8. SEAGRASS COMMUNITIES

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ABSTRACT

Nine species of seagrasses were recorded in a survey throughout Vanuatu. Six of these had not previously been recorded in Vanuatu. Beds were associated with coral reefs, occasionally very dense and extensive, and usually limited to shallow water. Their roles as feeding grounds for dugong, fish and turtles, as shelter and nurseries for juvenile fish, and as shoreline protector, are discussed. Threats to seagrasses and management consideration are discussed.

INTRODUCTION

There are only two previously published records of seagrasses from Vanuatu. Guillaumin (1937) reported *Cymodocea rotundata* from Lamap, (Malakula), whilst Taylor (1978) reported *C. rotundata* (Lamap, Efate and Santo), *Halodule uninervis* (Efate) and *Thalassia hemprichii* (Lamap, Efate, Santo).

Despite such sparse information, it can be predicted that several more species should occur in Vanuatu. Den Hartog's (1970) seagrass distribution maps showed a number of additional species in the Vanuatu region and moreover dugongs (*Dugong dugon*) are widespread throughout Vanuatu. Seagrasses form the staple diet of dugongs and thus could be expected to be distributed throughout the archipelago and to be abundant in some areas.

Seagrasses are found in both temperate and tropical regions. Their habitats are areas of clear, shallow waters, sheltered from severe exposure to waves and having substrates able to provide a suitable rooting medium (muds to coarse rubble). They may also grow abundantly in intertidal areas up to about mid-tide levels. In ideal conditions, seagrasses may form luxuriant meadows with high biomass and productivity (McRoy and Helfferich 1977).

Much of Vanuatu's coastal area does not appear to provide ideally sheltered and shallow seagrass habitats. These reefs are only exposed to heavy oceanic swells and wind-generated waves. Most coastal regions have narrow fringing reefs, generally 100-300 m wide, with shallow lagoons and/or an intertidal flat of limited extent and beyond the reef edge, the sea bed drops rapidly to great depths. Only inner reef areas and sheltered bays might be expected to provide good condition for seagrasses.

The general aims of this study were to greatly increase the existing information about the distribution and abundance of seagrasses in Vanuatu, both to gain knowledge on the country's natural resources and as an aid to coastal zone planning and development.

Generally, coastal zone developments should not be permitted if such would seriously degrade communities in the area.

The specific objectives of the seagrass survey were:

a) to record the species of seagrass occurring at a wide variety of coastal locations throughout Vanuatu, covering the range of habitats in the country.
b) to record the abundance of seagrasses in these localities.
c) to record selected ecological conditions in the study areas e.g. depth, substrate type, exposure, turbidity.
d) to determine from the above data information about factors controlling the distribution and abundance of seagrasses in Vanuatu.
e) to identify areas of major seagrass importance.
f) to derive recommendations for the management of seagrass areas.

METHODS

Studies were generally carried out in the same localities chosen for the coral and fish surveys (Done and Navin, this volume, Figure 2.1). In some cases, precisely the same locations were examined, while in others nearby areas were studied. In total, 60 localities (Appendix 4) were studied, from Aneityum in the south to Ureparapara in the north. These localities contained all the major habitats found along the coastal and shallow water areas of Vanuatu. Localities chosen for study were those which either could be seen to have seagrasses or looked suitable for seagrasses. Areas which did not have seagrasses or could not be expected to have them, e.g. rocky shores and very exposed reefs, were not studied.

At each site a thorough search and survey lasting from 30-120 minutes was carried out and the following information recorded:

a) Species of seagrass present. Identifications were made using the vegetative characteristics described by Lanyon (1986).
b) Total abundance of seagrasses, by estimating leaf cover. The categories used were: 1 (5% cover or less); 2 (6-25% cover); 3 (26-50% cover); 4 (51-75% cover) and 5 (more than 75% cover). At some sites, the abundance of individual species was also recorded.
c) Habitat type - reef crest, reef, reef passage, lagoon behind reef crest, bay, intertidal.
d) Maximum depth of seagrass occurrence at sublittoral sites.
e) Position on shore if intertidal.
f) Substrate type - mud, fine sand, medium sand, coarse sand, shelly sand, gravel, stones, coral rubble, and mixtures of these.
g) Exposure to prevailing east and southeast winds. Sites were designated as "exposed" or "sheltered".
h) Water clarity.

The site characteristics describe to some extent the average conditions prevailing at the site. In particular, cover category assessed subjectively, was an average for the site, and at some positions, abundance was greater or less than that recorded. Similarly, "substrate type" denoted the dominant substrate at each site.

RESULTS AND DISCUSSION

Table 8.1 presents the basic characteristics of each of the 60 sites studied. Table 8.2 lists the species of seagrass found at each of the 39 sites from which they were recorded.

Table 8.1 Details of seagrass sites surveyed. Site nos. indicate whether Phase 2 or Phase 3 of survey (to left of decimal point) and locations - as in Figure 2.1 (p. 11) and Appendix 2. Forams - accumulations of dead foraminifera shells, E = exposed to prevailing winds, S - sheltered. Water depth - maximum seagrass depth, some sites included both intertidal and sublittoral areas. Int - intertidal. Cover categories: 1 - 5% or less cover; 2 - 6-25% cover; 3 - 26-50% cover; 4 - 51-75% cover; 5 - more than 75% cover.

Location	Site No.	Habitat-substrate	Exposed (E) or Sheltered (S)	No. of Seagrass species	Water depth (m)	Cover Category
ANEITYUM						
Inyeug platform reef	2.9.a	Lagoon behind reef; coarse sand	E	1	1.0-1.5	2
Inyeug platform reef	2.9.b	Lagoon behind reef; coarse sand	E	1	1.0-1.5	2
Anelghowhat Bay	2.10	Bay; fine sand	S	6	0.5-3.0	5
Port Patrick	2.11	Lagoon behind reef; coarse sand	E	1	4.0	1
TANNA						
Leviar	2.4	Reef crest and outer slope	S	0	-	-
Port Resolution, Yewao Point	2.6	Lagoon behind reef; sand-rubble	E	3	1.0-2.0	2
ERROMANGO						
Dillon's Bay	2.12	Lagoon behind reef; sand-rubble	S	0	-	-
EFATE AND OFFSHORE ISLANDS						
Moso, southwest shore	2.2	Intertidal; coarse-gravelly sand	E	2	Int	5
Moso, east side	2.3	Lagoon behind reef; muddy-coarse sand	S	5	Int-1.0	5
COOK REEF						
Platform reef, west side	2.14.a	lagoon behind reef; sand-rubble	E	1	3.0-4.0	1
Platform reef, centre	2.14.b	Lagoon behind reef; sand-rubble	E	0	-	-
Platform reef, northeast	2.14.c	Lagoon behind reef; sand-rubble	E	0	-	-
MALAKULA AND OFFSHORE ISLANDS						
Uripiv	2.29.a	Intertidal; sand	E	1	Int	2
Uri	2.29.b	Intertidal; sand	E	4	Int	3
Crab Bay	2.31	Intertidal; sand-rubble	E	1	Int	1
Vulai	2.34	Lagoon behind reef; sand	S	7	1.0-2.0	4
Luoimalakai	2.35	Reef crest; coral rubble	E	1	1.0-2.0	2
Metai	3.2.a	Intertidal; coarse-shelly sand	E	5	Int	4
Metai	3.2.b	Lagoon behind reef; coarse sand	E	3	2.0	5
Sakao, south	3.3.a	Intertidal; sand, forams, rubble	E	3	Int	4
Sakao, south	3.3.b	Reef crest; sand and rubble	E	3	Int	1
Sakao, north	3.3.c	Intertidal; coarse sand, forams	S	9	Int	4
Sakao, north	3.3.d	Reef crest; coarse sand, rubble	S	3	1.0-1.5	2
Sakao, northeast	3.3.e	Intertidal; muddy-coarse sand	E	2	Int	4
Cook Bay	3.4.a	Intertidal; coarse sand, forams	E	3	Int	4
Cook Bay	3.4.b	Reef crest; sand, forams, rubble	E	2	1.5	1
Gaspard Bay	3.5	Intertidal; coarse sand	S	8	Int	4
Atchin	3.6.a	Lagoon behind reef; sand-rubble	E	2	1.0	1
Port Sandwich	3.7.a	Bay; gravel-coarse sand	S	3	1.0	1
Port Sandwich	3.7.b	Bay; coarse sand	S	2	1.0	2
Port Sandwich	3.7.c	Bay; coarse sand	S	1	1.0-2.0	1
Port Sandwich	3.7.d	Lagoon behind reef; sand-rubble	S	6	0.5-1.5	3
Port Sandwich	3.7.e	Lagoon behind reef; sand-rubble	S	6	0.5-1.5	3
Port Sandwich	3.7.f	Bay; deep soft mud	S	0	-	-
Port Sandwich	3.7.g	Bay; deep soft mud	S	0	-	-
Port Sandwich	3.7.h	Bay; deep soft mud	S	0	-	-
PENTECOST						
Wanuru	2.15.a	Lagoon behind reef; sand, rubble	S	0	-	-
Wanuru	2.15.b	Reef outer slope	S	0	-	-
Banmatmat	2.15.c	Lagoon behind reef; sand-rubble	S	2	0.5	3
Loltong	2.16	Bay; sand, forams, rubble	S	3	0.5-1.5	4
SANTO AND OFFSHORE ISLANDS						
Big Bay	2.22	Bay; coarse sand-rubble	S	0	-	-
Hog Harbour	2.23.a	Bay; find sand, turbid	S	0	-	-
Hog Harbour, Champagne Beach	2.23.b	Bay; find sand	S	0	-	-
Hog Harbour	2.23.c	Bay; fine sand	S	2	2.0-3.0	1
Turtle Bay	2.25.a	Bay; coarse sand-rubble	E	0	-	-
Turtle Bay	2.25.b	Reef; rubble, organic detritus	E	0	-	-
Turtle Bay	2.25.c	Reef; coarse sand-rubble	E	0	-	-
Malao	2.25.d	Reef; coarse sand-rubble	E	0	-	-
Palikulo Bay	2.26	Bay; coarse, shelly sand	S	3	Int-1.5	5
GAUA						
Lesalau Bay	2.17.a	Reef; sand-rubble	E	0	-	-
Lesalau Bay	2.17.b	Reef; coarse sand-rubble	E	1	0.5-1.5	2
Lesalau lagoon	2.17.c	Lagoon behind reef; coarse sand-rubble	E	3	1.5-4.0	1

(continued overleaf)

Table 8.1 (continued)

Location	Site No.	Habitat-substrate	Exposed (E) or Sheltered (S)	No. of Seagrass species	Water depth (m)	Cover Category
REEF ISLANDS						
Platform reef, south	2.19.a	Lagoon (blue hole); fine sand	E	0	-	-
Platform reef, south	2.19.b	Lagoon behind reef; fine sand	E	0	-	-
Platform reef, southwest	2.19.c	Lagoon behind reef; coarse sand	E	0	-	-
Platform reef, northwest	2.19.d	Reef outer slope; coarse sand	S	0	-	-
Enwut and Watansa	2.19.e	Lagoon behind reef; sand	E	1	Int-1.0	1
UREPARAPARA						
Lorup Bay, south	2.10.a	Intertidal; fine sand, turbid	E	2	Int-0.5	4
Lorup Bay, north	2.20.b	Intertidal; coarse sand	E	1	Int-0.5	4
Lorup Bay, village	2.20.c	Bay; fine sand	S	1	0.5-1.0	5

Seagrass species

A total of 9 species of seagrass were recorded during the survey (Table 8.2). Six of these were new records for Vanuatu - *Cymodocea serrulata*, *Enhalus acoroides*, *Halodule pinifolia*, *Halophylla ovalis*, *Syringodium isoetifolium* and *Thalassodendron ciliatum*. In addition, many specimens conforming to the characteristics of *Halophylla ovata* were seen. However, plants with characteristics intermediate between *H. ovata* and *H. ovalis* were also found, making it impossible to distinguish between the two species. Thus all were assigned to *H. ovalis*, a practice followed in other seagrass studies (Lanyon 1986).

Most of the Vanuatu species are those confined to tropical waters. The only exceptions are *H. ovalis* and *S. isoetifolium*, which also occur in temperate waters (McComb *et al.* 1981). All of the 9 species found in Vanuatu occur also in Australian tropical regions, from which a total of 14 species (including *H. ovata*) have been recorded. Thus the present survey recorded all or nearly all of the species that could be expected to occur in Vanuatu. The isolation of Vanuatu from Australia and its comparatively small area of suitable habitat probably mean fewer seagrass species occur here than in Australia. Short notes on each of the seagrasses are given in Appendix 5.

Distribution of seagrasses

Most seagrasses were widely distributed throughout the islands, but 4 species were recorded only from Malakula and one (*H. pinifolia*) was recorded from Malakula northwards (Table 8.2). There is, however, no reason to think that Malakula should form a natural boundary to seagrasses. Further study in the northern islands would probably reveal additional species, although the paucity of species may reflect fewer habitat types in the north of the country.

Although most species had a similar overall distribution pattern, their occurrences within this range varied markedly. Thus *T. hemprichii* was recorded from 33 of the 39 sites with seagrasses, whilst *H. pinifolia* occurred at 2 (Table 8.2). A further three species also occurred infrequently - *S. isoetifolium* (4 sites), *C. serrulata* (5 sites) and *T. ciliatum* (9 sites). The remaining species occurred at from 13-17 sites. As a very wide range of habitat types was examined in this survey, such differences in occurrence reflect the range of habitat types the species can occupy. Thus *T. hemprichii* can clearly occupy a wide range of habitat types whilst *H. pinifolia* is restricted to a narrow range.

Habitat preference, diversity and abundance of seagrasses

Table 8.1 lists the main habitats in which seagrasses were found - reef crest, reef or reef passage (12 sites); lagoon behind reef (21); bay (15); intertidal (12). Table 8.3 lists these sites together with the number of seagrass species and total cover of the seagrass community at each.

Table 8.2 Species of seagrass recorded from each site. (*Cym. rot.* - *Cymodocea rotundata*; *Cym. serr.* - *Cymodocea serrulata*; *En. acor.* - *Enhalus acoroides*; *Halo. pin.* - *Halodule pinifolia*; *Halo. uni.* - *Halodule uninervis*; *Hal. ov.* - *Halophylla ovalis*; *Syr. iso.* - *Syringodium isoetifolium*; *Thal. hemp.* - *Thalassia hemprichii*; *Th. cil.* - *Thalassodendron ciliatum*). Site nos. indicate whether Phase 2 or Phase 3 of survey (to left of decimal point) and locations - as in Figure 2.1 (p. 11) and Appendix 2.

Location	Site No.	*Cym. rot.*	*Cym. serr.*	*En. acor.*	*Halo. pin.*	*Halo. uni.*	*Hal. ov.*	*Syr. iso.*	*Thal. hemp.*	*Th. cil.*
ANEITYUM										
Inyeug platform reef	2.9.a								X	
Inyeug platform reef	2.9.b								X	
Aneighowhat Bay	2.10	X				X	X	X	X	X
Port Patrick	2.11								X	
TANNA										
Port Resolution, Yewao Point	2.6	X	X						X	
EFATE AND OFFSHORE ISLANDS										
Moso, southwest shore	2.2	X							X	
Moso, east shore	2.3	X		X		X	X		X	
COOK REEF										
Platform reef, west side	2.14a						X			
MALAKULA AND OFFSHORE ISLANDS										
Uripiv	2.29.a								X	
Uri	2.29.b	X	X	X		X				
Crab Bay	2.31								X	
Vulai	2.34	X		X		X	X	X	X	X
Luoimalakai	2.35								X	
Metai	3.2.a	X		X		X	X		X	
Metai	3.2.b			X		X			X	
Sakao, south	3.3.a	X		X					X	
Sakao, south	3.3.b			X		X			X	
Sakao, north	3.3.c	X	X	X	X	X	X	X	X	X
Sakao, north	3.3.c			X					X	X
Sakao, northeast	3.3.e	X							X	
Cook Bay	3.4.a			X					X	X
Cook Bay	3.4.b			X						X
Gaspard Bay	3.5	X		X	X	X	X	X	X	X
Atchin	3.6.a	X							X	
Port Sandwich	3.7.a			X			X		X	
Port Sandwich	3.7.b			X			X			
Port Sandwich	3.7.c					X				
Port Sandwich	3.7.d	X	X			X	X		X	X
Port Sandwich	3.7.e	X	X			X	X		X	X
PENTECOST										
Banmatmat	2.15.c	X							X	
Loltong	2.16	X				X			X	
SANTO										
Hog Harbour	2.23.c					X	X			
Palikulo Bay	2.26	X				X			X	
GAUA										
Lesalau Bay	2.17.b								X	
Lesalau lagoon	2.17.c					X	X		X	
REEF ISLANDS										
Enwut and Watansa	2.29.e								X	
UREPARAPARA										
Lorup Bay, south	2.20.a					X			X	
Lorup Bay, north	2.20.b								X	
Lorup Bay, village	2.20.c								X	
39 SITES		17	5	14	2	17	13	4	33	9

Table 8.3 Number of seagrass species and their total abundance recorded at each major habitat type. Cover categories: 1 - 5% cover or less; 2 - 6-25% cover; 3 - 26-50% cover; 4 - 51-75% cover; 5 - more than 75% cover.

Reef, reef crest or reef passage			Lagoon behind reef			Bay			Intertidal		
Site No.	No. of Species	Cover Category	Site No.	No. of Species	Cover Category	Site No.	No. of Species	Cover Category	Site No.	No. of Species	Cover Category
2.4	0	0	2.3	5	5	2.10	6	5	2.2	2	5
2.15.b	0	0	2.6	3	2	2.16	3	4	2.20.a	2	4
2.17.a	0	0	2.9.a	1	2	2.20.c	1	5	2.20.b	1	4
2.17.b	1	2	2.9.b	1	2	2.22	0	0	2.29.a	1	2
2.19.d	0	0	2.11	1	1	2.23.a	0	0	2.29.b	4	3
2.25.b	0	0	2.12	0	0	2.23.b	0	0	2.31	1	1
2.25.c	0	0	2.14.a	1	1	2.23.c	2	1	3.2.a	5	4
2.25.d	0	0	2.14.b	0	0	2.25.a	0	0	3.3.a	3	4
2.35	1	2	2.14.c	0	0	2.26	3	5	3.3.c	9	4
3.3.b	3	1	2.15.a	0	0	3.7.a	3	1	3.3.e	2	4
3.3.d	3	2	2.15.c	2	3	3.7.b	2	2	3.4.a	3	4
3.4.b	2	1	2.17.c	3	1	3.7.c	1	1	3.5	8	4
			2.19.a	0	0	3.7.f	0	0			
			2.19.b	0	0	3.7.g	0	0			
			2.19.c	0	0	3.7.h	0	0			
			2.19.e	1	1						
			2.34	7	4						
			3.2.b	3	5						
			3.6.a	2	1						
			3.7.d	6	3						
			3.7.e	6	3						
Means	0.8	0.7		2.0	1.6		1.4	1.6		3.4	3.6

It is apparent that seagrass diversity and abundance were lowest in the reef habitats and greatest in the intertidal areas, and intermediate in lagoons and bays. There were wide variations in diversity and abundance within each of these four major habitat types. For example, lagoons varied in species diversity from 0 to 7 and in cover from 0 to category 5.

When each habitat type was further subdivided according to exposure (Table 8.4), exposed and sheltered locations on reefs had similar seagrass diversity and abundance. However for lagoon sites, sheltered localities had more species and greater abundance than exposed sites. For intertidal sites, the same was true of species diversity, but abundance values were similar. Comparisons for bay sites were not possible because only one exposed bay site was examined.

Overall, it is clear that sandy, sheltered intertidal shores provided the most favourable habitat for seagrasses in Vanuatu. Such sites have both the greatest diversity and the greatest abundance of seagrasses, and one, on the north side of Sakao Island (Malakula) had all 9 species within a few metres of each other. Sandy intertidal shores exposed to the prevailing winds support fewer species, but their total cover is similar to that on sheltered shores. It thus appears that increasing exposure reduces diversity but not abundance.

In lagoon habitats, sheltered sites contained more species and a higher cover than exposed sites. Thus at lagoon sites, increased exposure reduced both diversity and abundance of seagrasses. Some of the bay sites also supported diverse and abundant seagrass communities.

Despite the apparent relationships between abundance and diversity of seagrasses and site characteristics of habitat type and degree of exposure, there was still much unexplained variation of the seagrass communities within particular habitat types. At exposed intertidal sites, for example, species diversity ranged from 1 to 5 and cover from category 1 to 5. Such variations are probably due to a number of other factors varying between sites - substrate type, turbidity, site uniformity, degrees of shelter and exposure and history of disturbance.

Major seagrass localities

The areas of seagrass beds were not measured in this survey, although in some localities their widths were estimated. We define 'major' seagrass areas as those with a cover category of 4 or 5 i.e. more than 50% cover. Altogether 16 such sites were located and these are listed in Table 8.5.

Major sea grass areas were found in shallow lagoons, bays and intertidal areas. In all instances, sand was the major or only substrate component, varying from muddy to coarse sands with additions of gravel, foraminifera shells or coral rubble in some localities (Table 8.1). Sites were equally divided between sheltered and exposed localities. The diversity of species ranged from 1 (*T. hemprichii*) to 9, with 10 of the sites having 3 or less species.

Although a number of major seagrass sites were located in this survey, most of them were rather small. This was because of the limitations imposed on them by the restricted area of the particular location (small bays, lagoons and intertidal shores) together with rapidly increasing depths (see below). The most extensive seagrass beds located in the survey were on the comparatively wide intertidal areas around the Maskelyne Islands and the southeast coasts of Malakula.

Table 8.4 Number of seagrass species and their total abundance at sheltered and exposed major habitats. Cover categories: 1 = 5% cover or less; 2 = 6-25% cover; 3 = 26-50% cover; 4 = 51-75% cover; 5 = more than 75% cover.

Reef, reef crest or reef passage						Lagoon behind reef						Intertidal					
Exposed			Sheltered			Exposed			Sheltered			Exposed			Sheltered		
Site No.	No. Sp.	Cover Cat.	Site No.	No. Sp.	Cover Cat.	Site No.	No. Sp.	Cover Cat.	Site No.	No. Sp.	Cover Cat.	Site No.	No. Sp.	Cover Cat.	Site No.	No. Sp.	Cover Cat.
2.17.a	0	0	2.4	0	0	2.6	3	2	2.3	5	5	2.2	2	5	3.3.c	9	4
2.17.b	1	2	2.15.b	0	0	2.9.a	1	2	2.12	0	0	2.20.a	2	4	3.5.b	8	4
2.25.b	0	0	2.19.d	0	0	2.9.b	1	2	2.15.a	0	0	2.20.b	1	4			
2.25.c	0	0	3.3.d	3	2	2.11	1	1	2.15.c	2	3	2.29.a	1	2			
2.25.d	0	0				2.14.a	1	1	2.34	7	4	2.29.b	4	3			
2.35	1	2				2.14.b	0	0	3.7.d	6	3	2.31	1	1			
3.3.b	3	1				2.14.c	0	0	3.7.e	6	3	3.2.a	5	4			
3.4.b	2	1				2.17.c	3	1				3.3.a	3	4			
						2.19.a	0	0				3.3.e	2	4			
						2.19.b	0	0				3.4.a	3	4			
						2.19.c	0	0									
						2.19.e	1	1									
						3.2.b	3	5									
						3.6.a	2	1									
Means	0.9	0.7		0.8	0.5		1.1	1.1		3.7	2.6		2.4	3.5		8.5	4.0

Table 8.5 Major seagrass areas of Vanuatu. Cover categories: 4 = 51-75%; 5 = more than 75%.

Locality	Site No.	No. of Species	Cover Category	Width (m)
LAGOON BEHIND REEF				
Moso	2.3	5	5	>200
Vulai Island	2.34	7	4	-
Metai Island	3.2.b	3	5	-
BAY				
Anelghowhat Bay	2.10	6	5	>100
Loltong Bay	2.16	3	4	150
Lorup Bay	2.20.c	1	5	30
Palikulo Bay	2.26	3	5	75
INTERTIDAL				
Moso	2.2	2	5	30
Lorup Bay	2.20.a	2	4	30
Lorup Bay	2.20.b	1	4	150
Metai Island	3.2.a	5	4	400
Sakao Island	3.3.a	3	4	200
Sakao Island	3.3.c	9	4	150
Sakao Island	3.3.e	2	4	300
Cook Bay	3.4.a	3	4	150
Gaspard Bay	3.5	8	4	100

Factors limiting seagrasses

It was shown above that habitat type, exposure and substrate were major determinants of seagrass diversity and abundance. From the survey however it became clear that seagrasses in Vanuatu were limited by additional factors. The maximum depth at which they were found was about 4 m, and usually, they were not found at depths greater than about 2 m.

According to several studies (e.g. den Hartog 1970; Lipkin 1977) the species of seagrass found in Vanuatu have all been recorded from much greater depths than found here, some of them as great as 45 m. It was frequently noted throughout this survey that seagrass beds, often quite luxuriant, ceased growing suddenly at depths from 1-2 m, although conditions in the grassless areas appeared to be no different than at the grassed areas. Sometimes the seabed in these areas was gently sloping, while, in other cases it was flat. Additionally seagrasses were scarce or absent from areas at which they were expected to be at least moderately diverse and abundant e.g. Cook Reef, Reef Islands. Both these localities have extensive areas of flat, shallow, sandy seabeds and are not severely exposed.

It is not clear why seagrasses should be restricted to such shallow depths in Vanuatu's clear oceanic waters, which would permit seagrass growth to great depth. In sites where water clarity was greatly reduced e.g. the western ends of Port Sandwich by suspended muds (where visibility was less than 1 m) seagrasses were found at 2 m depth. In the clearest of waters, seagrasses were rarely found deeper than this.

Restriction of seagrasses to shallow waters may be a consequence of cyclone effects. Vanuatu is regularly struck by cyclones, on average 2.6 per year (See Done, this volume). Heavy seas during these periods may destroy seagrasses below depths of about

2 m, perhaps as a consequence of substrate erosion. Cyclones may also have prevented the establishment of seagrasses in areas which appeared to be suitable, at least under the calm conditions they were observed in during this survey. Once removed from an area, seagrass beds are slow to re-establish themselves (Zieman 1976). Thus the absence of seagrasses from an apparently suitable area may be as a result of disappearance some years previously, and not due to some recent event.

Structure of seagrass beds

Detailed information of the structure of seagrass beds to determine zonations patterns of associations between species was not collected. In at least some areas, however, the seagrasses formed distinctive zones. For example at Moso east (Site 2.3), *C. rotundata*, *E. acoroides*, *H. uninervis* and *T. hemprichii* together formed a dense inshore zone 30 m wide. Beyond this and extending for at least 200 m was a zone of sparse *H. ovalis*. At Anelghowhat Bay (Site 2.10) *H. uninervis* and *H. ovalis* grew in a sparse narrow zone shorewards of the dense growths of *S. isoetifolium* and *T. ciliatum* and associated species.

Generally, the seagrass beds were comprised of few species. Most beds (29 = 74%) comprised one (12 sites), two (7 sites) or 3 species (10 sites). The single species sites were comprised mainly of *T. hemprichii* (10 sites) whilst the others were *H. ovalis* and *H. uninervis* (Table 2).

In the localities comprising two or more species, one species was usually dominant. In most cases this was *T. hemprichii*, but in some areas *C. rotundata*, *E. acoroides*, *S. isoetifolium* and *T. ciliatum* were dominant. Usually the species of each community grew together, but in others large areas were comprised of single-species stands. For example, *S. isoestifolium* and *T. ciliatum* both formed extensive pure growths at Anelghowhat Bay.

In some intertidal areas, seagrasses formed communities with distinctive patterns. At Banmatmat (Site 2.15.c) *T. hemprichii* grew only on the exposed surfaces of hummocks in a sandy intertidal pool. No seagrasses were present in the shallow (20 cm) water between the hummocks. On the wide sandy intertidal shores around the Maskelynes and southeast Malakula, the seagrasses frequently grew in distinctive mosaic patterns. This was due to the pronounced hummock-hollow configuration of the beach, caused by burrowing animals. Hummocks were created by the accumulation of sediments, deposited by burrowing animals and/or trapped and stabilized by seagrass fronds and roots. Hollows, up to 1 m in diameter, were formed by excavations of the burrowing animals, with the burrow entrance at the base of the hollow. In some localities the dark green *T. hemprichii* was dominant on the hummocks whilst the lighter green *C. rotundata* and *E. acoroides* were dominant in the water-filled hollows. In other localities the sides of the hollows had no or sparse seagrasses whilst the hummocks had dense growths. In both cases, the distinctive patterning of the seagrasses was clearly discernible both whilst surveying the beach and on aerial photographs.

In some localities, large amounts of algae were mixed with the seagrasses. This was particularly evident at the intertidal areas of the Maskelynes and southeast Malakula. Here, dense growths of green filamentous algae and *Caulerpa* spp. formed thick carpets under seagrass canopies. In some areas the filamentous algae were confined mainly to the exposed sand hummocks, again resulting in a characteristic patterning of the shore. Such beaches, with abundant growths of seagrasses and algae must have very high biomass and primary productivity.

Importance of seagrass beds

There have been no studies on the importance of seagrass beds in Vanuatu. However the results of findings from other countries will be generally applicable to Vanuatu.

Such studies have shown seagrass beds to be important as a food resource and shelter for marine animals and in stabilizing coastal sediments against erosion (den Hartog 1977; King 1981; McComb *et al.* 1981).

Although seagrass beds often have high biomass and productivity, few animals actually graze the seagrass directly. Fishes for which seagrasses may be an important dietary component include some parrot fishes (Scaridae) and surgeon fishes (Acanthuridae), whilst major invertebrate grazers include sea urchins and amphipods. In at least some of these cases the food utilized by such grazers is not the seagrass itself but rather the large numbers of small animals and plants (epibiota) attached to the leaves. In tropical regions, seagrasses provide the staple diet of dugongs (Nishiwaki and Marsh 1985) and the green turtle (*Chelonia mydas*). The dugong is widely spread throughout Vanuatu (Chambers *et al.*, 1989), as is the green turtle.

Seagrass beds provide protection and shelter to animals in a number of ways: by providing attachment surfaces for epibiota; by reducing current velocity; by reducing environmental extremes of temperature, salinity and light, particularly in intertidal and shallow water situations. All of these characteristics combine to give seagrass beds a more diverse and abundant fauna compared to nearby non-vegetated areas. This in turn makes seagrass beds important as spawning, nursery and feeding grounds for a large variety of fish and other animals.

Finally, the role of seagrasses in accumulating and stabilizing sediments is also of major importance. Seagrass fronds assist in trapping water-borne sediments by reducing current speeds. These sediments are then bound and stabilized by seagrass root and rhizome systems. Such mechanisms can result in major accumulations of coastal sediments (Hagan and Logan 1974) and reduce storm surges in shallow waters caused by tsunamis and cyclones (Burrel and Schubel 1977).

Thus extrapolating from overseas studies, and considering known factors in Vanuatu, seagrass beds are of major value because they:

(i) provide the staple diet of the dugong and green turtle.

(ii) provide food, shelter, protection and spawning grounds for a variety of invertebrates and fish. In turn, this will make at least major seagrass beds an important local resource for the subsistence fisheries of nearby coastal villages.

(iii) occur in close association with coral reefs. Thus the provision of adjacent feeding and breeding grounds for reef fauna may be an important factor in Vanuatu reef ecology, providing additional energy and nutrient sources to those from within the reef itself.

(iv) provide protection to coastal areas from flooding and erosion during cyclones.

Threats to seagrass beds

A large number of possible causes for seagrass depletions have been recorded. These include natural and human-made agencies. Natural causes include disease (Rasmussen 1977), climate changes (Orth 1976; Rasmussen 1977), sediment movements (Kirkman 1978), salinity changes (Orth 1976), sea-level changes (den Hartog 1977) and faunal influences (Ferguson-Wood 1959; Orth 1976). Due to the lack of previous studies in Vanuatu, there is no evidence for or against any of these agencies ever having affected seagrass beds here.

Possible human-induced causes for seagrass loss or depletion include: turbidity changes associated with dredging, urban and industrial influences or eutrophication; toxic chemicals; hot water effluents; oil spills; trawling; salinity changes (Larkum and West 1982). In Vanuatu none of these would appear to pose serious or widespread threats in the foreseeable future. Eutrophication of two lagoons has occurred at Port Vila, with associated increased turbidity. Seagrasses are present in both lagoons, but due to lack of previous information, it is not known if these communities are altered in any way from their original state.

During the present survey, dead or partially dead seagrasses were recorded at several intertidal areas e.g. *C. rotundata* at Moso (Site 2.2), *T. hemprichii* at Pentecost (Site 2.15) and both species at the Maskelyne Islands (Site 3.2.a). In these cases, either the whole plant or the distal ends of the leaf fronds were brown and decaying. Such plants generally were growing on the tops of sand hummocks and thus fully exposed to sunlight, high temperatures and rainfall coinciding with low-tide periods. Mortality may be due to one or a combination of these factors. The same species in shallow pools adjacent to hummocks were growing normally. In Papua New Guinea Johnstone (1975) attributed intertidal seagrass deaths to rainfall.

In other areas (e.g. *S. isoetifolium* at Anelghowhat Bay, Site 2.10) large amounts of apparently healthy green leaves were washed up on the shore. Presumably this was due to a period of rough weather, to which this species may be particularly susceptible.

Management of seagrass areas

The present survey has shown that seagrasses are widely distributed throughout Vanuatu. In at least some areas they form extensive beds (Table 8.5). Although there is no direct quantitative evidence, inferences possible from studies elsewhere show that such areas are an important resource by providing food, feeding, shelter, spawning and nursery areas for many animals. Thus seagrass beds enrich inshore and subsistence fisheries, support dugong and turtle populations and protect coastal areas from wave damage.

The protection of major seagrass sites should therefore be a priority consideration and objective, particularly when planning coastal developments that may have adverse impacts on them. Depletion or loss of major seagrass beds could have profound consequences on local subsistence economies by causing depletions of inshore fish and shellfish resources. Although no such major developments are planned at present, as a matter of policy all coastal developments should be screened for their possible impacts on adjacent seagrass sites. This is particularly important for developments close to major seagrass sites (Table 8.5). If the seagrass resource is unknown in a particular area then it should be assessed as part of the project screening procedure. Similarly, in all planning and resource maps of Vanuatu, major seagrass beds should be marked to facilitate their proper consideration in the planning process. If potentially adverse impacts are predicted as a result of a particular development, then alternatives such as re-siting the project or introducing mitigating procedures should be actively considered.

Seagrass areas are an important and integral component of the inshore resources and ecosystems of Vanuatu. They are always in close proximity to coral reefs. Thus when considering appropriate localities for marine reserves, areas containing both exceptional reef and seagrass communities should receive priority.

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