A rapid marine survey of the northern Raja Ampat Islands
Henry Foundation/The Nature Conservancy/NRM/EPIQ
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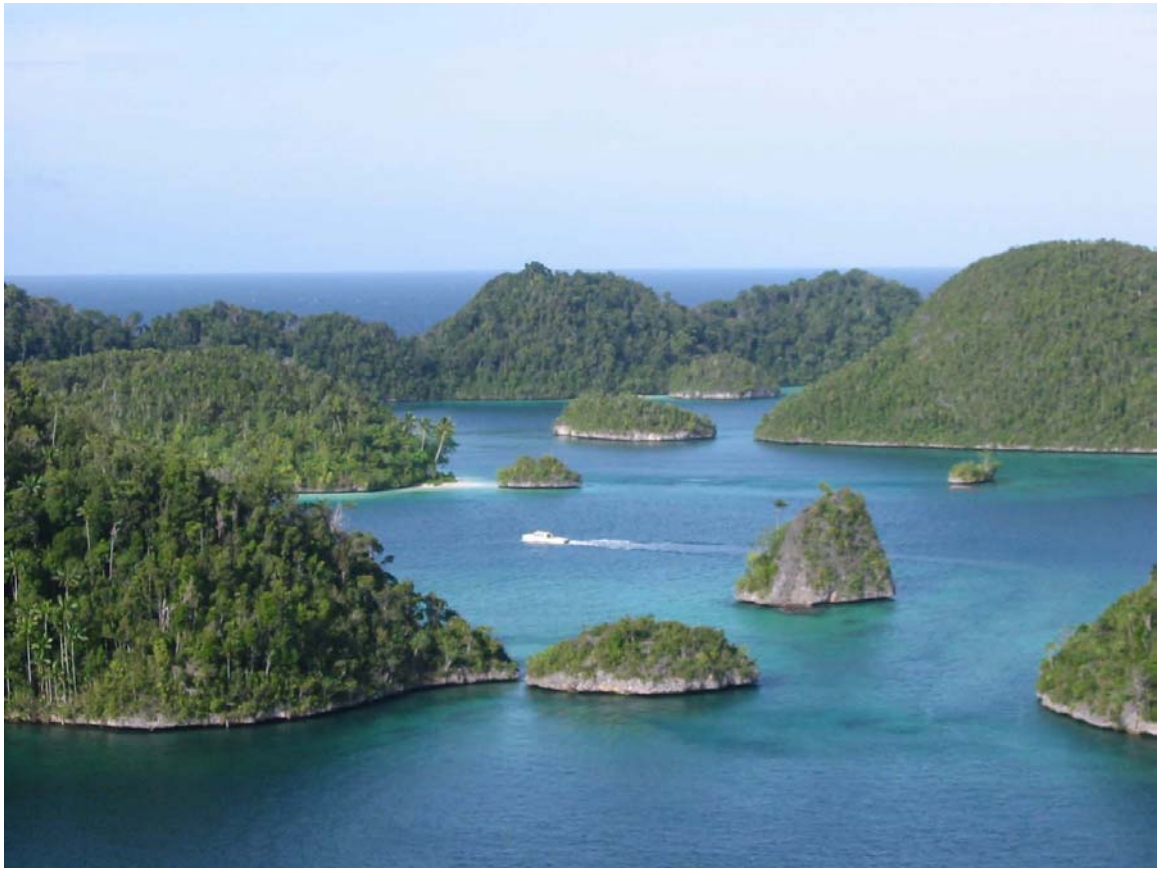

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Executive Summary

In early 2001, a team of taxonomic and coastal resource experts sponsored by Conservation International (in collaboration with the University of Cenderawasih and LIPI-Oseanologi) conducted a marine rapid assessment of the Raja Ampat Islands in NW Papua Province, Indonesia. During the course of 15 days, this survey covered 45 survey locations in an area described as possessing outstanding (though threatened) marine biological diversity and stunning natural beauty that is clearly in need of rapid conservation action to protect it.

Based upon this report and the plans for a joint TNC/CI/Henry Foundation continuation RAP in the remaining areas of the Raja Ampat Islands in late 2002, the Henry Foundation funded a follow-up survey of the same general area from 17-30 June 2002 in order to collect additional data on this high priority conservation site. Specific objectives of the survey were to:

1. Conduct a detailed taxonomic survey reef-associated stomatopod crustaceans.
2. Collect preliminary information on the abundances, size distributions, current exploitation levels and possible spawning aggregation sites (SPAGS) of target species for the live reef food fish trade (LRFFT)
3. Compile general observations on the current status of the marine (and terrestrial) natural resources of the area and specifically on resource use patterns and opportunities for future management and conservation initiatives.

A total of 33 sites (23 of which were CI RAP sites) were surveyed in 11 days in the islands, followed by 3 days of observations in the regency capital city of Sorong. During this survey, 34 reef-associated stomatopod species were identified (including 4 undescribed species and one that is apparently endemic to the Raja Ampats) from 6 families and 14 genera. This is the highest alpha diversity for reef-associated stomatopods from one area from anywhere in Indonesia sampled by the first author, and this finding is in line with those of the CI 2001 RAP which also found this area to be extremely biodiverse. A total of 375 specimens were collected in ethanol for future genetic connectivity studies.

Underwater visual censuses for target species for the LRFFT were conducted on 19 sites and revealed very low abundances of these target species, with a marked lack of large male groupers and Napoleon wrasse. This data, combined with that collected by the CI 2001 Raja Ampat RAP and our own fisher interviews suggest that the Raja Ampat area has been heavily exploited for these target species over the last decade – both by local fishers who target these species primarily using handlining techniques and by outside fishing groups who rely mostly on hookah compressors and cyanide solution to capture these fish.

Our general observations on the Raja Ampat reef system and the results of our local stakeholder interviews suggest that while the area is quite sparsely populated by humans and does possess outstanding natural beauty both above and below water, the reefs

especially have been strongly negatively impacted by human use, particularly by destructive fishing practices such as blast and cyanide fishing. Besides these destructive fisheries, other resource exploitation techniques which we observed and/or collected data on include shrimp trawlers, lift nets (bagan), commercial fisheries such as small pelagic pole and line and pearl farming, shark finning, turtle, clam and trepang harvesting, logging, and capture/collection of bats and swift nests. We noted that many of the more destructive techniques were primarily conducted by outside visitors to the region.

Despite these strong pressures on the reefs and forests of the area, the incredible diversity of habitats and sheer number of islands and reefs seems to provide a resiliency that should allow the area to recover relatively quickly with proper management. Although local communities seemed in many ways powerless at this time to prevent the onslaught of large and medium-scale outside business interests (often with political and/or military backing) from degrading their resources, these communities do have strong traditional claims to ownership of reefs and forests. If carefully empowered (while also insuring the rule of law through proper enforcement), these communities could become valuable guardians of their resources. A number of potential sustainable community development options were identified, including conservation concessions, mariculture of locally abundant species, pelagic capture fisheries, ecotourism, and value-added industries related to the byproducts from the pearl farm industry.

Several high priority next steps in the development of an integrated conservation and management strategy for the area were identified. These include gaining a much better understanding of traditional concepts of marine and land ownership in the area (including mapping these claims) and the legal basis for recognizing these ownership claims, initiating dialog with key stakeholder groups including the communities themselves, a range of local government agencies, the local private sector (tourism and fisheries) and the national level Department of Nature Conservation (PHKA), and clarifying the current status and size of the protected areas system in the Raja Ampat archipelago. A number of action items are listed for prioritization and completion before or during the planned late 2002 follow-up RAP.

1.0 Introduction

In March and April, 2001, a team of taxonomic and coastal resource experts sponsored by Conservation International (in collaboration with the University of Cenderawasih and LIPI-Oseanologi) conducted a marine rapid assessment of the Raja Ampat Islands in NW Papua Province, Indonesia (McKenna et al., 2002). This rapid assessment (hereafter referred to as the CI 2001 Raja Ampat RAP) covered 45 survey locations in the northern reaches of the Raja Ampat islands over the course of 15 days, focusing on surveys of the marine biological diversity of the area and the status of its coral reefs, as well as investigating patterns of marine resource exploitation by local villagers and outside interests.

The CI 2001 Raja Ampat RAP describes an area of outstanding biological diversity with stunning marine and terrestrial habitats which, although still relatively intact, are

currently threatened and clearly in need of rapid conservation action to protect them. Taxonomic surveys of scleractinian reef corals, molluscs and reef fishes suggest that this area has a higher taxonomic diversity of the first two groups than other areas in which CI has conducted marine RAPs (including Milne Bay, Papua New Guinea, Togian and Banggai Islands, Indonesia, and Calamianes Islands, Phillipines) and the second highest diversity of reef fishes of these four areas (McKenna et al, 2002). The report further suggests that no other area of comparable size in the world harbors as many species of scleractinian corals. Besides this impressive biological diversity, the CI team also found an area with relatively low human population densities and a tradition of community resource use rights that should greatly facilitate the development of an integrated conservation/resource management program in the area.

Based upon this encouraging report and the plans for a joint TNC/CI/Henry Foundation continuation RAP in the remaining areas of the Raja Ampat Islands in late 2002, the Henry Foundation funded a follow-up survey of the same general area as the CI 2001 Raja Ampat RAP in order to collect additional data on this high priority conservation site. Specific objectives of the survey were to:

1. Conduct a detailed taxonomic survey of an additional faunal group – reef-associated stomatopod crustaceans.
2. Collect preliminary information on the abundances, size distributions, current exploitation levels and possible spawning aggregation sites (SPAGS) of target species for the live reef food fish trade (LRFFT) – including select high value serranid species and *Cheilinus undulatus*.
3. Compile general observations on the current status of the marine (and terrestrial) natural resources of the area and specifically on resource use patterns and opportunities for future management and conservation initiatives.

The survey was conducted from 17-30 June 2002, with a survey team consisting of personnel from the USAID-funded NRM/EPIQ program and The Nature Conservancy's South East Asian Center for Marine Protected Areas. The authors have a combined 20+ years of experience in marine resource management research and implementation of conservation programs in Indonesia and have travelled extensively throughout the archipelago. The results and comments recorded below are not meant to be an exhaustive or comprehensive treatise on the subjects covered, but are based solely upon our observations and interview results during a 14 day survey (11 in the Raja Ampat area and 3 in the nearby capital city of Sorong) and on our combined experience in Indonesia.

2.0 Description of area

The Raja Ampat Islands encompass over 4 million hectares of land and sea area off the far northwestern tip of Papua Province, Indonesia. This area includes the four large islands of Waigeo, Batanta, Salawati and Misool (also known as Batanme) and hundreds of smaller islands scattered amongst these. McKenna et al. (2002) define the Raja Ampat area as occuring between 0°20' N and 2°15' S latitude and 129°35' E and 131°20' E longitude. Note that this boundary definition of the Raja Ampat islands includes the

peripheral islands of Sayang in the north and Gag, Kofiau and the "Bambu Islands" to the west, but specifically excludes the Ayu and Asia Islands to the north and the Boo Islands to the west (although the large-scale Bakosurtanal maps available to TNC suggest that these islands are indeed part of Sorong Regency – Barmawi, pers.comm.). The area so defined is entirely within the administrative boundaries of Sorong Regency (Kabupaten), with Sorong city as the regency seat. Included within this regency are the five districts (kecamatan) of Salawati, Samate, Misool, South Waigeo and North Waigeo, with a combined population of approximately 50,000 residents occupying 89 villages (McKenna et al., 2002). Interviews with local residents suggest that there is a current movement to redefine administrative boundaries and create a new regency (kabupaten) of Raja Ampat. This movement should be monitored closely as it will have a decided impact on possible future conservation strategies for the area.

0ceanographically (and biogeographically), the Raja Ampat Islands lie in an important region that is not only on the western border of the equatorial Pacific Ocean, but also at the northeastern "entrance" of the Indonesian Throughflow from the Pacific to the Indian Oceans (Wyrtki, 1961; Gordon and Fine, 1996). Salinity, temperature and chemical tracer data suggest that while it represents only a minor component of the Indonesian Throughflow, there is a general southerly flow of water from the westerly flowing South Equatorial Current (SEC) past the Raja Ampat area and into the Halmahera and Seram seas (Gordon and Fine, 1996). These data also suggest that some of this westerly flowing SEC water is entrained in the Halmahera Eddy to the north of the Raja Ampats, looping to the NE and joining the easterly flowing North Equatorial Counter Current (Gordon and Fine, 1996). While the current patterns in the area are certainly complex, there is a strong likelihood that the Raja Ampat reefs retain an important function as "source" reefs for larval propagules to reefs of northern and central Maluku, though this will require population genetic studies to substantiate the "connectivity" of these reefs to others. It is important to note that a separate line of evidence (the presence of apparent marine endemic species in the area) revealed in both the present survey and the CI 2001 RAP suggests a possible lack of connectivity with other reefs. We do note that the proposed endemics come from taxa that are highly speciose in the Indonesian seas and seemingly prone to endemism, but it is clear that the issue of genetic and ecological connectivity of the Raja Ampat reef system to other reefs is a priority research topic in the development of conservation and management strategies for the area.

The vast majority of the Raja Ampat area rests on one of two continental shelf areas (Misool and Salawati to the southwest and Batanta and Waigeo and associated island groups like Gam, Fam and Wayag islands to the northeast) separated by the narrow Sagewin Strait between Salawati and Batanta. The influence of the continental shelf is clearly evident on the reef system in the Raja Ampats; the visibility was generally on the order of 10-15 m, with a fair bit of suspended particulate matter . However, the presence of the continental shelf edge within the Raja Ampat area creates a strong gradient of clear water, wave-washed open oceanic conditions (e.g., to the north of the Wayag Islands and at the eastern edge of the Dampier Strait) to sheltered and murky bays. Simply put, the diversity of habitats and reef conditions in a relatively small area is highly impressive and is clearly a primary reason for the outstanding species diversity encountered in the area.

This survey focused on the northern reaches of the Raja Ampat Islands, from Northern Batanta Island northwards to Gam, Waigeo and the Wayag Islands and westwards to Kawe Island. Eastern Waigeo Island, Southern Batanta Island and the region of Salawati and Misool Islands were not covered in this survey and will be the target of the planned TNC/CI/Henry Foundation survey in late 2002. In total, 33 sites were sampled during 11 days in the islands (Table 1).). During this survey, we tried to broadly follow the sampling pattern of the CI 2001 Raja Ampat RAP, while also adding some additional sites we felt to be of interest. In all, we covered 23 of the 45 sites covered by the CI 2001 RAP. We also completed observations on the local fishing fleet based in Sorong, as well as the marine fisheries resources for sale at the main fish markets in Sorong. Finally, we gathered preliminary, second-hand information on export of marine resources from Sorong and the current status of naval and water police patrol facilities based in Sorong.

Appendix 1 includes a series of images that were taken during the survey and attempts to portray both the beauty of the area and some of the threats facing it. While the remainder of this report focuses on the detailed observations made during the survey, our general impressions of the surveyed area include the following:

- The Raja Ampat Islands encompass both intact forests and functional reefs , often separated by meters at most. It is unusual to find such "ridges to reefs" ecosystem integrity in Indonesia, and this fact alone strongly calls for conservation measures in the area.
- The reefs, while generally intact, have suffered extensive damage from human activities (particularly blast and cyanide fishing). Nonetheless, the sheer quantity of reef area and the overwhelming diversity of habitats seem to add a resiliency to the reef systems that allow relatively rapid recovery (as described by residents). Most reefs were a "patchwork quilt" of damaged areas and vigorously healthy areas, and it is our impression that if properly managed, these reefs would rapidly recover.
- The intertidal reef flats in the area were amongst the healthiest and most diverse the authors have seen in Indonesia, with an abundance of octopus, small sharks, giant clams, crustaceans and echinoderms. This is likely due to the very low human population density and a subsequent lack of gleaning pressure on these reef flats.
- Endangered marine species were relatively abundant in the Raja Ampats (as compared to other areas of Indonesia). Noteworthy examples include dugongs, at least 3 species of marine turtles including green, hawksbill and leatherback turtles, saltwater crocodiles and at least 5 species of giant clam (with *Tridacna gigas* and *T. derasa* being particularly noteworthy – PPKPL, 1990; 1992).
- The presence of a large number of huge *Porites* coral colonies (3-5 m diameter and easily 300+ years of age) and other massive coral colonies throughout the area suggests that recent mass coral bleaching episodes experienced in many areas of the world have been less severe in the Raja Ampats and at least spared these very old coral colonies.
- The above water scenery was stunning, with karst "beehive" and mushroom islands dotting the huge, lake-like protected bays. The coastal karst forests were largely intact (though illegal logging is rapidly threatening these forests) and support a diverse

Australasian flora and fauna that stands out for its unusual appearance with an abundance of palms, orchids, marsupials, birds (including 2 endemic birds of paradise), bats, and reptiles.

The CI 2001 Raja Ampat RAP report (McKenna et al., 2002) provides a comprehensive description of the area surveyed and the reader is referred to this report for a more thorough description of individual survey sites. One final noteworthy point is that the Raja Ampat area was recently nominated for UNESCO World Heritage Site status in early 2002 (Steffen, pers. comm.).

Table 1. Summary of survey sites for Henry Foundation/TNC/NRM survey of northern Raja Empat Islands, NW Papua (June 2002)

TNC Site No.	CI Site No.	Date Surveyed	Location Name	Coordinates	Stomatopod specimens collected?
2	2A	6/20,22/02	Cape Kri, Kri Island	0 33.470' S, 130 41.362' E	Yes
5	5	6/20/02	Gam-Waigeo Passage	0 25.570' S, 130 33.796' E	Yes
6	6	6/24/02	Paf Island	0 27.030' S, 130 26.444' E	Yes
7	7	6/18,23/02	Mios Kon Island	0 29.901' S, 130 43.531' E	Yes
10	10	6/21/02	Pulau Dua, Wai Reefs	0 41.435' S, 130 42.705' E	Yes
12	12	6/21/02	SW Wruwarez Island, Batanta	0 47.103' S, 130 45.865' E	Yes
13	13	6/18/02	Kri Island Dive Camp	0 33.457' S, 130 40.604' E	Yes
14	14	6/18,23/02	Sardine Reef	0 32.190' S, 130 42.934' E	Yes
17	17	6/21/02	W end of Wai Reef complex	0 42.212' S, 130 38.847' E	Yes
18	18	6/19/02	Melissa's Garden, N. Fam I.	0 35.390' S, 130 18.909' E	Yes
19	19	6/19/02	N. Fam Island Lagoon	0 34.202' S, 130 16.358' E	Yes
20	20	6/19/02	N. tip of Fam Island	0 32.755' S, 130 15.007' E	Yes
21	21	6/17,22/02	Mike's Reef, SE of Gam I.	0 31.032' S, 130 40.304' E	Yes
23	23	6/18/02	Besir Bay, Gam I.	0 39.005' S, 130 34.724' E	Yes
26	26	6/19/02	Keruo Island, N. Fam group	0 35.250' S, 130 18.105' E	Yes
28	28	6/27/02	Between Waigeo and Kawe I.	0 11.924' S, 130 07.506' E	No
29	29	6/27/02	Alyui Bay, W. Waigeo	0 01.003' N, 130 19.690' E	No
30	30	6/25/02	N end Kawe I (One Tree Is.)	0 00.214' N, 130 07.904' E	No
32	32	6/25/02	Equator Islands W. side	0 36.815' S, 130 09.805' E	Yes
36	36	6/26/02	Wayag Islands – E. side	0 10.202' N, 130 03.997' E	Yes
38	38	6/26/02	Wayag Islands – Inner lagoon	0 10.225' N, 130 01.827' E	Yes
40	40	6/24/02	Batang Pele Island, W. side	0 17.812' S, 130 12.329' E	Yes
42	42	6/24/02	Wofah Island, off SW Waigeo	0 15.259' S, 130 17.564' E	Yes
45	-	6/19/02	Fam Islands Inner Lagoon	0 34.083' S, 130 16.250' E	Yes
46	-	6/20/02	Crossover Reef (near Kri)	0 33.350' S, 130 40.902' E	No
47	-	6/21/02	Pulau Jerif (Wai Island)	0 42.206' S, 130 43.455' E	Yes
48	-	6/21/02	Pulau Birie (Batanta)	0 47.170' S, 130 44.660' E	Yes
49	-	6/23/02	Gam Island SE Reef flat	0 29.750' S, 130 40.010' E	Yes
50	-	6/23/02	Kabui Bay (Waigeo)	0 25.506' S, 130 42.950' E	Yes
51	-	6/24/02	Batang Pele Island, NE	0 16.820' S, 130 13.150' E	Yes
52	-	6/27/02	Black Rocks (W. Kawe)	0 04.950' S, 130 04.990' E	No
53	-	6/26/02	Wayag Islands – S. reef flat	0 09.404' N, 130 01.185' E	Yes
54	-	6/26/02	Wayag Islands – NE reef flat	0 10.142' N, 130 04.150' E	Yes

3.0 Stomatopod crustacean detailed taxonomic survey

3.1 Background

Stomatopods are benthic reef crustaceans that typically inhabit coral reef and seagrass habitats in tropical oceans. They are abundant and ubiquitous throughout the Indo-Pacific, with the highest stomatopod diversity recorded in the "Coral Triangle" that includes the Phillippines, Indonesia, Papua New Guinea, and northern Australia. The first author (MVE) has been sampling reef-associated stomatopod assemblages throughout this region for the past 10 years and has compiled a large database of species distributions, particularly in Indonesia (e.g., Erdmann, 1997; Erdmann and Manning, 1998, Erdmann and Sisovann, 1999). Though comprising many fewer taxa than the faunal groups surveyed in the CI 2001 Raja Ampat RAP (reef fishes, scleractinian corals, and molluscs), reef-associated stomatopods are an excellent alternative "biodiversity bioindicator" to these groups and have the advantage that "species accumulation" or rarefaction curves tend to approach their asymptotes more quickly due to the lower overall number of species present. Stomatopod species diversity patterns have been shown to closely parallel those of the CI taxonomic groups (eg, Wallace et al., in press), and data are available for a number of comparative sites in Indonesia (see Table 2). As such, a survey of the stomatopod diversity of the Raja Ampat Islands was conducted to provide a comparison to the species diversity patterns described in the CI 2001 Raja Ampat RAP.

3.2 Methodology

Methodology for the stomatopod survey roughly follows that described for the three taxonomic groupings in the CI Raja Ampat RAP. MVE would descend to approximately 30 meters depth using SCUBA, then gradually ascend in a zig-zag pattern to the reef flat, scanning hard and soft substrates for stomatopod cavities/burrows. Those species dwelling in soft bottom burrows were identified to species level without collection, while the majority of the specimens observed in hard substrates were collected using clove oil anaesthetic and a rock hammer and forceps to extract them. For several intertidal reef flat areas, coral rubble was collected and pulverized with a rock hammer to extract all cryptic stomatopods. Every effort was made to survey the widest possible range of microhabitats, as reef-associated stomatopods have been shown to finely divide the niches available on a reef (Ahyong, 2001; Erdmann, 1997). All specimens collected were preserved in 70% ethanol (for later genetic studies) and later examined under a dissecting microscope, with their species identification, total length and sex recorded.

3.3 Results

A total of 28 sites were sampled for stomatopod crustaceans (see Table 1). In total, 34 species comprising 6 families and 14 genera were observed, with 375 specimens collected and preserved in ethanol for future genetic studies (Appendix 2). Four of the species collected are currently undescribed, and one appears to be endemic to the Raja Ampat Islands. This is the highest number of reef-associated stomatopod species collected from one area from anywhere in Indonesia by MVE (see table 2; an "area" here refers to a contiguous geographic region of approximately .2-1.0 million hectares) and likely represents the highest known species diversity of reef-associated stomatopods for

an area of this size anywhere in the world. These results do not appear to be an artifact of sampling effort; Table 2 shows clearly that while this marine area survey had a similar number of sampling sites as the surveys in the Togian Islands, Pulau Seribu Islands, North Sulawesi and Spermonde Archipelago, the duration of sampling was among the lowest (compare 200 days in the Spermonde to 11 days in Raja Ampat). Moreover, Appendix 2 lists a further 10 species that are expected to occur in the area and have a high likelihood of collection with further sampling effort.

Table 3 shows the known geographic distributions of the stomatopod species collected in this survey. While roughly 40% of the collected species have a relatively wide distribution (Indo-West Pacific or greater), another 40% are restricted to the western Pacific or western Pacific and eastern Indian oceans, and nearly 20% are found only in eastern Indonesia (with one undescribed species apparently endemic to the Raja Ampats). This is in stark contrast to the findings of Wells (2002) for molluscs in the CI RAP survey, where almost 80% of the species collected had an Indo-West Pacific distribution. Allen (2002) found a higher percentage of restricted range species of coral reef fish in the CI RAP survey, but not to the extent observed in the stomatopod crustaceans.

The fantastic diversity of stomatopods in the Raja Ampat Islands is likely a direct result of the equally impressive diversity of reef habitats represented in the area, with a sharp gradient of exposure, sedimentation and current regimes. Protected bay fringing reefs, fringing reefs subject to freshwater influx, steep walls and platform reefs with strong currents, clear water slopes and lagoons, rocky reefs and wave-pounded reef flats were among the varied habitats sampled during the course of the survey. The sheer diversity of stomatopod species alone would argue for the prioritization of this area for conservation efforts, with the strong representation of restricted range species further emphasizing the importance of protecting this unique area. Planned population genetic studies of the ethanol-preserved stomatopod collection should help elucidate patterns of genetic connectivity of the Raja Ampat reef system with other reefs in eastern Indonesia and thereby give a clear indication of the importance of including the Raja Ampat islands in Indonesia's developing MPA network.

Table 2. Comparison of site data for areas in Indonesia sampled for stomatopod crustaceans, with an indication of sampling effort.

Location	No. sites sampled (No. sampling days)	No. of reef stomatopod species	No. of endemic species
Raja Ampat, NW Papua	28 (11 days)	34	1
Spermonde, SW Sulawesi	27 (200 days)	31	0
North Sulawesi (Bunaken to Lembeh)	21 (47 days)	30	0
Wakatobi, SE Sulawesi	20 (23 days)	29	0
Togian Islands, C Sulawesi	28 (31 days)	28	1
Komodo, E Nusa Tenggara	20 (32 days)	24	1
Derawan Islands, E Kalimantan	14 (14 days)	19	0
Banda Islands, Maluku	10 (6 days)	17	0
Pulau Seribu, W Java	27 (12 days)	10	0
Riau Islands, Sumatra	10 (10 days)	3	0

Table 3. Geographical distribution of stomatopod species collected during the Raja Ampat survey.

Geographic distribution	Number of species	Percentage
Circumtropical	1	3%
Indo-Pacific	11	32.5%
Indo-West Pacific	2	6%
West Pacific (incl. S. China Sea)	8	23.5%
West Pacific and Eastern Indian	6	17.5%
Eastern Indonesia	5	14.5%
Endemic to Raja Ampat	1	3%

4.0 Abundance and body size of reef fishes targeted by the live reef food fish trade

Abundance and body size for a number of reef fish species targeted both for local markets and for the Live Reef Food Fish Trade (LRFFT) were recorded by means of visual census by the second author (JSP) on 19 reef sites in the NW Raja Ampat area (Tables 4 & 5). The visual census methodology described in Pet and Muljadi (2001) for surveying grouper spawning aggregation sites (SPAGS) was used here, although the sites surveyed herein were not necessarily SPAGS. Relatively few specimens were encountered of the high-quality predatory reef food fish species such as groupers, snappers, large emperors, napoleon wrasse, and trevallies. None of the LRFFT target species observed in this survey, except *Plectropomus oligocanthus,* showed mean abundances of more than 2 specimens per site on average, whereas most species were observed at mean rates well below 1 specimen per species per site. Note that this survey differs considerably from the grouper stock assessment conducted by La Tanda (2002) in the CI 2001 Raja Ampat RAP in that only high value grouper species targeted by the LRFFT were recorded (ie, species of *Cephalopholis* and smaller, low value species of *Epinephelus* were NOT recorded in this survey). This important distinction is likely the cause of the considerable difference in estimates of overall grouper abundances between these two surveys.

Plectropomus oligocanthus seemed to be the most widely distributed (Table 5) and showed the greatest mean abundance (Table 4) of the LRFFT target species surveyed. *P.oligocanthus* is the least prefered of the coral trouts in the LRFFT, as fishers believe it to be aggressive, causing stress and wounds in other species which are kept in the same holding pens. This species is usually avoided by cyanide fishermen because of their aggressive nature and also since it is very hard for divers to capture, as it usually swims away from divers instead of trying to hide in the coral. The relative abundance of species in the Raja Ampat survey area is strongly skewed to *P. oligocanthus,* which is different from the relative abundance in the protected area of Komodo National Park where the preferred target species such as *P. leopardus* and *P. areolatus* showed higher relative abundance (Pet & Muljadi, 2001). This might of course simply be a regional difference, but abundance of high value target species was generally considered low and is thought to be linked to the high levels of fishing pressure targeting these species.

Table 4. Length frequencies of target species (live reef food fish trade), as encountered on reef sites in NW Raja Ampat Islands. 19 Sites surveyed for target species: 2, 5, 6, 7, 10, 13, 14, 17, 18, 20, 23 ,26, 30, 32, 36, 38, 42, 47, 51

Numbers per target species LRFFT	**length in cm:**	**10-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-99**	**100->**	**N total**
Plectropomus leopardus		1	6	7	7	2	2		25
Plectropomus laevis				1			3		4
Plectropomus areolatus					7	24	5		36
Plectropomus oligocanthus		1	13	17	17	15	5		68
Plectropomus maculatus		1	1	2	1				5

Epinephelus fuscoguttatus					1	4		5
Epinephelus polyphekadion				2				2
Epinephelus coioides						2		2
Epinephelus lanceolatus							1	1
Epinephelus caerulopunctatus				2				1
Cromileptes altivelis		1	3	1				5
Anyperodon leucogrammicus	1	1	3	5				10
Variola louti	1	1	2	1	3			8
Variola albimarginata		4	4					8
Cheilinus undulatus	2		3	1	5	10		21

Table 5. Observed occurrence of LRFFT target species on sample sites in NW Raja Ampat.

Target species	**Sample sites where species were recorded**
Plectropomus leopardus	2, 6, 7, 10, 14, 20, 38, 42, 47, 51
Plectropomus laevis	2, 17
Plectropomus areolatus	2, 14, 7, 18, 21, 30
Plectropomus oligocanthus	2, 5, 6, 10, 13, 14, 18, 20, 32, 42, 51
Plectropomus maculatus	5, 23
Epinephelus fuscoguttatus	2, 18, 20
Epinephelus polyphekadion	5, 14
Epinephelus coioides	7, 10
Epinephelus lanceolatus	2
Epinephelus caerulopunctatus	13, 30
Cromileptes altivelis	7, 13, 14, 23
Anyperodon leucogrammicus	5, 6, 14, 18, 21, 42
Variola louti	7, 10, 13, 17, 21, 51
Variola albimarginata	2, 7, 18, 20
Cheilinus undulatus	2, 7, 10, 14, 20, 21, 23, 30, 36

The size fequency distributions seem to indicate relatively low numbers of larger adult specimens for the main target species of coral trout, *P. leopardus*, which was specifically targeted by most fishermen interviewed during our survey. It was noted that especially larger adults above 50 cm were rare on the reefs as well as in the catches. Fish in the observed catches of fishermen, as well as those in the holding pens that are ubiquitous throughout the area, were not individually measured but they were estimated to be mostly well under 40-45 cm in length.

A distribution with relatively many large adults was observed for only one species of coral trout, *P. areolatus* (the second most abundant species of *Plectropomus*), though this species was confined to relatively few sites compared to *P. leopardus* and *P. oligocanthus*. Sites with *P. areolatus* were generally characterized by good hard coral

cover and high rugosity. It was noted that not a single full size adult male *C. undulatus* over 100 cm was recorded on any of the 19 sites in this survey. The low mean size of *C. undulatus* in the area was confirmed by inspection of live fish holding pens which contained only juvenile specimens. It was noted that also small juveniles (< 50 cm) were very rare on the reefs, even in comparison with medium sized fish between 50 and 100 cm.

Possible spawning aggregation sites for *P. areolatus* were noted at some of the sites included in this survey (sites 2, 14, and 21). Site number 2 (Cape Kri) in particular is expected to be a multi-species spawning aggregation site for *P. areolatus*, *P. laevis*, *P. oligocanthus*, *E. fuscoguttatus* and probably also *C. undulatus*. Densities of spawning aggregations are not expected to be very high here due to fishing pressure in the area but may fulfill an important function in the area and therefore warrant protection. This site, situated on a reef promontory, has a high percentage of live hard coral cover and is generally in a very good condition. Moreover, it is situated near a drop-off to deeper water (on the eastern edge of the shelf in the Dampier Strait) and is continually subject to strong currents running over it in different directions according to the tides. A rising tide brings clear water to this site from the deeper part of the Dampier Strait to the east, which is rare in the area. This same site was also observed to be the most diverse site in terms of reef fish species during the recent CI 2001 Raja Ampat RAP survey (Allen, 2002). The only giant grouper (*Epinephelus lanceolatus,* measuring 140 cm) observed during this survey was also recorded from this site.

It is our strong recommendation that the potential SPAGS identified above (including Cape Kri, Sardine Reef and Mike's Reef, as well as the eastern edge of the Pulau Dua/Wai reef system in the eastern Dampier Strait) should be monitored during the days just preceding the full moons of each month to determine patterns in reef fish aggregation and possible fisheries activity. These areas should be considered priority candidates for closure as "no-take" zones in future conservation initiatives in the area.

One final note regarding fish aggregation sites regards the apparent presence of several manta ray feeding areas in the surveyed region. At least two manta ray aggregation sites were reported to exist in the area, with one close to Airborai Island on a reef flat characterized by extensive rubble fields (near 0°34.40' S, 130°31.40' E) and one just east of Wai Island (0°40.30' S, 130°43.28' E). The above locations are not exact and the manta aggregations are best located with the help of experienced guides from Irian Diving. These resources may come under threat soon from a manta ray fishery which is developing in Indonesia and and which is supplying gill plates of manta rays to foreign markets (Hong Kong, China). This fishery is already leading to very heavy pressure on the manta ray population in the Alor area where 2,000 animals are harvested every year near the village of Lamakera on Solor Island (Kahn and Dewar, pers. comm.).

5.0 Resource Use Patterns and Current State of Resource

5.1 Marine

Live reef food fish trade (LRFFT).
The heavily depleted grouper and Napoleon wrasse stocks reported above are strong indications of the extent of the live reef food fish trade (LRFFT) in the area. Indeed, Amarumollo and Farid (2002) discuss the rampant use of cyanide for live capture of target fishes for the LRFFT and the apparently ever-increasing pressure on these target stocks. We also noted a very strong focus amongst local fishermen on these LRFFT target species, and it is interesting to note that the Raja Ampat area appears to support one of the last remaining large scale LRFFT fisheries in Indonesia (the LRFFT has largely collapsed in most areas of Indonesia since the late 1990's – e.g., Bentley, 1999; Erdmann and Pet-Soede, 1999). However, we noted that much of the serranid fishing was actually done using hook and line by traditional fishers with small live wells in their dugout canoes.

One large live fish holding cage installation located in the extensive platform reef system between Gam and Mansuar Islands (near 0°34.30' S, 130°33.30 E) provided insight into the dynamics of the LRFFT in this area. The cage installation was reportedly owned by a Sulawesi company (cooperating with local policemen) and manned by 10-15 fisher/divers from Sulawesi. These divers collect serranids (mainly *Plectropomus spp*, excluding *P. oligocanthus* which was not observed in the cages, *Epinephelus spp* and *C. altivelis*), live lobster (*Panuliris* sp.) and *Cheilinus undulatus* using hookah compressor and cyanide solution. However, in order to both increase their production and ensure their welcome stay in the area, they also are authorized to purchase live grouper from local fishermen. We observed a number of local fishers using hook and line to target small individuals of *Plectropomus spp.* for sale to this cage operation. Our observations and questioning of both fishers and cage divers suggest that most of the *C. undulatus* in the holding pens are caught by the professional cyanide divers, while a considerable percentage of the live coral trout are caught by local handliners. While we also heard reports of locals involved in cyanide/hookah diving for target species, it was our impression that a reasonably large percentage of the cyanide fishing for the LRFFT in the Raja Ampats was being conducted by outside fishers, while local handliners focused heavily on catching the remaining (dwindling) juvenile groupers in the area.

It is important to note that numbers of *Epinephelus fuscoguttatus* and *E. polyphekadion*, both high value LRFFT target species, were extremely low in both our reef surveys and observations of the contents of live fish holding pens. It seems likely that this was caused by aggregation fishing by large scale cyanide operations, as local fishermen indicated that these fish were once abundant in the area but had disappeared soon after the live fish operations entered the area.

There remains some confusion over the prices paid to fishers for target species in the LRFFT. Amarumollo and Farid (2002) report that grouper and Napoleon wrasse fetch Rp 3,000/kg, but then later report that serranids sell for Rp 80,000/kg and *Cheilinus*

undulatus for Rp 130,000/kg (?). Our discussions with local fishers revealed a slightly more narrow range of prices, with Rp 30,000/kg mentioned at the above holding pens as a standard price for small coral trout (*Plectropomus spp*) below 0.5 kg, Rp 70,000/kg specifically mentioned for choice *P. leopardus* and *C. altivelis* specimens over 0,5 kg, and Rp 100,000/kg fetched for *C. undulatus*. Fishermen closer to Sorong reported prices for sales directly to the carrier vessels of Rp 180,000 per kg of larger *P. leopardus* and Rp 250,000 per kg for *C. undulatus* and *C. altivelis*. The latter figures are in line with market prices across Indonesia for LRFFT target species. The large cage structure mentioned above reported production of approximately 400 kg/month, which it offloaded to a Hong Kong based live fish collecting vessel which visits the area once every month. The extensive reef systems in the area between Gam and Mansuar produced fish for a number of holding pens like the one we visited and were said to produce a total in the order of 1 to 2 tons of live fish per month.

Typically, interviews revealed the involvement of the armed forces in the larger live reef fish, cyanide and blast fishing operations. A number of fishers mentioned the frequent presence of armed forces personnel on board fishing vessels for "protection". These fishers further explained that armed forces had also been involved with the large-scale operations of "pukat harimau" illegal trawlers, which reportedly cleaned out the reef platforms south and east of Waigeo in the late 1990's before leaving under increasing threats from local fishers desperately defending their reefs. IT is important to note that several fishers discussed the dangers involved in these conflicts and that numerous local villagers had died while trying to protect their reefs and forests from outside operations with military support. We were also told that in cases where outside destructive fishers did not have such military support, local villagers were more inclined to go after these intruders and would frequently "beat them up."

Lobster fishing

Though not technically a LRFFT target fish species, the cyanide divers involved in the LRFFT also target any lobsters they come across. According to Max Ammer, *Panuliris* lobsters in the area are now at a fraction of the abundance they were a decade ago. Several dozen lobsters were observed during our surveys, comprised of several groups of 2-8 individuals at a handful of sites. Lobsters are exported from the area to markets in Indonesia and abroad, both in styrofoam boxes via the local airport to destinations inside Indonesia and alive on the live reef fish transport boats from Hong Kong, which visit the area at least once per month according to consistent interview results. Most lobsters in the area are caught by the same cyanide fishing operations which harvest live groupers and napoleon wrasse, and many were observed in a number of live fish holding pens in the area. Indeed, one particularly informative older fisherman on Wai Island explained that the best way to determine if a live cage operation was involved in cyanide fishing was the presence of lobster and Napoleon wrasse, as neither of these are taken by local handliners.

Blast fishing

Our observations are here yet again different from those of the CI RAP team, who report that they observed evidence of blast fishing at only 13.3% of the survey sites. By

contrast, we found evidence of blast fishing at most of the reefs we visited, backed up by convincing statements from local fishers (for a possible explanation of the differences in our observations, see the end of this section on "survey site selection"). The knowledgeable older fisherman interviewed at Wai Island claimed that he had watched more than 50% of the previously pristine reefs in the area destroyed by blast fishing during his career. Sadly, much of the extensive reef around Wai Island had been blasted into oblivion during the last few years, with only a rubble wasteland remaining and no fish of commercial value. This in an area where Irian Diving once thrilled guests with fantastically abundant fish life including sharks, snappers, emperors, sweetlips and even the giant Queensland Grouper *Epinephelus lanceolatus* (Ammer, pers. comm.). The old fisherman bleakly related how the surrounding reefs now yielded at most 2-3 small groupers a day to the few handliners who still worked the area. Unfortunately, blast scars were evident on most of the reefs we dived, with a familiar "patchwork quilt" pattern of healthy reef patches alternating with rubble fields.

The perpetrators of this blasting were often reported to be outsiders, although some local villages were also purportedly involved. One village close to Sorong on Pulau Buaya was said to be completely dedicated to blast fishing, as was the village on Pulau Amdui. Those we interviewed claimed that these villages were populated by Butonese people (from SE Sulawesi) – infamous as blast fishers throughout Indonesia. These Sulawesi fishers were reportedly involved in long-range multi-day blast fishing operations, with around seven fishers per vessel and a typical operations area of the northern half of Raja Ampat (into the remote reaches of the archipelago). We personally encountered several of these vessels while in the Wayag Islands, where they remained for several days (see photo in Appendix 1). One of these boats had divers in the water when we observed them in the Wayags, while the others were anchored. We observed the same vessels several days later near the fish landing site in Sorong. There are in fact two fish markets in Sorong and both had large quantities of fusiliers for sale – the most common target for blast fishers in other parts of Indonesia.

When we asked fishers about enforcement against blast fishers, we were told that although there had been several arrests for blast fishing over the past years, none of these led to prosecution. Apparently these arrests were settled with a local police reprimand and suspected bribery. Fishers said that larger blast operations either employed armed forces "protection" directly on their boats or made regular payments to police to prevent arrests. The only effective enforcement we were told of was a type of vigilante justice whereby smaller bomb operations were occasionally attacked and beaten by angry handliners.

Prawn trawlers

Although we did not directly observe prawn trawling activity in the Raja Ampat area, we did observe a large amount of typical bottom trawl catch (small demersal fishes from relatively shallow, sandy or muddy bottoms at the local fish market of Sorong. This fish arrived at the Sorong market in large frozen blocks as typically prepared from by-catch on larger prawn trawlers operating in eastern Indonesia. We concluded from this that large-scale bottom trawlers were based in the area and landing at least their by-catch in

Sorong. The Sorong harbour was then visited to confirm the presence of trawlers and several large bottom trawlers were indeed observed in the harbour (see photo in Appendix 1). Interviews revealed that several prawn trawling companies have been based in Sorong since the late nineties. One of them is a Japanese firm which owns 5 large trawlers. No conclusive evidence could be found in relation to the operating area of these trawlers, but interviews suggested that they operate mostly south of Sorong. It is feared that the shelf area between Eastern Misool and Bintuni Bay, which may have very high value for conservation and is partly inside designated conservation areas, is targeted by these bottom trawlers for shrimp. This area is well outside the Arafura Sea where prawn trawling is legally permitted.

Bagan fishing.

Omnipresent in the large protected bays of Waigeo were small bagan (lift-net) boats which typically target schools of squid and small baitfishes in the clupeid and atherinid families (see photo in Appendix 1). Amarumollo and Farid (2002) report that these bagans are causing overfishing in the area. They also imply that the small fishes captured are dried and sold to collectors who visit on a monthly basis. From our limited observations, it appears that there are at least two "types" of bagan fishery – one that collects live baitfish for the pelagic pole and line fishery (seemingly unreported by CI) and one that dries the fishes for sale for direct human consumption (we observed several drying operations in clearings on the inside of Kabui Bay, and these appeared to be run predominately by immigrants to the area – Ammer, pers.comm.). It is unclear upon what evidence Amarumollo and Farid (2002) base their suggestion of overfishing, but this is clearly an issue which is in need of clarification – as pelagic pole and line fishing (and its associated baitfish fishery) is often an important component of conservation initiatives for reef systems in Indonesia.

"Commercial fisheries".

Amarumollo and Farid (2002) list 11 commercial fishing operations that operate within the Raja Ampat Islands, including 4 companies focusing on small pelagics, 4 companies exporting live reef food fish (serranids and Napoleon wrasse), and 3 pearl farms. Unfortunately, it appears that these official statistics from the Sorong Department of Fisheries are quite incomplete; for pearl farms alone, there are five separate companies we observed in operation around Waigeo, at least one of which – PT Cendana Indopearls – is a publicly listed company whose name and yearly production do not even appear in the list in Amarumollo and Farid (2002). We were not able to speak directly with the Sorong fisheries department about their statistics, but we recommend that this should be a priority for the follow-up RAP in late 2002.

Shark finning

Amarumollo and Farid (2002) report that while dried shark fin commands a relatively high price in the local markets, few villagers engage in this activity due to the high cost of investment in gear and the skills required for the fishery. Nonetheless, there is strong evidence that shark finning by outside fishers has dramatically reduced the shark populations in the Raja Ampat Islands. During the early 1990's, fleets of Makassarese

shark fishing boats from the Spermonde Archipelago in SW Sulawesi frequently targeted the Raja Ampat Islands (MVE, pers. obs.). While we did encounter a variety of shark species on our short survey (grey, black tip, and whitetip reef sharks, and bull, wobegong and epaulet sharks), most of these were sightings of single individuals, and information gleaned from talking with local fishermen revealed that outside fishing boats (mostly from Sulawesi) still target sharks for finning to this day. Moreover, Max Ammer from Irian Diving reported that he believed shark populations to be a fraction of what they were when he began operations in the area a decade ago. Yet another dive operator familiar with the area reported that shark finners have moved on from more common sharks to targeting guitarfish in the northwestern reaches of Raja Ampat (Frommeweiler, pers. comm.).

Turtles, Trepang and Tridacna

As mentioned in Section 2.0, we were pleased to note the presence of a number of endangered marine species throughout the survey area, including 3 species of marine turtle (green, hawskbill and leatherback) and a number of large *Tridacna* clams, including *T. gigas, T. derasa* and *T. squamosa*. Unfortunately, we also saw abundant evidence of illegal exploitation of these resources. In several areas (including the remote Wayag Islands), turtle carapaces were hung in mangrove trees or on the sides of karst "mushrooms" – usually marking the camp sites of itinerant fishermen (purportedly from Sulawesi). Several large middens of giant clam shells were also observed near these camps. Nonetheless, overall abundances of giant clams on the reefs and especially reef flats were still higher than anywhere else we've recently observed in Indonesia. Within the Wayag Islands, Max Ammer found a series of small turtle nesting beaches, and the island of Sayang (to the NW of Wayag) is reputedly a large green turtle nesting area (and proposed as a wildlife sanctuary – Supriatna, 1999).

Although a trepang fishery was not observed by us, both Amarumollo and Farid (2002) and PPKPL (1990, 1992) report this fishery from the Raja Ampats. We observed several specimens of high value species such as *Thelanota ananas,* which are virtually extirpated on most Indonesian reefs. However, trepang abundances were certainly much lower than on unfished reefs in the Great Barrier Reef, for example.

Marine Ornamental Trade

We did not observe any evidence of a marine ornamental fish trade in the area, though it seems likely that if it is not currently an issue it will soon be given its rapid spread across Indonesia. The follow-up RAP in late 2002 should specifically look for evidence of an ornamental trade; the airline connections are certainly favorable for one and it can be quite profitable. Indeed, given the vast amount of reef area in the Raja Ampat archipelago, a potential conservation strategy may be to lease concession areas from local villagers for the purpose of developing a certified sustainable ornamental fishery (see below in section 7.0).

Survey site selection

Our observations listed above are often slightly at odds with those in the CI 2001 RAP report, which generally suggests relatively light fishing and other anthropogenic impacts

on the reef sites surveyed (though note the exception in Amarumollo and Farid, 2002). From surveying a representative number of the sites that were covered by the CI RAP, discussing RAP survey methods with Max Ammer and simultaneously surveying sites not included in the CI RAP, we believe that one reason for this difference in impression may be the apparent focus of the CI RAP on dive sites frequented by Irian Diving and hence "preselected" to represent the reefs in the best condition in the area. Unfortunately, the CI report does not identify the basis for RAP site selection, so our explanation remains speculative. Nonetheless, it is our conclusion that the fishing pressure and overall anthropogenic impact on the northwestern Raja Ampat area was more severe than on most of the selected CI survey sites; i.e., that the condition of the selected survey sites was not necessarily representative of the entire reef area surveyed. This observation is consistent with a comparison between Amarumollo and Farid's (2002) assertion that there is a generally high level of fishing pressure in the area and McKenna et al.'s (2002) report on reef condition which suggests only "slight" fishing pressure on the majority of the RAP survey sites. Our observations concur with both of these statements, which suggests that it may be misleading to compare the average Reef Condition Index (RCI) derived in the CI 2001 Raja Ampat RAP with those from other CI RAPs if the site selection in other RAPs was conducted either randomly or in a representative manner. The criteria for site selection for the planned follow-up RAP should be clearly articulated before the commencement of that survey.

5.2 Terrestrial

While the focus of our survey was the marine ecosystems in the Raja Ampats, one could not help but notice the presence of several large logging operations in the area, including areas that seem to be part of the protected nature reserve system. We observed and photographed (see Appendix 1) five logging areas, including roads on either side of the Gam-Waigeo passage, in the NE of Kabui Bay, in Warparim Bay on western Gam, and in the northeastern reaches of Alyui Bay. There are allegations that this logging is organized with the involvement of local government, the armed forces, and even the local conservation office (KSDA) in Sorong – all of whom purportedly receive direct benefits from the logging operations (FPA, 2002). Amarumollo and Farid (2002) report the presence of 9 logging companies operated by the "timber industry", and 9 logging companies operated by "the people." The distinction here is unclear, and it is unknown if this tally is for the entire Raja Ampat area or just Waigeo, Gam and Batanta. What is clear is that this logging poses a serious threat to the sustainable livelihoods of the local communities and especially to the reef system via the erosion and subsequent sedimentation caused by the logging. This threat will likely only increase in the near future and poses a major challenge for conservation of the area.

Other valuable but threatened terrestrial resources we observed include large fruit bat colonies and colonies of other species of bats in the limestone caves that are ubiquitous in the area. The bats in the caves are being harvested with gillnets and management of this resource seems to be absent. The bats are said to fetch between Rp 7,000 and 10,000 each, depending on their size. The caves also contain the nests of swiftlets, which are a valuable resource that is being carefully managed in other parts of Indonesia. One large cave which we visited seemed to be unguarded and more than 90% of the swiftlet nests

had been removed, judging from the empty spots where nests attachments made their marks on the ceiling of the cave. Very few nests and swiftlets were still present and it is our recommendation that these potentially valuable resources of birds' nests and bats deserve better management, especially as they are reportedly being plundered by migrating outside fishing groups.

6.0 Communities and Resource Management

While the previous section suggests that there is in fact little active resource management occurring in the survey area, local villages clearly have strong traditional claims of ownership of both land and reef areas in the Raja Ampats. For example, the villagers of Selpele in western Waigeo (the Kawe people?) apparently claim traditional rights over a vast uninhabited area to the north and west including Kawe Island, the Wayag Islands, much of western Waigeo/Alyui Bay, and possibly much of the Batang Pele group (Ammer, pers.comm., Frommeweiler, pers.comm.).

Besides simple ownership claims, evidence suggests that the Papuan peoples here have a long tradition of coastal resource management as well, though these traditions may be less strong today. Amarumollo and Farid (2002) report that the traditional "sasi gereja" system of seasonal closures on exploitation of marine resources is largely defunct in the Raja Ampat Islands, though at least two villages (Arefi and Yansaway on Batanta Island) showed interest in reviving this tradition. It is important to note that while various forms of the "sasi" tradition are known from throughout the Maluku and Sangihe/Talaud regions of eastern Indonesia, these traditions are generally in decline throughout much of their former range, though they remain strong and effective in some cases (Zerner, 1994).

Clearly, the related issues of local ownership rights (land and marine "tenure systems") and traditional sasi systems in the Raja Ampat Islands are critical ones to understand fully before planning and implementation of conservation activities can begin. While a full literature survey is certainly called for, we note at least three important direct sources of further information, including the "Raja Ampat Indigenous Peoples Board" or "Kalanafat" (reported in Amarumollo and Farid, 2002), PT Cendana Indopearl's community development officer (who has much experience with the nuances of working with the villagers on Waigeo), and the Summer Institute of Languages (SIL), a missionary group that works to study local languages and later translate the bible into those languages – and has likely gained extensive knowledge of the customs and traditional ownership claims of the local villages during their long presence in the area (Mr. Keith Berry from SIL is a specific contact person). These potentially excellent sources of information on the local communities should be the first target of further sociological research to facilitate development of marine conservation initiatives in the area. Additionally, the University of Cenderawasih's anthropology department is a likely source of additional information on the traditions of the people in this area.

A better understanding of these traditional ownership and management schemes (and why they may currently be in decline) will likely highlight potentially effective strategies to involve local villagers in conservation activities. While these local villagers clearly do

not currently have the resources or legal clout to enforce their ownership claims and prevent the resource destruction that is now occurring, this situation is likely to change in the near future with the ratification of the national coastal zone management law currently being prepared by the Department of Marine Affairs and Fisheries (DKP). This law will likely include provisions that recognize traditional coastal tenure and management systems and thereby provide an opportunity to rekindle these systems in the Raja Ampats.

7.0 Options for Sustainable Community Development

It is clear that that any conservation strategy for the Raja Ampats must include sustainable community development options. Fortunately, the population density here is quite low, while the natural resource base is conversely quite large – making it feasible to target a large percentage of the population for development programs. At the same time, human resource development and training will certainly be a challenge in this relatively underdeveloped area. Our brief survey indicated a number of potential avenues for community development, including conservation concessions, mariculture of locally abundant target species, pelagic capture fisheries, ecotourism, and value-added industries related to the byproducts from the pearl farm industry. Each of these options is very briefly touched upon below.

Given the traditional claims to ownership of forest and reef areas, the possibility for development of conservation concessions seems more plausible here than in most areas of Indonesia. Indeed, the pearl farm PT Cendana IndoPearls has already pioneered a type of concession agreement with the village of Selpele on western Waigeo, to whom they pay a "concession fee" in return for the right to utilize Alyui Bay for pearl farming for a defined time period. While the legal basis for development of conservation concessions needs clarification, there is clearly a huge potential in the concession concept in this area. Possible concession targets include sustainable forestry products, orchids, and marine ornamental fishes. One obvious potential target area for concession development would be the extensive and uninhabited terrestrial and marine areas claimed by the village of Selpele , including Kawe Island, the Wayag Islands, and much of western Waigeo.

Mariculture may also be a viable livelihood option, particularly if high value target species such as mangrove snapper (*Lutjanus argentimaculatus*), various grouper (especially *Epinephelus spp*.), and barramundi (*Lates calcifer*, whose natural presence in the area was not verified but seems likely given the abundance of appropriate habitat). Mangrove snapper in particular was highly abundant in the bays around Waigeo, and it is a robust and rapidly growing species that is quickly becoming a high value species in the LRFFT. Local fishers have some experience with husbandry of live fishes in the holding cages found throughout the area; this could provide a strong basis for establishment of community-based growout farms.

Besides mariculture, there appear to be viable alternatives in pelagic fisheries development for tuna and Spanish mackerel. Unusually high numbers of spanish mackerel were observed throughout the area and these could certainly sustain a high

value hook-and-line fishery. Logistics would need to be worked out (ice, transport, etc.) and none of this seems to be organized in the area for spanish mackerel at present. Most of the waters in the area include well protected fishing grounds which could be very productive and safe operation grounds for local small-scale mackerel fisheries. The local market situation for spanish mackerel was not completely clear but prices for the local market seemed well below those in other parts of Indonesia which usually export fish to more high-end markets. The airport facilities with daily flights from Sorong to western Indonesia improve the viability of such export. There is also an abundance of small tuna in the area, particularly in areas just off the continental shelf. A pole and line fleet is currently operating out of Sorong and there is a tuna cannery in town, which is however said to suffer from financial problems due to low prices for small tuna in recent years. The current market situation and possibilities for involvement of local communities in the tuna fisheries (e.g. as crew on larger tuna vessels) needs further analysis but seems potentially viable.

Ecotourism development is currently in its infancy in the area (Irian Divers resort and the Pindito diving liveaboard are the only companies to have set up operations in the area) but has enormous potential. Besides diving, the area is perfect for kayak touring, birding, and nature trekking. Flight connections to Sorong are already on a par with those to more heavily visited ecotourism destinations in Indonesia (e.g., Komodo National Park) and may well improve with the continued privatization of Indonesia's airline industry. Two potential hurdles to ecotourism development include the need for human resources development amongst locals and the dearth of clear visibility dive sites – which may limit the overall appeal to more "mainstream divers" who require more than exceptional biodiversity to draw them in. One very clear priority for ecotourism development is that legislation and/or a permitting system should be enacted that ensures that local communities benefit from this tourism; there are an abundance of examples from throughout the Indonesian archipelago of tourism development that provides few, if any benefits to local communities.

One final option for community livelihood development involves value-added industries related to byproducts from the extensive pearl farm industry in the area. Three byproducts which are currently underutilized include the pearl shell, the edible oyster meat (adductor muscle), and the discarded gonads and other organs of the harvested oysters. While the shell is currently shipped to Bali and Java for use in mother-of-pearl handicrafts, the managers at PT Cendana Indopearls indicated a desire to see local communities instead learn how to work with the mother of pearl such that shell could be bought, worked, and exported locally for community benefit. Similarly, while the oyster meat currently is shipped on an intermittent basis to buyers in Indonesia, this potentially highly valuable meat could feasibly be canned locally for export. Finally, PT Cendana Indopearls has pointed out that the remainder of the oyster's soft parts (which are currently discarded at sea) include a high percentage of gonads – which have high lipid content and would be valuable as a potential food source for mariculture operations. PT Cendana IndoPearls indicated a willingness to freely donate these discards if local communities could put them to use in an environmentally-friendly manner. It is unclear if the other pearl farms in the area have as generous an attitude towards local communities (in fact the evidence

suggests the contrary), but requirements could feasibly be built into their operating permits that would ensure good corporate citizenry.

8.0 Current Legal Conservation Status and Future Needs

In considering conservation strategies for the Raja Ampat area, a comprehensive system of protected areas is clearly an important component. Unfortunately, the current status of protected areas in the Raja Ampat area is difficult to decipher through the various conflicting published reports. Supriatna (1999) suggests a total of 8 official protected areas in the Raja Ampat area (including the Ayu and Asia islands), of which 4 were reported gazetted as of 1999 (including West Batanta Nature Reserve, North Salawati Nature Reserve, Waigeo Island Nature Reserve, and Misool Island Nature Reserve) and 4 (all officially to be categorized as Marine Protected Areas) were reported as proposed for gazetting (Raja Ampat Archipelago Marine Wildlife Sanctuary, Asia and Aru Islands Marine Wildlife Sanctuary, Sayang Island Marine Wildlife Sanctuary, and Lelintah Bay/South Misool Marine Wildlife Sanctuary). Note however that the Raja Ampat Marine Wildlife Sanctuary was officially gazetted in 1993 (SK Menteri Kehutanan No. 81/Kpts-II/93). By contrast, McKenna et al. (2002) report 5 conservation areas in the Raja Ampat area, but then proceed to list 6 areas (West Waigeo NR, East Waigeo NR, West Batanta NR, North Salawati NR, South Misool NR, and Raja Ampat Archipelago Marine Wildlife Sanctuary). The information available to us is summarized in Table 6; the most recent information suggests that there are indeed 6 protected areas in the Raja Ampat Islands, of which 5 are strict nature reserves (cagar alam) and one is a marine wildlife sanctuary (suaka margasatwa laut). The three additional proposed marine wildlife sanctuaries listed in Supriatna (1999) do not appear to have been gazetted in the 3 years since that report. Note also that the total area included in protected areas is also unclear; the latest data available to us in PHKA (2000) suggest a total of 483,000 hectares of protected areas in Raja Ampat (of which only the 60,000 hectares in the Raja Ampat wildlife sanctuary are clearly designated with MPA status), while Amarumollo and Farid (2002) report a total of 797,716 hectares of protected areas (121,136 hectares of which is reportedly coastal/marine area). Unfortunately, Amarumollo and Farid (2002) do not cite the source of their information. Clearly the legal status of the official protected areas in the Raja Ampat Islands must be clarified as a precursor to conservation planning for the area.

Beyond the need to determine the current legal status of protected areas in the Raja Ampats, our survey suggests there is a strong need to socialize protected area concepts, rules and borders to local communities. Many seemed vaguely aware of the nature reserves, but their knowledge was very limited and it is clear that there has been little active presence of the local conservation department (KSDA) in the area. Even worse, there are strong allegations that the KSDA officers in Sorong are involved in issuing permits for logging and gravel collection in the nature reserves (FPA, 2002). This situation is untenable for conservation development, and a strong lobby with the Department of Nature Conservation (PHKA) at the national level will probably be necessary to clean up this office and ensure responsible and dedicated conservation personnel.

From an MPA perspective, the Raja Ampats appear woefully underprotected and certainly in need of further MPA development. The only MPA readily discernible to us is the Raja Ampat marine wildlife sanctuary off SW Waigeo. Unfortunately, our survey results suggest that this is among the least favorable areas for MPA status, as it is relatively densely populated with fishing villages, including the two LRFFT export centers of Mutus and Miosmanggara villages (Amarumollo and Farid, 2002). Moreover, this area only encompasses a fraction of the marine habitat areas present in the Raja Ampat Archipelago. We strongly recommend that a priority for future conservation efforts in the area should be the gazetting of additional MPAs covering a larger range of habitats than the current wildlife reserve, with a focus on uninhabited or sparsely populated areas where resource use conflicts will be minimal. Also, an emphasis on identifying reef fish spawning aggregation sites (SPAGS) and including these areas in the MPAs is important. Preliminary observations suggest that the Wayag Islands, the Fam Islands, and the Mansuar-Kri-Pulau Dua area are top candidates for MPA status from amongst the area surveyed. The planned continuation RAP in late 2002 should help identify other priority MPA candidate sites.

Regarding the issues of regulation and enforcement, there is already a basis for enforcement in the area. While in Sorong we noted a number of naval and police fast patrol boats. While these boats appear to be underutilized at this time, it would be potentially straightforward to arrange cooperative agreements with these two agencies. PT Cendana IndoPearls currently has an arrangement with the water police force that stations a number of armed police officers within the relatively high tech radar-based surveillance and enforcement system they have set up in Alyui Bay to guard their significant investments. This could provide a model for further enforcement agreements in the region.

Beyond the water police and navy, Amarumollo and Farid (2002) report an encouraging initiative by the Kabupaten Sorong Fisheries Department to pass legislation to prevent further overexploitation of threatened fish stocks and specifically to limit the ability of outside interests to extract fisheries resources with no benefits passed on to local communities. This would apparently be done through a system of both licenses and quotas for specific target species, as well as the important step of banning the use of compressed air (hookah or SCUBA) to collect marine organisms in the Raja Ampat area. Amarumollo and Farid (2002) report the source of their information as an unpublished annual report of the Fisheries Department, so it is unclear if this legislation has actually been passed or has simply been proposed.

Table 6. Official Protected Areas within the Raja Ampat Island area (based on McKenna et al., 2002; PHKA, 2000; and Supriatna, 1999). Sections of the table for which data is unclear and needs further investigation are marked "ID" for incomplete data.

Name of Protected Area	Official Status and associated Forestry Ministerial Decree	Size of Protected Area	Marine Area Included?
West Batanta Nature Reserve	Gazetted in SK No. 912/Kpts/Um/1981	10,000 hectares	ID
North Salawati Nature Reserve	Gazetted in SK No. 14/Kpts/Um/1982	57,000 hectares	ID
South Misool Nature Reserve	Gazetted in SK No. 716/Kpts/Um/1982	84,000 hectares	ID
West Waigeo Nature Reserve	Gazetted in SK No. 395/Kpts/Um/1981	153,000 hectares	ID
East Waigeo Nature Reserve	ID, but clearly formally gazetted	119,500 hectares	ID
Raja Ampat Arch. Marine Wildlife Sanctuary	Gazetted in SK No. 81/Kpts-II/93	60,000 hectares (though Supriatna, 1999 lists only 2976 hectares)	YES
Lelintah Bay Marine Wildlife Sanctuary (South of Misool)	Proposed (Supriatna, 1999)	2,500 hectares	Proposed
Sayang Island Marine Wildlife Sanctuary	Proposed (Supriatna, 1999)	2,468 hectares	Proposed
Asia and Ayu Islands Marine Wildlife Sanctuary	Proposed (Supriatna, 1999)	1,531 hectares. Note: this area not included within boundaries of Raja Ampat area described in McKenna et al., 2002	Proposed

9.0 Conclusions

As previously underscored in the McKenna et al. (2002) CI 2001 RAP report, the Raja Ampat Islands are clearly an area of tremendous biological diversity and incredible natural beauty, both above and below water. Our findings regarding the diversity of stomatopod crustaceans in the northern section of the Raja Ampat Islands confirm the findings in McKenna et al. (2002) that this area is among the most biologically diverse marine areas in the world, in some part due to the tremendous diversity of habitats represented in a relatively small area.

At the same time, we concur with McKenna et al. (2002) that this area is currently highly threatened by both illegal and excessive resource exploitation (including logging on land and blast and cyanide fishing and shark finning in the marine areas) that may very well increase in intensity in the near future. Some fisheries (including the LRFFT fishery for groupers and Napoleon wrasse and the shark fin and trepang fisheries are currently largely overexploited), and the threat of increased use of blast fishing (especially by outside fishers) is clearly present. An integrated conservation and sustainable resource management strategy is urgently called for in this area. Specific conservation opportunities and difficulties which we have identified in our short survey include the following:

Conservation strengths/opportunities:

- Natural resources still largely intact (with specific exceptions such as shark and grouper populations), with vast areas of reef and mangrove habitat and large tracts of intact forest.
- Unique opportunity to adopt a "ridges to reefs" conservation approach in Indonesia – with both terrestrial and coastal/marine habitats intact and contiguous.
- Relatively low human population density.
- Strong potential due to oceanographic setting that marine habitats in Raja Ampat are acting as "sources" of propagules for reefs and mangroves throughout the Maluku region of eastern Indonesia (needs substantiation with genetic connectivity studies).
- Local tradition of ownership of land and marine resources, with strong potential to both strengthen and utilize these rights for development of conservation concessions and other innovative conservation/management agreements with local communities.
- Several local examples of conservation and community-development compatible industries in the area (PT Irian Diving dive resort and PT Cendana Indopearls pearl farm) which can provide important lessons learned in setting up conservation concessions in the area and in community development schemes. Private sector cooperation with conservation initiatives will be a key factor to future success of these initiatives.
- Strong potential for ecotourism development due to tremendous natural beauty above and below water, with relatively direct transportation connnections to the area.
- Entire area circumscribed by a single regency (kabupaten), simplifying issues of government relations and passage of conservation legislation.
- Apparent initiative (reported in Amarumollo and Farid, 2002) by the Sorong Regency fisheries department to pass legislation to limit potential for overfishing (especially by outsiders) via licensing and quota systems and by banning the use of compressed air (hookah or SCUBA) is an important "enabling condition" for marine conservation in the area.
- At least six protected areas (strict nature reserves and marine wildlife sanctuaries) already officially gazetted in the area (though see below for weaknesses of this same factor).

Conservation weaknesses/threats:

- Extremely large area (over 4 million hectares!) to be managed; clearly priority setting will need to occur to begin implementing conservation/management strategies
- Long tradition of illegal and overexploitative resource extraction practices (blast and cyanide fishing, logging, etc), often funded/implemented by outside businesses and with purported cooperation/involvement of local authorities (including police and local government officials).
- Poorly demarcated, socialized and enforced protected areas system, with seemingly minimal management of these areas by the local conservation office in Sorong.
- Those protected areas that currently exist are mostly strict nature reserves (cagar alam), which specifically exclude multiple uses such as ecotourism or extractive activities of any kind, irrespective of their potential "sustainability". This category of protected area is often the most difficult to gain acceptance for and to enforce, as local communities and governments see no direct economic benefits.
- The current socioeconomic "heirarchy" evident in the Raja Ampat Islands and especially in Sorong is strongly biased against native Papuans and seems to have engendered some strong local feelings of resentment towards Indonesians. This may prove a challenge for future conservation initiatives and argues strongly for inclusion of as many native Papuans in future initiatives as possible.

Taking the above factors into account, it is clear that while the Raja Ampat Islands present an unparalleled opportunity for integrated marine and terrestrial conservation, this will be a challenging (if not daunting!) and time-consuming process. There appear to be fantastic opportunities to implement conservation concessions and other innovative conservation initiatives that will likely prove much more difficult in other areas of Indonesia, but any such initiatives need to be preceded by a much greater understanding of traditional concepts of marine and land ownership in the area and the legal basis for recognizing these ownership claims. Dialog with several key stakeholder groups including the communities themselves, the local government (the fisheries, forestry and tourism offices of Kabupaten Sorong and the Bupati and 5 Camats), the private sector (including 5 pearl companies, Irian Diving and various fishing companies, and the Department of Nature Conservation PHKA) should be initiated in the immediate future to begin to understand further opportunities as well as potential conflicts in implementing an integrated conservation/resource management strategy for the Raja Ampat area. Moreover, while it is clear that official protected areas will play an essential role in any conservation strategy, it will be important to explore the opportunities for utilizing protected area categories that allow for multiple uses and are hence more attractive to local communities and government (such as national park, nature tourism park, or even Kabupaten-level multi-use classifications).

Besides the above general recommendations, we also suggest that the following action items (in our opinion necessary to properly design a conservation and management strategy for the area) be prioritized either before or during the upcoming follow-up RAP in late 2002:

1. Investigation of the ecological and genetic "connectivity" of the Raja Ampat reef system to other reefs in Indonesia and the western Pacific.
2. Interviews with Sorong Fisheries Department regarding the licensing initiative discussed by Amarumollo and Farid (2002) and the possibilities of greater involvement of locals in tuna pole and line fishery, as well as supporting evidence for Amarumollo and Farid's claim of overfishing by bagan liftnets.
3. Working with the University of Cenderawasih, PT Cendana IndoPearl's community development officer, Summer Institute of Languages, and the Kalanafat indigenous people's board, attempt to map the traditional ownership claims of the villages in Raja Ampat.
4. Before the late 2002 RAP, clarify the basis for survey site selection, attempting to standardize this with previous CI RAPs in the Togian and Banggai Islands, Milne Bay, and Calamianes Islands.
5. Before the late 2002 RAP, reconcile the various estimates of total area enclosed in protected areas within the Raja Ampats (working with CI and PHKA) and finalize a table summarizing this information.
6. During the late 2002 RAP, check carefully for evidence of the marine ornamental fishery and collect details on current levels of exploitation, capture techniques, export routes, and current level of involvement of local peoples.
7. During the late 2002 RAP, attempt to verify barramundi (*Lates calcifer*) presence in the area. Also, begin initial surveys of local fishers to ascertain their interest in mariculture programs.
8. During the late 2002 RAP, attempt to identify as many reef fish SPAGS in the area as possible, and consider setting up a monitoring program to refine the knowledge of these sites.
9. Using SPAGS and other data, attempt to identify candidate areas for MPA development in the area.
10. Hold high-level discussions with PHKA to assess the department's level of interest in the protected areas system in the Raja Ampat area and their commitment to upgrading it.
11. Meet with the local conservation office in Sorong (KSDA) to ascertain their level of commitment to conservation initiatives in the Raja Ampat area. Likewise with the Bupati and the 5 Camats for the area.

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Appendix 2. Species list of reef-associated stomatopod crustaceans from Henry Foundation/TNC/NRM survey of Raja Ampat Islands, NW Papua – June 2002.

Species	Collection Sites (# specimens collected)	Known Distribution
Family Gonodactylidae Geisbrecht, 1910		
Gonodactylaceus falcatus (Forsk□l, 1775)	**13** (3), **49** (12), **53** (1)	Indo-Pacific
Gonodactylaceus glabrous (Brooks, 1886)	**13** (2), **53** (6)	Phillipines, Indonesia, NW Australia, Vietnam (West Pacific/East Indian)
Gonodactylellus affinis (De Man, 1902)	**14** (4)	Indo-Pacific
Gonodactylellus espinosus (Borradaile, 1898)	**54** (3)	Indo-Pacific
Gonodactylellus micronesicus (Manning, 1971)	**54** (1)	Eniwetok to W. Australia/Cocos-Keeling (West Pacific/East Indian)
Gonodactylellus rubriguttatus Erdmann &Manning 1998	**14** (2)	West Pacific
Gonodactylellus viridis (Serène, 1954)	**13** (8), **23** (1), **49** (18), **53** (3), **54** (1)	Western Pacific to Andamans (West Pacific/East Indian)
Gonodactylellus sp. A (Ahyong and Erdmann, in prep)	**2a** (20), **26** (4), **32** (1)	Eastern Indonesia/Papua New Guinea
Gonodactylopsis sp. A (Erdmann, in prep)	**10** (9), **14** (7), **18** (2), **20** (2), **21** (6)	Eastern Indonesia
Gonodactylus chiragra (Fabricius, 1781)	**49** (1)	Indo-Pacific
Gonodactylus platysoma (Wood-Mason, 1895)	**54** (2)	Indo-Pacific
Gonodactylus smithii Pocock, 1893	**26** (1), **49** (1), **54** (1)	Indo-Pacific
Hoplosquilla said Erdmann and Manning, 1998	**2a** (4), **32** (2), **36** (7)	Eastern Indonesia
Family Odontodactylidae Manning 1980		
Odontodactylus latirostris Manning, 1980	**42** (2)	West Pacific/Eastern Indian
Odontodactylus scyllarus (Linnaeus, 1758)	**21** (0), **47** (1)	Indo-Pacific
Family Protosquillidae Manning, 1980		
Chorisquilla brooksii (De Man, 1888)	**26** (1)	Indonesia, S. China Sea, W Australia (Western Pacific)

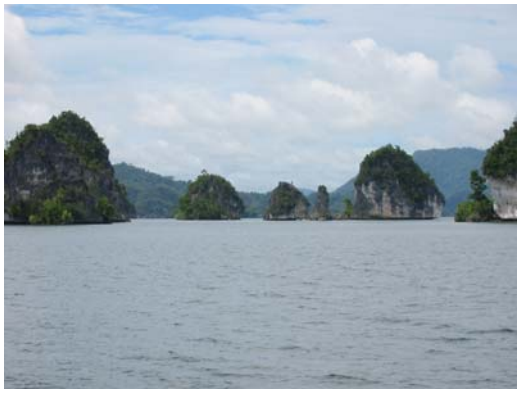
Chorisquilla gyrosa (Ohdner, 1923)	**2a** (1)	Indo-Pacific
Chorisquilla hystrix (Nobili, 1899)	**2a** (1), **10** (1), **14** (2), **18** (5), **20** (5), **32** (3), **36** (1)	Western Pacific
Chorisquilla mehtae Erdmann and Manning, 1998	**6** (22)	Eastern Indonesia
Chorisquilla pococki (Manning, 1975)	**2a** (1), **14** (6)	Western Pacific
Chorisquilla sp. A (Erdmann in prep)	**20** (6)	Eastern Indonesia
Echinosquilla guerini (White, 1861)	**21** (0)	Indo-Pacific
Haptosquilla glyptocercus (Wood-Mason, 1875)	**2a** (9), **7** (8), **26** (11), **49** (2), **50** (5)	Western Pacific to Andamans West Pacific/Eastern Indian
Haptosquilla pulchella (Miers, 1880)	**49** (1)	Indo-Pacific
Haptosquilla pulchra (Hansen, 1926)	**2a** (6), **7** (3), **12** (3), **13** (10), **26** (2), **38** (2) **47** (4), **49** (14), **50** (3), **53** (9)	Western Pacific, Indonesia, S. China Sea
Haptosquilla stoliura (Muller, 1886)	**5** (1), **7** (9), **38** (1), **53** (1)	Indonesia to W. Australia (Indo-West Pacific)
Haptosquilla trispinosa (Dana, 1852)	**2a** (2), **21** (6)	Central to West Pacific
Haptosquilla sp. A (Erdmann in prep)	**6** (5), **38** (13), **45** (7), **48** (12), **49** (1), **51** (2)	Endemic to Raja Empat
Siamosquilla laevicaudata (Sun and Yang, 1998)	**2a** (5), **18** (1), **21** (1), **32** (2)	Indonesia, S. China Sea, Australia (Western Pacific)
Family Pseudosquillida Manning, 1977		
Pseudosquilla ciliata (Fabricius, 1787)	**49** (14)	Circumtropical (except E. Pacific)
Family Takuidae Manning 1995		
Taku spinosocarinatus (Fukuda, 1909)	**54** (8)	Western Pacific (Japan, Indonesia, Vietnam, New Caledonia)
Family Lysiosquillidae Giesbrecht 1910		
Lysiosquillina maculata (Fabricius, 1793)	**2a** (0), **54** (0)	Indo- West Pacific
Lysiosquillina lisa Ahyong, 2001	**14** (0)	West Pacific/Eastern Indian
Pullosquilla litoralis Michel and Manning, 1971	**13** (0)	Indo-Pacific

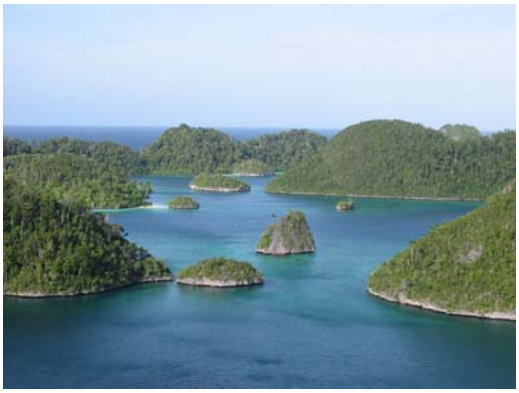
Additional expected species:

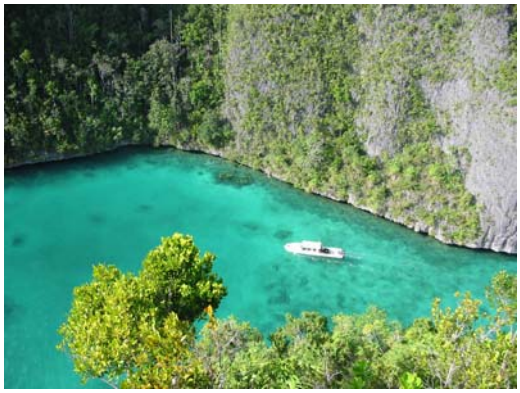
Gonodactylellus annularis, Gonodactylellus demani, Gonodactylellus erdmanni, Gonodactylus childi, Haptosquilla tuberosa, Haptosquilla proxima, Mesacturus furcicaudatus, Parvisquilla multituberculata, Raoulserenea ornata, Pullosquilla thomassini

Appendix 3: Photo collage of northern Raja Ampat rapid marine survey, June 2002.


Irian Diving base camp on Kri Island

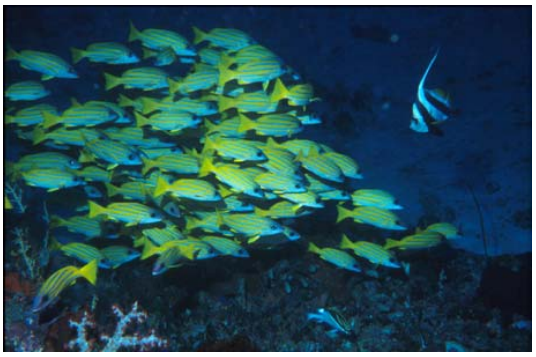

Limestone karst islands in Kabui Bay, Waigeo


Karst "beehives" in Wayag Islands


Clear lagoon waters in Wayag Islands


Harvesting pearls at PT Cendana Indopearls

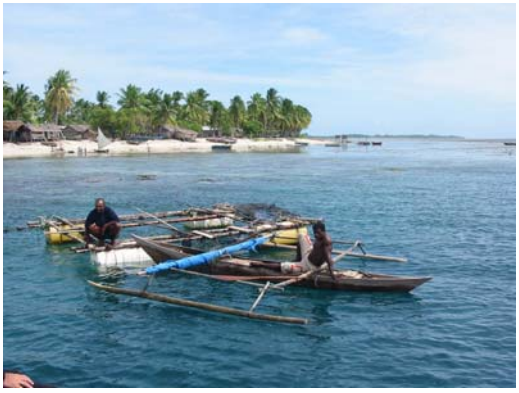

Pearl farm byproducts such as shell and meat could provide material for alternative livelihoods


Schooling snappers at Mios Kon Island


Dense aggregation of sweetlips at Cape Kri

Traditional lift net (bagan) boats in Kabui Bay

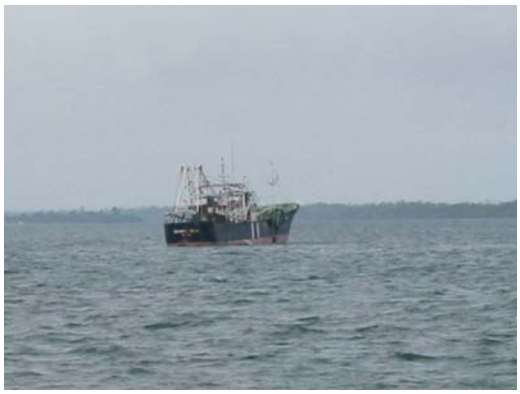
Logging road in Gam-Waigeo passage near West Waigeo Nature Reserve



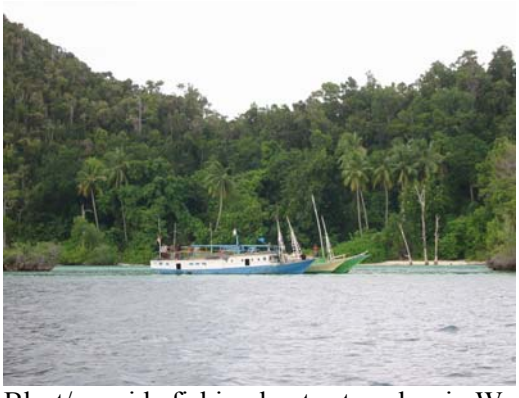
Small-scale grouper holding pen for LRFFT
Fish captured by hook and line by locals

Large-scale grouper/Napoleon wrasse holding pen
Most fish captured by cyanide fishing by Sulawesi divers

Frozen blocks of trawled fish in Sorong market



Trawler anchored in Sorong harbor. These boats may be operating illegally in southern Raja Ampat



Blast/cyanide fishing boats at anchor in Wayag Islands
These boats are apparently from Sulawesi

Green turtle carapaces marking itinerant fishing camp in Wayag Islands