

Report on the Current Status and Exploitation History of Reef Fish Spawning Aggregations in Eastern Indonesia

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Introduction

The Indonesian archipelago consists of over 17,000 islands, which straddle the equator for almost 5,000 km; its extensive coral reefs are a centre of global marine biodiversity and important for food and livelihoods, yet increasingly are under threat.. Indonesian marine natural resources are under heavy exploitation pressure due to the open access nature of the fishery, lack of fishery management, human population growth, and fishing technique changes (Pet-Soede, 2000). While pelagic fishes are important throughout Indonesia, in eastern Indonesia, the majority of the population relies on coral reefs as a primary source of food and income (Bentley, 1999). The live reef fish food trade (LRFFT – the catching and trading, including for export of live reef fish for luxury retail markets, mainly in Chinese communities) started in the mid-1980s, as stocks of targeted species (e.g. groupers, coral trouts and wrasses) in the Philippines started to dwindle and fishers moved further south into Indonesian waters. The trade expanded considerably in the 1990s (Bentley, 1999), and is known to target spawning aggregations, particularly of grouper species.

The estimated annual export volume of live reef fish for food, and especially groupers, from Indonesia is between 2,400 and 20,000 tonnes, depending on the source of information. Official exports of LRFF (the Indonesian Directorate General of Fisheries' International Trade of Fisheries Commodities, DGF data) are not available since there is not a clear category for LRFF, by either family or species. From the categories of 'trout', 'eel', 'carp' and 'others' in DGF data, the combined annual estimated export volumes of LRFF from Indonesia were 2,400-3,800 tonnes in 1994-1996 (Bentley, 1999). Johannes & Riepen (1995) estimated that 50% of the import volumes of LRFF in Hong Kong and Singapore were from Indonesia in the mid 19a, since Indonesia was the major supply country, according to Hong Kong's import records. Based on this assumption, and on the annual estimated import volumes of LRFF in (Hong Kong) HK and Singapore, the annual estimated export volumes of LRFF from Indonesia were 8,000 tonnes in the early 1990s (Johannes & Riepen, 1995). According to case studies from different areas, and to trader and fisher interviews, Cesar (1996) estimated the annual export volumes of LRFF from Indonesia to be 10,000-20,000 tonnes. The annual declared import volumes of LRFF from all sources into HK were 13,000-23,000 tonnes in 1997-2002 based on HK official data (Census & Statistic Department, CSD; Agriculture, Fisheries & Conservation Department, AFCD). Assuming 50% is from

Indonesia, this means that 6,500-11,500 tonnes were taken from the archipelago. Taking into account the poorly resolved export data and under-estimated imports to Hong Kong (Lau & Parry-Jones, 1999), annual export volume of around 15,000 tonnes LRFF from Indonesia is likely, much of it from aggregating species of grouper, with unknown quantities taken from spawning aggregations.

Many reef fishes aggregate in large number consistently every year at specific times (often according to specific moon phases) and places (e.g. outer reef edges and reef channels) to spawn, therefore, they are highly predictable. The Society for the Conservation of Reef Fish Aggregations (SCRFA) focuses on the international conservation and management of reef fish spawning aggregations. Its main aims are to raise awareness, develop initiatives to better manage reef fish spawning aggregation as valuable and irreplaceable resources, and enhance its Global Database on the history and current status of reef fish spawning aggregations (www.scrfa.org). Since scientific literature on reef fish spawning aggregations is very limited in many countries, individual country visits serve as a valuable means of establishing contact with relevant government offices and non-governmental organisations (NGOs), and obtaining knowledge of spawning aggregations directly from fishers through interviews in their home villages. The interviews are also an excellent opportunity for fisheries officers to learn more about the resources and fishers lives and problems; we often found that officers had not asked fishers about their catches and knew little of their problems and the declining catches experienced in many areas. The global database is used to summarise, in a standardised way, our knowledge on the current status of reef fish aggregations, location and exploitation history of all known cases, and provides a strong foundation on which support for aggregation management and protection can be based.

Many fish species exploited for the LRFFT have spawning aggregation behaviour; fishers like to target aggregations because many fish can be caught, especially for buyers of live fish which often have high demand for fish. In this study, several areas in eastern Indonesia were visited; Sinjai, Pangkep and Selayar regencies in southern Sulawesi, Kei Islands in southeastern Maluku, and the Raja Ampat Regency in western Papua. Areas were selected based on the recommendations of relevant Indonesian government offices, local contacts and NGOs; these areas have been important in the Indonesian LRFF, and aquarium fish, trades (Bentley, 1999). Two data collection trips were completed to conduct fisher interviews, for size weeks between March 21st and June 5th, 2004, on the status and history of

reef fish spawning aggregations. The objectives of these trips were to 1) meet with relevant government officers to discuss spawning aggregations and associated conservation issues, and make contacts; 2) explain the aims of the SCRFA and distribute educational materials; and 3) visit fishers in villages and establish which fish species, locations and in which month(s) spawning aggregations form (if any) through interviews, either with individual fishers or with groups. In each visited area, local LRFFT history was established by talking with fishery officers, fishers and traders, as well as from published and unpublished reports and papers.

1. Methodology

Government and NGO officers and others interested in the spawning aggregation project were invited to participate in the work. In each area, relevant government offices were visited and the heads were met if possible; the goals of the SCRFA were explained and information materials distributed. Local knowledge on spawning aggregations and associated conservation issues were discussed, fishery reports or information requested and local fish markets visited, if possible, to inspect species composition. In each village visited, the purpose of the visit was explained to village leaders and fishers, and general questions asked about the history of fishing activities and the LRFFT, and local regulations. Subsequently, interviews were carried out with either individual fishers or groups of fishers, using semi-structured questionnaires developed by the SCRFA (detailed in SCRFA website). Colour pictures of fish species (both alive underwater, and dead) were provided to the fishers to aid in species identifications. However, usually the fish were not seen such that identifications could not be validated – in most cases however, identifications were consistent among interviews, and where there appeared to be doubt or inconsistencies in fish identifications, these data were not used. The latitude and longitude of the identified spawning aggregation sites were determined from top quality admiralty charts or by GPS, if the site was visited. The information collected is summarized in this report and in the SCRFA Global Database on the SCRFA website.

2. Results (by area)

2.1. Regencies Sinjai, Pangkep and Selayar, South Sulawesi Province

Sulawesi consists of five provinces; South Sulawesi, Southeast Sulawesi, Central Sulawesi, North Sulawesi and Gorontalo (**Map 1.1**), and the population, mostly Moslem, is approximately 8.2 million. Makassar (i.e. Ujung Pandang) is the capital of South Sulawesi Province (Sulawesi Selatan in Indonesian). South Sulawesi has about 5,400 km of coastline and is one of the most important marine fishery production areas in Indonesia; contributing about 8.4% of the nation's total marine production of 2.83 million tones (from all 27 provinces) in 1995 (Venema, 1997; Bentley, 1999; Pet-Soede, 2000). There are 18 regencies in South Sulawesi; Bone, Luwu and Polmas were the largest contributors to marine production, followed by Sinjai and Takalar. In this work, three regencies, Sinjai, Pangkep (i.e. Pangkajene Kepulauan; Kepulauan means 'Archipelago' in English) and Selayar, were visited; Sinjai in eastern South Sulawesi; Pangkep in western, and Selayar in southeastern Sulawesi (**Map 1.2**).

2.1.1. General information

This work was conducted in fishing villages around the islands administrated by Sinjai, Pangkep and Selayar regencies from 25-28/03/2004 and 29/05/2004-02/06/2004, accompanied by staff from the Agency for the Assessment and Application of Technology (BPPT) (Dr. M. H. Amarullah & Dr. S. I. Sachoemar), and local government officers (Mr. P. Sunoro, Mr. I. Cahyono & Mr. A. A. Bakry). Boats and cars were used for transportation, and accommodation organised in villages, as necessary. All villages visited were Moslem. A brief history of the LRFFT in the area is given in **Section 3.1.2**. History and current status of spawning aggregations are described in **Section 3.1.3.**, with other details to be found in the website database.

Sinjai Regency: The number of officially recorded fishers was about 7,500-8,500 (Report of Dinas Kelautan Dan Perikanan, Kabupaten Sinjai, 2004). Two villages were visited and ten interviews conducted; Harapan Village in P. Kambuno (= Pulau Kambuno; Pulau means 'Island' in English) and Liangliang Village in P. Liangliang (**Table 1.1; Plate 1.1a & b**). The

two visited islands belong to the Sembilan Islands, which consist of 9 islands with 7,000 villagers; Batanglampe, Bulunruwe, Burungloe, Kambuno, Kanalo, Katindoang, Kodingare, Larearea and Liangliang.

Pangkep Regency: Pangkep covers approximately 340 km² of coastal waters, including 170 islands and 600,000 residents (12,000 are fishers). Three villages were visited and eleven interviews conducted; Mattiro Bombang Village in P. Salemo, Saugi Village in P. Saugi, and Materomatae Village in P. Kondongbali (**Table 1.1; Plate 1.1c**). Mattiro Bombang Village consists of four islands; Sabanko (176 residents), Sagara (375), Sakoata (536) and Salemo (1743). The three visited islands are within the Spermonde Islands, which cover four regencies Makassar, Maros, Pangkep and Takalar, and consist of hundreds of coral reefs and islands covering an area of 16,000 km² (Pet-Soede, 2000).

Selayar Regency: Selayar is a long and narrow island lying off southeastern South Sulawesi Province. Taka Bonerate, the largest coral atoll in Southeast Asia and the third largest one in the world, is located in southeastern P. Selayar and is about 2,220 km². Since 1992, Taka Bonerate has been part of the National Park by the Decree of Ministry of Forestry. There are 21 islands in Taka Bonerate National Park, 7 of which are inhabited. A total of 6 villages (4 in Taka Bonerate, 1 in P. Selayar & 1 around P. Selayar) were visited and 11 interviews conducted (**Table 1.1; Plate 1.1d**).

Table 1.1. Eleven villages visited around regencies Sinjai, Pangkep and Selayar, South Sulawesi, from 25-28/03/2004 and 29/05/2004-02/06/2004. LRFFT, the live reef fish food trade; SA, spawning aggregation. *Ca*, *Cromileptes altivelis*; *Cs*, *Cephalopholis sonnerati*; *Cu*, *Cheilinus undulatus*; *Ec*, *Epinephelus corallicola*; *Efa*, *E. fasciatus*; *Ef*, *E. fuscoguttatus*; *El*, *E. lanceolatus*; *Em*, *E. merra*; *Ep*, *E. polyphekadion*; *Pa*, *Plectropomus areolatus*; *Pla*, *P. laevis*; *Ple*, *P. leopardus*; *Po*, *P. oligacanthus*; *Vl*, *Variola louti*. *, Sinjai; **, Pangkep; ***, Selayar. (-) no information.

NOTE: SPECIES ARE THOSE REPORTED DURING INTERVIEWS BUT WERE NOT CROSS-CHECKED WITH SPECIMENS

Village (Island) (No. families/population in Is.) (Date for interview) (Year LRFFT started)	Type of interview (number)	Main fishing boats / gears / reef fish species	Fishers' concerns & village regulations
Harapan (Kambuno)* (-) (25-26/03/04) (1991)	Individual (4) Group of 2 fishers (1)	Rowboat, motorboat; Trap, hook-&-line, compressor, cyanide; <i>Ef, Ep, Pa, Ple, Po.</i>	1. Concerned about the decline of catch; 2. Should eliminate compressor divers associated with cyanide from fishing, only use hook-&-

			line; 3. Should prevent outside fishers come in; 4. Need to go further to fish; 5. Need alternative livelihoods.
Liangliang (Liangliang)* (-) (26/03/04) (1991)	Individual (5)	Rowboat, motorboat; Trap, hook-&-line, compressor, cyanide; <i>Cs, Ef, Ep, Pa, Pla, Ple, Po.</i>	1. Concerned about the decline of catch; 2. Should eliminate compressor divers associated with cyanide from fishing, only use hook-&-line; 3. Should protect SA; 4. Need alternative livelihoods.
Mattiro Bombang (Salemo)** (-/1743) (27/03/04) (1990)	Individual (3)	Rowboat, sailboat, motorboat; Trap, hook-&-line, compressor, cyanide; <i>Cu, Ef, El, Ep, Ple.</i>	1. Concerned about the decline of catch and fish getting smaller; 2. Should stop cyanide; 3. Need alternative livelihoods; 4. Protected areas set up in 2004.
Saugi Village (Saugi)** (-) (27/03/04) (1990)	Individual (2)	Rowboat, sailboat, motorboat; Trap, hook-&-line, compressor, cyanide; <i>Cu, Ef, El, Ep, Pa, Ple.</i>	1. Need alternative livelihoods; 2. Should stop cyanide & use trap & net.
Materomatae (Kondongbali)** (214/-) (28/03/04) (1999)	Individual (6)	Rowboat, sailboat, motorboat; Trap, hook-&-line, net, compressor, cyanide; <i>Cu, Ef, Ep, Pa, Ple, Po.</i>	1. Prohibited cyanide use since Dec 2002; 2. Outside fishers are not allowed to come in to fish since Dec 2002; 3. Prohibit targeting grouper, coral trout & angelfish during their spawning season since Dec 2002.
Tarupa (P. Tinabo Besar)*** (11/-) (29/05/04) (1995)	Individual (1) Group of 4 fishers (1)	Motorboat; Hook-&-line; <i>Cs, Ec, Pla, Ple, Po.</i>	1. Concerned about the decline of catch due to the increase of fishers both from outside & local areas; 2. Prohibit cyanide explosive & trawling fishing since 1992 due to implementation of Taka Bonerate National Park.
Rajuni (P. Rajuni Besar)*** (80/302) (30/05/04) (1995)	Group of 3 fishers (1)	Motorboat; Trap, hook-&-line; <i>Ca, Cu, Ec, Ef, Pa, Pla, Ple.</i>	Same as above.
Latondu (P. Latondu Besar)*** (128/594) (30/05/04) (1988)	Group of 2-5 fishers (2)	Motorboat; Hook-&-line; <i>Ca, Efa, Ef, Ep, Pa, Pla, Ple, Po.</i>	Same as above.
Tarupa (P. Tarupa Besar)*** (140/648)	Group of 6 fishers (1)	Motorboat; Hook-&-line;	Same as above.

(30/05/04) (1995)		<i>Cs, Cu, Em, Ple, Lutjanus</i> species.	
Jinatu (P. Jinatu)*** (156/847) (31/05/04) (1989)	Individual (2) Group of 2 fishers (1)	Motorboat; Trap, hook-&-line, compressor; <i>Cu, Ef, Ep, Pa, Pla, Ple, Vl.</i>	1. Concerned about the decline of catch due to the increase of fishers both from outside & local; 2. Concerned about compressor fishing associated with cyanide; 3. Need to go further & deeper to fishing, & look for new sites; 4. Prohibit cyanide, explosives & trawling since 1992 due to development of Taka Bonerate National Park.
Appatanah (Selayar)*** (-) (02/06/04) (1996)	Group of 3 fishers (1)	Motorboat; Hook-&-line; <i>Pa, Pla, Ple.</i>	1. Concerned about the decline of catch due to the increase of fishers both from outside & local; 2. Need to go further to fish; 3. Many fishers shifted to lobster fishing since 2000.
Pasi (Pasi)*** (-) (02/06/04) (1994)	Group of 2 fishers (1)	Motorboat; Hook-&-line; <i>Ca, Cu, Pa, Ple.</i>	1. Most fishers shifted to other activities, e.g. farming & transportation, due to low fish catch volume.

2.1.2. Brief history of the live reef fish food trade (LRFFT) in South Sulawesi

In South Sulawesi Province, Makassar is an important transit centre for LRFF export by air. Live reef fish from different regencies (e.g. Pangkep, Sinjai and Selayar) are shipped to Makassar by motorboats with holding tanks and/or by road using truck (about 100 kg fish in each holding tank) (**Plate 1.2a**). In some islands of Selayar, LRFF are also shipped directly to Bali by boats and then by air for export. Besides shipping by air, HK-based vessels also come to collect fish (see below).

There are about 10-20 LRFF traders in Makassar; before there were only 4. The demand for LRFF is always more than can be supplied according to a trader interviewed (Mr. Arfan Siga). In his holding capacity, the main species is *Plectropomus leopardus*, with a few *P. areolatus* and *Epinephelus fuscoguttatus*, and the body sizes are getting smaller than before, 1-2 kg/fish now. About 120 kg LRFF are exported daily to Hong Kong via Jakarta by air by

his business (about 40 tonnes annual export volume). The annual export volume of *Cheilinus undulatus* was about 1 tonne from 1990-1996, and it are none now because fishers cannot catch any, according to the trader.

Sinjai Regency: Bêche-de-mer, octopus, crab, shrimp and fish (pelagic and reef fish sold as fresh dead or dried/salted) fishing were the main activities before the LRFFT, which started in 1991 (**Table 1.1**). Official recorded annual grouper production (including dead fish landing data and live fish reported by traders) was about 160 tonnes in 2000-2002 in Sinjai; about 85 tonnes in 2003 from the Sembilan Islands (Report of Dinas Kelautan Dan Perikanan, Kabupaten Sinjai, 2004). Fishers agree that the LRFFT brings good income, but noted the catch volumes of many species are declining and they are facing real difficulties in maintaining that income; they have to go further to maintain the catch. There is a great interest in developing alternative livelihoods, such as mariculture, crab and octopus fishing to take pressure off the live reef fish fishery (**Table 1.1**).

In the Sembilan Islands, there are about 30 traders; 2 or 3 HK-based vessels (with about 12-15 tonnes/vessel in capacity) per month ship groupers and coral trouts to HK, according to local traders. Each trader has at least one unit of holding cages, i.e. about 2-4 net cages of 3 × 3 × 3 m together (**Plate 1.2b**). The conservative annual estimated export volumes of the LRFF from the Sembilan Islands by vessel, therefore, are about 300 tonnes from our findings, much higher than the official recorded data (i.e. 85 tonnes).

The main fishing gears are hook-and-line (traditional method), and compressor and cyanide (introduced with the LRFFT in 1991). A tiny metal tube with sharp tip on one end is used to release air from swim bladder after fish are caught (**Plate 1.2c**). Fishers go fishing daily by rowboats or motorboats mainly with 15 HP engines, except on Fridays in Moslem villages (prayer day for Moslems), and sometimes stay at sea overnight for up to several days if there is sufficient holding capacity on boats (**Plate 1.2d & e**). During bad weather (i.e. east season, May to September), fishers may go to other places to fish (e.g. Sorong and Manado), or stay at home.

Prices of LRFF do not differ between fish with eggs and with no eggs, and by season, but do differ among areas (**Appendix 1**). Fishers sell fish to particular traders since the traders

sometimes lend money to fishers and provide equipment such as engines and holding cages in return for access to their catches.

Fish grow-out activity started in 1991-1992 in the Sembilan Islands when fishers realized that HK traders wanted certain sizes of fish. Small, undersize fish, about 100-500 g, are collected by traps, cyanide and hook-and-line, and cultured (i.e. grown out) in holding cages and fed 'trash' fish.

Cheilinus undulatus were once common in the Sembilan Islands, but are now rare at all sizes. Before the LRFFT, *Cheilinus undulatus* were caught by hook-and-line, using red tilefish as bait, and traps for fishers' own consumption, or dried for sale. Catch declined substantially after cyanide fishing (the main gear for this species now) was introduced, according to fishers; only 1-3 fish/year/fisher at about 5 kg/fish are now taken of this species. The catch volume of *Cheilinus undulatus* by cyanide divers is unknown since the divers know that cyanide is an illegal fishing technique and keep their catches secret. Small, undersize *Cheilinus undulatus* are kept in holding cages for about 3-6 months to grow to market size, before been exported.

Pangkep Regency: The LRFFT started in 1990 in Pangkep, and in more remote areas such as P. Kondongbali, the trade started in 1999; mainly focusing on coral trout and grouper. Before the LRFFT, reef fish were sold as dried/salted, or for fishers' own consumption. Besides live reef fish, crab, bêche-de-mer, cuttlefish, shark and pelagic fish fishing also occur. Catch volumes of LRFF have declined in Pangkep, according to several indicators: fishers now have to go further to maintain their catches; fish body size is smaller; and fishers must use more hooks. In P. Kondongbali, catch volumes of bêche-de-mer have also declined, from 30 individuals/day/boat (in 1995, the year the trade started) to 2-3 individuals/day/boat now. Compressors were supplied by traders in 1997 to fishers to enable them to go deeper (> 20 m) for bêche-de-mer.

The main fishing gears are hook-and-line, trap, net, compressor and cyanide (**Plate 1.3a & b**). Fishers go fishing daily in the daytime or at night (except Friday, prayer day for Moslems), or stay at sea overnight. Most fishers have rowboat, sailboat or motorboat with 15 HP engine (**Table 1.1; Plate 1.3c**). In remote areas such as P. Kondongbali and P.

Kapoposang, live reef fish are shipped to Makassar by vessels with holding tanks; about 100 kg every 2-3 days (**Plate 1.3d**).

The reef areas near the Pangkep coast are possibly nursery grounds for several fish species, e.g. *Epinephelus lanceolatus* and *Cheilinus undulatus*; most fish caught are at 100-500g/fish. These juveniles have been targeted intensively by hook-and-line (up to 20-30 boats in an area) for a long time for fishers' own consumption or dried for sale. These species have shown a decline in catch according to local fishers. As one example, catch volumes of *Cheilinus undulatus* were 3-10 fish/day/boat with 100-300 g/fish 10 years ago, with plenty around P. Salemo beaches 20 years ago. Since then, catch volumes have declined markedly and the species is now rare in the area; 5 fish/month/boat. Since 2003, *Cheilinus undulatus* juveniles have been sold to traders, who keep them in holding cages for grow out to market size before exported.

Cheilinus undulatus adults were common around P. Kondongbali about 200-300 fish/year/fisher with 20 kg/fish, in the 1970s and sold dried according to fishers. In 2000, about 1,000 *Cheilinus undulatus* with > 60 cm TL were exported from this area. Since December 2002, several village regulations have been introduced, including a prohibition on fishing *Cheilinus undulatus* (**Table 1.1**).

Selayar Regency: The LRFFT started in 1988, but in most areas in the mid 1990s (**Table 1.1**). Major species are coral trout and groupers (**Plate 1.4a**). Before the LRFFT, reef fish were sold as fresh dead or dried/salted, or for fishers' own consumption. Bêche-de-mer, shark (for fins), squid and pelagic fish fishing also occur (**Plate 1.4b & c**). Catch volumes of LRFF have declined according to fishers interviewed: they now have to go further to maintain their catches; they are looking for new fishing grounds; some fishers have stopped fishing live reef fish, and shifted to lobster fishing (e.g. Appatanah Village), farm or use fishing boats for transportation (e.g. Pasi Village). In Appatanah Village, catch volume of lobster has shown a decline just four years after the trade started in 2000; from > 50 kg/week lobster two years ago to 30-40 kg/week now.

In Taka Bonerate National Park, approximately 6 tonnes of LRFF per month are shipped to Makassar and Bali by vessels and then by air to HK, according to local traders. During the spawning seasons of September-November, more fish are caught and shipped. Outside fishers

(e.g. Sinjai, Makassar & other islands in Selayar Regency) fishing inside the park also sell fish to villagers with holding cages. The estimated annual export volumes of the LRFF from the park by air, therefore, are about 80 tonnes.

The main fishing gears are hook-&-line, nets and traps; compressor (introduced in 1986 for *bêche-de-mer*) fishing is allowed. Cyanide associated with compressor diving and explosive are the major problems in the area, according to local government officers and fishers; used by both outside and local fishers. Fishers go fishing daily in the daytime or at night (except Friday, prayer day for Moslems) by motorboats; sometimes stay at sea overnight for up to several days if there is sufficient holding capacity on boats.

Prices of some LRFF species have declined in Selayar; e.g. *Plectropomus leopardus*, from 150,000-160,000 Rp/kg five years ago to 60,000-80,000 Rp/kg now.

There is no fish grow-out activity in Selayar. Around P. Pasi, fishers usually catch small *Plectropomus areolatus* and *P. leopardus* of around 100-500g, per fish. All these small fish are shipped to Makassar or Bali according to local traders; whether these small fish will grow out or be exported is unknown. In P. Tarupa Besar, there are set nets in shallow waters for fish grow out, but no fish inside according to the cage owner (**Plate 1.4d**).

Cheilinus undulatus are caught by trap, hook-&-line and cyanide in the area; fish sold as dried with 1,500 Rp/kg before the LRFF. *Cheilinus undulatus* is rare and never common around P. Selayar; 1-2 fish/year according to local fishers. In Taka Bonerate National Park, *Cheilinus undulatus* was common; the catch volume and fish size have shown a decline. In 1997, HK traders introduced cyanide to catch *Cheilinus undulatus* in the park; fishers saw about 20 cyanide boats in a fishing site, but the catch volume was unknown. After 1997, Bali traders introduced traps to catch *Cheilinus undulatus*; the catch declined from 10 fish/day to 1-5 fish/day now in north of the park. In P. Pasitallu, south of the park, 5 fish/day/boat with > 30 kg/fish by hook-&-line 10 years ago before the LRFF to 1 fish/year now; fish size declined from 5-10 kg/fish to maximum 5 kg/fish. Since 2002, no traders have been interested in purchasing *Cheilinus undulatus*, according to local fishers, due to the national regulation for *Cheilinus undulatus* export. Therefore, fishers consume the fish when these are caught occasionally.

2.1.3. Spawning aggregations

Sinjai Regency: Six spawning aggregations were identified along reef edges out from the Sinjai coast and up to the north, formed by *Epinephelus polyphekadion* and *Plectropomus areolatus* (**Table 1.2**). Most of these sites have been known for many years, but only started being intensively fished after the LRFFT started (live reef fish demand increased from traders). After learning of the sites and seasons for fish aggregations, some fishers focused on aggregations because they can catch fish more efficiently at this time, and shifted to other fishing activities, such as pelagic fish, bêche-de-mer and octopus in non-aggregation seasons. Within these six targeted spawning aggregations; three have declined clearly in catch volume compared to 5-10 years ago and two declined within the last 4 years (**Table 1.2; refer to SCRFA database**).

Pangkep Regency: Five spawning aggregations were identified around reef areas and islands in Pangkep formed by *Epinephelus fuscoguttatus*, *E. lanceolatus*, *E. polyphekadion* and *Plectropomus areolatus* during this work (**Table 1.2**). Most of these sites have been known for many years; fish were sold as dried/salted or for fishers' own consumption before the LRFFT, and kept live after the LRFFT. Within these five targeted spawning aggregations; three have declined clearly in catch volume and fish body size over 5-10 years, and the other two have shown a decline (**Table 1.2; refer to SCRFA database**).

Selayar Regency: Thirteen spawning aggregations were identified around reef edges of Taka Bonerate National Park formed by *Epinephelus corallicola*, *E. fuscoguttatus*, *E. polyphekadion*, *Plectropomus areolatus* and *P. leopardus* during this work (**Table 1.2**). Most of these sites have been known for many years; fishers use facemasks to look for higher densities of fish during aggregation seasons. Within these targeted spawning aggregations; 11 out of 13 aggregations declined in catch volume over 5-10 years (**Table 1.2; refer to SCRFA database**). Fishers have stopped targeting 4 aggregations of *Plectropomus areolatus* since 1999 because the catch volume declined substantially. After learning of the sites and seasons for fish aggregations, most fishers focused on fishing aggregations since they found they could catch many fish very efficiently.

Table 1.2. Twenty-four spawning aggregations with four species around Sinjai, Pangkep and Selayar, South Sulawesi were identified. To protect the sites, the locations were not listed here. *, in Sinjai; **, in Pangkep; ***, in Selayar. ^a, compared to last 1-4 years; ^b, compared to last 5-10 years. ‘A’ superscript refers to individual aggregations; (-) no information.

Species name (No. aggregations identified) (Aggregation category)	Current status of aggregations	Change in catch (kg or fish/day/boat)	
		Non-spawning aggregation seasons	Spawning aggregation seasons
<i>Epinephelus polyphemadion</i> (4) (A1-A4)*	No change (A1) ^a ;	-	Stable at 20-40 kg/day/boat; About 20-30 boats.
	Decline 75% (A2) ^b ;	-	From 20 kg/day/boat to 5 kg/day/boat now; About 40 boats.
	Decline 15-20% (A3) ^a ;	10 kg/day/boat	From 120 kg/day/boat to 100 kg/day/boat now; About 10-20 boats.
	Decline 25-85% (A4) ^a .	-	From 60-70 kg/day/boat to 10-50 kg/day/boat now; 2-3 kg/fish; About 10-20, up to 50 boats.
<i>Plectropomus areolatus</i> (2) (A5 & A6)*	Decline 50% (A5) ^b ;	-	From 20 kg/day/boat to 10 kg/day/boat now; About 40 boats.
	Decline 40-70% (A6) ^b .	-	From 50 kg/day/boat to 15-30 kg/day/boat now; 1-2 kg/fish; About 10-20, up to 40 boats.
<i>Epinephelus fuscoguttatus</i> (1) (A1)**	Decline 60% (A1) ^b .	-	From 5-6 fish/day/boat to 2 fish/day/boat now; 10 kg/fish; Fish body size declined.
<i>Epinephelus lanceolatus</i> (1) (A2)**	No change to decline slightly (A2) ^b .	-	200-400 kg/day/boat now; 30 kg/fish; About 30 boats.
<i>Epinephelus polyphemadion</i> (1) (Aggregation 3)**	Decline 75% (A3) ^b .	-	3-5 fish/day/boat now; 5-7 kg/fish; About 30 boats.
<i>Plectropomus areolatus</i> (2) (A4 & A5)**	No change to decline slightly (A4) ^b ;	-	10 kg/day/boat now; Fish body size declined from 3 kg/fish to 2 kg/fish.
	Decline 75% (A5) ^b .	-	2-5 fish/day/boat now; Fish body size declined; 1.5-2 kg/fish.
<i>Epinephelus corallicola</i> (2) (A1 & A2)***	Decline 25-40% (A1 & A2) ^b .	-	30 fish/day/boat now; Up to 2 kg/fish.
<i>Epinephelus fuscoguttatus</i> (3) (A3-A5)***	No change (A3 & A4) ^b .	-	5-10 fish/day/boat now; 5-15 kg/fish.
	Decline (A5) ^b .	-	5 fish/day/boat now; Up to 10 kg/fish.

<i>Epinephelus polyphekadion</i> (1) (A6)***	Decline (A6) ^b .	Do not catch this species.	8-10 fish/day/boat now; 1.5 kg/fish.
<i>Plectropomus areolatus</i> (5) (A7-A11)***	Decline (A7) ^b . Decline 60% (A8- A11) ^b .	- -	10-20 fish/day/boat now. Stop fishing in the sites now; 50 fish/day/boat in 1995 to 20 fish/day/boat in 1999.
<i>Plectropomus leopardus</i> (2) (A12 & A13)***	Decline (A12 & A13) ^b .	Do not catch this species.	10-25 fish/day/boat now.

2.1.4. Regulation and management

Sinjai, although there are no local regulations, fishers are concerned about the decline in catches, especially during spawning aggregations. They would like to eliminate compressor divers, associated with cyanide use, and develop alternative livelihoods, such as mariculture, crab or octopus fishing (**Table 1.1**).

Pangkep, the main concern of local government is the use of cyanide, which is considered to destroy coral habitat, although evidence for this was not presented when requested. A 6-year project is being carried out by local government on developing grouper culture and coral management, but there are apparently no plans for fish stock management.

Some village regulations have been carried out since local fishers were concerned about the decline of local resources. In Materomatae Village, P. Kondongbali, several regulations were introduced since December 2002, soon after the LRFFT started in the area (in 1999): cyanide was prohibited, following losses of cultured seaweed (cyanide was believed to be the cause) and concerns that fish may not come back after its use; outside fishers have been chased away; groupers, coral trout and angelfis fishing have been prohibited during their own spawning seasons; and *Cheilinus undulatus* fishing has been prohibited in all months (**Table 1.1**).

Around P. Sabanko, P. Sakoata, P. Sagara and P. Salemo (Mattiroy Bombang Village), protected areas were set up in two reefs (Torajae & Gusung) in 2004 (No. 078/DMBB/III/2004) (**Table 1.1; Plate 1.5**). In the core area 'Zona Inti', no fishing activity is allowed year-round, except during Syafar (the month of May in Moslem Calendar). In a buffer area 'Zona Penyangga', fishers can only use hook-and-line and other recommended traditional fishing gears.

Selayar, the main fishing grounds are in the Taka Bonerate National Park, which was set up in 1992. Local and outside fishers are allowed to fish inside the park by using hook-&-line, trap, set net and compressor. In the park, cyanide, explosive and trawling fishing are prohibited, but these destructive fishing techniques are still used according to government officers and local fishers, and cyanide is associated with compressor diving.

2.2. The Kei Islands, The Southeast Maluku Regency, Maluku Province

Maluku has an area of 850,000 km²; 90% water and 10% islands (about 1000 islands). The Kei Islands are located within the Southeast Maluku Regency, Maluku Province, which consists of about 80 islands (**Map 2.1**). In the Kei Islands, the largest islands are Kei Kecil (2,470 km²) and Kei Besar (580 km²), and the population is about 125,000, with 76,000 living in Kei Kecil. Tual is the capital of both the Regency and the Kei Kecil District, consisting of three islands, Dullah, Kei Kecil and Fair. The majority of residents are Moslems, followed by Christians. The language widely used in the Kei Islands is 'Kei' rather than Bahasa Indonesian. Most villagers are farmers and fishers. Copra and nutmeg businesses used to be the main farming activities and income sources in the area. Since the decline in their prices, people have started to fish more intensively or to work in town.

2.2.1. General information

Work was conducted around the Kei Islands from 31/03/2004-07/04/2004, accompanied and organized by Pastor Ulahayana Agus (local priest) who wanted to know more about local marine natural resources to help local villagers and also acted as translator for most visits. Mr. Bosco (local NGO officer) and Mr. Yos (translator when Pastor was away) also assisted in some of the interviews. Our residence was in Vilia Hotel, P. Kei Kecil (=Pulau Kei Kecil; Pulau means 'Island' in English), and speedboats and cars were used for daily transportation.

Six fishing villages were visited and 7 group interviews conducted, either individually or in group of fishers in the Kei Islands (**Map 2.1; Plate 2.1a**); general information is summarized in **Table 2.1**. All villages are Moslem except Dulahlaut Village on P. Duroa, which is Christian. A brief history of the LRFFT in the area is given in **Section 3.2.2**. History and current status of spawning aggregations are briefly discussed in **Section 3.2.3** with detailed information on spawning aggregations available in the database (www.scrfa.org).

Table 2.1. Six villages visited around the Kei Islands, Maluku, from 31/03/2004-07/04/2004. LRFFT, the live reef fish food trade; SA, spawning aggregations. *Ca*, *Cromileptes altivelis*; *Cu*, *Cheilinus undulatus*; *Ef*, *Epinephelus fuscoguttatus*; *Em*, *E. maculatus*; *Ep*, *E. polyphekadion*; *Pa*, *Plectropomus areolatus*; *Pla*, *P. laevis*; *Ple*, *P. leopardus*; *Vl*, *Variola louti*.

Village (Island) (No. fishers) (Date for interview) (Year LRFFT started)	Type of interview (number)	Main fishing boats / gears / reef fish species	Fishers' concerns & village regulations
Labitawi (Dullah) (-) (31/03/04) (1985)	Individual (1)	Rowboat, sailboat, motorboat; Traps, hook-&-line, compressor; <i>Cu, Ef, Ep, Pa, Pla, Ple.</i>	1. Should eliminate compressor divers target SA; 2. Should stop explosive fishing; 3. Prohibit compressor diving since 2003, regulated by Navy.
Dian (Kei Kecil) (50-60) (31/03/04) (1996)	Group of 10 fishers (1)	Rowboat, sailboat, motorboat; Hook-&-line, spear; <i>Ef, Ep, Ple.</i>	1. Concerned about too many fishers & traders; 2. Should avoid outside fishers coming in; 3. Prohibit shallow water fishing around village.
Languar Feer (Kei Besar) (70) (01/04/04) (1993)	Group of 5 fishers (1)	Rowboat, sailboat, motorboat; Hook-&-line, spear, compressor; <i>Cu, Ef, Ep, Ple.</i>	1. Need traders come to collect fish regularly; 2. Prohibit outside fishers (from Makassar & Bali) by chasing them away; 3. Prohibit using facemask to look for SA; 4. Prohibit compressor diving in SA seasons.
Tayandu Temtel (Walir) (100-150) (02/04/04) (Not yet)	Individual (1) Group of 5 fishers (1)	Rowboat, sailboat; Trap, hook-&-line, spear; <i>Ca, Cu, Ef, Em, Ep, Pa, Ple, Vl.</i>	1. Prohibit cyanide & compressor, regulated by the pearl farm near by & the village; 2. No concern about fishery since plenty of fish around.
Tawinohoi (Duroa) (1,000-1,500) (07/04/04) (1997)	Individual (1)	Rowboat, motorboat; Trap, hook-&-line, spear, compressor; <i>Cu, Ef, Ep, Ple.</i>	1. Concerned about the declines of catch volume and fish size, especially during SA; 2. Should eliminate outside fishers (from Thailand & Korea) who use cyanide in the area, which kills coral and makes it easy to catch fish.
Dulahlaut (Duroa) (100) (07/04/04) (1997)	Group of 2 fishers (1)	Rowboat, motorboat; Trap, hook-&-line, set net, spear; <i>Cu, Ef, Ep, Ple.</i>	Same as Tawinohoi Village.

2.2.2. Brief history of the live reef fish food trade (LRFFT) in the Kei Islands

Dead fish trade occurs locally, and with Java and elsewhere within Indonesia. Since there is only one cold storage company in the area, and none in villages, the LRFFT is a good

option providing income for fishers. Fishers also catch trochus (local name: Lola; **Plate 2.1b**), bêche-de-mer (sea cucumber), and farm. There is no grow-out activity of sub-size fish in holding cages in the Kei Islands, but fishers asked for information on grouper culture. In Dian, villagers made a pond by closing a shallow mangrove area (**Plate 2.1c**) to culture rabbitfish (seeds from wild), and are planning to culture *Epinephelus fuscoguttatus*.

Fishers go fishing by rowboat, sailboat or motorboat (mainly with 15 HP engine); fishing gears are traps, hook-and-line, spear, set nets (local name: Sero), compressor and cyanide (**Table 2.1; Plate 2.1d**). Compressors were introduced in the 1970s for bêche-de-mer (e.g. Languar Feer Village) from Madura Island, East Java and also in the 1990s associated with cyanide use for LRFF by trade companies (e.g. Labitawi, Languar Feer and Tawinohoi villages). Fishing activity depends on seasonal weather with daily trips, except on Fridays in Moslem villages, when the weather is good.

The LRFFT started in 1985 when HK companies first entered the Kei Islands; many villages visited started in the 1990s, but trade does not appear to have reached more remote areas (e.g. Tayandu Islands), such as Tayandu Temtel Village in Walir (**Table 2.1**). Fishers in Tayandu Temtel Village in Walir catch reef fish for their own consumption, or for sale in their own village (it is too far, and they have no ice to preserve fish, to sell fish in Tual, the main town in the region, and 3-4 hours by motorboat). So far, there are about 8 businesses, which share two HK-based transport vessels for LRFF export in the Kei Islands; 4-15 tonnes LRFF/month/vessel are exported, and about 200-300 *Cheilinus undulatus* fish/vessel. All major LRFFT species (e.g. *Cheilinus undulatus*, *Cromileptes altivelis*, *Epinephelus fuscoguttatus*, *E. polyphekadion*, *Plectropomus leopardus* and *P. areolatus*) can be found in the Kei Islands. Problems that fishers face in the LRFFT are not having enough money to buy equipment to improve fishing gear (e.g. engines), or to acquire cages to hold live fish prior to shipment. Fishers cannot catch fish quickly enough to fill live fish vessels to keep up with demand from live fish buyers; and traders do not come to collect fish regularly. Fishers also have to share the risk of the LRFFT with the traders. As one example, fishers have to hold fish and wait for transport vessels (2-4 weeks or longer); essentially absorbing the cost of holding fish between capture and shipment (i.e. costs due to mortality and feeding). Alternatively, fishers are told they will get paid a higher price after traders sell the fish in HK, but may not get paid at all if the traders lose money due to high mortality during transportation between Indonesia and Hong Kong.

Traders are reported to control live reef fish prices, with prices depend on species, body size and area, even village (**Appendix 1**); top priced fish are *Cheilinus undulatus* and *Cromileptes altivelis*, follow by *Plectropomus leopardus*, and then the others. Fish with eggs have higher mortality (10-15%) than those without eggs (< 5%) in holding cages; higher mortality is also experienced with deeper water fish, probably because of swim bladder expansion. Fishers are interested to know about any medicine that can reduce fish mortality.

Cheilinus undulatus are still plenty in some areas of the Kei Islands but hard to catch according to fishers (3 out of 6 villages visited); about 1-5 fish/day/boat at all sizes currently. Small fish are caught by trap, and large fish by hook-and-line and spear. The preferred sizes of *Cheilinus undulatus* for the traders are 30-60 cm and < 5 kg (**Appendix 1**). In the area where compressors are associated with cyanide have been used for the LRFFT (e.g. P. Duroa), the catch volume of *Cheilinus undulatus* has declined from 2-3 fish/day/boat in the mid 1990s (before the LRFFT) to 1 fish/month/boat nowadays. In Labitawi village, Dullah, fishers think that the numbers of this species have not changed over time; they commented that catch volumes of larger *Cheilinus undulatus* declined, while smaller ones increased.

2.2.3. Spawning aggregations

Six spawning aggregation sites were identified around the Kei Islands during this work for *Epinephelus fuscoguttatus*, *E. polyphkadion* and *Plectropomus areolatus* (**Table 2.2**). All these sites have been known for many years, but started being intensively targeted after the LRFFT came into the area.

Spawning aggregations are targeted using traditional fishing methods (e.g. hook-and-line) and compressors. The catch of all hook-and-line fishers interviewed declined compared to the early 1990s before the LRFFT started; a suggestion of over-fishing (**Table 2.2**). The reasons suggested by fishers were that (1) the numbers of fishers and traders have increased, (2) fish with eggs do not come out of their refuge to take bait or (3) fish do not like the bait; therefore, fishers try to find new bait. Signs of over-fishing also include fishers looking for new fishing grounds, moving further to maintain catches, needing outboard boats to move further away, and body size of fish caught has decreased. The catch of compressor divers shows no trend according to those interviewed; there was no change in catches over time in three aggregations, and show declines in two others. Where there appears to be no LRFFT (e.g.

Tayandu Islands), the marine natural resources appear to be in good condition; fishers only go fishing around (i.e., close to) the islands and do not typically look for aggregation sites to catch more fish.

Table 2.2. Six spawning aggregations with three species around the Kei Islands, Maluku were identified. To protect the sites, the locations are not listed here. *Compared to the early 1990s before the LRFFT started.

Species name (No. aggregations identified) (Aggregation category)*	Current status of aggregations*		Change in catch*	
	Compressor diver	Hook-&-line fisher	Compressor diver	Hook-&-line fisher
<i>Epinephelus fuscoguttatus</i> (3) (A1-A3)	No change (A1) No change (A2) Decline (A3)	Decline (A1) Decline (A2) Decline (A3)	- - From 30-40 fish/day/boat to 1-2 fish/day/boat now; Fish size smaller now; Saw 100 fish underwater to only 10 now.	- - From 20 kg/day/boat to 5 kg/day/boat now.
<i>Epinephelus polyphkadion</i> (1) (A4)	Decline (A4)	Decline (A4)	From 30-40 fish/day/boat to 1-2 fish/day/boat now; Fish size smaller now; Saw 100 fish underwater to only 10 now.	From 20 kg/day/boat to 5 kg/day/boat now.
<i>Plectropomus areolatus</i> (2) (A5 & A6)	Increase (A5) Decline (A6)	Decline (A5) Decline (A6)	From 10 fish/day/boat to 20-30 fish/day. Saw 10 fish underwater to only a few now; Fish size smaller now.	- -

2.2.4. Regulation and management

Export of *Cheilinus undulatus* needs a permit according to national regulations (HK.330/DJ.8259/95 and HK.330/S3.6631/96). Both live reef fish trade vessels buying fish from the Kei Islands (**Section 3.2.2**) export *Cheilinus undulatus*, although one of them reportedly does not have a permit.

Compressors were introduced into the Kei Islands in the 1970s for bêche-de-mer fishing and there are about 40 units in the area now. It is clear that compressor divers target the spawning aggregations intensively in the area (**Table 2.2**). As one example, there are up to 10 compressor units targeting aggregations 3, 4 & 6 during spawning seasons (**Table 2.2; refer to SCRFA database**). Compressor fishing has been prohibited and enforced by the Indonesian Navy around Dullah since 2003 (**Table 2.1**); it is unknown when this prohibition applies to all the Kei Islands.

Several villages visited are concerned about their local marine natural resources and have local regulations (**Table 2.1**). For instance, Languar Feer Village prevents violations by chasing outside fishers (e.g. Makassar and Bali) away, does not allow use of a facemask to look for the aggregation sites and compressor diving on Aggregation 5 site (**Table 2.2**), during the spawning aggregation, is prohibited. In the same village, trochus collection is prohibited for several years to allow for regeneration. Dian Village prevents fishers fishing in shallow waters around the village. This may protect Aggregation 2 site (**Table 2.2**) a major fishing ground of the village. Tayandu Temtel Village and the pearl farm nearby do not allow cyanide and compressor use locally.

2.3. The Raja Ampat Regency, Papua Province

There are 14 administrative Regencies (Regency is ‘Kabupaten’ in Indonesian) in Papua Province (i.e. Irian Jaya), including Raja Ampat (meaning ‘The Four Kings’ in English) Regency. Raja Ampat is located in western Papua and consists of the four large islands of Waigeo, Batanta, Salawati and Misool and more than 600 smaller islands (**Map 3.1**). The population is approximately 48,700 in area, and most inhabitants are Christians. There are 89 villages in the Regency, traditionally living on a subsistence economy. With the growth of the cash economy, however, the villages have become more dependent on marine natural resources as a commercial commodity, such as bêche-de-mer, shark fin, lobster, trochus and reef fish. The language widely used in Raja Ampat is Bahasa Indonesian. The Raja Ampat Regency lies in the heart of the ‘Coral Triangle’, a geographic area that encompasses the world’s greatest coral reef and near-shore biodiversity, and at least 1,000 coral reef fish species (Donnelly *et al.*, 2003).

3.3.1. General information

Work was conducted around south Waigeo and nearby islands from 12-15/04/2004, accompanied by Mr. A. H. Muljadi (officer from The Nature Conservancy, Sorong), and Mr. P. Thebu (fishery officer from the Raja Ampat Regency). Our residence was at the Papua Diving Base (the only diving club in Raja Ampat) in P. Kri, and a speedboat with two 180 HP engines was used for transportation.

Twelve interviews were conducted either individually or in group of fishers in seven different villages (**Map 3.1; Plate 3.1a**); general information is summarized in **Table 3.1**. Salio Village in Waigeo (86 families with 480 members) was also visited, which only focuses on bêche-de-mer and lobster fishing. All villages are Christians except Bianci Village, which is Moslem. A brief history of the LRFFT in Raja Ampat is given in **Section 3.3.2**. The history and current status of spawning aggregations is briefly discussed in **Section 3.3.3** with detailed information on spawning aggregation available in the database of the SCRFA (www.scrfa.org).

Table 3.1. Eight villages visited around Waigeo, Raja Ampat, from 12-15/04/2004. LRFFT, the live reef fish food trade; SA, spawning aggregations. *Ca*, *Cromileptes altivelis*; *Cs*, *Cephalopholis sonnerati*; *Cu*, *Cheilinus undulatus*; *Ec*, *Epinephelus caeruleopunctatus*; *Ef*, *E. fuscoguttatus*; *El*, *E. lanceolatus*; *Ep*, *E. polyphekadion*; *Pa*, *Plectropomus areolatus*; *Ple*, *P. leopardus*.

Village (Island) (No. families/members) (Date for interview) (Year LRFFT started)	Type of interview (number)	Main fishing boats / gears / reef fish species	Fishers' concerns & village regulations
Airborek (Airborek) (21/117) (12/04/04) (2002)	Individual (3)	Rowboat; Hook-&-line, spear; <i>Cs</i> , <i>Ec</i> , <i>Ef</i> , <i>El</i> , <i>Ep</i> , <i>Pa</i> , <i>Ple</i> .	1. Need traders to come to collect fish regularly; 2. Concerned about set up protected areas; 3. Regulation in 1995 prohibited compressor, explosives, cyanide fishing.
Yenwaopnor (Gam) (50/273) (12/04/04) (1999)	Individual (1)	Rowboat, motorboat; Hook-&-line, spear; <i>Ca</i> , <i>Cu</i> , <i>Ec</i> , <i>Ef</i> , <i>El</i> , <i>Ep</i> , <i>Ple</i> .	1. Concerned about the decline of fish catch; 2. Regulation in 1995 prohibited compressor, explosives, cyanide fishing.
Mutus (Mutus) (60/-) (13/04/04) (1987)	Individual (3)	Rowboat, motorboat; Hook-&-line; <i>Cu</i> , <i>Ec</i> , <i>Ef</i> , <i>Ep</i> , <i>Pa</i> , <i>Ple</i> .	1. Concerned about the decline of fish catch in SA; 2. Regulation in 1995 prohibited compressor, explosives, cyanide

			fishing.
Bianci (Biantsyi) (18/-) (13/04/04) (1989)	Group of 4 fishers (1)	Rowboat, sailboat; Hook-&-line; <i>Ef, Pa, Ple.</i>	1. No concern about the fishery since catch increases when better bait found; 2. Regulation in 1995 prohibited compressor, explosive, cyanide fishing.
Urbinasopen (Waigeo) (133/-) (14/04/04) (2002)	Group of 3 fishers (1)	Rowboat, motorboat; Trap, hook-&-line; <i>Ca, Cu, El, Pa, Ple.</i>	1. Need traders to come to collect fish regularly; 2. Compressor divers should get permit in the area, and use traps only; 3. Regulation in 1995 prohibited compressor, explosives, cyanide fishing.
Yensener (Waigeo) (50/-) (14/04/04) (2002)	Group of 5 fishers (1)	Rowboat, motorboat; Jook-&-line; <i>Cs, Pa, Ple.</i>	1. Need traders to come to collect fish regularly; 2. Concerned about the decline of bêche-de-mer, lobster, shark fin catches;
Serpele (Waigeo) (72/258) (15/04/04) (1987)	Individual (2)	Rowboat, motorboat; Hook-&-line; <i>Cu, Ef, Ep, Pa, Ple.</i>	1. Concerned about the decline of bêche-de-mer, lobster catches; 2. Concerned that outside fishers (Sulawesi) use cyanide and compressor in the area, and also employ village fishers to use compressors; 3. Regulation in 1995 prohibited compressor, explosives, cyanide fishing.

3.3.2. Brief history of the live reef fish food trade (LRFFT) in Raja Ampat

The Raja Ampat Regency has been exploited for marine natural resources of bêche-de-mer (sea cucumbers, since 1930s), shark fins (since 1960s), lobsters (since 1980s) and turtles for a long time (**Plate 3.1b & c**). The LRFFT first started in the late 1980s; more recently additional areas participated (late 1990s and early 2000s) (**Table 3.1**).

Most fishers go fishing by rowboat or motorboat with 15 HP engines; fishing grounds are either near the villages or up to 3-5 hours away by rowboat. Daily fishing trips during the daytime is common, except on Fridays in Moslem villages or Saturday for Christian villages. If boats have engines or holding facilities, the fishers may stay at sea overnight for up to 6 days. The traditional fishing method in Raja Ampat for reef fish is hook-and-line (one hook in a line). Fish were caught for own consumption, or sold locally or in Sorong (the nearest main town) as fresh dead/dried/salted before the LRFFT started. Local fishers only use compressors for lobsters, not for live reef fish.

There are at least 3 traders around Waigeo. Traders set up holding cages near villages or near the fishing grounds (e.g. P. Peniki) (**Plate 3.1d**); therefore, the fishers can sell fish directly to the traders after fishing. Fishers also set up their own holding cages near villages and wait for the traders to come to buy fish.

One trader interviewed from Sorong (Mr. Inh Mulyadi; mobile: 62-811-498999) has about 30 cages between western Waigeo and Misool. About 4 tonnes of LRFF from his cages are shipped to HK every 30-40 days by a HK-based vessel, which has a 12 tonnes LRFF capacity; fish are also collected from other traders or collectors in the area. The mortality from catching to shipping can be as much as 15%. Handling fish carefully and keeping low densities in holding cages can reduce mortality, e.g. maximum 100 kg of *Plectropomus leopardus* in a 3 × 3 × 3 m cage. *Plectropomus areolatus* has the highest mortality in holding cages; this species is sensitive to stress, according to fishers. The main species of the trader interviewed for export is *P. leopardus* (≥ 2 out of 4 tonnes). In the holding cages visited in P. Peniki, the main species is *P. leopardus* (700 out of 800 kg). There is no grow-out activity of sub market-size fish in holding cages in Raja Ampat.

The scale of the LRFFT in the Raja Ampat Regency is unknown, but it is small around south Waigeo and nearby islands. The holding cages in Mutus and Serpele villages can hold 700 kg to 1 ton LRFF at once; other villages visited only had capacity for 200 kg. HK-based vessels come to these villages to collect fish every 30-40 days, this is consistent with the trader interviewed. Holding cages in some visited villages (e.g. Urbinasopen and Yenwaopnor) have not had fish since the SARS (Severe Acute Respiratory Syndrome centred in SE Asia and particularly China) event, 2003, because no traders came to collect fish after this problem arose in HK, and the fishers therefore no longer keep fish alive. Although the LRFFT is not set up in Salio Village, the villagers know the potential for the trade in local village waters and would like to participate. The reason that Salio Village has not started the LRFFT is that no traders have come to contact them. The villagers also consider the LRFFT as a welcome alternative to bêche-de-mer, their major activity currently, because catch volume of sea cucumber has declined from 25 kg/boat/day 15 years ago to < 10 kg/boat/day now.

The LRFFT contains a narrow range of species around Waigeo, mainly *Plectropomus leopardus*, a few *Cheilinus undulatus*, *Cromileptes altivelis*, *Epinephelus fuscoguttatus*, *E. polyphekadion* and *P. areolatus*. Fishers focus on *P. leopardus* due to its relatively high price (just below the highest priced species *Cheilinus undulatus* and *Cromileptes altivelis*) (**Appendix 1**), and its abundance in the area. The traditional bait for *P. leopardus* was originally chicken feathers with brown or yellow colour, and subsequently local fishers found better bait (i.e. chicken feathers mixed with brown, red, white and yellow) (**Plate 3.1e**).

The prices of dried/salted reef fish in Sorong are 5,000-10,000 Rp/kg, which is several fold lower than the prices of live reef fish (**Appendix 1**). Prices are not different between spawning and non-spawning seasons, but traders can pay higher price to fishers for good quality fish (e.g. fish that have been kept in fisher's own cages for a couple of weeks and then sold to traders; survivors are likely fish in good condition). As one example, the same size of *Plectropomus leopardus* can get high price of 80,000 Rp/kg; normal price is 40,000 Rp/kg.

Cheilinus undulatus exported from Raja Ampat are mainly from south Misool and caught by hook-and-line. *Cheilinus undulatus* has the highest price in the LRFFT, but it is not the main targeted species since it is rare around Waigeo according to fishers and divers. *Cheilinus undulatus* was common in western Waigeo before the LRFFT (started in the late 1980s) (**Table 3.1; Map 3.1**), but declined due to the use of cyanide and compressor by non-resident fishers (e.g. from Sulawesi) from 1985 to the late of 1990s according to fishers interviewed; catch volume is about 6-10 fish/month/boat now. In eastern Waigeo where the LRFFT started in 2002 and was subsequently suspended after 2003 due to the SARS event in HK and no traders came to collect fish, the catch volume of *Cheilinus undulatus* is 2-3 fish/day/boat up to 5-10 fish/day/boat. None of the villages visited during this work have heard the national regulation on *Cheilinus undulatus* export (HK.330/DJ.8259/95 and HK.330/S3.6631/96).

3.3.3. Spawning aggregations

Spawning seasons and sites of several species were identified around Waigeo during this work, including *Cephalopholis sonnerati*, *Cromileptes altivelis*, *Epinephelus caeruleopunctatus*, *E. lanceolatus*, *E. polyphekadion*, *Plectropomus areolatus* and *P. leopardus* (**Table 3.2**). Since no compressor divers were interviewed in the area, spawning aggregations could only be suggested by clear increase of catch volumes (both relative and

absolute data) of fish with eggs, compared to non-spawning seasons, according to hook-and-line fishers. Fishers have known about all reported sites for many years and targeted these aggregations for their own consumption, or for sale as dried/salted before the LRFFT.

Nine spawning aggregations were identified; catch declined in five aggregations (one declined 60% compared to 10 years ago and four declined 15% compared to 5 years ago), and three have just started to show possible declines (**Table 3.2; refer to SCRFA database**). Four cases need further investigation; data of these four cases were not submitted to the database of the SCRFA. The body sizes of caught fish did not change noticeably over time.

Table 3.2. Nine spawning aggregations with three species and another four possible aggregations with four species around Waigeo, Raja Ampat were identified. To protect the sites, the locations were not listed here. *Data not included in SCRFA database; **Compared to 10 years ago; the others compared to 5 years ago.

Species name (No. aggregations identified) (Aggregation category)	Current status of aggregations	Change in catch (fish/day or week/boat)	
		Non-spawning aggregation seasons	Spawning aggregation seasons
<i>Epinephelus polyphkadion</i> (1) (A1)	Decline 60%** (A1).	3-4 fish/day/boat.	From 50 fish/day/boat to 20 fish/day/boat now; 2-2.5 kg/fish; About 10 boats.
<i>Plectropomus areolatus</i> (4) (A2-A5)	Decline 15% (A2-A5).	10-15 fish/day/boat.	From 60 fish/day/boat to 50 fish/day/boat now; About 10 boats.
<i>Plectropomus leopardus</i> (4) (A6-A9)	No change to decline 15% (A6-A8);	5-15 fish/day/boat.	From 60 fish/day/boat to 50 fish/day/boat now; About 20 boats.
	No change (A9).	2-3 fish/day/boat.	Stable in 20 fish/day/boat; About 5 boats.
<i>Cephalopholis sonnerati</i> (1)*	-	>5 fish/day/boat.	15-20 fish/day/boat.
<i>Cromileptes altivelis</i> (1)*	-	5 fish/day/boat.	15 fish/day/boat with 3-5 kg/fish.
<i>Epinephelus caeruleopunctatus</i> (1)*	-	5-6 fish/day/boat.	15 fish/day/boat with 5 kg/fish.
<i>Epinephelus lanceolatus</i> (1)*	-	1 fish/week/boat.	5-6 fish/week/boat with 50-70 kg/fish.

3.3.4. Regulation and management

Fishers around Waigeo know the regulation on prohibiting explosives, cyanide and compressor which came into effect in 1995, but none had heard about the national regulation on *Cheilinus undulatus* export which came into effect in the same year (HK.330/DJ.8259/95 and HK.330/S3.6631/96). Although compressors are not used for live reef live, they are used in lobster collection by local fishers. In Salio Village, local regulation on using compressor exists, e.g. compressor divers only allow lobster to be caught > 20 m deep and free divers within 20 m deep. In Urbinasopen Village, compressor divers from outside (e.g. Sulawesi and Sorong) need to get a permit to fish and must agree not to use cyanide (**Table 3.1**).

Non-residents (e.g. from Sulawesi) are the primary perpetrators of unsustainable fishing practices in Raja Ampat according to fishers, and have used destructive fishing techniques (i.e. explosives and cyanide) for the LRFFT as early as 1985. Local villages could not stop such destructive fishing since it was often accompanied by the army on boats. After establishment of the Raja Ampat Regency, destructive fishing by non-residents seemed to decline according to fishers; i.e., it was once common around Salio Village waters but is not so evident since 2003. If outside traders/collectors try to supply cyanide to local fishers, they are asked to leave. Fishers asked us information about how to set up the marine reserve areas since they heard that fish will come back to the areas that are protected.

The Regency government realizes that non-residents are the greatest beneficiaries of the LRFFT in Raja Ampat. Therefore, the Regency Fishery Office is planning to close the whole area to outside fishers (i.e. outside the Regency) (Mr. J. B. Rahawarin, personal communication). The Regency Fishery Office is also going to check fish volumes of export LRFF vessels frequently since they have found that traders under-report the export volumes by up to 50%. Since January 2004, all fishing grounds in P. Ayau (**Map 3.1**) have been closed to outside fishers as a practical regulation (covering six months from January to June). In this area, *Plectropomus areolatus* and *P. leopardus* have been heavily targeted in spawning aggregations (Mr. J. B. Rahawarin, and the community leader in Ayau, personal communications).

Cage culture of *Epinephelus fuscoguttatus* and *Cromileptes altivelis* has been recently carried out in P. Ayau and western Waigeo by the Regency Fishery Office (**Plate 3.1f**).

4. General discussion

A total of 39 spawning aggregation were identified in all areas visited during the current survey (**Figures 4.1 & 4.2**). In Sinjai, Pangkep, Selayar and Kei Islands, 25 out of 30 spawning aggregations have declined substantially. In Waigeo, Raja Ampat, in which some villages started the LRFFT in 2002 and the scale of the LRFFT is small, the current status of spawning aggregations is also not satisfactory; 5 out of 9 spawning aggregations have shown declines. There are 4 aggregations that fishers have stopped targeting in Selayar due to declines in catch volumes; some fishers are now shifting to lobster fishing. Therefore, protection of these aggregations is recommended.

Under-estimation of the export volume of the LRFFT in Indonesia occurs (Cesar, 1995; Johannes & Riepen, 1995; Bentley, 1999; Lau & Parry-Jones, 1999). From our study, the annual estimated export volume of the LRFF from the Sembilan Islands, by vessel, was about 300 tons, much higher than the official recorded data (i.e. 85 tons). To better understand the exploitation of the marine resources, the Indonesian government needs to monitor the trade in live reef fish. For example, after the Raja Ampat government discovered that traders under-report live fish export volume, officers decided to check vessels more frequently. Also, the Indonesian government should consider breaking down the live fish categories reported to species level in the custom declaration system, especially for the main LRFFT species, as was done by HK since 1997. The government could select specific airports, such as Bali, Makassar or Jakarta as the required one for exports to HK and elsewhere to help better control and regulate exports. It is also possible for the government to contact major LRFF import countries to cross-check Indonesian exports with reported imports.

In Pangkep, the nursery grounds of several important LRFFT species, e.g. *Epinephelus lanceolatus* and *Cheilinus undulatus*, are exploited. Juveniles of these species have been targeted intensively by hook-and-line (up to 20-30 boats in the areas) for a long time and have shown a decline in catch. It is important to protect these areas.

In all the places visited in eastern Indonesia, the government is evidently interested in developing grouper culture, and encouraging fishers and non-fishers to culture grouper: this

approach seems to be seen as an alternative to fishery management. The main concern of the government is that the use of destructive fishing leads to the death of coral and their solution to protect marine environment is to develop marine culture. Selection of the appropriate species for mariculture should consider several points, e.g. availability of artificially produced seeds, growth rate, market price, local and export consumption capacity, and feed availability (i.e. feed for culturing fish; if fish feed demand is too heavy then local marine resources will again be negatively impacted. So far, the focus culture species in Indonesia is *Epinephelus fuscoguttatus*; the hatching technique of this species is reliable and artificial produced seeds are available for culture. Although *Epinephelus fuscoguttatus* is a good species to culture because to its high growth rate (8-10 months to market size), the price of this species from wild is low (**Appendix 1**). In HK markets, *Epinephelus fuscoguttatus* from culture are mixed with those from wild before shipping to HK, since cultured individuals have lower prices in HK markets according to collectors and traders. Therefore, developing mariculture of *Epinephelus fuscoguttatus* may not be economically viable in the long-term. *Cromileptes altivelis* and *Cheilinus undulatus* may be good species to develop mariculture; prices are high (**Appendix 1**) and wild stocks have shown a large declines (**this work**; Sadovy et al., 2003b). Moreover, introducing fish culture of hatchery produced fish will not address the problems of over-fishing; fishery management is also needed.

The Indonesian government (according to responses from government officials interviewed and programmes in place or planned) is concerned about destructive fishing (e.g. cyanide and explosives) leading to the death of coral and destroying fish habitat; it does not appear to acknowledge the importance of fish stock management, or recognize the strong signs of over-fishing. For instance, in the Taka Bonerate National Park, cyanide and explosive have been prohibited since 1992 and there is no comprehensive fishery management. The current status of fish stock in the park does not show any improvement over earlier reported reduced levels, probably because the number of fishers (from outside and locally) is not limited by regulation; 11 out of 13 spawning aggregations have shown declines, as have daily catch volumes compared to 5-10 years ago (**this work**). There is a clear trend that many fishers from other islands in Selayar and other regencies (e.g. Sinjai & Makassar) enter the park for fishing live reef fish and lobster after the stocks of their own areas have been over-exploited. Continued reductions in reef associated fishes and invertebrates pose a long-term threat not only to incomes but also to food security and should be addressed as a priority.

Live reef fishes have low prices in Indonesia compared to most other export countries (Sadovy *et al.*, 2003a), and are lower in Raja Ampat than in other areas of Indonesia (**Appendix 1**). There are several possible reasons. First, most LRFF fishing grounds are remote and hard to access in Indonesia. Live reef fish are kept in holding cages after capture and wait for a relatively long time (up to 30-40 days) to be shipped. The traders pass such risk down to fishers by reducing the price. Second, before the LRFFT, the prices of fresh dead or dried/salted fish were particularly low, about 5,000-10,000 Rp/kg. After the LRFFT started, the fishers easily accepted whatever live reef fish prices the traders offered, even if the prices were not much higher than those of dead fish. Third, local fishers lack information on international or even regional, prices of the LRFFT, therefore, they are in disadvantaged bargaining position in the LRFFT. Better access to international prices would greatly assist fishers in their ability to gain better prices.

The high priced species, *Cheilinus undulatus* and *Cromileptes altivelis*, once common in Raja Ampat, are rare now (Erdmann & Pet, 2002; Donnelly *et al.*, 2003; this work). The local fishers now only focus intensively on the second most highly priced species, *Plectropomus leopardus*, which is also showing catch declines from spawning aggregations compared to 5 years ago. Management of this species needs to be carried out soon in the area.

Villages can play a very important role in the conservation of marine resources. Some villages visited have their own regulations due to the villagers' concern about the decline in their local resources. Local fishery officers and NGO's can help fishers in different ways by providing basic biological information, especially associated with spawning aggregations, and teaching fishers how to manage their money and better plan for the future.

Spawning aggregation management should be part of a long-term plan to help local fishers to manage their marine resources sustainably. In this work, the identified spawning aggregations were distributed in different areas; the same species may have different aggregation periods in different areas, and the same area may have different aggregation species in different periods (**Table 4.1; refer to SCRFA database**). Therefore, to protect these aggregations it is important to understand regional and local patterns in aggregation formation and in the condition of local fish stocks. Finally, inspection of fishery reports showed that target figures for grouper production appeared to be several times higher than was likely to be viable in the areas visited: this assessment is based on crude estimations of

grouper production and the indications of declining landings and fish sizes despite apparently being ‘under’ target production levels; target production should be revised to realistic levels.

Table 4.1. Spawning aggregation periods, according to fisher surveys, of the main species in the LRFFT in eastern Indonesia. The aggregation sites are not listed here to protect the site.

Species name	Spawning month				
	Sinjai	Pangkep	Selayar	Kei Islands	Raja Ampat
<i>Epinephelus corallicola</i>	-	-	March-May	-	-
<i>Epinephelus fuscoguttatus</i>	-	Sep, Nov-Dec	March-May, Sep-Nov	Jan-Mar, May, Sep-Nov	-
<i>Epinephelus lanceolatus</i>	-	Dec-Feb	-	-	-
<i>Epinephelus polyphekadion</i>	Jan-Mar. Feb-Apr	Dec	Sep-Nov	Sep-Oct	Apr
<i>Plectropomus areolatus</i>	Sep, Nov-Dec	Jun-Aug, Nov-Dec	March-April, Sep-Nov	Jan-Feb, Oct	May & Oct
<i>Plectropomus leopardus</i>	-	-	Sep-Nov	-	May & Oct, Jun-Jul

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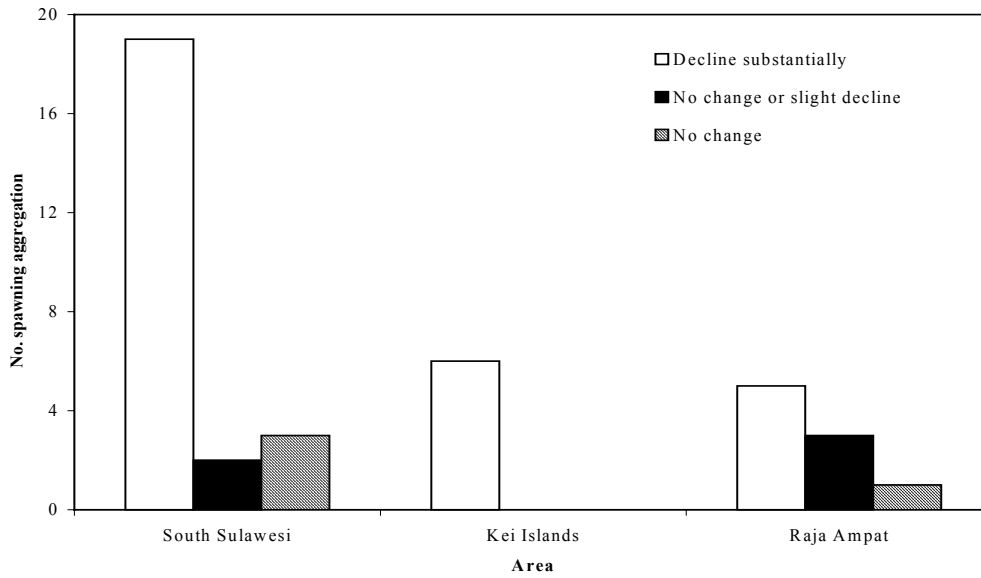


Figure 4.1: The current status of the 39 spawning aggregations identified in the areas visited during the surveys.

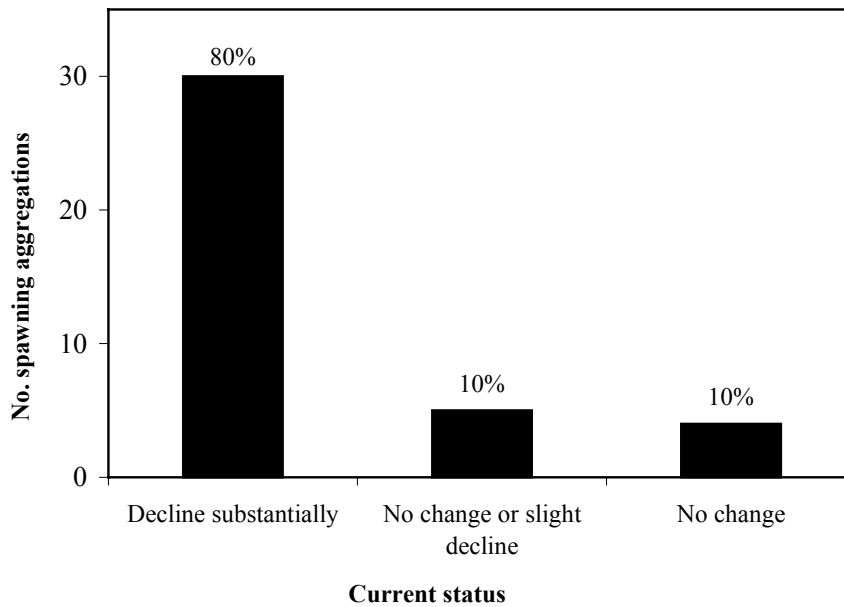


Figure 4.2: The current status of the 39 spawning aggregations identified during fisher, with all areas pooled.

Appendix 1. Comparisons of live reef fish prices that fishers are paid by traders in the areas visited in eastern Indonesia. (local fish names in brackets)

Scientific name (Local name)	Live reef fish food prices (Rp/kg or fish)		
	Sinjai, Pangkep & Selayar	Kei Islands	Raja Ampat*
<i>Cheilinus undulatus</i> (Maming, Angke)	250,000 Rp/fish (< 5 kg/fish) 40,000-70,000 Rp/kg	55,000 Rp/kg (<300g) 75,000-115,000 Rp/kg (300-500g) 130,000 Rp/kg (600g- 1.2kg) 170,000 Rp/fish (1.3- 3.3kg) 210,000 Rp/fish (3.4-5kg) 50,000 Rp/fish (>5kg)	90,000-150,000 Rp/kg (150g-1kg) 200,000 Rp/fish (>1kg)
<i>Cromileptes altivelis</i> (Low See, Mulutikus)	70,000 Rp/kg (< 1 kg/fish) 150,000 Rp/fish (> 1 kg/fish)	75,000 Rp/kg (300-500g) 130,000 Rp/kg (600g- 1.2g) 170,000 Rp/fish (>1.2kg)	70,000 Rp/kg (150g-1kg) 180,000-200,000 Rp/fish (>1kg)
<i>E. caeruleopunctatus</i> (Kerapu Abu)	-	-	10,000 Rp/kg
<i>Epinephelus fuscoguttatus</i> (Kerapu Tiger, Kerapu PaPa, Macam Cumming)	20,000-30,000 Rp/kg	35,000-45,000 Rp/kg	10,000-25,000 Rp/kg
<i>E. lanceolatus</i> (Kerapu Moso, Kerapu Roto)	8,000 Rp/kg (< 300g/fish)	-	60,000 Rp/fish (≤ 50kg) 100,000 Rp/fish (> 50kg)
<i>E. polyphekadion</i> (Kerapu Loreng, Kerapu Lumpur, Macam Aru)	30,000-35,000 Rp/kg	25,000 Rp/kg	10,000 Rp/kg
<i>Plectropomus leopardus</i> (Suno Merah, Ingkoi, Tong Sing)	60,000-100,000 Rp/kg (< 1 kg/fish) 70,000-100,000 Rp/fish (> 1 kg/fish)	31,000 Rp/kg (300-500g) 75,000 Rp/kg (600g- 1.5kg) 150,000 Rp/fish (>1.5kg)	17,500 Rp/kg (<200g) 40,000 Rp/kg (200g- 1.5kg) 50,000-60,000 Rp/fish (>1.5kg)
<i>P. areolatus</i> (Suno Papa, Sai Sing)	20,000-40,000 Rp/kg (< 1 kg/fish) 30,000 Rp/fish (> 1 kg/fish)	22,000 Rp/kg (300-500g) 30,000 Rp/kg (600g- 1.5kg) 50,000-75,000 Rp/fish (>1.5kg)	12,500 Rp/kg (< 200g) 18,000-20,000 Rp/kg (200g-1.5kg) 25,000 Rp/fish (>1.5kg)



Plate 1.1. Interviews in Sinjai, Pangkep and Selayar, South Sulawesi. a) & b) Interviews in Sinjai; c) Interview in Pangkep; d) Interview in Selayar.



Plate 1.2. Photos from Sinjai, South Sulawesi. a) A truck used to ship live reef food fish from different districts to Makassar by road; b) Holding cages for live reef food fish; c) A tool for air release from fish swim bladder; d) A fishing boat with holding capacity; e) A fishing boat with engine.



Plate 1.3. Photos from Pangkep, South Sulawesi. a) Fishing traps; b) Fishing nets; c) Fishing boat; d) Holding cage.



Plate 1.4. Photos from Selayar, South Sulawesi. a) *Plectropomus leopardus*, the main LRFFT species; b) Fishing nets for shark; c) Fishing boat for squid; d) Holding cages for fish grow-out, but not fish inside.

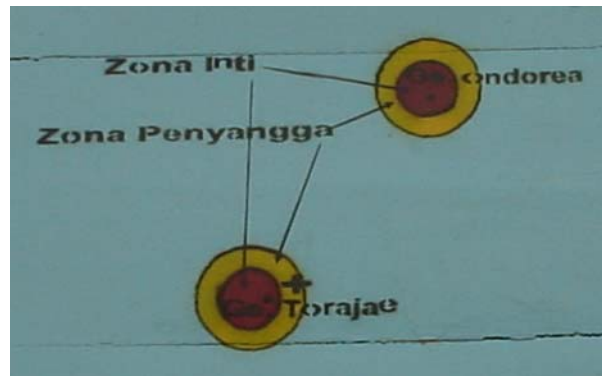
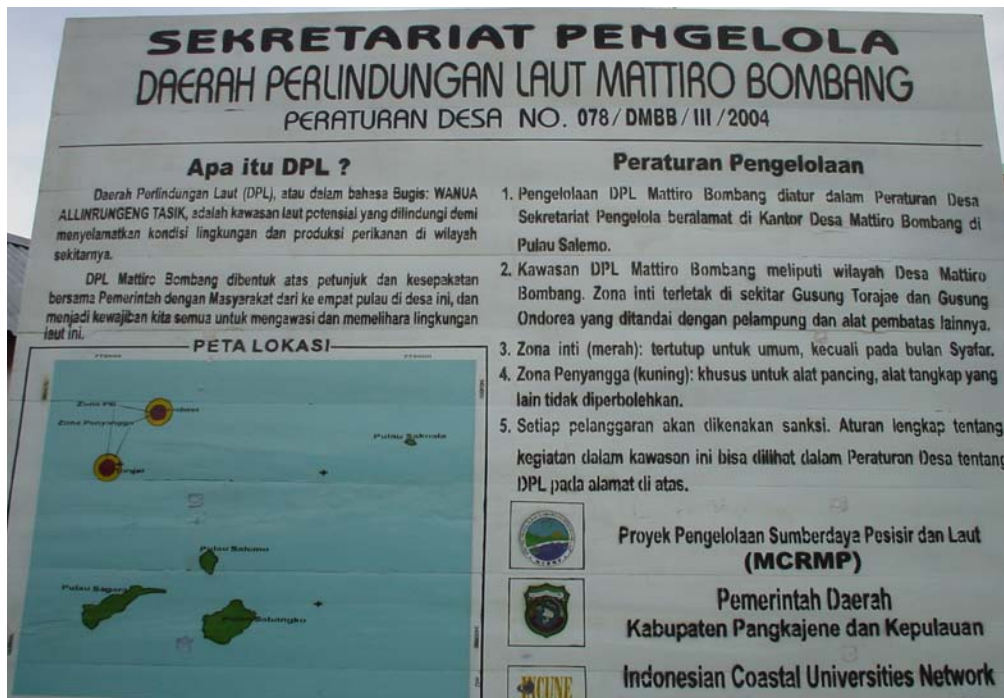


Plate 1.5. A protected area around Matiro Bombang Village, Pangkep. a) Detailed regulation and the location of the protected area; b) Core zones of the protected area.



Plate 2.1. Photos from the Kei Islands. a) Group of fishers' interview; b) Trochus; c) A pond for rabbitfish culture in Dian; d) Sailboat.



Plate 3.1. Photos from Raja Ampat. a) Interview; b) A tool for lobster; c) Turtles for fishers' own consumption; d) Holding cages near fishing ground, Pulau Peniki (Peniki Island); e) Bait made of chicken feather for *Plectropomus leopardus*; f) Cages for grouper culture.