



Australian Government

**Department of Sustainability, Environment,
Water, Population and Communities**

Corner Inlet Ramsar site

Ecological Character Description

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Chapters 5-6

Other chapters can be downloaded from:

www.environment.gov.au/water/publications/environmental/wetlands/13-ecd.html

5 CHANGES TO ECOLOGICAL CHARACTER AND THREATS

5.1 Overview of Threats

Given the size and diversity of wetland habitats present, the threats to the values of the Ramsar site vary greatly across multiple spatial and temporal scales and in terms of their potential severity. Some of these threats are discussed in the above section in relation to changes to ecological character and a range of threats have also been identified for each of the critical services/benefits.

Broad scale threats to the ecological character of the site are summarised in Table 5-1 and discussed below. The expected timing, likelihood and consequence have been estimated for each threat, and the risk of each threat has then been identified based on a simple risk matrix as follows:

		Consequence		
		Minor	Moderate	Major
Likelihood	High	Medium	High	High
	Medium	Low	Medium	High
	Low	Low	Low	Medium

Note that these threat types and the risk scores are largely consistent with independent risk assessments for the site undertaken by Carey et al. (2007).

5.1.1 Recreational Activities

Boating is the most popular recreational activity in Corner Inlet (Parks Victoria 2005). A range of boating-related threats, especially to seagrass beds, are apparent for Corner Inlet (Parks Victoria 2005), including:

- navigation across shallow seagrass beds at, or on either side, of low tide, resulting in direct physical damage
- discharges of sewage, oil or litter
- bow wash, especially from boats exceeding about five knots
- anchoring in sensitive seagrass areas (see also Walker *et al.* 1989).

This is particularly an issue with *Posidonia* given its slow growth and recolonisation rates following disturbance (Meehan and West 2000). However, pioneer species such as *Zostera muelleri* and *Heterozostera tasmanica* have a faster growth rate and adaptations that allow rapid recolonisation following disturbance, making them less at risk from disturbance than *P. australis* (West and Larkum 1983).

Table 5-1 Summary of Key Threats to the Ecological Character of the Corner Inlet Ramsar Site

Threat	Potential impacts to wetlands	Timing	Likelihood	Consequence	Risk
Recreational activities	Direct and indirect effects to habitats due to recreational activities (boat wash, anchor damage to seagrass, water quality impacts) Development impacts for tourism infrastructure developments	Short to long-term	Medium	Moderate	Medium
Natural resource utilisation	Grazing impacts to vegetation Changes to fish stocks due to recreational and commercial fishing Modifications to habitats due to fishing practices	Short to medium term	Low to Medium	Moderate	Low to medium
Modified flow regimes	Altered environmental process linked to river flows, including spawning and migrations of fish	Short to long-term	Medium	Major	High
Pollutant (sediment and nutrients) inputs affecting water quality*	Loss of seagrass and associated impairment of ecological functions Increase in algae Changes in biological assemblages	Short to long term	Medium to High (depending on location and degree of flushing)	Moderate to major	Medium to high
Future infrastructure development	Removal of vegetation and habitats Changes to water quality and hydrodynamics Interruption of surface water/groundwater flow paths	Medium to long term	Low to medium	Moderate to major	Medium to high
Acid sulphate soils	Water quality degradation and associated fish kills, or impairment to ecosystem functions	Medium term	Low	Moderate to major	Low to medium
Oil spill/marine incident	Injury/fatality of marine species and communities	Short to long term	Low to medium	Major	Medium to high
Habitat loss resulting from seawalls* and urban development	Loss of habitat Pollutants in stormwater runoff and sewage Weeds and pest fauna	Medium to long term	Medium	Moderate to major	Medium to high
Climate change	Reduction of freshwater species Reduction of suitable fauna habitat Greater fire risk Increase in disturbance due to storm surge	Long term	Medium to high	Major	High
Weeds*	Reduced regeneration of native flora	Medium term	Medium	Moderate	Medium
Exotic pest fauna*	Disturbance of birds and other fauna, resulting in impairment to ecological functions (such as bird breeding and feeding) Predation of native fauna Modification of marine fauna assemblages due to competition	Short to Medium term	Low to Medium	Moderate	Low to medium

(*) identified as a key hazard for the site by Carey et al. (2007)

Large tourism developments would have the potential to place additional pressures on the marine environment of Corner Inlet. Given the anticipated increase in population growth both locally and in Victoria generally, there will be commensurate pressures on tourist facilities and environmental resources of the site.

5.1.2 Natural Resource Utilisation

Grazing of vegetation and trampling of wetland habitat by native and non-native species as well as resource utilisation in terms of small scale commercial and larger scale recreational fishing effort that occurs in the wetland are identified as ongoing threats. The large sand islands (for example, Big Snake Island) are grazed by cattle, and vegetation communities are expected to be affected by ongoing grazing pressures.

Recreational angling and commercial net fishing are also likely to represent key ongoing threats to fish stocks, although there are no available data to determine impacts. Bait digging for worms and callinassid shrimps (ghost nippers) also represents a locally important fishery, however the impacts on values and habitat resources due to collection activities are also unknown.

O'Hara et al. (2002) suggests that fishing using weighted seine nets in *Posidonia* beds at Corner Inlet can also lead to damage to seagrass habitats. At one site examined by O'Hara et al. (2002), the senescent ends of the seagrass leaves and associated epiphytes had apparently been thinned and/or removed by seining. O'Hara et al. (2002) also found lower crab and gastropod abundances in areas subject to seining. O'Hara et al. (2002) remarked that seining techniques in Corner Inlet have changed in comparatively recent times. For most of last century, wooden boats and hand-hauled nets restricted seining to the shallow banks. The introduction of powered boats and boat-drawn nets in the 1980's opened up deeper (for example, *Posidonia*) seagrass beds and channels to seining operations.

Corner Inlet commercial fishers have developed an Environmental Management Plan (2004) which aims to manage some of the impacting processes associated with fishing activities. This includes, among other actions, measures to reduce seagrass damage including using specially designed nets that do not 'rip' the grass, not anchoring in beds, as well as not anchoring in seagrass meadows. The EMP recognises the role of land-based activities leading to damage and degradation of fisheries habitats, most notably increased pollutant loads and its effect on seagrass.

5.1.3 Modified Flow Regimes

The present Sustainable Diversion Limit (SDL) prevents diversions in summer, and allows winter diversions up to the river-specific SDL. In the absence of a more detailed, locally-specific investigation, the present SDL-based rules are the most appropriate limit of acceptable change for stream flows in Corner Inlet catchments. Adoption of these SDL-based rules should theoretically minimise the threat of water extraction on the ecological character of the site.

From a groundwater resource perspective, information from the Australian Natural Resources Atlas website indicates that the Seacombe GMA is currently overdeveloped, as total water consumption exceeds the sustainable yield by more than two-fold. Falling groundwater levels near Yarram (Latrobe Aquifer) have been of concern to farmers in recent times, especially during periods of drought (CSIRO 2005). Dewatering activities associated with the offshore extraction of oil and gas

has been identified as an underlying influence for the declining groundwater levels in the region (Hatton *et al.* 2004).

5.1.4 Pollutant Inputs

The main threats to the Corner Inlet Ramsar wetlands in terms of water quality are increased inputs of sediments and nutrients (Ecos unpublished; BL&A 2008; CSIRO 2005; Water Technology 2008). Increased sediment loads lead to increased water column turbidity resulting in lower light levels reaching benthic microalgae living on the sediment surface and seagrass meadows. Although light requirements vary between individual seagrass species, the minimum light requirements are much higher for seagrasses (two to 37 per cent of surface irradiance) than for macroalgae and phytoplankton (one to three per cent) (Lee *et al.* 2007). Therefore, potential impacts associated with decreased light levels may be most detrimental to the seagrass in Corner Inlet. Because seagrasses are important for stabilising the sediment (O'Hara *et al.* 2002), a decrease in seagrass coverage in Corner Inlet may lead to a negative feedback loop leading to more sediment resuspension and, hence, higher turbidity. Furthermore, the important role of seagrass as a nutrient sink (Connell and Walker 2001) may be impaired by loss of seagrasses. Increased sediment loads may also affect distribution and vegetation patterns of mangroves and saltmarshes by providing new substrate or smothering of mangrove pneumatophores and herbaceous saltmarsh plants (Ecos unpublished).

The main issues associated with increased nutrient input involve an increase in phytoplankton biomass, which may also include toxic blue-green algae such as *Nodularia spumigena*, as is frequently observed in nearby Gippsland Lakes (Stephens *et al.* 2004). The main impacts associated with increased nutrients may include (Ecos unpublished):

- shifts among periphyton, phytoplankton and macrophytes as dominant primary producers (that is, switches across stable states)
- shifts in phytoplankton populations to domination by bloom-forming species that may be toxic or inedible by fish and zooplankton
- decrease in seagrass coverage in favour of an increase in algal mats and biomass of benthic macroalgae
- increase in epiphyte density on seagrasses shading out the seagrass host
- increases in blooms of gelatinous zooplankton
- changes in macrophyte species composition and biomass
- decreases in water transparency and light availability to benthic primary producers
- increase in taste and odour issues
- increased incidence of fish kills
- changes in fish populations to taxa more tolerant of poor water quality
- reductions in amount or quality of harvestable fish or shellfish
- decreased aesthetic and amenity values.

An increase in nutrients could result in excessive growth of algae, leading to potentially deleterious changes including outcompeting of seagrasses, changes to physico-chemical sediment processes and a reduction in the abundance of benthic infauna that act as prey for fishes and birds (Raffaelli *et al.* 1998).

Corner Inlet (including the Nooramunga area) receives input of nutrients and sediments from several major streams (Franklin, Agnes, Albert and Tarra Rivers, Deep and Stockyard Creeks) and numerous smaller streams. Furthermore, three wastewater treatment plants discharge into Corner Inlet (South Gippsland Water 2002) as well as about 30 stormwater and agricultural drains (Parks Victoria 2005). Raw sewage may be discharged into Corner Inlet from septic systems in Port Welshpool during flooding periods and from boats not equipped with suitable toilets (Parks Victoria 2005). Another potential input of nutrients to Corner Inlet is the discharge of nutrient rich groundwater (Hindell *et al.* 2007).

Since catchment loads are mainly controlled by the prevailing hydrologic conditions, loads are generally higher during wetter periods than drier periods (Water Technology 2008). Catchment and receiving water modelling indicates that dryland agriculture contributes the greatest nutrient loads to Corner Inlet due to the extensive area of this land use in the catchment (Water Technology 2008). Production forests produced the highest sediment and high oxidised nitrogen loads, despite covering a small area of the catchment (22 per cent of the total catchment). Discharges from sewage treatment plants produced high loads of nutrients (particularly phosphorus), but represented a relatively small contribution of total pollutant loads to Corner Inlet.

It is important to note that while pollutant loads from the catchment are relatively high, the extensive tidal channel network promotes tidal exchange and flushing within the inlet (see Section 3.6.2). This tidal flushing regime reduces the risk of broad-scale water quality degradation, although as discussed previously, some areas within north and western Corner Inlet appear to be under water quality stress. In particular, die-off of *Posidonia* and possibly the occurrence of blooms of filamentous algae “slub” are consistent with the effects of nutrient enrichment (CSIRO 2005), which has also been reported to occur prior to site listing (Roob *et al.* 1998). Modelling by Water Technology (2008) confirms that under current conditions, the western streams, Foster WWTP, Franklin River, Angnes River and Albert River were producing loads significant enough to influence nearby seagrass beds.

5.1.5 Urban Encroachment and Habitat Modification

There is limited urban development within the site, although the land use change and future development could affect the character of the site. Direct impacts of future urban development include direct vegetation destruction, altered hydraulic regimes due to dredging, reclamation or seawall construction, and habitat fragmentation and associated loss of ecological functions.

Ecos (unpublished) suggests that developments such as canal estates, proposed for places such as Port Albert and Port Welshpool, as well as intensification of urban development currently being experienced in these towns and Foster, Manns Beach, Roberstons Beach and McLoughlins Beach, could result in direct loss of vegetation and habitat value. Furthermore, future developments could increase pollutant loads associated with increased stormwater runoff and increased sewage effluent releases.

Seawalls represent a key agent leading to fragmentation and isolation of littoral habitats from adjacent marine waters (Carey et al. 2007). While habitat isolation due to the presence of existing seawalls are thought to represent an existing threat to breeding success of gummy shark (*Galeorhinus galeus*) and green-back flounder (*Rhombosolea tapirina*), it is thought that the threat level has stabilised in time, and that tighter planning controls would reduce the likelihood of new seawalls being constructed (Carey et al. 2007). There have also been proposals for removing seawalls, which would reduce the threat level.

5.1.6 Acid Sulfate Soils

Corner Inlet contains soil types classified as acid sulfate prone, most notably tidal flats and recent marine sediments (CSIRO 2005). Examples include soils around Black Swamp Yanakie, Old Hat Road Foster, Toora foreshore and Port Albert.

Acid sulfate soils, which were initially formed under marine conditions, contain iron sulfide layers that when disturbed, may be oxidised resulting in the formation of sulfuric acid. The mobilisation of sulphuric acid can have a range of adverse environmental impacts including (CSIRO 2005):

- acidic run-off reduces the water quality in surrounding waterways
- toxicity to fish, crustaceans and other water species
- reduction in biodiversity of surrounding wetlands
- corrosion of buildings and other infrastructure
- reduced agricultural productivity.

Activities likely to disturb the iron sulfide layer include excavations for urban development, construction of foreshore facilities, and drainage of coastal swamps. CSIRO (2005) did not identify any reports of significant acidic runoff within and adjacent to Corner Inlet, although it was noted that occasional low pH levels may be a consequence of acid sulfate soils.

5.1.7 Oil Spills and Other Incidents

Parks Victoria (2005) noted that there was potential for “devastating effects” of oil spills on the ecological, social and economic values of Corner Inlet. Proposals to develop industrial estates, port facilities and marinas at locations such as Barry Beach, Port Welshpool and Port Albert are likely to increase the risk of spills of oils or other toxicants (Ecos unpublished).

5.1.8 Climate Change

As outlined in GCB (2006), a sea level rise of seven to 55 centimetres is predicted across Western Port, as well as Western and Eastern coastal regions of Gippsland (0.8 to 8.0 centimetres per decade) by 2070. The Gippsland coastal dune systems are erosion prone, and a number of climate change processes could lead to further erosion including increases in sea level, more severe storm surges and high wave actions.

There are two main considerations with respect to identifying potential impacts of sea level rise on Corner Inlet Ramsar site:

- increased erosion. Sea level rise could lead to coastal retreat where sandy beaches are present. Retreat magnitudes vary according to the local beach profile, which is typically in the range 1:50 to 1:100. Consequently, a retreat of between 25 to 50 metres would be expected were sea levels to rise by 0.5 metres. Such a retreat could impact on the size of some islands in the Nooramunga precinct in particular
- changes in distribution and extent of habitats due to altered water levels. A long-term change in sea level is likely to lead to migration in the positions of the various intertidal vegetation communities as well as in the positions of individual species within each community. A consequence of landward migration of mangroves and saltmarshes in response to sea level rise is “coastal squeeze”. In Corner Inlet this may result in the loss of mangrove and saltmarsh vegetation arising from the restriction of landward movement and long term survivability caused by levee banks, seawalls, embankments, public infrastructure such as roads and steeper topographical slopes and gradients (Ecos unpublished)
- impacts to coastal habitats and communities associated with an increase in frequency of storm surges. Changes to the frequency of storm surge events could affect the rate at which coastal habitats and species recover from disturbance, and possibly the distribution and extent of habitats and structure of coastal flora and fauna communities.

While attention to date in terms of climate change in the region has focussed on sea level rise and coastal inundation, other potential climate change impacts are also relevant for the Ramsar site. Particular issues include:

- increased extreme rainfall events associated with climate change given the dominant contribution to extreme water levels and water chemistry is due to elevated stream flow
- lower freshwater inputs
- increased drought and higher temperature between major rainfall events leading to increased evaporation, which could expose and oxidise acid sulphate soils and exacerbate salinity in the shallow marsh environments.

The extent and magnitude of these threats can only be qualitatively described as part of the current study but are significant issues that could affect future ecological values and usage of the site by wetland flora and fauna.

5.1.9 Weeds

Weeds have the potential to cause a number of adverse ecological impacts, including displacement of native flora species and reduced habitat suitability for fauna species. A total of 93 introduced plant species are known to occur within the Ramsar site, many of which pose a serious threat to the site (DSE 2003).

The most notable weed threatening the Ramsar site is spartina (Ecos unpublished). The common name spartina refers to *Spartina angelica* as well as the hybrid *Spartina x townsendii*, which are declared noxious pests under Victorian legislation. Spartina is a perennial aquatic grass that invades mudflats and sandy shores on sheltered coastal bays and estuaries (Blood 2001). Spartina is reported to have been widespread in the Ramsar site, but a control program has been successful in reducing infestations (Parks Victoria 2005). Continued management of spartina is essential due to the threats it places on wetland ecosystems, including prevention of mangrove germination,

reduced availability of mudflats for waterbird feeding and changes to mangrove tidal inundation regimes (either waterlogging or prevention of inundation, dependent on the scenario).

Intertidal feeding habitat degradation resulting from the spread of spartina is considered to be a significant threat to waterbirds, especially shorebirds. Spartina can form dense swards and can increase sedimentation rates which in turn can negatively affect the growth of mangroves and saltmarshes and the availability of intertidal areas as foraging habitat for waterbirds. This is particularly relevant to migratory shorebirds of the site as it can lead to the loss of foraging habitat because birds are unable to access prey when spartina becomes thick on mudflats (see Melville 1997 and Stralberg et al. 2004). Clemens et al. (2007) notes that Franklin Island was historically used on average by high numbers of shorebirds before a spartina invasion appeared to make the area unsuitable. Interestingly, shorebirds did not return to Franklin Island after spartina was controlled.

Sea spurge (*Euphorbia paralias*) is another notable threat within the Ramsar site. This species invades coastal areas and has the potential to alter dune morphology (Belbin 1999). It is known to occur on a number of islands and beaches within Corner Inlet, where it has the potential to result in breeding failure of Hooded Plover due to forcing this bird species to nest in the storm tide zones (DSE 2003).

The green macroalga *Codium fragile* ssp. *tomentosoides* is another weed species of concern. This species was first discovered in Corner Inlet in March 1995 (Trowbridge 1999). *Codium fragile* ssp. *tomentosoides* was introduced to south-east Australia in the mid 1990s, presumably via New Zealand (Ecos unpublished). Ecos (unpublished) suggests that it is "...a pest of cultivated shellfish beds and a serious ecological and economic pest on the north-west Atlantic coast as well as along the shores of southern England and western Ireland".

Codium fragile ssp. *tomentosoides* has reportedly formed dense populations in Corner Inlet and other locations in Victoria. It is possible that this species could out-compete native marine plants for space and nutrients. On the basis of its known temperature and salinity tolerances, Trowbridge (1999) predicted that *Codium fragile* ssp. *tomentosoides* had the potential to spread to wave-protected bays, lagoons and estuaries from New South Wales to Western Australia.

5.1.10 Feral Pests

Terrestrial

A variety of introduced fauna species are known to occur within the site (Martindale 1982; DSE 2003; Ecos unpublished). These include black rat (*Rattus rattus*), house mouse (*Mus musculus*), common starling (*Sturnus vulgaris*), house sparrow (*Passer domesticus*), common blackbird (*Turdus merula*), rabbit (*Oryctolagus cuniculus*), red fox (*Vulpes vulpes*), cat (*Felis catus*) and domestic dog (*Canis lupus*). The majority of these introduced taxa have been widely acknowledged as implicit in the degradation of habitat values for both native fauna biodiversity and threatened species.

Of the introduced species recorded on the site, comparatively higher threats to fauna habitat values are linked to the presence of foxes and cats, though also dogs. Threats include disturbance to birds on their feeding grounds, roost and breeding sites, and predation of birds, their chicks and eggs.

Such threats to waterbirds, and particularly shorebirds, have been widely acknowledged (for example, Davidson and Rothwell 1993; Environment Australia 1999; Harding and Wilson 2007).

Foxes are known to occur within areas used by shorebirds for feeding, roosting and breeding (for example, Dream, Snake and Little Snake Islands; Clemens et al. 2007). Foxes are known to predate on birds, their chicks and eggs, and are implicated in local declines of threatened shorebirds including Hooded Plover (Weston 2000 and 2003; Clemens et al. 2007) and pied oystercatcher (Minton 1997; Taylor and Minton 2006; Clemens et al. 2007).

Taylor and Minton (2006) contend that the poor usage of pied oystercatchers within what appears to be suitable nesting habitats on both Snake Island (the largest island within the site) and Little Snake Island, is largely influenced by the presence of foxes (compared with high numbers of oystercatchers recorded on Sunday Island – the only island within the site considered to be free of foxes and other introduced predators such as cats). Pied oystercatchers have been observed to have very low breeding success on islands where introduced foxes have eaten eggs and chicks (Clemens et al. 2007). Note that the bird count data presented in Section 3.3.2 are not of sufficient temporal resolution to detect long term changes in pied oystercatcher abundance in these areas.

Clemens et al. (2007) noted the high potential for threats to shorebirds along beaches and coinciding with human activity - accidental human induced mortality or breeding failure in these areas occurs primarily to well camouflaged eggs or chicks that are killed when they are accidentally stepped on or run over by vehicles. Clemens et al. (2007) also highlighted that domestic dogs, especially when not on a leash can step on or eat eggs and chicks. Thompson (1992) found that the presence of dogs (and humans) can impact on feeding and roosting shorebirds more than 200 metres away.

Invasive Marine Animals

Ecos (unpublished) identified three key invasive marine pest animal species as potential threats in Corner Inlet Ramsar site:

- Northern Pacific seastar (*Asterias amurensis*) - This invasive starfish occurs in mud, sand or rocky habitats, but typically in areas protected from direct wave action. It is a voracious predator and will eat almost any animal it can capture. It is considered a serious pest in Australia because of its impact on native marine ecosystems and marine industries such as shellfish farming (DSE 2007). This species has been recorded at Port Phillip Bay and represents an invasion risk to Corner Inlet. Ongoing survey work is required to detect and remove any infestations of this species within Corner Inlet
- European shore crab (*Carcinus maenas*) – This species has been present at Corner Inlet since the late 19th century (Parks Victoria 2005). It is an extremely tolerant and hardy species, and is found in both the intertidal and shallow subtidal zones of bays and estuaries rather than exposed, rocky or sandy open coasts. *C. maenas* is a voracious predator with a broad diet and has been implicated in the decline of native shellfish populations, some of commercial importance. In the northwest Atlantic it consumes a wide variety of native species, outcompeting most for food and habitat. Based on its invasion history around the world, the impacts that it may have had when it first reached Australia are likely to have been substantial. Similarly, its effects in Corner Inlet are unknown but are likely to have been significant. In Tasmania, *C. maenas* has been present for about 15 years and is a major cause of mortality in

native crab and mollusc populations (NIMPIS 2002). Survey work is required to map the extent of their invasion and its impact on the environment

- Mediterranean fanworm (*Sabella spallanzanii*) – this species has become established along the south eastern and south western Australian coastline including Port Phillip Bay. *S. spallanzanii* inhabits shallow subtidal areas between one and 30 metres depth, preferring harbours and embayments sheltered from direct wave action. It colonises both hard and soft substrata, often anchored to hard surfaces within the soft sediments. *S. spallanzanii* presents a potential invasion risk to Corner Inlet since it is established in similar habitats in other areas elsewhere along the Victorian Coast. Survey work is required to ascertain if there has been an infestation of the species in Corner Inlet.

5.2 Changes to Ecological Character

The National ECD Framework requires ECD studies to assess the extent to which the ecological character of the wetland has changed, with a specific point of reference or baseline from the date of designation into the Ramsar List of Wetlands of International Importance.

Following a review of scientific literature and planning documents relevant to the Corner Inlet Ramsar site, together with information contained within Ecos (unpublished), the study team engaged the Steering Committee members about their preliminary views regarding potential changes to ecological character that have occurred since listing of the site. In particular, the study team sought advice about impacts to those aspects of the site nominated as critical services/benefits and underlying components and processes as outlined in the previous sections of this report.

The literature review and experts have not identified any significant or overarching changes in ecological character of the site since 1982, but recognise that a number of long term threats are having an incremental and cumulative effect on ecological character and require further investigation (refer Section 6.1.1). Likewise, no views were expressed in the information sources reviewed or from the committee members to merit consideration that the ecological character of the site had significantly diminished with respect to the critical services/benefits, components and processes outlined in this study (that is, no LACs are known to have been breached, refer Section 6.1.2).

5.2.1 Key Trends

With regards to threats that are having an incremental and cumulative effect on ecological character, key issues in the context of perceived impacts and potential changes to ecological character of the Ramsar site are discussed as follows:

Localised Die-off of Seagrass Communities

In response to anecdotal reports from commercial fishers of recent seagrass loss, Hindell et al. (2007) examined seagrass at six locations in Corner Inlet since 1998. Analysis of aerial photographs showed that there had been a substantial loss of seagrass in the greater north-western region of Corner Inlet. Specifically, four sites showed considerable loss of seagrass, one site showed an increase in area and one site exhibited no change. Dense seagrass beds, mostly comprised of *P. australis*, were observed to have declined in extent, whereas there was an increase

in the distribution of sparse seagrass. Ecos (unpublished) concluded that the reasons for the loss of seagrass were not entirely clear, but were most likely due to high turbidity.

Given the importance of seagrass in supporting the nutrition of animals living in Corner Inlet (demonstrated for fish by Hindell *et al.* 2007), it would be reasonable to suggest that the loss could have led to changes in fish and prawn recruitment success and possibly productivity. Based on anecdotal reports by Corner Inlet Fisheries Habitat Association (2009), previous losses in *Posidonia* meadows in 1974 reportedly resulted in major declines in fish catches, to the extent that some commercial fishers could no longer operate. Therefore, there would likely be serious ramifications for the sustainability of estuarine and marine fauna in the inlet should the recently observed seagrass loss continue.

Further investigations are required to determine whether the recent loss of *Posidonia* beds in north and western Corner Inlet could be considered to represent a change to ecological character.

Use and Quality of Habitat for Migratory Waterbirds

Ecos (unpublished) analysis indicates that both migratory species richness and species abundance have remained stable since 1982 (see also section 3.3.2). Two notable exceptions to this are the curlew sandpiper and sharp-tailed sandpiper, though declines in abundance of both species may reflect overall declines across their range resulting from population impacts within other parts of the flyway and on breeding grounds (see Wilson 2001; Gosbell and Clemens 2006) rather than as a consequence of habitat change within the site *per se* (Ecos unpublished). For curlew sandpiper, there are positive signs within the last few seasons of a recovery (VWSG 2008; Ecos unpublished).

It is also possible that orange-bellied parrot has declined, as it has suffered loss at other sites in the region (Orange-bellied Parrot Recovery Team 2006). However, work on this species at Corner Inlet has only just begun and initial observations suggest that good quality habitat exists (C. Tzaros, Birds Australia pers. comm. in Ecos unpublished). The lack of reports may be due more to the small observer effort, especially given the remoteness of sites and it is still possible Corner Inlet represents a stronghold. This is a key data gap on a critically endangered species for which there are several recent records within the Ramsar site.

It is important to note that any changes in bird abundance are likely to be the result of multiple stressors both off and on-site. Off-site impacts that may contribute to decline are the quality and availability of habitat in other nations along the Australasian Flyway as well as the condition of Australia's inland wetland habitats (refer recent article on declines in waterbird presence as part of a long term survey by Nebel *et al.* 2008). On-site impacts may include habitat loss and modification, and increases in frequency of disturbance are also likely contributing factors.

Loss of Mangroves and Saltmarsh

Farmers undertook extensive clearing and draining of lowland coastal fringe habitats around the inlet in the first half of the twentieth century, resulting in loss and fragmentation of intertidal habitats (Glowrey 2009). Denis (1994) examined more contemporary changes within the site, finding that changes in mangrove coverage varied from 1941 to 1987. Some areas such as Millers Landing exhibited minor change, while other areas such as Long Island experienced loss of mangroves, and areas such as Port Welshpool and Toota experienced mangrove expansion. Based on EVC

mapping, it is estimated that mangrove extent has declined by approximately 235 hectares within the site between 1750 and 2005, and that saltmarsh extent has declined by approximately 282 hectares within the site between 1750 and 2005, representing a loss of approximately 10 per cent for each of these habitat types. The extent of change that may have occurred since time of listing is unknown, and therefore it is uncertain whether a change in ecological character has been experienced. Baseline studies are required to assess mangrove distribution and monitor future changes in extent.

Water Quality in North West Corner Inlet

There are limited water quality data from the time of listing (1982), although more recent data are available. The Waterwatch program and other awareness campaigns by the CMA, EPA and others, along with improvements to sewerage systems, have improved catchment management practices since 1982 (Ecos unpublished). However, Ecos (unpublished) notes that ongoing development, recreational and commercial pressure on the waterways in the catchment could potentially have offset some of these catchment management improvements.

In the absence of long-term monitoring data it is not possible to determine whether there has been a change in water quality since listing. The most notable line of evidence to suggest that there has been contemporary, long-term change in water quality outside the range of natural variability is the reported loss of *Posidonia* seagrass beds in northwest Corner Inlet in recent times (see discussion above). As *Posidonia* can take decades to recover from disturbance, the loss in seagrass is expected to be symptomatic of contemporary water quality change (that is, nutrients and turbidity) that is outside the range of natural variation. There is a clear need to collect additional water quality data to assess trends over time and space, and potential linkages to anthropogenic disturbances (see Sections 6.1 and 6.2).

Commercial Fish Catches

The commercial catch data presented in Figure 3-9 and Table 3-9 show the following trends:

- There was a decline in catch of two key species over time: Australian salmon (*Arripis* spp.) and yellow-eye mullet (*Aldrichetta forsteri*). In the years leading up to site declaration (1978–83), Australian salmon tended to dominate catches, but declined markedly in 1985–86, and is now ranked ninth in terms of total catch. Similarly, yellow-eye mullet, which represented the third to fourth most abundant species in 1980 to 1983, is presented ranked eighth in terms of total catch. Yellow-eye mullet catches prior to 1999–2000 were with only three exceptions (1978–79, 1983–84, 1993–94) greater than 17 tonnes, but in the eight years since this time, catch ranged from eight to 16 tonnes. Green-back flounder (*Rhombosolea tapirina*) catches also appear to have declined over time, with the twentieth percentile pre-1982 catch less than the median post-1982 catch
- Southern garfish (*Hyporhamphus melanochir*) and King George whiting (*Sillaginodes punctatus*) were ranked second and third respectively in terms of catch in 1978–83, but now dominate catches. These two species had a total catch that was within the range or greater than the post-Ramsar listing catch

- The catch of most other species was generally higher in post 1982 than pre-1982. This was particularly the case for southern calamari (*Sepioteuthis australis*) and rock flathead (*Platycephalus laevigatus*).

The differences in catch over time could relate to either changes in fishing effort, or changes in actual abundance of these species. In Table 3-8, catch per unit effort was calculated to determine possible influence of effort on catch. Notwithstanding the limitations of effort-based data, these results again indicate that there was a decline in Australian salmon and flounder catches. However, median yellow-eye mullet catches was similar before and after site listing, indicating that changes in catches were effort driven.

There is no empirical evidence to suggest that Australian salmon stocks in Australia are diminishing, although the fishery is considered to be fully exploited (NSW Industry and Development 2010). Australian salmon is a wide ranging species that does not rely on habitats that are in decline (for example, seagrass), and elsewhere stocks are thought to be secure. At the other three locations where this species is harvested in Victoria, catches show either no clear trend (for example, Port Phillip Bay), an increase (Gippsland Lakes) and decline (Western Port Bay) (DPI 2008). The main commercial use of this species is as bait for Rock Lobster fishery, which itself has been subject to significant regulatory changes post-2001. The change in catch of Australian salmon may be in response to these changes in fisheries regulations, or changes in other market sectors.

In the context of school sharks (*Galeorhinus galeus*), there is very little available information on their population status within the site. As discussed in Section 5.1.5, it is thought that building of seawalls in the 1920s resulted in isolation and fragmentation of pupping habitat, to the extent that shark numbers in Corner Inlet have markedly declined. All Victorian coastal waters are closed to targeted shark fishing (AFMA 2009), however any sharks incidentally captured are sold to market. Figure 3-9 shows that shark catches within the site have been variable over time, but show no clear trend between 1978 and 2008.

5.2.2 Comparison to Limits of Acceptable Change

Table 5-2 provides a summary of changes in ecological character, as described by LACs, since nomination. Comment is also provided on trends in LAC pre-listing in order to determine whether changes are a consequence of longer-term or contemporary impacting processes. Changes are subjectively ranked as likely or unlikely based on professional opinion or in some instances empirical data.

Table 5-2 Comparison of LACs to Observed Trends Post-Ramsar Listing

Critical C/P/S	Limits of acceptable change	Pre-1982 trend	Post-1982 trend
C1	<p>Inlet waters</p> <ul style="list-style-type: none"> • A greater than 20 percent reduction in the extent of permanent saline wetland – intertidal flats (areas mapped by DSE = 40 479 hectares), observed on two sampling occasions within any decade, will represent a change in ecological character (LAC – mapped area less than 36 431 hectares). 	<p>No data to quantify changes No large scale works (for example, training wall construction, dredging, sand extraction) have been undertaken that would cause a major change to extent.</p>	<p>Ecological Character Change unlikely. See pre-1982.</p>

Critical C/P/S	Limits of acceptable change	Pre–1982 trend	Post–1982 trend
	<ul style="list-style-type: none"> A greater than 20 percent reduction in the extent of subtidal channel (areas mapped by NLWRA = 16 349 hectares), observed on two sampling occasions within any decade, will represent a change in ecological character (LAC – mapped area less than 13 079 hectares). 		
	<p>Seagrass</p> <ul style="list-style-type: none"> Total mapped extent of dense <i>Posidonia</i> will not decline by greater than 10 percent of the baseline value outlined by Roob <i>et al.</i> (1997) at a whole of site scale (baseline = 3050 hectares; LAC = mapped area less than 2745 hectares) on any occasion. Total mapped extent of the dense and medium density <i>Zosteraceae</i> will not decline by greater than 25 percent of the baseline values outlined by Roob <i>et al.</i> (1998) at a whole of site scale on two sampling occasions within any decade. <ul style="list-style-type: none"> Dense <i>Zostera</i> - Baseline = 5743 hectares (LAC = mapped area less than 4307 hectares) Medium <i>Zostera</i> - Baseline = 1077 hectares (LAC = mapped area less than 807 hectares) 	<p>Major declines in <i>Posidonia</i> have been recorded over time, most notably the 1930s and 1974.</p>	<p>Unknown. Reduction in <i>Posidonia</i> density/cover recorded in north west Corner Inlet between 1998 and 2007. However, no data available on changes in overall extent.</p>
	<p>Mangroves</p> <ul style="list-style-type: none"> Based on EVC mapping, it is estimated that mangroves presently cover an area of 2137 hectares within the site. A 10 percent reduction in the total mapped mangrove area, observed on two sampling occasions within any decade, is an unacceptable change. (LAC – mapped area less than 1924 hectares). 	<p>EVC mapping indicates approximately 10 percent loss in mangroves/ saltmarsh since 1750.</p>	<p>Unknown. Post–1982 trend not quantified</p>
	<p>Saltmarsh</p> <ul style="list-style-type: none"> Based on EVC mapping, it is estimated that intertidal marshes presently cover an area of 6500 hectares within the site. A 10 percent reduction in the total mapped saltmarsh area, observed on two sampling occasions within any decade, is an unacceptable change (LAC – mapped area less than 149 hectares). 		
<p>C2</p>	<ul style="list-style-type: none"> Mean annual abundance of migratory bird species - Birds Australia (2009c) note that a maximum annual abundance of 	<p>Limited data</p>	<p>Ecological Character Change unlikely. While some species have declined (see below), there is no evidence to suggest that the overall average total count has declined by</p>

Critical C/P/S	Limits of acceptable change	Pre–1982 trend	Post–1982 trend
	<p>migratory species of 42 811 birds, with a mean annual abundance of migratory species being 31 487 birds. The annual abundance of migratory shorebirds will not decline by 50 per cent of the long-term annual mean value (that is, must not fall below 15 743 individuals) in three consecutive years.</p>		<p>50 per cent in three consecutive years.</p>
	<ul style="list-style-type: none"> • Mean annual abundance of species that meet the one per cent criterion will not be less than 50 per cent of the long-term annual mean value in five years of any ten year period. These values are follows: <ul style="list-style-type: none"> ○ curlew sandpiper – baseline = 2588 birds, LAC = 1294 birds ○ bar tailed godwit – baseline = 9727 birds, LAC = 4863 birds ○ eastern curlew – baseline = 1971 birds, LAC = 985 birds ○ pied oystercatcher – baseline = 893 birds, LAC = 446 birds ○ sooty oystercatcher – baseline = 285 birds, LAC = 142 birds ○ double-banded plover– baseline = 523 birds, LAC = 261 birds 	<p>See component above</p>	<p>Unknown. Most bird numbers have remained stable since 1982, although declines are evident for curlew sandpiper and sharp-tailed sandpiper. The trend for this latter species, however, has altered, with increases in their numbers being recorded since 2002 (Ecos unpublished). The decline in curlew sandpiper numbers reflects an overall decline across their range (including south-eastern Australia) and therefore, is unlikely to be a consequence of a change in habitat at Corner Inlet. It is possible that it is being adversely affected by flyway condition or breeding success in its breeding habitats of north-eastern Siberia and Alaska.</p>
P1	<ul style="list-style-type: none"> • A greater than 50 percent reduction in nesting activity at key nesting sites for fairy tern, hooded plover, Caspian tern, crested tern is an unacceptable change 	<p>No available data</p>	<p>Unknown</p>
S1	<ul style="list-style-type: none"> • An unacceptable change would have occurred if either growling grass frog, orange-bellied parrot or Australian grayling no longer supported 	<p>All species are threatened, primarily due to long term habitat loss and degradation throughout their range.</p>	<p>Ecological Character Change unlikely due to site specific threats.</p>
S2.	<ul style="list-style-type: none"> • Median abundance of key fisheries species will not fall below the 20th percentile baseline value over a five year period. 	<p>Like other estuaries, abundance of most fish species is likely to have declined in response to habitat loss and degradation, fishing and altered flow regimes (both within and external to site).</p>	<p>Ecological Character Change unlikely. Some declines in catch per unit effort of Australian salmon and green-back flounder (see Table 3.9), although the LAC value was not exceeded. There is no evidence that stocks of these species are in decline.</p>

6 INFORMATION GAPS, MONITORING AND EDUCATION

6.1 Information Gaps

The ECD preparation process promotes the identification of information or knowledge gaps about the Ramsar site that are principally derived through interrogation of the nominated ecosystem services/benefits, components and processes and associated understanding of natural variability and limits of acceptable change.

In general, data and information gaps have been identified in this ECD in three broad areas:

- in relation to the natural variability and LACs for critical wetland habitats and species (as outlined in Sections 4 and 5.2, particularly for those attributes/controls where there are no data)
- in relation to lack of information and data to support a more detailed assessment of ecological character change at a whole of site and individual waterbody/wetland scale (refer Section 5.1)
- in the context of the discussion of each of the critical services/benefits in the detailed ecological character description section (refer Section 3.3).

In analysing the information gaps identified in these three sections of the ECD, the following thematic information gaps are identified as priority areas for future investment:

- Baseline water quality characteristics within representative habitats throughout the site. In particular, inclusion of nitrogen species in routine monitoring and additional monitoring of wastewater treatment plants are seen as priorities (Water Technology 2008). This is considered to represent the most critical information gap in terms of identifying potential future impacts to most critical components and services/benefits
- Further investigation into the high nutrient concentrations in the Yanakie region
- Additional research and monitoring expenditure to establish an ecological character baseline for the key waterbodies/wetland habitats, with a priority on habitats such as seagrass and fringing littoral vegetation, which support important flora and fauna species, habitats and life-history functions (for example, breeding sites, roosting sites, spawning sites, etc.) that are at most risk of future ecological change
- Comprehensive seagrass mapping was undertaken by Roob et al. (1998) for the site and used for comparative purposes as part of more recent condition assessments (as documented by Hindell 2008). However, the primary purpose of this has been to assess the impact and recovery of seagrass (in terms of extent and density) from algal blooms in the lakes as opposed to repeating Roob et al.'s broad-scale resource mapping exercise (Hindell 2008)
- In terms of wetland flora, mapping layers for both the Victorian Wetland Classification System (VWCS) and Ecological Vegetation Classes (EVC) were made available to the study team. However, as previously mentioned, the classification systems on which these mapping layers are based do not have direct equivalents to Ramsar wetland types. As such, it is difficult to quantify the distribution and extent of Ramsar wetland types within the site. Furthermore, there is limited specific information on the condition of individual wetlands and/or areas within the site.

- The need for better information and data sets about the presence and natural history of critical wetland species and their habitat; and more systematic surveys of important avifauna and fish species and populations. Surveys should focus on quantifying patterns in the abundance of waterbirds, as well as identifying important areas and site usage by threatened wetland-dependent fauna species that are known (that is, growling grass frog, Australian grayling, orange-bellied parrot) or highly likely (for example, Australasian bittern) to occur in the site
- Better information and understanding about the natural variability of critical wetland fauna populations and key attributes and controls on those populations (including whether or not any non-avian fauna species meet the one per cent population requirement in Ramsar nomination criterion 9)
- More specific assessment of the vulnerability of the site to the impacts of climate change and adaptation options that could be explored to reduce the impacts
- The Nooramunga barrier islands and sandy dune systems are highly susceptible to erosion and impacts associated with climate change related increases to sea level and increased wave energy. There is currently no data describing sediment movements and long-term shoreline changes to identify climate change impacts
- Recorded information on waterbird counts were undertaken at only a few sites, or only for a short period of time, or were collected in a manner that is not directly comparable across different years or sites, or had gaps where monitoring/counting was not undertaken at all (refer data review in Appendix C). The population of waterbirds in Corner Inlet has been relatively low since 1982, with the variations that can be observed over this time strongly correlated with rainfall. Curlew sandpiper have shown a decline over time, however the reason for this is not known and requires further investigation
- LACs are difficult to assess for fish because of their high variability in abundances and recruitment. Furthermore, there are no systematic data available to assess trends over time. This is an important gap in the context of assessing (i) potential future changes to Australian grayling; and (ii) trends in commercially significant species.

6.2 Monitoring Needs

The Corner Inlet Ramsar Site Ecological Monitoring Program Brett Lane and Associates (2008) provided an overview of 34 existing and historical monitoring activities within the Corner Inlet Ramsar site, the majority based around water quality and waterbirds. There were significant gaps identified in the monitoring programs currently underway.

In the context of the site's status as a Ramsar site and in the context of the current ECD study, the primary monitoring needs relate to the need to assess the suitability of limits of acceptable change (versus natural variability) and to assess more definitively if changes to ecological character have occurred or are being approached. Principally, this monitoring should relate to:

- Broad-scale observation/monitoring of wetland habitat extent at representative wetland types within the site (noting that a logical precursor to this would be to establish a better correlation between Victorian wetland mapping and the Ramsar wetland type classification system).
- Habitat condition monitoring which should occur both as:

- long term analysis of vegetation community structure including identified trends in vegetation patterns in the freshwater fringing wetlands (particularly on the barrier islands); estuarine fringing wetlands (mangroves and saltmarsh); and seagrass meadows (focussing on *Posidonia*, but also other more transient species)
- monitoring underlying wetland ecosystem processes such as hydrological process (both surface and groundwater), water quality and surrogate biological indicators for these processes
- More targeted surveys of the threatened flora and fauna species (perhaps on a five year or ten year basis) to assess presence/absence or population changes of noteworthy species or communities identified in the critical components. Specifically this should target presence and usage of the site (at various spatial scales) by growling grass frog, orange-bellied parrot and Australian grayling (see Critical Service/Benefit 1)
- More regular counts of all waterbirds in accordance with the monitoring regime envisioned by the LAC (refer Critical Component 2)
- More regular counts of breeding waterbirds at identified breeding colony sites (refer location and description of sites in the discussion of critical Process 1)
- Continued and more intensive survey and monitoring of recreationally and commercially important fish stocks including key nursery area and spawning sites (refer Critical Service/Benefit 2).

Brett Lane and Associates (2008) provides a comprehensive monitoring plan to address many of these information gaps.

6.3 Communication, Education, Participation and Awareness Messages

Under the Ramsar Convention a Program of Communication, Education, Participation and Awareness (CEPA) was established to help raise awareness of wetland values and functions. At the Conference of Contracting Parties in Korea in 2008, a resolution was made to continue the CEPA program in its third iteration for the next two triennia (2009 – 2015).

The vision of the Ramsar Convention's CEPA Program is: "People taking action for the wise use of wetlands." To achieve this vision, three guiding principles have been developed:

- The CEPA Program offers tools to help people understand the values of wetlands so that they are motivated to become advocates for wetland conservation and wise use and may act to become involved in relevant policy formulation, planning and management
- The CEPA Program fosters the production of effective CEPA tools and expertise to engage major stakeholders' participation in the wise use of wetlands and to convey appropriate messages in order to promote the wise use principle throughout society
- The Ramsar Convention believes that CEPA should form a central part of implementing the Convention by each Contracting Party. Investment in CEPA will increase the number of informed advocates, actors and networks involved in wetland issues and build an informed decision-making and public constituency.

The Ramsar Convention encourages that communication, education, participation and awareness are used effectively at all levels, from local to international, to promote the value of wetlands.

A comprehensive CEPA program for an individual Ramsar site is beyond the scope of an ECD, but key communication messages and CEPA actions, such as a community education program, can be used as a component of a management plan.

One of the ten objectives of the strategic management plan for the Corner Inlet Ramsar site, Objective 8, is to 'promote community awareness and understanding and provide opportunities for involvement in management' (DSE 2003). The management objective is supported by four site management strategies in the management plan.

Key CEPA messages for the Ramsar site arising from this ECD, which should be promoted through this objective and associated actions, include:

- The site is a wetland of international importance based on the critical and supporting components, processes and services/benefits (C/P/S) that it provides, as described in this ECD
- The critical and supporting components, processes and services/benefits include the range of natural values under which the site has been listed as a Ramsar site as well as important social and scientific/research values
- The site provides habitat for threatened species and communities at the State, National and International level
- Most of the site is managed for conservation purposes. Most existing and future major threats are due to activities within the site's catchments located outside the site.
- Given the current and future threats, the site requires improved ecological understanding for proper management and more detailed monitoring of changes to ecological character
- The site is managed following a joint management approach that engages landowners, land managers and site users in a manner that aims to maintain its ecological condition.

Key stakeholders responsible for the communication of this central message include managers and site users, regulators, advisors and funders, and the broader community, as shown in Table 6-1.

Table 6-1 Stakeholder Groups of the Relevance to the Corner Inlet Ramsar Site

Stakeholder Group	Stakeholders
Managers and Users	West Gippsland CMA Parks Victoria South Gippsland Shire (including relevant Committees of Management) Wellington Shire (including relevant Committees of Management) Department of Sustainability and Environment Gippsland Ports Department of Primary Industries South Gippsland Water Authority Gippsland Coastal Board Landholders Corner Inlet Fisheries Association
Regulators	Environment Protection Authority DSEWPAC (EPBC) Department of Sustainability and Environment Department of Primary Industries (Fisheries)
Advisors and Funders	Australian Government – DAFF and DSEWPAC Consultants and Contractors Universities and Researchers: CSIRO University of Melbourne Monash University
Broader Community	Landholders Environment Victoria Birds Australia - Victoria Commercial Fishing Industry General Public