

Management of the Grouper Export Trade in Indonesia

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ABSTRACT

Indonesia is one of the largest exporters of groupers, both live and dead, as part of the reef fish food trade. These fisheries sub-sector plays an important role in the livelihoods of fishing communities, especially for those living on small islands. The aim of this article is to provide a baseline profile of the trade as currently practiced and develop a framework strategy for establishing a sustainable grouper export trade for Indonesia. Challenges faced in managing the country's (both live and dead) grouper fishery and trade include the overfishing of groupers, catch of sexually immature groupers, exploitation of grouper spawning aggregation, illegal and unreported fishing for live groupers and overall lack of management or monitoring of grouper fisheries. These factors, collectively, have resulted in declining wild grouper stocks. Management and export trade of these fisheries requires regular and standardized monitoring, management and trade controls. Control on minimum size, fishing quotas and improved spawning aggregation protection to ensure sustainability are needed in addition to oversight of vessel activity to control the trade, especially exports. To maintain viable stocks, it is essential to safeguard adequate spawning capacity and reduce the illegal fishing methods (particularly potassium cyanide and compressor diving). In particular, it is important to ensure that sufficient fish become sexually mature and that sufficient adults are able to breed, particularly those that depend on aggregating to spawn because they are easy to over-fish in such time, requiring their seasonal and/or spatial protection from fishing. Since the grouper fisheries are particularly heavily driven by export markets, regulating volumes and sizes exported, especially oversight of at-sea and air cargo exports is needed. Immediate measures are essential to stop further declines and begin to rebuild grouper stocks in Indonesia.

KEYWORDS



Overfishing; management measure; grouper stock; spawning aggregation

Introduction

Indonesia is a major producer of reef fish traded as food, especially groupers (Muldoon et al., 2016). According to FAO data for the period 2011–2015, Indonesia contributed 26.5% of the world grouper catch (Amorim and Westmeyer, 2015). This grouper fishery is important and highly profitable, with benefit cost (B/C) ratios as high as 1.25 and payback periods of less than a year (Afero et al., 2010). Groupers are caught for both export and local consumption and marketed live and dead (chilled/fresh/frozen).

While the fisheries for both live and dead groupers clearly need management, due to uncontrolled fishing pressure, if they are to be biologically sustainable in the long term, there are specific problems associated with the live grouper export trade in particular. These range from damaging fishing practices to high fishing pressure for plate-sized fish which are particularly

sought after for the restaurant trade supplied by this sector. For example, in order to catch live groupers, many fishers engage in poison fishing, mostly using potassium cyanide, to catch fish more easily (Cesar et al., 1997). Because the poison is very efficient, it can lead to overfishing as well as cause substantial damage to corals and other animals in the reef ecosystem especially if used repeatedly (Erdmann and Pet-Soede, 1997; Muallil et al., 2014; Pet-Soede, 2000). Furthermore, a premium price paid for "plate sized" live fish (Muldoon et al., 2016) for the restaurant trade often drives fishers to target quite small, often immature, either because the juveniles are plate-sized or because juveniles are caught and then grown out and marketed at 'plate size'. Moreover, many groupers are protogynous hermaphrodites, with larger (older) dominant individuals undergoing sex change from female to male (Sadovy de Mitcheson, 2016) and the

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majority of fish being caught while still in smaller, female size range. This can result in reduced male availability (too few females survive to change to males), influence spawning, or otherwise negatively affect reproductive capacity (Kindsvater et al., 2017).

Some species are mainly targeted during their spawning aggregations, when they are easier to catch or particularly predictable spatially and temporally to locate. If these aggregations are regularly targeted without controls on fishing effort reproduction could be compromised (Sadovy de Mitcheson, 2016). Hence, the spawning times and places for groupers need to be adequately protected to ensure that adults reproduce and produce the young needed to sustain the next generation of fish.

While the aquaculture sector for groupers in Indonesia (i.e. hatchery produced groupers) has had some success for several species, it is insufficient to satisfy the export demand for groupers and does not reduce fishing on wild groupers in general. This is partly because of insufficient mariculture production levels, low diversity of species produced at commercial levels, the on-going use of wild-caught juveniles (like hatchery produced juveniles of some species, these can have low survival rates) in grow-out operations, and consumer (especially in China) preference for wild-caught fish. These factors lead to a continued high dependency on wild-caught groupers (Kohno et al., 1997). Moreover, many fishers in coastal communities benefit directly from catching groupers (for both the live and dead grouper trades) which are important for their livelihoods and also contribute to national food security. Therefore, both means of grouper production, capture fisheries and aquaculture, are important to fulfill demand and maintain local livelihoods. In sum, increase in mariculture does not result in reduction in fishing effort and demand is so high that both are needed.

Without appropriate fisheries management and effective enforcement, Indonesia's grouper fisheries are not sustainable (Cochrane and Garcia, 2007) for several reasons. First, these species have naturally low productivity and cannot sustain heavy fisheries without management of fishing effort and ensuring sufficient levels of grouper reproduction. Second, destructive fishing methods, particularly potassium cyanide, cause damage to the coral reef habitat on which many groupers depend. Third, key life history events, as in the case of spawning aggregations, are easily compromised. Currently, the only Indonesian Government fishery regulation specifically addressing live reef food fisheries is that limiting the exploitation

trade of the Napoleon wrasse (*Cheilinus undulatus*, a non-grouper) (MMAF, 2013; Muldoon et al., 2016). Although there are controls on the registration and operations of domestic and foreign carrier vessels exporting live groupers (Ministerial Regulation Number 10/PERMEN-KP/2015), and potassium cyanide fishing is prohibited (De Alessi, 2014), there are no regulations regarding the live grouper fishery and export trade, while the existing regulations on live fish carrier vessels are rarely enforced effectively, if at all. There are no national regulations specifically addressing grouper fisheries, whether for live or dead fish. In view of the particular characteristics of groupers, strategies such as limiting allowable catch size, protecting grouper spawning aggregation, and controlling export volumes (quotas) and trade routes are important to prevent declines in wild grouper stocks.

The importance of and need for such regulations, as an initial step towards conserving Indonesian grouper stocks, was underlined by research showing that 73% of Indonesian grouper species for which there is enough information to make a conservation status assessment are listed as Near Threatened or Threatened in the IUCN Red List (Sadovy de Mitcheson et al., 2013). A recent study revealed that some grouper export are leaving the country illegally, by sea or air, thus reducing trade tax income (Nurdin and Grydehøj, 2014). Illegal exports of Napoleon wrasse are also known to occur on Hong Kong live fish carriers (Wu and Sadovy de Mitcheson, 2016).

The aim of this article is to provide a baseline profile of the grouper export trade as currently practiced and to develop a framework strategy for establishing a sustainable grouper export trade for Indonesia. This article consists of three parts: a profile of the Indonesian grouper trade, a summary of management issues and challenges, and a discussion on management options.

Current status of Indonesia grouper fisheries

Early demand for export

The export trade in groupers and Napoleon wrasse (which is also an important target of the LRFFT) from Indonesia began in 1985, and was originally centered on the Banggai Archipelago, Central Sulawesi (Davis, 2001). From there, the trade spread to South and Southeast Sulawesi and Maluku. The grouper trade grew in volume and stocks of the Napoleon wrasse dwindled in some areas due to overfishing (Johannes, 1999). There was a progressive shift from interested in dried (dead) groupers (for local market)

to live groupers for export (Johnston and Yeeting, 2006). Groupers were traded locally as fresh or dried fish before Hong Kong vessels offered opportunities to trade groupers alive. In the 1980's fishers initially sold Napoleon wrasse (*Cheilinus undulatus*), leopard coral trout (*Plectropomus leopardus*), estuary cod (*Epinephelus coioides*), areolate grouper (*Plectropomus areolatus*), and brown marbled grouper (*Epinephelus fuscoguttatus*), then subsequently diversified the species traded (Dg. Bonto, first live reef food fish traders in south Sulawesi personal communication, 18 April 2017).

In the early 1960s, fishers from Hong Kong taught Indonesian fishers how to catch live fish using potassium cyanide, locally called *bius* (Jones and Steven, 1997). In 1993 the Indonesian Government promulgated legislation forbidding the use of *bius* to catch fish, through Government Regulation PP No. 51 of 1993 on the Analysis of Environmental Impacts. However, fishers and managers paid little or no attention to this regulation, which was not effectively enforced (if at all). The widespread use of potassium cyanide fishing was feared to have caused extensive damage to coral reef ecosystems in many regions (Jones and Steven, 1997; Pet-Soede, 2000). The development of hatchery production for brown marbled grouper (*Epinephelus fuscoguttatus*) and humpback grouper (*Cromileptes altivelis*) began in 1999 at research stations in several regions (especially Bali and Lampung) (Notowinarno, 1999). Around the same time the large-scale catch and sale for grow out and export of juvenile groupers (brown marbled grouper and humpback grouper) became increasingly common (De Alessi, 2014).

Growing demand for live groupers

Growing demand for live groupers in particular, and good retail prices, particularly in Hong Kong and Mainland China, prompted increasing effort by fishers to collect more fish for live exports. To meet demand and catch more groupers, fishers changed gears (from traditional traps, spear, hook and net to potassium cyanide, hook and spears) (De Alessi, 2014) and started to use outboard engines on outrigger canoes in 2000 (Pajot and Gulbrandsen, 2014). As stocks in one part of the country declined, businesses moved to other areas to maintain catches earning them the term of roving bandit syndrome (Scales et al., 1999; Schwerdtner Manez and Ferse, 2010).

Biologically vulnerable and economically valuable, characteristics that without management quickly lead to overfishing

Vulnerability of groupers to fishing

Groupers are typically long-lived species, normally solitary and sedentary. Some species gather to mate in 'spawning aggregations' and some are protogynous hermaphrodites (changing sex from female to male). In Indonesia, most groupers live in coral-reef associate habitats in 0–200 m depth and feed on fishes and invertebrates (Heemstra and Randall, 1993).

Several groupers favored in the live reef fish food trade (LRFFT) reproduce in spawning aggregations, often highly predictable in location and timing each year, of large numbers of individuals. This habit makes them very easy to locate and fish heavily once the aggregations are discovered. Some species form large aggregations, such as areolate grouper (*Plectropomus areolatus*), brown marbled grouper (*Epinephelus fuscoguttatus*), and camouflage grouper (*Epinephelus polyphekadion*), which often aggregate at the same locations, though not necessarily at exactly the same time. Other species form many small aggregations briefly each year, such as such leopard coral trout (*Plectropomus leopardus*), and still other groupers do not aggregate at all (Jawad, 2012; Sadovy de Mitcheson and Colin, 2012). For aggregating species these times are the only known reproductive opportunities.

Many groupers are easily overfished because of their low productivity, longevity, or because they are taken in juveniles in large numbers, or exploited excessively on their aggregations. Management of these species for both live and dead fish trades (collectively) needs to focus on ensuring that their populations remain reproductively viable and prevent overfishing. Growing pressure to export, in particular, has significantly increased fishing pressure on groupers in Indonesia.

High demand for live grouper in Hong Kong and Mainland China

Since 1999–2000 Indonesia was recorded as the third most important exporter of live reef food fish to Hong Kong/mainland China (Mcgilvray and Chan, 2002) with the three main species (by value) traded being brown marbled grouper, Napoleon wrasse, and leopard coral trout (Sucoko, 2013). This study noted Indonesia to be the major supplier of live reef fish, with the main species being spotted coral grouper

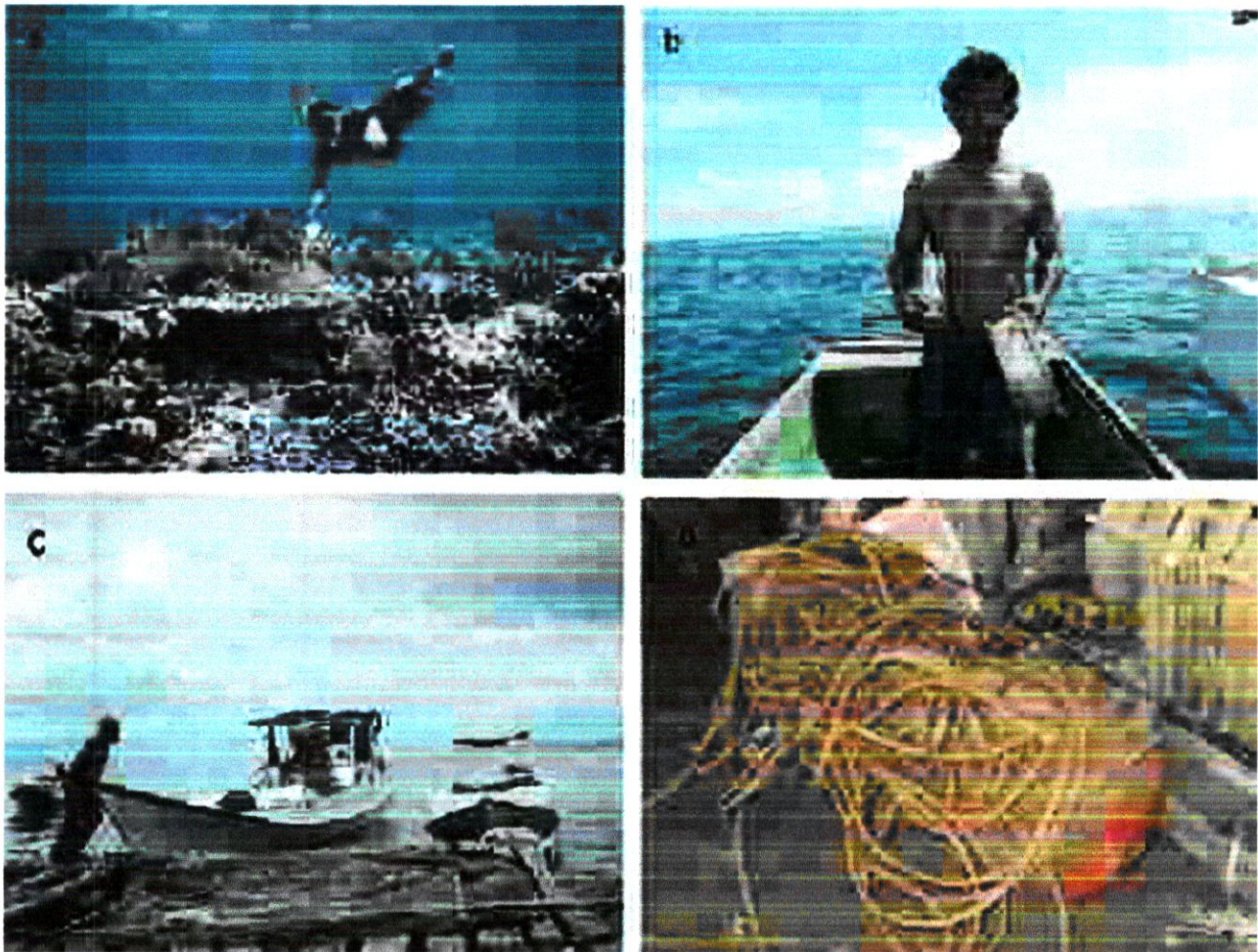


Figure 1. (a) Potassium cyanide fishing technique (done with free dive (<10 m depth) and with compressor (>10 m depth) Photograph: Adi Ps. (b) Hand line fishing technique (fish hook no. 6–9 and fishing line up to 20–30 m depth) Photograph: Miftakhul Khasanah. (c) & (d) Combination technique using fish trap and compressor (usually this gear is combined with potassium cyanide) Photograph: Miftakhul Khasanah.

("taising" *P. maculatus*), leopard coral grouper ("tungsing" *P. leopardus*) and areolate grouper "saising" (*P. areolatus*), collectively called 'sunu' in Indonesia (Sadovy de Mitcheson et al., 2017). Hong Kong and China are the biggest consumers of live reef fish food (Muldoon et al., 2016). Consumption of high-priced luxury fish, like live groupers, is often linked with high social status, and wild fish are generally preferred for their superior texture, taste, and appearance; for example the red color of wild-caught leopard coral trout is particularly appealing (Fabinyi, 2015; Muldoon et al., 2016). Some consumers also consider wild fish to be healthier (i.e. without chemicals). Given high demand for and vulnerability of several grouper species to heavy fishing, Indonesia needs appropriate management and export controls for grouper species, especially those that are high value and particularly desired, such leopard coral trout, and hence heavily exploited.

Grouper trade value

More than 20 countries supply live reef fishes to Hong Kong, the major international trade hub for this trade, and indirectly, to Mainland China via Hong Kong. Indonesia as one of the most important supplier countries of high value groupers (leopard coral trout, high fin coral grouper (*Plectropomus oligacanthus*), and humpback grouper) and low value species (e.g. estuary cod, tomato rockcod (*Cephalopholis sonnerati*)) (Petersen et al., 2004). Indonesia can supply the grouper trade year-round even at times when fishing activity is low due to weather conditions (e.g. 'jenekebo' - June-August) (Figure 2)

In certain places (e.g. Taka Bonerate), by the early 21st century small island fishing communities were no longer able to make a living from pelagic fisheries; the live reef food fish fisheries then become a solution to enable them to meet their basic needs (Hamzah professional fishers from Taka Bonerate,

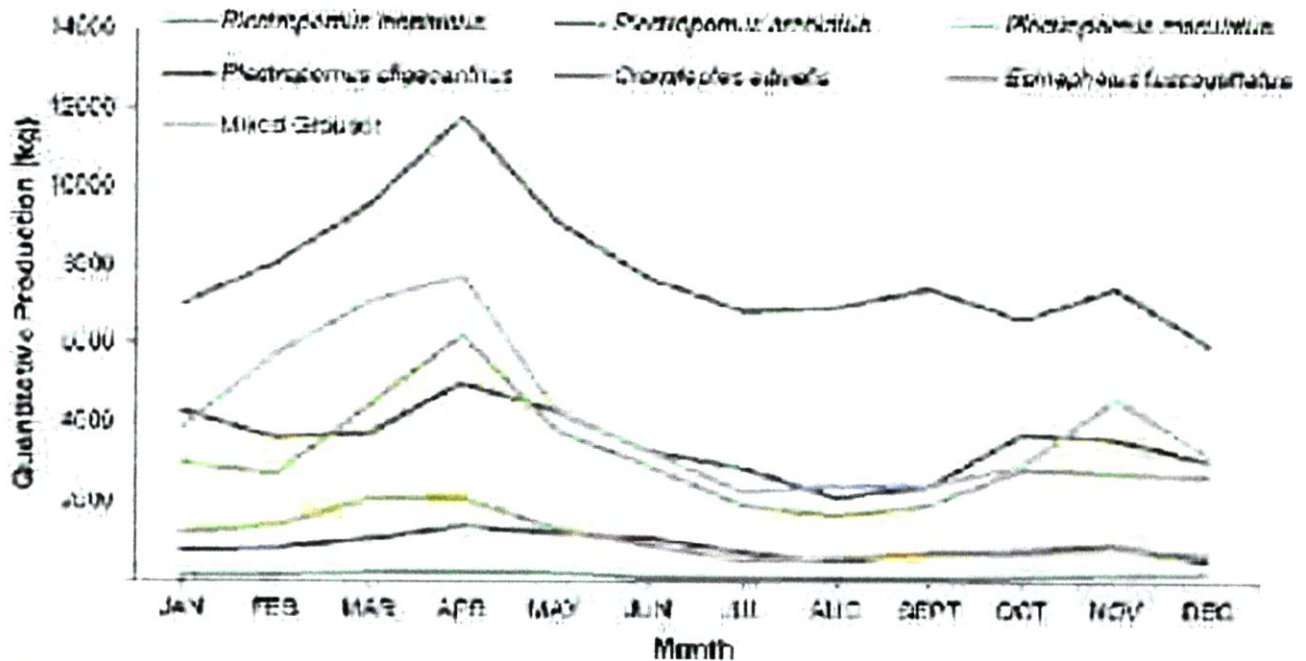


Figure 2. Total exports (kg), by month for 6 grouper species and for mixed groupers, in 2015 data from UD. Pulau Mas, Bali (largest legal LRFFT trader in Indonesia).

personal communication, 2 May 2017). In terms of income, local fishers selling live groupers receive about 10% of total retail value; 35% goes to buyers/local exporters (typically several levels), 5% to Hong Kong importers, and 50% to retailers (Petersen et al., 2004). Even though fishers get a small percentage of the total retail value, they still benefit more from live sales rather than dead grouper sales because dead sales are about 20–30% of the live grouper price. On the other hand, if grouper populations are overexploited, fishers will lose this income as well as the benefits that the contribution that (dead or unsold) groupers make to local food security (Foale et al., 2013).

Capture of immature groupers

The price of groupers traded in the LRFFT tends to be highest for 'plate-size' fish, typically weighing 500–1000 g, because of their suitability for the Chinese restaurant trade (serving families and banquets) (Johnston, 2007). Although this would be the preferred target size, such fish are not always available. When juveniles are caught, they can be grown-out to market size. Sometimes, in the case of larger species, the preferred plate-size is in the juvenile size range (e.g. brown marbled grouper, saddle grouper (*Plectropomus laevis*)) which puts heavy pressure on immature stocks which have not yet contributed to the next generation. Data from the Wildlife

Conservation Society (WCS) Indonesia shows that the capture of under-sized (i.e. juvenile) groupers is widespread across a broad range of species (Table 1, Kindsvater et al., 2017).

Interviews with fishers in Eastern Indonesia (during 2017) revealed that they generally sell fish both above and below the plate-size range (i.e. 100–450 g and >1000 g) as (dead) fresh fish because they still get a good price for dead fish. The fresh (dead) grouper trade has grown since around 2014, with annual reported exports currently around 5000 MT/year (Figure 3). Dead groupers caught across eastern Indonesia are often transported to Makassar by air or by sea. The best quality fish will then be exported, mainly to Hong Kong, and the remainder is sold domestically, often to Chinese restaurants (Jakarta, Bali, and Surabaya). This increase in the dead grouper trade is placing significant additional pressure on grouper populations; furthermore, unfortunately, around 50% of this catch tends to consist of juvenile fish (SEAFDEC, 2013). If there is no limit placed on the size of groupers which can be taken from the wild, there is a high risk of recruitment overfishing (Shapiro, 1987). Such a situation may cause some groupers to change sex early while still small, resulting in too few males or reduced reproductive potential (as fecundity increases exponentially with female size), leading to a situation where grouper populations are comprised of smaller and fewer fish (Gaspare and Bryceson, 2013).

Table 1. Sizes of some grouper species at maturity, maximum length (TL) and percentage catch under length at maturity in Indonesia.

Species	Length at maturity (cm)	Maximum length (cm)	Percentage of catch under length maturity (%)
<i>Cephalopholis sonnerati</i>	31.43	35.84	50.53
<i>Cromileptes altivelis</i>	33.64	38.78	71.93
<i>Epinephelus coioides</i>	57.04	71.57	58.21
<i>Epinephelus fuscoguttatus</i>	59.41	75.05	86.64
<i>Epinephelus polyphkadion</i>	38.29	45.06	67.33
<i>Plectropomus areolatus</i>	40.6	48.24	77.04
<i>Plectropomus laevis</i>	33.71	38.87	35.71
<i>Plectropomus leopardus</i>	42.98	62.56	89.91
<i>Plectropomus maculatus</i>	39.87	47.23	62.91
<i>Plectropomus oligacanthus</i>	39.78	47.11	53.41

Source: Grouper landing data collected by the Wildlife Conservation Society Indonesia, from WPP 713 during 2016–2017 (<http://www.data-ikan.org> accessed 10 November 2017).

Table 2. Main grouper species traded in/from Indonesia.

No	Species	Source			Sold as		
		Cultured	Cultured/wild-caught	Wild-caught	Fresh	Live/Fresh	Frozen
1	<i>Cromileptes altivelis</i>		•			•	•
2	<i>Cephalopholis boenak</i>			•	•		
3	<i>Epinephelus coioides</i>		•		•		•
4	<i>Epinephelus fuscoguttatus</i>		•			•	•
5	<i>Epinephelus merra</i>			•	•		
6	<i>Epinephelus polyphkadion</i>			•		•	•
7	<i>Epinephelus tauvina</i>			•	•		
8	<i>Plectropomus areolatus</i>			•		•	•
9	<i>Plectropomus laevis</i>			•		•	•
10	<i>Plectropomus leopardus</i>			•		•	•
11	<i>Plectropomus maculatus</i>			•		•	•
12	<i>Plectropomus oligacanthus</i>			•		•	•

Source: Government statistics on Indonesian exports (Bulletin Statistic Indonesia, 2010–2016) & (SEAFDEC, 2013).

Aquaculture vs. wild capture

Indonesia has been successful in culturing three species of grouper through hatchery production. Nonetheless, most live groupers exported from the country, by volume and in terms of species diversity, are wild-caught (SEAFDEC, 2013). Moreover, the survival rate of hatchery-produced grouper seeds is generally low (Kohno et al., 1997); feed is expensive (and depends heavily on wild-caught fish, putting further pressure on marine ecosystems); and consumers prefer wild-caught rather than cultured groupers (Akhmad Kholil, researcher from Gondol Mariculture personal communication, 2 June 2017). For every tonne of grouper cultured, over 8 tones of fresh fish may be required (Naylor et al., 1998); typically small pelagic fishes (such as sardines and mackerel) caught from wild populations (often using local lift-nets called *bagan*), may not be able to sustain increasing fishing pressure. Hence this feed may become limited and even more expensive in the future (Davis, 2001). Wild-caught groupers are either directly exported live or dead at market-size or grown-out in captivity to market size (Table 2).

The provisions of the recent law on live fish carrier vessels (No 32/KEPMEN-KP/2016), which specifically

increased the quota for the transport of live fish produced from aquaculture, has not yet had the anticipated positive response as a stimulant of the aquaculture sector, and in particular the culture of groupers for the LRFFT. Reasons for this include the challenges faced by grouper farmers to increase production, including the low survival rate of grouper seeds (Kohno et al., 1997), the high price of feed, and the lack of market demand for farmed groupers. Moreover, these carriers are also collecting wild caught fish which is not permitted.

Indonesia has successfully produced grouper seeds from hatcheries in Gondol, Bali; Takalar, Makassar and Lampung but is challenged to maintain high production from grow-out because of competition in culturing groupers, especially from China. The Gondol Marine Culture Research Centre in Bali has successfully developed hatchery-production for three species: brown marbled grouper, humpback grouper, and leopard coral trout with average survival rates of 30% for brown marbled grouper, but only 2% for leopard coral trout. With an annual production capacity of 2.5 billion grouper seeds by 2016 in Bali alone (Harbin Yake, Head Office from Gondol Mariculture personal communication, 2 June 2017), Indonesian grouper farmers cannot absorb this level of seed production at

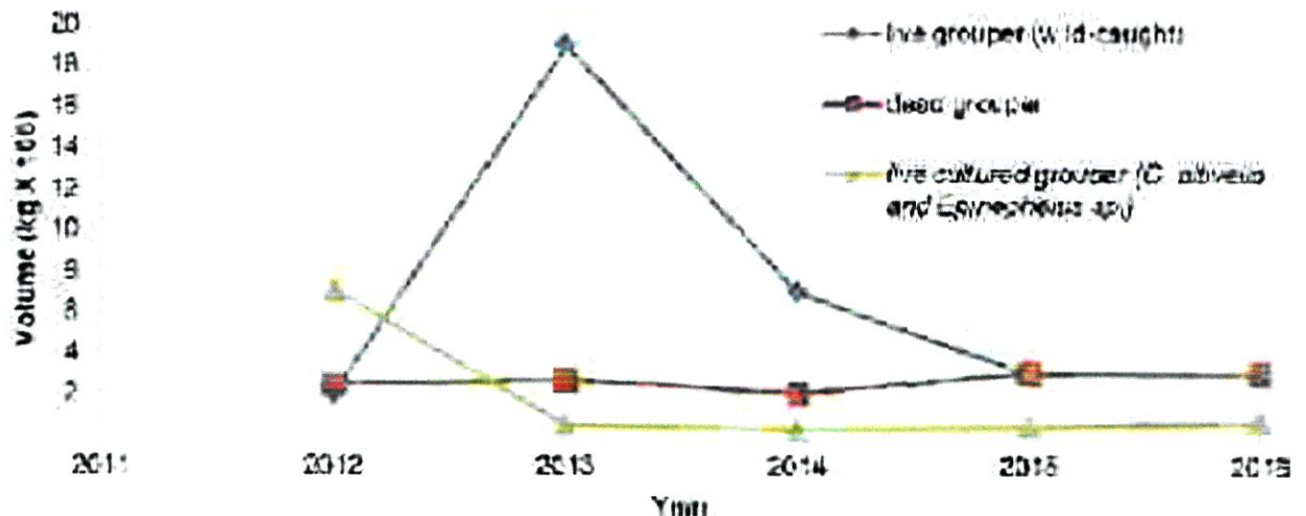


Figure 3. Grouper fisheries (live and dead) export data by volume. Source: Foreign trade statistical bulletin, Ministry of trade ID (BPS ID 2012-2016).

the grow-out to market size phase. This is largely because of low market prices for farmed groupers in Hong Kong and the high cost for grouper grow-out feed, making farmed grouper exports from Indonesia unprofitable and uncompetitive. The situation became even more challenging once China began producing increasingly higher volumes of cultured groupers at prices which are competitive to Indonesia's cultured fish and, also, compared to wild caught groupers. On the other hand, there is still a consumer interest in wild-caught grouper and China's grouper resources are so depleted that the country has to depend on imports of wild-caught grouper; hence Chinese trader interest in imports of wild-caught grouper from Indonesia remains high even though interest in cultured grouper has declined. The majority of grouper seeds produced in Indonesia is sold to aquaculture businesses in Malaysia, Taiwan, and the Philippines.

Decrease in grouper exports from Indonesia

Information obtained from the Indonesian Ministry of Trade for the period 2012–2016 indicates that the total recorded volume of live groupers legally exported from Indonesia has declined since 2013 (Figure 3). Interviews with local traders indicated that one possible reason for this decline is the impact of government regulation No. 56/2014 regarding the moratorium on foreign live fish carrier vessel permits which prohibit export of wild caught grouper. Some live reef food fish traders have been forced to close down due to this regulation, as they have lost their market/trading partners. Smaller traders with more limited financial resources were most affected because

of the high airfreight costs and high risk of mortality during the often long and complicated routes to Hong Kong, e.g. due to long transits and flight delays. In addition, Indonesian traders or other investors would need not only very high capital investment but also extensive capacity-building if they wanted to export directly by sea from Indonesia with Indonesian flagged vessels. Even though transport by sea is cheaper than airfreight, export by air from major airports direct to Hong Kong is usually safer (less risk of fish mortality); however, this option still requires substantial investment in domestic fish carriers meeting international standards, something which only one Indonesian trader has so far achieved. While changes in trade dynamics might account for this reduction, it is possible that the reduction in exports reflects grouper population declines, at least in some areas, as well as the reduction in export market access, because foreign vessels carry both cultured and wild-caught fish. There has also been increasing domestic market demand in local Chinese seafood outlets e.g. Surabaya, Jakarta, and Bali (H. Said, CEO of Perikanan Nusantara (PERINUS), Makassar personal communication: December 2017).

Several groupers have declined

High-value grouper species are traded (often under many names for one species) within Indonesia, and average ex-vessel prices vary substantially (Table 3). The most commonly traded species, from 4 genera, fall into three price categories. Comparing the prices of groupers in Indonesia (Table 3) with the conservation status of each species in the International Union

Table 3. Grouper species commonly exported from Indonesia (ranked by ex-vessel value).

English name	Scientific name	Indonesian name	Ex-vessel value (US\$/kg)
Leopard coral grouper	<i>Plectropomus leopardus</i> (Cornish and Kiwi, 2015)	Sunu merah/Tung sing	30–150
Humpback grouper	<i>Cromileptes altivelis</i>	Kerapu bebek/tikus	28–100
Areolate grouper	<i>Plectropomus areolatus</i>	Sunu hitam/Sai sing	15–60
Chinese footballer	<i>Plectropomus laevis</i>	Sunu raja	15–60
Brown marbled grouper	<i>Epinephelus fuscoguttatus</i>	Kerapu Macan Muara	8–30
Spotted coral grouper	<i>Plectropomus maculatus</i>	Sunu bone/Tai sing	8–30
High fin coral grouper	<i>Plectropomus oligacanthus</i> (Cabanban et al., 2008)	Sunu cambang	8–30
Small-toothed cod	<i>Epinephelus polyphekadion</i>	Kerapu batik	8–30
Tomato rockcod	<i>Cephalopholis sonnerati</i>	Karet merah	8–30
Estuary cod	<i>Epinephelus coioides</i>	Kerapu titik	8–30

Source: Heru Purnomo, Director of UD Pulau Mas personal communication, 30 July 2017.

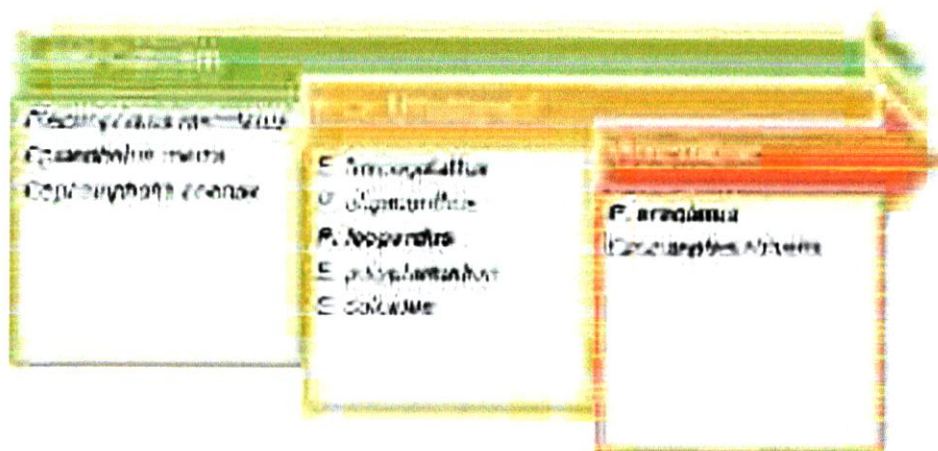


Figure 4. Status of some groupers commonly traded in Indonesia according to the 2007 IUCN Red List. Note, however, that these species are currently being reassessed by IUCN since reassessment must be done at least once a decade.

for the Conservation of Nature (IUCN) Red list (Figure 4), it can be seen that, in general, the higher priced species are also those that appear to be more threatened.

The high level of exploitation has not only caused the abundance of some populations of many grouper species to decline, but in some cases may have resulted in the extirpation of certain species from some areas e.g. camouflage grouper (*Epinephelus polyphekadion*) (Sadovy de Mitcheson et al., 2013). While attention to the management of grouper stocks in general is needed, there is a need for special focus on the species or groups of species that are more vulnerable to overexploitation and/or heavily sought after. For example, three popular grouper species (brown marbled grouper (*Epinephelus fuscoguttatus*), camouflage grouper (*Epinephelus polyphekadion*) and areolate grouper (*Plectropomus areolatus*)) tend to share the same spawning aggregation sites and can even spawn simultaneously (Pet et al., 2006, 2005; Sadovy de Mitcheson and Colin, 2012). While on the other hand, a focus on managing (protecting) their spawning aggregations could benefit all three species.

Need for monitoring and management of grouper fisheries

Emerging new regulations

There have been changes in the way that the LRFFT is managed in Indonesia since the New Order Period (1966–1998) (Table 4); while no regulations specifically apply to the dead grouper trade, some more general regulations effectively apply to both dead and live fish, for example restrictions imposed within an MPA, and the regulations on illegal and destructive fishing (e.g. cyanide and compressor diving). Nonetheless, even when laws are in place and their provisions are clear/well understood, monitoring and enforcement are often unevenly implemented, ineffective, or simply lacking (De Alessi, 2014). Moreover, many legal loopholes (see below) potentially open the way for illegal fishing (Radjawali, 2012) and the legal system is still open to corruption (Johannes, 1999; Radjawali, 2012). Currently, Indonesia has promulgated measures designed to manage marine habitat, to regulate the trade in certain live seafood species (Napoleon wrasse, lobsters, and crabs), fishing gear (prohibition on the use of diving compressors, and other gear), and

Table 4. Indonesian Government regulations relevant to the live grouper fishery and trade, from the New Order Period to the present (2017).

Habitat
(Prohibition on habitat destruction)
Law of the Republic of Indonesia No.9/1985 on Fisheries (prohibition of destructive gear include poison fishing)
Law of the Republic of Indonesia No.5/1990 regarding the Conservation of Natural Resources
Law of the Republic of Indonesia No 31/2004 on Fisheries (Republic of Indonesia State Gazette for 2004 Number 118, Supplement to the Republic of Indonesia State Gazette Number 4433) as amended by Law No. 45/2009 (Republic of Indonesia State Gazette 2009 Number 154, Supplement to the Republic of Indonesia State Gazette Number 5073);
Government Regulation No. 60/2007 regarding the Conservation of Fish Stocks (Republic of Indonesia State Gazette 2007, Number 134, Republic of Indonesia State Gazette Supplement Number 4779)
Law No. 27/2007 on the Management of Coastal Areas and Small Islands
Live reef food fish and invertebrates stocks
Ministerial Decree of the Minister for Marine Affairs and Fisheries Number KEP.37/MEN/2013 regarding the Conservation status of Napoleon wrasse (<i>Cheilinus undulatus</i>)
Ministerial Regulation of the Minister for Marine Affairs and Fisheries Number PER.56/MEN/2016 regarding the Prohibition on the Capture and/or Export of (undersized/berried) Lobster (<i>Panulirus</i> spp.), Mud Crab (<i>Scylla</i> spp.), and a Swimming Crab (<i>Portunus</i> spp.) from The Territory of The Republic of Indonesia
Gears
Law of the Republic of Indonesia No 31/2004 on Fisheries as amended by Law No. 45/2009 chapter 9(1-2)—provisions regarding illegal gear
Ministerial Regulation of the Minister for Marine Affairs and Fisheries Number PER.02/MEN/2012 regarding prohibition of diving compressors (hookah) as fishing gear
Regulation of the Directorate General for the Surveillance of Marine and Fisheries Resources No. 536/DJPT.2/P.1.370/011/2013 regarding the prohibition of diving compressors for fishing
Vessels (domestic and foreign)
Ministerial Decree of the Minister for Marine Affairs and Fisheries Number KEP.60/MEN/1975 as amended by Law No. 392/1999 regarding capture fisheries zones (3 zones)
Ministerial Decree of the Minister for Marine Affairs and Fisheries Number KEP.45/MEN/2000 as amended by Ministerial Regulation of the Minister for Marine Affairs and Fisheries Number PER.16/MEN/2010 regarding Fishing Licenses (SIUP/ SIPPI) for 30-60 GT vessels
Ministerial Regulation of the Minister for Marine Affairs and Fisheries Number PER. 5/MEN/2008 regarding Capture Fisheries Businesses
Ministerial Regulation of the Minister for Marine Affairs and Fisheries Number PER. 1/MEN/2009 regarding Fishing Areas within the Republic of Indonesia;
Government Regulation No. 56/2014 regarding the Moratorium on Foreign fishing vessels
Ministerial Regulation of the Minister for Marine Affairs and Fisheries Number PER.32/MEN/2015 as amended by Ministerial Decree of the Minister for Marine Affairs and Fisheries Number PER.15/MEN/2016 regarding live fish carrier vessels in Indonesia

control vessel licensing (fishing licenses, fisheries business licenses, moratorium on foreign vessels, etc.). Yet, none of these measures specifically mention or address grouper fisheries or the grouper trade, provide statutory protection for fish (e.g. grouper) spawning aggregations, or regulate grouper stock management, while enforcement of most measures is lacking or ineffective.

In 2006, a Government Regulation forbidding the degradation or destruction of marine habitats was incorporated into Ministerial Regulation PP/No.60/2007 (De Alessi, 2014). The government also made it obligatory for all fishers to have a fishing license, as set out under the Ministerial Regulation of the Minister for Marine Affairs and Fisheries Number: PER.17/MEN/2006. Designed to empower fishers, many perceived this regulation as a burden which made fisher's lives more difficult (Sucoko, 2013). One weakness of this regulation is that fishing vessels fewer than 5 gross tonnage (GT) do not need to be licensed, which, in effect, means that data on small-scale fisheries is not be recorded by the government. This data gap is a major obstacle to understanding the fishery or developing and implementing policies for managing the LRFFT because most live reef fish are caught by fishers using vessels under 5 GT or in the 5-10 GT range (De Alessi, 2014).

In 2014, the Indonesian Ministry for Marine Affairs and Fisheries imposed a moratorium on the issuance of fishing licenses to foreign flag fishing vessels operating in Indonesian waters (Ministerial Regulation Number 56/PERMEN-KP/2014), which was amended in 2015 (Ministerial Regulation Number 10/PERMEN-KP/2015). This regulation included fish carrier vessels and resulted in the closure of live reef fish holding businesses in many areas, because the Hong Kong carrier vessels (the major foreign vessel class collecting live fish from wild-caught fisheries) were no longer visiting them to buy/collect fish.

In 2016 the Government further tighten the regulations on foreign live fish carriers. A distinction was made between domestic vessels carrying wild-caught fish and foreign vessels carrying farmed fish in the Ministerial Regulation of the Minister for Marine Affairs and Fisheries No 32/2016 (see also No 15/KEPMEN-KP/2016). These regulations were developed to promote the growth of the aquaculture sector due to increasing the freight quota, and in particular to promote the trade in farmed groupers by increasing the export quota for farmed fish. Despite the new regulations, grouper farming in Indonesia continued to stagnate, at least partly due to the lack of market demand in Hong Kong and Mainland China for farmed grouper, as mentioned above. Thus, for groupers at least, the live reef fish food trade is still largely

dependent on wild grouper stocks. In addition, this regulation could be a loophole facilitating the illegal transfer of wild stock to the aquaculture quota which can still be legally collected by foreign vessels.

In view of the declines in and threats to several wild grouper species and stocks, as well as the heavy dependence of many fishers on wild-caught groupers, there is an urgent need for action to avoid further declines, including measures to regulate the catch and export of wild groupers traded both the live and exported chilled/fresh. Regulations need to eliminate loopholes and minimize the opportunities for fraud, theft, and corruption. In particular, permits should be adequately cross checked against each other or against the goods they carry (Brack, 2016), exports in airports need to be more effectively monitored and controlled, while foreign vessels need better oversight, such as tracking through effectively implemented vessel monitoring systems (VMS). Removed the groupers species that could not be culture on the "aquaculture- species" list and the customs officers also need to be trained in specific identification.

Lack of law enforcement

Various recommendations for regulatory mechanisms have been put forward in the past, but most have not been implemented, often due to low perceived priority and/or lack of resources. The inadequate enforcement of existing regulations may sometimes occur because of low environmental awareness, however there are many other challenges including lack of funds, lack of equipment, lack of expertise capacity, and lack of integration among laws, regulations and departments, including lack of coordination among fisheries managers at national and provincial levels (Dirhamsyah, 2005). For example, one reason for inadequate law enforcement in Wakatobi and Taka Bonerate National Parks is the lack of clear mandates, with overlaps and/or gaps between the roles and responsibilities of the various government agencies involved in identifying, declaring and monitoring these sites (e.g. provincial Fisheries and Marine Services, national park agencies, and other bodies) (Yusman, Head of Taka Bonerate National Park personal communication: June 2016). Data on illegal fishing activities in Taka Bonerate National Park showed that in 2015 only one case (out of over 50 known cases) reached the provincial level, with the appropriate (P-21) data form being completed by the surveillance division of Taka Bonerate National Park. Due to lack of funds, in 2016 none of the illegal fishing cases in this national park went

beyond the District level, with the offenders only being given verbal cautions (by the local police) and released; the police asked who would pay for their food if the offenders were detained in prison to await further legal procedures (Yusman, Head of Taka Bonerate National Park personal communication: June 2016). In Indonesia, local prisons do not have funds to provide detainees with food unless they have been convicted; the reporting agency (in this case the National Park) is expected to pay.

IUU fishing

The prevalence of illegal, unreported and unregulated fishing (IUU) is widely viewed as a major contributor to the increasingly rapid decline in many fish stocks (Belhabib et al., 2014). The unchallenged operation of fish carrier vessels from Hong Kong in Indonesian waters, in particular, has led to considerable loss of revenue to Indonesia from the live reef food fish trade in groupers (De Alessi, 2014). Despite the promulgation of Ministerial Regulation No. 15 of 2016 (MMAF, 2016) on Live Fish Carrier Vessels there are still many instances of IUU (Nurdin and Grydehøj, 2014). For example, Hong Kong vessels are only allowed to pick up live groupers of the 10 species in Table 3 from mariculture zones and load these fish in particular harbors (Bitung, Kendari, Surabaya and Lampung). In fact, 7 of the 10 species in Table 3 are only produced from wild capture (not from hatchery-bred seed), including *P. areolatus*, *P. laevis*, *P. leopardus*, *P. maculatus*, *P. oligacanthus*, and *E. polyphekadion*. These fish are therefore 'laundered' through these zones (i.e. wild caught fish are taken to marine culture zones to make them seem like cultured fish, including small fish that are grow-out). Measures needed for the government to address illegal fishing include the provision of adequate port inspection infrastructure and ensuring that technical staff members have the skills and resources to implement measures designed to prevent illegal fishing and trade/export. Some regulations are difficult to enforce and require clarification and/or reinforcement, for example through the drafting and promulgation of standard operational procedures. For capture fisheries these could cover the species caught, with catch origin (fishing ground) and volume by species as well as size limits. Such procedures could help to avoid misrepresentation or fraud, theft, and corruption.

Additionally, for all companies involved, the license and other ship documents should be collected and cross-checked (Brack, 2016). All foreign vessels should

have VMS, and vessels with a record of violations in every trip should be denied future permits. All vessels should have automatic identification system (AIS) switched on at all times to enable their tracking, should provide their unique vessel identifier provided by the international maritime organization number (IMO) or maritime mobile service identification (MMSI) and full ownership details to government at the time of registration. Exchange of information between the Indonesian and Hong Kong government in the case of suspect vessels would also help to close loopholes.

Lack of monitoring and national database on groupers

Data on groupers held by various government agencies are highly variable, in terms of species names and quality. Data collected on grouper catch differs substantially among Marine and Fisheries Services, Fish Quarantine Offices, and exporters (Gossen Sitanggang, statistic programmer from MMAF, personal communication, 2 May 2017). For example, exporters may use a trade name, marine and fisheries service officers compile data by family name or common name, and the Ministry of Trade lists groupers by product classification (live – cultured/wild caught; dead – fresh/frozen/chilled/other). In addition to different methods and procedures, the enumerators recording data are often unskilled in grouper species recognition, perhaps not surprisingly in view of the high number of grouper species with distributions in Indonesian waters (Hernandez Aguado et al., 2016). Despite, given that only a few, mostly distinctive, species make up the bulk of this trade (analogs to the situations with tuna, perhaps); it should be relatively easy to train relevant staff in identification. Data on fishing effort are also needed, as well as on the size of fish landed (live or dead); all parameters should be standardized to provide a valuable database that can be used in the long term across all sectors.

Good management practices for grouper fisheries, such as the Maldives grouper fisheries management plan (Marine Research Centre Maldives & Marine Conservation UK, 2011), state that the lack of reliable, standardized data is a major obstacle to the implementation of quota-based fisheries management. Certainly, this is true in the case of Indonesia. Furthermore, establishing the true status of wild grouper stocks, no simple matter given the nature of the stocks themselves, is further complicated by the ambiguity inherent in the trade data available; both

Indonesian and local names are used, where one name (e.g. sunu) can be used for several species (*P. leopardus*, *P. oligacanthus*, *P. areolatus*); conversely, several species may be recorded under one name, e.g. sunu. Latin names can also be ambiguous, for example "Epinephelus sp." can be used on Fish Quarantine documents for all grouper species. Keeping track of trends in market demand over time is also difficult with incomplete and/or inaccurate data. A new one-way data system (being proposed as one dataset or database for all departments of MMAF) is expected to improve future data collection and management, and thus contribute to improved fisheries management in general and in particular for the live grouper fishery and trade.

Lack of protection for spawning aggregations

Groupers are generally solitary, long-lived fish with populations spread at relatively low densities over large areas for most of the year, and have inherently low productivity; hence they cannot sustain major or intensive fisheries. The often predictable (e.g. annual) formation of spawning aggregations by many grouper species makes them easy to catch in large numbers, mostly before they have spawned, and thus intrinsically vulnerable to over-fishing during their spawning seasons (Sadovy de Mitcheson, 2016). This is a major reason why some grouper stocks can become overfished within a short time period. Because of this spawning behavior, and the scale at which their life-cycles and connectivity operate, with larvae dispersing over dozens to possibly hundreds of km (Green et al., 2015), even well designed and implemented marine protected areas are unlikely to be effective in protecting most grouper populations without other supporting measures. In an MPA context, if grouper populations are a conservation target, integration and synergy will be required across habitats, and most likely between MPAs, to connect and conserve spawning grounds, nursery grounds, and feeding grounds, and thus hopefully ensure a supply of fish recruiting to fishing grounds. Protection of species that aggregate to spawn during the spawning season can also be very effective: i.e. no fishing during this season.

According to the global NGO Science and Conservation of Fish Aggregations (SCRFA), it is estimated that 55% of reported fish aggregating sites of the world are of unknown status, while 25% are declining, 4% have been lost, 13% appear stable, and only 3% are increasing or recovering (<http://www.scrfa.org>, accessed 1 July 2017). There are at least 43

grouper spawning aggregation sites reported in Indonesia (Russell et al., 2014). The 43 spawning ground records for the Family Serranidae in Indonesia in the SCRFA on-line database (<http://www.scrfa.org/database/>, accessed 1 July 2017) which comprise just 6 species from two genera. The taxa and numbers of spawning aggregations are: *E. corallicola*, *E. fuscoguttatus*, *E. lanceolatus*, *E. polyphekadion*, *P. areolatus*, and *P. leopardus*. Of these reported grouper spawning sites, only four have so far been given any protection. These are situated in the Wakatobi National Park (Balai Taman Nasional Wakatobi, 2007), Komodo National Park (Pet et al., 2005) and the Ayyau Bay in West Papua (Momigliano et al., 2015) as collaboration project from National Park and local NGO's (WWF-ID and The Nature Conservancy ID). As one of the Coral Triangle Initiative (CTI) areas, Indonesia should be paying serious attention to preventing the degradation of coral reef habitat (Allen and Werner, 2002); with a national MPA target of 30% of Indonesian seas, protected areas could and should play a significant role in preventing the loss of and promoting the recovery of grouper habitat, including spawning areas, and stocks.

Grouper fishery management options; maintaining reproductive function and catch quotas

The allocation of catch quotas on a regional basis

The allocation of catch quotas at regional (e.g. Provincial) levels could contribute to addressing the issue of overfishing within each designated area. Such a measure is widely considered to be necessary to achieve sustainable fisheries. Despite, one major obstacle to effective implementation of this fisheries management tool is the poor quality, insufficient resolution and/or lack of appropriate data (fisheries statistics) in Indonesia. When the one-way data system for all fisheries data (has it been initiated during 2017) is in place, a quota system may become possible. Until then, without the necessary data, and with no way to trace the origin of particular fish or consignments, it would be extremely difficult, if not impossible, to implement an effective quota system (Gossen Sitanggang, personal communication, 17 March 2017).

Ban catch and export of fish taken from spawning aggregations or during their spawning seasons

Protection for spawning aggregation sites or seasons is one of the approaches in the responsible (sustainable)

fisheries management "tool box" if there are concerns about reproductive capacity (Sadovy de Mitcheson, 2016). Several grouper aggregation sites in Indonesia have already been identified, and some have been studied in sufficient detail to enable the planning and implementation season of such an approach without waiting for further research. Protecting aggregation sites will have multiple benefits, contributing not only to sustaining or recovery of specific grouper populations, but also contributing to the food security and welfare of fishing communities. To date, only two spawning aggregation sites in Indonesia are protected through the establishment of no take zones designated by Ministry for Marine Affairs and Fisheries. In addition to research, we can detect aggregation sites and spawning season of groupers in Indonesia through fisher information. This approach can be readily applied under the existing national legal framework, as the existence of aggregation sites is one criterion which can be used as the basis for establishing no grouper fishing activities during spawning seasons.

Indonesia could ban fishing and exports and protect spawning sites from any fishing during the aggregation seasons, if these were known. The challenges of enforcement for protecting fish in the reproductive season should be no different from enforcing size limits; in some cases, it might be easier, once the aggregations sites and times were identified. This identification would require substantial investment in terms of money (logistics etc.) as well as human resources (trained observers/researchers) but is not difficult. Aggregations are such a vulnerable part of biology and susceptible to overfishing that we need to pay attention to them, soon.

Size limits on allowable catch

Limiting the size and/or reproductive state of fish or invertebrates which can be legally exploited is one fisheries management tool which is currently implemented by many fisheries worldwide such as in Maldives (Marine Research Center Maldives & and Marine Conservation UK, 2011) and Great Barrier Reef Australia (Mapstone et al., 2008). Furthermore, it has already been applied for invertebrates species in Indonesia (e.g. Ministerial Regulation of the Minister for Marine Affairs and Fisheries Number PER.56/MEN/2016 on the Prohibition of Catching and/or Exporting (undersized/berried) Lobster (*Panulirus* spp.), Mudcrab (*Scylla* spp.), and Swimming Crab (*Portunus* spp.) from The Republic of Indonesia. Under current conditions, this tool would arguably be the most simple management measure to enforce in the context of Indonesian

grouper fisheries and would clearly be appropriate given concerns about the significant take of juvenile groupers and catches of ripe female groupers (i.e. equivalent to berried lobsters-see previous section).

In setting the size limits for groupers, it should be considered that many grouper species are protogynous sequential hermaphrodites, maturing first as females and then undergoing sex reversal when larger to become terminal males. Thus, any size limit controls need to be set at a level which will help to minimize the risk of fishing-induced imbalance in the sex ratio, or declines in average fish size (general population, size at first maturity as females and as males). Although, ideally size limits should be per species, and in some cases, even population (regionally) specific, research is needed to determine appropriate sizes. As a first step towards implementing this approach, and in order to test its application, one size limit could be applied to several species with reasonably similar characteristics. Based on monitoring data and the results from further scientific research, the regulation could be reviewed (at set periods or based on specific data) and refined to better reflect the characteristics of each grouper species and/or stock. The size limit would also apply in the case of wild capture seed.

All possible measures to support sustainable grouper fisheries in Indonesia require appropriate capacity building for fisheries managers and their staff as well as the development and implementation of better control systems to ensure the effectiveness of existing (and future) regulations. In addition, there is a need for better controls on and improved oversight of exports out of airports; while control of foreign vessels that collect fish from mariculture zone should be improved. Both measures would require training of Fish Quarantine officers in grouper identification.

Concluding remarks

Based on the evaluation of available evidence and input from stakeholders, it is abundantly clear that the grouper export trade in Indonesia is highly dependent on wild grouper stocks. Many grouper species and populations (stocks) are under severe threat and declining in abundance and/or quality (size). Some are Near Threatened or Threatened (IUCN Red List status), and without management action the conservation status of groupers will undoubtedly continue to worsen, and will very likely lead to sequential decline and loss (extirpation) of some stocks. Management is further complicated by the

reproductive biology of groupers, aggregation-spawning and sequential hermaphroditism.

After evaluating the advantages of and potential challenges associated with several policy options, two are considered most appropriate in the short-term (i.e. immediately applicable), as an initial strategy to stabilize and begin to rebuild grouper stocks in Indonesia. First, ban both the capture and export of fish from known spawning aggregation areas during grouper spawning seasons. Second, tighten up export regulations with properly enforced standard operating procedures for the oversight of grouper exports by species, both by air and sea, and for both dead and live groupers. Thirdly, place a minimum allowable landing size limits on selected grouper species. This strategy should be kept simple, with periodic revisions based on going research and stock monitoring as well as improved data collection and data management systems. Despite, such regulations should only be considered as a partial and temporary solution, to buy time for the design and implementation of a more holistic strategy including stakeholder education and capacity building, research, and the development of additional policy and regulatory instruments, once finer scale data are available (e.g. spawning times/sites for each grouper species, control of minimum capture sizes).

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