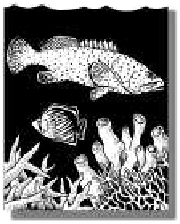

# Live reef food fish trade causes rapid declines in abundance of squaretail coralgrouper (*Plectropomus areolatus*) at a spawning aggregation site in Manus, Papua New Guinea

*Richard J. Hamilton[1] and Manuai Matawai[2]*

## Background

Overfishing by the live reef food fish trade (LRFFT) is recognised as being one of the greatest threats to fish spawning aggregations (FSA) of coral reef fish (Johannes and Riepen 1995; Sadovy and Vincent 2002; Sadovy et al. 2003; Warren-Rhodes et al. 2003). However, direct evidence of FSA loss or decline as a result of LRFFT activities is negligible in the Indo-Pacific (Rhodes and Warren-Rhodes 2005), with the majority of documented accounts being based on the local knowledge of fishers (Johannes et al. 1999; Hamilton et al. 2005a; Sadovy 2005; Sadovy and Domeier 2005). In this paper we present evidence from Melanesia that quantitatively demonstrates the impact of the LRFFT on the FSA of the squaretail coralgrouper (*Plectropomus areolatus*). We do this by compiling underwater visual census (UVC) data that were collected from three grouper FSA sites located on the south coast of Manus, in Papua New Guinea. Two of the three monitored sites (Sites 29 and 33)[3] have never been opened to the LRFFT, while the third site (Site 35) was exploited to supply the LRFFT between July and December 2005. Our preliminary results show that relative to the two unfished "control" sites, *Plectropomus areolatus* abundances and densities at Site 35 declined very rapidly following the commencement of the LRFFT. The UVC survey results also show that peak FSA of *P. areolatus* formed at Sites 29 and 33 between March and June 2006, as was predicted by local fishers. During the same period, no clearly defined peak season was detected at Site 35.

## Environmental and social setting

The locations, biological parameters, and status of more then 10 grouper FSA sites in Manus (Fig. 1) were documented in several local knowledge and UVC surveys that were commissioned by the Papua New Guinea National Fisheries Authority (NFA), The Nature Conservancy (TNC) and the Society for the Conservation of Reef Fish Aggregations (SCRFA) (Squire 2001; Hamilton 2003; Hamil-


**Figure 1.** Manus Island and the Hermit Islands, Papua New Guinea.

1. The Nature Conservancy, Indo-Pacific Resource Centre, PO Box 8106, Woolloongabba, Qld 4102, Australia. Tel: +617 3214 6913. Fax: +617 3214 6999. Email: rhamilton@tnc.org
2. The Nature Conservancy, Manus Field Office, PO Box 408, Lorengau, Manus Province, Papua New Guinea. Tel: +675 470 9368. Email: manuai.tnc@global.net.pg
3. By convention, The Nature Conservancy refers to aggregations by site numbers rather than their location names so as to limit dissemination of aggregation location information

ton et al. 2004). Out of all of the known FSA sites, three sites, Sites 29, 33 and 35, were identified as being of very high conservation priority. These three FSA sites are all located on reef promontories along the south coast of Manus Island and come under the customary ownership of four communities from the Titan tribe. They are the largest of all known grouper FSA sites in Manus and they all have a high biodiversity value (Hamilton et al. 2005b). The squaretail coralgrouper[4], brown-marbled grouper (*Epinephelus fuscoguttatus*) and camouflage grouper (*E. polyphekadion*) are known to aggregate at these sites at overlapping times and locations. Local fishers report that *P. areolatus* FSA form at Sites 29, 33 and 35 during the third quarter of every lunar month of the year, with a peak season in the months of March, April and May, during which time the abundance of *P. areolatus* at FSA sites is an order of magnitude higher than in other months of the year.

In early 2004 we held community awareness meetings on the importance of conserving grouper FSA with the four Titan communities that own the reefs on which Sites 29, 33 and 35 are located. All of the communities subsequently expressed an interest in managing their FSA sites and requested that TNC provide them with technical assistance in their efforts. Over a period of several months the communities discussed the issues among themselves and asked us for advice on a variety of management options they were considering for their spawning sites. By May 2004 all four Titan communities had banned spearfishing at these three FSA sites in the 10 days leading up to and including the new moon in every month of the year. Capturing fish for sale was also banned. Subsistence hook-and-line fishing was allowed at these sites but fishers could only catch enough fish to meet their daily food requirements. The Titan communities all made a point of not stating how long their harvesting restrictions would be in place. Rather, the communities stated that the suitability and effectiveness of these initial restrictions would be reassessed in several years' time.

Although compliance with these rules was strong, the robustness of community-based management to outside commercial pressures were tested in June 2005 when NFA and the Manus Provincial Government allowed the New Guinea Islands Sea Products (NGISP) LRFFT company into the south coast of Manus[5]. NGISP immediately expressed interest in fishing Sites 29, 33 and 35, along with several other known grouper FSA sites in the area. While the traditional owners of Sites 29 and 33 did not allow the company access to their reefs (the fishing was actually done by local fishers, who sold the catch to NGISP), the owners of Site 35 did. Between July and December 2005 the community that owns the reef on which Site 35 is located caught 13 tonnes (t) of fish for the LRFFT. Approximately 50% of this catch was made up of *P. areolatus*, with the humphead wrasse (*Cheilinus undulatus*) and *E. fuscoguttatus* being the second and third largest components of the catch. At least half of the *P. areolatus* captured was taken from Site 35 (personal observations of the author, Manuai Matawai, July to December 2005).

While many *P. areolatus* were captured by fishers drop-lining from canoes, some fishers utilized a unique and highly efficient means of capturing *P. areolatus*. A fisher would snorkel on the surface at Site 35 with a small handline, and when a *P. areolatus* was sighted on the reef below he would lower a baited hook directly in front of the fish. Hooked fish would be hauled up by the snorkeler and placed in a nearby canoe. Fishers report that this method has a much higher catch per unit of effort (CPUE) rate than handline fishing from a canoe.

## UVC methods

The first UVC surveys to be conducted at Sites 29, 33 and 35 were undertaken in the week leading up to the new moon in March 2001 (Squire 2001). Squire's UVC methodology involved descending to a depth of 20–30 m on scuba and swimming along the entire length of the aggregation site with the prevailing current, recording on underwater paper the total number of *P. areolatus, E. fuscoguttatus* and *E. polyphekadion* seen. Fish characteristics that are indicative of spawning in these species were also documented, such as colour change, territoriality, and gravid females. Manuai Matawai showed Squire the locations of Site 29, 33 and 35 and participated in Squire's 2001 surveys. In May and June 2004 he resurveyed the three sites using identical methods to those described above.

4. In this paper we limit our discussion to the effect of the LRFFT on *P. areolatus* aggregations. This species is the most abundant grouper at all three sites.
5. A second LRFFT company, Golden Bowl PNG Ltd, began operating around the Ninigo and Hermit Islands, within Manus Province to the west of Manus Island, in June 2005. This is the same area that was fished by LRFFT operations from 1990–1992. Those operations were stopped by the provincial government in 1992 because of various social and environmental concerns (Richards 1993; Gisawa and Lokani 2001). The 2005 Golden Bowl PNG Ltd operation purchased approximately 4 t of groupers and humphead wrasse (*Cheilinus undulatus*) from the Ninigo and Hermit Islands over a period of approximately one month. After the first month of operation a physical confrontation occurred between resource owners and company representatives, apparently because the company fished within two no-take *tambu* areas that the community had set aside as conservation areas. The company representatives subsequently left the region, and by September 2005 Golden Bowl PNG Ltd had left Manus Province (Hamilton et al. 2005b).

Manuai Matawai's 2004 surveys confirmed the presence of large FSA of both *P. areolatus* and *E. fuscoguttatus* at all three sites. At all sites *P. areolatus* and *E. fuscoguttatus* overlap in their spatial distributions, although *P. areolatus* primarily aggregates in the shallower part of these sites (3–15 m depth), whereas *E. fuscoguttatus* is primarily found in the deeper part (15–40 m depth). The UVC surveys conducted at Sites 29, 33 and 35 in May and June 2004 revealed that the number of groupers and the areas over which they aggregated were too large to enable total counts to be made in a single scuba dive, so a decision was made that in future surveys, fish would be counted over just a portion of the area in which they aggregate (Hamilton et al. 2004).

In July 2004, after consultations with the relevant communities, permanent belt transects were established at Sites 29, 33 and 35 (Fig. 2). Two transects were established at each site: a deep transect with a midline at 25 m that samples the high density *E. fuscoguttatus* and low density *P. areolatus* aggregations and a shallow transect with a midline at 10 m that samples the high density *P. areolatus* and low density *E. fuscoguttatus* aggregations. The permanent belt transects are all 100 m long and 10 m wide. Transects were established using the methodology set out in the TNC FSA monitoring manual (Pet et al. 2006). Logistical difficulties prevented monthly monitoring in much of 2004 and the first half of 2005.

Routine monthly monitoring commenced at Sites 29, 33 and 35 in July 2005 and has continued to the present. Monitoring occurs in the three days leading up to the new moon of each month, and involves two scuba divers counting all of the *P. areolatus*, *E. fuscoguttatus* and *E. polyphekadion* sighted within the transect boundaries. Each transect is surveyed once per month. For the purpose of this paper, only the monthly *P. areolatus* data collected along the single shallow 1000 $m^2$ transects at each site are presented. With the exception of the Squire (2001) data, all counts of *P. areolatus* presented in this paper were made by Manuai Matawai.

## UVC results

Titan fishers report that the largest *P. areolatus* FSA form at Site 35 (Hamilton 2003; Hamilton et al. 2004). This assertion is supported by UVC surveys that were conducted in March 2001 and May and June 2004 (Fig. 3). In all years and months sur-

**Figure 2.** Manuai Matawai (left) and Jerry Pakop (right) conducting monitoring along permanent transects at Site 33. Photo credit and copyright, Eric Henningsen, Ion Digital Films.

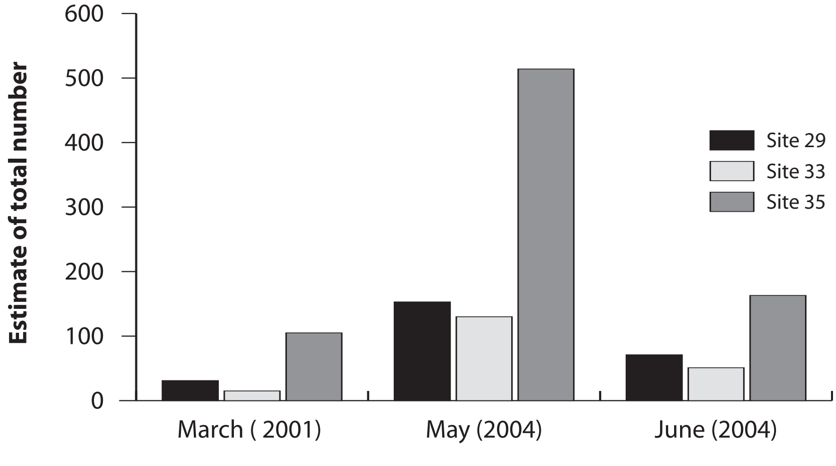


**Figure 3.** Number of *P. areolatus* counted at each site on a single dive prior to the new moon (these counts were intended to approximate the total number of fish at each site). March 2001 data were collected by Squire (2001). May and June 2004 data were collected by Manuai Matawai (Hamilton et al. 2004).

veyed, *P. areolatus* were at least twice as abundant at Site 35 as at Sites 29 and 33. Note that these counts of *P. areolatus* significantly underestimated total abundance during months when large aggregations formed. The 2001 and 2004 surveys focused predominantly in deeper water in order to get accurate counts of *E. fuscoguttatus*, but *P. areolatus* aggregate right up onto the reef flats in 2–3 m of water. We estimate that in May 2004, the actual total numbers of *P. areolatus* at the three surveyed sites were at least double the numbers counted (Hamilton et al. 2004).

Regular new moon monitoring along permanent belt transects began in July 2005. Figure 4 shows the densities of *P. areolatus* along 1000 $m^2$ shallow-water transects at each aggregation site between July 2005 and September 2006[6]. The UVC data show that densities of *P. areolatus* at Site 35 were, contrary to the observations in 2001 and 2003–2005, lower than at the two unfished sites in 2006, and in 2006 no peak season was detected at Site 35.

## Discussion

As was predicted by local fishers, UVC surveys show that *P. areolatus* were present at the FSA sites in virtually every month of the year between July 2005 and September 2006, with a marked peak season at Site 29 and 33 between the months of March and June 2006. The UVC surveys also show that during the peak season in 2006 much higher abundances of *P. areolatus* were seen at the two unfished sites than at the commercially fished site. This finding contrasts dramatically with local knowledge and historical UVC data that show that prior to 2006, the largest *P. areolatus* aggregations formed at Site 35 (Squire 2001; Hamilton 2003; Hamilton et al. 2004). Indeed, during the peak season in 2006 *P. areolatus* abundances at Site 35 fell well short of abundances seen at this site during the tail end of the 2005 season. The absence of a detectable peak season at Site 35 in 2006 may also be indicative of overfishing by the LRFFT.

However, our data series to date is limited and we will require several more years of continuous monitoring before the impact of the LRFFT at Site 35 can be assessed with confidence. At this stage our limited available data do not allow us to rule out the possibility that the annual variation in the numbers of *P. areolatus* sighted at Site 35 represents natural variation in response to factors such

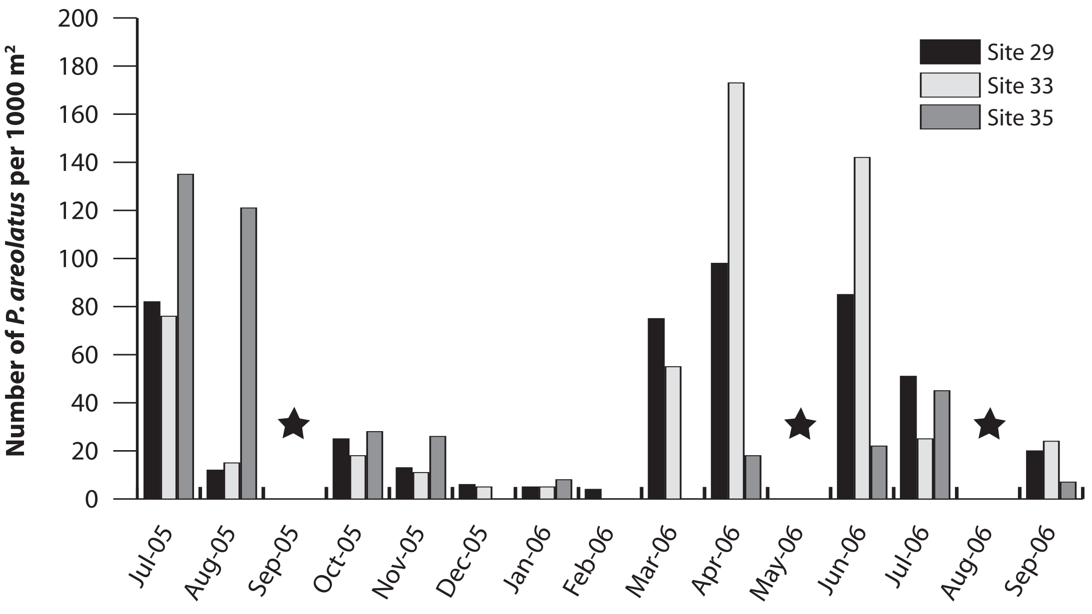


**Figure 4.** Number of *P. areolatus* counted in each shallow water 1000 $m^2$ transect at Sites 29, 33 and 35 (these counts are not directly comparable with those in 2001 and 2004). The symbol ★ indicates that no UVC surveys were conducted in that month. Between July and December 2005, Site 35 was fished to supply a LRFFT operation.

6 . The shallow water transects at Site 29 and 35 cover approximately 15 and 12 per cent, respectively, of the shallow water *P. areolatus* aggregation areas (Hamilton et al. 2005b). Estimates of total abundance of *P. areolatus* at depths of 3–15 m at Sites 29 and 35 in any particular month can be made by multiplying transect counts by 6.72 and 8.13, respectively.

as varying levels recruitment. Indeed, a longer term monitoring programme that focused on three FSA sites in Palau revealed considerable variation in the size of *P. areolatus* FSA between consecutive years, and such variability could not be attributed to fishing pressure (Johannes et al. 1999). These considerations aside, all available evidence indicates that in only six months of LRFFT activity the abundance of *P. areolatus* at Site 35 were reduced to one-third of what they were previously.

The Manus case study presented here provides some insights for conservationists and fisheries managers working in Papua New Guinea. It demonstrates that simply raising awareness of the potential environmental consequences of engaging in the LRFFT and targeting FSA will not necessarily prevent communities from entering into this trade. In southern Manus the same community that readily imposed and enforced some harvesting restrictions on Site 35 in early 2004 following TNC awareness campaigns also engaged in LRFFT operations at the very first opportunity. The about-turn of the community that owns Site 35 highlights the challenges of biodiversity-focused conservation and sustainable fisheries management in remote underdeveloped areas of Papua New Guinea. Within Melanesia, fundamental aspirational differences often exist between various sectors of a community with regards to resource exploitation levels and the management and conservation of FSA. The effective management and conservation of FSA will require approaches that acknowledge and deal positively with these aspirational differences.

The LRFFT operation around Site 35 in 2005 deeply divided the community that holds ownership of this site, with many individuals upset about the prices received and ecological damage caused by the trade. Yet despite this, in July 2006, Site 35 and surrounding reefs were again opened up to the LRFFT. Clearly, in spite of the social and ecological problems caused by the LRFFT, the lack of income-generating opportunities in the rural coastal areas of Manus means that interest in the LRFFT remains high.

On a more positive note, social and environmental concerns about the LRFFT resulted in the communities that own Sites 29 and 33 not participating in the LRFFT in 2005, and in 2006 the community that owns Site 29 took a further step towards conserving its grouper FSA by announcing a complete ban on all types of fishing at Site 29. This community is also working to have its community-based management regulations recognized and endorsed through local level government laws.

## Acknowledgements

First and foremost we thank the communities of Pere, Locha, Tawi and Peli for supporting the monitoring work that has occurred at their FSA over the past two years. We also owe a special thank you to Jerry Pakop, who has been conducting monthly UVC monitoring with Manuai Matawai since 2005. Dr Kevin Rhodes and Dr Andrew Smith both made helpful comments on an earlier version of this paper. This work has been generously supported by the US Agency for International Development, the Oak Foundation and The David and Lucile Packard Foundation. The US Agency for International Development support was provided to The Nature Conservancy through the Office of Procurement, under the terms of Award No. LAG-A-00-99-00045-00. The opinions expressed herein are those of the authors and do not necessarily reflect the views of the US Agency for International Development.

## References

Gisawa L. and Lokani P. 2001. Trial community fishing and management of live reef food fisheries in Papua New Guinea. SPC Live Reef Fish Information Bulletin 8:3–5.

Hamilton R. 2003. A report on the current status of exploited reef fish aggregations in the Solomon Islands and Papua New Guinea – Choiseul, Ysabel, Bougainville and Manus Provinces. Western Pacific Fisher Survey Series, Volume 1 (confidential appendix). Society for the Conservation of Reef Fish Aggregations.

Hamilton R.J., Matawai M. and Potuku T. 2004. Spawning aggregations of coral reef fish in New Ireland and Manus Provinces, Papua New Guinea: Local knowledge field survey report (unrestricted access version). TNC Pacific Island Countries Report No. 4/04 (Unrestricted). Pacific Island Countries Coastal Marine Program, The Nature Conservancy. iv + 99 p.

Hamilton R.J., Matawai M., Potuku T., Kama W., Lahui P., Warku J. and Smith A. 2005a. Applying local knowledge and science to the management of grouper aggregation sites in Melanesia. SPC Live Reef Fish Information Bulletin 14:7–19.

Hamilton R.J., Mous P. and Smith A. 2005b. Advanced workshop on monitoring reef fish spawning aggregations, 2–11 June 2005, Pere, Manus Province, Papua New Guinea. TNC Pacific Island Countries Report No. 6/05. Pacific Island Countries Coastal Marine Program, The Nature Conservancy. v + 37 p.

Johannes R.E. and Riepen M. 1995. Environmental, economic, and social implications of the live reef fish trade in Asia and the Western Pacific. The Nature Conservancy and the South Pacific Forum Fisheries Agency. 79 p.

Johannes R.E., Squire L., Graham T., Sadovy Y. and Renguul H. 1999. Spawning aggregations of groupers (Serranidae) in Palau. Marine Conservation Research Series Publication No.1. Honolulu, Hawaii: The Nature Conservancy.

Pet J.S., Mous P.J., Rhodes K. and Green A. 2006. Introduction to monitoring of spawning aggregations of three grouper species from the Indo-Pacific: A manual for field practitioners. Version 2.0 (January 2006). Sanur, Bali, Indonesia: The Nature Conservancy Southeast Asia Centre for Marine Protected Areas. 93 p.

Rhodes K.L. and Warren-Rhodes K. 2005. Management options for fish spawning aggregations of tropical reef fishes: A perspective. TNC Pacific Island Countries Report No. 7/05. Pacific Island Countries Coastal Marine Program, The Nature Conservancy. 65 p.

Richards, A. 1993. Live reef fish export fisheries in Papua New Guinea: Current status and future prospects. FFA Report No. 93/10. Honiara: Forum Fisheries Agency (FFA) Research Coordination Unit. 16 p.

Sadovy Y. 2005. Troubled times for trysting trio: Three aggregating groupers in the live reef food-fish trade. SPC Live Reef Fish Information Bulletin 14:3–6.

Sadovy Y. and Domeier M. 2005. Are aggregation-fisheries sustainable? Reef fish fisheries as a case study. Coral Reefs 24(2):254–262.

Sadovy Y.J. and Vincent A.C.J. 2002. The trades in live reef fishes for food and aquaria: Issues and impacts. p. 391–420. In: Sale P.F. (ed.). Coral reef fishes: Dynamics and diversity in a complex ecosystem. San Diego: Academic Press.

Sadovy Y.J., Donaldson T.J., Graham T.R., McGilvray F., Muldoon G.J., Phillips M.J., Rimme M.A., Smith A. and Yeeting B. 2003. While stocks last: The live reef food fish trade. Manila: Asian Development Bank. 147 p.

Squire L. 2001. Live reef fish trade at M'burke Island, Manus Province: A survey of spawning aggregation sites, monitoring and management guidelines. The Nature Conservancy. 32 p.

Warren-Rhodes K., Sadovy Y.J. and Cesar H. 2003. Marine ecosystem appropriation in the Indo-Pacific: A case study of the live reef fish food trade. Ambio 32(7):481–488.