***Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (s266B)**
Conservation Advice for

SUBTROPICAL AND TEMPERATE COASTAL SALTMARSH

1. The Threatened Species Scientific Committee (the Committee) was established under the EPBC Act and has obligations to present advice to the Minister for the Environment, Heritage and Water (the Minister) in relation to the listing and conservation of threatened ecological communities, including under sections 189, 194N and 266B of the EPBC Act.

2. The Committee provided its advice on the *Subtropical and Temperate Coastal Saltmarsh* ecological community to the Minister as a draft of this approved Conservation Advice. In 2013, the Minister accepted the Committee's advice, adopting it as the approved Conservation Advice.

3. The Minister amended the list of threatened ecological communities under section 184 of the EPBC Act to include the *Subtropical and Temperate Coastal Saltmarsh* ecological community in the **vulnerable** category. It is noted that the *Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions* listed as endangered under the New South Wales *Threatened Species Conservation Act 1995* corresponds in part to the *Subtropical and Temperate Coastal Saltmarsh* ecological community. Currently, Queensland, Victoria, Tasmania, South Australia and Western Australia do not list this ecological community.

4. The nomination and a draft description for this ecological community were made available for expert and public comment for a minimum of 30 business days. The Committee and Minister had regard to all public and expert comment that was relevant to the consideration of the ecological community.

5. This approved Conservation Advice has been developed based on the best available information at the time it was approved; this includes scientific literature, government reports, advice from consultations with experts, and existing plans, records or management prescriptions for this ecological community.

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1. DESCRIPTION

The ecological community consists of organisms including and associated with saltmarsh in coastal regions of sub-tropical and temperate Australia.

Name of the ecological community

A public nomination was received to list *Subtropical and Temperate Coastal Saltmarsh* as a threatened ecological community under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Threatened Species Scientific Committee recommended that it be assessed and it was placed on the 2010 Finalised Priority Assessment List (FPAL) with an assessment period ending in June 2013. The name of the ecological community is as nominated, as it clearly represents the key environmental location, wetland type, and vegetation.

Location

The *Subtropical and Temperate Coastal Saltmarsh* (hereafter *Coastal Saltmarsh*) ecological community occurs within a relatively narrow margin of the Australian coastline, within the subtropical and temperate climatic zones south of the South-east Queensland IBRA bioregion boundary at 23° 37' latitude along the east coast and south of (and including) Shark Bay at 26° on the west coast.

The ecological community spans six State jurisdictions: Queensland (southern), New South Wales, Victoria, Tasmania, South Australia and Western Australia (south-western). Based on the distribution of tropical and subtropical saltmarsh species and the analysis of Saenger et al. (1977) and Bridgewater and Cresswell (2003), Shark Bay (at about 26° latitude) is the most appropriate northern limit for *Coastal Saltmarsh* (G Keighery pers. comm.) on the west coast of Australia. At Shark Bay there is a transition zone for many saltmarsh species. For example, several tropical *Tecticornia* species[1] change over in this area, and a number of south-western species end at Shark Bay, such as some *Samolus* species[2] (G. Keighery pers. comm.).

Coastal saltmarsh occurring on islands within the geographic range is also included within the ecological community.

Physical environment

The physical environment for the ecological community is coastal areas under regular or intermittent tidal influence. In southern latitudes saltmarsh is often the main vegetation-type in the intertidal zone and commonly occurs in association with estuaries (Adam, 2002; Fairweather, 2011; Sainty et al., 2012). It is typically restricted to the upper intertidal environment, occurring in areas within the astronomical tidal limit, often between the elevation of the mean high tide and the mean spring tide (Saintilan et al., 2009). However, exceptions may occur that retain a regular or intermittent tidal connection and these are still considered to be the ecological community. For example, coastal saltmarsh may occur in intermittently open

[1] For example: *T. disarticulata*, *T. doleiformis*, *T. halocnemoides* subsp. *tenuis*, *T. indica* subsp. *leiostachya*, *T. pergranulata* subsp. *elongata*, *T. pterygosperma* subsp. *denticulata* and *T. pruinosa* (G. Keighery pers. comm.).
[2] For example: *Samolus repens* var *paucifolius* and *Samolus junceus* (G. Keighery pers. comm.).

lagoonal estuaries that are only intertidal when the lagoon is opened (which may only be for limited periods, with periods of several years of closure). Such estuaries, known as ICOLLs (intermittently closed and open lakes and lagoons), are common in NSW[3] and also occur in south-western Western Australia. Also, in South Australia there are extensive supratidal[4] saltmarsh communities which occur above the reach of astronomical tides, but are inundated by weather assisted tides (i.e. storm surges, e.g. Gulf St Vincent). Thus it occurs at places with at least some tidal connection, including rarely-inundated supratidal areas and intermittently opened or closed lagoons, but not areas receiving only aerosol spray (i.e. such as cliff tops).

The *Coastal Saltmarsh* ecological community may also include areas that have groundwater connectivity to tidal water bodies. For example, groundwater hydrology may play a role in the occurrence of species such as the nationally vulnerable *Tecticornia flabelliformis* (bead samphire) which has a preference for water logging (Coleman and Cook, 2008). Also, some sabka-related saltmarshes may be reliant on groundwater tidal flows.

Unlike eastern Australia, Western Australian coastal areas support an entire series of saline coastal wetlands that abut typical coastal saltmarshes. These include: saline lakes on the coast and offshore islands, coastal lagoons (open and closed) and the birridas (gypsum claypans) of Shark Bay. These wetlands are all connected to the sea in various ways, and contain typical saltmarsh vegetation (Keighery and Keighery, 2013a). As such they would be included within the ecological community. Many similar wetlands along the Western Australian coastline have lost their connection to the sea, for example the lagoon saline lakes of the Swan Coastal Plain (Keighery and Keighery 2013b), and it is likely that eventually others will also (G. Keighery, pers. comm.). These would not be considered as part of the ecological community if the disconnection were permanent.

Many authors (e.g. Laegdsgaard, 2006; Fotheringham and Coleman, 2008; VSS, 2011; Sainty et al., 2012a, b) have identified two types of saltmarsh based on elevation and the pattern and extent of tidal inundation: 'upper or high' and 'lower or low' and both occur in the ecological community. The seaward extent of the *Coastal Saltmarsh* ecological community is determined by the depth, duration and periodicity of tidal submergence, intensity and frequency of mechanical disturbance due to coastal processes (i.e. tidal or wave action), type of substratum (e.g. muddy vs. rocky), and mangroves (if present) (Adam, 2002; VSS, 2011). The landward extent is historically determined by the penetration of the highest tides but is now more often determined by man-made structures (e.g. sea walls, roads etc.).

Although tides are highly predictable, the interactions between tides, weather (e.g. evaporative loss), groundwater influences and vegetation result in complex patterns of environmental variation for the *Coastal Saltmarsh*. For example, on the NSW coast, spring tides reach their maximum inundation in summer and in winter (Saintilan, 2009a). Also, in some areas of the *Coastal Saltmarsh* ecological community, the upper regions may experience only irregular tidal inundation due to the highest tides or storm events (e.g. Fairweather, 2011). Thus the ecological community may occur in a range of environmental conditions - with the unifying

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[3] Of the 135 NSW estuaries, 67% (90) are ICOLLs (Intermittently Closed and Open Lakes and Lagoons) that are more than 1 ha in size (NSW DPI, undated).

[4] Supratidal zone (or supralitoral, splash zone) is the area above the spring high tide line on coastlines and estuaries that may receive regular or intermittent seawater via weather assisted tides such as storm surges in addition to the highest astronomical tides.

factor being some form of tidal connection and inundation, with most areas draining fully on the ebb tide (Connolly, 2009).

The *Coastal Saltmarsh* ecological community is mainly associated with the soft substrate shores of estuaries and embayments (sandy and/or muddy) and on some open, low wave energy coasts (Adam, 2009). Associated sediments generally consist of poorly-sorted anoxic sandy silts and clays, and may have salinity levels that are much higher than seawater due to evaporation (Fairweather, 2011; Oz Coasts, 2012). Although soil type does not seem to limit the development of saltmarsh vegetation, the drainage characteristics of coastal soils, along with tidal patterns and elevation, can strongly influence the distribution of flora and fauna within the *Costal Saltmarsh* ecological community (Clarke and Hannon, 1971; Fotheringham and Coleman, 2008; VSS, 2011). For example, the position of intertidal flats within an estuary will exert profound influences on water salinity, and provide a major control of the suite of saltmarsh species present (Saintilan et. al., 2009). Bare sediment areas, sometimes known as 'salt pannes (or pans)', or 'sabkah', can also be common amongst the complex vegetation mosaics of the ecological community (Fairweather, 2011).

Climate

There is a strong correlation between coastal saltmarsh distribution and diversity, and climate. Analysis has demonstrated a strong northern and southern division separated at around 23° 30' latitude (i.e. around the Tropic of Capricorn on the east coast) (Saintilan, 2009a, b; Saintilan and Rogers, 2013) and about 26° on the west coast (G. Keighery, pers. comm.). The relatively depauperate north corresponds broadly to the arid to wet tropical regions, while the highly diverse south (with a southerly increasing trend in species diversity with latitude) broadly corresponds with the warm subtropics to the cool temperate regions of Australia. The *Coastal Saltmarsh* ecological community occurs within this southern division.

Although mostly influenced by the tidal regime, temperature and local rainfall also exert an influence. For example, in Victoria, VSS (2011) distinguished two general forms of *Coastal Saltmarsh* based on climate (rain and evaporation), with saltmarsh differing greatly between the high ('wet') and low ('dry') rainfall areas. The driest form occurs in the central west where low summer rainfall and high temperatures can lead to intensely hypersaline conditions at the more elevated (but still tidal) sites (dominated by *Tecticornia pergranulata* and *T. halocnemoides*), while the wet form is found where rainfall is higher (dominated by *Sarcocornia* spp. and *Tecticornia arbuscula*) (VSS, 2011). Annual rainfall ranges from around 1000 mm in far south-west parts of eastern Victoria, to 400–600 mm in the rain shadow area of the western shores of Port Phillip Bay and parts of Gippsland. In these Mediterranean-climate regions, summers are typically hot and dry. This leads to hypersaline conditions developing over summer in the mid to upper *Coastal Saltmarsh* ecological community, relieved only by rainfall in the wetter seasons of autumn, winter and spring.

Similar high variations in rainfall occur across other jurisdictions. For example, Tasmanian *Coastal Saltmarsh* ecological community is reported to occur most often where the average rainfall ranges between 500 mm in the southeast to 1000 mm in the northwest (Kirkpatrick and Glasby, 1981; Prahalad and Pearson, 2012). However, there are no comprehensive national studies available to show how they relate to variations in flora composition.

Vegetation

The *Coastal Saltmarsh* ecological community consists mainly of salt-tolerant vegetation (halophytes) including: grasses, herbs, sedges, rushes and shrubs. Succulent herbs, shrubs and grasses generally dominate and vegetation is generally of less than 0.5 m height (with the exception of some reeds and sedges) (Adam, 1990; see also Sainty et al., 2012a, b for pictorial field guide). Many species of non-vascular plants are also found in saltmarsh, including epiphytic algae, diatoms and cyanobacterial mats (Adam, 2002; Fotheringham and Coleman, 2008; Green et al., 2012; Millar, 2012).

In Australia, the vascular coastal saltmarsh flora may include many species (well over 100), but it is dominated by relatively few families (Saintilan, 2009a, b; VSS, 2011; Sainty, 2012a, b). There is also often a high degree of endemism at the species level (Saintilan, 2009 a, b), although many non-endemic species also occur. This reflects the fact that only a select few families have the physiology to deal with the harsh saltmarsh environment. The two most widely represented coastal saltmarsh plant families are the Chenopodiaceae and Poaceae, however although the Chenopodiaceae has 228 species endemic to Australia, only 21 are found in *Coastal Saltmarsh*. Indicative families and dominant genera with several species present are shown in Table 1a and1b.

Coastal saltmarsh of South Australia has the highest floristic biodiversity (about 75% of saltmarsh plant species in Australia) and the ecological community often occurs in large areas behind the open coastline of sheltered waters such as in the Gulfs (Saintilan, 2009a,b; Fotheringham and Coleman, 2008; Fairweather, 2011). Species diversity of Western Australian saltmarsh is also high, at least 90 species, with many new taxa being identified (G. Keighery pers. comm. and see Table 2). There are several differences in species composition and abundance between the east and west coasts of Australia for *Coastal Saltmarsh*. For example, the south-west of Western Australia is an important region globally for high diversity and endemicity of several groups, such as *Tecticornia*, *Triglochin* (samphires), *Samolus* and *Puccinellia* (G. Keighery pers. comm.).

There is a strong trend of increasing diversity of saltmarsh plant species with increasing latitude, with the majority of species occurring southward of 23° 30' (which is just south of the Tropic of Capricorn) (Saintilan, 2009a,b; Saintilan and Rogers, 2013). Northern (tropical) Australia supports a relatively low diversity of saltmarsh plant species despite the large intertidal area available for colonisation - possibly due to climatic constraints.

Species characteristic of the ecological community, due to their dominance in at least some of its range, may include:

- *Austrostipa stipoides* (spear grass) – up to 1 m, in better drained landward margins.
- *Gahnia filum* (clumped sedge, can grow up to 1.5 m), with *Gahnia trifida* in WA.
- *Juncus kraussii* (sea rush) - dominates in fresher conditions in estuaries or seepage zones.
- *Samolus repens* (creeping brookweed, water pimpernel) - low-growing herb.

Table 1a and 1b: *Common families (1a) and dominant genera (1b) that often occur in the Coastal Saltmarsh ecological community, particularly on eastern and southern Australian coastline (Saintilan, 2009a, b; VSS, 2011).*

1a) Common Families	**Type**		**1b) Dominant Genera** [family]	**Common name**
Aizoaceae	shrub		*Atriplex* [Chenopodiaceae]	saltbush, orache
Amaranthaceae*	herb/shrub		*Austrostipa* [Poaceae]	spear grass, bamboo grass, foxtail, corkscrew
Apiaceae	herb/shrub		*Disphyma* [Aizoaceae]	noon flower
Asteraceae	herb		*Distichlis* [Poaceae]	saltgrass
Caryophyllaceae	herb		*Frankenia* [Frankeniaceae]	sea-heath
Chenopodiaceae*	herb/shrub		*Limonium* [Plumbaginaceae]	sea lavender
Convolvulaceae	shrub		*Juncus* [Juncaceae]	rushes
Cyperaceae	sedge		*Puccinellia* [Poaceae]	saltmarsh-grass
Frankeniaceae	herb/shrub		*Sarcocornia* [Chenopodiaceae]	beaded glasswort, beaded samphire
Juncaceae	rush		*Sporobolus* [Poaceae]	salt couch, saltwater couch, marine couch
Juncaginaceae	herb/grass		*Spergularia* [Caryophyllaceae]	sand-spurrey, sea-spurrey
Plumbaginaceae	herb/shrub		*Suaeda* [Chenopodiaceae]	Austral seablite, jellybean plant
Poaceae	grass		*Tecticornia* [Chenopodiaceae]	glasswort, blackseed samphire
			Triglochin [Juncaginaceae]	arrow grass, water ribbon (*T. procera*)
			Wilsonia [Convolvulaceae]	Wilsonia, bindweed

* Some taxonomists consider that the Chenopodiaceae are part of the Amaranthaceae (e.g. Duretto and Morris, 2011).

Table 2: *Species of coastal saltmarsh plants from Western Australia. Compiled by G. Keighery from various WA surveys and sources including: Webb et al., (2009), Keighery and Keighery (2013a, b), Western Australian Herbarium (2013). (* indicates exotic or native problem species)*

Aizoaceae
Carpobrotus modestus
Disphyma crassifolium subsp. *clavellatum*

Amaranthaceae
Hemichroa diandra
Hemichroa pentandra

Apiaceae
Apium annuum
Apium prostratum var. *prostratum*

Asteraceae
Angianthus micropodioides
Angianthus preissianus
Cotula coronopifolia
Cotula cotuloides
Senecio pinnatifolius
Sonchus hydrophilus

Caryophyllaceae
**Sagina maritima*
**Spergularia marina*
**Spergularia rubra*

Chenopodiaceae
Atriplex cinerea
Atriplex hypoleuca
Atriplex paludosa subsp. *baudinii*
**Atriplex prostrata*
Chenopodium glaucum subsp. *ambiguum*
Rhagodia baccata
Rhagodia crassifolia
Sarcocornia blackiana
Sarcocornia quinqueflora
Tecticornia disarticulata
Tecticornia doleiformis
Tecticornia halocnemoides subsp. *halocnemoides*
Tecticornia halocnemoides subsp. *tenuis*
Tecticornia indica subsp. *bidens*
Tecticornia indica subsp. *leiostachya*
Tecticornia lepidosperma
Tecticornia leptoclada subsp. *inclusa*
Tecticornia moniliformis
Tecticornia pergranulata subsp. *pergranulata*
Tecticornia pergranulata subsp. *elongata*
Tecticornia pruinosa
Tecticornia pterygosperma subsp. *denticulata*
Tecticornia syncarpa
Suaeda australis
Threlkeldia diffusa

Convolvulaceae
Wilsonia backhousei
Wilsonia humilis
Wilsonia rotundifolia

Cyperaceae
Baumea juncea
Bolboschoenus caldwellii
**Carex divisa*
Cyperus gymnocaulos
**Cyperus laevigatus*
Ficinia nodosa
Gahnia trifida
Isolepis cernua var *cernua*
Schoenoplectus pungens
Schoenoplectus tabernaemontani
Schoenus nitens

Frankeniaceae
Frankenia pauciflora
Frankenia tetrapetala

Gentianaceae
**Centaurium erythraea*
Schenkia australis

Goodeniaceae
Selliera radicans

Haemodoraceae
Tribonanthes violacea

Juncaceae
**Juncus acutus*
Juncus bufonius
Juncus kraussii subsp. *australiensis*

Juncaginaceae
Triglochin minutissima
Triglochin mucronata
Triglochin striata

Malvaceae
**Hibiscus diversifolius*
Lawrencia spicata
Lawrencia glomerata
Lawrencia squamata
Lawrencia viridigrisea

Plumbaginaceae
**Limonium companyonis*
Muellerolimon salicorniaceum

Poaceae
Distichlis distichophylla
**Hainardia cylindrica*
**Hemarthria uncinata*
** Hordeum marinum*
**Lolium loliaceum*
**Parapholis incurva*
**Paspalum vaginatum*
**Puccinellia ciliata*
Puccinellia stricta
Puccinellia vassica
Sporobolus virginicus
**Stenotaphrum secundatum*

Primulaceae
Samolus junceus
Samolus repens var *floribundus*
Samolus repens var *paucifolius*
Samolus repens var *repens*

- *Sarcocornia quinqueflora* (beaded glasswort/samphire) - dominates in wetter parts of coastal saltmarsh zone;
- *Sporobolus virginicus* (salt couch) - the most widely distributed saltmarsh plant (absent in Tasmania);
- *Suaeda australis* (seabite) - in drier, better drained conditions than Sarcocornia;
- *Tecticornia pergranulata* (blackseed samphire) - succulent shrub up to 1 m (rare in NSW; absent in Tasmania);
- *Tecticornia arbuscula* (shrubby glasswort) - succulent shrub up to 2 m (common in Tasmania);
- *Triglochin striata* (three-ribbed or stalked arrowgrass) - common in less well drained depressions of saltmarsh plain; and
- *Wilsonia backhousei* and *Wilsonia rotundifolia* - feature of southern Australian saltmarshes - both endangered species in NSW.

Distribution of coastal saltmarsh is determined by interactions between biota and physical factors, and both patterns of zonation and mosaics are common (Adam, 2002). For example in South Australia, close to 40 different vegetation associations are recognised for *Coastal Saltmarsh* (D. Fotheringham pers. comm.; Canty and Hille, 2002; Caton et al., 2009; and see Appendix A.2). Distribution of structural components appears related to the frequency of tidal inundation and aridity (Clarke and Hannon, 1971; VSS, 2011). For example, the upslope zonation of 'wet' shrub-dominated marshes to herbfields in Victorian saltmarshes (Barson and Calder, 1981) is also reflected in east-west transition to increasing herb-dominated arid saltmarshes (VSS, 2011). Four structural coastal saltmarsh forms have been proposed (Kirkpatrick and Glasby, 1981; Saintilan, 2009a, b) based on dominance of a particular vegetation type:

- dominance by succulent shrubs (e.g. *Tecticornia* species, *Suaeda australis*)
- dominance by grasses (e.g. *Sporobolus virginicus*, *Austrostipa stipoides*, *Zoysia macrantha*)
- dominance by sedges and rushes (e.g. *Juncus kraussii*, *Gahnia filum*) and
- dominance by herbs (e.g. low-growing creeping plants such as *Wilsonia backhousei*, *Samolus repens*).

The distribution of the four vegetation structure forms varies across the intertidal and supratidal zones and many studies have indicated that a combination of moisture content and salinity explain the distribution of vegetation types within *Coastal Saltmarsh* (Saintilan, 2009b). These factors often have a high degree of temporal variability due to tidal connectivity. For example:

- in New South Wales, the lower intertidal zone is often dominated by herbs and grasses (e.g. *Sarcocornia quinqueflora*, *Sporobolus viginicus*, *Samolus repens* and *Triglochin striata*) which give way to tall sedges and rushes in the landward sections of the intertidal zone
- in Victoria, the lower saltmarsh zone is often dominated by succulent shrubs of the genera *Tecticornia* and *Sarcocornia*, while herbs and grasses are more commonly found in the landward, upper-intertidal zones

- in Tasmania, *Sarcocornia quinqueflora* and *Samolus repens* are often found in the lower zone, with *Tecticornia arbuscula* often mixed with grasses and sedges in the mid zone, and a more diverse higher zone including *Sarcocornia backiana*, *Spergularia tasmanica* and *Disphyma crasssifolium*
- in South Australia, *Suaeda australis* and *Sarcocornia quinqueflora* often characterise the lower zone, with *Frankenia pauciflora* and *Tecticornia* species in the mid zone, and a diverse array of species in the higher, brackish zone including, *Puccinellia stricta, Wilsonia humilis, Disphyma crassifolium, Atriplex semibaccata* and *Triglochin striata*; the supratidal zone is often dominated by *Tecticornia indica*
- in the south-west of Western Australia there is a high diversity of *Tecticornia*, *Triglochin, Samolus* and *Puccinellia*, with many species endemic to the region (G. Keighery pers. comm.).

There also appears to be geographic zonation in saltmarsh around the Australian coastline, with eastern (i.e. south of 23° 37' latitude), southern and western sub-groupings evident (Saintilan 2009a, b; Saintilan and Rogers, 2013). These sub-groups characteristically share between 70 and 80% of species, with the remaining 20 – 30% of species being relatively unique to their region. For example (after Cresswell and Bridgewater, 1996; Bridgewater and Cresswell, 2003; Saintilan, 2009a, b; P. Adam pers. comm.):

- primarily eastern species include: *Aster sublates, Carpobrotus glaucescens, Fimbristylis ferruginea*
- primarily southern species include: *Sarcocornia blackiana, Hemichroa pentandra, Tecticornia arbuscula* and *Distichlis distichophylla* and
- primarily western species include: several *Tecticornia* species, *Atriplex* species, and *Neobassia astrocarpa*.

Faunal components

The ecological community is inhabited by a wide range of infaunal and epifaunal invertebrates, and low-tide and high-tide visitors such as prawns, fish and birds (Adam, 2002; Saintilan and Rogers, 2013). It often constitutes important nursery habitat for fish and prawn species. Insects (terrestrial and aquatic, including nuisance mosquitoes and midges) are abundant and an important food source for other fauna, with some species being important pollinators (Adam, 2002; Harvey et al., 2010, 2011). It is likely that insects are abundant on saltmarshes due to an abundance of food and shelter despite tidal inundation (Laegdsgaard et al., 2004). Spiders can also be abundant in drier areas (e.g. Laegdsgaard et al., 2004). There are several moths (Lepidoptera) that use saltmarsh for part of their lifecycle (Orr and Kitching, 2010). Table 3 lists commonly occurring families and species for molluscs, crabs and fish.

The dominant marine residents are benthic invertebrates, including molluscs and crabs that rely on the sediments, vascular plants, and algae, as providers of food and habitat across the intertidal landscape (Ross et al., 2009). The most abundant groups of molluscs are bivalves, slugs of the family Oncidiidae, and in particular, the pulmonate gastropods (snails and periwinkles), including the common families in Table 3. Limpets (Lottiidae) are sometimes present in brackish conditions. Burrowing crabs are also common, with their burrows profoundly modifying the physical environment (Jones et al., 1997). There are two common crab families, with six species generally found within the ecological community (Table 3).

Table 3: *Some common fauna in Australian coastal saltmarsh [Note: families and species are not necessarily directly related across the table columns] (after Ross et al., 2009; Green et al., 2009a, b; Mazumder 2009).*

Taxa	Common Families		Examples of Common Species
Gastropods	• Ellobiidae • Amphibolidae • Phallomedusidae • Assimineidae • Littorinidae • Hydrobiidae		• *Bembicium auratum and spp.* • *Cassidula zonata* • *Cryptassiminea buccinoides and spp.* • *Laemodonta typica* • *Littorina spp.* • *Onchidina australis* • *Ophicardelus ornatus* • *Ophicardelus sulcatus* • *Phallomedusa solida* • *Pleuroloba quoyi* • *Salinator spp.* • *Taiwanassiminea affinis*
Slugs	• Onchidiidae		• *Onchidium damelii* • *Onchidina australis*
Crabs	• Grapsidae • Ocypodidae		• *Australoplax tridentata* • *Heloecius cordiformis* • *Helograpsus haswellianus* • *Paragrapsus laevis* • *Parasesarma erythrodactyla* • *Scylla serrata*
Fish	• Ambassidae • Atherinidae • Gobiidae		• *Ambassis jacksoniensis* • *Atherinosoma microstoma* • *Gobiopterus semivestitus*

Fish, shrimp, and prawns (known collectively as 'nekton') are an important aspect of the biodiversity of the *Coastal Saltmarsh* ecological community - both in terms of resident species and regular or transient visitors (Connolly, 2009). The tidal hydrology of *Coastal Saltmarsh* causes strong linkages between marsh and adjacent aquatic habitats for mobile species (Odum et al., 1995). Therefore the *Coastal Saltmarsh* ecological community may involve one of multiple habitats used by such individuals over short (e.g. one tidal cycle) or long (e.g. different parts of the lifecycle) timeframes. The strong segregation of nekton species between tidal marsh flats and creek fringes reported in the Northern Hemisphere (Minello et al., 2003) is not evident in Australia where, instead, a well-defined subset of species from estuarine waters visit the marsh. These fish and crustaceans can swim large distances into marsh habitat with the incoming tide, and utilise all parts of the marsh, feeding on a diverse array of prey (Connolly, 2009).

Fish assemblages within inundated *Coastal Saltmarsh* are generally dominated by adults of one or two small species (often 60-90% of total abundance) (Connolly, 2009). These species are usually from the families Ambassidae (glassfishes), Atherinidae (hardyheads) and Gobiidae (gobies). The remainder of the fish fauna comprises small numbers of up to about 20 other fish species, including juveniles of many commercially important species (Connolly, 2009).

Other vertebrates, such as birds and mammals (e.g. bats and the native water mouse, *Xeromys myoides*) occur among the faunal assemblage of the ecological community. For example, the *Coastal Saltmarsh* ecological community is recognised as an important feeding, roosting and refuge habitat for resident and migratory shorebirds (including colonial water birds), as well as foraging habitat for insectivorous bats (such as several species of the family Vespertilionidae) and terrestrial birds of prey, seed eaters and insectivorous birds (Laegdsgaard et al., 2004; Spencer et al., 2009; Spencer, 2010; Saintilan and Rogers, 2013). In Gulf St Vincent, South Australia, *Coastal Saltmarsh* is the preferred, and often only, habitat of species such as *Tringa nebularia* (common greenshank), *Tringa stagnatilis* (marsh sandpiper), *Himantopus himantopus* (black-winged stilt) and *Pluvialis fulva* (Pacific golden plover) (Purnell et al., 2012). Also, the critically endangered *Neophema chrysogaster* (orange-bellied parrot) uses *Coastal Saltmarsh* in Victoria and South Australia as important foraging habitat during the winter migration of the species to the mainland. A range of incidental visitors, including macropods, reptiles and amphibians, may also occur within the ecological community (Laegdsgaard et al., 2009; Saintilan and Rogers, 2013).

Key diagnostic characteristics, condition thresholds and survey guidelines

The listed ecological community is limited to areas and patches of coastal saltmarsh that meet the key diagnostic characteristics and condition thresholds. National listing focuses legal protection on remaining areas or patches of the ecological community that are most functional, relatively natural (as described by the 'Description') and in relatively good condition. Key diagnostic characteristics and condition thresholds assist in identifying an area or patch of the threatened ecological community and when the EPBC Act is likely to apply to the ecological community. They provide guidance for when an area or patch of a threatened ecological community retains sufficient conservation values to be considered as a Matter of National Environmental Significance, as defined under the EPBC Act. This means that the referral, assessment and compliance provisions of the EPBC Act are focussed on the most valuable elements of Australia's natural environment, while heavily degraded patches will be largely excluded. Note that existing infrastructure, land already permanently replaced with crops/pasture/plantations, and human settlements do not form part of the ecological community.

Although significantly degraded or modified patches may not be protected as the ecological community listed under the EPBC Act, it is recognised that patches that do not meet the condition thresholds may still retain important natural values. Therefore, these patches should not be excluded from recovery and other management actions (also see 'Surrounding environment and landscape context').

Key diagnostic characteristics

The ecological community is the assemblage of organisms including and associated with coastal subtropical and temperate saltmarsh. Key diagnostic characteristics for describing the *Coastal Saltmarsh* ecological community include:

- occurs south of 23° 37' S latitude - from the central Mackay coast on the east coast of Australia, southerly around to Shark Bay on the west coast of Australia (26° latitude), and including the Tasmanian coast and islands within the above range
- occurs on the coastal margin, along estuaries and coastal embayments and on low wave energy coasts
- occurs on places with at least some tidal connection, including rarely-inundated supratidal areas, intermittently opened or closed lagoons, and groundwater tidal influences, but not areas receiving only aerosol spray
- occurs on sandy or muddy substrate and may include coastal clay pans (and the like)
- consists of dense to patchy areas of characteristic coastal saltmarsh plant species (i.e. salt-tolerant herbs, succulent shrubs or grasses, that may also include bare sediment as part of the mosaic) and
- proportional cover by tree canopy such as mangroves, *Melaleucas* or *Casuarinas* is not greater than 50%, nor is proportional ground cover by seagrass greater than 50%.

Condition thresholds and survey guidelines

Landuse history and local topography will influence the state in which a patch of the ecological community is expressed. In addition, the ecological community may occur in discrete patches, as part of a mosaic with a range of different substrates and vegetation types, including in ecotones. For the *Coastal Saltmarsh* ecological community the following apply:

Ecotones:

Where the ecological community intergrades with an adjacent community, such as seagrass, mangroves, paperbark (*Melaleuca* spp.) and *Casuarina* spp. swamp, or freshwater marshes, then in this ecotone region, if 50% or more of the groundcover/understorey is comprised of coastal saltmarsh vegetation then it is considered to be the ecological community.

Patch definition:

A patch is defined as a discrete and continuous area or mosaic of the ecological community. However, a patch may include bare area of substrate (e.g. salt pannes, salt pans, sabkahs, clay pans, cyanobacterial mats, tidal creeks, etc.) or small-scale disturbances, such as tracks or breaks, narrow watercourses or small-scale variations in vegetation that do not significantly alter its overall functionality (functionality here refers to ecological processes such as the movement of fauna and pollinators, the dispersal of plant propagules, provision of food, habitat attributes such as refuge, nesting, or nursery function, etc., all of which can operate at small to large scales).

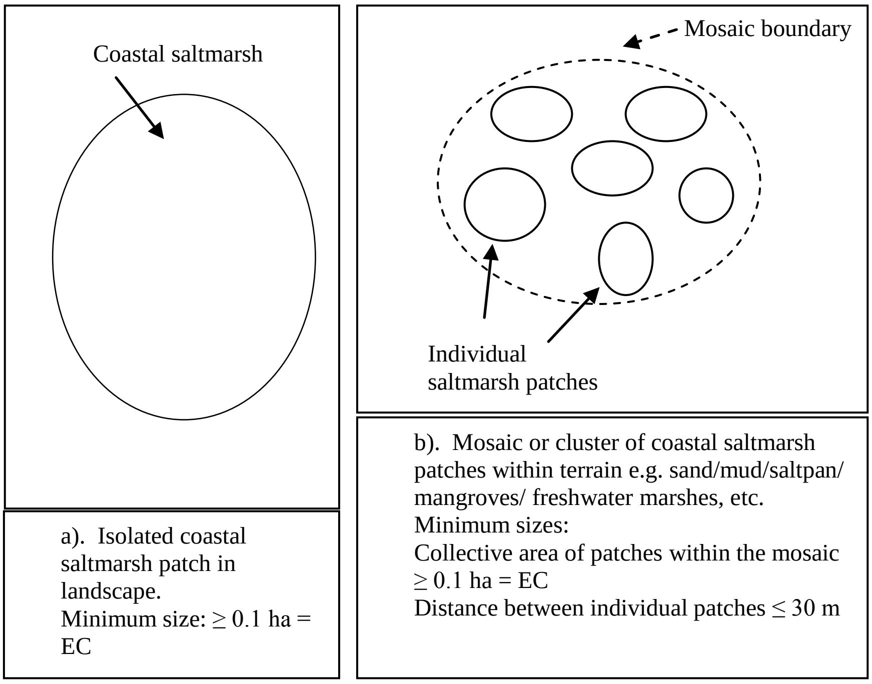

Figure 1: *Coastal Saltmarsh ecological community (EC) patch size and mosaic considerations.*

Patch size:

Research has demonstrated that coastal saltmarsh patches of 0.4 ha or greater have the typical food web dominated by marsh plants themselves, but below 0.4 ha, the saltmarsh system is less productive and swamped by external nutrient sources (e.g. adjacent mangroves or pelagic phytoplankton; Guest and Connolly, 2004, 2006). However other research suggests that conservation sensitive species tend to occur in patches > 0.1 ha (Williams et al., 2011) and propagule dispersal may be important at these small patch sizes (P. Adam, pers. comm.). Therefore patches of the *Coastal Saltmarsh* ecological community that are <0.1 ha and occur in isolation (as opposed to part of a mosaic) are excluded from the ecological community (see Figure 1a). However, it is not uncommon for the *Coastal Saltmarsh* ecological community to occur in a mosaic (for example, interspersed with other vegetation or bare sandy or muddy substrate), and thus consist of small patch sizes within that mosaic. Importantly, these small patches within the mosaic may still confer ecological function through their connection with other patches and as a source of propagules (e.g. Prahalad and Pearson, 2012). Therefore patches of saltmarsh within a mosaic that are within 30 m of each other, and collectively are 0.1 ha or more are considered to be the ecological community (Figure 1b).

Tidal connection:

The ecological community requires some form of ongoing connection to the tidal regime. This could occur via both surface and/or ground waters. It may occur within the intertidal or supratidal zone. It may be regular as per lunar tides, or periodic and intermittent, as via the highest tides or storm surges, or as with ICOLLs - lagoons open to the sea for limited periods due to rain, sea or anthropogenic intervention. Coastal saltmarsh cut off from the sea by natural barriers but subject to seepage from the sea should be included in the definition.

Exclusions:

The following are excluded from the *Coastal Saltmarsh* ecological community:

- saltmarsh occurring in seepage zones on sea cliffs and elevated rock platforms above the tidal limit and on elevated headlands subject only to aerosolic salt
- saltmarsh occurring on inland saline soils with no tidal connection
- isolated patches of saltmarsh < 0.1 ha
- patches or areas of saltmarsh that contain > 50% weeds (i.e. patches must be dominated by native saltmarsh plant species to be the ecological community) and
- patches of saltmarsh (possibly senescent) within the coastal margin that are disconnected (either naturally or artificially) from a tidal regime but were once connected. However, should the patch be reconnected to the tidal regime (e.g. via removal of an artificial barrier, or constructing a pipeline under a roadway), then the patch can become part of the ecological community (i.e. if it meets other key diagnostics and condition thresholds).

Buffer zone:

It is recommended that an appropriately sized buffer zone of influence be applied from the outer edge of the patch or area (i.e. size to be determined on a case-by-case basis depending on threat type, location and barriers). This may assist in the preservation of patches and broader areas of the *Coastal Saltmarsh* ecological community, as well as providing an opportunity for climate change adaptation, such as inland retreat (e.g. Saintilan and Rogers, 2013). For example, saltmarshes naturally retreat landward as sea level increases, and if space is unavailable due to local geomorphology or the presence of anthropogenic structures/activities, then saltmarsh will disappear with sea level rise due to climate change (Adam, 2002: Saintilan and Rogers, 2013). Buffers enhance protection of a patch by avoiding or minimising potential disturbance from surrounding land uses or activities. The size of the buffer zone should increase with increasing intensity and likely localised impact of the threat. While the buffer zone is not formally part of the ecological community, it should be taken into account when considering likely 'significant impacts' during EPBC Act decision-making (as should any other areas where an action may have a significant impact on the ecological community).

Surrounding environment and landscape context

In the context of actions that may have 'significant impacts' and require approval under the EPBC Act, it is important to consider the environment and habitats that surround patches of the ecological community that meet the condition thresholds. The surrounding environment and vegetation will also influence how important an area or patch of the ecological community is in the broader landscape.

The *Coastal Saltmarsh* ecological community forms one component of the complex of coastal and estuarine communities (Adam, 2002; Mount et al., 2010). On their seaward (lower) side, coastal saltmarshes are usually fringed by seagrass beds and/or mangroves, or they may abut intertidal flats. Landward they may intergrade with coastal forest and shrubland (e.g. *Casuarina*, *Melaleuca*) or be fringed by hypersaline flats in subtropical coasts. Such areas are influenced by tides (i.e. seawater) less regularly or if artificial barriers are present, may be permanently 'stranded' from tidal influence (and thus no longer form part of the ecological community). Alternatively, saltmarsh may be limited on their landward side by anthropogenic structures (e.g. sea walls) or activities (e.g. agriculture). Thus landward transition depends on local topography, geological history and human interference (Adam, 2002).

Towards the head of estuaries, conditions may be brackish or fresh (either from surface or groundwater) but may still be subject to some form of tidal influence. In areas such as these, the *Coastal Saltmarsh* ecological community may intergrade with freshwater tidal marshes, such as those with fringing reed and tall sedge communities (Adam, 2009).

The following indicators of additional conservation value should be considered when assessing the impacts of actions or proposed actions under the EPBC Act, or when considering recovery, management and funding priorities for a particular area or patch of the ecological community:

- evidence of recruitment of key native species or the presence of a range of age cohorts
- adequate tidal connection for ecological function and condition of the ecological community
- good faunal habitat as indicated by patches containing cover, refuge, and contribution to movement corridors
- species richness, as shown by the variety and proportion of native flora and the diversity of fauna species present
- presence of listed threatened species
- areas of minimal weeds and feral animals, or where these can be managed easily, and/or,
- patches that are in areas where the ecological community has been heavily degraded, and
- patches that contain unique variants of the ecological community.

Area critical to the survival of the ecological community

Of critical importance to the survival of the *Coastal Saltmarsh* ecological community is an ongoing connection with the adjacent tidal regime (whether regular or irregular).

Areas that meet the key diagnostic characteristics and condition thresholds plus an appropriate buffer zone are considered critical to the survival of the ecological community. Additional areas such as adjoining native vegetation and areas that meet the description of the ecological community but not the condition thresholds are also considered important to the survival of the ecological community.

Geographic extent and patch distribution

Estimates of the current national extent of the *Coastal Saltmarsh* ecological community nationally are provided in Appendix D (see assessment against Criteria 1 and 2). While there has been no detailed modelling of the likely pre-European distribution of the ecological community across its entire range, some jurisdictions have estimated the former extent. This information is also provided at Appendix D.

It should be noted that classification and mapping of vegetation such as saltmarsh is extremely complex and relies on recognition of vegetation type, vegetation extent and (sometimes) condition, and may use different methodologies in different areas (Kelleway et al., 2009; Williams et al., 2011; Prahalad and Pearson, 2012). The sometimes small size of patches also presents problems in regard to mapping.

From an ecological function perspective, it is important to consider patch size (e.g. medium, average, minimum) at which the ecological community remains functionally viable. It has been suggested that at less than a 0.4 ha saltmarsh patch is less productive (Guest and Connolly, 2006). In contrast to this, studies have also shown that very small patches can remain important for species survival. For example, in a study of 757 coastal saltmarsh patches at Parramatta River-Sydney Harbour (NSW), Williams et al. (2011) found that five recognised 'conservation sensitive' species (due to their rarity or decline) occurred mainly in patches greater than 0.1 ha. A detailed analysis of available patch size data is presented in Appendix D.

National context and existing protection

Ecosystem services

Nationally, the *Coastal Saltmarsh* ecological community provides extensive ecosystem services such as: filtering surface water prior to it entering the sea; carbon sequestration; coastal productivity; nursery habitat to a range of fisheries species; provision of food and nutrients for a wide range of adjacent marine and estuarine communities, including migratory shorebirds; and stabilising the coastline and providing a buffer from waves/storms (Morrisey, 1995; Boorman 1999; Mazumder et. al., 2006; Caton et al., 2009; Connolly, 2009; DCC, 2009).

Importantly, saltmarshes are among the most efficient ecosystems globally at sequestering carbon, although different areas of saltmarsh will vary in capacity (Pidgeon, 2009; Saintilan and Rogers, 2013). 'Blue Carbon' is the potential of marine/coastal ecosystems to trap atmospheric carbon dioxide (Nellemann et al., 2009). This value is due to the biogeochemical conditions in tidal wetlands being conducive to long-term carbon retention. In addition, methane (a potent greenhouse gas) emissions are dramatically reduced in environments where methanogenic bacteria are inhibited by salt (Choi and Wang, 2004; Poffenbarger et al., 2011; Saintilan and Rogers, 2013). An important concern with significant loss of saltmarsh habitat is that it could liberate the huge pool of carbon stored in wetland sediments to coastal waters or the atmosphere (DCC, 2009).

State distribution

The region of the ecological community spans six state jurisdictions: Queensland (southern), New South Wales, Victoria, Tasmania, South Australia and Western Australia (south-western). It also occurs within many IBRA bioregions, NRM/Catchment Management Authority areas and Local government jurisdictions (see Appendix A for further details).

Related State listings

In 2004, due to threats to long-term survival, the NSW Scientific Committee listed coastal saltmarsh as an endangered ecological community in New South Wales under the *NSW Threatened Species Conservation Act 1995* - i.e. *Coastal saltmarsh in the NSW North Coast, Sydney Basin and South East Corner bioregions*. Currently Queensland, Victoria, Tasmania, South Australia and Western Australia do not list this ecological community.

A suite of threatened and migratory species listed under various articles of federal or state legislation occur within the ecological community (see Appendix A). For example in the Victorian component of the national *Coastal Saltmarsh* ecological community, there are some 60 threatened, migratory or marine overfly birds listed under the EPBC Act, including the critically endangered *Neophema chrysogaster* (orange bellied parrot). Spencer et al., (2009) report seven birds listed as threatened under the EPBC Act or state legislation that occur in Australian saltmarsh that would also potentially occur within the ecological community. *Xeromys myoides*, the native water mouse, nests within the *Coastal Saltmarsh* ecological community and is listed as vulnerable at national and state levels (Russell and Hale, 2009). *Litoria aurea*, the EPBC Act vulnerable listed green and golden bell frog, has also been recorded in the *Coastal Saltmarsh* ecological community during periods of high rainfall (Spencer et al., 2009).

2. SUMMARY OF THREATS

Coastal saltmarshes are recognised nationally and globally as ecosystems of immense ecological value which are increasingly under threat (Adam, 2002; Adam et al., 2008; Laegdsgaard et al., 2009; Saintilan, 2009c; VSS, 2011; SoE 2011 Committee, 2011). Due to their position along the coast, where land is often required for human settlement, coastal saltmarshes have experienced a long history of modification and destruction (Thomsen et al., 2009; VSS, 2011 and references therein). Where there is a landward barrier to the potential movement of coastal saltmarsh, the threats may be intensified (as there is no potential for movement inland). The concentration of (human) population growth and development in the coastal zone, particularly along the subtropical and temperate Australian coastline, and the sensitivity of coastal saltmarsh to changes in climate and sea level continue to exacerbate all threats to the ecological community.

A summary of key threats to the *Coastal Saltmarsh* ecological community is provided below, with further description provided in Appendix C:

- ***Clearing and fragmentation*** - historical and contemporary vegetation clearing have resulted, and will continue to result in, loss or fragmentation of *Coastal Saltmarsh* habitat (Adam, 2002: Laegdsgaard et al, 2009). Many of the threats below cause or exacerbate this threat.
- ***'Land-claim' or infilling*** - land claim (conversion of saltmarsh to other uses), infilling and associated infrastructure are effectively an irreversible disturbance resulting in loss or permanent disconnection of coastal saltmarsh from the tide (Adam, 2002; Fairweather, 2011).
- ***Altered hydrology/tidal restriction*** - changes to tidal regime or tidal connection that result from development, land-use practices or infrastructure can lead to habitat loss, invasion of 'problem species' or modification of ecological function (Laegdsgaard et al., 2009; Williams et al., 2011).
- ***Invasive species*** - non-native weed species and other problem species (e.g. native species that can form monotypic stands) are increasingly replacing native *Coastal Saltmarsh* plants which limits biodiversity, changes vegetation structure and potentially alters ecosystem function, and in some cases fire regimes (Laegdsgaard et al., 2009; VSS, 2011; Harvey et al., 2011).
- ***Climate change*** - current and projected rises in temperature and sea level and increased storm events from climate change are considered severe threats to *Coastal Saltmarsh* that could result in landward retreat, transgression by mangroves, fragmentation and loss of habitat or function.
- ***Mangrove encroachment*** - over the past few decades *Coastal Saltmarsh* has been increasingly encroached on by mangrove along the south-east coast of Australia from Queensland to South Australia (Burton, 1982; Wilton, 2002; Saintilan, 2009a, b; Oliver et al., 2012; Saintilan and Rogers, 2012).
- ***Recreation*** - various recreational vehicles cause localised and widespread damage (and noise) to *Coastal Saltmarsh*, with documented decreases and disturbance to habitat and

fauna (e.g. nesting birds including ground egg layers) (Laegdsgaard et al., 2009; Spencer et al., 2009).

- ***Pollution/litter*** - pollution and litter from stormwater or dumping of waste can smother coastal saltmarsh plants and introduce contaminants such as heavy metals or organic chemicals (Adam, 2002; Laegdsgaard et al., 2009). Oil spills are also a major potential threat.
- ***Eutrophication*** - *Coastal Saltmarsh* is susceptible to a range of impacts from excess nitrogen from sewage and land-derived sources. Nitrogen can change patterns of productivity and species distribution, stimulate algal growth, and encourages non-saltmarsh vegetation to invade (Rose and McComb, 1992; Adam, 2002)
- ***Acid Sulfate Soils*** - actual or potential acid sulfate soils are found along much of the Australian coastline and therefore pose a threat to the ecological community (e.g. Adam, 2009; VSS, 2011). Acidification can have significant impacts on habitat quality, the health of aquatic organisms and biodiversity. (e.g., fish and shellfish kills, outbreaks of disease in fish, scalding of vegetation, and increases in nuisance algae) (Watkinson et al., 2000; ASEC, 2001; NRME, 2003; Fitzpatrick et al., 2009).
- ***Grazing*** - large-scale grazing by introduced farm animals is likely to impact on coastal saltmarsh vegetation, potentially changing composition and structure and adversely affecting rarer and more fragile species (Adam, 1990; Laegdsgaard et al., 2009).
- ***Insect control*** - controlling nuisance insects in *Coastal Saltmarsh* may involve the use of harmful insecticides or habitat modification such as runnelling, which alters drainage and tidal inundation patterns (Balla, 1994; Adam, 2002).
- ***Evaporative salt production and other mining*** - solar evaporative salt ponds are often constructed on *Coastal Saltmarsh*, thereby destroying vast areas of natural habitat (Adam, 2002; Bromberg Gedan et al., 2009). In South Australia, where the highest biodiversity of coastal saltmarsh occurs, vast areas are under lease for potential salt mining in the future (Fotheringham and Coleman, 2008). Shell-grit mining also occurs in some Victorian *Coastal Saltmarsh* (VSS, 2011).
- ***Inappropriate fire regimes*** - coastal saltmarsh vegetation is not well fire-adapted and fire is lethal to many species (Kirkpatrick and Glasby, 1981; VSS, 2011). Invasive problem species (e.g. *Juncus acutus* and *Baumea juncea*) may have high flammable fuel loads, putting *Coastal Saltmarsh* at risk (NSW SC, 2004).

3. SUMMARY OF ELIGIBILITY FOR LISTING AGAINST EPBC ACT CRITERIA

Further details about how the ecological community was judged against the EPBC Act listing criteria can be found at Appendix D.

Criterion 1 – Decline in geographic distribution
There is insufficient information about decline in extent that covers the full national extent of the *Coastal Saltmarsh* ecological community. Decline is less than 50% in those states where there is reliable information about decline, although it is recognised that the proportion can be much greater for specific sites. Therefore, the ecological community is **not eligible** for listing under this criterion.

Criterion 2 – Small geographic distribution coupled with demonstrable threat
The *Coastal Saltmarsh* ecological community has a very restricted distribution on the basis that it is fragmented with small patch sizes generally under 10 ha in size. It is subject to certain threats that could cause its loss over the medium-term future. Therefore, the ecological community has been demonstrated to have met the relevant elements of Criterion 2 to make it **eligible** for listing as **vulnerable**.

Criterion 3 – Loss or decline of functionally important species
The loss or decline of functionally important species either cannot be demonstrated or is unknown due to data deficiencies. Therefore, the ecological community is **not eligible** for listing in any category under this criterion.

Criterion 4 – Reduction in community integrity
The integrity of the *Coastal Saltmarsh* ecological community has reduced through the combined impacts of threats such as increased fragmentation, tidal restriction, increased marine inundation and mangrove transgression, and invasion by exotic plant species. Despite some local and regional actions to mitigate some of these threats, they are unlikely to restore the national ecological community within the medium-term future. The ongoing threat of sea level rise is recognised as particularly difficult to mitigate. The ecological community is eligible for listing as **vulnerable** under this criterion.

Criterion 5 – Rate of continuing detrimental change
The Committee considers the rate of continuing detrimental change in the *Coastal Saltmarsh* ecological community to be substantial as indicated by a serious intensification in the disruption of a key driver of important community processes (i.e. sea level rise). Therefore, the ecological community is **eligible** for listing as **vulnerable** under this criterion.

Criterion 6 – Quantitative analysis showing probability of extinction
There are no quantitative data available to assess this ecological community under this criterion. Therefore, it is **not eligible** for listing under this criterion.

Summary
Based on the highest conservation category triggered by this assessment, the *Coastal Saltmarsh* ecological community is **eligible** for listing as **vulnerable**.

4. PRIORITY CONSERVATION ACTIONS

Conservation goals

The Committee considers that maintenance of ecological function and increased resilience should be the guiding principles for conservation of the *Coastal Saltmarsh* ecological community. The optimal ecological community includes: permanent or intermittent connection with the sea; functioning trophic pathways; structural habitat; no loss of key native species; and the absence of problem invasive species (exotic pests/aggressive weeds).

Key priority conservation actions:

- Avoid native vegetation clearance and destruction of the ecological community and its buffer zones; including protecting potential areas of natural retreat.
- Collate effective policies and management actions already in progress (including development controls) to support and widely disseminate best practice and lessons learnt.
- Undertake surveys to identify areas where natural retreat of Coastal Saltmarsh may be possible and actively manage them to enable natural retreat in the future.
- Undertake effective community engagement and education to promote the value of the ecological community (e.g. it is not 'wasteland' as some perceive); also to highlight the importance of minimising disturbance (e.g. during recreational activities) and of minimising pollution and littering (e.g. via signage).
- Liaise with planning authorities to promote the inclusion of *Coastal Saltmarsh* protection and projected tidal inundation zones in their plans/responses to climate change and sea level rise and in coastal zone management generally.

Research Priorities

Research priorities that will inform priority conservation actions include:

- Develop a methodology for calculating appropriate buffer zone sizes for *Coastal Saltmarsh*.
- Undertake further research on *Coastal Saltmarsh* ecosystem function and services, for example:
    - 'nutrient' cycling/dynamics and energy flows
    - nursery function and links with coastal fisheries
    - 'Blue Carbon'
    - shoreline stabilisation and storm buffering capacity.
- Research the effects of disturbances (e.g. pollution, discharge of stormwater, and recreational use) on ecological function.
- Undertake surveys, encompassing a wide taxonomic range, across the national extent of the ecological community, to identify:

- sites of high conservation priority
- threatened species that may require specific conservation measures
- areas that would most benefit from removal of tidal restriction and/or other regeneration restoration efforts.

- Undertake or support analysis of the hydrological needs of the ecological community, including: interactions between saltmarsh and groundwater; and modelling altered hydrological regimes.
- Continue to support existing research on exotic weeds and support trials to control invasive weeds.
- Identify in more detail how *Coastal Saltmarsh* will be impacted by future sea level rise and the potential for mitigation or adaptation at local and regional scales.

Other Priority Conservation Actions

The following priority recovery and threat abatement actions will also support the conservation and recovery of *Subtropical and Temperate Coastal Saltmarsh* ecological community.

General

- Provide appropriate buffer zones around patches of *Coastal Saltmarsh* to increase resilience and make land available to accommodate landward migration of saltmarshes.
- Develop a fit-for-purpose national database of *Coastal Saltmarsh* extent (including a comparable approach across jurisdictions) and monitor and record changes in extent.
- Implement best practice standards for managing remnants on private and public lands (e.g. include 'inundation easements' as part of any foreshore redevelopment).
- Monitor the progress of recovery, through improved mapping and condition assessments of *Coastal Saltmarsh*, and implement effective adaptive management strategies.
- Liaise with planning authorities to ensure that planning decisions take into account the protection of *Coastal Saltmarsh*, with due regard to the need for long-term conservation.

Land clearing

- Avoid clearing native vegetation within *Coastal Saltmarsh* and its surrounds, including avoiding clearing within an appropriate buffer zone (e.g. at least 30 metres from the ecological community's boundary).
- Avoid clearing native vegetation and other activities in catchment areas that may result in altered sediment delivery to the ecological community.

Infilling

- Avoid infilling/raising the soil profile in saltmarshes (e.g. during development projects).

- Implement best practice standards and/or identify alternative construction techniques for projects which may have a land-reclamation component.

Altered hydrology

- Ensure that projects that lead to alterations in the hydrological characteristics of *Coastal Saltmarsh* areas do not occur.
- Avoid constructing levees, culverts, floodgates etc. that will lead to permanent inundation or permanent tidal restriction of *Coastal Saltmarsh*, or that will otherwise adversely alter existing inundation/tidal regimes.
- Avoid constructing outlets/drains that direct stormwater discharge into or near *Coastal Saltmarsh*.
- Investigate options to restore natural hydrological regimes to coastal saltmarshes that have been adversely impacted and implement restoration where appropriate.

Invasive species - flora

- Enhance/develop and implement management plans for the control of major weed infestations (such as *Juncus acutus*, *Spartina*, *Baccharis*, *Limonium hyblaeum*) within the ecological community, or for emerging weed threats as they develop (e.g. the increasing number of *Limonium* spp. entering cultivation).
- Ensure that chemicals or other mechanisms used to eradicate weeds do not have adverse impacts on saltmarsh species (including macro/micro-algae which may be particularly sensitive to some herbicides) or adverse impacts on adjacent areas such as mudflats.

Invasive species - fauna (see also Insect control)

- Manage shipping and aquaculture practices to minimise potential invasion of exotic macro-invertebrates, fish, meiofauna, and pathogen species; and include *Coastal Saltmarsh* in the sites monitored for such arrivals.
- Avoid deliberate introductions of other invasive fauna species into the ecological community (often by members of the public) e.g. through community education.
- Implement control measures to restrict the access of terrestrial invasive animals to the ecological community (e.g. fencing) and to reduce/control existing invasive populations.

Insect control

- Ensure that chemicals or other mechanisms used for insect control (e.g. of disease vectors/nuisance species such as mosquitoes, sandflies and midges) do not adversely impact other saltmarsh species, or those in adjacent areas (e.g. mudflat invertebrates).
- Avoid further deliberate introductions of predatory mosquito fish (*Gambusia holbrooki*).

- Explore insect management options and their wider applicability (e.g. in Queensland runnelling has had some success, but its impacts in more species rich saltmarshes are not known).

Recreation

- Where practical, restrict or prevent recreational vehicle access (including bicycles) to *Coastal Saltmarsh* and assist through public education measures such as signs.
- Implement best practise measures for constructing access tracks across *Coastal Saltmarsh* (e.g. use raised platforms) and ensure that access paths/tracks are not inundated at times of high tide. Support the use of these tracks and paths (e.g. erect educational signs and information points and promote their use).
- Implement restoration activities to mitigate the impacts of recreational use, including replanting of native species as appropriate.

Pollution/Litter (see also Invasive species – flora and insect control)

- Implement education and management strategies around areas of *Coastal Saltmarsh* that discourage littering (e.g. install bins, and/or signs requesting people take their litter home, in nearby parks/car-parks).
- Avoid constructing outlets/drains that direct stormwater discharge or industrial effluent into or near *Coastal Saltmarsh*.
- Where existing discharges occur investigate the feasibility and efficacy of retrofitting gross pollutant traps (GPTs).
- Identify *Coastal Saltmarsh* as important habitat in all oil spill contingency planning at national and State levels, and monitor the application of protocols on the management of spills involving saltmarshes.

Eutrophication

- Implement agricultural best practise measures to minimise nutrient (e.g. nitrogen and phosphorus) run-off in *Coastal Saltmarsh* catchment areas.
- Monitor the level of nutrient inputs into patches of the ecological community, especially those that fringe estuaries.

Acid sulphate soils

- Avoid disturbance of potential acid sulphate soils that may expose them to the atmosphere and may lead to the soils drying out (e.g. digging trenches or draining *Coastal Saltmarsh*).
- Use soil testing practises to test for the presence of potential acid sulphate soils prior to any activity that may lead to drainage or disturbance.
- Develop and maintain a register/s of known potential acid sulphate soil sites.

Evaporative salt production and mining

- Review mining tenements within coastal saltmarsh areas with a view to reducing the total area of potential mining, in particular in areas of high conservation value.
- Investigate and implement alternatives to creating new solar evaporative salt production ponds in coastal saltmarshes; alternatively implement best practise strategies when identifying sites for new solar evaporative salt ponds that take into account the ecological sensitivities of the land being considered/used.
- Develop and implement recovery actions for disused solar evaporative salt ponds.

Climate Change and Sea Level Rise

- Enhance the resilience of the ecological community to the impacts of climate change by reducing other pressures.
- Investigate potential refuge/retreat areas (including buffer zones) and determine appropriate adaptation management strategies.
- Expand programs such as those in a range of States (e.g. Victoria's *Future Coasts Program*) to cover more of the ecological community. These programs should inform and shape decision making for planning and management actions to ensure future sea level rise information is included in decisions about coastal management and development activities.
- Monitor change in species composition and distribution and sediment dynamics to elucidate the effects of climate change in priority, susceptible regions (including establishment of survey lines).

Inappropriate fire regimes (see also Grazing)

- Ensure controlled/planned burns in areas surrounding the ecological community are not allowed to spread into the ecological community.
- Develop and implement management practices/fire control methods in upper saltmarsh areas.
- Develop and implement recovery guidelines/actions for post-fire event management.
- Investigate measures that may facilitate recovery of the ecological community post-fire event, especially the recovery of fire intolerant species such as succulent chenopods.

Grazing

- Limit or prevent access of grazing animals to *Coastal Saltmarsh* (e.g. construct fences) where practicable.
- Develop and implement appropriate grazing regimes for the ecological community if grazing is to continue.
- Limit or prevent grazing access to recently burnt and/or recovering *Coastal Saltmarsh*.

Examples of existing management actions/plans

There are no approved State recovery plans for the ecological community. However, there are a number of documents that contain management and other guidance on coastal saltmarsh. These include:

DECC (2008). Best practice guidelines for coastal saltmarsh. NSW Department of environment and climate change
Viewed: 15/5/2013
Available online at:
http://www.environment.nsw.gov.au/resources/threatenedspecies/08616coastalsaltmarshbpg.pdf

Boon PI (undated). Understanding the Western Port Environment – 9 Saltmarshes.
Viewed: 15/5/2013
Available online at:
http://www.melbournewater.com.au/content/library/current_projects/rivers_creeks_and_ wetlands/westernport/Understanding_the_Western_Port_Environment_-_9_Saltmarshes.pdf

VSS [Victorian Saltmarsh Study] (2011) Boon PI, Allen T, Brook J, Carr G, Frood D, Hoye J, Harty C, McMahon A, Mathews S, Rosengren N, Sinclair S, White M & Yugovic J. Mangroves and coastal saltmarsh of Victoria: distribution, condition, threats and management. Report to the Department of Sustainability and Environment, East Melbourne. Institute for Sustainability & Innovation, Victoria University, Melbourne. e.g. Chapter 8 Recommendations.
Viewed: 15/5/2013
Available online at:
http://www.ozcoasts.gov.au/geom_geol/vic/SaltmarshCh8FinalLowRes.pdf

Corangamite CMA (undated). Corangamite Coast - Fact Sheet 3. Coastal Saltmarsh. Corangamite Catchment Management Authority.
Viewed: 15/5/2013
Available online at:
http://www.ccma.vic.gov.au/admin/file/content2/c7/Coastal%20Saltmarsh%20Fact%20S heet%203_1301289303279.pdf

Tasmanian Southern NRM Region (2012). Tasmanian Southern Coastal Saltmarsh Futures (Draft).
Viewed: 15/5/2013
Available online at:
http://www.nrmsouth.org.au/uploaded/287/15131490_06southernnrmregioncoasta.pdf

Redland City Council (2009). What is Runnelling? Fact Sheet 3.
Viewed: 15/5/2013

Available online at:
http://www.redland.qld.gov.au/SiteCollectionDocuments/Fact_Sheets/Mossies/FS062%20What%20is%20runnelling.pdf

UNEP (2011): Taking Steps toward Marine and Coastal Ecosystem-Based Management - An Introductory Guide. UNEP Regional Seas Reports and Studies No. 189. United Nations Environment Programme.
Viewed: 15/5/2013
Available online at: www.unep.org/pdf/EBM_Manual_r15_Final.pdf

Recovery plan recommendation

In formulating its recommendation on whether to have a recovery plan for the *Coastal Saltmarsh* ecological community, a number of factors were taken into consideration.

- The ecological community occurs over a very broad range of jurisdictions. Coordination of jurisdictions across the coastline from Queensland to Western Australia could be difficult to manage given inherent variation in saltmarsh composition, and differences in the type and degree of threats across its range. However a recovery planning effort would foster co-operative approaches for managing certain threatening processes that occur across jurisdictions and facilitate action on national priorities.
- Declines occur more at the local or regional level rather than at a State or national level. Consequently, recovery effort may be better targeted at the former to obtain conservation outcomes. A recovery plan could help co-ordinate the application of such approaches over a wider scale, particularly where the type and impacts of threats are similar.
- Some threats are more amendable to coordinated recovery effort, for instance planning to mitigate impacts due to tidal restrictions, management of fire and grazing regimes, clearing controls, or co-ordinated management of invasive species. A recovery plan could be an appropriate tool for these circumstances.
- *Coastal Saltmarsh* is particularly prone to impacts from climate change and sea level rises. Mitigation of this threat will require approaches additional to that available through recovery planning.
- A key feature of the listing and recovery planning process is raising awareness that an ecological community exists and is threatened. *Coastal Saltmarsh*, due to its appearance as low scrubby or grassy marsh systems, has a low public profile. This belies their importance in providing key ecosystem services and as a haven for biodiversity. Improving the public profile and awareness about the importance of *Coastal Saltmarsh* across its range could be a key outcome of recovery planning.

On balance of these considerations, it is recommended that a recovery plan be prepared for the *Coastal Saltmarsh* ecological community.

5. APPENDICES

APPENDIX A – DETAILED DESCRIPTION OF NATIONAL CONTEXT

This appendix presents more detailed information about how the *Coastal Saltmarsh* ecological community is identified in other jurisdictions and protected by other measures. This information is intended to help environmental assessment officers and others in determining if the ecological community is likely to be present.

The *Coastal Saltmarsh* ecological community occurs on the coastal zone south of the northern boundary of the South East Queensland IBRA bioregion. It spans six states: Queensland (limited to the South East Queensland IBRA bioregion), New South Wales, Victoria, Tasmania, South Australia and Western Australia. The national extent covers a large number of IBRA bioregions that occur on the coastline between South East Queensland and Carnarvon in Western Australia.

Equivalent vegetation units including State-listed ecological communities

<u>Caveat</u>

Ecological communities are a convenient way to classify complex and variable natural systems. Australia, and each State/Territory jurisdiction applies its own system to classify ecological communities; this can cause problems when cross-referring amongst systems which may vary in on-ground accuracy. Any reference to vegetation and mapping units as equivalent to a national ecological community at the time of listing should be taken as indicative, rather than definitive. A unit that is generally equivalent may include some elements that do not meet the description. Conversely, some areas mapped or described as other units (not identified here) may sometimes meet the description. Judgement of whether an EPBC-protected ecological community is present at a particular site should focus on how an area meets the description and condition thresholds of the national ecological community, rather than on any other classification system.

<u>National</u>

The Directory of Important Wetlands of Australia (DIWA) collates information about nationally and internationally important (Ramsar) wetlands in Australia. It uses a classification system slightly modified from the Ramsar Convention to classify Australian wetlands into 42 types. The *Coastal Saltmarsh* ecological community is primarily consistent with wetland type:

> ‘A8 Intertidal marshes; includes salt-marshes, salt meadows, saltings, raised salt marshes, tidal brackish and freshwater marshes’

but may also occur as elements of other DIWA wetlands, depending on the local context:

> ‘A6 Estuarine waters; permanent waters of estuaries and estuarine systems of deltas’; and

> ‘A10 Brackish to saline lagoons and marshes with one or more relatively narrow connections with the sea.’

Under the National Vegetation Information System (NVIS), the ecological community generally falls within either Major Vegetation Group (MVG) 21 ‘Other grasslands, herblands, sedgelands and rushlands’; or MVG 22 ‘Chenopod shrublands, samphire shrublands and forblands’ depending on the vegetation structure and composition within a particular saltmarsh patch. Both MVGs are broadly defined and include substantial elements that are not part of the national ecological community, for instance occurrences in freshwater habitats and semi-arid chenopod shrublands.

Queensland

Queensland classifies its vegetation using regional ecosystems which are bioregionally based units that incorporate the land zone type and vegetation structure and composition into the description. One regional ecosystem from the South East Queensland bioregion equates to the coastal saltmarshes ecological community. This is:

- RE 12.1.2 Saltpan vegetation including grassland and herbland on marine clay plains.

This regional ecosystem is confined to land zone 1 (tidal flats and beaches) and has a status of ‘Least concern’ under the *Vegetation Management Act 1999* and a Biodiversity status of ‘No concern’ at present. Regional ecosystem 12.1.2 is described as: saltpan vegetation comprising *Sporobolus virginicus* grassland and samphire herbland. Grasses including *Zoysia macrantha* subsp. *macrantha* sometimes present in upper portions of tidal flats. Includes saline or brackish sedgelands; and occurs on Quaternary estuarine deposits and marine plains/tidal flats.

New South Wales

A comprehensive vegetation classification system for all of NSW is only available at a broad scale, to vegetation class (Keith, 2004). The national ecological community falls within the vegetation class: *Saltmarshes.* This includes saltmarshes on estuarine mudflats subject to tidal inundation and also small soaks on headlands exposed to abundant salt sprays. The saltmarshes on headlands are excluded from the national ecological community.

A finer-scale vegetation classification system, the NSW Vegetation Classification and Assessment database (NSW VCA) is in progress. However, this database does not yet cover the coastal regions, so it not possible to identify equivalent NSW VCA communities at this time.

Within New South Wales, the *Coastal Saltmarsh* ecological community is equivalent to a State-listed endangered ecological community that applies across all of NSW:

- *Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions*.

NSW also has listed a faunal community that may occur in the national Coastal Saltmarsh ecological community. This endangered community is geographically limited to a locality near Sydney and is:

- *The Shorebird Community occurring on the relict tidal delta sands at Taren Point*.

Victoria

Victoria classifies its vegetation using a system of Ecological Vegetation Classes (EVCs). An EVC may be further subdivided into Floristic Communities. The EVC system includes complexes, mosaic and aggregate units for situations where specific EVCs cannot be identified at a site at the spatial scale used for vegetation mapping. EVC mosaics and complexes are included in the national ecological community where they conform with the description of the national ecological community. The delineation of wetland EVCs is complex. Victoria also has established benchmarks for each wetland EVC for the Index of Wetland Condition (DSE, 2009) so condition assessments can be made with respect to a reference patch of a particular vegetation type. Benchmarks are not a comprehensive description of an EVC, but do provide an accessible summary of its main features and ecology.

The *Coastal Saltmarsh* ecological community corresponds with two EVCs that are limited to the coastal bioregions in Victoria:

- EVC 9 Coastal saltmarsh aggregate; and
- EVC 10 Estuarine wetland.

EVC 9 is recognised to be an aggregate community that comprises a variety of shrubby to herbaceous to grassy/sedge vegetation.

Victoria allocates a bioregional conservation status for each EVC in each bioregion that are based on levels of extent and decline for an EVC (DSE 2007; Table A1).

Table A1. Bioregional conservation status (as at 2007) for two EVCs that best correspond to the Coastal Saltmarshes ecological community.

Victorian bioregion	**Bioregional conservation status**	
	EVC 9 Coastal saltmarsh	**EVC 10 Estuarine wetland**
Bridgewater	Vulnerable	Endangered
Victorian Volcanic Plain	Vulnerable	Endangered
Warnambool Plain	n/a	Depleted
Otway Ranges	n/a	Endangered
Otway Plain	Endangered	Endangered
Gippsland Plain	Least concern	Least concern
Wilsons Promontory	Least concern	Rare
East Gippsland Lowlands	Depleted	Vulnerable

Source: DSE (2007)

Victoria formally lists ecological communities as threatened under the *Flora and Fauna Guarantee Act 1988*. Coastal saltmarshes are not formally listed in Victoria. A nomination to list the Victorian Coastal Saltmarsh Community was rejected in 2002 as the nomination did not meet any of the criteria under Victorian legislation for listing at that time.

Tasmania

Tasmania has classified its vegetation state-wide through the Tasmanian Vegetation Monitoring & Mapping Program (TASVEG) (Harris and Kitchener, 2005; DPIPWE, 2013). Four TASVEG units correspond with the *Coastal Saltmarsh* ecological community in Tasmania. These are:

- AHS Saline aquatic herbland;
- ARS Saline sedgeland/rushland;
- ASS Succulent saline herbland; and
- AUS Saltmarsh (undifferentiated). The AUS unit is a generic one that recognises saltmarsh as present but has not yet been classified into one of the other three saline vegetation types.

Note that these vegetation units extend inland from the coast and include occurrences that fall outside of the tidal influence that characterises the *Coastal Saltmarsh* ecological community. These patches fall outside the definition of the national *Coastal Saltmarsh* ecological community.

Tasmania formally lists native vegetation communities as threatened under Schedule 3A of the *Nature Conservation Act 2002*. The list of threatened communities currently does not include coastal saltmarshes as a distinct threatened community. However, the Saline aquatic herbland (AHS) TASVEG unit is listed as part of a broad 'Wetlands' vegetation community.

<u>South Australia</u>

South Australia has adopted the NVIS classification system for identifying its vegetation communities and compiling them into its SAVEG database. A number of coastal SAVEG units have been identified by the South Australian Department of Water and Natural Resources as potentially corresponding to the *Coastal Saltmarsh* ecological community (Table A2). The table excludes other coastal samphire vegetation units that occur in landscapes (e.g. headlands, dunes) or are dominated by species (e.g. *Acrotriche* sp.) that do not conform to the description of the *Coastal Saltmarsh* ecological community.

There are no provisions under the South Australia *National Parks and Wildlife Act 1972* or *Native Vegetation Act 1991* to formally list ecological communities as threatened entities. However, a provisional list of threatened ecosystems is maintained by the South Australian Department of Environment and Natural Resources. The provisional list has some wetland communities, including *Gahnia* sedgelands, but these appear to focus on predominantly freshwater wetlands.

<u>Western Australia</u>

Western Australia does not have a state-wide vegetation classification system that identifies saltmarsh outside of a local or regional scale. However, the following major vegetation units generally correspond to the *Coastal Saltmarsh* ecological community (G. Keighery, pers. comm.):

- Samphire shrublands dominated by *Tecticornia* species or *Sarcocornia* saltmarsh complex
- Grasslands dominated by *Sporobolus virginicus*;
- Sedgelands dominated by *Bolobschoenus caldwellii* or *Gahnia trifida*;
- Rushlands dominated by *Juncus kraussiii*; and
- Herblands dominated by *Wilsonia humilis*/*W. backhousei* with *Frankenia* spp. and *Triglochin striata* or *Samolus repens*.

Coastal Saltmarsh currently is not included on Western Australia's list of threatened ecological communities endorsed by the Western Australia Minister for the Environment.

Table A2. SAVEG units identified as potentially corresponding to the *Coastal Saltmarsh* ecological community in South Australia.

SAVEG ID	Description based on NVIS level 4 and 5 classifications
CT0004	*Maireana oppositifolia* +/- *Halosarcia indica* low open shrubland
CT0005	*Sclerostegia arbuscula* +/- *Sarcocornia quinqueflora* +/- *Lycium australe* low shrubland
CT0053	*Sarcocornia quinqueflora* low shrubland
CT0054	*Tecticornia halocnemoides* +/- *Sclerostegia arbuscula* +/- *Maireana oppositifolia* low shrubland
CT0055	*Halosarcia indica* +/- *Maireana oppositifolia* +/- *Atriplex paludosa* low open shrubland \ low forbs
CT0057	*Halosarcia indica* +/- *Maireana oppositifolia* +/- *Halosarcia pergranulata* low shrubland
FW0008	*Tecticornia halocnemoides* +/*Maireana oppositifolia* +/- *Lawrencia squamata* low open shrubland \ low sparse shrubland
GR0002	*Halosarcia indica* subsp. *leiostachya*, *Atriplex vesicaria* low shrubland
KI1801	*Sclerostegia arbuscula* low shrubland
KI1802	*Sclerostegia arbuscula* low shrubland
MM3301	*Halosarcia* sp. low sparse shrubland
MN3501	*Halosarcia* sp., *Sarcocornia blackiana* low open shrubland
OS0010	*Tecticornia halocnemoides*, *Sarcocornia quinqueflora*, *Suaeda australis* low open shrubland
RM2101	*Tecticornia halocnemoides* subsp. *halocnemoides*, *Sclerostegia arbuscula*, *Disphyma crassifolium* subsp. *clavellatum* low shrubland
RM2104	*Halosarcia pergranulata* subsp. *pergranulata* +/- *Hordeum marinum* +/- *Suaeda australis* low open shrubland
RM2105	*Sclerostegia arbuscula* low sparse shrubland
RM2201	*Sarcocornia quinqueflora* +/- *Samolus repens* +/- *Suaeda australis* low shrubland
SE0029	*Sarcocornia* sp., *Halosarcia* sp., *Suaeda australis* low shrubland
SM4001	*Sarcocornia quinqueflora*, *Sclerostegia arbuscula* +/- *Suaeda australis* low shrubland
SM4002	*Tecticornia halocnemoides* subsp. *halocnemoides*, *Sarcocornia blackiana* low shrubland
SM4003	*Tecticornia halocnemoides* subsp. *halocnemoides*, *Sclerostegia arbuscula* low open shrubland
SM4004	*Halosarcia pergranulata* subsp. *pergranulata*, *Sarcocornia quinqueflora*, *Enchylaena tomentosa* low shrubland
SM4005	*Halosarcia* sp., *Sarcocornia quinqueflora* low open shrubland
YE0001	*Tecticornia halocnemoides*, *Halosarcia* sp., *Disphyma crassifolium* subsp. *clavellatum* low shrubland

Source: D. Fotheringham, pers. comm.

Nationally and State-listed threatened species

A suite of threatened and migratory species listed under various articles of federal or state legislation occur within the ecological community (Table A3). For example in the Victorian *Coastal Saltmarsh* ecological community, there are some 60 threatened/migratory or marine overfly birds listed under the EPBC Act, including the critically endangered *Neophema chrysogaster* (orange bellied parrot). Spencer et al., (2009) report seven birds listed as threatened under the EPBC Act or state legislation that occur in Australian saltmarsh that would also potentially occur within the ecological community. *Xeromys myoides*, the native water mouse, nests within the *Coastal Saltmarsh* ecological community and is listed as vulnerable at international, national and state levels (Russell and Hale, 2009). *Litoria aurea*, the EPBC Act vulnerable listed golden bell frog, has also been recorded in the *Coastal Saltmarsh* ecological community during periods of high rainfall (Spencer et al., 2009).

Relationships to other similar nationally-listed ecological communities

The *Coastal Saltmarshes* ecological community differs from some other EPBC-listed wetland communities by its coastal position in the landscape that is subject to marine tidal influence. For instance, the critically endangered *Seasonal Herbaceous Wetlands of the Temperate Lowland Plains* (in Victoria, NSW and SA) and the critically endangered *Claypans of the Swan Coastal Plain* ecological communities are also seasonal wetlands with a herbaceous/grass/sedge component. However, they are largely freshwater with inundation largely driven by rainwater and their landscape position is not subject to marine or tidal influences.

Other nationally listed ecological communities that occur on the coast are structurally different or occupy a different landscape position from the *Coastal Saltmarsh* ecological community. For instance, the critically endangered *Littoral Rainforest and Coastal Vine Thickets of Eastern Australia* ecological community is distinct from *Coastal Saltmarsh* by its complex canopy of shrubs and trees and its occurrence on a wider range of landforms that includes dunes and flats, cheniers, berms, cobbles, headlands, scree, seacliffs, marginal bluffs, spits, deltaic deposits, coral rubble and islands.

The endangered *Sedgelands in Holocene Dune Swales of the Southern Swan Coastal Plain* ecological community differs from the Coastal Saltmarsh ecological community by its occurrence in sandy damplands among the swales of Holocene dunes. The flora also is distinct in that typical species include the shrubs *Acacia rostellifera* (summer-scented wattle), *Acacia saligna* (orange wattle) and *Xanthorrhoea preissii* (grass tree) that are absent from the *Coastal Saltmarshes* ecological community.

The critically endangered *Swamps of the Fleurieu Peninsula* mostly occur well inland from the coast though some occurrences extend to the coast in the vicinity of the River Murray mouth and Lake Alexandrina. This ecological community is floristically distinct from the *Coastal Saltmarsh* ecological community by the presence of heathy shrubs, such as *Sprengelia incamata* (pink swamp heath), *Viminaria juncea* (native broom), *Leptospermum lanigerum* (silky tea-tree) and *Leptospermum continentale* (prickly tea-tree).

Level of protection in reserves

Comprehensive data on what extent of the ecological community is protected within reserves and other conservation-related tenure is not available for the entire range of the ecological community. However, reliable data are available for a few jurisdictions.

In Queensland, the extent of RE 12.1.2 that occurs in national parks and other conservation-related tenure is 5157 ha or about 18% of the total current extent (Accad et al., 2012).

The vegetation survey of the south coast of NSW (from Sydney to the Victorian border) by Tozer et al. (2010) recognised coastal saltmarsh as a single discrete vegetation unit: SL p509 Estuarine saltmarsh. The area of this unit that occurs in conservation reserves is 690 ha. This represents about 31.4% out of a total extant area of 2200 ha.

In Victoria, the extent of EVC 9 Coastal saltmarsh and EVC 10 Estuarine wetland that occur in conservation-related tenure (not including State forests) is 11 554 ha (DSE, 2007). This represents a considerable proportion, about 61% of the current extent of Coastal Saltmarsh in Victoria that was estimated by DSE (2007).

Detailed estimates of the extent in reservation are presently not available for Western Australia, South Australia, Tasmania and the north and central coasts of NSW.

The available data indicate that, on the east coast of Australia, at least, a variable and sometimes considerable proportion of the *Coastal Saltmarsh* ecological community is protected through inclusion under conservation tenure.

Table A3A: *Threatened flora listed under the Environment Protection and Biodiversity Conservation Act 1999 and State legislation likely to occur in or near the Subtropical and Temperate Coastal Saltmarsh ecological community. Known occurrences of some species may be in landscapes or vegetation communities nearby to the national ecological community.*

		Conservation status							
Scientific name	**Growth form**	**EPBC**	**VIC**	**NSW**	**QLD**	**NT**	**WA**	**SA**	**TAS**
Cuscuta tasmanica	parasitic								Rare
Distichlis distichophylla	grass			Endangered					
Juncus revolutus	rush		Rare						
Limonium australe	herb								Rare
Limonium baudinii	herb	Vulnerable							Vulnerable
Tecticornia flabelliformis	shrub	Vulnerable	Threatened				Poorly known	Vulnerable	
Triglochin minutissima	herb		Rare						Rare
Wilsonia backhousei	subshrub			Vulnerable					
Wilsonia humilis	subshrub								Rare
Wilsonia rotundifolia	subshrub			Endangered					Rare
Zannichellia palustris	submerged aquatic plant			Endangered					

Table A3B: *Threatened fauna listed under the Environment Protection and Biodiversity Conservation Act 1999 and State legislation likely to occur in or near the Subtropical and Temperate Coastal Saltmarsh ecological community. Known occurrences of some species may be in landscapes or vegetation communities nearby to the national ecological community*

		Conservation status								
Scientific name	**Common name**	**EPBC**	**VIC**	**NSW**	**QLD**	**NT**	**WA**	**SA**	**TAS**	**International/ migratory**
Mammals										
Miniopterus schreibersii oceanensis	eastern bentwing bat			Vulnerable						
Myotis macropus	southern myotis			Vulnerable						
Planigale maculata	common planigale			Vulnerable						
Scoteanax rueppellii	greater broad-nosed bat			Vulnerable						
Xeromys myoides	false water rat	Vulnerable			Vulnerable					
Birds										
Acanthiza iredalei iredalei	slender-billed thornbill	Vulnerable						Vulnerable		
Actitis hypoleucos	common sandpiper									Bonn, CAMBA, JAMBA, ROKAMBA listed
Amaurornis moluccana	pale-vented bush hen			Vulnerable						
Anas rhynchotis	Australasian shoveler		Vulnerable							
Anseranas semipalmata	magpie goose			Vulnerable						
Apus pacificus	fork tailed swift									CAMBA, JAMBA, ROKAMBA listed
Ardea modesta	great egret		Vulnerable							CAMBA, JAMBA listed
Ardea ibis	cattle egret									CAMBA, JAMBA listed

		Conservation status							
Scientific name	**Common name**	**EPBC**	**VIC**	**NSW**	**QLD**	**NT**	**WA**	**SA**	**TAS**	**International/ migratory**
Botaurus poiciloptilus	Australasian bittern	Endangered	Endangered	Endangered			Endangered	Vulnerable		
Burhinus grallarius	bush stone curlew		Endangered	Endangered				Vulnerable		
Calamanthus campestris	rufous field wren		Near Threatened	Vulnerable						
Calidris acuminata	sharp tailed sandpiper									Bonn, CAMBA, JAMBA, ROKAMBA listed
Calidris alba	sanderling			Vulnerable						Bonn, CAMBA, JAMBA, ROKAMBA listed
Calidris canutus	red knot									Bonn, CAMBA, JAMBA, ROKAMBA listed
Calidris ferruginea	curlew sandpiper									Bonn, CAMBA, JAMBA, ROKAMBA listed
Calidris ruficollis	red-necked Stint									Bonn, CAMBA, JAMBA, ROKAMBA listed
Calidris tenuirostris	great knot									Bonn, CAMBA, JAMBA, ROKAMBA listed
Charadrius bicinctus	double-banded plover									Bonn A2H
Charadrius leschenaultii	greater sand plover			Vulnerable						Bonn, CAMBA, JAMBA, ROKAMBA listed

		Conservation status							
Scientific name	**Common name**	**EPBC**	**VIC**	**NSW**	**QLD**	**NT**	**WA**	**SA**	**TAS**	**International/ migratory**
Charadrius mongolus	lesser sand plover			Vulnerable						Bonn, CAMBA, JAMBA, ROKAMBA listed
Circus assimilis	Spotted harrier			Vulnerable						
Cisticola juncidis normani	zitting cisticola/ normanton				Rare					
Ephippiorhynchus asiaticus	black-necked stork			Endangered	Rare					
Epthianura albifrons	white-fronted chat			Vulnerable (preliminary)						
Epthianura crocea macgregori	yellow chat	Critically endangered			Endangered					
Esacus magnirostris	beach stone curlew			Critically Endangered	Vulnerable					
Gallirallus philippensis macquariensis	buff-banded rail	Extinct								JAMBA Presumed extinct
Haematopus fuliginosus	sooty oyster catcher			Vulnerable						
Haematopus longirostris	pied oyster catcher			Endangered				Rare		
Haliaeetus leucogaster	white-bellied sea eagle		Vulnerable						Vulnerable	
Ixobrychus flavicollis	black bittern			Vulnerable						
Ixobrychus dubius	Australian little bittern		Endangered							
Lewinia pectoralis	Lewin's rail							Vulnerable		Bonn, CAMBA, JAMBA, ROKAMBA listed

		Conservation status								
Scientific name	**Common name**	**EPBC**	**VIC**	**NSW**	**QLD**	**NT**	**WA**	**SA**	**TAS**	**International/ migratory**
Limicola falcinellus	broad billed sandpiper			Vulnerable						Bonn, CAMBA, JAMBA, ROKAMBA listed
Limosa lapponica	bar tailed godwit									Bonn, CAMBA, JAMBA, ROKAMBA listed
Neophema chrysogaster	orange-bellied parrot	Critically endangered	Critically endangered	Endangered				Endangered	Endangered	JAMBA Endangered
Numenius madagascariensis	eastern curlew				Rare					Bonn, CAMBA, JAMBA, ROKAMBA listed
Nycticorax caledonicus hillii	nankeen night heron		Endangered							
Philomachus pugnax	ruff									Bonn, CAMBA, JAMBA, ROKAMBA listed
Pluvialis fulva	pacific golden plover									Bonn, CAMBA, JAMBA, ROKAMBA listed
Porzana pusilla	Baillon's crake		Vulnerable							
Rostratula australis	Australian painted snipe	Vulnerable	Threatened	Endangered	Vulnerable		Rare	Vulnerable		CAMBA listed
Sterna hirundo	common tern									CAMBA, JAMBA, ROKAMBA listed
Sternula nereis nereis	Australian fairy tern	Vulnerable	Threatened					Endangered	Vulnerable	

		Conservation status							
Scientific name	**Common name**	**EPBC**	**VIC**	**NSW**	**QLD**	**NT**	**WA**	**SA**	**TAS**	**International/ migratory**
Stipiturus malachurus intermedius	southern emu-wren	Endangered						Endangered		JAMBA Endangered
Tadorna radjah	radjah shelduck				Rare					
Thinornis rubricollis rubricollis	hooded plover		Vulnerable	Endangered				Vulnerable		
Tringa nebularia	common greenshank									Bonn, CAMBA, JAMBA, ROKAMBA listed
Tringa stagnatilis	marsh sandpiper									Bonn, CAMBA, JAMBA, ROKAMBA listed
Tyto longimembris	eastern grass owl			Vulnerable						
Xenus cinereus	terek sandpiper			Vulnerable						Bonn, CAMBA, JAMBA, ROKAMBA listed
Fish										
Mugilogobius platynotus	pale mangrove goby		Vulnerable							
Amphibians										
Litoria aurea	green & golden bell frog	Vulnerable		Endangered						
Invertebrates										
Argynnis hyperbius	laced fritillary			Endangered						
Dasybela achroa	saltmarsh looper moth								Vulnerable	

		Conservation status								
Scientific name	**Common name**	**EPBC**	**VIC**	**NSW**	**QLD**	**NT**	**WA**	**SA**	**TAS**	**International/ migratory**
Theclinesthes serpentata lavara	saltbush blue butterfly								Rare	

APPENDIX B – GENERAL BIOLOGY AND ECOLOGICAL PROCESSES

General

The environmental features which above all distinguish coastal saltmarshes from terrestrial ecosystems are the influence of salt and the fact that they are wetlands. They can be distinguished from inland saline wetlands because the salt influence arises from current ongoing tidal action rather than reflecting an ancient geological heritage. The wetland characteristics of coastal saltmarsh interact with salinity to give rise to complex spatial environmental gradients, which are also temporally variable on a variety of scales.

Useful reference literature on biology and ecology relevant to the *Coastal Saltmarsh* ecological community can be found in Adam (1990), Adam et al. (2008), Batzer and Swaritz (2006), Perillo et al. (2009), Saintilan (2009c), VSS (2011), Sainty et al. (2012d), and Saintilan and Rogers (2013). The following sections were prepared in consultation with saltmarsh expert P. Adam (pers. comm.).

Flora and salt tolerance

The number of vascular plants which can survive the wetland and saline conditions is relatively small, many of which are restricted to the habitat. Within saltmarshes, most plant species of coastal saltmarsh have both wide ecological distributions within individual sites and extensive geographical ranges. Some species are restricted to particular niches within the individual sites but have wide geographical distributions. Only a small number of species have both restricted niches and limited geographical distributions. Vascular plant species richness is inversely correlated with latitude, with only a small number of species towards the subtropics and a much higher number in temperate regions, particularly in South Australia and south-west Western Australia.

Saltmarsh plants come from a variety of families; the adaptations required to thrive in what is to most plants a hostile environment have evolved independently in different lineages. Adaptation to salinity comes at a cost. In saline habitats, plants occurring in these conditions (halophytes) have a competitive advantage over non-salt tolerant species. Under the non-saline conditions halophytes, in which a proportion of annual production is diverted to mechanisms of salt tolerance, are out competed by faster growing non-salt tolerant species. Where salinity is lowered in saltmarshes by human activity, for example around the discharge points of stormwater drains, invasion by low salt tolerant species can occur (Zedler et al. 1990).

Salt tolerance is achieved by a limited number of mechanisms, either acting singly or in combination (Adam 1990). One visible mechanism is through the excretion of salt from leaves and stems through salt glands. Examples of salt excreting species in temperate Australian saltmarshes are *Frankenia pauciflora, Limonium australe, Samolus repens,* and *Sporobolus virginicus*. An essential component of salt tolerance is the sequestering of salt taken up into foliage in vacuoles; as a consequence, to ensure osmotic balance within the cells, an osmoregulatory compound is accumulated in the cytoplasm. The particular compound involved varies between species, but is frequently nitrogenous. This has implications both for the nutritional requirements of halophytes and their value to herbivores.

Flora, tidal connection and zonation

Flooding by tides, or in the case of intermittently open lagoons, fluctuations in lagoon water level, affects both the subterranean and aerial environment. The effects on the soil depend on the frequency of flooding and the soil characteristics – sandy soil drains more freely than silt or clay. More frequently flooded and poorly drained sites may have anoxic soils for prolonged periods. Anaerobic conditions are inimical to plant growth, but the plants adapted to grow in wetland soils do not experience these conditions because aerenchyma within the roots provide a pathway for oxygen to diffuse from the shoot and thus retain aerobic conditions within tissues. Frequently, oxygen transport is sufficient to support radial oxygen loss into the sediment surrounding the root, creating an oxygenated microhabitat, with its own microbial and meiofaunal assemblages.

Above the ground, low vegetation at lower elevations within a marsh may be submerged for periods of up to several hours at high tide. For tides during daylight hours, such flooding results in a reduction in the time in which photosynthesis can occur. For tall vegetation at high levels in the marsh most of the foliage remains emergent throughout the tide cycle.

The tidal currents move material within, into, and out of marshes. Germinated seedlings are at risk of being dislodged by currents, so that there are limited windows of opportunity when the interval between tides is sufficiently long for the seedlings to become securely rooted before the next flooding event (Adam 1990).

At lower elevations in a marsh tidal flooding occurs sufficiently frequently that soil salinity is relatively constant. At higher levels soil salinity is more variable in both space and time, being strongly influenced by climate and weather. Soil salinity may exceed that of seawater if there are hot dry conditions between tides, but on high marshes with ground surface freshwater inputs, conditions may be consistently brackish.

In general it is possible to recognise a zonation in the flora and vegetation from low elevation to the tidal limit (Adam 1990), although at many sites the lowest levels in the vegetated intertidal are occupied by mangrove. While overseas there is a tradition of recognising three zones (low, mid and high), in temperate Australia a simple division between low marsh and high marsh is sufficient (Sainty et al., 2012 a, b). What may be loosely referred to as the upper marsh zone is often a mosaic of several recognisable plant communities (Zedler et al., 1995). The patchiness of community distribution within zones is more apparent in higher latitude marshes than it is in the species poor lower latitude marshes.

Cryptogamic flora

Particularly in the lower saltmarsh the sediment surface may support a film of microalgae and cyanobacteria. As well as stabilising the surface this film may be an important food resource for fauna (Adam 1990). There have been few studies on the microalgae in Australian saltmarshes, and there is no inventory of this important component of biodiversity. The most widespread and abundant macroalgae on saltmarshes are species of *Ulva* (including species formerly included in *Enteromorpha*), which may form smothering mats on eutrophic sites. Free-living forms of the brown alga, *Hormosira* occur at a few sites. A number of small red algae (*Bostrychia*, *Catenella*) may occur locally in some saltmarshes, but are more common as epiphytes on pneumatophores of mangroves.

A number of fungal species have been recorded from saltmarshes and may play an important ecological role but have been very little studied in Australia (Adam1990).

Flora - reproduction

Although most saltmarsh plants are tolerant of saltwater, and some species (including *Sarcocornia*) can germinate in seawater salinities or greater, many saltmarsh species require periodically fresher conditions to recruit sexually (Adam, 1990; VSS, 2011). For example, *Juncus kraussii* shows optimal germination in brackish to fresh water (Greenwood and MacFarlane, 2006; Naidoo and Kift, 2006), and fails to germinate in seawater. Saltmarsh diversity may therefore be more vulnerable to the consequences of ground- and surface-water diversions than the prevailing salinity conditions may indicate (Saintilan and Rogers, 2013).

Fauna

Saltmarshes have a rich fauna, which can be grouped on the basis of continuity of occurrence (resident, transient, migratory) on the basis of whether they are of marine or terrestrial origin, or by conventional taxonomy.

The resident fauna of marine origin is predominantly invertebrate, with molluscs and crustaceans being the most obvious components (Ross et al., 2009; Mazumder, 2009; Connolly 2009). In particular, crabs inhabiting salmarshes excavate burrows over extensive areas, profoundly modifying the physical structure of the environment (Jones et al., 1994, 1997). The breeding behaviour of crabs is synchronised with tidal amplitude, with larvae released when high spring tides flood the habitat (Mazumder, 2009). Resident marine fish inhabit permanent and semipermanent pools and creeks, although these habitats are far less extensive on Australian salt marshes than they are overseas. A diverse fish fauna is present across saltmarshes during flooding tides with many transient marine species often present (Connolly, 2009).

The resident marine vertebrate component of the fauna is mostly found in the lower, more frequently inundated, parts of the marsh, with normally only few individuals on the infrequently flooded upper marsh. Of the terrestrial lineage invertebrate fauna mosquito larvae may be present in wet sites in the lower marsh (Dale and Breitfuss, 2009), and large numbers of flying insects may be encountered above low marsh vegetation. A small number of insects are adapted to the marine environment, and, for example, a number of root living aphids have been studied in lower saltmarshes in the northern hemisphere (Foster, 2000). It is not known whether such species occur in Australia. The upper saltmarsh invertebrate fauna is dominated by species of terrestrial origin. The diversity of terrestrial invertebrates in saltmarshes is clearly large, with the most conspicuous being insects and spiders, but even that these groups there is far from a complete inventory. Groups such as the Acari (mites), for which saltmarsh in Europe has been shown to be an important habitat (Luxton, 2000), have not been studied in Australia.

In broad terms there is a zonation of the resident invertebrates with respect to elevation within saltmarshes, but the extent to which there is concordance between the distribution of plant assemblages and assemblage of fauna has not been explored.

The terrestrial vertebrate fauna of Australian saltmarshes is discussed by Spencer et al., (2009). The birds most associated with saltmarshes in the public mind are migratory waders, which primarily utilise saltmarshes for high tide roosts (Ashcroft and Major, 2013). However, there are many other species of bird which feed on saltmarsh, including nationally endangered species such as the Orange-bellied parrot (Hollands and Minton, 2012; Ashcroft and Major, 2013). A small number of species nest towards the upper limits of saltmarsh. The large number of insects associated with saltmarshes have been recognised as an important resource for insectivorous bats (Spencer et al., 2009). For ground dwelling mammals, saltmarshes are feeding habitat for a number of species of macropod. A number of species of rodent, including the threatened false water rat , *Xeromys myoides* , may also be resident in saltmarshes.

Productivity

Saltmarshes are frequently claimed to be amongst the world's most productive ecosystems, and the primary productivity measured at some sites is undoubtedly high. However, the high values are from *Spartina alterniflora* stands in the United States, and other types of saltmarsh may be considerably less productive (Adam 1990). There are few measures of either standing crop or productivity from Australian saltmarshes, but it is unlikely that productivities comparable to the world's highest are achieved. Nevertheless, for salt tolerant spaces the predictable tidal flooding provides a reliable access to water so productivity is less likely to be affected by drought than in most terrestrial communities and production is likely to be consistent between years.

Saltmarsh communities globally tend to have relatively high root-shoot ratios and there is no reason to suspect that Australian saltmarshes would not share the same characteristic. The importance of wetlands is carbon sinks is increasingly recognised (SEWPAC, 2012) and Chmura et al. (2003) have documented the importance of saltmarshes in this regard (often referred to as Blue Carbon). Organic matter below the ground is subject to decay and decomposition, but much of the material either remaining in *situ* (routes and rhizomes) or being buried will be stable for long periods.

Aboveground biomass is processed more quickly. Direct herbivory has not been quantified in Australia, but, as occurs overseas, it is likely that the most important herbivores are invertebrates, both marine species in the lower marsh and terrestrial species in the upper marsh. However, locally intensive grazing by vertebrates may occur at times. Nevertheless, in general, the proportion of aboveground primary production directly consumed by herbivores is likely to be fairly small. A much larger fraction of production is potentially exported unprocessed off-marsh. Movement can be in both inland and seaward directions. Material moved landward accumulates in the drift line, although drift line wrack deposits do not consist solely of material from saltmarsh but may contain large amounts of seagrass and/or algae as well as timber and litter. Wrack deposits are important habitats in their own right.

Material carried seaward enters detrital food chains. The magnitude of these fluxes has not been quantified in Australian saltmarshes, but saltmarsh production will contribute to ecosystem processes within estuaries and coastal waters.

Trophic linkages

In addition to fluxes in materials there are also fluxes of organisms. At high tides a diversity of fish species have access to the marsh surface. Overseas there have been many studies of fish in creeks but very little study off utilisation of the main marsh plain. Work in Australia has led to the application of appropriate nets to sample the fish fauna on the saltmarsh surface (Connolly 2009). A variety of techniques, including use of stable isotopes, has permitted elucidation of feeding habits of fish in saltmarshes. Even though fish have access to the marsh for only very limited periods, saltmarshes provide high-quality food resources. Reproduction of saltmarsh crabs is very closely tied to the incidence of flooding tides, and crab larvae are an important food resource for fish, including species which are either themselves of commercial or recreational importance or are consumed by commercially significant species (Mazumder et al., 2006, 2008; Mazumder, 2009; Hollingsworth and Connolly, 2006, 2009).

Habitat values and nursery function

Coastal saltmarsh is habitat for a very large range of species although comprehensive national data is not yet available. It is well recognised that coastal saltmarsh provides important shelter (protection from predation), feeding, roosting, nesting, and nursery habitat for a range of fish and birds (Connolly, 2009; Spencer et al., 2009). It is often referred to as important 'nursery' habitat for many fish species, including those with recreational and commercial importance (Connolly, 2009).

Even those species which can utilise other habitats, may be dependent on saltmarsh at particular times of the year. For example, migratory wading birds may utilise saltmarshes for only limited periods, but the protection of the full range of sites utilised throughout the world throughout the year is essential for the conservation of waders (e.g. Paton et al., 2009).

Coastal protection

Coastal saltmarshes play important roles in global geochemical (Chmura et al., 2003) and sedimentary processes. At local level they may also provide protection to the hinterland through absorption of wave energy, particularly during storm events (Moller, 2006), especially where mangroves are not present.

APPENDIX C - FURTHER DESCRIPTION OF THREATS

C.1: Clearing and fragmentation

Historical and contemporary clearing have resulted, and will continue to result in, loss or fragmentation of *Coastal Saltmarsh* habitat. Clearing can further fragment or degrade remaining patches, increasing the risk of disconnection and loss of ecological function. Fragmentation is a major factor contributing to coastal saltmarsh habitat and biodiversity decline (Kelleway et al., 2009; Laegdsgaard et al., 2009). Rare or specialised species, or species with lower dispersal capabilities are most affected (Tscharntke et al., 2002), and fragmentation is likely to have a major impact on *Coastal Saltmarsh* foodweb dynamics (Laegdsgaard et al., 2009).

C.2: 'Land-claim' or infilling

Coastal Saltmarsh has often in the past been considered as 'wasteland' by settlers and developers and therefore filled in and reclaimed for 'better' use (Fairweather, 2011). Land-claim (for urban, industrial or agricultural use) usually involves raising the soil profile to prevent flooding and the construction of levees, bunds or sea walls to prevent ingress of seawater. Creation of roads is often associated with land-claim and this further fragments saltmarsh patches and disconnects from tidal flows. Land-claim is effectively irreversible and can modify the local tidal range and patterns of inundation (Adam, 2002; Fairweather, 2011). Thus coastal saltmarsh remnants are usually impacted by disturbed tidal hydrology (i.e. 'stranded' from tidal influence). Also, many saltmarshes are starved of sediment because of catchment modification and coastal engineering (Adam, 2002).

C.3: Anthropogenically Altered Hydrology/Tidal restriction

Developments can impact on local microclimates, groundwater access and surface runoff changing hydrological regimes (freshwater and tidal) for vegetation. For example, as a result of agricultural and urban infrastructure, many coastal saltmarshes have had their tidal regime significantly changed (Laegdsgaard et al., 2009; Mount et al., 2010). Alterations to drainage and hydrology have occurred through constructing fixtures such as levees, culverts and floodgates. The impacts from such infrastructure range from habitat destruction to changes to ecological function. For example increased inundation can lead to rot and decomposition of succulent species (Laegdsgaard et al., 2009). Of note, in South Australia, the clearance of native vegetation for construction of flood mitigation levees is covered by an exemption under the Regulations of the *Native Vegetation Act 1991*.

Tidal disconnection often leads to invasion by plants such as *Phragmites australis* which can spread forming monotypic stands that alter the ecology and function of saltmarsh (Laegdsgaard et al., 2009 and references therein). Such downslope migration of *P. australis* and other freshwater reeds, which can also be caused by increased stormwater discharge, threatens *Coastal Saltmarsh* from its terrestrial side (Williams et al., 2011; Sainty et al., 2012c).

C.4: Invasive species

Invasive species such as non-native weeds (or in some cases native species that form monotypic stands) are increasingly replacing native plants in the *Coastal Saltmarsh* ecological community, limiting native biodiversity, changing vegetation structure and potentially altering fire regimes which may cause patches to decline over time (e.g. VSS, 2011, Carr, 2012a,b). Invasion by non-indigenous plant species can alter native plant assemblages, leading to losses of specialist herbivores, changes to patterns of herbivory and alterations to insect and other invertebrate community structure and ecosystem function (Harvey et al., 2011 and references therein). Some pertinent examples are:

- Of particular concern with estuarine saltmarsh is the weed *Juncus acutus* (sharp rush) in south-east and south-west Australia (e.g. Keighery and Keighery, 2006). This introduced rush out-competes the native rush *Juncus kraussii* on which many invertebrates depend (Laegdsgaard et al., 2009; Harvey et al., 2010, 2011). It is considered a potential threat in South Australia, where is has been observed in the Lower Lakes and Coorong, but as yet (in the main) has not invaded *Coastal Saltmarsh*.
- The introduction of *Spartina anglica* (common cordgrass, ricegrass) into Tasmania and Victoria is similarly causing broad-scale detrimental problems to saltmarsh habitat and native biodiversity (VSS, 2011). During 2005, all known patches of cordgrass (*Spartina anglica*) were removed in South Australia (Fotheringham and Coleman, 2008). Other aggressive invaders that displace native plants are groundsel bush (*Baccharis halimifolia*) and pampas grass (*Cortaderia selloana*).
- In the west there are several weeds that are of concern (Keighery and Keighery, 2013a,b) such as: *Atriplex prostrate*, a major weed of estuarine edges from Perth to Albany in south-west Western Australia; *Limonium hyblaeum* in coastal salt lakes north of Perth, and *L. companyonis* south of Perth (also present in Coorong, SA); *Puccinellia ciliata*, commonly used as a salt-land reclamation species in Western Australia is invading grazed *Coastal Saltmarsh* in the Vasse-Wonnerup system near Capel, as is *Carex divisa*; *Paspalum vaginatum/Boloboschoenus caldwellii* are native invaders of hydrologically altered marshes in some south-west estuaries.

Over the past few decades, there have been significant invasions of exotic macroinvertebrates into the *Coastal Saltmarsh* ecological community (Adam, 1990; Ross et al., 2009). Such invasive species may affect native invertebrates in a variety of ways, such as: competition for resources; introducing parasites or disease; or altering habitat. For example, the green crab (*Carcinus maenas*) was first (inadvertently) introduced into Port Phillip Bay in Victoria in the late 1800s (via ballast water) and has since spread throughout much of the temperate range of the ecological community (with the exception of Western Australia). The green crab competes with native species for habitat and food. It is also a significant predator of native molluscs, crustaceans and other species, and can dramatically alter species assemblages (Grosholz et al., 2000).

The predatory mosquito fish (*Gambusia holbrooki*) was deliberately introduced into Australian waters to control mosquito populations (Adam, 2002; Webb and Russell, 2012). It feeds on mosquito larvae in saltmarshes, but also consumes the eggs and larvae of fish, and larvae and adults of crustaceans and possibly molluscs (Komak and Crossland, 2000; Ross et al., 2009).

Feral animals (e.g. goats, pigs, deer, rabbits, etc.) browse and damage native vegetation and may eat or displace native fauna associated with *Coastal Saltmarsh* (Adam, 2002; Laegdsgaard et al., 2009).

C.5: Climate Change

Impacts from climate change on the *Coastal Saltmarsh* ecological community relate to changes to temperature, sea level, storm frequency, and sediment dynamics (Bromberg Geden et al., 2009; Ross et al., 2009; DCC, 2009; Prahalad et al., 2011; Saintilan and Rogers, 2013) and possibly enhanced CO_2 (Saintilan and Rogers, 2013). Anticipated consequences could result in conditions that may promote both the landward and seaward migration of the ecological community, although landward migration is the most likely (Bryant, 1990; Adam, 2002; Ross et al., 2009; Ross and Adam, 2013).

Sea level rise is considered a severe threat to coastal saltmarsh, particularly as there is little scope or area for recolonisation (DCC, 2009; Oliver et al., 2012; Rogers et al., 2012; Ross and Adam, 2013). The most likely effects of sea level rise will be to further squeeze saltmarshes into a narrowing space between the sea and human habitation and other structures. This 'coastal squeeze' phenomenon has already been reported in the eastern states (Saintilan, 2009b; Saintilan and Rogers, 2013).

Rising temperatures are likely to result in species shifts in distribution (e.g. southward), but it is unclear if species are able to respond in time (Adam, 2002). Concomitant impacts on saltmarsh pollinators (insects) may also be a problem. Changes to rainfall patterns and evaporation will also influence hydrology, sedimentation, and weed infestation. For example, increased landward spread and dominance by the invasive grass *Spartina anglica* in temperate coastal saltmarshes is projected under most climate change scenarios. In Tasmania, decreased rainfall and increased evaporation have led to the expansion of salt scalds (Prahalad et al., 2011).

Other threats from human activities have decreased the resilience of the *Coastal Saltmarsh* ecological community to cope with climate change (e.g. preventing distribution change). A further concern with significant loss of coastal saltmarsh habitat is that it could liberate the huge pool of carbon stored in wetland sediments to coastal waters or the atmosphere (DCC, 2009).

C.6: Mangrove encroachment

Saltmarsh plants generally dominate where mangrove plants are excluded by either low temperature or low moisture limitations. However, over the past few decades, saltmarsh has been increasingly encroached on by mangrove along the south-east coast of Australia from Queensland to South Australia (Saintilan, 2009 a,b; Saintilan and Rogers, 2013; and noting that mangroves are absent from Tasmania). There is no evidence of a similar encroachment by mangroves into the ecological community in Western Australia (G. Keighery, pers. comm.). For example, Burton (1982) showed that following the breaching of seawalls, mangroves at Barker Inlet, South Australia, migrated landward at speeds of up to 18 m per year, transgressing the saltmarsh. The interplay between mangroves and saltmarshes are driven by complex natural processes and are often influenced by human activity whether directly upon the communities themselves or within their catchments (Harty, 2009).

Mangrove encroachment is a response to various processes that have not been definitively identified and it is likely that a combination of a range of factors at various locations may be the reason for causing this phenomenon (Wilton, 2002). Some of these include local land subsidence which was the most likely cause cited in Burton (1982), greater freshwater input, higher sediment loads and surface elevation. However, increasingly it is considered that a link may exist between the incursion of mangrove and a steady rise in sea level (Lambeck, 2002; Rogers et al., 2005; 2006; 2012). Projections of the likely response of saltmarsh to moderate rates of sea level rise indicate that saltmarsh may be in serious decline by the end of the century (Saintilan and Rogers, 2013). Changes in rainfall pattern have also been suggested as a mechanism for the landward incursion of mangrove into saltmarsh. For example, Eslami-Andargoli et al. (2009, 2010) demonstrated that rainfall variability is one of the principal factors influencing the rate of upslope encroachment of mangrove.

C.7: Recreation

Many areas of *Coastal Saltmarsh* are accessible to vehicles (e.g. all terrain and off-road vehicles and motorbikes) and they can cause localised and widespread damage to saltmarsh vegetation and fauna (eg. ground nesting birds). Decrease or degradation of *Coastal Saltmarsh* in New South Wales has been directly attributed to recreational vehicle use (Kelleway, 2005). For example, 2.1 ha has been lost along the Georges River near Sydney as a consequence of recreational vehicle use (Kelleway, 2005). In South Australia and Western Australia, the use of four-wheel drive vehicles in coastal areas is generally permitted, in contrast to Victoria. The low growing succulent herbs of saltmarsh are particularly susceptible to damage by vehicles, and creation of large bare areas by 4-wheel drive vehicles is not uncommon (Laegdsgaard et al., 2009). Vehicle movement and noise may also threaten wildlife such as birds, bats and marsupials that use saltmarsh habitat for feeding, roosting or nesting (Spencer et al., 2009). Increased activity of people and vehicles in *Coastal Saltmarsh* may also lead to introduction of weeds via seeds.

C.8: Pollution/Litter

Notwithstanding that a drift line of wrack[5] is a natural and ecologically important feature of many coastal saltmarshes, litter is a common problem in areas with public access. Anthropogenic litter can cause smothering of low growing plants and introduce contaminants. Commonly dumped articles include garden waste and building materials, with the occasional derelict car and discarded fishing line. Garden waste may also introduce weeds. Pollution and litter may also enter C*oastal Saltmarsh* via tides and stormwater, or via industrial outlets. Further, stormwater may alter the salinity and nutrient regimes of *Coastal Saltmarsh* (Laegdsgaard et al., 2009).

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[5] Wrack - large seaweed or other marine vegetation cast up on the shoreline - often forms a 'drift line'.

Industrial developments near *Coastal Saltmarsh* have the potential to introduce contaminants (e.g. heavy metals) that can affect soil and water quality and enter biological food chains. Estuarine sediments in urbanised areas may contain substantial amounts of heavy metals and organic pollutants, such as polychlorinated biphenyls (Adam, 2002). Pollution of oil and petrol may occur via runoff into *Coastal Saltmarsh* due to direct or near-by vehicle use (on and off-road) or from adjacent industrial plants (Adam, 2002). Large oil spills may be catastrophic and have the potential to eliminate significant areas of *Coastal Saltmarsh* and significantly impact fauna such as birds and fish (Adam, 2002; Laegdsgaard et al., 2009).

C.9: Eutrophication

Nitrogen inputs into many estuaries, from sewage discharge, run-off from agriculture and atmospheric deposition have increased in recent decades. There is evidence that many saltmarshes are nitrogen limited, and increases in available nitrogen may thus change patterns of productivity and species distribution, encouraging non-saltmarsh vegetation to invade (Adam, 2002 and references therein). Saltmarshes fringing estuaries appear to intercept a substantial part of land-derived nitrogen loads and thus protect other components of estuaries from eutrophication; loss of these fringing marshes would therefore have wider consequences (Adam, 2002). Increased nitrogen also stimulates algal growth which could smother *Coastal Saltmarsh* and contribute to dieback of vegetation (Ranwell, 1981 in Adam, 2002). Excessive superphosphate applications to sandy soils with little phosphorus retention capacity can result in eutrophication and algal growth - as occurred to the Peel-Harvey estuary in southwest Western Australia (Rose and McComb, 1995; Adam, 2002). Also, extensive areas of filamentous algae were recorded in Tasmania on saltmarsh subject to runoff from industrial agricultural areas, particularly containing high levels of phosphorous (Prahalad et al., 2011).

C.10 Acid Sulfate Soils

Acid sulfate soils are naturally occurring soils and sediments that contain iron sulphides (predominately iron pyrite). If left undisturbed these waterlogged soils pose little threat to the environment and ecological community. However, disturbance of these soils allows for an oxidation process to occur and the consequent production of sulphuric acid which acidifies soil water, ground water, and surface waters (Sammut, 2000; Fitzpatrick et al., 2009). These soils (or potential acid sulphate soils) occur in coastal embayments and estuarine back swamps under 10m above mean sea level along much of Australia's coastline. As the ecological community is mainly associated with the soft substrate shores of estuaries and embayments (sandy and/or muddy) and open, low wave energy coasts (Adam, 2009), it is likely that potential acid sulphate soils are prevalent.

Acidification can have significant impacts on habitat quality, the health of aquatic organisms and biodiversity (NRME, 2003; Fitzpatrck et al., 2009). Fish and shellfish kills, outbreaks of red spot disease in fish, scalding of native terrestrial vegetation, degradation of aquatic flora, and increases in the severity of *Lyngbya* blooms have all been associated with acid sulfate soils in areas of the ecological community (Watkinson et al., 2000; ASEC 2001; NRME, 2003). The early 2000’s saw increasingly severe *Lyngbya* blooms in Deception Bay and Pumicestone Passage, Moreton Bay, an area containing the ecological community (Watkinson et al., 2000; ASEC, 2001). Numerous other acid sulphate related events have been recorded within the ecological community such as acid scalding around the Port Adelaide/Gillman region of South Australia (SACPB, 2003) and the frequent low-level acidic discharges from the Richmond and Macleay Rivers in northern New South Wales that have affected the local estuarine ecosystem (ASEC, 2001). The severity and longevity of acid sulfate events within *Coastal Saltmarsh* will depend on: the level of iron sulphides in the soil, the exposure of these sulphides to oxygen (a once-off disturbance or ongoing), the rate at which acids are introduced into the environment (as a consequence of environmental factors such as rainfall and/or drought), flushing of the system by tides/freshwater flows, and the presence and timing of re-inundation of drained or disturbed sites.

C.11 Grazing

Large scale grazing by introduced farm animals is likely to impact on *Coastal Saltmarsh* vegetation composition and structure (e.g. by selective grazing and trampling) (Adam, 1990). In particular, grazing may adversely affect rarer and more fragile species within a saltmarsh (e.g. mosses and lichens) (Laegdsgaard et al., 2009). For example, *Limonium australe* seems to be restricted to coastal saltmarshes and parts of these marshes in Tasmania where grazing does not take place (Kirkpatrick and Galsby, 1981). Deposits of excrement from large numbers of grazing animals may lead to increased nutrient loads and algal levels, and potentially oxygen depletion in shallow pools within *Coastal Saltmarsh*.

C.12 Insect control

A number of abundant insects in *Coastal Saltmarsh* have 'nuisance' value or are vectors for transmission of disease to humans or livestock (Adam 2002; Webb and Russell, 2012). Examples are mosquitoes, sandflies and midges (Webb and Russell, 2012; Webb et al., 2012). A range of techniques are employed for control of these insects, including the use of insecticides and habitat modification, particularly runelling (e.g. Dale and Hulsman, 1990; Dale and Knight, 2006). Runelling involves the construction of narrow shallow drainage channels to increase tidal flushing. There is concern over the impacts of such techniques on non-target species in *Coastal Saltmarsh*, including effects on food chains. In addition, the mosquito fish (*Gambusia holbrooki*) has been deliberately introduced to coastal saltmarsh in some areas, specifically to control mosquito larvae. This species is of questionable effectiveness for mosquito control (Balla, 1994), and is a voracious predator of many invertebrates and fish (Adam, 2002). For example, in NSW, predation by *Gambusia* has been listed as a Key Threatening Process under the *Threatened Species Conservation Act 1995*.

C.13 Evaporative salt production and other mining

Solar evaporative salt production ('salt mining') occurs by evaporating seawater in shallow 'evaporation ponds'. These ponds can occupy extensive areas of coastal land and are often constructed on saltmarsh (Adam, 2002; Bromberg Geden et al., 2009). They occur on the mid and north Western Australian coast, in South Australia and on the central Victoria coast. At one time, Western Australia, was the world's leading producer of solar salt and significant areas of *Coastal Saltmarsh* and tidal flat were converted (Adam, 2002). However, it seems the continuing removal of coastal saltmarsh to develop salt ponds is at present not a major issue in

Western Australia south of North West Cape (G. Keighery, pers. comm.). In South Australia, large areas of coastal saltmarsh are under lease for potential salt mining in the future. Of the 12 700 ha of Coastal Saltmarsh at South Australia's Gulf St Vincent (about 20% of the state's coastal saltmarsh), 36% of intertidal samphire and 40% of supratidal coastal saltmarsh habitats occur within ongoing Mining Tenements (Fotheringham and Coleman, 2008). Shell-grit mining has also occurred in some Victorian *Coastal Saltmarsh*, with removal of shell-bank material causing soil disturbance and changed inundation patterns (VSS, 2011; Carr, 2012a).

C.14 Inappropriate fire regimes

Fire is a potential habitat-modifying process. The various flora that constitute *Coastal Saltmarsh* are not well fire-adapted. For example, Kirkpatrick and Glasby (1981) reported that fire followed by grazing is capable of eliminating the succulent *Tecticornia arbuscula* from marshes. Fire is lethal to many saltmarsh species, particularly the succulent chenopods (e.g. *Sarcocornia* and *Tecticornia*) (VSS, 2011). In NSW, upper saltmarsh stands dominated by *Juncus kraussii* and *Baumea juncea* have high flammable fuel loads. While the natural incidence of fire in saltmarshes is likely to have been low, the incidence of fires within coastal saltmarsh has risen over the past decade (NSW SC, 2004). The recovery of these sites is relatively slow and the long-term impacts of burning are uncertain (NSW SC, 2004).

APPENDIX D: DETAILED ASSESSMENT OF ELIGIBILITY FOR LISTING AGAINST THE EPBC ACT CRITERIA

This appendix presents a detailed assessment of how the *Subtropical and Temperate Coastal Saltmarsh* ecological community meets each of the listing criteria.

Criterion 1 - Decline in geographic distribution

A range of estimates of extent and decline are available for the State jurisdictions within which the *Coastal Saltmarsh* ecological community occurs. As each jurisdiction classifies and manages vegetation differently, the details and kinds of data available vary with jurisdiction.

Queensland

Queensland classifies its vegetation using regional ecosystems which are bioregionally based units that incorporate the land zone type and vegetation structure and composition into the description. Regional Ecosystem 12.1.2 Saltpan vegetation was considered as equivalent to the *Coastal Saltmarsh*. Estimates of extent and decline are presented in Table D1. On the basis of these data, the overall loss in extent across Queensland to 2009 is from 32 727 ha to 28 529 ha, or a decline of 12.8%.

Table D1: *Estimate of decline and extent of Queensland Regional Ecosystem (RE) 12.1.2. RE broadly equivalent to the Subtropical and Temperate Coastal Saltmarsh ecological community.*

RE no.	Pre-European (ha)	Extent 1997 (ha)	Extent 2009 (ha)	Decline 2009 (%)
12.1.2	32 727	28 599	28 529	12.8

Source: Accad et al. (2012).

New South Wales

There is scattered information about the extent and decline of the *Coastal Saltmarsh* in NSW. Keith (2004) estimated that the current area of *Coastal Saltmarsh* covered an area of 7000 to 12 000 ha and that about 30 to 70% had been cleared since European settlement. West et al. (1985 quoted in NSW SC, 2004)) estimated the extent of *Coastal Saltmarsh* in NSW to be approximately 5700 ha while Creese et al. (2009) estimated the extent as 7259 ha.

More recently, Daly (2013) summarised information about the extent of saltmarshes across all natural resource management regions and estuaries within NSW (Table D2). This indicated the ecological community covered an area of 7240 ha – i.e. it fell towards the lower end of Keith's (2004) range. Although Daly (2013) provided no overall estimate of loss across NSW, he did note that specific estuaries showed losses of saltmarsh ranging from 12 to 97%. In some cases there were apparent increases in saltmarsh extent but it was unclear whether this was due to actual expansion of the ecological community or improved mapping techniques. Tozer et al., (2010) determined the current extent of estuarine saltmarshes on the south coast of NSW (from Sydney to the Victorian border) to be about 2167 ha and estimated that this represented <50% of the original extent.

Table D2: *Estimates of current extent (ha) for the Subtropical and Temperate Coastal Saltmarshes ecological community in NSW.*

<table>
<tr><th>Region</th><th>Daly (2013)</th><th>Tozer (2010)</th></tr>
<tr><td>Northern Rivers</td><td>2230</td><td></td></tr>
<tr><td>Hunter/Central Rivers</td><td>3270</td><td></td></tr>
<tr><td>Hawkesbury Nepean</td><td>290</td><td></td></tr>
<tr><td>Sydney Metropolitan</td><td>190</td><td rowspan="2">2167</td></tr>
<tr><td>Southern Rivers</td><td>1260</td></tr>
<tr><td>TOTAL</td><td>7240</td><td>7957 [1]</td></tr>
</table>

[1]Total across NSW with Tozer's estimate replacing Daly's estimates for estuaries south of Sydney.

On the basis of the available survey data for NSW, the current extent of the ecological community is likely to be about 7000 to 8000 ha. Decline in extent is recognised to be highly variable but is estimated to be between 30 to 70% across the State.

Victoria

Victoria classifies its vegetation using bioregionally-based landscape units termed Ecological Vegetation Classes (EVCs). Two EVCs that occur in coastal bioregions best equate with the *Coastal Saltmarsh* ecological community. Estimates of their extent and decline are presented in Table D3A.The extent estimates for EVCs compiled in 2007 indicate a loss for saltmarsh vegetation units from about 25 000 ha to 18 800 ha, or a decline of about 25%.

Recent and more detailed surveys of coastal mangrove and saltmarsh communities in Victoria by VSS (2011) and Sinclair and Boon (2012) have updated these earlier EVC estimates (Table D3B). One difficulty noted with the revised estimates is uncertainty over determining whether some patches are natural saltmarsh or represent expansions of saltmarsh since European colonisation. The uncertainty over the origin of certain patches resulted in range values for the pre-European estimate of *Coastal Saltmarsh* in Victoria. The estimates for both pre-European and current extent by Sinclair and Boon (2012) are more extensive than for the 2007 EVC depletion statement. However, the estimates of decline are similar, being in the order of a 25% loss across Victoria. It should be noted that more extensive declines were noted in some regional sectors, for instance declines of 50 to 60% in Port Philip Bay, the Lonsdale Lakes, Powlett-Kilcunda and at Corner and Anderson Inlets.

Taking all the estimates in Table D3 into account, the pre-European extent in Victoria is estimated to be between 25 000 – 36 000 ha, the current extent between 18 000 and 28 000 ha and decline in extent in the order of <36%.

Table D3A: *Estimates of decline and extent of coastal saltmarshes in Victoria. Ecological Vegetation Classes (EVC) most equivalent to the Subtropical and Temperate Coastal Saltmarsh ecological community.*

EVC no. and name	Pre-European (ha)	Extent 2007 (ha)	Decline 2007 (%)
9 Coastal saltmarsh aggregate	15 022	11 118	26.0
10 Estuarine wetland	10 259	7 702	24.9
Total	25 281	18 820	25.6

Source: DSE (2007). EVC Bioregional Conservation Status, Tenure and Depletion Statement for Victoria.

Table D3B: *Estimates of decline and extent of coastal saltmarshes in Victoria. Recent estimates for saltmarshes and estuarine wetlands, excluding mangroves.*

Source	Pre-European (ha)	Current (ha)	Decline (%)
VSS (2011)	25 635 – 28 910	18 593	27.5 – 35.7
Sinclair and Boon (2012)	28 970 – 36 480	27 878	3.8 – 23.8

Tasmania

Tasmania has classified its vegetation state-wide through the Tasmanian Vegetation Monitoring & Mapping Program (TASVEG) (Harris and Kitchener, 2005; DPIPWE, 2013). The data from this program provide information about current extent and patch sizes, but estimates of pre-European extent were unavailable. The current extent is estimated to be about 6 070 ha (Table D4A).

The Tasmanian Planning Commission (2009) estimated the current extent for *Coastal Saltmarsh* to be about 4 922 ha and that they have declined by 34% from their pre-European extent (Table D4B).

Table D4A. *Estimates of current extent for saltmarshes in Tasmania. TASVEG units most equivalent to the Subtropical and Temperate Coastal Saltmarsh ecological community in Tasmania.*

TASVEG unit	Extent (ha)
AHS Saline aquatic herbland	1442.5
ARS Saline sedgeland/rushland	1188.2
ASS Succulent saline herbland	594.3
AUS Saltmarsh (undifferentiated)[1]	2844.5
Total	6069.5

Source: DPIPWE (2013). Data on TASVEG units supplied to DSEWPaC. Data were clipped to only consider patches that occur within 2 km of the coast as this was most likely to approximate the distribution of saltmarshes and exclude inland samphire and similar vegetation that were not subject to tidal influence. [1] AUS is a generic map unit that includes patches not yet differentiated into one of the other three specific saltmarsh units.

Table D4B. *Estimates of current extent and decline of Coastal Saltmarsh in Tasmania by IBRA Bioregion.*

Bioregion	Current extent (ha)	Decline (%)
Flinders	853	25
King	1170	18
Tasmanian Northern Midlands	65	75
Tasmanian Northern Slopes	230	40
Tasmanian South East	2604	14
Total	4922	34

Source: Tasmanian Planning Commission (2009).

South Australia

Detailed state-wide estimates of *Coastal Saltmarsh* extent and decline are not available for South Australia. Fotheringham (pers. comm.) estimated the pre-European extent of saltmarshes to be 97 000 ha and the current extent as 87 630 ha, a decline of 9.7%.

More detailed data on extent and decline are available for the Gulf St Vincent, a major region of saltmarsh habitat in South Australia. The gulf accounts for about 15% of the state's intertidal samphire and 22% of the supratidal samphires (D. Fotheringham pers. comm.). Fotheringham and Coleman (2008) estimated there are about 12 700 ha of saltmarshes along the Gulf St Vincent. More recent mapping in the gulf estimated the pre-European extent of saltmarsh to be about 25 691 ha and the current extent as 17 959 ha. This indicates a loss of 30.1%. The degree of loss is assumed to be representative of *Coastal Saltmarsh* decline across South Australia. However, a higher loss may be assumed to occur where coastal populations and development pressures are more intense.

Western Australia

There are no consistent State-wide analyses of *Coastal Saltmarsh* extent and decline that covers all of Western Australia. Keighery and Keighery (2013a, b; G. Keighery pers. comm.) noted the original extent of *Coastal Saltmarsh* in Western Australia was likely to have been in the order of 3000 to 4000 hectares, and provided estimates of decline since pre-European extent on a broad regional basis within Western Australia.

- North of Perth : 70 – 80% decline.
- Swan Coastal Plain: extensive area of saltmarsh that has generally declined by over 50%.
- Swan estuary: about 70% decline (from about 700 ha to <300 ha).
- Peel estuary: >50% decline from 600 ha to <200 ha.
- Leschenault estuary: 50% decline from 750 ha to <350 ha.
- South coast of WA: 10 to 20% decline in extent.

Declines at the local or regional scale

There is considerable variation in the degree of loss of the *Coastal Saltmarsh* ecological community. A low overall State-wide decline of *Coastal Saltmarsh* may mask declines that are more extensive at a regional or local level. Where a range of decline estimates are available, it could be useful to note decline as a range of values. The available data relevant to local and regional declines are presented in detail against Criterion 4. Only the data for NSW and Queensland are relevant as only data on regional decline from these jurisdictions were available.

The range and median values are:

- For NSW local decline ranged from 15 to 92 % with a median value of 37.5% based on eleven estimates, and
- For Victoria local decline ranged from 10 to 65% with a median value of 22.5% based on twenty estimates.

Although some estimates indicate extensive declines, the median values remain relatively low.

It should also be noted that, in some circumstances, a local increase in the extent of *Coastal Saltmarsh* was noted. This was the case for the Shoalhaven River in NSW and for the Glenelg and Nooramunga Island regions in Victoria. Daly (2013) noted a general increase in saltmarsh extent for NSW since the 1980s, despite some localised losses. This may be attributed to improved mapping techniques more likely to pick up small areas of saltmarsh and does not necessarily reflect a natural expansion in range. The NSW SC (2004) noted in its final determination for listing *Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions* as endangered that there had been a further reduction and fragmentation of the ecological community in NSW since the study by West et al. (1985).

Criterion 1: Summary Conclusion

It is noted that:

- Precise data on pre-European and current extent are not available from all jurisdictions to undertake a complete analysis of the decline in extent across the entire range of the ecological community from Queensland to Western Australia.
- In terms of decline within entire State jurisdictions, the degree of decline appears to be less than 50% for most States where there is information about broad-scale decline of the ecological community. This is the case for the eastern and southern coastal extent of the ecological community.
- At a local or regional scale there have been substantial declines in parts of the ecological community's range but this does not apply generally.

There are insufficient data to fully assess the decline in extent of the *Subtropical and Temperate Coastal Saltmarsh* ecological community. In particular, data on pre-European extent is lacking in most jurisdictions. The information that is available suggests that the ecological community is unlikely to have undergone a substantial decline in its national extent. Therefore, the ecological community has not been demonstrated to have met the relevant elements of Criterion 1 and it is **not eligible** for listing under this criterion.

Criterion 2 - Small geographic distribution coupled with demonstrable threat

This criterion aims to identify ecological communities that are geographically restricted to some extent. Three indicative measures apply:

1) extent of occurrence, an estimate of the total geographic range over which the ecological community occurs;

2) area of occupancy, an estimate of the area actually occupied by the ecological community (which generally equates with its present extent); and

3) patch size distribution, an indicator of the degree of fragmentation of the ecological community.

It is recognised that an ecological community with a distribution that is small, either naturally or that has become so through landscape modification, has an inherently higher risk of functional extinction if it continues to be subject to ongoing threats that may cause it to be lost in the future. There are demonstrable and ongoing threats to the ecological community, as detailed in Appendix C.

Extent of occurrence

The *Subtropical and Temperate Coastal Saltmarsh* ecological community is a very broad-scale ecological community that occurs in scattered patches along the temperate and subtropical coastline of Australia. Therefore, its extent of occurrence is not geographically limited.

Area of occupancy

The *Subtropical and Temperate Coastal Saltmarsh* ecological community only occupies specific coastal landscapes within its broad extent. The estimates of its area of occupancy by jurisdiction are summarised in Table D5, below. The current extent is likely to approach 81 000 to 162 000 ha although there is uncertainty about the full extent present in South Australia and Western Australia. However, an area of occupancy that is greater than 100 000 ha is not geographically limited.

Table D5: *Estimates of current extent by State jurisdiction.*

Bioregion	Current extent (ha)
Queensland	29 000
New South Wales	7000 – 8000
Victoria	18 000 – 28 000
Tasmania	5 000 – 6 000
Total - Eastern coast	142 000 – 154 000
South Australia	> 18 000 – 87 000
Western Australia	< 4000
Total	81 000 – 162 000

Patch size distribution

Within the eastern states from Queensland to Tasmania, the majority of mapped patches of the ecological community are less than 10 ha in size (85.9%), and most (98.5%) are under 100 ha in size (Table D6). This pattern is less marked for mapped patches in South Australia, with about 52% of patches being under 10 ha in size but about 94% of patches being under 100 ha in size. Patch size data was unavailable from Western Australia to enable similar statistical analyses. However, Keighery (pers. comm.) noted that median patch sizes in Western Australia were likely to be under 10 ha on the south coast and north of Perth but were likely to be >10 but under 100 ha on the major Swan Coastal Plain estuaries.

The degree of fragmentation across the national extent of the ecological community is consistent with at least a restricted geographic distribution, making it potentially eligible for endangered status, depending on the timeframe of threats operating.

Table D6: *Patch size distribution for the Subtropical and Temperate Coastal Saltmarsh ecological community along the eastern States (Queensland, NSW, Victoria and Tasmania), in relation to thresholds for fragmentation in Criterion 2 under the EPBC Act.*

Thresholds		Size range (ha)	No. patches	% patches	Cumulative %	
Restricted	Very Restricted	≤ 1	3452	53.1	85.9	98.5
		> 1 - 10	2135	32.8		
		> 10-100	819	12.6		
		> 100	95	1.5		
		Total	**6501**	**100**		

Source: Data supplied to SEWPaC on equivalent vegetation units through NVIS. The vegetation units for which detailed patch size data were available are: QLD – RE 12.1.2; NSW – p509 for the coast south of Sydney; VIC – EVCs 9 and 10; TAS – TASVEG AHS, ARS, ASS and AUS within 2 km of the coast.

Criterion 2: Summary Conclusion

The *Subtropical and Temperate Coastal Saltmarsh* ecological community is under demonstrable threat as detailed in Appendix D on threats. However, the nature of threats and timeframes over which they appear to operate is over a longer term. There have been significant degrees of clearing and impacts, e.g. due to tidal restriction, particularly at a local level. Encroachment by mangroves and changes due to climate change impacts, such as sea level rise are not anticipated to occur substantially in the immediate or near future. Therefore, the most appropriate timescale for projected threats is the medium-term future.

The ecological community has a restricted distribution on the basis of its fragmented patch sizes, and it is subject to certain threats that could cause it to be lost over the medium-term future. Therefore, the ecological community has been demonstrated to have met the relevant elements of Criterion 2 to make it eligible for listing as **vulnerable**.

Criterion 3 - Loss or decline in functionally important species

There is little information about the *Coastal Saltmarsh* ecological community that is directly relevant to the assessment of this criterion. This is due to several reasons:

- The ecological community is inherently variable and dynamic and can be expressed in a range of forms. The diagnosis of the ecological community is based on hydrologic and landscape features as well as the presence of a suite of coastal wetland flora and fauna. Consequently, it is not possible to identify any particular species (or suite of species) that is of clear, keystone functional importance across the entire range of the ecological community and for which there are adequate data.
- Coastal saltmarsh plant and animal species may be widespread geographically and many are not confined to this ecological community.

- Changes in species composition may be driven by disturbances to the tidal and freshwater flows and landscape form of a coastal saltmarsh site. This may eventually result in the loss or decline of entire floristic suites, within the coastal wetland.

Criterion 3: Summary Conclusion

Due to the nature of the ecological community, combined with insufficient data to determine the loss or decline of relevant functionally important species, the ecological community **is not eligible** for listing in any category under this criterion.

Criterion 4 - Reduction in community integrity across most of its geographic distribution

This criterion is intended to capture detrimental changes in the identity and number of component species, the relative and absolute abundances of those species, and the state of the abiotic environment that supports them. It includes declines and irretrievable loss of native species and invasion by non-native species, as well as changes in the physical environment sufficient to lead to ongoing changes in the biota. This criterion also recognises that ecological processes are important to maintain an ecological community and that disruption to those processes can lead to a decline in integrity of the ecological community. Importantly, this criterion allows for recognition of a problem at an early stage and allows for consideration of inherent variability due to natural dynamics (i.e. as covered in the description).

For the purposes of assessment of Criterion 4 for the *Subtropical and Temperate Coastal Saltmarsh* ecological community, the Committee notes the following drivers and indicators of reduction in community integrity, with loss of biodiversity a universal theme across all:

a) increased fragmentation
b) tidal restriction
c) increased marine inundation and mangrove transgression
d) invasion by non-native and problem species
e) loss of coastal productivity and nursery function.

a) Decline in integrity from increased fragmentation

Fragmentation refers to the splitting up of large saltmarsh areas into smaller, discrete patches or disconnection of saltmarsh areas from each other and from other estuarine habitats; it is a major factor contributing to *Coastal Saltmarsh* habitat decline (Laegdsgaard et al., 2009). The impact of human activities has exacerbated the fragmentation of coastal saltmarsh by increasing the distances and disconnection among individual patches or mosaics (Thomsen et al., 2009). Data confirm that for much of *Coastal Saltmarsh* there are local or regional losses in area, resulting in increased fragmentation across the national extent of the ecological community (see Tables D7 and D8). Importantly, while these losses are variable, they are generally considerable and demonstrate that a trend of fragmentation is occurring, especially on the eastern coastline. Although data are scarcer, there are also indications that fragmentation is similarly occurring in south-west Western Australia (G. Keighery, pers. comm.).

The extensive loss of significant proportions of localised *Coastal Saltmarsh* and the degree of fragmentation, as indicated in Tables D7 and D8, therefore represent a significant decline of ecological integrity (DCC, 2009; Laegdsgaard et al., 2009) due to concomitant:

- loss of diversity of flora and fauna
- depletion of the ecological community's ability for resilience against disturbance
- impacts on saltmarsh foodweb dynamics
- reduction of sediment trapping and nutrient cycling
- reduction of carbon and nutrient subsidies to nearshore waters resulting in reductions in the productivity of coastal foodwebs, and
- impacts on migratory birds that prefer larger areas of saltmarsh for protection and breeding (Baxter and Fairweather, 1998; Wilson et al., 2011).

Table D7: *Patch size distribution for Coastal Saltmarsh by jurisdiction. Data reflect number of patches in each patch size range category.*

Jurisdiction	Size Range (ha)		
	0-10	>10 – 100	>100
Queensland (south of Rockhampton)	78.9	18.3	2.8
NSW (Sydney to Vic border)	92.8	7.0	0.1
Victoria	89.9	8.5	1.6
Tasmania	81.3	17.6	1.1
South Australia (Gulf of St Vincent)	52.2	42.1	5.7

Source: Based on sources identified under Criterion 1.

Importantly, even small patches of *Coastal Saltmarsh*, down to 0.1 ha, serve as sources from which other patches can recruit diversity after disturbance (e.g. Williams et al., 2011). Their presence, therefore, acts as a refuge and helps to maintain biodiversity and confers resilience against disturbance at a broader landscape scale.

In particular, impacts of fragmentation on foodweb dynamics can be great. Large unfragmented saltmarsh habitats with a diverse array of molluscs and crabs produce large quantities of larvae that are exported with the tide, and are an important food source for coastal and estuarine fish, some of which have commercial significance (Mazumder et al., 2006). Crabs and molluscs are generally absent from very small and/or fragmented patches of saltmarsh, thereby limiting the supply of larval zooplankton to estuarine fish species (Laegdsgaard et al., 2009). Where crabs are present in very small patches of saltmarsh, stable isotope analysis has shown a different trophic function to crabs in larger patches (Guest and Connolly, 2004, 2006). With increasing fragmentation and reduced patch size it is predicted that the foodweb will become limited to small predators and a few insects, particularly if the patch also becomes tidally isolated (Laegdsgaard, 2006) and shifts away from the typical saltmarsh state.

It is considered that the degree and increasing nature of fragmentation at local and regional scales across the national range of the *Coastal Saltmarsh*, and the detrimental impacts of fragmentation on a wide variety of ecological functions has resulted in a decline in the integrity of the ecological community that is ongoing.

Table D8: *Estimates of saltmarsh losses at a local or regional scale on the east coast of Australia. Bold values highlight losses of 50% or more.*

LOCATION	PERIOD OF LOSS	AREA LOST (%)
Queensland		
Oyster Point	1944 - 1983	**75**
Coolangatta- Caloundra	1974 - 1987	11
Moreton Bay	Pre-175- - 2010	**>50**
New South Wales		
Tweed River	1947 - 1986	**72**
Clarence River	1942 - 1986	15
Macleay River	1942 - 1986	35
Hunter River excl Hexham)	1954 - 1994	**67**
Lake Macquarie	1954 - 1986	25
Berowra – Marramarra Ck	1941 - 1994	25
Careel Bay	1938 - 1994	**92**
Homebush Bay	1930 - 1983	**>80**
Minnamurra River	1938 - 1997	49
Merimbula Lake	1948 - 1994	30
Pambula Lake	1948 – 1994	40
Tuggerah Lakes	Pre-1750 - 2003	**80**
Victoria		
Fawthrop - Belfast	Pre-1750 - 2008	45
Breamlea	Pre-1750 - 2008	10
Connewarre - Barwon	Pre-1750 - 2008	10
Lonsdale Lakes	Pre-1750 - 2008	**60**
Salt Lagoon	Pre-1750 - 2008	10
Swan Bay	Pre-1750 - 2008	15
Mud Islands	Pre-1750 - 2008	10
Port Philip	Pre-1750 - 2008	**50**
The Inlets	Pre-1750 - 2008	40
Western Port	Pre-1750 - 2008	10
Bass River	Pre-1750 - 2008	25
Powlett - Kilcunda	Pre-1750 - 2008	**65**
Anderson Inlet	Pre-1750 - 2008	**55**
Shallow Inlet	Pre-1750 - 2008	**60**
Corner Inlet	Pre-1750 - 2008	45
Nooramunga Coast	Pre-1750 - 2008	15
Lake Reeve	Pre-1750 - 2008	15
Lake Wellington *	Pre-1750 - 2008	35
Lakes Victoria and King *	Pre-1750 - 2008	20
East Gippsland Inlets	Pre-1750 - 2008	15
Tasmania		
Coal River – Ralph's Bay – Pipe Clay Lagoon	1975 - 2009	43
South Australia		
Gulf St Vincent	Pre-1750 - 2012	30

Sources: Saintilan and Williams (2000); Prahalad et al. (2011); Sainty and Jennings (2012); Sinclair and Boon (2012); Fotheringham (pers. comm.). * Assumed all saltmarshes were naturally present.

b) Decline in integrity from tidal restriction

Around 85% of Australia's population lives in the coastal zone, especially along the eastern seaboard (DCC, 2009). Consequently, coastal development, including agricultural and urban infrastructure, has resulted in often significant changes to the tidal regime of much of the ecological community around the populated sections of the Australian coastline (Laegdsgaard et al., 2009; Thomsen et al., 2009).

Coastal Saltmarsh, by definition, must have some form of tidal connection (either permanent or intermittent/ irregular) to form the salt-tolerant vegetative assemblage that creates the structural habitat of the ecological community. Disconnection from the tide can lead to degradation or even loss of the ecological community.

Tidal restriction (i.e. of normal tidal flushing) occurs from alterations to drainage and hydrology, often through the construction of roads, bridges, causeways, retaining walls, levees, culverts and floodgates or tidegates (Williams and Watford, 1997). These structures can lead to a substantial reduction in porewater salinity in the substrate, lowering of the water table, and a relative drop in marsh surface elevation (Roman et al., 1984). The latter occurs from drying out of marsh peat and subsequent compaction, and from increased microbial populations better adapted to the drier and less saline environment which accelerate decomposition (i.e. biochemical oxidation, Roman et al., 1984). This in turn can have severe detrimental effects on saltmarsh vegetation and fauna, ranging from complete habitat destruction to modification of the ecology (Laegdsgaard et al., 2009). For example, resulting loss of tidal energy may reduce: exchange of organic and inorganic materials between the coast and ocean; the standing crop production of intertidal halophytes; and the feeding and spawning cycles and zonation of many estuarine and inshore marine consumer populations (Roman et al., 1984 and references therein).

Many coastal floodplains along the eastern coast of Australia over the last century have been radically modified by drainage and/or the installation of tidal restrictions, known as 'headworks' which form a fixture for floodgates (Williams and Watford, 1997; Laegdsgaard et al., 2009). In most cases the gates are hinged to shut as the tide rises and therefore restrict tidal penetration onto land that can be used for crops and grazing in the absence of saltwater. As a result of being closed or tidally blocked, water levels rise from localised freshwater runoff leading to the inundation of saltmarshes for extended periods, with varying levels of survival for different species (Laegdsgaard et al., 2009). For example, many succulent saltmarsh plants such as *Sarcocornia* spp. can only withstand short periods of inundation before the plants rot and decompose (Adams and Bate, 1994). These structures affect nutrient exchange and limit the natural movement of fish and other aquatic life, thereby affecting foodwebs and coastal productivity.

Conditions associated with tidal restriction can also alter vegetation patterns. In general, unrestricted coastal saltmarsh exhibits a mosaic pattern of mixed species, with 'low' and 'high' zonation also present. However, tidal restriction often favours the establishment and spread of glycophyte[6] species such as common reed (*Phragmites australis*), water couch (*Paspalum vaginatum*) and river clubrush (*Schoenoplectus tabernaemontani*), and the loss of succulent and other halophytic saltmarsh species (Roman et al., 1984; Laegdsgaard et al., 2009). In particular, common reed may recruit rapidly to areas that have become tidally isolated and transform coastal saltmarsh into extensive, nearly monotypic stands that restrict the movement of aquatic biota and alter the ecology and function of the entire system (Adams and Bate 1994; Weinstein and Balletto, 1999). Northern hemisphere studies have found that dense monotypic *Phragmites* stands, which are much taller and denser than typical halophytic saltmarsh plants, may provide unsuitable habitat and food for wildlife and waterfowl, reduce biodiversity and impact on trophic dynamics (e.g. Roman et al., 1984; Able and Hagan, 2000). There is also an increased risk of fire with these types of monotypic stands which can be lethal to many other coastal saltmarsh species (Kirkpatrick and Glasby 1981; Roman et al., 1984). Importantly, reintroduction of tidal flow has been demonstrated to reduce the height and density of monotypic *Phragmites* stands (Roman et al., 1984 p. 149).

Some structures can increase the duration and frequency of tidal inundation to such a degree that it becomes more marine dominated. For example, the installation of a culvert into Karaaf Wetlands in Victoria led to encroachment by the seagrass *Zostera muelleri* (Billows, 2006).

Given the high and ongoing degree of pressure from coastal population and development, it is considered that, by association, tidal restriction constitutes a continuing detrimental impact to the integrity of the *Coastal Saltmarsh* ecological community.

c) Decline in integrity from increased marine inundation and mangrove transgression

Given their geomorphic situation within narrow elevation ranges in the intertidal zone, saltmarshes are sentinel ecosystems in the coastal zone and many consider the impacts of relative sea-level rise are already occurring (Lovelock et al., 2009; Saintilan et al., 2009). Saltmarshes are generally sensitive to slight changes in tidal inundation and are therefore affected by the flow path in the estuary, build-up of sediment and sea level change (Sainty et al., 2012d). IPCC[7] (see Meehl et al., 2007) single out Australia, and note that by 2050 ongoing coastal development and population growth in some parts of Australia are projected to make worse the risk from sea level rise and increase the severity of damage from storms and coastal flooding (and see Criterion 5). The IPCC further report that climate change-related sea level rise is projected to accelerate in the 21st century (Meehl et al., 2007; Saintilan and Rogers, 2013). Thus there is likely to be an ongoing and increasing decline in integrity of the ecological community from marine inundation due to the impacts of climate change such as increased frequency of storm surge and projected sea level rise (DCC, 2009).

Consistent with changes in relative sea level, there have been trends in transgression of mangrove (where they naturally occur) at the expense of *Coastal Saltmarsh* (Saintilan and Rogers, 2013). While, saltmarshes increased in extent relative to mangrove in Australia in both tide- and wave-dominated geomorphic settings through the latter Holocene (Saintilan and Williams, 2000; Saintilan and Rogers, 2013), in many areas of temperate Australia (excluding

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[6] Glycophytic plants, are typically those incapable of living in salty environments (i.e. cannot complete the entire life cycle in a saline environment) ; as opposed to a halophyte which is typically a plant that grows in and can complete its entire life cycle in a saline environment.
[7] IPCC - Intergovernmental Panel on Climate Change

Western Australia) there has been a transgression of mangroves into saltmarsh, particularly over the past century (Saintilan and Williams, 2000; Rogers et al., 2005; 2006; Saintilan and Rogers, 2013). This process is occurring in a range of geomorphic settings (Saintilan and Williams, 2000) and many cases of expansion in NSW, Victoria and southern Queensland have been documented over the past century (e.g. 1900 to 1940, McLoughlin, 1987; 1930 to 1970, Haworth, 2002). Similarly, decreases in area of saltmarsh ranged from 35 to 79% across the cases cited, with concomitant increases in mangrove (references as above and see VSS, 2011 p. 45 and Saintilan and Rogers, 2013, p. 69). Loss in saltmarsh extent and changes in saltmarsh community composition are also occurring in the absence of mangrove in south-eastern Tasmania and this transgression is attributed to sea-level rise, higher waver energy and direct human modification (Prahalad et al., 2011).

Modelling of the impacts of projected sea level rise, incorporating sedimentation and other surface-elevation drivers, suggests that the survival of saltmarsh in developed estuaries will depend on the flexible management of hard structures and other impediments to coastal wetland retreat (Saintilan and Rogers, 2013). The level of threat from the expansion of mangrove into saltmarsh is heightened in urban areas where saltmarsh is already heavily fragmented (e.g. Evans and Williams, 2001).

Given the impacts of sea level rise (including projections) on *Coastal Saltmarsh*, and the concomitant, often significant, encroachment of mangrove it is considered that these threats have resulted in a decline in integrity of the ecological community, and this is ongoing.

d) Decline in integrity from increased invasion by exotic species

Coastal Saltmarsh is susceptible to invasions by exotic plants and invasion is often related to anthropogenic disturbance (Laegdsgaard et al., 2009). This is especially the case where there has been shore-line development, increasing eutrophication (i.e. from excess nutrients) and the removal of native vegetation (Bertness et al., 2002). In Victoria, some 47% of plants in coastal saltmarshes are exotic, and of these about 30 taxa are halophytes (VSS, 2011). The exotic annual and perennial invaders have had catastrophic, although largely undocumented, impacts on upper saltmarsh in south-eastern Australia and the situation is predicted to worsen (VSS, 2011). Often the exotic invaders form extensive monotypic stands, at the expense of native saltmarsh plants and associated faunal biodiversity, and ecological function. Some examples of exotic invasions of particular concern follow:

- *Spartina* is a problematic, salt-tolerant weed of saltmarshes around the world, and capable of both asexual and sexual propagation, making it robust and opportunistic. One species of *Spartina* (*S. anglica*) is currently found in coastal saltmarshes of southern Australia, including Tasmania, Victoria and South Australia (Fotheringham, 1996; Williamson 1996 inVSS, 2011; Kriwoken and Hedge, 2000; Nightingale and Weiller, 2005). These species also have the potential to invade into estuaries of south-western Western Australia (Keighery, 1996). *Spartina* was mostly deliberately introduced. Mapping in 1993 showed there to be between 150 and 280 ha of *Spartina* in Victoria (including 130 ha in Anderson Inlet and 42 ha in Corner Inlet) (VSS, 2011). One of the largest infestations (approximately 420 ha) of common cord grass (*S. anglica*) occurs within the Tamar Estuary in Tasmania (Pringle, 1993).

Spartina tends to form dense, monotypic stands that replace more diverse coastal saltmarsh assemblages; with species such as *Sarcocornia quinqueflora* and *Samolus repens* particularly prone to competitive exclusion by common cord grass (Simpson, 1995; Hedge and Kriwoden, 2000; Laegdsgaard et al., 2009). Birds have been observed to avoid common cord grass and species richness and abundance of fauna are greater in saltmarshes dominated by native plants compared to those dominated by common cord grass (Simpson, 1995; Hedge and Kriwoden, 2000; Cutajar, 2009). Potential ecological impacts of *Spartina* on *Coastal Saltmarsh* are given in Table D9, and these impacts also generally apply to many other exotic weed species.

Table D9: *Potential ecological effects of Spartina on Coastal Saltmarsh (VSS, 2011).*

Potential Impact	Likely mechanisms
Competitive replacement of native taxa	Higher seed production and germination; more rapid clonal growth
Increased rate of sedimentation	Greater stem densities; larger and more rigid stems
Impacts on foodweb structure	Changes in quality and quantity of detritus
Decreased benthic algal productivity	Shading under dense *Spartina* canopy
Impacts on upper saltmarsh	Increased production of wrack and deposition in upper marsh
Impacts on habitat quality	Greater stem densities
Impacts on benthic fauna	Greater root/rhizome densities; colonisation of subtidal zones
Loss of foraging areas for shorebirds and waders	Colonisation of bare mudflats; colonisation of subtidal zones; less invertebrate food available to birds

- The sharp rush (*Juncus acutus*), introduced from the Mediterranean, is now widespread throughout the south-east and south-west of Australia (Greenwood and MacFarlane, 2006; Keighery and Keighery, 2006; Paul and Young, 2007). This species occupies the same niche as the native rush, *Juncus kraussii*, but is more resilient and easily out-competes it (Laegdsgaard, et al., 2009). The introduced rush alters the structure and complexity of *Coastal Saltmarsh*. Once established, its sharp tough cylindrical photosynthetic stems form dense impenetrable thickets so that the native rush is displaced. Importantly many gastropods and other invertebrate fauna are believed to depend on *J. kraussii* for completion of their lifecycle and the same function is not afforded by *J. acutus* due to its differing structure (Harvey, 2006).
- Tall wheat grass *Lophopyrum ponticum*, a very large tussock grass, is currently widely promoted by government agencies for establishment on saline lands as stock fodder. It is considered the most serious invader of upper saltmarsh in Victoria due to its very broad ecological amplitude and robust life form (VSS, 2011).
- Common weeds reported as particularly problematic in Western Australian *Coastal Saltmarsh* where they have outcompeted resident native species include: *Atriplex prostrata*,

Carex divisa, *Limonium hyblaeum*, *L. companyonis*, and *Paspalum vaginatum*/ *Boloboshoenus caldwelli* (native invaders, G. Keighery, pers. comm.).

Victoria has recognised the seriousness of at least two of these exotic weeds and has listed them as potentially threatening processes under the Victorian *Flora and Fauna Guarantee Act 1988*, viz:

- Introduction and spread of *Spartina* to Victorian estuarine environments.
- Invasion of native vegetation communities by tall wheat-grass *Lophopyrum ponticum*.

Exotic invasive plant species are establishing throughout the range of the ecological community. Their impacts to local biodiversity and ecological function, as demonstrated above, is varied and significant. It is therefore considered that exotic species have caused a detrimental decline in the integrity of *Coastal Saltmarsh*, and that this trend is likely to continue if left unabated.

e) Decline in integrity from reduced productivity and nursery function

Research conducted in temperate and subtropical coastal saltmarsh has demonstrated important trophic contributions to estuarine and inshore coastal fisheries, mediated by the synchronised mass-spawning of crabs, which feed predominantly on succulent saltmarsh plants and microphytobenthos. Visiting zooplankivorous fish are able to feed efficiently and voraciously during their brief residence on the saltmarsh plain (Hollingsworth and Connolly, 2006). Grazing crabs therefore occupy a keystone position in the saltmarsh ecosystem, transforming carbon into forms utilised by a range of fish species (Richardsen et al., 1998; Mazumder and Saintilan, 2003; Imgraben and Dittmann, 2008). Coastal saltmarsh also provides unique feeding habitat for several species of threatened microbats and birds, including migratory shorebirds listed under international conventions (Laegdsgaard et al., 2004; Saintilan and Rogers, 2013). In particular, insectivorous microbats feed on abundant and diverse arthropods, a common feature of *Coastal Saltmarsh*, such as spiders, mites and a variety of insects (Laegdsgaard et al., 2004).

Coastal Saltmarsh is often subject to nutrient enrichment because it is located in or near estuarine systems that, since the 1950s at least, have become progressively more eutrophic (VSS, 2011). Deegan et al. (2007) showed that even mild nutrient enrichment disrupted ecological responses at several trophic levels in a Northern hemisphere coastal saltmarsh. Excess nutrients reduce coastal saltmarsh diversity and also reduce the amount of below-ground biomass and carbon accumulation in sediments (Crain, 2007; Turner et al., 2009). Importantly, nutrient enrichment affects primary production and a wide range of ecological interactions in *Coastal Saltmarsh*, (VSS, 2011), such as:

- competitive interactions between plant species
- rates of herbivory and the relative roles of bottom-up versus top-down control of plant biomass, and
- effects on biota other than plants, especially on ecosystem-scale biogeochemical processes and microbial dynamics.

There is substantial literature on the value of *Coastal Saltmarsh* as habitat (including nursery habitat) for birds and fish, although less is known of use by mammals or reptiles (Crinall and

Hindell, 2004; VSS, 2011; Saintilan and Rogers, 2013). For example, in Tasmania, the Ramsar listed Pitt Water-Orielton Lagoon (PWOL) area is considered to be one of the most important nursery areas for commercially harvested juvenile school and gummy sharks in Tasmania (Prahalad and Pearson, 2013). The juvenile sharks feed on abundant molluscs and crustaceans in the shallow intertidal flats, which are in turn fed by high organic export from saltmarshes. It is estimated that about 25% of the saltmarsh in this area has been lost and another 25% degraded, from the combined impacts of climate change, sea level rise, nutrient enrichment, clearing, filling and grazing (Prahalad et al., 2011). Able and Hagan (2000) demonstrated a negative effect on larval and small juvenile fish in a Northern Hemisphere coastal saltmarsh after invasion by *Phragmites*, but less or no effect on larger fish. A more recent study also demonstrated that a similar Northern Hemisphere *P. australis*-invaded saltmarsh was inferior for reproduction, migration and overwintering survival for many fish taxa (Weinstein et al., 2009).

While many bird taxa use saltmarsh episodically or seasonally rather than as residents, in some areas of coastal Victoria, for example, where the clearance of hinterland vegetation has been severe, more sedentary birds (passerines) depend on coastal saltmarsh for more or all of their lifecycle (VSS, 2011). Thus *Coastal Saltmarsh* provides an important role in providing refuge to such fauna. *Coastal Saltmarsh* is also known to provide a pivotal role for some migratory and wading bird species, providing food by day and predator-free roosting by night (Spencer et al., 2009; Wilson et al., 2011). However, several studies have demonstrated declines in abundance of many shorebird species that relate in part to *Coastal Saltmarsh* decline (e.g. Paton et al., 2009 in SA; Jenner et al., 2011 in NSW; Wilson et al., 2011 in QLD). In Victoria and South Australia, *Coastal Saltmarsh* (mosaic with bare patches) is the principal overwintering feeding and roosting habitat for the critically endangered *Neophema chrysogaster* (orange bellied parrot) (Loyn et al., 1986; VSS, 2011).

Thus there is evidence from a range of taxa and locations regarding the impacts of various threats such as fragmentation, tidal restriction, exotic invasions, mangrove encroachment, eutrophication, etc., that have resulted in a decline in the productivity of coastal saltmarsh systems and reduced the functional roles of providing shelter and feeding and reproductive (nursery) habitat. This is particularly important due to the increased role that the ecological community serves in the broader coastal marine and estuarine ecosystems. Such impacts constitute a significant decline in the integrity of *Coastal Saltmarsh*.

Criterion 4: Summary Conclusion

The combined impact of the various threats operating have reduced the integrity of the ecological community through: increased fragmentation; tidal restriction; increased marine inundation and mangrove transgression; and invasion by exotic plant species.

In addition to increases in non-native/problem species, reductions in integrity have resulted from loss of biodiversity and a decline in key ecological functions related to productivity and nursery and feeding habitat. This has further impaired the resilience of the ecological community to ongoing natural and anthropogenic pressures. While there are a number of actions at a range of jurisdictional scales to remove some of these pressures (and it is acknowledged that at some local scales restoration actions have resulted in increased coverage of *Coastal Saltmarsh*), it is considered that overall these actions will not be implemented at the appropriate scales for some time and unlikely to restore the national ecological community within the medium-term future. The ongoing threat of sea level rise is recognised as particularly difficult to mitigate, although there may be options at local scales for adaptation measures (e.g. planned retreat).

The change in integrity experienced by the ecological community is **substantial** and restoration across its geographic range is unlikely in the medium-term future. Therefore, the ecological community is eligible for listing as **vulnerable** under this criterion.

Criterion 5 - Rate of continuing detrimental change

Eligibility under this criterion is about demonstrating an observed, estimated, inferred, or suspected ongoing detrimental change; where detrimental change may refer to either of the components of this criterion, i.e. to:

(a) changes in the geographic distribution of, or changes to populations of, critically important species; or,

(b) degradation, or disruption of important processes.

Data to demonstrate this criterion must be documented. They can be in the form of direct measurements of any of the components, levels of exploitation, or the known effects of introduced biotic or abiotic elements on any of the components. Natural fluctuations will not normally count as a continuing change, but an observed change should not be considered to be part of a natural fluctuation unless there is evidence for this.

Seawater inundation and its periodicity is a major factor in determining which plants and animals colonise and utilise particular intertidal areas within *Coastal Saltmarsh*. This is also a key driver of the cycling of nutrients and other important elements such as organic carbon, nitrogen, sulphur, iron and phosphorus (Tobias and Neubauer, 2009).

Coastal Saltmarsh generally occurs at the higher end of the coastal intertidal zone and is covered in seawater for varying periods, usually during high tide (although there are exceptions to this, for example, intermittently open or closed lagoon systems). The permanent plant life is essentially terrestrial in origin but with a tolerance for wet and saline conditions. Regular, temporary inundation (typically exposure to air at low tide and under seawater at high tide) is a key ecosystem driver which not only controls what flora can thrive but also provides a diversity of faunal habitats and facilitates a range of ecosystem functions. The landward boundary of saltmarsh is naturally dynamic; salt-tolerant plants migrate landwards in drought times while freshwater plants may invade saltmarsh in high rainfall periods.

Sea level rise is considered a severe threat to the *Coastal Saltmarsh* ecological community which is particularly vulnerable to change, This is due to its occurrence in places that attract development, where sea level rise from climate change will have a greater impact, and where there is little scope or area for decolonisation or landward retreat (Adam, 2002; DCC, 2009; Oliver et al., 2012; Rogers et al., 2012; Ross and Adam, 2013; Saintilan and Rogers, 2013). Sea levels are rising now and are expected to continue rising for centuries, even if greenhouse gas emissions are curbed and their atmospheric concentrations stabilised (Hunter et al., 2012; Church and White, 2011).

The most likely effects of increasing sea level rise will be to further squeeze *Coastal Saltmarsh* into the narrowing space between the sea and human habitation and other structures. Reports of this 'coastal squeeze' phenomenon are already coming from the eastern states (Saintilan, 2009b). *Coastal Saltmarsh* naturally retreats landward as tidal height increases. If space is unavailable due to local geomorphology (or the presence of anthropogenic structures or activities, such as roads, urban areas, agriculture and levees), and accretion is limited (e.g. by sediment supply or plant growth rate), then these areas of *Coastal Saltmarsh* will likely eventually disappear as sea level rises. Many coastal saltmarshes are starved of sediment because of catchment modification and coastal engineering (Adam, 2002). Coastal squeeze will reduce the total area of *Coastal Saltmarsh*, reduce primary productivity and reduce the time that is available to biota (such as birds and fish) for feeding, shelter and reproduction (Hughes, 2004; Connolly, 2009).

Sea level rise is also likely to impact on nutrient cycling in saltmarshes. Thomas and Christian (2001) concluded that under coastal squeeze, not only will there be a reduction in total coastal saltmarsh area, the marsh will cycle less nitrogen per unit area because the high marsh (which has a greater above-ground rate of nitrogen fixation than the low marsh) will decrease in size relative to the low marsh. A replacement of high coastal saltmarsh by low coastal saltmarsh assemblages has been observed in the east coast of the United States and largely attributed to a 4 mm/year relative sea level rise (Civco et al., 1986; Warren and Niering, 1993; Perry and Herchner, 1999; Field and Philipp, 2000; Donnelly and Bertness, 2001; Smith, 2009).

Average global sea-level rise from 1880 to 2009 is approximately 210 mm (Church and White, 2011). The estimated linear trend for the rate of sea level rise from 1900 to 2009 is 1.7 mm/y, with that estimated since 1961 being 1.9 mm/y (Church and White, 2011). There is considerable variability in the rate of rise during the twentieth century but there has been a statistically significant acceleration since 1880 and in particular since 1900 (Meehl et al., 2007; Church and White, 2011; Hunter et al., 2012).

While the rate of sea level rise is not uniform around the globe (nor around the continent of Australia) and varies from year to year, rates on the central east and southern coasts of Australia are mostly similar to the global average (CSIRO and BOM, 2012). Church and White (2011) estimated the rise in global average sea level since 1880 using tide-gauge[8] records and since 1993 using both tide-gauge records[9] and satellite altimeters. The estimated linear trend from1961–2009 is 1.9 mm/y. For 1993–2009, after correcting for glacial isostatic adjustment[10], the estimated rate of rise is 3.2 mm/year from the satellite data and 2.8 mm/year from the tide-gauge data.

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[8] A tide gauge is a device at a coastal location (and some deep-sea locations) that continuously measures the level of the sea with respect to the adjacent land; time averaging of the sea level so recorded gives the observed secular changes of the relative sea level (Meehl et al., 2007).

[9] Note: Albeit tide-gauge records from the northern hemisphere.

[10] Glacial isostatic adjustment is the local land motion following the 'last 'ice-age' (also called post-glacial rebound, or continental rebound) and accounts for the fact that the ocean basins are getting slightly larger since the end of the last glacial cycle about 12 500 years ago.

Importantly, Church et al. (2013) suggest that the increased rate of rise since 1990 is not part of a natural cycle but a direct response to increased radiative forcing (both anthropogenic and natural), which will continue to grow with ongoing greenhouse gas emissions.

The Intergovernmental Panel on Climate Change (IPCC) report that climate change-related sea level rise is projected to accelerate in the 21st century (Meehl et al., 2007; Saintilan and Rogers, 2013). Projections of future global sea-level rise by 2100 range from 0.2–2 m (although a more plausible upper end to the range is 0.8 m) (Meehl et al., 2007; Vermeer and Rahmstorf, 2009, Pfeffer et al., 2008 both cited in Willis and Church, 2012)[11].

Unless global sea level rise trends towards the bottom of the IPPC's (fourth assessment) projected range for 2100, which now seems unlikely, a significant increase in the rate of sea level rise is expected (for example, since the start of the satellite altimeter[12] record in 1993, global average sea level rose at a rate near the upper end of the sea level projections of the IPCC's Third and Fourth Assessment Reports (Church and White, 2011).

Criterion 5 Summary Conclusion

The recent increase in the rate of sea level rise, from 1.9 mm/y to between 2.8 mm/y and 3.2 mm/y represents an increase of between 47 and 68 % (i.e. of between (2.8-1.9)/1.9x100% and (3.2-1.9)/1.9x100% respectively) over the recent past. The IPCC further report that climate change-related sea level rise is projected to accelerate in the 21st century (Meehl et al., 2007; Saintilan and Rogers, 2013).

This detrimental change represents a substantial intensification, across most of the ecological community's geographic distribution, of sea level rise. The rate of continuing detrimental change in the ecological community is substantial as indicated by a serious intensification in the disruption of a key driver of important community processes (sea level rise). Therefore, the ecological community is eligible for listing as **vulnerable** under this criterion.

Criterion 6 - Quantitative analysis showing probability of extinction

There are no quantitative data available to assess this ecological community under this criterion. Therefore, it is **not eligible** for listing under this criterion.

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[11] This range of projections for global sea-level rise by 2100 (of 0.2 – 2 m since 1990) represents an average value over the 110 year period of 1.8 – 18 mm/year; a 0.8 m (800 mm) rise represents an average value over the 110 year period of 7.3 mm/year.

[12] Satellite altimetry provides data on sea-surface heights by measuring the time taken by a radar pulse to travel from the satellite antenna to the surface and back to the satellite receiver.

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