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# Southern Tasmanian Coastal Saltmarsh Futures

## A Preliminary Strategic Assessment

Vishnu Prahalad and Jill Pearson

March 2013

# Executive summary


Southern Tasmanian coastal saltmarshes form a crucial 'link' between terrestrial and marine systems, providing critical ecological functions that support a range of ecosystem services and biodiversity values. Close to a half of these important coastal ecosystems have already been lost or degraded due to land use change and impacts, sporadic and variable management approaches and lack of broad awareness of the important values provided by these habitats. In addition, future climate change and sea level rise projections leave these ecosystems in a precarious position given that they occupy shores within 1 m of high water. This raises the question: is there a future for coastal saltmarshes in southern Tasmania?

The Southern Tasmanian Coastal Saltmarsh Futures project has completed an inventory and mapping of the current extent of coastal saltmarshes throughout the southern region of Tasmania, as well as 'future footprint' mapping under sea level rise conditions out to 2100, to further assess this question. The inventory database, which sits alongside the mapping of current extent, brings together a range of environmental and management related information that has either been collected in previous projects or is presented here for the first time.

This report provides:

- an introduction to coastal saltmarshes in southern Tasmania
- an outline of the mapping methods used
- summary results from the inventory and mapping components
- a brief discussion on ecosystem based management as a possible way forward for improved management of coastal saltmarshes into the future.

Mapping of the future footprint of coastal saltmarshes in southern Tasmanian shows that for the areas where modelling data is available, approximately 75% of coastal saltmarshes have either 'some' or 'sufficient' room to move. Hence, there is a future for coastal saltmarshes in southern Tasmanian; however, the future needs to embrace shared responsibility and a shift in management from site based to a more holistic and systematic approach where management considers broader components, processes and functions within the landscape and seascape.

To obtain the GIS mapping layers produced as part of this project please contact NRM South. Coastal saltmarsh maps and inventory data are also available on the NRM South website.

Any data, information or mapping that can be used for updates to the current information base on coastal saltmarshes in southern Tasmania can also be sent to



**NRM South**
PO Box 425
SOUTH HOBART TAS 7004
Phone: 03 6221 6111
Email: admin@nrmsouth.org.au

# Contents

# Acknowledgements

NRM South would like to acknowledge the following contributors, who contributed technical knowledge and participated in a forum on 2 February 2012 to guide the development of this project:

- Dr Karen Parsons (Ecomarine Consulting)
- Dr Alastair Richardson (University of Tasmania)
- Dr Peter McQuillan (University of Tasmania)
- Dr Stewart Blackhall (Department of Primary Industries, Parks, Water and Environment)
- Dr Janet Smith (Department of Primary Industries, Parks, Water and Environment)
- Richard Schahinger (Department of Primary Industries, Parks, Water and Environment)
- Phil Watson (Clarence City Council)

NRM South would also like to acknowledge the following people who have contributed their time and knowledge to various aspects of the project, including the development of this report:

- Tessa McDonald (Southern Coastcare Association of Tasmania)
- Dr Jason Whitehead (Derwent Estuary Program)
- Dr Eric Woehler (BirdLife Tasmania)
- Dr Jamie Kirkpatrick (University of Tasmania)
- Dr Richard Mount (University of Tasmania)
- Lynne Sparrow (Parks and Wildlife Service)
- Melanie Kelly (Glamorgan Spring Bay Council)
- Tony Davidson (Tasmanian Planning Commission)
- Eric Tierney, Shirley Zheng (field volunteers)
- Luke Einoder (Derwent Estuary Program)
- Wendy and Bruce Andrew (Clarence – Tranmere Landcare and Coastcare Inc.)
- Chris Ross (Primrose Sands Coastcare Group)
- Chris Auricht (Auricht Projects)
- Dr Christine Crawford (IMAS)

NRM South would also like to acknowledge the private land owners who allowed us to access their property.

# Disclaimer

# 1. Introduction

## 1.1. Tasmanian Coastal Saltmarshes

Saltmarshes are habitats generally defined by the presence of halophytic communities (salt tolerant plants) which can tolerate salinity levels of more than 0.5 parts per thousand and are subject to waterlogging (Adam, 1990). Saltmarshes can be found in both inland and coastal areas where high salinity and waterlogging occurs. Besides these two key formative factors, the general distribution and relative extent of saltmarshes is further determined by the landscape setting, topography and substrate, climate, wind, sea level, sedimentation and biotic factors (see Perillo et al., 2009).

In Tasmania, saltmarshes occur in both inland and coastal areas. Inland saltmarshes are restricted to the dry Tasmanian Midlands region (e.g. Township Lagoon, Tunbridge) and are relatively limited in distribution and extent. Coastal saltmarshes are however more extensive in their distribution and extent (Kirkpatrick and Glasby, 1981). They occur extensively in sheltered, low energy, shallow intertidal environments in coastal embayments and estuaries particularly in the south-east, east, north and north-west parts of the state, as well as Flinders Island (Figure 1). In places where estuaries occur within embayments (i.e. estuarine embayments) the most extensive saltmarsh areas are formed (e.g. Moulting Lagoon, Pitt Water-Orielton Lagoon). These areas are characterised by relatively low rainfall (average range between 500 mm/yr in the south-east to 1000 mm/yr in the north-west) and high evaporation rates resulting in increased salinity levels favourable for saltmarshes.

Coastal saltmarshes are relatively uncommon along the expansive high energy open shorelines along the west and south-west coast due to a lack of favourable landform settings (i.e. protection from high energy swell waves). Where few indented shorelines are found within Port Davey and Macquarie Harbour, heavy freshwater runoff consequent with large amounts of rainfall flush any salt accumulation, thus giving way to marsupial lawns, which can be considered as the freshwater counterpart of saltmarshes in Tasmania.

Within their favoured low energy environments, Tasmanian coastal saltmarshes occupy the upper intertidal areas starting below the mean high tide mark and extending inland to the extent of storm tide flooding (Saintilan et al., 2009; Prahalad et al., 2009; Mount et al., 2010). Typically, the low marsh is covered by the high tide while the high marsh and back marsh is covered by higher tides (spring tides to storm tides). This zone is extended inland in some cases due to salt spray and/or shallow saline groundwater. On the other hand, this zone can be contracted if sufficient freshwater runoff/seepage aids the glycophytes (salt intolerant plants) to outcompete the halophytes.

Previous desktop mapping of coastal saltmarsh extent (at a state-wide level) was undertaken by the Conservation of Freshwater Ecosystem Values (CFEV) project (DPIW, 2008). Some field validation of the mapped CFEV saltmarsh data was subsequently undertaken by Hydro Tasmanian for the three NRM regions (HEC, 2008). However, the coverage remains to be improved for many parts of the State (Prahalad, unpublished data).

The particular focus of this report will be **coastal saltmarshes in the southern NRM region of Tasmania**, including those found in closed lagoons adjacent to the coastal marsh zone. In most cases these spatially separated closed lagoon marshes are connected via environmental processes that operate at a larger scale and are considered part of the bigger coastal wetland complex (Auricht, 2011).

The most extensive areas of saltmarsh habitats in southern Tasmania include Moulting Lagoon (with Swan and Apsley Rivers) and Pitt Water-Orielton Lagoon (with Coal River and Duckhole Rivulet). Examples of saltmarshes found in coastal lagoons include Pipe Clay Lagoon and Cloudy Bay Lagoon, and river and creek mouth examples include the Derwent, Huon and Little Swanport estuaries. Some relatively small areas of halophytes associated with saltmarshes also occur perched on rocky shores and at the back of beach dunes which front higher energy swell waves (e.g. Calverts Beach, South Arm).

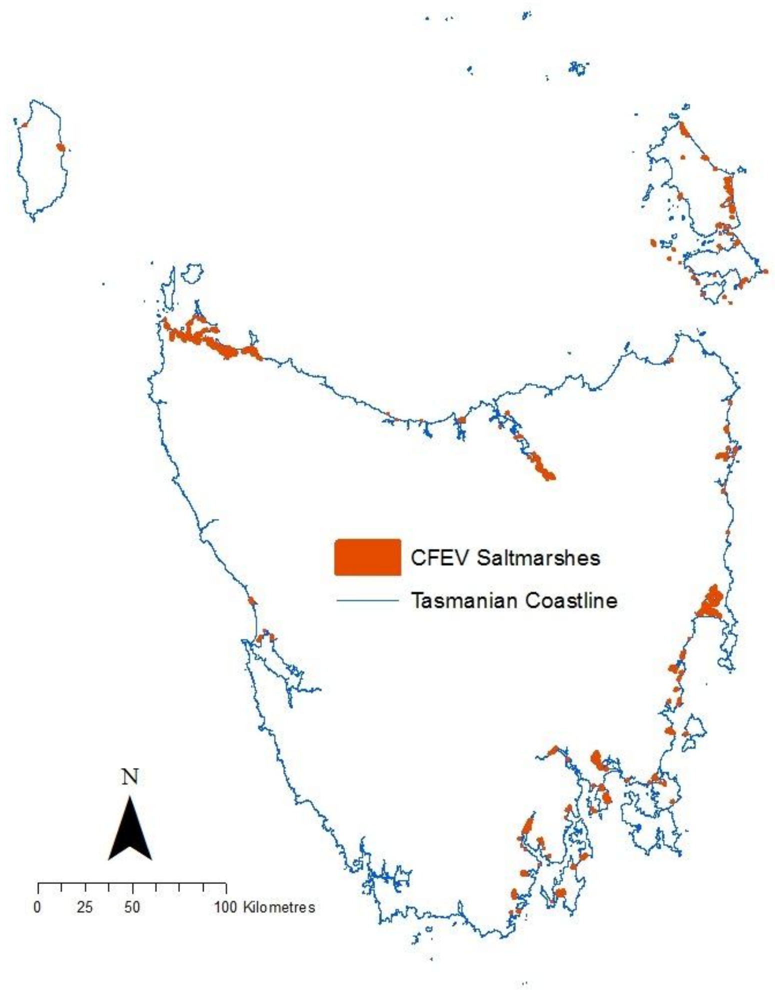


**Figure 1. Tasmanian coastline (nearly 8000 km long, excluding the subantarctic Macquarie Island) with coastal saltmarshes mapped by the Conservation of Freshwater Ecosystem Values (CFEV) project. Base data from theLIST, © State of Tasmania.**

## 1.2. Saltmarsh Ecosystem Services

Coastal saltmarshes and the associated coastal wetlands form a crucial link between terrestrial and marine systems. They are increasingly being recognised both for their biodiversity values as well as for the range of ecosystem services they provide such as: supporting coastal and marine food production, improving coastal water quality, acting as buffers against storm surges and sea level rise, attenuating global warming by sequestering carbon (C), supporting elements of biodiversity, providing recreational amenities and as living laboratories for research and development in science and technology (e.g. detailed in Boorman, 1999; Weinstein and Kreeger, 2000; Doody, 2008; Saintilan, 2009; illustrated in Figure 2).

The following summary has been adapted and developed from Mount et al. (2010):

**Supporting Elements of Biodiversity**

- Saltmarshes support highly specialised flora species (halophytes) such as succulent shrubs, herbs, grasses, rushes and sedges (Kirkpatrick and Glasby, 1981). These include rare obligatory species (restricted in their geographical distribution) such as sea-lavenders (*Limonium australe* and the endemic *Limonium baudinii*), Wilsonias (*Wilsonia humilis* and *Wilsonia rotunidfolia*) and golden dodder (*Cuscuta tasmanica*).
- Saltmarshes provide crucial feeding, roosting and breeding habitats for resident and migratory shorebirds (Spencer et al., 2009). They also support large populations of waterbirds such as ducks, hens, herons, egrets and pelicans. Saltmarshes also support a wide range of terrestrial birds including parrots, wrens, chats, pipits, swallows, ravens and raptors. Notably, they provide critical habitat for white-fronted chats (*Epthianura albifrons*), which are noted as becoming rare on mainland Australia (Major and Johnson, 2010). Saltmarshes also provide habitat for native vertebrates other than birds, such as macropods and water rats.
- Saltmarshes provide habitat to numerous invertebrates, especially supporting large numbers of molluscs and crustaceans that play an important role in saltmarsh ecology especially through detritivory, soil aeration and soil building (Wong et al., 1993). These invertebrates provide important food for higher animals such as birds and fish. Terrestrial invertebrates such as the rare saltbush blue butterfly (*Theclinesthes serpentata lavara*) and the vulnerable saltmarsh looper moth (*Dasybela achroa*) use saltmarshes as important feeding areas.

**Increasing Coastal Food Production**

- Saltmarshes produce organic materials (plant and animal matter) that are exported to coastal waters through tides, thus improving coastal productivity (Merrill and Cornwell, 2000; Valiela et al., 2000). For example, high concentrations of crab and gastropod larvae in saltmarshes has been shown to feed fish species (Mazumder et al., 2006; Mazumder et al., 2009).
- Saltmarshes provide a secure habitat for juvenile fish (at high tide) to evade predation risk in the open sea (Deegan et al., 2000). Studies reporting the use of saltmarshes by Australian fish species suggest that up to 56 species can be found within an area of 100 $m^2$ (summarised in Connolly, 2009).

### Improving Coastal Water Quality

- Saltmarshes intercept land driven nutrients (both from aboveground and belowground flows) and hence regulate the response of phytoplankton (algal blooms) on macroalgae and seagrasses in the nearby coastal waters. Especially, the health of seagrass meadows has been directly linked to land driven nitrogen (N) interception by saltmarshes (Valiela and Cole, 2002).
- Saltmarshes intercept and settle down suspended sediments in the water column which would otherwise make the coastal waters murky, less productive and aesthetically unpleasant. The ability of saltmarshes to intercept nutrients and sediments from the water is recognised as extremely important to maintaining and enhancing coastal water quality (Doody, 2008).

### Acting as Buffers against Storm Surges and Sea Level Rise

- Saltmarshes build up soil and provide a buffer between the land and sea. They greatly reduce wave energy by channelling and diffusing it in their tidal creek systems. The dense and robust saltmarsh vegetation acts as a buffer attenuating wave energy. In the UK for instance, saltmarshes have been highly valued for their role in coastal defence as they have proven to be more cost effective than raising and maintaining artificial defences like sea walls or levees (Doody, 2008).

### Attenuate Global Warming by Sequestering Carbon

- The value of coastal saltmarshes as efficient stores of carbon is increasingly being recognised internationally. Especially in the northern hemisphere, studies have noted that saltmarsh soils store about 210 g C $m^{-2}yr^{-1}$ and that the carbon stored in saltmarsh soils in USA constitutes 1–2% of its total yearly C sink (Chmura, 2009).

### Providing Recreational, Amenity and Educational Values

- The services that flow on from saltmarshes are important for maintaining many recreational pursuits in coastal areas, especially fishing, bird watching, duck hunting, and other activities that require good water quality. Saltmarshes also engender a sense of place with people who relate to these habitats at a personal level (as seen in the 'Save Ralphs Bay' campaign to protect the saltmarshes and intertidal flats at Lauderdale). The widely distributed and extensive saltmarshes in Tasmania can also provide excellent opportunities for communication and public awareness of coastal ecological values and ecosystem services, such as nutrient flows and processes in the landscape, climate change and sea level rise processes.

### Living Laboratories for Research and Development in Science and Technology

- Saltmarshes are living laboratories that provide us with several research and development opportunities. For example, saltmarshes can be used to reconstruct old sea levels as their sediments provide a record of sea level changes. Also, saltmarsh vegetation and geomorphology can be used to study the rate and effect of sea level rise (Prahalad, 2009). A team led by Arko Lucieer at the University of Tasmania is using saltmarshes as key habitats to test and develop new remote sensing technologies that have potential for use in agriculture, horticulture and viticulture (http://www.terraluma.net/).

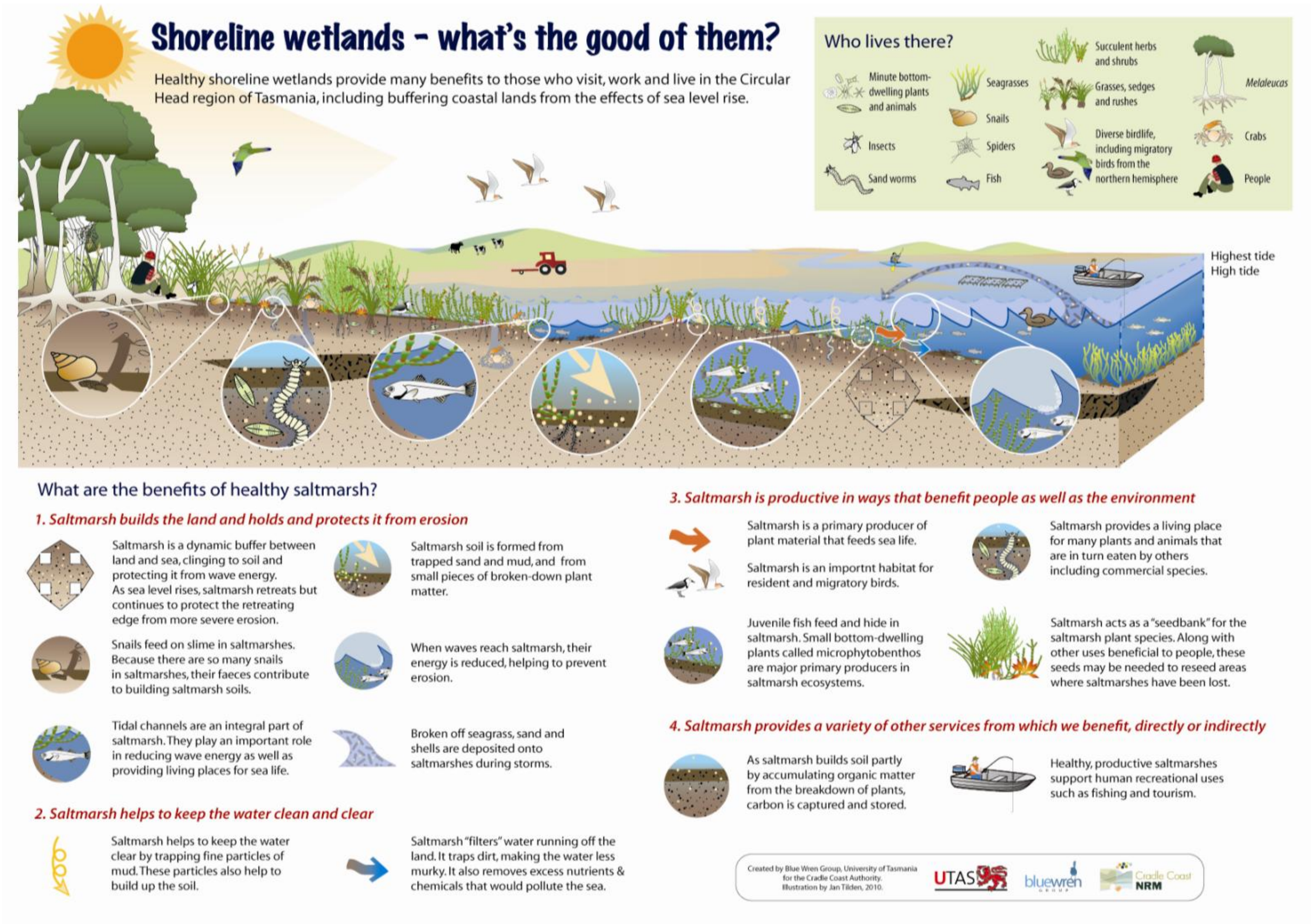


**Figure 2. Illustration of the typical benefits and services provided by saltmarshes. Prepared for north-west coast saltmarshes and largely applicable across Tasmania. Reproduced from Mount et al. (2010) and used here with permission from Cradle Coast NRM.**

**Figure 3. *Limonium baudinii*, a rare Tasmanian saltmarsh endemic occurring with *Sarcocornia quinqueflora* (in the front) and *Suaeda australis* (in the back).**

**Figure 4. Left: back marsh with *Tecticornia arbuscula* heath and *Gahnia filum* sedge backed by *Bursaria – Acacia* woodland and scrub. Right: great egret (*Egretta alba*) resting on *Sarcocornia quinqueflora*, with *Juncus kraussii* in the back and open mudflats in the foreground, populated with crustaceans breaking down the organic matter derived from saltmarshes.**

## 1.3. Conservation and Threats

In Tasmania, coastal saltmarshes are formally defined under TASVEG (Tasmanian Vegetation Monitoring and Mapping Program) by any of the following three halophytic vegetation community types (adapted from Harris and Kitchener, 2005):

**Succulent Saline Herbland (ASS)**

Vegetation dominated by herbaceous species growing on the margins of highly saline, protected, flat estuarine shorelines inundated with sea water at high tide, dominated by halophytic plants, predominantly *Sarcocornia quinqueflora* and/or *Sclerostegia arbuscula* [now *Tecticornia arbuscula*].

**Saline Sedgeland/Rushland (ARS)**

Vegetation dominated by sedges, rushes and occasionally tussock grasses growing in highly saline environments, often inundated by tidal water, dominated by halophytic plants, commonly *Gahnia filum* and/or *Juncus kraussii*.

**Saltmarsh (undifferentiated) (AUS)**

Any area of saltmarsh where community mapping has not been completed.

While these saltmarsh communities are considered to provide a 'critical ecological function' (RPDC, 2009), they are not currently listed under Schedule 3A of the *Nature Conservation Act 2002* (TAS). Related vegetation communities including 'Saline Aquatic Herblands' (AHS – TASVEG code) and 'Wetland Undifferentiated' (AWA – TASVEG code) are listed as threatened vegetation communities under this Act (DPIPWE, 2012). Particularly since 2009 there has been significantly more information collected on saltmarsh extent around the State as well as historical losses of saltmarsh communities. The availability of this information increases the feasibility of nominating the above communities for listing in the future (see Table 1).

At the time of writing this report, Subtropical and Temperate Coastal Saltmarsh were being assessed for listing as a threatened national ecological community under the Federal *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*. The outcome of this assessment is expected in June 2013.

Two coastal saltmarsh and wetland complexes within southern Tasmania, Pitt Water-Orielton Lagoon (PWOL) and Moulting Lagoon, have some conservation protection through international listings under the Ramsar Convention on Wetlands.

Expanding on PWOL as one example, this important estuarine ecosystem supports migratory and resident shorebirds, marine species as both a nursery ground and food production area, and a variety of other plants and animals.

The lagoon and its habitats, including the saltmarshes, are major feeding and roosting grounds for migratory shorebirds in Tasmania and are the most southern major feeding ground for waterbirds in Australia (Parks and Wildlife Service, 2010).

The importance of the lagoon as a feeding and resting site is recognised through listing on the East Asian-Australasian Flyaway Reserve Network that links some of the world's internationally important wetlands. Many of the migratory bird species that use this site are listed on the Japan-Australia Migratory Bird Agreement (JAMBA), China-Australia Migratory Bird Agreement (CAMBA) and the Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA) (see Appendix 6 of Parks and Wildlife Service, 2010, for species lists under each agreement). The lagoon also provides year round habitat for resident shorebirds. The saltmarshes here play an important role in this ecosystem, delivering services that underpin the habitat that supports the birds that frequent this area (e.g. Spencer et al., 2009). However, despite these conservation listings, there are still significant pressures from surrounding land uses and activities that impact on the biodiversity values of these sites.

The PWOL area is considered to be one of the most important nursery areas for commercially harvested juvenile school shark (*Galeorhinus australis*) and gummy shark (*Mustelus antarcticus*) in Tasmania. Juvenile sharks visit the area to feed on the crustaceans and molluscs abundant in the shallow intertidal flats. The healthy populations of marine invertebrates which occur extensively in the area are in turn known to be supported by the high organic (plant and animal) matter exported from saltmarshes (Merrill and Cornwell, 2000; Valiela et al., 2000). Besides providing the organic matter that drives intertidal food webs, saltmarshes also sequester sediments and nutrients thus improving the water quality (Doody, 2008). The PWOL area is also an important oyster farming area (e.g. Barilla Bay Oysters), benefitting heavily from the services provided by saltmarshes. To some extent, these ecosystem services have been ignored in managing these commercially (and culturally) important species.

Other significant conservation efforts to protect key saltmarsh and wetland communities in southern Tasmania include the permanent reservation of three properties, Long Point in Moulting Lagoon, Lutregala Marsh on Bruny Island and parts of Egg Islands in the Huon Estuary, which are managed by the Tasmanian Land Conservancy. Lutregala Marsh is also listed on the register of the National Estate due to its rare natural values.

Both historically and on a continuing basis, despite the formal understanding that saltmarshes provide a 'critical ecological function' in Tasmania, saltmarshes are subjected to myriad threatening processes (Prahalad, 2009; Mount et al., 2010). The key threats to southern Tasmanian coastal saltmarshes can be summarised as:

- coastal development (residential and industrial)
- development infrastructure (roads, stormwater pipes, buildings, rubbish tips etc.)
- landfill, sea wall construction, tidal restriction/manipulation via levee banks, channels etc. (in many cases becoming more prevalent with sea level rise)
- catchment modification (including changes in nutrient, sediment and freshwater flow budgets cause by land use practices, dams etc.)
- eutrophication caused by increased nutrients from surface and ground water flows
- acid sulphate soils (often occur beneath saltmarshes and are a hazard if disturbed)
- grazing by livestock and rabbits
- trampling by livestock, humans and off road vehicles

- encroachment by weeds (primarily following disturbance caused by removal of buffer/backing vegetation)
- dumping of general rubbish, including waste from aquaculture industries.

An additional future threat to coastal saltmarsh will be as a result of climate change and relative increases in sea level and coastal erosion (exacerbated by strengthening winds predicted for the region (see McIntosh et al., 2005)). Recent research in the region already indicates climate change and sea level rise related losses in wetland and saltmarsh extent at Pitt Water-Orielton Lagoon, Ralphs Bay and Pipe Clay Lagoon (Prahalad et al., 2011). Changes in saltmarsh extent due to sea level rise have also been recorded in the north-west of the State where marshes were noted to be eroding rapidly on the seaward edge along with evidence of landward retreat of saltmarsh vegetation (Mount et al., 2010). These changes are consistent with global studies reporting the landward retreat of saltmarshes with sea level rise.

Saltmarsh habitats around the Pitt Water-Orielton Lagoon (PWOL) are a typical example of these threats being realised, including increased shoreline erosion as a result of sea level rise. The only available study on temporal changes in Tasmanian saltmarsh communities (between 1975 and 2009) has indicated that close to a quarter of the PWOL saltmarsh area has been lost and almost an equal extent affected due to climate change, sea level rise and nutrient enrichment (Prahalad et al., 2011). Losses due to direct human impacts such as clearing, filling, grazing and nutrient enrichment of saltmarshes still occur in the area, with some disturbance adjacent to oyster farming and marine nature reserves (Figure 5).


**Figure 5. Three major causes of saltmarsh decline in Tasmania (Oval – land clearing; Polygon – eutrophication; Square – land filling) occurring in an area (Barilla Bay, part of Pitt Water-Orielton Lagoon Ramsar Site) supporting considerable economic interests in marine food production and internationally recognised conservation values. Base data from theLIST, © State of Tasmania. Screen grabs from NearMap (http://www.nearmap.com/).**

This indicates the low value assigned to coastal saltmarshes even in an area supporting considerable economic interests in marine food production and internationally recognised conservation values.

Further evidence of the low valuation of saltmarsh ecosystem services and function in the Tasmanian coastal landscape is provided as a summary in Table 1.

**Table 1. A summary of the documented condition of Tasmanian saltmarshes (adapted from work undertaken by Trish Clements and Vishnu Prahalad in 2011 on preparing a nomination for listing saltmarshes as *vulnerable* under State legislation).**

| | |
|---|---|
| **34%** | Loss of saltmarshes from pre-European extent, State of the Environment Report 2009 (RPDC, 2009) |
| **37.6%** | Extent of saltmarshes in poor condition as per the Conservation of Freshwater Ecosystem Values (CFEV) project (CFEV, 2008) |
| **30.2%** | Extent of saltmarshes with low level of natural backing vegetation and/or other natural features (CFEV, 2008) |
| **46.6%** | Extent of saltmarshes with grazing impacts (CFEV, 2008) |
| **75%** | Extent of saltmarshes that lie within areas of low land tenure security/on private land (CFEV, 2008) |
| **40.9 to 55.5%** | Extent of saltmarshes determined by the CFEV project to have 'very high' Conservation Management Priority (CFEV, 2008) |
| **58.4%** | Extent of saltmarshes determined by the CFEV project to have 'very high' Representative Conservation Value (CFEV, 2008) |
| **20%** | Extent of saltmarsh shorelines (21.4 km) in the north-west of Tasmania with levees on saltmarshes (Mount et al., 2010) |
| **43%** | Extent of loss or change of 1975 saltmarsh area in south-east Tasmania (Prahalad et al., 2011) |

## 1.4. Project Background and Objectives

The Southern Tasmanian Coastal Saltmarsh Futures project aims to address three strategic questions:

- What is the current extent and range of coastal saltmarshes in the southern region of Tasmania?
- Where are coastal saltmarshes likely to remain or establish within the region into the future under sea level rise conditions (the 'future footprint')?
- Are we providing space and appropriate land use and management to enable saltmarshes to exercise their inherent adaptive capacity in the future as they respond naturally to sea level rise?

In this report the term 'future footprint' is used for the mapping of potential future extent under sea level rise (SLR) conditions. 'Future footprint' is preferred here over 'future extent' as the latter suggests a definite demarcation of saltmarsh boundary, which given the uncertainties involved in mapping is not possible to predict.

The above strategic questions align with previous work carried out in the Derwent Estuary (by the Derwent Estuary Program in partnership with NRM South) to identify potential retreat pathways for coastal saltmarshes under future sea level rise conditions (Prahalad et al., 2009). Following on from the interest in the Derwent Estuary work, this project was initiated to increase the spatial coverage to include all saltmarshes across the southern NRM region. NRM South recognises that strategic planning for the future protection and management of coastal saltmarshes requires this information.

# 2. Mapping of Current and Future Footprint

## 2.1. Mapping of Current Distribution and Extent

### 2.1.1. Defining the Study Area

For the purpose of this project, the study area has been confined to the seven 'coastal catchments' within the southern NRM region of Tasmania (NRM South), namely Derwent Estuary-Bruny, Huon, Little Swanport, Pitt Water-Coal, Prosser, Swan-Apsley and Tasman (Figure 6). These catchments cover all coastal saltmarshes recorded within the southern region by the CFEV project. Two other 'riverine catchments', the Lower Derwent and Jordan, are also known to contain saltmarsh communities but were excluded from this study due to their relatively limited extent and reduced coastal influence compared to the above listed coastal catchments. However, the marshes in these catchments have been mapped by other projects (Jordan – Kirkpatrick and Glasby, 1981; Lower Derwent – Prahalad et al., 2009; Prahalad and Mount, 2011).

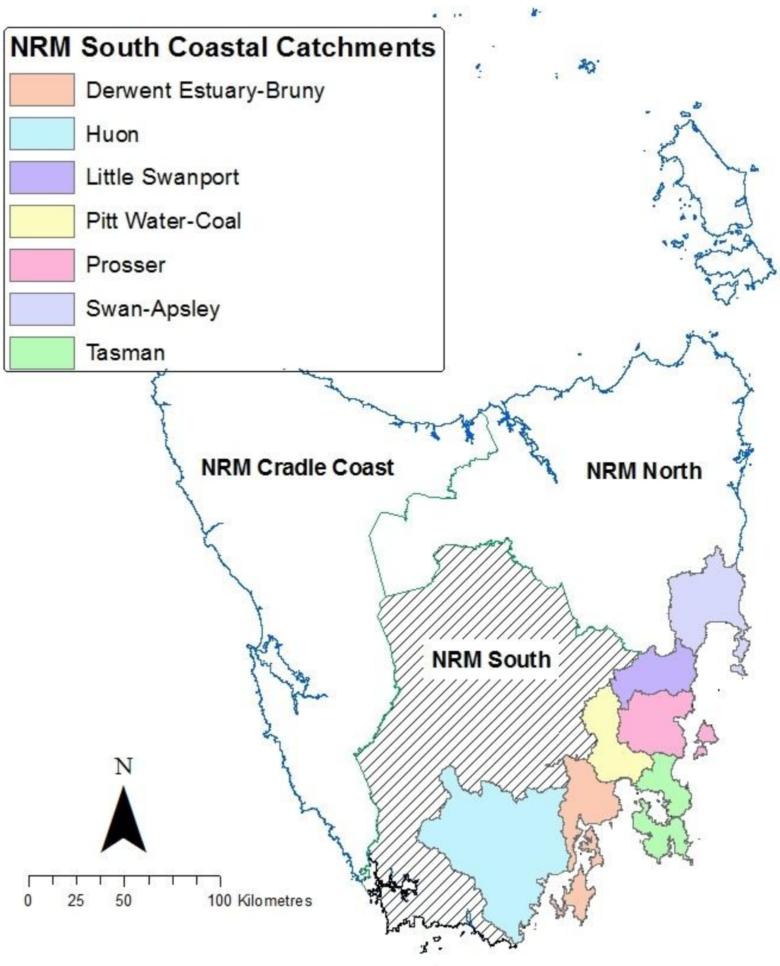


**Figure 6. Study area – estuarine/coastal catchments – within the southern NRM region. Base data from theLIST, © State of Tasmania.**

### 2.1.2. Defining the Study/Mapping Unit

The particular focus of this report is coastal saltmarshes, including those found in closed lagoons adjacent to the coastal marsh zone. In most cases these spatially separated marshes are connected via processes that operate at a larger scale and are considered part of the bigger coastal wetland complex.

Saltmarshes have been formally classified in Tasmania as either Succulent Saline Herbland (ASS), Saline Sedgeland/Rushland (ARS), or as Saltmarsh (undifferentiated) (AUS) vegetation communities (see 1.3 Conservation and Threats ). The CFEV project used these three communities as broad 'mapping units' to study and map saltmarshes consistently across the State (DPIW, 2008). Within these broad TASVEG communities, an additional 15 distinct floristic communities based on 'structural dominance' have been noted along with key indicator species to assist in identification (Harris and Kitchener, 2005, pp. 410–414, based on Kirkpatrick and Glasby, 1981). Further 'structural dominance' communities and key indicator species have been identified in this project to allow for more detailed identification of saltmarsh communities and finer scale mapping units (Table 2). This broader set of communities and indicative species enable us to more comprehensively and consistently answer the question, 'what communities and species are expected to occur in saltmarshes?'

Besides the above definition that focuses on vegetation, other non-vegetated areas such as tidal channels, salt scalds/flats and marsh pools are included here in defining the mapping unit fully. The inclusion of these non-vegetated areas is justified as they form an integral part of the saltmarsh ecosystem and may potentially be revegetated as their driving factors change (mainly rainfall, climate, relative position to sea level, nutrient and sediment budgets). Particularly, tidal channels are a defining aspect of the saltmarsh ecosystem, forming networks in more extensive marshes and functioning to distribute tidal water with biotic and abiotic material to and from the marsh to lower down in the tidal profile (Allen, 2000).

**Table 2. Saltmarsh 'structural dominance' communities and indicative species used in identifying and demarcating the mapping unit.**

| Communities incorporated within TASVEG classes Succulent Saline Herbland (ASS) or Saline Sedgeland/Rushland (ARS) | Additional (finer scale) communities identified |
|---|---|
| ***Tecticornia arbuscula* heath (*Sclerostegia arbuscula*)**<br>***Suaeda australis* heath**<br>***Sarcocornia quinqueflora* low-open heath**<br>***Sarcocornia blackiana* low-open heath**<br>***Hemichroa pentandra* low-open heath**<br>***Disphyma crassifolium* succulent herbfield**<br>***Austrostipa stipoides* tussock grassland**<br>***Distichlis distichophylla* closed grassland**<br>***Puccinellia stricta* open grassland**<br>***Gahnia filum* tussock sedgeland**<br>***Juncus kraussii* open rushland**<br>***Apodasmia brownii* open rushland (=*Leptocarpus brownii*)**<br>***Wilsonia backhousei* herbfield**<br>***Samolus repens* herbfield**<br>***Deschampsia caespitosa* tussock grassland** | *Lawrencia spicata* open shrubland<br>*Limonium australe/Limonium baudinii* open-closed heath<br>*Wilsonia humilis* herbfield<br>*Atriplex paludosa* closed-open heath<br>*Atriplex cinerea* closed-open heath<br>*Selliera radicans* herbfield<br>*Triglochin striata* grassland<br>*Spergularia spp.* herbfield<br>*Schoenus nitens* segdeland<br>*Mimulus repens* herbfield<br>*Wilsonia rotundifolia-Cuscuta tasmanica* herbfield<br>*Cotula coronopifolia* herbfield (non-native)<br>*Atriplex prostrata* heath (non-native) |
| Additional species not generally associated with saltmarshes but found occurring sporadically in and around the marsh (list excludes large woody plants):<br>*Poa spp.* (strong association with ARS); *Ficinia nodosa*; *Lachnagrostis spp.*; *Agrostis spp.*; *Schoenoplectus pungens; Baumea juncea; Phragmites australis; Thypha spp.* (includes non-natives); *Tetragonia implexicoma; Rhagodia candolleana; Senecio spp.* (includes non-natives); *Rumex crispus* (non-native); *Vellereophyton dealbatum* (non-native); *Lobelia anceps*; *Plantago coronopus* (non-native); *Eryngium vesiculosum; Melaleuca gibbosa*. | |

### 2.1.3. Mapping of Current Extent

Once the mapping units were defined, the current extent of saltmarshes was mapped using a two-pass mapping process. In the first-pass mapping, existing distribution and extent maps were collated and compiled into a base Geographical Information System (GIS) shapefile (in ESRI ArcMAP™ Version 9.3.1) with polygons representing the current mapped distribution and extent of coastal saltmarshes. The information sources used for this mapping were:

- CFEV saltmarsh polygon layer (CFEV1) – developed using the TASVEG 1:25 000 vegetation layer (Version 0.1 May 2004) (DPIW, 2008).
- CFEV partially validated saltmarsh polygon layer (CFEV2) – developed using CFEV1 as the base and incorporating surveyed (field-validated) data for 56% of the CFEV1 saltmarsh polygons, i.e. 187 of the 336 saltmarsh polygons mapped (HEC, 2008).
- Saltmarsh mapping (partially validated) conducted in the Derwent Estuary Program area (Prahalad et al., 2009).
- Saltmarsh mapping (fully validated) conducted in parts of Pitt Water-Orielton Lagoon, Pipe Clay Lagoon and Ralphs Bay area (Prahalad, 2009).

Where two or more of the above layers overlapped, the more accurate (in terms of spatial resolution and field validation) of the saltmarsh polygons were selected.

The base GIS shapefile (made of discrete saltmarsh polygons) was then updated using two primary sources of aerial imagery obtainable for NRM South:

- State orthophoto mosaic generated from ortho-rectified vertical aerial colour photographs produced by TASMAP, Tasmanian Government. The photographs were taken in one of the flying seasons of 2001, 2004, 2005, 2006, 2007 or 2008 and range from a scale of 1:20 000 to 1:42 000. The list of photos used is in Appendix 1: List of Aerial Photos Used in Mapping.
- QuickBird satellite imagery compiled for the Greater Hobart Area in 2005 (provided by DigitalGlobe). The imagery has a combined mean error of 0.85 m, in relation to on-ground accuracy.

Using the above imagery, previously mapped saltmarsh polygons were corrected where necessary and several new polygons identified and digitised on-screen (within the ArcMAP environment) based on discernible colour differences. All on-screen digitising was carried out at a scale ranging from 1:500 to 1:3000 depending on the quality of imagery available. Web-based Google Earth (http://www.google.com/earth/index.html) and NearMap (http://www.nearmap.com/) provided additional sources of high quality (in terms of spatial resolution) aerial imagery to pick up additional colour differences between saltmarshes and adjacent non-saltmarsh communities that were not apparent in the orthophoto mosaic and QuickBird imagery, thereby considerably improving the mapping resolution.

Studies on mapping saltmarshes recommend a scale of 1:25 000 for resource monitoring and a scale of 1:10 000 or greater for change detection (Wilton and Saintilan, 2000). However, land use planning may often be at higher spatial scales (especially in urban and semi-urban environments) and one of the key objectives of this project is to create a saltmarsh layer that can be used for land use planning at various spatial scales. Hence, this project uses a scale in the range of 1:500 to 1:3000 to identify the distribution of saltmarshes and to provide the approximate extent of the saltmarsh. Smaller polygons/saltmarsh patches necessitated the use of higher scale mapping (nearing 1:500) while larger polygons were able to be mapped at lower scales (nearing 1:3000). The output of the first-pass mapping process was a shapefile comprising polygons, with each polygon representing a discernible saltmarsh patch.

The second-pass mapping involved validating the distribution and extent of the first-pass mapping in the field to improve the accuracy of the mapping. Field validation was limited to about 30% of the total area mapped. Additionally, about 15% of the study area has already been mapped and documented to comparable detail in previous studies and the results are incorporated in this report. Of the remaining 55% of NRM South study area not covered by field validation, notable exclusions include: areas north of Bicheno (not mapped); large areas in Moulting Lagoon which did not have public access, including the Apsley Marshes; all areas south of Moulting Lagoon around Coles Bay and in Freycinet National Park; some parts along the east coast which did not have public access, including areas in the Little Swanport Estuary; Maria Island; Tasman Peninsula; fringing marshes along the Derwent Estuary within Hobart and Glenorchy City Council areas; and all areas south of Dover.

The method for field validation, where it was undertaken, was as follows. The large extent of the NRM South coastline (about 3,338 km long) was broken down into smaller sections (largely aligned with coastal catchments, see Figure 6). Relevant local council NRM officers and key community coastcare groups were contacted for the study sections to organise field visits, and where necessary in consultation with private land managers. Several copies of the first-pass maps (saltmarsh polygons overlain on aerial imagery) were printed out in colour at various scales and taken in to the field for on-ground validation. Oblique field photographs and field notes taken on the printed maps were used in making necessary changes to the distribution and extent of saltmarshes.

## 2.2. Mapping of Future Footprint

### 2.2.1. Tasmanian Coastal Inundation Mapping

Inundation mapping involved the identification of coastal areas/zones potentially affected by flooding associated with 'storm-tide events' (i.e. a combination of storm surges and tides) while also accounting for predicted sea level rise.

Initial work around coastal inundation mapping in Tasmania was completed by Mount et al. (2011). This data has been used in this project as part of the 'future footprint mapping'. Subsequently in October 2012, the Tasmanian Government released official sea level rise benchmarks for Tasmania. Accompanying these benchmarks are newly updated coastal inundation mapping layers referred as 'TidalInundationModel_V2', building on the work previously undertaken by Mount et al. (Lacey et al., 2012). These updated coastal inundation mapping layers are available through the LIST (Land Information Systems Tasmania).

Storm tide modelling data was derived from the work of Kathy McInnes, CSIRO, and the projections of sea level rise derived from the IPCC's A1FI scenario predictions and sourced from the Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC). Inundation mapping was done on the Climate Futures LiDAR Digital Elevation Model (DEM) dataset that was compiled for the Climate Futures of Tasmania project. The DEM has a reported vertical and horizontal accuracy of +/- 25 cm, although this accuracy has been found to be variable across its range. Mount et al. (2011) have excluded areas such as Marion Bay, Connellys Marsh, South Arm and Taranna, which they noted as having 'significant height discrepancies' and hence are not reliable for land use planning.

Outputs from the mapping indicate 'storm-tide coastal flooding zones' with three specific exceedance probabilities (0.25 (25%), 0.5 (50%) or 0.75 (75%)) over two time periods (2010–2050 or 2010–2100). These were available as six separate GIS shapefiles that show the extent of storm-tide flooding zones for these various probabilities and time periods under a projected sea level rise. In addition to the above, six more shapefiles were generated with similar exceedance probabilities and time periods, but without sea level rise. This represents 'present day' extent of storm-tide flooding zones for these various probabilities and time periods under current sea level (Mount et al., 2011).

Key shortcomings of the inundation mapping as noted by Mount et al. (2011) are:

- Wave set-up or wave run-up (generated by fetch distance and wind speed) were not accounted for and they can have a variable effect on the extent of the landward penetration of storm tide.
- The projected sea level rise is based on the IPCC's A1FI scenario predictions, which may change with future greenhouse gas emissions and improvements in the science behind the complex modelling.

The spatial coverage of the inundation mapping is restricted to the extent of reliable LiDAR DEM available (Figure 7). Current mapping covers only the Pitt Water-Coal catchment in its entirety. The coverage for Derwent Estuary-Bruny and Swan-Apsley catchments are high (>75%), with areas not covered being South Bruny, parts of the D'Entrecasteaux Channel and the section of Great Oyster Bay south of Swansea. The coverage for Huon catchment is good (>50%), with areas south of Dover not covered. There is limited coverage in the Tasman catchment with only Pirates Bay and Dunalley covered. The mapping does not cover Little Swanport and Prosser catchments.

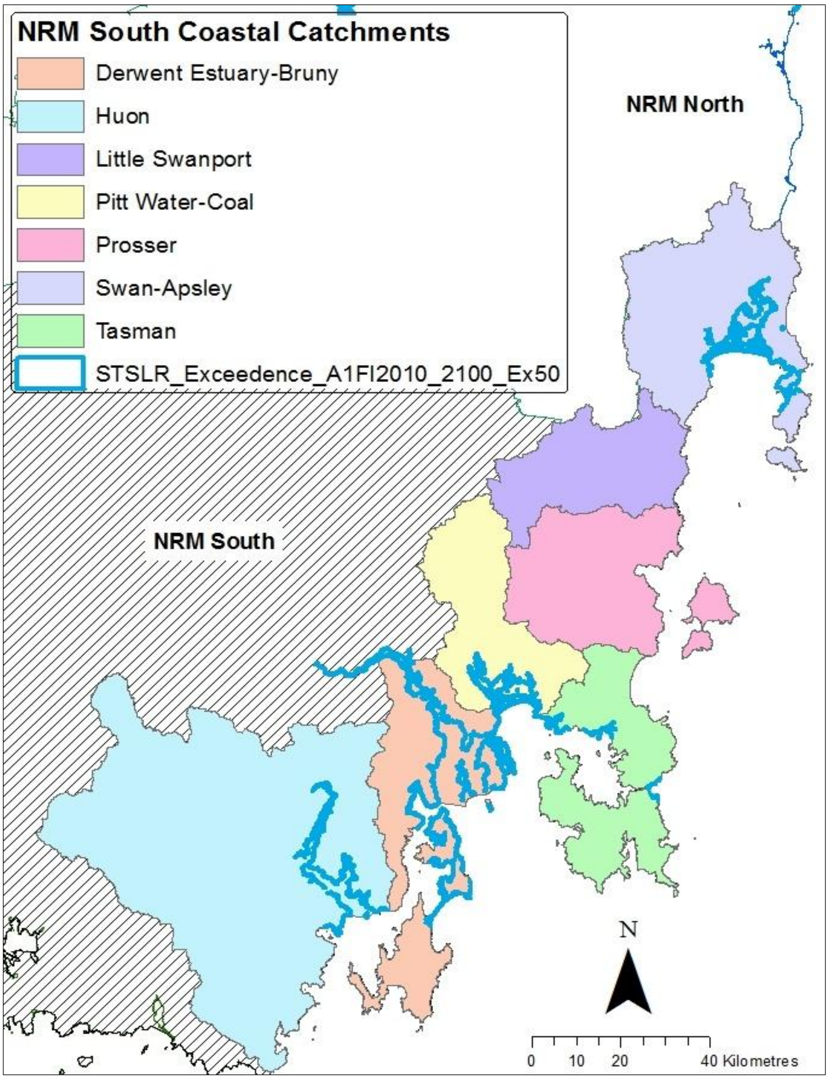


**Figure 7. Extent of coastal inundation mapping undertaken in the southern NRM region. STSLR_Exceedance_A1FI2010_2100_Ex50 – Storm-tide coastal flooding zones with an exceedance probability of 50% over the time period 2010–2100 with projected sea level rise. Data from Mount et al. (2011), courtesy of the Tasmanian Planning Commission. Base data from theLIST (© State of Tasmania).**

### 2.2.2. Coastal Saltmarsh Future Footprint Mapping Process

In the report the term 'future footprint' is used for the mapping of potential future extent under SLR conditions. 'Future footprint' is preferred here over 'future extent' as the latter suggests a definite demarcation of saltmarsh boundary, which given the uncertainties involved in mapping is not possible to predict.

Mapping of the future footprint for saltmarshes was undertaken using three base layers (see below) and supplemented by some field validation. The future footprint mapping produced as part of this project was also restricted to the areas of the southern region where LIDAR data is available and storm-tide coastal flooding zones with an exceedance probability of 50% over the time period 2010–2100 with projected sea level rise has been mapped (STSLR_Exceedance_A1FI2010_2100_Ex50) (Mount et al., 2011) as shown in Figure 7 above.

The base layers used for future footprint mapping were:

- Verified current extent of saltmarshes mapped as described in section 2.1 'Mapping of Current Distribution and Extent'.
- ST_Exceedance_e2000_91y_Ex50.shp generated by Mount et al. (2011) indicating 'storm-tide coastal flooding zones' with an exceedance probability of 50% over the time period 2010–2100 **without sea level rise**.
- STSLR_Exceedance_A1FI_2010_2100_Ex50.shp generated by Mount et al. (2011) indicating 'storm-tide coastal flooding zones' with an exceedance probability of 50% over the time period 2010–2100 **with projected sea level rise**.

While it is difficult to model the variables involved in determining the relative extent of saltmarshes within their natural range in a given area, we may be able to compare the current extent of saltmarshes mapped in a given area (i.e. the 'realised niche') with the modelled present day storm-tide flooding zones (i.e. the 'fundamental niche') to roughly gauge the cumulative effect of these variables on saltmarsh extent. This relationship can then be used to map the potential future footprint in the area by employing the modelled storm-tide flooding zones over the time period 2010–2100 with projected sea level rise.

A similar method was employed by Prahalad et al. (2009) and Mount et al. (2010) in mapping future saltmarsh footprints in the Derwent Estuary Program area and Circular Head area, respectively. However, one important difference is noted. The modelling by Mount et al. (2011) does not use a particular 'height of sea level rise' as they deemed it to be hard to predict what height the sea levels may be at, compared to current levels, when the storm tides (or 'exceedances') occur over the modelled time period (2010–2100). This approach is different from previous modelling by Prahalad et al. (2009) and Mount et al. (2010) in that they used a predetermined height of 1.1 m sea level rise by 2100. Comparing the estimates from both these approaches, Mount et al. (2011) predict a lesser extent of landward areas inundated by storm tide flooding. Hence, the areas mapped as the future footprint of saltmarshes are conservative estimates and it is likely that further inland areas may be considered for management planning using detailed topographic information from the available LiDAR DEM on a case-by-case basis.

The modeled future saltmarsh footprint for this project does not take into account sedimentation and erosion rates, wind-wave modelling, vegetation associations, herbivory, historical change analysis or anthropogenic threats. The cumulative effect of these factors can either increase or decrease the extent and function of a particular saltmarsh patch. Future work may be required to better predict/model the relationship between these factors and potential future saltmarsh extent.

An additional key aspect taken into consideration here is the effect of human infrastructure footprints in the form of houses, roads and other constructed/built environments. As saltmarshes are unlikely to compete with these built environments, these areas have not been included in mapping the future saltmarsh footprints. Cleared land, not supporting hard infrastructure, such as golf courses, play fields, agriculture areas and open parks, however, have been included in the mapping of future saltmarsh footprints. An illustration of the methodology applied is shown in Figure 8 using Snug, in the Derwent Estuary – Bruny Catchment, as a case in point.

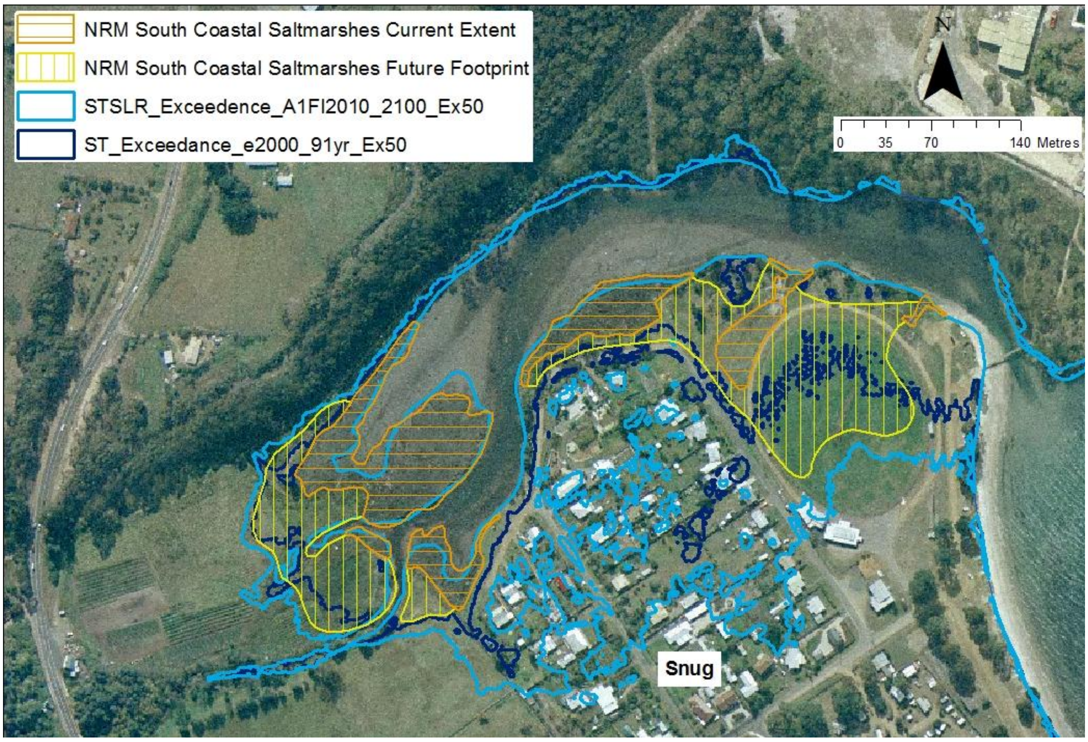


**Figure 8. Illustration of the mapping process employed to identify the future footprint of saltmarshes over the time period 2010–2100 with projected sea level rise. STSLR_Exceedance_A1FI2010_2100_Ex50 – Storm-tide coastal flooding zones with an exceedance probability of 50% over the time period 2010–2100 with projected sea level rise. ST_Exceedance_e2000_91yr_Ex50 – Storm-tide coastal flooding zones with an exceedance probability of 50% over the time period 2010–2100 without projected sea level rise. Data from Mount et al. (2011), courtesy of the Tasmanian Planning Commission. Base data from theLIST (© State of Tasmania).**

Areas mapped as future footprints of saltmarshes are likely to show displacement of glycophytes by halophytes over the time period 2010–2100 with increases in salinity. Consequently, mapped future saltmarsh footprints may over time support healthy functional saltmarsh communities if allowed to naturally realise their niche.

# 3. Saltmarsh Inventory and Database

## 3.1. Background to Identifying Saltmarsh Inventory Attributes

As part of the coastal saltmarsh inventory and mapping of current saltmarsh extent, key values and management information were collected and collated, and comprise the GIS attribute data for each of the saltmarsh polygons in the saltmarsh inventory database.

Three key areas of information captured for the saltmarsh inventory attributes are saltmarsh **components** ('static elements' such as vegetation, fauna), **processes** ('dynamic elements' such as tidal inundation, freshwater runoff), and **ecosystem services** ('values' assigned such as nutrient cycling). These three aspects are promoted for wetlands by the Ramsar Convention on Wetlands.

Saltmarsh components are determined by key processes that generate and sustain them over space and time (e.g. Angermeier and Karr, 1994). Together, the components and processes determine the 'ecological character' of a saltmarsh, and the ecosystem services are the recognised values derived from the maintenance of the ecological character of a saltmarsh.

For coastal saltmarshes, the primary mappable components are their distribution and extent, which is determined by the existence of the saltmarsh vegetation communities (see Table 2). The plants form the habitat that is then occupied by other static components such as invertebrates and birds (Adam, 1990). Several processes (or dynamic elements) operate at varying spatial and temporal scales to influence the plant cover and thereby the structure, extent and function of coastal saltmarshes (Figure 9).

Coastal saltmarshes are rich and productive ecosystems that provide a whole range of ecosystem services that benefit people either directly or indirectly (summarised in Section 1.2). These ecosystem services are made available through interplay of the static and dynamic components operating at various spatial and temporal scales (see Figure 2).

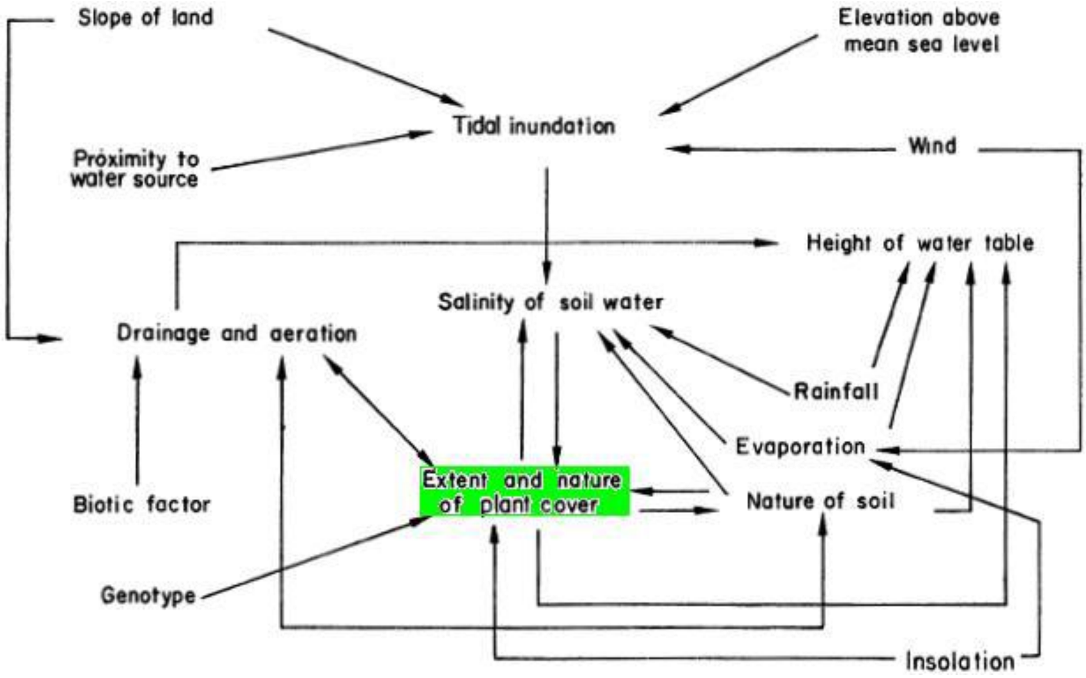


**Figure 9. The various environmental factors influencing the saltmarsh structure, extent and function (from Clarke and Hannon, 1969, p. 214; also see Adam, 1990, p. 147).**

## 3.2. Summary of Inventory Attributes

Information collected and collated as part of the inventory of coastal saltmarshes in the southern region (held in inventory database previously referred to) aims to improve information and knowledge of the components, processes, values and management context of coastal saltmarshes, to aid future management, 'wise-use' and conservation.

The information collected and collated as part of the inventory of coastal saltmarshes is listed and discussed, within this section of the report. Some of the attribute fields were inherited from the CFEV saltmarsh database, while other attributes have been used in other projects, including work completed in south-east Tasmania (Prahalad, 2009), the Derwent Estuary (Prahalad et al., 2009) and the Tasman and Forestier Peninsulas and Blackman Bay (Fazackerley, 2002). Several new attribute fields have also been added to further the objectives identified for this project. In particular, saltmarsh sites have been framed in a broader context, with respect to their terrestrial and coastal contexts, in acknowledgement of the fact that saltmarshes are not self-contained landforms, but are very much a functional component of the broader terrestrial and coastal environment, depending on and supporting larger scale processes.

It is envisaged that the inventory attribute fields used in this project will also facilitate the capture of relevant new information as it becomes available for coastal saltmarshes in southern Tasmania. Of particular interest is information about sub-catchments, shoreline stability, bird, terrestrial invertebrate and fish values, which has not been captured as part of this project due to the lack of information available at this time.

Information about these values may be researched and/or collected in the future to improve understanding of coastal saltmarsh processes, values and services to further inform management. These attribute fields are included in the inventory database for this reason, but currently have no information against them.

Table 3 below lists the attribute fields used in the coastal saltmarsh inventory database and was populated as far as information was available. Table 4 (on page 42) shows an example of the inventory database and typical information collected, where available, under the relevant fields.

**Table 3. A list of inventory database attributes used.**

| | |
|---|---|
| • Site context | Area: spatial extent mapped in hectares (as mapping units defined in section 2.1.2 Defining the Study/Mapping Unit) |
| | Vegetation communities: dominant vegetation communities (from the communities identified as constituents of the mapping unit, in section 2.1.2 Defining the Study/Mapping Unit), mapped at a finer scale to TASVEG |
| | TASVEG: dominant TASVEG community (either ASS, ARS or AUS) |
| | Land disturbance: noticeable land disturbance within the mapped unit |
| | Adjacent land disturbance: noticeable land disturbance immediately adjacent to the mapped unit (landward buffer zones) |
| | Eutrophication: noticeable eutrophication or nutrient loading (evidenced by the presence of filamentous algal mats on the vegetation and in pools and tidal channels/creeks) |
| • Coastal context | Cluster: part of a saltmarsh 'cluster' associated with coastal landscape feature, identified in geomorphic context, i.e. within a bay, or a creek mouth etc. |
| | Complex: part of a larger coastal complex at an 'aquatic ecosystem' scale, suitable for managing coastal aquatic ecosystem health and productivity, i.e. for ecosystem based management |
| • Terrestrial context | Catchment: at the receiving end of a major catchment area, larger spatial scale relevant for natural resource management planning related to catchment management |
| | Sub-catchment: at the receiving end of a smaller sub-catchment, smaller spatial scale relevant for catchment management works (data not currently available) |
| | River section: connected to a river section, local scale relevant for site-specific on-ground works |

| | |
|---|---|
| • Land management context | NRM region: constituent of an NRM region, for natural resource management planning at a regional scale |
| | Municipality: constituent of a local council, for land use and development planning at a local scale, through planning zones and restrictions |
| | Land tenure: relevant land tenure(s) spanning the extent of the site, either private parcel, or public land with specific land use status (e.g. nature reserve) |
| | Land manager: relevant land managers for the site, either land owner(s) or management agencies (e.g. DPIPWE) |
| • Community engagement context | Care group: relevant landcare/coastcare groups currently/potentially interested in partnering for land management |
| • Adaptive capacity to sea level rise | Retreat pathway: is there room to move for the saltmarsh site? |
| | Shoreline stability: susceptibility to wave erosion (data not currently available) |
| • Associated environmental values | Flora: any associated flora values? (e.g. *Limonium baudinii* recorded) |
| | Birds: any associated bird values? (data not currently available) |
| | IBAs: any Important Bird Area (IBA) associated? |
| | Terrestrial invertebrates: any associated terrestrial invertebrate values? (e.g. saltbush blue butterfly, *Theclinesthes serpentata*, recorded)(data not currently available) |
| | Marine invertebrates: any associated marine invertebrate values? (e.g. unique complex of crustaceans and molluscs) |
| | Fish: any associated fish values? (data not currently available) |
| | MCAs: any associated Marine Conservation Area (MCA)? |
| • Database management | Update person: database last updated by? |
| | Update date: database last updated on? |
| | Field validation: has the site context data has been field validated? |
| • Additional notes | Notes: any additional notes not covered by other attributes or to qualify any of the attribute data |
| • Suggested management actions | Management: key suggested management actions for the site (e.g. fencing) |

## 3.3. Inventory Attribute Descriptions

This section outlines the various attribute fields in the coastal saltmarsh inventory database, and where deemed necessary outlines the rationale for including a particular attribute field, and lists the sources of information used to populate it.

### 3.3.1. Site Context

#### 3.3.1.1. Area (Spatial Extent)

Mapping of spatial extent has been described in 2.1.3 and was recorded in hectares.

#### 3.3.1.2. Vegetation Communities

The vegetation of each saltmarsh polygon was recorded in the inventory database in terms of the dominant vegetation communities as listed in Table 2. The vegetation community records are descriptive in nature, endeavouring to provide a snapshot of the saltmarsh vegetative character for each polygon as a whole. For smaller polygons, especially occurring as fringing marshes, the descriptions would generally include one or two dominant species (such as '*Juncus* and *Schoenoplectus* dominant'). For larger polygons, the descriptions varied depending on the diversity of communities observed, with more diverse marshes requiring greater detail to capture the vegetative character (such as 'Extensive areas of *Tecticornia* (~70%), with *Sarcocornia* prevalent as low marsh dominant; *Gahnia* and *Austrostipa* occur in elevations; saltflats and pools recorded'). Particular attention has been placed to record the presence of the three rare communities, namely *Limonium australe*/*Limonium* baudinii open-closed heath, *Wilsonia humilis* herbfield, and *Wilsonia rotundifolia*-*Cuscuta tasmanica* herbfield. Attention was also directed to record the *Lawrencia spicata* open shrubland community, which was considered as rare under State legislation until it was delisted in 2008.

#### 3.3.1.3. TASVEG Mapping Unit

Based on the vegetation community descriptions, a suitable TASVEG mapping unit has been assigned for each saltmarsh polygon. Where both the succulent or graminoid saltmarsh communities co-occur, with either type occupying about a third of the mapped area, both the classes ASS – Succulent Saline Herbland and ARS – Saline Sedgeland/Rushland have been assigned to the polygon. This differs from TASVEG mapping, where only one vegetation code is assigned per polygon. As the scale of TASVEG mapping is much broader (1:25 000), TASVEG does not cater for the finer scale community composition and labels a polygon based on which community occupies greater than 50% of the polygon area.

#### 3.3.1.4. Land Disturbance (Within)

Any land disturbance observable *within* a mapped saltmarsh polygon was recorded descriptively to provide a snapshot of the nature and intensity of anthropogenic disturbance at the site (such as 'heavily degraded by land tilling' or 'horse riding, dog walking, cycling'). Where the site has had no noticeable disturbance, the land disturbance within was 'recorded absent.'

Where the site had few noticeable disturbances but were deemed relatively insignificant, the land disturbance within was recorded as 'minimal' along with any relevant notes (such as 'Minimal, rabbit grazing may be an issue').

#### 3.3.1.5. Adjacent Land Disturbance

Any land disturbance observed adjacent to a mapped saltmarsh polygon was recorded descriptively to provide a snapshot of the nature and intensity of anthropogenic disturbance from the upland margins of the site (such as 'No backing veg, backed by highway, numerous weeds' or 'Adjacent to farm land with some backing veg'). For island marshes with no upland margins, adjacent land disturbance has been attributed as 'not relevant – island marsh'.

#### 3.3.1.6. Eutrophication

Any eutrophication observable through the presence of filamentous algal mats both within the saltmarsh polygon and in the adjacent channels and creeks was recorded descriptively to provide a snapshot of the level/impacts of eutrophication in the area (such as 'Large areas of *Sarcocornia* marsh affected by algal growth' – Figure 10). Where the site had no noticeable algal mats present, eutrophication was 'recorded absent.'

**Figure 10. Example of a marsh affected by filamentous algae, part of Carlton River saltmarsh cluster.**

### 3.3.2. Coastal Context

#### 3.3.2.1. Coastal Complex

There has been increasing recognition that saltmarshes are not self-contained landforms but an integral part of the larger coastal seascape/landscape, or 'coastal complex'.

The definition of a coastal complex strongly follows the definition of an Aquatic Ecosystem under the Australian National Aquatic Ecosystem Classification Scheme (ANAECS) currently under development (Auricht, 2011). Under ANAECS, aquatic ecosystems are addressed at three spatial scales: regional scale; landscape scale; and local habitat scale (Figure 11). These three scales can be translated to the mapping of coastal saltmarshes, where: coastal complexes reflect the regional scale; saltmarsh clusters reflect the landscape scale (discussed below in section 3.3.2.2 Saltmarsh Cluster); and saltmarsh sites reflect the local habitat scale. It should be noted that the use of the term 'regional' in this context differs from the spatial scales of regional NRM bodies. NRM regions are much larger spatial scales and would include many coastal saltmarsh complexes.

Taking into consideration the regional scale, 25 coastal complexes were identified and each saltmarsh polygon was attributed to a coastal complex they fell under (Figure 16).

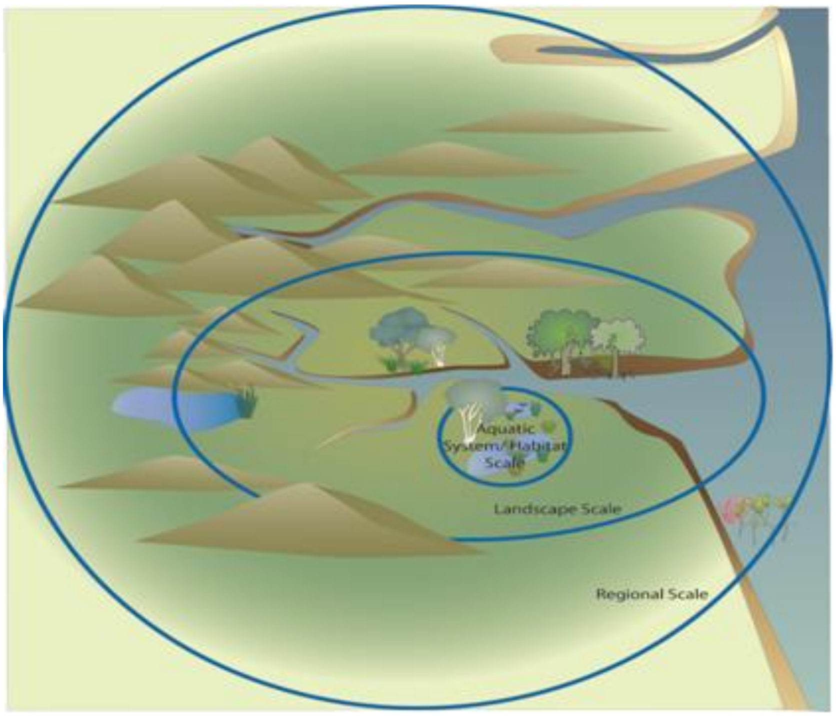


**Figure 11. Spatial scales within the Australian National Aquatic Ecosystems Classification Scheme. Image reproduced with permission from Auricht (2011).**

## 3.3.2.2. Saltmarsh Cluster

Saltmarshes are essentially geomorphic landforms and tend to 'cluster' around a coastal landscape feature, i.e. within an embayment, or a creek mouth etc. (Allen, 2000). Hence, at a landscape scale, saltmarsh clusters have been identified and named based on the defining landscape feature (such as Coal River Saltmarsh Cluster shown in Figure 12 or Orielton Lagoon Saltmarsh Cluster shown in Figure 13). Saltmarsh clusters occur as sub-systems under the larger coastal complex with each complex being made up of a minimum of one cluster to up to 12 as in the case of Huon River-Port Cygnet coastal complex.

## 3.3.3. Terrestrial Context

### 3.3.3.1. Catchment

The major drainage catchments used as part of the Conservation of Freshwater Ecosystem Values (CFEV) project have been adapted for this project. These catchments are largely consistent with Tasmania's Land and Water Management catchments, which were mapped prior to the CFEV project. Aside from being a hydrological region, catchments have a broader relevance for natural resource management in that catchment scale management is commonly held as an appropriate scale for sustainable natural resource planning and management. Integrated catchment management, as an NRM approach, considers both land and water interactions and the variety of values and threats at a landscape scale.

Saltmarshes are invariably at the receiving end of a catchment area and hence land management within the catchment has an impact on saltmarshes. Of particular relevance are sediment, nutrient and freshwater flows (both above and below ground) all of which affect the condition and function of coastal saltmarshes.

Seven 'estuarine/coastal catchments' within the study area (NRM South), namely Derwent Estuary-Bruny, Huon, Little Swanport, Pitt Water-Coal, Prosser-Maria, Swan-Apsley and Tasman, were used as part of this project (see Figure 6). All mapped saltmarsh polygons occurring under their respective catchments were attributed by the name of the catchment. For saltmarsh polygons occurring in Maria and Bruny Island, however, they were separately attributed to individual catchments of the same name.

### 3.3.3.2. Sub-catchment

The relevant area of a catchment (relevant sub-catchment) for a particular saltmarsh depends on its relative position in the landscape/catchment, the size of the saltmarsh patch and the particular focus of management. While sub-catchment mapping has been undertaken as part of the CFEV project, the scale of this mapping and relevance to coastal saltmarshes is such that it cannot be suitably used to inform coastal saltmarsh management objectives. Information on finer scale sub-catchment mapping is not presently available and therefore has not been added under the relevant heading in the inventory database as part of this project. As noted previously, the inventory headings such as this have been included in the inventory database to recognise the need and opportunity to undertake this work in the future.

More detailed mapping of sub-catchments, of relevance to saltmarsh management, can be done on a case-by-case purpose-driven basis for individual saltmarshes based on the management objectives set. An illustration of this approach is provided in Figure 12, taking the example of Coal River saltmarshes, which have very high conservation value (being part of the Pitt Water-Orielton Lagoon Ramsar Site) and are in a highly developed catchment area with intensive agricultural land use nearby. For the management of these saltmarshes, their sub-catchment could be mapped taking into account the surrounding landscape topography (contours) and drainage lines, and the type and intensity of land use.

This information could inform site and cluster specific saltmarsh planning and management, such as assigning buffer zones, stock access and managing the nature and intensity of land use to be consistent with healthy wetland functioning.

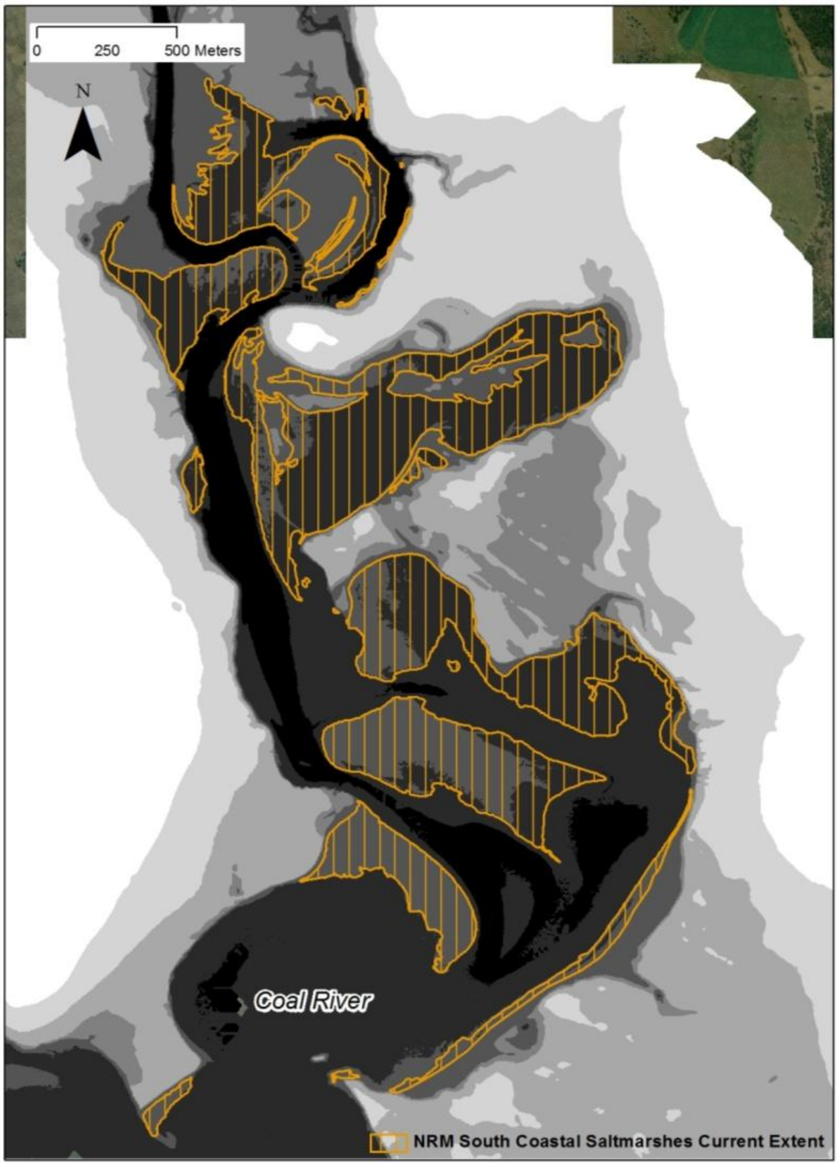


**Figure 12. Illustration of sub-catchment mapping with Coal River saltmarshes. Variations in colour represent changes in contour with areas in white representing an elevation of > 25 m relative to mean sea level and areas in black representing elevation < 0 m. Base data from theLIST, © State of Tasmania.**

#### 3.3.3.3. River Section

Considerable proportions of saltmarshes are associated with river or creek mouths. For these marshes, the relevant river or creek has been recorded as the 'River Section' attribute.

This attribute aims to link the saltmarsh polygons to relevant local scale river sections for consideration of water management issues, such as freshwater flows, sediments and nutrients and to plan for management of site specific on-ground works such as riparian fencing and rehabilitation. Furthermore, saltmarshes are expected to move up the rivers/creeks with sea level rise and hence the identification of these river sections will assist management objectives to allow this natural upstream retreat of saltmarshes. Where saltmarsh polygons are strongly associated with a recognised (i.e. mapped and named) river or creek, they are attributed with the name of the relevant waterbody. Many of the smaller creeks, however, have not been mapped and named, and the saltmarsh polygons associated with these smaller creeks have been attributed to have 'no data' for their respective river section. This acknowledges that from desktop analysis such attributed saltmarshes have an associated waterway, in most cases very small, however such waterways may still require management focus and attention. Other saltmarshes without strong association with a river or creek section, especially the fringing marshes in coastal embayments, are attributed to have 'none' of the river sections associated with them.

An illustration of this process is provided in Figure 13, taking the example of Orielton Lagoon saltmarshes. Here the majority of the saltmarsh area is associated with either or both the Orielton Rivulet and Frogmore Creek. The fringing marshes on the southern and western sections of the lagoon are not associated with a river or a creek and are hence attributed as 'none'. One saltmarsh on the north-eastern section of the lagoon is associated with an unnamed creek and is hence attributed as 'no data.' As a case in point, extensive algal mats are observable in the Frogmore Creek channel, which runs through the largest saltmarsh in the lagoon indicating that nutrient management is of a priority in the creek.


**Figure 13. Illustration of River Section attribution with Orielton Lagoon saltmarshes.**

## 3.3.4. Land Management Context

### 3.3.4.1. NRM Region

All saltmarshes mapped as part of this project are within the southern NRM region. The boundary of NRM South mirrors the ABS Southern Statistical Region, spanning from Bicheno on the east coast to Port Davey in the south. The region is defined by local council areas (rather than catchment boundaries) and includes 12 councils. Nine coastal councils were included in the project area as outlined below (section 3.3.4.2). The relevant catchments within the southern NRM region have been discussed above in section 3.3.3.1. The southern NRM region also includes adjacent State coastal waters up to 3 nautical miles (NRM South, 2005).

### 3.3.4.2. Municipality/Local Councils

Nine councils coincided with the study area, i.e. including coastal/estuarine catchments. They include: Glamorgan-Spring Bay Council; Sorell Council; Tasman Council; Clarence City Council; Brighton Council; Glenorchy City Council; Hobart City Council; Kingborough Council; and Huon Valley Council. All mapped saltmarsh polygons occurring under their respective municipalities were attributed by the name of the relevant council.

### 3.3.4.3. Land Tenure and Managers

The property ID data layer (dated Aug 2009) and Tasmanian reserve estate layer (dated June 2010) provided by the Land Information Services Tasmania (LIST) were used to attribute land tenure and land managers to each of the mapped polygons. The different public land tenure types recorded include: Conservation Area; National Park; Nature Reserve; Nature Recreation Area; State Reserve; Indigenous Protected Area; Game Reserve; Informal Reserve; Authority Land; and land Below High Water.

In many cases saltmarsh polygons crossed administrative boundaries, for example from public to private land. Where this occurred, relevant land tenures and land managers were recorded for the saltmarsh polygon. Because an ecosystem based approach was adopted for this project, saltmarsh areas were mapped on a site, cluster and complex basis. Saltmarsh polygons were not mapped according to administrative/land tenure boundaries where polygons crossed such boundaries. As such it is not possible to provide accurate statistics for the different land tenure types. Addition mapping would be required for this and it was not deemed necessary to meet the objectives of this project.

## 3.3.5. Community Engagement Context

### 3.3.5.1. Care Groups

In the context of this project and objectives for saltmarsh management in the future it is relevant to identify care groups in and around saltmarsh areas. Twenty-nine care groups working on natural resource management projects in and around the saltmarsh areas (such as in Figure 21) were identified as part of the project.

These groups were identified by NRM South and the Southern Coastcare Association of Tasmania (SCAT) based on information available. It should be noted that this list of groups many not represent the entire range of groups working at a local scale.

Saltmarsh polygons occurring in areas where these care groups operate have been attributed with the relevant group name. In some cases these groups are actively working on managing saltmarshes and adjoining coastal areas and were contacted through SCAT to assist with information regarding their local saltmarsh sites. Other groups listed below may have different focuses other than on-ground NRM projects, such as advocacy, planning or community education.

## 3.3.6. Adaptive Capacity to Sea Level Rise

### 3.3.6.1. Migration/Retreat Pathway

Three major attribute classes were assigned to indicate the extent of low lying inland areas immediately adjacent to the saltmarsh patch. They include:

**Sufficient room to move**

This class indicates that the extent of low lying inland areas immediately adjacent to the saltmarsh patch is equal to or greater than the current extent of the saltmarsh. With all other factors being equal, the saltmarsh patch can retreat inland and maintain its position and function in the landscape.

**Some room to move**

This class indicates that low lying inland areas occur immediately adjacent to the saltmarsh patch but their extent is lesser than the current extent of the saltmarsh.

**Backed by steep upland**

This class indicates that there are no low lying inland areas immediately adjacent to the saltmarsh patch.

Two classes were used for saltmarshes of smaller area occurring as either island marshes or fringing marshes: 'Fringing marsh' and 'Not applicable – island marsh'. Some marshes in the relevant coastal zone were not connected to the sea, i.e. land locked, and are far enough from the coastline to not be considerably affected by sea level rise and storm surges. These marshes were attributed as 'Not applicable – land locked marsh'.

All saltmarsh polygons that occurred outside the areas where storm-flood modelling data was available were attributed as 'No data'. These accounted for about 30% of the total saltmarsh area mapped excluding the Apsley Marshes.

#### 3.3.6.2. Erosion/Sedimentation

The modelled future saltmarsh footprint for this project does not take into account sedimentation and erosion rates of saltmarshes as this data is currently not available for the majority of sites across the region. However, it is important to better understand these processes in order to more accurately predict future footprints, and as such this heading has been included in the inventory database for future research and incorporation when data becomes available.

### 3.3.7. Associated Environmental Values

The following Associated Environmental Values are recognised values associated with the static and dynamic elements of the saltmarsh habitats. The values listed in the results section and the saltmarsh inventory database have been largely compiled based on observations as part of the field component of the project. Records of flora and fauna species associated with coastal saltmarshes can also be sourced from the Natural Values Atlas.

#### 3.3.7.1. Flora

This attribute captures the presence of any flora that has been formally recognised as rare or vulnerable under State legislation. Tasmanian saltmarsh flora that is currently recognised as rare are *Limonium australe*, *Limonium baudinii*, *Wilsonia humilis*, *Wilsonia rotundifolia* and *Cuscuta tasmanica*. Any saltmarsh polygon known to contain one of the above flora has been attributed to record their presence. In addition to the above flora known to be saltmarsh obligates, other listed flora noted to occur on the margins of saltmarshes have been recorded (such as '*Wilsonia humilis* recorded, *Calocephalus citreus* on backing land'). These records are aimed to improve the conservation status of listed species in and immediately around the saltmarsh polygons.

#### 3.3.7.2. Birds

Records of the use of Tasmanian saltmarshes by birds are either largely anecdotal or recorded in the Birddata database maintained by BirdLife Australia (Woehler, E., pers. comm.). Future work is needed to record and distill this information for use in this inventory database, where bird species values can be assigned to individual saltmarshes or more practically to saltmarsh clusters.

#### 3.3.7.3. Important Bird Areas

Important Bird Areas (IBAs) have been identified to be priority areas of global conservation significance for key bird species (see http://www.birdlife.org.au). IBAs have been included here as one of the Associated Environmental Values attributed in the inventory database in order to recognise some of the globally significant bird values associated with saltmarshes. While IBAs have been used here as a proxy to represent bird values, it is acknowledged that they do not fully represent the range of values afforded for birds in saltmarsh habitats in southern Tasmania in both a regional and local level. IBAs are selected on specific criteria, however there are many other saltmarsh sites that support a range of birds but do not meet the IBA criteria.

All saltmarsh polygons that fell within one of the above IBAs have been attributed with the name of the IBA.

**Figure 14. Black Swans (*Cygnus atratus*) in Moulting Lagoon IBA.**

#### 3.3.7.4. Terrestrial Invertebrates

Many smaller invertebrates associated with Tasmanian saltmarshes are not sufficiently studied and their values are yet to be fully understood (McQuillan, P., pers. comm.). Work is currently underway to collate existing information relevant to coastal saltmarshes collected by Peter McQuillan at the University of Tasmania. This area of information is therefore not populated in the inventory database but has been included as an inventory heading for when further information becomes available.

#### 3.3.7.5. Marine Invertebrates

Marine invertebrates have been studied and documented across Tasmanian saltmarshes by Alistair Richardson and others based at the University of Tasmania. Notably, a detailed study by Richardson, Swain and Wong (1997, based on Wong et al. (1993)) documented the crustaceans and molluscs of 27 saltmarsh sites across the study area (65 sites were examined across the State). These sites include: Blackman Bay, Forestier Peninsula; Bryans Lagoon, Freycinet Peninsula; Hildyards Point, Blackman Bay; Cloudy Bay Lagoon, Bruny Island; Cockle Creek; Carlton River; Dolphin Sands Road, Moulting Lagoon; Earlham Lagoon; Hazards Lagoon, Freycinet Peninsula; Hastings Bay, Southport; Huon River, Surges Bay; Ida Bay, Southport; Lauderdale, Ralphs Bay; Swan Lagoon, Tasman Peninsula; Lutregala Marsh, Bruny Island; Moulting Lagoon, road to Coles Bay; North West Bay; Old Beach, Derwent Estuary; Port Arthur; Port Cygnet; Port Esperance; Railway Point, Pittwater; Southport Lagoon; Sloping Lagoon; Saltwater River; Triabunna; and Little Swanport.

Other publications pertaining to marine invertebrates in the study area include: Richardson and Mulcahy (1996); Richardson et al. (1997); and Richardson et al. (1998).

While these studies do not extend the coverage to other areas outside the 27 sites listed above, they have served to further describe the nature, extent and distribution of marine invertebrates in these sites.

#### 3.3.7.6. Fish

In Tasmania the use of saltmarshes by fish species is not well documented and warrants further investigation (Richardson, A., Parsons, K., pers. comm.). Fish values have not been attributed in the saltmarsh database as part of this project due to insufficient information, however 'fish values' has been included as a heading in the attribute database to recognise the opportunity to capture and store this important information in the future as it becomes available.

#### 3.3.7.7. Marine Conservation Areas

Marine Conservation Areas (MCAs) have been included as one of the Associated Environmental Values attributes in the inventory database in order to recognise some of the marine values associated with saltmarshes. It is recognised that there are many other marine habitats and values adjacent to saltmarsh communities. In many cases their mapping is variable or lacking.

All saltmarsh polygons that fell within one of the listed MCAs have been attributed with the relevant names.

### 3.3.8. Additional Notes

Any additional notes not covered by other attributes or to qualify any of the attribute data were recorded in this attribute (such as 'Informal management agreement exists between land owner and care group' for Clarence Plains Rivulet saltmarsh).

Information recorded in the Additional Notes column of the database largely relates to tenure information where a polygon crosses over two or more land tenures.

### 3.3.9. Suggested Management Actions

Where relevant, key suggested management actions have been recorded against saltmarsh sites/polygons within the attribute inventory database.

**Table 4: Example of attribute date collected and collated for 5 saltmarsh polygons**

| Coastal Complex | Saltmarsh Cluster | River Section | Council | Catchment | NRM Region | Area (ha) | Land Disturbance (within) | Land Disturbance (adjacent) | Eutrophication | Retreat Pathway | Tenure | Manage-ment Authority | Notes | Coastcare Group | Bird values | Flora Values | Important Bird Area | Marine Invertebrate Hotspot | Marine Conservation Area | Management Actions | Field Validation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Carlton River | Carlton River | Carlton River | Sorell Council | Tasman | South | 22.3 | Section of the marsh closer to Primrose Sands dwellings highly eutrophic with thick mats of filamentous algae | Extent and quality of buffer zone variable, with areas closer to Primrose Sands dwellings having narrow buffer strips with numerous weeds | Extensive mats of algae noted – a quarter of the site area highly eutrophic | Backed by steep upland | Private Parcel, Informal Reserve, Authority Land | Land Owner, DPIPWE | Private Parcel PID – 5950355; 7608991 (both ~50%) | Southern Beaches Landcare and Coastcare Inc. & Primrose Sands Landcare Group | | | Not relevant | | None | Fencing and weed management; stormwater management; discourage access to dogs | Yes |
| Cloudy Bay | Cloudy Bay | Saintys Creek | Kingbor-ough Council | Bruny | South | 3.8 | | | No data | No data | Private Parcel, Informal Reserve | Land Owner, DPIPWE | | Bruny Island Environment Network | | | Bruny Island IBA | | Cloudy Bay Lagoon Marine Conservation Area | | Prior |
| Derwent Estuary | Calverts Lagoon | None | Clarence City Council | Derwent Estuary | South | 29.0 | Not recorded | Surrounded by native veg buffer | No data | Not applicable - land locked marsh | Conservation Area | DPIPWE | | Unidentified | | *Cuscuta tasmanica, Wilsonia rotundifolia* | South Arm IBA | | None | | Prior |
| Mercury Passage | Earlham Lagoon | Sandspit River, Griffiths Rivulet | Glamorg-an-Spring Bay Council | Prosser | South | 160.2 | | | No data | No data | Private Reserve | Land Owner, DPIPWE | | Unidentified | | | Not relevant | Marine Invertebrate Hotspot | None | | Partially |
| Pitt Water-Orielton Lagoon | Duckhole Rivulet | Duckhole Rivulet, Malcolms Creek, Belbin Rivulet, Stony Creek | Clarence City Council | Pitt Water - Coal | South | 12.6 | | | | Backed by steep upland | Private Parcel, Authority Land, Nature Reserve | Land Owner, DPIPWE | | Unidentified | | *Wilsonia humilis* recorded, *Calocephal-ous citreus* on the landward buffer | None | | None | | Prior |

*Information not available for fields: Sub-catchment, Shoreline Stability, Terrestrial Invertebrates and Fish Values.

## 3.4. Database Management

### 3.4.1. Guide to Using the Inventory Database and Mapping

The inventory database developed as part of the project is expected to provide a snapshot summary of key environmental and management information relevant to a particular saltmarsh site. The inventory has not as its primary purpose aimed to generate broad statistics and trends for saltmarshes across the region, but instead to provide information relevant for better understanding and management of individual saltmarsh sites (Figure 15). Planning and management of saltmarsh often happen at higher spatial scales than individual patches. For these purposes the database can be queried and interpreted to pull out information, statistics and trends relevant for a particular planning purposes at a required spatial scale (for example, ‘how many saltmarsh sites are within private land in Sorell?’ or ‘how many sites are owned and managed directly by Tasman Council?’).

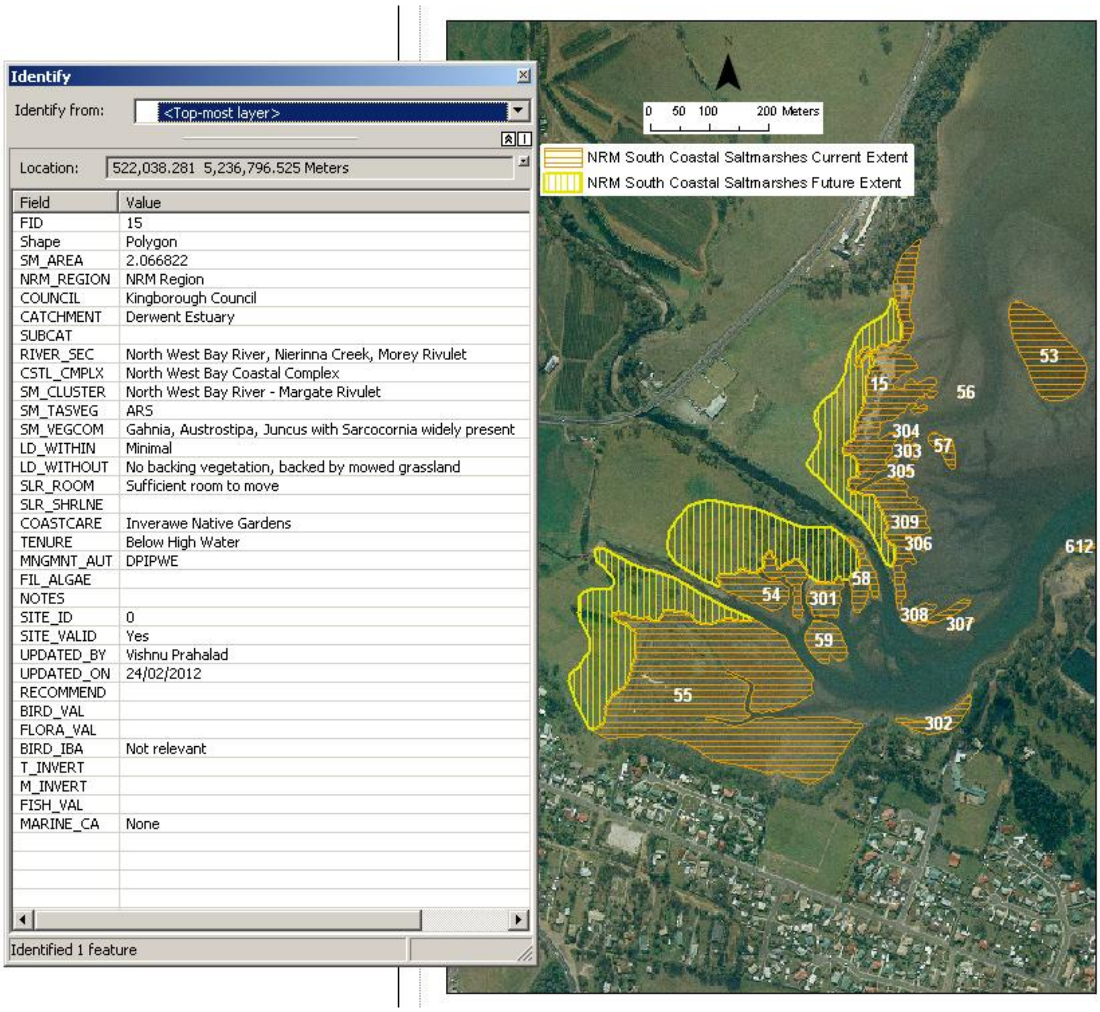


**Figure 15. Database entries for a saltmarsh site (FID = 15) in North West Bay, part of the Derwent Estuary catchment area.**

### 3.4.2. Data Lineage and Currency

Data relevant to the inventory database is expected to be evolving constantly. To keep track of all changes made to the database, the fields 'Data Lineage' and 'Data Currency' have been attributed with the person who updates the data and the date of the update. All records in version 1 of the database were updated by Vishnu Prahalad (co-author) on 24/04/2012. This information is not shown in Table 4 due to the size of the inventory database and space limitations (page size) within this report.

### 3.4.3. Data Accuracy – Field Validation

Data accuracy is variable depending on the field validation conducted for each saltmarsh polygon. Four different levels of accuracy were assigned:

- **Yes**: If field validation has been conducted to sufficient detail in recording all of the Site Context data.
- **Partially**: If field validation has been conducted partially, i.e. if only one section of the marsh was surveyed or if a marsh on private land was surveyed at a distance from an access/vantage point.
- **Prior**: If field validation has not been conducted as a part of this project and the data was inherited from previous work known to be of comparable standard.
- **No**: Where no field validation was conducted. Some of the saltmarshes validated by the CFEV project fall within this category and can be used where relevant.

# 4. Results Summary

This section provides a summary of key results of the coastal saltmarsh inventory and mapping of current extent and future footprints under sea level rise conditions. Detailed results on coastal saltmarshes across the region, their future footprints and attributes, are contained in the GIS mapping layers and inventory database, which is a further output of this project (available through NRM South). This report is intended to be read in conjunction with the GIS mapping layers and attribute data or the coastal saltmarsh maps available on NRM South's website as a booklet.

This section of the report highlights some statistical information about coastal saltmarshes across the region, based on the inventory and mapping process. In some cases statistical results are not available as not all saltmarsh patches were ground truthed and hence statistical comparison across all sites in some cases could not be supported by the data. Furthermore in some cases inventory information, such as vegetation communities, has been collected through observation only rather than systematic surveys and therefore cannot be used to support statistical analysis in this report.

A total of 3419 ha of saltmarshes has been mapped, comprising 618 polygons or discrete spatial units. The size of the polygons varied greatly, from a minimum of 0.005 ha to a maximum of 628 ha. The smaller polygons were generally associated with fringing marshes and small island marshes while the largest polygon was associated with Apsley Marshes. In the case of Apsley Marshes, however, saltmarshes are known to occupy only a relatively small portion of the larger wetland area which is yet to be mapped and validated. The second largest polygon of 352.5 ha was the Long Point Saltmarsh associated with Moulting Lagoon. Only three other saltmarsh polygons recorded an area of greater than 100 ha – those associated with Earlham Lagoon (160 ha), Moulting Lagoon (104 ha) and Huon Estuary (101 ha). Twelve polygons recorded areas between 30 and 100 ha. Significantly, 35% of the saltmarsh polygons ranged between one and 30 ha in area while close to 63% covered an area of less than 1 ha.

Table 5 lists the nine catchments in the southern region with their respective saltmarsh spatial units mapped, total area and average polygon size in hectares. Table 6 lists municipalities in the region with their mapped saltmarsh spatial units, the total area and average polygon size in hectares.

The Swan-Apsley catchment contained the most significant areas of saltmarshes mapped with 972.2 ha and accounted for close to 35% of the total area within NRM South. This figure excludes Apsley Marshes (628 ha) as these marshes have not been field validated as part of this project and are known to contain considerably large areas of non-saltmarsh vegetation. Glamorgan-Spring Bay municipality contains about half of all the saltmarshes mapped (1404.3 ha), followed by the Clarence City municipality which contains close to one fifth (494.5 ha). No saltmarsh polygons were recorded within the Hobart City municipality, while numerous fringing marshes were recorded within Glenorchy City municipal area (with an average patch size of 0.07 ha).

**Table 5. Catchments with the respective spatial units mapped along with the total area and average polygon size in hectares. *Does not include Apsley Marshes.**

| Catchment | Spatial Units | Total Area (ha) | Average Size (ha) |
|---|---|---|---|
| Bruny | 23 | 98.5 | 4.3 |
| Derwent Estuary | 167 | 239.5 | 1.4 |
| Huon | 114 | 316 | 2.8 |
| Little Swanport | 30 | 209 | 7 |
| Maria | 6 | 20 | 4 |
| Pitt Water-Coal | 86 | 371 | 4.3 |
| Prosser | 33 | 203 | 6.1 |
| Swan-Apsley* | 87 | 972.2 | 11.2 |
| Tasman | 71 | 361 | 5.1 |

**Table 6. Municipalities with the respective spatial units mapped along with the total area and average polygon size in hectares. *Does not include Apsley Marshes.**

| Local Council | Spatial Units | Total Area (ha) | Average Size (ha) |
|---|---|---|---|
| Brighton Council | 1 | 5 | 5 |
| Clarence City Council | 125 | 494.5 | 4 |
| Glamorgan-Spring Bay Council* | 156 | 1404.3 | 9 |
| Glenorchy City Council | 46 | 3.4 | 0.07 |
| Hobart City Council | 0 | 0 | 0 |
| Huon Valley Council | 114 | 316.4 | 2.8 |
| Kingborough Council | 71 | 122.5 | 1.7 |
| Sorell Council | 64 | 277.4 | 4.3 |
| Tasman Council | 40 | 167.3 | 4.2 |

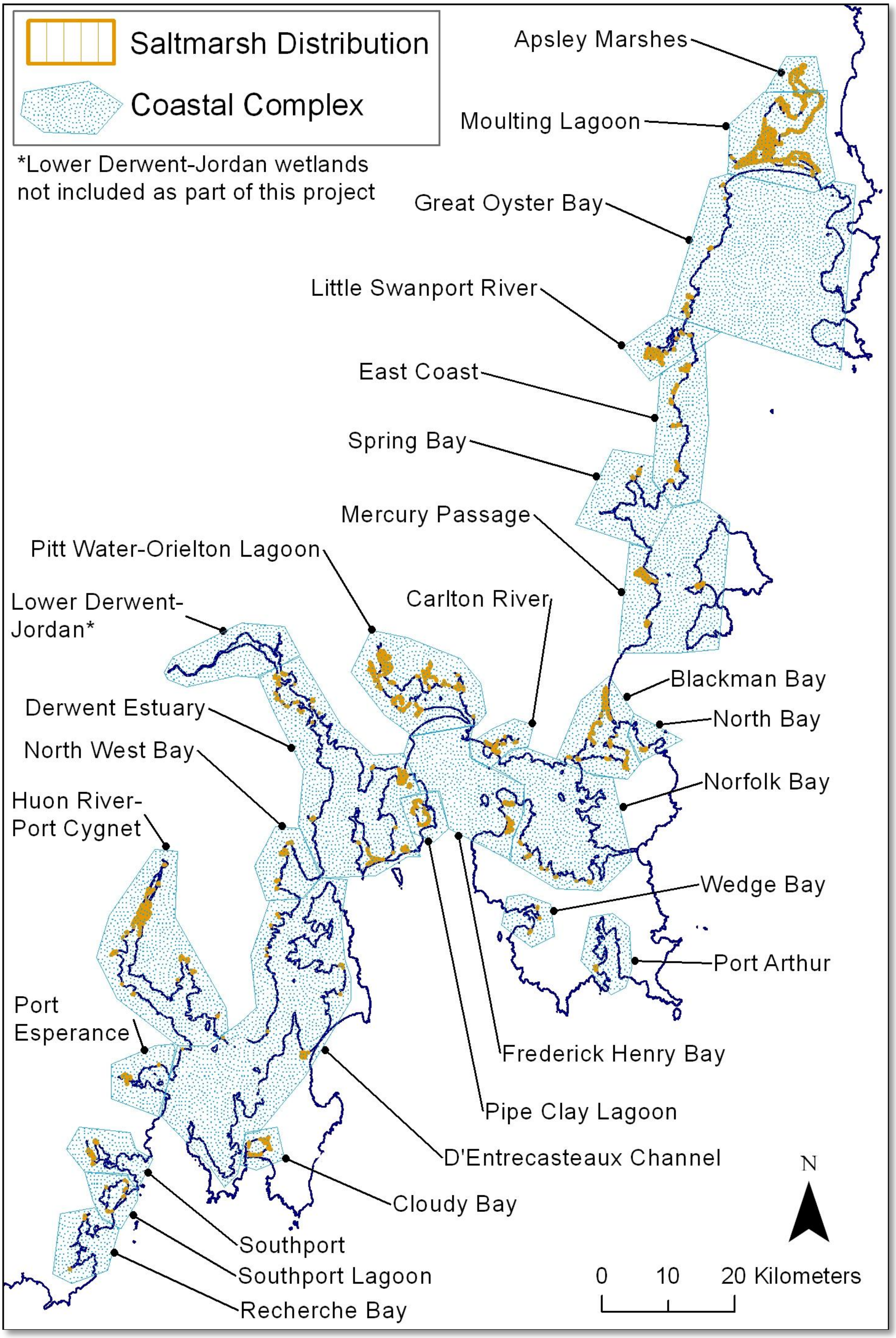


Figure 16. The various coastal complexes identified across the NRM South study area.

Looking at the region from a coastal ecosystems perspective, 25 coastal saltmarsh complexes were identified (see Figure 16).

Table 7 identifies the various saltmarsh clusters along with their respective coastal complexes and catchments. In total, eighty-three saltmarsh clusters and 15 individual sites (that did not have a strong association with a cluster) comprise the 25 coastal complexes. Two coastal complexes in the table below lie within two catchments. The East Coast coastal complex crosses over the Little Swanport and Maria-Prosser catchments, while the Great Oyster Bay coastal complex cross the Swan Apsley and the Little Swanport catchments.

**Table 7. The various saltmarsh clusters identified along with their respective coastal complexes and catchments.**

| Catchment | Coastal Complex | Saltmarsh Cluster |
|---|---|---|
| Derwent Estuary-Bruny | Cloudy Bay | Cloudy Bay |
| | D'Entrecasteaux Channel | Adams Bay Wetland |
| | | Great Bay Wetland |
| | | Simpsons Bay-Lutregala Marsh |
| | | Little Oyster Cove Creek |
| | | Roaring Bay Beach (Saltmarsh Site) |
| | | Masons Creek |
| | | Oyster Cove |
| | | Schemers Creek (Saltmarsh Site) |
| | | Three Hut Point (Saltmarsh Site) |
| | Derwent Estuary | Browns River |
| | | Calverts Lagoon |
| | | Clarence Plains Rivulet |
| | | Clear Lagoon (Saltmarsh Site) |
| | | Middle Derwent Estuary Fringing Marshes |
| | | Ralphs Bay-Lauderdale |
| | | Ralphs Bay-South Arm |
| | | Risdon Cove |
| | | South Arm Beach Dune Barred Lagoon (Saltmarsh Site) |
| | North West Bay | Coffee Creek-Howden |
| | | North West Bay River-Margate Rivulet |
| | | Snug Bay-Snug Creek |
| | | Snug River |

| | | |
|---|---|---|
| | Pipe Clay Lagoon | Pipe Clay Lagoon |
| Huon | Huon River-Port Cygnet | Castle Forbes Bay (Saltmarsh Site) |
| | | Crowthers Bay Fringing Marshes |
| | | Forsters Rivulet |
| | | Garden Island Creek |
| | | Gardners Bay |
| | | Huon River Marsh |
| | | Kermandie River |
| | | Lasts Creek |
| | | Nicholls Rivulet |
| | | Port Cygnet |
| | | Surges Bay Marsh |
| | | Waterloo Bay |
| | Port Esperence | Bells Lagoon |
| | | Chale Bay |
| | | Esperence River |
| | Recherche Bay | Cockle Creek |
| | | D'Entrecasteaux River |
| | Southport | Ida Bay (Saltmarsh Site) |
| | | Lune River |
| | | Hastings Bay (Saltmarsh Site) |
| | Southport Lagoon | Southport Lagoon |
| Little Swanport | Little Swanport River | Little Swanport River |
| | Great Oyster Bay | Buxton River |
| | | Lisdillon |
| | East Coast | Banwell Beach (Saltmarsh Site) |
| | | Boltons Beach Marsh |
| Pitt Water – Coal | Pitt Water-Orielton Lagoon | Barilla Bay |
| | | China Creek (Saltmarsh Site) |
| | | Coal River |
| | | Cross Rivulet |
| | | Duckhole Rivulet |

| | | |
|---|---|---|
| Pitt Water - Coal | Pitt Water-Orielton Lagoon | Hele Rivulet |
| | | Hobart Aiport |
| | | Iron Creek |
| | | Orielton Lagoon |
| | | Penna Beach |
| | | Pitt Water Fringing Marshes |
| | | Sorell Rivulet |
| | | Unnamed Pitt Water |
| Prosser - Maria | East Coast | Eighty Acre Creek-Grindstone Bay |
| | | Okehampton Bay (Saltmarsh Site) |
| | | Okehampton Lagoon |
| | Mercury Passage | Chinamans Bay |
| | | Cockle Bay Lagoon |
| | | Earlham Lagoon |
| | Spring Bay | MacLaines Creek |
| | | Rostrevor Creek |
| Swan – Apsley | Apsley Marshes | Apsley Marshes |
| | Great Oyster Bay | Kelveden Lagoon |
| | | Meredith River |
| | | Saltwater Creek (Saltmarsh Site) |
| | Moulting Lagoon | Barney Wards Bay |
| | | Great Swanport Fringing Marshes |
| | | Little Bay-Long Point |
| | | Moulting Lagoon Fringing Marshes |
| | | Pelican Bay |
| | | Sanwick Bay |
| | | Sherbourne Bay |
| | | Swan River-King Bay |
| Tasman | Blackman Bay | Blackman Bay Fringing Marshes |
| | | Blackman Rivulet |
| | | East Bay (Saltmarsh Site) |
| | | Marion Bay Back-Beach |

| | | |
|---|---|---|
| Tasman | Carlton River | Carlton River |
| | | Primrose Sands Dune Barred Wetland |
| | Frederick Henry Bay | Burdens Marsh |
| | | Sloping Lagoon (Saltmarsh Site) |
| | Norfolk Bay | Norfolk Bay Fringing Marshes |
| | | Dunalley Bay |
| | | Saltwater River |
| | North Bay | Swan Lagoon |
| | Port Arthur | Safety Cove |
| | Wedge Bay | Cripps Creek-White Beach |
| | | Parsons Bay |

Land tenure was one of the key attributes identified as part of the land management context of saltmarshes across the region.

For saltmarsh polygons on public land, the majority is managed by the Department of Primary Industries, Parks, Water and the Environment (DPIPWE). DPIPWE is therefore the most important public land manager, with management responsibility for over half of the area mapped on public land (66% of the saltmarsh polygons mapped on public land had DPIPWE as either a primary or co-owner). Within DPIPWE, the Parks and Wildlife Service and Crown Land Services are the two prominent land managers. Other land managers include the Commonwealth of Australia, the Federal Department of Defence, the State Department of Education and local councils.

Saltmarsh polygons on private land were either recorded as Private Parcel or Private Reserves. Significantly, about 74% of the total mapped area (2535 ha, including the Apsley Marshes) was associated either entirely or partly with private land. A large proportion of these (about 1500 ha or 44% of the total mapped area, made up of 169 individual sites/polygons) were entirely within private land not managed as private reserves (attributed as ‘Private Parcel’ in the database). An additional 743 ha (made up of 50 sites/polygons) was within mixed tenure partly as Private Parcel and partly as public land of various management designations.

Within private land, 22 sites/polygons were within Private Reserves, of which 19 sites were entirely within Private Reserves and three other sites straddled between Private Reserves and either unreserved private land or public land.

Notable saltmarsh areas under Private Reserves included Long Point in Moulting Lagoon, Lutregala Marsh on Bruny Island and parts of Egg Islands in the Huon Estuary, all managed by the Tasmanian Land Conservancy (TLC). The Long Point saltmarsh site is the single largest in terms of spatial extent (352 ha) and falls predominantly within the land managed by TLC with some parts within the nearby Private Parcel. Other notable areas included three sites within the Earlham Lagoon Saltmarsh Cluster (162 ha), three sites within Marion Bay (113 ha), one site in Barilla Bay (35 ha), and one along the Coal River (12 ha).

Coastcare and landcare groups located in and around saltmarsh sites include:

- Bruny Island Environment Network (BIEN)
- Friends of Adventure Bay Inc.
- Castle Forbes Bay Landcare and Coastcare Group
- Friends of Coningham
- Friends of Maria Island
- Howden Landcare Group
- Huonville Landcare Group
- Kettering Coastcare/Landcare Group
- Kingston Beach Browns River Coastcare
- Lauderdale Coastcare Group
- Marion Bay Coastcare Inc.
- Mortimer Bay Coastcare Group Inc.
- Penna Landcare Group Inc.
- Pipe Clay Lagoon Coastcare Inc.
- Port Cygnet Landcare and Watercare Group
- Port Esperance Coastcare Group
- Seven Mile Beach Coastcare Group Inc.
- Snug Landcare Coastcare Inc.
- South Arm Coastcare Group
- Southern Beaches Landcare and Coastcare Inc.
- Primrose Sands Landcare Group
- Surveyors Bay Coastcare Group
- Swansea Tidy Towns
- Tasman Landcare Group Inc.
- Saltwater River Coastcare Group
- White Beach Landcare Group Inc.
- Tasmanian Land Conservancy
- Tranmere-Clarence Plains Land & Coastcare Inc.

As noted in 3.3.5.1, this list only identifies care groups working in and around saltmarsh patches and does not distinguish which groups have an interest in saltmarshes or are currently actively involved in saltmarsh management.

As outlined in section 3.2, information around a number of environmental values associated with coastal saltmarshes was collected, where information was available.

Statistics for vegetation composition have not been produced, as the vegetation composition of coastal saltmarsh across the region was extremely diverse, depending on local environmental conditions. Sufficient data was not able to be collected for all saltmarsh patches within the region to generate statistics. There is an opportunity to undertake further survey work in the future to complete the vegetation composition information in the inventory database and analyse for trends on a need basis.

Where ground truthing/field observation was carried out, saltmarsh flora that are currently recognised as rare were recorded where observed. *Limonium sp.* was observed within the Saltwater River, Rostrevor Creek, Maclaines Creek, Coal River and Barilla Bay clusters. Observations of *Wilsonia humilis* were recorded for Orielton Lagoon, Coal River, Barilla Bay, Iron Creek and Duckhole Rivulet clusters. *Wilsonia rotundifolia* was observed at Calverts Lagoon and Barilla Bay clusters as well as *Cuscuta tasmanica* at Calverts Lagoon and Primrose Sands clusters. *Calocephalous citreus* was recorded at Duckhole Rivulet and Orielton Lagoon cluster and *Vittadinia sp.* was recorded at Penne Beach and Clarence Plains Rivulet cluster. Other flora records associated with saltmarshes can also be found in the Natural Values Atlas database available online.

In terms of bird values, seven Important Bird Areas (IBAs) have been identified within the study area:

- Marion Bay (focal species: Pied Oystercatcher, Hooded Plover, Fairy Tern)
- Moulting Lagoon (Black Swan, Pied Oystercatcher)
- Maria Island (no relevant waterbirds or shorebirds)
- Bruny Island (Pied Oystercatcher)
- Egg Islands (Australasian Bittern)
- South Arm (Pied Oystercatcher)
- South-east Tasmania (no relevant waterbirds or shorebirds)

Moulting Lagoon IBA notably accounted for close to half of all saltmarsh mapped within the southern region and is recognised as a key Black Swan (*Cygnus atratus*) habitat (Figure 14).

Marine invertebrates have been studied and documented across Tasmanian saltmarshes by Alistair Richardson and others based at the University of Tasmania. Notably, a detailed study by Richardson, Swain and Wong (1997, based on Wong et al. (1993)) documented the crustaceans and molluscs of 27 saltmarsh sites across the study area.

Of these 27 sites, Cockle Creek, Lutregala Marsh, Old Beach, Hildyard Point and Earlham Lagoon were ranked highest in terms of conservation value taking into consideration marine invertebrates and site disturbance criteria (Richardson, A., pers. comm.). These 5 sites are attributed as ‘marine invertebrate hotspots’ in the saltmarsh inventory database.

Marine Conservation Areas were chosen as a proxy to represent marine values (including broad marine ecosystem process and services) associated with coastal saltmarshes. The following Marine Conservation Areas were found to be relevant to coastal saltmarsh clusters or complexes across the region:

- Blackman Rivulet Marine Conservation Area
- Central Channel Marine Conservation Area
- Cloudy Bay Lagoon Marine Conservation Area
- Huon Estuary Marine Conservation Area

- Port Cygnet Marine Conservation Area
- River Derwent Marine Conservation Area
- South Arm Marine Conservation Area
- Ralphs Bay Conservation Area
- Southport Lagoon Conservation Area

Only 12% of the total mapped coastal saltmarsh was found to be associated with one of the above conservation areas. Notably, both Moulting Lagoon coastal complex and Pitt Water-Orielton Lagoon coastal complex were not associated with an MCA but are known to support significant marine values such as nursery grounds and habitat for various marine species (Parks and Wildlife Service, 2010 & 2003).

Threats to coastal saltmarshes were recorded where information was available or ground truthing carried out. Weeds and littering were noted to be the two most common land disturbances within saltmarsh patches. Four wheel driving was noted to be an important threat for specific coastal saltmarsh areas, given the level of damage that four wheel drives can cause. Tidal restriction and land filling were also an important source of land disturbance and can do long term damage to saltmarshes (especially in the case of land filling, the damage can often be irreversible). Sites where these activities were evident are noted in the inventory database.

Most commonly, agricultural land clearing and associated disturbances (e.g. weeds, grazing, nutrient enrichment) were noted to be the most prevalent adjacent land disturbance. Areas such as the Coal River saltmarshes are an example of such adjacent land disturbances. Built environments such as roads and housing areas were noted to be the second most important adjacent land disturbance. Ralphs Bay saltmarshes are a good example of where infrastructure, in this case a road, is an adjacent land disturbance.

The majority of coastal saltmarsh areas had minimal observable effects of eutrophication. However, several saltmarsh patches associated either with drains from housing/industrial areas (e.g. Carlton River saltmarsh for the former – Figure 10, Barilla Bay saltmarsh for the latter –Figure 5) or with artificially fertilised agricultural lands (Coal River/Duckhole Rivulet saltmarshes) showed strong signs of eutrophication. The effect of eutrophication in these affected saltmarshes has left noticeable 'rotten spots' devoid of plant cover.

The results of the SLR modelling, where Tasmanian Coastal Inundation Mapping data was available, paints a positive picture for coastal saltmarshes in southern Tasmania. For areas where modelling data was available, about a quarter of the total saltmarsh area was recorded as having 'sufficient room to move', meaning the saltmarsh patch can retreat inland and maintain its position and function in the landscape. Furthermore, close to half of the total saltmarsh area (where modelling data was available) was recorded as having 'some room to move', whereby saltmarshes can move into immediately adjacent low lying areas but their extent is lesser than the current extent of the saltmarsh.

Thus in total approximately 75% of the saltmarsh area, where modelling data was available, has been found to have room to move.

Saltmarsh clusters that showed good results in regards to having 'sufficient room to move' include Great Bay Wetland cluster, Ralphs Bay-South Arm cluster, Clarence Plains Rivulet cluster, Browns River cluster, Surges May Marsh cluster, Huon River Marsh cluster, Sherbourne Bay cluster, Pelican Bay cluster, Swan River-King Bay cluster, Great Swanport Fringing Marsh cluster, Penna Beach cluster, Orielton Lagoon cluster, Hobart Airport cluster, Pipe Clay Lagoon cluster, Dunalley Bay cluster, North West Bay River-Margate Rivulet cluster, Snug River and Snug Bay and Creek cluster and Bells Lagoon cluster.

In comparison, about 17% of the total saltmarsh area (where modelling data was available) was recorded as 'backed by steep upland' indicating that there are no low lying areas immediately adjacent to the saltmarsh patch for the saltmarsh to move into.

As highlighted in 3.3.6.1 saltmarsh polygons that occurred outside the areas where storm-flood modelling data was available accounted for about 30% of the total saltmarsh area mapped. This figure excludes the Apsley Marshes.

Suggested management actions were variable from site to site depending on location, condition, evidence of pressures, and associated values etc. One of the most recurrent management actions suggested in the inventory database was to establish buffer zones along the saltmarsh terrestrial boundary through revegetation or regeneration. A buffer of about 50–200 m can be considered for saltmarshes depending on the area of the saltmarsh patch along with the catchment area and land use. Site specific management recommendations are included in the inventory database where information was available or ground truthing carried out.

# 5. Developing a Ecosystem Based Management Approach

## 5.1. Ecosystem Based Management

An **ecosystem based management approach** for coastal saltmarshes embraces the understanding and management of individual saltmarsh patches in the context of the broader coastal and terrestrial context (Figure 17). Saltmarsh patches are geomorphic habitats that are shaped by surrounding landscape and coastal processes (e.g. Allen, 2000). Coastal saltmarsh patches form part of broader clusters of costal saltmarshes and clusters of saltmarsh form part of larger coastal saltmarsh complexes, which have been identified at the regional scale from an aquatic ecosystem perspective.

Coastal complexes generally comprise various types of wetland habitats which exchange matter and energy over various spatial and temporal scales (e.g. Perillo et al., 2009; Weinstein and Kreeger, 2000) with adjoining terrestrial and coastal areas. Hence, managing coastal saltmarshes requires understanding of both the 'coastal context' and the 'terrestrial context'.

Implicit in the understanding of an ecosystem based management approach is recognition that the diversity and abundance of ecological components, processes and services increase with spatial scale and complexity (see Figure 17).

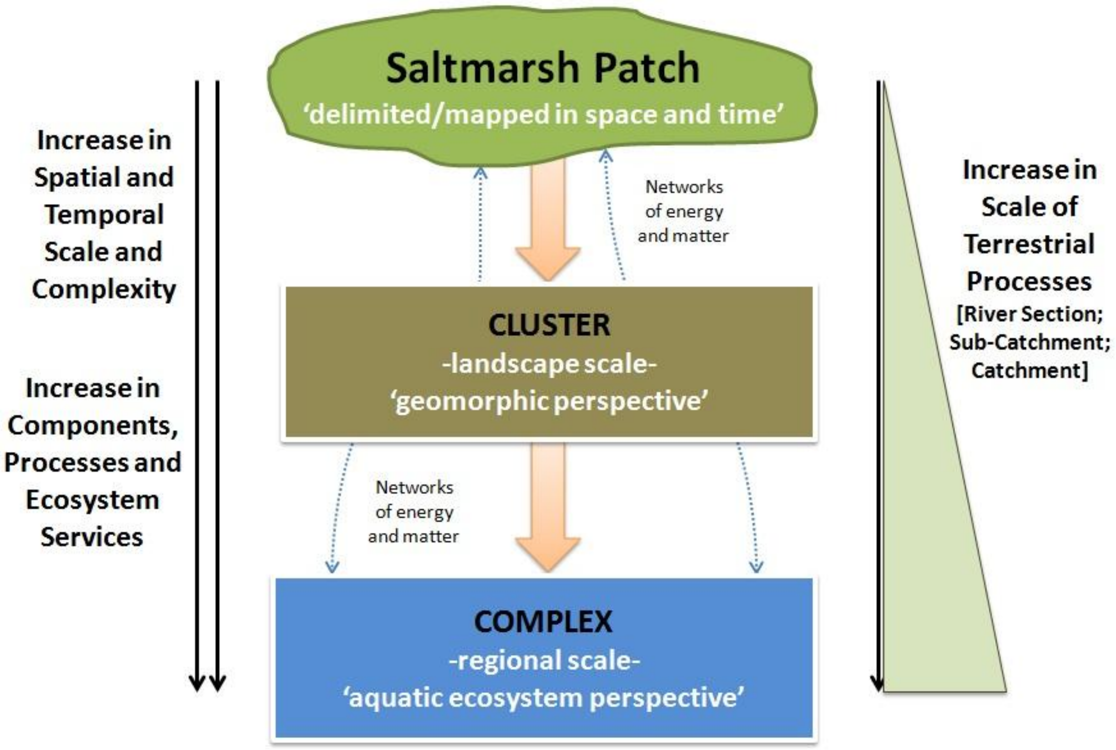


**Figure 17. An 'ecosystem based approach' for understanding and managing coastal saltmarshes with the three spatial (and temporal) scales with increasing levels of complexity and function.**

Management under an ecosystem based approach requires consideration of all the three spatial scales and, importantly, recognising the connections that exist between these spatial scales (i.e. networks of energy and matter, see Figure 17).

Two notable examples in southern Tasmania include Pitt Water-Orielton Lagoon (PWOL) (depicted in Figure 20) and Moulting Lagoon coastal complexes. These two complexes include the largest extent of saltmarshes recorded in southern Tasmania, have extensive areas of seagrass beds and other marine habitats, and support numerous elements of biodiversity including abundant commercially/recreationally harvested fish species, and important bird populations.

Under an ecosystem based approach, the management of saltmarsh patches in these areas cannot be done in isolation to the broader coastal complex, and further, the management of important elements of biodiversity supported by these coastal complexes cannot be undertaken in isolation to the saltmarshes. Also in need of consideration are the terrestrial processes that affect coastal complexes through networks of freshwater, sediment and nutrient flows, among others. Essentially, management should focus on multi-scale processes (or connections, networks) that shape and sustain key components of the system and provide essential ecosystem services.

This approach has been detailed in a publication by UNEP titled 'Taking Steps toward Marine and Coastal Ecosystem-Based Management' (UNEP, 2011). As outlined in the guide, 'ecosystem approach is a strategy for the integrated management of land, water and living resources that provides sustainable delivery of ecosystem services in an equitable way' (UNEP, 2011, p. 13). The five core elements of management with an ecosystem approach as outlined by UNEP are:

- **Recognising connections within and across ecosystems** (e.g. between saltmarshes, seagrass beds, intertidal flats and other marine habitats)
- **Utilising an ecosystem services perspective** (e.g. as summarised in section 1.2 Saltmarsh Ecosystem Services)
- **Addressing cumulative impacts** (e.g. land clearing, eutrophication, inappropriate coastal development)
- **Managing for multiple objectives** (e.g. improving fisheries, increasing water quality, providing for bird habitat)
- **Embracing change, learning, and adapting** (e.g. planning for sea level rise).

The first step in the process should be to consider the three spatial scales relevant to saltmarshes. In the first instance, a saltmarsh cluster is recommended to be the most appropriate scale to consider and plan for management given the nature of the landscape scale terrestrial and coastal influences that affect the condition and function of saltmarsh sites, including river and creek flow regimes and water quality, adjacent and surrounding sub-catchment land uses, localised habitat values of fauna such as birds, and so on. The second step in the management process would be to link clusters at higher organisational scales as coastal complexes and manage for large scale aquatic ecosystems for multiple objectives (e.g. improving fisheries, increasing water quality, providing for bird habitat). This approach is currently being promoted by the Australian Government's Aquatic Ecosystem Task Group (AETG) under their High Ecological Value Aquatic Ecosystem (HEVAE) framework (Auricht, 2011).

Another aspect of ecosystem based management is the consideration of predicted changes. Studying these changes both spatially and temporally can improve understanding of adaptation pathways which can be used to inform management which also supports the maintenance or enhancement of ecological functions and services . As a significant part of the project, projected sea level rise scenarios have been taken into account and retreat areas (future footprints) have been identified. Indeed, close to 75% of the total saltmarsh area in the region, with modelling data, have been found to have room to move.

These identified areas provide potential for supporting future saltmarsh areas and in general allowing the coastal complex to adjust by moving upwards and landwards (Figure 18). While each coastal complex is made up of many habitats zoned across the tidal profile, each of these habitats or habitat zones can be expected to move upwards and landwards (e.g. Pethick, 1993). Saltmarshes are at the frontline of change, being at the terrestrial boundary of the coastal complex, and require high priority ecosystem based management planning for accommodation with projected sea level rise.

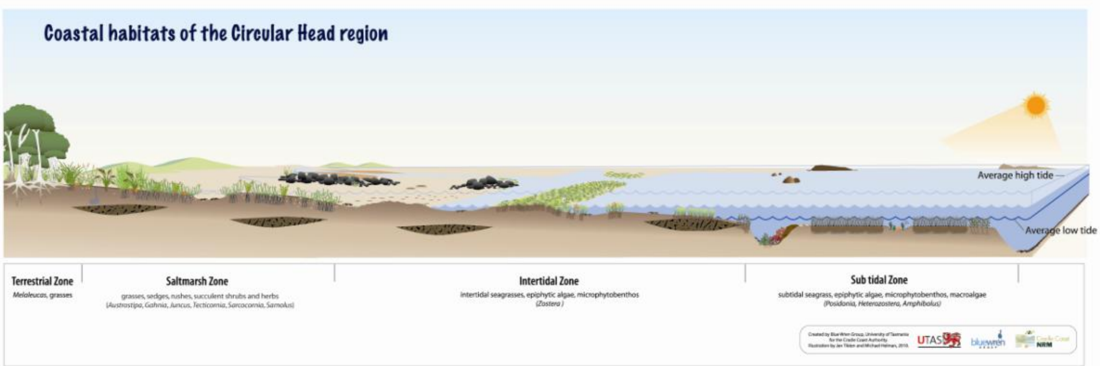


**Figure 18. Cross section view of the coastal complexes (i.e. continuum of coastal habitats divided into four zones) of the Circular Head region, and relatively applicable for southern Tasmania. Reproduced from Mount et al. (2010) and used here with permission from Cradle Coast NRM.**

Managing from an ecosystem based perspective would, however, require further examination into the connections (or processes, networks) that exists between saltmarsh clusters and their coastal complexes as they are still scantily understood and poorly appreciated (Boon, 2012). Hence further work bringing together data relating to individual components of biodiversity and drawing out networks/processes between the individual components will be of value. Establishing the linkages between ecosystem function and services can also lead to greater appreciation of the need for ecosystem based management.

The saltmarsh inventory endeavours to provide the necessary background for progress in this direction. For example, if more values are identified and strongly associated with saltmarshes and their coastal complexes, their importance from an ecosystem services perspective is further understood and can be translated to management. The inventory database fields also provide a basis for identifying future research questions to gain deeper insights into saltmarshes and their coastal complexes.

## 5.2. Saltmarsh Management Network

In following an **ecosystem based approach**, a management network is outlined for coastal saltmarshes that links the different geographic scales that saltmarshes can be considered to stakeholders in the management network (Figure 19).

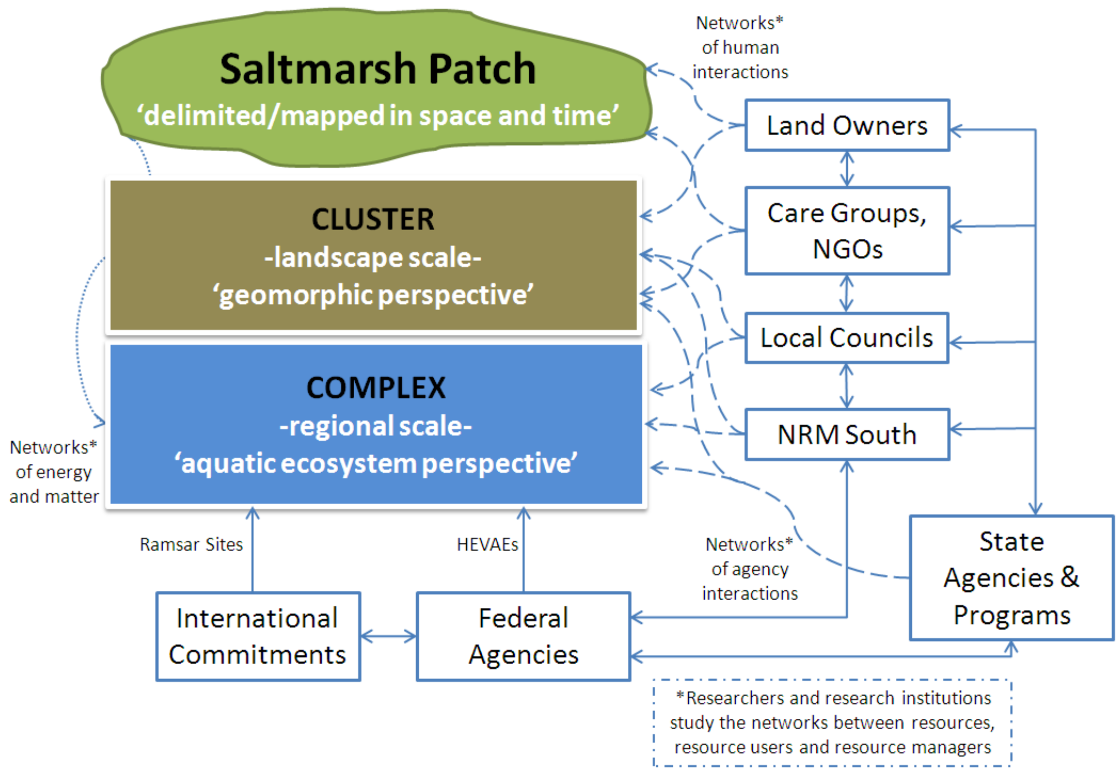


**Figure 19. Coastal saltmarsh management network. Hollow boxes show the various 'nodes of the network' that differentially affect saltmarsh management at multiple scales/levels of organisation. Ramsar Sites and High Ecological Value Aquatic Ecosystems (HEVAEs) are two key management approaches that similarly focus on managing for multiple objectives at the level of organisation of coastal complexes.**

The following text explores some of the linkages and areas of work and/or influence in the saltmarsh management network in southern Tasmania, as presented in Figure 19. As illustrated by the boxes in Figure 19, the nodes in the network are many and the associated roles, responsibilities and areas of influence (as shown by the arrows) are also many and varied across the various spatial scales.

At the patch scale saltmarshes overlap with various land use types. Land managers and private owners undertake various land use activities within the broader context of the requirements of the various federal and state land tenures or municipal land use planning zones. Land managers include councils, state agencies and in some cases non-government organisations (NGOs). Also at this scale, care groups and some NGOs operate alongside land owners and managers (i.e. on both public and private land) playing an important role in delivery of on-ground management works and raising awareness about the values and services of coastal saltmarshes (e.g. see Figure 21).

In addition to working at the patch scale as a land manager, State agencies also work at the other two scales in the saltmarsh management network, providing protection and management guidance through legislation, policy and strategies (e.g. *Nature Conservation Act 2002*, State Coastal Policy 1996, Wetland Strategy 2003) and data and information tools (e.g.

Conservation of Fresh Water Ecosystems Values, Coastal Works Manual 2010, Water Information Systems, TASVEG).

Many of the nodes of the NRM management network also work in partnership with federal agencies for funding and research collaboration to further NRM activities (e.g. Caring for our Country initiative, Aquatic Ecosystem Task Group). Nationally, the main scale of consideration for management is large aquatic ecosystems of national prominence, such as 'aquatic ecosystem' under the HEVAE framework (or coastal complexes). This scale is consistent with many Ramsar Sites which occupy large areas encompassing several types of wetland habitats occurring as a 'wetland complex' of international and national prominence.

An example of the interplay of various saltmarsh stakeholders as highlighted in Figure 17 can be seen for the Pitt Water-Orielton Lagoon coastal complex (see Figure 20). Two local councils (Sorell and Clarence City) are involved in management at the cluster level. While council's direct on-ground management actions are limited to council owned land, they control land use activities on private land through the planning scheme and therefore play an important role in planning for appropriate development or preventing inappropriate development and land use activities on private land where important environmental values, such as saltmarshes, exist.

Large areas of land in the PWOL complex, mostly on the marine side, are under State management (partly as Pitt Water Nature Reserve), while most other areas especially on the terrestrial side are within private ownership. Hence the multiple land tenures within this complex include two councils, DPIPWE and many private land owners. Recent collaborative projects with Sorell Council, Parks and Wildlife Service, NRM South and BirdLife Australia (Tasmanian Branch) have delivered collaborative management in the broader area through coordination of on-ground works activities, engagement with private land owners, information dissemination and awareness raising with the surrounding community. Similar collaborative endeavours have involved some private land owners in the PWOL complex within State agencies as part of the Protected Areas on Private Land (PAPL) program.

There is an increasing need for all nodes of the management network to work together. Historically, the nodes of network such as land owners, care groups, NGOs, local councils, State agencies and NRM bodies have largely tended to be either site specific or activity specific. Such activities and initiatives, while beneficial for promoting saltmarsh health, are in themselves not integrated or cumulative enough to address increasing pressures at multiple spatial and temporal scales across the coastal saltmarsh complex. This can be evidenced by the levels of historical degradation that is currently reported for the PWOL area (Prahalad, 2009).


**Figure 20. Pitt Water-Orielton Lagoon coastal complex (also a Ramsar Site) with its 11 saltmarsh clusters falling under two local council areas and a variety of land tenures.**

## 5.3. Management Options Summary

To answer the central question underlying this report, i.e. is there a future for coastal saltmarshes in southern Tasmania? The answer is yes, but it needs to be a **shared future** contingent on providing space for coastal saltmarshes to move with SLR and the adoption of a more integrated and coordinated ecosystem based approach to management. The responsibility for the future of saltmarshes is shared between all the stakeholders in the management network identified in Figure 19 above. Below are a few ways through which integrated management can be progressively improved with the involvement of the various nodes in the network.

**State Agencies**

The State Government has varying roles when it comes to initiatives that relate to saltmarsh management. The State Government's Department of Primary Industries, Parks, Water and Environment (DPIPWE) administers the *Nature Conservation Act* (*NCA*) *2002* and is responsible for listing threatened communities under this Act. There is a good case for listing Tasmanian saltmarsh communities under the NCA, particularly as more data becomes available to support the listing (summarised in Table 1).

The Parks and Wildlife Service (PWS) manage saltmarshes under the *National Parks and Reserves Management Act 2002* where it is found on reserved land (approximately 23% of saltmarshes). PWS has responsibility for delivering on-ground management such as access control, weed management, and management of other pressures from surrounding land and land use activities. State agencies are well positioned to enhance integration and multi-stakeholder/objective based management at the scale of complexes (also see Prahalad and Kriwoken, 2010).

A Natural Heritage Strategy is also currently being prepared by DPIPWE. This high level document will inform future management priorities for threatened species, threatened communities and nature conservation more generally. At the time of writing this report, the detail for this strategy was still in development, however priorities for coastal and wetland systems were expected to be included and could further guide ecosystem based management.

DPIPWE programs such as the Protected Areas on Private Land (PAPL) and Land for Wildlife involve private land holders as mentioned previously. Programs such as this provide opportunity to engage with private land owners who own saltmarsh areas which may be suitable for conservation. Under these programs covenants for high value coastal saltmarshes and wetlands and their future footprints may also be a viable management option.

PWS plays a significant role in supporting care groups to undertake conservation and management activities on their land. Fostering increased interest in saltmarsh habitats and supporting management actions which aim to maintain and enhance saltmarsh condition and function at the patch scale, while also being consistent with the management needs of the broader complex, is a further area that PWS can influence with their volunteer groups.

DPIPWE also manages TASVEG (Tasmanian Vegetation Monitoring and Mapping Program) on a state-wide basis. While TASVEG mapping is done at a broader scale (1:25 000) than the mapping done as part of this project, it is still a very useful tool for broader scale planning and management. Continual updates as new data becomes available ensures that this mapping tool is as up to date and useful as possible.

**NRM South**

NRM regions can also play a key role in facilitating coordinated ecosystem based management within the region by working at different scales with various stakeholders. The inventory database and mapping made available through this project supports the identification and assessment of management needs at all three management scales, i.e. complex, cluster and site. Given that saltmarshes often cross administrative boundaries, a landscape scale, cross tenure approach to management is essential and can be supported by regional bodies.

With baseline inventory information now available for a large proportion of the southern NRM region, there is an opportunity to update this inventory as new information and data becomes available and as management actions are rolled out.

As data custodians for the database and mapping layers produced as part of this project, NRM South has a strong interest in using this to build the information and knowledge base for coastal saltmarshes in the southern region into the future.

With ongoing funding opportunities for landscape scale natural resource management through programs such as Caring for our Country and Biodiversity Fund, there are opportunities to further saltmarsh restoration and management through an ecosystems based management approach. Future collaborative projects which target key complexes and adopt an ecosystem based approach should be well positioned for funding, particularly when the current nomination of Subtropical and Temperate Coastal Saltmarsh is consummated under the federal *Environment Protection and Biodiversity Conservation Act 1999* (assessment of the nomination ongoing until mid 2013).

Continuing to consider saltmarshes and their ecosystem services in NRM regional plans, catchment plans and other strategies and planning documents is essential if saltmarshes are to become a more valued and 'visible' component of marine and terrestrial landscapes.

**Local Councils**

As both planning authorities and land managers, councils also play a lead role in the long term protection and management of saltmarsh areas within their jurisdiction, both through land use planning and the management of saltmarsh habitats on council owned or managed land.

Planning for land uses that are not in conflict with natural values, including saltmarshes, is increasingly important as population growth continues to drive urban, peri-urban and agricultural expansion, and pressures on natural values and the ecosystems services they provide grows. Climate change induced sea level rise is an additional pressure that will impact coastal environments, including saltmarshes in the future. Land use planning that allows space for landward movement of saltmarshes with sea level rise is increasingly important if we are to maintain these habitats and their services. The Derwent Estuary Program has created a discussion paper planning for saltmarsh refugia corridors, in their report 'Climate change mitigation – natural coastal assets: Derwent Estuary Program planning tool discussion paper for tidal wetlands & saltmarshes' (Whitehead, 2011). This report describes a possible local government planning option that could be applied more generally throughout the southern NRM region, and other parts of Tasmania as new information becomes available that identifies crucial areas of current saltmarsh and the areas needed for saltmarsh movement into the future as sea level rises. Key discussion points with key stakeholders for future progress in this area include:

- Potential to develop planning overlays, for i) current ii) near-future (e.g. to 2100) and iii) long–term future (refugia corridors beyond 2100) for tidal wetlands and saltmarsh extent. The creation of such planning overlays could be informed by mapping undertaken by Prahalad et al. (2009), the Derwent Estuary Program (Whitehead, 2011) and this NRM South report.

- Development of planning codes pertaining to the overlay areas that find an appropriate balance between infrastructure development, land use activities, and long term sustainability of tidal wetlands and saltmarshes.

There are opportunities for local councils to further saltmarsh management at the cluster and complex scale, building on past and current works. With saltmarsh habitats often crossing land tenures, councils can also play a key role in communicating and coordinating with other land managers/owners to ensure that management actions are consistent and consider the landscape/ecosystem perspective.

Recognising saltmarshes in council plans and strategies such as biodiversity strategies and reserve management plans is also essential to raising the profile of saltmarshes and their ecosystem services and advancing strategic, coordinated management.

Councils play a significant role in supporting care groups in their municipalities. As such there is an opportunity for councils to foster increased interest in saltmarsh habitats with care groups as well as the broader community. Local works that involve the community and councils working together and considering saltmarshes as an integral part of the local coastal/estuarine environment would further benefit saltmarsh conservation and management. Tools such as conceptual diagrams of saltmarshes (such as in Figure 2) may also be useful for increasing understanding of the values and services of saltmarshes as part of the broader coastal system.

Councils can also be a key agent in improving understanding and information about saltmarsh ecosystem dynamics for sites/clusters in priority management areas within their jurisdiction. New data can be used to improve the broader understanding of saltmarsh complexes to inform future management needs as well as help maintain the regional data set to improve the broader understanding of these communities.

**Care Groups**

Some care groups in southern Tasmania have been very active in saltmarsh restoration and conservation activities, and have also played a key role in raising awareness within other stakeholders and the broader community (e.g. see Figure 21). Championing saltmarshes and bringing attention to their values and management needs is important from all nodes in saltmarsh management network, however care groups are particularly well positioned to promote the local values and management needs within their community networks.

Care groups are a significant asset to land managers in the delivery of local scale on-ground works. Groups often develop site based management or actions plans in partnership with land managers to guide their on-ground works. Where relevant, there is opportunity to ensure that saltmarshes are factored in such plans to facilitate patch scale outcomes which are also consistent with cluster and complex scale needs and issues.

Tranmere-Clarence Plains Land & Coastcare is one example of a care group actively championing and managing a saltmarsh area.

This group has developed an informal management agreement with the land owner and has undertaken on-ground activities such as fencing, weed control and establishing a vegetative buffer zone (Figure 21). This work has been very successful and the group has promoted their efforts and outcomes in order to raise awareness and share learning with various stakeholders and the wider community at events such as the Seafarers Festival.


**Figure 21. Part of the action undertaken by a coastcare group, namely the Tranmere-Clarence Plains Land & Coastcare Inc., to conserve and sustainably manage their local saltmarsh.**

In the future there is opportunity to further connect care groups with saltmarsh habitats in their geographical areas of interest to strengthen stewardship of saltmarsh habitats. Having community members as champions and educators highlighting the many and varied values of saltmarshes within the broader community as well as with land owners and managers will further enhance the likelihood of achieving good outcomes for saltmarshes into the future.

**Non-Government Organisations (NGOs)**

There are a range of NGOs in southern Tasmania in the coastal/NRM space with a range of management aims and objectives. Some organisations operate more in the realm of supporting and facilitating opportunities for care groups, such as the Southern Coastcare Associate of Tasmania (SCAT) and the Tasmanian Landcare Association, while others are involved in more direct land conservation initiatives such as the Tasmanian Land Conservancy (TLC). There are many ways in which NGOs can help to educate, advocate, facilitate, build understanding through research or deliver direct conservation actions in support of saltmarsh restoration and management at the local and landscape scales.

**Land Owners**

Through many of the above organisations there is a wide range of opportunities for land owners to access grants, land owner incentives, volunteer support, information products, technical assistance, and training/educational opportunities. By getting involved in NRM networks, land owners can readily access many of these opportunities to their advantage.

There is also a range of ways land owners can voluntarily conserve environmental values on their land through management agreements, conservation covenants (where criteria is met), or involvement with programs such as Land for Wildlife.

In the future national programs such as the Biodiversity Fund and the Carbon Farming Initiative are likely to offer more opportunities for land owners to protect natural values represented in saltmarshes and enhance carbon sequestration.

**Researchers and Research Bodies**

Several researchers and research bodies have undertaken research on saltmarsh and coastal wetland/estuarine ecology and management. Continued efforts to publish and publicise studies that highlight key values derived from healthy functioning of saltmarsh habitats within their coastal complexes and highlighting the economic rationale for improved management and conservation will further advance management of these important habitats and associated services.

A collaborative way forward in the future may be to develop comprehensive management strategies with specific objectives for key saltmarsh complexes. These could involve local councils as active land managers and planners; state agencies as larger scale land managers; and private land owners, care groups and NGOs with interests in site specific management measures. These strategies could serve to further engender a sense of ownership of coastal saltmarshes, increase recognition of the connections that occur within a coastal complex and improve understanding of the ecosystem services made available through healthy functioning saltmarshes.

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# Appendix 1: List of Aerial Photos Used in Mapping

| FILM_NEG | FILM_NO | NEG_NO | M_PROJ_NO | AP_SCALE | FLY_DATE | AP_SEASON |
|---|---|---|---|---|---|---|
| 1343-149 | 1343 | 149 | A135 | 24000 | 09-JAN-01 | 00-01 |
| 1343-025 | 1343 | 25 | A135 | 24000 | 09-JAN-01 | 00-01 |
| 1346-127 | 1346 | 127 | A135 | 24000 | 17-FEB-01 | 00-01 |
| 1343-002 | 1343 | 2 | A135 | 24000 | 09-JAN-01 | 00-01 |
| 1344-059 | 1344 | 59 | A135 | 24000 | 21-JAN-01 | 00-01 |
| 1343-113 | 1343 | 113 | A135 | 25500 | 09-JAN-01 | 00-01 |
| 1343-023 | 1343 | 23 | A135 | 24000 | 09-JAN-01 | 00-01 |
| 1343-121 | 1343 | 121 | A135 | 24000 | 09-JAN-01 | 00-01 |
| 1341-254 | 1341 | 254 | A135 | 24000 | 03-JAN-01 | 00-01 |
| 1346-210 | 1346 | 210 | A135 | 24000 | 26-FEB-01 | 00-01 |
| 1343-015 | 1343 | 15 | A135 | 24000 | 09-JAN-01 | 00-01 |
| 1343-132 | 1343 | 132 | A135 | 24000 | 09-JAN-01 | 00-01 |
| 1343-134 | 1343 | 134 | A135 | 24000 | 09-JAN-01 | 00-01 |
| 1346-207 | 1346 | 207 | A135 | 24000 | 26-FEB-01 | 00-01 |
| 1343-009 | 1343 | 9 | A135 | 24000 | 09-JAN-01 | 00-01 |
| 1343-013 | 1343 | 13 | A135 | 24000 | 09-JAN-01 | 00-01 |
| 1344-069 | 1344 | 69 | A135 | 24000 | 21-JAN-01 | 00-01 |
| 1345-057 | 1345 | 57 | A135 | 24000 | 31-JAN-01 | 00-01 |
| 1343-126 | 1343 | 126 | A135 | 24000 | 09-JAN-01 | 00-01 |
| 1344-061 | 1344 | 61 | A135 | 24000 | 21-JAN-01 | 00-01 |
| 1341-256 | 1341 | 256 | A135 | 24000 | 03-JAN-01 | 00-01 |
| 1344-057 | 1344 | 57 | A135 | 24000 | 21-JAN-01 | 00-01 |
| 1382-196 | 1382 | 196 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-078 | 1383 | 78 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-042 | 1383 | 42 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-062 | 1383 | 62 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1382-207 | 1382 | 207 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1382-197 | 1382 | 197 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1374-219 | 1374 | 219 | A135 | 24000 | 29-NOV-03 | 03-04 |
| 1383-082 | 1383 | 82 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1382-198 | 1382 | 198 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1382-251 | 1382 | 251 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-047 | 1383 | 47 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1374-221 | 1374 | 221 | A135 | 24000 | 29-NOV-03 | 03-04 |
| 1374-225 | 1374 | 225 | A135 | 24000 | 29-NOV-03 | 03-04 |
| 1383-051 | 1383 | 51 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1382-209 | 1382 | 209 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-060 | 1383 | 60 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-064 | 1383 | 64 | A135 | 24000 | 28-MAR-04 | 03-04 |

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|---|---|---|---|---|---|---|
| 1383-073 | 1383 | 73 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1382-135 | 1382 | 135 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-040 | 1383 | 40 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-004 | 1383 | 4 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-079 | 1383 | 79 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-036 | 1383 | 36 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-044 | 1383 | 44 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1382-190 | 1382 | 190 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-032 | 1383 | 32 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-038 | 1383 | 38 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1374-223 | 1374 | 223 | A135 | 24000 | 29-NOV-03 | 03-04 |
| 1383-030 | 1383 | 30 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-053 | 1383 | 53 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-018 | 1383 | 18 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1382-164 | 1382 | 164 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-069 | 1383 | 69 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-002 | 1383 | 2 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-057 | 1383 | 57 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1382-243 | 1382 | 243 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-010 | 1383 | 10 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1382-241 | 1382 | 241 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-059 | 1383 | 59 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1380-227 | 1380 | 227 | A135 | 24000 | 11-MAR-04 | 03-04 |
| 1383-016 | 1383 | 16 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-028 | 1383 | 28 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1382-211 | 1382 | 211 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-061 | 1383 | 61 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1382-205 | 1382 | 205 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1382-137 | 1382 | 137 | A135 | 24000 | 28-MAR-04 | 03-04 |
| 1383-071 | 1383 | 71 | A135 | 24000 | 28-MAR-04 | 03-04 |
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| 1390-241 | 1390 | 241 | A110 | 42000 | 25-JAN-05 | 04-05 |
| 1394-059 | 1394 | 59 | A110 | 42000 | 13-MAR-05 | 04-05 |
| 1394-071 | 1394 | 71 | A110 | 42000 | 13-MAR-05 | 04-05 |
| 1396-054 | 1396 | 54 | A133 | 42000 | 30-MAR-05 | 04-05 |
| 1394-096 | 1394 | 96 | A110 | 42000 | 13-MAR-05 | 04-05 |
| 1391-013 | 1391 | 13 | A110 | 42000 | 25-JAN-05 | 04-05 |
| 1390-244 | 1390 | 244 | A110 | 42000 | 25-JAN-05 | 04-05 |
| 1390-194 | 1390 | 194 | A110 | 42000 | 25-JAN-05 | 04-05 |
| 1391-090 | 1391 | 90 | A110 | 42000 | 25-JAN-05 | 04-05 |
| 1391-019 | 1391 | 19 | A110 | 42000 | 25-JAN-05 | 04-05 |
| 1391-084 | 1391 | 84 | A110 | 42000 | 25-JAN-05 | 04-05 |

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|---|---|---|---|---|---|---|
| 1402-131 | 1402 | 131 | A147 | 20000 | 07-JAN-06 | 05-06 |
| 1396-074 | 1396 | 74 | A118 | 42000 | 06-NOV-05 | 05-06 |
| 1402-112 | 1402 | 112 | A147 | 20000 | 07-JAN-06 | 05-06 |
| 1407-198 | 1407 | 198 | A118 | 42000 | 02-MAR-06 | 05-06 |
| 1407-117 | 1407 | 117 | A118 | 42000 | 02-MAR-06 | 05-06 |
| 1407-114 | 1407 | 114 | A118 | 42000 | 02-MAR-06 | 05-06 |
| 1402-133 | 1402 | 133 | A147 | 20000 | 07-JAN-06 | 05-06 |
| 1402-096 | 1402 | 96 | A147 | 20000 | 07-JAN-06 | 05-06 |
| 1402-111 | 1402 | 111 | A147 | 20000 | 07-JAN-06 | 05-06 |
| 1406-218 | 1406 | 218 | A118 | 42000 | 02-MAR-06 | 05-06 |
| 1407-204 | 1407 | 204 | A118 | 42000 | 03-MAR-06 | 05-06 |
| 1407-015 | 1407 | 15 | A118 | 42000 | 02-MAR-06 | 05-06 |
| 1396-148 | 1396 | 148 | A118 | 42000 | 06-NOV-05 | 05-06 |
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| 1402-134 | 1402 | 134 | A147 | 20000 | 07-JAN-06 | 05-06 |
| 1402-094 | 1402 | 94 | A147 | 20000 | 07-JAN-06 | 05-06 |
| 1396-147 | 1396 | 147 | A118 | 42000 | 06-NOV-05 | 05-06 |
| 1402-098 | 1402 | 98 | A147 | 20000 | 07-JAN-06 | 05-06 |
| 1396-152 | 1396 | 152 | A118 | 42000 | 06-NOV-05 | 05-06 |
| 1407-196 | 1407 | 196 | A118 | 42000 | 02-MAR-06 | 05-06 |
| 1421-273 | 1421 | 273 | A110 | 42000 | 13-FEB-07 | 06-07 |
| 1422-050 | 1422 | 50 | A110 | 42000 | 13-FEB-07 | 06-07 |
| 1421-224 | 1421 | 224 | A110 | 42000 | 13-FEB-07 | 06-07 |
| 1422-055 | 1422 | 55 | A110 | 42000 | 13-FEB-07 | 06-07 |
| 1421-270 | 1421 | 270 | A110 | 42000 | 13-FEB-07 | 06-07 |
| 1422-006 | 1422 | 6 | A110 | 42000 | 13-FEB-07 | 06-07 |
| 1422-060 | 1422 | 60 | A110 | 42000 | 13-FEB-07 | 06-07 |
| 1426-081 | 1426 | 81 | A135 | 24000 | 02-DEC-07 | 07-08 |
| 1426-079 | 1426 | 79 | A135 | 24000 | 02-DEC-07 | 07-08 |
| 1426-072 | 1426 | 72 | A135 | 24000 | 02-DEC-07 | 07-08 |
| 1426-199 | 1426 | 199 | A135 | 24000 | 03-JAN-08 | 07-08 |
| 1433-102 | 1433 | 102 | A135 | 24000 | 18-FEB-08 | 07-08 |
| 1426-212 | 1426 | 212 | A135 | 24000 | 03-JAN-08 | 07-08 |
| 1430-054 | 1430 | 54 | A135 | 24000 | 25-JAN-08 | 07-08 |
| 1426-076 | 1426 | 76 | A135 | 24000 | 02-DEC-07 | 07-08 |
| 1426-211 | 1426 | 211 | A135 | 24000 | 03-JAN-08 | 07-08 |