the park. Villagers throughout the park (there are 30,000 of them!) put the newly-installed VHF village radio system to good use — cyanide and blast fishing incidents were reported immediately to the patrols, who quickly arrested those involved and confiscated compressors, boat engines, and bombs and cyanide.

Bombing in the southern section of the park, previously rampant, was halted completely in a matter of months. Big businessmen behind the live fish cages tried numerous ploys to stop the campaign (including lobbying hard to senior police force members and even the governor for the transfer of the newly-invigorated water police chief), but an active media campaign to 'glorify' the police, rangers and villagers involved in the war seems to have provided job security (at least for now) for these key players. Just as importantly, several judges in the court system have taken note of the declaration of war, and have been actively cooperating in sentencing the perpetrators to the fullest extent of the law.

And what of the average villager in Bunaken National Park? That's always a tough question to answer, but the general impression is that most are very satisfied with the tough stance on DFP. To be sure, there are those complaining loudly (i.e. those with a direct economic stake in DFP), but the fact that villagers from the more remote islands in the park are calling for an expansion of the patrol system to include posts in their area is positive proof that most fishers would prefer to make their own choices on how to use their reef resources rather than have DFP criminals unilaterally deciding to destroy them. Perhaps most interestingly, there have been very few calls for alternative livelihoods. Folks in Bunaken seem to have the attitude that it is a person's own responsibility to choose a legal livelihood. Governments, NGOs and aid programmes should give this perspective serious consideration…

Two responses to:

The live fish trade on Queensland's Great Barrier Reef: Changes to historical fishing practices.

by Mapstone et al., this Bulletin #9 (Dec. 2001): 10–13.

1. Comments by Melita Samoilys[1]

The article by Mapstone et al. (2001) was a summary of their extremely detailed and comprehensive study on the commercial line fishery on the Great Barrier Reef (GBR) and the impacts of the live reef food fish trade (LRFFT) on that fishery, which is reported in full in a Cooperative Research Centre Technical Report (Mapstone et al. 2001). This work is part of the broader Effects of Line Fishing Project (ELF) of which I was a part from 1995–1999. There are two main points I would like to make in response to their article. One concerns the viability of a live reef food fish trade, and the other concerns the targeting of spawning aggregations.

Although there have been various statements that the LRFFT is managed well on the GBR and does not have a detrimental effect on fish populations, Mapstone and co-workers provide the first set of comprehensive data to support this statement. This finding is extremely relevant to the debate on whether the LRFFT is a sustainable fishery. In most parts of the Pacific it is clearly not (see many articles in this Bulletin).

However, on the GBR Mapstone and co-workers show that the LRFFT has actually resulted in decreased catch rates of the target species, coral trout, probably from increased handling time. In addition, fishing for live fish significantly reduces the catch of byproduct. Therefore, if fishers are switching from dead to live product because it is value adding, it is likely to have both economic and ecological benefits for the commercial fishery. These workers point out, the LRFFT may have been responsible for an increase in effort in the fishery, but this reflects poor effort control within the fishery rather than inherent problems with the LRFFT (see Mapstone et al. 1996, 2001; QFMA 1996, 1999 for details on the fishery and its regulations).

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The GBR fishery provides an example that other countries considering the LRFFT should examine. Herein lies the challenge: What are the dynamics and behaviour of the fishery in other countries that are comparable to those of the GBR? Is the GBR fishery a good example for Pacific Island and Southeast Asian countries where the LRFFT is prevalent and spreading? I believe the answers will lie in the species being targeted, the methods of targeting and the dynamics of the fishery. Mapstone and co-workers focus on coral trout, predominantly *Plectropomus leopardus*, because it forms the bulk of the commercial catch on the GBR (Mapstone et al. 1996; Turnbull and Samoilys 1997). In contrast, the LRFFT in Pacific Island countries targets *P. areolatus*, as well as *Epinephelus fuscoguttatus* and *E. polyphekadion* (e.g. Johannes et al. 1999). There are large differences in the population abundance, spawning aggregation characteristics and other life history parameters of these species that will all have a bearing on their vulnerability to fishing, whether live or dead. *P. leopardus* mature early, are fast growing and occur in relatively high numbers on the GBR compared with other *Plectropomus* species and other LRFFT targeted serranids in the Pacific Islands (Ferreira and Russ 1994; Samoilys et al. 1995; Froese and Pauly 1998; Ayling et al. 2000; Samoilys 2000; S. Adams unpubl. data). Furthermore, spawning aggregations of *P. leopardus* are relatively small, and there are probably more of them per unit area of reef, compared with other LRFFT serranids (Johannes 1988; Samoilys 1997; Johannes et al. 1999; Samoilys 2000).

The second point I wish to make concerns the lack of evidence for targeted fishing of spawning aggregations of coral trout found by Mapstone and co-workers. As regular readers of this Bulletin will know, spawning aggregations are highly vulnerable to targeted fishing in many parts of the world, therefore the GBR situation needs to be carefully examined.

Mapstone and co-workers' study was comprehensive and involved three different methods for assessing the commercial GBR fishery: 1) compulsory logbooks (number not given, but up to nearly 600 vessels are involved (QFMA 1999)); 2) voluntary logbooks (n = 126 fishing trips from 17 fishers selling their catch frozen, and 17 fishers selling their catch alive); and 3) observers on board commercial fishing trips (n = 29, 16 'dead trips', 13 'live trips'). (The fourth method mentioned interviews with fishers was not used to look at the issue of targeting aggregations).

Assessment was based on comparing daily catch and effort data between moon phases since coral trout aggregate to spawn on the new moon (Samoilys 1997). Most analyses appear to come from the compulsory log book data. The accuracy of the compulsory log book data depends on fishers faithfully recording their catch and effort on a daily basis, and this has never been formally validated. Extensive analyses of this data indicate that they are useful and effective for revealing broad patterns, trends, and dynamics in the fishery, particularly over years, seasons and regions (Mapstone et al. 1996, 2001). Their reliability for detecting daily patterns in catch and effort has not been tested.

To detect a correlation between effort, catch or CPUE and lunar phase within a short spawning season is highly dependent on log books being recorded accurately to the day, and this is questionable. Of greater interest is the fact that the observer programme was unable to examine fishing of spawning aggregations because those skippers participating in the programme were not structuring their fishing to correspond with the lunar phase. This in itself is revealing, because it suggests that these fishers were not structuring their trips to target spawning aggregations.

However, fishers often guard their knowledge, though the ELF project has developed an impressive relationship of trust with commercial operators (pers. obs.). Probably of more relevance is the fleet structure of the GBR commercial fishery. The fishery is dominated in terms of effort, catch and catch rate by a relatively small proportion of large vessels run by highly experienced skippers (Mapstone et al 1996). These vessels operate over large areas of the GBR and are therefore far less likely to operate with local or traditional knowledge of specific reef sites, the sort of knowledge that enables the targeting of spawning aggregations. They are therefore not likely to be targeting spawning aggregations. The observer programme was based on these vessels and therefore it is not surprising that Mapstone and co-workers could not structure their observer programme around the lunar phase.

The lack of evidence for changes in catch and effort at the time of spawning aggregations of coral trout is not conclusive evidence that targeted fishing of spawning aggregations is not occurring. Since we lack historic data both on the fishery and on spawning aggregations, it is difficult to progress this debate. I can provide a small example of possible targeted fishing on a spawning aggregation of *P. leopardus*. My research with the Queensland Department of Primary Industries established a long-term monitoring programme of two spawning aggregations of *P. leopardus* that started in 1990 (Samoilys 1997).

Recent surveys have shown that one aggregation has collapsed and information from local fishers suggests this was caused by targeted fishing by local commercial vessels that know the spawning site. These results have been presented to ELF, the Great Barrier Reef Marine Park Authority and two conferences (Australian Coral Reef Society 1999 and the Indo Pacific Fish Conference, 2001) but remain unpublished (Samoilys et al. in prep.) and therefore, understandably ignored. This example illustrates that the state of knowledge of reef fish spawning aggregations and their vulnerability to fishing on the GBR is close to zero.

In conclusion, the real issue is the dearth of information on spawning aggregations of exploited reef fish species on the GBR. To my knowledge there have only been two studies, both on *P. leopardus*, spanning three reefs (Samoilys and Squire 1994; Samoilys 1997; Zeller 1998). This is extraordinary considering there are close to 3000 reefs on the GBR where a wide range of commercially exploited serranids and lutjanids occur, and these species are known to form consistent, large, spawning aggregations elsewhere (e.g. Domeier and Colin 1997). The article by Mapstone and co-workers should provide a strong impetus for research in this very open field. Comparative studies across the Pacific would be especially revealing and relevant to the management of the LRFFT.

2. Comments by Lyle Squire[2]

I applaud the extensive work by Mapstone and co-authors (this Bulletin, #9:10–13) on the live reef fishery on the Great Barrier Reef (GBR). I would like to comment, however, on their statements that there is ‘little evidence of the consistent targeting of spawning aggregations of coral trout by commercial fishers’ and that because aggregations of this species (*P. leopardus*) are small, this would make them ‘difficult to find and the benefits of searching for them minimal’.

Here I would like to provide information that casts some doubt on these assertions, although I realise that scientific proof is absent. Although aggregations of *P. leopardus* (henceforth ‘coral trout’) are typically small,[3] there are a great many of them. As an aquarium fish collector my work has sometimes involved many hours per day working in shallow water while covering large areas of reef. During this work my research interest in spawning aggregations of coral trout (e.g. Samoilys and Squire 1994; Johannes et al. 1999) have prompted me to make particular note of them. In the course of single days during peak coral trout spawning aggregation periods I have counted more than 100 coral trout spawning aggregations spread over reef complexes on the order of 5 km^2.

Only a small percentage of coral trout may join spawning aggregations at any one time (Fulton et al. 2000). But this is where these fish are found to be most heavily concentrated during spawning periods. Fishers who search for ‘hangs’ (areas where the fishing is especially good) are thus most likely to find them when aggregated during these periods.

This is true whether or not they recognise them as spawning aggregations. Some do not; it may not be apparent if they don’t gut the fish, and since a catch of 10 to 20 per aggregation today is much less than what one normally associates with spawning aggregations of many other species. For these fishermen they are just good ‘hangs’. In recent years I have found that at any one time the average coral trout aggregation site holds about 30 fish at peak spawning time.

However, other fishermen do recognise when they are fishing from spawning aggregations. After reading the Mapstone et al. article I asked the managers of two live reef fish facilities to question their fishermen on my behalf on whether or not they targeted spawning aggregations. Eight out of twenty replied that they did.

To get a better handle on this issue, I suggest that some form of validation of fishers’ logbooks be introduced, so that they provide information on fishing trends in which fisheries managers can have more confidence. For validation one might periodically pick fishers at random to see how well their logbooks match their invoices or tally with buyers’ records. Eventually a more reliable picture of fishing trends should emerge, including improved time-related catch data that will provide a better indication of whether or not targeting of spawning aggregations of coral trout is important. I believe it is.

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3. Coral trout have been fished on the GBR for three generations and they have been and continue to be the most important species by far in the commercial fishery. Most of today’s aggregations could be mere remnants of once much larger aggregations. I was involved in a study of an aggregation that consisted of 50–75 fish ten years ago (Samoilys and Squire 1994). We considered it to be quite large by the standards of the day. It has since been largely protected from fishing. The last time I visited it at peak spawning time in 2001 there were over 400 fish in it.

References

Ayling, A.M., M.A. Samoilys and D. Ryan. 2000. Trends in common coral trout populations on the Great Barrier Reef. Report to the Queensland Fisheries Management Authority. Inf. Ser. Dep. Prim. Ind. (Queensl.), QDPI, Brisbane, Qld., Australia, 37 p.

Domeier, M.L. and P.L. Colin. 1997. Tropical reef fish spawning aggregations: Defined and reviewed. Bull. Mar. Sci. 60(3):698–726

Ferreira, B.P. and G.R. Russ. 1994. Age validation and estimation of growth rate of the coral trout, *Plectropomus leopardus*, (Lacepede 1802) from Lizard Island, Northern Great Barrier Reef. Fish. Bull. 92:46–57.

Froese, R. and D. Pauly (eds). 1998. Fishbase 98: Concepts, design and data sources. ICLARM, Manila, Philippines.

Fulton, E.A., D. Dault, B.D. Mapstone and M. Sheaves. 2000. Spawning season influences on commercial catch rates: Computer simulation and *Plectropomus*, a case in point. Canadian Journal of Fisheries and Aquatic Sciences 56:1096–1108.

Johannes, R.E. 1988. Spawning aggregation of the grouper, *Plectropomus areolatus* (Ruppel) in the Solomon Islands. Proc. 6th Coral Reef Symp. 2:751–755

Johannes, R.E., L. Squire, T. Graham, Y. Sadovy and H. Renguul. 1999. Spawning aggregations of groupers (Serranidae) in Palau. The Nature Conservancy Marine Research Series Publication No.1, 144 p. (Available online at: www.tnc.org/asiapacific).

Mapstone, B.D., J.P. McKinlay and C.R. Davies. 1996. A description of the commercial reef line fishery logbook data held by the Queensland Fisheries Management Authority. Report to the QFMA from the CRC Reef Research Centre and the Department of Tropical Environment Studies and Geography, James Cook University, Townsville, Australia, 480 p.

Mapstone, B.D., C.R. Davies, S.J. Slade, A. Jones, K.J. Kane and A.J. Williams. 2001. Effects of live fish trading and targeting spawning aggregations on fleet dynamics, catch characteristics, and resource exploitation by the Queensland commercial demersal reef line fishery. CRC Research Centre, Townsville, 72 p.

QFMA. 1996. Queensland Tropical Coral Reef Fish Species. Discussion Paper No.2. Prepared for the Queensland Fisheries Management Authority by the Reef Fish Management Advisory Committee.

QFMA. 1999. Draft Management Plan and Regulatory Statement. Queensland coral reef fin fish fishery. Prepared by the Queensland Fisheries Management Authority with the Reef Fishery Management Advisory Committee

Samoilys, M.A. 1997. Periodicity of spawning aggregations of coral trout, *Plectropomus leopardus* (Pisces: Serranidae) on the northern Great Barrier Reef. Mar. Ecol. Prog. Ser. 160:149–159.

Samoilys, M.A. 2000. Reproductive dynamics of an exploited serranid on the Great Barrier Reef. PhD dissertation, James Cook University, Townsville, 105 p. + appendix.

Samoilys, M. and L. Squire. 1994. Preliminary observations of the spawning behaviour of coral trout, *Plectropomus leopardus* (Pisces, Serranidae), on the Great Barrier Reef. Bulletin of Marine Science 54:332–342.

Samoilys, M.A., L.C. Squire and A. Roelofs. (in prep.). Long term monitoring of coral trout spawning aggregations: implications for fisheries management.

Samoilys, M., H. Fuentes, I. Tuwai, B. Tikomainiusiladi, J. Leqata, E. Oreihaka, A. Mobiha, T. Potuku, D. Die, S. Connell, M. Lincoln Smith, M. Wilson and R. Watson. 1995. Application of Underwater Visual Census to Assessing Coral Reef Fish Stocks in the Tropical Pacific. Report prepared for the Australian Centre for International Agricultural Research (ACIAR). ACIAR Project Number 9304, Final Report, September 1995, (unpubl.) 225 p. + appendices.

Zeller, D.C. 1998. Spawning aggregations: Patterns of movement of the coral grouper *Plectropomus leopardus* (Serranidae) as determined by ultrasonic telemetry. Mar. Ecol. Prog. Ser. 162:253–263.