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Biocénotique

ASSESSMENT OF THE CORAL REEFS OF THE LUWUK PENINSULA, CENTRAL SULAWESI, INDONESIA

par

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Reef status was assessed by SCUBA surveys at nine sites along the end of Luwuk Peninsula, Central Sulawesi, Indonesia. Biotic cover ranged from 39 to 87 % and was more dense in pinnacle sites than in fringing reef sites. Living hard coral cover was low ranging from 7 to 29 %. Benthic communities were dominated by soft corals (mainly alcyoniid species of the genera *Sinularia* and *Sarcophyton*). The proportions of hard massive faviid and poritid coral species were more important in pinnacles sites whereas branching acroporid coral species dominated fringing reefs sites.

Large edible fishes (barramundi cods, humphead wrasses, groupers, Haemulidae, bumphead parrotfish) and invertebrates (lobsters, giant clams, sea cucumbers) were rare or absent in the survey sites. Very few coral predators (crow-of-thorns sea stars, corallivorous gastropods and soft coral eating snails) were observed throughout the sites surveyed. There were no visible signs of coral bleaching or coral disease. No marine debris was observed. Although the water was not particularly clear, the reefs did not show signs of damage from sediment.

Overall, reefs and coral communities of the Luwuk Peninsula were in good condition despite evidence of over-harvesting of commercially targeted reef species. Pinnacle sites have a higher conservation value than fringing reef sites due to their higher biotic cover and good visual appearance.

Évaluation des récifs coralliens de la péninsule de Luwuk, Sulawesi central, Indonésie

L'état de santé des récifs coralliens de la péninsule de Luwuk, située dans la partie orientale de Sulawesi central en Indonésie, n'avait jusqu'à présent jamais été apprécié, bien que ces récifs soient localisés dans le triangle corallien. Dans cette optique, neuf sites situés

à l'extrémité terminale de la péninsule de Luwuk ont été évalués, en plongée sous-marine, en utilisant le protocole Reef Check. Deux types de formations coralliennes sont présents dans la région. Les récifs frangeants sont attenant au rivage et sont caractérisés par une crête récifale bien développée qui se prolonge par une pente récifale douce se terminant sur un fond de nature sableuse. Les pinacles sont des formations coralliennes positionnées plus au large et sont caractérisés par leur pente raide.

Le recouvrement biotique s'échelonne de 39 à 87% et est plus important au niveau des pinacles qu'au niveau des récifs frangeants. Le recouvrement en scléractiniaires hermatypiques est faible et varie de 7 à 29%. Les communautés benthiques sont dominées par les coraux mous (essentiellement des alcyonidés appartenant aux genres *Sinularia* et *Sarcophyton*). Les gorgones et les coraux noirs (*Antipathes* spp. et *Cirripathes* spp.) colonisent la partie profonde des pentes des pinacles. Les densités moyennes de scléractinaires hermatypiques sont faibles et varient de 2,6 à 4,48 colonies/m^2. De plus, les colonies sont généralement de petite taille. Les colonies massives de poritidés et de faviidés sont présentes en plus grands nombres au niveau des pinacles alors que les acroporidés branchus dominent les récifs frangeants.

Les espèces de poissons comestibles de grande taille [mérous de Grace Kelly (*Cromileptes altivelis*), mérous, haemulidés, perroquets à bosse (*Bolbometopon muricatum*)] de même que les espèces d'invertébrés comestibles [langoustes, bénitiers (*Tridacna* spp.), concombres de mer] sont rares ou absentes des sites évalués. Peu d'organismes prédateurs de coraux [étoiles de mer couronne d'épines (*Acanthaster planci*), gastéropodes se nourrissant de coraux durs (*Drupella cornus* et *Coralliophila* spp.) ou de coraux mous (*Ovula ovum*)] ont été observés durant cette évaluation. Les mollusques ectoparasites (*Epitonium* spp.) et endoparasites de scléractiniaires [*Leptoconchus* spp., *Lithophaga* spp. *Gastrochaena* spp.] sont rares ou quasiment absents. Certaines espèces présentant un intérêt pour le grand public [requins gris (*Carcharhinus amblyrhynchos*), raies mantas (*Manta birostris*), dauphins (*Tursiops trucatus* et *Stenella longirostris*) et tortues vertes (*Chelonia mydas*)] ont été aperçues de façon incidente au cours de cette évaluation. Aucun signe visible de blanchissement ou de maladie touchant les coraux n'a été détecté et aucun débris marin n'a été observé. Bien que les eaux ne sont par particulièrement transparentes, les récifs ne montrent pas de signes évidents de dommages causés par une hyper-sédimentation.

Dans l'ensemble, les formations coralliennes de la péninsule de Luwuk demeurent dans de bonnes conditions générales malgré la présence de signes évidents de surexploitation commerciale de certaines espèces cibles. Les pinacles ont une valeur de conservation plus importante que les récifs frangeants du fait de leur plus fort recouvrement biotique et de leur aspect esthétique.

Introduction

The Luwuk Peninsula is situated in Indonesia in the eastern part of Central Sulawesi. The land area of the Luwuk Peninsula consists mainly of hilly or montainous terrain. The climate is monsoonal but rainfall is relatively low compared to other parts of Indonesia. At Luwuk, the wettest (122-184 mm) period occurs between March and August. Yearly figure based on average monthly rainfall between 1971 and 1985 is 1162 mm. Predominant winds in Indonesia are southeast (May-September) and northwest (November to March) monsoons, although the pattern is highly variable depending on locality (ALLEN *et al.*, 2004). Tidal fluctuations in the area are relatively slight. The maximum spring-tidal fluctuation is only about 1 m (ALLEN *et al.*, 2004).

The area lies near the center of global marine biodiversity or "coral triangle" composed of Indonesia, Philippines, Malaysia and Papua New Guinea (HOEKSEMA, 1992; WALLACE *et al.*, 2002). At the time of the survey no information was available on the status of the coral reefs in the area. The principal aim of this survey was to assess the current status of the reefs of the Luwuk Peninsula for conservation purposes.

Materials and Methods

A total of nine reef sites (Fig. 1) was surveyed along the end of Luwuk Peninsula between 26 February to 05 March 2007 (Table 1). We selected sites that were representatives of special interest (i.e. reported to be impacted or of touristic, fisheries and/or conservation value) and strategically accessible (established dive sites). An effort was made to space the sites as evenly as possible within all available exposures and reef types, but prevailing sea conditions restricted surveys to relatively deep areas of moderate exposure. The expedition took place aboard the Paisubatu II, a 25 m, live-aboard dive boat, operated by Wallacea Dive Cruise (http://www.wallacea-divecruise.com).

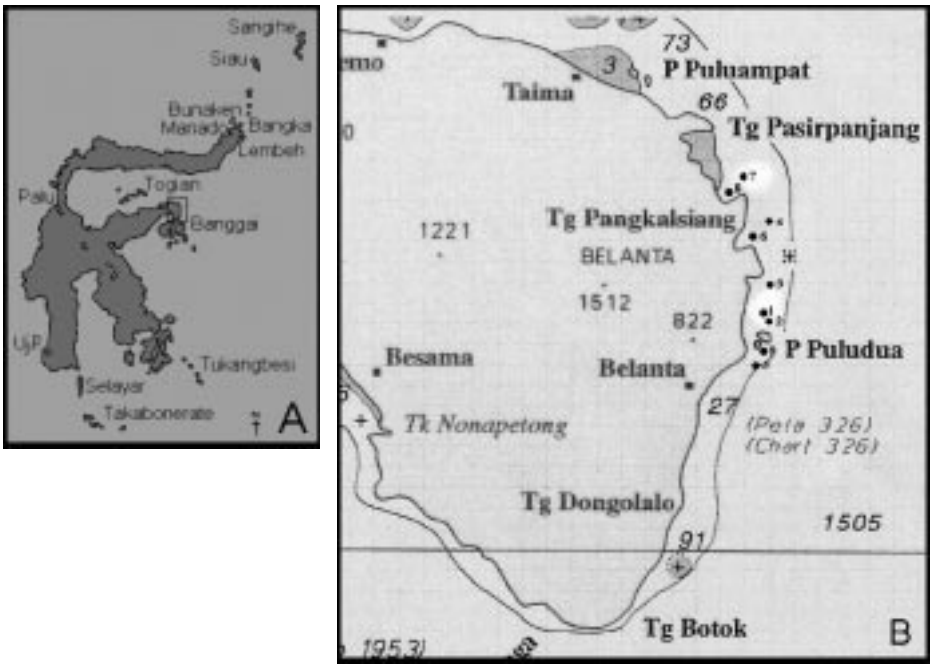

Figure 1

Location of the Luwuk Peninsula in the eastern part of Central Sulawesi (A) and location of the survey sites (B). For details see Table 1.

Localisation de la péninsule de Luwuk dans la partie orientale de Sulawesi central (A) et localisation des sites évalués (B). Pour le détail des stations voir le tableau 1.

Table 1

Location and characteristics of the selected sites.
Localisation et caractéristique des sites étudiés.

Date	Site	Name	Latitude South	Longitude East	Depth	Type of reef
26/02 AM	1	Ali baba	00°48'946''	123°27'236''	10 m	Fringing reef
26/02 PM	2	Entre 2 mers	00°49'568''	123°27'378''	7 m	Fringing reef
27/02 AM	3	PD Magreef	00°47'904''	123°27'369''	10 m	Pinnacle
27/02 PM	4	Hydrochoc	00°44'550''	123°28'452''	12 m	Fringing reef
28/02 AM	5	Tanduk	00°50'354''	123°26'710''	4 m	Pinnacle
28/02 PM	5	Tanduk	00°50'354''	123°26'710''	12 m	Pinnacle
02/03 AM	6	Ondolean rock	00°44'607''	123°26'915''	14 m	Pinnacle
04/03 AM	7	Rock and wreck	00°42'382''	123°26'566''	19 m	Pinnacle
04/03 PM	8	Rock and roll	00°42'766''	123°25'316''	10 m	Fringing reef
05/03 AM	9	Pulau dua kecil	00°49'816''	123°27'134''	9 m	Pinnacle

Table 2

Summary of the percentage cover of each benthic category as recorded by the Reef Check transect method from the different survey sites. Data from fringing reef sites are shown in normal font, data for pinnacle sites in bold.
Pourcentages de recouvrement des différentes catégories benthiques pour les différents sites évalués. Les données provenant des récifs frangeants sont indiquées en caractères normaux, celles provenant des pinacles en caractères gras.

Site	HC	SC	Algae	SP	OT	RKC	RC	RB	SD	SI	Abiotic	Biotic
1	18.12	16.87	1.87	2.50	0.00	0.00	32.50	3.12	25.00	0.00	61	39
2	8.75	27.50	0.62	3.75	4.37	5.62	14.37	15.00	20.00	0.00	55	45
3	**11.66**	**38.33**	**4.16**	**21.66**	**11.66**	**0.00**	**12.50**	**0.00**	**0.00**	**0.00**	**13**	**87**
4	15.62	29.37	0.00	0.62	6.25	0.00	11.87	1.25	34.38	0.62	48	52
5*	**13.54**	**39.58**	**4.16**	**8.85**	**2.08**	**0.00**	**27.60**	**0.52**	**3.64**	**0.00**	**32**	**68**
5 **	**6.87**	**36.87**	**2.50**	**6.87**	**3.12**	**0.00**	**29.37**	**0.00**	**14.37**	**0.00**	**44**	**56**
6	**29.06**	**21.87**	**0.31**	**14.37**	**1.25**	**0.00**	**10.31**	**0.00**	**22.50**	**0.00**	**33**	**67**
7	**13.28**	**33.77**	**0.62**	**17.90**	**2.34**	**0.00**	**32.09**	**0.00**	**0.00**	**0.00**	**32**	**68**
8	25.62	31.25	0.00	0.00	0.00	0.00	24.37	8.75	10.00	0.00	43	57
9	**11.25**	**42.50**	**0.00**	**5.00**	**1.25**	**0.00**	**16.25**	**5.00**	**18.75**	**0.00**	**40**	**60**

* shallow (4 m); ** deep (12 m).

The surveys were carried out following the Reef Check protocol (http://www.reefcheck.org) by a team of 11 volunteer SCUBA divers. All surveys were carried out between 08.00 and 17.00, under generally sunny conditions (mean air temperature 30°C).

Indicators were choosen to provide information about the effects of human activities such as dynamite fishing, cyanide fishing, aquarium fish collection, and harvesting of invertebrates (HODGSON, 1989). One survey line was placed along the depth contour to obtain a total length of 100 m. The survey line was sub-divided into four, non-independent sections of 20 m long, 5 m wide (100 m^2) belt transects (separated by 5 m gaps) for the fish indicator survey. The same belt transects were used for the invertebrate survey. Following the invertebrate survey, the four 20 m segments were point-sampled at 0.5 m intervals and substrate type was recorded (ENGLISH *et al.*, 1997). Results were expressed as means ± standard deviations.

In order to quantify the densities of scleractinian colonies and to identify the most common genera of hard corals, quadrats of 1 m^2 were deployed at each selected site and each colony was noticed and identified to the genus level. Incidental encounters of other marine organisms during the survey were also recorded.

Results

Oceanography

The salinity and the temperature were assessed at two depths (3 and 10 meters). The seawater temperature was 28-29°C. The salinity ranged from 35 to 36 ‰. No difference was noticed between the different studied sites and between the two depths. The transparency of the water, measured with a Secchi disk, was 9.5-14 m.

Bottom covers estimates

Biotic cover ranged from 39 (site 1) to 87 % (site 3) (Table 2) and was significantly more important in pinnacle sites than in fringing reef sites (P = 0.019, non parametric Mann-Whitney U test) (Fig. 2). Living hard coral cover was low ranging from 7 (site 5

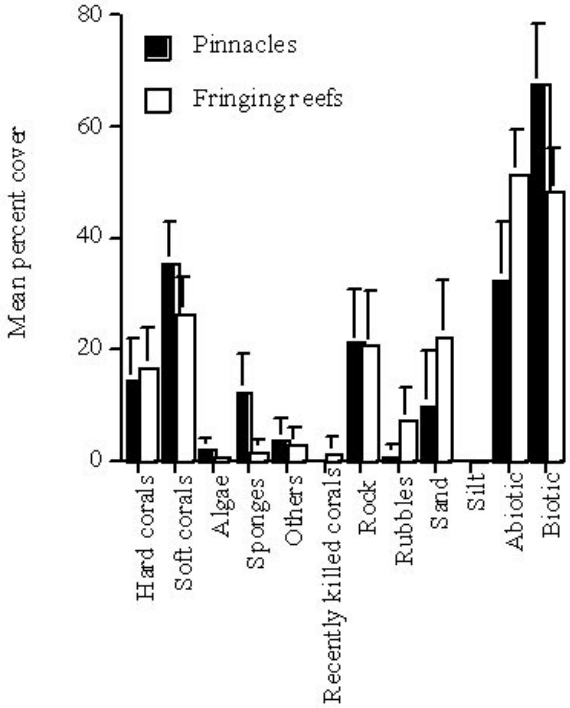

Figure 2

Benthic categories in pinnacle and fringing reef sites.

Différentes catégories benthiques au niveau des récifs frangeants et des pinacles.

Table 3

Values of mean, standard deviation (SD), range in numbers of hard coral colonies per m^2 and variation coefficient in the nine survey sites.
Valeurs des moyennes, des écart-types (SD) et des gammes de distribution du nombre de colonies de scléractiniaires par m^2 et coefficients de variation pour les 9 sites évalués.

	Mean density	SD	Range	Variation coefficient
1	4.38	2.69	0-8	0.614
2	2.63	1.77	0-6	0.673
3	2.88	1.16	1-4	0.402
4	3.19	2.20	0-7	0.691
5*	3.25	2.35	0-7	0.723
5**	2.87	1.84	0-6	0.641
6	4.36	2.39	1-9	0.548
7	3.31	2.40	0-6	0.725
8	4.48	1.95	1-8	0.435
9	3.01	1.99	0-7	0.661

* shallow (4 m); ** deep (12 m).

deep) to 29 % (site 6), averaging 15 % overall and was not different between pinnacle and fringing reef sites (Fig. 2). Soft coral cover was higher than scleractinian cover and ranged from 17 (site 1) to 43 % (site 9) (average 32 % overall) and no significant differences was found between pinnacle and fringing reef sites. The most common soft corals genera were *Sinularia* (55 %) and *Sarcophyton* (42 %) followed by *Lobophytum* (3 %), *Cladiella* (1 %) and *Xenia* (0.1 %). Sponge cover was very low in fringing reef sites ranging from 0 to 4 % (mean = 2 %) and was significantly lower than in pinnacle sites (P = 0.0095 non parametric Mann-Whitney U test) (Fig. 2). In general cover of other faunal categories was low. Algal cover was minimal (0 to 4 %). Dead coral cover was low (0 to 6 %), while abiotic cover occupied 32 to 61 % and was significantly more important at fringing reef sites compared to pinnacle sites (P = 0.019 non parametric Mann-Whitney U test).

The mean density of hard coral colonies was low and ranged from 2.6 to 4.5 colonies/m^2 (Table 3), averaging 3.4 colonies/m^2 overall. Variation coefficients were very important ranging from 0.4 to 0.7 indicating a very high variability of the numbers of stony coral colonies between quadrats. The majority of hard coral species had unusually small colony sizes. There were few hard coral colonies greater than 50 cm diameter.

The most common scleractinian coral genera were *Favia, Porites* and *Acropora* followed by *Favites, Fungia* and *Goniopora* (Table 4). The proportions of hard massive faviid and poritid coral species were significantly more important in pinnacles sites compared to fringing reefs sites (P = 0.019, non parametric Mann-Whitney U test). On the contrary, the proportion of branching acroporid coral species was more important in fringing reef sites compared to pinnacle sites (P = 0.009, non parametric Mann-Whitney U test) (Table 5).

Zooxanthellate non-scleractinian corals that also produce large skeletons contributing to the reef matrix (e.g. *Heliopora, Tubipora* and *Millepora*), several azooxanthellate scleractinian corals (*Tubastrea, Dendrophyllia* and *Rhizotrochus*) and a few azooxanthellate non-scleractinian corals (*Distichopora* and *Stylaster*) were also observed on the reefs.

Table 4

Proportions of the different scleractinian coral genera for the different survey sites.
Genera which represent more than 10% of the overall are shown in bold.
Proportions des différents genres de scléractiniaires au niveau des différents sites évalués.
Les valeurs qui représentent plus de 10% du total sont indiquées en caractères gras.

	1	**2**	**3**	**4**	**5***	**5****	**6**	**7**	**8**	**9**
Astrocoeniidae	0.40		2.06		1.96		0.64	1.06		
Stylocoeniella	0.40		2.06		1.96		0.64	1.06		
Pocilloporidae	**11.45**	**15.44**	**15.45**	**11.75**	6.76	4.34	2.57	7.43	4.97	1.78
Pocillopora	4.50	3.63	5.15	2.20	6.76	2 .17	1.93	2.12	2.26	
Seriatopora	5.32	5.45	9.27	3.67			4.34	2.12	1.08	
Stylophora	1.63	6.36	1.03	5.88		2.17	0.64	3.19	1.63	1.78
Acroporidae	**21.72**	**32.71**	**12.36**	**16.74**	9.80	9.77	**12.90**	6.37	**17.38**	8.92
Acropora	19.26	27.27	5.15	12.33	9.80	8.69	11.61	2.12	16.84	8.92
Astreopora		0.9	1.03							
Montipora	2.46	4.54	6.18	4.41		1.08	1.29	4.25	0.54	
Poritidae	**10.23**	**10.89**	**12.37**	**9.55**	**21.56**	**19.55**	**11.60**	**10.58**	8.69	**18.44**
Alveopora		0.90								
Goniopora	0.40	2.72	1.03	2.94	1.96	1.08	1.93	3.14	0.54	0.59
Porites	9.83	7.27	11.34	6.61	19.60	18.47	9.67	7.44	8.15	17,85
Siderastreidae	4.09	0.90	4.12	2.20	3.92	4.34	3.87	6.38	0.54	
Coscinarea	0.40	0.90								
Psammocora	3.69		4.12	2.20	3.92	4.34	3.87	6.38		
Siderastrea									0.54	
Agariciidae	1.63	0.90	5.15	3.67		1.08	5.80	5.31	1.08	2.36
Coeloseris										0.59
Gardineroseris			1.03							
Leptoseris			3.09	2.20			2.58	3.19		0.59
Pachyseris	1.63	0.90	1.03	1.47		1.08	2.58	1.06	1.08	0.59
Pavona							0.64	1.06		0.59
Fungiidae	**18.81**	3.61	1.03	1.47	5.97	2.17	6.51	**10.63**	**17.92**	5.35
Ctenactis	0.81							1.06	0.54	
Fungia	15.59	1.81	1.03	1.47	5.97	2.16	2.58	9.57	15.22	4.76
Halomitra	0.81								0.54	
Heliofungia		0.90							0.54	
Herpolitha	0.40								0.54	0.59
Lithophyllon	0.40	0.90								
Podobacia	0.40						3.93			
Sandalolitha	0.40								0.54	
Oculinidae	2.46			8.80	1.96	1.08	7.77	**12.76**	9.78	1.78
Galaxea	2.46			8.80	1.96	1.08	7.77	12.76	9.78	1.78
Pectiniidae	7.34	0.90	4.12	**13.22**		2.16	**11.60**	6.39	**12.54**	**10.11**
Echinophyllia	0.40						3.22	1.06	2.17	
Mycedium	4.50	0.90	1.03	7.35		1.08	3.87	2.12	1.63	8.92
Oxypora	0.40			2.20			2.58	1.06	1.08	
Pectinia	2.04		3.09	3.67		1.08	1.93	2 .12	7.66	1.19

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Table 4 *(following)*

	1	2	3	4	5*	5**	6	7	8	9
Mussidae	2.02	3.62	6.18	8.81	5.88	8.67	3.22	3.18	2.71	7.14
Acanthastrea						2.17				
Blastomussa		0.90				1.08				
Lobophyllia	0.81		2.06	5.14	1.96	2.17	1.29	1.06		2.38
Scolymia				0.73		1.08				
Symphyllia	1.21	2.72	4.12	2.94	3.92	2 .17	1.93	2.12	2.71	4,76
Merulinidae	2.87	2.71	2.06		3.92	1.08	5.15		1.08	1.19
Hydnophora	2.87	1.81	2.06		3.92	1.08	5.15			1.19
Merulina									1.08	
Scapophyllia		0.9								
Faviidae	**13.47**	**26.34**	**35.03**	**16.15**	**35.89**	**38.02**	**25.77**	**27.64**	**14.09**	**32.09**
Caulastrea									0.54	
Cyphastrea			1.03	0.73		1.08	1.29			
Diploastrea			1.03	1.47			0.64			1.78
Echinopora	0.40								1.08	1.19
Favia	8.60	16.36	17.52	8.82	20.64	26.09	13.54	9.57	2 .71	8.92
Favites	1.63	6.36	8.24	0.73	11.80	6.52	3.87	11.70	7.06	15.47
Goniastrea		1.81	1.03	0.73		1.08				1.78
Leptastrea	0.81		1.03					1.06	0.54	
Leptoria					1.96					
Montastrea						2.17	0.64	2.12	0.54	1.19
Oulophyllia							0.64		1.08	
Platygyra	1.63	1.81	4.12	3.67	1.49	1.08	3.22	3.19	0.54	1.78
Plesiastrea	0.40		1.03				1.93			
Trachyphylliidae										0.59
Trachyphyllia										0.59
Euphylliidae	2.87			2.20			4.51		4.34	5.35
Euphyllia	2.87			2.20			4.51		4.34	5.35
Dendrophylliidae	0.40	0.90		2.20				4.25	3.80	2.97
Turbinaria	0.40	0.90		1.47				2.13	2.72	2.97
Tubastrea#				0.73		2.17		1.06	1.08	
Flabellidae#								1.06		
Rhizotrochus#								1.06		

* shallow (4 m); ** deep (12 m).
# ahermatypic.

Table 5

Mean pooled scleractinian coral families percentages for the fringing reef and pinnacle sites. Standard deviations in parentheses.
*** (P<0.001) ; * (P<0.05) (non parametric Mann-Whitney U test).
Pourcentages moyens des différentes familles de scléractiniaires pour les récifs frangeants et les pinacles. Écarts-types entre parenthèses.
*** (P<0.001) ; * (P<0.05) (test non paramétrique U de Mann-Whitney).

	Fringing reefs	**Pinnacles**
Astrocoeniidae	0.10 (0.20)	1.43 (0.69)
Pocilloporidae	10.90 (4.35)	6.38 (4.96)
Acroporidae	22.13 (7.38)	10.01 (2.38)***
Poritidae	9.84 (0.94)	15.68 (4.70)*
Siderastreidae	1.93 (1.60)	3.76 (2.07)
Agaricidae	1.82 (1.27)	3.28 (2.07)
Fungiidae	10.45 (9.18)	5.27 (3.41)
Oculinidae	5.26 (4.77)	4.22 (4.98)
Pectinidae	8.50 (5.70)	5.73 (4.52)
Mussidae	4.29 (3.08)	5.71 (2.17)
Merulinidae	1.66 (1.37)	1.89 (2.14)
Faviidae	17.51 (5.99)	32.40 (4.84)*
Trachyphylliidae	0.00	0.098 (0.24)
Euphylliidae	2.33 (1.79)	1.64 (2.55)
Dendrophylliidae	1.37 (0.99)	1.20 (1.90)
Flabellidae	0.00	0.17 (0.43)

Table 6

Average densities of selected fishes per 100 m^2 of reef for the different survey sites. Data from fringing reef sites are shown in normal font, data for pinnacle sites in bold.
Densités moyennes des espèces de poissons sélectionnées pour 100 m^2 de récif au niveau des différents sites évalués. Les données provenant des récifs frangeants sont indiqués en caractères normaux, celles issues des pinacles en caractères gras.

	1	**2**	**3**	**4**	**5***	**5****	**6**	**7**	**8**	**9**	**Mean (SD)**
Butterflyfishes	9.37	7.75	4.00	5.75	17.75	18.25	7.62	2.50	8.50	17.00	9.84 (5.77)
Haemulidae	0.75	0.50	1.50	0.50	1.00	0.00	1.00	0.25	0.25	0.25	1.95 (4.59)
Snappers	0.25	3.00	1.50	2.00	0.50	1.00	31.37	0.00	0.50	0.00	4.01 (9.66)
Groupers	0.25	0.25	0.00	0.25	0.25	0.25	0.37	1.00	0.00	0.00	0.26 (0.29)
Barramundi cods	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Humphead wrasses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bumphead parrots	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02 (0.08)
Parrotfishes	1.50	1.50	0.50	0.00	2.25	1.00	0.87	0.75	3.50	0.00	1.18 (1.07)
Moray eels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.25	0.05 (0.10)

* shallow (4 m); ** deep (12 m).

Reef condition

The reefs were generally in good health. There were no visible signs of coral bleaching despite consistent sea surface temperature of 29°C over the duration of the survey. Only limited damage to corals from blast fishing was seen. There were no signs of damage to corals from coral disease. We saw no evidence of marine pollution and no marine debris was observed. Our survey did not result in higher than usual amounts of siltation.

Reef fishes

The average densities (as numbers of individuals/100 m^2) of the select fishes in the different survey sites are represented Table 6. Mean pooled fish densities for select species are shown in Figure 3.

Butterflyfishes (chaetodontids) were the more common fishes recorded in the belt transects. The average chaetodontids density ranged from 2.5 ind/100 m^2 (site 7) to 18.3 ind/100 m^2 (site 5). Large edible fishes were rare or absent in the belt transects. Barramundi cods (*Cromileptes altivelis*) and humphead wrasses (*Cheilinus undulatus*) were not recorded in the belt transects. Only two napoleon wrasses and one barramundi cod were observed outside our belt transect areas. Bumphead parrotfish (*Bolbometopon muricatum*) (one individual) and moray eels (two individuals) were seen only occasionaly.

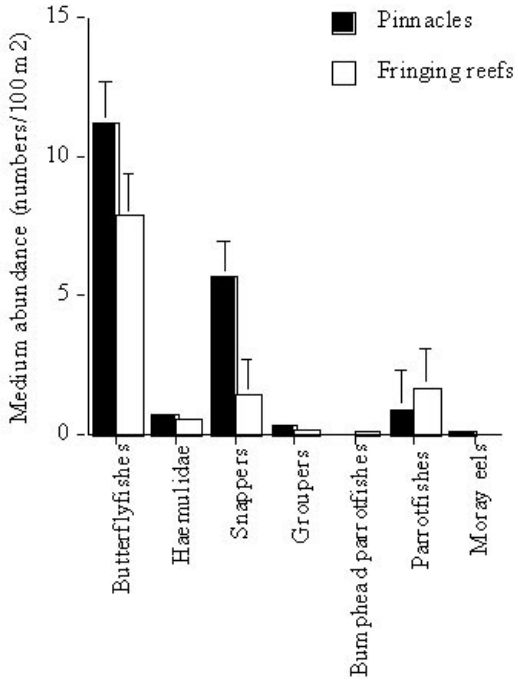

Figure 3

Mean pooled fish densities for selected species.

Valeurs moyennes de la densité calculées pour les différentes espèces de poissons sélectionnées.

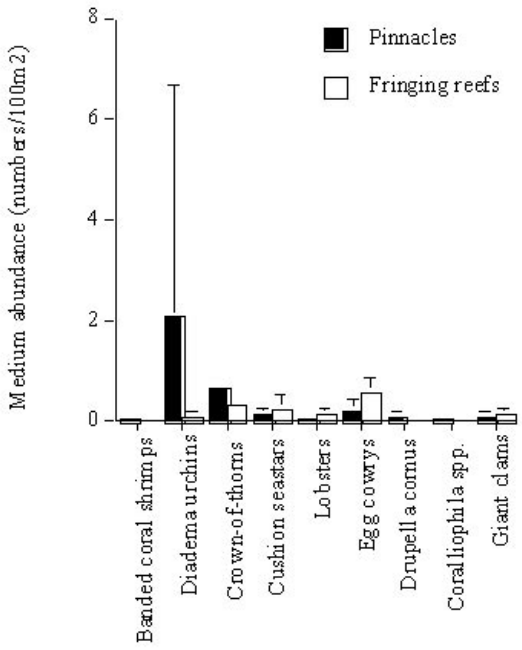

Figure 4

Mean pooled invertebrate densities for selected species.

Valeurs moyennes de la densité calculées pour les différentes espèces d'invertébrés sélectionnées.

We recorded low abundance of parrotfishes (mean pooled density: 1.2 ind/100 m^2), groupers (mean pooled density: 1.2 ind/100 m^2) and emperors (mean pooled density: 2 ind/100 m^2). Moreover, groupers were small (they were all in the 30-40 cm-size class). The average snapper density ranged from 0 to 31.4 ind/100 m^2, due to the presence of a large school of fishes swimming along the reef at site 6.

Invertebrates

The average densities (as numbers of individuals/100 m^2) of selected invertebrates in the different surveyed sites are represented Table 7. Mean pooled invertebrate densities for select species are shown in Figure 4.

Invertebrate data showed no evidence of pencil urchins, collector urchins, sea cucumbers and giant tritons (*Charonia tritonis*) on any of the nine survey sites. We found few Tridacna clams (*Tridacna* spp.), banded coral shrimps (*Stenopus hispidus*) and lobsters. Moreover, recorded giant clams were small (25 % in the 20-30 class and 75 % in the 31-40 cm-size class). The long-spined echinoids *Diadema* spp. were absent or present in small number in most of the sites except at site 3 where a density of 11.5 ind/100 m^2 was recorded. Very few coral predators were observed throughout the sites surveyed. Crow-of-thorns (COTs) (*Acanthaster planci*) sea stars were rarely seen except at site 8 where five individuals were observed. Nevertheless, no site had above normal

Table 7

Average densities of selected invertebrates per 100 m² of reef for the different survey sites. Data from fringing reef sites are are shown in normal font, data for pinnacle sites in bold.
Densités moyennes des espèces d'invertébrés sélectionnées pour 100 m² de récif au niveau des différents sites évalués. Les données provenant des récifs frangeants sont indiqués en caractères normaux, celles issues des pinacles en caractères gras.

	1	**2**	**3**	**4**	**5***	**5****	**6**	**7**	**8**	**9**	**Mean (SD)**
Banded coral shrimps	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.02 (0.08)
Diadema urchins	0.00	0.25	11.5	0.00	0.00	0.00	0.25	0.25	0.00	0.50	1.27 (3.59)
Pencil urchins	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Collector urchins	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sea cucumbers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crown-of-thorns	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	1.25	0.00	0.15 (0.39)
Cushion sea stars	0.00	0.50	0.00	0.50	0.00	0.00	0.25	0.25	0.00	0.25	0.18 (0.20)
Giant tritons	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lobsters		0.25	0.25	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00 0.07 (0.12)
Egg cowrys	0.50	1.00	0.50	0.50	0.50	000	0.25	0.00	0.25	0.00	0.35 (0.31)
Drupella cornus	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.25	0.05 (0.10)
Coralliophila spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25 (0.02)
Giant clams	0.25	0.25	0.25	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.10 (0.13)

* shallow (4 m); ** deep (12 m).

COTs. Signs of damage to corals from COTS activity were limited (partial tissue mortality (average 30 %) in *Acropora, Platygyra, Lobophyllia* and *Pocillopora* colonies at site 8). Cushion sea stars (*Culcita novaeguineae*) were observed on five of the nine sites surveyed but at very low densities. The hard-coral eating gastropods *Drupella cornus* and *Coralliophila* spp. were rarely observed. The soft-coral eating snail *Ovula ovum* was seen at most locations. However numbers were always very low and damage was very limited. Only adults were observed.

Ectoparasites on corals such as wentletrap snails (*Epitonium* spp.) and also endoparasitic gall crabs and molluscs in corals such as *Leptoconchus* spp., *Lithophaga* spp., *Gastrochaena* spp., *Pedum spondyloideum* were rare or strikingly absent.

Vertebrates

"Charismatic marine fauna" includes any marine species that appeal to non-scientists (Mc KENNA *et al.,* 2002). "Charismatic marine fauna" was observed during the survey and while on route to and from sites. A total of two grey sharks (*Carcharhinus amblyrhynchos*) and one manta ray (*Manta birostris*) were observed at Batugong a site dived but not surveyed. Other marine marine fauna observed whilst underway were several schools of dolphins (*Stenella longirostris* and *Tursiops truncatus*) and a couple of green turtles (*Chelonia mydas*).

Discussion

Two types of sites were assessed during this survey. Fringing reef sites were characterized by a developed reef rest and a gentle reef slope after which a flat gentle slope of sandy habitat dominates. In contrast, pinnacle sites were characterized by a steep reef slope. Nevertheless, the number and variety of sites, which could be assessed, was restricted by the heavy weather and the exposed nature of the reefs. The majority of the sites (either fringing reefs or pinnacles) were "high energy" environments.

There was a greater proportion of biotic cover in pinnacle sites than in fringing reef sites. Living hard coral cover was low and the benthos of both sites was dominated by soft corals. On the deeper slopes of the pinnacle sites gorgonian fans and black corals (*Antipathes* spp. and *Cirripathes* spp.) were common (Pl. I, 1 and 2). *Sarcophyton* and *Sinularia* were the most common genera of soft corals. Rich coastal alcyoniid assemblages joined by a few nephtheids and xeniids can dominate reefs space in flow-exposed and wave-protected shallow areas, leaving little space for hard corals. Current-swept and wave-protected areas such as channels between reefs or islands or flanks and ridges on deeper reef slopes, are often extremely rich in soft corals and gorgonians (FABRICIUS & ALDERSLADE, 2001). Many octocorals require consistent and moderately strong preferably unidirectional currents for maximum food encounter. Sponges were also relatively abundant in pinnacle sites but rare in fringing reef sites.

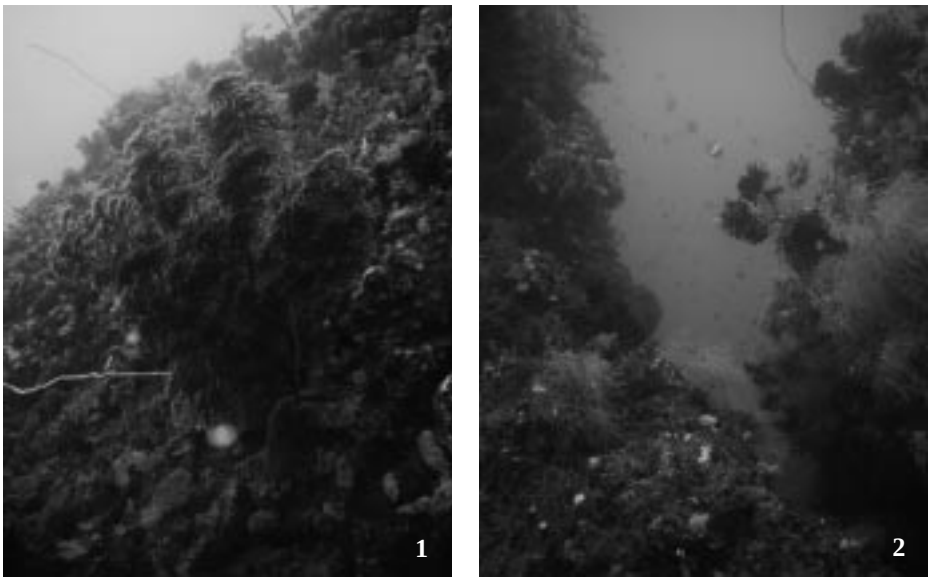

Plate 1

1: big gorgonian fans are common on the deeper slopes of the pinnacle sites;
2: deeper slopes are heavily colonized by dense populations of gorgonians, black corals, sponges and crinoids.

1 : les gorgones de grande taille sont communes sur la partie profonde des pentes des pinacles ;
2 : la partie profonde des pentes des pinacles est colonisée par des populations denses de gorgones, de coraux noirs, d'éponges et de crinoïdes.

Some general observations concerning hard coral communities are included here. Corals varied widely among surveyed sites. Branching acroporid coral species appeared to be prevalent in the fringing reefs sites whereas massive faviid coral species (mainly corals of the genera *Favia* and *Favites*) and poritid coral species appeared to be most dominant in the pinnacle sites. Pocilloporid and fungiid coral species were also often seen on most of the surveyed sites. Corals were in good condition and no trace of bleaching or disease was detected.

Fishes are known to occur at high species diversity and density in undisturbed coral reefs. They play important roles in reef ecosystems as herbivores and as top predators (HATCHER & LARKUM, 1983 ; HAY, 1997). Reef fishes can be sensitive indicators of general reef condition. Furthermore, in Indonesia certain large-sized species of fish such as those of the family Serranidae (specifically species from the genera *Plectropomus* and *Epinephelus*) and of the family Labridae, specifically the Napoleon wrasse (*Cheilinus undulatus*), have been historically targeted by fishers and they are know to be particularly susceptible to fishing pressure. Therefore, their relative abundance should serve as a good indicator of fishing pressure. Groupers were rare during this survey and Napoleon wrasses were not recorded in the belt transects. Other edible indicators (barramundi cods, bumphead parrotfish, Haemulidae) were absent or rare, indicating over fishing in the Luwuk Peninsula. Butterflyfish abundance was high (9.8 ± 5.8 individuals $100\ m^{-2}$) suggesting that aquarium fish fishing was not important. Many species in this family are obligate corallivores depending on hard corals for both food and shelter. Their relatively high abundance in all sectors is an asset that should be preserved.

Some of the commercially important species of invertebrates were low in abundance (giant clams (*Tridacna* spp.) or lobsters) or virtually absent (sea cucumbers). This again highlights the overexploitation of commercial invertebrate stocks within the shallow reef waters of the Luwuk Peninsula. Very few coral predators (COTs and corallivorous gastropods) were observed throughout the sites surveyed. Parasitic molluscs were rare or strikingly absent. This may indicate a shortage of food for the endoparasites. Ectoparasites may easily loose their host when it occurs on steep slopes with not so much a stable position. Predators (labrid fishes) of these snails may easily reach them when the underside of the coral hosts gets exposed.

Despite evidence of over-fishing, the coral reefs of the Luwuk Peninsula remain in relatively good condition. Most reefs visited were not impacted by human activities, which are usually of concern in other areas of the region.

Conservation merit of the Luwuk Peninsula area

The Luwuk Peninsula area has:

a. A majority of sites that are in good condition compared to the majority of regions in Indonesia, with very limited damage from bleaching, explosive fishing and other human impacts.

b. Very rich soft coral communities.

c. A very high potential of attraction for divers and eco-tourists due to the presence of “Charismatic species” such as manta rays, sharks, dolphins and turtles as well as scenic reefs.

Pinnacles sites have a higher conservation value than fringing reef sites due to their higher biotic cover and good visual appearance.

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