Spatial variation in the morphological structure of mangrove stands in an arid World Heritage Area: challenges for management and conservation

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INTRODUCTION

For management purposes, mangrove forests are often assumed to be of uniform conservation value at a regional scale, and areas that are protected for conservation purposes are generally perceived to be 'representative' of mangroves across that region. This approach, however, may fail to recognize differences in the morphological structure of superficially similar mangrove stands. Mangroves can display considerable plasticity in morphological traits in response to environmental conditions and the area and biomass of forests can vary in relation to physical parameters such as rainfall and freshwater input, tidal inundation and wave action across relatively small areas[1]. Such variation in the morphological structure (e.g. density, areal extent, height etc.) of mangrove patches is likely to lead to differences in the ecological role of, and ecosystem services (e.g. primary productivity, nutrient cycling, sediment trapping etc.) provided by, mangroves[2] over various spatial scales. Thus, treating mangroves as homogeneous units may not be an appropriate management strategy in some areas, particularly when there are regional-scale gradients in the physical environment.

The Shark Bay Marine Park and World Heritage Area (SBMPWHA) is a large, semi-enclosed and shallow marine embayment set in a semi-arid landscape with strong regional-scale gradients of rainfall, temperature and evaporation, which form persistent zones of increasing salinity from the ocean to the inner reaches of Shark Bay (Fig 1). Mangroves in Shark Bay are represented by a single species, the grey mangrove *Avicennia marina*, which exist as small, isolated stands at the southern edge of distribution on the west coast of Australia. These mangroves exhibit considerable differences in their structure across the bay (Fig. 2); however, morphological variation has never been quantified. The aim of this study was to examine variation in structure of mangroves across their distribution in Shark Bay in relation to environmental factors such as salinity. Differences in the structure of A. marina stands across Shark Bay were then considered in relation to the management of mangroves as a key ecological value of the SBMPWHA.

METHODS

Morphological variation of mangrove stands was examined at 12 sites across the SBMPWHA (Fig 1). At each site, 5 randomly placed 5 x 5m plots were established, and a range of morphological variables were measured (Table 1). All data were averaged or scaled to the plot level, so that there were replicates (n = 5) from each site for each variable. Data were examined using a range of univariate and multivariate analyses.

Fig. 2 Extremes of mangrove forest types within the SBMPWHA

RESULTS AND DISCUSSION

Most variables displayed considerable variation between sites and differences were generally significant for all comparisons (Table 1). The multivariate analysis of the combined suite of morphological variables also found a significant difference between sites and pairwise tests revealed significant differences for almost all comparisons. Additionally, Canonical Analysis of Principal Coordinates (CAP) revealed a significant difference in the multivariate structure of mangrove patches between salinity zones (Fig. 3).

The results suggest that the structure of mangrove stands varied at a regional scale and may be influenced by background physical conditions. It is likely that variations in the structure of *A. marina* stands across Shark Bay also results in ecological differences between these stands. This suggests that, while mangroves in Shark Bay comprise a single species, these typically isolated stands should not be considered as uniform 'units' for conservation management. Any review of management zoning in the SBMPWHA should consider appropriate protection for representative examples of these different structural types.

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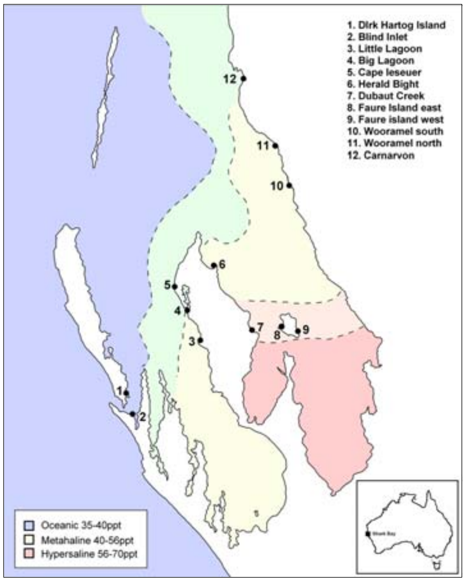

Fig. 1 The sites sampled in the SBMPWHA

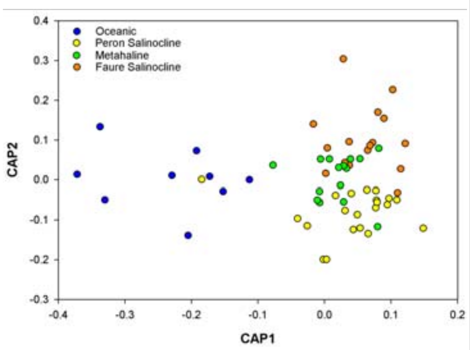

Fig. 3 The CAP analysis

Table 1 Summary of one-way ANOVA between sites for all characters measured

Character	Mean min	Mean max	ANOVA
Mature trees (per plot)	2.4	22.6	***
Saplings (per plot)	0	10	***
Recruits (per plot)	0	91	***
No. of pneumatophores (per plot)	5033	12973.3	***
% cover	22.5	72.5	***
Height (m)	1.2	5.6	***
Diameter at 30cm (cm)	9.5	61.8	***
No. of primary branches (per tree)	1.2	3.8	ns
Leaf weight (g)	0.9	1.7	***
Leaf length (cm)	8.6	12.3	***
Leaf width (cm)	2.7	3.8	***
Leaf area (cm²)	14.2	27.4	***

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