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Spawning Aggregations of Coral Reef Fish in New Ireland and Manus Provinces, Papua New Guinea: Local Knowledge Field Survey Report

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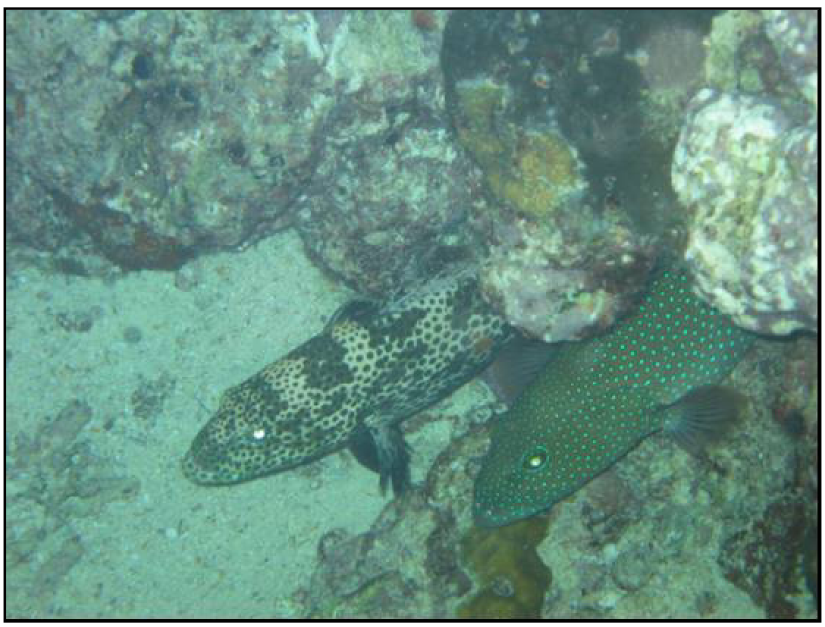

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Cover photo: Two resting *P. areolatus* at a spawning aggregation site. This photo was taken at night. The fish on the left is in the camouflage color phase that is seen in males and females. The one on the right is displaying the yellow/green color phase only seen in females (R. Hamilton).

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INTRODUCTION

Many large commercially valuable species of reef fish aggregate in the hundreds or thousands at fixed sites during specific lunar and seasonal periods for the purpose of spawning (Domeier and Colin, 1997). Not surprisingly, fishers have often taken advantage of this predicable behavior, as exceptionally high catches can be made from spawning aggregations (Johannes, 1978). Although fishers have been aware of spawning aggregations for centuries, biological interest in them is far more recent (Colin *et al*., 2003). There is now a growing awareness among marine biologists and coastal managers of the need to understand the biological parameters of spawning aggregations and the effects of fishing these aggregations (Vincent and Sadovy, 1998; Levin and Grimes, 2002). This awareness has stemmed from the realization that: firstly, spawning aggregations of many commercially important species have often been rapidly over-fished, and secondly, the spawning aggregation phenomena represents a bottleneck in the life histories of many reef fish species, and their conservation and management is critical for ensuring the persistence of the populations that form them (Sadovy and Vincent, 2002).

Although many species of reef fish aggregate to spawn, recent research on coral reef fish spawning aggregations has predominantly concentrated on groupers (e.g. Samoilys, 1997; Zellar, 1998; Johannes *et al*., 1999; Rhodes and Sadovy, 2002). This family's large size, susceptibility to over fishing and importance in destructive commercial ventures such as the Live Reef Food Fish Trade (LRFFT) has brought global attention to the spawning aggregation phenomena (Levin and Grimes, 2002; Pauly *et al*., 2002). The Live Reef Food Fish Trade actively targets spawning aggregations of reef fish, and is considered one of the major threats to spawning aggregations worldwide (Sadovy and Vincent, 2002).

In the Pacific, there is currently little awareness of the importance of the spawning aggregation phenomena, and limited capacity to address the threats being placed on spawning aggregations. The Nature Conservancy (TNC) is seeking to address these issues through a variety of awareness and capacity building initiatives. A component of these initiatives is documenting local knowledge on spawning aggregations for management and conservation purposes. The TNC local knowledge surveys focus in Melanesia, in areas where scientific databases are scarce or non-existent, and commercial LRFFT ventures are operating or likely to operate in the near future. This report outlines the findings of a local knowledge field survey that was carried out between January 4 to February 2, 2004 in New Ireland and Manus Provinces, Papua New Guinea[1].

The objectives of this survey were to:

1. Identify the locations, seasonality, exploitation history and current status of spawning aggregations in these regions.

2. Collect preliminary data on existing local management practices and Customary Marine Tenure (CMT) estates in these regions.

3. Identify the level of interest that communities have in managing their spawning aggregations, the capacity of communities to effectively manage spawning aggregations and their information and expertise needs.

It was envisaged that this study would assist in future collaborative conservation efforts between TNC and local communities in New Ireland and Manus. The majority of the information documented in this report was obtained through interviews with local fishers, LRFFT operators, fisheries officers, government officials and local NGO's, with published and unpublished literature being reviewed

[1] Since February 2004 the authors have been conducting ongoing scientific and ethnographic research at many of the transient spawning aggregation sites that are described in this report. Some of this data is also included in this report.

where available. The success of this project hinged on drawing on Indigenous Ecological Knowledge (IEK) on spawning aggregations. Consequently, the main priority of this research was visiting remote fishing communities and interviewing expert fishers on their knowledge of spawning aggregations. The community liaison and interview procedures that were used are explained in a latter section of this report. We begin below by providing an overview of indigenous ecological knowledge and customary marine tenure. Both need to be understood in order to appreciate how they may be utilized and incorporated into spawning aggregation research and management in PNG.

INDIGENOUS ECOLOGICAL KNOWLEDGE

Indigenous ecological knowledge is an important component of the intellectual and cultural property of many indigenous societies, and it plays an integral part in a wide range of social and cosmological dimensions of these communities' lives (Carrier, 1987; Foale, 1998). From a rationalist viewpoint, indigenous knowledge bases also contain a great deal of information that is useful for management and science. Fishers often know much more than biologists about the location of critical habitats such as spawning grounds (Johannes, 1981 and 1989; Hamilton, 2003a), feeding areas (Hamilton, 1999) and nursery areas (Johannes and Ogburn, 1999; Hamilton, 2004; Aswani and Hamilton 2004a). IEK can also be useful in providing a perspective on the historical state of reef fish resources (Johannes *et al*., 2000), and in instances where large-scale ecological changes have occurred within the lifespan of fishers, knowledge of such changes can be extremely detailed (Hamilton, 2003b; 2004). There is now a burgeoning body of literature advocating the documentation of IEK and its integration with more quantitative types of research (e.g. Christie and White, 1997; Johannes, 1998).

Utilizing local knowledge for spawning aggregation research

The value of utilizing local knowledge in the initial stages of spawning aggregation research is becoming increasingly well recognized, and there have been recent attempts by biologists to develop broad guidelines for obtaining this cultural information (Colin *et al*., 2003). It is noteworthy however that the precision and depth of documented local knowledge on spawning aggregations has varied widely between both regions and researchers (Graham, 2002), no doubt reflecting:

- The amount of local knowledge on spawning aggregations present in each region
- The willingness of local fishers to divulge this information
- The skills of the researcher and appropriateness of the methods used to obtain local knowledge
- The amount of time spent documenting this cultural information

Detailed anthropological based studies that have focused purely on documenting the local knowledge of Pacific island fishers have revealed that as well as knowing the locations of spawning sites, local fishers can also provide highly precise information on: the annual and lunar periodicity of spawning aggregations, species composition at mixed species spawning sites, the spawning behavior of aggregating fish and changes in the status of aggregation over time (Johannes, 1981 and 1989; Johannes and Kile, 2001; Hamilton, 2003a).

It is important to highlight the fact that although indigenous marine knowledge can be enormously rich and of great practical value to scientists and conservationists, there are several common problems associated with documenting local knowledge that need to be taken into account.

1. Indigenous ecological knowledge exists as part of complex cultural systems. Consequently, researchers require an understanding of the cognitive framework of the indigenous culture, and must use anthropological methodologies such as interviewing and participant observation to accurately document this material. Obstacles such as language barriers frequently face foreign scientists wishing to work with IEK (Foale, 1998).

2. IEK is often stratified by gender, age and geographical location (Hviding, 1996; Christie and White, 1997) and specific knowledge pertaining to specific families of fish is often restricted to expert fishers who specialize in targeting those species (Hamilton, 1999; Johannes *et al*., 2000).

3. Most indigenous knowledge of marine ecologies is ultimately directed towards identifying patterns that maximize capture success. Thus some details of fish biology that are important to a marine biologist studying reef fish ecology may well be irrelevant to a local knowledge base, since these biological parameters have no influence on subsistence practice (Hamilton and Walter, 1999).

4. While indigenous knowledge on recent changes in the abundance or size structure of local fish stocks will often be very accurate, local explanations for the mechanisms underlying these changes may not be compatible with scientific paradigms (Ruddle *et al*., 1992:262). "In some places declining yields may be attributed to sorcery or a failure to propitiate the gods".

5. Fishers' knowledge, like scientists, is fallible, and thus cultural information needs to be gathered systematically and treated with the same critical scrutiny that is applied by scientists to any other data set (Hamilton and Walter, 1999; Johannes *et al*., 2000).

CUSTOMARY MARINE TENURE (CMT)

Customary marine tenure is a situation in which identifiable groups of people have informal or formal rights to coastal areas, and in which their rights to use and access resources are, in principle, excludable, transferable, and enforceable, either on a conditional or permanent basis (Ruddle, 1996). Virtually all Melanesian coral reef fisheries operate within well developed CMT systems, where ownership of, and hence access to, coastal areas depends on a range of culturally defined variables including descent line (e.g. Carrier and Carrier, 1983; Hviding, 1996; Aswani, 1999). Various authors working in the coastal Pacific have promoted the idea that in countries where governments do not have the legislative or financial capacity to enforce management rules, CMT systems could be used as an effective basis for managing inshore fisheries (e.g. Ruddle *et al*., 1992; Foster and Poggie, 1993; Johannes, 1998; Thomas 2001).

In some regions of the Pacific, CMT estates and IEK has been successfully incorporated into contemporary inshore management programs (e.g. Johannes, 1998; Fa'asili, and Kelekolo, l999; Aswani and Hamilton, 2004b). However, it has become apparent that CMT systems alone will not conserve marine resources in many countries, especially when the economic incentives to harvest these resources are high and tenure disputes among differing parties are unresolved (Foale 1998; Aswani, 1999). It has been argued that CMT systems throughout the Pacific and Asia were developed primarily for "gain not restrain" (Carrier and Carrier, 1983; Polunin, 1984; Ruttan, 1998) and this issue has been the point of some controversy among academics (Hviding, 1996; Aswani, 1998). Regardless of the mechanisms behind the development of CMT systems, their obvious and undisputed management benefits are:

1. They can provide an existing culturally recognized ownership structure around which management incentives can be based (Johannes *et al*., 1993)

2. Robust CMT systems can effectively restrict outsiders access to traditional fishing grounds (Johannes, 1981; Hviding, 1996) hereby eliminating some of the problems associated with common property that are prevalent in many of the world's inshore fisheries (Hardin, 1968).

It is vital to recognize that CMT systems vary markedly between different regions, and the intricacies of these systems and their robustness and appropriateness to management or conservation objectives need to be carefully evaluated for each region in question. A successful sea tenure regime requires that boundaries be well defined, that they are recognized within the local region, that there is little or no poaching by neighboring groups, that there is the local capacity to enforce rules and that most of the stakeholders are willing to endorse a management initiative. In other words, it is meaningless to implement community based marine management measures, no matter how rich the biodiversity, if harvest restriction rules and exclusion of non-members cannot be enforced (Aswani and Hamilton, 2004b).

KAVIENG, NEW IRELAND PROVINCE

Between January 7 and 20, 2004 Richard Hamilton and Tapas Potuku visited 14 communities in the Tigak, Dyual and Tsoilik Islands surrounding Kavieng, New Ireland. We interviewed local fishers in each community on their knowledge of spawning aggregations, local management practices and views on conservation. Towards the end of the Kavieng field trip we returned to seven of the identified aggregations and conducted Underwater Visual Census (UVC) surveys during the third lunar quarter. The findings of the ethnographic and UVC surveys are presented below. The findings of a further nine UVC surveys that were conducted by the authors in May and July 2004 are also presented.

COMMUNITY LIAISON AND INTERVIEWING PROCEDURE

Upon arriving in a community we would ask to speak to the community leaders, where we would explain who we were working for and what our agenda was. Typically, the village leaders would then call a group of available expert fishers together under a tree or by the beach. We would then introduce ourselves and TNC and give an introductory talk on the life cycle of serranids, outlining among other things, aggregating behavior, spawning, the pelagic larval stages of fish and sex reversal. We would then point out that while biologists knew a lot about serranids' biology; we knew nothing about where or when spawning aggregations occurred on reefs in this region, which is why we wanted to ask local fishers for their help. We ended by clearly stating that the information we were collecting was part of a preliminary assessment of spawning aggregations that TNC was making in their region, and specific details on locations of sites and other sensitive local knowledge would remain confidential.

These introductory talks frequently generated a great deal of interest, and served as a very effective way of initiating conversations on local spawning sites. Many fishers had witnessed spawning behaviors such as fighting, courtship and actual spawning on numerous occasions, but often had not realized that these behaviors related to spawning, instead thinking the fish were 'drunk' or simply 'playing'. Fishers often enthusiastically shared their own observations and asked numerous questions on spawning behavior. Importantly, these introductory talks also served as a quick way of assessing the level of local knowledge on spawning aggregations in the area visited. If we drew completely blank stares from all fishers at the completion of a talk, and further inquires confirmed that no such aggregations where known to occur on surrounding reefs, then we moved onto the next location fairly quickly. On the other hand, when we discovered an area that had a wealth of knowledge on spawning aggregations, we would often ask to stay for a few nights so that we could learn as much as possible. In these instances we would also ask local experts to show us the aggregation sites, so that we could observe aggregation habitats and collect Global Positioning System (GPS) coordinates on the aggregation boundaries.

Individuals or groups of knowledgeable fishers who were willing to be interviewed in detail were asked a wide range of questions on possible spawning aggregations that occurred within their fishing grounds. The questions laid out in the Society for the Conservation of Reef Fish Aggregations (SCRFA) questionnaire (www.scrfa.org) formed the template of the questions covered, although interviews were unstructured, with the interviewee(s) being able to lead the interviewer when appropriate. All interviews were conducted in Papua New Guinea Tok Pidgin. At the end of an interview we cross-checked with the SCRFA questionnaire to confirm that all the points of interest had been covered.

LOCAL KNOWLEDGE OF SPAWNING AGGREGATIONS

The local knowledge surveys in Kavieng enabled us to document information on 27 single and multi-species aggregation sites, and information on one migration route for Plectropomus leopardus and Ctenochaetus striatus. Species that had spatially overlapping territories were deemed to occur at the same aggregation site. A summary of the species said to aggregate at each site, the moon phase when these single or multi-species aggregations occur, and the months when aggregations form are summarized in Table 1. For the majority of these aggregations their precise location was marked using GPS[2], and oral histories of the fisheries (status, exploitation, methods employed) were documented. Detailed information for each aggregation site, including the direct and indirect evidence of spawning for each species is presented in tables in Appendix 1. The aggregation parameters in these tables are adapted from the SCRFA questionnaire guidelines.

[2] In accordance with fisher's requests and in an effort to protect these sites from heavier exploitation, the GPS coordinates of each aggregation site, reef names and the names of informants interviewed have been removed from the aggregation tables in Appendix 1.

Table 1: A summary of the aggregation data documented from around Kavieng, showing species known to aggregate at each site, the moon phase(s) when these aggregations are said to occur and the months of formation.

Detailed information on each aggregation site can be found in Appendix 1.

Aggregation Site No.	Aggregating species	Moon Phase	Months of formation
1	*Plectropomus areolatus* *Epinephelus fuscoguttatus* *Epinephelus polyphekadion* *Symphorichthys spilurus* *Cheilinus undulatus*	Third quarter	Every month of the year
2	*Plectropomus areolatus* *Epinephelus fuscoguttatus* *Epinephelus polyphekadion* *Symphorichthys spilurus* *Cheilinus undulatus*	Third quarter	Every month of the year
3	*Plectropomus areolatus*	Third quarter	Unknown
4	*Plectropomus areolatus*	Third quarter	Every month of the year
5	*Plectropomus areolatus*	Third quarter	Every month of the year
6	*Epinephelus polyphekadion*	Third quarter	Unknown
7	*Epinephelus polyphekadion*	Third quarter	Unknown
8	*Epinephelus polystigma*	Third quarter	Every month of the year
9	*Plectropomus areolatus* *Epinephelus fuscoguttatus* *Epinephelus polyphekadion*	Third quarter	Every month of the year
10	*Plectropomus areolatus* *Epinephelus fuscoguttatus*	Third quarter	Every month of the year
11	*Plectropomus areolatus* *Epinephelus fuscoguttatus*	Third quarter	Every month of the year
12	*Plectropomus areolatus* *Epinephelus fuscoguttatus*	Third quarter	Every month of the year
13	*Plectropomus areolatus*	Third quarter	Every month of the year
14	*Plectropomus areolatus*	Third quarter	Every month of the year
15	*Plectropomus areolatus*	Third quarter	Every month of the year
16	*Plectropomus areolatus*	Third quarter	Every month of the year
17	*Epinephelus fuscoguttatus* *Symphorichthys spilurus*	Third quarter	Every month of the year
18	*Siganus lineatus*	First quarter	Every month of the year
19	*Siganus lineatus*	First quarter	Every month of the year
20	*Siganus lineatus*	First quarter	Every month of the year
21	*Siganus lineatus*	First quarter	Every month of the year
22	*Siganus lineatus*	First quarter	Every month of the year
23	*Plectorhinchus chrysotaenia*	First quarter	Every month of the year
24	*Naso caeruleacauda* *Naso caesius*	First and Third quarter	Every month of the year
25	*Lutjanus boutton* *Lutjanus gibbus*	Unknown	Unknown
26	*Sphyraena barracuda*	Full moon	Every month of the year
27	*Plectropomus areolatus* *Epinephelus fuscoguttatus* *Epinephelus polyphekadion*	Unknown	Unknown
28	**Plectropomus leopardus* **Ctenochaetus striatus* (* Information relates to migrations)	Unknown	Unknown.

There were remarkable consistencies in the local information recorded on species-specific aggregations, both between and within the areas visited. For example, all documented local knowledge pertaining to the lunar and seasonal timing and spawning behavior of *P. areolatus* was identical. The highly precise nature of this indigenous ecological knowledge gives strong support to the validity of this information, and also demonstrates that the timing of many species-specific aggregations vary little in these areas.

It is noteworthy that the depth of knowledge on any particular aggregation varied both by region and between individuals interviewed, and it was only by covering a wide area that we obtained a comprehensive pool of data on species specific aggregations. In a sense, each interview had the potential to add another piece of information to the puzzle. To again use *P. areolatus* as an example, some knowledge was fairly broadly known (i.e. knowledge on lunar periodicity) while other aspects of ecological knowledge, (such as observations of pair spawning and sneaking by other males in *P. areolatus*) was only recorded in two interviews.

Throughout the region the most detailed information was gained by interviewing spear fishers. As well as being able to identify the precise locations of aggregations and their lunar and seasonal periodicity, spear fishers also provided information on:

- Aggregation habitat
- Depth ranges of species at aggregations
- Migrations between day time resting areas and night time spawning sites
- Daily fluctuations in the core aggregation densities
- The response of aggregating fish to human disturbances
- Predominant currents at aggregation sites
- Spawning behavior of aggregating fish

As mentioned above, specific details on each aggregation site are detailed in tables in Appendix 1 and will not be repeated here. Below we simply summarize the main biological points of interest to come out of this work.

The main biological findings of interest

- All aggregations of all species are reported to occur monthly, either just before the new or full moon. *Naso caeruleacauda* and *Naso caesius* are reported to aggregate bimonthly, just prior to the new and full moons. In Palau, Johannes *et al*. (1999) were surprised to find that *P. areolatus* aggregated during 23 out of 26 months at Ngerumekaol. This finding contradicted Palauan fishers' widespread and long held assertion that the main spawning period for this species occurred between April and July each year (Johannes, 1981). Johannes *et al*. (1999) concluded that monthly aggregations of *P. areolatus* may represent a very recent biological phenomenon at Ngerumekaol that had come about as a consequence of heavy fishing pressure on female populations of *P. areolatus*. Unlike Palau, in Kavieng local fishers affirm that *P. areolatus* aggregations have been forming monthly for generations, indicating that this is likely to be a natural phenomena in this region.

- Although *P. areolatus*, *E. fuscoguttatus*, *E. polyphekadion* and *S. spilurus* are reported to aggregate monthly, these species are also said to have a peak season of several months a year, when much larger than normal numbers of each species aggregate at the known sites. This peak season is said to be most pronounced for *E. fuscoguttatus*, *E. polyphekadion* and *S. spilurus*. Local knowledge on when exactly this peak season occurred was vague, with some fishers reporting peak aggregations occurred around the middle of the year, and others reporting aggregations peaked near the end of the year. Many fishers stated that they had not bothered to note the months when peak aggregations occur.

- Two single species aggregations of *E. polyphekadion* (Sites 6 and 7) and a small single species aggregation of *P. areolatus* (Site 3) are reported to only form during peak seasons.

- Two to three very large *E. lanceolatus* are known to sometimes join mixed species aggregations at Sites 1 and 2, with these fish often coming into shallow water.

- *P. areolatus* aggregates to spawn in many different habitat types (channel, patch reef, promontory, and drop off), often forming single species aggregations in small areas that seem unsuitable for *E. fuscoguttatus* and *E. polyphekadion*.

- In some regions there were multiple, spatially separated, aggregation sites that occurred within a very limited geographical area. The most extreme example of this was in and around the mouth of a large passage, where four *P. areolatus* aggregations (Sites 13, 14, 15 and 16), one *E. fuscoguttatus* and *S. spilurus* aggregation (Site 17), and five *S. lineatus* aggregations (Sites 18, 19, 20, 21 and 22) occurred within an area of approximately 5 km sq.

- We documented local knowledge of a recently discovered nocturnal aggregation of *E. polystigma* at a remote location in New Ireland. *E. polystigma* aggregates monthly around the new moon in shallow water near the open seaward end of a large mangrove lined estuary. We were able to visit this site during an aggregation period and collect demographic data from local catches. This species behavior seems to make it very susceptible to over-fishing (See Appendix 2).

- We documented information on mass migrations of *P. leopardus* and *C. striatus* that travel for considerable distances in very shallow water on the eastern side of Ysabel Passage after a violent thunder and lightening storm. It is unlikely that these migrations represent pre-spawning runs (See Appendix 3).

- Spawning aggregations of *Lutjanus gibbus* are said to form over large reef areas in the Tsoi region when the leaves on the coastal Talise tree turn red (Site 25), while spawning aggregations of *Lutjanus boutton* are said to form over the same reef areas (Site 25) when the leaves of the coastal Inou tree turn yellow (Figure 1). For centuries, Pacific Islanders have pinpointed predicable aggregating behavior in reef fish to the flowering or reddening of the leaves of certain coastal trees (e.g. Johannes, 1981: Hviding 1996). Perceivably, the same environmental cues that cause certain trees to flower or lose their leaves may also trigger spawning in certain species of fish. In Buka, the reddening of the Talise tree is used to mark spawning seasons of several species of grouper (Hamilton, 2003a). In New Ireland fishers were vague on the months in which the leaves of these trees color, stating that they followed the trees not calendar months.

Figure 1: A large Inou tree.

FISHING PRESSURE PLACED ON SPAWNING AGGREGATIONS

In the Kavieng region, spawning aggregations are targeted by subsistence, artisanal and commercial fisheries. At some sites all of these fisheries target spawning aggregations simultaneously. Fishing pressure has had a marked affect on many serranid aggregations. Local fishers report that catch rates of serranids have declined dramatically at 11 of the 18 serranid spawning aggregations identified in this study (Sites 1,2,3,9,10,11,13,14,15,16,17). In one instance an aggregation of *P. areolatus* was reported to have been fished to extirpation (Site 13). Of the remaining seven serranid aggregation sites documented, an assessment of status was impossible at four sites (Sites, 5, 6, 7, 8), since these sites were first exploited in 2003. Catch rates at Site 4 are reported as stable; however, this site was only discovered in 2000. Catch rates at Site 12 are said to be stable, which relates to unfavorable fishing conditions at this site. At Site 26 catch rates are reported to be stable. However fishers who exploit Site 26 do not know the lunar periodicity that aggregations form, and the site appears to be only very lightly exploited.

Fishing pressure does not appear to have had as widespread affect on other aggregating species. Catch rates of *S. barracuda* at Site 26 are known to have declined over recent decades, but catch rates from *S. lineatus* aggregations (Sites 18, 19, 20, 21, 22), *P. chrysotaenia* aggregations (Site 23) *Naso* aggregations (Site 24) and *Lutjanus aggregations* (Site 25) were reported to have remained stable. The reported rapid declines in catch rates at serranid aggregation sites is likely to reflect both the life history characteristics of this family (Coleman *et al*., 2000) and the level of fishing pressure frequently placed on these sites. An overview of the subsistence, artisanal and commercial fisheries that target spawning aggregations is provided below.

Subsistence fishing

Many of the serranid aggregations identified around Kavieng region have been exploited by local fishers for subsistence purposes for generations. Today the main forms of subsistence fishing at aggregation sites are hook and line and daytime spearfishing (Figure 2). The degree to which each spawning aggregation is targeted for subsistence needs is highly variable, and relates to how closely an aggregation is located to human settlements, the size of these settlements, the extent to which fishers are aware of the aggregation site and the abundance of other non-aggregating fish in the nearby area. In remote areas where there is a small human population and large healthy reef systems, fishers generally do not exploit known aggregation sites for day-to-day subsistence purposes.

Figure 2: Local fishers displaying from left to right, a *P. areolatus*, *E. fuscoguttatus* and *E. polyphekadion* that were speared during the day from a known spawning aggregation site.

Artisanal fishing

In this report the term artisanal fishing refers to local fishers who are fishing specifically for the purpose of harvesting fish for sale. The predominant fishing method used by artisanal fishers at aggregation sites is nighttime spearfishing, with fishers typically limiting their activities to lunar days when aggregation numbers are known to peak. Night spear fishers use a variety of equipment; the most basic gear consists of a pair of goggles, an underwater flashlight and a handheld steel spear that is thrust into sleeping fish. The most advanced technologies involve using underwater flashlights, masks, snorkels, fins and rubber powered steel spears or short homemade spear guns. Interviews revel that like other coastal regions of Melanesia (e.g. Hamilton, 2003b) this fishing method is fairly recent.

Nighttime spearfishing with flashlights is reported to have been increasingly introduced throughout the Kavieng region since the late 1980's, with the introduction of this method relating to the increasing availability and affordability of underwater flashlights in trade stores at the regional centre of Kavieng. Wright and Richards (1985) conducted a comprehensive 13 month survey of the species composition and fishing methods used by subsistence and artisanal fishers in the Tigak Islands in 1980 and 1981. Their study shows that in the early 1980's, night spearfishing was an important fishing method for Tigak Islanders, however because underwater flashlights were not used fishers were limited to shallow water. "Seventy three percent of the speared catch was taken at night. This was done by drifting in a canoe with a kerosene pressure lantern attached to its bow over shallow reef and seagrass areas.

Spearfishers work from the canoe (with 2-3 m long handheld spears) or dive beside it (with homemade spear guns) using a mask or hand-carved wooden goggles with glass eyepieces" (Wright and Richards, 1985).

The aggregating species most commonly targeted by nighttime spear fishers is *P. areolatus*. This species is a prime target because:

- During peak spawning periods large numbers of *P. areolatus* aggregate in very shallow water on the reef, where they are often exposed and clearly visible (Figure 3).

- *P. areolatus* is inactive at night and consequently is easy to spear (this contrasts with *E. polyphekadion* and *E. fuscoguttatus* which often flee from divers at night).

- *P. areolatus* is an intermediate size that is easy for spear fishers to catch and handle. (Many spear fishers stated that they did not spear *E. fuscoguttatus* when they came across them, as these fish bend their spears and occasionally escaped with the spears lodged in them).

- *P. areolatus* is generally more numerically abundant that *E. fuscoguttatus* and *E. polyphekadion* at aggregation sites, and this is especially true in shallow water ranges that are accessible to free divers.

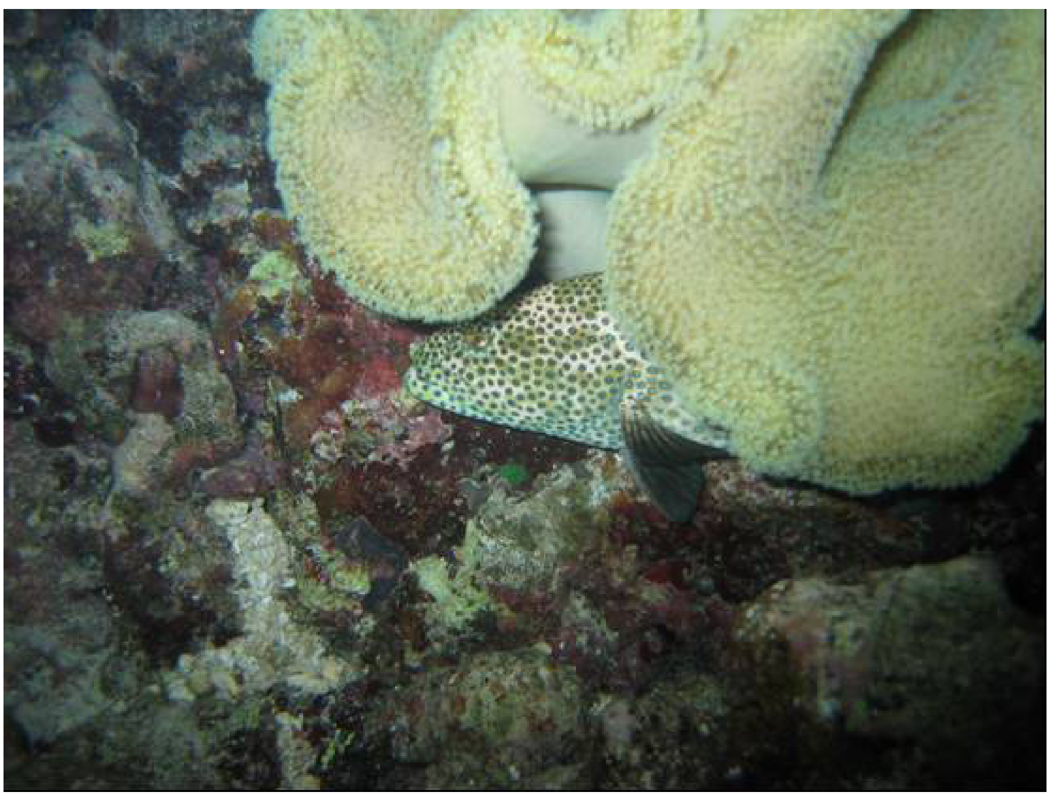

Figure 3: A partially exposed *P. areolatus* sleeping under a soft coral. This fish was photographed at a spawning aggregation site at night in less than 10 meters of water.

Maximum catch rates from healthy aggregation sites can be very high; with fishers reporting that four night divers who conducted 'one sweep' of Site 2 can take 70-80 *P. areolatus* in approximately an hour. Likewise, fishers report that two night divers can capture up to 60 *S. spilurus* from a recently discovered nocturnal aggregation (Site 17) in several hours. These maximum catch rates reported for moderately exploited sites seem reasonable, given that maximum catch rates for night time spearfishing at a recently discovered aggregation site in the Solomon Islands are 16.8 kg *P. areolatus* per hour per fisher (Hamilton, not dated). The exceptionally high catch rates that can be made at aggregation sites using this method appear to have largely spelt the end to other fishing methods (such as hook and line) for artisanal purposes.

In at least one case, night spearfishing pressure alone appears to have been sufficient to over fish a widely known aggregation site (Site 9). It is noteworthy that at many sites where LRFFT operations were in progress, local fishers continued to dive for *P. areolatus* at night.

Commercial fishing – the LRFFT

A Hong Kong based live fishing company, Niugini Islands Sea Products (NISP), commenced operations in Kavieng in June 1994 (Aini and Hair, 1995) and this company has been active on and off around Kavieng ever since. Initial operations concentrated in the Tigak Islands and the Tsoi Islands and were expanded to Mait Island near Dyual in 1997 (Butler, 1997). An initial shipment of 4000 kg from the Tigaks was made in November 1994, with a second shipment of 5,500 kg of live fish captured from around Mait and the Tigaks being made in November 1997 (Butler, 1997). Hand lines and traps have been the most commonly used gear for capturing serranids. In New Ireland LRFFT operators have consistently sought out and targeted spawning aggregation sites, with a line of traps purposely placed along known spawning migration routes and at spawning sites by local divers operating on hookah gear (Figure 4).

Figure 4: Tapas Potuku holding onto a functional fish trap from previous LRFFT operations that that had been left behind at a spawning aggregation site.

In 1998, a moratorium was imposed on the LRFFT in Papua New Guinea, following information that LRFFT operators were secretly using cyanide (Gisawa and Lokani, 2001; Gisawa, not dated). However, realizing that there was much interest in the LRFFT and that there were opportunities for local communities to benefit from it, the National Fisheries Authority (NFA) approved two trial

LRFFT licenses in late 2000 (Gisawa and Lokani, 2001). The purpose of the trial was to collect the necessary biological and social information required to base management plans for future LRFFT operations in PNG (Gisawa, not dated). One trial license was issued for NISP around the Tigak area in New Ireland and the other was approved to operate at M'Buke Islands in Manus Province (Gisawa and Lokani, 2001). The operation in New Ireland was the only one of the two that commenced. NISP commenced fishing in February 2001, but by April 2001 its license was suspended for reasons relating to reef tenure disputes and unregulated fishing (Gisawa, not dated). During the period in which the trial license was suspended, NFA, with assistance from TNC, conducted an in-water search of likely serranid spawning aggregation sites around the trial fishing areas, with a view to identifying and protecting important aggregation sites from commercial exploitation (Lokani, 2001; Graham, 2002). Relatively little aggregation activity and spawning-related behavior was observed but a few likely aggregation sites were identified (Lokani, 2001), and subsequently several areas in the Tigak region were closed to LRFFT operations (Gisawa, not dated).

The trial operations re-commenced from August to October 2001 and catches from these operations were monitored by NFA staff. In late 2001 a total of 6,100 kilograms of fish were exported to Hong Kong, with the most common species by weight being *E. fuscoguttatus*, *E. polyphekadion*, *C. undulatus* and *P. areolatus* respectively (Gisawa, not dated). The species composition reflects what this interview survey has confirmed, that LRFFT activities around Kavieng have largely concentrated on spawning sites. The three serranid species listed above are known to aggregate to spawn in overlapping territories during similar lunar and seasonal periods (Johannes *et al*., 1999; Rhoades, 2003). The endangered serranid *E. lanceolatus* also appears sporadically in LRFFT exports (Aini and Hair, 1995; Gisawa, not dated). It is likely the *E. lanceolatus* captured for LRFFT operations were also taken from spawning sites, as local fishers from throughout the region report that this rare species is frequently present in low numbers at mixed species spawning aggregation sites. Gisawa (not dated) estimated that 70 percent of the fish exported in 2001 were captured with traps, with hook and line fisheries having mortalities as high as 70 percent.

A summary of some of the main NFA findings from monitoring the trial LRFFT operation around Kavieng in 2001 are presented below. These are adapted from a comprehensive NFA technical report on the trial fishing process in the Kavieng area (Gisawa, not dated).

- Local communities are widely interested in being involved in the fishery, since it has the ability to generate income both through royalty payments, and through local resource owners selling the fish they capture directly to the LRFFT operators.

- In order to be successful, all LRFFT operations need to be fully endorsed by the resources owners.

- Seasonal or permanent closure of the spawning aggregation sites is recommended as a prerequisite to conducting live food fish fishing activities. (Note though, that Graham (2002) states that a ban on fishing spawning aggregations would probably make LRFFT operations economically unviable).

- The majority of *P. areolatus* and *E. polyphekadion* captured were considered to be above the estimated size of first sexual maturity, while the majority of E. fuscoguttatus captured were below the estimated size of first sexual maturity. Approximately 17 percent of the captured *C. undulatus* were below estimated size of first maturity.[3]

- Community based co-management is recommended as the appropriate management regime for managing the LRFFT in PNG.

[3] Gisawa calculated these figures using available species specific size-frequency distributions and an empirical formula provided in Froese and Binohlan (2000)

Upon completion of the LRFFT trial in Kavieng, NFA decided to advertise for new LRFFT licenses. Two new licenses were granted to NISP, and NISP continued to fish sporadically in the Tigak Islands in 2002 and 2003, although it was plagued with financial problems and tenure disputes (John Aini, pers. com. 2004). In response to tenure disputes and low catches around the Tigaks, in mid-2003 LRFFT operators again negotiated to commence fishing in the Dyual region. Local resource owners agreed on the condition that only local fishers would be allowed to fish, and traps would be banned. Between approximately May and July 2003 between 2-4 tonnes of live fish (made up predominantly of *E. fuscoguttatus* and *E. polyphekadion*) were captured from known aggregation sites in the Dyual region. In January 2004 a shipment of approximately 7,000 kg was exported out of Kavieng; approximately half of this shipment came from around Dyual. NISP has now downsized its operations in Kavieng and extended out to Milne Bay (Leban Gisawa, pers. com. 2004).

In New Ireland the commencement of LRFFT operations have significantly increased the fishing pressure on known aggregation sites and have also led fishers to target aggregations of groupers that were previously little known and relatively unexploited. This was aptly demonstrated when the location of a little known serranid aggregation (Site 6) was widely publicized to local fishers once LRFFT operations commenced. Prior to this, the aggregation had never been fished and its location was known to only one fisher. Similarly, the large number of individuals hook and line fishing for LRFFT operations around Site 6 resulted in fishers discovering another previously unknown aggregation that was located nearby.

Summary on fishing pressure on spawning aggregations

The whereabouts and seasonality of many of the spawning aggregations around Kavieng have been known and exploited for generations. In the last two decades artisanal nighttime spearfishing and commercial LRFFT operations have targeted many of the known spawning aggregations in the Kavieng region, and in many cases this has resulted in the dramatic declines in catch rates. Site 13 was fished to extirpation by LRFFT and night diving activities. Aggregations of *P. areolatus* at Site 9 (which appears to have never been targeted by the LRFFT) are reported to be in an abysmal state after years of heavy nighttime spearfishing pressure.

On a more positive note, at this stage even heavily over fished aggregations appear to have the ability to re-establish. Spear fishers report that aggregations of *P. areolatus* at Site 13 have started to recover since LRFFT operations ceased, with very small numbers of fish (<10) now seen aggregating at this site on a regular basis since late 2003. Populations of *E. fuscoguttatus* at Site 1 are also reported to have recovered over a five year period of no commercial fishing. Finally, it would appear that in the more lightly populated regions around Kavieng, there may still be aggregation sites that are undiscovered. Five of the serranid aggregation sites that were identified in this survey were discovered within the last five years.

UVC SURVEYS AT IDENTIFIED AGGREGATION SITES

In mid-January 2004 we conducted UVC surveys at seven sites in the Kavieng region that fishers had previously identified as spawning aggregations. These surveys were conducted towards the end of the third quarter, the lunar period when the numbers of fish at aggregation sites are said to peak. In January three surveys were conducted using SCUBA gear, with four other sites being surveyed while snorkeling on the surface. A further nine UVC surveys were carried out on SCUBA at seven sites towards the end of the third quarter in May and July 2004. Eight of these surveys were conduced on SCUBA, and one on snorkel. The main objectives of these surveys were to:

1. Verify that the aggregation sites identified by local fishers were indeed spawning aggregation sites.

2. Record the abundance of *P. areolatus, E. fuscoguttatus* and *E. polyphekadion* at each site, and any signs of spawning that these fish displayed.

The UVC survey methods were as follows: When surveying on SCUBA, we used previously saved GPS waypoints to navigate back to one of the end points of the aggregation site. Once in the water we descended to 20 m and then proceeded to swim along the entire length of the aggregation site with the prevailing current, recording on underwater paper the numbers of all *P. areolatus, E. fuscoguttatus* and *E. polyphekadion* seen. At the largest aggregation Site 2, we did not cover the entire aggregation area. When surveying on snorkel, we navigated to an endpoint using the same methods described above, then swam over the entire length of the aggregation site while remaining on the surface, recording the numbers of *P. areolatus, E. fuscoguttatus* and *E. polyphekadion* seen. At all sites surveyed on snorkel visibility was greater than 20 m. Sites 6 and 7 were surveyed on snorkel. These sites are located in passage mouths, with *E. polyphekadion* said to aggregate on the sand at the bottom of the passage. At both sites the passage bottom is no more than 15m deep and was clearly visible on snorkel. The species abundance data obtained from these surveys is summarized in Table 2.

Table 2: Summary of the species abundance data collected from the UVC surveys conducted in January, May and July 2004.

Site	Date	Lunar stage	Survey method	*Plectropomus areolatus*	*Epinephelus fuscoguttatus*	*Epinephelus polyphekadion*
1*	29-Mar-03	Third quarter	SCUBA	73	62	2
1	20-Jan-04	Third quarter	SCUBA	72	4	4
1	19-May-04	Third quarter	SCUBA	21	78	3
2	19-Jan-04	Third quarter	SCUBA	377	14	14
2	19-May-04	Third quarter	SCUBA	69	15	0
6	19-Jan-04	Third quarter	Snorkel	0	0	0
7	19-Jan-01	Third quarter	Snorkel	2	1	0
7	14-Jul-04	Third quarter	Snorkel	0	0	0
9	20-Jan-04	Third quarter	Snorkel	15	4	0
9	17-May-04	Third quarter	SCUBA	3	4	4
9	13-Jul-04	Third quarter	SCUBA	3	14	28
10	18-May-04	Third quarter	SCUBA	10	0	0
10	13-Jul-04	Third quarter	SCUBA	52	19	15
11	18-May-04	Third quarter	SCUBA	8	0	0
16	18-Jan-04	Third quarter	Snorkel	3	0	0
17	18-Jan-04	Third quarter	SCUBA	0	1	0
17	18-May-04	Third quarter	SCUBA	1	0	0

* Based on maximum abundance data collected at this site during a TNC spawning aggregations monitoring workshop (Rhodes, 2003).

The UVC data collected to date provides a powerful testimony to the value of incorporating local knowledge into the initial stages of spawning aggregation research in this region. Of a total of nine sites surveyed to date, there is sufficient data to verify that four of these nine sites (Sites 1, 2, 9, 10) are serranid spawning aggregations sites. Site 11 also appears to be an aggregation site for *P. areolatus*, although abundances at this site were low when surveyed. At the remaining four sites surveyed there are currently insufficient data to verify that these sites are serranid spawning sites. The available data for each site is discussed below.

- The most information available is for Site 1, which was first surveyed during a TNC spawning aggregation monitoring workshop in April 2003 (Rhodes, 2003). *P. areolatus* aggregations were observed in April 2003, and in January and May 2004. They were also observed here in July 2004, although no counts were in July 2004, as we were in the process of setting permanent transects there at that time. On all occasions gravid females and chasing and color changes associated with spawning were observed. The available data concurs with local fishers assertions that this species aggregates to spawn every month of the year in this region. At Site 1 *E. fuscoguttatus* aggregated in April 2003 and May 2004, but not in January 2004. *E. fuscoguttatus* also aggregated in July 2004 when we were setting transects at this site. The very low abundance of this species in January 2004 indicates that this species may have a more defined season than *P. areolatus*, a statement also made by local fishers. To date *E. polyphekadion* has never been seen in large numbers at this site.

- Site 2 has been surveyed in both January and May 2004. *P. areolatus* aggregated and displayed signs of spawning in both months (gravid females, chasing and color changes). Much larger abundances of this species were seen in January 2004. The observed differences could be due to three factors. Firstly, the observed differences in fish numbers may reflect real differences in absolute abundance between the two months. Secondly, the observed differences may relate to the lunar timing of the two surveys. The May survey was done on the new moon while the January survey was three days before the new moon. It is possible that by the time the surveys were completed in May many of the aggregating *P. areolatus* had already spawned and dispersed. Finally, observed differences in abundance may in part reflect a fishing effect, as this site was targeted by night spear fishers during the third lunar quarter in May in order to supply a commercial fishing vessel from Kavieng. *E. fuscoguttatus* were aggregated in small numbers at this site in both January and May 2004. *E. polyphekadion* was observed here in low numbers in January 2004.

- Site 9 and 10 have been both been surveyed twice on SCUBA. In July 2004 moderate sized aggregations of *E. fuscoguttatus* and *E. polyphekadion* had formed at both sites, and chasing behavior was observed in both species. At both sites these fish were extremely wary and would flee into deeper water or into the extensive small cave systems on the outer slopes as soon as they sighted a SCUBA diver. Their wariness no doubt in part reflects the heavy spearfishing that has and continues to occur at these sites. At Site 10, *P. areolatus* aggregated in both May and July, although many more fish were seen in July. In both months *P. areolatus* at Site 10 were displaying signs of spawning (gravid females, chasing and color changes).

- Site 11 was surveyed in May 2004, and eight *P. areolatus* were sighted and seen displaying chasing and color changing behaviors that are associated with spawning. The low abundances sighted here may relate to historical fishing pressure, as aggregations at this site are heavily exploited, or aggregations may have simply been small at this site in May. It is noteworthy that abundances of *P. areolatus* at Site 10 were far lower in May 2004 than in July 2004.

- At the remaining sites 6, 7, 16 and 17 the numbers of fish sighted were not high enough to constitute spawning aggregations. The very low numbers of aggregating serranids at Site 16 and 17 may represents over fishing at these sites. These aggregation sites have been heavily exploited by night divers and LRFFT operators in recent years, and their numbers are known to have declined dramatically.

- The absence of aggregations from Sites 6 and 7 should be interrupted with caution. Sites 6 and 7 are reported to be single species aggregation sites for E. polyphekadion. This species is reported to show a peak aggregation period in this region, the timing of which is poorly defined in local knowledge bases. It is quite possible that this species may not have been aggregating in January 2004 or July 2004.

The results of the UVC surveys conducted to date are being interpreted with available social data to assist TNC in determining where to focus future intensive monitoring and conservation efforts. These next steps are discussed in a latter section of this report.

LOCAL MANAGEMENT PRACTICES WITHIN EXISTING CMT ESTATES

Local reef owners in New Ireland Province have implemented and enforced a variety of customary closures on their reefs for centuries (Aini, 2002). Aini (2002) states that traditionally reef closures have been initiated for a variety of cultural reasons relating to:

- *Tumbuan* practices (i.e. where beaches or reefs that are near areas of importance to *Tumbuans* (indigenous religious figureheads) are closed, either seasonally or permanently.

- *Malagan* practices (i.e. where a certain reef area directly in front of a deceased person's grave is closed for a period of time).

- The presence *masalais* (evil spirits). Local reef owners put taboos on reefs that are inhabited by *masalais*.

- Stockpiling for upcoming events. Reefs or valuable reef resources (such as sea cucumbers) are closed for a period of time to allow these resources to increase in abundance. These resources are then harvested in one go in order to raise cash or a large supply of food for an important community event. In recent times these types of closures have typically been put in place in order to stockpile resources for future important events such as church openings.

- Rain making practices

- Conservation practices. Some reefs adjacent to communities are closed in the belief that this will result in many fish accumulating close to shore, where they will be easily captured.

Depending on the situation, closure periods can vary from one month to many years. In the past these closures were strictly enforced. Traditionally, individuals who fished in a closed area were expected under customary laws to pay fines in *mis* (shell money) and pigs, with the level of the fine depending on the nature of the closure, the amount of fish taken from a closed area, and the status of the person in charge of the closed area (Aini, 2002). Aini (2002) states that today the power of chiefs and community leaders have been seriously degraded in many parts of New Ireland. As a consequence, customary closed areas are often not respected. It is noteworthy that in the majority of instances, any conservation benefits that have come about as a result of traditional customary closures have been the by-product of these closures, rarely the intention.

In some coastal areas around Kavieng town there has been increased local interest in implementing community based management measures for marine resources in order to ensure the sustainability of local fisheries. This interest has stemmed from the widely perceived notion that many valuable resources are in decline, and as a result of education and awareness campaigns in this region (Aini, 2002). Aini (2002) notes however, that in many instances 'interest in management' has not often translated into actual management measures being put in place. In part because many communities do not have the capacity to implement or enforce community based management controls. A brief overview of some of the existing CMT structures in the Tigak and Dyual Islands is provided below.

CUSTOMARY TENURE ESTATES IN THE TIGAK ISLANDS AND AT DYUAL ISLAND

Tigaks

With the exception of the reefs surrounding a few leased islands, all reef systems in the Tigak Islands are owned communally by various clans and communities under traditional systems of customary marine tenure. While there was no attempt to document the intricacies of sea tenure estates in the Tigak region in this study (this would be a major anthropological study in itself), several broad observations that are relevant to future conservation and management objectives are overviewed below. In the Tigak Islands individual clans and communities continue to claim primary ownership of various sea estates in their nearby vicinity. However, in many instances, resource owners now have limited capacity to restrict outsiders from fishing in their traditionally defined grounds (Aini, 2002). Aini (2002) states that respect for the rights and beliefs of customary reef owners has eroded considerably in the Tigak Islands, resulting in a situation where requests made by customary owners are frequently ignored. Indeed, it is apparent that in the Tigak Islands marine resources are exploited by a wide range of people, including both Tigak Islanders and outsiders from Kavieng town who are not descended from this area. Poaching inside some of the more stringently controlled customary defined fishing grounds is also said to occur. Tigak Islanders themselves seem to have almost open access to fishing within the entire Tigak region if fishing is for subsistence purposes. However, when customary ownership of reefs has translated into a cash value (i.e. in the form of royalty payments from LRFFT operators to customary reef owners) tenure disputes have arisen frequently, and have remained unresolved (Gisawa, not dated).

The fact that traditional CMT systems have eroded and appear poorly defined in many areas in the Tigaks implies that it will be a challenging task for communities to enforce their management decisions, and it is unlikely that they will be successful without external support. In the Tigak Islands, any process of community-based management will require a significant level of consultation and cooperation between all stakeholders. Poaching from outsiders also has the potential to undermine management measures agreed on by all traditional reef owners in this region. In short, although many communities in the Tigaks were enthusiastic about the need to manage their aggregation sites, this enthusiasm may not translate smoothly into effective community based management initiatives in all areas. It is important to recognize that some communities in the Tigaks will be more capable of effectively managing their aggregation sites than others. Indeed, several aggregation sites in the Tigaks have been identified where the risks of poaching and tenure disputes are low. These sites are located in close proximity to the communities that own and exploit them, and occur within sea tenure regimes that appear reasonably nucleated and well defined.

Dyual Island region

The population of Dyual Island is smaller than in the Tigak Islands and communities on this island are sparsely distributed. All reef areas around Dyual are customarily owned, and in many of the areas visited, ownership of resources appeared more clearly defined and robust than in the Tigak Islands. Primary ownership of many of the aggregation sites in this region can be traced back to one family or clan. Although only one clan may claim primary ownership of an aggregation, a much larger group of people (i.e. all the inhabitants of nearby communities) may have rights to fish in this area. Some traditional reef owners in this region also enforce access to their reefs. Outside fishers wanting to fish in their waters ask for permission first, and during the recent LRFFT operation in this area buoys were used to demarcate the boundaries of traditional fishing grounds. Nether the less there are some aggregation sites in this region where customary ownership is disputed and the topic of primary ownership remains a sensitive issue; however this will not be discussed further in this report.

Community leaders in the Dyual region are aware that the artisanal and commercial fishing pressure has had a large detrimental impact on many of their spawning aggregations in recent years, and they have expressed interest in finding ways to manage their aggregations in a sustainable way. In summary, it appears that many of the aggregations around this region could be adequately managed by local communities. In many instances customary marine tenure estates in this region appear well defined and robust, and local fishers appear to have the ability to enforce access restrictions to some aggregations. Furthermore, because Dyual Island is some distance from Kavieng town, resource owners do not have as many problems with outsiders poaching in their waters. Finally, placing management restrictions on aggregations will have little impact on day-to-day subsistence livelihoods, since these spawning aggregations are generally only utilized for generating cash.

RECOMMENDATIONS FOR FURTHER BIOLOGICAL AND ETHNOGRAPHIC RESEARCH

The overall aims of the local knowledge surveys were to firstly identify spawning aggregations sites. Secondly, assess the interest that local communities have in managing their spawning aggregations and thirdly, assess the capacity of local communities to effectively manage these resources under existing customary marine tenure estates. Although this local knowledge survey and follow on research in this region has produced a substantial amount of information, many of the identified spawning aggregations sites remain unverified, and the finer details pertaining to the customary ownership of specific aggregation sites remain largely unknown. Carrying out the following biological and ethnographic research will place TNC in a position to provide sound advice to all stakeholders on the most appropriate ways to manage and conserve their spawning aggregations in the Kavieng region.

Biological recommendations

1. Since May 2004 Tapas Potuku has been leading UVC surveys at the grouper aggregation sites around Kavieng that were identified through the local knowledge survey. The available UVC collected to date has helped verify that many of the aggregation sites are transient grouper spawning aggregations. These UVC surveys are also providing preliminary data on the status of these aggregations. A critical next step of the UVC surveys should be to focus on collecting quantitative comparable monthly data from several of the sites over the next 12-24 months. Obtaining this data will allow us to determine the months of the year in which spawning aggregations of each species are forming, and the months in which the abundance of each species peaks. Peak spawning season is poorly defined in the local knowledge base in Kavieng; however, identifying this period is vital for developing future community based and regional management measures such as closed seasons. Identifying peak seasonality is also important for identifying the time frames in which future UVC research on spawning aggregations in this region should be conducted. The following steps are recommended and are currently being initiated.

    - Place permanent belt transects at Site 1 and Site 10, and begin routine monthly monitoring of these transects over the next one to two years. Three 50 m long 10 m wide transects were established at Site 1 in July 2004, and permanent transects will be established at Site 10 shortly. For a detailed description of the methodology used for establishing these belt transect refer to Pet, *et al*. (2005). By conducting monthly UVC surveys at these sites during the late part of the third quarter over the next 1-2 years, we will be able to pinpoint the peak spawning seasonality of these species, and more accurately assess the status of the aggregations. Sites 1 and 10 have been chosen by TNC as locations to focus further conservation efforts, as communities that claim ownership over the reefs on which they occur are interested in initiating conservation measures, and they also appear to have some capacity to enforce these measures.

    - Place temperature data loggers at Site 1 and 10. Temperature data loggers are being placed at spawning aggregations sites in several locations in Melanesia where spawning aggregation monitoring programs are underway, so that the effect of temperature on spawning can be investigated.

    - Continue to survey at the remaining transient spawning aggregation sites in Kavieng that were identified in this survey but are yet to be verified.

2. Given the rarity and vulnerability of *E. polystigma*, further documentation of these aggregations is warranted, including a detailed analysis of its reproductive biology, spatial distribution, spawning season and sexual pattern. Further effort also needs to be placed on raising awareness of the significance and vulnerability of this aggregation with local fishers. Specific recommendations for this aggregation are detailed in Appendix 2.

Ethnographic recommendations

To further TNC's understanding of social and political setting in which spawning aggregations of interest are located, it would be valuable to document the following information through detailed interviews with individuals in the communities who own and exploit these aggregations. This research should initially focus in the areas around Site 1 and Site 10, where long term monitoring efforts will be carried out.

- Determine which communities, clans, and individuals claim primary customary ownership of the aggregation sites of interest.
- Document the names of all individuals, clans and communities that exploit each aggregation of interest. This includes recording information on individuals with legitimate customary claims to these sites and individuals who are poaching.
- Determine which individuals have overlapping access rights to more than one aggregation, and how they acquired these overlapping rights.
- Document how ownership of these aggregations is passed on from generation to generation and if ownership rights changed over time.
- Determine how much a closure on spawning aggregations would affect fishers who target these aggregations.
- Document individual's thoughts on community based management of resources, and if they think this is a necessary and workable approach for managing spawning aggregations.
- Determine the level of interest that communities have in community based management.
- Document information gaps and misunderstandings in local knowledge bases on spawning aggregations.

MANUS

Manus Province is one of the smallest and most isolated provinces of Papua New Guinea. The capital of Lorengau is based on Manus Island, which is the largest island in the province. The majority of the population is subsistence based. Cash crops include cocoa, copra, timber, fish, beche-de-mer, trochus and shark fin. Remittances from family members working outside of Manus are also a very important source of rural income. Around Manus Island there is a marked distinction between what is known as bush people and sea people. Sea people live on small islands at varying distances from Manus Island. Many sea people are almost completely dependent on marine resources as a means of survival. In many areas around Manus Island barter systems between marine and land based communities still exist, where fish and other marine products are exchanged for food staples and building materials.

In Manus spawning aggregations of groupers are actively targeted by subsistence and artisanal fisheries, with the eggs of female groupers being considered a delicacy. The depth of local knowledge on spawning aggregations is highly variable from region to region in Manus, relating in part to whether communities currently living by the sea have originated from bush or sea tribes. The most detailed local knowledge on spawning aggregations is held by individuals from the Titan tribe who live on the southern side of Manus (Hamilton, 2003a). These seafaring people are renowned throughout Manus for their local knowledge on all aspects of sea life.

Between January 22 and February 2, 2004, Manuai Matawai and Richard Hamilton visited six island communities off the southern coast of Manus Island. We interviewed local fishers in each community on their knowledge of spawning aggregations, local management practices and views on conservation. We also held community meetings in three of the communities visited. The Manus fieldwork differed somewhat from the Kavieng fieldtrip in that both Manuai Matawai and Richard Hamilton already knew of several important spawning aggregation sites around southern Manus. Manuai Matawai is from the Titan tribe and has his own local knowledge base on spawning aggregations in this region, and Richard Hamilton had accompanied Manuai Matawai to Pere village in southern Manus on a SCRFA spawning aggregation survey in February 2003 (Hamilton, 2003a).

Consequently, prior to conducting this fieldtrip, we had already decided to make revisiting the wider region around Pere a priority. Revisiting the Pere community and visiting the surrounding communities proved to be a very valuable exercise. It allowed us to document local knowledge on several aggregations that we were unaware of. It also enabled us to document some important details on multi species spawning aggregation sites that we had missed in previous surveys. Since we already knew of the locations of several of the major spawning aggregation sites, it also gave us the chance to organize community meetings with the local reef owners of these aggregations, the procedures and outcomes of which are outlined later on. On completing our work in this region we traveled to the outer Johnson, Pak and Rambutso Islands. None of these areas had been visited previously.

INTERVIEWING PROCEDURE

The interviewing procedures were the same as those outlined for Kavieng.

LOCAL KNOWLEDGE OF SPAWNING AGGREGATIONS

In some areas of southern Manus, the depth and precision of indigenous ecological knowledge bases are extremely detailed. This reflects both the dependence of these communities on the sea and their customs regarding harvesting rights. In several parts of southern Manus, various clans within a village specialize in targeting certain important marine species. One clan might specialize in targeting *P. areolatus* spawning aggregations, while another targets mud crabs, and yet another targets aggregations of bumphead parrotfish. These clans have targeted specific species for many generations, and are known as the fishing clan of the species that they harvest. For example, in Loniu village in southern Manus the harvesting of spawning migrations of mullet is the responsibility of the

Kanas (mullet) clan. In PNG Pidgin the *Loniu Kanas* clan is referred to as "*Haus boy bilong Kanas*", which means "the group of people (under one roof) who look after this fish". Within this clan is a head figure, known as "*Papa bilong Kanas*", the "father of *Kanas*". The Kanas clan has a meeting house (*Kanas haus*) where they store the fishing equipment used to capture *Kanas*, and where fishers from this clan can meet to organize fishing trips or simply to relax (Hamilton, 2003a). Traditionally each fishing clan of an important marine species was the only clan permitted to harvest that species. Today, this custom has broken down in some areas, and in such cases reefs are said to have "gone public". Throughout the region however, fishing clans are still recognized, and it is widely known that each clan holds very detailed and highly preserved local knowledge bases on the species that they target.

The local knowledge surveys in Manus enabled us to document information on nine single and multi-species aggregation sites. Species that had spatially overlapping territories were deemed to occur at the same aggregation site. A summary of the species said to aggregate at each site, the moon phase when these single or multi-species aggregations occur and the months when aggregations form are summarized in Table 3. For all of these aggregations their precise locations were marked using GPS, and oral histories of the fisheries (status, exploitation, methods employed) were documented. Detailed information for each aggregation site, including the direct and indirect evidence of spawning for each species is presented in tables in Appendix 1. The aggregation parameters in these tables are adapted from the SCRFA questionnaire guidelines (www.scrfa.org).

Table 3: A summary of the aggregation data documented around Manus, showing species known to aggregate at each site, the moon phase (s) when these aggregations occur and the months of formation.

Detailed information on each aggregation site can be found in Appendix 1.

Aggregation Site No.	Aggregating species	Moon Phase	Months of formation
29	*Plectropomus areolatus*	Third quarter	Every month of the year. Peak season March, April, May
29	*Epinephelus fuscoguttatus*	Third quarter	March, April, May
29	*Epinephelus polyphekadion*	Third quarter – New moon	March, April, May
29	*Epinephelus ongus*	Third quarter – New moon	March, April, May
29	*Lethrinus erythropterus*	Third quarter	March, April, May
30	*Epinephelus ongus*	Third quarter – New moon	March, April, May
30	*Lethrinus erythropterus*	Third quarter	March, April, May
31	*Siganus vermiculatus*	New moon	Every month of the year
32	*Siganus canaliculatus*	New moon and First quarter	Every month of the year
33	*Plectropomus areolatus*	Third quarter	Every month of the year. Peak season March - May
33	*Epinephelus fuscoguttatus*	Third quarter	March, April, May
34	*Plectropomus areolatus*	Third quarter	Every month of the year. Peak season March, April, May
35	*Plectropomus areolatus*	Third quarter	Every month of the year. Peak season March, April, May
35	*Epinephelus fuscoguttatus* *Symphorichthys spilurus*	Third quarter	March, April, May
36	*Plectropomus areolatus*	Third quarter	Every month of the year. Peak season March, April, May
37	*Plectropomus areolatus* *Epinephelus polyphekadion* *Epinephelus lanceolatus*	Unknown	Peak season in March
38	*Epinephelus polystigma*	New moon	Every month of the year

The main biological findings of interest to come out this field survey

- *P. areolatus* form both minor and major spawning aggregations in this region. Minor aggregations (less than 100 fish during peak seasons) are often located in close proximity to major multi-species aggregation sites.

- There is consistent and predicable variation in the days of arrival and departure of *P. areolatus* at spawning aggregation sites that are separated by only 3.5 kilometers. *P. areolatus* are known to begin arriving at Site 34 several lunar days later than at site 33, and depart several days after *P. areolatus* aggregations at Site 33 have dispersed. Johannes (1989) verified local knowledge of Marovo fishers regarding known variation in the lunar days when *P. areolatus* arrive and depart from two spawning aggregation sites that are in close proximity to each other in the Western Solomon Islands.

- *P. areolatus* aggregates to spawn every month of the year around the new moon, with a peak season from March –May. Fishers report that at major aggregation sites, the abundance of *P. areolatus* is a magnitude higher during peak months than in other months of the year.

- Male *P. areolatus* begin arriving after the full moon, with schools of females migrating to the aggregation sites from shallow inner reef areas closer to the new moon.

- *E. fuscoguttatus, E. polyphekadion, E. ongus, L. erythropterus* and *S. spilurus* aggregate to spawn at overlapping sites with *P. areolatus* in the months of March – May each year.

- Fishers are aware that the month in which peak aggregations commence may vary from year to year, stating that in some years spawning seasons will begin in February and end in April, and in other years aggregations will begin in April and end in June.

- Many thousands of *E. ongus* and *L. erythropterus* aggregate to spawn in shallow water in the months of March – May.

- One to two very large *E .lanceolatus* are known to join a spawning aggregation of *P. areolatus* and *E. polyphekadion* at Site 37. E. lanceolatus move into very shallow water (> 5m) at this time.

- *Siganus vermiculatus* forms aggregations every month of the year after the new moon (Figure 5), and *Siganus canaliculatus* form aggregations bimonthly throughout the year in the new moon and first quarter.

Figure 5: A spear fisher's catch from a known *S. vermiculatus* aggregation site. This spawning aggregation was targeted on January 24, 2004, two days after the new moon.

FISHING PRESSURE PLACED ON SPAWNING AGGREGATIONS

In the southern Manus spawning aggregations are targeted by subsistence and artisanal fisheries. These fisheries have had a marked effect on many spawning aggregations. Local fishers report that catch rates of *P. areolatus* and *E. fuscoguttatus* and several other aggregating species have declined dramatically in recent decades, although in no cases were there any reports of spawning aggregations being fished to extirpation. Maximum catch rates for *P. areolatus* at spawning aggregation Sites 29, 33, 34 and 35 are said to have declined markedly in the past decades, both for hook and line and spear fishing. Fishers report that prior to the 1990's a single hook and line fisher using live bait could take over 20 *P. areolatus* in a day at Site 29, but today would catch less than 10 fish. Catch rates of *E. fuscoguttatus* are known to have declined markedly at aggregation sites 29, 33 and 35. *E. ongus* aggregations are the exception. Although many thousands of *E. ongus* can be removed during an aggregation, catch rates are reported not to have declined. Many fishers are well aware that their activities have caused these declines, listing more effective harvesting technologies, an increase in market fishing, the break down of the traditional clan fishing system and population increase as reasons why catches had declined.

An oral history of aggregation fishing

The history of the spawning aggregation fishery at Site 29 is outlined below. This oral history is based on interviews with several members of the Kalou clan who are renowned expert spear fishers. It provides a clear example of how the fishery is constantly evolving, incorporating new technologies and new indigenous ecological knowledge as it becomes available and discarding traditional knowledge and technologies as they become obsolete.

The spawning aggregations around Site 29 were discovered by chance many generations ago by the Kalou clan, who had customary ownership over this reef and fished here using the *Kalou* fishing method. This labor intensive method involved driving numerous long bamboo poles into a reef slope in fairly close proximity to each other, in order to make a submerged wall of bamboo. Bamboo poles became progressively shorter as the barrier advanced, and eventually led into a large maze of bamboo compartments. Fish that were swimming along the reef slope would often swim out from the reef once they came to the bamboo barrier, and proceed to swim parallel to the bamboo barrier and into the maze, where they would become confused and trapped, and subsequently netted out with scoop nets. After discovering spawning aggregations while *Kalou* fishing at Site 29, fishers from the Kalou clan learnt to pinpoint spawning aggregations to the lunar cycle, and pinpointed seasonality to the months of the year when certain constellations of stars were directly overhead.

Members of the Kalou clan quickly developed new technologies to specifically target aggregating fish. Wooden hand spears were used to spear pre- and post-spawning aggregations of female *P. areolatus* that formed in the shallow reef flats above aggregation slopes. Fish were also speared by divers floating over shallow reef areas. A fisher would use his canoe to block the prevailing wind and then tip coconut oil into the water that was sheltered by the canoe. This allowed the fisher to look down through the coconut oil into the water and spear fish.

When iron started to become readily available in the rural communities (presumably early in the last century) fishers began to make hooks out of scrap iron, and using fishing line constructed out of bush materials, would hook and line at aggregation sites using live damsel fish as bait. Damsel fish were trapped in woven basket traps. As western fishing technologies became available in provincial center trade stores, bush rope and hand made hooks were discarded for monofilament fishing line and steel hooks. Nets were also introduced. The arrival of goggles, steel and rubber resulted in fishers discarding handheld wooden spears and coconut oil, and turning to underwater spearfishing. Calendar months were increasingly used to mark aggregating seasons, and eventually knowledge of the star constellations used to mark spawning seasons was lost. Spearfishing practices were continually upgraded as the opportunities arose (introduction of fins, snorkels etc) and in the mid 1980's the availability of underwater flashlights allowed night diving to commence. Spear fishers using goggles and later masks, had the advantage of being able to observe aggregating fish in their environment, and subsequently some individuals learnt much more about fish behavior and how it influenced capture than their predecessors had been able to.

Subsistence fishing

Today the main fishing methods used by subsistence fishers are daytime spearfishing (with very long homemade spear guns) and hook and line fishing. The expense of batteries for underwater flashlights means that night diving is generally not carried out for obtaining fish for day-to-day subsistence purposes.

Artisanal fishing

As is the case in Kavieng, today one of the predominant fishing methods used by artisanal fishers at serranid spawning aggregation sites is night time spearfishing, with fishers typically limiting their activities to lunar days when aggregation numbers are known to peak. The aggregating species most commonly targeted by nighttime spear fishers is *P. areolatus*, for the same reasons listed in the Kavieng section of this report. Many spear fishers refer to night diving at *P. areolatus* aggregation sites as a good way of making "fast money". Night spear fishing continues to remove a substantial number of *P. areolatus* from aggregation sites. Spear fishers who exploited Site 35 every month of the year in 2003 reported that the largest aggregation occurred in April 2003. On one night in April 2003 three spear fishers removed 130 kg of *P. areolatus* (wet weight) over a 3 hour period, representing a maximum yearly CPUE rate of 10.8 kg/*P. areolatus*/fisher/hour.

Commercial fishing.

None of the Manus aggregations reported on in this study have been exploited by the LRFFT. LRFFT operations took place in the Hermit Islands in 1990 and 1991, but in 1992 this operation was stopped by the Provincial Government due to a variety of social and environmental concerns that the operation caused (Richards 1993). In 2001 a trial license was issued for operations at M'Buke Islands in Manus Province, however a study commissioned by TNC on the feasibility of the M'Buke Islands supporting a LRFFT operation concluded that the M'Buke Island fishery could not supply the quantity of fish required to make a LRFFT operation successful (Squire, 2001). Based on this report NFA revoked the trial license, and operations never went ahead (Hamilton, 2003a). It seems very unlikely that any of the aggregations reported on here could sustain a LRFFT operation.

COMMUNITY MEETINGS

Community meetings were held with local communities from Pere, Locha and Peli villages on January 26, 27 and 28, 2004, respectively. Prior to holding these meeting we had traveled to each community, where discussions with community leaders were held about our work, and we asked for permission to hold a wider community awareness meeting. All community leaders were very supportive and invited us to return to hold community awareness meetings. At Pere (which is by far the largest of the three communities) ward members also spent a considerable amount of time advising us on how to present the talk, and what sort of questions to expect. The meeting procedures and outcomes at each community are overviewed below.

Pere

The meeting at Pere was held in the church and around 120 individuals attended. The minister opened it with a prayer. Following this, a representative from each ward was asked to come forward and receive a pile of *buai* (betel nut) and cigarettes that we had provided. The objective of this Titan custom is to have everyone smoking and chewing *buai* before the talk is underway, so that "they are relaxed and their ears are open". After all the cigarettes and *buai* was distributed Richard Hamilton was invited to speak. He introduced himself and TNC and outlined how TNC's current focus in Manus was on spawning aggregations. He then explained what spawning aggregations were and why conservationists were concerned about the status of spawning aggregations.

Following this, he talked about the current status of spawning aggregations in many regions in the Pacific. To aid this he drew a graph on a blackboard showing the changing status of a hypothetical spawning aggregation site over time, and the type of factors that were leading to these changes (Figure 6). It was explained how past experience from other regions in the world has shown us that under heavy fishing pressure, fish numbers in transient spawning aggregations can decline to zero, and the aggregations are lost. At the end of Richard's talk Manuai Matawai asked some of the older fishers if they could share their experiences on the history of spawning aggregations in their area. This worked very well, with many older fishers addressing the community and giving oral accounts of changes in their aggregation fisheries that they had experienced through their lifetimes. Fishers would often refer back to the graph on the blackboard and describe how these changes coincided with increasing population, cash markets and new technologies. Older fishers made many statements such like: "When I was a small boy in the 1940s and my grandfather took me to the aggregation site, we could fill a five meter long rope with *kekwa* (*P. areolatus*) in a few hours, simply using hand held spears" The status of a large number of marine resources were discussed by older fishers.

Once everyone had finished talking, Richard Hamilton was again invited to speak. He began by saying that he would explain the lifecycle and biology of some of the larger aggregating serranids, as it was these features that made this family vulnerable to over fishing. Topics discussed included how aggregations form, lunar and annual seasons, the distances that some groupers traveled to spawning sites, spawning behavior, how to distinguish between male and female fish, how actual spawning occurred, the pelagic larval stage of fish, adult sex change, slow growth and late maturity in serranids. Richard then reiterated how these features can make transient spawners vulnerable. An example that was well received was comparing fast growing abundant tuna to the slow growing serranids which are easily over fished.

Pelagic fertilization, recruitment and sex change were not well understood and some time was spent answering questions on these points. Following this, ward members spoke and asked the community what they thought they should do about managing their aggregations. There was also a lot of discussion on this and we were asked for our advice on possible management options. The majority of individuals were in favor of immediately placing a *tambu* (customary fishing ban) on one of the major serranid spawning aggregation sites in their area in order to let it recover. However, a few individuals wanted to know if TNC could provide alternative development options to compensate for closures, and others stated that while they liked the idea, people live by the sea and they didn't think it would work. In the end ward members decided to discuss the matter among their respective wards and make a final decision on what management option to take at a later date. The meeting ended with a prayer.

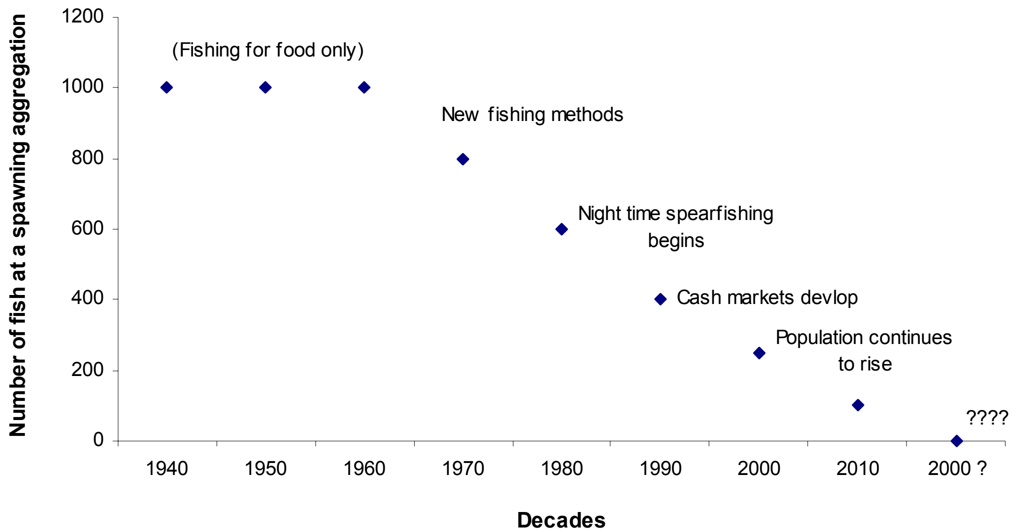

Figure 6: A hypothetical example of the type of pressures being placed on many transient spawning aggregations in the Pacific, and the subsequent impact on aggregation numbers.

Locha

The community meeting procedures were the same as those in Pere, however the meeting was more informal and held by the sea (Figure 7). The Locha community is very small, being made up of just one clan consisting of 4-5 families. At the end of my talk the community had a brief discussion on management options, asked us for our advice on several maters and then announced they would immediately place *tambu* (bans) on certain types of fishing at one of the major spawning sites in the region that comes under their customary control. The specific details of these management measures are outlined in a latter section of this report. The Locha clan said that they would announce to other Titan communities in this area that a *tambu* on certain fishing methods had been placed on one of their major spawning aggregation sites in order to allow stocks to recover. They stated that while they could easily ensure that their *tambu* was upheld within the Locha community, the biggest threat would be poaching from night divers from surrounding Titan communities who also exploited this aggregation.

Another separate concern that the Locha community raised was the environmental impacts that proposed gold mining activities on the mainland behind Locha village would have on the mangroves and reefs surrounding Locha. These concerns are also shared by the surrounding Pere and Peli communities. Twelve bush clans on the Manus mainland directly behind Locha have allowed gold prospectors into their customary land. A region that has been named Ere Gold. To date initial surveys have been completed, and exploratory mining is underway (Powaseu Pokatou pers. comm. 2004). Titan communities in this region are very concerned that if gold mining does proceed, waste products and sediment will be dumped into the rivers, and subsequently be washed out to sea. The Locha community has every right to be concerned, as several rivers that drain the hilly Ere Gold region open into the sea directly behind Locha village. It seems inevitable that if gold mining in this area does proceed, there will be considerable runoff into these rivers, with disastrous consequences for the mangroves and reefs surrounding Pere, Locha and Peli. While the Titan clans have no customary jurisdiction over the land behind them, their lifestyles will clearly be detrimentally impacted by any mining activates in this region. These communities have asked TNC to assist them with conducting marine environmental impact assessments of the region, so that if full scale mining does proceed, they can be in a better position to prevent the mining company from disposing their wastes directly into the rivers.

Figure 7: Richard Hamilton about to begin talking about spawning aggregations with the Locha community.

Peli

The community meeting procedures were the same as those described above. The meeting was held on Peli Island and all other Titan fishers from nearby surrounding areas (Tawi and Timoenai) were invited to attend, however none did. Consequently, the Papa reef of the aggregation that forms in this area said that while he was happy to put a *tambu* on his clans aggregation to allow it to recover, he did not have all his tribe standing behind him, and consequently could not speak on their behalf. He said that he would spread the word and a decision would be made at a later date. If customary *tambu* are placed on the multi-species aggregation in this area there may be enforcement issues, as the Peli community is a long way from this site and night poachers would not be seen.

CURRENT MANAGEMENT MEASURES AT AGGREGATION SITES 29, 33, AND 35

After our initial awareness talks in January 2004, Manuai Matawai held several follow up meetings with the communities of Pere, Locha and Peli and Tawi regarding managing their multi species transient spawning aggregation sites. As a result of these consultations, these communities have all now decided to impose identical fishing restrictions on three large multi species spawning aggregation sites that occur within their customary fishing grounds (Sites 29, 33 and 35). These three sites are spawning aggregation sites of *P. areolatus* and *E. fuscoguttatus*, and the seasonality and location of these aggregations is common knowledge to Titan communities in this area. Large reductions in the catches of *P. areolatus* and *E. fuscoguttatus* at these three aggregation sites have been raising communities' concerns for some time, with day and night time spearfishing identified by all communities as the major cause of these recent declines in catches, and the most likely threat to the future persistence of these aggregations.

Consequently, these communities decided to impose lunar bans of all types of day and night spearfishing at sites 29, 33 and 35. Spearfishing is currently banned at these aggregation sites in the 10 days leading up to and including the new moon. This is the lunar period when *P. areolatus* and *E. fuscoguttatus* are known to aggregate to spawn at these sites. This lunar ban is in force for every month of the year, in recognition of the fact that *P. areolatus* aggregates monthly at these sites. Hook and line fishing is currently allowed at these sites, however communities have decided that hook and line fishers may only catch enough fish to meet daily food requirements. Although these management measures have been put in place specifically for *P. areolatus* and *E. fuscoguttatus*, all of these sites appear to represent multi-species spawning aggregation sites. Consequently, these lunar bans on spearfishing also provide some protection for species such as *E. polyphekadion, E. ongus, L. erythropterus* and *S. spilurus* that are known to aggregate here in the week prior to the new moon. These fishing restrictions were enforced at Site 33 in January, at Site 29 in March and at Site 35 in May 2004.

At all sites the bans on spearfishing and artisanal fishing have been implemented primarily to allow spawning aggregation stocks to recover. It is noteworthy that communities have made a point of not stating how long these site based fishing restrictions will be in place. Rather, the communities have stated that the suitability and effectiveness of these initial restrictions will be re assessed in several years time based upon the results of UVC monitoring programs that are being initiated at these sites. Communities have not ruled out lifting gear restrictions if the numbers of aggregating serranids increase dramatically in the future, and likewise, they have not ruled out taking further steps (i.e. complete site closures or seasonal closures) if future monitoring of these sites indicates that this is necessary.

The fact that all of the Titan communities in this region have now imposed identical management measures on the major known transient spawning aggregation sites within this area of Manus is a significant achievement for two reasons: firstly, it provides protection from spearing and artisanal fishing for all reef fish species that are aggregating to spawn at these sites during this lunar period. Secondly, since all of the major multi species aggregation sites have had restrictions placed on them, the possibility of spearfishing and artisanal fishing pressure simply shifting to major spawning aggregation sites that may have remained open to all forms of fishing has been eliminated. A shifting fishing pressure scenario could have easily arisen here, as all three aggregations are in close proximity to each other, and many Titan individuals have overlapping customary rights to more than one major aggregation site in this area.

Another development in this region is that the Pere Ward Development Committee is in the process of implementing a five-year sustainable development plan for Pere. An Environmental Committee has recently been formed under the Pere Ward Development Committee, and one aspect that the Environmental Committee will be addressing is marine conservation issues. Manuai Matawai has been chosen as the person to head the Environmental Committee, and he will be responsible for providing ongoing advice on the best management options for spawning aggregations in this area. Such advice will not be limited to spawning aggregations of serranids. In a Pere Ward Development Committee meeting in late July 2004, local leaders discussed placing bans on monthly spawning migrations of mullet that occur in this area. These spawning migrations of mullet have been heavily over fished in this region in recent decades.

LOCAL MANAGEMENT PRACTICES WITHIN EXISTING CMT ESTATES

As well as having highly detailed IEK bases, many Manus communities actively implement management measures for valuable fish and invertebrate stocks through existing customary marine tenure estates. The Loniu community actively prevents outsiders from harvesting monthly pre-spawning migrations of mullet that occur within their customary sea estates, while also imposing numerous restrictions on their own tribe as to where, when and how these migrations can be harvested (Hamilton, 2003a). At Andras Island, trochus and beche-de-mer fisheries are frequently closed and indefinite bans on night time spearfishing, dynamiting and the use of traditional derris root fish poisons were put in place in 2003 (Hamilton, 2003a).

In 1997, the Pere community put in place various gear restrictions on the reef area directly in front of their village, in order to allow fish socks to recover. This included a ban on day and night time spearfishing, a ban on net mesh below 75 mm, and a ban on the traditional encircling net loh (Matawai, 2000). These restrictions were adhered to for just under a year, until rough weather that prevented fishers form accessing more distant reefs caused the closure to be broken. In the time frame that the closure was in place the Pere community noticed marked increases in the abundance and sizes of food fishes (e.g. siganids and lethrinids) that are targeted in this area. The Pere community is currently in the process of re imposing these restrictions in this area through the Environmental arm of the Pere Ward Development Committee.

One of the most interesting examples of customary management documented to date occurs at Pak Island. Here community leaders have banned fishing for all serranids indefinitely over a 7 km stretch of reef area. The reasons for this closure relates to both customary beliefs on the powers of *E. lanceolatus* and other serranids, coupled with contemporary environmental concerns (See Appendix 4). The various examples of customary management that are outlined above reflect that:

- Many fishers in Manus have an awareness that local fishing practices can have large impacts on their own marine resources
- Many Manus fishers have a conservation ethic.
- Many existing CMT systems in Manus are robust.
- CMT systems in this region and the communities that operate within them have the ability to adapt to changing ecological and social circumstances. At Pak, this has involved merging customary beliefs with contemporary environmental concerns.

RESULTS FROM UVC SURVEYS CONDUCTED AT SITES 29, 33 AND 35

All of the Titan communities that own and exploit Sites 29, 33 and 35 asked TNC to assist them in building their capacity to adequately monitor the status of their aggregation sites. In May 2004 Manuai Matawai and a team of local SCUBA divers from Pere and Peli began a long term spawning aggregation monitoring program at Sites 29, 33 and 35. These are the largest of the known multi-species aggregation sites in this region of southern Manus, and these three sites had previously been surveyed by Lyle Squire and divers from the provincial fisheries division in March 2001 (Squire, 2001). It was Manuai Matawai who informed Lyle Squire of the locations of these sites, and he was one of the divers who accompanied Squire on these initial dive surveys. Squire (2001) was able to quickly verify that these three sites were grouper spawning aggregation sites. In May and June 2004 Manuai Matawai and his team monitored these three sites several days prior to the new moon on SCUBA, using the same methods described for the Kavieng section of this report. These UVC methods were also very similar to those used by Squire (2001). Squire's (2001) data and the 2004 UVC data verify much of the local knowledge present on these spawning aggregation sites, and is leading to a better understanding of the status of these aggregations. The abundance of *P. areolatus,* *E. fuscoguttatus* and *E. polyphekadion* sighted at sites 29, 33 and 35 in March 2001 and May and June 2004 is shown in Figure 8.

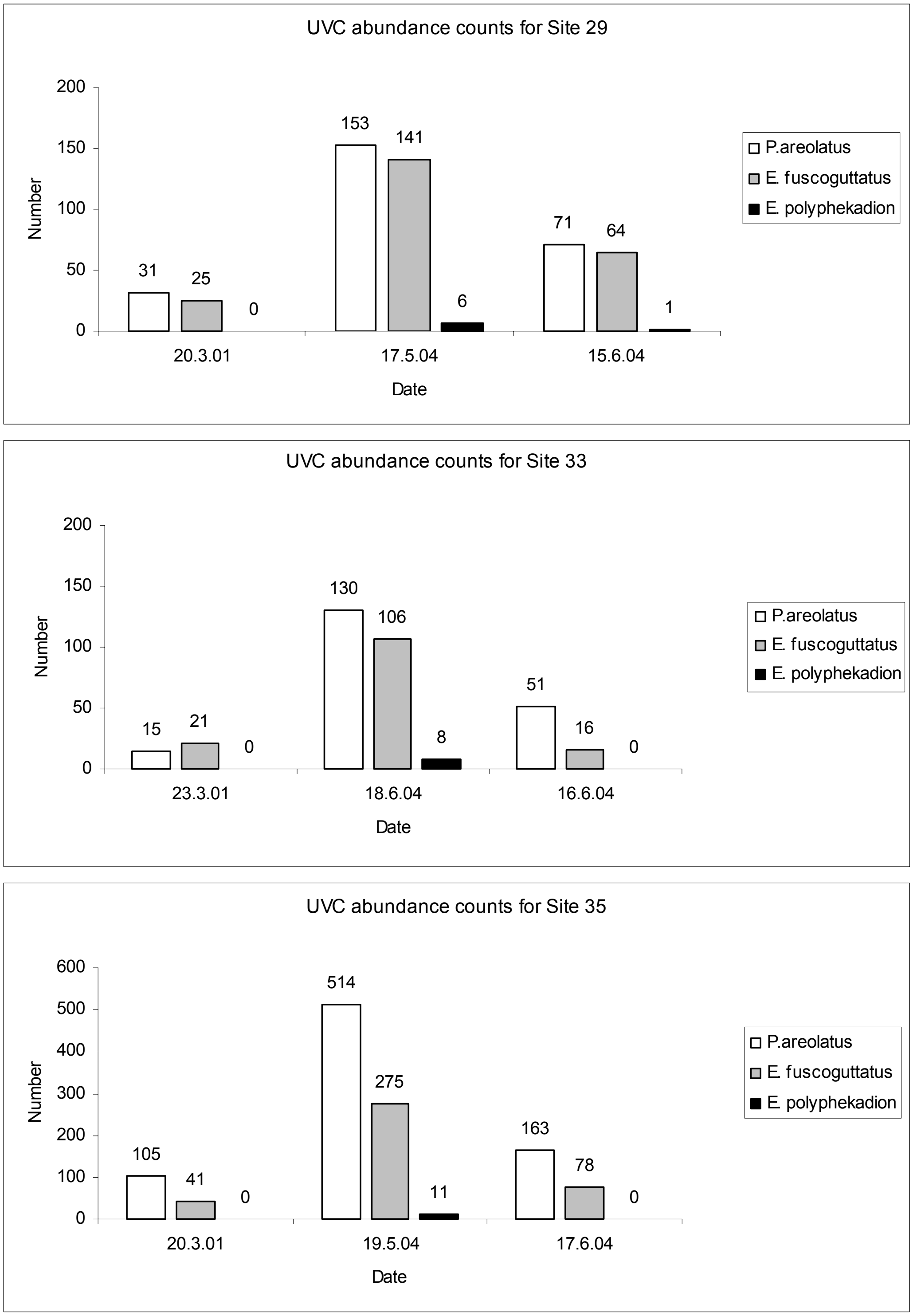

Figure 8: Abundance of *P. areolatus, E. fuscoguttatus* and *E. polyphekadion* sighted at Sites 29, 33 and 35 during the third lunar quarter in March 2001 and May and June 2004.

The main points of interest that can be summarized from the available data are outlined below:

- At all three sites the highest numbers of *P. areolatus* and *E. fuscoguttatus* were sighted May 2004, the month when aggregations of these species are said to peak in abundance. This was also the only month when small numbers of E. polyphekadion were seen at each site. In May 2004 counts of *P. areolatus* were 5-9 times higher than counts made at these sites in March 2001, and 2-3 times higher than counts of this species made at these sites in June 2004. Counts of *E. fuscoguttatus* in May 2004 were also 5-7 times higher than counts made in March 2001, and 2-7 times higher than counts made in June 2004.

- The actual numbers of *P. areolatus* at these three sites in May 2004 far exceeded the numbers counted in the surveys. Divers conducted the UVC surveys at a depth of 25 m, counting below and above their position in the water column. However, a substantial number of *P. areolatus* were aggregated into water as shallow as 3 m in May 2004, and these fish were not counted in these surveys. Manuai Matawai estimates that the actual abundances of *P. areolatus* at each site in May 2004 were approximately double the number that was counted.

- Regardless of the month or year that these three sites were surveyed, abundances of *P. areolatus* and *E. fuscoguttatus* were far higher at Site 35 than at the other two sites. Likewise, abundances of these two species were consistently lower at Site 33 than at other sites. This is in line with what fishers had predicted regarding differences in maximum *P. areolatus* abundances at the three sites (Appendix 1). It appears that the sizes of aggregations at each site in part relates to the amount of suitable aggregating habitat. Initial minimum estimates of aggregation areas that were made at each site using a hand held GPS and local knowledge of aggregation boundaries and aggregation depths (Appendix 1) show that the largest aggregation area is Site 35, followed by Site 29 and then Site 33.

- The very high abundances of *P. areolatus* and *E. fuscoguttatus* observed in May 2004 highlight the importance of quantifying the months of peak seasonality, so that the status of aggregation sites in this area can be accurately assessed. When these sites were initially surveyed in March 2001, the low abundances observed led Squire (2001) to conclude that these sites were heavily over fished and in need of urgent management. While it is clear from local knowledge surveys that catch rates at these sites have declined markedly in recent decades in response to heavy fishing pressure, the available May and June 2004 data portrays a far more optimistic view of their status than the March 2001 UVC data.

- While local fishers widely define the peak spawning season as March – May each year, they are also aware of natural variability in the month in which peak aggregation may commence and cease between years. The low abundances observed by Squire in March 2001 imply that these UVC surveys may have been conducted at the very beginning of the peak aggregation period for that year.

- If local knowledge on the length of peak seasons is precise, than the significant abundances of *E. fuscoguttatus* sighted at each site in June 2004 implies that the three month long peak aggregation period in 2004 started in April. A feasible alternative is that the peak season is more protracted than is widely recognized by local fishers. Interestingly, in July 2004 very few *E. fuscoguttatus* were sighted at Site 35 during UVC surveys along permanent transects, implying that the peak season for this species had finished for 2004.

Update on UVC monitoring at Sites 29, 33 and 35

It was decided that in order to collect quantitative UVC data on the aggregation sites, permanent transects needed to be established at each site. In July 2004 after consultations with the relevant communities, permanent transects were established at Sites 29, 33 and 35. Two transects were established at each site, a deep transect at 25 m that samples the *E. fuscoguttatus* aggregations, and a shallow transect at 15 m that samples the *P. areolatus* aggregations. These transects were established using the methodology set out in the spawning aggregation monitoring manual (Pet, *et al*., 2005). Manuai and his survey team commenced surveys along the permanent transects at Site 35 in July 2004, and plan to survey all six transects monthly just prior to the new moon over the next 12-24 months. Temperature data loggers have been placed at each of these three sites. The objectives of these surveys are to:

1. Collect baseline data on species abundance at each site

2. Pinpoint peak seasonality for each species in this region.

Obtaining this data for each species will be invaluable for designing future site specific and regional spawning aggregation management plans in Manus.

RECOMMENDATIONS FOR FURTHER BIOLOGICAL AND ETHNOGRAPHIC RESEARCH

Biological recommendations

1. The likelihood of gold mining proceeding in the Ere Gold region of southern Manus should be properly investigated. If mining is to proceed, than TNC should consider commissioning an urgent environmental impact assessment on the likely impacts of mining on coastal regions and coastal communities that reside below Ere. The effects of mining runoff could be detrimental to important spawning aggregation sites and entire coastal ecosystems in this region.

2. TNC should carry on providing scientific advice and expertise to the Manus monitoring team. While the Manus monitoring team is doing a great job, they still require scientific advice with regards to monitoring methodologies and data analysis. Having a scientist actively involved with the Manus monitoring program will build local capacity and ensure that the monitoring programs remain scientifically rigorous.

3. At some stage the Manus monitoring team will need to be shown how to estimate the total areas of the *P. areolatus* and *E. fuscoguttatus* spawning aggregations at Site 29, 33 and 35. The estimation of aggregation areas needs to take place during the next peak season, which perceivably will be between March and May 2005. Estimating each aggregation area is required so that;

   - Monthly abundance data obtained from surveying transects can be scaled up to give relative abundance data for the entire aggregation sites.

   - The absolute area of the aggregations can be estimated and compared from year to year, to establish changes in fishing pressure at these sites is resulting in changes in the total aggregation area.

4. It would be valuable to investigate the specific lunar days on which each aggregating species begin to aggregate, spawn and then subsequently disperse, and determine if this varies on a monthly basis both within and between sites. This would involve surveying every day for approximately two weeks at each site during an aggregation period, ending surveys once all aggregated species of interest have dispersed. For the purpose of looking at intra-site variability, these intensive weekly surveys would need to be repeated at each site at least twice in a year. Obtaining this data would enable communities to evaluate if their current monthly 10 day lunar closures at sites 29, 33 and 35 are long enough to protect all aggregated *P. areolatus* and *E. fuscoguttatus* at these sites.

5. Conduct ongoing community awareness programs in southern Manus on what spawning aggregations are and the importance of conserving them. To date the awareness discussions have

taken place with very few visual aids and within a short period of time. It would be valuable to conduct broader educational campaigns, targeting in particular schools, and seeking to involve young people with the monitoring and management of their spawning aggregations in whatever capacity possible.

Ethnographic recommendations

To further TNC's understanding of social and political setting in which spawning aggregations of interest are located, it would be valuable to document the following information through detailed interviews with individuals in the communities that own and exploit these aggregations.

- Determine which clans and individuals claim primary customary ownership of the aggregation sites of interest.
- Document the names of all individuals that exploit each aggregation of interest. This includes recording information on individuals with legitimate customary claims to these sites and individuals who are poaching.
- Determine which individuals have overlapping access rights to more than one aggregation and how they acquired these overlapping rights.
- Document how ownership of these aggregations is passed on from generation to generation and how ownership rights changed over time.
- Determine how much a closure on spawning aggregations would affect fishers who target these aggregations.
- Document individuals thoughts on community based management of resources, and if they think this is a necessary and workable approach for managing spawning aggregations.
- Determine the level of interest that communities have in community based management.
- Document information gaps and misunderstandings in local knowledge bases on spawning aggregations.

THE DANGERS OF DOCUMENTING LOCAL KNOWLEDGE ON SPAWNING AGGREGATIONS.

The widespread dissemination of IEK on spawning aggregations may result in heavier fishing pressure then was previously the case. There are two ways that this can happen. Firstly, publishing the specific locations of spawning aggregation sites can increase fishing pressure on aggregations. In areas of Melanesia where the locations of spawning sites are already widely known by local reef owners and poaching is not a problem, this may not be an issue. But in areas where poaching is common and the locations of spawning sites are not well known, identifying aggregation sites is likely to lead to increased fishing pressure on spawning aggregations. Making information on the precise locations of spawning aggregations publicly available would also fast track LRFFT operators who were wishing to establish ventures in the region. In Melanesia, LRFFT operators use identical methods to the ones used in this study to identify spawning aggregation sites.

Secondly, the lunar periodicity (and possibly seasonality) with which aggregations form appears to be fairly set for some species in Melanesia. While some fishers and communities have detailed knowledge of this and concentrate fishing pressure on peak aggregation periods accordingly, other communities in nearby regions may be unaware of this precise lunar timing with which aggregations form. If knowledge on when different species aggregate within a large geographical area becomes public, it may lead to the more efficient exploitation of aggregations that are situated in areas where currently there is little local knowledge of aggregations, other than a general knowledge of location (Hamilton, 2003a).

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APPENDICES

APPENDIX 1. Data tables for aggregations around New Ireland and Manus Provinces

At several sites up to five species aggregate at the same site during the same lunar and seasonal phases. When there was detailed data for each species that aggregated at a multi-species aggregation site, then separate tables for each species were compiled. However, if the information documented was generic for all species that aggregated at a multi-species aggregation site, then only one table of parameters was compiled, with all species that aggregate at this site being listed in a single table. In several instances several single species aggregations of *P. areolatus* occurred within close proximity to each other. The local knowledge colleted on these aggregations is also summarized in single tables. When no information was available for an aggregation parameter that row is left blank[4].

Note – Aggregation area was estimated as follows: Local fishers who had taken us to an aggregation site were asked to mark the approximate boundaries of the aggregation, which they did either from the boat or at times by snorkeling besides the slowly moving boat. Aggregation boundaries were marked using a handheld GPS. Local fishers were also asked to estimate the vertical depth ranges of the aggregation. The aggregation area was then estimated by multiplying the vertical depth range (in meters) of the aggregation by the total horizontal distance (meters) between aggregation boundaries, as determined by the GPS. Since the vertical depth estimates do not account for the slope of the reef walls, these aggregation area estimates they should be considered as a rough estimate of minimum aggregation area.

[4] Sensitive information that was documented under the aggregation parameters 'Site name, Location, Coordinates and Source (informants interviewed)' has purposely been omitted from all of the aggregation tables in this appendix.

Aggregation Site #	**1**
Site name.	
Species names	*Plectropomus areolatus*
Local name	Kakatip
Location	
Coordinates	
Depth (m)	5 -35 m
Habitat	Promontory, fish aggregated on coral and sand
Duratio	One week
Month(s) of formation	Every month of the year but aggregation size variable
Sign of spawning	Spawning observed, gravid females and chasing and color changes associated with spawning.
Type of aggregation	Transient
Time of spawning	Dawn and dusk
Type of spawning	Pair spawning
Moon phase	Third quarter. Aggregations disperse on new moon
Fish numbers	Fishers state that large aggregations are made up of approximately 200 -500 fish; however > 100 *P. areolatus* were seen in three UVC surveys have been conducted at this site during aggregating periods. Refer to Table 2 in this report.
Area of aggregation (m. sq)	16 000 m. sq (Rhodes, 2003).
Year discovered	The whereabouts of this aggregation have been known for generations
How discovered	Fisher
Year first exploited	Has been exploited for generations
Gear used	Spearfishing at night is the main method used to capture fish for local sale. (These aggregations are rarely targeted to meet subsistence needs). Hook and line fishing by local reef owners is used to supply live fish for LRFFT operations. In the past traps and cyanide were used by LRFFT operators. This fish is reported to 'go off' feeding when it is near to spawning, and does not feed at night.
CPUE trend	Decreasing
Current status	Decreasing
Status parameters	Fishers all report that aggregations form in much smaller numbers than in the past, with notable declines after 1990. Commencement of night diving, LRFFT operations and population increase listed as reasons why fishers thought these aggregations had declined in numbers
Management/Protection	None
Additional notes	
Source	(Rhodes, 2003).

Aggregation Site #	**1**
Site name.	
Species names	*Epinephelus fuscoguttatus*
Local name	Manang
Location	
Coordinates	
Depth (m)	15 -35 m
Habitat	Promontory, fish aggregated on coral and sand
Duration	One week
Month(s) of formation	Every month of the year but likely to have a peak season
Sign of spawning	High densities, gravid females
Type of aggregation	Transient
Time of spawning	This species spawns at night (Rhoades and Sadovy, 2002)
Type of spawning	
Moon phase	Third quarter. Aggregations disperse on new moon
Fish numbers	200-300 in peak seasons. However > 100 *E. fuscoguttatus* were sighted here in three UVC surveys have been conducted at this site during aggregating periods. Refer to Table 2 in this report.
Area of aggregation (m. sq)	16 000 m. sq (Rhodes, 2003).
Year discovered	The whereabouts of this aggregation have been known for generations
How discovered	Fisher
Year first exploited	Has been exploited for generations
Gear used	Hook and line fishing by local reef owners has been used to supply this species to several LRFFT operations that are currently no longer operating here. In the past traps and cyanide were used by LRFFT operators. Hook and line is currently being used to supply this species to a local buyer who sells frozen fish. This species is also taken by night spear fishers (These aggregations are rarely targeted to meet subsistence needs).
CPUE trend	Variable. Spear fishers and local fishers who were employed by LRFFT operators to set traps at this site (while diving on hookah) noticed drastic declines in numbers in late 1990's after several years of LRFFT operations. These dramatic declines in abundance are listed as one of the reasons why local fishers forced the LRFFT out of this area. However fishers believe that the numbers of *E. fuscoguttatus* have recovered significantly over the last 4 years, as very large numbers of this species were removed from this site in May to July 2003 to supply another short LRFFT operation. Fishers report up to nine boats that targeted peak aggregations of this species removed over 100 E. fuscoguttatus in a day. Fishers were surprised the numbers caught, stating that they hadn't thought this aggregation would have recovered so quickly after previous LRFFT operations.
Current status	Decreasing
Status parameters	Local fishers report that they removed 2-4 tonnes of *E. fuscoguttatus* from this site in 2 months (approx. May – July, 2004) for a LRFFT operation. > 100 *E. fuscoguttatus* were sighted here in May 2004, refer to Table 2 in this report.
Management/Protection	None
Additional notes	
Source	

Aggregation Site #	**1**
Site name.	
Species names	*Epinephelus polyphekadion*
Local name	Pikpikay
Location	
Coordinates	
Depth (m)	5 -35 m
Habitat	Promontory, fish aggregated on coral and sand
Duration	One week
Month(s) of formation	Every month of the year, but aggregation size variable, likely to have a peak season
Sign of spawning	High densities, gravid females
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	Third quarter. Aggregations disperse on new moon
Fish numbers	Unknown. Very few *E. polyphekadion* seen in UVC surveys that have been conducted at this site, Refer to Table 2 in this report.
Area of aggregation (m. sq)	Approx. 16 000 m. sq (Rhodes, 2003).
Year discovered	The whereabouts of this aggregation have been known for generations
How discovered	Fisher
Year first exploited	Has been exploited for generations
Gear used	Spearfishing (day and night). Hook and line fishing by local reef owners is used to supply live fish to LRFFT and dead fish trade. In the past traps and cyanide were used by LRFFT operators.
CPUE trend	
Current status	Unknown
Status parameters	Fishers interviewed report that *Epinephelus polyphekadion* is the less abundant than E. fuscoguttatus or P. areolatus, and were unsure if the abundance of this species had changed.
Management/Protection	None
Additional notes	*Cheilinus undulatus* and *Symphorichthys spilurus* also reported to aggregate here prior to the new moon on a monthly basis and be running ripe. Rhodes (2003) reports that *P. oligacanthus* formed a spawning aggregation at this site in April 2003. 2-3 very large *Epinephelus lanceolatus* aggregate at this site at the same time, often in shallow water. This species is never targeted by spear fishers.
Source	Rhodes, (2003)

Aggregation Site #	**2**
Site name.	
Species names	*Plectropomus areolatus*
Local name	Kakatip
Location	
Coordinates	
Depth (m)	5 - 50 m Highest densities between 15 -25m
Habitat	Promontory, fish aggregated on coral and sand, and ledges that protrude out of coral slope
Duration	One week
Month(s) of formation	Every month of the year, aggregation size variable
Sign of spawning	High densities, gravid females, chasing and color changes associated with spawning.
Type of aggregation	Transient
Time of spawning	Sawn and dusk
Type of spawning	Pair spawning
Moon phase	Third quarter. Aggregations disperse on new moon
Fish numbers	More than 500. 377 counted during a survey of this site in January 2004. NB: This UVC survey did not cover the entire site. Refer to Table 2 in this report.
Area of aggregation (m. sq)	20000 – 25000 m. sq
Year discovered	The whereabouts of this aggregation have been known for generations
How discovered	Fisher
Year first exploited	Has been exploited for generations
Gear used	Spearfishing at night is the main method used to capture fish for local sale. Night spearfishing commenced at this site in the mid 1980's. Spear fishers who do not have access to ice, often target this aggregation between 4.30 -5.30 am, so that they can immediately take their catch to Kavieng for sale after finishing fishing.
CPUE trend	Decreasing
Current status	Decreasing
Status parameters	Fishers report that from 2000 onwards, maximum catch rates for a party of 4 spear fishers over a one hour period is around 70 -80 P. areolatus. Compared to the late 1980's when a 4 spear fishers could remove over 200 *P. areolatus* in the same time frame. Notable declines in catch rate were noted from 1990 onwards.
Management/Protection	None
Additional notes	This is the largest aggregation site identified in this region. *P. areolatus* aggregated down as far as 50m
Source	

Aggregation Site #	**2**
Site name.	
Species names	*Epinephelus fuscoguttatus, Epinephelus polyphekadion*
Local name	Manang Pikpikay
Location	
Coordinates	
Depth (m)	15 - ??m.
Habitat	Promontory, fish aggregated on coral and sand, and ledges that protrude out of coral slope. These two species concentrate at the most western end of the aggregation where the outer reef slope becomes a steep 90-degree wall drop.
Duration	One week
Month(s) of formation	Every month of the year, although some months aggregations larger than others. Actual months of peak aggregations not noted.
Sign of spawning	High densities of gravid females
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	Both species said to aggregate around the third quarter. Aggregations disperse on new moon
Fish numbers	No information provided from fishers on the relative numbers of *E. fuscoguttatus* and *E. polyphekadion*. Low numbers of both species sighted in two UVC surveys at this site, refer to Table 2 in this report.
Area of aggregation (m. sq)	20000 -25000 m. sq
Year discovered	The whereabouts of this aggregation have been known for generations
How discovered	Fisher
Year first exploited	Has been exploited for generations
Gear used	Spearfishing (day and night). Some hook and line.
CPUE trend	
Current status	Stable
Status parameters	These two species are said not have decreased notably in abundance. The depths at which aggregations of these two species form makes them much less accessible to divers than *P. areolatus* aggregations that form here. It is noteworthy that the LRFFT has never operated at this site.
Management/Protection	None
Additional notes	Aggregations of up to 500 ripe Symphorichthys spilurus form here late in the third quarter. This species is said to aggregate most if not all months of the year, with aggregation size being highly variable. Possibly with a peak season around December. 2-3 very large *Epinephelus lanceolatus* aggregate at this site at the same time, often in shallow water. This species is never targeted by spear fishers. Mixed sized schools of up to 40 *Cheilinus undulatus* have been sighted at this location.
Source	

Aggregation Site #	**3**
Site name.	
Species names	*Plectropomus areolatus*
Local name	Kakatip
Location	
Coordinates	
Depth (m)	5 - 30 m
Habitat	Promontory beside a channel. Fish aggregated on coral wall drop
Duration	One week
Month(s) of formation	Unknown. This aggregation only said to form when *P. areolatus* aggregations at other major sites peak, however the months that these aggregations peak is not well known.
Sign of spawning	High densities, gravid females, chasing and color changes associated with spawning.
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	Third quarter. Aggregations disperse on new moon
Fish numbers	Less than 100
Area of aggregation (m. sq)	Approx 3000 – 5000 m. sq
Year discovered	The whereabouts of this aggregation have been known for generations
How discovered	Fisher
Year first exploited	Has been exploited for generations
Gear used	Hook and line fishing and spearfishing. Hook and line fishing main method used at this site. Trap fishing used to capture fish live for LRFFT operations.
CPUE trend	Decreasing
Current status	Decreasing
Status parameters	Fishers report aggregation size and catch rates are markedly lower today than a decade ago. Rhodes (2003) surveyed this site in the third lunar quarter in April 2003 and determined that this site did not have sufficient numbers and densities of grouper to be characterized as a spawning aggregation
Management/Protection	None
Additional notes	
Source	(Rhodes, 2003).

Aggregation Site #	**4**
Site name.	
Species names	*Plectropomus areolatus*
Local name	Kakatip
Location	
Coordinates	
Depth (m)	4- 30m
Habitat	Promontory, fish aggregated on coral slopes and on top of the reef.
Duration	One week
Month(s) of formation	Every month of the year
Sign of spawning	High densities, gravid females, chasing and color changes associated with spawning.
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	Third quarter. Aggregations disperse on new moon
Fish numbers	Estimated by fishers to be 200 -500 in peak aggregations. Fishers state that *P. areolatus* are far more abundant below their free diving range (i.e. below approximately 20m)
Area of aggregation (m. sq)	Approx. 10 000 m. sq
Year discovered	2000
How discovered	Fisher
Year first exploited	2000
Gear used	Hook and line and spearfishing.
CPUE trend	
Current status	Stable
Status parameters	Fishers report catch rates at this site have remained stable.
Management/Protection	None
Additional notes	The size of aggregations at this site is reported to be highly viable from month to month.
Source	

Aggregation Site #	**5**
Site name.	
Species names	*Plectropomus areolatus*
Local name	Kakatip
Location	
Coordinates	
Depth (m)	5 -40 m
Habitat	Small patch reef. Fish aggregated on top of reef and on reef slopes. Reef slopes descend into sand at around 40 m
Duration	One week
Month(s) of formation	Every month of the year
Sign of spawning	High densities, gravid females, chasing and color changes associated with spawning.
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	Third quarter. Aggregations disperse on new moon
Fish numbers	Over 100
Area of aggregation (m. sq)	Approx. 4000 m. sq
Year discovered	2003
How discovered	Discovered by a spear fishers
Year first exploited	Exploited since 2003, individual who discovered this aggregation told many people from his village of its whereabouts
Gear used	Spear guns and hook and line.
CPUE trend	
Current status	Unknown as only exploited for a short period of time
Status parameters	
Management/Protection	None
Additional notes	
Source	

Aggregation Site #	**6**
Site name.	
Species names	*Epinephelus polyphekadion*
Local name	Pikpikay
Location	
Coordinates	
Depth (m)	15 -25m
Habitat	Mouth of a wide passage that cuts through the barrier reef. *E. polyphekadion* aggregate on the deeper portions of coral passage walls and on sandy bottom of passage.
Duration	One week
Month(s) of formation	Knowledge on months of formation not precise, but known to only to form in large numbers during some months of the year. Large aggregations reported to have formed in approximately June and July 2003.
Sign of spawning	Numerous gravid females
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	End of third quarter and first few days of new moon. Known to occur later than P. areolatus at other nearby aggregation sites.
Fish numbers	1000 plus.
Area of aggregation (m. sq)	Greater than 10 000 m. sq
Year discovered	1999
How discovered	Discovered by a fishers
Year first exploited	1999, heavily exploited for LRFFT in June-July 2003 when the fisher who discovered this aggregation told his extended family of its whereabouts. Prior to this he had kept its location a secret.
Gear used	Hook and line only. Fishers have never spear fished here.
CPUE trend	
Current status	Unknown
Status parameters	Fishers who targeted this aggregation for LRFFT operations in 2003 stated that 3-4 fishers in two canoes could remove over 100 kg of this species in a day during peak aggregation periods. This was the first year of heavy exploitation, so there is no way of evaluating the current status of this aggregation.
Management/Protection	None
Additional notes	Snorkeled at this site in excellent visibility on the 19th of January 2004, 3 days before the new moon. No *E. polyphekadion* were sighted. See Table 2, this report.
Source	

Aggregation Site #	**7**
Site name.	
Species names	*Epinephelus polyphekadion*
Local name	Pikpikay
Location	
Coordinates	
Depth (m)	10 -20 m
Habitat	Mouth of a wide passage that cuts through the barrier reef. *E. polyphekadion* aggregate on the deeper portions of coral passage walls and on sandy bottom of passage.
Duration	One week
Month(s) of formation	Knowledge on months of formation not precise, but known to only to form in large numbers during some months of the year. Large aggregations formed here in approximately June and July 2003.
Sign of spawning	Numerous gravid females
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	End of third quarter and first few days of new moon. Known to occur later than *P. areolatus* aggregations in the same area.
Fish numbers	1000 plus. NB: No *E. polyphekadion* sighted during UVC surveys on snorkel that were done in the last lunar quarter in January or July 2004. See Table 2, this report.
Area of aggregation (m. sq)	Greater than 10 000 m. sq
Year discovered	2003
How discovered	Discovered by local fishers who were targeting a nearby aggregation of this species (Site 6) in June 2003.
Year first exploited	Heavily exploited for LRFFT in June-July 2003
Gear used	Hook and line only. Fishers have never spear fished here.
CPUE trend	
Current status	Unknown
Status parameters	Fishers who targeted this aggregation for LRFFT operations in 2003 stated that 3-4 fishers in two canoes could remove over 100 kg of this species in a day during peak aggregation periods. This was the first year of exploitation, so there is no way of evaluating the current status of this aggregation.
Management/Protection	None
Additional notes	
Source	

Aggregation Site #	**8**
Site name.	
Species names	*Epinephelus polystigma*
Local name	Avou
Location	
Coordinates	
Depth (m)	> 1m
Habitat	Seaward mouth of a large estuarine bay, fish sleeping in the outer most mangrove regions
Duration	Approx 1 week
Month(s) of formation	Every month of the year
Sign of spawning	High densities and multiple gravid females and males running ripe
Type of aggregation	??
Time of spawning	
Type of spawning	
Moon phase	Third quarter
Fish numbers	Unknown
Area of aggregation (m. sq)	Unknown
Year discovered	2003
How discovered	Discovered by fishers who were hunting for mud crabs at night
Year first exploited	2003
Gear used	Bush knifes, hand spears. These nocturnal resting aggregations are targeted at night on low tides.
CPUE trend	
Current status	Unknown
Status parameters	Ease with which this aggregation could be over fished and history of *E. polystigma* aggregations elsewhere in Melanesia suggests that this aggregation is highly vulnerable (see Appendix 2)
Management/Protection	None
Additional notes	Currently only targeted to meet subsistence needs. Fishers say that "we simply get however much we want then come home" This species is rare with a limited geographical distribution and further research and conservation attention on this aggregation is needed.
Source	

Aggregation Site #	**9**
Site name.	
Species names	*Plectropomus areolatus, Epinephelus fuscoguttatus* and *Epinephelus polyphekadion*
Local name	Kakatip, Manang and Pikpikay
Location	
Coordinates	
Depth (m)	3 – 20 m
Habitat	Spawning aggregation forms on coral and sand eastern side of passage mouth and surrounding outer reef.
Duration	Approx. 1 week.
Month(s) of formation	Every month of the year
Sign of spawning	Gravid females (all species), color changes, chasing and pair spawning observed for P. areolatus
Type of aggregation	
Time of spawning	Early morning for *P. areolatus*, spawning said to occur only 1-2 m above the reef
Type of spawning	Pair spawning for *P. areolatus*. *E. fuscoguttatus* reported to "always be sleeping", spawning never witnessed.
Moon phase	Third quarter. Aggregations disperse on the new moon
Fish numbers	Less than 100 (all 3 species combined). Refer to Table 2 in this report.
Area of aggregation (m. sq)	Approx 8000 -10 000 m. sq
Year discovered	Known for generations
How discovered	
Year first exploited	Exploited for generations
Gear used	Spearfishing at night. In the past, hook and line.
CPUE trend	Decreasing
Current status	Decreasing
Status parameters	A fishers living directly adjacent to this aggregation reported being able to catch a maximum of 20 of these 3 aggregating species in a night (the majority of which were *P. areolatus*) in the late 1990's. This catch rate is reported to have steadily declined over the last five years, with the same fisher reporting that he rarely caught ten of these three species in a night from 2001 onwards, and that in 2003, the aggregations "no longer formed every month, and catch were very disappointing".
Management/Protection	None
Additional notes	It appears that this aggregation has never been targeted by the LRFFT, yet has been seriously over fished by subsistence and artisanal fishers. The location and lunar periodicity of this aggregation is known by many communities in the nearby vicinity, and it is in fairly close proximity to Kavieng markets. Numerous fishers from more than five surrounding communities are known to target this aggregation. The current here can be extremely strong.
Source	

Aggregation Site #	**10**
Site name.	
Species names	*Plectropomus areolatus* and *Epinephelus fuscoguttatus*
Local name	Kakatip Manang
Location	
Coordinates	
Depth (m)	5 -40m. E. fuscoguttatus in deeper water on passage wall. *P. areolatus* on top of reef an on wall.
Habitat	Promontory. Reef top is approx. 5m deep, with 90-degree wall drops either side of the Promontory.
Duration	
Month(s) of formation	Every month of year, but some month's aggregations much larger than others. Months of peak aggregations not noted.
Sign of spawning	Multiple gravid females
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	Third quarter
Fish numbers	Fishers estimate less than 100 of all species. Refer to Table 2 in this report for UVC results from this site.
Area of aggregation (m. sq)	Approx. 5000 m. sq
Year discovered	Known for generations
How discovered	
Year first exploited	Exploited for generations
Gear used	Spearfishing (day) and hook and line. Do not spearfish at night here as Tiger sharks have been sighted here.
CPUE trend	Decreasing
Current status	Decreasing
Status parameters	Daytime spear fishers report being able to capture up to 20 fish (both species) in several hours during peak aggregations. Older fishers report that the number of both species aggregating today is 'nothing like what they were in the 1950's and 60's" and also report that the total aggregation area has also decreased.
Management/Protection	None
Additional notes	Many species of shark said to be particularly abundant when aggregations form. NB: UVC surveys have revealed that *E. polyphekadion* also aggregates at this site. See Table 2, this report.
Source	

Aggregation Site #	**11**
Site name.	
Species names	*Plectropomus areolatus* and *Epinephelus fuscoguttatus*
Local name	Kakatip Manang
Location	
Coordinates	
Depth (m)	5 -20m. E. fuscoguttatus in deeper water on passage wall. *P. areolatus* on top of reef and on wall.
Habitat	Passage mouth. Reef top is approx. 5m deep, passage walls slope into sand at approximately 20m..
Duration	
Month(s) of formation	Every month of year, but some month's aggregations much larger than others. Months of peak aggregations not noted.
Sign of spawning	Multiple gravid females, color changes and chasing associated with spawning.
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	Third quarter
Fish numbers	Not stated. >10 *P. areolatus* seen here during a UVC survey in May 2004 (see Table 2, this report).
Area of aggregation (m. sq)	Approx. 4000 – 6000 m. sq
Year discovered	
How discovered	Known for generations
Year first exploited	
Gear used	Exploited for generations
CPUE trend	Spearfishing (day and night) and hook and line. Dynamiting also used here in the past and traps set here by LRFFT operators in 2002.
Current status	Very recent history, Increasing. General trend: Decreasing
Status parameters	Increasing
Management/Protection	Numbers reported to have decreased markedly over the last 4-5 decades, and hit all time low numbers after LRFFT traps were used in this area in 2002, but since trap fishing ceased numbers are reported to be increasing.
Additional notes	None
Source	*E. fuscoguttatus* reported to inhabit the deeper slope by day, and move into shallower water by night. LRFFT set traps here for several months in 2002. Arguments over royalties resulted in the traps being pulled up by local fishers and take back to the LRFFT base.

Aggregation Site #	**12**
Site name.	
Species names	*Plectropomus areolatus* and *Epinephelus fuscoguttatus*
Local name	Kakatip Manang
Location	
Coordinates	
Depth (m)	10 -20m
Habitat	Reef top approx 10m deep, coral slope terminates in sand at approximately 20m.
Duration	1 week
Month(s) of formation	Every month of year, but some month's aggregations much larger than others. Months of peak aggregations not noted.
Sign of spawning	Multiple gravid females
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	Third quarter
Fish numbers	
Area of aggregation (m. sq)	Approx. 5000 -7000 m. sq
Year discovered	Known for several decades
How discovered	Fisher
Year first exploited	Exploited for several decades
Gear used	Spearfishing (day). The current is so strong here that spear fishers anchor their boat facing into the prevailing current and let out 100 m of rope behind the boat. They then jump in the water and dive down onto the aggregation. Upon returning to the surface they grasp the rope and pull themselves back to the boat and repeat this process. Large sharks are said to be very abundant here and frequently aggressive.
CPUE trend	Stable
Current status	Stable
Status parameters	Spear fishers report no declines in catch rates. The very strong currents at this site and abundance of large sharks appear to provide it with a considerable level of protection.
Management/Protection	None
Additional notes	Abundance of both species said to be far more abundant here than at other two nearby aggregations.
Source	

Aggregation Site #	**13, 14, 15 and 16**
Site name.	
Species names	*Plectropomus areolatus*
Local name	Kitkitip
Location	Four single species aggregations (13-16) form in this area. All in close proximity to each other but do not overlap. Three of the aggregations (13, 14 and 16) form on reef slopes at the sides of a wide passage. Aggregation 15 forms on a promontory of a submerged reef that extends out past the mouth of this passage.
Coordinates	
Depth (m)	7- 30 m
Habitat	Passage walls and seaward facing reef slopes, fish aggregated on coral and sand
Duration	1 week
Month(s) of formation	Every month of the year
Sign of spawning	Spawning observed, as well as chasing and color changes associated with spawning.
Type of aggregation	Transient
Time of spawning	Dawn and dusk
Type of spawning	Pair spawning and sneaking observed for *P. areolatus.* Spear fishers report sometimes seeing single fish "disturbing" a pair of fish at the peak of their spawning ascent.
Moon phase	Third quarter. Aggregations disperse on new moon
Fish numbers	
Area of aggregation (m. sq)	All roughly estimated to be between 5000 – 10 000 m. sq
Year discovered	The whereabouts of these aggregations have been known for generations
How discovered	Fisher
Year first exploited	Has been exploited for generations
Gear used	Spearfishing (day and night). Spearfishing at night is the main method used to capture fish for local sale. Traps and hook and line fishing used in the recent past to capture live fish for LRFFT operations, which have focused intensely in this area. Note that when LRFFT operations were in progress, P. areolatus were also being targeted at night by spear fishers to supply local markets.
CPUE trend	Decreasing
Current status	Decreasing – threatened
Status parameters	Catch rates said to have declined notably in last three decades. Aggregation 13 is reported to have been completely fished out in early 2001 by both spearfishing and LRFFT operations. Spear fishers report that they dived here for many months during aggregation periods without seeing any *P. areolatus* in 2001. Spear fishers then gave up targeting this site, and in 2003 dived here again and report that very small numbers of fish (<10) have began reappearing. (Which they targeted). Many communities target these aggregations, including individuals from Kavieng town.
Management/Protection	None
Additional notes	The western and eastern most aggregations are 2.5 kilometers apart. On the 18-Jan-04 (4 days before the new moon) we surveyed Site 16, only 3 P. areolatus were sighted. See Table 2 in this report. A local fisher from this area who has worked for NISP setting traps throughout the region, reports that aggregations at Dyual are far bigger than the ones that occur in this region.

	P. areolatus are said to be tightly aggregated around promontories in the early morning and the late afternoon, and widely dispersed at other times of the day.
Source	

Aggregation Site #	**17**
Site name.	
Species names	*Epinephelus fuscoguttatus*
Local name	Mangan
Location	
Coordinates	
Depth (m)	10 -40m
Habitat	Seaward facing reef slopes, coral and sand
Duration	4-5 days
Month(s) of formation	Every month of the year
Sign of spawning	Multiple gravid males. Spawning stupor, fishers state that "its as their eyes are closed at this time"
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	Third quarter. Aggregations disperse around new moon
Fish numbers	
Area of aggregation (m. sq)	Approx. 10000 m. sq
Year discovered	Known for generations
How discovered	Fisher
Year first exploited	Has been exploited for generations
Gear used	Spearfishing (day and night) at night is the main method used to capture fish for local sale for subsistence and artisanal purposes. Traps and hook and line fishing used in the recent past to capture live fish for LRFFT operations, which have focused intensely in this area.
CPUE trend	Decreasing
Current status	Decreasing
Status parameters	Catch rates of hook and line and daytime spearfishing reported to have decreased considerably over the past two decades. In 2001 spear fishers in this area started diving at this site at night in order to obtain reasonable catches, and report that several spear fishers can capture 20 or less on a good night. The currents here are very strong so spearfishing is only done around slack tides.
Management/Protection	None
Additional notes	UVC surveys have been conducted at this site twice (See Table 2, this report) but no aggregations were sighted. Several functional fish traps that the LRFFT operators had left behind were located at this site. The current was so strong we had to pull ourselves along the bottom. The site is exposed to severe wave action, and the reef top (that was 10m deep) was almost entirely rubble. A local fisher from this area who has worked for NISP setting traps throughout the region, reports that aggregations at Dyual are far bigger than the ones that occur in this region. Spear fishers report that E. fuscoguttatus have become accustomed to their activities, and are now easily disturbed by daytime spear fishers. They report that the aggregation of E. fuscoguttatus will move approximately 300m from the promontory back onto the deeper sandy bottom of passage when targeted. The location of this aggregation is widely known, and targeted by many communities. Indeed, the first fishers to inform us of the location of this aggregation were over 20 km away from this site.
Source	

Aggregation Site #	17
Site name.	
Species names	*Symphorichthys spilurus*
Local name	Lo
Location	Daytime aggregation site: Passage wall. Nocturnal aggregation site: Reef Promontory on submerged outer reef that extend out past the mouth of a passage.
Coordinates	
Depth (m)	Nocturnal aggregation site: < 5m Daytime aggregation site: 10-30m
Habitat	Daytime aggregation site: Passage wall. Fish loosely aggregated during the day. Nocturnal aggregation site: Seaward facing reef slopes, fish tightly aggregated in top 5 meters of water column above reef.
Duration	4-5 days
Month(s) of formation	Every month of the year, Aggregation size is variable from moth to month
Sign of spawning	Multiple gravid females.
Type of aggregation	Transient
Time of spawning	?? Night. Spawning may occur at night. Fish are loosely aggregated over a fairly wide area along side a passage wall during the day. At night, spear fishers report seeing tight clusters of fish "floating' in the upper water column. The flashlights and spearing disturb these aggregations, which descend back onto the reef top at approximately 10m.
Type of spawning	
Moon phase	Third quarter. Aggregations disperse around new moon
Fish numbers	Over 200
Area of aggregation (m. sq)	Nocturnal site Approx. 2000 -4000 m. sq Daytime site: Approx. 10 000 m. sq
Year discovered	Daytime aggregations of this species known to form in this area for generations. The precise location of the nocturnal aggregation site was discovered in 2003 by a spear fisher
How discovered	Fisher
Year first exploited	Nocturnal aggregations have been exploited since 2003. Daytime aggregations have been occasionally targeted by ay spear fishers for decades.
Gear used	Spearfishing at night is the main method used to capture fish for subsistence and artisanal purposes.
CPUE trend	
Current status	Stable
Status parameters	Fishers report that catch rates from nocturnal aggregation sites have not declined. However, exploitation of this nocturnal aggregation is very recent, and fishers place heavy fishing pressure on it, reporting that several spear fishers can remove up to 60 fish from an aggregation in less than 2 hours. Given that aggregations are reported to in the order of several hundred fish, this is considerable. The currents here are very strong so spearfishing is only done around slack tides.
Management/Protection	None
Additional notes	The distance between day and night aggregation areas is one kilometer.
Source	

Aggregation Site #	18, 19, 20, 21, 22
Site name.	
Species names	*Siganus lineatus*
Local name	Gagaus
Location	Five aggregations (18-22) form along both sides of the seaward end of a large passage. All aggregations are within close proximity of each other.
Coordinates	
Depth (m)	10 m
Habitat	Sides of channel. Aggregations form above the sand. (Just below the point where the coral walls of the passage descend into sand). Several aggregations form at locations where smaller channels drain into the main passage.
Duration	2- 3 days
Month(s) of formation	Every month of the year
Sign of spawning	Multiple gravid females
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	End of first quarter (2-3 days before the full moon, with aggregations breaking on the full moon)
Fish numbers	200 -1000 per aggregation
Area of aggregation (m. sq)	All aggregation areas small, approx. 1000 – 3000 m. sq
Year discovered	Known for generations
How discovered	
Year first exploited	Exploited for generations
Gear used	Spear guns (day).
CPUE trend	
Current status	Stable
Status parameters	Fishers report no declines in catch rates
Management/Protection	None
Additional notes	
Source	

Aggregation Site #	**23**
Site name.	
Species names	*Plectorhinchus chrysotaenia*
Local name	Papul
Location	
Coordinates	
Depth (m)	Aggregation occurs on patch reef and directly above it in water depths of approx. 5 -10 m
Habitat	Patch reef on seaward facing coral rock slope. Very little live coral, predominantly table corals, area exposed to heavy wave action.
Duration	3 days
Month(s) of formation	Every month of the year
Sign of spawning	Spawning observed
Type of aggregation	Transient
Time of spawning	Dawn and Dusk
Type of spawning	Pair spawning and group spawning of up to 10 individuals observed. Spawning ascents begin on or near the reef substrate, with spawning occurring about 3 m below the surface.
Moon phase	3 days prior to the full moon
Fish numbers	Several hundred fish, Fisher interviewed stated: "I've never tried to count them, but the reef is completely yellow, at this time, you can hardly see the stones"
Area of aggregation (m. sq)	2000 - 4000 m. sq
Year discovered	Not known when this site was discovered, fisher interviewed was told of this aggregation by fishers from Kavieng town five years ago, and has targeted it since
How discovered	Fisher
Year first exploited	
Gear used	Spear gun fishing during the day, fishers interviewed used goggles, but neither fins nor snorkel.
CPUE trend	
Current status	Same.
Status parameters	Fishers reported stable catches in the five years he has targeted this aggregation. The fishers interviewed stated he could spear a maximum of 30-40 fish (60 kg) from an aggregation site over several hours. Fishers interviewed smokes captured fish and markets them at Kavieng town.
Management/Protection	None
Additional notes	Fisher reports often targeting spawning ascents. He floats below the surface above the aggregation, and spears fish in spawning ascents that rush up towards the surface. He reports being able to spear up to 3 fish at once from a group spawning ascent, stating that "the fish are almost stuck together as they race up towards the surface ". Grey reef sharks were said to be very abundant at this site when aggregations have formed.
Source	

Aggregation Site #	**24**
Site name.	
Species names	*Naso caeruleacauda* and *Naso caesius*
Local name	Naknak
Location	
Coordinates	
Depth (m)	
Habitat	Promontory. Aggregations form in open water above reef.
Duration	1 day
Month(s) of formation	Every month of the year
Sign of spawning	Spawning observed, multiple gravid females
Type of aggregation	
Time of spawning	Early morning and late afternoon
Type of spawning	Group and pair spawning seen for both species.
Moon phase	Aggregations of both species form bimonthly, just before new and full moon
Fish numbers	Several 100
Area of aggregation (m. sq)	
Year discovered	1999
How discovered	Discovered when targeting the nearby aggregation Site 23
Year first exploited	1999
Gear used	Spear gun (day)
CPUE trend	
Current status	Stable
Status parameters	Fishers interviewed state that catch rates at this aggregation site have not changed in the years that they have targeted it.
Management/Protection	None
Additional notes	These two species are said to be easy to spear at this time, as they are aggregated in shallow water and more easily approached than normal.
Source	

Aggregation Site #	**25**
Site name.	
Species names	*Lutjanus boutton*
Local name	Bae
Location	
Coordinates	
Depth (m)	3-30m
Habitat	Reef slope
Duration	2 weeks
Month(s) of formation	Not known. The timing of this aggregation is linked to the yellowing of the leaves on the Inou tree.
Sign of spawning	Multiple gravid females
Type of aggregation	Resident?
Time of spawning	
Type of spawning	
Moon phase	Not noted
Fish numbers	>1000
Area of aggregation (m. sq)	Large area. Schools of running ripe *L. boutton* are said to occur all over the barrier reefs at this time.
Year discovered	The whereabouts of these aggregations have been known for generations
How discovered	Fisher
Year first exploited	Has been exploited for generations
Gear used	Hook and line and spearfishing
CPUE trend	
Current status	Stable
Status parameters	Fishers report no decrease in CPUE
Management/Protection	None
Additional notes	
Source	

Aggregation Site #	**25**
Site name.	
Species names	*Lutjanus gibbus*
Local name	Tausun
Location	
Coordinates	
Depth (m)	3-30m
Habitat	Reef slope
Duration	1 week
Month(s) of formation	Not known. The timing of this aggregation is linked to the reddening of leaves on the Talise tree.
Sign of spawning	Multiple gravid females
Type of aggregation	Resident?
Time of spawning	
Type of spawning	
Moon phase	
Fish numbers	Over 1000
Area of aggregation (m. sq)	Large area. Schools of running ripe *L. gibbus* are said to occur all over the barrier reefs at this time.
Year discovered	The whereabouts of these aggregations have been known for generations
How discovered	Fisher
Year first exploited	Has been exploited for generations
Gear used	Hook and line and spearfishing
CPUE trend	
Current status	
Status parameters	Stable
Management/Protection	Fishers report no decrease in CPUE
Additional notes	
Source	None
	In other costal regions of PNG the reddening of Talise leaves is also used as reference for pinpointing the times when aggregations of serranids form (Hamilton, 2003a).

Aggregation Site #	**26**
Site name.	
Species names	*Sphyraena barracuda*
Local name	Malisa
Location	
Coordinates	
Depth (m)	Near surface
Habitat	Above submerged patch reef that is between 7-30 m deep
Duration	4-5 days
Month(s) of formation	Every month of the year
Sign of spawning	Multiple gravid females
Type of aggregation	??
Time of spawning	Unknown
Type of spawning	
Moon phase	Full moon. Aggregations form several days either side of the full moon
Fish numbers	Unknown
Area of aggregation (m. sq)	Approx. 40 000 – 50 000 m. sq
Year discovered	Location known for generations
How discovered	
Year first exploited	
Gear used	Trolling and jigging at night, spearfishing during the day
CPUE trend	Declining
Current status	Decreasing
Status parameters	In the early 1990's a single fisher trolling at this aggregation site at would take 18-20 fish in 3-4 hours of fishing on a good night. Catch rates said to have steadily declined, and by 2003 fishers say that a single fisher trolling at night can catch 7-10 fish in a good night over 3-4 hours, and on some nights they catch nothing. The size structure of the catch is also reported to have changed, with very few large fish in the 6-7 kg size range captured these days. Up to 6 canoes target this aggregation site at one time.
Management/Protection	None
Additional notes	
Source	

Aggregation Site #	**27**
Site name.	
Species names	*Plectropomus areolatus, Epinephelus fuscoguttatus* and *Epinephelus polyphekadion*
Local name	
Location	
Coordinates	
Depth (m)	5- 30m
Habitat	Promontory, aggregations form on seaward facing slope on coral and sand
Duration	
Month(s) of formation	
Sign of spawning	All 3 species have developed gonads at this stage, chasing and nudging seen in *P. areolatus*.
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	Not noted by fishers, who reports that he only comes across this aggregation if he is lucky.
Fish numbers	*P. areolatus* reported to be most abundant of the three species, with over 500 at peak aggregations. Numbers of *Epinephelus fuscoguttatus* and *Epinephelus polyphekadion* said to be in the order of 100- 200 fish.
Area of aggregation (m. sq)	< 10 000 m. sq
Year discovered	Early 1990's
How discovered	Spear fisher discovered this aggregation when diving for Beche-de-mer during the day
Year first exploited	Early 1990's
Gear used	Spear gun (day). Fisher doesn't use fins so is restricted to fairly shallow water.
CPUE trend	Stable
Current status	Stable
Status parameters	Fisher who discovered this aggregation and has exploited it sporadically ever since reports no declines in fish numbers of CPUE. Fisher reports being able to catch up to 15 *P. areolatus* over several hours.
Management/Protection	Nothing formal. Note however that a nearby island is currently uninhabited as it is believed to be haunted. Repeated attempts to inhabit this island over the last 50 years have been short lived, with newly settled families being frightened off by the resident devils on the island. This undoubtedly offers the nearby aggregation some protection.
Additional notes	Highest densities of *P. areolatus* said to occur at approx. 20m where the coral wall turns descends into sand. This fisher was one of the only individuals interviewed in this study that apparently had no knowledge of the lunar periodicity with which these spawning aggregations form in this region.
Source	

Aggregation Site #	28
Site name.	
Species names	*Plectropomus leopardus* and *Ctenochaetus striatus*
Local name	Taulave
Location	
Coordinates	
Depth (m)	1-3 m
Habitat	Sand
Duration	2-3 day
Month(s) of formation	Unknown – said to occur several times a year following a violent thunder and lightening storm
Sign of spawning	These migrations may not be spawning migrations – refer to additional report 2 for a discussion on this.
Type of aggregation	Corridor (Migration route) ??
Time of spawning	
Type of spawning	
Moon phase	
Fish numbers	Approx. 100 in each migrating group, with several groups moving pat this point in a single day.
Area of aggregation (m. sq)	
Year discovered	Known for generations
How discovered	
Year first exploited	For generations
Gear used	Netting (day) Spearfishing at night
CPUE trend	
Current status	Stable
Status parameters	Fishers report being able to catch up to a 100 *P. leopardus* in a day. Catch rates are reported to have remained stable for decades.
Management/Protection	None
Additional notes	Fishers report that the flesh of captured fish is very oily and none of the fish have any food in their guts at this time. Aggregations occur over 3 days, with peak aggregations forming on the second day. Sometimes up 2 -3 groups of *P. leopardus* will migrate past this point in a single day Schools of many 100s of *Ctenochaetus striatus* also known to migrate past here at this time. These schools do not mix with schools of *P. leopardus*
Source	

Aggregation Site #	**29**
Site name.	
Species names	*Plectropomus areolatus, Epinephelus fuscoguttatus* and *Epinephelus polyphekadion*
Local name	Kekwa, Kali Mbuangeu and Kali Kot
Location	
Coordinates	
Depth (m)	5 -30m
Habitat	Promontory on one side of the mouth of a large passage. Aggregations form on coral and sand. *E. fuscoguttatus* in deeper water.
Duration	One week
Month(s) of formation	Peak season for both species is March, April, and May. *P. areolatus* forms small aggregations year round.
Sign of spawning	Multiple gravid females, chasing and color changes associated with spawning.
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	Third quarter, with aggregation dispersing on the new moon. NB however that small numbers of large *P. areolatus* (presumably male) begin aggregating here shortly after the full moon.
Fish numbers	*P. areolatus* approx. 200 - 500 during peak seasons *E. fuscoguttatus* more than 100. *E. polyphekadion* < 50. See Figure 8 in this report for UVC results from this site.
Area of aggregation (m. sq)	Approx. 10 000 m. sq
Year discovered	Known for generations
How discovered	
Year first exploited	Exploited for generations. Currently aggregation fishing is widely viewed as a easy way of making "fast money"
Gear used	Traditionally pre and post spawning runs off female *P. areolatus* that form in the shallow reef flats above the aggregation site were targeted with hand spears. Today methods used are spearfishing and hand lines. Spearfishing mainly targets *P. areolatus* which aggregate in shallower water.
CPUE trend	Decreasing
Current status	Decreasing
Status parameters	Fishers report that prior to the 1990's a single hook and line fisher (live bait) could take over 20 *P. areolatus* in a day, but today, would catch less than 10 fish. (i.e. a CPUE decline of at least 50%). Nighttime spearfishing is blamed for the declines.
Management/Protection	In March 2004 a ban was placed on day and nighttime spearfishing at this site in the 10 days leading up to and including the new moon. This lunar ban is in force for every month of the year. Only subsistence hook and line fishing is allowed here during this lunar period. See the Manus section of this report for more detail on this.
Additional notes	A very knowledgeable spear fisher gave this information on precise aggregating timing of these different species. Arrival: *P. areolatus* and *E. fuscoguttatus* begin to aggregate a few days after the full moon. *E. polyphekadion* begin to aggregate at the very beginning of the third quarter. Departure: *E. fuscoguttatus* disperse a day or so before the new moon, followed by *P. areolatus* a day or two latter. *E. polyphekadion* disperses last, that being several days after the new

	moon. *E. fuscoguttatus* is said to be more numerous here than at other nearby sites 33 and 35. Note however that significantly more *E. fuscoguttatus* were seen at Site 35 than at this site in the 2004 UVC surveys at these sites. (Refer to Figure 8 in this report).
Source	(Matawai, 2000; Squire, 2001; Hamilton, 2003a).

Aggregation Site #	**29**
Site name.	
Species names	*Epinephelus ongus*
Local name	Kalindreken
Location	
Coordinates	
Depth (m)	1 -12 m
Habitat	Passage wall. These fish reside on sand and coral on the passage wall.
Duration	Approximately 10 days
Month(s) of formation	March, April, May
Sign of spawning	Very large numbers and multiple gravid females.
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	Aggregations form at the beginning of the third quarter and disperse several days after the new moon.
Fish numbers	Many thousands A fishers described their numbers as "uncountable"
Area of aggregation (m. sq)	Approx. 20 000 m. sq
Year discovered	Known for generations
How discovered	
Year first exploited	Exploited for generations.
Gear used	Spear fishing and hook and line. Today spearing is the dominant method. Reported to be very approachable and consequently extremely easy to capture at this time.
CPUE trend	Stable. Spear fishers report that they can harvest more than 50 *E. ongus* in an hour.
Current status	Stable
Status parameters	CPUE rates are reported not to have declined in several decades despite the fact that levels of fishing have increased.
Management/Protection	In March 2004 a ban was placed on day and nighttime spearfishing at this site in the 10 days leading up to and including the new moon. This lunar ban is in force for every month of the year. Only subsistence hook and line fishing is allowed here during this lunar period. See the Manus section of this report for more detail on this.
Additional notes	Aggregating *E. ongus* are highly sought after for both its eggs and oily flesh. Much of this aggregation occurs outside of the area where fishing restrictions are in place.
Source	(Hamilton, 2003a).

Aggregation Site #	**29**
Site name.	
Species names	*Lethrinus erythropterus*
Local name	Kolangindrou
Location	
Coordinates	
Depth (m)	1 -12 m
Habitat	Passage wall. These fish occupy the mid water above the passage slope.
Duration	3-4 days. 10 days after the full moon schools of *L. erythropterus* migrate along corridors from shallow sea grass and inner reefs to the passage. *L. erythropterus* aggregations remain in the passage for several days before moving back to seagrass and inner reefs via the same corridors.
Month(s) of formation	March, April, May
Sign of spawning	Fishers note that all fish moving down into passage are full of eggs/sperm, whereas returning schools of fish are all spent.
Type of aggregation	Transient
Time of spawning	This species spawns at night in the Western Solomon Islands, and aggregates around the same lunar period (Hamilton 2005).
Type of spawning	Group spawning (Hamilton 2005).
Moon phase	Third quarter.
Fish numbers	Many thousands
Area of aggregation (m. sq)	Approx. 20 000 m. sq
Year discovered	Known for generations
How discovered	
Year first exploited	Exploited for generations.
Gear used	Gill nets are used to intercept pre spawning and post spawning runs at shallow gullies (corridors) that connect the seagrass / inner lagoon areas to the passage, and hand lines and spear guns are used to target aggregations that form in the passage.
CPUE trend	
Current status	Stable
Status parameters	Fishers report that size of schools and catch rates have not declined over their lifetimes.
Management/Protection	In March 2004 a ban was placed on day and nighttime spearfishing at this site in the 10 days leading up to and including the new moon. This lunar ban is in force for every month of the year. Only subsistence hook and line fishing is allowed here during this lunar period. See the Manus section of this report for more detail on this.
Additional notes	Some of the aggregation and the corridors for this species occur outside of the area that has fishing restrictions in place.
Source	(Hamilton, 2003a; Hamilton 2005).

Aggregation Site #	**30**
Site name.	
Species names	*Lethrinus erythropterus* and *Epinephelus ongus*
Local name	Kolangindrou Kalindreken
Location	
Coordinates	
Depth (m)	1 -7 m
Habitat	Seaward reef slope wall.
Duration	*Epinephelus ongus*: Approximately 10 days *Lethrinus erythropterus*: 3-4 days.
Month(s) of formation	March, April, May
Sign of spawning	Multiple gravid females for both species
Type of aggregation	Transient
Time of spawning	*L. erythropterus* spawns at night in the Western Solomon Islands (Hamilton 2005). Spawning behavior not described for *E. ongus*
Type of spawning	*L. erythropterus* group spawns (Hamilton 2005).
Moon phase	*E. ongus*: Third quarter – New moon. *L. erythropterus*: Third quarter
Fish numbers	Over 1000 of both species
Area of aggregation (m. sq)	Approx. 10000 m. sq
Year discovered	Known for generations
How discovered	
Year first exploited	Exploited for generations.
Gear used	Spearfishing is the main method used to capture both species that aggregate here.
CPUE trend	
Current status	Stable
Status parameters	Fishers report that size of aggregations and catch rates have not declined for either species.
Management/Protection	None
Additional notes	This aggregation site is 6 km away from Site 29, where these two species aggregate over a larger area and in greater numbers.
Source	Hamilton (2005).

Aggregation Site #	**31**
Site name.	
Species names	*Siganus vermiculatus*
Local name	Kuapat
Location	
Coordinates	
Depth (m)	1- 30m
Habitat	Seward facing reef slope
Duration	3-4 days
Month(s) of formation	Every month of the year. Fish move out from the seagrass beds and sheltered inner reefs to spawn in deeper water.
Sign of spawning	Multiple gravid females
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	New Moon. 3-4 days immediately following the new moon.
Fish numbers	200 -500
Area of aggregation (m. sq)	Large area, roving schools along slope, > 20 000 m. sq
Year discovered	Known for generations
How discovered	
Year first exploited	Exploited for generations
Gear used	Spear guns
CPUE trend	
Current status	Decreasing
Status parameters	Fishers reported declines in catch rates over the last 4 decades, but did not specify the magnitude of these declines.
Management/Protection	None
Additional notes	Several hundred seen at this site on 24/1/04 while free diving (One day after new moon). Four fishers from two canoes were targeting this aggregation. Spear fishers said that their activities had driven the aggregation into deep water. Several captured fish were examined, all males and females were running ripe. There are several other known spawning aggregation sites for this species in this region, all occurring on outer reef slopes that are located within several kilometers of the mainland.
Source	

Aggregation Site #	**32**
Site name.	
Species names	*Siganus canaliculatus*
Local name	Pachar kuapat
Location	
Coordinates	
Depth (m)	1- 3m
Habitat	Shallow sandy sea grass areas that slope down into Toloas passage
Duration	Several hours
Month(s) of formation	Every month of the year. Fish move out from the seagrass beds and sheltered inner reefs to spawn in deeper water.
Sign of spawning	Fish in pre spawning runs have ripe gonads. Fish returning the following day are spent.
Type of aggregation	Pre spawning and Post spawning migrations
Time of spawning	
Type of spawning	
Moon phase	New Moon and First quarter. Pre spawning aggregations occur in the late afternoon (1700 -1800 hrs) on the 1st day of the new moon and 10 days after the new moon. Post spawning aggregations occur in the morning (0700 -1000 hrs) on the 2nd day of the new moon and 11 days after the new moon.
Fish numbers	Several thousand fish migrate along these corridors in a day. Any one school may range between 100 -500 fish.
Area of aggregation (m. sq)	
Year discovered	Known for generations
How discovered	
Year first exploited	Exploited for generations
Gear used	Traditionally: basket traps (Pawalu) were placed in corridors. As schools of migrating fish moved towards the Pawalu traps, fishers beat the surface of the water with Butut (custom whips), which resulted in frightened fish taking cover in the Pawalu traps. Today gill nets are used.
CPUE trend	Decreasing
Current status	Decreasing
Status parameters	Fishers report that sizes of aggregations have declined markedly since the 1940's when traditional Pawalu traps where last used. Old fishers state they could catch over 1000 fish in a Pawalu trap, whereas today with gill nets fishers get a maximum of several hundred fish.
Management/Protection	Pere community based management. Dynamiting aggregations is banned.
Additional notes	Pre spawning aggregations are heavily targeted as the gonads of this species are sought after.
Source	(Hamilton, 2003a)

Aggregation Site #	**33**
Site name.	
Species names	*Plectropomus areolatus* and *Epinephelus fuscoguttatus*
Local name	Kekwa Kali Mbuangeu
Coordinates	
Depth (m)	5 -30m
Habitat	Promontory, aggregations form on coral and sand. *E. fuscoguttatus* predominantly in deeper water.
Duration	5-6 days
Month(s) of formation	Peak season for both species is March, April, and May. *P. areolatus* forms small aggregations year round.
Sign of spawning	Multiple gravid females, chasing and color changes associated with spawning.
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	Main aggregation occurs in the Third quarter, with aggregation dispersing on the new moon. NB however that small numbers of large *P. areolatus* (presumably male) begin aggregating here shortly after the full moon.
Fish numbers	*P. areolatus* 100-300 (peak season) *E. fuscoguttatus* < 100 (See Figure 8 in this report for UVC results from this site).
Area of aggregation (m. sq)	Approx. 8000 m. sq
Year discovered	Known for generations
How discovered	Fisher
Year first exploited	Exploited for generations
Gear used	Hand lines using live damselfish as bait is the main method used to exploit this fish. Some spearfishing (day and night).
CPUE trend	Decreasing
Current status	Decreasing
Status parameters	Fishers report catch rates and number of aggregating fish has declined markedly in the last two decade since the commencement of night diving in the mid 1980's.
Management/Protection	In January 2004 a ban was placed on day and nighttime spearfishing at this site in the 10 days leading up to and including the new moon. This lunar ban is in force for every month of the year. Only subsistence hook and line fishing is allowed here during this lunar period. See the Manus section of this report for more detail on this.
Additional notes	The ripe gonads and internal organs of *P. areolatus* are a delicacy. They are removed from captured fish, stuffed into the fish's gut lining and boiled. Many fishers reported not particularly liking the meat of this species.
Source	(Squire, 2001; Hamilton, 2003a)

Aggregation Site #	**34**
Site name.	
Species names	*Plectropomus areolatus*
Local name	Kekwa
Location	
Coordinates	
Depth (m)	3 -30 m
Habitat	Promontory of a small patch reef. Aggregations form on reef slopes and reef top
Duration	5-6 days
Month(s) of formation	Peak season is March, April, and May. Small aggregations form year round
Sign of spawning	Multiple gravid females
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	Third quarter. Disperse on or just after the new moon.
Fish numbers	Approximately 100 in the peak season
Area of aggregation (m. sq)	Approx. 4000 -5000 m. sq
Year discovered	Known for generations
How discovered	Fisher
Year first exploited	Exploited for generations
Gear used	Spearfishing (day and night) and Hand lines using live damsel fish as bait
CPUE trend	Decreasing
Current status	Decreasing
Status parameters	Fishers report catch rates have declined in recent decades, but did not specify to what extent.
Management/Protection	None
Additional notes	Aggregations form latter at this site than mixed species aggregations at a nearby Site 33, and disperse several days latter. These two sites are 3.5 km apart
Source	

Aggregation Site #	**35**
Site name.	
Species names	*Plectropomus areolatus* and *Epinephelus fuscoguttatus*
Local name	Kekwa Kali Mbuangeu
Location	
Coordinates	
Depth (m)	5 -30m
Habitat	Promontory, aggregations form on coral and sand. *E. fuscoguttatus* in deeper water.
Duration	5-6 days
Month(s) of formation	Peak season for both species is March, April, and May. *P. areolatus* forms small aggregations year round.
Sign of spawning	Multiple gravid females, chasing and color changes associated with spawning.
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	Third quarter, with aggregation dispersing on the new moon. NB however that small numbers of large *P. areolatus* (presumably male) begin aggregating here shortly after the full moon.
Fish numbers	Fishers state that *P. areolatus* approx. 500 -1000 during peak seasons. *E. fuscoguttatus* 100 -200 (See Figure 8 in this report for UVC results from this site).
Area of aggregation (m. sq)	Approx. 12000 - 15000 m. sq
Year discovered	Known for generations
How discovered	
Year first exploited	Exploited for generations. Currently aggregation fishing is widely viewed as a easy way of making "fast money"
Gear used	Traditionally pre and post spawning runs off females that form in the shallow reef flats above the aggregation site were targeted with hand spears. Today methods used are spearfishing (day and night) and hand lines. Spearfishing mainly targets *P. areolatus* which aggregate in shallower water.
CPUE trend	Decreasing
Current status	Decreasing
Status parameters	Fishers report that catch rates have declined considerably in recent decades, with poaching from fishers from the nearby heavily populated villages being blamed for these declines. Spear fishers who exploited this aggregation every month of the year in 2003 report that the largest aggregations in 2003 occurred in April. Three spear fishers who targeted this aggregation site at night over a 3 hour period removed 130 kg of *P. areolatus* (wet weight), representing a maximum yearly CPUE rate of 10.8 kg/*P. areolatus*/fisher/hour. An expert spear fishers from Pere village removed 41 and 39 *P. areolatus* respectively during two mornings from a peak aggregation in May 2003.
Management/Protection	In May 2004 a ban was placed on day and night time spearfishing at this site in the 10 days leading up to and including the new moon. This lunar ban is in force for every month of the year. Only subsistence hook and line fishing is allowed here during this lunar period.
Additional notes	This aggregation site is widely regarded by local fishers as having the highest abundance of fish out of the 3 large aggregations that form in this region (Sites 29, 33 and 35).
Source	Squire (2001), Hamilton. (2003a).

Aggregation Site #	**35**
Site name.	
Species names	*Symphorichthys spilurus*
Local name	Ndrang
Location	
Coordinates	
Depth (m)	10 -25m
Habitat	Promontory. Aggregation occurs around a large rocky outcrop that begins at approx. 25m and protrudes up to a depth of approx. 10m. The rocky outcrop has several cave systems in it, which is where aggregations reside during the day.
Duration	3 days
Month(s) of formation	March, April, May
Sign of spawning	Multiple gravid females
Type of aggregation	Transient
Time of spawning	Possibly in late evening or at night. Aggregating fish are known to leave their shelter and come up into shallower water just prior to dark.
Type of spawning	
Moon phase	Third quarter, with aggregation dispersing on the new moon.
Fish numbers	Less than 100
Area of aggregation (m. sq)	
Year discovered	Known for generations
How discovered	
Year first exploited	Since the 1970's.
Gear used	Spear guns (day).
CPUE trend	Stable. Several good spear fishers can remove up to 20 fish in several hours.
Current status	Stable
Status parameters	Spear fishers report that the size of aggregations and their catch rates have not decreased in the last 2 decades.
Management/Protection	In May 2004 a ban was placed on day and night time spearfishing at this site in the 10 days leading up to and including the new moon. This lunar ban is in force for every month of the year. Only subsistence hook and line fishing is allowed here during this lunar period. See the Manus section of this report for more detail on this.
Additional notes	*Lutjanus argentimaculatus* that were displaying spawning behaviors were sighted here during the third quarter in March 2001 (Squire, 2001).
Source	(Squire, 2001; Hamilton, 2003a).

Aggregation Site #	**36**
Site name.	
Species names	*Plectropomus areolatus*
Local name	Kekwa
Location	
Coordinates	
Depth (m)	3 - 15 m
Habitat	Promontory of a small patch reef. Aggregations form on the gentle coral reef slope and on the shallow reef top. Coral slope descends into sand at 12-15m. Strong current and site is exposed to big seas.
Duration	5-6 days
Month(s) of formation	Peak season is March, April, and May. Small aggregations form year round
Sign of spawning	Multiple gravid females
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	Third quarter. Aggregations disperse on the new moon.
Fish numbers	Approximately 40 -60 in the peak season
Area of aggregation (m. sq)	Approx. 2000 -3000 m. sq
Year discovered	2000
How discovered	Discovered by a spear fisher who was hunting for turtles in this area.
Year first exploited	2000
Gear used	Spearfishing (day)
CPUE trend	Stable
Current status	Stable
Status parameters	Only the fisher who discovered this aggregation knows of its whereabouts. He reports capturing up to 10 *P. areolatus* in several hours of fishing, and has not noted a decline in abundance in the time he has targeted this site.
Management/Protection	None
Additional notes	Hawksbill and green turtles known to aggregate here. A survey of the entire patch reef in January 2004 revealed that there is no suitable habitat to support aggregations of *E. fuscoguttatus*.
Source	

Site number	**37**
Site name.	
Species names	*Plectropomus areolatus, Epinephelus polyphekadion* and *Epinephelus lanceolatus*
Local name	Auo, Wie and Putu Kero
Location	
Coordinates	
Depth (m)	3 – 8m
Habitat	Bottom of a shallow passage that runs parallel to Pak Island. Aggregations form on shallow reef and on nearby surrounding sand. At one end of the aggregation site several large boulders (3-4m high) rise up from the passage floor and this is where *E. lanceolatus* reside during the aggregating period.
Duration	1-2 weeks
Month(s) of formation	Have noticed that large aggregations frequently form in March
Sign of spawning	Fishers describe chasing, nudging and color changes associated with spawning in these species, and report that they believe the fish are behaving this way at this time because they are happy.
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	Not noted
Fish numbers	*E. polyphekadion* 80 -100 *P. areolatus* 50-60 *E. lanceolatus* 1-2
Area of aggregation (m. sq)	Approx. 15 000 m. sq
Year discovered	Known for generations
How discovered	
Year first exploited	Exploited for generations.
Gear used	Traditionally hand spears were used to target *P. areolatus and E. polyphekadion*, in more recent time's night and daytime spearfishing was the main fishing method. *E. lanceolatus* is a customary fish and is not targeted.
CPUE trend	N/A
Current status	Increasing
Status parameters	Numbers are said to have increased slightly since this aggregation site was fully protected under customary law in 2002. Full protection of this site was established based on; 1. Customary beliefs about the power of *E. lanceolatus* (and serranids in general) to bring other fish in close to shore, 2. Marked declines in abundance of aggregating serranids were raising communities concerns about sustainability. Note: All serranids over a wide area of reef surrounding this region (approx 7 km of linear reef) are currently fully protected (see additional report 3).
Management/Protection	Completely protected as of 2002.
Additional notes	See additional report for the customary story on this aggregation.
Source	

Site number	**38**
Site name.	
Species names	*Epinephelus polystigma*
Local name	Kali Moniol
Location	
Coordinates	
Depth (m)	1-3 m
Habitat	Muddy/sandy area with some fragmented coral reef. This region is in close proximity to mangroves.
Duration	2 days
Month(s) of formation	Every month of the year
Sign of spawning	Many gravid females. All fish captured from this site on these lunar days are running ripe
Type of aggregation	Transient
Time of spawning	
Type of spawning	
Moon phase	New moon. Fish said to aggregate at this site on the 1st and 2nd day of the new moon. At other times of the lunar month this species is not found here.
Fish numbers	Unclear as there is always such poor visibility here.
Area of aggregation (m. sq)	Approx. 5000 m. sq
Year discovered	
How discovered	
Year first exploited	
Gear used	Spear gun fishing during the day appears to be the main method used to exploit this aggregation. Although fishers interviewed stated that this fish will also take a baited hook.
CPUE trend	
Current status	Stable?
Status parameters	Spear fishers that have exploited this aggregation for over ten years did not report any declines in catch rates. 15 *E. polystigma* was reported to be the maximum number of fish taken in a spearfishing trip.
Management/Protection	None
Additional notes	The very dark color of this species combined with the muddy substrate and very poor visibility in this area make it difficult to spot aggregated *E. polystigma*, which are typically motionless on the mud. Fishers report often only seeing a fish once they have disturbed it and it is darting away. To enhance capture rates, spear fishers who target this site will sink coconut fronds within the aggregation area several days prior to the known aggregation period. When spear fishers return during an aggregation period, *E. polystigma* are often sheltering under the coconut leaves and are easy to spear. Fishers report that they will often only see the eyes of fish that are residing under the coconut fronds. The fishers interviewed stated that only a few individuals knew of the location and timing of this aggregation, and that most spear fishers did not target this area due to the very poor visibility.
Source	

APPENDIX 2: A preliminary report on nocturnal aggregations of *Epinephelus polystigma* – a little known and highly vulnerable estuarine grouper

Heemstra and Randall (1993) describe *E. polystigma* as a seemingly rare species that is known only from brackish or fresh water areas, with its geographical distribution restricted to the western pacific regions of Indonesia, Philippines, Papua New Guinea and the Solomon Islands. Although little is known about this species, *E. polystigma* does form a component of subsistence catches in lightly fished regions of Solomon Islands (Johannes, 2001). To date there is no scientific knowledge on the reproductive biology of this species (Johannes, 2001). In this report we describe the nocturnal aggregating behavior of *E. polystigma* at a remote location in New Ireland Province, Papua New Guinea. We draw on detailed local knowledge, our own observations and preliminary demographic data collected from a subsistence fishing trip to show that these nocturnal aggregations may represent spawning aggregations. A biological phenomena that is common to the serranids but unknown for this species.

Local knowledge

While conducting routine interviews with fishers from New Ireland, we were informed of the location and lunar timing of a large and recently discovered nocturnal aggregation of black estuary groupers. This species, known as *avou* in the local language (and later identified as *E. polystigma*) is reported by fishers to be a common fish in the river mouths and brackish mangrove regions surrounding their island. Fishers report that by day this is a solitary wary species. They also referred to this fish as 'sneaky', due to its common behavior of lurking in wait below Banded Archerfish (*Toxotes jaculatrix*), so that it may 'steal' any crabs that the archerfish knocks from the mangrove roots with jets of water that it propels from its mouth.

The *E. polystigma* aggregation site reported on here was discovered when local fishers who were hunting for mud crabs at night came across this aggregation in early 2003. At the time this aggregation was discovered it was low tide, and fishers report discovering large numbers of loosely dispersed *avou* sleeping in very shallow water in among the mangrove roots and on shallow sandy and rocky substrate at the mouth of a large remote estuarine bay. Fishers report that fish were in water not much deeper than their ankles, and that they removed over 50 fish from a small area (> 5 000 m. sq) in less than an hour, simply using a bush knife to cut the sleeping fish in half.

The fishers who discovered this aggregation noted that the night they discovered it coincided with peak aggregations of *P. areolatus* that are known to form on a monthly basis in this region, and they suspected that *avou* nocturnal aggregations might also display a predictable lunar periodicity. Over the last year fishers have confirmed their own theory, by returning many times to this site at a variety of lunar stages. At the time of this fieldwork, all fishers interviewed were in agreement that aggregations occurred for approximately a week prior to the new moon, every month of the year. Fishers interviewed were unable to tell us if captured fish from these aggregations were full of ripe gonads.

Interviews reveal that exploitation of this recently discovered nocturnal aggregation is growing, as more individuals from a nearby village learn of the location and timing of this aggregation. It is noteworthy however that this aggregation is not targeted every month, as fishers limit their activities to aggregation periods that coincide with low tides at night. Furthermore, to date this aggregation has only been fished to meet local consumption needs. There is widespread belief among fishers that this aggregation must occur throughout the entire estuary bay, which stretches for several kilometers. However fishers have not yet bothered to investigate the boundaries of the aggregation, stating that all the fish required can still be easily collected within the limited aggregation area that was initially discovered in 2003.

Field Observations

On January 19, 2004, three days before the new moon, we accompanied a local fishing party to the recently discovered *E. polystigma* nocturnal aggregation site. It was 10 pm and low tide. We quickly located several *avou* that were sleeping on the sand and mud up against stones or mangrove roots in water depths of approximately 10-20 cm. Larger fish that were in very shallow water were all lying on their sides, presumably to keep their gills underwater, while fish in slightly deeper water often had their bellies resting on the bottom (Figure 9 and 10). The first fish to be speared enabled me to identify the species as *E. polystigma* (Figure 11).

Figure 9: A sleeping *E. polystigma* lying on its side in very shallow water.

Figure 10: A sleeping *E. polystigma* in slightly deeper water resting on its belly.

Figure 11: Photo of a freshly captured male *E. polystigma*. Small yellow (sometimes white) dots that cover most of the body in this species (Heemstra and Randall, 1993) can be seen on the caudal and dorsal soft fin rays in this specimen.

Over the next 50 minutes we accompanied two local fishers who searched for this species. In this time period we sighted approximately 30 *E. polystigma* and captured 18 in an area of approximately 4000 m. sq (Figure 12). Fish were located with the light of a flashlight, and then speared with a handheld spear.

Figure 12: Two local fishers holding up their catch of *E. polystigma*. The fisher on the left is holding the hand held spear that was used to capture these fish.

During the time that fish were being captured we made the following observations:

- *E. polystigma* were aggregated near or in among mangrove roots. Fish were patchily distributed in small clumps over a fairly large area. At times we would walk for several minutes without seeing a fish, and at other times we would spot 5-6 individuals in an area of < 100 m. sq. At no time did we see two individuals in very close proximity to each other.

- All large *E. polystigma* sighted remained completely motionless regardless of the amount of disturbance we made nearby. Even the repeated flashlight of a camera did not disturb them.

- Smaller individuals were much more flighty and more numerous than big fish, and would often dart away from fishers before they could spear them.

- All small individuals had pronounced swollen bellies, indicating that they were ripe females.

- No *E. polystigma* were seen in water deeper than 20 cm and no other fish other than *E. polystigma* were seen.

Sex specific size structure and sex ratio

The 18 *E. polystigma* speared were measured to the nearest mm (Total Length) and sexed macroscopically. All *E. polystigma* examined were mature ripe individuals that could easily be sexed in the field. Ripe ovaries were dark orange and a mass of oocytes was clearly visible when a transverse section of a ripe ovary was cut. All males were running ripe, with white compact testes and extractable milt.

The sex specific length frequency distributions of the sample examined are shown in Figure 13.

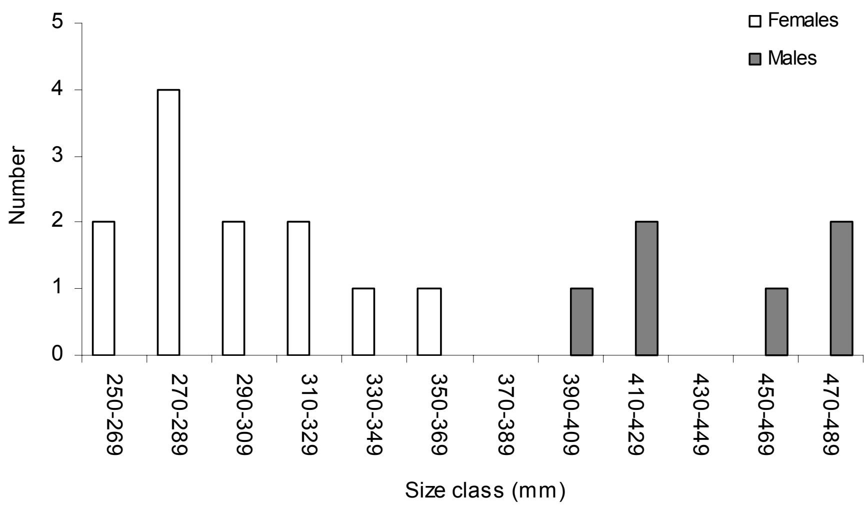

Figure 13: Size frequency distribution of *E. polystigma* in 20 mm size classes (n=18).

Male and female *E. polystigma* had a pronounced bimodal size distribution, with there being no overlap in the size range of males and females sampled. Females outnumbered males 2:1 in this sample. Given that all small (presumably female) individuals were more flightily and harder to capture than large (presumably male) fish, females were probably under represented in this sample and the operational sex ratio of the population is likely to be more female biased.

We did not have any equipment to weigh individual fish or their gonads, so we were unable to work out GSI for the sexes. However, macroscopic investigation revealed that all male gonads were both absolutely and relativity much smaller than the gonads of all females sampled (Figure 14).

Figure 14a

Figure 14b

Figure 14: (a) Gonads of a ripe 305 mm female; (b) Gonads of a ripe 475 mm male.

Discussion

The nocturnal aggregation site that we visited was located at the seaward end of a large estuary bay. It is plausible that *E. polystigma*, which local fishers report are normally non-aggregated, travel to the estuary mouth for the purpose of spawning a week prior to the new moon. The lunar periodicity of aggregation formation and the fact that all sampled fish were ripe gravid individuals provides indirect evidence for this scenario. However it must be stressed that spawning was not verified in this study. Fish may aggregate at night for reasons other than spawning [i.e. nocturnal resting aggregations of *Bolbometopon muricatum* (Hamilton, 2003b)]. Consequently, spawning needs to be confirmed for this aggregation before these *E. polystigma* nocturnal aggregations are classified as spawning aggregations (Colin *et al*., 2003). Unequivocal evidence of spawning requires observing actual spawning or demonstrating the presence of hydrated eggs or post-ovulatory follicles in the ovaries of aggregating females (Colin *et al*., 2003).

Despite the fact that this study has not quantified whether or not these nocturnal aggregations represent spawning aggregations, it is clear that the remarkable ease with which these shallow nocturnal aggregations can be exploited makes this species highly susceptible to over fishing. Indeed, available ethnographic data from Melanesia indicates that historical over fishing may have attributed to their apparent rarity throughout much of their range. Fishers from Isabel Province in the Solomon

Islands report that this species occurs in low numbers in mangrove and estuary areas that are in close proximity to human settlements (Johannes, 2001). In two other areas of Melanesia, nighttime subsistence fishing pressure has had a marked effect on nocturnal aggregations of *E. polystigma*. Below we provide brief histories of *E. polystigma* fisheries in the Western Solomon Islands and Manus Island, Papua New Guinea, to demonstrate the rapid rate with which this species can be over fished.

Nusabanga village, Roviana Lagoon, Western Solomon Islands.

In mid-2000, the late Robert Johannes asked one of the authors (RH) to interview fishers in Roviana Lagoon on their knowledge of the behavior and status of *E. polystigma* populations in this region. At the time RH was residing in Nusabanga village, Roviana Lagoon and was completely unaware of this species, having never seen it in local catches. However interviews with several older fishers' revealed detailed information on past *E. polystigma* fisheries in this region. Known as *kobili* in the Roviana language, *E. polystigma* is reported to have once been very abundant in the shallow inner lagoon areas directly surrounding Nusabanga village, and easily captured at night. In the 1950's when the island of Nusabanga was settled, fishers report at times being able to capture over 50 *kobili* in a night. *E. polystigma* were speared in very shallow water, using burning coconut fronds and later flashlights as a source of light. Interviews did not reveal any information on the reproductive state of captured *kobili*, or the best lunar times to capture this fish.

The very close proximity of Nusabanga village to these *kobili* fishing grounds had rapid negative effects on this population, with older fishers reporting that *kobili* catch rates quickly declined and had completely disappeared from the inner lagoon areas around Nusabanga by the early 1970's. Indeed, an experienced Nusabanga fisher in his early 30's who came across and speared two *kobili* in 1998 had to ask his father to identify these fish, having never seen this species before. Over an uninterrupted 12 month period that RH resided in Nusabanga village (August 2000 – July 2001), only once did he examine two *E. polystigma*. A Nusabanga fisher speared both specimens at night on November 28, 2000 in shallow water in the inner lagoon adjacent to Nusabanga village. These two *E. polystigma* were 510 mm and 470 mm long (1.6 kg and 1.35 kg total weight), and could not be sexed macroscopically as they had no obvious gonad development.

Manus Island, Papua New Guinea

In 2003 Pomat Powayai, a Manus fisheries officer, told RH of large aggregations of two estuary cod that formed monthly in a shallow estuarine bay near his village over a five day period prior to the new moon. Females of both aggregating species are known to be gravid at this time (Hamilton, 2003a). In 2003, Pomat Powayai identified one of these aggregating estuary cod as *Epinephelus coioides*. The other fish was said to be absent from available coral reef fish identification books and thus not identified. In January 2004 RH was again able to interview Pomat Powayai about these aggregations, and show him the digital photos of *E. polystigma* captured in Kavieng. He verified that *E. polystigma* was the other cod that aggregates in the estuary bay near his village. This Manus aggregation of *E. coioides* and *E. polystigma* was discovered in the 1970's, and initial catch rates of these two species were said to exceed 200 fish per night. Fishing pressure has had a marked impact on these aggregations, with current catch rates being several magnitudes lower than original catch rates (Hamilton, 2003a), and continuing to decline (Pomat Powayai, pers. comm. January 2004).

Reproductive biology

The pronounced bimodality and female bias sex ratio observed in this sample of *E. polystigma* suggests the possibility of monandric protogynous hermaphrodism (adult female to male sex change), a sexual mode of development that typifies the serranids (Sadovy, 1996). However, the sample size presented here is very small, consequently these features may simply be artifacts of a small sample size. Furthermore, these features alone are not conclusive evidence for protogyny. "Bimodal size-frequency distributions with males larger than females and female-biased sex ratios are non specific features that that may have many causes, only one of which is protogyny" (Sadovy and Shapiro, 1987). A conclusive diagnosis of the sexual pattern of *E. polystigma* will require histological examination of gonads from representatives of all size classes of this species (Sadovy and Shapiro, 1987).

Recommendations

1. Verify spawning within *E. polystigma* aggregations. Unequivocal evidence of spawning requires observing actual spawning or demonstrating the presence of hydrated eggs or post-ovulatory follicles in the ovaries of aggregating females (Colin *et al*., 2003). Given that this species is not known to aggregate to spawn, confirming this is significant. The gonad material needed for such histological examination could easily be obtained from catches that subsistence fishers make at aggregations, and may prove the simplest way to verify spawning in this case.

2. Determine the spatial parameters of the nocturnal aggregation site. An important first step will be to determine the total area over which nocturnal aggregations of *E. polystigma* form. Currently there is no information on the spatial scale over which *E. polystigma* nocturnal aggregations form, and thus no means of evaluating the threat that local fishers are placing on these aggregations. A nighttime mapping survey of the entire estuary bay during an aggregating period would quickly reveal the spatial parameters of the nocturnal aggregations of *E. polystigma*.

3. Determine the abundance and density of *E. polystigma* at this nocturnal aggregation site. Once the spatial parameters of the aggregation have been determined, an estimate of abundance and density could be obtained by counting the number of *E. polystigma* in the aggregation site. If the aggregation site is not too large, a census could be obtained by simply walking along at night with a floodlight and counting all *E. polystigma* within the aggregation area. If the aggregation area proves to be very large, then transect counts could be done in representative areas, and used as a relative measure of abundance and density.

4. Estimate the amount of fishing pressure being placed on this aggregation. Detailed information on the level of fishing pressure at this site could be obtained by having fishers who target this site record CPUE data for each time that they visit this aggregation. Given that it is a single species fishery at specific lunar periods, this data could be quickly obtained at very little inconvenience to fishers. Furthermore, the fact that only one village currently targets this aggregation, means that there is the opportunity to collect very precise fishing pressure data. Baseline CPUE data could also serve as an inexpensive way of evaluating the ongoing status of this aggregation.

5. Raise awareness on the vulnerability of these nocturnal aggregations to over-fishing and need to protect them. Oral histories in other regions of Melanesia indicate that *E. polystigma* aggregations can be quickly over fished, which is hardly surprising given the ease with which these fish can be captured. The aggregation investigated in detail has only very recently been discovered, and remains only lightly exploited, with fishers currently only targeting this aggregation to meet subsistence requirements. It is unknown if this level of fishing is currently sustainable. Raising awareness of the vulnerability of these *E. polystigma* nocturnal aggregations should be incorporated into the proposed TNC spawning aggregation awareness campaigns that will focus in this area.

6. Determine sexual ontogeny and growth parameters of *E. polystigma*. The sexual ontogeny and age-based demographics of *E. polystigma* should be determined through laboratory examination of a sample of gonads and otoliths collected from the nocturnal aggregation site. Determining these biological parameters will further our understanding of this species conservation requirements. Slow growth and late sexual maturation are two of the criteria used to identify aggregating species that are particularly at risk and in need of conservation action (Domeier *et al*., 2002). Furthermore, monandric protogynous species are thought to be more vulnerable to over-fishing than gonochores, as a consequence of the potential for sperm limitation via the disproportionate selective removal of larger males (Vincent and Sadovy 1998; Coleman *et al*., 2000).

APPENDIX 3: Mass migrations of *Plectropomus leopardus* and *Ctenochaetus striatus*– spawning runs or simply running scared?

While conducting routine interviews in the Northern New Hanover region of New Ireland we learnt of highly unusual mass migrations of *P. leopardus* and a *C. striatus* that travel in very shallow water on the eastern side of Ysabel Passage. Numerous local fishers from the Soi Island group reported that a day after a violent thunder and lightening storm, single species schools of up to a hundred *P. leopardus* and a thousand *C. striatus* migrate north-west past their villages for 2-3 days. The most detailed information documented relates to *P. leopardus* migrations, a species known as *taulave* in the local language.

Typically, migrations of *P. leopardus* start the day after a thunderstorm, peak on the following day, and cease after the third day. Fishers report *P. leopardus* migrations are always made up of slow moving tightly aggregated fish that are all of intermediate sizes (30- 40 cm TL). Fishers report that aggregations of up to 100 *P. leopardus* will slowly travel along the side of the passage, often moving over very shallow sandy areas, which is where they are most frequently intercepted by local fishers (Figure 15). Up to four aggregations may pass by a given location on one day. At this time *P. leopardus* are said to appear drunk and confused, and schools of migrating *P. leopardus* are so slow and so tightly aggregated that the school will stop moving forward and circle slowly on the sand if several fishers simply stand in front of the migration path. Frequently the first individuals to spot a migrating school of *P. leopardus* will run down and block the migration in this way while other individuals run and collect nets to capture these fish. The individuals interviewed stated that 3-4 fishers using nets can catch up to 100 *P. leopardus* in one day. Fishers who have known and exploited these aggregations for decades stated that the numbers of *P. leopardus* in migrating schools and the catch rates made from these aggregations are have not changed. Night time spear fishers also target these aggregations, and report that *P. leopardus* that migrate past known sandy locations in the afternoon will reside at night around shallow rocky sandy reef areas that are a kilometer or two further up the passage.

All fishers interviewed stated that they were not aware of these migrating fish having large developed gonads, but they had noticed that no fish captured from these aggregations had food in their intestines, and that the flesh of captured fish was particularly oily at this time. Fishers from Soi-Lik Island were not sure where the migrating schools begin, but knew that runs of *P. leopardus* travel up as far as Lukas Island, but not beyond it. Fishers were confident that these were the same schools of fish, stating that the last schools to migrate past Lukas Island occurred a day after the last schools had migrated past Soi-lik Island. Soi-lik and Lukas Island are approximately 10 km apart, which indicates that migrating fish travel a maximum of at 10 km in a day.

To a biologist, the documented local knowledge poses more questions than answers. The fact that schools of *P. leopardus* are slow moving, of an intermediate size range, appear 'drunk' and travel over a considerable distance are all signs that could be taken to imply that these migrations represent transient spawning runs of females (this species is protogynous, so small fish are predominantly female). Schools of female *P. areolatus* are known to travel from shallow inner reef and inner lagoon areas to deeper outer reef aggregation sites (Johannes, 1999; Hamilton, 2003a), but no such information has been recorded for *P. leopardus*. Indeed, available scientific evidence indicates that, on the Great Barrier Reef (GBR) at least, *P. leopardus* form much smaller aggregations than *P. areolatus*, usually consisting of less than 100 fish (Samoilys, 1997).

Figure 15: One of the shallow sandy regions in Ysabel Passage that schools of *P. leopardus* are known migrate past following a violent thunderstorm.

Despite these factors, much of the local knowledge documented on this species does not support a conclusion of spawning runs. Captured fish were not known to consistently have ripe gonads and migrations display no lunar or seasonal periodicity, instead being linked only to violent thunderstorms. It seems extremely unlikely that an event as random as a severe storm could trigger migration to a spawning aggregation site. Furthermore, large schools of *C. striatus* are also said to travel over considerable distances during this same period. This species is a resident spawner (Domieir and Colin, 1997), which by definition means that it does not travel long distances to reach spawning sites. An alternative hypothesis is that fork lightening striking the water causes some form of long lasting shock to these fish, which causes them to migrate away from the source of the stress. Although this hypothesis appears rather far-fetched, it is interesting to note that Lokani (2001) reports that "*Cromileptis altivelis* aggregates on a reef system located in Kavieng harbor every time there is a large storm". These aggregations of *C. altivelis* do not represent spawning aggregations (Graham, 2002). Finally, the possibility that interviewees mistakenly identified migrating schools of *P. areolatus* as schools of *P. leopardus* is unlikely, since both species have different local names, and we checked on this detail many times.

APPENDIX 4: Local customs and environmental concerns protect *Kele* (Serranidae) populations around Pak Island.

In 2002 a community on Pak Island placed a ban on fishing for all species of serranids (known generically as *kele* in this region) over a large area of reef (approximately 7 linear kilometers) that lies directly adjacent to their village. The area closed encompasses a multi-species serranid aggregation (Site 37) located in a shallow passage directly in front of the village. This community-based closure was implemented because of customary beliefs regarding the power of serranids to bring other fish inshore, and due to fishers concerns about declining numbers of aggregating serranids and other reef fishes.

E. polyphekadion, P. areolatus and *E. lanceolatus* aggregate at Site 37 during several months of the year. These fish are known locally as *wie*, *auo* and *putu kero*. One or two *E. lanceolatus* are known to aggregate near some big boulders at one end of the site, while much larger numbers of *E. polyphekadion* and *P. areolatus* aggregate over a wider area on coral and sand. The customary story regarding these aggregations is present below, it is a translation from a conversation with Livai Tapan, Ward One Member, Pak Island.

> "When *putu kero* comes to the aggregation site, many other types of fish follow it. Its cousins *wie* and *auo* come in large numbers at this time. Many other species of fish also come close to the shore during this time and are easy to catch. We are not sure why the other fish follow *putu kero* inshore, some people think that perhaps this fish has a very strong smell that brings the other fish in, while others have suggested that perhaps the other fish come to feed on scraps that it discards while eating. We have noticed however that *wie* and *aou* in particular are very happy to see *putu kero*. At these times you can see them doing unusual things, playing and chasing each other, and they will sometimes swim over *putu kero*. [The behaviors described are very likely to be spawning behaviors]. When *putu kero* departs, all the other fish go with it. The aggregation site that you see today is the second aggregation site. The original aggregation site was closer to the shore. A long time ago, one of our forefathers speared a *putu kero* with a wooden spear. It escaped from the fishers with the spear still in it, and was so angry that it ran into the stones at the original aggregation site and destroyed the entire aggregation area. Ever since that time it has been *tambu* to kill *putu kero*, and the aggregations now form further off shore".

Although *E. lanceolatus* has been protected at this aggregation site for generations, until recently *P. areolatus* and *E. polyphekadion* were harvested on a regular basis. In the past this site was only heavily targeted if aggregation periods coincided with important cultural events where a large amount of food was required. In recent years the aggregation site was heavily targeted by individuals who smoked captured fish and then marketed them at Lorengau. Night and day spearfishing were the most common methods used at this site in recent years.

Fishers noticed large reductions in their numbers of *P. areolatus* and *E. polyphekadion* at the aggregation site over the last ten years, as well as a general decline in the abundance of other reef fish species near the shore. In 2002, Livai Tapan was elected as a ward member for his community and he addressed the status of the serranid aggregations. The community then decided to place a ban on catching any serranids over a large reef area that is under their customary control. Since then, numbers of aggregating serranids are reported to have begun to increase, and other species of fish are said to have returned close to the shore where they are easier to catch. Internal or external poaching was reported not to be a problem, and the community recently decided to make the ban on serranid fishing permanent. They are also considering implementing other fisheries management measures, such as banning the use of ½ inch nets. The driving force behind getting these management measures put in place is Livai Tapan. Very much a conservationist, Livai says that his small island community is very aware of the limits of both their land and marine resources (some management measures have also been put in place by the community for bush resources), and that they recognize the need for customary *tambu* and fisheries restrictions in order to ensure that their grandchildren have an adequate supply of resources.