



Troubled times for trysting trio: Three aggregating groupers in the live reef food-fish trade

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The live reef food-fish trade has a long history in Southeast Asia, but expanded particularly rapidly during the 1990s. Today the trade constitutes a multimillion US dollar business that involves countries throughout much of the tropical Indo-Pacific region (Johannes and Riepen 1995; Sadovy et al. 2003). The geographic expansion of the international trade in live fish was due in part to improvements in economic climate and higher consumer demand, and in part to declines in fish stocks in the South China Sea. Improved air links also spurred the expansion, allowing for the more rapid transport necessary for live animals. With the increase in the number of source countries (many located a significant distance from the trade centers of Singapore and in particular Hong Kong, with the latter a gateway to mainland China) came an increase in the number of species in the trade. Most of the species in the trade belong to just a few fish families, above all the groupers (Serranidae).

Groupers make up the bulk of the live reef food-fish trade in terms of both volume and value, comprising hundreds of tonnes each year, and attracting high unit prices at retail (Figs. 1 and 2; Table 1). Groupers tend to be susceptible to high levels of uncontrolled fishing, however, because they are typically long-lived (it is not unusual to find groupers aged 15 or 20 years, or more) and slow to mature; in addition, many species aggregate (form groups) to spawn (reproduce). Their long life and late sexual maturation mean that populations are typically slow to replace themselves, or to recover from overfishing, while their aggregating habit makes them easy to target in large numbers while spawning. In an economically valuable fishery, in which there is much interest in catching as many fish as possible in a short time and shipping them back to demand centres, targeting spawning aggregations is particularly attractive. However, aggregation-fishing can very

rapidly deplete spawning aggregations and, in more extreme cases, lead to serious declines in the fishery (Sadovy and Domeier 2005). All of the species in Table 1 are important live food fish, all aggregate to spawn, and their aggregations are sometimes targeted for the live reef food-fish trade.



Figure 1. Live groupers and a few snappers in a tank outside a restaurant in Hong Kong, awaiting sale to diners. All of the fish have been imported; the sources of live reef food fish found in Hong Kong's markets include Southeast Asia, the eastern Indian Ocean and the western Pacific Ocean. Hong Kong imports an estimated 60% of all fish in the trade (Johannes and Riepen 1995).

In this article I chronicle our growing understanding of the particular vulnerability of and biological interrelationships between three of the most economically valuable species in the live reef food-fish trade: brown-marbled grouper, camouflage grouper and squaretail coral grouper (Fig. 2). I use these three species to demonstrate the vulnerability of aggregating species in the Indo-Pacific to unmanaged fishing (whether for live or dead fish), and explore what we need to know to manage them effectively.

Underwater observations and fisher surveys undertaken over the last three to four years indicate that the camouflage grouper, brown-marbled grouper and squaretail coral grouper form spawn-

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Table 1. The most valued species in overall volume in the live reef food-fish trade centred in Hong Kong. Note that the mouse grouper, *Cromileptes altivelis*, and the giant grouper, *Epinephelus lanceolatus*, are also high in unit value but are not traded in high volumes. Almost all fish of the four listed species have been sourced from the wild.

Scientific name	FAO (Hong Kong trade name) name	Wholesale (retail) price (USD kg ⁻¹) in Hong Kong and southern China (2001) ^a	Price paid to fisher (USD kg ⁻¹) (1999–2001) ^b
<i>Epinephelus fuscoguttatus</i>	Brown-marbled (tiger) grouper	26 (51)	7–12 (Philippines) 1–2 (Indonesia) 4–5 (Australia)
<i>Epinephelus polyphekadion</i>	Camouflage (flowery) grouper	26 (51)	Same as for <i>E. fuscoguttatus</i> although depends on fish size as well
<i>Plectropomus areolatus</i>	Squaretail coralgroupers	Approximately between the prices for <i>E. polyphekadion</i> and <i>P. leopardus</i>	
<i>Plectropomus leopardus</i>	Leopard coralgroupers	38.5 (64)	7–28 (Philippines) 6–12 (Indonesia) 10–25 (Malaysia) 10–17 (Vietnam) 12–33 (Australia)

a. International Marinelife Alliance, Hong Kong Office — data from regular market surveys.

b. Sadovy et al. (2003) — the values are for guidance only since they can vary somewhat within country, according to fish size, etc.

ing aggregations together throughout much of their geographic ranges, and do so more frequently than any other known species groups. The co-occurrence of the three species was initially noted in Palau (Johannes et al. 1994), but only after fisher surveys had been conducted much more widely did it become apparent that this particular species association was both quite widespread and apparently consistent (see the fisher survey reports database of the Society for the Conservation of Reef Fish Aggregations (SCRFA) at www.scrfa.org). Associations between at least two of the species (and often all three) have now been reported from Indonesia, Palau, Federated States of Micronesia, Solomon Islands, Papua New Guinea, Seychelles (no squaretail coralgroupers), New Caledonia (no squaretail coralgroupers), Malaysia, Maldives (no squaretail coralgroupers) and Fiji. The natural geographic ranges of the three species partially explain these patterns: while the camouflage and brown-marbled groupers have very similar global distributions, the squaretail overlaps with the other two only in some areas (Heemstra and Randall 1993). In at least one place where the squaretail coralgroupers does not occur a different *Plectropomus* species makes up the trio. An example of this is *P. punctatus* in the Seychelles (Robinson 2004). In addition to forming large aggregations at sites shared by the two groupers, *P. areolatus* also spawns in other outer reef areas in small groupings. It thus shows signs of being a resident spawner (i.e. it may not travel far from resident sites to form spawning aggregations), like its congener, *P. leopardus* (Domeier and Colin 1997).

Despite these differences, the three species often spawn in the same general areas in outer reef passes or channels or along the outer reef slopes, often not far from passes. Within such shared sites, however, they typically occupy distinctly different areas or habitats, and may not all aggregate at exactly the same time, with spawning activity possibly separated by approximately a month. Moreover, different species will be dominant (numerically) at individual sites, which may reflect individual site characteristics. In some fisher interviews I have even noted that the more observant spearfishers can describe the distribution of these different species in some detail.

The three groupers are economically valuable and vulnerable to uncontrolled fishing, as noted by specific case studies and documented in fisher interviews. One early indication of their vulnerability came from Palau: several grouper spawning aggregations disappeared in or after the 1970s (Johannes and Riepen 1995), possibly due to over-fishing. One of these aggregations consisted mainly of camouflage grouper and brown-marbled grouper and was lost in the 1990s. Another aggregation, mostly of squaretail coralgroupers and brown-marbled grouper, was almost eliminated from Denges Channel in the late 1980s by a live grouper-for-export fishing business.

Fisher interviews conducted by SCRFA in several western Pacific countries during 2003 and 2004 revealed that many of the aggregations of one or more of these species were thought to be declin-

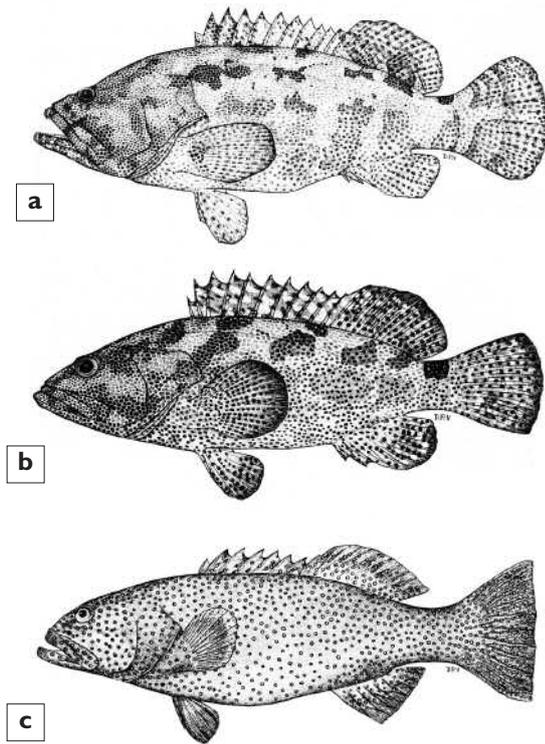


Figure 2. (a) *Epinephelus fuscoguttatus*, brown-marbled grouper; (b) *E. polyphkadion*, camouflage grouper; (c) *Plectropomus areolatus*, squaretail coral grouper. Reproduced with permission from the Food and Agriculture Organization of the United Nations from the publication by Heemstra and Randall (1993).

ing in terms of numbers of fish (Fig. 3). Although these general trends could only be very crudely determined and await validation, different communities often reported very similar patterns for the same aggregation sites and species, suggesting that changes had been consistently perceived by interviewees.

There is a growing realization that spawning aggregations are particularly vulnerable to fishing and that they often need management or protection from excess fishing activity. Aggregations may be targeted for subsistence or commercial purposes, and for live or dead fish. It is the intensity of commercial fishing activities that appears to pose a real threat to spawning aggregations. While the most intense threat in some places may be from the large-scale live reef fish operators (some of whom aim to catch more fish than they need to compensate for mortalities), there is a significant trade in chilled fish that is based on fish caught in aggregations. Moreover, some live fish traders prefer not to take groupers from aggregations because the stress experienced by the animals (especially females full of eggs) during those periods tends to result in high levels of mortality (Patrick Chan, pers. comm. 2003, Chairman, Chamber of Seafood Merchants, Hong Kong). Nonetheless, many fishers and traders continue to view these gatherings as a way to quickly obtain many fish, reduce crew costs, and in the case of traders, to sometimes benefit from the lower prices paid to fishers due to the large numbers of fish that suddenly become available on the market. Aggregations consisting of a trio of grouper species are particularly attractive to fishers and, thus, susceptible to overfishing.

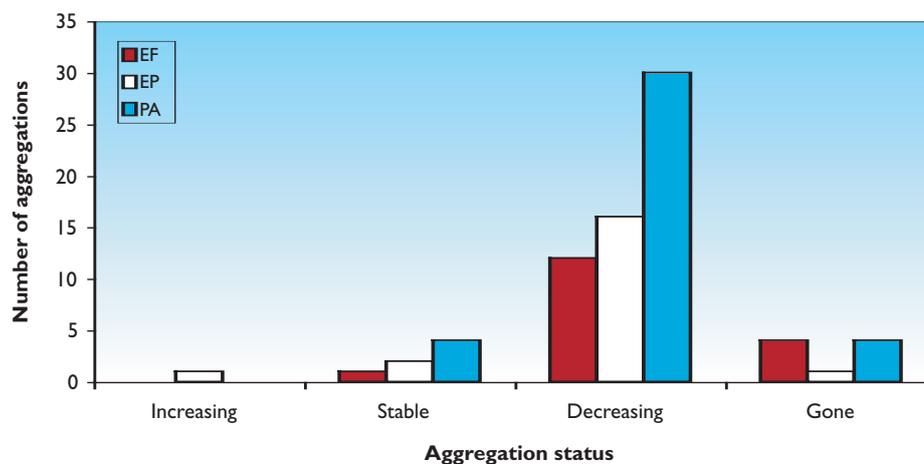


Figure 3. The status (in terms of 4 categories that refer to trends in catches) of 75 aggregations (according to not yet validated fisher surveys) of *Epinephelus fuscoguttatus*, brown-marbled grouper (EF), *E. polyphkadion*, camouflage grouper (EP) and *Plectropomus areolatus*, squaretail coral grouper (PA) from 11 countries in the Indo-Pacific (see database at www.scrfa.org).

To better manage aggregating groupers we need more information on several issues. Some of the most pressing questions are:

- How far do fish travel from their home reefs to the aggregation site and, consequently, how large an area does a single aggregation site “service”? It is important to know how large an area might be affected if an aggregation disappears due to overfishing, and to determine the management area that needs to be considered.
- What proportion of annual landings come from aggregations, and what proportion from fishing activity that targets the species at other times of the year? This information is important in order to determine when and how management can best be implemented — management may be needed during aggregation periods and also at non-aggregating times, for example.
- How should the aggregation be managed? Seasonal closures and sales bans are widely practiced, but it is also possible to protect the spawning site itself. The best approach will depend on the location of the aggregation, enforcement capacity, etc.
- How should the aggregation be monitored, given local social and economic circumstances, enforcement capacity and fishing pressure? Effective management is possible only with good monitoring (see the article by Sadovy, Colin and Domeier in this issue).
- How large is the aggregation area of all species combined? Each species tends to gather in different areas within a larger site, so the combined areas of all three species should be considered if area management is used.
- What are the spawning seasons for each species? This information is important for seasonal management. For example, although the three groupers share an aggregation area, they often do not overlap completely in terms of the timing (months) when aggregation takes place; even within one country, the aggregation timing can vary widely. Therefore, national-level seasonal regulations may not be appropriate and locally relevant measures would need to be adopted.
- Does the value of the fish vary according to whether or not the species is taken during the spawning season or according to the number of fish on the market? For example, in Fiji, fish caught during the aggregating season are sold for 50% of the price at non-aggregating times. Better economic data could help communities plan to get better value for their fish.

I have focused on the three grouper species because they are valuable, heavily sought after for the live reef food-fish trade, and their aggregations can be very predictable in terms of location and timing (although studies are needed to better understand the patterns). Moreover, their potential economic yield makes them especially appealing to target. Careful management can ensure that the aggregations persist, and, with them, both the fish and their fisheries.

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