The effect of causeway construction on seagrass meadows in the Western Pacific — a lesson from the ancient city of Nan Madol, Madolenihmw, Pohnpei, FSM

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Two seagrass meadow sites were chosen at Nan Madol adjacent to the now permeable remnants of an ancient causeway constructed 500 to 700 years ago: one immediately on the shoreward side of the causeway, and one immediately on the seaward side. The shoreward site had greater seagrass cover, canopy height, algal abundance, and epiphyte abundance and lower species diversity (both seagrass and macro-algae), as well as muddier sediments than the seaward site. The abundance of associated fauna did not appear to differ between sites, although the composition of the faunal communities was different. On the seaward site, average epiphyte cover was less than one-tenth the epiphyte cover of that on the shoreward side. *Halimeda* species were the most common algae on the seaward side, while on the shoreward side *Hypnea* species were dominant. *Cymodocea rotundata* was the dominant seagrass species (54% of seagrass cover) on the seaward site, but was absent on the shoreward site, which was dominated by *Thalassia hemprichii* (84%) and *Enhalus acoroides* (16%). There was no difference in salinity between the two sites. Sediments had a higher proportion of fine mud shoreward. The beche-de-mer, *Holothuria atra,* was common on the seaward side of the causeway, but not on the shoreward side. The causeway is open to water flow at all tide heights and does not appear to influence water height in any way. The effects of even this simple permeable barrier on seagrass meadows are evident and include differences in seagrass species, algal species, and fauna. We discuss the management lesson from this historic location for present-day Pacific island causeway developments.

Key words: Seagrass, Causeway, Pacific island, Management.

INTRODUCTION

POHNPEI is the largest island in the Federated States of Micronesia and is approximately 5 degrees north of the equator. It is a high island with a fringing reef and extensive coastal reef-flats and seagrass meadows.

There are three species of seagrass in the waters surrounding Pohnpei: *Cymodocea rotundata, Thalassia hemprichii* and *Enhalus acoroides* (McDermid and Edward 1999), all typical of coral reef flat communities in the western Pacific (Coles *et al.* 2003a). Pohnpei seagrasses are presently being studied as part of a global seagrass monitoring programme (www.seagrassnet.org and www.seagrasswatch.org) to analyse long-term trends and changes, and to transfer monitoring and mapping skills to local seagrass groups. Part of the rationale of this programme is to study both pristine and impacted sites. Nan Madol, on the south-east coast of Madolenihmw municipality on Pohnpei Island, was targeted as a site where long-term historical impacts are evident.

Nan Madol reportedly was the ceremonial and political seat of the Sau Deleur dynasty which united Pohnpei's estimated 25 000 people in late prehistoric times (Ayres 1990a). Nan Madol forms an archaeological district covering more than 18 km^2. It includes the stone architecture built up on a coral reef flat along the shore of Temwen Island (Fig. 1). The site core, with its stone walls, encloses an area approximately 1.5 km long by 0.5 km wide and is composed of ninety-two human-made islets constructed on the reef flat. Nan Madol was built over an extended period of time with megalithic architecture characterized by long, naturally prismatic log-like basalt stones. Archaeological data indicates active construction on Nan Madol occurred from approximately A.D. 500 to the mid-1500s (Ayres 1990b, 1992). Extensive seagrass meadows are found on Pohnpei's sheltered inner reef platforms and occur to the north and south of Nan Madol. The Pohnmweirok rock causeway, which was likely used to access Peiniot islet for burial or other ceremonial purposes, divides the seagrass meadow to the north of the main ancient city into two parts (Figs 1 and 2).

Causeway construction is common in the western Pacific island countries, with extensive construction occurring for transport connections after World War II. Changes in seagrass meadow distributions have been observed near these causeways due to changes to water and sediment movement and this is well recognized as a

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