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CHAPTER 1 The Significance of Saltmarshes

J.A. Latchford, A.J. McComb

Saltmarshes are complex ecosystems. Numerous studies have been undertaken on them in different parts of the world, mostly in the northern hemisphere. A few previous studies have been made of the marshes of the Peel-Harvey System (Rose & McComb, 1980; Backshall & Bridgewater, 1981; McComb & Lukatelich, 1986) but increased pressure for development, and the need for an understanding the possible effects of the then proposed Dawesville Channel highlighted the lack of information about saltmarshes in the area. This report endeavours to addresses this lack of information by presenting recent research into the extent, composition and functioning of the Peel-Harvey saltmarshes.

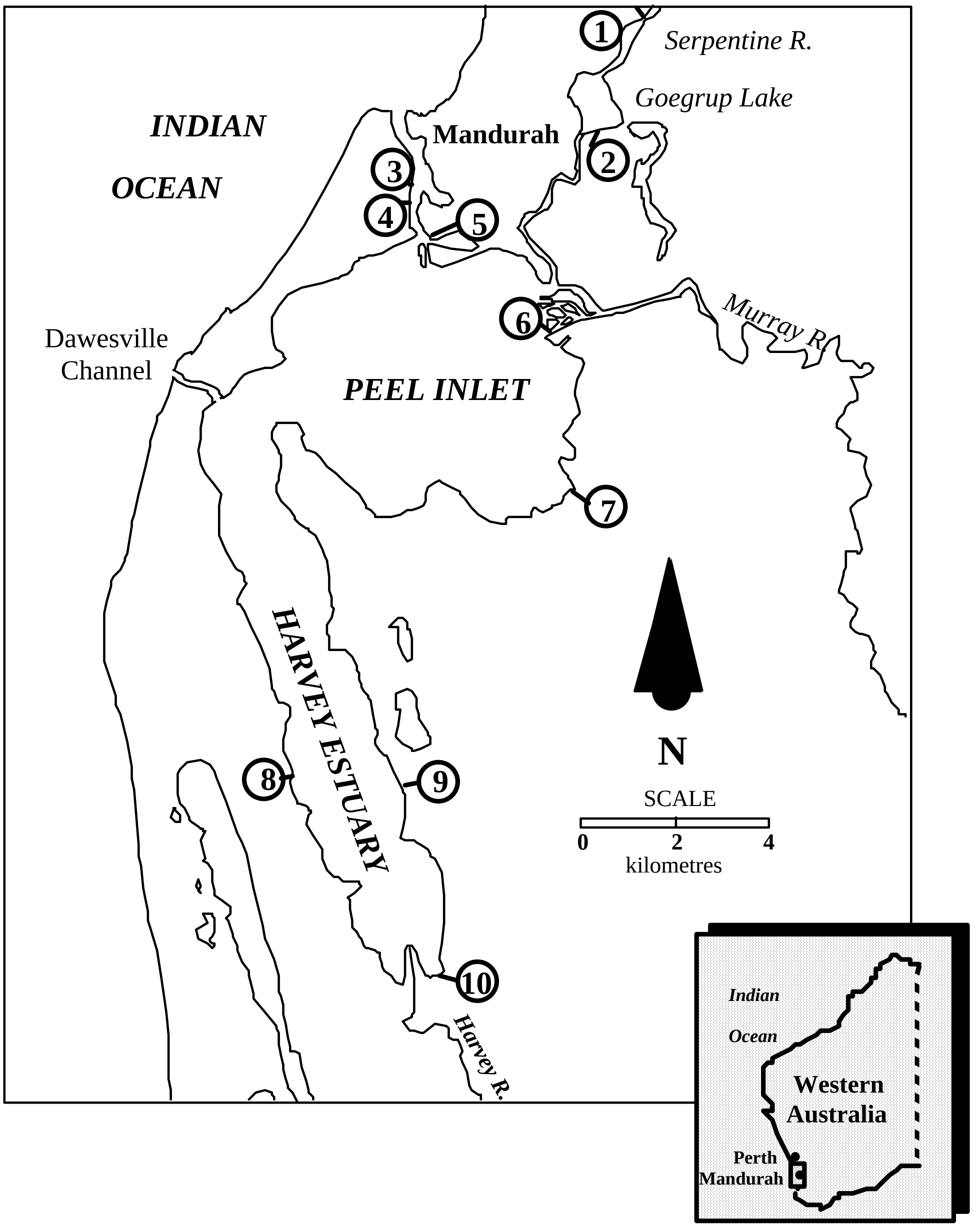

Figure 1.1. The location of study sites within the Peel Harvey estuarine system.

1.1 Peel-Harvey System

This system is 75 km south of Perth by road (between 32°21' and 33°00' south, and 115°30' and 115°30' east). It is a large (133 km^2) shallow water body which is fed in winter by three rivers, the Murray, Serpentine and Harvey (Figure 1.1). It lies on the western edge of the Swan Coastal Plain within the Darling System of Western Australia, and is separated from the sea by a line of sand dunes, the Spearwood system, which has a core of Tamala limestone.

The system has strongly seasonal river flow and, until recently, very limited water exchange with the Indian Ocean. Over geological time, natural processes would gradually complete the infill process towards a marsh system (Waterways Commission, 1992). Human impacts have accelerated this process of infilling, and fertiliser runoff has led to severe eutrophication problems; massive accumulations of macroalgae in Peel Inlet, and seasonal blooms of the blue-green 'alga' *Nodularia spumigena* in Harvey Estuary. These problems have reduced the commercial and recreational values of the system (McComb and Lukatelich, 1986). To ameliorate these problems several management recommendations have been adopted, one of which has been the construction of a new channel from the Harvey Estuary directly to the Ocean near Dawesville. The aim of the channel is to increase water exchange between ocean and estuary.

Before April 1994 astronomic tides were of small amplitude (typically about 10 cm) superimposed on longer-term changes in water level of similar magnitude. These long-term changes are due to barometric effects, coupled on occasions with river flow, with cycles of 5 to 15 days (DCE, 1980). The amplitude of the tide increased to 40 cm once the channel had been opened (Ryan, 1993).

There are saltmarshes on either side of the Mandurah channel, on the eastern side of Peel Inlet and around the southern part of Harvey Estuary. Narrow fringing marshes also border the Serpentine River (DCE, 1980).

1.2 Definition

Saltmarshes are defined as areas of land, vegetated by herbs, grasses or low shrubs, bordering saline water bodies (Chapman, 1974). They are among the most productive ecosystems in the world (Montague and Wiegert, 1991) and are distributed along coastlines in temperate climates. Different plant groups dominate different coastlines, but the ecological structure and function of saltmarshes are essentially similar in different parts of the world (Chapman, 1974; Montague & Wiegert, 1991; Adam, 1993;

Mitsch & Gosselink, 1993). Saltmarshes in Western Australia are usually found in estuaries or on sheltered coastlines, in the north west often adjacent to mangroves (Bridgewater *et al.*, 1981). They are subjected to periodic flooding as a result of fluctuations in the level of the adjacent water body (Adam, 1993).

A saltmarsh can be regarded as a highly modified terrestrial ecosystem, as the organisms which characterise saltmarshes are vascular plants of terrestrial origin. However, as the marsh occupies areas at the interface between land and sea, its environment has some features of both land and sea, and its biota has marine and terrestrial elements (Adam, 1993).

One of the dominant features influencing saltmarshes is water level fluctuation which is usually tidal in origin. Tides control soil salinity and the degree of waterlogging; they also carry sediment and nutrients in and out of the marshes. Saltmarshes are highly dynamic environments subject to erosion, accretion and progradation. Other environmental factors which characterise saltmarsh, such as nutrient availability, may modify the nature and distribution of the biota (Adam, 1993).

1.3 Physical Characteristics

Saltmarshes may occur as narrow fringes on steep shorelines, or on more shallow slopes as flat expanses up to several kilometres wide. They are found near river mouths, in bays, on protected coastal shores and around protected lagoons. Coastal saltmarshes are predominantly intertidal, that is, they are found in areas at least occasionally inundated by high tide but not flooded during low tide. In the tropics of Australia saltmarshes are partially replaced by mangrove swamps, which function in a similar manner, any saltmarsh present existing adjacent to the mangrove community (Allen & Pye, 1992; Adam, 1993) (Plate 1.1).

The sediments that build saltmarshes originate from upland runoff, marine reworking of coastal shelf sediments, and organic production within the marsh itself. The long-term stability of a saltmarsh is determined by the relative rates of two processes acting on the marsh: sediment increase or accretion, which causes the marsh to expand outward and grow upward in the intertidal zone; and by loss, or submergence, caused by rising sea level and marsh surface subsidence (Allen & Pye, 1992).

Although physical processes dominate sediment accretion, the effects of plants and animals can also be significant. Algae have an important role in the stabilisation of mudflats, which can then be colonised by flowering plants. These plants then slow water movement, allowing sediment in the water to accrete in the marsh, where it can be trapped by algal, bacterial and diatom mats (Adam, 1993).

Saltmarshes act as a buffer to the intertidal zone. Erosion of the surface of the marsh and its edges protects the shore behind it from erosion by high-energy waves. Saltmarsh creeks also allow the dissipation of tidal energy, which would otherwise erode the mudflats and the shoreline behind them (Allen & Pye, 1992).

Tides influence a wide range of physical and chemical processes. These processes in turn influence the species in the marsh and their growth. The lower and upper limits of the marsh are generally set by the tidal range. In fact, the marsh is often divided into two zones, the upper (or high) marsh and the lower (or intertidal) marsh. The upper marsh is flooded irregularly and has a minimum of ten days of continuous exposure to the air, whereas the lower marsh is flooded almost daily (Allen & Pye, 1992; Adam, 1993).

A notable feature of saltmarshes, and especially the low marsh, is the development of pans and tidal creeks. The term 'pan' is used to describe shallow depressions in the marsh which are filled periodically with water (Plate 1.2). They range from half a metre to several metres in width and a few centimetres to a half a metre deep. Because of their shallow depth and occasionally submerged vegetation, pans are used extensively by migratory wading birds searching for food. Tidal creeks, another feature of saltmarshes, serve as important conduits for material and energy transfer between the marsh and the adjacent body of water (Allen & Pye, 1992).

The development and zonation of vegetation in a saltmarsh are influenced by several chemical factors. Salinity of the overlying water and soil water is a dominant factor determining the species present and their rate of growth. Salinity is affected by the frequency of tidal inundation; rainfall; soil texture; vegetation; depth of water table; fresh water inflow; and occurrence of salt deposits (Montague & Wiegert, 1991; Adam, 1993).

As the elevation of a marsh surface increases, the number of flooding tides decreases. This may be expected to result in decreased salinity, but the salinity of the interstitial soil water does not have a constant relationship with elevation. In the lower marsh, with frequent immersion, soil salinity is relatively constant and rarely exceeds that of the flooding water. At higher elevations there is a stronger interaction between flooding and climate, leading to greater variability in soil salinity (Adam, 1993).

Soils of the saltmarsh are frequently waterlogged and anaerobic. After tidal immersion many areas of marsh drain slowly, as a result of local topography and the low hydraulic conductivity of many saltmarsh soils (Adam, 1993).


Plate 1.1 A saltmarsh within the Peel- Harvey estuary

Plate 1.2 A saltmarsh pan within the low marsh.

1.4 Productivity

Tidal marshes are amongst the most productive ecosystems in the world. Woodwell *et al*. (1973) have suggested that although saltmarshes and estuaries make up only 0.35% of the world's surface area, they are estimated to produce some 2% of net world primary production.

Saltmarshes are often cited as exporting nutrients to the estuary, but this view has been challenged and refined in recent years. It is now believed that coastal marshes display a high degree of individuality. They are still able to fix carbon at very high rates, but the fate of this carbon is not readily predicted. Systems with large river flows are likely to transport large fractions of their net primary production during spring runoff; those systems with broad tidal amplitude may export organic matter year round; or marshes experiencing rapid sea-level rise may accumulate plant matter in the sediments; and finally small, semi-enclosed marshes may use the energy of photosynthesis to produce organic matter and recycle large portions of their fixed carbon. Thus, the high productivity is either exported as detritus, accumulated as peat, or released in respiration (Zedler, 1992).

In the Peel-Harvey system during winter and spring, there is the potential for organic matter and nutrients to be washed into the estuary from the marsh. At other times, there may be an import of organic matter and nutrients from the estuarine waters. Saltmarshes also convert nutrients into forms that can be easily absorbed by estuarine plants and animals (Mitsch & Gosselink, 1993).

The availability of nutrients in the saltmarsh soil, particularly nitrogen and phosphorus, is important for the productivity of the saltmarsh ecosystem. Several studies have shown that saltmarsh vegetation can be nitrogen limited (Valiela & Teal, 1985; Barko and Smart, 1981). Phosphorus, however, accumulates in plant tissue at relatively high concentrations and apparently does not limit growth. Other nutrients which may influence the productivity of the marsh are iron, manganese and sulphur (Mitsch & Gosselink, 1993).

1.5 Ecosystem Structure

The saltmarsh has many biological components. These include vegetation, animal and microbe communities in the marsh itself, and also plankton, invertebrates, and fish in the tidal creeks, pans, and open estuarine waters (Montague & Wiegert, 1991; Mitsch & Gosselink, 1993).

The saltmarsh flora is composed of bacteria, fungi, algae, and flowering plants. In general the diversity of the flora increases with elevation above sea level, which results from differences in the soil, and competition among plant species (Adam, 1993).

Bacteria and fungi are important components of saltmarsh microflora. They are responsible for breaking down plant and animal matter and transforming it into forms of nutrients available to other organisms. Fungi are also found in the soil and on the flowering plants in the higher marsh. Almost three-quarters of the detritus produced in a saltmarsh ecosystem is broken down by bacteria and fungi (Montague & Wiegert, 1991; Adam, 1993).

Algae are found attached to flowering plants, as free-living phytoplankton, and as macroalgae. The algae are important as food sources for aquatic and terrestrial animals. Algal mats, dominated by blue-green algae, diatoms and green algae are also present (Montague & Wiegert, 1991; Adam, 1993; Mitsch & Gosselink, 1993; Paling & McComb, 1994).

The flowering plants of the saltmarsh include herbs, grasses, sedges, dwarf shrubs and trees. They are dominated by halophytic flowering plants. The lower marsh is usually dominated by one species. With increasing elevation species diversity tends to increase and distinct communities of flowering plants can be recognised (Chapman, 1974; Montague & Wiegert, 1991; Adam, 1993).

In the Peel-Harvey the lower marsh is dominated by *Sarcocornia quinqueflora* (samphire) with communities of *Halosarcia* species (grasswort), herbs and grasses occurring with increased elevation inland. Further inland communities of *Juncus kraussii* (shore rush), *Melaleuca cuticularis* (saltwater paperbark) and *Casuarina obesa* (saltwater sheoak) occur (Figure 1.2).

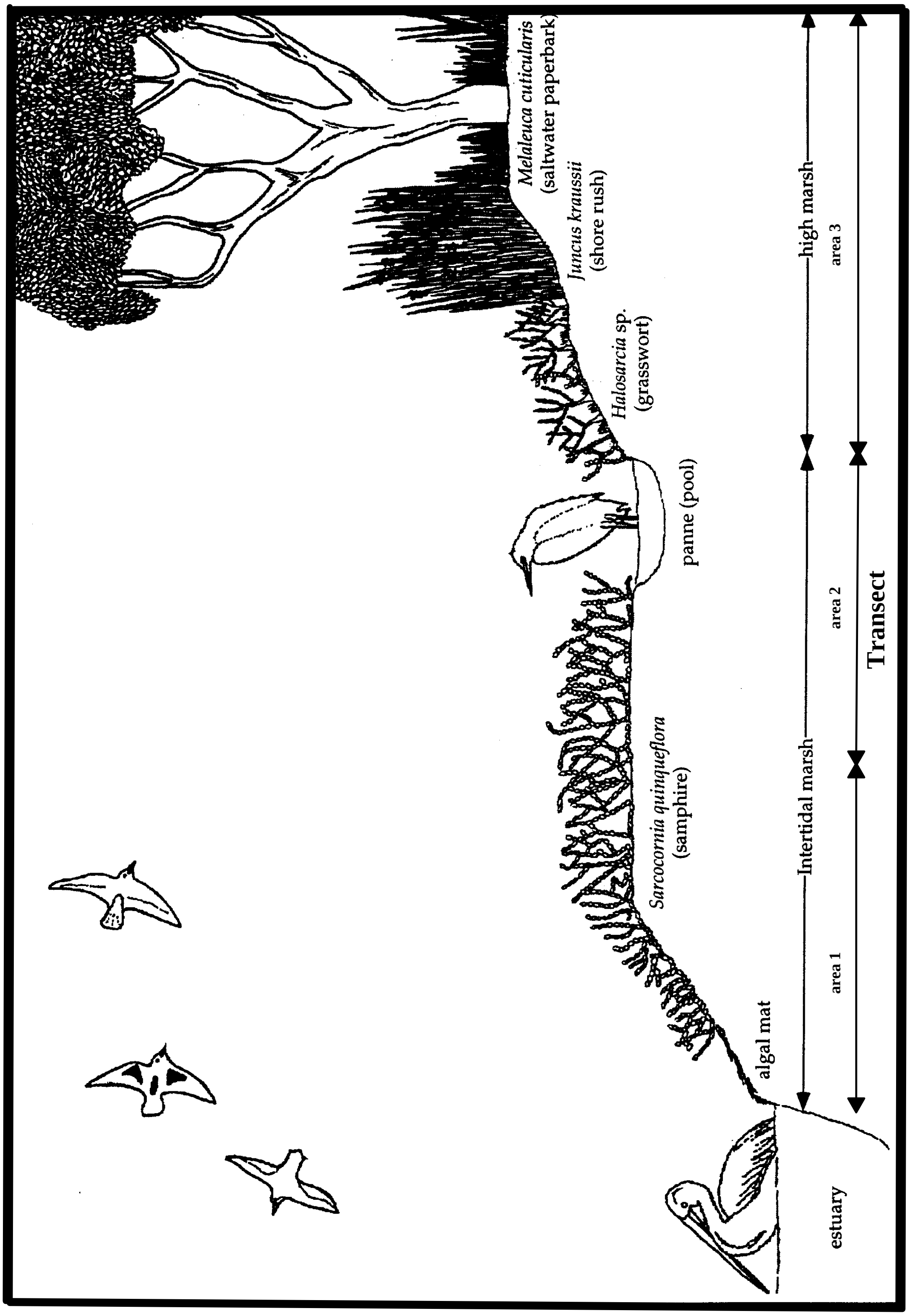

Figure 1.2. Cross section of a typical saltmarsh in the Peel-Harvey estuary.

The aerial habitat is dominated by insects such as grasshoppers, plant hoppers, wasps and beetles, and spiders that live in and on plant leaves. The stems and leaves of saltmarsh plants are also visited by snails. These animals make up the grazing portion of the saltmarsh food web (Figure 1.3). Large numbers of birds forage on the aerial invertebrate community, including egrets, little grassbirds, white-fronted chats, richard's pipits and Australian magpie-larks. The stems and leaves of saltmarsh plants are used as nesting material for resident saltmarsh birds such as the black-winged stilt, which build their nests sufficiently high to avoid all but the highest tides (Montague & Wiegert, 1991).

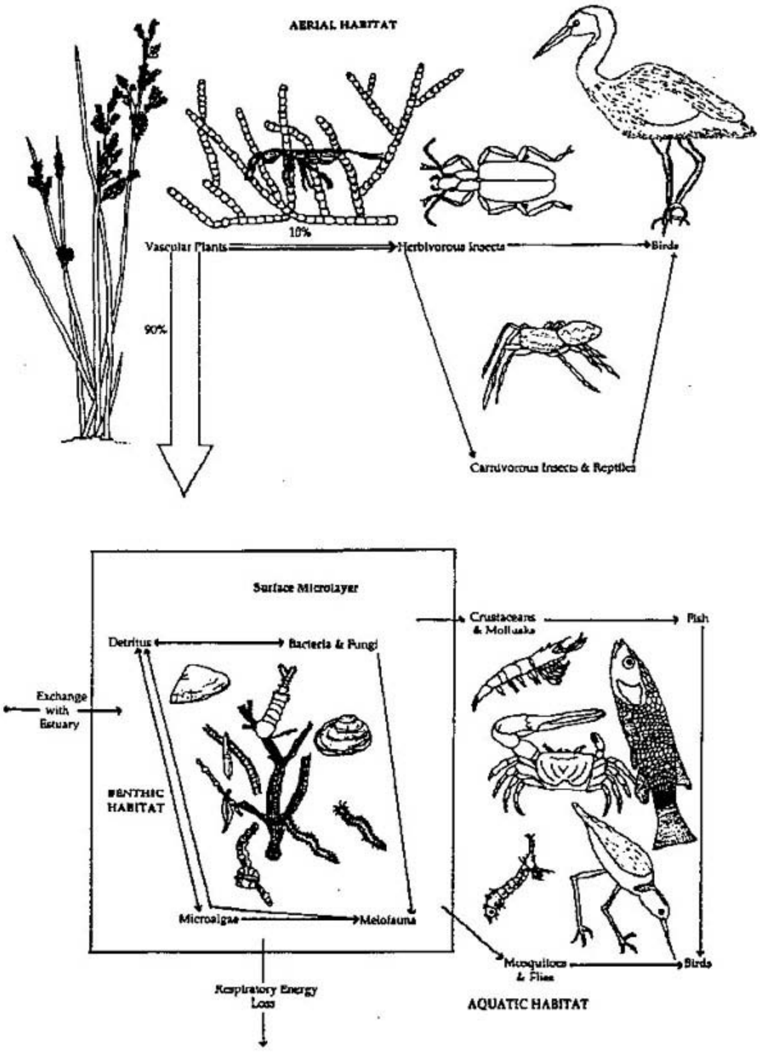

Figure 1.3. Food chain of a typical saltmarsh system.

Less than 10 percent of the plant material produced each year in a saltmarsh is removed by animal grazing. Most plant biomass dies and decays on the marsh surface, and its energy is processed by fungi and bacteria. These organisms serve as a food source for microscopic animals in the decaying vegetation and on the sediment surface of the marsh. Most of these benthic organisms are protozoa, nematodes, harpacticoid copepods, annelids, rotifers, and the larval stages of macro-invertebrates (Montague & Wiegert, 1991).

Benthic macrofauna forage on the sediment or filter floodwater. The common macro-invertebrates present in the sediment include polychaetes, gastropod molluscs and crustaceans; these in turn become food for a variety of predators such as the blue manna crab and egret (Montague & Wiegert, 1991).

Aquatic animals in saltmarshes often overlap in distribution with those in the benthic habitat of the open water (Figure 1.3). Zooplankton in saltmarsh creeks and in pans are similar in species composition and abundance to those of the open estuarine waters of the marsh. These may include copepods, ostracods and chaetognaths. These animals are important food for small fish which shelter in the saltmarsh creeks and pans. The macroinvertebrates that inhabit the saltmarsh creeks and pans include fly and mosquito larvae. These larvae in turn are food for fish, wading birds, and ducks. Adult mosquitoes feed from the nectar of plants, and in doing so help to pollinate these plants (Montague & Wiegert, 1991).

Although the main fish habitat is the creek and associated marsh edge, fish and shellfish venture from tidal creeks into the marsh when it becomes flooded. When the water recedes, small fish may remain in pans in the marsh, where they are often eaten by wading birds or eventually die of exposure (Montague & Wiegert, 1991).

The Peel-Harvey estuary is one of the largest and most important wetlands for birds in southwestern Australia. The wading birds often encountered in the saltmarshes of the Peel-Harvey estuary include the great and little egret, the white-faced heron, the yellow-billed spoonbill, the common sandpiper, and the red-necked stint. Some of the waders are listed in the Japan-Australia Migratory Birds Agreement. The marshes also support a variety of waterfowl such as the Australian shelduck, pacific black duck and musk duck (Halse *et al*, 1989; Chester & Klemm, 1990; Ninox, 1990).

Several species of reptiles occur in the Peel-Harvey saltmarshes, the most notorious being the common tiger snake which preys on frogs, fish, lizards, small mammals and birds. The native mammals most likely to be found on the saltmarshes are kangaroos and wallabies. Introduced species, such as cats and foxes can also be found hunting birds of the marshes.

1.6 Significance of saltmarshes to the Peel-Harvey system

The Peel-Harvey saltmarshes are important locally and regionally for some of the following reasons. Firstly, plant and animal material produced within the marsh is exported into the estuary. This material then supports food webs as explained above, becoming food for fish and crustaceans, so forming a resource base for commercial production and recreational pleasure. Secondly, saltmarshes, like fresh water wetlands, act as 'biological filters' which remove nutrients and pollutants, preventing these compounds from reaching the estuary waters. Thirdly, the saltmarshes are important areas for the rich array of birds that inhabit the estuary at various times of year. Finally, they provide physical stability to the shores of the Peel-Harvey estuary (Chester, 1990).

1.7 Aims

To provide more detail about these points, a study was undertaken into the ecology of saltmarshes of the Peel-Harvey. The aims of the study were:

1) To examine the extent and composition of the samphire saltmarshes and to document any changes in area and condition of the marshes with time. This was done using aerial photography over the whole estuary, and detailed field surveys at ten sites.

2) To examine the relationship between plant distribution and water level, to predict the possible effects which construction of the Dawesville Channel might have through establishing a new water regime.

3) To investigate the distribution of invertebrates in summer and winter in the saltmarsh.

4) Recommend areas of management priority and process by which they may be protected.

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