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Habitats and Biodiversity of Ningaloo Reef Lagoon, Western Australia

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Abstract. As part of the CSIRO Wealth from Oceans Ningaloo Collaborative Cluster programme currently underway in Western Australia, this study aims to examine lagoonal habitats and biodiversity within Ningaloo Reef. Key habitat types were identified using information from hyperspectral remote sensing and were used to develop a stratified sampling approach. Two focal areas were selected, based on sanctuary zones within Ningaloo Marine Park: Osprey Bay and Coral Bay in the north and south respectively. A nested quadrat sampling regime was used to attempt to link field-collected data with remotely-sensed data, collected at different scales. Preliminary results confirm that northern sections of Ningaloo Reef differ greatly from the south, with a greater diversity of habitats present in the broader lagoons in the south. Greater areas of coral are found close inshore and across the entire reef at the southern location, compared with the northern section, which has a broad expanse of sand and limestone pavement before grading to corals further offshore (back-reef and reef-crest). These differences in habitat may have implications for the overall biodiversity of the two locations and more broadly along the reef.

Key words: Biodiversity, Ningaloo Reef, habitats, hyperspectral imagery, lagoon.

Introduction

Habitats and biodiversity of lagoonal areas at Ningaloo Reef, Western Australia are currently being studied as part of the CSIRO Wealth from Oceans Ningaloo Collaborative Cluster programme. The aim of the Cluster is to integrate knowledge of reef use and socioeconomics with biodiversity and habitat maps to deliver a management strategy for the Marine Park. This study will deliver high-resolution spatial data on the habitats of the marine and coastal areas of the Ningaloo Marine Park and an understanding of how biophysical characteristics of the ecosystem relate to Ningaloo's biodiversity.

Ningaloo Marine Park extends for some 280 km along the northwest Australian coastline. The unusual circumstances of the poleward-flowing Leeuwin Current, low rainfall and low runoff (resulting in very clear waters), remoteness and strong management regime have resulted in a highly diverse, high-latitude coral reef system in relatively undisturbed condition (Cassata and Collins 2008). The region's low rainfall and low runoff (resulting in very clear waters) makes aerial photography an ideal tool to examine coastal geomorphology and habitat structure. High-resolution hyperspectral aerial photography is being used to provide detailed habitat maps for the entire Ningaloo Marine Park.

The remoteness of this region means that much of the reef is difficult to access. Existing habitat maps have been derived from in-water surveys that have focused on small sections of the reef (Bancroft and Sheridan 2000). The oceanography of Ningaloo Reef is dominated by the southward-flowing Leeuwin Current, which is forced offshore around Point Cloates by the northward-flowing Ningaloo Current (Taylor and Pearce 1999). This effectively divides the Ningaloo Reef into two distinct zones, with the northern zone under stronger influence of the Leeuwin Current than the south, resulting in a potentially higher proportion of tropical species in the northern section of the reef.

Most of the major taxonomic groups have received little or no attention at Ningaloo; biodiversity surveys will especially target the macroalgae, the Cnidaria other than hard corals and the sponges. These groups have had very little work done on them despite the fact that they are critical components of coral reef community structure. This component of the Ningaloo Wealth from Oceans Collaborative Cluster is combining biodiversity surveys and remote sensing

data to develop detailed habitat maps of the entire Ningaloo Marine Park. This paper presents preliminary data from the nested quadrat sampling programme.

Material and Methods

Key habitat types were identified using information from hyperspectral remote sensing and were used to develop a stratified sampling approach. Study areas were also selected to encompass differences caused by current flows along the Ningaloo Reef. The Coral Bay region in the south and Yardie Creek/Osprey Bay in the north have been selected as representative of the northern and southern geographic regions of the reef (Figure 1). Four habitat sub-types were sampled at each location: reef-crest, back-reef, lagoon and inner reef-flat. This paper describes preliminary data from nearshore sampling.

Sampling strategies included monitoring benthic habitat types along transects, nested quadrats to match up with the pixel size obtained by remote sensing, and transects to quantify numbers of key invertebrate species (holothurians, tridacnid clams, and the corallivorous snail, *Drupella*).

The nested quadrat design is intended to provide a link between the remotely sensed data (3.5 m pixel size) and diver-monitored benthic sampling. 9 x 9 m quadrats were marked out underwater and divided into nine 3 x 3 m sub-quadrats (Figure 2) (McDonald 2007). Estimates of benthic cover were obtained for the large quadrat and sub-quadrats using modifications of the categories developed for the Australian Institute of Marine Science long-term benthic monitoring programme (English et al. 2004). A minimum of three nested quadrats were sampled for each sub-region; further sampling is currently underway.

Results

Data presented here include preliminary nested quadrat samples from lagoon areas within Osprey Bay, Yardie Creek and Five Finger lagoon, which is within the Coral Bay region. All sites showed a predominance of sand, macroalgae and rubble as expected; the key difference observed was a significant level of soft coral cover at the Osprey Bay site (Figure 3). The pie charts represent the major benthic categories within the lagoonal areas at the three study sites (mean of 5, 6 and 3 samples at Osprey Bay, Yardie Creek and Five Finger Lagoon respectively). Osprey Lagoon showed a greater proportion of sandy substrate although the diversity of substrates was greater than the other sites. The dominant categories have been highlighted in each chart for clarity.

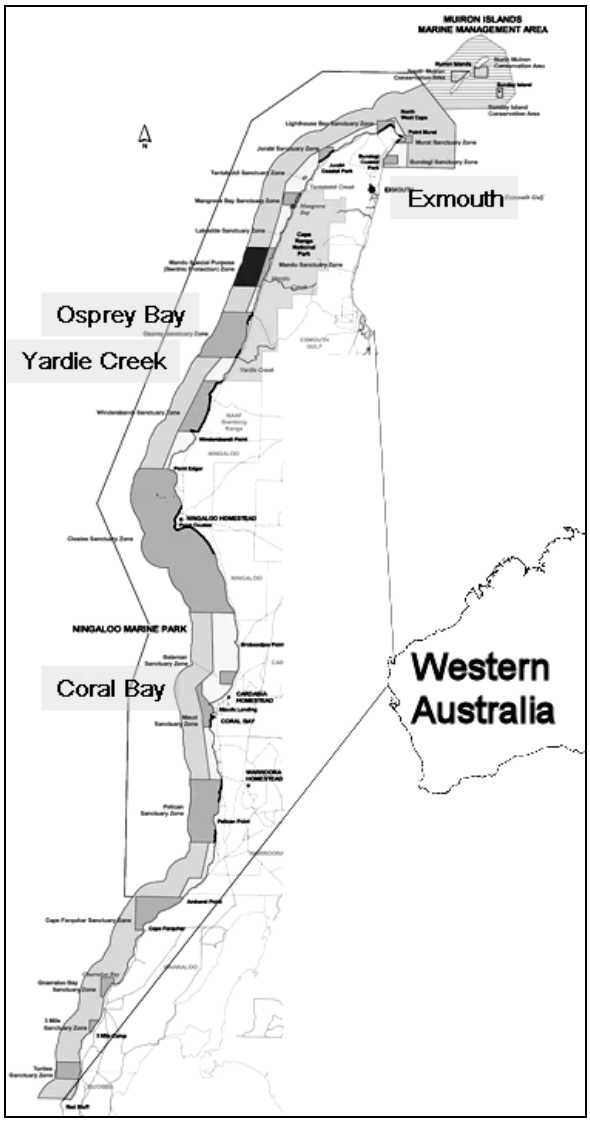

Figure 1: Ningaloo Marine Park in NW Australia. The Park boundary is indicated as State waters (to 3 nautical miles) and Australian Commonwealth waters (to 12 nautical miles). The specific study sites, Coral Bay, Yardie Creek and Osprey Bay are marked.

Discussion

The biodiversity sampling associated with the CSIRO Wealth from Oceans Ningaloo Collaborative Cluster programme has two primary purposes: firstly, to validate the hyperspectral data used to develop detailed habitat maps of the Ningaloo Marine Park; and secondly, to help fill gaps in the biodiversity knowledge of the Ningaloo Reef system. The data collected by the process described in this paper provides excellent validation for the hyperspectral remote sensing programme and good spatial determination of benthic habitat categories. Preliminary habitat classification was used to identify possible field sampling targets and this provides a

powerful mechanism for obtaining both confirmation of the classification process but also the relevance of the benthic categories being used in water. Additional validation sampling has included cross-reef transects, point sampling and diver-towed in-water GPS records of identifiable features.

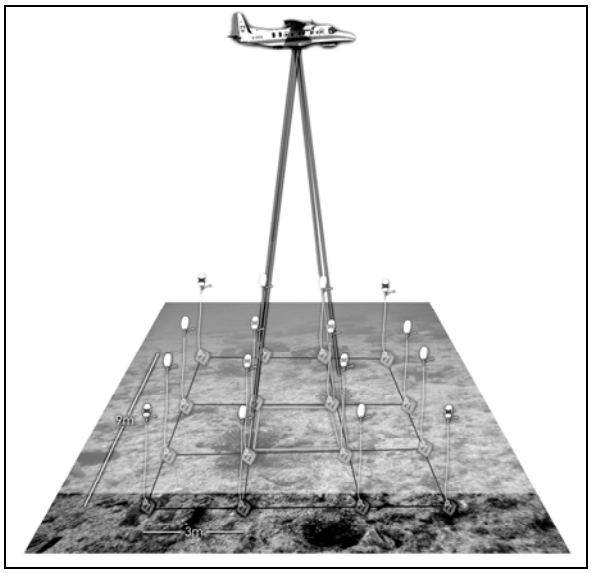

Figure 2: Schematic of nested quadrat design. Large quadrats are 9 x 9 m, sub-divided into nine 3 x 3 m sub-quadrats, approximately matching the aerial photography pixel size of 3.5 m.

Studies of oceanographic processes offshore of Ningaloo Reef indicate an interruption to the flow of the major local currents at Point Cloates, located approximately halfway along the length of the reef. At this point the southward flowing Leeuwin Current is forced offshore by the Ningaloo counter-current, which loops back as an eddy (Taylor and Pearce 1999). This interruption of the warm, nutrient-poor Leeuwin Current has considerable implications for trophic relationships on the reef. One of the preliminary observations that can be made from the data presented in this paper is the difference in major taxonomic and substrate categories identified at the sample sites. While sandy substrates predominate at all three sites (as expected from lagoon samples), there is a significant component of soft corals present in the Osprey Lagoon samples which does not occur further south. Conversely, the southern site is dominated by macroalgae, coralline algae and tabulate *Acropora*. It is anticipated that further samples from other sectors of the reef will shed more light on these differences in taxonomic categories and benthic habitats.

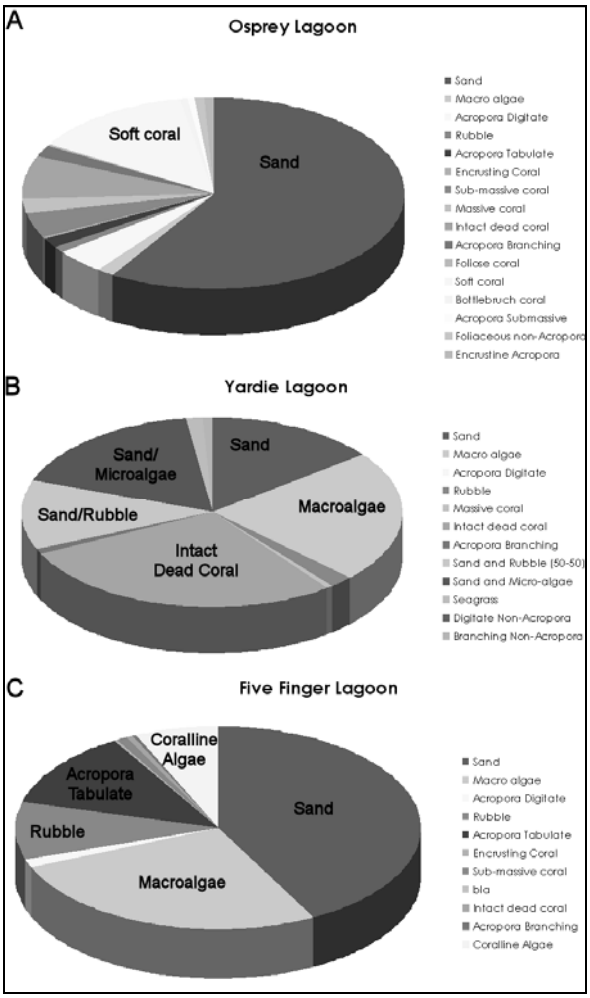

Figure 3: Major benthic categories identified from benthic nested quadrat surveys at A) Osprey Lagoon (n = 5), B) Yardie Creek Lagoon (n = 6) and C) Five Finger Lagoon (n = 3). Dominant categories have been labeled for clarity.

When combined with bathymetric data also derived from the hyperspectral aerial photography it is anticipated the habitat maps generated from this project will provide a framework for studies examining biodiversity patterns and factors influencing the distribution of significant wildlife aggregations in the region. The data generated by this study will be integrated with several other biodiversity studies currently underway in the Ningaloo region and will help to inform management decisions about the Ningaloo Marine Park.

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