PROJECT UPDATE
FISH SPAWNING AGGREGATION MONITORING AROUND GHIZO ISLAND, WESTERN PROVINCE, SOLOMON ISLANDS

May 2013

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INTRODUCTION

In Solomon Islands, the spread of economic development and rapid human population growth in recent decades has resulted in increased fishing pressure on inshore marine resources. Reef fish spawning aggregations (FSAs), traditionally fished by a select few "master fishers" using simple fishing gears (hand-lines & dug-out canoes), are increasingly being targeted with more sophisticated fishing gears (snorkeling gear, under-water flashlights, spear-guns, gill-nets) by a growing number of artisanal fishers who supply expanding urban and semi-urban markets. A large number of economically important species (e.g. snappers & groupers) form these predictable reproductive gatherings; therefore the incentive to find and exploit fish spawning aggregations is high and increasing dramatically. Overexploitation of aggregations ultimately leads to negative consequences for the targeted fish populations, and the fisheries and livelihoods they support.

The WWF program in Solomon Islands has identified the conservation of fish spawning aggregations as a priority in fisheries management. Such conservation will help to ensure that inshore fisheries are being managed in a sustainable manner and, thus, enhance food security efforts in the area. In order to design successful management and conservation protocols for fish spawning aggregations, monitoring is required to obtain the required information necessary for understanding the dynamics of the system. With support from the David and Lucile Packard Foundation, the initial stage of a scientific monitoring program was established in 2009 to collect a baseline of information on grouper spawning aggregation dynamics within the reef system of Ghizo Island, Western Province. Subsequent fish spawning aggregation monitoring (2010-present) incorporate baseline data on additional species and on an additional spawning aggregation site, as well. The latter activities were, and continue to be, carried out with support from the Coral Triangle Support Partnership (CTSP) under the USAID funded Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security (CTI-CFF).

This report highlights key findings of the 2-year baseline assessment and subsequent monitoring efforts until the end of the 2012 monitoring season. Although data has been collected from two different FSA sites for five fish species, there is an insufficient amount of data for certain analyses due to various restraints and limitations encountered. Therefore, the majority of the data presented in this summary illustrates FSA dynamics for three grouper species at Site A: Epinephelus fuscoguttatus (brown marbled grouper), Epinephelus polyphekadion (camouflage grouper) and Plectropomus areolatus (coral squaretail grouper). As monitoring continues, data on all five fish species from both FSA sites will be incorporated into the data analyses and included in reports documenting project progress and findings. Upon completion of the 2013 monitoring season, an updated report will be made available.

BACKGROUND & METHODOLOGY

FSA Survey

In early 2008, discussions with members of the local scuba diving and fishing community indicated that the above mentioned grouper species increase in density during the week before new moon on the months of March, April and May at Site A, in the northwestern end of the Ghizo reef system. Exploratory dives conducted in April and May of 2008 confirmed that P. areolatus primarily aggregates in the shallower part of the site (5-15 m) and the two Epinephelus species aggregated within the deeper section of the site (15- 40 m). For effective sampling within safe scuba diving limits, a protocol was proposed based on two permanently installed transects. Both transects run the length of the horizontal distribution of the spawning aggregations at 2 depth profiles. The 1st transect (Transect A) measures 250 m by 20 m (5000 m^2) at a depth of 25 m and effectively samples the combined E. fuscoguttatus and E. polyphekadion aggregations, along with the deeper portion of the P. areolatus aggregation. The 2nd transect (Transect B) measures 150 m by 20 m (3000 m^2) and is installed along a 10 m depth to primarily sample P. areolatus aggregation in the shallower water.

In April 2009, a daily sampling exercise commenced on the day of full moon and continued up until 2 days after new moon (18-day period) to record the changes in daily spawning aggregation activity. A similar sampling effort was repeated in June and July of the same year but focused on a 5-day period (3 days before new moon, day of new moon, and 2 days after new moon) to further validate the monthly peak and cessation of spawning activities. Based on the data collected during these sampling exercises, it was decided that the monitoring for the remainder of the baseline assessment would concentrate mainly on the 3-day period before new moon of each month.

In mid 2010, the discovery of two large 200L eskies filled with gravid female P. areolatus at the Gizo fish market led the monitoring team to the location of another multi-species spawning aggregation area (Site C) on a neighboring reef system SE of Gizo town. An exploratory dive in July 2010 confirmed the presence of a P. areolatus spawning aggregation. The monitoring team noted that this site had a much larger density of aggregating P. areolatus compared to Site A.

Due to financial and logistical constraints, monthly fish surveys commencing at Site C in February 2011 were restricted to 6 months in 2011 (Feb-Jul), 4 months in 2012 (Apr-Jul), and so far 2 months in 2013. The aggregation area covers a longer horizontal reef area that has a shallower and narrower fore-reef structure compared to Site A. Core aggregation density has been recorded between 10-20 m depth. A single transect (Transect C), 300 m by 20 m (6000 m^2), exists at 15 m depth for sampling P. areolatus aggregation. However, unlike Site A, limited funds prohibited the installation of a permanent transect for the entire length of the spawning site.

At both sites, data is collected by a pair of divers swimming roughly 5 m above the transect recording fish numbers within a 20 m wide swath for its entire length. Fish counts along the deeper transect at Site A would always be completed before divers would ascend to the shallower transect and count fish in the opposite direction. The outer boundaries of all transects are marked by re-bars installed at 50 m intervals to aid divers in collecting data within the transect area. Each dive normally lasts 45-60 min.

Calculation of FSA area (2012)

In 2012, the monitoring team calculated the area of both FSA sites. Using a line connected to a surface float, the divers swam around the boundaries of the aggregation site signaling to the boat driver every 20-30 m by tugging on the line. Upon receiving the signal, the boat driver would position the the boat next to the bobbing float and record the location onto a handheld GPS unit. The GPS data was later imported into Google Earth and the approximate area calculated (Figure 1). Using this technique, the surface area of Site A was estimated to be 15,500 m^2 and site C 18,800 m^2. Whilst not an accurate method of measuring reef area (especially reef slopes), future plans include combining the GPS data with 3-D bathymetry data in a GIS software (e.g. ArcGIS) to provide more precise area estimates. This knowledge is important as it enables more effective monitoring of fish population and aggregation dynamics. It is recommended that this mapping exercise takes place at least once a year at both sites, preferably during peak spawning months, to ensure that changes in the size and shape of the aggregation are captured.

Figure 1. FSA Site A approximate size = 15,500 m^2; SPAG Site C approximate size = 18,800 m^2.

Typically, fish surveys conducted along permanent transects provide density estimates for the total transect area. To provide further information on changes on the density and spatial structure of spawning aggregations over time, it was decided to sub-divide each existing transect into 25 m segments to better document small-scale horizontal shifts within the aggregation boundaries between sampling periods. Such shifts could alert managers of increasing and decreasing trends in fish densities which might necessitate the extension or reduction of transect areas. Star pickets installed at 25 m intervals identify the segments, helping to define the "block" within which each diver conducts his/her fish counts. For the monitoring purposes of this project, each diver is focused on estimating fish density within a 500 m^2 block, every 25 m. This modification and improvement to the fish survey methodology was made in 2012 and will continue to be a part of the long-term monitoring protocol for Ghizo and the surrounding reef systems.

BACKGROUND & METHODOLOGY

Basis of FSA Monitoring Protocol

Daily Aggregation Changes

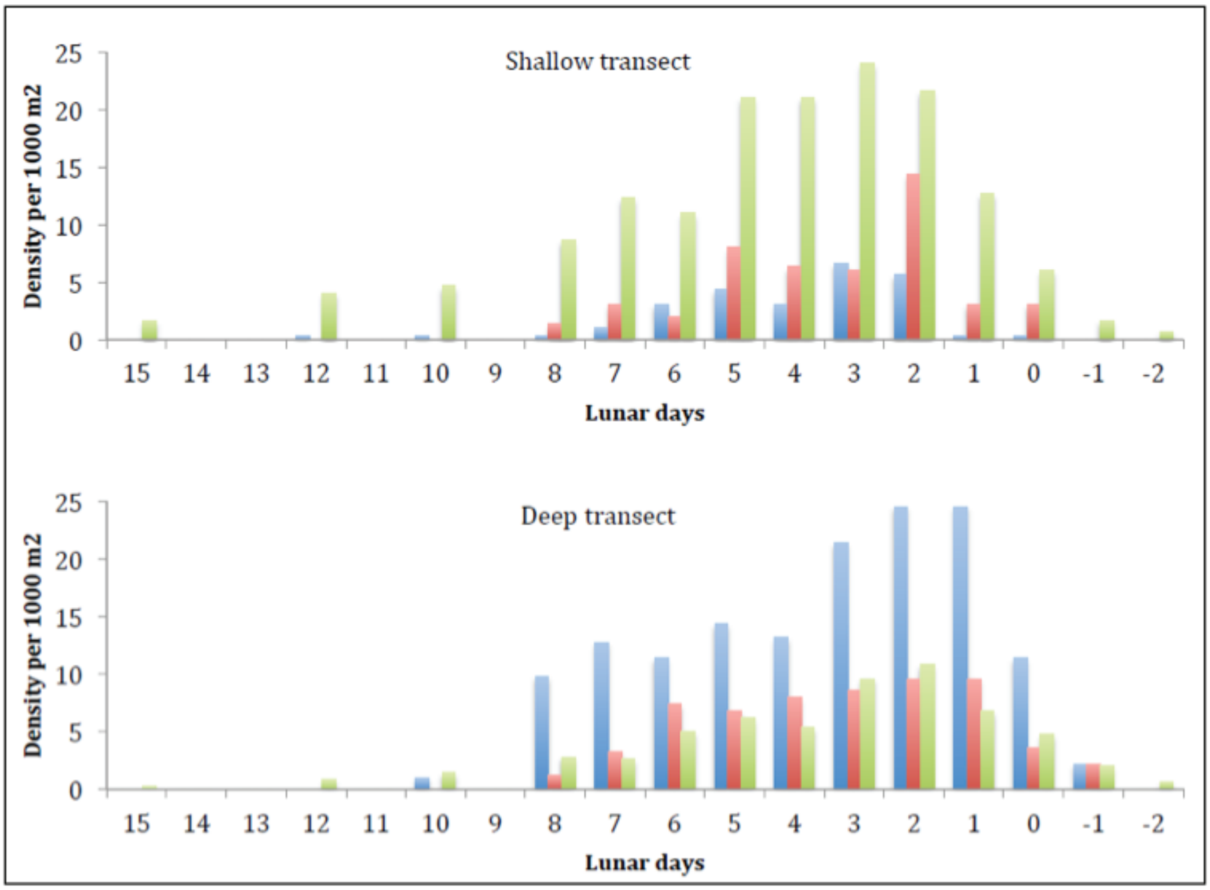

Figure 2. Daily aggregation build-up of *E. fuscoguttatus* (blue bars), *E. polyphekadion* (red bars) and *P. areolatus* (green bars) at Site A in April 2009. ***Note***: No monitoring was conducted on Lunar days 14, 13, 11 and 9.

Data collected over the 18-day sampling period in April 2009, provided a useful snapshot of the aggregation build-up at Site A **(Figure 2)**. *Epinephelus fuscoguttatus* was observed in low densities beginning 12 days before new moon and peaked 7-9 days later. *Epinephelus polyphekadion* was present 8 days before new moon, peaking 2-3 days prior to new moon. *Plectropomus areolatus* individuals were present in low numbers at the start of the sampling exercise (full moon), before rapidly increasing during the week before new moon. Repeat sampling over June and July 2009 confirmed a decline in aggregation density numbers for all 3 species commencing either a day before or on new moon. Numbers were drastically reduced by 2 days after new moon to indicate the cessation of spawning activities **(Figure 3)**.

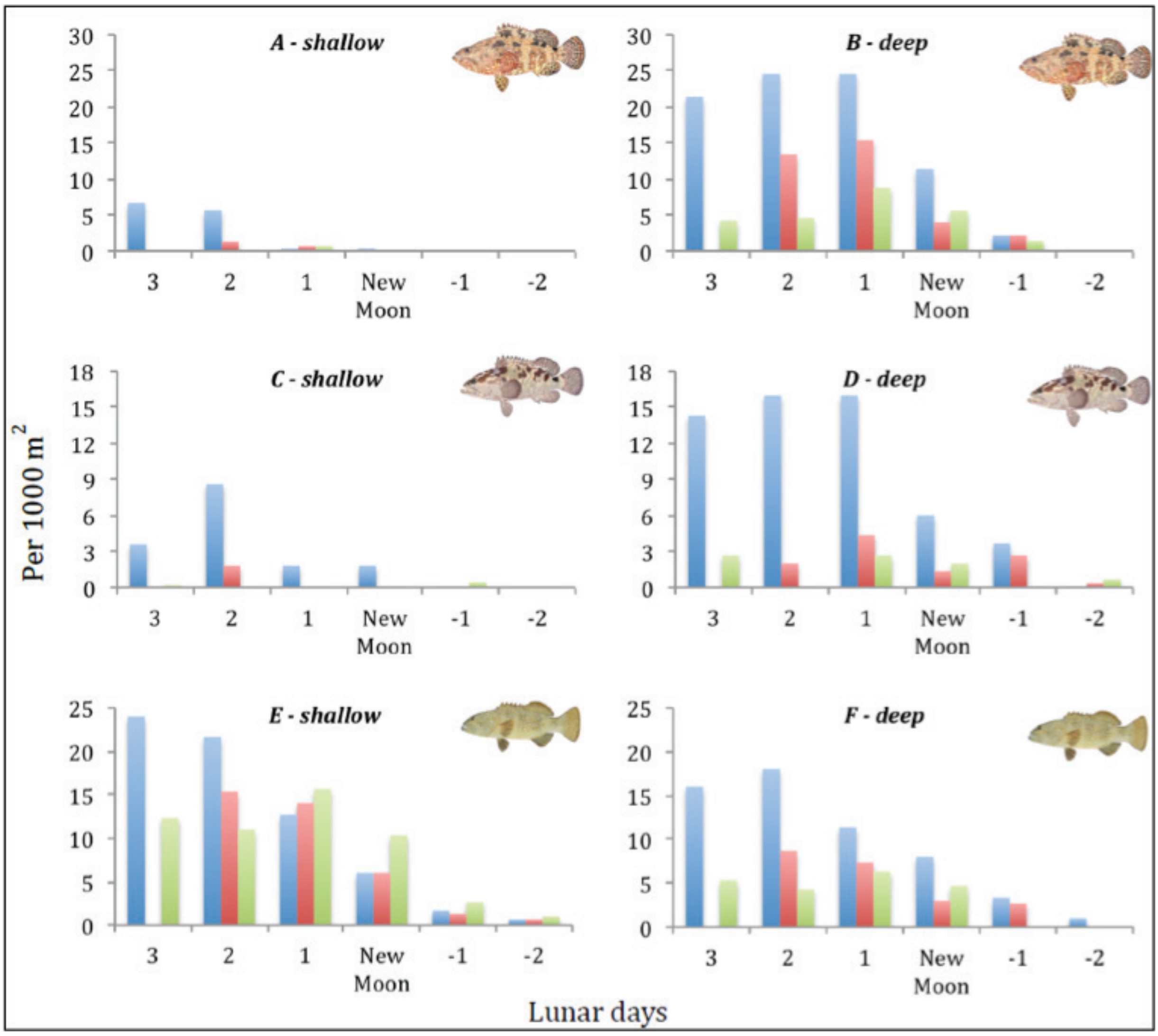

Figure 3. Densities of *E. fuscoguttatus* (A, B), *E. polyphekadion* (C, D) and *P. areolatus* (E, F) at shallow & deep transects before, during and after new moon over the months of April (blue bars), June (red bars) and July (green bars) in 2009. ***Note***: No monitoring took place on the month of May.

FSA Monitoring

Effort

As discussed above, the FSA monitoring protocol decided upon was informed by the sampling exercises carried out in April, June and July of 2009. Monitoring efforts continued in 2009 and are ongoing to date. Various funding and logistical challenges meant that monitoring was suppressed in the 2011 and 2012 monitoring season. Monitoring efforts, during these 2 years, were therefore focused on the months hosting peak spawning activity. **Table 1** illustrates the monitoring effort for each year at both FSA sites, from August 2009 until July 2012 (the end of the 2012 monitoring season). It should be noted that for each day of monitoring at Site A, both transects A and B were surveyed. The table shows that the density of the 3 target grouper species has been monitored throughout the course of the project at Site A, while at Site C only 2 of the grouper species were originally surveyed (*P. areolatus and E. polyphekadion*).

Table 1. Monitoring effort for both SPAG sites from August 2009 until July 2012.

Site	Year	Monitoring Season No. of Months	Monitoring Season No. of Days	No. of Fish Species Monitored
A (Njari)	2009	5	16	3
	2010	12	27	3
	2011	5	10	3
	2012	4	13	3/6[1]
	Total	**26**	**60**	
C (Agana)	2011	6	12	2
	2012	4	13	2/4[1]
	Total	**10**	**25**	

[1] In June 2012, monitoring of *Balistoides viridescens* (titan triggerfish), *Pseudobalistes flavimarginatus* (yellow margin triggerfish) and *Chelinus undulates* (humphead wrasse) began, bringing the total number of fish species monitored at Site A to 6 and 4 for Site C (*E. fuscoguttatus* and *Chelinus undulates* are absent from Site C).

Inter-annual Seasonality

Spawning seasonality at Site A differs between the 3 species, as illustrated in **Figure 4**. *E. fuscoguttatus* aggregates over a 5-6 month period between January and July with peak densities occurring in the months of April and May. In comparison, *E. polyphekadion* has a shorter spawning aggregating season that takes place between March and June but peaking in the same months as *E. fuscoguttatus*, albeit with lower densities. Unlike the two Epinepheline species, *P. areolatus* appears to have a protracted all-year round spawning season. However, months of peak density coincide with the other two species, which occur within the 2nd quarter of the year. *E. fuscoguttatus* and *E. polyphekadion* maintain higher densities along the deep transect during the spawning season, while *P. areolatus* is consistently found in greater densities in the shallow transect during peak spawning months.

Monitoring, thus far, at Site C has been restricted to 6 months in 2011, 4 months in 2012 and 2 months in 2013. Only 2 of the 3 grouper species at Site A (*E. polyphekadion* and *P. areolatus*) have been observed aggregating at this site. Because of the limited data available for this site it is not possible to determine the length of spawning season and peak reproductive months, however, peak densities for the available period were recorded between April and June (**Figure 5**), similar to Site A.

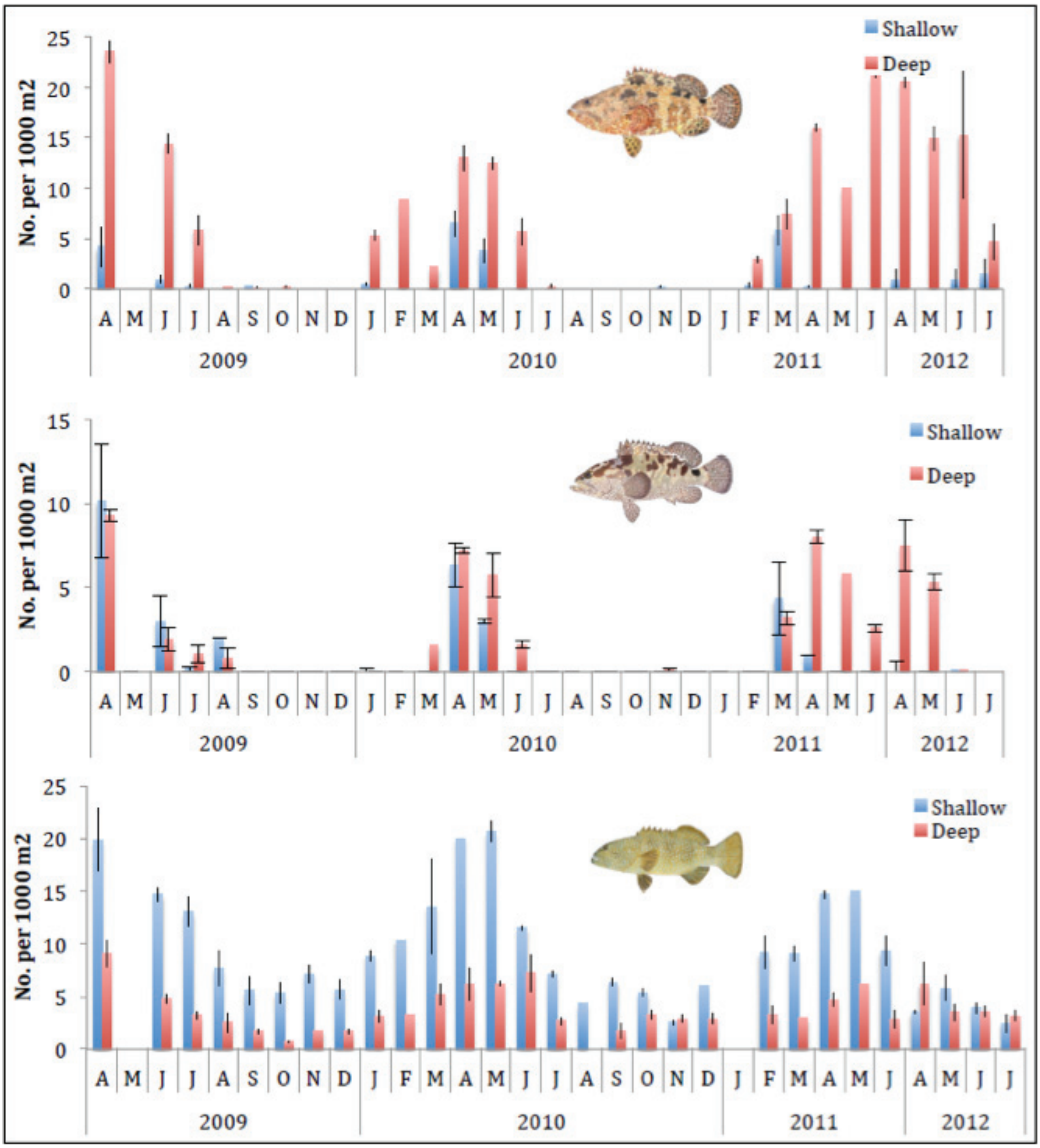

Figure 4. Mean densities of *E. fuscoguttatus*, *E. polyphekadion* and *P. areolatus* at Site A from the commencement of monitoring until the end of the 2012 monitoring season. ***Note***: No monitoring occurred in May 2009 and January 2011. The absence of error bars indicates that only one count was conducted during the 3 days before new moon.

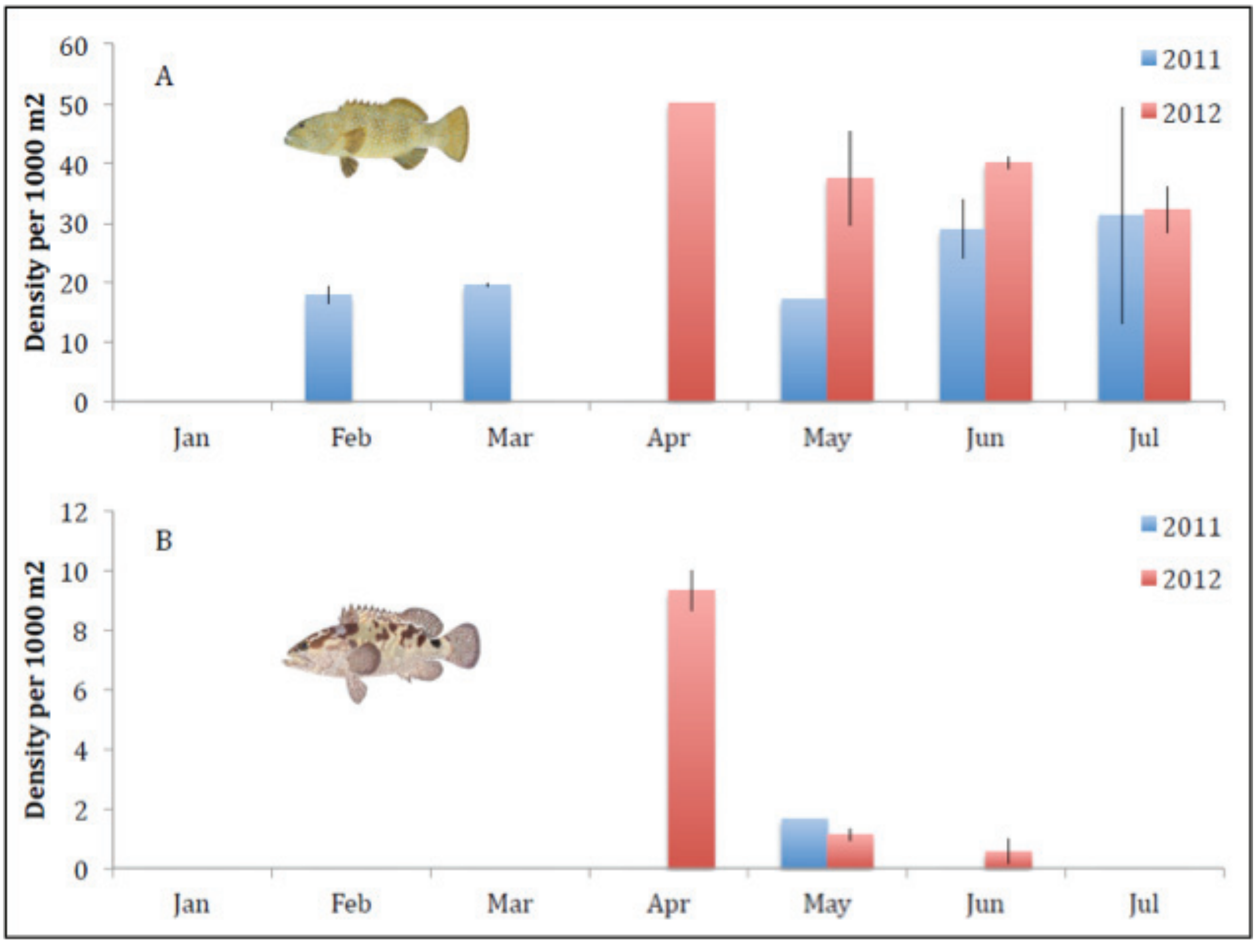

Figure 5. Mean densities of A) P. areolatus and B) E. polyphekadion at Site C during 2011 and 2012.
Note: no monitoring in January of both years and April, 2011. The absence of error bars indicates that only one count was conducted during the 3 days before new moon.

Density Changes

To illustrate changes in density throughout the course of monitoring, mean density was plotted for each species from **Site A**. Density data from peak spawning times (where possible 3 days prior to new moon and from March-June), was taken from the transect hosting the majority of spawning activity for each species, to calculate a mean for the entire monitoring year. **Figure 6** shows an alarming downward trend in *P. areolatus* density (coral squaretail grouper) in recent years. It should be mentioned that the squaretail grouper is the only species, of the 3, that more actively spawns in the shallow transect. Although these shallow aggregations are formed well within spearfishing limits, it is unknown whether the reduction in numbers is related to fishing pressure or the result of abundance variations between years due to ecological factors. Thus, it is important that data collection and monitoring continues to enhance understanding of P. areolatus spawning dynamics and inform appropriate management efforts.

The density trends for *E. fuscoguttatus* (camouflage grouper) and *E. polyphekadion* (brown marbled grouper) are illustrated in **Figures 7** and **8**, respectively. *E. fuscoguttatus* data showed a drop in density in 2010, which appeared to rebound in 2011 and 2012. A similar trend was observed for *E. polyphekadion*, with a reduction in abundance during 2010 and 2011. Of the three species forming spawning aggregations at Site A, *E. polyphekadion* has the lowest spawning density (maximum mean density of 5.4/1000m^2, as compared to 15.6/1000m^2 for *P. areolatus* and 17.2/1000m^2 for *E. fuscoguttatus*).

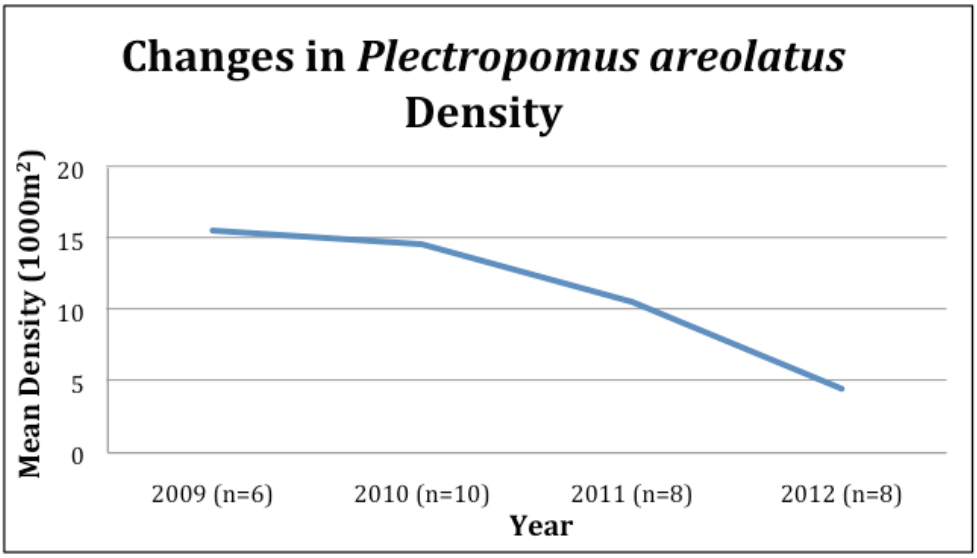

Figure 6. Changes in mean spawning densities (shallow) of the coral squaretail grouper during peak spawning activity throughout the course of the project.

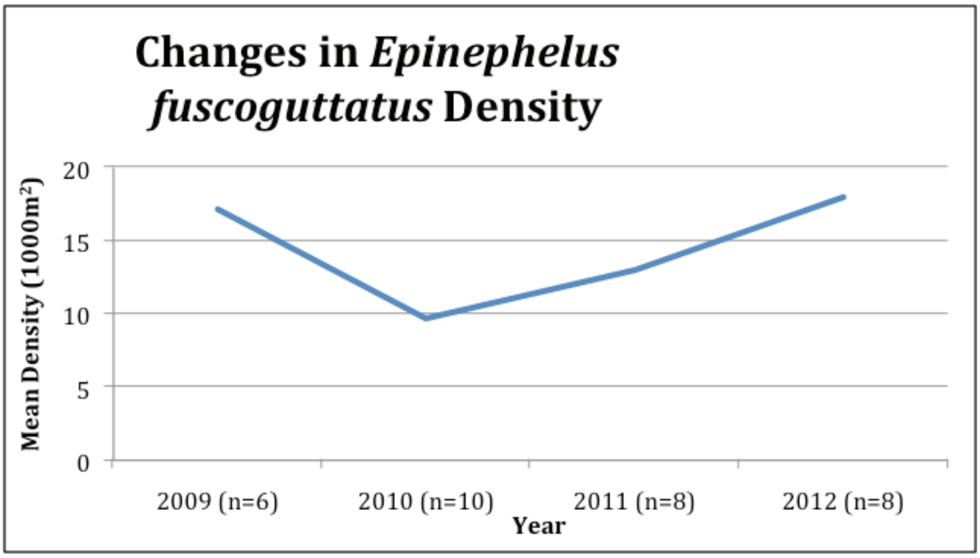

Figure 7. Changes in mean spawning densities (deep) of the camouflaged grouper during peak spawning activity throughout the course of the project.

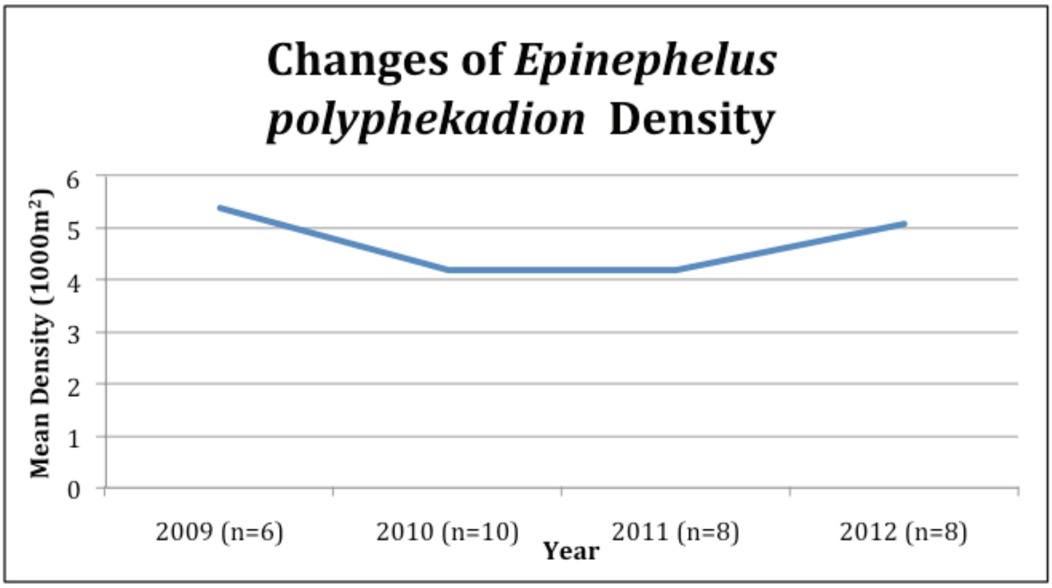

Figure 8. Changes in mean spawning densities (deep) of the brown marbled grouper during peak spawning activity throughout the course of the project.

Despite minimal data collection at Site C, there appear to be significant differences in P. areolatus between Site A and C. In comparison to Site A, P. areolatus transect densities recorded at Site C are anywhere from 2-27 times greater during the same peak months in 2011 and 2012 (**Table 2**). This is an important finding and has great implications for future management efforts at FSA Site C.

Table 2. Comparison of transect density estimates for P. areolatus between the two FSA sites.

Estimated density/transect					Standard Error		
Year	Month	Site A		Site C	Site A		Site C
		Transect A	Transect B	Transect C	Transect A	Transect B	Transect C
2011	F	28	16	108	5	6	9
	M	27	15	118	2	0	1
	A	44	24	X	1	5	X
	M	45	31	103	X	X	0
	J	28	14	174	4	6	29
	J	X	X	187	X	X	109
2012	A	11	31	300	1	14	0
	M	17	17	225	4	7	47
	J	12	18	241	1	4	6
	J	9	12	193	1	7	23

MANAGEMENT RECOMMENDATIONS

The results of the monitoring and data collection conducted from 2009-2012 provide important insights into spawning aggregation dynamics within the Ghizo, and nearby, reef systems. This increased understanding can be used to implement specific management measures aiming to protect spawning populations. The data clearly indicates that certain grouper populations spawning in the waters around Ghizo Island would substantially benefit from increased protection during their respective breeding seasons.

FSA Site Closures

As a result of the work conducted by WWF, the Western Provincial Government has undertaken a precautionary step towards conserving grouper spawning aggregations in the Province. The recently approved Western Province Fisheries Ordinance (2013) addresses the protection of vulnerable species during their reproductive periods and empowers Fisheries Officers to declare certain areas off-limits to harvesting during certain times (Section 22). Although a step in the right direction, it is important that Fisheries staff and other stakeholders not only work together to implement such protection, but that they also conduct appropriate education and awareness programs to ensure management efforts are understood and, hopefully, supported.

One of the primary objectives of a marine protected area (MPA) is to conserve reproductive biomass. As spawning aggregations represent a concentrated period of recruitment, their incorporation into MPA network plans will help ensure healthy fish populations and thus contribute to the maintenance of a properly functioning ecosystem. Plans are currently underway to include Site A within a network of community-based MPAs within the Ghizo reef system. A similar approach urgently needs to be carried out for Site C, which is located on a neighboring reef system. Although outside of the Ghizo reef system, the site a) currently has higher densities of P.areolatus (high reproductive output), b) is being targeted by spearfishers supplying the Gizo fish market, c) is a multi-species aggregation site (e.g. snappers, groupers, sweetlips, trevallies) and d) is a popular tourist dive site, making it a high priority for inclusion in MPA plans.

Long-term Monitoring

The monitoring work conducted to date has taken place prior to the implementation of any management efforts. Therefore, there exists a valuable pre-management database that can be used to measure the effectiveness of future management initiatives. It is recommended that monitoring continue, as frequently as possible, at both FSA sites. At a minimum, it is recommended that long-term monitoring occurs at Site A, between February and July of each year, focusing on the 3 days before new moon. The establishment of a monitoring protocol specific to Site C can take place upon completion of a 12-month monitoring cycle (the installation of a permanent transect for the entire length of the spawning site should also be carried out as soon as available funding allows for it).

Lessons learnt, thus far, should be incorporated into future monitoring efforts/protocols and help inform the most effective means of protecting FSA sites.

Role Reversal and Capacity Building

The ultimate goal is for the Provincial Fisheries Office to assume the leading role in the continuation of this fish spawning aggregation project, while WWF will take on more of a supporting role. In order to achieve the transfer of this responsibility, and maintain FSA monitoring progress, it is important to include Fisheries staff, as much as possible, during the next 12 months of work in an attempt to build their capacity for the successful continuation of this work. Areas in which Fisheries staff should be involved include: monitoring of spawning aggregations, education and awareness, fish market surveys and community engagement.

ACKNOWLEDGEMENTS

First and foremost, WWF Solomon Islands would like to thank Alec Hughes for his expertise and guidance throughout the course of this project. Alec continues to support WWF SI with his data management skills, ensuring that the monitoring and data collection results are interpreted in a meaningful way. Other valuable contributions, deserving of mention, were those made by the Western Province Fisheries staff and the Dive Gizo gang, who assisted in various capacities. Lastly, many thanks to the surrounding Ghizo communities. This project would not have been possible without their cooperation and support.

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