

# **SECTION 3: MACROINVERTEBRATES**

# Quantitative Assessment of Conspicuous Epibenthic Macroinvertebrates of Unai Bapot, Unai Laulau, and Unai Laolao Kattan: Dry Season, Part I

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## METHODS

Populations of conspicuous epibenthic macroinvertebrates inhabiting the reef areas of Unai Bapot and Unai Laulau of Laulau Bay and of Unai Laolao Kattan near Kagman, Saipan were sampled along 50-m transects established in three zones designated as reef flat platform stations, spur and groove stations, and reef front terrace stations. Species of macrobenthos (i.e., invertebrates greater than 35 mm in maximum dimension) encountered within 1 m of the transect line were identified and enumerated by an observer swimming along the line. Data were recorded for 10-m segments of the line; thus, each transect consisted of five 20-m<sup>2</sup> rectangular quadrats and covered a total area of 100 m<sup>2</sup>. A 3-level nested ANOVA (Sokal and Rohlf, 1969) was used to identify variance components of the data.

Because of the difficulty involved in distinguishing individuals among the abundant colonially-associated organisms such as alcyonacians and sponges, aggregations of these organisms were treated as individuals for the purposes of this survey. The data generated, therefore, estimate the density of colonies present, but do not provide any indication of the numbers of individuals within the colonies.

The abundant tetillid sponge *Cinachyra australiensis* was sampled with a 1 m X 1 m quadrat tossed at 10-m intervals along transects in the reef flat zone. Thus, population density estimates are based on a total of five 1-m<sup>2</sup> samples per transect.

Areas adjacent to the transects were also examined as time permitted to

record the presence of epibenthic species inhabiting the reef but not occurring within the selected study sites. Although cryptic and infaunal species were not investigated, remains of dead macroinvertebrates were noted, when present, but not quantified.

## RESULTS

The mean densities of conspicuous epibenthic macroinvertebrates at the three locations are presented in Appendices 1-7. Holothurians were predominate in terms of abundance in the reef flat zone at all stations in Laulau Bay. Areas characterized by low-relief sandy rubble were generally dominated by *Holothuria atra*, while areas with boulders provided suitable habitat to enable *Holothuria leucospilota* to attain densities similar to those of *Holothuria atra*. In terms of species diversity, the molluscs were the predominant taxon, but few species attained notable abundance. Juveniles of the commercial topshell *Trochus niloticus* inhabited this zone, but their numbers were considerably lower than those reported for similar areas in Guam (Smith, 1987).

In the spur and groove zone, echinoids replaced holothurians as the predominant taxon. The boring urchin *Echinostrephus aciculatus* was especially abundant on oblique surfaces of channel walls extending perpendicular to the reef margin. As in the reef flat zone, molluscs comprised the most species taxon in the spur and groove zone.

The reef front terrace supported a diversity of echinoderms in considerable abundance. While echinoids were predominant in terms of density, the most diverse

group of echinoderms in this zone were the asteroids. The phylum exhibiting the greatest species diversity was the Mollusca.

At Unai Laolao Kattan, where only the reef flat zone was investigated, both species diversity and abundance were much lower than that of Laulau Bay locations. Most species occurring at Station A-1 and A-2 were associated with depressions and holes in the reef flat pavement. At Station A-3, the reef flat is generally below the mean lower low water level; consequently, species diversity and abundance were greater at this station.

The results of a three-level nested ANOVA for the species with the greatest distribution in each zone are presented in Table 1. The preponderance of the variance among the data exists among the quadrat samples, i.e., the error variance. This is indicative of the great patchiness of the coral reef environment. For most of the species included in this analysis, there is a statistically significant difference between replicate transects. As more data are included at the higher levels (i.e., sampling stations and locations), the effects of patchy distribution are reduced, and most of the species do not exhibit any statistically significant differences between the samples. Only one species, the giant clam *Tridacna maxima*, has a statistically significant different mean density between Unai Bapot and Unai Laulau.

Table 1. Distribution of variance among data for the species occurring on the greatest number of replicate transects in each of the three zones sampled. Variance component is expressed as percentage (to the nearest 0.1 percent) as calculated by three-level nested ANOVA. Total percentages greater than or less than 100 percent are the result of rounding errors.

	Location (B,C)	Station 1,2,3	Replicate Transect	Quadrats (Error Variance)
<b>Reef Flat Zone</b>				
<i>Holothuria atra</i>	0.0	75.1***	0.8	24.2
<i>Holothuria leucospilota</i>	0.0	15.3	22.6**	62.1
<i>Cinachyra australiensis</i>	4.6	2.3	12.2	80.9
<i>Actinopyga echinites</i>	0.0	18.9***	0.0	81.1
<i>Vasum turbinellus</i>	1.4	0.0	31.8***	66.8
<b>Spur and Groove Zone</b>				
<i>Echinostrephus aciculatus</i>	12.9	10.3	29.8***	46.9
<i>Echinometra mathaei</i>	0.0	16.0	21.5	62.5
<i>Echinothrix diadema</i>	0.0	33.0**	20.4**	46.6
<i>Tridacna maxima</i>	0.0	5.2	36.0***	58.8
<i>Dardanus spp.</i>	2.7	6.1	0.0	91.2
<i>Stichopus chloronotus</i>	34.7	31.1**	23.3***	10.9
<b>Reef Front Terrace Zone</b>				
<i>Echinostrephus aciculatus</i>	10.0	12.7	30.7***	46.6
<i>Tridacna maxima</i>	9.6**	0.9	0.0	89.5
<i>Echinometra mathaei</i>	13.1	23.6**	10.3*	53.0
<i>Dardanus spp.</i>	3.0	0.2	0.0	96.8
<i>Sinularia spp.</i>	2.3	0.0	17.1*	80.7
<i>Stichopus chloronotus</i>	16.6	3.2	40.4***	39.8

\*Significant difference at the .05 level

\*\*Significant difference at the .01 level

\*\*\*Significant difference at the .001 level



Appendix 2. Densities of conspicuous epibenthic macroinvertebrates of the reef flat zone at Unai Laulau, Saipan. Density is reported as mean  $\bar{T}$  standard deviation of five 20-m<sup>2</sup> quadrats sampled along a 50-m belt transect, except for the sponge *Cinachyra australiensis*, which was sampled in 1-m<sup>2</sup> quadrats at 10-m intervals along the transect.

	Station 1			Station 2			Station 3		
	Replicate	Transect		Replicate	Transect		Replicate	Transect	
	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	C-9
<b>Phylum Porifera</b>									
<i>Cinachyra australiensis</i>	0.4±0.55			0.6±1.34		1.0±1.00	0.6±0.89	0.4±0.89	0.2±0.45
<b>Phylum Mollusca</b>									
<i>Trochus niloticus</i>	0.2±0.45	0.2±0.45		0.4±0.89			0.6±0.55		0.2±0.45
<i>Cerithium nodulosum</i>	0.2±0.45		0.2±0.45						
<i>Cypraea lynx</i>		0.2±0.45	0.2±0.45	0.2±0.45	0.4±0.89		0.2±0.45	0.2±0.45	
<i>Vasum turbinellus</i>									
<i>Conus flavidus</i>			0.2±0.45	0.2±0.45					
<i>Conus lividus</i>			0.2±0.45						
<i>Conus sanguinolentus</i>									
<i>Tridacna maxima</i>		0.2±0.45							
<b>Phylum Arthropoda</b>									
<i>Dardanus</i> spp.	0.2±0.45								
<b>Phylum Echinodermata</b>									
<i>Echinometra mathaei</i>	0.2±0.45		0.2±0.45					0.2±0.45	
<i>Stichopus chloronotus</i>	0.4±0.55	0.2±0.45							
<i>Holothuria atra</i>	7.8±2.39	2.6±1.52	6.8±3.03	4.6±3.51	3.6±1.52	6.2±4.44	3.8±2.59	3.8±3.35	2.4±1.67
<i>Holothuria edulis</i>	0.2±0.45								
<i>Holothuria leucospilota</i>	0.6±0.89	3.2±1.92	4.4±2.79	4.2±4.92	3.2±4.87	1.6±2.51	0.6±0.55	3.6±3.58	8.8±3.42
<i>Actinopyga echinites</i>	0.4±0.55	0.6±0.89	0.2±0.45	0.4±0.89			0.8±1.79	1.2±1.31	0.6±0.89

Appendix 3. Densities of conspicuous epibenthic macroinvertebrates of the spur and groove zone at Unai Bapot, Saipan. Density is reported as mean  $\pm$  standard deviation of five 20-m<sup>2</sup> quadrats sampled along a 50-m belt transect.

	Station 1		Station 2			Station 3			
	B-10	Replicate B-11	B-12	B-13	Replicate B-14	B-15	B-16	Replicate B-17	B-18
Phylum Cnidaria									
<i>Sinularia</i> spp.		0.6 $\pm$ 0.89		2.6 $\pm$ 3.44	3.6 $\pm$ 6.99			0.2 $\pm$ 0.45	0.4 $\pm$ 0.89
<i>Sarcophyton</i> spp.		0.4 $\pm$ 0.55					4.6 $\pm$ 10.29	0.2 $\pm$ 0.45	
cf. <i>Actinodiscus</i> sp.									
Phylum Annelida									
<i>Sabellastarte sanctijosephi</i>					0.2 $\pm$ 0.45				
Phylum Mollusca									
<i>Trochus niloticus</i>					0.4 $\pm$ 0.89				
<i>Tectus pyramis</i>		0.2 $\pm$ 0.45		0.2 $\pm$ 0.45					0.2 $\pm$ 0.45
<i>Turbo argyrostomus</i>									
<i>Thais armigera</i>									
<i>Latirus polygonus barclayi</i>		0.2 $\pm$ 0.45							
<i>Vasum ceramicum</i>		0.4 $\pm$ 0.55							
<i>Vasum turbinellus</i>		0.2 $\pm$ 0.45		0.2 $\pm$ 0.45				0.2 $\pm$ 0.45	0.2 $\pm$ 0.45
<i>Conus flavidus</i>		0.2 $\pm$ 0.45						0.2 $\pm$ 0.45	0.2 $\pm$ 0.45
<i>Conus miles</i>		0.2 $\pm$ 0.45						0.4 $\pm$ 0.55	
<i>Conus moreleti</i>		0.2 $\pm$ 0.45							
<i>Conus sanguinolentus</i>		0.2 $\pm$ 0.45		0.2 $\pm$ 0.45	0.4 $\pm$ 0.55			1.6 $\pm$ 1.14	0.4 $\pm$ 0.89
<i>Tridacna maxima</i>	0.2 $\pm$ 0.45	1.0 $\pm$ 0.71							
Phylum Arthropoda									
<i>Dardanus</i> spp.		0.4 $\pm$ 0.55		0.2 $\pm$ 0.45				0.2 $\pm$ 0.45	
Phylum Echinodermata									
<i>Ophiocoma erinaceus</i>	0.6 $\pm$ 0.89	0.2 $\pm$ 0.45		0.2 $\pm$ 0.45	0.6 $\pm$ 0.89			0.4 $\pm$ 0.55	0.2 $\pm$ 0.45
<i>Fronia milleporella</i>					0.2 $\pm$ 0.45			0.2 $\pm$ 0.45	
<i>Diadema savignyi</i>	11.4 $\pm$ 5.81	5.0 $\pm$ 2.55	6.8 $\pm$ 4.97	8.0 $\pm$ 7.52	4.4 $\pm$ 4.39	10.4 $\pm$ 1.52	4.0 $\pm$ 2.92	4.4 $\pm$ 1.14	5.2 $\pm$ 1.30
<i>Echinometra mathaei</i>	22.0 $\pm$ 6.52	28.2 $\pm$ 8.53	17.6 $\pm$ 2.79	9.4 $\pm$ 4.45	1.6 $\pm$ 1.95	58.2 $\pm$ 48.53	73.4 $\pm$ 20.95	47.2 $\pm$ 34.69	40.2 $\pm$ 27.52
<i>Echinostrephus aciculatus</i>	0.4 $\pm$ 0.55		0.6 $\pm$ 1.34	5.6 $\pm$ 3.05	3.4 $\pm$ 2.30	0.2 $\pm$ 0.45	0.2 $\pm$ 0.45	0.2 $\pm$ 0.45	0.6 $\pm$ 1.34
<i>Echinothrix diadema</i>									
<i>Heterocentrotus mammillatus</i>			0.2 $\pm$ 0.45						



Appendix 3. Continued.

	Station 1		Station 2			Station 3			
	Replicate	Transect	Replicate	Transect	Replicate	Transect	Replicate	Transect	
	B-10	B-11	B-12	B-13	B-14	B-15	B-16	B-17	B-18
<i>Stichopus chloronotus</i>	25.2±6.14	7.0±3.54	17.2±6.22	3.8±2.17	5.2±1.79	13.4±6.31	0.4±0.55	2.8±2.49	0.8±0.84
<i>Holothuria atra</i>	0.4±0.55	0.8±1.03	0.2±0.45	0.2±0.45	0.4±0.55				
<i>Holothuria edulis</i>		0.6±0.55		0.2±0.45	0.2±0.45				
<i>Holothuria nobilis</i>			0.2±0.45	4.0±2.74	0.2±0.45		0.2±0.45		
<i>Actinopyga mauritiana</i>	0.2±0.45				0.6±0.55			0.2±0.45	

Appendix 4. Densities of conspicuous epibenthic macroinvertebrates of the spur and groove zone at Unai Laulau, Saipan. Density is reported as mean  $\pm$  standard deviation of five 20-m<sup>2</sup> quadrats sampled along a 50-m belt transect.

	Station 1			Station 2			Station 3		
	C-10	C-11	C-12	C-13	C-14	C-15	C-16	C-17	C-18
Phylum Porifera									
<i>Stylotella agminata</i>								0.2 $\pm$ 0.45	
Phylum Cnidaria									
<i>Sinularia</i> spp.			0.2 $\pm$ 0.45		0.2 $\pm$ 0.45		0.4 $\pm$ 0.89	0.8 $\pm$ 0.45	3.4 $\pm$ 3.85
<i>Heteractis aurora</i>	0.2 $\pm$ 0.45	0.2 $\pm$ 0.45	0.6 $\pm$ 0.89				0.4 $\pm$ 0.55	0.2 $\pm$ 0.45	
<i>Heteractis crispa</i>			0.4 $\pm$ 0.55						
cf. <i>Actinodiscus</i> sp.				0.2 $\pm$ 0.45				0.2 $\pm$ 0.45	
Phylum Mollusca									
<i>Trochus ochroleucus</i>			0.2 $\pm$ 0.45		0.4 $\pm$ 0.55		0.2 $\pm$ 0.45		0.2 $\pm$ 0.45
<i>Tectus pyramis</i>									0.2 $\pm$ 0.45
<i>Turbo argyrostomus</i>	0.2 $\pm$ 0.45	0.2 $\pm$ 0.45							
<i>Cypraea depressa</i>	0.2 $\pm$ 0.45	0.4 $\pm$ 0.89					0.2 $\pm$ 0.45	0.2 $\pm$ 0.45	
<i>Thais armigera</i>	0.2 $\pm$ 0.45								
<i>Thais tuberosa</i>	0.2 $\pm$ 0.45								
<i>Latirus polygonus barclayi</i>									0.4 $\pm$ 0.55
<i>Vasum ceramicum</i>									
<i>Vasum turbinellus</i>	0.6 $\pm$ 0.89								
<i>Conus balteatus</i>			0.4 $\pm$ 0.55						
<i>Conus distans</i>							0.4 $\pm$ 0.89		
<i>Conus flavidus</i>							0.4 $\pm$ 0.55		
<i>Conus lividus</i>		0.2 $\pm$ 0.45	0.2 $\pm$ 0.45						
<i>Conus miles</i>	0.2 $\pm$ 0.45	0.6 $\pm$ 0.89	0.6 $\pm$ 0.55	0.2 $\pm$ 0.45	0.6 $\pm$ 0.89			0.2 $\pm$ 0.45	
<i>Conus moreleti</i>	0.4 $\pm$ 0.55	0.2 $\pm$ 0.45	0.6 $\pm$ 0.89	0.2 $\pm$ 0.45	0.2 $\pm$ 0.45				
<i>Conus sanguinolentus</i>		0.2 $\pm$ 0.45	0.2 $\pm$ 0.45						
<i>Tridacna maxima</i>	1.2 $\pm$ 0.45	0.2 $\pm$ 0.45	0.4 $\pm$ 0.55		2.2 $\pm$ 1.92	0.2 $\pm$ 0.45			
Phylum Arthropoda									
<i>Dardanus</i> spp.	0.6 $\pm$ 0.89	0.8 $\pm$ 1.30	0.4 $\pm$ 0.55	0.8 $\pm$ 0.84	0.2 $\pm$ 0.45			0.2 $\pm$ 0.45	
Phylum Echinodermata									
<i>Ophiocoma erinaceus</i>	0.8 $\pm$ 0.84	0.8 $\pm$ 1.10	0.8 $\pm$ 1.10	1.4 $\pm$ 1.95			1.0 $\pm$ 1.22	0.6 $\pm$ 0.89	1.0 $\pm$ 1.22

Appendix 4. Continued.

	Station 1			Station 2			Station 3		
	Replicate	Transect		Replicate	Transect		Replicate	Transect	
	C-10	C-11	C-12	C-13	C-14	C-15	C-16	C-17	C-18
<i>Linckia multifora</i>	0.2±0.45			0.2±0.45	0.2±0.45		0.2±0.45	0.2±0.45	
<i>Echinometra mathaei</i>	12.0±7.07	6.4±3.44	8.8±6.87	7.2±6.02	14.8±5.07	3.2±2.77	2.8±3.11	1.4±0.89	2.8±2.77
<i>Echinostrephus aciculatus</i>	30.0±19.94	18.0±8.37	5.4±6.19	18.8±7.26	31.4±12.46	5.6±7.33	20.4±15.79	4.0±5.52	10.2±4.60
<i>Echinothrix diadema</i>		0.6±0.89	0.2±0.45			0.2±0.45	1.2±0.84	1.8±2.49	2.0±1.87
<i>Stichopus chloronotus</i>	0.2±0.45			0.2±0.45					
<i>Holothuria atra</i>		0.2±0.45							
<i>Actinopyga mauritiana</i>			0.4±0.89	0.2±0.45		0.2±0.45	1.2±1.30		0.2±0.45

Appendix 5. Densities of conspicuous epibenthic macroinvertebrates of the reef front terrace zone at Unai Bapot, Saipan. Density is reported as mean  $\pm$  standard deviation of five 20-m<sup>2</sup> quadrats sampled along a 50-m belt transect.

	Station 1			Station 2			Station 3		
	Replicate B-19	Replicate B-20	Replicate B-21	Replicate B-22	Replicate B-23	Replicate B-24	Replicate B-25	Replicate B-26	Replicate B-27
<b>Phylum Porifera</b>									
<i>Stylotella aguinata</i>	0.2 $\pm$ 0.45								
<b>Phylum Cnidaria</b>									
<i>Sinularia</i> spp.	0.2 $\pm$ 0.45	0.2 $\pm$ 0.45	0.2 $\pm$ 0.45	0.2 $\pm$ 0.45	0.2 $\pm$ 0.45			3.0 $\pm$ 3.39	
<i>Sarcophyton</i> spp.								0.2 $\pm$ 0.45	
<i>Heteractis crispata</i>								0.2 $\pm$ 0.45	
<i>Palythoa tuberculosa</i> cf. <i>Actinodiscus</i> sp.		2.8 $\pm$ 4.38							0.4 $\pm$ 0.89
<b>Phylum Annelida</b>									
<i>Sabellastarte sanctijosephi</i>		0.2 $\pm$ 0.45							
<b>Phylum Mollusca</b>									
<i>Trochus niloticus</i>						0.2 $\pm$ 0.45			0.2 $\pm$ 0.45
<i>Tectus pyramis</i>	0.2 $\pm$ 0.45	0.4 $\pm$ 0.55	0.4 $\pm$ 0.55	0.2 $\pm$ 0.45		0.2 $\pm$ 0.45	0.2 $\pm$ 0.45		0.2 $\pm$ 0.45
<i>Turbo argyrostomus</i>			0.4 $\pm$ 0.89						
<i>Lambis truncata sebae</i>				0.2 $\pm$ 0.45					
<i>Bursa</i> sp.									0.2 $\pm$ 0.45
<i>Chicoreus brunneus</i>									
<i>Vasum turbinellus</i>			0.2 $\pm$ 0.45	0.4 $\pm$ 0.55					
<i>Conus flavidus</i>					0.2 $\pm$ 0.45	0.2 $\pm$ 0.45			
<i>Conus miles</i>									
<i>Conus moreleti</i>							0.4 $\pm$ 0.89		
<i>Conus rattus</i>							0.2 $\pm$ 0.45		
<i>Phyllidia</i> spp.								0.4 $\pm$ 0.89	
<i>Pedum spondyloideum</i>							0.2 $\pm$ 0.45		
<i>Tridacna maxima</i>	0.8 $\pm$ 1.10	0.4 $\pm$ 0.55	0.2 $\pm$ 0.45	0.2 $\pm$ 0.45	0.2 $\pm$ 0.45	0.6 $\pm$ 0.89	0.6 $\pm$ 0.55	0.2 $\pm$ 0.45	0.4 $\pm$ 0.55
<i>Tridacna squamosa</i>							0.2 $\pm$ 0.45		

Appendix 5. Continued.

	Station 1		Station 2			Station 3			
	Replicate	Transect	Replicate	Transect	Replicate	Transect	Replicate	Transect	
	B-19	B-20	B-21	B-22	B-23	B-24	B-25	B-26	B-27
<b>Phylum Arthropoda</b>									
<i>Dardanus</i> spp.	0.4±0.55		0.4±0.89	0.2±0.45	0.2±0.45	0.2±0.45	0.2±0.45		0.2±0.45
<b>Phylum Echinodermata</b>									
<i>Ophiocoma erinaceus</i>		0.2±0.45	0.2±0.45						
<i>Acanthaster planci</i>									0.2±0.45
<i>Fromia milleporella</i>									
<i>Gomophia egyptiaca</i>							0.2±0.45		
<i>Linckia multifora</i>	0.2±0.45	0.2±0.45						0.2±0.45	
<i>Echinometra mathaei</i>	3.4±2.30	6.4±3.36	7.8±6.91	3.6±2.07	0.2±0.45	4.8±3.27	0.8±0.84	1.4±1.52	0.2±0.45
<i>Echinostrephus aciculatus</i>	0.2±0.45	0.4±0.55	6.4±4.98	17.8±18.82	3.4±3.05	2.6±2.07	21.6±5.98	6.4±4.98	5.2±2.59
<i>Echinothrix diadema</i>			0.2±0.45	0.4±0.55		0.2±0.45		0.2±0.45	
<i>Stichopus chloronotus</i>	1.2±1.30	1.4±0.55	4.0±3.46	6.2±3.42		2.0±1.58		0.6±0.55	0.4±0.55
<i>Holothuria edulis</i>	0.2±0.45	0.2±0.45	1.6±1.14			0.2±0.45		0.2±0.45	0.2±0.45
<i>Holothuria nobilis</i>			0.4±0.55	0.2±0.45					

Appendix 6. Densities of conspicuous epibenthic macroinvertebrates of the reef front terrace at Unai Laulau, Saipan. Density is reported as mean  $\pm$  standard deviation of five 20-m<sup>2</sup> quadrats sampled along a 50-m belt transect.

	Station 1			Station 2			Station 3		
	Replicate	Replicate	Replicate	Replicate	Replicate	Replicate	Replicate	Replicate	Replicate
	C-19	C-20	C-21	C-22	C-23	C-24	C-25	C-26	C-27
<b>Phylum Cnidaria</b>									
<i>Simularia</i> spp.	0.4 $\pm$ 0.55	0.2 $\pm$ 0.45	14.0 $\pm$ 21.44		0.4 $\pm$ 0.55	0.8 $\pm$ 0.84	2.4 $\pm$ 4.83	2.2 $\pm$ 2.59	0.2 $\pm$ 0.45
<i>Lobophyton</i> spp.		0.8 $\pm$ 1.30	0.2 $\pm$ 0.45		0.6 $\pm$ 0.89	0.6 $\pm$ 1.34	3.4 $\pm$ 4.28	1.6 $\pm$ 1.52	
<i>Heteractis aurora</i>						0.2 $\pm$ 0.45			
<i>Palythoa tuberculosa</i>						0.2 $\pm$ 0.45			
cf. <i>Actinodiscus</i> sp.						0.2 $\pm$ 0.45			
<b>Phylum Mollusca</b>									
<i>Trochus niloticus</i>			0.2 $\pm$ 0.45	0.6 $\pm$ 0.55		0.4 $\pm$ 0.55	0.2 $\pm$ 0.45		0.4 $\pm$ 0.55
<i>Tectus pyramis</i>	0.2 $\pm$ 0.45	0.2 $\pm$ 0.45	0.2 $\pm$ 0.45			0.2 $\pm$ 0.45	0.4 $\pm$ 0.89	0.4 $\pm$ 0.55	
<i>Turbo argyrostomus</i>			0.2 $\pm$ 0.45						
<i>Latirus nodatus</i>				0.2 $\pm$ 0.45					
<i>Vasum turbinellus</i>									
<i>Conus balteatus</i>					0.2 $\pm$ 0.45		0.4 $\pm$ 0.89		0.4 $\pm$ 0.55
<i>Conus distans</i>	0.4 $\pm$ 0.55								
<i>Conus flavidus</i>	0.4 $\pm$ 0.55							0.2 $\pm$ 0.45	
<i>Conus litoglyphus</i>	0.2 $\pm$ 0.45		0.4 $\pm$ 0.89						
<i>Conus lividus</i>	0.4 $\pm$ 0.55						0.2 $\pm$ 0.45		0.8 $\pm$ 0.45
<i>Conus miles</i>	0.6 $\pm$ 0.89	0.2 $\pm$ 0.45	0.6 $\pm$ 0.89	0.2 $\pm$ 0.45	0.8 $\pm$ 1.30		0.2 $\pm$ 0.45	0.2 $\pm$ 0.45	0.8 $\pm$ 0.84
<i>Conus moreleti</i>		0.6 $\pm$ 1.34	0.2 $\pm$ 0.45		0.2 $\pm$ 0.45				
<i>Phyllidia</i> spp.	1.2 $\pm$ 1.30	0.4 $\pm$ 0.55	1.0 $\pm$ 1.41	0.2 $\pm$ 0.45	1.2 $\pm$ 2.17	0.4 $\pm$ 0.55	1.0 $\pm$ 1.22	1.2 $\pm$ 0.84	1.4 $\pm$ 1.52
<i>Tridacna maxima</i>	0.2 $\pm$ 0.45		0.2 $\pm$ 0.45						
<i>Tridacna squamosa</i>									
<b>Phylum Arthropoda</b>									
<i>Dardanus</i> spp.	0.6 $\pm$ 0.89	0.2 $\pm$ 0.45		0.2 $\pm$ 0.45	1.6 $\pm$ 2.51	0.6 $\pm$ 0.55	0.4 $\pm$ 0.55	0.6 $\pm$ 1.34	
<b>Phylum Echinodermata</b>									
<i>Comanthus parvicirrus</i>		0.2 $\pm$ 0.45	0.2 $\pm$ 0.45		0.4 $\pm$ 0.55		0.2 $\pm$ 0.45	0.4 $\pm$ 0.55	0.4 $\pm$ 0.55
<i>Ophiocoma erinaceus</i>	0.4 $\pm$ 0.89			0.2 $\pm$ 0.45		0.4 $\pm$ 0.55	0.2 $\pm$ 0.45		
<i>Culcita novaeguineae</i>		0.2 $\pm$ 0.45			0.2 $\pm$ 0.45				
<i>Gomophia egyptiaca</i>	0.2 $\pm$ 0.45				0.2 $\pm$ 0.45				
<i>Linckia guildingi</i>		0.2 $\pm$ 0.45							



Appendix 7. Densities of conspicuous epibenthic macroinvertebrates of the reef flat zone at Unai Laolao Kattan, Saipan. Density is reported as mean  $\pm$  standard deviation of five 20-m<sup>2</sup> quadrats sampled along a 50-m belt transect.

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	Replicate Transect		
	A-1	A-2	A-3
<i>Bursa bufonia</i>			0.2 $\pm$ 0.45
<i>Vasum turbinellus</i>	0.6 $\pm$ 0.89	0.4 $\pm$ 0.89	
<i>Conus flavidus</i>		0.2 $\pm$ 0.45	0.2 $\pm$ 0.45
<i>Conus lividus</i>			0.2 $\pm$ 0.45
<i>Echinothrix diadema</i>			0.4 $\pm$ 0.89
<i>Holothuria atra</i>	2.6 $\pm$ 3.13		3.0 $\pm$ 2.00
<i>Holothuria leucospilota</i>	0.8 $\pm$ 1.79		8.2 $\pm$ 8.44
<i>Actinopyga echinites</i>			0.2 $\pm$ 0.45

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Appendix 8. Systematic inventory of species of conspicuous epibenthic macroinvertebrates observed in the reef flat zone, spur and groove zone, reef front terrace zone of Laulau Bay (Unai Bapot and Unai Laulau) and Unai Laolao Kattan, Saipan. An "X" indicates observation of a live specimen, and an asterisk indicates observation of a dead specimen.

	UNAI BAPOT	UNAI LAULAU	UNAI LAOLAO KATTAN
	RF S/G T	RF S/G T	RF
Phylum Protista			
Class Rhizopodea			
Order Foraminifera			
Family Calcarinidae			X
<i>Baculogypsina sphaerulata</i> (Parker & Jones)	X	X	
Phylum Porifera			
Class Demospongiae			
Order Dictyoceratida			
Family Dysideidae	X	X X	X
<i>Dysidea cf. herbacea</i> (Keller)			
Order Hadromerida			
Family Suberitidae		X	X
<i>Stylotella aguinata</i> (Ridley)			
Order Choristida			
Family Tetillidae			
<i>Cinachyra australiensis</i> (Carter)	X	X	
Phylum Cnidaria			
Class Anthozoa			
Order Alcyonacea			
Family Alcyoniidae		X X	X X
<i>Sinularia</i> spp.	X X	X X	X X
<i>Lobophyton</i> spp.	X X	X X	
<i>Sarcophyton</i> spp.			
Order Coralliomorpha			
Family Actinodiscidae	X X		X X
<i>cf. Actinodiscus</i> sp.			
Order Actiniaria			
Family Stichodactylidae			
<i>Heteractis aurora</i> (Quoy & Gaimard)		X X	X X

Appendix 8. Continued.

	UNAI BAPOT		UNAI LAULAU		UNAI LAOLAO KATTAN	
	RF	S/G T	RF	S/G T	RF	S/G T
<i>Heteractis crispata</i> (Ehrenberg)	X	X		X		
Order Zoanthiniaria						
Family Zoanthidae	X	X		X		
<i>Palythoa tuberculosa</i> (Esper)						
Phylum Annelida						
Class Polychaeta						
Order Terebellida						
Family Terebellidae	X			X		
terebellid spp.						
Order Sabellida						
Family Sabellidae	X	X		X	X	
<i>Sabellastarte sanctijosephi</i> (Gravier)						
Family Serpulidae	X	X		X	X	
<i>Spirobranchus giganteus</i> (Pallas)						
Phylum Mollusca						
Class Gastropoda						
Order Archaeogastropoda						
Family Acmaeidae						X
<i>Patelloida chamorroorum</i> Lindberg & Vermeij			X			
Family Trochidae						
<i>Trochus histrio</i> Reeve	X	X		X	X	
<i>Trochus niloticus</i> Linnaeus	X	X	X	X	X	
<i>Trochus ochroleucus</i> Gmelin				X	X	
<i>Tectus pyramis</i> (Born)	X	X		X	X	
Family Turbinidae						
<i>Turbo argyrostomus</i> Linnaeus	X	X		X	X	
<i>Astraea rhodostoma</i> Lamarck	X	X		X	X	
Family Neritidae						
<i>Nerita guamensis</i> Quoy & Gaimard						X
<i>Nerita plicata</i> Linnaeus						X
<i>Nerita polita</i> Linnaeus						

Appendix 8. Continued.

	UNAI BAPOT		UNAI LAULAU		UNAI LAOLAO KATTAN	
	RF	S/G T	RF	S/G T	RF	S/G T
<b>Order Mesogastropoda</b>						
<b>Family Littorinidae</b>						
<i>Littorina coccinea</i> (Gmelin)			X			X
<i>Littorina pintado</i> (Wood)						X
<i>Nodilittorina quadricincta feejeensis</i> (Reeve)						X
<b>Family Vermetidae</b>						
<i>Dendropoma maxima</i> Sowerby		X	X	X	X	
<i>Pedaloconchus</i> spp.	X					
<b>Family Modulidae</b>						
<i>Modulus tectum</i> (Gmelin)		X				
<b>Family Cerithiidae</b>						
<i>Cerithium alveolus</i> (Hambron & Jacquinot)	X		X		X	
<i>Cerithium mutatum</i> Sowerby		X				
<i>Cerithium nodulosum</i> Bruguiere	X		X			
<b>Family Strombidae</b>						
<i>Strombus microceus</i> (Kira)				X		X
<i>Strombus mutabilis</i> Swainson	X	X		X		
<i>Lambis chiragra</i> Linnaeus	X	X				
<i>Lambis truncata sebae</i> Kiener			X			
<b>Family Cypraeidae</b>						
<i>Cypraea annulus</i> Linnaeus	X					
<i>Cypraea caputserpentis</i> Linnaeus				X		X
<i>Cypraea depressa</i> Gray				X		
<i>Cypraea lynx</i> Linnaeus	X		X			
<i>Cypraea moneta</i> Linnaeus	X		X			X
<b>Family Ranellidae</b>						
<i>Cymatium muricinum</i> (Roeding)	X					
<i>Cymatium nicobaricum</i> (Roeding)	X			X		
<b>Family Bursidae</b>						
<i>Bursa bufonia</i> (Gmelin)						X
<i>Bursa cruentata</i> (Sowerby)		X				
<i>Bursa</i> sp.		X				

Appendix 8. Continued.

	UNAI BAPOT		UNAI LAULAU		UNAI LAOLAO KATTAN	
	RF	S/G T	RF	S/G T	RF	S/G T
<b>Order Neogastropoda</b>						
<b>Family Muricidae</b>						
<i>Chicoreus brunneus</i> (Link)	X				X	
<i>Thais aculeata</i> (Dehayes)				X		
<i>Thais armigera</i> (Link)	X				X	
<i>Thais intermedia</i> (Kiener)				X		
<i>Thais tuberosa</i> (Roeding)					X	
<i>Morula granulata</i> (Duclos)				X		
<i>Morula uva</i> (Roeding)					X	
<i>Drupa grossularia</i> Roeding				X		
<i>Drupa morum</i> Roeding	X					
<i>Drupa ricinus</i> (Linnaeus)	X	X			X	
<i>Drupa rubusidaeus</i> Roeding	X	X			X	
<i>Drupella elata</i> (Blainville)	X	X			X	
<b>Family Coralliophilidae</b>						
<i>Coralliophila violacea</i> (Kiener)	X	X			X	
<b>Family Fasciolaridae</b>						
<i>Latirus nodatus</i> (Gmelin)		X			X	
<i>Latirus noumeensis</i> (Crosse)		X			X	
<i>Latirus polygonus barclayi</i> (Reeve)		X				
<i>Peristernia nassatula</i> (Lamarck)	X	X			X	
<i>Peristernia cf. ustulata</i> (Reeve)		X			X	
<b>Family Olividae</b>						
<i>Oliva annulata</i> Gmelin					X	
<b>Family Vasidae</b>						
<i>Vasum ceramicum</i> (Linnaeus)	X	X			X	
<i>Vasum turbineus</i> (Linnaeus)	X	X			X	
<b>Family Mitridae</b>						
<i>Mitra cucumerina</i> Lamarck					X	
<i>Strigatella pauperula</i> (Linnaeus)						X
<i>Imbricaria vanikoroensis</i> (Quoy & Gaimard)		X				
<b>Family Costellariidae</b>						
<i>Vexillum semifasciatum</i> (Lamarck)		X				
<i>Pusia cancellarioides</i> (Anton)						X

Appendix 8. Continued.

	UNAI BAPOT	UNAI LAULAU	UNAI LAOLAO KATTAN
	RF S/G T	RF S/G T	RF
<b>Family Carditidae</b>			
<i>Cardita variegata</i> Bruguiere			
<b>Family Tridacnidae</b>			
<i>Tridacna maxima</i> (Roeding)	X	X X	X X
<i>Tridacna squamosa</i> Lamarck	X	X	X
<b>Family Tellinidae</b>			
<i>Quidnipagus palatum</i> Iredale			
<i>Scutarcopagia scobinata</i> (Linnaeus)	*		
<b>Family Veneridae</b>			
<i>Gafrarium pectinatum</i> (Linnaeus)	X	*	
<i>Periglypta reticulata</i> (Linnaeus)	X	*	
<b>Class Cephalopoda</b>			
<b>Order Octopoda</b>			
<b>Family Octopodidae</b>			
<i>Octopus cf. cyanea</i> Gray			X
<b>Phylum Arthropoda</b>			
<b>Class Crustacea</b>			
<b>Order Decapoda</b>			
<b>Family Stenopidae</b>			
<i>Stenopus hispidus</i> (Olivier)	X		
<b>Family Diogenidae</b>			
<i>Dardanus</i> spp.	X	X X	X X
<i>Trizopagurus strigatus</i> (Herbst)	X	X X	X X
<b>Family Paguridae</b>			
<i>Paguritta harmsi</i> (Gordon)	X	X	X
<b>Family Thalassinidae</b>			
<i>Thalassina</i> spp.	X	X	X
<b>Family Grapsidae</b>			
<i>Grapsus tenuicrustatus</i> (Herbst)	X	X	X

Appendix 8. Continued.

	UNAI BAPOT		UNAI LAULAU		UNAI LAOLAO KATTAN	
	RF	S/G T	RF	S/G T	RF	T
<b>Family Conidae</b>						
<i>Conus balteatus</i> Sowerby		X		X X		
<i>Conus coronatus</i> Gmelin		X		X		X
<i>Conus distans</i> Hwass				X		
<i>Conus ebraeus</i> Linnaeus	X	X	X	X		X
<i>Conus flavidus</i> Lamarck	X	X	X	X		X
<i>Conus litoglyphus</i> Hwass	X	X	X	X		X
<i>Conus lividus</i> Hwass	X	X	X	X		X
<i>Conus miles</i> Linnaeus		X		X		
<i>Conus miliaris</i> Hwass				X		
<i>Conus moreleti</i> Crosse		X		X		
<i>Conus musicus</i> Hwass		X		X		
<i>Conus rattus</i> Hwass		X		X		
<i>Conus sanguinolentus</i> Quoy & Gaimard	X	X		X		
<i>Conus sponsalis</i> Hwass	X	X		X		
<i>Conus vexillum</i> Gmelin		X		X		
<i>Conus vitulinus</i> Hwass		X		X		
<b>Family Turridae</b>						
<i>Turridrupa bijubata</i> (Reeve)				X		
<b>Order Nudibranchia</b>						
<b>Family Phyllidiidae</b>						
<i>Phyllidia</i> spp.		X		X		
<b>Order Basommatophora</b>						
<b>Siphonariidae</b>						
<i>Siphonaria</i> cf. <i>guamensis</i> Quoy & Gaimard						X
<b>Class Bivalvia</b>						
<b>Order Mytiloidea</b>						
<b>Family Mytilidae</b>						
<i>Modiolus auriculatus</i> (Krauss)	X					X
<b>Family Pectinidae</b>						
<i>Pedum spondyloideum</i> (Gmelin)		X				
<b>Order Veneroidea</b>						
<b>Family Lucinidae</b>						
<i>Ctena bella</i> (Conrad)						*

Appendix 8. Continued.

	UNAI BAPOT UNAI LAULAU UNAI LAOLAO KATTAN			
	RF	S/G	T	RF
<b>Phylum Echinodermata</b>				
<b>Class Asteroidea</b>				
Order Phanerozonia				
Family Oreasteridae				
<i>Culcita novaeguineae</i> Mueller & Troschel	X			X
<b>Family Ophidiasteridae</b>				
<i>Fromia milleporella</i> (Lamarck)	X	X		X
<i>Gomophia egyptiaca</i> Gray	X			X
<i>Linckia guildingi</i> Gray			X	X
<i>Linckia multifora</i> (Lamarck)	X	X		X
Order Spinulosa				
<b>Family Acanthasteridae</b>				
<i>Acanthaster planci</i> (Linnaeus)	X	X		
<i>Mithrodia clavigera</i> (Lamarck)	X	X		
Class Ophiuroidea				
Order Ophiuræ				
<b>Family Ophiocomidae</b>				
<i>Ophiocoma erinaceus</i> Mueller & Troschel	X	X		X
<i>Ophiocoma scolopendrina</i> (Lamarck)	X			X
Class Echinoidea				
Order Regularia				
<b>Family Diadematidae</b>				
<i>Diadema savignyi</i> Michelin	X			X
<i>Echinothrix diadema</i> (Linnaeus)	X	X		X
<b>Family Echinometridae</b>				
<i>Echinometra mathaei</i> (Blainville)	X	X		X
<i>Echinostrephus aciculatus</i> (A. Agassiz)	X	X		X
<i>Heterocentrotus mammillatus</i> (Linnaeus)	X			X
Class Holothuroidea				
Order Aspidochirota				
<b>Family Holothuriidae</b>				
<i>Actinopyga echinites</i> (Jaeger)			X	
<i>Actinopyga mauritiana</i> (Quoy & Gaimard)	X		X	X
<i>Bohadschia graeffei</i> (Semper)				X

Appendix 8. Continued.

	UNAI BAPOT		UNAI LAULAU		UNAI LAOLAO KATTAN	
	RF	S/G T	RF	S/G T	RF	T
<i>Bohadschia marmorata</i> Jaeger	X					
<i>Holothuria atra</i> Jaeger	X	X X	X	X	X	
<i>Holothuria edulis</i> Lesson		X X	X	X		
<i>Holothuria leucospilota</i> (Brandt)	X		X		X	
<i>Holothuria nobilis</i> (Selenka)		X X				
Family Stichopodidae						
<i>Stichopus chloronotus</i> Brandt	X	X X	X	X X	X	
Class Crinoidea						
Order Articulata						
Family Comasteridae						
<i>Comanthus parvicirrus</i> (J. Mueller)						X