

## Management of the grouper fishery of the Maldives

Shahaama A. Sattar<sup>1</sup>, Ahmed Najeeb<sup>1</sup>, Fahmeeda Islam<sup>2</sup>, Mariyam Shidha Afzal<sup>2</sup>, Elizabeth Wood<sup>3</sup>

<sup>1</sup>Darwin Reef Fish Project, MCS(UK), MRC, Min. of Fisheries & Agriculture, Male', Rep. of Maldives

<sup>2</sup>Marine Research Centre, Min. of Fisheries & Agriculture, Male', Rep. of Maldives

<sup>3</sup>Marine Conservation Society, Unit 3, Wolf Business Park, Alton Rd., Ross-on-Wye, Herefordshire, HR9 5NB, United Kingdom

Corresponding author: [anajeeb.drfp@gmail.com](mailto:anajeeb.drfp@gmail.com)

**Abstract.** The grouper (family Serranidae, Subfamily Epinephelinae) fishery in the Maldives has reached a crucial stage in its exploitation, where management is not simply an issue of something that is required for the fishery, but something, which at this stage is critically needed. The market oriented grouper fishery in the Maldives which started in the early 1990s, soon escalated, spreading throughout the Maldives, with the export market (live and fresh chilled exports) being the sole source of demand. The lack of management of this fishery has resulted in an unsustainable fishery showing a declining trend. Live exports (high value) are on a continual decline. Decrease in size, a classic sign of over-fishing is observed for the commonly exploited species. Majority (70%) of the individuals belonging to the ten most in-demand species are currently being caught prior to them reaching their theoretical maturity lengths. These include the high valued species such as those belonging to the *Epinephelus* genus, *Plectropomus laevis* and *P. pessuliferus* which are exported live in large numbers. Recent work to manage the fishery started with the formulation of a management plan through a participatory approach. Measures such as size limits on catch and exports, spawning area closures and export quotas have been recommended and are being put forward to policy makers for their endorsement, and implementation. Strengthened data recording and reporting systems, monitoring and enforcement are also incorporated for efficient implementation of the management plan.

**Key words:** Groupers, fisheries, Biomass, Maldives, Management

---

### Introduction

Groupers belong to the family Serranidae, Subfamily Epinephelinae and over 100 species of groupers are known worldwide (Heemstra and Randall, 1993). The Maldives has approximately 40 – 45 species of groupers, which belong to the genera *Aethaloperca*, *Amyperodon*, *Cephalopholis*, *Epinephelus*, *Gracila*, *Plectropomus* and *Variola*.

A market oriented grouper fishery in the Maldives began in the early 1990s and intensified over the years due to the huge demand from the export market. The fishery became quite a targeted fishery over the years, with the evolution of fishing methods. Fishing is now carried out by visually aided snorkeling. To summarise the fishery and export industry, grouper fishermen go out on either daily or three day fishing trips. At the end of each trip, their catch is sold to the exporter holding facilities which are located throughout the Maldives. Groupers once purchased by the exporters are held in these facilities, either as live grouper in floating cages or fresh/chilled in large containers filled with ice. Fresh/chilled and live shipments of groupers are sent out via air freight or via collection vessels which visit the cages from Hong

Kong. Main export destinations are Hong Kong, Taiwan, and Thailand. Shakeel (1994), Sattar and Adam (2005) and Sattar et al. (2011) give detailed descriptions of the fishery and export industry from its beginning to date. While the method of fishing and export have evolved and developed over the years, key target species have remained the same. Species such as *Epinephelus fuscoguttatus*, *Plectropomus areolatus*, *Plectropomus laevis* and *Plectropomus pessuliferus* have always been favourites due to their high market value. Unfortunately these are species which are listed in the IUCN Red List as either “Near threatened” or “Vulnerable” thus stressing the vulnerability of groupers to intense fishing effort.

As evidenced from previous studies, the biology of groupers, i.e. sex change strategy, long life, aggregation behaviour and the fact that they take bait readily, makes grouper populations highly susceptible to overfishing. Coleman et al. (1996) studied the effects of fishing on spawning aggregations of groupers (e.g. *Mycteroperca microlepis*) in eastern Gulf of Mexico. Their results revealed changes to population demographics such as decreased sizes of fish caught and decreased sizes at sex change as well

as decreased male to female sex ratios (Coleman et al. 1996). Heavy targeting of spawning aggregations of Nassau grouper (*Epinephelus striatus*) in the Caribbean have resulted in diminished population numbers and decreased aggregations (Sadovy, 2002).

Studies on grouper fisheries in the Maldives began in the early 1990s (Van der Knaap et. al 1991, Anderson, et. al. 1992, Shakeel 1994). Shakeel (1994) made management recommendations which if they had been implemented and enforced at the time would have helped to conserve grouper stocks. Similar recommendations were also made after a further study in 2003 and 2004, though these were also not implemented at the time (Sattar and Adam, 2005).

The current review of the grouper fishery, by the Marine Research Centre was started in 2010, together with the Darwin Reef Fish project (a four year collaborative project between the Marine Research Centre and the Marine Conservation Society of UK). The aim of the review was to collect all baseline information necessary to assess the current status of the fishery and the stock as well as for the formulation of a grouper fishery management plan. The review collected both qualitative and quantitative data of the fishery and export industry as well as conducting underwater surveys to estimate grouper biomass.

A Grouper fishery Management plan was formulated based on the findings of the current review and earlier surveys of the fishery as well as abundance and spawning aggregation identification interviews. This plan has been finalised through a participatory approach and involvement of all key stakeholders. Regulations are currently being formulated, so as to gazette and implement the plan.

### Material and Methods

Fishery Data collection for this review was done in key fishing and purchase areas of Baa, Vaavu, Faafu, Kaafu and Gaafu Dhaalu atoll.

Fishermen interviews were conducted during consultation visits to the atolls, as well as at the exporter holding cages. Length frequency sampling of catch was conducted during cage sampling trips and fishing trips, while export statistics were based on those reported by the Ministry of Fisheries and Agriculture.

It should be noted here that while target areas might seem few, these were the atolls of origins of the main fishermen involved in the fishery. Furthermore although fishermen travel to different atolls on their fishing trips, they return to the main export holding facilities to sell their catch to exporters. Further details of the fishing trips are given in Sattar and Adam (2005) and Sattar et. al. (2011).

### Fisherman Interviews

Consultations with the grouper fishermen of Vaavu, Baa and Faafu atolls were held during the survey trips, to assess their views and opinions on the current status of the fishery and whether management was needed or important for this resource. Fishermen were also asked what management practices, in their opinion, would be the most effective in making the existing grouper fishery in the Maldives a sustainable fishery.

### Sampling on board fishing vessels

A total of 12 days of data collection was undertaken by participating in 8 fishing trips of grouper fishermen. Sampling on board the fishing vessel was done on site or when the catch was being unloaded and sold to the cage. Individuals in each basket-load brought back to the boat, were identified to the species level and their length (fork length) measured in centimetres. This enabled us to obtain site specific length frequency data.

In the instances where this was not possible, individuals were identified and measured when they were being sold to the cage. Additional information on fishing effort, fishing locations, quantities of each species caught on each trip and income earned per trip were also collected.

### Sampling at the grouper cages

Length frequency sampling at the exporter holding facility was done over a total of 25 days. Details of number of sampling trips per atoll and total number of vessels sampled are shown in Table 1.

Atoll	No. of sampling trips	No. of vessels sampled
Vaavu	6	19
Faafu	5	41
Gaafu Dhaalu	3	8
Kaafu	11	24

Table 1: Details of cage sampling trips conducted (May 2010 to June 2011)

Cage sampling from Baa atoll was not undertaken as fishermen from Baa atoll mainly undertake their fishing in other atolls and thus sell to exporter holding facilities outside their atoll.

Attempts were made to get a representative sample of the catch, when it was brought to the cage by the fishermen, though most times this was only possible for the fresh/chilled exports, as exporters and fishermen were hesitant willing to let us handle the live exports due to the risk of mortality. We were able to sample the live exports on an occasional basis, though rarely and their length samples were taken on separate days when the fish were washed at the cages (necessary for disease prevention). Further details of

these sampling trips are also given in Sattar et. al. (2011).

#### Fishwatch surveys

Underwater surveys under the “Fishwatch” programme were initiated in 2010 and conducted in Gaafu Alifu, Gaafu Dhaalu, Haa Alifu and Male’ Atoll. A total of 156 surveys were conducted in 40 sites, using timed swim methodology on a range of reefs at depths between 0-25m. Key grouper species were counted and size estimates were made during these underwater surveys. These size estimates were then used to calculate the total biomass for each species based on a total reef habitat of 4,513 km<sup>2</sup> as reported by Naseer and Hatcher (2004). Maximum Sustainable Yields for these species were also calculated using Cadima’s equation (DRFP, 2011).

### Results

#### Qualitative analysis of fishermen opinion

During the course of the consultations, fishermen revealed that they were now unable to get large quantities of and larger sized individuals of the high valued grouper species such as *E. fuscoguttatus* and those species belonging to the *Plectropomus* genera. These were now mainly being caught during the breeding seasons when the larger individuals aggregate to spawn. Although these species used to be the main target species of this fishery, this trend has now shifted and fishermen are targeting all species of groupers, even the low valued ones, which are now being paid much higher prices by the exporters.

All interviewees were aware of the effects of continuous exploitation of the stock and majority of the fishermen were in favour of a management plan, but only if it is properly implemented and enforced. Size limits and area/time closures of spawning grounds were identified as key management measures which fishermen felt should be implemented.

#### Quantitative analysis

##### Species composition

A total of 12,797 individuals belonging to 26 species were identified to the species level and measured for size during the current survey.

Most commonly exploited species were observed to be the same for the different areas surveyed and were seen to be *Aethaloperca roga*, *Anypserodon leucogrammicus*, *Cephalopholis argus*, *Cephalopholis miniata*, *Epinephelus fuscoguttatus*, *Epinephelus spilotoceps*, *Plectropomus areolatus*, *Plectropomus pessuliferus*, *Plectropomus laevis* and *Variola louti*.

Majority of the 26 species sampled are exported chilled, while only large sized individuals of high valued species such as *E. fuscoguttatus*, *E.*

*polyphkadion*, *P. areaolatus*, *P. laevis* and *P. pessuliferus* are exported live.

Comparison between species composition of catch in 2010 and 2003 show that overall, commonly caught species have remained the same during the years, although quantities caught have varied. However, species such as *E. fuscoguttatus*, *V. louti* and *C. argus* were seen to contribute more towards the overall catch composition in 2003, than they do at present. On the other hand, *P. pessuliferus*, which now has a higher value than in 2003 are caught in greater quantities and contribute 2<sup>nd</sup> highest to the current catch composition.

#### Size compositions

A comparison of mean length of the most commonly exploited species show that mean length of majority of these species have decreased over the years (Fig. 1). While certain species are seen to have smaller lengths in the unexploited stock, a T-test for significance showed that the difference between mean lengths of individuals caught in 2003 and 2010 are significant for all species, indicating a significant decrease in length over the last seven years.

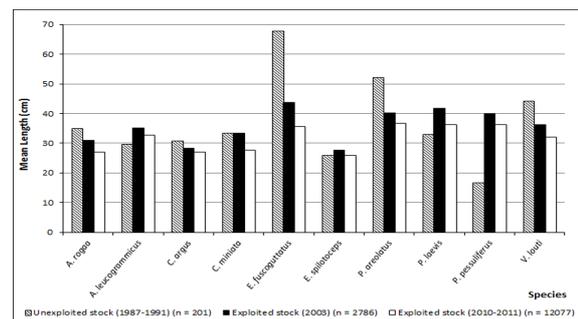


Figure 1: Comparison of mean length of groupers in the unexploited stock (Van der Knaap et. al. 1991; Anderson et. al. 1992) and exploited stock (Sattar and Adam 2005 and current review) (Sample numbers in parenthesis’s are for total numbers of individuals represented by 10 species shown in the graph)

Shakeel (1996) theorised that a grouper matures at half its maximum length. Use of this theory to identify the proportion of catch which were immature shows that 70% of the individuals belonging to the most commonly exploited species are caught prior to them reaching their theoretical maturity lengths (Table 2). This is in comparison to the 43% of immature individuals reported in Sattar and Adam (2005). As evident from Table 2, for 8 of these 10 species more than 50% of the catch is composed of immature individuals, while for 3 of the high valued species, namely *E. fuscoguttatus*, *P. laevis*, and *P. pessuliferus*, more than 90% of the catch is composed of immature individuals. Even the low valued species such as *A. roga*, *C. argus* and *V. louti* are seen to have high exploitations of immature individuals.

Species	Sample Size, n	Length range surveyed (cm)	Percent immature
<i>A. rogaea</i> *	1254	16 - 45	74.32
<i>A. leucogrammicus</i>	1552	17 - 49	51.48
<i>C. argus</i> *	2443	15 - 48	79.70
<i>C. miniata</i>	1408	13 - 43	8.52
<i>E. fuscoguttatus</i> *	499	19 - 102	96.38
<i>E. spilotoceps</i>	420	15 - 44	13.37
<i>P. areolatus</i>	693	21 - 79	69.99
<i>P. laevis</i> *	1046	20 - 88	98.85
<i>P. pessuliferus</i> *	1897	19 - 89	99.00
<i>V. louti</i> *	898	19 - 59	88.75

Table 2: Immature percentage represented in the catch of commercially important grouper species

Size composition graphs for the 10 most commonly exploited species show that the size classes of individuals exploited in 2010 have shifted to the left, indicating that individuals which are exploited now are smaller than those taken in 2003. This is especially significant for the high valued species such as *E. fuscoguttatus*, and *P. pessuliferus* (Fig. 2)

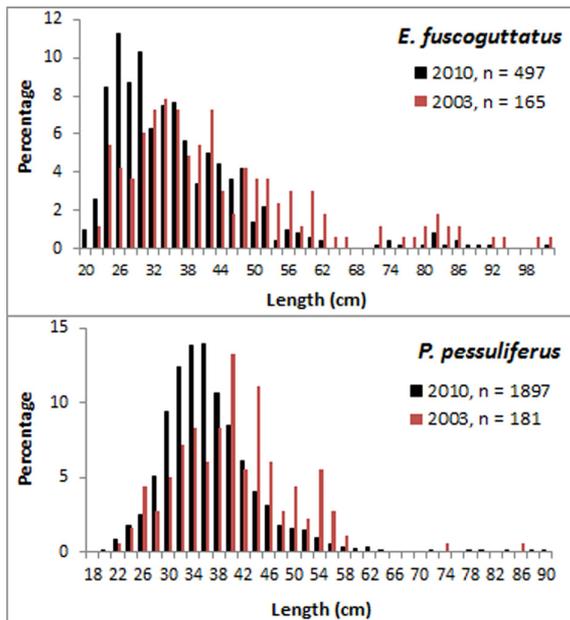


Figure 2: Size composition of the sampled stock in 2010 and 2003 for *E. fuscoguttatus* and *P. pessuliferus*

#### Grouper exports and income generated

Fishery statistics for grouper exports shows a dramatic increase in the quantity of groupers exported from 1994 to 1995, when the fishery peaked in the Maldives (Fig. 3). One of the key points to be seen in Fig. 3 is the trend shown in the export of live groupers, which are mainly composed of high valued species such as *E. fuscoguttatus*, *E. polyphkadion*, *P. areolatus*, *P. pessuliferus* and *P. laevis*. Live exports reached a peak of over 400,000 individuals annually between 1995 and 1997, but then by 2004 had

declined to about a quarter of this number. The decrease in live exports is seen to be compensated for by increasing quantities of fresh/chilled exports. However, live exports have been on an increasing trend since 2007 though the rate of increase is very slow compared to that for the fresh/chilled exports over the same period.

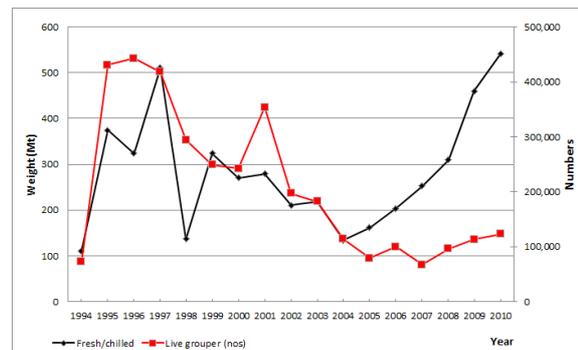


Figure 3: Export quantities of fresh/chilled and live groupers (1994 - 2010) (Source: MOFA, 1996-2011)

#### Fishwatch survey results

Key results of these surveys show that most commonly encountered species were *C. argus*, *V. louti* and *C. miniata* (63%, 47% and 42% of surveys respectively). High valued species were rarely encountered. On occasions when they were observed, they were found to be more common on house reefs of tourist resorts (where fishing is absent) than in areas which were open to fisheries. This is indicative of the effect of fisheries on population numbers for these species.

Preliminary estimates of biomass showed that approximately 15,000 MT of groupers are found in all reef habitats of Maldives. MSY calculations showed that 2118 MT of groupers can be harvested from the Maldivian reefs.

#### Discussion

Since the grouper fishery in the Maldives is highly targeted and fishing method very selective, it enables the fishermen to target the high valued species, such as *E. fuscoguttatus*, *E. polyphkadion*, *P. areolatus*, *P. laevis* and *P. pessuliferus* and its aggregations. Such intensive fishing of certain species, especially from their aggregations could be one reason for the recent decline in availability of these species. Secondly, the higher prices being paid by exporters for the low valued species also serves as an incentive for fishermen to target the easy-to-catch and readily available low valued species, thus again leading to increased fishing pressure on these species. However, the higher prices being paid is evidence of the fact that the larger sized individuals and high valued species are decreasing in quantity and availability.

Although availability of larger sized individuals of high valued species were seen to be on a decline, the recent trend in exports show a gradual increase in live exports which could be attributed to a number of factors, one of which is the ability to export live groupers via air freight in oxygenated fish bins. This means that live groupers have to be kept in holding facilities for a shorter period of time and 1 to 2 shipments can be exported per week, in comparison to export via sea freight where a shipment would be sent out once every 2 to 3 months.

Size comparison analysis show that theoretically majority of the individuals caught are been caught before they have had a chance to mature and breed, and thus contribute to the population. This fact together with the decrease in size and thus decreased fecundity, and the spawning aggregation targeted fishery, would quite possibly result in lower population numbers as has been seen in other parts of the world (Sadovy, 2002).

The most noticeable finding of the quantitative survey in the current study was the decrease in mean size of all commonly exploited species of groupers over the past 7 years. Size selective fisheries have been seen to have this effect on the populations, whereby populations evolve to sizes smaller than what they used to be prior to exploitation, hence showing reduced size distributions (Coleman et al. 1996). The smaller sizes of certain species observed in the unexploited stock can be attributed to the smaller sample surveyed at the time.

While the preliminary statistics for Maximum Sustainable Yield of groupers show that 2118 MT of groupers can be harvested from the Maldivian reefs, it is important to note that these results are the first estimates of its kind and more comprehensive surveying is needed to provide a more accurate estimate. However, these results do provide a good benchmark for management.

As evident from this study and the stakeholder consultations, the Maldivian grouper fishery is on a declining trend, especially when taking into consideration the availability and export of live groupers. This is evidence of the fact that the current grouper fishery cannot be sustained without proper management. A management plan for the grouper fishery which has been finalised through a participatory approach will be implemented in the very near future. Majority of fishermen and exporters are in favour of a properly implemented and enforced plan which would take into account management measures which considers all aspects of the fishery.

The finalised plan will address management issues such as fishing of smaller sized individuals and fishing from spawning aggregations. Size limits and total closure of certain spawning aggregations to

fishing and other activities have been finalised as the two measures to be implemented during this phase of the management plan. The plan will be reviewed annually, based on research and review of data.

It should be noted that this is the first fisheries management plan to be implemented in the Maldives. While management has come at a delayed stage of the fishery, it is hoped that through these management measures, the grouper populations of the Maldives can be turned into one which is sustainable both as a source of income and natural resource.

### Acknowledgement

The authors would like to thank the Darwin Initiative and the Government of Maldives for funding this program. Special gratitude to the field/research team at MRC, DRFP, FMA and contracted staff who participated in all field trips and assisted with the data collection. Our gratitude also to all those who read through various versions of the paper and provided their insightful comments and ideas. We also wish to thank all the fishermen and exporters who helped us along the way and collaborated with us during the project. We hope such collaborations will continue in the future, so as to achieve a sustainable fishery, for the benefit of all involved.

### References

- Anderson, R.C., Waheed, Z., Rasheed, M. and Arif, A. (1992) Reef Fish Resources Survey in the Maldives – Phase II, BOBP/WP/80, 54pp
- Coleman, F.C., Koenig, C.C. and Collins, L.A. (1996) Reproductive styles of shallow water groupers (Pisces: Serranidae) in the eastern Gulf of Mexico and the consequences of fishing spawning aggregations. *Environ. Biol. Fish.* **47**:129–141
- DRFP (2011) Preliminary analysis of Maldives grouper populations and sustainable yield. DRFP (Marine Research Centre/Marine Conservation Society (UK))
- Heemstra, P.C and Randall, J.E. (1993) FAO species catalogue. Vol. 16. Groupers of the world (Family Serranidae, Subfamily Epinephelinae). An annotated and illustrated catalogue of the grouper, rockcod, hind, coral grouper and lyretail species known to date. Rome, FAO, 382pp, 522 figs with 31 colour plates
- MoFAMR/MoFA (1995 – 2010) Basic Fisheries Statistics
- Naseer, A. & Hatcher, B.G. (2004) Inventory of the Maldives' coral reefs using morphometrics generated from Landsat ETM+ imagery. *Coral Reefs* **23**:161-168
- Sadovy, Y. (2002) Biological Considerations related to the Live Reef Food Fish Trade, Paper presented in Workshop on the Live Reef Fish Trade in the Pacific Region, Hong Kong
- Sattar, S. A. and M. S. Adam (2005) Review of Grouper Fishery of the Maldives with additional notes on the Faafu Atoll Fishery. Marine Research Centre, Male', Maldives. 54 pp
- Sattar, S. A., Najeeb, A., Afzal, M. S., Islam, F and Wood, E (2011) Review of the Maldivian Grouper Fishery and Export Industry. Darwin Reef Fish Project (Marine Research Centre/Marine Conservation Society (UK)). 36 pp
- Shakeel, H. (1994) Study of Grouper Fishery and Live Grouper Holding Operations in the Maldives, Marine Research Section, Maldives, 49pp
- Shakeel, H. and Ahmed, H. (1996) Exploitation of Reef Resources, grouper and other food fishes in the Maldives, Workshop on Integrated Reef Resources in the Maldives, BOBP/REP/76, 312pp
- Van Der Knaap, M., Waheed, Z., Shareef, H. and Rasheed, M. (1991). Reef fish resources survey in the Maldives. Reef fish Research and Resources Survey. B. O. B. Programme. Madras, Bay of Bengal Programme/ FAO: 60 pp.