

NAIQORO PASSAGE IN KADAVU, FIJI: GROUPEL SURVEY AND TAGGING PROJECT 2011



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General Introduction

In 2009 the Society for the Conservation of Reef Fish Aggregations, working in collaboration with the research section of the Fish Fisheries Department, initiated a project to study the grouper aggregations at Naiqoro Passage, situated in an small marine protected area in northern Kadavu, Fiji. This work was to begin a new collaborative phase in recognition of concerns for spawning aggregations in Fiji that arose during earlier work and of the need for a better understanding of aggregation dynamics. Earlier interviews conducted in fishing communities around Fiji had revealed both exploited and unexploited spawning aggregations and identified declines in catches from aggregations in many locations. The purpose of the Kadavu work was to document in detail the best known, and only protected, aggregation site in Fiji thereby to provide a baseline for future comparisons and to understand the major species and their temporal and spatial movements in relation to reproduction.

The initial site visit in 2008 enabled a preliminary survey of the site and an evaluation of the feasibility of the study and local dive facilities and accommodation. Study visits in 2009 and 2010 developed the project in terms of sampling protocols and tagging. This report covers the 2011 survey period in July/August 2011.

Objectives of the Naiqoro Passage Study

1. To determine the catchment area, and local movements, of *Epinephelus polyphkadion*, the *kawakawa*, that aggregates in the Naiqoro Passage, by tagging and recapture.
2. To determine the spawning time and aggregation duration of *E. polyphkadion* and other groupers at Naiqoro Passage (especially *delambelewa*, *E. fuscoguttatus*, and *Donu*, *Plectropomus laevis* and *P. areolatus*).
3. To train fisheries staff and other marine workers in Fiji interested in tagging and aggregation survey methods.
4. To use the tagging study as a basis for marine outreach work to enhance understanding of the marine environment and provide information that could be used for protected area or fishery management by coastal communities in northern Kadavu.
5. To provide information that complements other marine conservation and management initiatives in Kadavu and serve as a case study that could be used to inform aggregation work in other areas of Fiji.
6. To establish a water temperature profile for Naiqoro Passage and in relation to the timing of grouper spawning.
7. To assess peak numbers of fish in grouper aggregations over several years thereby to provide a baseline for future survey and management action.
8. To provide recommendations for more efficient management and monitoring of the Naiqoro Passage in Kadavu and for spawning aggregations at the national level.
9. To produce a broader overview and account of Naiqoro Passage, in recognition of its importance as a reef channel habitat for megafauna and threatened species and its value as a diving destination.

10. To demonstrate the importance of spawning aggregations and aggregating species to Fijian fishing communities from both food security and economic perspectives.

Methods

Planning for the 2011 project was conducted and developed in collaboration with Mr. Aisake Batibasaga of the Fiji Fisheries Research Division and other interested parties in Fiji. An invitation was issued to local NGOs to send a participant to join the Kadavu project for training in tagging work and to learn about the study. The Wildlife Conservation Society sent Waisea Naisilisili for one week in early August and Waisea later presented to work to WCS staff in Suva. Permission to tag and study fish from Naiqoro Passage was obtained from the community of Matasewalevu, the traditional stewards for the Passage.

Support and assistance were provided by the Kavala Bay Fisheries Office, Mr. Thomas Peckham. Dr. Rick Nemeth (University of the U. S. Virgin Islands – rnemeth@uvi.edu), Dr. Allen To (WWF-HK), Stanley Shea (Bloom Foundation – Hong Kong, Dr. William Donaldson (ex. USA Fisheries) and George Mitcheson (University of Hong Kong) assisted during the project period which lasted from 27th July to 16th August, 2011. The team stayed at the Waisalima resort.

Underwater surveys for aggregating groupers were conducted over the same areas as in 2010 and 2009 on both north and south sides of the seaward opening of Naiqoro Passage. For each daily survey during the study period, three divers swam in parallel across the width of the area in which all three grouper species are located and from the extreme north end to the extreme south end of the aggregation site. In this way the entire aggregation area was included in the underwater SCUBA surveys; the total site extended from the outer channel entrance to S19 00.816; E178 30.166 in the northern side of the passage entrance, and to S19 00.990; E178 30.125 on the southern side of the passage entrance, with the exception of the central waters of the Passage. A GPS was towed underwater to document the outer boundary of the aggregation area.

Surveys were conducted by three divers swimming in parallel and horizontally along the reef, approximately 10-16 m apart, and 5-7 m above the substrate. Shallow surveys were between 16-20 m and deeper surveys between 20-25 m. These surveys covered the aggregating area for *Epinephelus polyphekadion*, *E. fuscoguttatus* and *Plectropomus laevis*. Two dives were conducted daily, one to the north and one to the south of the Passage in the direction of the prevailing currents. Surveys in strong currents were avoided whenever possible because it was considered that these affected the counts due to the rapid movement of the divers. Also, we had the impression that fish tended to remain more sheltered under rocks when the current was strong. In the 2008 study, *P. areolatus* was found to aggregate in more shallow water but few of this species were noted in 2009, 2010 or 2011 and it is possible that these shallower located fish, which are easily accessible to spear divers, were fished out after 2008. Alternatively, they may aggregate earlier than our typical summer field survey periods.

Surveys were conducted in both morning and afternoon periods and at different phases of the tide; divers were instructed to count fish within either side of their 'transect' to half way between each diver pair and an equal distance to the outside, i.e. up to between 5 and 8 m either side of the transect line. Distance apart was adjusted according to visibility and care was taken to minimize the possibility of double-counting.

In addition to surveying grouper numbers, observations were made on tagged fish and photos taken of groupers and other megafauna in the Passage habitat. Numbers of sharks (grey and white tip) and Napoleon fish (*Cheilinus undulatus*) were documented during each dive and other megafauna noted. The objective of documenting and photographing other species was to record the beauty and diversity of the marine protected area.

In 2009, about 40 groupers were tagged with external anchor tags and released on the spawning site with a further 8 tagged in 2010 and 11 in 2011. Fish were caught by using hook and line from a boat at the site or by fishing on SCUBA in the water. Following the full moon, most of the groupers departed the spawning site but about 5-10% remained and were followed for up to a week. In 2010, 8 fish were tagged with acoustic tags as well as externally, with a further 11 marked in 2011. A single acoustic receiver was placed in 2010, with two more in 2011 for a total of 59 tagged fish, 19 of these with both external and acoustic tags. A single acoustic receiver was placed at the site in 2010, with two more added in 2011.

Temperature information

Temperature as determined by HoboWare (trademark) temperature gauges installed on site and logging every 30 minutes provided annual temperature data at the depth of the spawning aggregation.

Results

Fish tagging

A total of 59 *Epinephelus polyphekadion* have been tagged externally since 2009, with yellow tags marked with individual numbers, and contact details (Lami Fisheries and phone number); 19 of these fish also have acoustic tags. Fishery Department personnel at Vunisea and Kavala are aware of the project, posters have been circulated and the project introduced during various community visits over the three year period. Information provided from recaptures was to be collected by Akasita – the fisheries librarian at Lami but this arrangement did not work successfully and no information was retained. Information needed from fishermen include the number of the fish tag, the location caught and the date. T-shirts (50 ordered from Unitex Garments with groupers printed on them) were to be provided as rewards for returned tags and to the tagging team. However, the T-shirts went missing and so I purchased additional T-shirts and added a 20Fiji \$ note.

Tagged fish were within the mature size range of the species. Fish recovered very quickly from tagging and were seen shortly after tagging swimming around a home

range and fighting other fish. In 2011 at least 8 fish tagged one or two years earlier were again at Naiqoro, showing excellent tag retention and also site fidelity between years. See photos of tagged fish below.

Fishers returned four tags and one report of a tagged fish (2 in 2010 and 3 in 2011). This information showed that fish move at least 15 km away from Naiqoro Passage outside of the spawning season.

Communities visited/outreach

At the start of the project and variously during the last three summers, coastal communities both north and south of Naiqoro were visited with *sevusevu* to provide information on the project and its relevance to the fishery and to marine protected areas, explain its objectives, request permissions as necessary and solicit tag returns. Fishermen were also advised that once the tag is removed the fish can be eaten. Discussions also addressed marine conservation and management issues in general. We were well received by villages and presented materials on the project in the form of posters and a double-sided information sheet in Fijian (see 2009 report). In 2011 further visits and interviews conducted and additional materials distributed. The following communities were visited with the aid of Mr. David O'Connor and/or Mr. Thomas Peckham and/or Waisea Naisilisili (WCS): Nakasaleka District, Lagalevu Village, Tiliva Village, Nakoronawa Village, Lomakoro Village, Lawaki Village, Kavala Bay, Salotavui Village, Kavala Bay, Kavala Village, Kavala Bay, Ono Island, Narikoso Village, Ono Island, Vabea Village, Matasulevu.

Visit to Matesulevu with Thomas Peckham to present results of study and plan activities for 2012

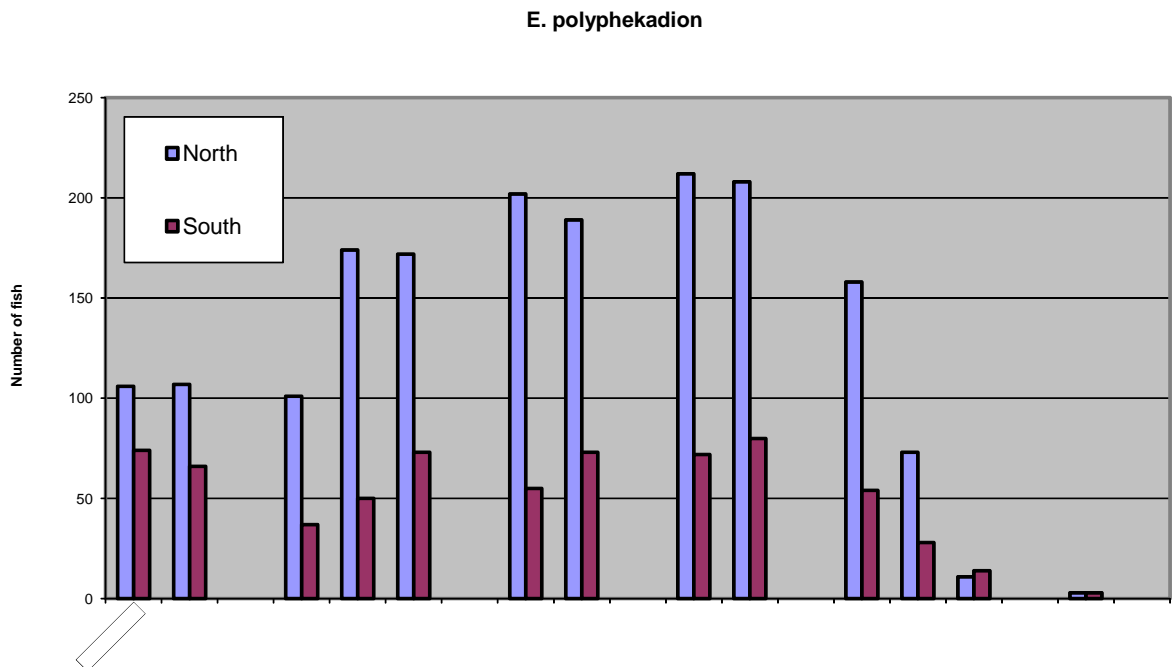


Each Ratu was provided with a copy of the SCRFA DVD, posters for the village hall and or school, and brochures about spawning aggregations as well as information on the research being conducted in Naiqoro Passage. The external fish tag was also shown and discussed, and the WCS minimum fish length sticker was shared. Visits to the head teachers at Kavala Bay Primary School and Kadavu Provincial Secondary School were conducted on 8/10/11. Materials were distributed and the head teachers were briefed on the research project and spawning aggregations. The head teacher of Tiliva Village School was visited 8/11/11. Materials were distributed and a very brief explanation of the research and FSAs was shared.

Timing of Aggregation and Spawning of Three Grouper Species

The three grouper species differed a little in the timing of spawning and also in location of aggregation. The numbers of *E. polyphkadion* at the spawning aggregation site peaked a couple of days before the full moon and gathered in numbers in the two weeks leading up to full moon. Numbers of this species were clearly much higher in the northern side of the channel than the southern side and were particularly numerous from 16-26 m or so between S19 00.816;E178 30.133 to S19 00.803;E178 30.089. Observations of clearly gravid fish in the water (see fat female in photo below) and on inspection during tagging were consistent with the underwater observations of changes in fish numbers over time and considerable chasing was frequently observed.

Numbers of camouflage grouper counted in the aggregation area to the north (mauve) and south (plum) sides of the outer Naiqoro Passage from 29th July to 16th August, 2011



**Large female with belly swollen with eggs-a sign of imminent spawning.
Spawning occurred two days after this photo was taken**

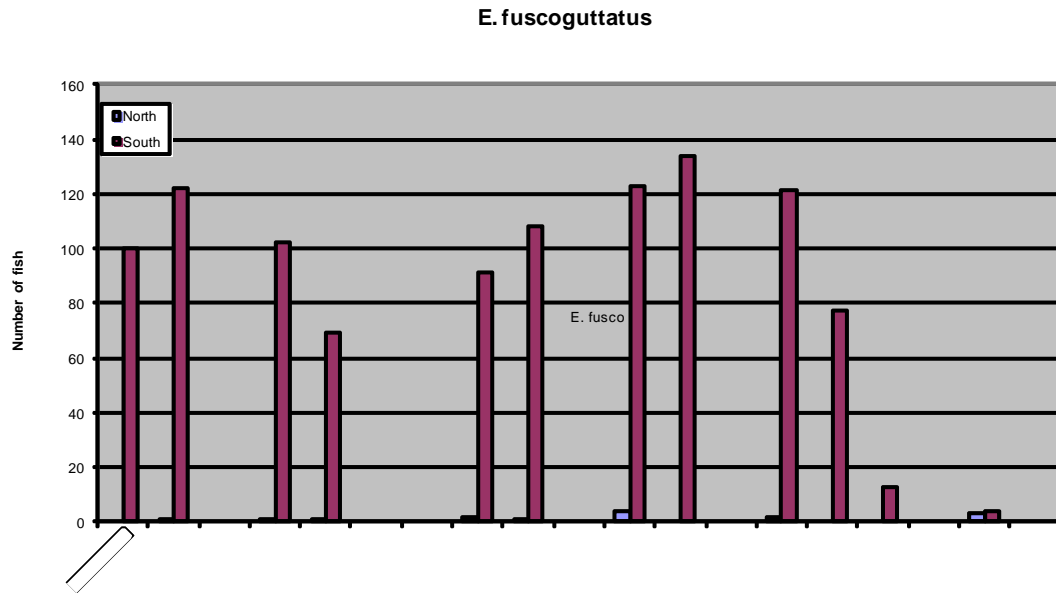


In 2011 sampling ran from July 27th to August 16th. Maximum numbers of *E. polyphkadion* have reached 288 fish 3-4 days before the full moon of August 13th. Numbers of *E. fuscoguttatus* peaked about 4 days before the August full moon at 134 fish and *P. laevis* reached about 50 fish.

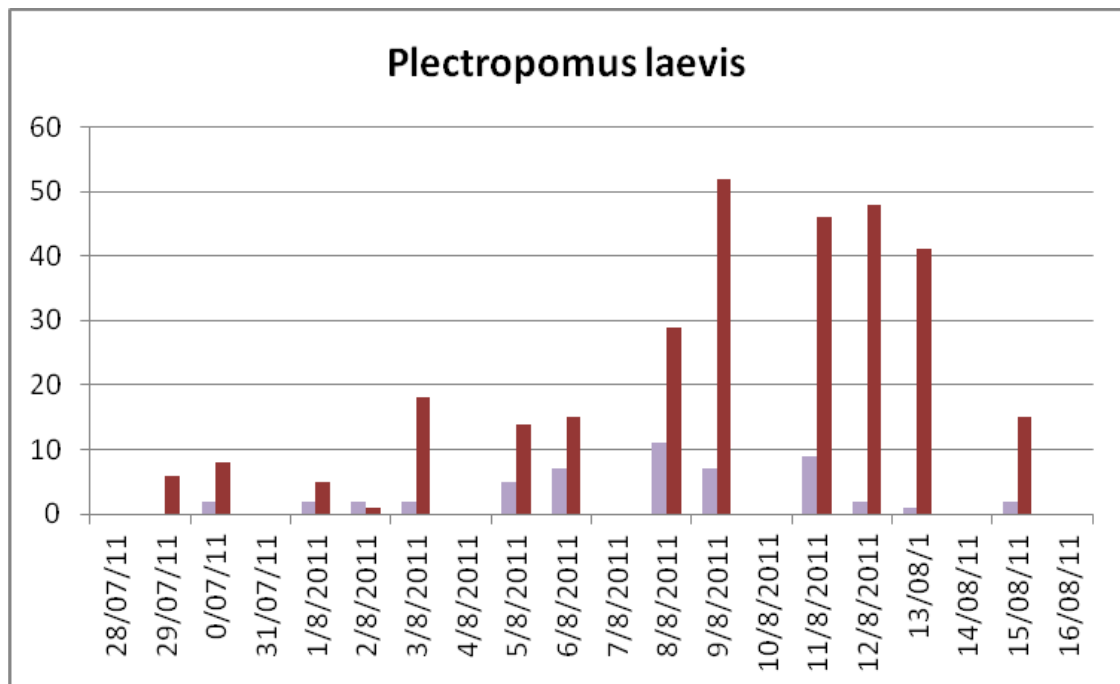
P. laevis were evident largely on the southern outer side of the channel entrance. Numbers started increasing about 8th August and dropped just after the new moon. There was intense activity with courtship coloured males (see photo below) patrolling high up and widely in the water column and across a deeper sand flat with groups of 9-10 fish seen a little deeper over a sandy flat. Numbers of other *Plectropomus* (donu) species were very low with only the occasional leopard coral grouper (*Plectropomus leopardus*) and squaretailed coral grouper (*P. areolatus*). The small number of *P. areolatus* is noteworthy in that large numbers of this species were seen in 2009 and have not been seen since. Either the aggregation occurs earlier in July than our study periods or it has been fished out. The male courtship colour was recorded for the first time for this species.

E. fuscoguttatus occurred predominantly to the south of the passage in a relatively small area of the overall study site. Large individuals in pale coloration were frequently chasing each other with smaller fish tending to stay more hidden in shelter. The species is hard to approach and photograph.

Numbers of brown-marbled grouper counted in the aggregation area to the north (mauve) and south (plum) sides of the outer Naiqoro Passage from 29th July to 16th August, 2011



Numbers of black-saddled grouper counted in the aggregation area to the north (mauve) and south (plum) sides of the outer Naiqoro Passage from 29th July to 16th August, 2011

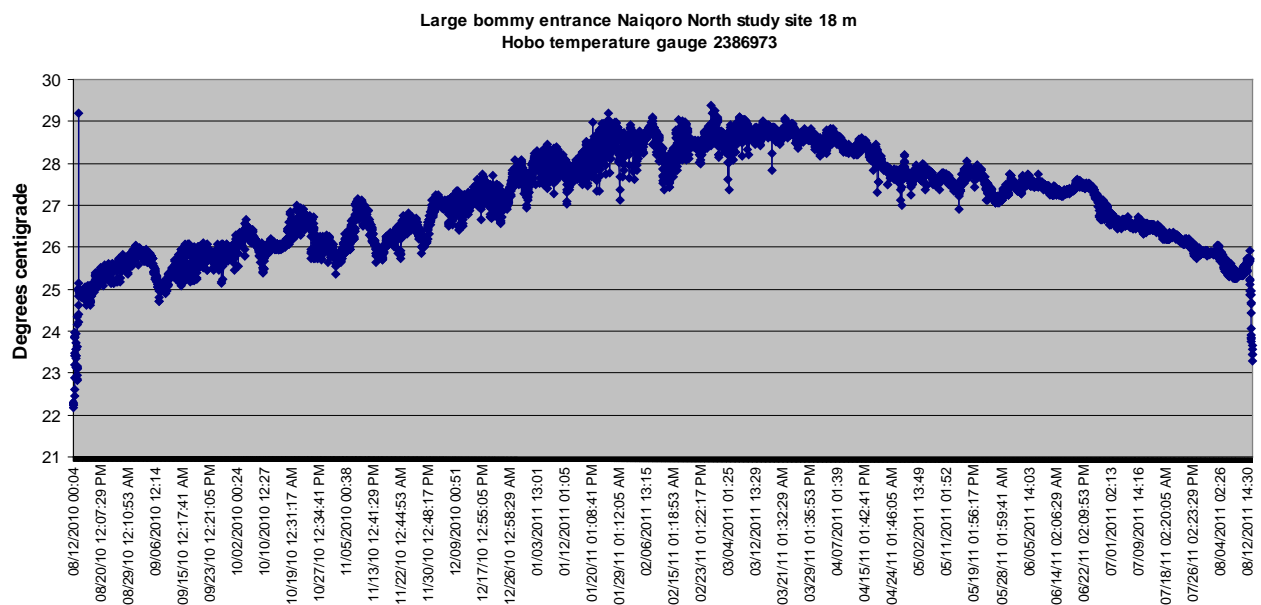


Male *P. laevis* in temporary courtship colour to the southern side of outer Naiqoro Passage



Temperature

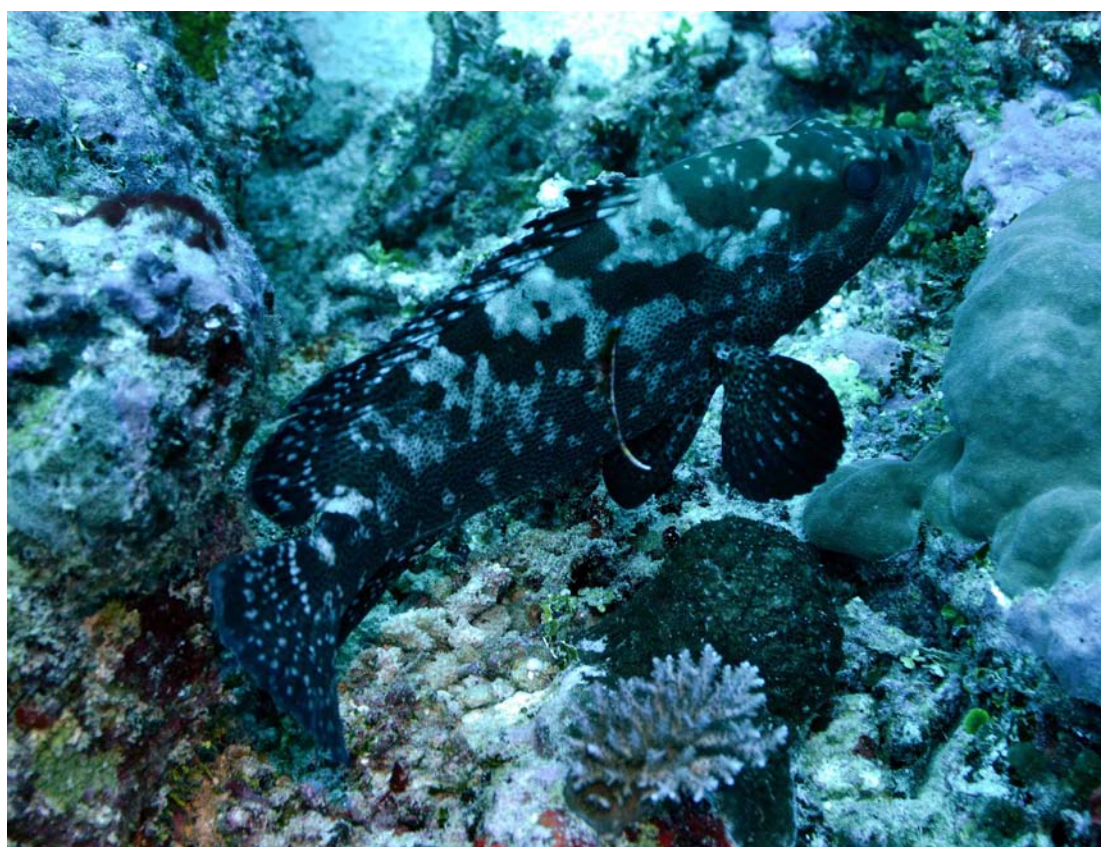
Annual temperature at 18 m in Naiqoro Passage ranged from 24.5-29 degrees Centigrade, with spawning occurring at the lowest temperature of the year. This temperature is considerably lower than temperatures recorded at spawning time for *E. polyphkadion* elsewhere in the Pacific (Pohnpei, Palau, Solomon Islands). Temperature may be one way to predict spawning time in this species if it is an important environmental parameter closely associated with reproduction.



Space use and activity patterns by residing and emigrating fish

At least 8 tagged fish were noted at the aggregation site very close to the location where they were first tagged in 2009. Most of these fish disappeared after spawning but their home ranges were marked as for 2010 and each fish maintained a limited home range area (see 2009 report for more details). Depths of tagged fish ranged from about 20 to 30 m and territory size ranged up to 200 m² with several fish observed to make what appeared like extended forays from their shelter site. **The following two images show two different tagged fish.** Although individual numbers could not be read from the tags on free-moving fish, the differences in tag positions and sides on the body enabled at least 8 different tagged fish to be recognizable. These fish, most of which were tagged in 2009, plus the 5 recaptures have provided a very good return/recapture rate for tagged fish and an indication that the specially designed tags by Dr. Michael Domeier and trialled in Fiji have excellent retention rates.

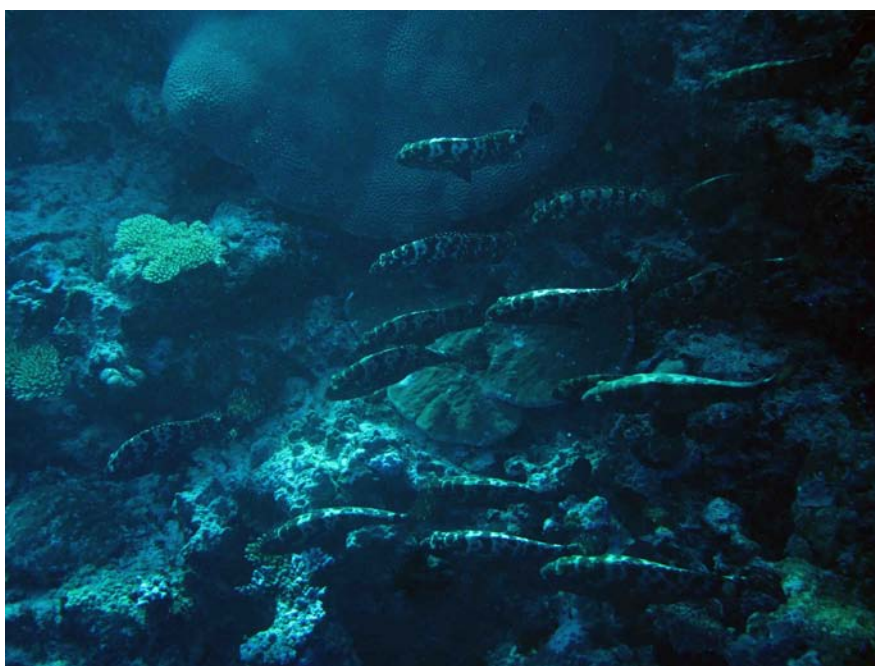
Tagged camouflage grouper showing two different individuals that had returned to the same area in the aggregation where they were tagged two years ago. Note how the two fish can be distinguished by the location and body side of the tags





A particularly exciting observation this year was to see a group of camouflage grouper migrating away from the aggregation site and into the lagoon just after spawning terminated. The fish were quite small (about 30 cm TL) and were clearly and quickly moving as a tightly configured school. This behaviour has not been documented before for this species. However, a dive guide advised us that she had seen very large such schools in the past.

Part of a school of 30-40 camouflage grouper migrating from the aggregation site into the lagoon at about 10 m on the northern wall of Naiqoro Passage after termination of spawning on August 11th, afternoon dive on incoming current



Naiqoro Passage beyond the Groupers

Naiqoro Passage is a beautiful habitat and highly deserving of protection. It not only provides income from divers who pay a levy to local communities but can also be considered a ‘bread-basket’ -- a highly biodiverse environment that is important for generating commercially important resources from the seasonal spawning aggregations and home to several threatened species. The continued formation of grouper spawning aggregations significantly contributes to the economic and food security well-being of communities in the area. The Passage is also a habitat which is used by various megafauna for moving between shallow lagoon habitat and the open sea. Within the study area, we regularly documented sharks, particularly grey reef and whitetip sharks (see graph), Napoleon fish (see graph), and turtles. Humpback whales have been seen in the Passage and heard by divers working at the site. This year we saw a manta ray. Bumphead parrotfish, *Bolbometopon muricatum*, however, have never been seen at the site over all the study years. Many photos were taken by the divers providing material for a pamphlet to be prepared on the Passage for presentation to Matesulevu in 2012. The community is interested in a marine science workshop in 2012 and SCRFA will discuss this option with Fisheries.

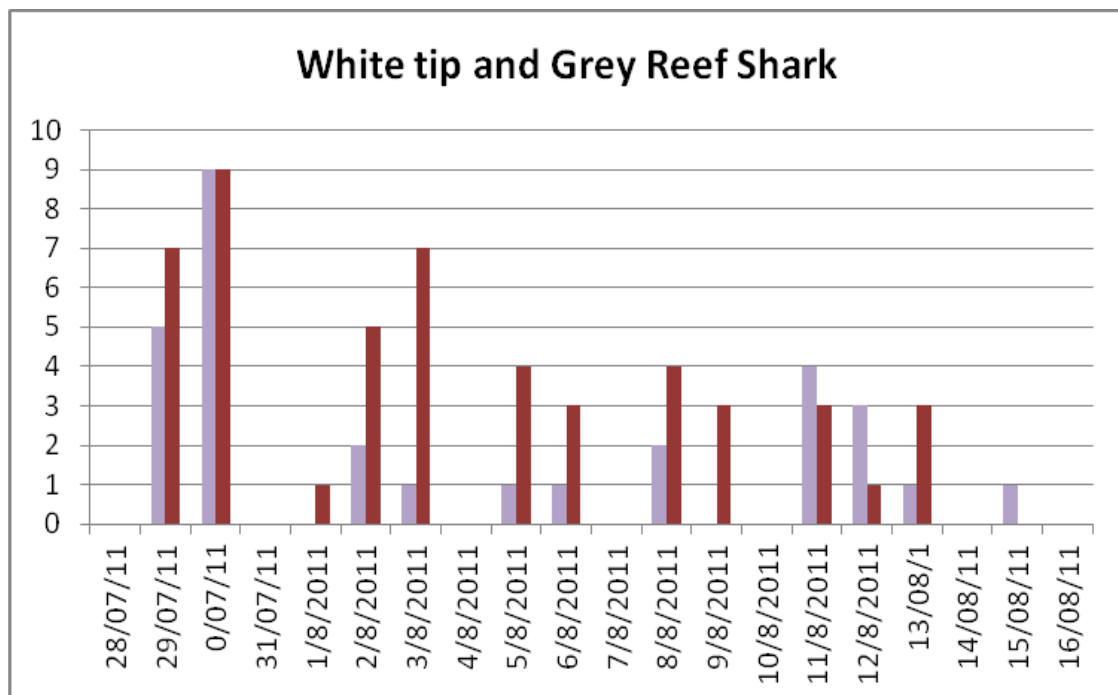
Manta ray entering the aggregation area from the lagoon along the southern wall of the Passage on August 11th, in the afternoon



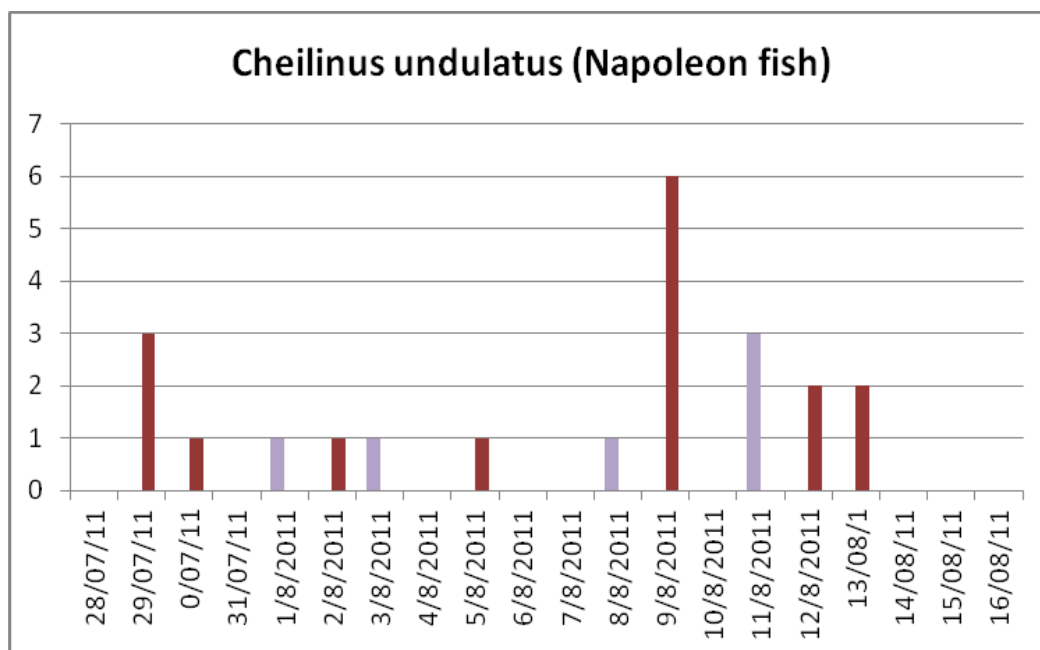
**White-tipped reef shark seen regularly on and around the study site:
the most commonly seen shark at Naiqoro Passage**



Numbers of whitetip (predominantly) and grey reef shark counted in the aggregation area to the north (mauve) and south (plum) sides of the outer Naiqoro Passage from 2th July to 16th August, 2011



Numbers of Napoleon fish counted in the aggregation area to the north (mauve) and south (plum) sides of the outer Naiqoro Passage from 2th July to 16th August, 2011



2011 Summary

- Aggregation and spawning in the three grouper species appear to occur between mid July and mid August, just before the full moon, with fish numbers building from prior to the new moon to just before the full moon.
- Spawning of the three target grouper species occurs at annual temperature lows of about 25 degrees C.
- Maximum numbers of *E. polyphkadion* recorded in 2011 were about 290, *E. fuscoguttatus* about 130 and *P. laevis* about 50 fish. Numbers for these three species in 2011 were similar to peak numbers in 2010. There was little indication of any aggregation of *P. areolatus* (last seen in 2008) and we believe that this (shallower) aggregation has been fished out.
- It is clear that care is needed to determine the aggregation area, in length and breadth on both sides of reef passages to ensure a representative sampling protocol is established to document numbers and species, and with sufficient divers for consistent counts.
- Based on tagging studies and 5 tags returned by fishers over two years, *E. polyphkadion* travels at least 15 km to and from Naiqoro Passage and so the stock of this species is shared by many communities. The health of the aggregation will determine the health of the fishery for this species in the northern Kadavu area and for many fishermen.
- Individual fish can return to the same place in the aggregation year after year, showing strong site fidelity.

- It is recommended that Naiqoro Passage has surveillance for at least 10-14 days prior to the full moon that falls in August, especially on calm days when boats from Suva might bring poachers; there were anecdotal reports of poaching and Matesulevu has very limited capacity to enforce (this year the outboard motor was not working and last year there was insufficient fuel; villagers informed me that the money from the diver levy is not set towards Passage enforcement).
- It is recommended that surveys of the aggregations be repeated at least once every few years to judge the effectiveness of protection compared to the baseline data that we have collected during this project. To survey the full aggregation area, at least three divers are needed and both south and north sites need to be surveyed with underwater visual census.
- From fisher and dive guide reports, the numbers of groupers which once aggregated in Naiqoro Passage were considerably higher (possibly by tenfold or more) and have been severely reduced over the last decade or so. It is hoped that successful enforcement will allow the numbers to recover.
- An increase in the levy paid by divers in the Passage would further help to fund enforcement activities.
- Naiqoro Passage (including the adjacent outer reef area and the channel) is clearly important for a range of megafauna beyond groupers and should be considered for protection that goes beyond present boundaries of the current MPA.
- A colour pamphlet in English and Fijian to describe Naiqoro Passage to tourists and other communities would be useful and SCRFA will help produce this for Mataselevu.
- An economic analysis of the important of the Passage for food security and livelihoods is pending.

Lessons Learned

- Careful planning and a clear understanding of the full extent of the aggregation area are essential to establish a robust sampling protocol.
- Communities must be kept informed of study plans and progress and appropriate permissions obtained.
- Sufficient divers are needed on a regular basis each year to ensure regular sampling with three divers – a minimum of 4 is recommended to accommodate illness, travel delays, etc. Divers need to be disciplined, focused and comfortable in the water to be able to produce reliable counts.
- For tag and recapture studies, considerable effort is needed to inform communities the procedure for returning recaptured animals with tags and a reliable system is needed for reporting recaptured animals
- The reef passage is an important habitat for a range of megafauna, including threatened species like the Napoleon fish, black-saddle coral grouper and squaretail coral grouper (threatened on IUCN Red List).
- **Naiqoro Passage needs stronger protection and the issue of poaching (especially by divers coming from Suva according to anecdotal accounts) needs serious attention. This is likely also applicable to many other**

aggregations within Fiji and national legislation is clearly needed if exploited aggregations are to persist in future.

- The local Kadavu fishery officers could play a stronger role in assisting with the tagging study and informing communities about aggregations.

Acknowledgements

The project in 2011 would not have been possible without the help and support of the following: David and Lucile Packard Foundation, Christian Barnard and Waisalima Resort, Wildlife Conservation Society Fiji, Rick Nemeth, George Mitcheson, Bill Donaldson, Stan Shea and Allen To, and field and logistic support from Masau, Tulala and Rogo. Stan and Allen provided many of the wonderful photos included in this report. In particular, thanks are given to the communities and fishers who shared their knowledge and experience with us, returned tags and assisted in many other ways that made our work possible. The community of Matasulevu is thanked for its generous permission for us to work at Naiqoro.