grouper *E. coioides*.

Giant grouper *E. lanceolatus* is the largest grouper species with a common size of around 1m TL. Since mature size is thought to be approximately 129 cm and max size is 270 cm, this means that all smaller individuals and

[8] http://www.fishbase.org/summary/6473

maybe some larger individuals are consumed before they reach sexual maturity. It rarely reaches its final weight of about 400 kg[9].

Leopard (*Plectropomus leopardus*) - NT

Humpback grouper (*Cromileptes altivelis*) - VU

Spotted (*Plectropomus maculatus*) - LC

Highfin (*Plectropomus oligacanthus*) – NT

Blacksaddled (*Plectropomus laevis*) – VU

Squaretail (Plectropomus areolatus) - VU

Camouflage grouper (Epinephelus polyphekadion) - NT

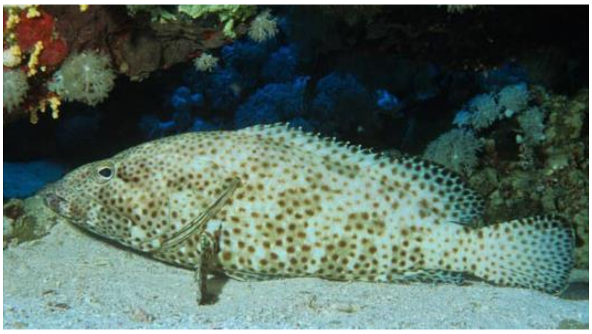
Malabar grouper (*Epinephelus malabaricus*) - NT

Figure 20: Some representatives of the subfamily of Epinephelinae (groupers) with corresponding IUCN status

[9] http://www.fishbase.org/summary/6468

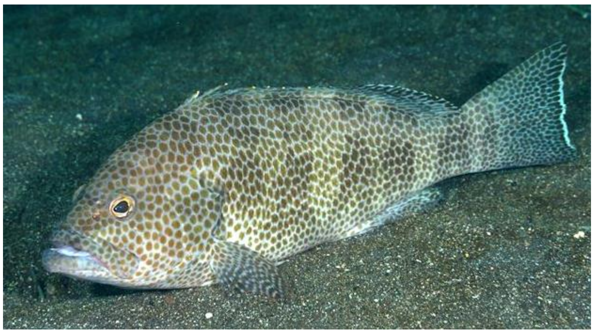
Duskytail grouper (*Epinephelus bleekeri*) - NT

Greasy grouper (*Epinephelus tauvina*) - DD



Honeycomb grouper (*Epinephelus merra*) - LC

Areolate grouper (*Epinephelus areolatus*) - LC

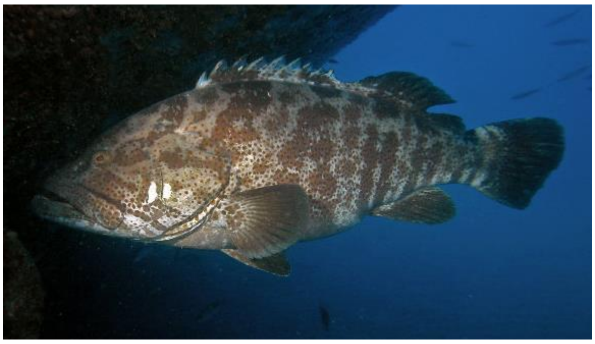


Highfin grouper (*Epinephelus maculatus*) - LC

Giant grouper (*Epinephelus lanceolatus*) – VU

Orange-spotted Grouper OR Green Grouper

(*Epinephelus coioides*) - NT



Brown-marbled grouper OR Tiger grouper

(*Epinephelus fuscoguttatus*) – NT

Figure 20 cont.: Some representatives of the subfamily of Epinephelinae (groupers) with corresponding IUCN status

Orange-spotted Grouper (*Epinephelus coioides*), also called green grouper, is one of the most common groupers taken by fisheries. The Orange-spotted Grouper is unlikely to become extinct as hatcheries in several countries are now able to produce fry from captive brood stock. However, there is only a limited supply of grouper seed for mariculture, and much current grouper mariculture is still based on the supply of wild-caught grouper seed (Sadovy 2000). This reliance on wild caught seed may remove groupers that might otherwise reproduce and supplement the wild stock (Sadovy 2000). Given that *E. coioides* adults are widely targeted across its global range for food, and as juveniles in SE Asia for mariculture, it is unlikely that such heavy harvest on this grouper is sustainable in long term and wild populations of this grouper are likely being depleted. *Epinephelus coioides* is assessed as being Near Threatened because the overall decline of imports of plate-sized fish from SE Asia into Hong Kong (a major import centre for live fish), extensive take of juveniles for international juvenile trade for mariculture grow-out, which is completely unregulated and documented, and large losses in mangroves in some of the largest countries in SE Asia, key habitat for young *E. coioides*. This species also forms spawning aggregations (at least in some regions), and shows long life (maximum recorded 22 years, FishBase 2003), factors which are likely to increase its vulnerability as a result of overexploitation. Females are mature at 25–30 cm total length (2–4 years old), sexual transition occurs at a length of 55–75 cm, and maximum observed size was 1.2 m[10].

Brown-marbled grouper (*Epinephelus fuscoguttatus*), also called tiger grouper, is inherently vulnerable to fishing and heavily sought after for the live reef food fish trade. It can be cultured by hatcheries, but is still extensively taken from the wild (and marketed as adults or large juveniles or removed from the wild as small juveniles and grown out to market size in captivity) including from spawning aggregations in many cases. *E. fuscoguttatus* is reef-associated and occurs in depth ranges of 1-60 m. Little is known on the status of wild stocks, but it is assigned Vulnerable (VU) due to its inherent vulnerability to fishing, being a large species that aggregates to spawn. In Komodo Marine Park, Indonesia, spawning aggregation protected zones with seasonal closure were recommended for traditional use zones (Reef fish spawning aggregations working group, 2002). In Palau, sampled mature males ranged in size from 698–870 mm total length, mature females from 420 to 850 mm (Johannes et al. 1999). In general terms, *E. fuscoguttatus* matures at a size of around 50 and grows to a maximum size of 1.2 m and might have a lifespan of about 40 years[11].

9.3 Shrimp farming on Selayar Island

Aside from unorganized and occasional grouper farming, shrimp farming is a model that currently seems to work on Selayar. According to the Ministry of Maritime Affairs and Fisheries (MMAF), there are 810 shrimp farmers and around 1600 ponds on Selayar island. The ponds usually have a size of 0.5 ha and a farmer might operate 1-10 ponds, on average around two. The cultured species are whiteleg shrimp (*Litopenaeus vannamei*) and black tiger shrimp (*Penaeus monodon*), although the majority nowadays work with *L. vannamei*.There is an ongoing tendency to switch from *P. monodon* to *L. Vannamei* due to the recently experienced white-spot disease in *P. monodon*, and probably also due to the longer farming cycle of *P. monodon*. The cycle of *L. vannamei* is 2.5-3 months, hence 3-4 cycles per year are possible (with two weeks of cleaning and preparation of ponds in between). The cycle of *P. monodon* is 4-6 months, hence only 2 farming cycles per year are possible. The production for *L. Vannamei* increased from 153 t in 2014 to 264 t in 2015 (according to MMAF data), while the production of *P. monodon* decreased from 80t in 2014 to 56 t in 2015. The majority (80%) use an intensive farming model with high stocking densities of around 70 Post-Larvae (PL) per m^2. The rest mainly do extensive farming and some try even more intensive approaches (with 50% higher stocking densities). On Selayar, the approach 70 PL per m^2 is called "semi-intensive", but semi-intensive is internationally understood to correspond to stocking densities of 15-25 PL/m^2.

[10] http://www.fishbase.org/summary/6465
[11] http://www.fishbase.org/summary/Epinephelus-fuscoguttatus.html

The PL for *L. vannamei* are bought from a shrimp hatchery based in Makassar at a cost of 55 IDR/PL and are usually stocked at intensive densities of 350'000 pieces per pond or 700'000 pcs per ha (70 PL/m²). During low tide the water is actively pumped into the ponds, another pump is used for aeration, both maintained by generators. The generators consume a fuel volume of 4'000 l/ha per farming cycle at a cost of 6'500 IDR/l (1.3 million IDR for a drum of 200 l). The 700'000 shrimp will consume 12 t of feed at a cost of 16'800 IDR/kg (420'000 IDR per sack of 25kg), and in addition a few kg of supplements are used. The farmer employs 3 people for farming during the three months at 1 million IDR/month, and depending on how it goes these will receive a bonus of up to 15 million IDR each. Furthermore, 10 people are employed for the cleaning during 2 weeks, which each receive one million IDR. The revenue then mainly depends on the mortality and growth of the shrimp, as the different size classes result in different pricing per kg.

According to the farmers a hectare can produce 7-11 t of shrimps with 2-4 t in the size class 30-50 pcs/kg, 4-5 t of the size class 50-70 pcs/kg and 1-2 t shrimps in the size class 70+ pcs/kg, and the production would thus result in a net profitability of 30-40%. These assumptions are however a bit optimistic and would imply a survival ratio of 70% and an eFCR of 1.3, while for such small-scale intense production systems typical survival ratios are in the range of 50-60% and eFCR in 1.5-1.6. Furthermore, shrimp farming usually experiences a complete breakdown every 3 years. This might therefore rather represent a best case scenario and we have assumed an output 7.5 t/ha resulting in the expected survival ratio and eFCR (Table 14). With the given assumptions this scenario results in an EBITDA of roughtly 20%, which can still be considered optimistic as an average, since it doesn't account for the regular breakdowns.

REVENUE	**Value [IDR]**	**Unit**	**Amount**	**Revenue [IDR]**	**[%] of Revenue**
30-50 pcs/kg	70'000	kg	2'500	175'000'000	42%
50-70 pcs/kg	50'000	kg	4'000	200'000'000	48%
70 + pcs/kg	42'000	kg	1'000	42'000'000	10%
Total			**7'500**	**506'000'000**	**100%**
COST OF GOODS	**Cost [IDR]**	**Unit**	**Amount**	**Cost [IDR]**	**[%] of Revenue**
Post-larvae (PL)	55	pc	700'000	38'500'000	9%
Fuel	6'500	l	4'000	26'000'000	6%
Feed (pellets)	16'800	kg	12'000	201'600'000	48%
Feed (supplements)	350'000	kg	24	8'400'000	2%
Total				**274'500'000**	**66%**
GROSS MARGIN				**142'500'000**	**34%**
OPERATIONAL EXPENSURE	**Cost [IDR]**	**Unit**	**Amount**	**Cost [IDR]**	**[%] of Revenue**
Labour (farming)	1'000'000	personmonth	9	9'000'000	2%
Bonus	15'000'000	person	3	45'000'000	11%
Labour (cleaning)	1'000'000	person	10	10'000'000	2%
Total				**64'000'000**	**15%**
EBITDA				**EBITDA [IDR]**	**[%] of Revenue**
				78'500'000	**19%**

Table 14: Revenue, cost of goods, operational expenditures and resulting profitability of a semi-intensive *L. vannamei* farm on Selayar island.

Shrimp farming is boom and bust, as long as it works well, profitability can also be 30-40%, as indicated by the farmer, for successful batches. At breakdown, however, nothing works anymore. In any case, shrimp farming seems a convenient short term activity to generate decent incomes but it seems to be a workable alternative to generate decent incomes. Hence, any alternative livelihood would have to be able to compete with the option of shrimp farming.

9.4 Growth and FCR fitting

Growth of green and tiger grouper were fitted to the anecdotal age and size information as described in the text using the model in eq.2 by non-linear least squares in R (Fig. 21):

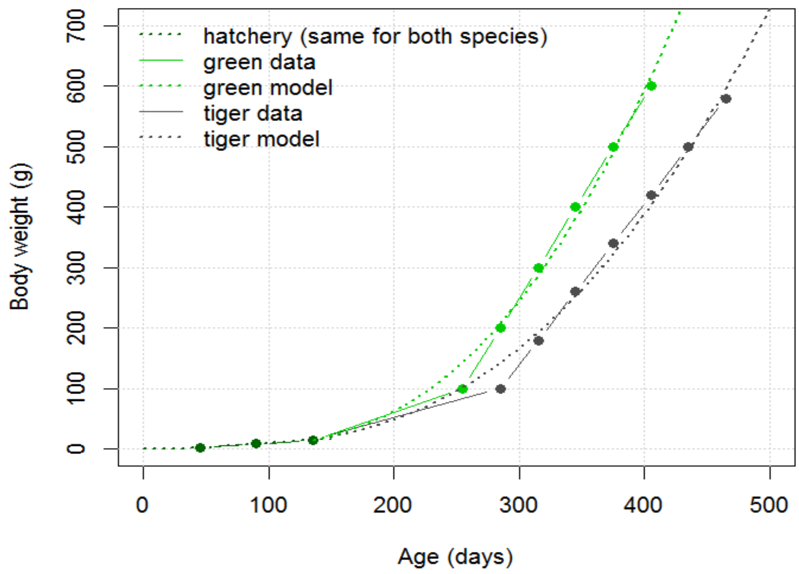


Figure 21: Assumed data points and growth model fit to green and tiger grouper size at age.

The energy necessary to be acquired as a function of size and time can also be derived from the energy allocation model in terms of energy, obtained by integration of $aw^{3/4}$:

$$\int_{w(t)}^{w(t+1)} aw^{3/4}\partial t = \frac{4a}{3b}\left[w(t)^{3/4} - w(t+1)^{3/4}\right] - \frac{2a^2}{b^2}\left[w(t)^{1/2} - w(t+1)^{1/2}\right] + \frac{4a^3}{b^3}\left[w(t)^{1/4} - w(t+1)^{1/4}\right] + \frac{4a^4}{b^4}\log\left[\frac{a - bw(t)^{1/4}}{a - bw(t+1)^{1/4}}\right]$$

Given the energy density of somatic tissue of groupers and the energy density of the feed this can be converted in amount of feed by individual required for any time interval. Furthermore, it should be considered what part of the feed offered is actually ingested by the fish and what part of the ingested feed is actually assimilated into somatic tissue. For simplicity, we have applied a constant proportionality factor to the above function and adjusted its value to the eFCR that could be expected from practical experience.

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