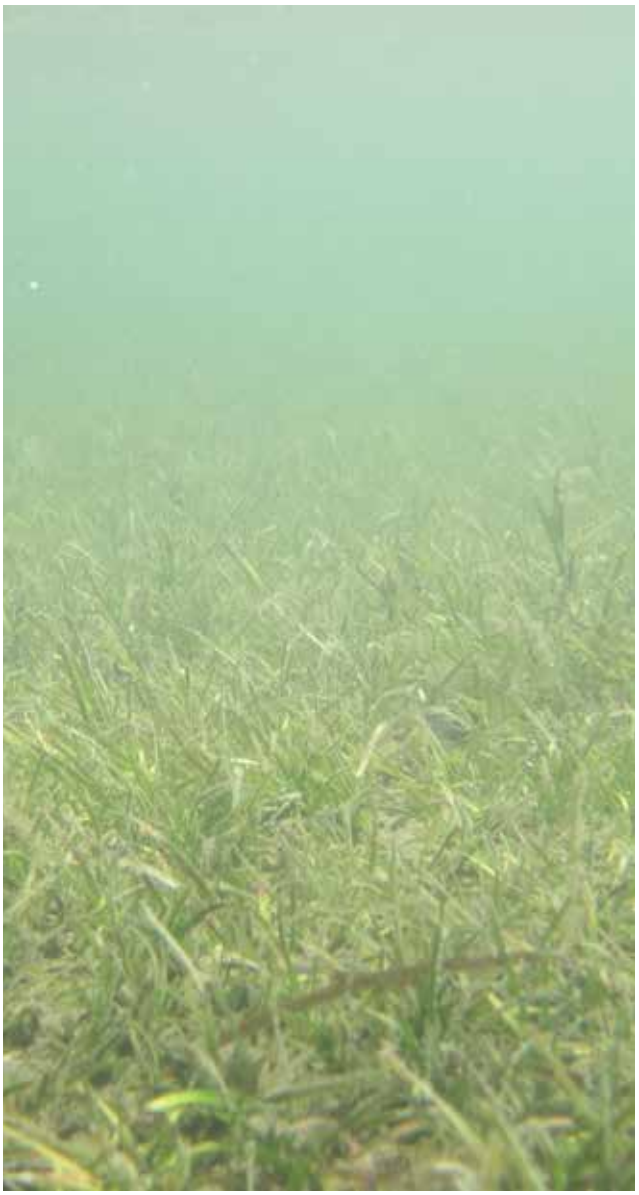
Soft Sediment Macrophytes

The NSW Government has undertaken mapping of sub-tidal macrophytes in Sydney Harbour using aerial photographs. Mangroves and saltmarsh are restricted to intertidal regions in Lane Cove River, Middle Harbour, and Parramatta River.

Saltmarsh has declined in Sydney Harbour and less than 37.5 ha remain. Of the 757 patches of saltmarsh remaining, most are small (< 100 m^2) and isolated.

Mangroves have become more common in Sydney Harbour. Over 184 ha have been observed in the Harbour, despite being relatively uncommon prior to the 1870's.



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General Introduction and Context

Estuaries contribute US$7.9 trillion annually to the global economy (Costanza et al., 1998). Much of this wealth can directly or indirectly attributed to estuarine flora. In estuaries, the main vegetation types are seagrasses (worth AUS$19,000 $ha.yr^{-1}$), saltmarsh and mangroves (AUS$9,990 $ha.yr^{-1}$ combined; Costanza et al., 1998)). These three habitats support the ecological and economic wealth of Australia's productive estuarine ecosystems. In this section of the report we deal with seagrasses, mangroves and saltmarsh collectively. However, it is important to note that the three floral types are not without significant differences in ecology.

Seagrasses are the only estuarine plants that can live totally submerged in oceanic water. While not truly grasses (i.e. not in the family Poceae), they are angiosperms (flowering plants). The term seagrass itself refers to a taxonomic grouping with much convergent morphology (Connell and Gillanders, 2007). Like most angiosperms, seagrass roots provide a mechanism for nutrient uptake. Unlike many terrestrial plants, however, a complex rhizome system linking individual shoots across several square km provides much of the structural support needed in high energy submerged environments. Rhizomes, shoots and roots often form extensive biological mats over the seafloor. *Posidonia* spp. in southern Australia, for example, are sometimes known to form mats almost 7 m high (Kuo and den Hartog, 2006). The fibrous leaves, roots, shoots and rhizomes can provide much of the primary production in estuarine systems (Connell and Gillanders, 2007). *Posidonia australis* is implicated as an extremely important food source, even when dead. Here, large amounts of decaying 'wrack' are often washed up onto south east Australian shorelines to form the base of extensive food chains (Kuo and den Hartog, 2006).

The term mangrove refers to a group of about 55 species of phylogenetically unrelated plants that have adaptions allow for living in high salinity environments (Tomlinson, 1986). Mangroves form extensive forest systems along the intertidal areas throughout the tropical and warm-temperate world (usually between 25° N and 25° S, Connolly and Lee, 2007). In these areas, water temperatures do not usually fall below 20°C during winter.

Like mangroves, the term saltmarsh refers to an ecological grouping, and includes grasses and herbaceous shrub-like plants that inhabit the upper shoreline above the mean tidal height. Saltmarshes provide a number of important ecosystem services. These include sediment stabilisation and protection, filtering of sediments and nutrients, and supporting fisheries (Pennings and Bertness,

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2001). Unlike saltmarshes in the United States and Europe, saltmarshes in Australia exist in the zone immediately above mangrove forests along sheltered estuarine shorelines (Adam, 1990). While mangroves are predominantly tropical in their distribution, saltmarsh are primarily temperate (Connolly and Lee, 2007). In Australia, however, it is interesting to note that saltmarsh area is generally greater in estuaries along the tropical Queensland coast (Connolly and Lee, 2007).

In NSW there are only two common species of mangrove: the grey mangrove *Avicennia marina* and the river mangrove *Aegiceras corniculatum*. Several species of seagrass have been recorded but seagrass beds are dominated by three taxa: *Posidonia australis; Zostera* sp. and *Halophila* spp. (Creese et al., 2009). Saltmarsh in south eastern Australia is comprised of a large and diverse assemblage of plant species. Coastal saltmarsh is listed as an endangered ecological community in NSW (NSW Threatened Scientific Committee 2004) and *P. australis* (seagrass) has six listed endangered populations in NSW including Sydney Harbour (NSW Fisheries Scientific Committee 2010).

Soft Sediment Macrophytes in Sydney Harbour

Aerial photographs have been used to map estuarine macrophytes for NSW estuaries including Sydney Harbour (Creese et al., 2009). Some historical aerial photographs have also been analysed, but much of this information is currently unpublished (see West et al., 2004). Mangroves and saltmarsh are generally restricted to the intertidal margins of sheltered bays and inlets of the Middle Harbour, Lane Cove River and Parramatta River arms of the upper harbour (Kelleway et al., 2007). Conversely, seagrasses are found intertidally and subtidally in the lower reaches of the harbour.

The spatial extent of saltmarsh in Sydney Harbour has declined significantly since colonisation (Mcloughlin, 2000; West et al., 2004; West and Williams, 2008), and the area mapped from aerial photographs in 2005 was less than 37 ha. It is difficult to identify small patches from aerial photographs, and the extent is probably slightly underestimated (Kelleway et al., 2007). The largest contiguous patch of saltmarsh remaining in Sydney Harbour occurs in Newington Nature Reserve (approx 6 ha.), but over 70 % of the 757 patches identified by Kelleway et al. (2007) are small (< 1 ha) and isolated. In contrast, mangroves have increased their distribution, being relatively uncommon until the 1870's (McLoughlin, 2000). Their mapped extent has continued to increase between the 1940's and the 2000's (NSW Government *unpub.*), with the current estimate being nearly 184 ha. In many places in the harbour, mangroves have replaced saltmarsh habitats (Kelleway et al., 2007). Seagrass has also declined in extent, and is now estimated to occupy less than half the area (approx 51.7 ha) it did in 1943. The reasons for declines in saltmarsh and seagrass and increases in mangrove area are discussed further in the Threats section of this review.

In Sydney Harbour, mangrove litter material forms the basis of detrital based food webs, which support a variety of species from most trophic levels (e.g. algae, barnacles, molluscs, fish; Ross and Underwood, 1997; Chapman, 1998; Ross, 2001; Clynick and Chapman, 2002; Chapman et al., 2005; Tolhurst, 2009), although the communities are not exceptionally different from those found in other mangroves forests in NSW.

Several species of seagrass have been reported from Sydney Harbour (Creese et al 2009), including: *Halophila ovalis, H. minor, H. major, H. decipiens, Posidonia australis, Zostera capricorni and Hetrozostera nigricaulis.* Mapping usually cannot distinguish between the species, and most studies simply categorise taxa to the level of genus (e.g. West and Williams 2008, Creese et al 2009).

The extent of seagrass is mapped using aerial photographs. Suitable photographs for Sydney Harbour go back to the 1940's. The NSW Government has used aerial photographs to generate orthorectified imagery from those photographs from 1978, 1986, 2000 and 2003 (West and Williams 2008). Recent analysis (DPI unpublished) has now investigated aerial photographs from pre-1978. This work is ongoing and is likely to be reported in the next several years.

Seagrass cover in the estuary was around 59.2 ha in 1978. In 1986 this had grown to 87.4 ha, before being reduced to an estimated 49.5 ha in 2003. Seagrass persistence in certain areas of the harbour are variable. Seagrass meadows around Rose Bay and Middle Harbour, for example, show dramatic changes in the extent of seagrass (West and Williams 2008). Across the whole harbour, 25 % of all mapped seagrass meadows were consistently present over all time periods. The other 75 % of seagrass meadows were ephemeral and were not present over all time periods.

Knowledge Gaps

Currently, there are no harbour wide management strategies for mangroves, seagrass and saltmarsh in Sydney Harbour. This is despite the suggestion the future of mangroves in the harbour is threatened by their supposed low genetic diversity (Melville and Burchett, 2002). However, under the *Fisheries Management Act 1994,* harm to vegetation (including all three macrophyte types) is illegal. Therefore removal or damage can result in fines. Further, there are now 'Habitat Protection Guidelines' set out by the NSW Government.

Practices that aim to minimise disturbance to mangroves, but at the same time allow public access, such as the building of walkways, can themselves have effects on the local biota. For example, Kelaher et al. (1998) demonstrated that the abundance of the semaphore crab, *Heloecius cordiformis*, was higher closer to boardwalks than further away due to the environmental changes (e.g. changes in sediment structure) associated with the boardwalks.

Other than distributional data, the only species we have substantial information on are mangroves, and even that is limited (Ross and Underwood, 1997; Chapman, 1998; Ross, 2001; Clynick and Chapman, 2002; Chapman et al., 2005; Melville et al., 2005; Melville and Pulkownik, 2006; Tolhurst, 2009). We have little understanding of how the resilience of these valuable habitats respond to environmental change (see Threats), and how changes in the abundance and structure mangroves, seagrasses and saltmarsh affects associated biodiversity and ecosystem function within Sydney Harbour.

Open Water / Pelagic Systems

Little is known of pelagic flora and fauna in Sydney Harbour, with most studies focusing on water quality.

Outbreaks of both toxic and non-toxic algal blooms have been observed since the 1930's. Blooms of toxic algae have occurred in the estuary in 1983, 1996, and 1999, however similar outbreaks have thought to have occurred prior to this.

A single study has examined the sizes of fin-fish in Sydney Harbour, using commercial fishing by-catch. 90 % of all by-catch were found to be less than 20 cm in length. Invertebrate species such as shrimp and crabs were consistently caught at around 100 individuals per day.

Sydney Harbour is home to one of five little penguin colonies found on the eastern coast of Australia.