Reef Fish Aggregations in Sabah, East Malaysia.

A report on stakeholder interviews conducted for the Society for the Conservation of Reef Fish Spawning Aggregations.

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Executive Summary

Spawning aggregations of reef fish are becomingly increasingly recognised as important for the sustainable management of reef fisheries. In E. Malaysia, where reef fish catches have been declining for several years, there was little information available on the existence of spawning aggregations or whether they are exploited by fisheries.

In January 2004 Tim Daw was contracted by the Society for the Conservation of Reef Fish Aggregations (SCRFA) to conduct interviews with a variety of stakeholders (largely fishers) to investigate the existence, status and use of reef fish spawning aggregations (FSAs) within Sabah.

Ninety-two interviews in the Kudat, Banggi, Semporna, Kota Kinabalu and Lahad Datu areas uncovered evidence of exploited spawning aggregations, mostly of serranids (groupers) including *Plectropomus* and *Epinephelus* species. Trends of catch per unit effort (CPUE) from the memories of fishers indicated that most of these aggregations had declined substantially and some had either ceased to exist or declined to such an extent that fishers no longer bothered to exploit them. Lyang Lyang in the Spratley Islands and Sipadan Island in the Semporna Region are exceptions due to the strict control of fishery activities which have allowed spawning aggregations of endangered *maming* (*Cheilinus undulatus*) to persist.

Protection of Sabah's remaining FSAs should be seen as an important priority for sustaining the valuable fishery for reef species. However, further research to determine and confirm the locations and times of FSAs and collaborative research and awareness-raising within local fishing communities are prerequisites to effective management of Sabah's reef fish stocks.

1. Introduction

1.1. Coral Reefs of Sabah

Sabah is one of two Malaysian states on the island of Borneo in the Southeast Asian Indo-Malay Archipelago. East Malaysia also includes the state of Sarawak to the south and the small Federal Territory of Labuan off the west coast of Sabah (Figure 1). The small Sultanate of Brunei lies on the coast between Sabah and Sarawak while the southern three-quarters of Borneo form the Indonesian region of Kalimantan.
Sabah contains the largest concentration of coral reefs in Borneo due to the large river systems which preclude extensive coral growth along the coastlines of Sarawak and Kalimantan (Oakley et al. 2000). The southeast and northeast shores of Sabah and the Spratley islands in the South China Sea are most notable for coral reef development.

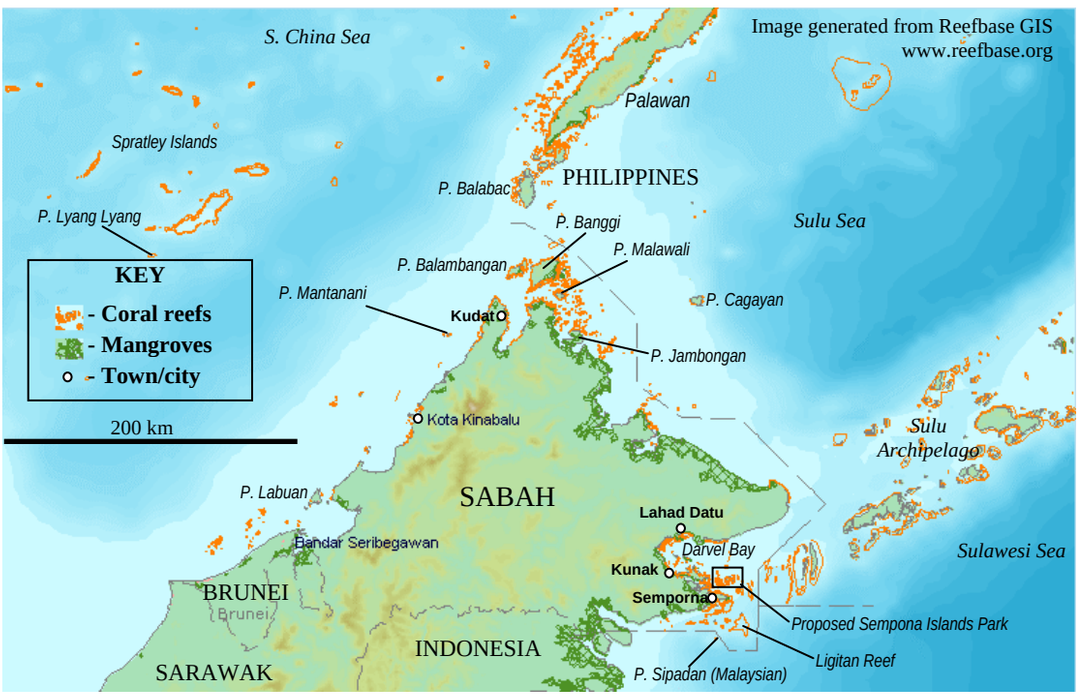

Figure 1. Sabah, showing the main islands and areas visited during this survey.

The Semporna area and Darvel Bay form part of a chain of reefs and islands which continue into the Philippine Sulu Archipelago and lie between the Sulu and Sulawesi Seas. Pulau Banggi and Pulau Balambangan, at the northern extent of Sabah lying between the Sulu and South China Seas have good reef development extending through a series of reefs and small islands south towards Sandakan, out into the Sulu Sea towards the Philippine island of Cagayan and North towards Balabac and Palawan in the Philippines. The 100 oceanic coral islands and reefs of the Spratley Archipelago in the central South China Sea are jointly claimed by Malaysia, China, the Philippines, Taiwan and Vietnam (Oakley et al. 2000). Malaysia has an established presence on the most accessible and well studied of these atolls, Lyang Lyang in the southern part of the group, in the form of a naval base and exclusive dive resort.

Sabah lies within a highly biodiverse region and coral surveys in northern Sabah and near Semporna have suggested that the reefs there should be included in the "coral triangle", the heart of the World's marine biodiversity (MCS; Fenner 2001).

In a review of the status of the reefs of East Malaysia, Pilcher and Cabanban (2001) painted a general picture of decline as a result of destructive fishing with bombs and cyanide (Plate 3). Lyang Lyang and Sipadan were identified as exceptions, with high fish diversity and live coral cover.

1.2. Reef Fisheries of Sabah

Reef fisheries make an important contribution to the fisheries of Sabah and accounted for 10% of landings between 1980-1990 (Cabanban and Biusing 1999). Catches of demersal hook and line fisheries (those most relevant to most species highlighted in this report) in 1999 amounted to 17,849 tonnes according to Fisheries Department statistics (Biusing 2001). Reef fish landings are highest in Semporna, Tawau, Sandakan, Kudat and Kota Kinabalu (Cabanban and Biusing 1999).

Fisheries for reef species are conducted by a range of vessels from small canoes paddled or powered by pump engines or outboards to larger inboard engine vessels (Plate 5) which may have a compressor on board or act as a mothership for small dugout canoes (Plate 7) or pump-boats in more distant operations. Handlines (*pancing*), bamboo, wire or plastic mesh traps (*bubu*, Plate 9), homemade bombs (*bom*), gill nets (*pukat*), sodium cyanide solutions (*sujum*) and fish corrals (*kelong*, Plate 8) are all widely used to catch reef species commercially and for subsistence while spears (*panat*) are used for subsistence fishing.

The lucrative export trade in live reef fish (largely for Hong Kong) specifically targets reef dwelling groupers (Serranidae, Plate 1) and certain species of wrasse (Labridae, Plate 2) and snappers (Lutjanidae). Official statistics indicate that the live reef fish trade (LRFT) has been in Sabah since the mid 1980s (Biusing et al. 1999) although individual fishers in the Kudat region have reported selling live fish as early as the 1970s (Daw et al. 2002a).

Blast and cyanide fishing are illegal in Malaysia but have been widely reported for schooling species and large piscivorous fishes respectively (Wood 1979; Oakley et al. 1999; Fisher 2000; Harding et al. 2000; Pilcher and Cabanban 2001; Daw et al. 2002a; Daw et al. 2002b). These have been blamed for declining reef condition and loss of coral cover (Plate 3) around Sabah (Pilcher and Cabanban 2001) and extremely low densities and a lack of reproductively mature adults of targeted species on all unprotected reefs throughout Sabah (Oakley et al. 1999) and in South-eastern Banggi (Daw et al. 2002b). Analysis of catches of coral reef fish families in Sabah by Cabanban and Biusing (1999) indicated more than a 50% decline in both yields and catch per unit effort (CPUE) from the 1980s until the early 1990s.

1.2.1. Composition of fishing communities in the areas surveyed.

In Northern Sabah, the local fishermen are comprised mainly of the Suluk, Ubian and Orang Sungai ethnic groups. Some transient fishermen and illegal immigrants from the Philippines also occur in this region, employed either as crewmembers of the commercial fishing fleet based in Kudat town or engaged in traditional fishing in the Banggi Group of islands. Fishermen in southeastern Sabah are comprised of local Orang Sungai, Suluk, Bugis and Bajau and transient fishers from the Philippines (Bajau Laut or Suluk). Fisheries in Kota Kinabalu and Tuaran on Sabah's west coast are dominated by Bajaus and Ubians (Biusing 2001). All the fishing communities surveyed in this study were Muslim.

1.2.2. Management

The conservation, management and development of fisheries in Malaysia is governed by the federal Fisheries Act 1985 (revised 1993). This act has provisions for licensing, technical conservation measures, prohibition of destructive fishing gears and fishing zones defined by vessel size, engine power and method of fishing. The Act also contains provisions for the establishment of marine parks and reserves aimed at the conservation and rehabilitation of fish stocks and the environment. (http://agrolink.moa.my/dof/Regulation/Fisheries_Act/fisheries_act.html). Sabah Fisheries Department is responsible for developing and managing fisheries within Sabahan waters including licensing fishing vessels for specific gears (although it is acknowledged that not all small scale fishers have licences) monitoring landings, conducting research on target species and assisting the development of fisheries through gear, boat and engine distribution to fishing cooperatives, and research and development of aquaculture (including fish cage culture and seaweed farming). In an attempt to control effort, no new capture fishery licences have been issued since 2000[1]. Dead fish landings are monitored in the main landing ports through a standardised sampling scheme and live reef fish trade is also monitored on a port by port basis (see section 5.1.1). Licences are issued for holding and export of live fish but as yet, no controls or limits have been placed on the trade.

1.3. Reef Fish Spawning Aggregations (FSAs)

Many of the valuable species targeted for the live and dead fish trade within Sabah are thought to aggregate at specific times and locations for the purpose of spawning. Due to their predictable nature and the unusual concentrations of fish present, these reef fish spawning aggregations (FSAs) present the opportunity for fishers to make extraordinary catches and have been traditionally targeted in many societies. During recent decades, increased commercial fishing pressure, efficient fisheries technology and extremely high market demand for certain species have pushed some of these species and their aggregations to decline with the possibility of local extinctions in extreme cases (Colin et al. 2003). Hence, careful management of FSAs is increasingly being recognized as important for the sustainability of reef fisheries. The call to action

[1] Personal communication, Mr Manaf Datu Unjung, Head of Kudat Fisheries Office

adopted at the Second International Tropical Marine Eco-systems Management Symposium held in Manila in 2003, stated that:

> *"Many commercially valuable reef fishes are particularly vulnerable to over-exploitation because they form spawning aggregations that are highly predictable in time and location … The evidence is unequivocal that spawning aggregations can be decimated rapidly by heavy fishing, resulting in serious declines in the fish populations ... Evidence is growing of aggregation depletions in SE Asia and the western Pacific…Fish spawning aggregations should be conserved, through robust management strategies … to ensure persistence of the populations that form aggregations, the integrity of reef ecosystems and the livelihoods and food supply of communities that depend on aggregating species."*

Sustainable management of FSAs is generally limited by a lack of information on their location, timing, extent and exploitation status. This is particularly true in Sabah where local ecological knowledge of fishers is one of the only sources of information and a starting point for their study and management.

1.4. The Society for the Conservation of Reef Fish Aggregations

The Society for the Conservation of Reef Fish Aggregations (SCRFA) was formed in 2000 to promote and facilitate scientifically informed conservation and management of FSAs. Since 2002, SCRFA has funded aggregation surveys in the western Pacific to identify management issues and potential actions on a country by country basis. The data is also collated in a database, which allows the global trends and patterns in aggregations to be assessed and public access to the information collected. The precise locations of aggregations are not released however, to avoid the possibility of accelerating their exploitation.

2. Aims

The aim of this study was to compile a database on the reef fish aggregations of East Malaysia covering:

- species, locations and seasonal timing of aggregations as well as the current and historical fishing activity including level of effort, gears used and type of exploitation.
- management of aggregation sites or management of any reef species currently in place or being planned
- planned or existing tourism associated with spawning aggregations
- cultural and general attitudes to conservation, as well as any perceived problems or misconceptions in respect of conservation and management.

This database was to be compiled through interviews with as wide a range of stakeholders as possible and consultation with available reports, statistics and existing research on FSAs. The fisheries department statistics or reports could not be used to

identify spawning periods of reef fishes or the presence of spawning aggregations (see section 5.1.1).

3. Methodology

3.1. Use of Fishers' Knowledge

The general crisis in World fish stocks (FAO 1998) has lead to more openness by many fisheries scientists towards new approaches to the assessment and management of fishery resources (Pitcher et al. 1998). Meanwhile, traditional and local ecological knowledge of resource users has been increasingly recognised as having the potential to inform attempts at sustainable management. For example, indigenous knowledge was recognised in the 1992 Convention on Biological Diversity (Berkes et al. 2000). Within fisheries science it has been suggested that fishers' knowledge could play an important role by filling some of the gaps in the scientific understanding and management of fisheries, especially in the case of identifying FSAs and in the extensive but poorly studied expanses of tropical shallow water ecosystems (Johannes 1998; Neis and Felt 2000).

Fishers' knowledge can encompass various forms of information from hard facts and observations, to implicit understanding or perception of the marine ecosystem. The use of fishers' knowledge can have advantages over conventional fisheries science in terms of cost effectiveness, efficiency, spatial resolution, length of time series and non-reliance on previously conceived hypotheses and models. Fishers' knowledge can also complement more conventional scientific approaches providing basic data, a yardstick for comparison, hypotheses for subsequent investigation or a context for interpretation of data or trends observed by scientists. Fishers can also provide valuable knowledge about their own activities and likely responses to interventions and regulations. Bringing fishers' expertise to bear on the design and implementation of fisheries management could ensure measures were appropriate, effective and acceptable to fishing communities due to their participation in the planning process.
With regards to fisheries like the rapidly expanding live reef fish trade in relatively poorly studied areas of Sabah, fishers knowledge can be particularly useful due to the scarcity of conventional scientific information on stock condition and behaviour.

3.2. Interviews with fishers

Nearly all information collected during this study was obtained from interviewing stakeholders throughout Sabah between 7th and 30th January 2004. The main focus was placed on active fishers, but divemasters, fisheries officers and fish traders were also interviewed (Plates 11-14). Summaries of general fisheries information from these interviews is organised by village in Appendix IV.

3.2.1. Fisher interview method and identification of FSAs

Interviews generally comprised a brief introduction, questions about the fishing activities of the interviewee and then specific questions on the interviewee's knowledge of spawning aggregations. To maximise the likelihood that any knowledge

of spawning aggregations would be related to the questions and be brought to light, several approaches were used. Fishers were asked in turn:

- whether (and when) there was a season in which they could catch most reef fish
- whether they had ever seen or caught an *unusually* large group of one species
- whether they had caught any fish with eggs and which species
- whether they had ever seen more than one or two groupers or humphead wrasse together
- whether they knew of any *pullak* or *mullak* (bajau words for fish aggregations) and
- whether they knew how, when or where fish reproduced.

If any of these approaches yielded memories apparently of spawning aggregations, details of each were requested. Finally, questions were asked about general trends in catches, the occurrence of humphead wrasse (*Cheilinus undulatus*) and the interviewee's opinions regarding the reasons for any declines in fish stocks.

Interviewees often responded *dari kecil* (from when they were small) when asked when they started fishing. In this case the assumption was made that they started at age 15 and their years of experience was calculated as their age minus 15 years.

The structure of the interview varied according to the circumstances. Most fisher interviews followed a planned schedule (Appendix III) although this was often shortened or edited if time was very limited or the interviewee appeared uncomfortable answering certain questions. For example, fishers who appeared to use illegal fishing gears like bombs or sodium cyanide were not probed on their fishing techniques unless they were obviously very trusting of the survey team. If time was limited or the interviewee was apparently unwilling to spend much time on the interview, questions would focus on their knowledge of aggregations as this was priority for this study. Most interviews took between 20 and 45 minutes.

Most interviews were conducted in Malay although specific fishing information and fish names were often conferred using local Ubian or Bajau words and phrases. Tim Daw could speak elementary Malay sufficient to ask and understand most of the interview but in all cases, except those interviews towards the end of the study in Lahad Datu and Kota Kinabalu, a fluent Malay, Ubian or Bajau speaker was present to assist with probing or explaining more complicated questions and answers. Some specific vocabulary useful for FSA research in Sabah is included in Appendix VI and local fish names collected during the survey are listed in Appendix VII.

Although individual interviews were preferred, situations often involved the team talking to groups of fishers. Curious observers often accumulated around the interviewer and onlookers often contributed to interviews. In Karakit on P. Banggi a meeting with interested fishers was organised through the president of the local fishing cooperative and the chief clerk of the Sub-District Office. For data collection purposes this was operated like a focus group meeting and was recorded on minidisc for later extraction of information.

3.2.2. Identification of FSA locations and timings

It was not possible during this trip to visit any locations to obtain GPS-derived positions. Positions were usually indicated by interviewees by the use of a familiar place name or on a marine chart of the area obtained from Sabah Marine Department. If the fisher used a name which was unclear or unknown, they were asked to indicate the position on a chart in more detail. Before fishers were asked to use the chart, the interviewers were careful to orient the chart correctly and indicate several well known features (islands, villages, obvious reefs etc) to allow the fishers to get a sense of the scale and the way the chart was drawn. Fishers generally did not have any problem relating to and understanding the charts, indicated by their consistent pointing out of known reefs in their correct locations.

The Malay word *batu* translates as "rock" and the translation of coral is *batu karang*. However it is common for fishers to refer to coral as merely batu (as shown by use of the phrase *batu hidup*, "live rock"). Therefore interview responses describing the substrate at an aggregation site as *batu* were interpreted as meaning coral.

Fishers referred to seasonal events according to the distinct monsoonal seasons (north wind and south wind) or naming specific months of the Gregorian calendar. The Islamic calendar is widely used in the communities interviewed. This was of limited use for describing seasonal trends (as it shifts each year relative to the Gregorian calendar) but, being a lunar calendar, was excellent for identifying synchrony between FSAs and the phases of the moon. Fishers were specifically asked which day of the Malay (Islamic) month aggregations occurred on.

3.2.3. Indications of magnitude of aggregations

Although fishers were asked how many fish they believed were in an aggregation, it was usually only diving fishers who could give an estimate of actual numbers. Where aggregations were in the form of many small groups of fish spread over a wide area, fishers would often state the number of fish in any one group. In some cases this created a discrepancy between one interview which reported a small number of fish (per group) and others which reported very high numbers of fish in an entire aggregation.

Catch per unit effort (CPUE) was normally used as a relative indicator of fish density at aggregations (and as an indicator of general fish abundance during times when FSAs did not occur).

Catches were related in terms of numbers or weight of fish. In the case of rare or valuable species like those used for the live fish trade, fishers often referred to individual numbers (*ekor*, literally meaning "tails"). When relating large numbers they would typically refer to the number of kilograms or full ice boxes (*pikul*). One *pikul* was taken to be equivalent to 100 kg. The old Chinese unit of katis (0.5 kg) was occasionally used for older memories of catches. Sometimes extremely large catches were remembered in terms of how much effort was required to fill a whole boat.

Indications of effort varied widely from interview to interview according to what seemed most simple and appropriate in each situation. Where possible effort included

a measure of numbers of fishers, time period and fishing method (e.g. one boat with 3 handline fishers over one week). Emphasis was placed on trying to establish a constant measure of effort to allow comparison through the fishers' memories rather than an absolute CPUE figure which could be compared between interviews. Comparing CPUE between interviews may be problematic due to the different way in which fishers integrate their naturally fluctuating catches. For example, one fisher may give a maximum value saying, "One a lucky day I could catch up to…" when another, experiencing the same catch rates, might give a lower figure to reflect more of an average catch. The use of CPUE measures as absolute measures to be compared between interviews also has the problem of being susceptible to subtle differences in the skill, commitment, typical fishing pattern and technique of individual fishers.

3.2.4. Sampling

Logistical or security concerns often limited the team to one-day trips to a particular village or island. In this event interviewees had to be selected opportunistically amongst those fishers who were at home at the time. Each village visit began by seeking out the *Ketua Kampong* (village headman), if available, the *JKKK* (chair of the security and development committee, *Jawatankuasa Kemajuan dan Keselamatan Kampung*) or the next most senior member of the community in order to explain the purpose of the visit, ask permission to conduct surveys and request recommendations of knowledgeable fishers who would be good to interview. The Ketua Kampong was himself often one of the most senior fishers and thus supplied the first interview. Personal contacts of the survey team or fishers who had been cooperative with previous investigations were sought out, especially in communities in which cooperation was impeded by fear of authorities or suspicion of the team's activities.
No attempt was made to obtain a representative sample of any of the communities as the sample sizes were inevitably too small to achieve this and the objective was to obtain as much reliable information as possible on spawning aggregations within the limited time available.

3.2.5. Practicalities of interviews

Fieldwork was occasionally constrained by security concerns in the light of recent kidnappings of both tourists and locals from islands and communities on the east coast of Sabah by guerrillas from the Philippines and occasional incidences of piracy in northern Sabah. The survey team generally returned to a larger population centre each night.

In the Banggi region (where Tim Daw had spent 1.5 years working previously), Sabahan authorities have recently increased their efforts to control illegal fishing activities (particularly blast fishing) and remove people who do not have official Malaysian identity cards. The frequency of operations aiming to arrest illegal immigrants and dismantle their dwellings and the enforcement of a ban on the use of the ubiquitous pump-boats (a widely used wooden canoe of varying sizes powered by one or more water-pump engines) seemed to have led to a climate of fear and suspicion of outsiders and officials, which in some cases hampered attempts to interview fishers. If interviewees were obviously uncomfortable, efforts were made to direct the interview away from fishing techniques used and to emphasise the purely

biological nature of the study and the survey team's independence from Sabah Fisheries Department. In some cases only first names or no names were asked.

3.2.6. Verification and assessment of reliability

A major constraint of the use of fishers' knowledge is the difficulty of assessing the reliability and accuracy of information collected. Data collected during this study are therefore subject to an unknown level of errors and inaccuracies. Potential reasons for these errors are listed below, roughly in order of their significance as perceived from the experience of conducting the interviews.

Potential Sources of error

1. Incorrect recollections or confusion between different memories/experiences or between different species
2. Purposefully lying specifically to disguise illegal activities (although this would only affect responses to questions about fisheries).
3. General reluctance to cooperate with interview as a result of suspicion/fear of the team's affiliation and motives
4. Misunderstanding in the communication of either the questions or the answers as a result of translation issues.
5. Confusion, or misinterpretation of observations made
6. Secrecy about sites and timings to maintain exclusive access to aggregations[2]
7. Optimistic assessments of the health of stocks to discourage management controls being imposed

Surprisingly perhaps, the last two problems did not appear to be the most significant even though they were most anticipated.

When a fisher had information on more than one aggregation, it was often difficult (both in the memory of the fisher and in the course of the interview) to clearly distinguish which parameters related to which aggregation. Every attempt was made to make clear distinctions between different aggregations but only the most patient fishers were willing or able to focus on the tedious repetition of the same detailed questions for each aggregation separately. Fishers would sometimes respond that the details were the same for all the aggregations while others would constantly refocus on different aggregations perhaps indicating the difficulty of remembering specific information about similar aggregations. Naturally, this was particularly problematic when fishers were talking about aggregations that had occurred or been observed long ago and between different aggregations of the same species.

[2] It was not felt that this was as important as the first 5 error sources because of the way in which fishers freely spoke of aggregations when they knew them. They would often nonchalantly state that "everyone knows them" when asked how they learnt about an aggregation and state that many boats from other communities would often fish the aggregation. Both these points suggest that the "secret was out" so that withholding information from the survey team in order to protect exclusive knowledge and access to aggregations would have been futile. A small number of interviewees did say that they didn't share information on aggregations with other fishers but it would have been clear that the survey team was not likely to come back and compete with them in their fishery. Nor would it have been likely for competing fishers to read the scientific report of the team.

A standard practise to assist with verification of information obtained from stakeholders is to ask "test questions", the answers to which are already known by the investigator (Johannes 1981; Colin et al. 2003). This technique was found to be somewhat problematic in practice for the following reasons:

- Fishers may have a good knowledge of one aspect but not of another. For example, many fishers believed that groupers gave birth through their mouths. Although this is not compatible with scientific understanding of grouper reproductive biology, it does not devalue their memories of times or locations where they observed aggregations.
- Interviewees may incorrectly answer some questions in order to disguise illegal methods but be honest about others. For example a fisher may claim to catch mostly *maming* (*Cheilinus undulatus*) using hook and line. This is known to be unlikely from interviews and experience in the region but would not necessarily mean that other aspects of the interview would be unreliable.

Thus, it was not possible to use one individual test question to assess the accuracy of an interview, general impressions were made from all answers given along with the consistency of answers, the team's familiarity with the interviewee, and a subjective impression of the interviewee's attitude and body language. These impressions were often checked between members of the survey team for agreement. The reliability of each interview was then summarised on a three point scale as Good, Medium or Poor and further notes were made on the interview where necessary.

3.3. Informal discussions

During the course of the survey, conversations were held with many different individuals and sometimes relevant comments or stories would be related in the course of conversation. It was not always possible to formally interview these individuals but the comments and any further details were noted down as soon as possible.

3.4. Interviews with divers

Two days were spent interviewing divemasters and instructors on resorts in the Semporna region. The interview format was similar to that used for fishers covering the career history and usual dive sites and frequency of diving of the diver before focussing on eliciting any details of potential spawning aggregations they had witnessed. Photographers were generally more useful than Divemasters as they were looking out for unusual footage rather than taking guests round usual sights. Interviews with divers were generally conducted in English.

On Sipadan, divers tend to always dive at the same time of day and follow the sun around the island. Therefore they are on the east side in the morning and the west in the afternoon and usually dive at 08:30, 10:30 and 15:30. They would, therefore, miss any spawning activity which did not occur at these places and times. Night dives are only conducted off the Drop Off on the northeast side of the island.

3.4.1. Analysis and synthesis of interview information

Following the fieldwork, information from all interviews was entered into a hierarchically structured Access database. Each interview constituted a record with personal details and notes on the interviewees, their typical fishing behaviour, opinions on the status of stocks and the reasons for any declines and notes on the circumstances and perceived reliability of each interview. These were linked to information on individual aggregations from each survey which constituted single records stored in a separate table along with coordinates of aggregation locations (to the nearest minute of latitude and longitude) read from the charts used in interviews. Individual aggregation records were assessed and grouped by location and species in order to identify those which appeared to relate to the same aggregation. These cases were then agglomerated into a single aggregation record in a separate table. In the event of disagreement on aggregation details between interviews, responses were usually summed non-exclusively rather than discarding the details from one interview in preference for another. For example, if one interviewee claimed that an aggregation occurred from February till April while another claimed March till July, the agglomerated record would be entered as February till July. If contributing records directly contradicted each other, the interview with the highest confidence rating or the most information in other fields would be used. Finally these aggregation records had to be disaggregated by species to create individual species/aggregation records which were compatible with the SCRFA format (Figure 2). Fields which related individually to one species (for example, fishers sometimes reported different timing of aggregation for different species) were edited at this stage to try to ensure that parameters which had been stated for one species were not inherited by all species present at that aggregation

A qualitative assessment was made of the likelihood that any individual species presence at an aggregation genuinely represented a spawning aggregation (very likely, maybe, none) based on the quality and number of interviews relating the information the species involved and signs of spawning related by the fishers. Only those records that were deemed very likely to represent spawning were entered into the SCRFA database.

Each aggregation record was categorised according to relative measures of CPUE (catch per unit effort) through time as Stable, Moderate Decline (<50% decline in CPUE), Severe decline (>50% reduction in CPUE), Extinct (when fishers had actually claimed that the aggregation no longer occurred) or Unknown.

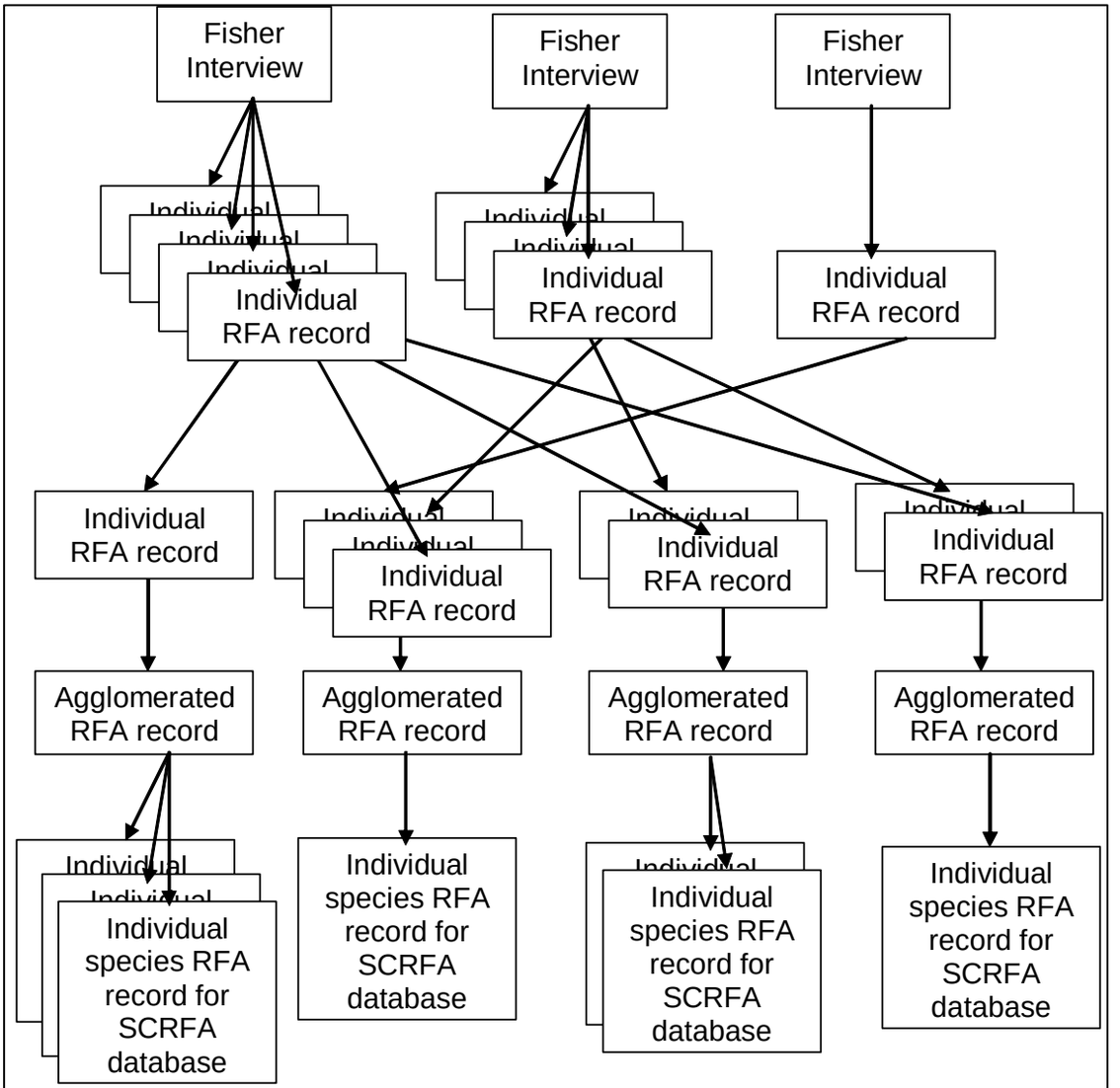

Figure 2. Responses from individual interviews had to be disaggregated, sorted and agglomerated into different RFAs and finally disaggregated by species to generate records for the SCRFA database.

3.5. Use of secondary data and reports

Official statistics collected by the Sabah Fisheries Department were examined and interviews were held with data collectors, regional fisheries officers and Fisheries Department research staff to understand and appraise the available data with regards to its potential use for identifying the targeting of spawning aggregations.

3.6. Direct observations

On one occasion the opportunity was taken to make direct observations, using SCUBA, of a group of maming (*Cheilinus undulatus*) which had been observed by divemasters. Video equipment was not available at such short notice so notes documenting the behaviour of the fish were made immediately after the dive and

following corroboration with the dive buddy's memories. A number of still photographs were taken.

4. Regional Summaries

4.1. Kota Kinabalu (KK)

4.1.1. Background

Although there are limited reefs in the KK immediate area it is the base port for several vessels which fish in the Malaysian South China Sea. As the capital and first city of Sabah it also has the headquarters for the State Fisheries Department, several fish exporters and traders and WWF Malaysia's Sabah office.
There were 551 traditional fishers registered in KK in 2000 and demersal hook and line landings in 1999 amounted to 979 tonnes.

4.1.2. Work Conducted

On arrival in KK, meetings were arranged with WWF Malaysia's marine team in Sabah, the Director, Deputy Director and senior staff of Sabah Fisheries Department, Dr Annadel Cabanban from the University Malaysia Sabah (UMS) and Dr Nicolas Pilcher from the Marine Research Foundation. The SCRFA survey was introduced and the opportunity was taken to request relevant data and reports, solicit contacts and generally discuss the status of reef fisheries and spawning aggregations in Sabah. Arrangements were made with WWF for collaboration with their field officers while conducting surveys in the Kudat and Semporna regions.

Towards the end of the project a meeting was also held with staff of the Research Division of the Fisheries Department to discuss the survey, fisheries statistics and potential future research into reef fish reproductive biology.

A limited number of fishers and traders were interviewed while in KK but this activity was constrained by the timing (following Chinese New Year), which led to the absence of many traders and key contacts within the Fisheries Department. Experienced underwater photographers and divers were also interviewed opportunistically about any observations or memories of aggregation behaviour.

4.1.3. Findings

It appears that several live fish trade vessels operating in the Spratley Islands, Labuan, Mantanani and off the coast of Sarawak are based in KK. They sell their catches to nearby holding facilities by Pulau Gaya or in Tuaran.

Several sources told of these vessels making large single-species catches of up to 3-4 tonnes suggesting that they target (or at least inadvertently encounter) reef fish aggregations These are probably some of the most significant aggregations in Sabahan waters due to their remoteness and the large areas of reefs available.

However despite the expansive and remote nature of these reefs, declines have been evident during the 1990s with one aggregation apparently no longer worth fishing at.

These findings are necessarily preliminary due to the small number of interviews conducted in KK. However, information relating to the existence of large aggregations in the Spratley Islands came from many different sources.

The atoll of Lyang Lyang is protected from commercial fishing by the Naval Base there. Divers and scientists have observed both *maming* (*Cheilinus undulatus*) and *pamantan* (*Plectropomus laevis*) aggregations around this island, which presumably experience exceptionally low levels of exploitation.[3]

4.1.4. Potential Future Research and Partners

The vast area covered by KK fleets in the S. China Sea coupled with several reports of significant aggregations warrant further investigation. More interviews with vessel captains and owners would be worthwhile and large catches may be detectable in records of individual operations. Mr Chio Fui Lin of the Sabah Fisheries Department Marine Branch has a good knowledge of these operations and familiarity with the vessel owners. During the meeting in KK he discussed the possibility of observers (perhaps staff of Greenforce) accompanying some of the relevant boats to document the aggregations. WWF Malaysia are actively studying the live fish trade as part of their programme "Understanding the Live Reef Fish Trade in Sabah" under the Sulu-Sulawesi Marine Ecoregion initiative and already have some contact with traders operating from Tuaran.

Live fish from KK and Kudat based operations are exported by air from Kota Kinabalu, generating fairly detailed export records (licences are required for export) which are due to be analysed (for trends in *maming*, *Cheilinus undulatus*, exports initially) by Rooney Biusing of the Fisheries Department.

Sabah's first marine park, Tunku Abdul Rahman Park is based around the islands close to Kota Kinabalu and is managed by Sabah Parks. It is unlikely that major spawning aggregations currently exist in this area as mature carnivorous fish have been eradicated from the area by artisanal fishing, and habitat condition (live coral cover) has declined significantly (Pilcher and Cabanban 2001).

4.2. Kudat Area

4.2.1. Background

Kudat is the most northern major town in Sabah and the administrative centre for a district which includes the Kudat peninsula, P. Banggi and surrounding islands. This makes it a natural centre for the exploitation and trading of marine resources from Banggi and even the Philippine islands around Balabac and Cagayan. Live and dead fish from small scale fishers in the islands are transported to Kudat for sale, while many larger Kudat-based vessels fish throughout the surrounding islands and reefs from the South China to Sulu Sea and sometimes into Philippine waters (Daw et al.

[3] Steve Oakley, Pers comm.

2002a; Cooke 2003). Many fishing communities around Kudat are composed of recent migrants from the islands (Cooke 2003) who often maintain links with friends and relatives on their original islands.

Kudat district had 1,531 registered traditional fishers in 2000. Fisheries statistics indicate that the hook and line catch of demersal fishes for the district was 4,800 tonnes in 1999 (Biusing 2001). Seventy tonnes of live fish were reportedly traded through Kudat in 2001 (official Fisheries Department statistics) but this may be a considerable underestimate (Daw et al. 2002a). Workers and traders in the live fish trade during this survey indicated that volumes had dropped considerably during that time due to declining catches.

4.2.2. Work Conducted

Meetings were held with Mr Abd. Manaf Datu Unjung, the head of the Kudat Fisheries office, Mr Chin, who is largely responsible for monitoring the live fish trade, and Mr Adnan Amna, who is responsible for collection of landings data.
Two live fish traders, Mr Ho and Mr Stephen were interviewed about their feelings about fish aggregations in the area and any other observations from their perspective that were relevant to the study (Plate 13).

Two strategies were used to meet fishers in Kudat to conduct interviews. Captains of vessels delivering fish to the live-fish cages (which in Kudat are collected together along two side-by-side jetties, Plate 6) or moored up at the main wet-fish quay were asked for interviews on the quay, in the nearby cafe or on their vessel. This strategy sampled local fishers as well as fishers from further afield who came to Kudat to sell fish and/or collect supplies. In addition, fishers were sought in their homes in the Kudat suburb of Tanjung Kapor, where it was known that many fishers lived. Individuals recommended by other interviewees were sought out in their homes and people in the community were also simply asked where vessel captains lived.

The UK volunteer-driven NGO Greenforce has a project in Sabah, which recently moved from Banggi to a base on the West Coast of the Kudat peninsula. A short visit was made to the camp to meet the scientific staff and discuss the SCRFA project and how their research could contribute.

4.2.3. Findings

Aggregation sites suggested by the Kudat interviews ranged from the Spratley islands to a large area of reefs called “Herot” east of P. Jambongan. More than half of the cited aggregations related to *Plectropomus* species, perhaps reflecting the predominance of hook and line fisheries for the live fish trade which target these species.

Interviews also collected aggregation records from in the South China Sea and Banggi (described in sections 4.1 and 4.3 respectively).

The remoteness and complexity of the Herot reef system and lack of well-known islands and communities made it impossible to pinpoint individual aggregations. Thus information on aggregations were more in the form of general descriptions of the area.

Accompanying vessels to get GPS locations would be necessary to identify individual aggregations.

4.2.4. Potential Future Research and Partners

Sabah fisheries department have a branch based in Kudat who were collaborative and interested in the survey but have limited resources to conduct additional research or monitoring.

WWF has no permanent presence in Kudat but have an interest in the region through their Sulu-Sulawesi Marine Ecoregion Project. Mr Leonardo Daim is the officer largely responsible for marine activities in Kudat and Banggi and is familiar with many of the fishers and traders in the area.

Greenforce have two scientific staff, logistical facilities and trained volunteers to conduct reef surveys along the west coast of the Kudat Peninsula and possibly further a field in collaboration with the Fisheries Department. During the survey, the chief scientist on the camp was Mr Tim Burns, although he is due to hand over to a successor in early 2004. They also regularly visit Kudat fish market and thus are in a position to observe seasonal trends or peaks of abundance of reef species.

The constant supply of live and dead fish to Kudat from the outlying regions of Banggi and beyond could be used to cost-effectively sample for studies of seasonal patterns of reproductive behaviour in the main species (e.g. *Plectropomus leopardus*). If coupled with detailed interviews and perhaps even GPS monitoring of the activities of trusted fishers, a picture could be built up of spawning times and areas.

4.3. Banggi Area

4.3.1. Background

The Pulau Banggi region lies to the north of Sabah between Borneo and the Philippine islands of Balabac and Palawan and between the basins of the Sulu and South China seas. Pulau Banggi is the largest island in Malaysia and is surrounded by approximately 70 other islands including 33 that are inhabited (Biusing 2001). The total area of the Banggi group of islands is 270 square miles.

Despite the size of the Banggi area, it remains poorly developed economically with most of the communities relying on exploitation of coastal and marine resources including selling live and dead fish, seaweed farming and mangrove cutting (Cooke 2003).

4.3.2. Work Conducted

From a base at the UMS seaweed culture project house in Karakit, interviews were conducted in the communities of Karakit, Lok Tohog, Lumais, Padang and Kobong Laut on P. Banggi itself, Tanjung Malawali on P. Malawali, Batu Siri on P. Balambangan and Sibogo near P. Bankawan (see Appendix V, Plates 11, 17 and 18). A focus group was organised with the aid of the local government chief clerk and the local fishermen's cooperative in Karakit (Plate 10) and an extensive discussion was

held with the village headman of Tg. Malawali. All interviews were assisted by Mohd Asri bin Barail, a Bajau Ubian resident from Karakit who had contributed to previous survey work in the area. Mr Leonardo Daim from WWF Malaysia and Dr Annadel Cabanban from the Borneo Marine Research Unit at University Malaysia Sabah also took part in some interviews (Plate 18).

4.3.3. Findings

Fishers in Karakit reported that annually for one month, *tuntungan* (Blacktip reef sharks, *Carcharhinus melanopterus*) aggregate in shallow waters at various sites around southern Banggi and are caught in large numbers by gillnets set overnight. This is not a major fishery but is important for a small group of fishers who specialise in gill netting and catch the majority of their annual catch during this month. They believed that the aggregations were for spawning as it is also the only season when they find a lot of eggs inside. As this is a live-bearing species it is not clear whether this interpretation is incorrect or whether they were using the word *telur* (egg) to mean embryos.

Most aggregations cited in this region related to *kut kut* (small species of *Epinephelus*) and s*unoh* (*Plectropomus spp). P. leopardus, P. areolatus* where most prevalent in records but *P. maculatus* and *P. laevis* also featured. Aggregations had generally shown moderate to severe declines during the 1980s or 1990s. *Batta* (*E. ongus*) aggregations appeared to be most persistent in the region with some showing no changes in catches and some showing moderate to severe declines.

Some observations of groups of *Maming* (*Cheilinus undulatus*) were reported which could relate to spawning aggregations but generally fishers said that large adults of this species were rare or extinct.

4.3.4. Potential Future Research and Partners

WWF Malaysia is active in the region as part of their Sulu-Sulawesi Marine Ecoregion project and have funded studies of the live fish trade in the Kudat area and community use of coastal resources as well as holding fisheries stakeholder workshops in Karakit and Kudat. They have a community education centre in Karakit and a staff member in the KK office allocated to primarily work in the region who is familiar with key members and representatives of the fishing communities in Banggi. They are interested in the management and conservation of marine resources in the region, actively supported this SCRFA survey, and would be interested to support further work (for information on current and future activities contact Ms Robecca Jumin or Mr Leo Daim at the Sabah office of WWFM).

A long discussion was held with Panglima Akmdju Bin Unding, the headman of the village of Tanjung Malawali, in which he related many carefully made observations of reef fish ecology and fisheries in the area and asked about the reproductive ecology of reef fish. In response to explanations about aggregations, pelagic larvae, increasing fecundity with age, sex change and late maturation of more valuable reef species, he expressed strong support for the establishment of small marine protected areas (MPAs) for the protection of local fish populations. He could be a key contact for the

understanding of the local fisheries situation, implementation and design of conservation measures and a means of communicating with the people in his village. The fisheries department used to have an officer based in the Banggi sub-district office in Karakit but since he was transferred to KK in 2002, Banggi has been remotely administered from the Kudat branch of the fisheries office.

The whole area of Banggi and surrounding islands is proposed to become the Tun Mustapha Marine Park which will be the largest marine park in Sabah. The management proposal for a zoned, multi-use marine area is being prepared by the Borneo Marine Research Institute at the University Malaysia Sabah (contact Prof Ridzwan Abdul Rahman or Dr Annadel Cabanban).

4.4. Semporna Area

4.4.1. Background

The south western district of Semporna is important both as a centre for fishing and trading activities, and due to it's wealth of coral reef areas that are heavily utilised by the dive tourism and fishing industries. Seine fisheries for pelagic resources dominate the marine fisheries activities of this district but there is also a significant population (861 in 2000) of traditional fishers. The demersal fish catch from hook and line fisheries in 1999 was 1,100 tonnes (Biusing 2001). An extensive live reef fish trade involving several holding cages and traders also operates in Semporna. This accounted for 742 tonnes of live fish in 2002 according to Fisheries Department statistics.

Blast fishing was responsible for severe decline of reef condition in this region (Pilcher and Cabanban 2001) but according to Sabah Fisheries department blast fishing has declined since 2000 due to stronger enforcement. This generally agreed with the stated views of both fishers and divers. However, at least one blast was clearly heard during this survey.

4.4.2. Work Conducted

Initial work in Semporna was conducted with the aid of Mr Marcel Eging, the WWF Malaysia field staff for Semporna[4]. He assisted with arranging meetings and travel logistics and accompanied Tim Daw on all of the interviews conducted in fishing villages in Semporna (Plate 14).

Meetings were also held with Mr Ruzlee Jumatin, head of Sabah Fisheries Department's Semporna office and various staff to introduce the project and solicit advice and any experience or opinions relevant to the aims of the survey. Official statistics of live and dead fish landings for the region were also made available (see Appendix VI).

With the assistance of the Fisheries Department, in particular Mr Alfred Karom, head of the seaweed aquaculture project, communities on the islands of Bum Bum,

[4] Marcel has since moved on from WWF Malaysia and has been replaced by Ms Nazmahwati Walli

Omadal, Menampilik and Selakan were visited to conduct interviews (Plates 12, 15 and 16).

During the Chinese New Year celebrations (which disrupted other survey activities) Borneo Divers provided logistical support to interview divemasters and instructors on the dive resort islands of Sipadan and Mabul. During this period sightings of potential maming (*Cheilinus undulatus*) spawning activity were reported on the Southern tip of Sipadan reef and a single dive was conducted to make first-hand observations.

4.4.3. Findings

Around the Semporna area several fishers told of large aggregations of groupers which had been exploited for generations in the area of the Semporna Islands Park in the southeast of Darvel Bay, Ligitan reef and at reefs along the Ligitan Channel. *Plectropomus areolatus* (known in the region as *sunoh bodoh* or "stupid coralgrouper") was the most commonly cited species but *Epinephelus fuscoguttatus, P. laevis, E. ongus* and *P. leopardus* also featured. Nearly all of these large aggregations of groupers had declined severely or ceased to occur in the 1980s and 1990s. Large monthly aggregations of Belais (Siganidae) in shallow water still occur on many reefs but often these had apparently also declined to a certain extent as a result of bomb fishing in during the 1980s.

One rare example was a site within the proposed Semporna Islands Park which had annual aggregations of *E. fuscoguttatus, E. ongus* and Lutjanids. These had personally been protected from outside fishers by the owner of the adjacent land and are now somewhat protected by the Park staff.

The islands of Sipadan, Mabul and Kapali now operate as de-facto reserves due to the high intensity of dive tourism in the area and the extensive patrolling by the Malaysian military following kidnaps of tourists from the area in 2000 and 2001. Divemasters on Sipadan island reported regularly observing Siganids group spawning and rarer observations which may be indicative of spawning amongst *P. areolatus,* bumphead parrotfish (*Bolbometopon muricatum*) and humphead wrasse (*Cheilinus undulatus*). During a dive on 24/1/04 at 11:00 am Tim Daw saw a loose group of 5-6 individuals including two mature males and watched apparent courtship behaviour (swimming out together 10-20m from reef) of a large (1.5m) male and a smaller (50cm) fish presumed to be a female (Plate 19). Actual spawning was not observed however.

4.4.4. Potential Future Research and Partners

A clearer picture of aggregations could be obtained by further interviews in communities on other islands and within Semporna town itself not covered during this survey. These could include interviews within the Bajau Laut community and captains of larger vessels which are based in Semporna but fish on the surrounding reefs and islands.

Live fish traders in Semporna could provide insights into temporal fluctuations in supply which may indicate the targeting of FSAs as well as links with larger, more commercial fishing operators amongst their suppliers.

The many dive operators around Semporna may be natural partners for any further FSA research in the area in terms of logistical support as well as making observations. Mr Randy Davis, Director of Borneo Divers, who kindly assisted with the logistics of interviews and observations on Sipadan and Mabul islands, was interested in the work of SCRFA and may be willing to provide further support in the future. Two main videographer companies have operations embedded within the resorts (and throughout Sabah) and collect a huge quantity of underwater footage each week. Mr Eric Madeja, operation manager of Treasure Images within the Borneo Divers resort on Sipadan discussed the possibility of making an arrangement for them to look out for and film particular fish behaviour which could then be sent regularly to SCRFA for analysis. Scubazoo Images is another large organisation with videographers located on many resorts throughout Sabah and an interest in marine conservation.

The Semporna Islands Project, with the involvement of Sabah Parks, WWF, the UK Marine Conservation Society and funded by European Union funds has prepared a detailed management plan for the Semporna Islands Park (http://www.mcsuk.org/semporna/header_nav/headerframes.htm) which is in the process of being gazetted. Many activities have already been undertaken including the employment of park staff, surveys of the natural resources and human settlements of the area, and discussion and awareness raising amongst local communities. A zoning scheme is proposed for the park including no-take and limited-use zones and the development of diving based tourism is envisaged (MCS).

The Semporna area falls within WWF's Sulu-Sulawesi marine Ecoregion programme. They have already conducted an preliminary assessment of the live reef fish trade in the Semporna and Tawau areas (Suliansa 2002).

4.5. Lahad Datu

4.5.1. Background

Lahad Datu is the urban centre for a large district which encompasses all the scattered islands in the north of Darvel Bay. Fisheries statistics cite a population of 451 traditional fishers in 2000, and demersal hook and line catch of 4,666 tonnes in 1999 (Biusing 2001). There is also an active live fish trade. One large holding operation was visited which transports about 12-17 tonnes of live fish to Hong Kong by boat per year[5]. The area apparently has suffered from intensive blast fishing activity which is largely blamed on the sizeable illegal immigrant population (Biusing 2001).

4.5.2. Work Conducted

On arrival I was met by Mr Amla bin Emta, a member of staff with the Lahad Datu Fisheries Department office who had arranged boat and road transport to conduct interviews in the area. Only four fisher interviews were made in the Lahad Datu area due to the limited time available and time required to travel between islands. These were made in Lok Terusan and Kg Teruakan near P. Sakar and in Lamak near Silam.

[5] A worker on the cage (owned by Mr Abadi and near Silam) claimed that 2-3 shipments of about 7 tonnes were made to Hong Kong per year or a single shipment of about 12 tonnes would be made once per year.

A large live fish holding facility (Plate 4) and the Fisheries Department office were visited and the officer responsible for collecting fisheries statistics for the area was interviewed.

4.5.3. Findings and Data Appraisal

Little information on aggregations was uncovered during the brief time spent conducting interviews in the Lahad Datu area. None of the fishers interviewed provided specific details about individual aggregations although they were aware of monthly peaks of abundance of rabbitfish. One fisher did state that seasonality in catches of *Sunoh* (*Plectropomus*) had been evident in the past but had not been discernable since the populations declined in the 1980s. All the fishers reported significant declines in catches, especially those of LRFT species.

4.5.4. Potential Future Research and Partners

More interviews in the region could well be worthwhile and would be likely to uncover more information. The large fishing community of Silam would be a readily accessible and potentially interesting area to conduct more interviews.

The Fisheries Department office in Lahad Datu was interested in the SCRFA work and extremely cooperative but would have limited resources to conduct any additional research. There is also a small Fisheries office in Kunak, in the south west of Darvel Bay.

P. Tambisan near the most Eastern point of Sabah apparently has a form of community management in operation[6]. It would be worthwhile to interview fishers from this community to see whether this management coupled with the more remote location of the island had allowed aggregations to persist in the area.

[6] Personal communication, Robecca Jumin and Marcel Eging, WWF Malaysia

5. Overall Findings and Recommendations

5.1. Results

5.1.1. Fisheries Statistics

Official statistics are collected by regional offices of Sabah Fisheries Department according to the SMPP (*Sistem Maklumat Pengurusan Perikanan*, Fisheries Information Management System). These data were examined in the Fisheries offices of Semporna (see Appendix VI), Lahad Datu and Kudat but they proved to be of limited use for detecting the targeting of spawning aggregations for several reasons:

- **Lack of taxonomic resolution** – Landing statistics were usually grouped into very broad categories (e.g. Serranidae) which were sometimes broader than their strictly scientific meaning. For example while some local officers recorded *Sunoh* (*Plectropomus* spp) and *Maming* (*Cheilinus undulatus*) separately, others grouped them in a general *Kerapu* (Groupers) category. Fisheries officers were of the opinion that whereas the statistics gave a good representation of overall total landings, individual species based data were relatively poor;
- **Availability of temporal spread** – Within the offices visited there were generally only one or two years of data readily available making it difficult to corroborate apparent seasonal trends in CPUE. Longer time series would be available from the central Fisheries Department statistical branch in KK;
- **Lack of or unreliable measures of effort** – There was some discrepancy between offices as to how (or whether) reliable measures of effort were recorded. Extensive use of illegal gears (bombs and cyanide) confuses the picture further as it is unknown under which legal gear category these catches are usually recorded;
- **Inaccuracies related to inadequate sampling –** Officers responsible for collecting data for the SMPP have very limited resources to conduct extensive sampling of landings. One or two officers are generally responsible for sampling many different gear types and thus often rely on declarations from fishers rather than direct measurements or observation. Some fishers or vessel owners are believed to misreport catches for tax reasons.

Live fish landings are not included in the SMPP and are collated by the fisheries department from declarations of traders and cage owners. These may also be inaccurate or misrepresentative for tax reasons. For example a previous study of the trade in the Kudat region suggested that official landing statistics of 70 tonnes in 2001 were underestimated by over 50% (Daw et al. 2002a). Export statistics for the live fish trade are also available which may provide a more useful indication of seasonal trends in the catches of more valuable and easily identified species. These data are held by the Fisheries Department and Rooney Biusing (Deputy Director) is in the process of analysing this information, particularly for *maming* (*Cheilinus undulatus*).

5.1.2. Main species reported as aggregating in Sabah

Nearly half of the 75 records likely to represent actual spawning aggregations were of *Plectropomus* species and 36% were *Epinephelus*[7]. Fourteen species were included in these records and the number of records corresponding to each are shown in table 1. Siganids were also mentioned, particularly in the Semporna region but it was not always possible to identify them to species.

Table 1. Species featuring in interviews which were "very likely" to represent spawning (see the SCRFA database for details, www.scrfa.org)

Species	No of Records
Plectropomus areolatus	10
Epinephelus ongus	10
Plectropomus leopardus	9
Plectropomus oligocanthus	5
Cheilinus undulatus	5
Carcharhinus melanopterus	5[a]
Plectropomus maculatus	3
Epinephelus fuscoguttatus	3
Epinephelus fasciatus	2
Siganus guttatus	1
Epinephelus quoyanus	1
Epinephelus polyphekadion	1
Epinephelus merra	1
Bolbometopon muricatum	1

[a] NB. The 5 aggregation records for black tipped reef sharks (*Carcharhinus melanopterus*) were all described during one interview.

5.1.3. Seasonality of FSAs in Sabah

The interviews gave some indication of the periodicity of spawning of some species. Figure 3 shows the number of spawning aggregation records that related to each month for 5 of the most commonly cited species within each region. The trends are quite different for each of the species with April being the most important month when all of the species are considered.

[7] The large number of grouper (Serranidae) species aggregations reported may partially be a result of the data collection procedures. As groupers and mameng (Cheilinus undulatus) are not normally shoaling species, it was possible to ask fishers if they had ever seen large groups of them and assume that any responses indicated unusual aggregations. This particular question could not be used in this way for rabbitfish (Siganidae), mullets (Muglidae) or snappers (Lethrinidae) because these are commonly shoaling families, so a positive response would not necessarily indicate any unusual aggregation of fish.

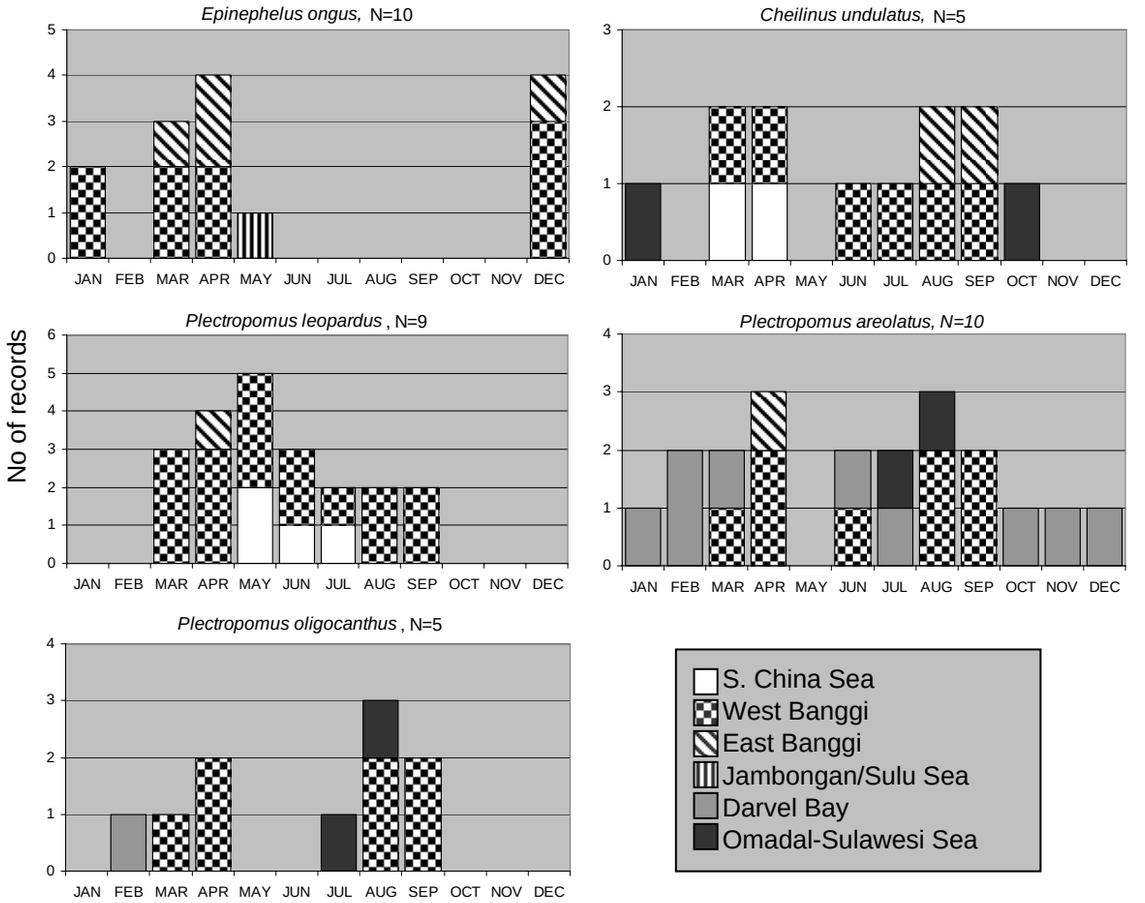

Figure 3. Plots of months of spawning for 5 of the most well represented species from the survey with records separated by region. (Only records where spawning was thought to be very likely are included)

5.1.4. Status of FSAs in Sabah

Aggregations which had been observed at Sipadan and on Lyang Lyang atoll were unusual in being fully protected from fishing. If all other aggregation sites disclosed during interviews (i.e. at fished sites) are considered, only 20% appeared to be stable and more than half of all aggregations in which a trend could be discerned were either extinct or suffering severe (>50%) declines (Figure 4).

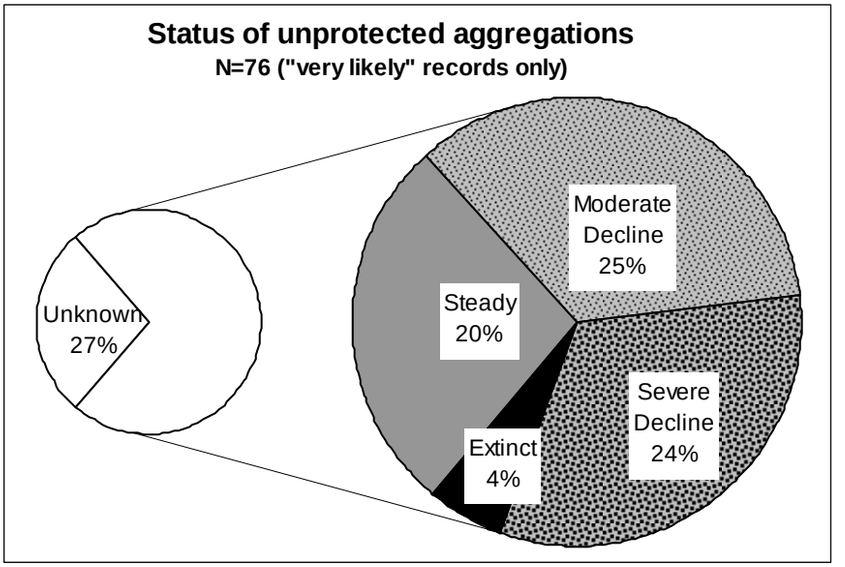

Figure 4. Status of aggregations identified in Sabah (Moderate decline: <50% decline in CPUE, Severe decline: >50% decline in CPUE).

5.1.5. Attitudes of fishers to conservation and aggregations

In agreement with previous studies in the Banggi region (Fisher 2000; Daw et al. 2002a; Cooke 2003) nearly all fishers agreed with the view that stocks and catches of reef fish have declined. In a few notable exceptions, fishers in the Semporna region claimed that there were more fish now since fish bombing had been reduced. Where a decline was observed, fisheries reasons were commonly cited. However, no clear consensus seemed to exist on the need to curtail fishers' own fishing practises. Some fishers appeared unconcerned with the declines, pointing out that prices had increased to such an extent that they were actually better off now even with lower catches, as well as the range of other species which could be collected in order to survive. Others seemed to think that declines were inevitable or caused by other parties (outsiders or commercial fisheries). It must be emphasised that these findings are very preliminary due to the small, unrepresentative sample taken during this study but it should be made clear that fishers in Sabah may not be easily convinced of the need or desirability of protecting spawning aggregations, especially in cases where overall catches have declined and aggregations may be the only opportunity to make sizeable catches. Fisher (2000), Daw et al. (2002a) and especially Cooke (2003) should be consulted for a more thorough analysis of fishers' perceptions in Banggi.

Table 2. Perceived reasons why fish stocks have declined? (N=61)

No. responses	Percentage of responses	Reason
39	64%	Lots fishers
15	25%	Blast fishing
14	23%	Trawlers, purse seiners
13	21%	Cyanide use
6	10%	Outsiders
1	2%	Echo-sounders

5.2. Research Recommendations

Effective management and conservation of reef fish stocks and FSAs within Sabah will depend on a certain knowledge of the species which aggregate and how and when these FSAs occur. Although this survey gives some preliminary information, research on FSAs within East Malaysia should be extended both in terms of the geographical area examined and the range and detail of investigations.

The limited time available for this study constrained its geographic coverage. Many other areas within East Malaysia could be important for FSAs and it would be worth extending interviews with fishers to those areas. A preliminary list of these would include:

Kuching
Bintulu, Miri
Pulau Labuan
Spratley Islands
Pulau Mantanani
Pulau Mandidarah, Pulau Tigabu, Pulau Jambongan
Pulau Lankayan, Pulau Bilean
Kunak area

All of the records of FSAs “discovered” during this survey must be considered provisional as they have not been confirmed by first-hand observation of actual spawning. An obvious initial follow-up to this study would be to attempt to confirm the records of aggregations suggested by interviews through direct underwater observations at described times. To avoid conflicts with fishers who use the aggregations, this should be conducted in collaboration with them and alongside further information and explanation of why the research is being conducted and its importance.

The density of dive resorts in some of the popular areas of Sabah leads cumulatively to very intensive underwater observation of certain reefs. Many resorts (e.g. Manatanani, Sipadan, Lyang Lyang) have resident videographers who may be interested to assist in FSA research by putting aside footage which they (after brief training) thought represented spawning behaviour. This could then be sent to outside experts for analysis and confirmation.

Regular catches of reef fish and delivery fresh to Sabah's fish markets (particularly Kudat, Semporna, KK and Sandakan) creates the opportunity to purchase regular samples of fish from the surrounding reefs and monitor biological signs of spawning activity. Analysis of gonadosomatic index (GSI see Colin et al. (2003) for explanation) and/or gonad maturation stage could help identify spawning seasons in each region. Sabah Fisheries Department are already conducting reproductive research on some pelagic species and thus have some personnel with experience in the sexing and staging of fish gonads[8]. This research would be more effective if it were supported by the collaboration of fishers who were willing to share information on the geographical location of the source reefs on a trip by trip basis.

5.3. Management Recommendations

There is conclusive evidence from many studies that stocks of reef fish (especially predators) are in steep decline on Sabah's reefs and management measures are needed to sustain catches of these valuable fish (Cabanban and Biusing 1999; Oakley et al. 1999; Fisher 2000; Harding et al. 2000; Pilcher and Cabanban 2001; Daw et al. 2002a; Daw et al. 2002b). Aggregations could specifically be protected by spatial or temporal closures. Marine protected areas (MPAs) which are closed to all fishing are one measure which can be used to sustain populations of reproductively mature stocks which could replenish fished areas. These areas should be planned to include spawning sites in cases where they have been confirmed as present and where the necessary community support *and* enforcement capacity exists. Issues of enforcement are likely to be a serious constraint on the ability to protect aggregations, especially in remote reasons and there may be little point in the legislative protection of aggregations in the absence of these factors. In such cases, programmes of joint research and awareness raising with the communities involved would be the first stage of long-term management and sustainability. During this study, if fishers were interested enough to learn some key facts about reef fish biology they generally became more supportive of the idea of MPAs *on the condition that* the areas were small enough or located in such a way that they did not loose substantial proportions of their fishing grounds. These key facts to describe to them included:

- Fish continue to grow throughout their lives;
- A few larger fish produce many times more eggs than many small fish;
- Fish do not stop producing eggs when they are old – in fact they produce more;
- Many species mature late and change sex so that fish of a certain age are necessary for a reproductively viable population;
- Fish eggs and larvae are generally planktonic and can drift from reef to reef whereas adults normally remain on one reef.

Even very reomote communities in Sabah often have video or VCD facilities, so the production of an information VCD in simple Malay or local languages could be a useful way to efficiently disseminate these facts to many fishing communities. This could include interviews with fishers and scientists as well as graphical representation

[8] Personal communication, Dr Ahemad Sade, Mr Irman Isnain, Research Division, Sabah Fisheries Department.

of the concepts. Good quality underwater footage of valuable species would no doubt be of great interest to the fishers and encourage them to watch the VCD.

Virtually all the results of this SCRFA survey has been dependent on the goodwill of the communities and fishers involved who were willing to share their knowledge of fish aggregations. This leads to an ethical question if the resultant management measures led to economic hardship of those very same fishers by restricting their activities. This issue may be reconciled by further communication with the communities involved if they can agree that the aggregations which they have identified should be protected for the long term benefit of themselves as well as outside conservation interests.

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Appendix II. Itinerary

Date	Location/Activity
30/12/03	Arrive Kuala Lumpur - Collect research pass, travel to Kota Kinabalu
31/12/03 – 4/1/04	Kota Kinabalu – Organise research visa, meetings
5/1/04	Travel to Tawau & Semporna meet Marcel Eging
6/1/04	Meetings in Semporna, travel to P. Bum Bum and start interviews with Marcel Eging
7/1/04	Interviews on P. Omadal with Marcel Eging, return to Semporna
8/1/04	Interviews on P. Menampilik with Marcel Eging
9/1/04	Meeting Fisheries Department in Semporna
9-11/1/04	Interviews on P. Selakan with Marcel Eging
11/1/04	Return to Kota Kinabalu
12-13/1/04	Meetings and interviews in Kudat with Leo Daim
14/1/04	Travel to Banggi, Interviews in Lok Tohog with Leo Daim & Asri bin Barail
15/1/04	Interviews on Malawali and Focus group with fishers in Karakit with Leo Daim & Asri bin Barail
16/1/04	Interviews in Batu Siri, Balambangan with Dr Annadel Cabanban & Asri bin Barail
17/1/04	Interviews in Sibogo with Dr Annadel Cabanban & Asri bin Barail
18/1/04	Interviews in Lumais with Asri bin Barail
19/1/04	Interviews in Padang and Kobong with Asri bin Barail
20/1/04	Interviews in Karakit with Asri bin Barail
21/1/04	Travel to Kudat, interviews in Kudat with Asri bin Barail
22/1/04	Interviews in Kudat with Asri bin Barail, Visit Greenforce project camp
23/1/04	Interviews in Longgom Kecil, Travel to Kota Kinabalu
24/1/04	Travel to Semporna & P. Sipadan, interviews on Sipadan
25/1/04	Observation on Sipadan, Travel to & interviews on P. Mabul
26/1/04	Return to Semporna, Travel to Lahad Datu
27/1/04	Interviews around Lahad Datu with Amla bin Emta
28/1/04	Interviews around Lahad Datu with Amla bin Emta, Return to KK
29-31/1/04	Interviews and meetings in KK
1/2/04	Leave Malaysia

Appendix III. Interview Schedule

SCRFA E. Malaysia Reef Fish Aggregation Survey
Fisher interview schedule

METADATA

Interview number:	Interviewer:
Date:	Fisher's Name:
Location:	

FISHER DETAILS

Bilakah kamu mula-mula tankap ikan? (When did you start fishing?)			
Macam mana kita tankap ikan? (How do you fish?)			
Apa jenis ikan yang paling banyak tankap? (Which species do you mostly catch?)			
Kaedah? (gear)			
Jenis? (species)			
Apa jenis bot yang kamu pakai untuk tangkap ikan? (what kind of boat do you use?)			
Apa jenis enjin? (what kind of engine?)			
Berapa orang dalam bot? (How many people in the boat?)			
Berapa kali turun ke laut dalam satu bulan? (How many times to sea in a month?)			
Berapa lama di laut? (How long do you stay at sea?)			
Kalau kapal besar...(if large boat)	Siapa kapten kapal? (who is captain?)		
	Kapal ada CAS? (does it have echosounder?)		
	Kapal ada GPS? (does it have GPS?)		
Di mana tankap ikan? (where do you fish?)			

AGGREGATION QUESTIONS

Apa musim ada yang paling bagus untuk tangkap banyak ikan takat? (Which season is the best for catching reef fish?)			
Pernah kah kamu tangkap ikan yang ada telur? (Have you ever seen fish with eggs?)			
Pernah kamu tangkap ikan dalam kumpulan besar? (Mullak?/Pullak) (Have you ever seen fish aggregations?)			
For the above Qs.			
Apa jenis? (What species?)			
Bila? Bulan apa? (When, Which month?)			
Dalam hari Bulan Melayu apa tarikh? (Which day in Malay Calendar?(moon state))			
Pagi/Malam...? (Morning/Evening?)			
Di mana? (Where?)			
Apa nama itu kawasan? (What is the place name?)			
Kamu boleh menyatakan mana atas peta ini? Apa arah petunjuk? Berapa kilometer dari sini? (Can you show on this chart? Which direction? How many km from here?)			
Berapa meter dalam, itu kawasan? (How deep is that place?)			
Ada batu karang/pasir/batu batu besar? (Is there coral/sand/large rocks...?)			
Berapa besar itu kawasan? (How big is the place?)			
Berapa banyak ikan dalam kumpulan kamu angar? (How many fish are in the aggregation?)			
Bila kali pertama kamu tankap ikan dari kumpulan ikan itu? (When was the first time you went there?)			
Macam mana kamu boleh jumpa/tahu itu kumpulan ikan? (How did you find/know it?)			
Berapa banyak ikan kamu dapat dari kumpulan ikan itu pada duluh/sekarang? (How many fish could you catch there before/now?)			
Berapa nelayan tangkap ikan dari itu kumpulan dulu/sekarang? (How many fishers were catching fish there before/now?)			
Nelayan dari mana? (Fishers from where?)			

Macam mana nelayan tankap ikan dari itu kumpulan duluh/sekaran? (What gears did fishers use there?)			
Adakah size ikan berubah sejak dulu? Macam mana? Lebih kecil/sama/besar? (Has the size of fish in the aggregation changed from before?)			
Kimu tidak risau dengan keadaan ini? (Do you worry about /regret this?)			
[*If yes*] Apa yang perlu di lakulkan? (What could be done about this?)			

GENERAL TRENDS

Biasanya berapa banyak kamu dapat tankap dalam satu minggu/trip etc? (Normally, how much fish do you catch in one week/trip etc?)	Sekarang ? (Now?)	5 tahun dulu? (5 years ago?)	(Other time depending on experience & memory)
Pendapat kamu, kenapa ada kurang ikan sekarang? (In your opinion why is there less fish now?)			
Apa jenis jenis ikan yang paling kurang sekarang? (Which species has declined the most?)			
Masi ada maming di sini? (Is there still *C. undulatus* here?)			
Masi ada lankawit di sini? (Are there still large adult *C. undulatus* here?)			

PERSONAL INCOME

Selain daripada tangkap ikan, kamu ada sumer pendapatan lain? (Other than fishing do, you have other sources of income?)			
Berapa banyak kamu dapat dari... (How much/what proportion do you get from...)	Jual ikan hidup? (...selling live fish?)	Jual ikan mati? (...selling dead fish)	Selain daripada tankap ikan? (...other than catching fish?)
Apa bangsa kamu? (What ethnicity are you?)	Berapa umur? (How old?)		

Reliability of interview? VERY MID POOR

Other Notes:

Appendix IV. Summaries of interviews by village

Region	Village	Date	No Interviews	Years Fishing	Gears mentioned	Species Caught	Catch trends	Mgmt & concerns	Catches of maming (*Cheilinus undulatus)*
Banggi	Batu Putih, Karakit	20-Jan-04	3	16-20	Spear	Plectropomus sp, Cuttlefish, Carangidae, Types of Mixed reef fish,	live fish catches have halved since 90s	Declines blamed on CN and Blast fishing. Outside fishers useed CN since late 90s.	declines of 70+% in nos maming. Sizes smaller.
	Batu Siri, Balambangan	16-Jan-04	3	15-27	Trolling. Hook & Line, Gill net	Epinephelus fuscoguttatus, Brown patterned Epinephelus, Small brown Epinephelus spp (E. merra, ongus etc), Plectropomus leopardus, Plectropomus sp, Plectropomus maculatus, Caranx sexfasciatus, Carangoides fulvoguttatus, Caranx ignobilis, Alectus indicus, Alectus ciliaris, Atropus atropus, Atule mate, Types of Mixed reef fish, Argyrops spinifer, Lutjanidae, Scomberomorus sp,	One fisher thought all catches halved another thought catches of reef fish same as 10yrs ago but that now got 1-2 spanish mackerel as opposed to 4 10 yrs ago.	blast fishing and many outsider fishers blamed	adult male caught in 2003
	Karakit	16-Jan-04	5	15-45		Caesio cuning, Plectropomus leopardus, Plectropomus maculatus, Types of Mixed reef fish,	catches less than half of previously - now 1-2 live fish per day	large no of fishers, CN and bomb fishing blamed for decline. Belive that fish would come back if just hook and line	significant declines. No adults any more due to CN fishing
	Kobong Laut	19-Jan-04	2	5-25		Plectropomus leopardus, Plectropomus maculatus,	declines of 50% or more in catches of live and general reef fish	large no of fishers blamed for declines	rarely catch maming in this area. Too shallow for adult males
	Lok Tohog	14-Jan-04	7	16-35	Trolling, Spear Hook & Line, Fish Trap	Plectropomus leopardus, Plectropomus sp, Plectropomus maculatus, Carangidae, Types of Mixed reef fish, Scomberomorus sp,	most fishers cited declines of >60-80% in live fish catches to from 50 to 10-20 pcs per time collecting traps. One fisher claimed no change	Increase in fishing pressure. Higher prices and more fishers	catches/day of one fisher declined from 5 to 1 individual/trip

Region	Village	Date	No Interviews	YearsFishing	Gears mentioned	Species Caught	Catch trends	Mgmt & concerns	Catches of maming (*Cheilinus undulatus)*
Banggi	Lumais	18-Jan-04	3	15-27			live fish catches have declined from 15 (20yrs ago) to 10 (5yrs ago) to 2-3 pcs	Lots of people catching live fish. Some people using CN for ~20 yrs.	still catch some but decline from 10 pcs/day 5 yrs ago to 6 pcs/month now.
	Padang	19-Jan-04	4	20-45	Hook & Line, Gill net	Caesio cuning, Carangidae, Atule mate, Siganidae, Dasyatidae,	live fish catches declined from 20 to 4-5 pcs/day since 10yrs ago. General reef fish catches down to 10-20 kg/day/person from 100 kg/day/person. Steady declines since 1981	No. fishers and industrial vessels blamed.	
	Sibogo	17-Jan-04	5	10-23	Hook & Line, Compressor	Brown patterned Epinephelus, Plectropomus leopardus, Plectropomus sp, Plectropomus maculatus, Types of Mixed reef fish, Unidentified fish, Cheilinus undulatus,	Significant declines (30-50 to 5 kg/day) in live fish catches	Less fish now but prices have gone up	catches have declined due to fishing pressure but still some adults around
	Tanjung Malawali	15-Jan-04	2	25-30	Hook & Line, Gill net, Fish Trap	Plectropomus sp, Plectropomus maculatus, Types of Mixed reef fish,	All catches declined. Blast fishing yields declined from tonnes to 50kg	Prices have increased so decline in catches is ok. But Headman concerned by increase in no fishers, actions of trawlers and use of echosounders, CN & dive compressors. Blast fishing used sicne WWII. Weather and seasonality of catches has become unpredictable	Used to have aggregations of maming in 60s & 70s. Not seen adults for years. Used to catch 5-7 individuals/day. Now 1 per month if lucky.
KK	KK	30-Jan-04	3	11-20	Hook & Line	Cromileptes altivelis, Plectropomus leopardus, Plectropomus sp, Lutjanidae, Scomberomorus sp, Cheilinus undulatus,	One team of CN divers could get 100kg live fish & lobster per trip in 1990. Declined ever since to 5 - 6 kg now. Epinephelus lanceolatus has declined the most.	Numbers of fishers, trawlers and destructive fishing blamed for declines	rarely caught and only occasionaly see adults in deep places

Region	Village	Date	No Interviews	Years Fishing	Gears mentioned	Species Caught	Catch trends	Mgmt & concerns	Catches of maming (*Cheilinus undulatus)*
Kudat	Inarunto ng, Pitas	13-Jan-04	1	30	Fish Trap	Lethrinidae, Plectropomus sp,	Live fish catch declined from 70 to 50 kg/trip in good season over last 10 years.	not sure of why declines	from 7/day 5yrs ago to 1-2/day now
	Kg Layak Lyak, Pitas	13-Jan-04	1	20	Gill net	Hemirhamphidae, Carangidae, Liza vaigiensis, Liza subviridis, Unidentified mullet, Gerreidae, Types of Mixed reef fish, Lutjanidae,	Gill net catches have declined	concerned about no. of fishers and competition with large industrial boats	
	Kg. Bingolon	21-Jan-04	1	6	Driftnets	Unidentified Sharks, Scomberomorus sp, Tunas, Unidentified scombrid,	catch half amount of pelagics in on trip compared to one night 5 years ago. Spanish mackerel especially has declined	Blame declines on industrial purse seiners	
	Lok Linkan, Pitas	13-Jan-04	1	10	Fish Trap	Plectropomus sp, Lutjanidae,	Plectropomus per week declined from 100 kg to 50 kg in 10 yrs. Lobster declined from 50kg to 20kg in last 5 yrs.	blame lots of fishers. Follow unsafe diving practises. Interviewee had many friends who had died and had been hospitalised himself.	
	Longgo m Kecil	23-Jan-04	2	15 - 20	Gill net	Epinephelus fasciatus, Epinephelus coioides, Carangidae, Siganidae, Nemipterus sp,	Gill net catches have declined from 50 kg/night to 10-20 kg/night since 1990s	Prawn trawlers and purse seiners blamed. Sometimes conflicts with fishers from other villagers	v. rarely caught
	Tajau Laut, Kudat	21-Jan-04	1	17	Hook & Line, Diving		200 kg reef fish/day in 80s to 20 kg/day now. Plectropomus most affected	Blame lots of fishers.	
	Tg Kapor	13-Jan-04	8	4-40	Hook & Line, Compre ssor	Lethrinidae, Caesio cuning, Plectropomus oligocanthus, Brown patterned Epinephelus, Plectropomus leopardus, Plectropomus sp, Plectropomus maculatus, Carangidae, Types of Mixed reef fish, Lutjanidae,	50-70% decline in live fish CPUE over 5 years. Also declines in dead fish catch though not quite as severe	Blame lots of fishers primarily. Also bombs, CN, echosounders. CN used since 90s.	Massive decline since 80s. One fishers used to catch 50-100 kg/trip in 70s now "might not see one in 10 trips". Rarely see adults but one 30kg fish caught in 2003.

Region	Village	Date	No Interviews	Years Fishing	Gears mentioned	Species Caught	Catch trends	Mgmt & concerns	Catches of maming (*Cheilinus undulatus*)
Semporna	Gusung Melantas	06-Jan-04	2	17-20	Spear Hook & Line, Fish corral, Gill net	Lethrinidae, Brown patterned Epinephelus, Crabs, Carangidae, Siganidae, Types of Mixed reef fish, Lutjanus bohar,	declines in catches since before	Feel catches are recovering due to better control of blast fishing	
	Mabul	25-Jan-04	1	20	Hook & Line	Types of Mixed reef fish, Scomberomorus sp, Tunas,	declines in Plectropomus catches from 10/day to 1-2/day since 1980s	Several exclusive dive resorts on island. Community collaborates with police to stop destructive fishing. Only hook and line allowed on fringing reefs around Mabul	
	Menampilik	08-Jan-04	6	7-48	Hook & Line, Gill net, Fish Trap	Brown patterned Epinephelus, Crabs, Lobsters, Types of Mixed reef fish, Lutjanidae,	Reef fish catches down from 5-10 yrs ago but improving since reduction in use of bombs	Have novel community managmement of Mullet aggregation around island. Protect fringing reefs from outsiders using destructive fishing. All interviewees believed this was improving their catches. Bombing in this area since 70s but less in last couple of years.	
	Omadal	07-Jan-04	4	20-40	Long line, Hook & Line, Gill net, Fish Trap	Lethrinidae, Brown patterned Epinephelus, Plectropomus sp, Plectropomus maculatus, Carangidae, Types of Mixed reef fish, Dasyatidae, Cheilinus undulatus,	Major (80%+) declines in catches in last 5 years. Large groupers very rare now.	Blame commercial purse seiners too close to shore & lots of fishers	
	Selakan	09-Jan-04	9	17-55	Spear, Hook & Line, Gill net, Fish Trap	Lethrinus nebulosus, Lethrinidae, Brown patterned Epinephelus, Mullidae, Carangidae, Chanos Chanos, Unidentified mullet, Siganidae, Symphorus nematophorus, Plectorhynchus celebicus, Haemulidae, Scomberomorus sp, Tunas, Rays,	80-95% declines in catches reported over 10yrs.	Blame blastfishing and lots of effort, particularly from outsiders including Filippinos. Bajau Laut (Sea Gypsies) keen to see destructive fishing controlled. Sabah Islands Park will include many of these islands in zoned scheme. Core areas around Bohadulong apparently in good condition.	generally no adults seen since 80s but apparently two at nearby island

Region	Village	Date	No Interviews	Years Fishing	Gears mentioned	Species Caught	Catch trends	Mgmt & concerns	Catches of maming (*Cheilinus undulatus)*
Lahad Datu	Kg Teruakan, Nr. P. Sakar	27-Jan-04	1	5-18	Long line, Gill net, Fish Trap	Epinephelus bleekeri, Epinephelus fuscoguttatus, Brown patterned Epinephelus, Epinephelus lanceolatus, Epinephelus quoyanus, Plectropomus leopardus, Epinephelus coioides, Plectropomus maculatus, Epinephelus sexfasciatus, Carangidae, Lutjanidae,	Live fish per 25 traps declined from 30kg to 5kg in 5 years. Whole catch declined from 100kg to 50kg in same period. Declines noticable since 1990.	Blame lots of fishers	
	Lamak, Silam	28-Jan-04	1	37	Purse seine Hook & Line, Kelong / Fish corral, Gill net, Driftnets, Fish Trap	Sphyraena sp, Brown patterned Epinephelus, Unidentified clupeid, Crabs, Lobsters, Carangidae, Unidentified mullet, Siganidae, Types of Mixed reef fish, Lutjanidae, Dasyatidae, Scomberomorus sp, Tunas, Unidentified fish,	handline catches declined by over 50% since 80s. Plectropomus declined even more in same period	Blame lots of fishers. Worried about demersal spp but believes pelagics are inexhaustable.	Used to see adults in 70s and 80s in central Darvel Bay
	Lok Terusan, Nr. P. Sakar	27-Jan-04	2	35-55	Kelong / Fish corral, Fish Trap	Caesio cuning, Plectropomus oligocanthus, Epinephelus fuscoguttatus, Brown patterned Epinephelus, Plectropomus leopardus, Carangidae, Siganidae, Lutjanus jonii, Lutjanidae,	declines of trap catches of up to 90% described since 60s	declines blamed on lots of fishers, CN, commercial fishing with lights, trawlers, drifnets, bombs. Can't fish traps on productive soft grounds any more because of trawlers.	still catch some but not targetted.

NB. Due to the small numbers of interviews at each village and the non-representative sampling design, these summaries cannot be assumed to represent each whole village.

Appendix V. Village locations

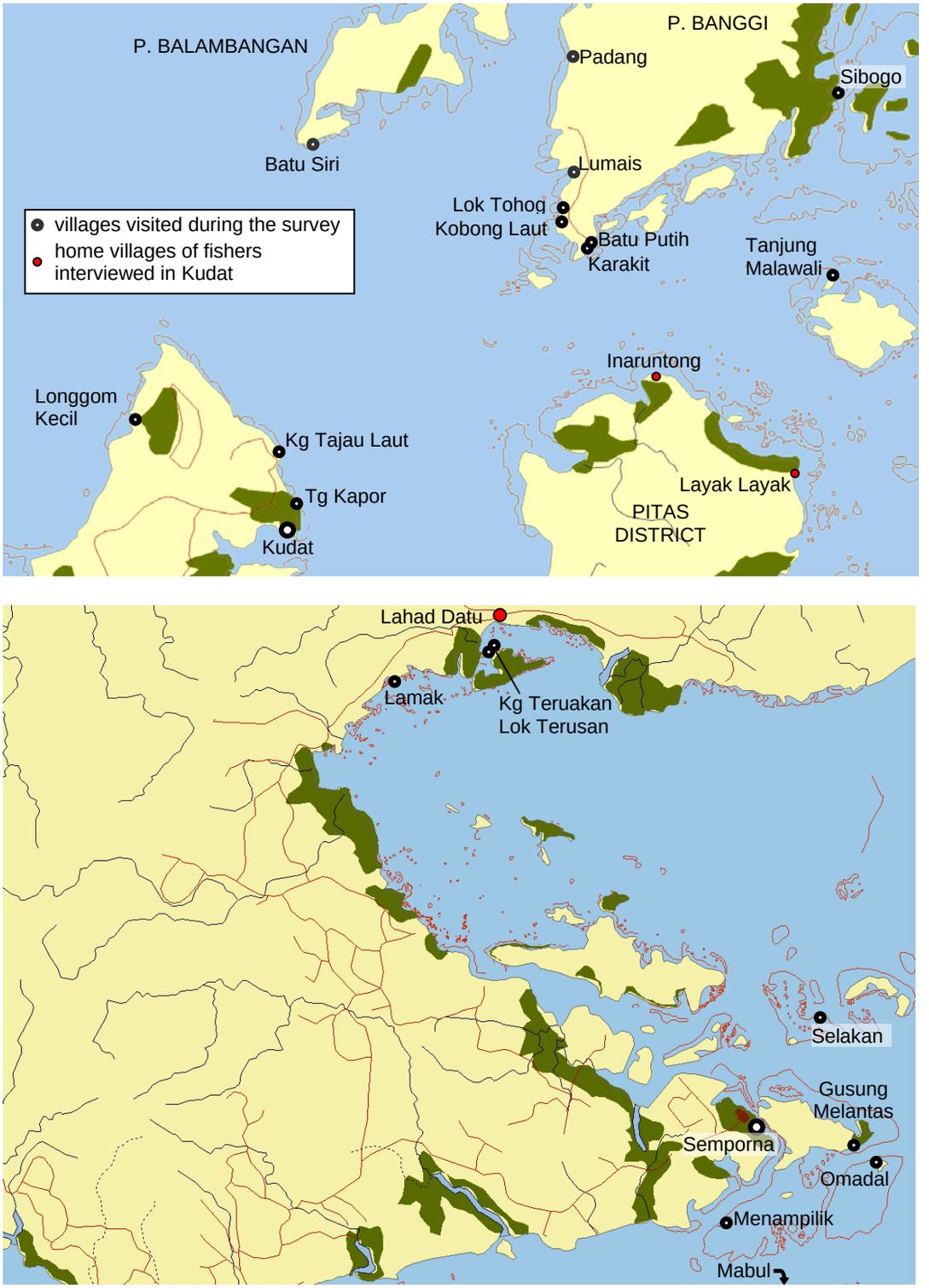

Figure 5. Approximate position villages visited and referred to in Appendix IV in the Kudat/Banggi region (top) and the Semporna/Lahad Datu region (lower).

Appendix VI. Sample of Fisheries Department catch statistics

The following data was supplied from the Semporna branch of Sabah Fisheries Department and had been collected according to the SMPP (*Sistem Maklumat Pengurusan Perikanan*, Fisheries Information Management System). Fisheries staff survey a sample of vessels using each type of gear to record catch volume, number of trips/month and number of days fishing then multiply this sample up by the number of vessels known to operate that gear from the port. This was used to generate a mean catch per unit effort (CPUE) for each month for hook and line fisheries (Figure 6). Potential inaccuracies in the data combined with the coarse level of identification preclude the use of this data for identification of the targeting of spawning aggregations.

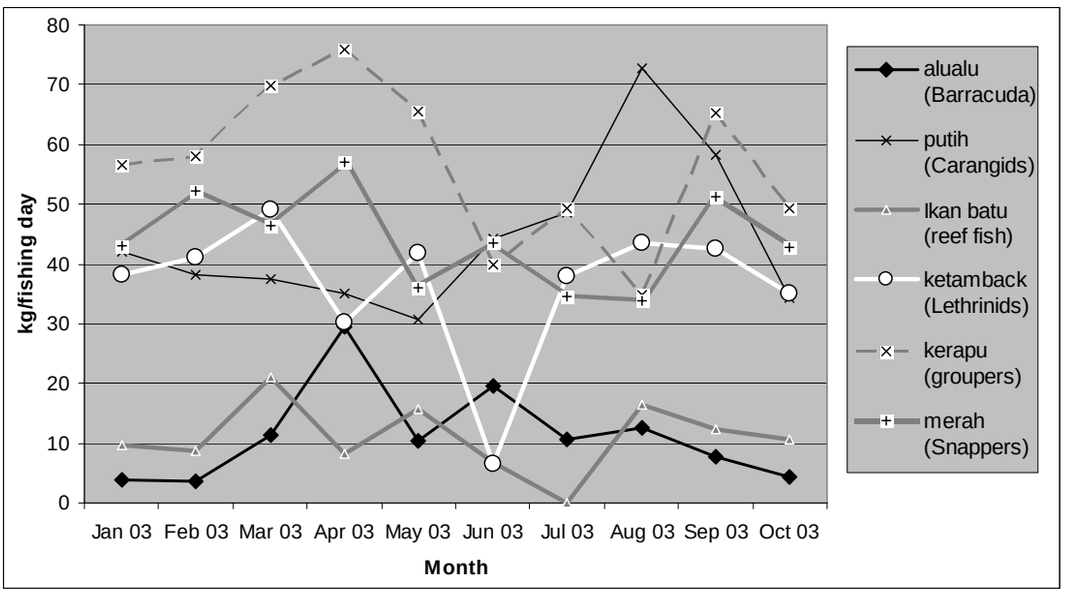

Figure 6. Monthly mean catch per unit effort (CPUE) of reef fish species from hook and line operations landing in Semporna in the first ten months of 2003.

Appendix VII. Local vocabulary useful for FSA research or used in this report

Apah	Male fish gonads
Bubu	Fish box trap
JKKK	*Jawatankuasa Kemajuan dan Keselamatan Kampung.* Committee (or chair of committee) for the security and development of the village
Kampung	Village (abbreviated to Kg.)
Kapal	Larger, inboard engine fishing boat
Kelong	Fish corral
Ketua Kampung	Village headman
Mancing	Fishing (usually with hook and line)
Mullak	Aggregation of fish (Bajau word)
Panat	Spear
Pancing	Hook, hook and line gear
Pehak	Female fish gonads
Piskadul	Mother-dory fishing operations in which the captain pays each fisher for the fish that he catches during the trip
Pukat	Gill net
Pulau	Island (abbreviated to P.)
Pullak	Aggregation of fish (Bajau word)
Sampan	Small one man canoe used in Mother-dory fishing operations
Sujum	Sodium cyanide
Sungai	River or (in a marine context) estuary (abbreviated to Sg.)
Telur	Eggs
Timbak daing	Fish bomb (Bajau)

Appendix VIII. Local names of fish species collected during surveys

Local Name	Scientific Name	Family	No. times used
Alu Alu	Sphyraena sp	Sphyraenidae	1
Anoupin	Lethrinus nebulosus	Lethrinidae	1
Anupin	Lethrinus nebulosus	Lethrinidae	1
Asli	Plectropomus leopardus	Serranidae	1
Baculan	Unidentified scombrid	Scombridae	1
Bagaha	Epinephelus fuscoguttatus	Serranidae	3
Bagaha Palu Palu	Epinephelus malabaricus	Serranidae	1
Bagahak	Epinephelus fuscoguttatus	Serranidae	1
Baguan	Plectropomus areolatus	Serranidae	2
Bakuku	Plectorhinchus chaetodonoides	Haemulidae	1
Batta	Epinephelus merra	Serranidae	1
Batta	Epinephelus quoyanus	Serranidae	1
Batta	Epinephelus ongus	Serranidae	4
Batu	Types of Mixed reef fish		17
Batu	Argyrops spinifer	Sparidae	1
Bauiluu	Chanos Chanos	Chanidae	2
Bawal hitam	Formio niger	Formionidae	1
Belais	Siganus javus	Siganidae	1
Belais	Siganidae	Siganidae	8
Belanak	Liza vaigiensis	Muglilidae	1
Belanak	Liza subviridis	Muglilidae	1
Belanak	Unidentified mullet	Muglilidae	4
Belaning	Tunas	Scombridae	1
Belawis	Siganus javus	Siganidae	1
Belawis		Siganidae	1
Belawis	Siganidae	Siganidae	2
Bolong	Siganus guttatus	Siganidae	2
Bukan	Choerodon anchorago	Labridae	1
Bulong	Siganus guttatus	Siganidae	1
Bumpheads	Bolbometopon muricatum	Scaridae	1
Dag	Siganus vulpinus	Siganidae	1
Dag	Siganus virgatus	Siganidae	2
Dapak	Lutjanus gibbus	Lutjanidae	1
Flagtail Grouper	Cephalopholis urodeta	Serranidae	1
Footballer groupers	Plectropomus laevis	Serranidae	1
Groupers	Plectropomus areolatus	Serranidae	1
Haan Haan	Lutjanus bohar	Lutjanidae	1
Ikan Batu	Types of Mixed reef fish		3
Ikan Batu	Lutjanidae	Lutjanidae	1
Ikan Merah	Lutjanidae	Lutjanidae	2
Ikan Puteh	Carangidae	Carangidae	1
Ikan Putih	Caranx ignobilis	Carangidae	1
Ikan Putih	Carangidae	Carangidae	2
Jenis ikan batu	Types of Mixed reef fish		1
Kalui	Plectropomus oligocanthus	Serranidae	3
Kalui	Plectropomus sp	Serranidae	1
Katumbak	Lethrinidae	Lethrinidae	2

Local Name	Scientific Name	Family	No. times used
Kayu	Tunas	Scombridae	2
Kelabutan	Cuttlefish	Invertebrates	1
Kelawi	Plectropomus oligocanthus	Serranidae	1
Kembong	Unidentified fish	Unknownus	1
Kerapu	Epinephelus bleekeri	Serranidae	1
Kerapu	Epinephelus fasciatus	Serranidae	1
Kerapu	Brown patterned Epinephelus	Serranidae	16
Kerapu	Epinephelus microdon	Serranidae	1
Kerapu	Epinephelus coioides	Serranidae	2
Keratong	Epinephelus lanceolatus	Serranidae	1
Kerisi	Lutjanidae	Lutjanidae	1
Kerusi	Nemipterus sp	Nempipteridae	1
Ketam	Crabs	Invertebrates	3
Ketamback	Lethrinidae	Lethrinidae	1
Ketambak	Lethrinidae	Lethrinidae	3
Ketumbak	Lethrinus ornatus	Lethrinidae	1
Ketumbak	Lethrinidae	Lethrinidae	2
Ketumbak sokong	Lutjanidae	Lutjanidae	2
Ku'au	Epinephelus areolatus	Serranidae	1
Kubal Kubal	Carangidae	Carangidae	1
Kubing	Cromileptes altivelis	Serranidae	1
Kumai	Naso sp	Acanthuridae	1
Kut Kut	Brown patterned Epinephelus	Serranidae	1
Kut Kut	Small brown Epinephelus spp (E. merra, ongus etc)	Serranidae	3
Kut Kut	Epinephelus quoyanus	Serranidae	2
Kut kut (Batta)	Epinephelus ongus	Serranidae	1
Kut Kut Gusing	Epinephelus merra	Serranidae	1
Kut Kut Pasir	Epinephelus merra	Serranidae	1
Lahusu	Lethrinus miniatus	Lethrinidae	1
Lampet	Cheilinus trilobatus	Labridae	1
Lankawit	Cheilinus undulatus	Labridae	1
Lanohan	Carangidae	Carangidae	1
Lepe	Plectrorhinchus sp	Haemulidae	1
Lepe	Haemulidae	Haemulidae	1
Leppa	Plectorhinchus flavomaculatus	Haemulidae	1
Li Pan	Epinephelus areolatus	Serranidae	1
Licin	Cheilinus undulatus	Labridae	5
Lumahan	Carangidae	Carangidae	3
Malapisang	Symphorus nematophorus	Lutjanidae	1
Mameng	Cheilinus undulatus	Labridae	5
Mamin	Cheilinus undulatus	Labridae	1
Maming	Cheilinus undulatus	Labridae	1
Mangilap	Siganus chrysopilos	Siganidae	1
Manila	Plectorhynchus celebicus	Haemulidae	1
Manila	Plectorhynchus goldmanni	Haemulidae	1
Manila	Plectorhynchus diagrammus	Haemulidae	1
Manila	Plectorhynchus lineatus	Haemulidae	1
Manksa	Caranx ignobilis	Carangidae	1
Meangud	Hemigymnus melapterus	Labridae	1
Merah	Lutjanidae	Lutjanidae	6
Napoleon	Cheilinus undulatus	Labridae	1
Obon	Epinephelus polyphekadion	Serranidae	1
Ogos	Scaridae	Scaridae	1

Local Name	Scientific Name	Family	No. times used
Pari	Dasyatidae	Dasyatidae	3
Pari	Rays		1
Pasinko	Plectorhynchus celebicus	Haemulidae	1
Puteh	Carangidae	Carangidae	1
Putih	Caranx sexfasciatus	Carangidae	1
Putih	Carangoides fulvoguttatus	Carangidae	1
Putih	Caranx ignobilis	Carangidae	1
Putih	Alectus indicus	Carangidae	2
Putih	Alectus ciliaris	Carangidae	1
Putih	Atropus atropus	Carangidae	1
Putih	Carangidae	Carangidae	12
Putih	Atule mate	Carangidae	1
Salai Salai	Carangoides fulvoguttatus	Carangidae	1
Selar kuning	Atule mate	Carangidae	1
Sulig	Caesio cuning	Caesionidae	4
Sulig	Caesionidae	Caesionidae	1
Sunoh	Plectropomus oligocanthus	Serranidae	5
Sunoh	Plectropomus leopardus	Serranidae	5
Sunoh	Plectropomus sp	Serranidae	25
Sunoh	Plectropomus laevis	Serranidae	3
Sunoh	Plectropomus maculatus	Serranidae	2
Sunoh	Plectropomus areolatus	Serranidae	3
Sunoh Asli	Plectropomus leopardus	Serranidae	1
Sunoh Baguan	Plectropomus areolatus	Serranidae	1
Sunoh batu	Plectropomus leopardus	Serranidae	1
Sunoh Bodoh	Plectropomus areolatus	Serranidae	2
Sunoh hitam	Plectropomus leopardus	Serranidae	4
Sunoh Kalui	Plectropomus oligocanthus	Serranidae	1
Sunoh merah	Plectropomus leopardus	Serranidae	11
Sunoh negro	Plectropomus leopardus	Serranidae	2
Sunoh tai sing	Plectropomus maculatus	Serranidae	5
Sunoh taising	Plectropomus maculatus	Serranidae	3
Surgeonfish	Acanthuridae	Acanthuridae	1
Taballung	Trunkfish spp	Ostraciidae	1
Tabong	Lutjanus jonii	Lutjanidae	1
Tai sing	Plectropomus maculatus	Serranidae	8
Taising	Plectropomus maculatus	Serranidae	2
Tamban	Unidentified clupeid	Clupeidae	1
Tamudol	Epinephelus ongus	Serranidae	1
Tangalla	Epinephelus fasciatus	Serranidae	1
Temanu	Atule mate	Carangidae	2
Temenong	Unidentified fish	Unknownus	1
Tengerri	Scomberomorus sp	Scombridae	2
Tenggeri	Scomberomorus sp	Scombridae	6
Timbungan	Mullidae	Mullidae	2
Tokek	Unidentified Bamboo Sharks	Hemiscyllidae	1
Tulisan	Plectorhynchus celebicus	Haemulidae	1
Tutungan	Carcharhinus melanopterus	Carcharhinidae	2
Udang	Lobsters	Invertebrates	2
Yu	Unidentified Sharks	Carcharhinidae	1

Appendix IX. Plates

Plate 1. *Epinephelus fuscoguttatus* and *Epinephelus coioides* on sale in a live fish restaurant in Kudat.

Plate 2. Live *Cheilinus undulatus* for sale in a Kudat restaurant.

Plate 3. Heavily degraded reef in Banggi region with likely damage from blast fishing.

Plate 4. Large life reef fish holding facility near Lahad Datu

Plate 5. Larger fishing vessel of the type used for mother/dory operations unloading live fish to a floating cage in Sibogo, Banggi

Plate 6. The Live Fish Holding facilities at Kudat Esplanade

Plate 7. Paddled canoes (*sampans*) used during mother-dory operations equipped for handline fishing for serranids.

Plate 8. A small *kelong* or fish corral.

Plate 9. New plastic *bubu* (fish traps) supplied to fishers in Selakan by the Fisheries Department

Plate 10. Focus group meeting with fishers in Karakit, Banggi

Plate 11. Checking identification of local names with a fisher in Palak, Banggi.

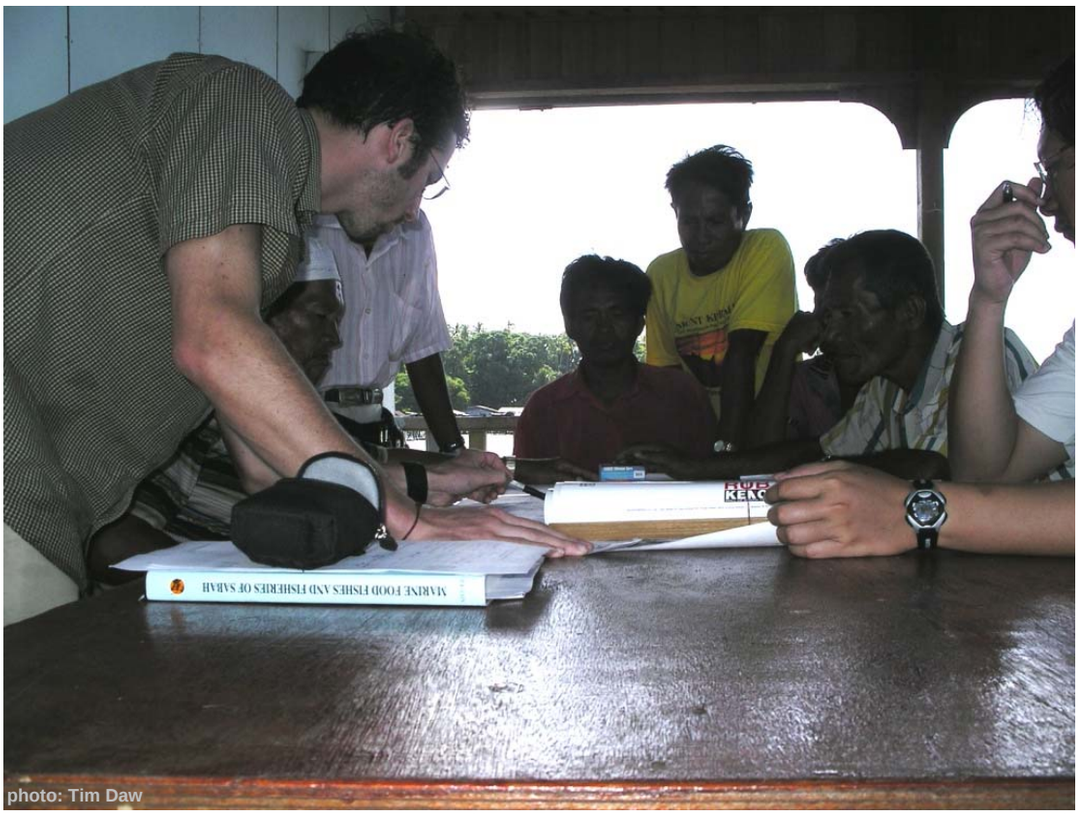

Plate 12. Interviews with Bajau Laut fishers on P. Selakan assisted by the headman of Selakan.

Plate 13. Interviewing Mr Ho, Life fish trader in Kudat.

Plate 14. Marcel Eging from WWF with interviewees Kurasia and Laguna on P. Selakan

Plate 15. Approaching P. Selakan, Semporna Islands Park

Plate 16. Village at P. Menampilik, Semporna Region

Plate 17. Village at P. Malawali, Banggi

Plate 18. Dr Annadel Cabanban from UMS and Mhd. Asri bin Barail during transport by local pump boat between stilt villages in Sibogo, Banggi.

Plate19. Pair of adult maming (*Cheilinus undulatus*) observed separating from a larger group and swimming together off the Sipadan Island reef.