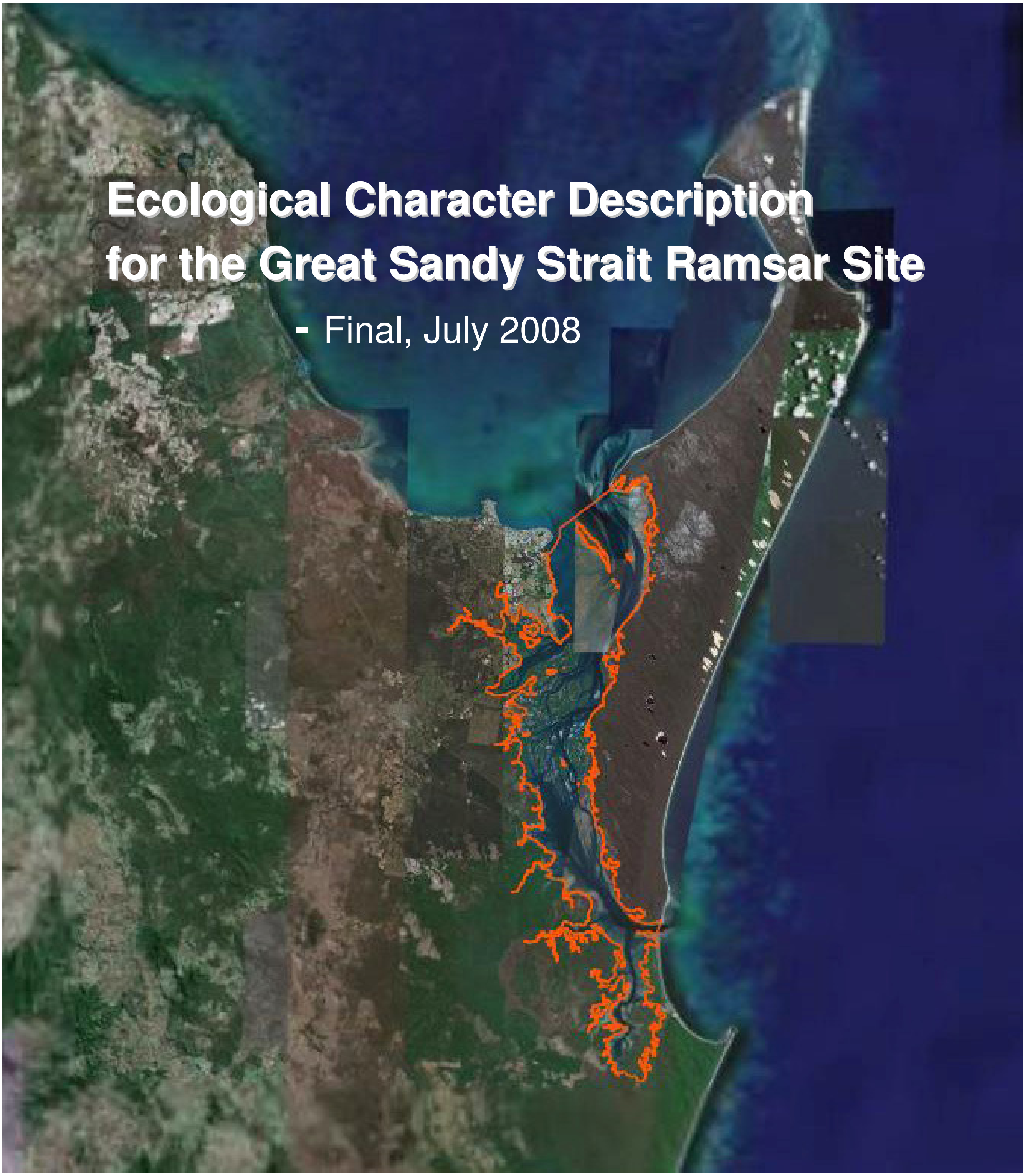
# Ecological Character Description for the Great Sandy Strait Ramsar Site

- Final, July 2008



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Front cover image: courtesy of Google Earth

## Disclaimer

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## Abbreviations

| | |
|---|---|
| **BMRG** | Burnett Mary Resource Management Group |
| **CEPA** | Communication Education and Public Awareness |
| **DIWA** | A Directory of Important Wetlands in Australia |
| **DPI&F** | Queensland Department of Primary Industries and Fisheries |
| **ECD** | Ecological Character Description |
| **ENSO** | El Nino Southern Oscillation |
| **EPA** | Environmental Protection Agency, Queensland |
| **EPBC Act** | Environment, Protection and Biodiversity Conservation Act 1999 |
| **HEV** | High Ecological Value |
| **IBRA** | Interim Biogeographic Regionalisation for Australia |
| **IMCRA** | Interim Marine and Coastal Regionalisation for Australia |
| **IUCN** | International Union for Conservation of Nature |
| **NRM** | Natural Resource Management |
| **NRW** | Department of Natural Resources and Water |
| **QPW** | Queensland Parks and Wildlife Service |
| **RIS** | Ramsar Information Sheet |
| **SOI** | Southern Oscillation Index |

# PART A Executive Summary

## Background

As a party to the Ramsar Convention on Wetlands, Australia has obligations to maintain the ecological character of its Wetlands of International Importance (Ramsar sites). An Ecological Character Description (ECD) for a Ramsar site is a management tool providing a benchmark that managers can use for planning and action, including site monitoring. In Australia this is an essential tool for implementing the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) when proposed activities are assessed for potential impacts on a Ramsar site.

This report provides an ECD for the Great Sandy Strait Ramsar site, the first for a Ramsar site in Queensland. The ECD includes a combination of the ecosystem components, processes and services that characterised the site at the time of its Ramsar nomination (1999), and notes on subsequent changes to the site. Importantly, the ECD recognises site features that relate to the Ramsar criteria for which the site was nominated, but is not limited to them because it includes ecosystem services that, for example, relate to uniqueness or human benefits.

The project to develop the ECD was funded through the Queensland Wetlands Programme which is a joint initiative of the Australian and Queensland Governments to protect wetlands in the Great Barrier Reef catchment and throughout Queensland. This ECD aims to inform and relate to documents, instruments and processes, at local to international scales, for natural resource management affecting Great Sandy Strait. The project also provided an updated Ramsar Information Sheet (RIS) and digital maps for boundaries of the Ramsar site. This ECD should be appended to the RIS and each subsequent updated RIS. Updating an ECD should only be considered in one or more of the following circumstances:

1. If further substantial data, knowledge or resources are available to improve the original description;
2. If the boundaries of the site are extended, reduced or modified, in which case the Ramsar Information Sheet and the ecological character description should be re-examined and updated; or
3. If the wetland undergoes favourable human-induced changes as a result of a rehabilitation and/or restoration project or if the wetland undergoes natural evolutionary change.

## Approach taken to describe key elements of the Ecological Character Description

The procedure for development of the ECD was based on the draft *National Framework and Guidance for describing the ecological character of Australia's Ramsar wetlands 2007* (the draft Framework). The Ramsar information sheet (RIS) for the site was also updated as part of this project. Within this process, the Ramsar criteria that the site was deemed to have met at the time of designation were reviewed and translated to the current (restructured and expanded) set of criteria. This revealed that eight criteria were met at the time of listing, including criterion 4 and criterion 7 which were omitted in the original nomination.

A list of ecosystem services provided by the site was derived, with reference to the four categories of ecosystem service defined by the Ramsar Convention and Millennium Ecosystem Assessment (2005), and the Ramsar criteria that the site met at the date of designation (see **Appendix 1**). Consideration was thus given to: provisioning, regulating, cultural, and supporting services.

Selection criteria within the draft Framework were used to identify the **critical ecosystem services** for the Great Sandy Strait Ramsar site. According to the four criteria, the critical ecosystem services should be:

1. key determinants of the site’s unique character;
2. important for supporting the Ramsar or DIWA criteria that the site was listed for;
3. be reasonably likely to show changes over short or medium time scales (<100 years);
4. cause of significant negative consequences if change occurs.

Using collated geological and ecological knowledge about the site, the components and processes that supported these ecosystem services were listed, with a description of how they each supported the service. The same criteria that were used to select critical ecosystem services were used again to select the **critical ecosystem components and processes** needed to maintain the site’s ecological character.

For the critical ecosystem services and the critical components and processes, the key variables that best quantify these elements of ecological character were described. For each key variable, knowledge about their levels of natural variability is given, and from this knowledge Limits of Acceptable Change were also proposed where possible.

An important aspect of the ECD is the **Limits of Acceptable Change**. They establish thresholds which in most cases may be used to signify or assess change in ecological character since the date of Ramsar listing. These limits are taken to be outside what would be expected through natural variation, and thus should represent a change from natural conditions through human induced impacts or interference.

The Limits of Acceptable Change were determined where possible from published and expert knowledge about levels of natural variability of key parameters that best quantified the critical ecosystem services, components and processes. Depending on the role of the component or process, the limits may have been equal to the known or expected boundaries of natural variability, or a more conservative threshold was proposed. In several cases information and expert advice was insufficient to propose any threshold.

Depending on the state of knowledge to date, the proposed Limits of Acceptable Change fall into one of four “categories”:

1. information is insufficient and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed;
2. information is insufficient for proposing a threshold for change in ecological character, but more conservative triggers for management intervention are proposed;
3. information is only sufficient for proposing an interim Limit of Acceptable Change (threshold for change in ecological character), and further information is required to set a more precise threshold; or
4. information is sufficient to propose a specific threshold (Limit of Acceptable Change) for use in management decisions, but a more precise threshold may still be set as further information becomes available.

The descriptions given in this document on ecological character, including the indicators of ecological character, their natural variability and Limits of Acceptable Change, are relevant at the time of publication (detailed in Section 4). They are expected to remain current until new information becomes available. Updates of the ECD should incorporate improvements in this information and any new limits of acceptable change.

The Limits of Acceptable Change will also inform the development of monitoring plans. Depending on the degree to which a single variable might affect other components or processes, and based on expert advice, these limits of acceptable change might in some cases also be used as potential trigger points or levels that help in assessing potential impacts of overall land-use and development affecting the site.

The impacts, however, from a single development will often not exceed these limits. Impacts of other developments must also be considered to ensure that the overall limit of acceptable change is not exceeded.

## Other required elements of the Ecological Character Description

**Threats** (Section 5) to the site have been summarised to identify the elements of ecological character which are at risk, and to help guide monitoring and management resources.

**Knowledge Gaps** (Section 6) have been identified when considering the critical ecosystem services, components, processes and related threats. These are summarised to provide guidance for managers in developing strategic improvements in monitoring and management for maintaining the critical elements of ecological character and for addressing the key threats to ecological character.

**Changes in Ecological Character** (Section 7) have been difficult to quantify. The site still meets the original criteria which it met on the date of Ramsar listing. This includes two additional criteria which were not included in the original nomination[1]. Some ecosystem components have shown indications of downward trends but often with insufficient information to confirm the exact degree of change. Some of the changes commenced prior to the date of Ramsar listing, thus may be part of long-term declines.

**Monitoring Needs** (Section 8) have been identified to help inform the development of monitoring programs. The monitoring needs are based on the variables outlined for the critical ecosystem services, components, processes, and their related threats. The monitoring indicators, frequencies and priorities listed are indicative only and may be revised with the benefit of improved information or according to prevailing needs and resources.

## Site Description

The Great Sandy Strait Ramsar site lies in South-eastern Queensland at Latitude 25° 28' 46" S, Longitude 152° 54' 9" E and includes Great Sandy Strait, Tin Can Bay, Tin Can Bay Inlet and parts of Fraser Island and the mainland (**Figure 1**). It is in the Tweed-Moreton marine and coastal bioregion (IMCRA), at the convergence of tropical and temperate zones. The area of the Ramsar site is 93,160 ha.

The site falls partly within or is bordered by Fraser Coast and Gympie Regional Councils. Land and water within the site are primarily under the jurisdiction of Queensland Government agencies. The Queensland EPA holds functional authority for management of the Ramsar site, but other State government agencies are responsible for management of coastal navigation and fisheries.

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[1] *The Great Sandy Strait Ramsar site was not originally nominated for Criteria 4 or 7, or their 1999 equivalents:*

- *The pre-1999 Criterion 2c = post-1999 Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.*
- *The pre-1999 Criterion 4a = post-1999 Criterion 7: A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.*


**Figure 1. The Great Sandy Strait Ramsar site. [Data Source: Queensland EPA, 2002].**

## Summary Ecological Character Description

The Great Sandy Strait is a particularly outstanding Ramsar site in Australia in that it supports a large diversity of wetland habitats, a high diversity of wetland flora and fauna species, a number which are nationally and internationally threatened, and several community types that reflect the transition between tropical and temperate marine and coastal zones. The proximity and connectivity between wetland types further enhances biodiversity and productivity in the site. At the date of listing, the site met seven of the current Ramsar criteria.

Fourteen critical ecosystem services were identified for the Great Sandy Strait Ramsar site. A large number of ecological components and processes support these ecosystem services, but only eight were selected as critical components or processes. Aspects of climate, geomorphology, hydrology, water quality, physical form and nutrient dynamics interact to support the key wetland communities and recognised set of ecosystem services (**Figure 2**). Together, these critical core elements of ecological character provide a focus for management of the Ramsar site. To assist this management focus, this ECD identifies parameters which best represent the critical elements of ecological character and, where possible, describes their levels of natural variability and proposes limits of acceptable change.

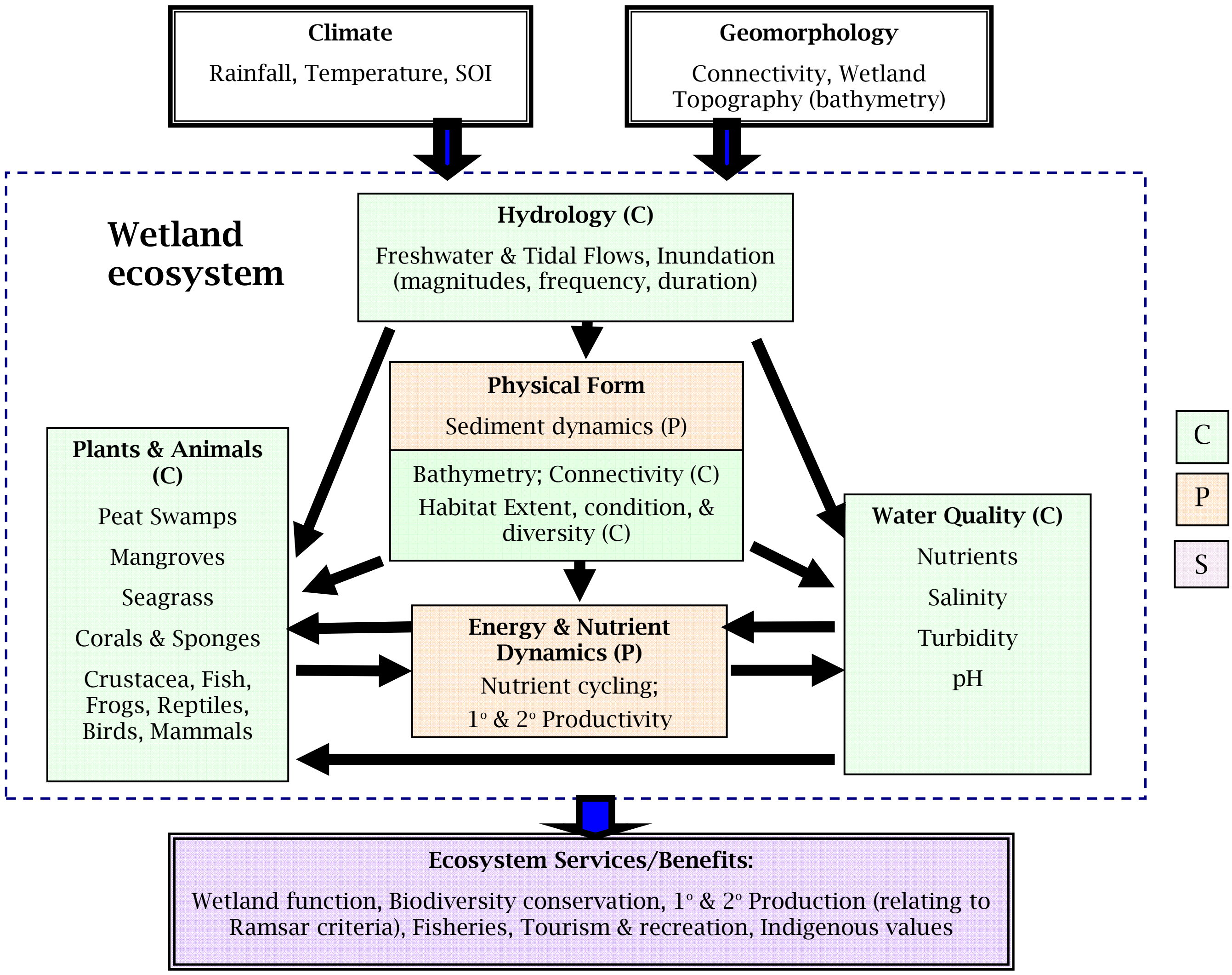


**Figure 2. Broad conceptual diagram of relationships between critical ecosystem components, processes and benefits/services that provide the ecological character of the Great Sandy Strait Ramsar site. C = ecosystem component; P = ecosystem process. (Adapted from DEWR 2007)**

## Ecosystem services of the site

In describing the critical elements of ecological character of the Great Sandy strait Ramsar Site, the following features of the Site were of primary importance:

Great Sandy Strait is located at the transition between tropical and temperate marine and coastal biogeographic zones (Commonwealth of Australia 2006). It is one of the best examples of a tide-dominated sand passage estuary system on Australia's eastern seaboard. The Ramsar site comprises this passage estuary and margins of a large sand island and sandy mainland and therefore includes both estuarine and freshwater wetlands, which are extensive and diverse (**Figure 3**).

The site supports a diverse and regionally significant area of seagrass beds as well as mangrove wetlands habitats that comprise species at, or near to, their northern or southern geographical limits. The site also supports large intertidal mud and sand banks, small but regionally significant coral reefs and sponge gardens, and other estuarine elements. These habitats in turn support feeding, roosting, shelter and/or migration pathways for abundant and diverse communities of crustaceans, fishes, sea turtles, mammals (dolphins, dugong, whales, a water mouse), migratory and resident shorebirds, sponges and corals. The site is at or near the limits of geographic extent of several species of flora and fauna.

A substantial area of non-forested peat swamp, comprised mainly of rare 'patterned fens', occurs within the site. These fens together with areas of 'wallum' heath swamps, support species adapted to the prevailing acidic water and substrate including threatened frogs and fishes as well as species of crayfish and earthworm. Rainfall, surface and groundwater flows, water table levels and water chemistry are crucial supporting factors.

Fauna of special significance in the site are:

- substantial populations of nationally and/or internationally threatened species (**Appendix 2**): four marine turtle species (green, loggerhead, hawksbill, flatback), dugong; the intertidal-dwelling water mouse; the mangrove-dwelling Illidge's ant-blue butterfly in estuarine/marine areas; and the honey blue-eye and Oxleyan pygmy perch plus four species of acid frogs in the patterned fens and the wallum heath plains and swamps.
- a population of at least 20,000 shorebirds comprising at least 20 species that occur at the site annually; eight of these species occurring in numbers exceeding 1% of their flyway population, with the highest site count worldwide for the far eastern curlew.
- substantial stocks of juvenile and adult fishes, prawns and crabs many of which are, or may be, subject to commercial and/or recreational harvest; and
- a relatively large number of species of marine mammals, including several cetaceans.

In terms of human use, Great Sandy Strait includes sites and resources of considerable cultural significance to indigenous Australians and contains natural resources that potentially may be harvested sustainably by indigenous people for traditional purposes. The site's rich diversity and abundance of natural resources also supports a range of nature-based tourism and recreational activities.

Ecosystem services provided in the Great Sandy Strait Ramsar site include those relating to Ramsar criteria and those relating to human benefits. The fourteen **critical** ecosystem services summarised in **Table 1** were identified using the four selection criteria from the draft Framework (2007). In most cases a critical ecosystem service (**Table 1**) is supported and described by several critical components and processes (**Table 2**) which in turn are often described by more than one critical variable. Where possible, Limits of Acceptable Change for these critical variables have been proposed. The Limits of Acceptable Change are described in **Table 3**.


**Figure 3. Conceptual diagram illustrating the critical ecosystem services supported within the Great Sandy Strait Ramsar site.**

**Table 1. Ecosystem Services that form the basis of the ecological character description for the Great Sandy Strait Ramsar site**

| Ecosystem services | Relevant Variable Description | Related Critical Components and Processes (see Table 2 for description) | Limits of Acceptable Change† (See Table 3 for description) |
|---|---|---|---|
| 1. Great Sandy Strait Ramsar site includes **a large sand island and passage estuary** which provides habitat and **migration pathways** for marine animals (fishes, prawns, turtles) between riverine, sheltered nursery/feeding areas and open ocean. SEE SECTION 4.1.1 for details | Geomorphology/ Physical form: Sand bank and channel topography/bathymetry | E,G | 1.1, 1.2 |
| | Freshwater/Estuarine Hydrology: Freshwater flow regime | | E.1, E.2 |
| | Marine Hydrology: Tidal flow regime | | E.3 |
| 2. A substantial area of peat swamp, consisting mainly of the **regionally unique patterned fens**, occurs within the Great Sandy Strait Ramsar site. SEE SECTION 4.1.2 for details | Extent of patterned fens occurring within the Great Sandy Strait Ramsar site | B,C | 2.1 |
| | Condition of patterned fens occurring within the Great Sandy Strait Ramsar site | | 2.2 |
| 3. A regionally significant area of **seagrass habitat** and **diversity of seagrass species** occurs within the Great Sandy Strait Ramsar site. SEE SECTION 4.1.3 for details | Area of seagrass habitat | E,F,H | 3.1 |
| | Abundance (e.g., biomass, ground cover) and species composition of seagrass meadows | | 3.2 |
| | Depth range of seagrasses | | 3.3 |
| | Physiological health of seagrasses | | 3.4 |
| 4. Great Sandy Strait Ramsar site supports a **large and diverse area of mangrove communities** as part of a tidal wetlands ecosystem that also | Extent of tidal wetlands (includes mangroves, saltmarsh and saltpans) | E,F,H | 4.1 |

| Ecosystem services | Relevant Variable Description | Related Critical Components and Processes (see Table 2 for description) | Limits of Acceptable Change† (See Table 3 for description) |
|---|---|---|---|
| supports an **endangered butterfly**. SEE SECTION 4.1.4 for details | Physiological condition of mangroves | | 4.2 |
| 5. Great Sandy Strait Ramsar site supports a substantial area of **sub-tropical inshore reefs including coral and sponge communities and species** near their geographic limits. SEE SECTION 4.1.5 for details | Area of live coral reef habitat | E,F | 5.1 |
| | Cover of dominant coral growth types within core high density habitat: live hard coral (dendritic, foliose, boulder) versus dead coral cover on permanent transects (where established) | | 5.2 |
| | Extent of macro- and turf- algae cover on permanent transects, once established, would be a useful indicator of habitat health at permanent monitoring sites on reefs | | 5.3 |
| 6. Four **nationally threatened species of marine turtle** (green, loggerhead, hawksbill, flatback) occur annually in substantial numbers within Great Sandy Strait Ramsar site. SEE SECTION 4.1.6 for details | Growth rates of young turtles | D, F,G,H | 6.1 |
| | Physiological indices of “preparedness for breeding” (using hormone and metabolic markers) | | 6.2 |
| 7. A relatively large number of species of **marine mammals** use the Great Sandy Strait Ramsar site, including several cetaceans and a local population of the **internationally vulnerable dugong**. SEE SECTION 4.1.7 for details | Abundance of dugong using the site | D,E,F,G,H | 7.1 |
| | Abundance of Indo-Pacific humpback dolphins using the site | | 7.2 |
| | Abundance of humpback whales using the site | | 7.3 |

| Ecosystem services | Relevant Variable Description | Related Critical Components and Processes (see Table 2 for description) | Limits of Acceptable Change† (See Table 3 for description) |
| --- | --- | --- | --- |
| | Abundance of cetaceans, other than humpback whales and Indo-Pacific humpback dolphins, using the site | | 7.4 |
| 8. The **nationally threatened water mouse** *Xeromys myoides* occurs in mangrove, saltmarsh and/or associated freshwater wetlands within the Great Sandy Strait Ramsar site. SEE SECTION 4.1.8 for details | Number of water mouse nests in use | A,D,E | 8.1 |
| | Diversity of water mouse nests in use | | 8.2 |
| 9. The **nationally threatened fishes the honey blue-eye and Oxleyan pygmy perch** occur permanently in freshwater swamps and/or in associated streams within the Great Sandy Strait Ramsar site. SEE SECTION 4.1.9 for details | Numbers of honey blue-eye and the Oxleyan pygmy perch (numbers within genetically distinct sub-populations) | A,B,C | 9.1 |
| 10. Four species of **threatened acid frogs** occur permanently in the wallum swamps and lakes within the Great Sandy Strait Ramsar site. SEE SECTION 4.1.10 for details | Abundance of four acid frog species | A,B,C | 10.1 |
| 11. Great Sandy Strait Ramsar site supports **substantial stocks of fishes, prawns and crabs** which may be subject to commercial or recreational harvest. SEE SECTION 4.1.11 for details | Diversity of fish species | D,E,F,G,H | 11.1 |
| | Indices of abundance for fish and crustacean target species | | 11.2 |
| 12. Great Sandy Strait Ramsar site supports **large numbers of waterbirds (>20 000) with 8 species of shorebirds occurring in numbers >1% of their population**, including the highest counts in the world for far eastern curlew. SEE SECTION 4.1.12 for details | Using the dominant species far eastern curlew and bar-tailed godwit as a surrogate for shorebird numbers (species which exceed the 1% threshold), however other species may be included in future if considered appropriate | D,E,F,H | 12.1 |

| Ecosystem services | Relevant Variable Description | Related Critical Components and Processes (see Table 2 for description) | Limits of Acceptable Change† (See Table 3 for description) |
| --- | --- | --- | --- |
| 13. Great Sandy Strait Ramsar site contains sites of considerable **significance to indigenous Australians** and natural resources that potentially may be harvested sustainably by indigenous people using traditional methods. <br> SEE SECTION 4.1.13 for details | Quality and integrity of landforms and habitats that hold spiritual value and/or used by indigenous people | D,F,G,H | 13.1 |
| | Abundance and condition of artefacts, structures and sites that hold cultural significance: eg., "booral" shell, oyster areas, fish traps, middens | | 13.2 |
| | Species and communities of wetland fauna and flora | | 13.3 |
| 14. Great Sandy Strait Ramsar site contains a rich diversity and abundance of natural resources that support a range of **nature-based tourism and recreational activities**. <br> SEE SECTION 4.1.14 for details | Number of tourists or recreational users (by type of use) | D,G | 14.1 |
| | Quality and integrity of wetland habitats that are considered attractions for tourism and recreation activities | | 1.1,1.2,2.1,2.2, 3.1,3.2,3.3,3.4, 4.1,4.2,5.1,5.2, 5.3,E.1,E.2,E.3 |
| | Abundance of significant and targeted fauna | | 6.1,6.2,7.1, 7.2,7.3,8.1, 8.2, 11.1,11.2,12.1 |

† These limits were determined, where possible, from knowledge about levels of natural variability of parameters that best quantified the critical ecosystem services, components and processes. Descriptions of natural variability and proposed limits of acceptable change are expected to be improved as new information becomes available.

## Components and processes which support the ecosystem services

The prevailing climatic regime (rainfall and temperature) and characteristic geomorphology are important determinants of the outstanding diversity and extent of wetlands and wetland species in the site. A conceptual model of the critical components and processes which support the ecological character of the Great Sandy Strait Ramsar site appears in Section 4.3 of the ECD. Components and processes which support ecosystem services in the site include:

- passageways to the sea at northern and southern ends of the Strait, which allow for migration by marine animals between riverine, estuarine and open sea areas;
- the sheltering effects of the Fraser Island sand mass;
- the presence of high dune systems that supply surface- and ground- water flows westward into adjacent wetlands;
- estuarine and freshwater connectivity and flows, particularly from the Mary River which support freshwater, estuarine and marine ecosystems;
- the transport and deposition of sediments of both marine and terrestrial origin. Tidal exchange and inundation regimes are important to supporting the above-mentioned assets of the estuarine component of the site.

There is hydrological connectivity of water bodies within the site, between adjacent habitats and between estuarine habitat and the upper reaches of the Mary River. The latter is enhanced through high volume freshwater flow-events. This is a critical element to ensuring passage of fish that need to use riverine habitats to feed or complete essential life-history migrations.

Moderate- to high- water quality exists throughout Great Sandy Strait Ramsar site, except for brief periods during major flood events. This quality helps to support the high primary productivity of seagrass and mangrove habitat, rich food webs, secondary productivity, and abundant and diverse fauna within the site. The physicochemical water components - especially nutrient and sediment loads, salinity and turbidity regimes, and the processes of nutrient cycling and sediment erosion, transport and deposition are important in helping to maintain these water quality and special biotic features.

Ecosystem components and processes critical to maintaining the site's ecological character were identified using the same four criteria applied in selecting the critical ecosystem services. These selection criteria help to focus on the components and processes deserving management attention. The components and processes which support ecosystem services of the freshwater wetlands are in many respects different to those associated with the estuarine/marine wetlands, and are best treated separately for the purpose of understanding and managing the site. The critical components and processes at the site include:

*for Freshwater Wetlands:*

- Habitat Extent, Condition and Diversity
- Hydrology (surface and groundwater inputs)
- Physicochemical Components

*for Estuarine & Marine Wetlands*

- Habitat Extent, Condition and Diversity
- Hydrology (freshwater flow from catchments; tidal regimes)
- Physicochemical Components (water quality)
- Geomorphology (connectivity and bathymetry of channels)
- Energy & Nutrient Dynamics (primary and secondary productivity)

The several variables that best describe these critical components and processes are described **(Table 2)**, and the proposed Limits of Acceptable Change for these variables are listed in **Table 3**.

**Table 2. Critical Components and Processes that support ecosystem services in the Great Sandy Strait Ramsar site, and proposed Limits of Acceptable Change† for key variables.**

| Critical component and process | Quantitative description | Supported Ecosystem Services<br>(see Table 1 for description) | Limits of Acceptable Change†<br>(see Table 3 for description) |
|---|---|---|---|
| ***A. Freshwater Wetlands - Habitat Extent, Condition and Diversity.***<br>SEE SECTION 4.3.1 | **Area of healthy ephemeral and semi-permanent perched swamps** | 8,9,10 | A.1 |
| | **Area of healthy permanent freshwater lakes (**critical habitat for Cooloola sedgefrog) **and small streams** (critical habitat of Oxleyan pygmy perch and the honey blue-eye) | | A.2 |
| | **Area of non-forested peat swamps, in particular patterned fens.** | | 2.1 |
| ***B. Freshwater Wetlands - Hydrology*** *(rainfall, surface water and groundwater).*<br>SEE SECTION 4.3.2 | **Sustained surface and groundwater flows** (Fraser and the Cooloola western coastal plain) supporting the patterned fens, wallum swamps, lakes and streams | 2,9,10,11 | B.1 |
| | **Sustained surface and groundwater flows,** particularly from major streams into the wallum swamp areas around Tin Can Bay and the Maroom and Tuan areas (ie. Kauri and Snapper Creek inputs to the western side of the Great Sandy Strait and freshwater wetlands where they fall within the Ramsar boundary) | | B.2 |
| ***C. Freshwater Wetlands - Physicochemical components***<br>SEE SECTION 4.3.3 | **pH of acidic waters in freshwater wetlands:** with a focus on known habitats of the threatened fish and frog species. | 2,9,10,13 | C.1 |
| | **Other water quality parameters:** It is believed that small elevated levels of nitrogen and / or phosphorus may have deleterious effects on the survival of the honey blue-eye, Oxleyan pygmy perch and the four acid frog species (Pusey *et al* 2004, Meyer *et al* 2005). However there is currently insufficient information available to establish levels of variability of these water quality parameters for the wallum swamps and patterned fens within the Ramsar site. | | C.2 |
| **D. Estuarine & Marine Wetlands - Habitat Condition, Extent and Diversity**<br>SEE SECTION 4.3.4 | **Area of available roosting habitat for shorebirds** | 3,4,5,6,7,8,<br>11,12,13,14 | D.1 |
| | **Area of supralittoral mangroves, saltmarsh for the water mouse** | | 4.1,4.2 |
| | **Depth, shape, bathymetry of sea openings and intertidal banks:** to support coral and sponge habitat, feeding areas for shorebirds, fish, crustaceans, turtles, dugong. | | 1.1,1.2 |
| | **Area of estuarine, seagrass, mangrove and coral reef habitat** for dugong, sea turtles, targeted food fish and crustacea | | 1.1,1.2,3.1, 3.2,3.3,3.4, 4.1,4.2,5.1, 5.2,5.3 |
| **E. Estuarine and Marine wetlands -** | **Freshwater/Estuarine Hydrology: Total annual freshwater outflow** into estuarine wetlands | 1,3,4,5,7,8, 11,12 | E.1 |

| Critical component and process | Quantitative description | Supported Ecosystem Services (see Table 1 for description) | Limits of Acceptable Change† (see Table 3 for description) |
|---|---|---|---|
| Hydrology<br>SEE SECTION 4.3.5 | **Freshwater/Estuarine Hydrology: Key indices/aspects of flow regime** from the Mary River | | E.2 |
| | **Marine Hydrology:** Tidal flow and inundation regimes. | | E.3 |
| ***F. Estuarine & Marine Wetlands - Physicochemical Components***<br>SEE SECTION 4.3.6 | **Physicochemical water quality parameters** | 3,4,5,6,7,11, 12,13 | F.1 |
| | **Salinity levels in the sediments** | | F.2 |
| | **Toxicants** | | F.3 |
| | **Maximum depth limit of seagrass** | | 3.3 |
| ***G. Estuarine & Marine Wetlands – Geomorphology***<br>SEE SECTION 4.3.7 | **Bathymetry at sea openings** | 1,6,7,11,13, 14 | 1.1 |
| | **Bathymetry and habitat connectivity at estuary mouths and channels** | | 1.1, 1.2 |
| ***H. Estuarine & Marine Wetlands - Energy & Nutrient Dynamics****<br>SEE SECTION 4.3.8 | **Primary production and secondary production rates*** | 3,4,5,6,7,11, 12,13 | H.1 |

† These limits were determined, where possible, from knowledge about levels of natural variability of key parameters that best quantified the components and processes. Descriptions of natural variability and proposed limits of acceptable change are expected to be improved as new information becomes available.

* Some parameters such as benthic health (eg., abundance of infauna) may be potential proxies for secondary productivity, but currently remain expensive to measure due to difficulties in taxonomy and high variability in estuarine areas.

## Limits of Acceptable Change

The Limits of Acceptable Change were determined from knowledge about levels of natural variability of key parameters that best quantified the critical components and processes. Descriptions of natural variability and proposed limits of acceptable change are expected to be improved within this document as new information becomes available (see detailed discussion at Section 3.4).

**Table 3. Limits of Acceptable Change (proposed at July 2009) for key variables relevant to ecosystem services and critical components and processes in the Great Sandy Strait Ramsar site.**

| **Limits of Acceptable Change†**<br>**(proposed at July 2009)** | **Relevant Ecosystem Services**<br>**(see Table 1 for description)** | **Relevant Critical Components and Processes**<br>**(see Table 2 for description)** |
|---|---|---|
| **1.1** For sand bank and channel topography/bathymetry and connectivity to sea openings, **Limits of Acceptable Change** are:<br>• Minimum depths at major channels connecting the southern section of the Great Sandy Strait with the open sea (Wide Bay and Inskip bars) no more than 10% shallower than 1999 bathymetry. | 1,14 | D,G |
| **1.2** For estuarine sand bank and channel topography/bathymetry and connectivity, **Limits of Acceptable Change** are:<br>• Minimum depths of the Mary River mouth connecting riverine /stream, estuarine and marine habitats should be no shallower than 1m at mean low water.<br>• For other estuarine channels connecting riverine /stream, estuarine and marine habitats, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed. | 1, 14 | D,G |
| **2.1** For the extent of patterned fens within the Ramsar site, information is only sufficient for proposing **an <u>interim</u> Limit of Acceptable Change**:<br>• Any detectable loss of patterned fen habitat area. (When reliable estimates of aerial extent are obtained, statistically significant (detectable) declines can be measured.) | 2,13,14 | A |
| **2.2** For the condition of patterned fens within the Ramsar site, i**nformation is insufficient** for proposing a Limit of Acceptable Change, but the following **trigger for management intervention** is proposed:<br>• Any detectable deterioration in any variable of habitat condition. | 2,13,14 | B,C |
| **3.1.** For the area of seagrass habitat, **Limits of Acceptable Change** are:<br>• A 20% reduction from December 1998 levels of total seagrass habitat area, and sustained longer than 3 years.<br>• An event-related loss of 50% of total aerial extent of seagrass habitat (from December 1998 levels) in Great Sandy Strait more than once every 8 years. | 3,13,14 | D |
| **3.2.** For seagrass abundance and species composition, the **Limit of Acceptable Change** is:<br>• At any site, complete loss of above ground abundance more than once every 8 years. | 3,13,14 | D |
| **3.3.** For the depth range of seagrasses, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed | 3,13,14 | D,F |
| **3.4.** For the physiological health of seagrasses, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention**,** can be proposed. | 3,13 | D |
| **4.1.** For the extent of tidal wetlands (including mangroves, saltmarsh and saltpans), information is insufficient for proposing a Limit of Acceptable Change but the following **trigger for management intervention** is proposed: | 4,13,14 | D |

| Limits of Acceptable Change† (proposed at July 2009) | Relevant Ecosystem Services (see Table 1 for description) | Relevant Critical Components and Processes (see Table 2 for description) |
|---|---|---|
| • Any detectable nett loss of total area of tidal wetlands. | | |
| **4.2.** For the physiological condition of mangroves, information is insufficient for proposing a Limit of Acceptable Change but the following **trigger for management intervention** is proposed:<br>• A "dieback" or significant reduction in condition in more than 15% of mangrove habitat area and sustained for more than 5 years (this allows for drought cycles). | 4,13,14 | D |
| **5.1.** For the area of live coral reef habitat, information is insufficient for proposing a Limit of Acceptable Change, but the following **trigger for management intervention** is proposed:<br>• Any observed downward trends in total area of live coral reef habitat (combined hard and soft corals) or sponge/gorgonian habitat. | 5,13,14 | D |
| **5.2.** For the cover of dominant coral growth types, information is insufficient for proposing a Limit of Acceptable Change but for coral reef and sponge/gorgonian habitats the following **triggers for management intervention** are proposed:<br>• Any observed downward trend in a) live hard coral cover or b) percent cover estimates of any key growth form or species.<br>• Any localised coral bleaching. | 5,13,14 | D |
| **5.3.** For the extent and percent of macro- and turf-algae cover, information is only sufficient for proposing an **interim Limit of Acceptable Change:**<br>• **20**% increase in macro- or turf algae cover for more than 2 years.<br>The following **trigger for management intervention** is also proposed:<br>• a **10**% increase in macro- or turf algae cover for more than 2 years. | 5,13,14 | D |
| **6.1.** For the growth rates of young marine turtles, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed. | 6,13,14 | |
| **6.2.** For physiological indices of 'preparedness for breeding' for marine turtles, i**nformation is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed. | 6,13,14 | |
| **7.1.** For the abundance of dugong, the **Limit of Acceptable Change** is:<br>• A reduction in the dugong population in the Great Sandy Strait to below 400 individuals for more than 2 years. | 7,13,14 | |
| **7.2.** For the abundance of Indo-Pacific humpback dolphins, the **Limit of Acceptable Change** is:<br>• A detectable decline in the population of Indo-Pacific humpback dolphins using the site. | 7,13,14 | |
| **7.3.** Information on the number of humpback whales using the site is insufficient for proposing a Limit of Acceptable Change, but the following **trigger for management intervention** is proposed:<br>• A downward trend in the frequency of humpback whale sightings in the site unless explainable by mortality or other causes operating outside the Ramsar site. | 7,13,14 | |

| Limits of Acceptable Change†<br>(proposed at July 2009) | Relevant Ecosystem Services<br>(see Table 1 for description) | Relevant Critical Components and Processes<br>(see Table 2 for description) |
|---|---|---|
| **7.4** For other cetaceans using the site, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed. | 7,13,14 | |
| **8.1.** For the number of water mouse nests in use, the **Limit of Acceptable Change** is:<br>• Greater than a 10% reduction in the number of active water mouse nests. | 8,14 | |
| **8.2.** For the diversity of water mouse nests in use, the **interim Limit of Acceptable Change** is:<br>• Greater than 10% reduction in the use of any particular water mouse nest type (with priority given to habitat adjacent to pressures such as uncontrolled vehicle use or urban expansion). | 8,14 | |
| **9.1.** Information on the number of honey blue-eye and the Oxleyan pygmy perch is only sufficient for proposing an **interim Limit of Acceptable Change**:<br>• Significant decline in any sub-population of honey blue-eye or Oxleyan pygmy perch. (When information is obtained on population sizes or densities and their natural variability, statistically significant (detectable) declines can be measured.) | 9 | |
| **10.1.** For the abundance of four acid frog species, information is only sufficient for proposing an **interim Limit of Acceptable Change**:<br>• A statistically significant decline in the numbers of any of these four frog species over five years. (When information is obtained on population sizes or densities and their natural variability, statistically significant (detectable) declines can be measured.) | 10 | |
| **11.1.** For the diversity of fish species, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed | 11,14 | |
| **11.2.** For indices of abundance for fish and crustacean target species, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed.<br>Note: Fish and crustacean stocks within the site move across a large region and indices of abundance are currently assessed within regional fisheries which the Great Sandy Strait forms a part of. These fishery assessments are also at spatial resolutions currently too coarse for assessing fishery stocks within the discrete geographical area of the Great Sandy Strait Ramsar site. | 11,14 | |
| **12.1** For shorebird numbers, the **Limit of Acceptable Change** is**:**<br>• Using the larger, dominant and easily measurable species (as a surrogate for all shorebirds which exceed the 1% threshold) - the December/January counts of far eastern curlew or bar-tailed godwit in the Ramsar site decline to 40% below the baseline level for 3 out of any 7 years.<br>**Note:** These two dominant species are suggested as useful proxies for | 12,14 | |

| Limits of Acceptable Change† (proposed at July 2009) | Relevant Ecosystem Services (see Table 1 for description) | Relevant Critical Components and Processes (see Table 2 for description) |
|---|---|---|
| numbers of other shorebirds using the site, but other species may be included for monitoring ecological character if considered appropriate. | | |
| **13.1.** For landforms and habitats that hold spiritual value and/or used by indigenous people, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed. | 13 | |
| **13.2.** For the abundance and condition of artefacts, structures and sites that hold cultural significance to indigenous Australians, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed. | 13 | |
| **13.3.** For species and communities of wetland fauna and flora of considerable significance to indigenous Australians, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed. | 13 | |
| **14.1.** For the number of tourists or recreational users, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed. | 14 | |
| **A.1** For the extent of ephemeral and semi-permanent perched swamp habitats for acid frogs and water mouse, information is insufficient for proposing Limits of Acceptable Change, however given the importance of this component to at least four threatened species, the following **interim Limit of Acceptable Change** is proposed:<br>• Any loss or deterioration of areas of critical freshwater habitats for acid frogs and water mouse in the Ramsar site. | 8,10 | A |
| **A.2** For the area of healthy permanent freshwater lakes and small streams, information is insufficient for proposing Limits of Acceptable Change, however given the importance of these habitats to the threatened fish and frog species, the following **interim Limit of Acceptable Change** is proposed:<br>• A 5% loss of the critical habitats (such as permanent freshwater refuges) for the Oxleyan pygmy perch or the honey blue-eye and sustained longer than 3 years (during seasons of average rainfall).<br>• Any loss or deterioration of the known habitat area of the Cooloola sedgefrog.<br>The following **trigger for management intervention** is proposed:<br>• Any reduction or deterioration in the known critical habitat (such as permanent freshwater refuges) for the Oxleyan pygmy perch and the honey blue-eye. | 9,10 | A |
| **B.1.** For surface and groundwater flows (Fraser and the Cooloola western coastal plain) feeding the patterned fens,wallum swamps,lakes and streams, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed.<br>However given the importance of freshwater flows to ecological character, the following **interim Limits of Acceptable Change** are proposed for when | 2,9,10 | B |

| Limits of Acceptable Change† (proposed at July 2009) | Relevant Ecosystem Services (see Table 1 for description) | Relevant Critical Components and Processes (see Table 2 for description) |
|---|---|---|
| baseline information becomes available:<br>• A significant reduction in flows that would result in inadequate breeding habitat for the acid frogs and the Oxleyan pygmy perch and honey blue-eye, during average rainfall periods,<br>• A significant reduction in flows that would result in inadequate permanent refuges and connectivity between those refuges in the site for the two fish species, during drought periods. | | |
| **B.2.** For surface and groundwater flows, particularly from major streams into the wallum swamp areas around Tin Can Bay and the Maroom and Tuan areas (ie. Kauri and Snapper Creek inputs to the western side of the Great Sandy Strait and freshwater wetlands where they fall within the Ramsar boundary), **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed.<br>However given the importance of freshwater flows to ecological character, the following **interim Limits of Acceptable Change** are proposed for when baseline information becomes available:<br>• A significant reduction in flows that would result in inadequate breeding habitat for three of the acid frogs and honey blue-eye, during average rainfall periods.<br>• A significant reduction in flows that would result in inadequate permanent refuges and connectivity between those refuges in the site for the honey blue-eye, during drought periods. | 2,9,10 | B |
| **C.1.** For the pH of waters in key freshwater wetlands, **Limits of Acceptable Change** are:<br>• pH should not exceed the tolerance ranges of the following resident species:<br>- Oxleyan pygmy perch: 4.4 – 6.5 (B. Pusey, pers. comm., 2007)<br>- honey blue-eye: 4.4 – 6.8 (B. Pusey, pers. comm., 2007)<br>- four species of acid frog: < 6 (Meyer *et al* 2005). | 2,9,10 | C |
| **C.2.** For freshwater wetlands, **Limits of Acceptable Change** for water quality parameters other than pH are:<br>• Maintain water quality objectives for the parameters set for different waters of the Great Sandy Strait and coastal creeks by Great Sandy Strait Coastal Creeks Environmental Values and Water Quality Objectives (Queensland EPA 2007).<br>• Maintain existing water quality (20$^{th}$, 50$^{th}$ and 80$^{th}$ percentiles), habitat, biota, flow and riparian areas as set by Queensland Water Quality Guidelines (Queensland EPA, 2006b).<br>Where 20/50/80 percentiles have been defined for particular water quality indicators, then the “no change” test could be applied against these percentiles for assessing long term changes.<br>**Note:** Refer to Appendix D in Queensland Water Quality Guidelines (Queensland EPA 2006) for details on how to establish a minimum water quality data set for deriving local 20$^{th}$, 50$^{th}$ and 80$^{th}$ percentiles. | 2,9,10 | C |

| **Limits of Acceptable Change†**<br>**(proposed at July 2009)** | **Relevant Ecosystem Services**<br>**(see Table 1 for description)** | **Relevant Critical Components and Processes**<br>**(see Table 2 for description)** |
|---|---|---|
| **D.1**. For the area of available roosting habitat for shorebirds, information is only sufficient for proposing an **interim Limit of Acceptable Change**:<br>• The number and locations of key roosts (roosts supporting 300 or more migratory shorebirds each year) should remain within 40% of what they were (based on historical and subsequent surveys) at date of Ramsar-listing.<br>Further study is required before any Limits of Acceptable Change or more conservative triggers for management intervention can be proposed. | 12,14 | D |
| For other components of Estuarine & Marine Wetland Habitat Condition, Extent and Diversity, refer to **Limits of Acceptable Change 1.1, 3.1, 3.2, 3.3, 3.4, 4.1, 4.2, 5.1** and **5.2** above. | 3,4,5,6,7, 8,11,12,13,14 | D |
| **E.1**. For the combined freshwater flow from all sources, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed. See also Limits of Acceptable Change for the critical component: Hydrology, Section 4.3.2). | 1,11,13,14 | E |
| **E.2**, For estuarine and marine wetlands, the critical component represented by Mary River freshwater/estuarine flows, information is only sufficient for proposing **interim Limits of Acceptable Change**:<br>• After allowing for variations in rainfall, any index or aspect of freshwater flow (eg mean annual flow) from the Mary River catchment should not be degraded more than 10% since the date of Ramsar listing (1999).<br>NB: For maintaining conditions necessary for fish passage, change from natural total flow volumes should be minimized (Brizga *et al* 2005). Further information is required to set a more precise threshold.<br>• Any cessation in fishway operation or function on the Tinana Creek and Mary River tidal barrages for longer than 1 year. | 1,3,4,5,6,7,<br>11,12,13,14 | E |
| **E.3.** For changes to the tidal flow regime, **information is insufficient** and further study is required before any Limits of Acceptable Change or more conservative triggers for intervention can be proposed. | 1,14 | D,E |
| **F.1.** For estuarine and marine wetlands, **Limits of Acceptable Change** for physicochemical water quality parameters are:<br>• Maintain water quality objectives for the parameters set for different waters of the Great Sandy Strait and coastal creeks by Great Sandy Strait Coastal Creeks Environmental Values and Water Quality Objectives (Queensland EPA 2007).<br>• Maintain existing water quality (20th, 50th and 80th percentiles), habitat, biota, flow and riparian areas for Great Sandy Strait as set by Queensland Water Quality Guidelines (Queensland EPA, 2007).<br>Where 20/50/80 percentiles have been defined for particular water quality indicators, then the “no change” test could be applied against these percentiles for assessing long term changes.<br>**Note:** Refer to Appendix D in Queensland Water Quality Guidelines (Queensland EPA 2006b) for details on how to establish a minimum water | 3,4,5,6,7,8,<br>11,12, 13,14 | F |

| **Limits of Acceptable Change†**<br>**(proposed at July 2009)** | **Relevant Ecosystem Services**<br>**(see Table 1 for description)** | **Relevant Critical Components and Processes**<br>**(see Table 2 for description)** |
|---|---|---|
| quality data set for deriving local 20th, 50th and 80th percentiles. | | |
| **F.2.** For salinity levels in the sediments of estuarine and marine wetlands, **information is insufficient** and further study and advice is required before Limits of Acceptable Change or triggers for intervention can be proposed. | 4 | F |
| **F.3.** For toxicants in a high conservation/ ecological value site, the **Limit of Acceptable Change** is:<br>• Any deterioration of existing condition (ANZECC 2000 Guidelines; Queensland Water Quality Guidelines 2006b).<br>The ANZECC 2000 Guidelines (ANZECC and ARMCANZ 2000) default approaches are focussed on assessing long-term compliance with guidelines that are designed to protect against chronic effects. The ANZECC 2000 Guidelines (Section 3.1.7. Volume 1) state that "for the non-biological indicators, the guideline trigger values represent the best currently available estimates of what are thought to be ecologically low-risk levels of these indicators for chronic (sustained) exposures." (See also, Queensland EPA 2006b.) | 3,4,5,6,7,8,<br>11,12,13,14 | F |
| For Estuarine & Marine Geomorphology (G), refer to **Limits of Acceptable Change 1.1 and 1.2** | 1,6,7,11,13, 14 | G |
| **H.1.** For primary or secondary production rates, **information is insufficient** and further study and advice is required* before Limits of Acceptable Change or triggers for intervention can be proposed. | 3,4,5,6,7,11, 12,13,14 | H |

**†** These limits were determined where possible from knowledge about levels of natural variability of key parameters that best quantified the components and processes. Descriptions of natural variability and proposed limits of acceptable change are expected to be improved as new information becomes available, which should then be used to update the ECD.

* Some parameters such as benthic health (e.g., abundance of infauna) may be potential proxies for secondary productivity but still remain expensive to measure due to difficulties in taxonomy and high variability in estuarine areas.

## Key Threats to the Great Sandy Strait Ramsar site

The Great Sandy Strait is relatively undisturbed and thus particularly significant in the east coast of Australia. However, the site faces a number of human related threats, many of which are increasing with expanding populations and development in the catchments and coastal areas adjacent to the site. These threats can impact critical ecosystem components, processes and services directly, or have indirect impacts through deterioration of food resources or habitat integrity. Threats to ecological character of the site arise both within and outside the site boundaries, and have been listed to assist in clarifying management needs and ongoing monitoring requirements.

Key threats within the Great Sandy Strait Ramsar site include:

- boating activities (eg., high speeds, anchoring and moorings)
- abandoned fishing gear
- over-fishing

- disturbance/mortality of roosting waterbirds by humans or feral animals
- damage to claypans, saltmarsh and mangrove areas and high tide roosts from adjacent urban expansion
- high intensity, dry-period fires in peat swamps; and
- the exotic mosquito fish *Gambusia holbrooki*

Key threats originating off-site – but that managers can influence – include:

- land-use practices leading to habitat damage or loss
- reductions in connectivity between marine, estuarine and riverine habitats
- alterations to freshwater flows into the site
- elevated levels of erosion-derived sediment entering the estuary and strait
- changes in water quality including salinity regime, nutrient and sediment loads
- influx of pollutants and toxins, including persistent herbicides ; and
- impacts to migratory fauna at other sites and countries in their migration paths.

Increases in population and development in the catchments and coastal areas adjacent to the site create increases in many of the threats listed above. A conceptual model of the key threats to ecological character of the Great Sandy Strait Ramsar site appears in Section 5 of the ECD.

Climate change and sea level rise could result in major changes to freshwater and tidal flow regimes, erosion and deposition patterns, and the subsequent distribution of tidal flat, seagrass and mangrove habitats.

Migratory fish, shorebirds, sea turtles and cetaceans from the Great Sandy Strait may also be impacted by factors in other parts of their range, with consequent changes to the populations visiting the site.

Threats operating external to the site might not be within the direct sphere of influence of site managers, but other mechanisms are available through relevant domestic and international conservation instruments where Australia may have obligations or opportunities for influence.

## Knowledge Gaps

Knowledge Gaps are summarised below (**Table 4**) into those of highest priority for strategic improvement of monitoring and management with focus on critical components, processes and services and the key threats to ecological character. This list is considered a guide to assist site managers and should not be viewed as comprehensive (see also **Section 6, Table 9**).

**Table 4. Summary of specific information gaps and the critical ecosystem services, components, processes or key threats to which they relate.**

| Knowledge Gaps | Ecosystem Service (see Table 1 for description) | Component or Process (see Table 2 for description) |
|---|---|---|
| ***Relating to critical ecosystem components, processes and services:*** | | |
| The extent and condition of patterned fen habitat within and outside the Ramsar boundary, e.g., on the western parts of the Cooloola/ Inskip Peninsula, Fraser Island and the processes that maintain them. | 2,9,10 | A |
| The extent of critical habitats for water mouse, threatened fish and acid frog species within and outside the Ramsar boundary, eg., on the western parts of the Cooloola/ Inskip Peninsula, Fraser Island and the mainland areas immediately west of the Ramsar site; and whether these receive adequate protection. | 2,9,10 | A |
| Identification and measurement of condition indicators of peat & wallum. | 2,9,10 | A |
| Minimum flow and inundation requirements in freshwater wetlands (peat and wallum) for wetland vegetation, fish and frogs. | 2,9,10 | B |
| Water quality requirements for the wallum swamps and patterned fens. | 2,9,10 | C |
| Identification and measurement of appropriate indicators of primary production or physiological condition in algae, seagrasses and/or mangroves for monitoring ecological character. | 3,4,5 | D, H |
| Environmental flow (freshwater) requirements for estuarine species (especially diadromous fish). | 1, 11 | E |
| Impacts of different flow regimes scenarios on fish passage, feeding, breeding and other critical physical and biological processes. | 1,3,4,11 | E |
| Historical changes in bathymetry, especially minimum channel depths affecting sediment and nutrient transport and passage of animals. | 1, 11, | E, G |
| Natural variability in mangroves, seagrass and corals. | 3,4,5 | D |
| Extent, composition and condition of coral reef and sponge garden habitats. | 5,11,14 | D |
| Illidge's ant-blue *butterfly* distribution, habitat use and management requirements within the site and how to improve their monitoring and management. | 4 | D |
| Inter-annual variability of growth rates in young green turtles and in physiological condition or “readiness for breeding” in adult green turtles in Great Sandy Strait. | 6 | H |
| Numbers and movements of marine mammals (dugongs and cetaceans) using the site. | 7,14 | - |
| Water mouse detailed distribution and habitat requirements. | 4,8 | D |
| Detailed distribution and habitat requirements of the four frog species. | 10 | A,B,C |
| Two threatened freshwater fish species: natural variability of populations or sub-populations; habitat extent and habitat quality requirements. | 10 | A,B,C |
| Natural mortality and other fishery-independent variables of estuarine fish and crab stocks. | 11 | - |
| Sustainability and appropriateness of current fisheries management practices. | 11 | - |

| Knowledge Gaps | Ecosystem Service<br>(see Table 1 for description) | Component or Process<br>(see Table 2 for description) |
|---|---|---|
| Natural variability in shorebird numbers and their use of feeding areas and roost sites; and the influence of variability in shorebird food resources (e.g. abundance and composition of invertebrate fauna) on shorebird use of tidal flats. | 12 | D |
| Inventories and assessments of indigenous artefacts and sites. | 13 | D |
| Quantitative estimates of recreational and tourism use at the site. | 14 | - |
| ***Relating to Threats:*** | | |
| Appropriate burning regimes, if any, to sustain the patterned fens. | 2,9,10 | A |
| Factors affecting condition of mangroves, seagrasses, corals in the site. | 3,4,5 | D,E,F,H |
| Environmental levels of persistent organo-compounds at the site and effects of long-term, low concentrations of herbicide exposures on seagrasses, mangroves, dugong and green turtles. | 3,4, 6,7 | D,F,H |
| Levels of occurrence (natural and human induced) of *Lyngbya majuscula* (a cyano-bacteria), and impacts on other components, eg., seagrass, turtles, dugong, fisheries. | 3,6,7,11 | F,H |
| Coral recovery rates following flood-associated losses, and potential for corals to adapt to frequent floods and the associated pulse loads of sediment, freshwater and nutrients. | 5,11 | D,F,H |
| Impacts of coral harvesting on coral cover and reef health. | 5, 11 | D |
| Information on likely outcomes for coral reefs in the site under the complex scenarios of climate change and sea level rise – this can be sought through research programs elsewhere. | 5 | D,F,H |
| Incidence of toxins, disease and boat strike in sea turtle and dugong populations in Great Sandy Strait. | 6,7 | - |
| Impacts of feral animals on water mouse and shorebirds. | 8,12 | - |
| Extent and impacts of the exotic *Gambusia holbrooki* on two threatened fish species and acid frogs in the site. | 9, 10 | - |
| Impacts of water resource development on flow regimes and consequences for estuarine habitats, water quality and dependant species - particularly w.r.t. Mary River catchment influences on salinity, sediment and habitat condition. | 1,3,4,5,11,14 | E, F, G |
| External factors influencing tourism and recreational use within the Ramsar site. | 14 | - |

## Changes in Ecological Character

The Site still meets all the Ramsar criteria recognised in the previous RIS (at the time of listing, 1999), and two additional criteria - Criterion 2c (new Criterion 4) and Criterion 4a (new Criterion 7) - which were omitted in the original RIS. Changes to the site since Ramsar listing (1999) have mostly been small. Some ecosystem components have shown indications of downward trends but data is insufficient to indicate whether any of these changes represent changes to ecological character (i.e., exceed the limits of acceptable change). Some of the changes had commenced prior to the date of Ramsar listing, thus may be part of long-term declines.

Shallowing of the mouth of the Mary River estuary has occurred and may have started before Ramsar listing. Major floods before listing caused large losses of seagrass with three to five years for recovery, and incomplete recovery, in some meadows, particularly those near the mainland. There are indications of long-term downward trends in seagrass meadow and coral reef health and cover since 1988. These should be cause for concern in the longer term.

Local commercial fishers have noted substantial reductions in fisheries resources after 1999. These perceived reductions were cause for substantial reductions in fishing effort by fishers up until 2007 (C. Shurey, pers. comm., 2007). However analyses of fisheries catch and fisheries-independent data is required to investigate these observations. Anecdotal evidence links these changes in fishing activity and resources to an extended period of drought since the date of listing, and other impacts on freshwater flow may have been influential (C. Shurey, pers comm., 2007; also see **Section 4.3.5** Estuarine & Marine Critical Component / Process E: Hydrology).

Anecdotal observations also indicate likely reductions in numbers of dugong, sea turtle and dolphins using the site. A strong link between southern oscillation index (SOI) and ENSO cycles and physiological condition (e.g., preparedness for breeding) in green turtles (Limpus & Nicholls 2000) at other eastern Queensland sites lends some support to these observations.

Recent summer (December/January) counts of far eastern curlew in the Great Sandy Strait Ramsar site indicate a declining trend toward potential change in ecological character. This reflects growing concerns for populations of migratory shorebirds elsewhere in Australia and in the flyway. Although local threats of coastal development and direct disturbance are a concern, impacts elsewhere in the flyway are also considered to be very large (Barter 2002).

Data is insufficient to indicate whether any of the abovementioned changes represent changes to ecological character (e.g., exceed the limits of acceptable change).

The ECD includes recommendations for monitoring to address these information needs and highlights other knowledge gaps that require attention, to improve understanding of the site's ecological character, levels of natural variability and acceptable change.

### Essential Elements of Monitoring Ecological Character of the Great Sandy Strait Ramsar site

Monitoring needs have been identified focussing on assistance to managers to maintain ecological character of the site. The monitoring needs (detailed in **Section 8**) are identified primarily on variables that relate to the critical ecosystem services, components, processes and threats. They therefore include variables considered to have most influence on ecological character of the site.

In summary, the key monitoring needs suggested to help maintain the ecological character of the Great Sandy Strait Ramsar site include the following:

- **Sedimentation rates at estuaries** in order to understand connectivity issues between marine and riverine habitats for migrating fish.
- **Extent, diversity and condition of key habitats types** such as seagrass, mangroves, shorebird roost sites, wallum swamps and lakes and non-forested peat swamps including patterned fens.
- **Distribution and abundance of key fauna.** This includes four species of turtle and frogs, dugong, cetaceans, water mouse, Illidge's ant-blue butterfly, migratory shorebirds, honey blue-eye, Oxleyan pygmy perch as well as a number of fish and crustacean species important for commercial and recreational fishing in the Ramsar site.
- **Water quality and flow/ inundation** necessary for maintaining key habitats.
- **Threats such as disease, toxicants/pollutants, introduced species as well as boat strikes and uncontrolled vehicle use** and the effects these have on key habitat types and fauna.

- **Fire** and its effects on the Ramsar site, in order to identify ideal fire regimes (if any).
- **Condition of cultural artefacts and sites such as fish traps and bora rings,** in order to manage and maintain them.

## Communication, education and public awareness (CEPA) messages

Communication, education and public awareness (CEPA) programs are essential to gain widespread support for management efforts in maintaining the site's ecological character. In developing the ECD, several primary education and awareness messages and themes were identified, which provide a useful framework for developing more targeted messages to go to users, community and decision makers.

Examples of core messages and themes that can be used for the site are:

1. The Great Sandy Strait is a particularly outstanding Ramsar site in Australia in that it supports a large diversity of wetland habitats, a high diversity of wetland flora and fauna species, and several community types that reflect the transition between tropical and temperate zones. The proximity and connectivity between wetland types further enhances biodiversity and productivity within the site.
2. Great Sandy Strait Ramsar site comprises a regionally important sand passage estuary that provides for an extensive and diverse set of both estuarine and freshwater wetlands, and regionally important biodiversity.
3. A substantial area of non-forested peat swamp, comprised mainly of the rare 'patterned fen', occurs within the Great Sandy Strait Ramsar site. These fens together with areas of 'wallum' heath plains and swamps support species adapted to the prevailing acidic water and substrate including threatened frogs and fishes as well as species of crayfish and earthworm.
4. The Great Sandy Strait Ramsar site supports exceptional biodiversity of freshwater, estuarine and marine wetland fauna, including important populations of crustaceans, insects (butterflies), fish, frogs, marine turtles, shorebirds, terrestrial and marine mammals.
5. The Great Sandy Strait Ramsar wetlands support substantial populations of nationally and/or internationally threatened species. Estuarine/marine areas support four marine turtle species (green, loggerhead, hawksbill, flatback), dugong; the intertidal-dwelling water mouse; the mangrove-dwelling Illidge's ant-blue butterfly, and the highest site counts worldwide for the endangered shorebird, far eastern curlew. The patterned fens and wallum heath plains and swamp support two threatened freshwater fish (honey blue-eye and Oxleyan pygmy perch) and four threatened species of acid frogs.
6. The Great Sandy Strait Ramsar site is relatively undisturbed and thus a particularly significant site on the eastern coast of Australia. However, downward trends in some ecosystem components are apparent and the site faces a number of threats which need to be minimised through targeted management.
7. Hydrological connectivity of water bodies within the site, between adjacent habitats and between estuarine habitat and the upper reaches of the Mary River, enhanced through high volume freshwater flow-events, is a critical element to ensuring passage of fish that need to use riverine habitats to feed or complete essential life-history migrations.
8. Hydrological flows – in particular from the Mary River catchment and coastal streams– are a major influence in maintaining several other elements of the site's ecological character, including water quality and sediment erosion, transport and deposition.
9. Moderate- to high- level water quality exists throughout Great Sandy Strait Ramsar site, which helps to support high primary productivity of seagrass and mangrove habitat, rich food webs, secondary productivity, and abundant and diverse fauna within the site.

10. Specific messages derived from the fourteen (14) critical Ecosystem Services and 8 critical components and processes are suitable for use directly in development of CEPA plans and products.

## Conclusions

The Great Sandy Strait is an outstanding Ramsar site in Australia in that it supports a large diversity of wetland habitats and a high diversity of wetland flora and fauna species, including many threatened species, on a large scale. The site is also relatively undisturbed and thus particularly significant when viewed against the background of coastal modification along the eastern Australian coastline. Some changes in components and processes, however, are apparent. Whilst data is insufficient to assess whether ecological character has changed, and the site still meets the criteria for which it was recognised on the date of Ramsar listing, the site faces a number of threats which require management actions and ongoing monitoring.

This ECD for the Great Sandy Strait Ramsar site is the first for a Ramsar site in Queensland. The document provides a benchmark for managers and other stakeholders when planning management actions such as site monitoring. It also has potential to assist in implementing the *EPBC Act* when proposed activities are being assessed for potential impacts on the Ramsar site.

Fourteen critical ecosystem services have been identified for the Great Sandy Strait Ramsar site and eight critical components or processes. Together, these core elements of ecological character provide a focus for management of the Ramsar site. Parameters which best represent these critical elements of ecological character have been identified in most cases and will further assist in developing this management focus. Limits of acceptable change for these key parameters are an important part of the Ecological Character Description and, where possible, provide thresholds or triggers for management intervention, or indicators of change in ecological character. These proposed thresholds are expected to be updated as improved information becomes available.

The document thus provides a comprehensive baseline description of ecological character for the site, and indicators for assessing change in ecological character and for informing management planning and decisions. Information provided on key threats, knowledge gaps and core CEPA messages has also been presented to assist in developing more targeted management actions.

# PART B: The Ecological Character Description

## 1. Introduction

The Australian Government Department of the Environment and Water Resources has a responsibility and an interest in relation to meeting the obligations of the Ramsar Convention. The Queensland Government is responsible for managing the Ramsar sites that come under its jurisdiction. The Australian and Queensland governments have agreed to progress the implementation of Australia's international obligations in relation to wetlands and migratory birds. This includes the development of ecological character descriptions (ECDs) for Ramsar sites in Australia.

In accordance with the Ramsar Convention, appropriate management of Ramsar wetlands includes describing and maintaining the ecological character of the wetland, and implementing planning processes promoting conservation and wise use. The ecological character description (ECD) of a Ramsar site has recently been promoted as a fundamental management tool which should form the baseline or benchmark that managers and other parties can use for management planning and action, including site monitoring.

The project to develop this ecological character description for the Great Sandy Strait Ramsar site was funded through the Queensland Wetlands Programme which is a joint initiative of the Australian and Queensland Governments to protect wetlands in the Great Barrier Reef catchment and throughout Queensland.

The project also provided an updated Ramsar Information Sheet (RIS) and digital map for boundaries of the Ramsar site. This ECD should be appended to the Ramsar Information Sheet and each subsequent updated RIS. This ECD may also be updated, but should only be updated in the following circumstances:

1. If further substantial data, knowledge or resources are available to improve the original description;
2. If the boundaries of the site are extended, reduced or modified, in which case the Ramsar Information Sheet and the ecological character description should be re-examined and updated; or
3. If the wetland undergoes favourable human-induced changes as a result of a rehabilitation and/or restoration project or if the wetland undergoes natural evolutionary change.

### 1.1 Task

This ECD was prepared as part of a project that involved 3 core tasks:

1. The development of an ECD for the Great Sandy Strait Ramsar site, using the draft *National Framework and Guidance for describing the ecological character of Australia's Ramsar wetlands 2007* (the draft Framework);
2. Develop a list of monitoring needs to help maintain the ecological character of the site based on information contained in the ECD;
3. Provide an updated Ramsar Information Sheet and a digital map for the boundaries of the Ramsar site. The ECD is appended to the Ramsar Information Sheet.

## 1.2 Background on Ecological Character Descriptions for Ramsar Listed Wetlands

Australia was one of the first signatories to the Convention on Wetlands (Ramsar Convention) when it joined in 1975. As part of its commitment under the Convention, Australia has now nominated 65 sites for the List of Wetlands of International Importance, 5 of which are located in Queensland. A key obligation under the Convention is to maintain the ecological character of listed wetlands.

For the first three decades of the Ramsar Convention the Ramsar Information Sheet was taken to be a description of the ecological character of the Ramsar site. In recent years the Ramsar Conference of Parties has directed the Ramsar Scientific and Technical Review Committee to develop additional guidance on the description of ecological character. This issue has gained additional importance in Australia with the passing of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) which identified Ramsar sites as Matters of National Environmental Significance. This Legislation requires an action that "has, will have, or is likely to have, a significant impact on the ecological character of a Ramsar wetland" to be referred to the Commonwealth Environment Minister.

In response, the Australian Department of the Environment and Water Resources (DEW) has been working with the Wetlands and Waterbirds Taskforce in developing a framework for describing ecological character of Ramsar sites. Australia is the first Party to the Ramsar Convention to have developed a systematic framework (Department of Sustainability Environment 2005). The current draft Framework for an ECD was developed through a national workshop in May 2006, the *Framework for Describing Ecological Character of Ramsar Wetlands* (Department of Sustainability and Environment 2005) and substantial input from the Natural Resource Management Ministerial Council's (NRMMC) Wetlands and Waterbirds Taskforce, which includes representatives from Australian, state and territory government agencies. It draws on the learnings and recommendations from a series of early projects that developed ECDs for a diverse range of Ramsar sites across Australia.

The draft Framework has a 12 step process to describe ecological character and it includes some essential elements such as the development of conceptual models/diagrams, identification of critical component, processes and benefits/services, key threats, proposing Limits of Acceptable Change for the critical elements of ecological character, identifying the key monitoring requirements, and core CEPA messages for the site. The ECD also aims to inform and relate to other documents and processes for natural resource management affecting the Great Sandy Strait.

In this project the draft Framework was applied to Great Sandy Strait. This is the first detailed description of ecological character of a Ramsar site in Queensland. It will guide both planning and management decisions for the Ramsar site.

## 1.3 Purpose of the Ecological Character Description

The ECD provides a baseline for management planning and action, including monitoring to detect and minimise degradation of the site's ecological character. In Australia this information is also essential for implementing the *EPBC Act* (*Environment, Protection and Biodiversity Conservation Act 1999*) where activities are assessed for potential impacts on a Ramsar site.

This ECD should be able to fulfil several roles, including at least the following (outlined by McGrath 2006):

1. To assist in implementing Australia's obligations under the Ramsar Convention, as stated in Schedule 6 (Managing wetlands of international importance) of the Environment Protection and Biodiversity Conservation Regulations 2000:
   a) to describe and maintain the ecological character of declared Ramsar wetlands in Australia; and
   b) to formulate and implement planning that promotes:
      i) conservation of the wetland; and

ii) wise and sustainable use of the wetland for the benefit of humanity in a way that is compatible with maintenance of the natural properties of the ecosystem.

2. To assist in fulfilling Australia's obligation under the Ramsar Convention to arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the Ramsar List has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference.
3. To supplement the description of the ecological character contained in the Ramsar Information Sheet submitted under the Ramsar Convention for each listed wetland and, collectively, form an official record of the ecological character of the site.
4. To assist the administration of the *EPBC Act*, particularly:
   a) to determine whether an action has, will have or is likely to have a significant impact on a declared Ramsar wetland in contravention of sections 16 and 17B of the *EPBC Act*; or
   b) to assess the impacts that actions referred to the Minister under Part 7 of the *EPBC Act* have had, will have or are likely to have on a declared Ramsar wetland.
5. To assist any person considering taking an action that may impact on a declared Ramsar wetland whether to refer the action to the Minister under Part 7 of the *EPBC Act* for assessment and approval.
6. To inform members of the public who are interested generally in the declared Ramsar wetland to understand and value the wetland site.

Furthermore, whilst a specific Ramsar management plan has not been developed for the Great Sandy Strait Ramsar site, several related plans and programs (ongoing and in development) have direct relevance to management of the site and its ecological character. The detailed information obtained in this ECD will also contribute to these plans and programs, which include, but are not limited to:

- Register of the National Estate
- Great Sandy Region Management Plan 1994-2010,
- Marine Parks (Great Sandy) Zoning Plan, 2006
- Burnett Mary Regional Natural Resource Management (NRM) Plans, or Burnett Mary Regional Group for Natural Resource Management Inc (BMRG),
- Mary River Water Resource Plan (July 2006),
- Mary River Catchment Committee - Action Plans.
- Draft Wide Bay Coast Regional Coastal Management Plan (in development)

The site also forms a part of several other regional reports and planning documents, including:

- Integrated Planning Act Planning Schemes by Local Authorities,
- Tweed-Moreton (TMN) Marine Region, In the Interim Marine and Coastal Regionalisation for Australia, Version 3.3 (IMCRA Technical Group, 1998),
- Wide Bay Coast regional description - contained in the Queensland State Coastal Management Plan (Environmental Protection Agency, 2001),
- Coastal Wetland Resources Assessment from Round Hill Head to Tin Can Inlet (Bruinsma and Danaher, 2000),
- Commission of Inquiry into the Conservation, Management and Use of Fraser Island and the Great Sandy Region (Queensland 1991) (3 Volumes 1990 plus Report 1991),
- Nomination of the Great Sandy Region for Inclusion in the World Heritage List (Hemmings and Sinclair, 1984),
- Overview of the Scenic Resources of the Queensland Coast (EDAW Aust., 1996),

- Reports of the Wide Bay 2020 Regional Planning Project (see for example, Queensland Dept. of Local Government and Planning 1998), and
- Fraser Island World Heritage Area (DASET 1991) and proposal for extension.

## 1.4 Relevant Legislation, Treaties or Regulations

Relevant Legislation, Treaties or Regulations that influence management of the Great Sandy Strait Ramsar site include international, national, state, regional and local instruments. These are used in multiple ways by local interest groups, site managers, regional bodies, and by local, state and commonwealth government agencies.

**International Instruments:**

- The Convention on Wetlands of International Importance (Ramsar, Iran 1971) http://www.ramsar.org/
- *Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment* (JAMBA) http://www.austlii.edu.au/au/other/dfat/treaties/1981/6.html;
- *The Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment* (CAMBA) http://www.austlii.edu.au/au/other/dfat/treaties/1988/22.html;
- *The Agreement between the Government of Australia and the Republic of Korea for the Protection of Migratory Birds and their Environment* (ROKAMBA) *http://www.austlii.edu.au/au/other/dfat/treaties/2007/24.html*
- The *Convention on the Conservation of Migratory Species of Wild Animals* (the Bonn Convention) http://www.cms.int/;
- *International Convention for the Prevention of Pollution from Ships, 1973*, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78) http://www.imo.org/Conventions/contents.asp?doc_id=678&topic_id=258
- The Convention concerning the Protection of World Cultural and Natural Heritage (1972) http://whc.unesco.org/

**Commonwealth legislation:**

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)

**State legislation and regulations:**

- *Aboriginal Cultural Heritage Act 2003*
- *Coastal Protection and Management Act 1995*
    - *State Coastal Management Plan 2001*
- *Environmental Protection Act 1994*
    - *Environmental Protection (Water) Policy 1997*
    - *Great Sandy Strait Environmental Values and Water Quality Objectives 2007*
    - *Great Sandy Strait Coastal Creeks Environmental Values and Water Quality Objectives 2007*
- *Fisheries Act 1994* (Queensland Government 2006a)
- *Integrated Planning Act 1997*
- *Land Act 1994*
- *Marine Parks Act 2004*
    - *Marine Parks (Great Sandy) Zoning Plan 2006*.
- *Native Title (Queensland) Act 1993*

- *Nature Conservation Act 1992* (Queensland Government, 2006b)
- *Queensland Heritage Act 1992*
- *Recreation Areas Management Act 2006*
- *State Development and Public Works Organisation Act 1971*
- *Torres Strait Islander Cultural Heritage Act 2003*
- *Transport Operations (Marine Safety) Act 1994*
- *Transport Operations (Marine Pollution) Act 1995*
- *Water Act 2000*
    - *Water Resource (Mary Basin) Plan 2006*
    - *Water Resource (Mary Basin) Amendment Plan (No.1) 2007*
- *Wild Rivers Act 2005*

**Local Instruments:**

- Local Government Planning (under the *Integrated Planning Act 1997*)

# 2. General Description of the Ramsar site

## 2.1 Site Details

| | |
|---|---|
| **Site Name** | Great Sandy Strait (including Great Sandy Strait, Tin Can Bay and Tin Can Bay Inlet) |
| **Location in coordinates** | Latitude:25° 28' 46" S Longitude:152° 54' 9" E |
| **Site Location Details** | The Ramsar site falls partly within or is bordered by the Fraser Coast and Gympie Regional Shires in South-eastern Queensland, Australia. The nearest towns are Maryborough and Hervey Bay on the north west boundary, Tin Can Bay in the south west and Rainbow Beach in the south east (**Figure 1**).<br>The site includes Great Sandy Strait, Tin Can Bay, Tin Can Bay Inlet and parts of Fraser Island and the mainland.<br>The Mary River catchment flows into the northern portion of the Ramsar Site and is a major source of freshwater and sediment to this portion. The southern portion receives surface and ground water inputs from several small creeks entering the western, southern and eastern boundaries of the Site.<br>The Site is at the southern part of Australia's "Northeast Coast" drainage division, and within the Tweed-Moreton marine and coastal bioregion (IMCRA), located at the convergence of tropical and temperate marine zones. |
| **Site Boundary Description** | The northern boundary is a line south of the Urangan Boat Harbour northeast to include Round Island and surrounds, north of Datum Point on Woody Island then across open water to Moon Point on Fraser Island.<br>The site extends the length of Great Sandy Strait to the eastern end of Inskip Point and the southern extent includes Tin Can Inlet and Tin Can Bay. Its western extent continues along the Mary River as far as the boundary between Lot 45 Plan W3745 and Lot 23 Plan MCH1393 (downstream of Brothers Islands), and includes the Susan River mangrove system. Along other creeks, such as Kauri Creek and Tuan Creek, it extends as far as the tidal influence. It excludes private freehold lands, local government foreshore reserves on the mainland, the Urangan Boat Harbour and a 500 m zone around it, Snapper Creek Boat Harbour, jetties and boat launching ramps, and 30 m either side of these structures. |
| **Area** | Approximately 93,160ha |
| **Date of Ramsar site designation** | May 1999 |
| **Ramsar Criteria met by wetland** | New (2005) Ramsar criteria 1, 2, 3, 4, 5, 6, 7 and 8. Criteria 4 and 7 (including their pre-1999 equivalents) were met at the time of listing but were not included in the original RIS document. |
| **Management authority for the site** | The Queensland EPA holds functional authority for management of the Ramsar site, but other State government agencies are also responsible for management of some components and activities within the Site, eg, coastal navigation, fisheries, Dugong Protection Areas.<br>**Terrestrial areas:**<br>Queensland EPA (national parks and conservation parks);<br>Department of Natural Resources and Water (Unallocated State Land).<br>**Intertidal and marine areas:**<br>The Ramsar site is contained within the Great Sandy Marine Park (2006). Queensland National Parks and Wildlife, within the Queensland EPA, processes |

| | |
|---|---|
| | applications for works below the high water mark.<br>Queensland Transport (Marine Safety Queensland) for jetties, boat ramps and channels.<br>Department of Primary Industries and Fisheries for declared Fish Habitat Areas, marine plants and waterway barrier works; Dugong Protection Areas. |
| **Land Tenure** | The Ramsar Site is contained within the Great Sandy Marine Park (2006), and includes Queensland State waters and State national park lands. Islands in the Strait which are currently Unallocated State Land are reserved for coastal management purposes under the Coastal Protection and Management Act 1995. Small areas of freehold and leasehold land exist in the Great Sandy Strait, but are excluded from the Ramsar Site.<br>Most of the land in the eastern portion of the Ramsar site is within conservation areas (Queensland State land), with the remaining areas comprised of Unallocated State Land.<br>Wide Bay Military Training Area (Commonwealth, Department of Defence) abuts the south-western coast of the Ramsar site as does large areas of state forest (Queensland State). Numerous freehold blocks also border the western boundary of the Site. The mid to north western side of the Strait adjacent to the site contains mostly freehold land with some Unallocated State Land.<br>There are four native title claims over the site and adjacent lands and waters.<br>**See Figure 4.** |
| **Date the ECD applies** | The ECD applies retrospectively to about the time the Ramsar site was listed - May 1999. |
| **Status of ECD** | The ECD is the first one for this Ramsar site. |
| **Date of Compilation** | July 2008. |
| **Name(s) of compiler(s)** | Warren Lee Long and Woo O'Reilly<br>Wetlands International – Oceania<br>Contact: warren.leelong@wetlands-oceania.org |
| **References to the Ramsar Information Sheet (RIS)** | The RIS was also updated in 2008 as part of this project.<br>Australian Wetlands Database - Database Search |
| **References to the Management Plan** | Great Sandy Region Management Plan 1994-2010<br>Marine Parks (Great Sandy) Zoning Plan, 2006<br>Burnett Mary Regional Natural Resource Management (NRM) Plans) |

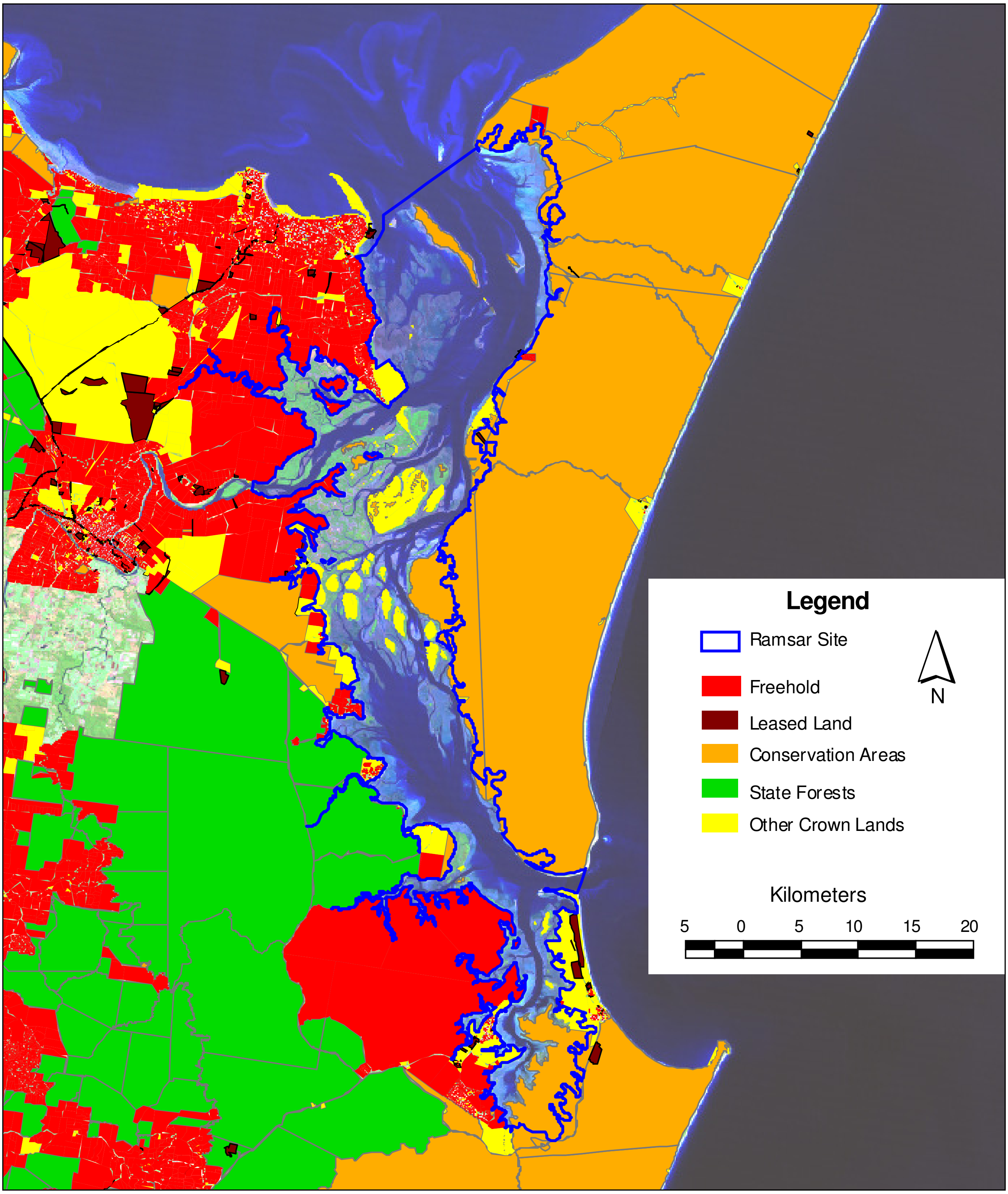


**Figure 4. Great Sandy Strait Ramsar site and broad tenure types**

**Data Sources: Queensland EPA (2002); Department of Natural Resources and Mines (2007).**

## 2.2 Relevant Ramsar criteria for the site

The Great Sandy Strait was officially declared a Ramsar site in May 1999. At the date of listing, the site met eight of the current Ramsar criteria. An update of the Ramsar Information Sheet (RIS) for Great Sandy Strait conducted as part of the current ECD project notes that the Site met two additional criteria - Criterion 2c (or new Criterion 4) and Criterion 4a (new Criterion 7) - which were omitted in the original RIS. The old (pre-1999) criteria and corresponding new criteria met by the site at the time of listing are provided below (**Table 5**). The RIS update associated with the present project found that the Site continued to meet the same criteria in 2008.

**Table 5. Ramsar Criteria met at date of listing, with comparison of pre-and post-1999 criteria.**

| ***Original Ramsar Criteria met (as recognised in the Great Sandy Strait Ramsar Information Sheet dated May 1999)*** | ***Equivalent new Ramsar Criteria met (based on the list of new Criteria 2005)*** |
|---|---|
| **1(a):** it is a particularly good representative example of a natural or near-natural wetland, characteristic of the appropriate biogeographical region. | **Criterion 1:** A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region. |
| **1(b):** it is a particularly good representative example of a natural or near-natural wetland, common to more than one biogeographical region. | |
| **1(d):** it is an example of a specific type of wetland, rare or unusual in the appropriate biogeographical region. | |
| **2(a):** it supports an appreciable assemblage of rare, vulnerable or endangered species or subspecies of plant or animal, or an appreciable number of individuals of any one or more of these species. | **Criterion 2:** A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities. |
| **2(b):** it is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna. | **Criterion 3:** A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.<br><br>***Note that there is no closer equivalent Criterion for old Criterion 3(b).*** |
| **3(b):** it regularly supports substantial numbers of individuals from particular groups of waterfowl, indicative of wetland values, productivity or diversity. | |
| **2(c):** (Omitted in the original nomination)<br>it is of special value as the habitat of plants or animals at a critical stage of their biological cycle. | **Criterion 4:** A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions. |
| ***Specific criteria based on waterbirds*** | |
| **3(a):** it regularly supports 20 000 waterfowl. | **Criterion 5:** A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds. |
| **3(c):** where data on populations are available it regularly supports 1% of the individuals in a population of one species or subspecies of waterfowl. | **Criterion 6:** A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird. |
| ***Specific criteria based on fish*** | |
| **4(a):** (Omitted in the original nomination)<br>it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and | **Criterion 7:** A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby |

| | |
|---|---|
| thereby contributes to global biological diversity. | contributes to global biological diversity. |
| **4(b):** it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend. | **Criterion 8:** A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend. |

## 2.3 Wetland types

Using the Ramsar Classification System for Wetland Type (see www.ramsar.org), the Ramsar Information Sheet for the Great Sandy Strait Ramsar site lists 10 wetland types at the site. The key wetland habitat types that have been mapped accord with a Queensland wetland typology for management purposes, and do not yet include all of the Ramsar wetland types listed at the Site. A cross-table of Ramsar vs Queensland wetland typologies for the key wetland types mapped to date is provided here. The general distribution of these mapped wetland types is illustrated in **Figure 5**.

| Ramsar Wetland Classification | Queensland wetland classification for mapped habitats |
|---|---|
| ***Estuarine Wetlands*** | |
| **A** -- **Permanent shallow marine waters** in most cases less than six metres deep at low tide; includes sea bays and straits. | **Estuarine habitat** (including channels, subtidal sandbars, rocks and snags) |
| **B** -- **Marine subtidal aquatic beds**; includes kelp beds, sea-grass meadows, tropical marine (algae) meadows. | **Seagrasses** |
| **C** -- **Coral reefs** | **Coral reef** |
| **E** -- **Sand, shingle or pebble shores**; includes sand bars, spits and sandy islets; includes dune systems and humid dune slacks. | (not mapped) |
| **F** -- **Estuarine waters**; permanent water of estuaries and estuarine systems of deltas. | **Estuarine habitat** (including channels, subtidal sandbars, rocks and snags) |
| **G** -- **Intertidal mud, sand or salt flats**; includes many seagrass meadows | **Inter-tidal flats** |
| **H** -- **Intertidal marshes**; includes salt marshes, salt meadows, saltings, raised salt marshes; includes tidal brackish and freshwater marshes. | **Saltmarsh and saltpans** |
| **I** -- **Intertidal forested wetlands**; includes mangrove swamps, nipah swamps and tidal freshwater swamp forests. | **Mangroves** |
| ***Freshwater wetlands*** | |
| **U** -- **Non-forested peatlands**; includes shrub or open bogs, swamps, fens. | **Palustrine** (peat swamps) |
| **Xf** -- **Freshwater, tree-dominated wetlands**; includes freshwater swamp forests, seasonally flooded forests, wooded swamps on inorganic soils. | **Palustrine** (freshwater swamp forests). |

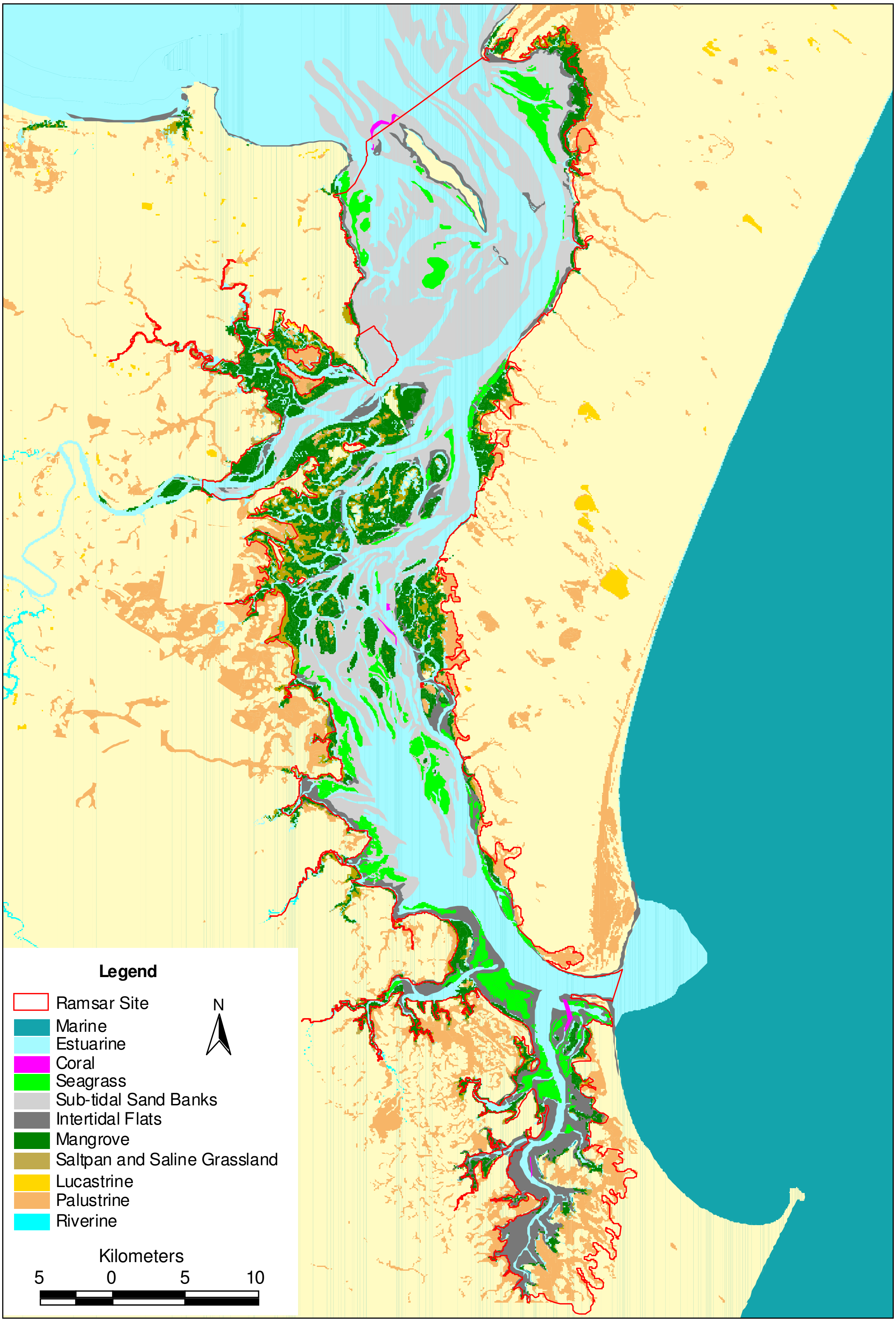


**Figure 5. Key estuarine and freshwater wetlands in the Great Sandy Strait Ramsar site.**

**Source: Queensland EPA 2007. Queensland Wetland Mapping and Classification for the Wide Bay catchments, 2001 extent. Version 1.1**

# 3. Methods

This document describes the ecological character of the Great Sandy Strait Ramsar site at the time of Ramsar listing (1999).

The definition of Ecological Character was revised at the Ramsar Convention of Contracting Parties in November 2005 as follows:

> *"Ecological character is the combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time."* (Ramsar Convention, Resolution 1X.1 2005).

This definition builds on the previous Ramsar definition of ecological character. It recognises that wetlands are complex systems that provide a range of ecosystem services. It also emphasises the links between the ecological components (i.e. biological, physical and chemical), their interactions (i.e. ecological processes) and the products, functions and attributes (i.e. ecosystem services) that they support.

The description of ecological character of the Great Sandy Strait Ramsar site refers to the time of Ramsar listing (1999); and changes to the site since then are noted separately in **Section 6**. The ECD document is also to be appended to the updated Ramsar Information Sheet.

## 3.1 Approach Taken for Ecological Character Description

This report uses the draft Framework and following core definitions are central to the current interpretation and application of Ecological Character as defined by the Ramsar Convention 2005 (Resolution IX.1 Annex A):

- **Ecosystem services** are the products, functions and/or attributes of the wetland at the time of listing (or date chosen as basis for the description of ecological character) i.e. the benefits (direct or indirect) people obtain from ecosystems e.g. water purification, recreation, tourism, biodiversity etc.
- **Ecological components** are the actual entities, features and physical characteristics of the wetland e.g. number of species and habitats, water temperature, nutrients, size of wetland etc.
- **Ecological processes** are the dynamic forces within an ecosystem and include interactions with both the living and non-living environment e.g. nutrient cycling, reproduction, predation, migration, competition etc.

The Ramsar Convention defines benefits/services in accordance with the Millennium Ecosystem Assessment definition of ecosystem services: as "the benefits that people receive from ecosystems (Ramsar Convention 2005, Resolution IX.1 Annex A). Whilst this definition focuses on the benefits (economic, social and cultural) that people receive from ecosystems, it also includes benefits/services of direct importance to biota (eg., biodiversity, ecosystem regulatory functions, etc), which ultimately provide benefits/services to communities that depend on the wetland, as well as to humanity generally.

## 3.2 Choosing Ecosystem Services for the Ecological Character Description

The four main categories of ecosystem services described by the Millennium Ecosystem Assessment (2005) are:

1. **Provisioning services** - the products obtained from the ecosystem such as food, fuel and fresh water;
2. **Regulating services** – the benefits obtained from the regulation of ecosystem processes such as climate regulation, water regulation and natural hazard regulation;
3. **Cultural services** – the benefits people obtain through spiritual enrichment, recreation, education and aesthetics; and

4. **Supporting services** – the services necessary for the production of all other ecosystem services such as water cycling, nutrient cycling and habitat for biota. These services will generally have an indirect benefit to humans or a direct benefit over a long period of time.

The first and third categories mostly include benefits of direct importance to people. The second and fourth categories include benefits/services of importance to people and other biota, and often relate to the Ramsar criteria met by the site, but can include additional ecosystem services which are not recognised in the Ramsar Information Sheet.

The process for selecting the critical ecosystem services, components and processes (summarised in **Figure 6**) also led to identifying the key elements for inclusion in conceptual diagrams on the Site's ecological character.

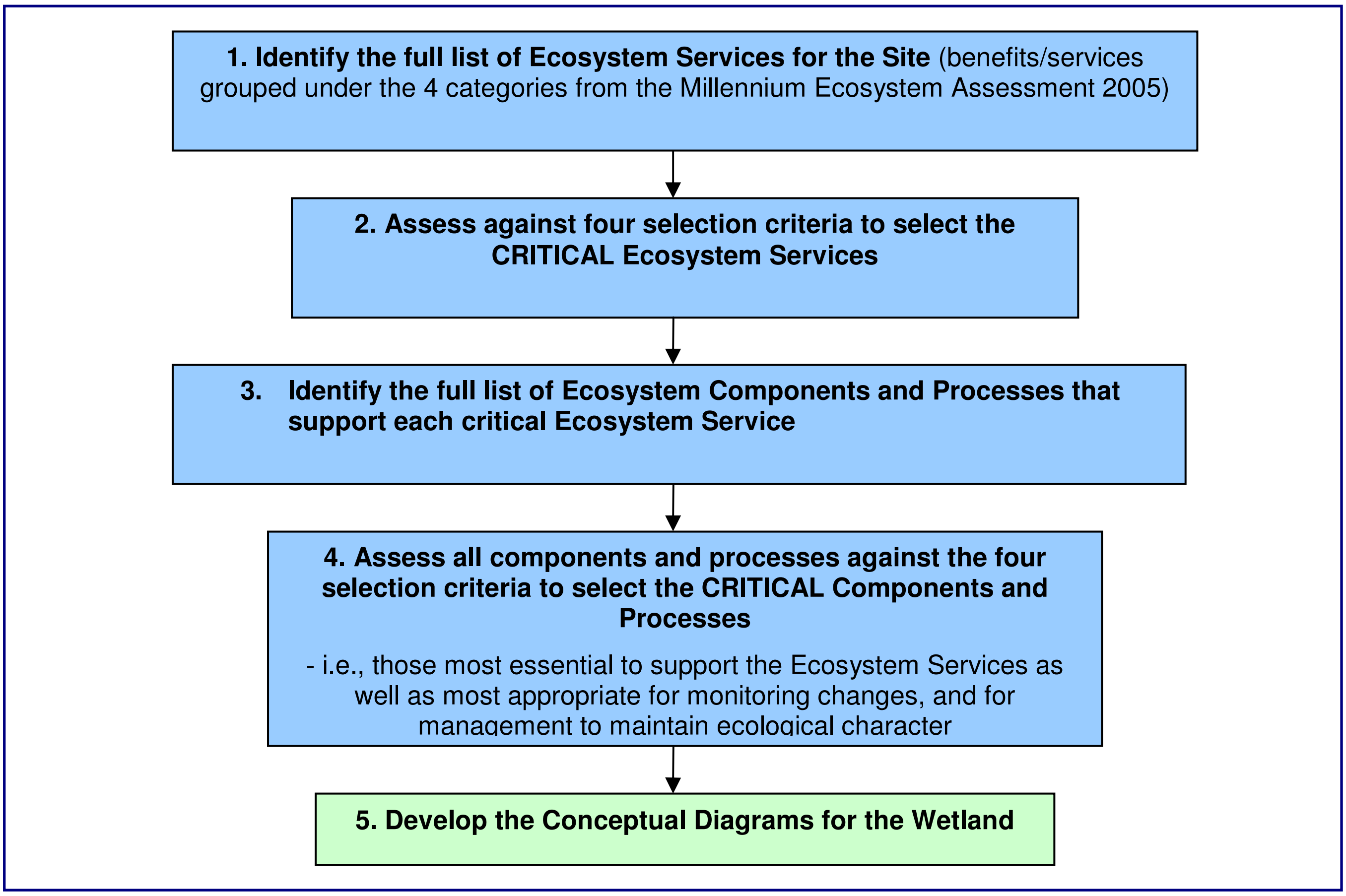


**Figure 6. The process used to select Critical Ecosystem Services and Components and Processes that underpin Ecological Character for the Great Sandy Strait Ramsar site.**

As a first step, a nominal list of ecosystem services was developed using the set of Ramsar criteria identified for the site (see **Appendix 1**). Additional ecosystem benefits/services were also identified using the four categories listed above, in accordance with the draft Framework (Department of the Environment and Water Resources 2007).

Consolidating this comprehensive list of services into a final selection of critical ecosystem services involved two steps. Firstly, services that shared similar characteristics were grouped as one broad service. Secondly, this initial list was checked against the set of four criteria from the draft Framework to indentify critical ecosystem services. According to the Framework, critical ecosystem services should be:

1. key determinants of the site's unique character;
2. important for supporting the Ramsar or DIWA criteria that the site was listed for;
3. reasonably likely to show changes occur over short or medium time scales (<100 years); and
4. cause of significant negative consequences if change occurs.

Thus fourteen <u>critical</u> Ecosystem Services were identified for the Great Sandy Strait Ramsar site (**Table 6**).

**Table 6. Critical Ecosystem Services chosen for the Ecological Character Description of the Great Sandy Strait Ramsar site.**

| Ecosystem services derived from the Criteria met. | Ramsar Criteria met* | Ecosystem Service Categories (cf., Millennium Ecosystem Assessment, 2005) | Draft Framework Criteria met (see above) plus supporting details |
|---|---|---|---|
| **1.** Great Sandy Strait Ramsar site includes **a large sand island and passage estuary** which provides habitat and **migration pathways** for marine animals (fishes, prawns, turtles) between riverine, sheltered nursery/feeding areas and open ocean**.**<br>SEE SECTION 4.1.1 | Criteria 1,4*,8 | **Regulating:** shoreline stabilisation, storm protection.<br>**Cultural:** enrichment for indigenous and non-indigenous people;<br>**Supporting:** habitat for biota, water cycling, nutrient cycling, sediment retention | 1,2,4<br>Regionally unique feature not necessarily recognised under other services |
| **2.** A substantial area of peat swamp, consisting mainly of the **regionally unique patterned fens**, occurs within the Great Sandy Strait Ramsar site.<br>SEE SECTION 4.1.2 | Criteria 1 | **Regulating:** Maintenance of hydrological regimes.<br>**Supporting:** Carbon sequestration. Provides habitat for four species of acid frog, water mouse, Oxleyan pygmy perch and honey blue-eye. | 1,2,3,4<br>Regionally unique feature not necessarily recognised under other services |
| **3.** A regionally significant area of **seagrass habita**t and **diversity of seagrass species** occurs within the Great Sandy Strait Ramsar site.<br>SEE SECTION 4.1.3 | Criteria 3, 4*, 8 | **Regulating:**, pollution control and detoxification<br>**Supporting** - contributes to biodiversity, nutrient cycling and processing, provides food or feeding habitat for green turtles, dugongs, shorebirds, fish and crustacea. | 1,2,3,4<br>Hosts a great diversity of plant and animal species and crucial to the health of the Great Sandy Strait. |
| **4**. Great Sandy Strait Ramsar site supports a **large and diverse area of mangrove communities** as part of a tidal wetlands ecosystem **that also supports an endangered butterfly**.<br>SEE SECTION 4.1.4 | Criteria 3, 4*, 8 | **Regulating:** erosion control, pollution control and detoxification, hazard control, protects shoreline<br>**Supporting:** contributes to biodiversity, nutrient cycling and processing. Provides nursery for many fish species, water mouse and Illidge's ant-blue butterfly | 1,2,3,4<br>Crucial to the health of the Great Sandy Strait. Limits of geographical distribution of several mangrove species. |
| **5.** Great Sandy Strait Ramsar site supports a substantial area **of sub-tropical inshore reefs including coral and sponge communities** and species near their geographic limits.<br>SEE SECTION 4.1.5 | Criteria 3, 8 | **Provisioning:** food<br>**Cultural:** dive and fishing tourism<br>**Supporting:** contributes to biodiversity, food webs | 1,3,4<br>Limits of geographical distribution of some species. |
| **6.** Four **nationally threatened species of marine turtle** (green, loggerhead, hawksbill, flatback) occur annually in substantial numbers within Great Sandy Strait Ramsar site.<br>SEE SECTION 4.1.6 | Criteria 2,3 | **Supporting** - contributes to biodiversity | 1,2,3,4<br>Four threatened species. |
| **7.** A relatively large number of species of **marine mammals** use the Great Sandy Strait Ramsar site, including several cetaceans and a local population of the **internationally vulnerable dugong.**<br>SEE SECTION 4.1.7 | Criteria 2, 4* | **Cultural:** Dugong and dolphins are an important species in Aboriginal culture in the Great Sandy Strait.<br>**Supporting:** Contributes to biodiversity, supports a threatened species. | 1,2,3,4<br>Two threatened species use the site. |

| Ecosystem services derived from the Criteria met. | Ramsar Criteria met* | Ecosystem Service Categories<br>(cf., Millennium Ecosystem Assessment, 2005) | Draft Framework Criteria met (see above) plus supporting details |
|---|---|---|---|
| **8.** The **nationally threatened water mouse** *Xeromys myoides* occurs in mangrove, saltmarsh and/or associated freshwater wetlands within the Great Sandy Strait Ramsar site.<br>SEE SECTION 4.1.8 | Criterion 2 | **Supporting:** Nationally threatened species | 1,2,3,4<br>The water mouse can be cryptic so may not meet criteria 6. |
| **9.** The **nationally threatened fishes the honey blue-eye and Oxleyan pygmy perch** occur permanently in freshwater swamps and/or in associated streams within the Great Sandy Strait Ramsar site.<br>SEE SECTION 4.1.9 | Criteria 2,3 | **Supporting:** Nationally threatened species | 1,2,3,4<br>Two threatened species. |
| **10.** Four species of **threatened acid frogs** occur permanently in the wallum swamps and lakes within the Great Sandy Strait Ramsar site.<br>SEE SECTION 4.1.10 | Criterion 2 | **Supporting:** Nationally threatened species | 1,2,3,4<br>Four threatened species. |
| **11.** Great Sandy Strait Ramsar site supports **substantial stocks of fishes, prawns and crabs** which may be subject to commercial or recreational harvest.<br>SEE SECTION 4.1.11 | Criteria 3, 7*, 8 | **Provisioning**: food<br>**Cultural:** Indigenous use; recreational and commercial fishing<br>**Supporting**: contributes to biodiversity and food webs | 1,2,3,4 |
| **12.** Great Sandy Strait Ramsar site supports **large numbers of waterbirds (>20 000) with 8 species of shorebirds occurring in numbers >1% of their population**, including the highest counts in the world for far eastern curlew.<br>SEE SECTION 4.1.12 | Criteria 3, 5 & 6 | **Cultural:** tourism, education, aesthetics;<br>**Supporting:** contributes to biodiversity, nutrient cycling on mudflats, threatened species. | 1,2,3,4<br>Outstanding international importance; one threatened species. |
| **13.** Great Sandy Strait Ramsar site contains sites of considerable **significance to indigenous Australians** and natural resources that potentially may be harvested sustainably by indigenous people using traditional methods.<br>SEE SECTION 4.1.13 | Nil | **Provisioning:** food, traditional medicines<br>**Cultural** - Indigenous heritage | 1,3<br>Cultural importance. |
| **14**. Great Sandy Strait Ramsar site contains a rich diversity and abundance of natural resources that support a range of **nature-based tourism and recreational activities.**<br>SEE SECTION 4.1.14 | Nil | **Cultural –** Recreation, Education and Aesthetics | 3,4<br>Cultural importance. |

**The Great Sandy Strait Ramsar site was not originally nominated for Criteria 4 and 7 or their 1999 equivalents, but the current review indicates that the Site did meet these criteria at time of listing:*

> ***Criterion 4:** A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions).*
> ***Criterion 7:** A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.*

The ecosystem services were each described in terms of their importance to the Ramsar criteria and/or for their values under any of the four categories described by the Millennium Ecosystem Assessment 2005. For each critical ecosystem service, the key indicators (variables) for measuring this element of ecological character were identified and, where possible, we described the natural variability of these indicators, and proposed Limits of Acceptable Change (**Section 3.4**). In many cases, it is difficult to obtain objective measures for an ecosystem service. Furthermore, many measures of human-use associated with an ecosystem service may vary independently of the wetland's capacity to support the service. Thus the indicators that provided the best measure for an ecosystem service were most often indicators or variables of critical components or processes that directly underpin the service.

The accumulated geological and ecological knowledge about the site was used to list the many components and processes that underpin each ecosystem service, and to describe how they support the ecosystem service. The critical components and processes (see **Section 3.3** below) were identified and marked (with a **#**) - for further detailed description in **Section 4.3**.

## 3.3 Selecting the Critical Ecosystem Components and Processes

Of the many components and processes that support the 14 ecosystem services in the Great Sandy Strait Ramsar site, a subset of **critical ecosystem components and processes** was identified. The four criteria used to select the critical ecosystem services were once again used to identify these critical components and processes.

For each of the critical components and processes, key indicators (variables) were identified as appropriate for monitoring, and to assist management decisions and actions necessary for maintenance of ecological character.

Whilst this ecological character description will include some components or processes that are not yet practical to monitor, the critical importance in maintaining ecological character warrants not only their inclusion, but some efforts to improve the information base for assessing change in these elements of ecological character.

Components and processes that support ecosystem services associated with the freshwater wetlands have been presented separately to those which support estuarine and marine wetland associated ecosystem services.

Most components and processes support several ecosystem services, and some may directly represent some aspect of the site's unique character. Each critical component or process was described in detail, including how it supports the range of critical ecosystem services.

## 3.4 Describing levels of natural variability and proposing Limits of Acceptable Change

For each of the critical ecosystem **services** (Section 4.1) and the critical **components and processes** (Section 4.3), key defining indicators or variables were identified. For each key indicator knowledge about its levels of natural variability is given and, where possible, Limits of Acceptable Change are proposed.

The **Limits of Acceptable Change** establishes thresholds which in most cases may be used to signify or assess change in ecological character since the date of Ramsar listing. These limits/thresholds are taken to be outside what would be expected through natural variation. Exceedance of these thresholds for any critical element of ecological character should represent a significant ecological change from natural conditions, usually through human induced impacts or interference, and thus represent a change in ecological character.

The Limits of Acceptable Change were determined where possible from published and expert knowledge about levels of natural variability of key variables that best quantified the critical ecosystem services, components and processes. In some cases information and expert advice was insufficient to propose any threshold. However for some indicators information was sufficient to enable recommendations on more conservative levels of change (usually declines) that would trigger management intervention, and help mitigate against potential changes in ecological character. Where data were insufficient for developing statistically robust limits of acceptable change, interim Limits of Acceptable Change were proposed where possible, based on expert opinion. Some of these interim thresholds will only be useable when certain information becomes available.

Thus, depending on the state of knowledge to date, the proposed Limits of Acceptable Change fall into one of four "categories":

1. information is insufficient and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed;
2. information is insufficient for proposing a threshold for change in ecological character, but more conservative triggers for management intervention are proposed;
3. information is only sufficient for proposing an interim Limit of Acceptable Change (threshold for change in ecological character), and further information is required to set a more precise threshold; or
4. information is sufficient to propose a specific Limit of Acceptable Change for use in management decisions, but a more precise threshold may still be set as further information becomes available.

The complex inter-dependence of critical components, processes and ecosystem services is such that a significant change in any single critical ecosystem component might not immediately lead to other dependant components or ecosystem services exceeding their Limits of Acceptable Change. Nevertheless, a sufficiently large change in the primary critical component would still be used to trigger a management response.

The Limits of Acceptable Change will also inform the development of monitoring plans. Depending on the degree to which a single variable might affect other components or processes, and based on expert advice, these limits of acceptable change can be used in assessing potential impacts of overall land-use and development affecting the site.

Descriptions of natural variability and proposed Limits of Acceptable Change are expected to be improved as appropriate information becomes available, and this ECD should be updated with the improved information.

## 3.5 Other requirements of the Ecological Character Description

**Threats** (Section 5) to the site have been summarised to identify what elements of ecological character are at risk, and to help focus monitoring and management effort. This project does not enable an extensive analysis of threats, nor a comprehensive assessment of the imminent threats. It presents a list of key threats to ecological character, to assist in the prioritisation of approaches and resources for maintaining ecological character.

**Knowledge Gaps** (Section 6) were identified under each of the critical ecosystem services and threats. In most cases, knowledge gaps were listed only if strategic improvements in information and knowledge might have large benefits for managers.

**Changes in Ecological Character** (Section 7) have been difficult to quantify. Some ecosystem components have shown indications of downward trends but often with insufficient information to confirm the exact degree of change. Some of the changes commenced prior to the date of Ramsar listing, thus may be part of long-term declines.

The site still meets the original Ramsar criteria which it met on the date of Ramsar listing*. This includes two additional criteria which were not included in the original nomination.

**Monitoring Needs** (Section 8) have been identified to assist managers to maintain ecological character of the site. The monitoring needs listed are based primarily on the critical ecosystem services, components, processes and threats. They therefore include variables considered to best reflect the critical elements of ecological character and/or of most influence on ecological character of the site.

The monitoring indicators, frequency and priorities listed are indicative only, to help inform the development of formal monitoring programs. They may be varied with the benefit of improved research knowledge or used according to prevailing needs and resources.

**Community Education and Public Awareness (CEPA) messages** (Section 9) include the key messages and themes that pertain to the site's ecological character. This list is provided as a focus for managers and stakeholders to elaborate on in management or CEPA plans that help to maintain the site's Ecological Character.

# 4. Critical Components, Processes and Services

In describing the critical elements of ecological character of the Great Sandy strait Ramsar Site, the following features of the Site were of primary importance:

**Great Sandy Strait is located** at the transition between tropical and temperate marine and coastal biogeographic zones (Commonwealth of Australia 2006). It is one of the best examples of a tide-dominated sand passage estuary system on Australia's eastern seaboard. The Ramsar site comprises this passage estuary and margins of a large sand island and sandy mainland and therefore includes both estuarine and freshwater wetlands, which are extensive and diverse (**Figure 3**). This diversity of wetland types supports a very high biodiversity.

**The site supports** a diverse and regionally significant area of seagrass beds as well as mangrove wetlands habitats that comprise species at, or near to, their northern or southern geographical limits. The site also supports large intertidal mud and sand banks, small but regionally significant coral reefs and sponge gardens, and other estuarine elements. These habitats in turn support feeding, roosting, shelter and/or migration pathways for abundant and diverse communities of crustaceans, fishes, sea turtles, mammals (dolphins, dugong, whales, a water mouse), migratory and resident shorebirds, sponges and corals. The site is at or near the limits of geographic extent of several species of flora and fauna.

A substantial area of non-forested peat swamp, comprised mainly of rare 'patterned fens', occurs within the site. These fens together with areas of 'wallum' heath swamps, support species adapted to the prevailing acidic water and substrate, including threatened frogs and fishes as well as species of crayfish and earthworm. Rainfall, surface and groundwater flows, water table levels and water chemistry are crucial supporting factors.

**Fauna of special significance** in the site are:

- substantial populations of nationally and/or internationally threatened species (**Appendix 2**): four marine turtle species (green, loggerhead, hawksbill, flatback), dugong; the intertidal-dwelling water mouse; the mangrove-dwelling Illidge's ant-blue butterfly in estuarine/marine areas; and the honey blue-eye and Oxleyan pygmy perch plus four species of acid frogs in the patterned fens and the wallum heath plains and swamps.
- a population of at least 20,000 shorebirds comprising at least 20 species that occur at the site annually; eight of these species occurring in numbers exceeding 1% of their flyway population, with the highest site count worldwide for the far eastern curlew.
- substantial stocks of juvenile and adult fishes, prawns and crabs many of which are, or may be, subject to commercial and/or recreational harvest; and
- a relatively large number of species of marine mammals, including several cetaceans.

**In terms of human use**, Great Sandy Strait includes sites and resources of considerable cultural significance to indigenous Australians and contains natural resources that potentially may be harvested sustainably by indigenous people for traditional purposes. The site's rich diversity and abundance of natural resources also supports a range of nature-based tourism and recreational activities.

Ecosystem services provided in the Great Sandy Strait Ramsar site include those relating to Ramsar criteria and those relating to human benefits. Fourteen critical ecosystem services were identified for the Great Sandy Strait Ramsar site and are each described in detail below. Several ecological components and processes were recognised as important in supporting these ecosystem services, but only eight were selected as critical components or processes (**Section 4.3**). Together, these critical core elements of ecological character provide the focus for management of the Ramsar site. As a step toward developing this management focus, this section identifies a number of variables that best represent these critical elements of ecological character. Where possible, their levels of natural variability are described, and Limits of Acceptable Change are proposed.

## 4.1 A description of the Ecosystem Services and Limits of Acceptable Change, plus their Components and Processes, and Knowledge Gaps

### 4.1.1 Ecosystem Service 1: Great Sandy Strait Ramsar site includes **a large sand island and passage estuary** which provides habitat and **migration pathways** for marine animals (fishes, prawns, turtles) between riverine, sheltered nursery/feeding areas and open ocean.

***Ramsar criteria met:*** *Criterion 1*

***Type(s) of service: Regulating:*** *Shelter from sea swell and currents, stabilises sand movements and provides sands for beach replenishment "downstream" of the site.* ***Supporting:*** *Provides geomorphological characteristics and hydrological regimes for a diversity of coastal wetland habitat types.*

The presence of the large sand island - Fraser Island - presents a large, sheltered, sandy strait, with coastal river and streams inputs and two sea openings provides for the development of this regionally significant area of large and diverse wetland types. Great Sandy Strait is one of the largest and best examples of a tide-dominated sand passage in eastern Australia. Similar passage estuaries are confined to Queensland's south-eastern coastline and are associated with Stradbroke/Moreton islands, Bribie Island and Curtis Island. Its latitudinal position at the transition of tropical and temperate marine and coastal zones also influences the nature of floral and faunal species complexes and communities and thus the site's importance to biogeography and conservation. The following features are important:

- Presence of high dune systems supplying surface and sub-surface freshwater flows into the non-forested peat swamps.
- Sheltering effects of Fraser Island sand dune system.
- Functional passages to the open sea at northern and southern ends of the Strait.
- Water exchange for biological systems that depend on flows between freshwater, estuarine and marine habitats.
- Transport of sediments of both marine and terrestrial origin.

The southern channel opening is considered most likely to be relatively stable over a 100 year period because tidal forces are sufficient to flush sediments to the open sea; whilst bathymetry of the Mary River mouth, the northern opening and central strait are more likely to vary, subject to changes in river and tidal flow regimes and associated sediment budgets (P. O'Keeffe, pers. comm., 2007). The central strait is at the confluence of two opposing tidal systems and thus likely to be an area of accretion over decadal periods.

**Natural Variability and Limits of Acceptable Change**

| Variable | Proposed Limits of Acceptable Change |
|---|---|
| **Sand bank and channel topography/bathymetry** (see also Critical Component/Process G, Section 4.3.7) within the strait are crucial features that determine the availability of tidal flats, seagrass and mangrove wetland habitat. Shoreline structure and morphology are also important determinants of sediment transport, and deposition processes in turn shape sand bank and channel topography. River and catchment sources of sediment also influence the extent of sand bar formation at estuary mouths and in the strait.<br><br>The Inskip Bar and southern channel opening are most likely to be relatively stable over a 100yr period. Bathymetry of the Mary River mouth, northern opening and central strait are considered to be more variable, as they are subject to changes in river flow regimes and associated sediment budgets (P. O'Keeffe, pers. comm., 2007). The central strait and Mary River estuary channel have shallowed significantly over the decade up to 1999 and the trend may continue (C. Cockburn, pers. comm., 2007), with some indications already of impacts on vessel navigation. Impacts of shallowing here on passage of other fish, marine mammals, sea turtles, etc, are not yet known, but given the importance of these passages to movements of biological materials, fauna and vessels, further shallowing of these passages should be avoided (P. O'Keefe, C. Cockburn, pers. comm.. 2007). | **1.1** For sand bank and channel topography and connectivity to sea openings, **Limits of Acceptable Change** are:<br>• Minimum depths at major channels connecting the southern section of the Great Sandy Strait with the open sea (Wide Bay and Inskip bars) no more than 10% shallower than 1999 bathymetry.<br><br>**1.2** For sand bank and channel topography/bathymetry and connectivity, **Limits of Acceptable Change** are:<br>• Minimum channel depths of the Mary River mouth connecting riverine /stream, estuarine and marine habitats should be no shallower than 1m at mean low water.<br>• For other estuarine channels connecting riverine /stream, estuarine and marine habitats, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed. |

| | |
|---|---|
| **Freshwater flow regime**<br><br>The average annual discharge of the Mary River into the system is 2300 GL (Mary River Catchment Coordinating Committee 1996, ANCA 1996). Large inputs of fresh water and sediment occur during flooding on a more or less annual basis (ANCA 1996). Smaller though still significant inflows result from the Susan River and a number of smaller creeks of which Kauri Creek is the largest on the western side of the Strait. Significant quantities of pure freshwater drain from the Fraser Island and Cooloola sandmasses via small creeks and drainage lines, supporting the non-forested peat swamps.<br><br>A set of long term (100 years+) and short term (10 years) flow indices must be considered, and be used collectively (see critical components: Estuarine and Marine Wetlands - Hydrology, **Section 4.3.5**). The complexities of these combined freshwater flow regimes and their effects on bathymetry and habitat connectivity currently preclude setting any simple Limits of Acceptable Change. The time scale for monitoring changes is also greater than decadal and may be insufficient to alert timely management responses.<br><br>Nevertheless, information on the Mary River freshwater/estuarine flows is more substantial (Refer to Critical Component/Process E: Estuarine and Marine Wetlands - Hydrology, **Section 4.3.5**). The Mary River component of freshwater flow is very significant in the site and critical to several elements of ecological character in the site.<br><br>**The performance of fishways** on the Tinana Creek and Mary River tidal barrages is also crucial to passage of several fish species that migrate between the Ramsar Site and upstream reaches. These are monitored by barrage and fishway owners in cooperation with fisheries experts. Species and size class compositions of fish using the fishways are monitored and assessed against prevailing flow conditions, barrage/fishway operation and fish populations in the local system (A. Berghuis, Z. Sarac, pers com 2008). However statistical rigour of these assessments is difficult and until more reliable assessments are possible, a cessation in fishway operation is considered necessary before changes in ecological character can be indentified with confidence. | **E.1** For the combined freshwater flow from all sources, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed. See also Limits of Acceptable Change for the critical component Hydrology Section 4.3.2<br><br>**E.2** For estuarine and marine wetlands, the critical component represented by Mary River freshwater/estuarine flows, information is only sufficient for proposing **interim Limits of Acceptable Change:**<br><br>• After allowing for variations in rainfall, any index or aspect of freshwater flow (e.g. mean annual flow) from the Mary River catchment degraded by more than 10% since the date of Ramsar listing (1999).<br><br>NB: For maintaining conditions necessary for fish passage, change from natural total flow volumes should be minimized (Brizga *et al* 2005). Further information is required to set a more precise threshold.<br><br>• Any cessation in fishway operation or function on the Tinana Creek and Mary River tidal barrages.<br><br>(see also **Critical Component/Process E, Section 4.3.5**)<br><br>(Refer to **Monitoring Needs, Section 8.1**) |
| **Tidal flow regime**.<br><br>Tidal regimes are well documented within Bureau of Meteorology tide records, and are considered stable over the last 100 years. Sea level rise may change these levels of variability. Models of tidal influence on sediment dynamics are needed to test the current variability of tidal regimes and its impact on bathymetry of the wetland. | **E.3** For changes to the tidal flow regime, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed.<br><br>(see also **Section 4.3.5**) |

### Knowledge Gaps

- Quantitative descriptions of marine and freshwater (catchment) flows required to maintain sediment dynamics and bathymetry within limits of acceptable change.
- Relative contribution to sediments in the site from fluvial (primarily Mary River), Fraser Island and continental shelf sources.

**Related Ecological Components and Processes**

| Ecosystem Components and Processes | How they support the Ecosystem Service |
|---|---|
| **Geomorphology:** Bathymetry/connectivity **#** | The presence of the large sand island - Fraser Island – creating a large, sheltered, sandy strait, with coastal river and streams inputs and two sea openings provides for the development of this significant complex of wetland types. The following features are important:<br>• Presence of high dune systems supplying surface and subsurface freshwater flows into the non-forested peat swamps.<br>• Sheltering effects of Fraser Island sand dune system; functional passages to the sea at northern and southern ends of the Strait. Transport of sediments of both marine and terrestrial origin.<br>• Channel and tidal flat bathymetry enabling water exchange and connectivity for biological systems using freshwater, estuarine and marine habitats. |
| **Hydrology:** Freshwater flows **#** | Riverine flow rates, volumes and periodicity are key determinants of estuary mouth shape and form, and therefore habitat area available for fish passage, breeding or feeding in the estuary mouths. This is critical for several fish species that must migrate between the Ramsar site and river reaches to complete their lifecycle. |
| **Geomorphology:** Wetland soils: sediment types and grain size | Silica sands of Fraser island provide characteristic sand dune features and supply of sediments to the eastern part of the strait. Their poor buffering capacity also leads to the unique acid waters of the sites' freshwater peat swamps. Sediment grain sizes in channels and tidal banks are results of partitioning by hydrological forces, and in turn influence the types of fauna and flora occupying the tidal flats. |
| **Physical processes:** Sediment dynamics (fluvial and marine) | Supply and movements of both fluvial and marine (continental shelf) sands contribute to the mud and sandbanks on which seagrasses and mangrove habitats grow within the site. These include:<br>• fine fluvial sediments from the Mary and Susan Rivers and smaller coastal streams,<br>• continental shelf sediments from Hervey Bay, and<br>• sands from western Fraser Island (Beach Protection Authority 1989, p.33 Fig 3-5).<br>Tidal movements transport these sands off-site through the northern and southern openings to the sea, where they assist in replenishing beaches. The sand banks north of Urangan Boat Harbour are considered potential sand replenishment for the eroded beaches in southern Hervey Bay (BPA 1989). |
| **Physicochemical components:** Particularly salinity and temperature regimes/ profiles. | The salinity structure of the estuary is an important control on sediment deposition processes, as water salinity determines whether flocculation or deflocculation of clays occurs. |

**#** Considered a critical Component or Process and thus described further in Section 4.3.

### 4.1.2 **Ecosystem Service 2**: A substantial area of peat swamp, consisting mainly of the **regionally unique patterned fens**, occurs within the Great Sandy Strait Ramsar site.

***Ramsar criteria met:*** *Criterion 1*

***Type(s) of service: Regulating:*** *Maintains hydrological regimes.* ***Supporting:*** *Provides habitat for seven threatened species. Carbon sequestration*

A substantial area of non-forested peat swamp, mainly consisting of patterned fens, occurs within the Great Sandy Strait Ramsar site boundary along the west coast of Fraser Island and on the northwest coastal plain of the Cooloola section (Ingram *et al* 2004a and 2004b). Some patterned fens also occur within the Ramsar boundary on Fraser Island around Yankee Jack Creek, Ungowa Creek and just north of Bogimbah Creek as well as on both Unallocated State Land and in national park on the northwest coastal plain of the Cooloola section. These, in addition to other patterned fens adjacent to the Ramsar boundary, are the only known sub-tropical fens and the only known examples in the world of patterned fens flowing into tidal wetlands (Ingram *et al* 2004a). The patterned fens at Cooloola differ somewhat from those on Fraser Island and appear to represent different developmental stages. It is not known if these differences are the result of differing fire regimes or the age of the fens (Ingram *et al* 2004b).

Complex spatial patterns of ridges (“strings”) and depressions (“flarks”) in the patterned fens of the Great Sandy Strait Ramsar site are not known elsewhere in the sub-tropics worldwide.
**Photo:** courtesy of QPW

Non-forested peat swamps, including the patterned fens, at both Fraser Island and Cooloola (as well as wallum swamps and lakes included in the Ramsar site) provide habitat for a number of nationally and/ or internationally threatened species that have adapted to the acidic waters. This includes threatened frogs and fishes and the water mouse (previously known as the false water rat) *Xeromys myoides* which is known to nest in the patterned fens (R. Hobson, pers. comm., 2007). The patterned fens are also described as having distinctive faunal inhabitants such as the swamp crayfish (*Tenuibranchiurus glypticus*) and earthworms that would not normally be found in such acid environments (Ingram *et al* 2004a).

**Natural Variability and Limits of Acceptable Change**

| Variable | Proposed Limits of Acceptable Change |
|---|---|
| **The extent of patterned fens occurring within the Great Sandy Strait Ramsar site:** It is believed that the majority of the peat swamps are made up of patterned fens (R. Hobson, pers. comm., 2007). The area of fens therefore gives a clear indication of the area of Ramsar Wetlands type U (non-forested peat swamp) that occurs in the Ramsar site.<br><br>Knowledge of the area of patterned fen within the Ramsar site are currently insufficient for understanding levels of natural variability and thus for proposing Limits of Acceptable Change. The patterned fens appear to align with some of Regional Ecosystem 12.2.15 (Queensland EPA 2004) but this classification encompasses a broader range of habitat types. | When reliable estimates of aerial extent are obtained, statistically significant (detectable) declines can be measured.<br><br>**2.1** For the extent of patterned fens within the Ramsar site, information is only sufficient for proposing **an interim Limit of Acceptable Change**:<br><br>• Any detectable loss of patterned fen habitat area.<br><br>(refer to Monitoring Needs **Section 8.2**) |
| **The condition of patterned fens occurring within the Great Sandy Strait Ramsar site:** There is little information on the patterned fens that occur both in and directly adjacent to the Ramsar site. Factors such as health and diversity of flora and fauna and water content and quality are most likely important factors that need to be measured in order to improve our understanding and management of these unique sub-tropical fens.<br><br>Consequently, knowledge of the condition of patterned fens within the Ramsar site is currently insufficient for understanding levels of natural variability and thus for proposing limits of acceptable change. | **2.2** For the condition of patterned fens within the Ramsar site, **information is insufficient** for proposing a Limit of Acceptable Change, but the following **trigger for management intervention** is proposed:<br><br>• Any detectable deterioration in any variable of habitat condition.<br><br>(see also **Sections 4.3.2** and **4.3.3**)<br><br>(refer to Monitoring Needs **Section 8.2**) |

**Knowledge Gaps**

- Information required to explain the differences between the patterned fens of Fraser and Cooloola and whether they develop and persist through different means.
- Full extent of patterned fen habitat and the critical processes required to maintain them both within and outside the Ramsar boundary, eg. on the western side of the Cooloola and Inskip Peninsula and Fraser Island.
- The different faunal species within the fens and the degree to which they use the patterned fens.
- Parameters for monitoring the condition of patterned fens.

**Related Ecological Components and Processes**

| Ecosystem Components and Processes | How they support the Ecosystem Service |
|---|---|
| **Hydrology:** Freshwater flows **#** | Sustained **surface and groundwater flows** link peat swamps / patterned fens (AREA 1 HEV).<br><br>The pool formations of the patterned fens have apparently formed in response to **high volume surface freshwater flows** from the dune systems (Ingram *et al* 2004a) |
| **Hydrology:** Rainfall | **Rainfall** is also important to feeding the high dune systems that then feed into the lakes, swamps and fens. |

| | |
|---|---|
| **Geomorphology:** Wetland soils | **Low nutrient siliceous soils** (such as those in the sand dunes on Fraser Island and Cooloola) are conducive to soft, poorly buffered waters which can become quite acidic when exposed to **decomposing organic matter**. |
| **Physicochemical components:** pH **#** | Dilute, **poorly buffered waters** will become acidic (low in pH) with high levels of **dissolved organic acids** sourced from decomposing organic matter. |
| **Geomorphology:** Presence and composition of peat | Conditions where plant growth exceeds the rate of residue composition in wet areas may result in the formation of peat. **The attributes of the peat** (such as the coarseness, compactness and ability to hold water) may influence the patterning effect formed in the fens. |
| **Geomorphology:** Topography | The **high dune systems** supply surface and sub-surface freshwater flows to the patterned fens. These flows appear to influence the shape of the peat, thus creating the patterned effect (Ingram *et al* 2004a). |

**#** Considered a critical Component or Process and thus described further in Section 4.3.

### 4.1.3 Ecosystem Service 3: A regionally significant area of **seagrass habitat** and **diversity of seagrass species** occurs within the Great Sandy Strait Ramsar site.

***Ramsar criteria met:*** *Criteria 1, 3, 4, 8*

***Type(s) of service: Supporting -*** *contributes to biodiversity, nutrient cycling and processing, food webs and/or habitat/shelter for regionally important populations of green turtles, dugongs, fish and crustaceans;* ***Regulating -*** *pollution control and assimilation of nutrients and sediments.*

Seven species of seagrass have been recorded from the Strait: *Cymodocea serrulata, Halodule uninervis, Halophila ovalis, H. spinulosa, H. decipiens, Syringodium isoetifolium* and *Zostera capricorni* (McKenzie 2000). These include all of the species found in shallow waters of the South East Queensland region south of Gladstone. They comprise a diversity of intertidal and subtidal community types with a total aerial extent of 7,007 ±1,945ha (McKenzie and Campbell 2003).

This complex of seagrass habitats thus provides a food-web base, a direct food source and/or shelter for substantial local populations of seagrass-dependant fauna, including crustaceans, fish, sea turtles and dugongs in the site. Seagrass meadows here provide refuge for a number of species of pipefish.

These meadows also perform functions of sediment stabilisation and nutrient assimilation, helping to maintain quality of these coastal waters. The seagrasses in the Great Sandy Strait Ramsar site are likely to be one of the most important habitat components for maintenance of the present ecological health and outstanding biodiversity that the site represents within the Tweed-Moreton IMCRA Region. The proximity of seagrasses to mangrove and coral reef habitats in the Great Sandy Strait is likely to enhance the levels of faunal biodiversity and productivity (eg. Grober-Dunsmore *et al* 2007).

All marine plants in Queensland, regardless of land tenure, are protected and authorisation is required for disturbance of these species and communities (Queensland Fisheries Act 1994).

Seagrass-Watch program volunteers monitor a range of seagrass abundance and community parameters at up to 10 localities in the Ramsar site.

Photo: Len McKenzie, Seagrass-Watch HQ.

**Natural Variability and Limits of Acceptable Change**

| Variable | Proposed Limits of Acceptable Change |
|---|---|
| **Area of seagrass habitat*:** There is limited information on natural variability in extent of seagrass habitat in the Ramsar site. However, mapping events have shown massive losses of seagrass meadows after flood events, e.g. 50% loss after the Feb 1999 flood (McKenzie *et al* 2000). Recovery has taken three to five years in some places. Since the first seagrass survey was conducted in 1973 (Dredge *et al* 1977) various mapping events suggest a consistent reduction in seagrass biomass, density and habitat area within the Great Sandy Strait. Local declines in seagrass density and area in the Tin Can Bay area have been perceived by fishers who frequent particular locations in the Strait, and limited mapping in the southern section has supported these claims (Fisheries Research Consultants, 1994a). It is difficult to determine the real extent of changes in seagrass aerial extent in the site due to the difference in mapping techniques to date and the large mapping errors involved, especially those prior to February 1998 (McKenzie *et al* 2000).<br><br>An estimate of 12,300ha of seagrass habitat in Great Sandy Strait in 1988 was produced from interpretation of aerial photos (Lennon & Luck 1990, Moreton & Healy 1992), which may have included algae habitat and thus an overestimate of seagrass extent. Aerial and limited ground surveys in October-November 1992 estimated at least 11,000ha (Fisheries Research Consultants, 1993a), which again may have included algae habitat. In 1994, with additional ground truthing, only 6,630 ha was mapped (Fisheries Research Consultants, 1994a).<br><br>In 1998 a detailed ground and aerial survey estimated that only 5,554 ±1,446ha existed in Great Sandy Strait (McKenzie 2000). A resurvey in February 2002, mapped 7,007 ±1945 hectares of intertidal seagrass meadows on the mud/sand banks of the Great Sandy Strait (Campbell & McKenzie 2004; McKenzie and Campbell 2003). | **3.1** For the area of seagrass habitat, **Limits of Acceptable Change** are:<br><br>• A 20% reduction from December 1998 levels of total seagrass habitat area, and sustained longer than 3 years.<br><br>• An event-related loss of 50% of total aerial extent of seagrass habitat (from December 1998 levels) in Great Sandy Strait more than once every 8 years. |

| Variable | Proposed Limits of Acceptable Change |
|---|---|
| **Abundance** (eg. biomass, ground cover) **and species composition of seagrass meadows:** reflect the availability of preferred food species for the key herbivores (dugong and green turtles). These parameters of seagrass meadow health can also provide some indication of environmental stress. Abundance and species composition also reflect the seagrass canopy structure, which is important for plankton, crustacean and fish species which shelter and feed in the meadows. Canopy structure also determines the influence of seagrasses on water flow and assimilation of nutrients and sediments. These parameters have been monitored at up to 10 localities in the Ramsar site approximately every 3 months since 1999 in the Seagrass-Watch program (Seagrass-Watch 2007). There was widespread decrease in abundance following a flood in February 1999, with good recovery at sites on the eastern side of the strait, but limited recovery on the western (mainland) side (http://www.seagrasswatch.org/GreatSandyStrait.html 2007-05-27). At some of the 27 Seagrass-Watch monitoring sites in the Great Sandy Strait Ramsar site, abundance estimates have changed up to 100% between years. Recovery from total loss has taken up to five years. | **3.2** For seagrass abundance and species composition, information is only sufficient for proposing an interim **Limit of Acceptable Change**:<br>• At any Seagrass-Watch monitoring site, complete loss of above ground abundance more than once every 8 years. |
| **Depth range of seagrasses:** The depth to which the seagrass *Zostera muelleri* subsp. *capricorni* grows, provides an integration of ambient light reaching seagrass leaves and thus an indication of the water clarity at a site. Transects for monitoring depth distribution were established in 1993 (Fisheries Research Consultants, 1994b), but have not been continued sufficiently to provide adequate measures of variability – natural or otherwise. | **3.3** For the depth range of seagrasses, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed. |
| **Physiological health of seagrasses:** Further study is needed to test the appropriateness and cost-effectiveness of monitoring parameters of physiological health against other early warning indicators such as seagrass depth range or seagrass abundance. | **3.4** For the physiological health of seagrasses, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention**,** can be proposed. |

### Knowledge Gaps

- There is some information from different years on seagrass aerial extent, depth distribution and meadow composition, but insufficient for understanding the extent of natural variability or for proposing Limits of Acceptable Change with statistical confidence for any of these parameters.
- Seed production in Great Sandy Strait seagrasses and importance in seagrass resilience and recovery.

### Related Ecological Components and Processes

| Ecosystem Components and Processes | How they support the Ecosystem Service |
|---|---|
| **Hydrology:** Freshwater flow and tidal exchange regimes **#** | Freshwater and seawater (tidal) flow regimes over seagrasses determine the salinity regime and several other critical ambient water quality parameters that seagrasses will be subject to. Most seagrass species are distributed in depth zones according to their tolerances to exposure (at their upper depth limits) and light requirements for photosynthesis (at their lower depth limits). Each species has different tolerances to low salinity, and freshwater plumes, and flood events in particular, influence the distribution of seagrasses species around river mouths. |
| **Physicochemical components:** Nutrient loads, turbidity, light, temperature and salinity **#** | Seagrasses are important in assimilating land derived nutrients and sediments. However, excessive nutrient and sediment loads can stress or kill seagrasses through direct smothering by sediments or epiphytic algae, and excessive water turbidity (suspended sediments/ phytoplankton densities) leading to reductions in light needed for photosynthesis. |
| **Geomorphology:** Protection by Fraser Island, double openings to the sea and connectivity with a major river catchment. | Seagrasses require relatively sheltered coastal areas with ample exchange of marine water. The integrity of the strait for sustaining a sheltered coastal zone and clean water exchange are important prerequisites for seagrasses to grow here. |
| **Physical form:** Sediment dynamics (erosion, transport, deposition) | Sediment deposition patterns determine the physical form (depth, shape, and bathymetry) and thus the extent of suitable sea-bed available for seagrass growth. |
| **Physical form:** Depth, shape, bathymetry | The area of available sheltered, intertidal and subtidal habitat with ample light penetration is a prerequisite for potential areas of seagrass growth. |
| **Climate:** Sea level | Current sea levels determine the periods of inundation and the water depths over tidal and sub-tidal areas, which are key determinants of conditions suitable for seagrass growth and survival. Most seagrass species are distributed in depth zones according to their tolerances to exposure (at their upper depth limits) and light requirements for photosynthesis (at their lower depth limits). Ambient climate conditions of sunlight, temperature, storm activity are key influences on these scales (Voice *et al* 2006; Waycott *et al* in prep). |
| **Energy and nutrient dynamics:** Seagrass seed production and seed bank storage in sediments | Seed banks in the site are depleted, possibly because of too frequent losses and disturbance for high latitude seagrasses (which possibly produce seeds less frequently or successfully than tropical plants). This may affect the ability of the Great Sandy Strait seagrasses to recover from losses, and leave them susceptible to much further loss in the longer term. |

**#** Considered a critical Component or Process and thus described further in Section 4.3.

### 4.1.4 Ecosystem Service 4: Great Sandy Strait Ramsar site supports **a large and diverse area of mangrove communities** as part of a tidal wetlands ecosystem that also supports an **endangered butterfly**.

| |
|---|
| ***Ramsar criteria met:*** *Criteria 3, 4, 8* |
| ***Type(s) of service: Supporting -*** *contributes to biodiversity, nutrient cycling and processing. Provides nursery for many fish species and habitat for water mouse and Illidge's ant-blue butterfly.* ***Regulating -*** *erosion control, pollution control/ detoxification, hazard control, protects shoreline.* |

The Great Sandy Strait supports a very large component of the aerial extent of tidal wetlands in the Tweed-Moreton coastal and marine bioregion (Bruinsma & Danaher 2000; IMCRA Technical Group 1998). Mangroves are predominant over saltpans and saltmarshes. Eleven species of mangrove occur in Great Sandy Strait:

| | |
|---|---|
| *Acrostichum speciosum* Willd | Mangrove fern |
| *Aegialitis annulata* R. Br. | Club mangrove |
| *Aegiceras corniculatum* (L.) | Blanco River mangrove |
| *Avicennia marina* (Forsk) Vierh. | Grey mangrove |
| *Bruguiera gymnorrhiza* L. Lam. | Large-leafed orange mangrove |
| *Ceriops tagal* C. T. White | Yellow mangrove |
| *Crinum pedunculatum* R.Br. | Mangrove lily |
| *Excoecaria agallocha* L. | Milky mangrove |
| *Hibiscus tiliaceus* L. | Native hibiscus |
| *Lumnitzera racemosa* Willd. | Black mangrove |
| *Osbornia octodonta* F. Muell. | Myrtle mangrove |
| *Rhizophora stylosa* Griff. | Red mangrove |
| *Xylocarpus granatum* Koen | Cannonball mangrove |

Twelve mangrove community types and 2 saltpan communities are recognised in the site (Danaher and de Vries, 2003; Duke 2006).

| | |
|---|---|
| Closed *Rhizophora* | Open *Bruguiera* |
| Closed *Avicennia* | Closed *Rhizophora*/*Avicennia* |
| Open *Avicennia* | Closed *Rhizophora*/*Aegiceras* |
| Closed *Ceriops* | Closed *Avicennia*/*Ceriops* |
| Open *Ceriops* | Open *Avicennia*/*Ceriops* |
| Closed *Aegiceras* | Closed Mixed |

Saline Grassland
Saltpan

These mangrove communities and species represent a transition between essentially temperate and tropical flora on the eastern Australia coastline (eg, Duke 2006).

Within the Tweed-Moreton bioregion mangrove communities become more diverse north of the Great Sandy Strait (IMCRA Technical Group 1998). Tin Can Inlet (at the southern part of the Ramsar site) is the southern distributional limit for three species, the club mangrove *Aegialitis annulata* and cannonball mangroves *Xylocarpus granatum* and *Osbornia octodonta* (Hegerl 1993; Lovelock 1993; Bruinsma & Danaher 2000). In addition, *Casuarina glauca* (not a mangrove) uncharacteristically grows below high water mark in the region (Hegerl 1993).

This complex of mangrove habitats provides a substrate, a direct food source and/or shelter for a range of mangrove-dependant fish and crustacean fauna. The mangrove forests also provide ecosystem services of sediment stabilisation (controlling coastline erosion) and nutrient assimilation (to buffer nutrient loads on adjacent coastal habitats). Sediment trapped by mangroves may enable further expansion of the habitat if other ideal conditions prevail (N. Duke, pers. comm., *2007*).

The mangrove communities of the Great Sandy Strait provide habitat for the Illidge's ant-blue butterfly *Acrodipsas illidgei*. This butterfly is listed as vulnerable under the Queensland legislation (Queensland Museum 2007) and endangered under the IUCN Redlist (IUCN 2006). The females lay eggs on the trunks and branches of grey mangrove trees where the larvae predate on the immature stages of the *Crematogaster* ants (Sands and New 2002). It was originally thought that the adult butterfly was rare but it is now believed that this is more likely a result of their cryptic nature of settling high in the branches of mangroves and flying infrequently (Sands and New 2002). The mangrove areas around the Susan / Mary River inlet are believed to be their most important habitat in the Great Sandy Strait (HEV 3). The mangrove areas also play an important role in supporting the nationally vulnerable water mouse *Xeromys myoides* (see Ecosystem Service 8).

The endangered Illidge's ant-blue butterfly *Acrodipsas illidgei* is found in mangroves at the mouth of the Susan River in the Ramsar site.

Photo: courtesy of Qld EPA.

Mangroves, as with seagrasses, are likely to be one of the most important habitat components for maintenance of the present ecological health and outstanding biodiversity that the Great Sandy Strait Ramsar site represents within the Tweed-Moreton IMCRA Region and on the Australian east coast.

**Natural Variability and Limits of Acceptable Change**

| Variable | Proposed Limits of Acceptable Change |
|---|---|
| **Extent of tidal wetlands (includes mangroves, saltmarsh and saltpans):** According to the Queensland Wetlands Mapping and Classification for 2001 (Version 1.2), the area of tidal wetlands in the Ramsar site at time of listing was approximately 16,115ha (Danaher & de Vries 2003).<br><br>Interpretation of historical aerial photography spanning two decades indicated that the overall distribution of mangroves and sediments within the Ramsar site has shown little change and is considered relatively stable (Bruinsma and Danaher 2000).<br><br>The area of different mangrove communities within the intertidal zone however can change constantly due to drivers such as rainfall, nutrients and sedimentation. More important is the area of mangroves in terms of its proportion to adjacent intertidal habitats such as saltmarsh & saltpans (N. Duke, pers. comm., 2007). | **4.1** For the extent of tidal wetlands (including mangroves, saltmarsh and saltpans), information is insufficient for proposing a Limit of Acceptable Change but the following **trigger for management intervention** is proposed:<br><br>• Any detectable nett loss of total area of tidal wetlands (Refer to **Monitoring Needs, Section 8.4**). |
| **Physiological condition of mangroves:** Information on conditions of mangroves in the Ramsar site are currently insufficient for understanding levels of natural variability and thus for proposing Limits of Acceptable Change. Nevertheless, knowledge to date indicates that measures of condition such as area of dieback and canopy cover may be proxies for general water quality in the | **4.2** For the physiological condition of mangroves, information is insufficient for proposing a Limit of Acceptable Change but the following **trigger for management intervention** is proposed:<br><br>• A "dieback" or significant |

| | |
|---|---|
| Ramsar site (N. Duke, pers. comm., 2007). | reduction in condition in more than 15% of mangrove habitat area and sustained more than 5 years (this allows for drought cycles). |

**Knowledge Gaps**

- Factors affecting condition of mangroves in the Great Sandy Strait Ramsar site.
- Details on where *Acrodipsas illidgei* is found in the Great Sandy Strait Ramsar site and info on how best to manage and monitor them.

**Related Ecological Components and Processes**

| Ecosystem Components and Processes | How they support the Ecosystem Service |
|---|---|
| **Climate:** Temperature | The Great Sandy Strait is at the interface of tropical and temperate provinces (IMCRA bioregionalisation) and the mangrove species composition reflects this (Duke 2006). Mangrove species distribution is limited latitudinally by the physiological tolerance of each species to low temperatures (Duke *et al* 1998). |
| **Energy and nutrient dynamics:** Nutrient cycling # | Certain fauna (eg crabs eating leaves) feed on mangroves and break down the vegetation into nutrients that are re-absorbed back into the system. |
| **Physical form:** Sedimentation | Sediment trapped may enable mangroves to expand their range if other ideal conditions prevail. |
| **Geomorphology** | Mangroves require sheltered coastal areas with ample exchange of marine water. The shelter of Fraser Island, a low energy shoreline has resulted in fluvial sediments being readily deposited in the Great Sandy Strait creating a substrate for mangroves. |
| **Hydrology:** Frequency and volume of freshwater inputs, frequency and duration of tidal inundation # | Freshwater inputs and tidal regime help regulate the growth, height, survival and zonation of mangroves. |
| **Climate/ Hydrology:** Rainfall # | The potential area of mangrove habitat depends on the area of suitable land with tidal inundation. However the total area of mangrove habitat in any region also appears to correlate well with rainfall (N. Duke, pers. comm., 2007). |
| **Physicochemical components:** Nutrient loads, turbidity, # | Mangroves are important in assimilating land derived nutrients and sediments. However, excessive sediment loads can stress or kill mangroves through direct smothering of the aerial roots of some species. |
| **Physicochemical components:** Water and soil salinity # | The level of salinity often influences the types of mangrove that will occur at a site. For example, in the Great Sandy Strait, *Avicennia marina* and *Rhizophora stylosa* dominate in saline locations, whilst *Aegiceras corniculatum* often form bands along the edge of rivers (Fisheries Research Consultants, 1993b). |

**#** Considered a critical Component or Process and thus described further in Section 4.3.

### 4.1.5 Ecosystem Service 5: Great Sandy Strait Ramsar site supports a substantial area of **sub-tropical inshore reefs including coral and sponge communities and species** near their latitudinal limits.

***Ramsar criteria met:*** *Criteria 3 & 8*

***Type(s) of service: Provisioning -*** *habitat for fish stocks of recreational value;* ***Cultural -*** *dive and fishing tourism;* ***Supporting -*** *contributes to biodiversity, nutrient cycling and processing, nursery and/or feeding habitat for many fish and invertebrate species.*

Several coral reefs and bommies occur in the shallow waters of the northern part of the Strait, including substantial coralline substrate and reef structure plus coffee rock and other substrata. Coral growth occurs primarily at the northern ends of Big Woody Island and Round Island and extends to at least 6m depth. Quickbird and Landsat imagery from 2006 and 2002 respectively have provided a basis for indicating the likely extent of coral reef habitat types for the site at the time of listing (1999). Whilst the Ramsar boundary intersects and excludes almost half (221ha) of the reef habitat on the northern end of Woody Island, management is for practical reasons focussed on the whole reef habitat area (500ha) rather than just the subset of what is inside the Ramsar boundary (278ha).These large reefs of the northern Great Sandy Strait, extending inside and outside of the Ramsar site, have been mapped by several categories of coral cover, and include in total approximately 99ha of habitat of at least 80% live hard coral cover (M. Zann, pers. comm., 2007).

Large freshwater and sediment loads associated with Mary River floods in February 1992 and February 1999 may have degraded parts of these reefs from their state prior to Ramsar listing, but historical information is presently insufficient to confirm this.

Striking sponges are found on coarse coral grit south of Little Woody Island at 10-13m depths, with hard and soft corals, hydroids, gorgonians, sea pens and small reefs of wormshell (*Vermiculariai sipha*) in the same area. Small areas of hard and soft coral also occur further south adjacent to islands in the Great Sandy Strait, near Tinnanbar in the southern part of the site (M. Zann, pers. comm., 2007), and two reefs are known within Tin Can Inlet. The northern coral reef habitats support local tourism businesses around diving and fishing, and a limited commercial industry in coral collection.

*Goneastrea* sp. hard coral, Great Sandy Strait Ramsar site.

Photo: courtesy of Kirsten Wortel, QPW.

Coral communities in the site are of biogeographic interest in supporting several species at or near their limits of their respective tropical and subtropical ranges, and are thus unusual communities in a transitional region (M. Zann, pers. comm., 2007). These reefs are at the northern part of a transition zone between tropical and temperate reef biotypes. Visual, non-quantitative assessments (M. Zann, pers. comm., 2007) indicate that the reefs of Round Island and Big Woody are likely to support at least 70 species of corals, including two unusual *Dendronephthya* species and several unidentified gorgonian species at Little Woody Island. They also include regionally significant examples (large stands) of *Turbinaria* reefs and bommies. The bommies of wormshell, *Vermiculariai sipha*, are thought to be the only ones in Queensland (M. Zann, pers. comm., 2007).

Proximity and connectivity between the coral reefs, seagrass and mangroves in the site are also likely to result in higher than normal fish species diversity on the reef habitats (Grober-Dunsmore *et al* 2007).

The coral reef habitat supports populations of scribbled angelfish (*Chaetodontoplus duboulayi*) and Müllers butterflyfish (*Chelmon mulleri*) at the southern end of the species' range, and population densities appear to have declined under harvesting pressure (K. Wortel; M. Zann, pers. comm., 2007). Scribbled angelfish was recently noted by Wabnitz *et al* (2003) as a "species of concern" in the global aquarium fish industry.

### Natural Variability and Limits of Acceptable Change

| Variable | Proposed Limits of Acceptable Change |
|---|---|
| **Area of live coral reef habitat:** The total area of coral reef habitat under management in the northern Great Sandy Strait at the time of Ramsar listing (1999) is estimated to be up to 500 ha. This includes 221 ha that is immediately outside the Ramsar boundary. Approximately 99ha of reef habitat is >80% live cover (hard coral), but the remainder is of <10% live coral cover. No quantitative estimates of historical change or variability are available at present, but might be obtainable through analysis of historical aerial photos. | **5.1** For the area of live coral reef habitat, information is insufficient for proposing a Limit of Acceptable Change, but the following **trigger for management intervention** is proposed:<br>• Any observed downward trends in total area of live coral reef habitat (combined hard and soft corals) or sponge/gorgonian habitat.<br>(Refer to **Monitoring Needs Section 8.5**) |
| **Cover of dominant coral growth types within core high density habitat:** live hard coral (dendritic, foliose, boulder) versus dead coral cover. Total live hard coral cover at monitoring sites in core high density habitat is at least 80 percent.<br>Reductions in coral cover may have commenced many years prior to the time of Ramsar listing for the Site, associated with major flood events in 1992 and 1999. Coral cover at Lady Musgrave Reefs (further north) dropped from 80% to 10% during the same flood events in 1992 and 1999, with recovery to only 40% from 1993 to 2000 (M. Zann pers. comm., 2007). | **5.2** For the cover of dominant coral growth types, information is insufficient for proposing a Limit of Acceptable Change but for coral reef and sponge/gorgonian habitats the following **triggers for management intervention** are proposed:<br>• Any observed downward trend in a) live hard coral cover or b) percent cover estimates of any key growth form or species.<br>• Any localised coral bleaching.<br>(Refer to **Monitoring Needs Section 8.5**) |
| **Extent of macro- and turf- algae cover:** macro-algae and turf-algae may increase on reefs due to excessive nutrient loads, and can continue to occupy substrate that is left following coral death. Filamentous algae associated with high sedimentation are also a useful indicator of adverse change. Shifts in cover from live hard coral to soft coral or macro-algae are important indicators of adverse impacts.<br>Natural variability in extent of macro- and turf- algae is not yet studied at the site. | **5.3** For the extent and percent of macro- and turf-algae cover, information is only sufficient for proposing an **interim Limit of Acceptable Change:**<br>• **20**% increase in macro- or turf- algae cover on monitoring sites for more than 2 years.<br>The following **trigger for management intervention** is proposed:<br>• a **10**% increase in macro- or turf- algae cover on monitoring sites for more than 2 years (**refer to Monitoring Needs, Section 8.5**). |

### Knowledge Gaps

- Improved baseline monitoring of the extent and species composition of coral reef and sponge garden habitat, and improved assessment of the biogeographic significance of these communities.

**Related Ecological Components and Processes**

| Ecosystem Components and Processes | How they support the Ecosystem Service |
| --- | --- |
| **Hydrology:** Tidal (seawater) exchange **#** | Regular and full tidal flushing and exchange of relatively clean seawater is essential to maintain water quality conditions for coral and sponge growth. |
| **Physicochemical components:** Nutrient loads, turbidity, and salinity sustained within present ranges **#** | Coastal corals have slightly higher tolerances to sediment and nutrient loads than offshore corals. Most corals have relatively specific requirements of salinity, temperature and turbidity. |
| **Geomorphology:** Sea-bed topography/ bathymetry; openings to the sea. | These corals are located at sites where hard substrates, strong tidal flushing and exchange of relatively clean seawater helps to maintain habitat and water quality conditions for coral growth. |
| **Physicochemical components:** Sea temperature **#** | Several coral species here are at or near their latitudinal limits, because of their specific temperature tolerances and needs. |

**#** Considered a critical Component or Process and thus described further in Section 4.3.

### 4.1.6 Ecosystem Service 6: Four **nationally threatened species of marine turtle** (green, loggerhead, hawksbill, flatback) occur annually in substantial numbers within Great Sandy Strait Ramsar site.

| |
| --- |
| ***Ramsar criteria met:*** *Criteria 2 & 3* |
| ***Type(s) of service: Supporting -*** *contributes to biodiversity.* |

The Ramsar site provides feeding habitats for at least four species of sea turtle, which occur regularly and in substantial numbers. Green turtles are numerically dominant and primarily feed on seagrass throughout the site. The feeding requirements of the main four species are (Kirkwood and Hooper 2004):

- Green turtles, (*Chelonia mydas*) - seagrass and invertebrates;
- Loggerhead turtles (*Caretta caretta*) - a range of invertebrates, but mostly gastropods, bivalves and portunid crabs, on sandy bottom and reef habitats;
- Hawksbill turtle (*Eretmochelys imbricata*) - predominantly sponges;
- Flatback turtle (*Natator depressus*) - soft corals and other sessile (non-motile) invertebrates, mostly on muddy bottoms in the deeper inter-reefal zone.

Two other species of sea turtle, the Pacific Ridley (or olive Ridley) and leatherback, have been recorded at the site but not in significant numbers or over long periods. Each of these six species is listed as threatened (either endangered or vulnerable) under State, Commonwealth and International categories (**Appendix 2**). The loggerhead, hawksbill and flatback turtles comprise part of populations that extend at least to the northern coastline of Australia and to the outer Coral Sea.

Most information is available for the green turtles. These animals are part of regional populations which extend roughly from northern New South Wales, north to Cape Melville and east to New Caledonia. The Great Sandy Strait population is part of the Southern Great Barrier Reef breeding stock, and most individuals migrate to and from specific nesting beaches in areas away from Great Sandy Strait (C. Limpus pers comm.. 2007). There is also some green turtle and loggerhead turtle nesting on Big Woody Island.

Young animals recruit to the area several years after hatching and a period of life presumably spent in the open sea. Whilst there is strong fidelity to feeding areas in southern Queensland, it is difficult to monitor local populations because of their diving behaviour and cryptic colourations.

Loggerhead turtle. *Caretta caretta*

Photo courtesy of Qld EPA.

**Natural Variability and Limits of Acceptable Change**

| **Variable** | **Proposed Limits of Acceptable Change** |
|---|---|
| Abundance of sea turtles (by species) using the site during non-breeding periods would be a useful indicator of this ecosystem service, but data on population numbers in the Great Sandy Strait is insufficient. A statistically reliable monitoring program for assessing local sea turtle numbers is not useful unless the whole meta-population is monitored. Turtle abundance in the site is thus not recommended as an appropriate indicator at this stage (C. Limpus pers comm.. 2007).<br><br>Rather, a set of other parameters on turtle biology are proving to be more useable and appropriate as early warning indicators for management to maintain health of the meta-populations. Green turtles are numerically dominant in Great Sandy Strait, and is the species for which most data is available to assist conservation; and is thus the species to which most of the following information refers. | |
| **Growth rates of young turtles** is perhaps one of the most useful parameters for assessing the health of sea turtle populations in Great Sandy Strait. They are a function of habitat quality and are likely to provide early warnings of change in population health (C. Limpus, pers. comm., 2007).<br><br>Information on inter-annual variability in growth rates is very limited for Great Sandy Strait. Growth rates of juvenile green turtles is a useful early warning of environmental stresses on the population (C. Limpus, pers. comm., 2007). | **6.1** For the growth rates of young marine turtles, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed. |
| **Physiological indices of "preparedness for breeding"** may also provide early indicators of population health. Percent of the population "ready to breed" (using hormone and metabolic markers) shows a relationship to El Niño climatic cycles (Limpus and Nicholls 2000, Hamann *et al* 2005).<br><br>Information on inter-annual variability in "readiness to breed" is very limited for Great Sandy Strait. | **6.2** For physiological indices of 'preparedness for breeding' for marine turtles, i**nformation is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed. |

**Knowledge Gaps**

- Inter-annual variability of growth rates in young green turtles in Great Sandy Strait;
- Inter-annual variability in physiological condition and "readiness for breeding" in adult green turtles at Great Sandy Strait;
- Confirmation on the regular occurrence of two additional threatened species of marine turtle: leatherback and Pacific Ridley; and
- Extent of feeding habitats for omnivorous and carnivorous turtles.

**Related Ecological Components and Processes**

| Ecosystem Components and Processes | How they support the Ecosystem Service |
|---|---|
| **Climate:** ENSO climatic cycles | There is a possible relationship between the Southern Oscillation Index (SOI), seagrass primary productivity and physiological health and abundance of green turtles (Limpus and Nicholls 2000). There appears to be a strong signal of a 2-year lag between peak La Niña and reduced numbers at nesting beaches, or from peak El Niño years to increased numbers at nesting beaches. ENSO and SOI related climatic conditions may directly affect condition and extent of seagrass food resources in feeding areas such as Great Sandy Strait (C. Limpus, pers. comm., 2007). |
| **Geomorphology:** Channel bathymetry # | Connectivity of riverine, estuarine and marine habitats. |
| **Energy and nutrient dynamics:** Seagrass primary production; secondary production (and abundance) of invertebrate food items for sea turtles **#** | Nutrient cycling processes that support seagrass primary production will influence the food volumes available for green turtles. Sources of nutrients are through river flow and marine waters. Primary production of seagrass food species and abundance of invertebrate food species are critical to supporting the local populations of sea turtles. |
| **Habitat condition, extent and diversity:** Extent and condition of preferred food resources, i.e. seagrasses, sponges, soft coral habitat and other benthic invertebrates **#** | Seagrass habitats and sessile invertebrates over soft and hard bottoms provide the key feeding habitats for sea turtles. A critical habitat component for green turtles is the extent of preferred seagrass species. Mangrove seeds (*Avicennia marina*) are also part of the diet of Great Sandy Strait green turtles (C. Limpus, pers. comm., 2007). For the loggerheads, hawksbill and flatback, abundance of invertebrate food sources is important e.g. in sandy bottoms, coral reef and sponge garden habitats. |
| **Physicochemical components:**: Water quality including salinity regimes **#** | Water quality parameters influence the health of seagrasses - the primary food resource for green turtles (see 4.1.3). Water quality also directly influences survival and abundance of the invertebrate food items eaten by other turtle species. |
| **Maintenance of animal and plant populations:** Turtle migrations to and from nesting locations | Turtle migrations to and from nesting locations and the Great Sandy Strait are fundamental to maintenance of populations using the site. The behaviour and physiological cues that underlie these migrations help to ensure that individual turtles come back to the same feeding grounds each year. |

**#** Considered a critical Component or Process and thus described further in Section 4.3.

### 4.1.7 **Ecosystem Service 7:** A relatively large number of species of **marine mammals** use the Great Sandy Strait Ramsar site, including several cetaceans and a local population of the **internationally vulnerable dugong.**

***Ramsar criteria met:*** *Criteria 2 & 4*

***Type(s) of service: Supporting -*** *Contributes to biodiversity, supports a threatened species.* ***Cultural -*** *Dugong are an important species in Aboriginal culture in the Great Sandy Strait.*

***Dugong***

The Great Sandy Strait Ramsar site has a resident population of around 400 dugong *Dugong dugon* (I.R. Lawler, pers. comm., 2007) a species listed as vulnerable under the *Queensland Nature Conservation (Wildlife) Regulation 1994* and the IUCN Redlist (IUCN 2006) but not under national legislation.

The site supports seven species of seagrass, three of which are considered preferable as dugong food types. Of these 3 species, *Halodule uninervis* is considered the most nutritious for dugongs followed by *Halophila ovalis* and *Zostera capricorni* depending on whether nitrogen or starch is the most important limiting nutrient in their diet (Sheppard, *et al* 2006). Dugong diet can also include some invertebrates (Preen 1995).

While more extensive seagrass habitat occurs adjacent to the site in Hervey Bay, the Great Sandy Strait is considered a refuge for dugongs with sheltered areas around Poona Point and Kauri Ck inlet being of particular importance (I.R. Lawler and J. Sheppard pers. comm., 2007). Other core habitat in the Great Sandy Strait is the northern side of Turkey Island and southern end of Big Woody Island (J. Sheppard, pers. comm., 2007)

Dugongs usually require shallow water away from seagrass for breeding (McKenzie *et al* 2000). It is not known whether they breed within the Great Sandy Strait. In terms of migration, Dugongs may stay within their core feeding habitat, make medium scale movement (15-100kms) within the Hervey Bay region, or large scale movements (>100kms) to other seagrass areas along the Queensland coast (Sheppard *et al* 2006b). It would appear that dugongs in the Great Sandy Strait move between a network of core seagrass habitats in the Ramsar site and adjacent Hervey Bay (J. Sheppard, pers. comm., 2007). It also appears that some dugongs in Hervey Bay move across to the coast off Sandy Cape for some time during the winter months to take advantage of the warmer waters that occur there (Sheppard *et al* 2006b) but it is not yet certain whether dugongs from the Great Sandy Strait are doing this.

***Dolphins***

The Indo-Pacific humpback dolphin *Sousa chinensis* is found in the Great Sandy Strait Ramsar site and, together with adjacent Hervey Bay, supports the largest known population of the species in Australia (Cagnazzi unpublished data 2006). It is listed as 'insufficiently known' under the *Action Plan for Australian Cetaceans* (Bannister *et al* 1996) and 'Data Deficient' under the IUCN Red List. Recent research in the Ramsar site suggests that 2 sub-populations of Indo-Pacific humpback dolphin occur there each containing over fifty dolphins (Cagnazzi *et al* 2005). The northern population is believed to have a home range from just north of the Maaroom Fish Habitat Area to the northern mouth of the Strait. Its core feeding habitat is believed to be around the Mary River mouth, around Little Woody Island and between Woody Island and Hervey Bay. Indo-Pacific humpback dolphins have been sighted in a wide range of water conditions in the Ramsar site and appear to remain mostly within 50 m of the shore, sandbanks or islands, in water less than 8 m deep (Cagnazzi *et al* 2005).

The Indo-Pacific humpback dolphin *Sousa chinensis*.

Photo: Daniele Cagnazzi.

Another two species of dolphin are believed to regularly occur in the Ramsar site, the common dolphin *Delphinus delphis* and the inshore bottlenose dolphin *Tursiops aduncus,* although it is not clear in what numbers and to what extent they depend on the site as part of their lifecycle. Recent work conducted on inshore bottlenose dolphins has indicated that their home range may occur in the north and north-western areas of the Ramsar site, with key feeding areas occurring directly opposite the Mary River mouth (Cagnazzi unpublished data 2006).

### *Whales*

Based on local sightings and the EPA strandings database, a total of seven whale species have been found in the Great Sandy Strait (QPW unpublished data and K. Wortel, pers. comm. 2007).

Of all the whale species found in the Ramsar site, the nationally and internationally vulnerable humpback whale *Megaptera novaeangliae* is the most well known and visible. It appears to use the site to rest during its southward migration to the Antarctic waters between August and October (Kirkwood and Hooper 2004). As their numbers continue to recover, humpback whales appear to be moving farther into the Strait. They have been observed entering the Strait on the incoming tide and have been seen as far south in the Strait as opposite Kingfisher Bay (K. Wortel, pers. comm., 2007) and stranded farther south near Ungowa (QPW unpublished data) They have also been known to enter in to Wide Bay Harbour (southern end of the strait) through the southern channel opening (K. Wortel, pers. comm., 2007).

Regular reports of other cetaceans such as melon-headed whales *Peponocephala electra* and pilot whales *Globicephala macrorhynchus* are recorded in the Ramsar site (K. Wortel, pers. comm. 2007) and minke whales *Balaenoptera acutorostrata* are also cited frequently in the northern end, travelling through the Straits as far south as Poona and Boonooroo (M. Zann, pers. comm., 2007). False killer whales *Pseudorca cras* have been stranded at Booral, south of Big Woody Island (QPW unpublished data). The internationally endangered sei whales *Balaenoptera borealis* have been stranded at Tuan and Tin Can Bay and the sperm whale *Physeter macrocephalus* has also been stranded. Both these whales are believed to be dead animals washed in from deeper waters. It is not clear in what numbers and to what extent these and other species of whales depend on the site as part of their lifecycle.

### Natural Variability and Limits of Acceptable Change

| Variable | Proposed Limits of Acceptable Change |
|---|---|
| **Abundance of dugong using the site.** The site supports a local population within the Great Sandy Strait Ramsar site of around 400 individuals at any point in time (I.R. Lawler, pers. comm., 2007). Numbers have exceeded this, for example, in 1992 when widespread loss of seagrass in Hervey Bay led to over 1300 animals seeking refuge in the Great Sandy Strait (Marsh *et al* 1995). Given the degree of movements possible within the Hervey Bay-Great Sandy Strait region and beyond (see above), the proportions of dugongs in the Great Sandy Strait that are resident or mobile are not yet clear. | **7.1** For the abundance of dugong, the **Limit of Acceptable Change** is:<br>• A reduction in the dugong population in the Great Sandy Strait to below 400 individuals for more than 2 years. |
| **Abundance of Indo-Pacific humpback dolphins using the site:** Studies done in 2004-2005 revealed two distinct populations in the Ramsar site totalling approximately 103 individuals (Cagnazzi *et al* 2005). In addition there were 26 individuals counted in the adjacent waters of Hervey Bay though it is not clear to what degree these mix with the populations in the Ramsar site. | **7.2** For the abundance of Indo-Pacific humpback dolphins, the **Limit of Acceptable Change** is:<br>• A detectable decline in the population of Indo-Pacific humpback dolphins using the site. |
| **Abundance of humpback whales using the site:** The number of incidental sightings of humpback whales in the Ramsar site has continued to increase since 1999 when the site was listed (K. Wortel, pers. comm., 2007). This species is recovering from heavy exploitation in the 1950s and 1960s (Kirkwood and Hooper 2004) and the ***number of sightings*** (per season) in the site is expected to continue to increase and eventually plateau. A baseline for future monitoring is still needed however. | **7.3** Information on the number of humpback whales using the site is insufficient for proposing a Limit of Acceptable Change, but the following **trigger for management intervention** is proposed:<br>• A downward trend in the frequency of humpback whale sightings in the site unless explainable by mortality or other causes operating outside the Ramsar site. |
| **Abundance of cetaceans, other than humpback whales and Indo-Pacific humpback dolphins, using the site:** Obtaining reliable counts of cetaceans can be expensive, and for many species, the numbers using the Great Sandy Strait may be influenced more by factors outside the site. | **7.4** For other cetaceans using the site, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed. |

### Knowledge Gaps

- Further studies to assess the level of genetic interchange between the two communities of Indo-Pacific humpback dolphins and to assess eventual immigration from other areas.
- Information on growth, health & population size of dugongs using in the Great Sandy Strait.
- Understanding of large-scale movements and tidal migrations of dugongs using the site.
- Clarity on which species of cetaceans are using the site and in what numbers they occur there.
- Movements and habitat needs of cetaceans using the Great Sandy Strait.

**Related Ecological Components and Processes**

| Ecosystem Components and Processes | How they support the Ecosystem Service |
|---|---|
| **Habitat Condition, Extent and Diversity:** Area and condition of seagrass. **#** | Seagrass habitats provide the key feeding habitats for dugong. Select sessile (non-motile) invertebrates over soft and hard bottoms are also diet items for dugong, but their importance is not well understood (Preen 1995). See also Ecosystem Service 3 |
| **Habitat Condition, Extent and Diversity:** Area and condition of mangrove, coral reef & sponge habitat. **#** | These habitats support food resources for dolphins. |
| **Geomorphology:** Channel bathymetry # | Connectivity between riverine, estuarine and marine habitats |
| **Water Quality:** Temperature | May influence migration of dugongs |
| **Energy and nutrient dynamics:** Food items # | Primary & secondary productivity supporting seagrass & fish |
| **Physicochemical components:** To support habitats and food webs **#** | A range of water quality parameters are critical to the productivity of seagrass and bait fish food which support these marine mammals (See Ecosystem Service 3 and Ecosystem Service 11). |
| **Physicochemical components:** Tidal exchange regimes and freshwater flow **#** | Tidal flows and water exchange through the Strait support bait-fish food for dolphins. Inundation regimes maintain feeding areas.<br>Major flow events impacting on seagrass growth/survival directly impact on dugong habitat and therefore distribution and probably survival. |

**#** Considered a critical Component or Process and thus described further in Section 4.3.

### 4.1.8 Ecosystem Service 8: The **nationally threatened water mouse** *Xeromys myoides* occurs in mangrove, saltmarsh and/or associated freshwater wetlands within Great Sandy Strait Ramsar site.

***Ramsar criteria met :*** *Criterion 2*

***Type(s) of service: Supporting -*** *Nationally threatened species*

The water mouse (formerly known as the false water rat) *Xeromys myoides* lives in areas of the intertidal and freshwater wetlands in the Great Sandy Strait Ramsar site. It is listed as vulnerable under the Queensland Nature Conservation Act, the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and internationally under the IUCN Redlist (IUCN 2006).

The water mouse occurs within intertidal wetlands and adjacent supra-littoral zones. It has a number of different and unusual nesting strategies (see Burnham 2000, Gynther and Van Dyck 2003) that it establishes in mangrove communities, sedgelands, saltmarsh and even the patterned fens on Fraser Island (R. Hobson, pers. comm., 2007). It is not known if they use the patterned fens at Cooloola western coastal plain although they are found in the adjacent intertidal zone (Burnham 2000). It would seem that the chosen location of the nest site, and therefore the nest type, is a balance between the ability to withstand spring tides versus proximity to the most highly productive resources of the mangrove zone (Van Dyck and Gynther 2003).

The southern half of the Ramsar site appears to be a stronghold for the water mouse. Intertidal and adjacent freshwater wetlands around the western coastal plains of Cooloola, Teebar Creek to the east, and Kauri Creek further north, are all considered to be important habitat (Burnham 2000). Habitat has also been identified between the Poona and Boonooroo areas as well as at August Creek on Fraser Island. They are known to nest in the patterned fens on Fraser though it is not clear whether they occur in areas that fall within the Ramsar boundary.

**Natural Variability and Limits of Acceptable Change**

| Variable | Proposed Limits of Acceptable Change |
|---|---|
| **Number of water mouse nests detected in the Ramsar site:** Given the cryptic nature of the water mouse, the number of nests is considered the predominant indicator of their presence or absence (see Burnham 2000 and Van Dyck and Gynther 2003) | **8.1** For the number of water mouse nests in use, the interim **Limit of Acceptable Change** is:<br>• Greater than a 10% reduction in the number of active water mouse nests. |
| **Diversity of water mouse nests detected in the Ramsar site:** The water mouse appears to favour the intertidal wetlands and adjacent supra-littoral zones where it has a range of available and suitable habitat to build its nests. The detection of a diversity of nest types (using the 5 types used in Burnham 2000 and Van Dyck and Gynther 2003) may therefore indicate that a healthy range of habitat is available. | **8.2** For the diversity of water mouse nests in use, the **interim Limit of Acceptable Change** is:<br>• Greater than 10% reduction in the use of any particular water mouse nest type (with priority given to habitat adjacent to pressures such as uncontrolled vehicle use or urban expansion). |

**Knowledge Gaps**

- Full extent of water mouse habitat within and outside the Ramsar boundary, eg., on the western parts of the Cooloola/ Inskip peninsular, Fraser Island and the mainland areas immediately west of the Ramsar site; and whether these receive adequate protection.
- Number of water mouse needed to maintain the population.

**Related Ecological Components and Processes**

| Ecosystem Components and Processes | How they support the Ecosystem Service |
|---|---|
| **Habitat condition, extent and diversity:** Freshwater and estuarine **#** | The water mouse requires a range of habitats such as mangroves, saltmarsh and sedgelands as foraging grounds. (Burnham 2000, Van Dyck and Gynther 2003). It also appears they use the patterned fens on Fraser extensively for feeding and nesting (R. Hobson, pers. comm., 2007). These habitats harbour a range of crustaceans, bivalves and other invertebrates that are the main components of the water mouses' diet. |
| **Geomorphology:** Wetland soils | The water mouse requires sediment substrate to build tunnels and nests. |
| **Geomorphology:** Topography | The shelter of Fraser Island has resulted in a low energy shoreline which means that fluvial sediments are readily deposited in the Great Sandy Strait creating a substrate for mangroves and adjacent intertidal wetlands. |

| | |
|---|---|
| **Hydrology:** Tidal regimes and freshwater flows # | These help regulate the growth, height, survival and zonation of mangroves. Tidal regimes have a particularly strong influence on where water mouse will choose to nest and the type of nest they will build. |

**#** Considered a critical Component or Process and thus described further in Section 4.3.

### 4.1.9 Ecosystem Service 9: The **nationally threatened fishes honey blue-eye and Oxleyan pygmy perch** occur permanently in freshwater swamps and/or in associated streams within the Great Sandy Strait Ramsar site.

| |
|---|
| ***Ramsar criteria met:*** *Criteria 2 & 3* |
| ***Type(s) of service: Supporting -*** *Nationally threatened species* |

The wallum heath plains and swamps, including the patterned fens, at both Fraser and Cooloola provide habitat for the nationally threatened honey blue-eye *Pseudomugil mellis* and the Oxleyan pygmy perch *Nannoperca oxleyana* (Ingram *et al* 2004a and 2004b; K. Neilson, pers. comm., 2007). They are both reported as being found within the Ramsar site boundary adjacent to the coastal margins along the west coast of Fraser Island and on the northwest coastal plain of the Cooloola section including Seary creek (K. Neilson, pers. comm., 2007) In addition the honey blue-eye has also been found in tributaries of Snapper and Teewah creeks in the south-west section of the Great Sandy Strait (HEV Area 1; K. Neilson, pers. comm., 2007) although it is not clear if these habitats fall within the Ramsar site. Both species have restricted patchy distributions (Pusey *et al* 2004). The most northerly distribution of Oxleyan pygmy perch is recorded adjacent to the Ramsar site in the Mary River system, specifically in Coondoo and Tinana Creeks (Pusey *et al* 2004).

Oxleyan pygmy perch
*Nannoperca oxleyana*
(Gunther Schneider)

Honey blue-eye and the Oxleyan pygmy perch appear to have similar habitat requirements in dystrophic acidic freshwater ponds and small streams with little stream flow and low water transparency. Substrate preference appears to be siliceous sands, fine muds, aquatic vegetation or plant debris and both species prefer dense aquatic vegetation along the margins such as emergent and submerged sedges (Arthington & Marshall 1993; Thompson *et al* 2000), aquatic macrophtyes and rushes (Pusey *et al* 2004).

The honey blue-eye has been recorded in small coastal streams, coastal and insular dune wetlands and lakes and lower tidal reaches of coastal streams (Pusey *et al* 2004). It is thought that the Oxleyan pygmy perch prefers more dense vegetation than the honey blue-eye (K. Neilson, pers. comm., 2007) in areas with leaf litter beds, undercut banks, woody debris and fine roots of riparian vegetation (Pusey *et al* 2004). It is also believed that they are both adversely affected by excessive turbidity and contaminants in the water as they have not been detected in a number of streams in the Ramsar site that have suitable habitat but that are subjected to disturbance (K. Neilson, pers. comm., 2007). Honey blue-eye cannot tolerate low dissolved oxygen levels and are susceptible to minor increases in nitrogen and phosphorous levels (Pusey *et al* 2004).

Hundreds of small honey blue-eye juveniles have been observed in shallow warm waters among sedges in streams feeding into Tin Can Bay (Pusey *et al* 2004).

The Oxleyan Pygmy Perch Recovery Plan (NSW Department of Primary Industries, 2005), prepared in accordance with NSW legislation and the Commonwealth EPBC Act (1999), and in collaboration with the Queensland EPA/Parks and Wildlife, identifies a number of Queensland organisations as potential contributors to its implementation in Queensland. In the Plan, water bodies supporting Oxleyan pygmy perch are recommended as components of Critical Habitat to be protected. This is regarded as a necessary step towards conservation and recovery of this species.

**Natural Variability and Limits of Acceptable Change**

| Variable | Proposed Limits of Acceptable Change |
|---|---|
| **Numbers of honey blue-eye and the Oxleyan pygmy perch that occur in the Ramsar site:** It appears the Oxleyan pygmy perch has high genetic variation which suggests that dispersal among populations is limited (Hughes *et al* 1999).<br><br>Genetic studies indicate that dispersal among isolated populations of honey blue-eye is also limited and thus loss of local populations would not be easily corrected by natural dispersal (Semple 1991; Pusey *et al* 2004).<br><br>**For both fish species it would thus be important to monitor numbers within subpopulations** to ensure the health of the overall populations, as subpopulations are unlikely to be restored by natural dispersal (Pusey *et al* 2004).<br><br>Seasonal variability in abundance has been recorded for honey blue-eye, which may be attributed to water temperature, flushing of large numbers of fish to intertidal areas below natural barriers due to flooding, and recruitment (Pusey *et al* 2004). | When information is obtained on population sizes or densities and their natural variability, statistically significant (detectable) declines can be measured.<br><br>**9.1** Information on the number of honey blue-eye and the Oxleyan pygmy perch is only sufficient for proposing an **interim** **Limit of Acceptable Change**:<br><br>• Significant decline in any sub-population of honey blue-eye or Oxleyan pygmy perch.<br><br>(Refer to **Monitoring Needs, Section 8.9**) |

**Knowledge Gaps**

- Full extent of honey blue-eye and Oxleyan pygmy-perch habitat within and outside the Ramsar boundary, eg., on the western parts of the Cooloola/ Inskip Penninsular, Fraser Island and the mainland areas immediately west of the Ramsar site.
- Population sizes and levels of natural variability of the honey blue-eye and the Oxleyan pygmy-perch in the Great Sandy Strait Ramsar site.
- The extent to which Oxleyan pygmy-perch and honey blue-eye rely on wallum heath swamps for nursery grounds, feeding, cover and spawning.

**Related Ecological Components and Processes**

| Ecosystem Components and Processes | How they support the Ecosystem Service |
|---|---|
| **Hydrology:** Freshwater inputs# | Sustained surface and groundwater flows provide links to wallum and wet heathlands and patterned fens. The pool formations of patterned fens have apparently formed in response to high volume surface freshwater flows from |

| | |
|---|---|
| | the dune systems (Ingram *et al*. 2004a).<br>Aquatic macrophytes are critical habitat for both species, and are susceptible to low water levels. Maintenance of hydrological connectivity within individual drainage systems should be a key conservation objective (Pusey *et al* 2004). |
| **Habitat condition, extent and diversity:** Habitat within coastal lakes, wallum swamps, non-forested swamps and streams **(**macrophytes, submerged and emergent sedges, patterned fens, riparian fine roots, woody debris)# | Acidic waters in coastal wallum lakes (including patterned fens) and streams with emergent and submerged reeds are the most suitable habitat for these two fish species. Ideal habitat has aquatic macrophyte vegetation that acts as important cover for insect feeding behaviour displayed by both species as well as shelter and reducing the impact of short periods of high flow that can disrupt spawning, increase fish movement and displace eggs (Pusey *et al* 2004). |
| **Hydrology:** Rainfall # | Ephemeral 'perched' swamps and lakes occur as part of the wallum complex and these are often highly dependant on rainfall for their freshwater input.<br>Rainfall is also important for linking streams and other water bodies that would help aid in the dispersal of populations.<br>Freshwater habitats within coastal wallum are particularly susceptible to local rainfall events. Drought affects perched/window lake water levels and creek discharge where aquatic macrophytes drown at high water levels and are destroyed by exposure at low levels. |
| **Geomorphology:** Wetland soils | **Low nutrient siliceous soils** (such as in the sand dunes on Fraser Island and Cooloola) are conducive to soft, poorly buffered waters which can become acidic when exposed to the **decomposing organic matter** present in the Ramsar site. |
| **Physicochemical components:** pH, N, P # | Dilute, **poorly buffered waters** will become acidic (low in pH) with high levels of **dissolved organic acids** sourced from decomposing organic matter.<br>Small changes in nitrogen and phosphorous levels in these water bodies may have deleterious affects to sub-populations of both species of fish. |

**#** Considered a critical Component or Process and thus described further in Section 4.3.

### 4.1.10: Ecosystem Service 10: Four species of **threatened acid frogs** occur permanently in the wallum swamps and lakes within the Great Sandy Strait Ramsar site.

***Ramsar criteria met :*** *Criterion 2*

***Type(s) of service: Supporting –*** *Four threatened species*

The wallum swamps, patterned fens and lakes within the Ramsar site provide habitat for the four threatened species of acid frog: the wallum sedgefrog *Litoria olongburensis*, the Cooloola segdefrog *L. cooloolensis*, the wallum rocketfrog *L. freycineti* and the wallum froglet *Crinia tinnula* (Meyer *et al* 2005). All four species are listed as threatened by the World Conservation Union (IUCN, 2006) while only the wallum sedgefrog is listed nationally as vulnerable under the EPBC Act 1999.

All four acid frog species are believed to be found within the Ramsar site boundary along the west coast of Fraser Island and on the northwest coastal plain of the Cooloola section (Meyer *et al* 2005). In addition, the wallum rocketfrog has been located in the southwest section of the site around Teebar Creek, and all but the Cooloola sedgefrog have been noted from the Tuan and

Maroom area (Meyer *et al* 2005). Due to a lack in survey effort, it is not clear to what extent these three species are surviving in wallum areas on the western side of the Great Sandy Strait and how much of this habitat is contained within the Ramsar site.

The prime breeding habitat for wallum sedgefrog, wallum rocketfrog and the wallum froglet are ephemeral (seasonally inundated) and semi-permanent perched swamps with emergent reeds, ferns and/or sedges (Meyer *et al* 2005). Fish are generally scarce at these sites (E. Meyer, pers. comm., 2007). The Cooloola sedgefrog prefers permanent freshwater ponds that have dense, aquatic vegetation along the margins such as emergent reeds (Meyer *et al* 2005).

Knowledge to date (Meyer *et al* 2005) indicates that the habitat for these species has declined or is under threat in areas adjacent to the Ramsar site.

Cooloola sedgefrog – one of four acid-tolerant frog species found within the Ramsar site. Photo: courtesy of H.B. Hines, QPW.

### Natural Variability and Limits of Acceptable Change

| Variable | Proposed Limits of Acceptable Change |
|---|---|
| **Abundance of four acid frog species:** Monitoring of wallum sedgefrog populations in New South Wales (Lewis and Goldingay 2005) established that long term studies are important to determine initial population sizes as the numbers may vary substantially from year to year.<br><br>Key habitat and populations for the four frog species needs to be identified and monitoring plans put in place in order for them to be properly managed (refer to Monitoring Needs, **Section 8.10**). | When information is obtained on population sizes or densities and their natural variability, statistically significant (detectable) declines can be measured.<br><br>**10.1** For the abundance of four acid frog species, information is only sufficient for proposing an **interim Limit of Acceptable Change**:<br><br>• Statistically significant decline in the numbers of these four frog species over five years. (refer to **Monitoring Needs, Section 8.10**) |

### Knowledge Gaps

- Key populations for the four acid frog species plus their size and natural variability in the Great Sandy Strait Ramsar site.
- The full extent of acid frog habitats (for feeding and breeding) within and outside the Ramsar boundary, e.g., on the western parts of the Cooloola/ Inskip Peninsular, Fraser Island and the mainland areas immediately west of the Ramsar site; and whether these receive adequate protection.

### Related Ecological Components and Processes

| **Ecosystem Components and Processes** | **How they support the Ecosystem Service** |
|---|---|
| **Hydrology:** Freshwater **#** | Sustained surface and groundwater flows provide links to wallum swamps as well as patterned fens (AREA 1 HEV). |
| **Geomorphology:** Wetland soils | **Low nutrient siliceous soils** (such as those in the sand dunes on Fraser Island and Cooloola) are conducive to soft, poorly buffered waters which can become quite acidic when exposed to **decomposing organic matter**. |
| **Habitat condition, extent and diversity:** Freshwater lakes, wallum swamps, patterned fens and creeks with fringing vegetation # | **Permanent acidic freshwater 'perched' lakes that have dense, aquatic vegetation along the margins** are ideal breeding habitat for the Cooloola sedgefrog.<br>**Ephemeral 'perched' swamps with emergent reeds, ferns and/or sedges in acidic waters** is the most suitable breeding habitat for the wallum sedgefrog, wallum rocketfrog and the wallum froglet. |
| **Physicochemical components:** pH **#** | Dilute, **poorly buffered waters** will become acidic (low in pH) with high levels of **dissolved organic acids** sourced from decomposing organic matter. |
| **Hydrology:** Rainfall **#** | The ephemeral 'perched' swamps that are the main breeding habitat for the wallum sedgefrog, wallum rocketfrog and the wallum froglet are mostly dependant on rainfall for their freshwater input.<br>Rainfall is also important to feeding the high dune systems that then feed into the permanent lakes, swamps and patterned fens. |

**#** Considered a critical Component or Process and thus described further in Section 4.3.

### 4.1.11 Ecosystem Service 11: Great Sandy Strait Ramsar site supports **substantial stocks of fishes, prawns and crabs** which may be subject to commercial or recreational harvest.

***Ramsar criteria met:*** *Criteria 3, 4 & 8*

***Type(s) of service: Provisioning -*** *food for indigenous, recreational and commercial fishing;* ***Cultural -*** *indigenous cultural uses and tourism.* ***Supporting -*** *contributes to biodiversity and food webs.*

The Great Sandy Strait tidal wetlands are extremely important habitats that provide food and shelter for juvenile and adult fish, prawns and other crustaceans. They support highly valued commercial and recreational fishing industries that extend beyond the boundary of the Ramsar site. The Burnett-Mary NRM region includes commercial fisheries estimated to be worth approximately $52M annually (Kirkwood and Hooper 2004). It is difficult to obtain an estimate of the economic value of fisheries resources generated solely within the Ramsar site. Within the site are commercial gill-net, seine-net, fixed-net (including a unique use of stripe net for selective prawn harvest), beam trawl, potting for crabs, aquarium fish collecting, limited coral collecting; as well as recreational line fishing, spear-fishing, bait netting, cast netting, bait collection (bloodworms and yabbies) and crabbing. The estuarine and coral reef fish stocks within the site also support some tourism for line fishing. The Great Sandy Strait supports nursery habitats for juvenile stocks of fish, prawns and crabs that migrate to adjacent nearshore and offshore waters as recruits into net, otter-trawl and pot fisheries that are significant contributors to the Queensland economy.

At least 39 fish and 6 crustacean species are taken as food by commercial, recreational and/or indigenous harvests, and include key target species such as sea mullet (including the estuarine phases), whiting, yellow fin bream, king salmon, barramundi, estuary cod, flathead, garfish, grunter, luderick, mangrove jack, tailor, mud crab, sand crab, banana, greasy-back and king prawns (Beumer and Halliday 1994). 63 species of fishes were recorded in one survey of the mangrove wetlands near Moon Point, at least 18 of which were important to commercial or recreational fishing (Hegerl 1993). Some 104 species of fish from 60 families were recorded from Tin Can Bay (Beumer and Halliday 1994), of which 39 species were of commercial, recreational or indigenous importance. Mary river estuary is the southern-most gill-net fishery for barramundi.

The fish fauna complex represents a mix of species at the transitional region between tropical and temperate marine and coastal zones, and includes many species at the edge of their geographic limits (Kirkwood and Hooper 2004). Proximity and connectivity between the seagrass and mangroves and some coral reefs in the site are likely to result in higher than normal fish species diversity in each of these habitats. A complete inventory of fish species for the whole Ramsar site would be a large task, and several habitats and areas have not been surveyed.

Several species use the site for part of their lifecycle and move to other habitats upstream (into freshwater) or to the continental shelf where they support substantial fisheries. A large proportion of the fish species within the site are diadromous, that is they must have passage between marine areas and estuarine or freshwater reaches of the Mary River and other coastal streams to complete their life cycle (Stockwell *et al* 2004). There are 39 species that migrate between the Mary River and estuarine or marine habitats to complete their life cycle (Kirkwood and Hooper 2004).

These migrations are triggered by flow (either low or peak flow according to species). The volume and extent of freshwater influence through mangrove estuaries also determines the area of suitable brackish habitat for juveniles.

The Mary River is relatively unregulated and, apart from the totally unregulated Baffle Creek (to the north), is considered one of the better examples of a relatively minimally-regulated coastal catchment in southeast Queensland. In-stream structures in the catchment currently include two barrages in the lower catchment, four dams in the upper catchment and several weirs (Brizga *et al* 2005).

**Natural Variability and Limits of Acceptable Change**

| Variable | Proposed Limits of Acceptable Change |
|---|---|
| **Diversity of fish species**: Some measures of species richness have been obtained for specific parts of the Ramsar site as part of fisheries resource studies. However no measures of change in species richness/ diversity have been attempted, and this is very difficult to achieve. | **11.1** For the diversity of fish species, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed. |
| **Indices of abundance for fish and crustacean target species**.<br>Measures of absolute abundance for fisheries stocks or populations in the Ramsar site have not been monitored and are difficult to monitor. Fishery catch statistics are collected for many species and areas, and whilst they do not necessarily reflect population abundance of the species being caught, may be the best available measure of health of this ecosystem service.<br>The Great Sandy Strait is either part of, or contributes juvenile recruitment stocks into, inshore net fisheries and trawl fisheries of the wider southern Queensland region, all of which are managed by the Queensland Government Department of Primary Industry and Fisheries with other stakeholders. The fisheries management programs are not in a position at present to manage populations at local scales or within discrete geographic areas such as the Great Sandy Strait[1], but are developing population indices for the fisheries | **11.2** For indices of abundance for fish and crustacean target species, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed.<br>Note: Fish and crustacean stocks within the site move across a large region and indices of abundance are currently assessed within regional fisheries which the Great Sandy Strait forms a part of. These fishery assessments are also at spatial resolutions currently too coarse for assessing fishery stocks within the |

| | |
|---|---|
| which Great Sandy Strait forms part of [2].<br><br>These indices include fishery catch statistics and fishery-independent statistics, and in some cases can potentially be assessed on data that is recorded on a 6 minute lat/long grid resolution. | discrete geographical area of the Great Sandy Strait Ramsar site. |

[1] Commercial and recreational fisheries catch data, collected from a number of sources, is held in the Queensland Fisheries Information System (QFISH). Up until 2004 the data was recorded and assessed at the 1 degree (lat/long) grid resolution. For the 1 degree geo-spatial grid areas that include the Great Sandy Strait, the total combined species annual catch for the commercial inshore net fisheries (all species combined) averaged about 1000 tonnes. Since 2004, QFISH catch data was recorded at a 6 minute (lat/long) geo-spatial grid resolution. However some of these grids still extend outside the Ramsar site boundary, thus may include catch data from areas adjacent to the Ramsar site.

[2] As some indication of possible variability in the commercial inshore net and pot fishery of the Great Sandy Strait, total annual catches in the whole south-eastern Queensland inshore net fishery over the 12 year period 1988-2000 varied up to 52% between a maximum 3260 tonnes and a minimum 1681 tonnes but was still considered to be a relatively stable fishery (Williams, 2000). These levels of regional fishery catch appeared to continue up to 2005 (QDPI&F CHRIS database).

[3] Aligning fisheries commercial logbook data with discrete spatial areas such as Great Sandy Strait is only one step towards achieving effective management of fish stocks (I. Brown, pers. comm., 2007): Recreational catch of inshore fish species often outweighs commercial catch and management tools vary according to the requirements of each species. Managing different fish species on small spatial scales can result in the development of complex management arrangements that are difficult to enforce. Anthropomorphic impacts such as water management, catchment management, barriers to fish passage and the introduction of pest fish species can also far out-weigh the effects of fishing in certain circumstances.

### Knowledge Gaps

- Natural levels of variability of fish stocks or populations;
- Natural mortality and other fishery-independent variables are not well understood for all species;
- Critical riverine and estuarine habitat and environmental flow needs for diadromous species;
- Response of different fish species to changes in freshwater flow regimes;
- Responses of fish to habitat rehabilitation;
- Improvements in design and performance of fishway structures for multiple species;
- Impacts of translocated and exotic species;
- Stock sizes of several target food species;
- Sustainability of current fisheries management practices;
- Food sources (eg. planktonic, micro-algal) for fish.

### Related Ecological Components and Processes

| Ecosystem Components and Processes | How they support the Ecosystem Service |
|---|---|
| **Climate:** Southern Oscillation Index (SOI), rainfall # | In central Queensland rivers (north of here), barramundi and banana prawns were significantly influenced by summer flow and rainfall (Halliday and Robins 2007; Robins & Ye, *In Prep.*): For both species, catch was positively correlated with flow in the same year. Barramundi catches were also significantly and positively correlated to flow lagged by three and four years, suggesting a recruitment effect. Similar correlations were seen with larger scale climatic variables (e.g. Southern Oscillation Index, Madden Julian Oscillation and sea surface temperature) lagged by four years. Such correlations are very likely to occur in the Mary River, given the life cycle requirements of the key fisheries species here. |

| Ecosystem Components and Processes | How they support the Ecosystem Service |
|---|---|
| **Geomorphology:** Connectivity of marine, estuarine and riverine surface waters. | Connectivity between upper freshwater reaches and estuarine/marine areas is crucial to several diadromous fish species, including many species of commercial and recreational value (Robins & Ye, In Prep.). Permanent **hydrological connectivity,** enhanced through annual high (river) flow events, between riverine habitat and lower reaches of the Mary River, is important for fishes using the Great Sandy Strait Ramsar site.<br><br>Sustained connectivity from the open sea to upstream reaches is necessary for fish and larval passage and transport of nutrients, foods and wastes. Water flow and connectivity between habitats should be maintained at levels that do not compromise these processes. |
| **Habitat condition, extent and diversity:** Marine and estuarine habitat diversity **#** | The Great Sandy Strait supports a very complex and diverse marine habitat system (beta diversity - saltmarsh, tidal flats, mangroves, seagrass, algae and coral bommies) and estuary mouths (rocky, muddy and sandy shorelines, seagrass, mangroves and snags), supports a correspondingly rich diversity of fish, crustaceans and other invertebrates. |
| **Habitat condition, extent and diversity:** Extent of critical habitats **#** | Critical habitats for spawning, feeding migration.<br><br>The large area of seagrass, mangrove, intertidal banks, estuarine and coral reef habitats lead to large wetland productivity and support for stocks of fish, crustaceans and invertebrates. A threshold area of mangrove habitat has been suggested that enhances fish production.<br><br>Points, ledges and channels are critical spawning and aggregation sites for fish, and are located at specific sites rather than widely distributed. |
| **Hydrology:** Freshwater flow regimes and tidal exchanges **#** | Total flow volumes determine exports of fresh water and associated sediment, nutrients and organic matter to receiving waters, provide cues affecting the behaviour of nearshore and resident estuarine fauna, and influence the ecological productivity of estuaries and receiving waters (Brizga *et al* 2005; Robins & Ye, In Prep.).<br><br>Halliday & Robins (2007) found significant correlations between freshwater flow and a number of statistics for several species of commercial and recreational value (eg. barramundi, king threadfin and summer whiting, banana prawns and mud crabs) in the Fitzroy and Calliope Rivers further north. From these correlations they observed that freshwater flow had clear positive influences on total fishery catches, growth and survival of recruits, juveniles and adults of several coastal species that used estuaries and/or freshwater habitats in their life cycle. They speculate that freshwater flows (and/or coastal rainfall) are important in delivering nutrients to the estuary, thereby creating environmental conditions favourable to species eaten by juvenile fish. Freshwater flows may also create, or allow access to, nursery habitats that are important for sustaining populations of estuarine fish and crustaceans.<br><br>Tidal intrusion to estuarine areas is needed to create habitat water quality conditions suitable all estuarine-dependant species. |
| **Geomorphology:** Channel bathymetry/connectivity # | Connectivity between riverine, estuarine and marine habitats is essential to allow some species to complete their life cycle, |
| **Physicochemical components:** Particularly turbidity and salinity **#** | Flow-driven changes in salinity and turbidity are important factors influencing the distribution and abundance of fish and crustaceans (Brizga *et al* 2005) and determine the freshwater and saline cues for certain species to emigrate. |

| Ecosystem Components and Processes | How they support the Ecosystem Service |
|---|---|
| **Energy and nutrient dynamics:** Primary and secondary productivity **#** | Nutrients exported from rivers to coastal areas stimulate the production of microalgae, which are thought to be important primary sources of energy to coastal food webs and fisheries (for example, Fry and Wainwright 1991; Mallin *et al* 1992). Fish contribute to nutrient cycling in mangrove and seagrass systems. **Primary production** within seagrass and mangrove wetlands is crucial to large herbivores (e.g. dugong and green turtles) and supports complex detritus-based food webs and fisheries stocks. Indicators of plant health may be useful early indicators of changes in primary production and value for herbivores and food webs. |

**#** Considered a critical Component or Process and thus described further in Section 4.3.

### 4.1.12 Ecosystem Service 12: Great Sandy Strait Ramsar site supports **large numbers of waterbirds (>20 000) with 8 species of shorebirds occurring in numbers >1% of their population**, including the highest counts in the world for far eastern curlew.

***Ramsar Criteria Met:*** *Criteria 3, 5 & 6*

***Type(s) of service: Cultural:*** *tourism, aesthetics;* ***Supporting:*** *contributes to biodiversity, nutrient cycling on mudflats*

The Great Sandy Strait is one of the most important shorebird areas in eastern Australia. It holds up to 46,000 shorebirds during the non-breeding season (November to February) with internationally significant numbers of seven migratory species (far eastern curlew, whimbrel, bar-tailed godwit, grey-tailed tattler, greenshank, lesser sand plover and terek sandpiper) and one non-migratory species (pied oystercatcher) during those periods (Harding *et al* 2005).

There are 50 known shorebird roosts in the area, including over 40 key roost sites in the Great Sandy Strait (Harding *et al* 2005). Over 60% of these occur on the western shore, where threats of coastal development and human disturbance are greatest. Some of these western shore roost sites are not yet adequately mapped to determine whether they are entirely within the Ramsar site, but are most certain to be used by birds that feed within the site and should be included when considering management issues and threats for the site.

The most abundant wading bird in the Great Sandy Strait is the bar-tailed godwit (Driscoll 1998), which made up over 50% of the waders counted by the Queensland Waders Study Group. Bar-tailed godwits are found in numbers exceeding 1000 at 5 sites (Harding *et al* 2005). These are Puthoo Creek (east of Moon Pt) on Fraser Island, Inskip Point (at the southern mouth of the Strait) and three sites on the western shore near Thangawan Creek and Boonooroo. It is not clear whether Thangawan Creek roost site falls within the Ramsar boundary.

The maximum counts of the far eastern curlew in the Great Sandy Strait Ramsar site (6,018 in 1993) are the largest recorded for this species worldwide (Bamford *et al* 2006). There are 7 roost sites where far eastern curlew are found in numbers exceeding 100 (Harding *et al* 2005). These are at Mangrove Point South Claypan, Thangawan Creek, Boonooroo section 2, Boonooroo section 3, Poona Creek, Kauri Creek and Inskip Point. Of these, 6 are on the western side of Great Sandy Strait and three (Mangrove Point, Thangawan Creek and Poona Creek) are at or just outside the Ramsar boundary. One roost site (Mangrove Point South Claypan) hosts numbers of far eastern curlew that exceed 1% of the total flyway population. This important site is of particular concern given its close proximity to the built up area in the northwest of the Ramsar site.

Far eastern curlew (pictured): numbers in the Great Sandy Strait Ramsar site are the highest site counts for this species worldwide. Photo: Norio Kawano.

In addition to the above-mentioned Mangrove Point South Claypan, other important sites include Thangawan Creek, the Boonooroo area and Inskip Point. All of these roost sites are subject to disturbance and some to development threats.

**Natural Variability and Limits of Acceptable Change**

| Variable | Proposed Limits of Acceptable Change |
|---|---|
| **Shorebirds numbers (species which exceed the 1% threshold):** The great majority of shorebirds in the Great Sandy Strait are migratory species, so their numbers fluctuate seasonally every year. They may also be influenced by factors in other parts of the populations' migratory routes. Driscoll (1990, 1998) did not notice any significant increase or decrease in the total number of shorebirds in the Great Sandy Strait between 1990 and 1997.<br><br>The far eastern curlew and the bar-tailed godwit are two easily distinguishable and relatively conspicuous species that use fairly accessible roosts such as sand bars and claypans. They both comfortably meet the 1% threshold at the site and could provide a surrogate for all seven species present at the site in numbers exceeding 1% of their population. The Limits of Acceptable Change proposed here are based on current understanding of population dynamics and biology of the species at Great Sandy Strait (Driscoll 1998), plus the statistical power required to detect population changes for large migratory shorebirds at major Australian sites (Rogers et al 2006; Gosbell and Clemens 2006; Milton and Driscoll 2006). | **12.1** For shorebird numbers, the **Limit of Acceptable Change** is:<br><br>• Using the larger, dominant and easily measurable species (as a surrogate for all shorebirds which exceed the 1% threshold) - the December/January counts of far eastern curlew or bar-tailed godwit in the Ramsar site decline to 40% below the baseline level for 3 out of any 7 years.<br><br>**Note:** These two dominant species are suggested as useful proxies for numbers of other shorebirds using the site, but other species may be included for monitoring ecological character if considered appropriate. (Refer to **Monitoring Needs, Section 8.12** ) |

**Knowledge Gaps**

- Extent to which the Ramsar boundary adequately protects roost sites

- Natural variability in shorebird numbers in relation to particular feeding areas and roost sites; and the influence of variability in shorebird food resources (eg abundance and composition of invertebrate fauna) on shorebird numbers using tidal flats
- Condition of benthos and shorebird food resources in key feeding areas

**Related Ecological Components and Processes**

| Ecosystem Components and Processes | How they support the Ecosystem Service |
|---|---|
| **Habitat extent, condition and diversity:** Feeding and roosting areas **#** | Shorebird feeding areas - mudflats, sand flats and saltmarsh<br>Shorebird roost sites - sand spits and some mangrove areas |
| **Maintenance of animal and plant populations:** Migration | The majority of shorebirds migrate to the site for the September to March period from breeding areas in the Russian Far East. Suitable conditions at wetlands along their whole flyway are needed to maintain these populations. |
| **Hydrology:** Tidal regime # | Tidal inundation over tidal flats determines area of suitable and available feeding habitat. |
| **Geomorphology:** Sedimentation | Coastal sediments that are transported and deposited along the coastline arise from fluvial, continental shelf and shoreline sources (Beach Protection Authority, 1989). The Mary River is the main source of fluvial sediments to Great Sandy Strait. |
| **Energy and nutrient dynamics:** Nutrient cycling | Primary and secondary productivity of seagrasses, algae, invertebrates and fish on the tidal flats are essential processes in ensuring food supplies for shorebirds. Shorebirds also play an integral role in cycling nutrients through the system through their waste products. |
| **Physicochemical components:** Water quality **#** | Water quality is crucial to maintaining high primary and secondary productivity on the Great Sandy Strait tidal flats where shorebirds feed. |
| **Energy and nutrient dynamics:** Food abundance and availability # | Tidal-flat benthos and small fish and crustaceans are the primary food source for shorebirds. Their productivity and abundance is necessary for birds arriving and leaving on their annual migration flights. |

**#** Considered a critical Component or Process and thus described further in Section 4.3.

### **4.1.13 Ecosystem Service 13:** Great Sandy Strait Ramsar site contains sites of considerable **significance to indigenous Australians** and natural resources that potentially may be harvested sustainably by indigenous people using traditional methods.

***Ramsar Criteria Met:*** *Criteria 2, 3 & 4*

***Type(s) of service: Cultural -*** *Indigenous heritage in and around Great Sandy Strait* ***Provisioning -*** *traditional food, medicines and spiritual connections.*

The site is part of traditional lands of the Butchulla Nation (including Wondunna clan), and is currently used by these people.

Physical evidence of Aboriginal occupation of coastal parts of the region dates back at least 5,500 years. Shellfish, mullet and other fish species are commonly used foods. Dugong were harvested on a limited scale for ceremonial occasions, but this was discontinued in 2004. Dolphins, dugongs, turtles, seagrass and mangroves all provide a strong ongoing cultural significance. Sea turtles are no longer hunted here but are of cultural importance, and a particular island site is noted as their resting (passing on) place. Certain creeks and waterways hold ongoing spiritual significance; and bush medicines and bush foods are also used regularly, all within their special cultural, spiritual and conservation contexts (Nai Nai Bird, pers. comm., 2007).

A large number of recorded archaeological sites remain along the coastline and islands (McNiven 1991; Frankland 1990). Recent surveys found approximately 100 points of interest in Tin Can Inl*et al*one, and several thousand sites are likely throughout the Great Sandy Strait (L. Barrowcliffe (Kalulah Bird), pers. comm., 2007). These include shell middens, stonewalled fish traps, ceremonial bora rings, stone artefact scatters, painting clay (for painting & dietary intake), tree scars as markers and signs, and burial sites. Particular locations hold special "booral" shells that were very highly valued in stories, ceremony and in regional trade. Indigenous people also cultured natural oysters along rock piles in the Great Sandy Strait before European settlement.

Oyster aquaculture was conducted by indigenous people in Great Sandy Strait before European settlement. Photo: Luke Barrowcliffe

Traditional burning practices, eg. in wallum and peat swamps, were used to (spiritually) "cleanse" a site as well as minimise build-up of "fuel vegetation".

Whilst some of the abovementioned uses of the site may be significantly reduced, spiritual and cultural values remain strong; and significant sites, cultural signs and artefacts are maintained wherever possible. The remaining indigenous users also restrict conduct of their normal cultural and spiritual activities to minimise potential conflicts with mainstream society and law, and for conservation reasons (Nai Nai Bird, pers, comm., 2007).

**Natural Variability and Limits of Acceptable Change**

| Variable | Proposed Limits of Acceptable Change |
|---|---|
| **Also see other relevant Ecosystem Services: 2, 3, 4, 5, 6, 7.** | |
| **Quality and integrity of landforms and habitats that hold spiritual value and/or used by indigenous people**.<br>Natural variability of key wetland habitats in the site are described in relevant sections on freshwater wetlands, seagrasses, mangroves and coral reefs. Changes in other physical features of cultural value are likely to be mostly minimal, but potentially more vulnerable now to disturbance and degradation by tourism or recreational use of the area. | **13.1** For landforms and habitats that hold spiritual value and/or used by indigenous people, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed. |
| **Abundance and condition of artefacts, structures and sites** that hold cultural significance: eg. "booral" shell, oyster areas, fish traps, middens, bora rings. | **13.2** For the abundance and condition of artefacts, structures and sites that hold cultural significance to indigenous Australians, |

| | |
|---|---|
| | **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed.<br><br>(Refer to **Monitoring Needs, Section 8.13**) |
| **Species and communities of wetland fauna and flora:** Biology of specific wetland plants (eg., changes in flowering or growth) often include signals and indicators of related ecosystem conditions or spiritual events. Vegetation types related to traditional burning regimes is also important aspect of indigenous culture in the site (L. Barrowcliffe, pers. comm., 2007).<br><br>Several changes in species composition at the site have been noted by indigenous people, but as yet not quantified. | **13.3** For species and communities of wetland fauna and flora of considerable significance to indigenous Australians, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed. |

### Related Ecological Components and Processes

| Ecosystem Components and Processes | How they support the Ecosystem Service |
|---|---|
| **Geomporphology:** Geo-physical landscape features with spiritual value and/or use by indigenous communities in passage through the site **#** | Many geo-physical landscape features of the wetland are a critical part of dreaming stories and creation stories for the site. These are inextricably linked to the spiritual origins of the indigenous people that are attached to these sites, and continue as important to the ongoing spiritual integrity of the people.<br><br>Advice needed on specific sites and features of importance. |
| **Habitat condition, extent and diversity:** Food and medical resources **#** | Seagrass habitats and sessile invertebrates over soft and hard bottoms provide the key feeding habitats for fish, crabs, dugong, sea turtles. Fish traps are also present, but their location and numbers are not willingly disclosed to non-users. |
| **Energy and nutrient dynamics:** Primary and secondary productivity supporting key resources) **#** | Productivity and health of the wetland types, fish, crabs, dugong and sea turtle populations are all considered important to the cultural and spiritual values of indigenous communities that use the site. |
| **Physicochemical components:** Water quality **#** | The traditional owners have advised EPA that good water quality is important to maintaining quality of open water, river and riparian habitats where they source food and spiritual and cultural values. Within indigenous cultural and spiritual contexts, water quality is considered equally important as abundance and health of the habitat or food resources. |

**#** Considered a critical Component or Process and thus described further in Section 4.3.

### Knowledge Gaps

- Impacts of camping and previous sand extraction on adjacent intertidal habitats (eg. Pelican Bay, Tin Can Bay) and requirements for recovery.
- Specific threats and impacts need to be further assessed and addressed in consultation with traditional owners.

### 4.1.14 Ecosystem Service 14: Great Sandy Strait Ramsar site contains a rich diversity and abundance of natural resources that support a range of **nature-based tourism and recreational activities.**

| |
|---|
| ***Ramsar Criteria Met:*** *Nil* |
| ***Cultural:*** *Recreation, aesthetics, nature-based tourism economy.* |

By virtue of the large and visually aesthetic coastal wetland landscape, and rich diversity and abundance of wetland types, shorebirds, dolphins, dugongs, fish, crabs, prawns, and several threatened species, a range of nature-based tourism and recreational activities are supported in the site. These include:

- barge and ferry services which cross the site to Fraser Island from Urangan, River Heads and Inskip Point,
- recreational and tourism boating, coral viewing, diving, spear fishing and line fishing; shorebird, dolphin and dugong watching,
- aesthetic and wilderness experiences.

**Tourism and recreation** is an ecosystem benefit/service which is supported by the site's critical ecological components and processes. However it is one of the few elements of the site's ecological character that is not necessary for maintaining or supporting other components or processes in the site. Moreover, it may be diminished without resulting in adverse consequences to the site's key ecosystem components and processes.

Increases in tourism and recreational use may have adverse impacts on the site unless sustainable-use practices and activities are achieved.

**Natural Variability and Limits of Acceptable Change**

| Variable | Proposed Limits of Acceptable Change |
|---|---|
| **Also see other relevant Ecosystem Services: 1,2,3,4,5,6,7,8,11,12** | |
| **Number of tourists or recreational users (by type of use):** Use of the site forms part of a wider regional tourism and recreation industry, and data on total annual use cannot presently be separated from the regional statistics. Within the region, numbers of users have increased over several decades, along with increases in local and regional populations and with greater facilities for access to natural and remote areas. | **14.1** For the number of tourists or recreational users, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed.<br>(Refer to Monitoring Needs, Section 8.14) |
| **Quality and integrity of landforms and habitats that are considered attractions for tourism and recreation activities.**<br>Natural variability of key wetland habitats in the site are described in relevant sections on seagrasses, mangroves and coral reefs. The major geo-physical features of recreational and aesthetic value (vast waterway and landscape) are likely to change minimally, but reduced water quality and increased development could potentially compromise the current aesthetic value of the site. | See relevant proposed limits of acceptable change for Ecosystem Services: 1, 2,3,4,5. |

| Variable | Proposed Limits of Acceptable Change |
|---|---|
| **Abundance of significant and targeted fauna** using the site: e.g., dolphins, dugong, turtles, targeted food fish, prawns, crabs.<br>Natural variabilities of significant and targeted fauna are described in relevant sections on ecosystem services relating to mammals, sea turtles and fisheries. | See relevant proposed limits of acceptable change for Ecosystem Services: 6,7,8,11,12. |

### Knowledge Gaps

- Quantitative estimates of recreational and tourism use at the site
- Direct impact of tourism on the value of the straits
- Trends in visitor numbers and projected population within the region influencing the straits
- External factors influencing tourism and recreational use within the Ramsar site.

### Related Ecological Components and Processes

| Ecosystem Components and Processes | How they support the Ecosystem Service |
|---|---|
| **Habitat condition, extent and diversity:** Habitats with recreational, aesthetic and tourism value. **#** | Mangroves, seagrass habitats, coral reefs and sessile invertebrates over soft and hard bottoms provide important feeding habitats for dugong and sea turtles, fish prawns or crabs – all species that attract tourism and recreational use. |
| **External factors:** Economic, social or political factors may affect the broader tourism and recreation industry and thus total use of this site. | Growth in local economies, demographics and social patterns can enhance this element of the ecological character. However visitor perceptions on quality of experience, and impacts on other components of ecological character at the site, may be compromised by increased human use. |
| **Geomorphology:** Landscape features with recreational, aesthetic and tourism value. # | The spectacular landforms, landscapes, and aesthetic amenity of the site overall are some of the key features of the site that provide value as an attraction for eco-tourism, wilderness experiences and recreation activities. |
| **Physicochemical components:** Water quality | Good water quality is important to maintaining primary and secondary productivity and condition (health) of the wetland habitats and fauna that support these tourism and recreational activities. |

# Considered a critical Component or Process and thus described further in Section 4.3.

## 4.2 Overview of Critical Components and Processes which support the Ecosystem Services

Of the several components and processes associated with the 14 critical ecosystem services of the Great Sandy Strait Ramsar site, a subset of critical components and processes are identified below (**Tables 7 and 8**) and described in detail in Section 4.3. These are considered of the greatest importance in maintaining the ecological character of the Ramsar site and have been attributed variables that should be monitored in order to advise management decisions that would help maintain the site's ecological character.

Most components and processes support several ecosystem services. Some may directly represent an aspect of the site's unique character. Components and processes that support ecosystem services associated with the freshwater wetlands have been presented separately to those that support services associated with estuarine and marine wetlands.

Users of the following information should be aware that the complex inter-dependence of critical ecosystem components, processes and services is such that a change detected in any single component might NOT immediately equate to a change in other dependant components or services. Nevertheless, a sufficiently large change in that component would still be used to trigger an appropriate management response.

**Table 7. Summary of Freshwater Ecosystem Services and their critical components and processes for the Great Sandy Strait Ramsar site.**

| Ecosystem Services (Freshwater Wetlands) | Critical Components and Processes | | |
|---|---|---|---|
| | A. Habitat Extent, Condition and Diversity See 4.3.1 | B. Hydrology See 4.3.2 | C. Physicochemical components See 4.3.3 |
| **2**. A substantial area of peat swamp, consisting mainly of the **regionally unique patterned fens,** occurs within the Great Sandy Strait Ramsar site. | | Sustained freshwater flow (surface and sub-surface) feed and form the patterned fens | Poor Buffering Capacity / Low pH |
| **8.** The **nationally threatened water mouse** *Xeromys myoides* occurs continuously in mangrove, saltmarsh and/or in associated freshwater wetlands within the Great Sandy Strait Ramsar site. | Freshwater component - sedges and fens (also found in the intertidal zone – covered in estuarine table) | | |
| **9.** The **nationally threatened fishes honey blue-eye and Oxleyan pygmy perch** occur permanently in freshwater swamps and/or in associated streams within the Great Sandy Strait Ramsar site. | Habitat within coastal lakes, wallum swamps, non-forested swamps and streams (macrophytes, submerged and emergent sedges, patterned fens, riparian fine roots, woody debris | Sustained surface and groundwater flows to support patterned fens, wallum swamps, lakes and streams<br>Rainfall to feed habitat and aid dispersion through runoff | Poor Buffering Capacity / Low pH |
| **10.** Four species of **threatened acid frogs** occur permanently in the wallum swamps and lakes within the Great Sandy Strait Ramsar site. | Freshwater lakes, wallum swamps, patterned fens and creeks with fringing vegetation | Sustained surface and groundwater flows to wallum swamps<br>Rainfall to feed perched lakes | Poor Buffering Capacity / Low pH |

**Table 8. Summary of Estuarine Ecosystem Services and their critical components and processes for the Great Sandy Strait Ramsar site.**

| **Ecosystem Services** (Estuarine & Marine Wetlands) | **D.** Habitat Extent, Condition and Diversity See 4.3.4 | **E.** Hydrology See 4.3.5 | **F.** Physicochemical components See 4.3.6 | **G.** Geomorphology See 4.3.7 | **H.** Energy & Nutrient Dynamics See 4.3.8 |
|---|---|---|---|---|---|
| **1.** Great Sandy Strait Ramsar site includes **a large sand island and passage estuary** which provides habitat and **migration pathways** for marine animals (fishes, prawns, turtles) between riverine, sheltered nursery/feeding areas and open ocean**.** | | Freshwater flow from adjacent catchment and Fraser Island | | Bathymetry/connectivity between riverine, estuarine and marine habitats | |
| **3.** A regionally significant area of **seagrass habita**t and **diversity of seagrass species** occurs within the Great Sandy Strait Ramsar site. | | Freshwater flow and tidal exchange regimes | Nutrient loads, turbidity, toxins, light and salinity | | Seagrass growth |
| **4.** Great Sandy Strait Ramsar site supports a **large and diverse area of mangrove communities** as part of a tidal wetlands ecosystem that also supports an **endangered butterfly**. | (Also see Ecosystem Service 4 variables) | Rainfall<br>Frequency and volume of freshwater inputs, frequency and duration of tidal inundation | Water and soil salinity regimes<br>Nutrient loads and turbidity | | Nutrient cycling |
| **5.** Great Sandy Strait Ramsar site supports a substantial area of sub-tropical inshore reefs including **coral and sponge communities and species** near their geographic limits. | (Also see Ecosystem Service 5 variables) | Tidal (seawater) exchanges essential for water quality over coral and sponge colonies | Nutrient loads, turbidity, salinity and sea temperature | | |
| **6.** Four **nationally threatened species of marine turtle** (green, loggerhead, hawksbill, flatback) occur annually in substantial numbers within Great Sandy Strait Ramsar site. | Extent and condition of preferred food resources, i.e. seagrasses, sponges, soft coral habitat and other benthic invertebrates | | Water quality to support habitat and food webs (Also see Ecosystem Services 3,4,5) | Channel bathymetry/connectivity | Seagrass primary production; secondary production (and abundance) of invertebrate food items for sea turtles |
| **7.** A relatively large number of species of **marine mammals** use the Great Sandy Strait Ramsar site, including several cetaceans and a local population of the **internationally vulnerable dugong**. | Area & condition of seagrass habitat (of preferred food species)<br>Area and condition of mangrove, coral reef & Sponge habitat – which support foods for dolphins | Tidal exchange regimes and freshwater flow | Water quality to support habitats and food webs consistent | Channel bathymetry/connectivity | Primary & secondary productivity supporting seagrass & fish (food items) |

| **Ecosystem Services**<br>**(Estuarine & Marine Wetlands)** | **D.**<br>**Habitat Extent, Condition and Diversity**<br>**See 4.3.4** | **E.**<br>**Hydrology**<br>**See 4.3.5** | **F.**<br>**Physicochemical components**<br>**See 4.3.6** | **G.**<br>**Geomorphology**<br>**See 4.3.7** | **H.**<br>**Energy & Nutrient Dynamics**<br>**See 4.3.8** |
|---|---|---|---|---|---|
| **8.** The **nationally threatened water mouse** *Xeromys myoides* occurs in mangrove, saltmarsh and/or associated freshwater wetlands within the Great Sandy Strait Ramsar site. | Estuarine component: Supralittoral mangroves, and saltmarsh | Tidal regimes: influences nesting preference and food availability preferences | | | |
| **11.** Great Sandy Strait Ramsar site **substantial stocks of fishes, prawns and crabs** which may be subject to commercial or recreational harvest. | Habitat diversity<br>Extent of critical habitats (spawning, feeding, migration) | Freshwater flows<br>Tidal exchanges<br>Rainfall<br>SOI | Water quality , especially turbidity and salinity | Connectivity between riverine, estuarine and marine habitats (channel bathymetry) | Primary and secondary productivity (of habitat & food items) |
| **12.** Great Sandy Strait Ramsar site supports **large numbers of waterbirds (>20 000) with 8 species of shorebirds occurring in numbers >1% of their population**, including the highest counts in the world for far eastern curlew. | Feeding and roosting areas | Tidal regimes | Water quality | | Food abundance and availability |
| **13.** Great Sandy Strait Ramsar site contains sites of considerable **significance to indigenous Australians** and contains natural resources that potentially may be harvested sustainably by indigenous people using traditional methods. | Food and medical resources | | Water quality supporting critical wetland habitats and foods | Landscape features with spiritual value and/or use by indigenous communities in passage through the site | Primary and secondary productivity supporting key resources |
| **14.** Great Sandy Strait Ramsar site contains a rich diversity and abundance of natural resources that support a range of **nature-based tourism and recreational activities.** | Habitats with recreational, aesthetic and tourism values | | | Landscape features with recreation, aesthetic and tourism value | |

## 4.3 Detailed Description of Critical Components and Processes

The critical components and processes are outlined in more detail below (sub-sections 4.3.1 to 4.3.8) and are displayed in **Figure 7**. Each sub-section contains the ecosystem services the component or process relates to and a general description. In addition one or more specific variables (parameters) that are appropriate for monitoring and to help alert managers to pending changes in ecological character of the site were identified. Where possible, levels of natural variability have been described as understood from expert and literature sources.

Using the available knowledge about levels of natural variability for these variables, Limits of Acceptable Change have been proposed. Depending on the role of the relevant component or process, the Limit of Acceptable Change was equal to the known, or expected, boundaries of natural variability, or a more conservative threshold was proposed. In some cases information and expert advice was insufficient to propose any threshold.

The proposed Limits of Acceptable Change should be improved as new information is obtained on levels of natural variability.

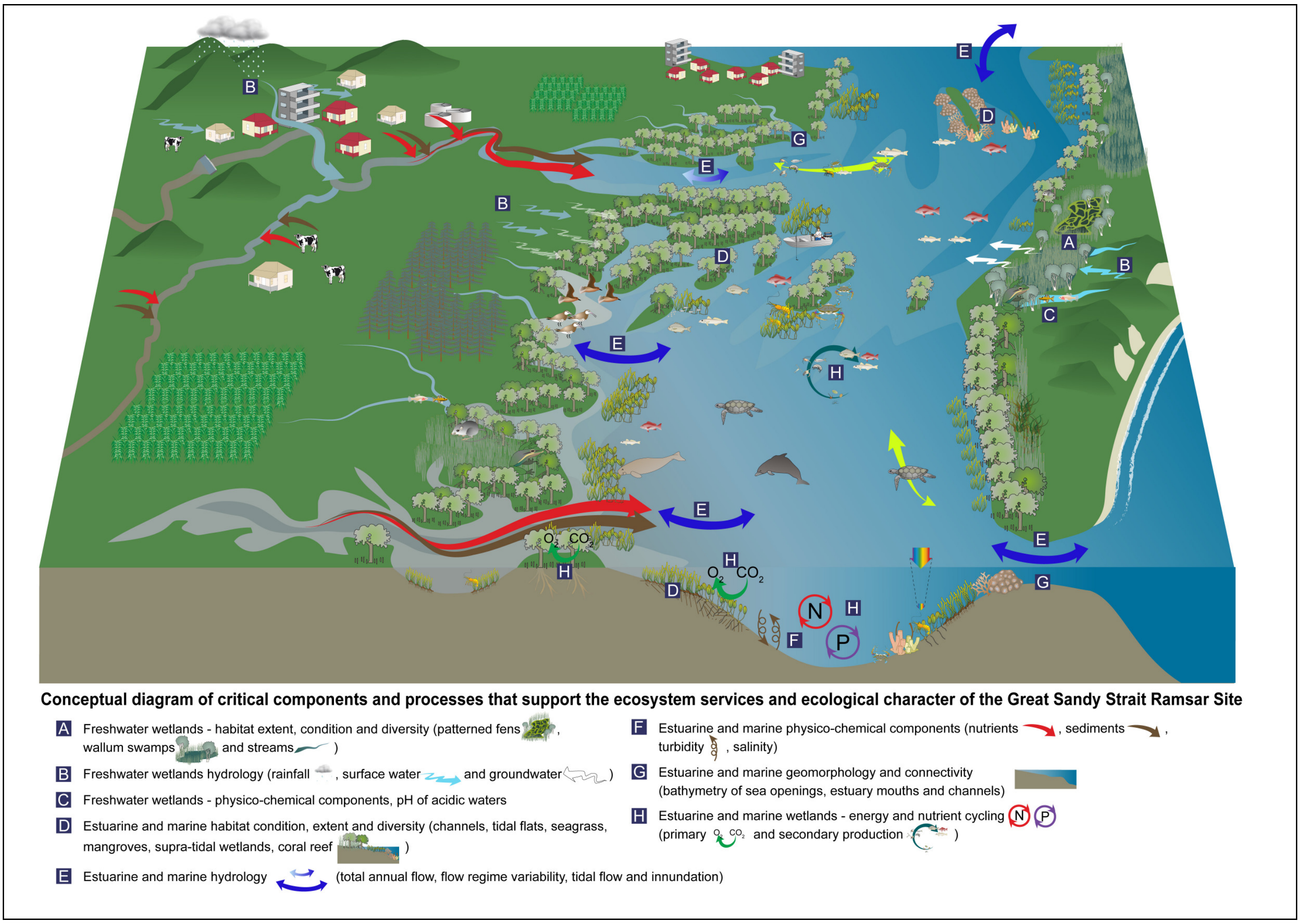


**Figure 7. Model of the critical ecosystem components and processes that support ecosystem services of the Great Sandy Strait Ramsar site.**

**<u>Freshwater Wetland</u> Critical Components and Processes in the Great Sandy Strait Ramsar site**

Wallum sedgefrog. Photo courtesy of H.B. Hines QPW

From the available information (Regional Ecosystem Mapping Queensland EPA 2004), it appears that the "freshwater wetlands" in the Ramsar site are principally comprised of wallum swamps, patterned fens and some freshwater streams. Water in the wallum swamps and peat swamps is acidic (pH <6) because the waters are poorly buffered and become acidic when exposed to waterlogged decomposing organic matter. Consequently, the freshwater wetlands host a range of unique fauna that have adapted to this acidic environment.

Identifying the location of wallum swamps and patterned fens within the Ramsar site has proved difficult because, under these names, they have not necessarily been delineated: they appear to fit across seven regional ecosystems (12.2.12, 12.2.15, 12.2.7, 12.3.13, 12.3.4 and 12.3.5 - Queensland EPA 2004). While it is clear that some wallum swamp and patterned fens occur within the Ramsar boundary on the west coast of Fraser Island and the western Cooloola coastal plain, it is not clear whether or not similar freshwater wetlands on the western side of the Ramsar site are included. Future realignment of the boundary to encompass unallocated State and protected lands containing these freshwater wetlands would increase capacity to manage the freshwater components of the Ramsar site.

Due to its proximity to the coast in the fastest growing region in Australia, much acid frog habitat has been destroyed, degraded or is under threat from housing and infrastructure developments – for example, on the Gold and Sunshine Coasts – as well as agricultural, and forestry practices (Hines *et al* 1999). The *Recovery plan for the wallum sedgefrog and other wallum-dependent frog species* (Meyer *et al* 2005) identifies management actions for four threatened frog species that occur within the Ramsar site. It states the need to properly identify and manage critical habitat for these species.

### 4.3.1 Freshwater Critical Component / Process A: Habitat Extent, Condition and Diversity

**Relates to Ecosystem Services:** Water mouse (8), Threatened fish (9), Acid frogs (10)

**Why 'Habitat Extent, Condition and Diversity' is critical to the freshwater wetlands of the Great Sandy Strait Ramsar site**

Seven nationally and/ or internationally threatened species are present in the freshwater wetlands in the Ramsar site (in the western Cooloola coastal plain, on the west coast of Fraser Island and, possibly, in the Tin Can Bay inlet) and all depend on a range of habitats for breeding, feeding and shelter. This range of freshwater wetlands is made up of coastal wallum swamps, small streams and patterned fens.

Main areas of importance are:

- **Ephemeral and semi-permanent perched swamps with emergent reeds, ferns and/or sedges**: Prime breeding habitat for wallum sedgefrog, wallum rocketfrog, the wallum froglet and occasionally for Cooloola sedgefrog and the water mouse.

- **Permanent freshwater lakes and small streams with little flow that have dense, aquatic vegetation along the margins such as emergent sedges and submerged sedges:** Prime habitat for the honey blue-eye and Oxleyan pygmy perch (small streams), the Cooloola sedgefrog and occasionally for the wallum rocketfrog, the wallum froglet and the wallum sedgefrog (lakes) and possibly the water mouse in adjacent vegetation.
- **Non-forested peat swamps, in particular patterned fens:** Nesting habitat for the water mouse. Also habitat for the honey blue-eye, Oxleyan pygmy perch and, of varying unknown importance to the four acid frog species. (Refer to **Ecosystem Service 2, Section 4.1.2**)

The above habitats are used by the four species of acid frog for breeding. While it is believed that the wallum sedgefrog is relatively sedentary, the other three species are known to disperse some distance from the free standing water to use non wetland habitats (Meyer *et al* 2005). Such non-breeding habitat is currently not identified but would most likely include areas outside the current Ramsar boundary.

The Oxleyan pygmy perch and the honey blue-eye are entirely freshwater species (Pusey *et al* 2004) and require continual access to freshwater ponds and streams to complete their annual life history.

The Oxleyan Pygmy Perch Recovery Plan (NSW Department of Primary Industries, 2005), prepared in accordance with NSW legislation and the Commonwealth EPBC Act (1999), and in collaboration with the Queensland EPA/Parks and Wildlife Service, identifies a number of Queensland organisations as potential contributors to its implementation in Queensland. In the Plan, water bodies supporting Oxleyan pygmy perch are recommended as components of “critical habitat” to be protected. This is regarded as a necessary step towards conservation and recovery of this species.

**Natural Variability and Limits of Acceptable Change**

| Variables | † Proposed Limits of Acceptable Change (as at July 2007) |
|---|---|
| **Area of healthy ephemeral and semi-permanent perched swamps:** These habitat types are thought to be relatively stable but in unprotected areas much has been destroyed or severely fragmented through urban development (Hines *et al* 1999). Meyer *et al* (2005) also note a history of fragmentation and destruction of known acid frog habitat (and potentially water mouse habitat).<br><br>Areas of critical habitat in the Ramsar site, particularly for the acid frogs, are not clearly identified or measured. This is most notable on the western shore where survey of habitats in relation to the Ramsar boundary is required. | **A.1** For the extent of ephemeral and semi-permanent perched swamp habitats for acid frogs and water mouse, information is insufficient for proposing Limits of Acceptable Change, however given the importance of this component to at least four threatened species, the following **interim Limit of Acceptable Change** is proposed:<br><br>• Any detectable loss or deterioration of critical freshwater habitat for acid frogs or water mouse in the Ramsar site. |

| | |
|---|---|
| **Area of healthy permanent freshwater lakes and small streams.**<br>The location and area of critical habitat in the Ramsar site for the Cooloola sedgefrog, Oxleyan pygmy perch and the honey blue-eye is not well understood.<br>It is not clear how many permanent 'perched' lakes occur within the Ramsar boundary but it is likely that they fall within protected areas (Meyer *et al* 2005) and are therefore relatively secure.<br>Nevertheless, a history of fragmentation and destruction of known acid frog habitats near the site (Meyer *et al* 2005) raises concerns of overall decline in habitat area. | **A.2** For the area of healthy permanent freshwater lakes and small streams, information is insufficient for proposing Limits of Acceptable Change, however given the importance of these habitats to the threatened fish and frog species, the following **interim Limits of Acceptable Change** are proposed:<br>• A 5% loss of the critical habitats (such as permanent freshwater refuges) for the Oxleyan pygmy perch or the honey blue-eye sustained longer than 3 years (during seasons of average rainfall)<br>• Any loss or deterioration of the known habitat area of the Cooloola sedgefrog.<br><br>The following **trigger for management intervention** is proposed:<br>• Any reduction or deterioration in the known critical habitat (such as permanent freshwater refuges) for the Oxleyan pygmy perch or the honey blue-eye. |
| **Area of non-forested peat swamps, in particular patterned fens:** Natural variation is not understood, but is assumed to be relatively stable. | **Limits of Acceptable Change** are the same as for Ecosystem Service 2.<br>**2.1** For the extent of patterned fens within the Ramsar site, information if only sufficient for proposing **an interim Limit of Acceptable Change**:<br>• Any detectable loss of patterned fen habitat area. |

**Knowledge Gaps**

- The extent of critical habitat of the Oxleyan pygmy perch and the honey blue-eye.
- The habitat conditions (e.g. water flow, depths, quality) required for the Oxleyan pygmy perch and the honey blue-eye.
- Extent of habitat for the four acid frog species in the Ramsar site.
- Non-breeding habitat requirements for the four acid frog species.

### 4.3.2 Freshwater Critical Component / Process B: Hydrology

**Relates to Ecosystem services:** Peat swamp (2), Threatened fishes (9), Acid frogs (10)

**Why 'Hydrology (rainfall, surface water and groundwater flows)' is critical to the Freshwater Wetlands of the Great Sandy Strait Ramsar site**

Rainfall is critical for the Ramsar site as it:

- Feeds the sand dunes / water table;
- Feeds the perched swamps; and
- Aids in the dispersal of the honey blue-eye and Oxleyan pygmy perch through runoff

Surface water and groundwater flows:

- Help feed the patterned fens and are believed to contribute to their form/structure; and
- Feeds the permanent freshwater ponds and streams.

While acknowledging the importance of rainfall to the freshwater wetlands, interim Limits of Acceptable change are only being proposed for surface and groundwater as they may be influenced by management activities.

**Natural Variability and Limits of Acceptable Change**

| Variables | Limits of Acceptable Change |
|---|---|
| **Surface and groundwater flows** from the high sand dunes support the patterned fens as well as the wallum swamps, lakes and streams on Fraser and the Cooloola western coastal plain.<br><br>Surface and groundwater requirements to maintain adequate breeding habitat for the acid frog species and the honey blue-eye and Oxleyan pygmy perch and permanent refuges and connectivity among those refuges for the two fish within the Ramsar site, are not well known<br><br>(Also refer to **Monitoring Needs, Section 8.15**) | **B.1** For surface and groundwater flows (Fraser and the Cooloola western coastal plain) feeding the patterned fens and other lakes and streams in the wallum swamp, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed.<br><br>However given the importance of freshwater flows to ecological character, the following **interim Limits of Acceptable Change** are proposed for when baseline information becomes available:<br><br>• A significant reduction in flows that would result in inadequate breeding habitat for three of the acid frogs, the Oxleyan pygmy perch or the honey blue-eye, during average rainfall periods.<br><br>• A significant reduction in flows that would result in inadequate permanent refuges and connectivity between those refuges in the site for the two fish species, during drought periods. |
| **Surface and groundwater flows** in the Tin Can Bay area help support wallum swamps which are habitat for the honey blue-eye and, possibly three species of acid frog (not the Cooloola sedgefrog). The Maroom and Tuan areas on the western side of the Ramsar site also have records of the three frog species. It is not clear how much of this habitat falls within the Ramsar site. | **B.2** For surface and groundwater flows, particularly from major streams into the wallum swamp areas around Tin Can Bay and the Maroom and Tuan areas (ie. Kauri and Snapper creek inputs to the western side of the Great Sandy Strait and freshwater wetlands where they fall within the Ramsar boundary), **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed.<br><br>However given the importance of freshwater flows to ecological character, the following **interim Limits of Acceptable Change** are proposed for when baseline information becomes available:<br><br>• A significant reduction in flows that would result in inadequate breeding habitat for three of the acid frogs or the honey blue-eye, during average rainfall periods.<br><br>• A significant reduction in flows that would result in inadequate permanent refuges and connectivity between those refuges in the site for the honey blue-eye, during drought periods. |

**Knowledge Gaps**

- **Minimum flow/input requirements for the wallum swamps to maintain permanent fish refuges:** Oxleyan pygmy perch are considered to have a patchy distribution and are not locally abundant. Fish move, mix and interbreed within individual drainage systems with little or no dispersal between individual catchments in present configurations. Therefore a reduction in flow sufficient to impact on connectivity of the individual drainage patterns would impact on abundance (Pusey *et al* 2004).
- Minimum flow and inundation requirements for wallum swamps and lakes and non-forested peat swamps, including patterned fens
- Surface and groundwater requirements to maintain adequate breeding habitat for the acid frog species.

### 4.3.3 Freshwater Critical Component / Process C: Physicochemical components

| |
|---|
| **Relates to Ecosystem services:** Peat swamp (2), Threatened fishes (9), Acid frogs (10) |

**Why 'Physicochemical components' is critical to the Freshwater Wetlands of the Great Sandy Strait Ramsar site**

Waters of the peat swamp and patterned fens were identified as having "high environmental values" under the Great Sandy Strait coastal creeks: environmental values and water quality objectives: Basin 140 (Queensland EPA 2007)

The water in these freshwater wetlands is typically dilute with negligible levels of bicarbonate ions (Bayly 1964, Bensink and Burton 1975).This means the water is unable to buffer the acid it is exposed to from the decomposing organic matter found in the wallum swamps and the patterned fens.

The honey blue-eye, Oxleyan pygmy perch, the four acid frog species and a number of other state-listed and unique fauna have all adapted to these acidic waters, and have specific tolerance ranges.

**Natural Variability and Limits of Acceptable Change**

| Variables | Proposed Limits of Acceptable Change |
|---|---|
| **pH of acidic waters in freshwater wetlands:** The natural pH values for Wallum/tannin-stained waters may range from 3.6 to 6 (Queensland EPA 20006b). | **C.1** For the pH of waters in key freshwater wetlands, **Limits of Acceptable Change** are:<br>• pH should not exceed the tolerance ranges of the following resident species:<br>- Oxleyan pygmy perch: 4.4 – 6.5 (B. Pusey, pers. comm., 2007)<br>- honey blue-eye: 4.4 – 6.8 (B. Pusey, pers. comm., 2007)<br>- four species of acid frog: < 6 (Meyer *et al* 2005).<br>(Refer to Monitoring Needs, Section 8.2) |
| **Other water quality parameters:** It is believed that small elevated levels of nitrogen and / or phosphorus may have deleterious effects on the survival of the honey blue-eye, Oxleyan pygmy perch and the four acid frog species | **C.2** For freshwater wetlands, **Limits of Acceptable Change** for water quality parameters other than pH are:<br>• Maintain water quality objectives for the parameters set for different waters of the Great Sandy Strait and coastal creeks by Great Sandy Strait coastal creeks: |

| | |
|---|---|
| (Pusey *et al* 2004, Meyer *et al* 2005). | environmental values and water quality objectives: Basin 140 (Queensland EPA 2007).<br>• Maintain existing water quality (20th, 50th and 80th percentiles), habitat, biota, flow and riparian areas as set by Queensland Water Quality Guidelines (Queensland EPA, 2006b).<br>Where 20/50/80 percentiles have been defined for particular water quality indicators, then the "no change" test could be applied against these percentiles for assessing long term changes.<br>**Note:** Refer to Appendix D in Queensland Water Quality Guidelines (Queensland EPA 2006) for details on how to establish a minimum water quality data set for deriving local 20th, 50th and 80th percentiles.<br>(Also refer to **Monitoring Needs, Section 8.16**) |

**Knowledge Gaps**

- Water quality parameters for the wallum swamps and patterned fens within the Ramsar site.

## Estuarine and Marine Wetland Critical Components and Processes of the Great Sandy Strait Ramsar site

Five critical components/processes identified for estuarine wetlands of the site, are described in detail below, including information on their levels of natural variability and proposed Limits of Acceptable Change where possible.

In addition, **Physical Processes (Sediment Dynamics)** was considered a critical process. The dynamic processes of sediment transport, deposition and re-suspension are, however, far too complex to be used in monitoring ecological character of the site.

**Sediment dynamics** (sediment supply, transport, deposition and re-suspension) influences the morphology of channels and banks that provide the diversity and connectivity between habitats from the estuary through to the open sea. Sedimentation in the strait has formed the intertidal banks which are suitable for growth of seagrasses and mangrove habitat and for invertebrate infauna. Sediment re-suspension has maintained the channels and passageways that are important for transport of nutrients and movements of wetland fauna.

The Mary River freshwater flow regime in particular is considered the greatest contributor to fluvial sediments into the northern part of the Ramsar site, above contributions from Fraser Island and the continental shelf (Beach Protection Authority 1989). Predictive models estimate that the Mary River currently contributes on average 445,000 tonnes of sediment per annum to the coast (DeRose *et al* 2002).

The dynamic processes of sediment transport, deposition and re-suspension are far too complex to be used in monitoring ecological character of the site. The final result of sediment processes is best measured as the wetland topography or bathymetry. See Ecosystem Service 1 'Occurrence of large sand island and passage estuary' (Section 4.1.1).

The balance of freshwater and tidal flows also determines the transport and deposition of sediments and is particularly important to bathymetry in the Mary River estuary and the northern strait. See Critical Component "Hydrology" (Section 4.3.5).

### 4.3.4 Estuarine & Marine Critical Component / Process D: Habitat Condition, Extent and Diversity

**Relates to Ecosystem services:** Sand passage (1), Seagrass (3), Mangroves (4), Reefs (5), Turtles (6), Marine mammals (7), Water mouse (8), Fish and crustacea (11), Waterbirds (12), Indigenous values (13), Tourism and recreation (14)

**Why 'Habitat Condition, Extent and Diversity' is a critical component to estuarine wetlands of the Great Sandy Strait Ramsar site**

The site supports a diverse and regionally significant area of seagrass and mangrove habitats that comprise species at, or near to, their northern or southern geographical limits, substantial coral reef and sponge garden habitats, and a diversity of large intertidal mud and sand banks and estuarine habitats. These large and diverse wetland habitats in turn provide for feeding, roosting, shelter or migration pathways for abundant and diverse communities of sponges, corals, crustaceans, fish, sea turtles, marine mammals (dolphins and dugong), migratory and resident waterbirds, and the intertidal-dwelling water mouse (a partial list of species recorded in the site is provided in **Appendix 3**). They are also the primary habitats that support the values the site has for indigenous people, tourism and recreational use.

**Natural Variability and Limits of Acceptable Change**

| Variable | Proposed Limits of Acceptable Change |
|---|---|
| **Area of available roosting habitat for shorebirds:** Key shorebird roost sites in or immediately adjacent to the Ramsar site have been identified by the Queensland Wader Study Group (Harding *et al* 2005).<br><br>Any roost sites that host 300+ birds can be considered an important roost site. While there may be a substantial number of roost sites containing 300+ shorebirds in, or immediately adjacent to, the Ramsar site, this is a reflection of the overall importance of the Great Sandy Strait for shorebirds and thus it warrants special attention.<br><br>Roosts on dry ground tend to be used year after year unless the roost has been damaged or destroyed. There may be some natural variability in the number of birds at a particular roost as birds shift to other roost sites, but the scale and drivers of this variability are not known. | **D.1**. For the area of available roosting habitat for shorebirds, information is only sufficient for proposing an **interim Limit of Acceptable Change**:<br><br>• The number and locations of key roosts (roosts supporting 300 or more migratory shorebirds each year) should remain within 40% of what they were (based on historical and subsequent surveys) at date of Ramsar-listing.<br><br>Further study is required before any Limits of Acceptable Change or more conservative triggers for management intervention can be proposed.<br><br>(Refer to **Monitoring Needs, Section 8.12**) |
| **Area of supralittoral mangroves, saltmarsh and saltpan for water mouse**<br><br>For details, see **Ecosystem Service 4, Section 4.1.4** | **Limits of Acceptable Change** are the same as for Ecosystem Service 4:<br><br>**4.1** For the extent of tidal wetlands (including mangroves, saltmarsh and saltpans), information is insufficient for proposing a Limit of Acceptable Change but the following **trigger for management intervention** is proposed:<br><br>• Any detectable nett loss of total area of tidal wetlands (Refer to **Monitoring Needs, Section 8.4**).<br><br>**4.2** For the physiological condition of mangroves, information is insufficient for proposing a Limit of Acceptable Change but the following **trigger for management intervention** is proposed: |

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| | • A "dieback" or significant reduction in condition in more than 15% of mangrove habitat area and sustained for more than 5 years (this allows for drought cycles). |
| **Depth, shape, bathymetry of sea openings and intertidal banks:** to support coral and sponge habitat, feeding areas for shorebirds, fish, crustacea and cetaceans.<br>(For details, see **Ecosystem Service 1, Section 4.1.1**) | **Limits of Acceptable Change** are the same as for Ecosystem Service 1:<br>**1.1** For sand bank and channel topography and connectivity, **Limits of Acceptable Change** are:<br>• Minimum depths at major channels connecting northern and southern sections of the Great Sandy Strait with each other (Wide Bay bar) and with the open sea (Inskip Point Bar) no more than 10% shallower than 1999 bathymetry.<br>• Minimum depths of the Mary River mouth connecting riverine /stream, estuarine and marine habitats no shallower than 1999 bathymetry.<br>**1.2** For other estuarine channels connecting riverine /stream, estuarine and marine habitats, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed.<br>(Refer to **Monitoring Needs, Section 8.1**) |
| **Area of estuarine, seagrass, mangrove and coral reef habitat** for dugong, sea turtles, targeted food fish and crustaceans. | Refer to Limits of Acceptable Change for Ecosystem Service 1 estuarine geomorphology (1.1, 1.2), 3 seagrass (3.1, 3.2, 3.3, 3.4), 4 mangrove/tidal wetlands (4.1, 4.2) & 5 coral reef habitat (5.1, 5.2, 5.3). |

### 4.3.5 Estuarine & Marine Critical Component / Process E: Hydrology

**Relates to Ecosystem services:** Sand passage (1), Seagrass (3), Mangroves (4), Reefs (5), Turtles (6), Marine mammals (7), Water mouse (8), Fish and crustacea (11), Shorebirds (12), Indigenous values (13), Tourism and recreation (14)

**Why 'Estuarine and marine hydrology' is critical to estuarine wetlands in the Great Sandy Strait Ramsar site**

**Tidal heights and inundation** are critical to maintaining the area of marine intertidal habitat available for growth of invertebrate fauna, corals, seagrass, mangroves, salt marsh and estuarine habitats in Great Sandy Strait. Tidal penetration and water exchange is important for maintaining ambient water quality conditions over all these vital habitats, Tidal regimes also directly influence the area of habitats preferred by the water mouse, as well as a range of fish, prawns, crabs and other marine and estuarine fauna. In the eastern and southern sections of the site tidal flows are the dominant hydrological force determining sediment transport and bathymetry (P. O'Keeffe, pers. comm., 2007).

**Freshwater flows** provide nutrients, sediments, organic matter and brackish water conditions necessary for maintaining the key biological systems within estuarine areas of the site in a healthy and productive state. The Mary River is the greatest single contributor to freshwater flow into the northern section of Great Sandy Strait. The associated contribution of nutrients and salinity regimes is thus one of the most important components supporting life cycles and productivity of fisheries stocks and wetland resources in the northern Great Sandy Strait. For several key estuarine species of fish and crustacea using this site, various aspects of freshwater flow are necessary for triggering migrations or breeding, creating brackish habitat for larvae or juveniles, and ensuring productivity of the food webs that support the fish or crustacean stocks (Robins & Ye, In Prep.).

The Mary River freshwater flow regime is also considered the greatest contributor to fluvial sediments into the northern part of the Ramsar site (Beach Protection Authority 1989, De Rose *et al* 2002). The balance of freshwater and tidal flows also determine the transport and deposition of sediments. Hydraulic forces under flood flow conditions are particularly crucial for moving the accumulated sediment bed-loads and thus maintain benthic habitats, channel depths and connectivity between riverine and marine areas necessary for overall ecosystem health.

**The flow regime** of a river or stream necessary for supporting the site's ecological character is made up of several indices /aspects of flow and is more complex than a simple set of flow statistics can adequately represent. Whilst a range of freshwater flow inputs affect ecosystem components and processes in the Ramsar site, the importance of the Mary River inputs into the estuary and northern Great Sandy Strait has justified placing a priority focus on Environmental Flow Indicators related to the Mary River.

Six major categories of flow characteristics hold particular ecological relevance, as well as being sensitive to the changes produced in flow regimes by various aspects of water resource development (Brizga *et al* 2005). These important flow characteristics are:

1. magnitude of river flow at any given time;
2. timing of occurrence of particular flow conditions (eg., low, medium and peak flows);
3. frequency of occurrence of particular flows such as flood flows;
4. duration of time over which specific flow conditions extend;
5. rate of change in flow conditions such as rise and fall of flood waters; and
6. seasonality and variability of the overall flow regime.

Key attributes of the flow regime can be characterised with reference to five functional categories: total flow volumes, no flow, low flows, medium to high flows and flow regime variability (Brizga *et al* 2005). Variability of these indicators cannot be described concisely or by any single index or simple set of indices.

In such a complex system, a change in one aspect of flow is more likely to have consequences on multiple components of ecological character, far more important than any possible masking of impacts by other aspects of flow. Because of this, the greater the change from natural flow regime, the greater the risk of geomorphological and ecological impacts.

**The performance of fishways** on the Tinana Creek and Mary River tidal barrages is crucial to passage of several fish species that migrate between the Ramsar Site and upstream reaches. These are monitored by barrage and fishway owners in cooperation with fisheries experts. Species and size class compositions of fish using the fishways are monitored and assessed against prevailing flow conditions, barrage/fishway operation and fish populations in the local system (A. Berghuis, Z. Sarac, Pers comm 2008). Each fishway management plan seeks to continually improve fishway performance, although no fixed targets are set.

**Natural Variability and Limits of Acceptable Change**

| Variables | Proposed Limits of Acceptable Change |
|---|---|
| **Freshwater/Estuarine Hydrology:**<br>**The combined freshwater flow from all sources** into estuarine | **E.1** For the combined freshwater flow from all sources, **information is insufficient** and further study is |

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| habitats is not sufficiently understood for establishing levels of natural variability or thresholds for management.<br><br>**Total annual freshwater outflow from the Mary River** to the estuary under current water resource development and use is reduced about 6% from the estimated pre-development regime (Brizga *et al* 2005).<br><br>In the Burnett River catchment immediately north of the Mary River catchment, benchmarking methodology was used to estimate that **79-84 percent of total annual river flow volume and 72-91 percent of natural flood magnitudes would be needed to ensure full ecosystem health** (Brizga 2000).<br><br>"Flow duration curves" for the Mary River, derived from long-term data sets (eg., Brizga *et al* 2005), may provide a preliminary tool to developing some overall coarse-level guides for acceptable total flow regimes for the Mary River estuary. This might have application for scenario planning at 10-year, 25-year or longer time scales.<br><br>Different applications of "Flow Duration Curves" (for example, seasonal flow duration curves rather than annual flow curves) might be useful to help set acceptable levels of change for some selected indices of freshwater flow to the estuary (See Knowledge Gaps).<br><br>**Key Indices /aspects of flow regime** from the Mary River have ecological relevance at many scales and can include flow characteristics over inter-annual, seasonal and daily periods. Different estuarine and aquatic species have different requirements of freshwater flow regimes.<br><br>The flow indicators are complex and need to be considered collectively rather than as separate statistics because ecosystems respond to the entire flow regime rather than individual components. Sets of both Long-term flow indicators (based on approx. 100yr periods of information) and Short-term flow indicators (relevant to approx 10-yr periods of flow scenarios) are necessary. Any flow regime needed to maintain the overall ecological character of the site would best be described by these sets of flow indicators, and cannot be described by any single flow regime index (Brizga *et al* 2005).<br><br>Variability of these several indicators is not easily assessed nor easily described.<br><br>In such a complex system, a change in one aspect of flow is more likely to have consequences on multiple components of ecological character, far more important than any possible masking of impacts by other aspects of flow. Because of this, the greater the change from natural flow regime, the greater the risk of geomorphological and ecological impacts.<br><br>**Fishway performance** on the Tinana and Mary Rivers tidal barrages is monitored by assessing the fish species and size class composition using the fishway in the context of prevailing flow conditions, barrage/fishway operations and the local fish populations. However statistical rigour of these assessments is difficult and until more reliable assessments are possible, a cessation in fishway operation is considered necessary before changes in ecological character can be identified with confidence. | required before any Limits of Acceptable Change or triggers for intervention can be proposed. See also Limits of Acceptable Change for the critical component: **Hydrology, Section 4.3.2**)<br><br>**E.2** For the critical component represented by Mary River freshwater/estuarine flows, information is only sufficient for proposing **interim Limits of Acceptable Change** :<br><br>• After allowing for variations in rainfall, any index or aspect of freshwater flow (e.g. mean annual flow) from the Mary River catchment degraded by more than 10% since the date of Ramsar listing (1999).<br><br>NB: For maintaining conditions necessary for fish passage, change from natural total flow volumes should be minimized (Brizga *et al* 2005). Further information is required to set a more precise threshold.<br><br>• A cessation in fishway operation or function on the Tinana Creek and Mary River tidal barrages for longer than 1 year.<br><br>(Refer to **Monitoring Needs, Section 8.1**) |
| **Marine Hydrology:**<br><br>**Tidal flow and inundation regimes.**<br><br>Tidal regimes at the site are considered to be relatively stable over the last 100 years. The site is classed as a macro-tidal system, with MSL = 2.17m and HAT = 4.49m at River Heads (Maritime Safety Queensland 2007). | **E.3** For the tidal flow regime, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed.<br><br>. |

**Knowledge Gaps**

- Environmental flow requirements vary for different life history stages and different estuarine species, especially for upstream migrations.
- Effects of reductions in lows flows on salinity gradients and immigration of fish into upper estuary and freshwater environments in Mary River
- Managers of the Ramsar site need to manage for multiple species, and require some simplified set of flow regime parameters that may satisfy the overall requirements for maintaining ecological character or at least the key ecosystem services.
- Investigation into the application of specific "Flow Duration Curves" (for example, seasonal flow duration curves) to develop ecologically appropriate indices of freshwater flow for estuarine species and to which may be used to propose some "acceptable levels of change" in freshwater flow.
- Impacts of water resource development on longer-term dynamics of estuarine sand bars in the Lower Mary River estuary.

Garry's Anchorage – Great Sandy Strait. Photo courtesy of EPA.

### 4.3.6 Estuarine & Marine Critical Component / Process F: Physicochemical Components

**Relates to Ecosystem services:** Seagrass (3), Mangroves (4), Reefs (5),Turtles (6),Marine mammals (7), Fish and crustacea (11), Shorebirds (12), Indigenous values (13)

**Why 'Physicochemical Components' is critical to estuarine wetlands in the Great Sandy Strait Ramsar site**

**Nutrient** (particularly species of N and P) and suspended **sediment** loads plus **salinity** and **turbidity** regimes are all important in supporting high value habitats and food webs within the Great Sandy Strait Ramsar site. All ecosystem services are supported either directly or indirectly by these water quality components. Nutrient inputs provide the elements for primary and secondary productivity, and provide the basis on which the complex food webs and habitats depend. Water turbidity influences the amount of light that reaches photosynthetic plants such as intertidal and sub-tidal seagrasses - a primary food and habitat for many key animal species in the Great Sandy Strait.

Salinity regimes and gradients influence estuarine plants and animals, and their various life history stages. Salinity levels in mangrove sediment are also a key determinant in the diversity of mangrove species.

Whilst sediment, nutrient and freshwater inputs to the Ramsar site are important for maintaining critical habitats and water quality parameters for biota, land-use practices have modified the total loads and nature of these inputs and present major threats to several critical components and processes in the site (see **Section 5**).

**Toxins, including persistent herbicides,** such as diuron, atrazine, simazine, hexazinone and ametryn have been identified as threats to seagrasses and other biota in the Great Sandy Strait (McMahon *et al* 2003). These pollutants may stress plant physiology, making them more vulnerable to other adverse impacts. Elevated concentrations of **dioxins** have been detected in marine sediments and dugongs and turtles in Hervey Bay, which is immediately adjacent to the Ramsar site. Studies on health effects of these compounds on dugongs, turtles and indigenous people have commenced (Gaus *et al* 2004).

**Natural Variability and Limits of Acceptable Change**

| Variables | Proposed Limits of Acceptable Change |
|---|---|
| **Physicochemical water quality parameters:** Water quality is a primary driver of many other elements of the site's ecological character. However there is naturally high variability over daily tidal, monthly, seasonal, and inter-annual time scales, and difficulties arise in identifying an appropriate set of indices of the water quality regimes required to maintain ecosystem health.<br><br>Under the Great Sandy Strait Coastal Creeks Environmental Values and Water Quality Objectives (Queensland EPA 2007) the Great Sandy Strait meets an ecosystem condition category of level 1 (high conservation/ ecological value). As such, the management intent for the Great Sandy Strait as a high ecological value (HEV) site is 'to maintain existing water quality, habitat, biota and flow conditions', which is to allow **no change**.<br><br>However, while the eastern portion of the Great Sandy Strait has a moderate to high level of water quality, adjacent to the mainland water quality is generally poorer. In the Mary River (mid-to-upper) estuary section of the Ramsar site, almost all recorded water quality parameters, except for cholorphyl-a, ammonia-N and naturally high turbidity (at mid and upper estuary sites), exceed environmental criteria for the Queensland Water Quality Guidelines (D Scheltinga, pers. comm., 2007).<br><br>(Refer to Monitoring Needs, Section 8.17) | **F.1** For estuarine and marine wetlands, **Limits of Acceptable Change** for physicochemical water quality parameters are:<br>• Maintain water quality objectives for the parameters set for different waters of the Great Sandy Strait and coastal creeks by Great Sandy Strait Coastal Creeks Environmental Values and Water Quality Objectives (Queensland EPA 2007).<br>• Maintain existing water quality ($20^{th}$, $50^{th}$ and $80^{th}$ percentiles), habitat, biota, flow and riparian areas for Great Sandy Strait as set by Queensland Water Quality Guidelines (Queensland EPA, 2007).<br><br>Where 20/50/80 percentiles have been defined for particular water quality indicators, then the "no change" test could be applied against these percentiles for assessing long term changes.<br><br>**Note:** Refer to Appendix D in Queensland Water Quality Guidelines (Queensland EPA 2006b) for details on how to establish a minimum water quality data set for deriving local $20^{th}$, $50^{th}$ and $80^{th}$ percentiles.<br><br>Refer to C.1 |

| | |
|---|---|
| **Salinity levels in the sediments:** variations in freshwater flows could alter the saline levels in the soils and potentially reduce the diversity of mangrove species in the site. Levels of natural variability are not yet sufficiently understood. | **F.2** For salinity levels in the sediments of estuarine and marine wetlands, **information is insufficient** and further study and advice is required before Limits of Acceptable Change or triggers for intervention can be proposed. |
| **Toxicants** are elements of water quality that are mostly foreign elements of anthropogenic origin and present threats to ecological character of the site (see sections on threats and monitoring needs). Management goals are to minimise these water quality elements to below ANZECC (ANZECC and ARMCANZ 2000) and Queensland Water Quality Guidelines (Queensland EPA 2006b). Levels of "natural variability" for toxicants are therefore not considered relevant guidelines.<br><br>Pollutants and toxicants are threats rather than critical ecosystem components, but because of their influence on water quality, are listed both here and under "Threats" (Sections 5.3, 5.4, 5.6).<br><br>Diuron concentrations measured during low-flow conditions in the Mary River had no impact on seagrass photosynthesis, but moderate flow or flood events may deliver concentrations that are known to inhibit photosynthesis (McMahon *et al* 2005). Particularly elevated concentrations of dioxins have been detected in marine sediments and dugongs and turtles in Hervey Bay, which is adjacent to the Ramsar site. | **F.3** For toxicants in a high conservation/ ecological value site, the **Limit of Acceptable Change** is:<br><br>• Any deterioration of existing condition (ANZECC 2000 Guidelines; Queensland Water Quality Guidelines 2006).<br><br>The ANZECC 2000 Guidelines default approaches are focussed on assessing long-term compliance with guidelines that are designed to protect against chronic effects (ANZECC and ARMCANZ 2000). The ANZECC 2000 Guidelines (Section 3.1.7. Volume 1) state that "for the non-biological indicators, the guideline trigger values represent the best currently available estimates of what are thought to be ecologically low-risk levels of these indicators for chronic (sustained) exposures." (see also, Queensland EPA 2006b.)<br><br>Refer to **Monitoring Needs, Section 8.17** |
| **Maximum depth limit of seagrass:** is being investigated as a potential ecological indicator for water quality in the Queensland Stream and Estuary Assessment Program (SEAP). The depth to which the seagrass *Zostera muelleri* grows, may provide an indication of the water clarity at a site, as the depth to which seagrass can grow is directly dependent on the penetration of light through the water.<br><br>Transects for monitoring depth distribution were established in the Great Sandy Strait in 1993 (Fisheries Research Consultants, 1994b), but have not been continued sufficiently to provide measures of variability – natural or otherwise. | **Limits of Acceptable Change** are the same as for Ecosystem Service 3:<br><br>**3.3** For the depth range of seagrasses, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed<br><br>For seagrass depth ranges, it is likely that Limits of Acceptable Change will be unique to each site. |

* See Queensland Water Quality Guidelines (Queensland EPA 2006) Section 8.4.2 "Assessing compliance for physicochemical indicators".

### Knowledge Gaps

- Locally appropriate and cost effective water quality criteria (eg., habitat condition, seagrass depth range). The Queensland Stream and Estuary Assessment Program (SEAP) currently being developed will help to address this gap.
- Appropriate biological indicators of water quality.
- Baseline information on all estuaries flowing into the Great Sandy Strait Ramsar site. This includes basic 'structure' data such as, length of estuary, estuarine volumes, freshwater inflow volume, mean spring tidal range, etc. In order to determine what impact a particular change will have on an estuary or what the risk to, and vulnerability of, an estuary is then this information is critical.

- Condition baseline/reference data, such as natural levels of heavy metals, pre-European seagrass extent, etc. for a particular waterbody. For example, if the waterway has naturally high levels of a heavy metal then the condition should not score badly when monitoring finds high levels of heavy metals.
- Condition indicators that respond specifically to changes to freshwater flow regime.

### 4.3.7 Estuarine & Marine Critical Component / Process G: Geomorphology

**Relates to Ecosystem services:** Sand passage estuary (1), Turtles (6), Marine mammals (7), Fish and crustacea (11), Indigenous values (13), Tourism and recreation (14).

**Why 'Geomorphology' component is critical to the Great Sandy Strait Ramsar site**

Connectivity of surface waters: sea openings, estuary mouths and river reaches - for tidal and freshwater flows and exchanges is a fundamental requirement for transport of nutrients sediments, organic matter and larvae, maintenance of water quality, and movements of fish, crustacean, turtles and dolphins dugongs through the site. In particular, connectivity across the estuary mouth is crucial for fish passage by species and life history stages that need to move between fresh, estuarine and marine areas. This includes the majority of species in the site that carry commercial and recreational value.

Sand bar shape and area in the site provides inter-tidal habitat available for growth of invertebrate fauna, corals, seagrass, mangroves, salt marsh and estuarine habitats in Great Sandy Strait. These in turn provide key feeding habitats for several fish, crustacean, shorebirds, as well as green turtles and dugong.

The overall form of the wetland includes landscape features of indigenous cultural significance.

**Natural Variability and Limits of Acceptable Change**

| Variables | Proposed Limits of Acceptable Change |
|---|---|
| **Bathymetry at sea openings:** (see also **Ecosystem Service 1, Section 4.1.1**)<br><br>No significant shallowing or constriction in either the northern or southern sea openings have been recorded over the last 50 years (C. Cockburn, pers. comm., 2007). The Inskip Bar and Wide Bay bar may regularly change shape and size, but the southern channel opening is considered most likely to be relatively stable over a 100yr period (C. Cockburn, P. O'Keeffe, pers. comm., 2007). A change of 10% in minimum depths would be considered unusual and would likely have impacts on tidal exchange in the southern section (P. O'Keeffe, pers. comm., 2007; Beach Protection Authority 1989).<br><br>Bathymetry of the northern section of the strait (north of the Mary River mouth) is considered to be more prone to some variability because it is subject to large changes in river flow regimes and associated sediment loads from the Mary River (P. O'Keeffe, pers. comm., 2007; Beach Protection Authority 1989).<br><br>Natural aggradations of sediments and shallowing have occurred at Sheridan Flats in the mid-sections of the Great Sandy Strait over several decades (C. Cockburn, pers. comm., 2007). Decadal-scale shallowing is expected in this section where the northern and southern tide systems meet and tidal flows energy is relatively low (P. O'Keeffe, pers. comm., 2007). | **1.1** For sand bank and channel topography/bathymetry and connectivity to sea openings, **Limits of Acceptable Change** are:<br><br>• Minimum depths at major channels connecting the southern section of the Great Sandy Strait with the open sea (Wide Bay and Inskip bars) no more than 10% shallower than 1999 bathymetry.<br><br>(Refer to **Monitoring Needs, Section 8.1**) |
| **Bathymetry and habitat connectivity at estuary mouths and channels:**<br><br>**The Mary River mouth** bathymetry is likely to be mildly variable because it is subject to changes in river flow regimes and associated sediment budgets (P. O'Keeffe, pers, comm., 2007). Shallowing was already evident in 1999, and appeared to commence after installation of the Mary River tidal barrage (C. Cockburn, pers. comm., 2007).<br><br>A further decrease (of approximately 1m) in minimum channel depth in the Mary River estuary mouth has occurred since approximately 1999. This is considered an unusual degree of shallowing for this area in its 50 year history (C. Cockburn, pers. comm., 2007). Minimum channel depth at Horeshoe Banks is currently 1.8m at mean low water, and any further shallowing should be avoided (C. Cockburn, pers. comm., 2007). Vessel navigation would be significantly compromised if minimum channel depth became shallower than 1m at mean low water (C. Cockburn, pers. comm., 2007).<br><br>Natural aggradations of sediments and shallowing have occurred at Sheridan Flats in the mid-sections of the Great Sandy Strait over several decades (C. Cockburn, pers. comm., 2007). Decadal-scale shallowing is expected in this section where the northern and southern tide systems meet and tidal flows energy is relatively low (P. O'Keeffe, pers. comm., 2007). | **1.2** For sand bank and channel topography/bathymetry and connectivity, **Limits of Acceptable Change** are:<br><br>• Minimum channel depths of the Mary River mouth connecting riverine /stream, estuarine and marine habitats should be no shallower than 1m at mean low water.<br><br>• For other estuarine channels connecting riverine /stream, estuarine and marine habitats, **information is insufficient** and further study is required before any Limits of Acceptable Change or triggers for intervention can be proposed.<br><br>(Refer to **Monitoring Needs, Section 8.1** |

**Knowledge Gaps**

- **Impacts of water resource development** on longer-term dynamics of estuarine sand bars in the Lower Mary River estuary.
- **Historical trends in bathymetry**, particularly minimum depths of channels, estuary mouths and sea openings.
- **Ground-water flow characteristics from mainland sources** and their influence on sediment dynamics and bathymetry in the Great Sandy Strait Ramsar site.

### 4.3.8 Critical Component / Process H: Energy & Nutrient Dynamics

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| **Relates to Ecosystem services:** Seagrass (3), Mangroves (4), Reefs (5), Turtles (6), Marine mammals (7), Fish and crustacea (11), Shorebirds (12), Indigenous values (13), Tourism and recreation (14) |

**Why 'Energy & Nutrient Dynamics' is critical to estuarine wetlands of the Great Sandy Strait Ramsar site:**

As with any ecosystem, the Great Sandy Strait depends on nutrient cycling within the wetland food chain. This includes the assimilation of nutrients by phytoplankton, bacteria (in the water-column, sediments and detritus) and wetland plants (algae, seagrasses and mangroves). Primary productivity subsequently supports planktivores and detritivores (eg.,coelenterates, molluscs, annelids and crustaceans) and herbivores (bait-fish, sea turtles, dugong), which in turn support predators (eg., fish, turtles and dolphins).

**Finding appropriate indicators for the ecological process '*Nutrient Dynamics*'**

Success of nutrient cycling can be partly represented by primary production rates and secondary production rates. Complex interactions of multiple factors influence nutrient cycling and, consequently, primary and secondary productivity are often selected as measures that integrate those factors such as water quality. Some indicators such as algae, seagrass or mangrove primary production may be used in monitoring to provide early alerts on changes to key ecosystem components. At present, there is insufficient information on natural variability of primary production at this site to recommend indicators.

Indicators of physiological condition in algae, seagrasses and mangroves have been advocated for monitoring ecosystem health in south east Queensland locations (see seagrasses 4.1.3 and mangroves 4.3.4). Further research is still needed before selecting the most appropriate indicators of wetland plant physiological condition for monitoring ecological character of the Great Sandy Strait.

Some parameters such as benthic health (eg. abundance of infauna) may be potential proxies for secondary productivity, but still remain expensive due to difficulties in taxonomy and high variability in estuarine areas.

| Variables | Proposed Limits of Acceptable Change |
|---|---|
| **Primary production and secondary production rates:**<br>Information is insufficient to describe natural variability of primary or secondary production at this site or to recommend indicators for monitoring. | **H.1** For primary or secondary production rates, **information is insufficient** and further study and advice is required* before Limits of Acceptable Change or triggers for intervention can be proposed. |

**Knowledge Gaps**

- Appropriate indicators of primary production or physiological condition in algae, seagrasses and/or mangroves for monitoring ecological character.
- Appropriate indicators of secondary production (eg. abundance of infauna).

# 5. Key Threats to the Great Sandy Strait Ramsar site

The Great Sandy Strait is relatively undisturbed and thus particularly significant in the east coast of Australia. The site, however, faces a number of human related threats, many of which are increasing with expanding populations and development in the catchments and coastal areas adjacent to the site (**Figure 8**). These threats can impact critical ecosystem components, processes and services directly, or have indirect impacts through deterioration of food resources or habitat integrity. Threats to ecological character of the site arise both within and outside the site boundaries, and have been listed to assist in clarifying management needs and ongoing monitoring requirements.


**Figure 8. Conceptual model of the key threats to ecosystem components, processes and services in the Great Sandy Strait Ramsar site.**

The following lists of key threats operating on-site and off-site are intended to help focus management attention for maintenance of the site's ecological character. Descriptions of threats include likely consequences of these threats, but expert advice was not sufficient to provide agreed estimates of either their likelihood or timing. Iinformation was thus not sufficient to identify the imminent threats, or to prioritise which threats should be monitored. Expert advice generally indicated that further workshop exercises were required to properly identify these details.

## 5.1 Threats to Ecosystem Service 1: Great Sandy Strait Ramsar site includes **a large sand island and passage estuary** which provides habitat and **migration pathways** for marine animals (fishes, prawns, turtles) between riverine, sheltered nursery/feeding areas and open ocean.

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|---|
| **Climate Change and sea level rise** could result in major changes to water flows, erosion and deposition patterns, tidal flat development and the subsequent distribution of seagrass and mangrove communities. |
| **Reduced connectivity between riverine, estuarine and marine habitats** via direct blockages to river flow (weirs, barrages and dams) can only further diminish the degree of connectivity available for migrating fish and other biological processes crucial to ecological function of the Ramsar site. |
| **Changes to shoreline structure and morphology** through development activities in the strait. Clearing of mangroves bordering the Ramsar site can exacerbate bank erosion and further losses of habitat. |
| **Hill slope, gully and bank erosion** are major sources of excessive sediment inputs to the river and estuarine system, with approximately 50% of total sediments exported from the estuary mouth (DeRose *et al* 2002). Bank erosion is considered a major concern, particularly in the lower reaches and mouth of the Mary river itself (DeRose *et al* 2002) It is the major sediment source and contributes mostly to in-stream bedloads, reducing depths and connectivity between estuary and riverine habitats, and loss of estuarine habitat for fish shelter, feeding or spawning. |

**Knowledge Gaps**

- Quantification of sediment accretion and transport in the Mary River estuary mouth and mid-sections of the strait, particularly with respect to habitat needs for movements of fish, crustacean, turtles, dolphins, dugongs, etc.
- Structures, illegal and otherwise, which could prevent connectivity etc

## 5.2 Threats to Ecosystem Service 2: A substantial area of peat swamp, consisting mainly of the r**egionally unique patterned fens,** occurs within the Great Sandy Strait Ramsar site.

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| **Climate Change and sea level rise:** A possible rise in sea level as a consequence of global warming could be devastating to these sites.given their proximity to near sea level and, in many examples, direct hydrological connection to estuarine wetlands. Add to service description |
| **Fire:** High intensity fires when the peat is dry could result in it burning for long periods (Ingram *et al* 2004a,b) with consequential impacts on dependant fauna and long term viability of the peat wetlands. Fire would also release large amounts of carbon to atmosphere and destroy pollen records/reserves in peat. |
| **Water Extraction:** Reduction in amount of freshwater water flowing into the patterned fens could affect the flow patterns and water levels (Ingram *et al* 2004a)**.** This could be a particular problem in the Cooloola section where the township of Rainbow Beach currently uses water from the creeks that feed the fens (Queensland EPA 2005)**.** Salt water intrusion may also occur. |
| **Pollution/Runoff:** Nutrient-laden runoff from urban areas around Rainbow Beach could alter the water composition for the acid-dependant species that depend on the fens and also make the fens more susceptible to invasive plant species. Runoff from nearby roads could also lead to some contamination or pollution (Ingram *et al* 2004b). |

**Knowledge Gaps**

- Ideal burning regimes, if any, to sustain the patterned fens (Ingram *et al* 2004a,b).
- Understanding of ground and surface water flows into the patterned fens and the role of freshwater in maintaining the fens' structure.

- Full extent of patterned fen habitat within and outside the Ramsar boundary, eg. on the western side of the Cooloola and Inskip Penninsular and Fraser Island.

## 5.3 Threats to Ecosystem Service 3: A regionally significant area of **seagrass habitat** and **diversity of seagrass species** occurs within the Great Sandy Strait Ramsar site.

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| **Climate Change and sea level rise:** Regularity and intensity of flood events<br><br>Temperature increases, sea level rise, storm events, and flood impacts were identified as the most important factors associated with climate change likely to adversely affect seagrasses in Queensland (Waycott *et al* in prep; Voice *et al* 2006). Excessive sediment and nutrient loads during major floods have been suggested as the major cause of widespread seagrass losses in the Great Sandy Strait. Seagrass recovery after such losses has taken between 3 years (in deep water) and 5 years (in shallow and intertidal depths). Major flood events at frequencies higher than every 7 or 8 years may lead to permanent reductions in abundance and productivity of seagrasses. Shortage of seagrass seed reserves in Great Sandy Strait sediments is a concern, limiting the potential for seagrass recovery after such widespread losses (L. McKenzie, pers. comm., 2007). |
| **Hill slope, gully and bank erosion** are major sources of excessive sediment inputs to the river and estuarine system, with approximately 50% of total sediments exported from the estuary mouth (DeRose *et al* 2002). Excessive and prolonged sediment loads, particularly associated with flood events, have led to loss of seagrasses through direct smothering and high turbidity (see **Section 4.1.3**). High sediment loads during summer wet season floods have been a threat since the early 1900's when more extensive land clearing commenced. |
| **Pollution/runoff:** Water quality is generally considered good but increasing urban and industrial development and sewage loads at several points adjacent to the site are of significant concern. Nutrients (primarily nitrogen and phosphate) and sediment loads from land sources threaten seagrasses through increasing phytoplankton and epiphytic algal growth on seagrass plants, increasing water turbidity, or direct smothering by sediments.<br><br>Diffuse-source pollution from agricultural lands and pine forestry plantations entering via the Mary River and coastal creeks.<br><br>Point-source pollution is increasing and includes sewage treatment plant and stormwater outlets at Urangan, Poona, Boonaroo, Tin Can Bay, Rainbow Beach, and Cooloola Village. |
| **Herbicides:** such as diuron (DCMU) [3-(3',4'-dichlorophenyl)-1,1-dimethylurea] is a common herbicide in south-east Queensland catchments and is toxic to seagrasses at high acute exposures (Haynes *et al* 2000). Diuron concentrations measured during low-flow conditions in the Mary River had no impact on seagrass photosynthesis, but moderate flow or flood events may deliver concentrations that are known to inhibit photosynthesis (McMahon *et al* 2005). A range of other chemical pollutants (eg. the herbicides atrazine, simazine, hexazinone and ametryn) have been identified as threats to seagrasses and other biota in the Great Sandy Strait. These pollutants may allow plants to become more vulnerable to other adverse impacts. |
| **Blooms of *Lyngbya majuscula*** (a cyano-bacteria) in Moreton Bay have smothered seagrasses and been associated with significant impacts on dugong populations. *Lyngbya* blooms have resulted from increased bioavailability of iron caused by the interaction between organic matter, iron and UV light, phosphorus availability and atmospheric nitrogen fixation (Ahern 2003). Almost all of these threats come from agricultural and urban pollution and via mainland catchments, streams and groundwater, as well as runoff of acidic water and associated metal ions (especially Fe) from oxidated acid sulphate soils, and coffee rock (which is high in iron). Pine plantations adjacent to marine wetlands were identified as potentially large contributors to water quality conditions that trigger *Lyngbya* blooms (Ahern 2003). |
| **Direct impacts:** Damage from boat propellers is often localised to areas where high levels of boat traffic intersect shallow seagrass meadows. Damage from anchoring and moorings is an increasing threat. However the extent of these impacts within the site is not well documented. |

**Knowledge Gaps**

- Effects of long-term, low concentrations of herbicide exposures on seagrass health.
- Water quality data, adjacent to mainland, coastal villages to assess water quality changes and impacts on seagrasses.
- Levels of natural variability of *Lyngbya* in nature, where human impacts are minimal.

## 5.4 Threats to Ecosystem Service 4: Great Sandy Strait Ramsar site supports a **large and diverse area of mangrove communities** as part of a tidal wetlands ecosystem that also supports an **endangered butterfly.**

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| **Pollution/runoff:** Water quality is generally considered good (but needs EHMP data & confirmation). Diffuse-source pollution may arise from agricultural adjacent lands, Mary River catchment and State pine forestry plantations. Point-source pollution includes sewage treatment plant outlets (Urangan, Poona, Boonaroo, Tin Can Bay, Rainbow Beach and Cooloola Village). |
| **Pollution/runoff:** Nutrient loads. Evidence is emerging that suggests **excess nutrients** may lead to a collapse in soil structure that could result in mangroves being unable to colonise certain areas (N. Duke, pers. comm., 2007). |
| **Insecticides:** Midge spraying may have a direct adverse impact on the Illidge's ant-blue butterfly. |
| **Herbicides:** Five herbicides (diuron, atrazine, simazine, hexazinone and ametryn) were found in water samples from Hervey Bay, the Great Sandy Strait and the Mary River with the most common and most toxic being diuron (McMahon *et al* 2003). Preliminary investigations have also implicated diuron as the potential cause of mangrove dieback within the Mackay region (Duke *et al* 2001; 2003). |
| **Urban development:** Urban expansion could lead to a potential reduction in the intertidal wetlands zone. This would reduce the ability of mangroves to naturally fluctuate due to factors such as rainfall. May also have an adverse impact on the Illidge's ant-blue butterfly. |
| **Altered hydrological regimes:** Particular species of mangrove require certain levels of inundation and/or drainage. Regulation of fresh and saline waters could have an adverse impact on these species. |

**Knowledge Gaps**

- Impacts of changes in salinity regime on mangroves in the Great Sandy Strait.
- Effects of herbicides on mangrove health needed for this area.
- Potential impacts of excess nutrients on soil structure and success of mangrove colonisation.

## 5.5 **Threats to Ecosystem Service 5:** Great Sandy Strait Ramsar site supports a substantial area of **sub-tropical inshore reefs including coral and sponge communities and species** near their geographic limits.

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| **Climate Change and sea level rise:** Regularity and intensity of flood events. Increased sediment and nutrient loads are associated with agricultural land use, and major flood events have been suggested as the main deliverer of high nutrient and sediment loads and cause for coral death in the site. Increases in frequency of such events associated with climate change could pose an important threat to long-term health of these corals.<br><br>Sea temperature rise under global warming conditions may lead to both coral bleaching (mortality) and success of northern latitude species, however complexities of increased carbon dioxide concentrations in seawater may complicate these impacts. Sea level rise may lead to loss of corals at the deep end of their distribution, but potentially increased area of coral growth at shallow depths. |
| **Pollution/runoff:** Nutrient loads. Water quality in the site is generally considered good (Queensland EPA 2006), but increasing urbanisation & development pose threats. Excessive nutrients can lead to high phytoplankton densities and water turbidity or excessive macro-algal growth that completes with corals for light and space on reef substrates.<br><br>Diffuse-source pollution originates from agricultural adjacent lands, Mary River catchment and State pine forestry plantations. Point-source pollution includes sewage treatment plant outlets (Urangan, Poona, Boonaroo, Tin Can Bay, Rainbow Beach, Cooloola Village). |
| **Sedimentation:** Excessive and prolonged sediment loads can stress or kill corals through direct smothering. High sediment loads during summer wet season floods have been a threat since the early 1900's when land clearing commenced. Effects of Mary River floods on corals in this area have not been formally investigated, but sedimentation was considered a major cause of reef degradation during the 1992 flood. |
| **Harvesting:** Selective coral collecting (mainly *Goniopora*) around Big Woody Island (Harriott, 2001). At least 10 aquarium or coral fishing authorities are current for this area – (D. Gilson, J. Wolf, pers. comm., 2007). Local depletions of rarer species are a concern in this industry (Harriott, 2001). |
| **Aquaculture:** Line and rack culture of invertebrates, which might be allowed in the Great Sandy Marine Park, potentially pose threats to benthic communities through shading and dumping of shell and bio-fouling material. |

### Knowledge Gaps

- Impacts of pesticides/ herbicides, eg. inhibiting coral reproduction.
- Pollutant levels, especially in waters adjacent to the mainland, and their effects on the flora and fauna of Great Sandy Strait.
- Pre-1999 extent of coral reef and sponge garden habitats.
- Impacts of coral harvesting on coral cover and reef health.
- Coral recovery rates following flood-associated losses.
- Potential for corals to adapt to more frequent flood events and the associated pulse loads of sediment, freshwater and nutrients.
- Likely outcome for coral growth under the complex scenarios of climate change and sea level rise. Information on this matter is best sought through research programs elsewhere in Queensland and globally.

## 5.6 Threats to Ecosystem Service 6: Four **nationally threatened species of marine turtle** (green, loggerhead, hawksbill, flatback) occur annually in substantial numbers within Great Sandy Strait Ramsar site.

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| **Hill slope, gully and bank erosion** are major sources of excessive sediment inputs to the river and estuarine system, with approximately 50% of total sediments exported from the estuary mouth (DeRose *et al* 2002). Excessive and prolonged sediment loads, particularly associated with flood events, have led to loss of seagrasses through direct smothering and high turbidity (see **Section 4.1.3**). High sediment loads during summer wet season floods have been a threat since the early 1900's when more extensive land clearing commenced. |
| **Climate change:** Increased frequency of storms and flooding may lead to more frequent estuarine sediment inputs, re-suspension, turbidity and smothering over seagrass. If intervals for seagrass recovery are insufficient, this critical food resource for green sea turtles may decline to unacceptable levels. |
| **Direct threats:** For marine turtles these include boat strike (high speed ferries and recreational boating), drowning in buoy lines, entanglement, injury or drowning in discarded fishing lines, ghost nets (discarded, unattended netting) and crab pots (affecting loggerheads only); ingestion of plastic bags and the effects of pollutants. |
| **Fibropapilloma disease:** A common disease amongst turtles elsewhere in Queensland, and may be related to industrial or agricultural runoff. Incidences have also been associated with *Lyngbya* blooms (Dennison and Abal 1999). Green turtles exposed to, and assimilating, these tumour promoting compounds are at risk of Fibropapilloma (Arthur *et al* 2007). |
| **Toxins:** Dioxins (eg. polychlorinated dibenzo–p-dioxins and dibenzofurans) are organic pollutants of global concern as they are toxic, persistent and can biomagnify through the food chain. Particularly elevated concentrations of dioxins have been detected in marine sediments and dugongs and turtles in Hervey Bay, which is adjacent to the Ramsar site. Health effects associated with the exposure of these compounds to dugongs, turtles and indigenous people have commenced (Gaus *et al* 2004). |
| **Deterioration or loss of food resources:** including seagrasses, benthic and pelagic food items is considered a key threat to turtle numbers in the site. A general decline in seagrass biomass, density and area since the 1980s has been suggested (see section on ES3 Seagrasses). |
| **Predation:** Turtle populations nesting on the mainland coast are under threat from feral species such as foxes and dogs (Kirkwood and Hooper 2004) |
| **Off site impacts:** during migrations, breeding, or other life history stages.<br>Turtles will migrate distances of 100's to 1000's of kilometres from their foraging grounds to their nesting beaches which are generally believed to be their place of birth. Threats to these eastern Australian turtle populations include incidental capture in otter trawls, predation of eggs, and damage to nesting habitat. Off-site threats from trawling have been substantially reduced with implementation of the Queensland Fisheries East Coast Trawl Management Plan 1999 which requires all trawlers operating outside coastal streams on the east coast of Queensland to use approved turtle exclusion devices (TEDs). |

### Knowledge Gaps

- Incidence of toxins, disease and boat strike in sea turtle populations in Great Sandy Strait. These are considered some of the most useful parameters for monitoring to provide early alerts of impacts on sea turtle populations in Great Sandy Strait (C. Limpus, pers. comm., 2007).
- Sub-lethal and cumulative impacts on food resources through successive deteriorations in water quality.

## 5.7 Threats to Ecosystem Service 7: A relatively large number of species of **marine** mammals use the site, including several cetaceans and a local population of the **internationally vulnerable dugong.**

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| **Hill slope, gully and bank erosion** are major sources of excessive sediment inputs to the river and estuarine system, with approximately 50% of total sediments exported from the estuary mouth (DeRose *et al* 2002). Excessive and prolonged sediment loads, particularly associated with flood events, have led to loss of seagrasses through direct smothering and high turbidity (see **Section 4.1.3**). High sediment loads during summer wet season floods have been a threat since the early 1900's when more extensive land clearing commenced. |
| **Climate change:** Increased frequency of storms and flooding may lead to more frequent estuarine sediment inputs, re-suspension, turbidity and smothering over seagrass. If intervals for seagrass recovery are insufficient, this critical food resource for dugong may decline to unacceptable levels. |
| **Pollution/runoff:** may affect seagrass habitat and/or fauna – particularly water pollution via agriculture and urban sewage.<br>Excessive nutrient loads can lead to high levels of macrophytes and epiphytes on particular species of seagrass (*Halophila sp*, *Halodule sp*. and *Zostera sp.*) which have an adverse impact on their health. These seagrass species are the main food for dugongs and there are considerable linkages between seagrass health and dugongs (L. McKenzie, pers. comm., 2007). |
| **Toxins:** Dioxins (eg. polychlorinated dibenzo–p-dioxins and dibenzofurans) are organic pollutants of global concern as they are toxic, persistent and can biomagnify through the food chain. Particularly elevated concentrations of dioxins have been detected in marine sediments and dugongs and turtles in Hervey Bay, which is adjacent to the Ramsar site. Health effects associated with the exposure of these compounds to dugongs, turtles and indigenous people have commenced (Gaus *et al* 2004). |
| **Blooms of *Lyngbya majuscula*** (a cyano-bacteria) at Hervey Bay and Moreton Bay nearby have been associated with significant impacts on dugong populations. Causes of *Lyngbya* blooms have included agricultural and urban pollution, runoff of acidic water and associated metal ions from oxidated acid sulphate soils, and coffee rock, which is high in iron. Almost all of these threats come from the mainland catchments, streams and groundwater. |
| **Direct threats:** By-catch from fisheries, gill nets and shark nets at swimming beaches as well as discarded and free-drifting netting (ghost nets) are all known threats dugongs and Indo-pacific humpback dolphins in and adjacent to the Ramsar site. These are also potential threats to other cetaceans using the site.<br>Boat traffic at any speed close to dugongs and cetaceans can lead to direct mortality or at least have adverse impacts on feeding and social behaviour. |
| **Mariculture:** Given their proximity to estuarine waters, Indo-pacific humpback dolphin are particularly vulnerable to habitat loss and degradation through aquaculture developments |
| **Off site impacts:** (for example the hunting of certain cetaceans whilst on migration) might not be within the direct sphere of influence of site managers, but other mechanisms are available through relevant domestic and international conservation instruments. |

Deterioration of seagrass habitat is a major threat to dugong (pictured). Photo courtesy of EPA.

**Knowledge Gaps**

- Impacts of diuron (DCMU) on dugong physiology and morbidity/mortality.
- Local factors which may lead to blooms of *Lyngbya majuscula* in the Ramsar site.

## 5.8 Threats to Ecosystem Service 8: The nationally threatened water mouse *Xeromys myoides* occurs in mangrove, saltmarsh and/or associated freshwater wetlands within Great Sandy Strait Ramsar site.

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| **Climate Change and sea level rise:** a possible rise in sea levels as a consequence of global warming could greatly impact on the water mouse through a substantial reduction in nesting habitat. They are particularly at risk given their proximity to near sea level. |
| **Pollution/runoff:** Contaminated runoff from urban development and certain farming practices may effect the saline composition and nutrient levels in the sediment of the mangroves and have a negative impact on the water mouses' food resources. |
| **Direct impacts:** Uncontrolled vehicle use occurs throughout water mouse habitat in the Great Sandy Strait – particularly in the saltmarsh and sedgeland communities (Burnham 2000). This potentially destroys nesting and feeding habitat. Fraser Island is considered a very important site due to the minimal impacts of recreational vehicles to wetland habitat (Burnham unpublished report 2000). |
| **Predation:** Feral cats, dogs and pigs may prey on the water mouse. Fraser Island is considered a very important location due to the absence of feral pigs, foxes (Burnham unpublished report 2000). |
| **Urban development:** Urban development and associated activities in tidal wetland areas can potentially lead to the degradation, fragmentation and/or reduction in water mouse habitat. |

**Knowledge Gaps**

- Effects of runoff on mangrove invertebrates in the Great Sandy Strait Ramsar site.
- Impacts of feral animals on the water mouse are limited but there is evidence of them occurring in water mouse habitat in the Great Sandy Strait (Burnham 2000).

## 5. 9 Threats to Ecosystem Service 9: The **nationally threatened fishes honey blue-eye and Oxleyan pygmy perch** occur permanently in freshwater swamps and/or in associated streams within the Great Sandy Strait Ramsar site.

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| **Pollution/runoff:** Pollution from forestry and agriculture and urban development could be a threat to two fish species, particularly the population on the southeast side of the Ramsar site (Thompson *et al* 2000). Roads near sites could also lead to some contamination or pollution in Cooloola and Fraser (Ingram *et al* 2004a,b) |
| **Fire:** High intensity fires when the peat is dry could result in it burning for long periods and possibly have a negative impact on the Oxleyan pygmy perch and honey blue-eye habitat. |
| **Predation/competition:** *Gambusia holbrooki* are present in the western coastal streams and the Mary river. This species competes with both fish species for both space and food resources.<br>Alien species such as *Gambusia holbrooki* are considered to pose a significant threat to sub-populations of both species in terms of competition for food and space and predation on eggs (Pusey *et al* 2004). |
| **Drought or changes in flow regime/groundwater levels:** These could cause loss of connectivity between populations during drought conditions and loss of permanent habitat |
| **Housing development and associated infrastructure:** Waterway barriers, road construction and urban land uses are considered serious threats to coastal wallum vegetation. Both of the threatened freshwater fish species have a close association with this habitat and heavy impacts have occurred to date (Pusey *et al* 2004). |

### Knowledge Gaps

- Ideal burning regimes, if any and the effects of fire on the 2 fish populations.
- Effects of *Gambusia holbrooki* on the populations of the two fish.
- Vulnerability to drought or changes in flow regime/groundwater levels.

## 5.10 Threats to Ecosystem Service 10: Four species of **threatened acid frogs** occur permanently in the wallum swamps and lakes within the Great Sandy Strait Ramsar site.

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| **Climate Change and sea level rise:** a possible rise in sea levels as a consequence of global warming could be devastating to acid frog habitat. They are particularly at risk given their proximity to the sea. |
| **Pollution/runoff:** Nutrient-laden runoff from urban areas such as Rainbow Beach (and possibly areas on the western side of the Ramsar site) could adversely affect the water composition in the wallum lakes and swamps. It could also result in the habitat becoming more susceptible to invasive plant species (Meyer *et al* 2005). Runoff from nearby roads could also lead to some contamination or pollution (Ingram *et al* 2004a,b). |
| **Water extraction:** A reduction in flows into wallum habitat, through actions such as water extraction, would reduce breeding habitat availability for the frogs and adversely impact on the site's condition. |
| **Fire:** An increase in frequency and intensity of fires in the wallum swamps could lead to the destruction of acid frog habitat or direct mortality. High intensity fires in the patterned fens when the peat is dry could also result in it burning for long periods and destruction of habitat. |
| **Predation:** possible threat to eggs and larvae by introduced fish (in particular the plague minnow *Gambusia holbrooki)* in the Cooloola section of the wallum swamps and lakes. |

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| **Agriculture, urban development and forestry practices:** Land-use practices associated with these sectors directly and indirectly threaten habitat utilised by the frogs, particularly on the western side of the Great Sandy Strait.. Queensland's human population growth was 12.7% between 2001-2006, (ABS Census 2006) – such expansion will continue to increase development pressures on these habitats. |
| **Chytrid Fungus:** In Australia, amphibian chytridiomycosis, an exotic disease caused by the chytrid fungus *Batrachochytrium dendrobatidis*, is now listed as a key threatening process under the EPBC Act. It is not known if this disease poses a serious threat to the acid frog species. |

**Knowledge Gaps**

- Ideal burning regimes, if any, for the wallum swamps and the effects of fire on acid frog populations.
- Distribution and abundance of of *Gambusia holbrooki* in the Cooloola section of the Ramsar. Though supposedly present on Fraser island it is not currently considered a threat there (E. Meyer, pers. comm., 2007)
- Whether Chytrid fungus has been located in the Ramsar site and if it has impacted on acid frogs.

## 5.11 Threats to Ecosystem Service 11: Great Sandy Strait Ramsar site supports **substantial stocks of fishes, prawns and crabs** which may be subject to commercial or recreational harvest.

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| **Pollutants/runoff:** As for several estuarine waters in north-eastern Australia, agricultural pollution and runoff of acidic water and associated metal ions from oxidated acid sulphate soils pose threats to fish, particularly in estuarine portions of the Ramsar site. Almost all of these threats come from the mainland catchments, streams and groundwater. These effects have led to serious *Lyngbya* (cyano-bacteria) blooms at Hervey Bay and Moreton Bay further south, with impacts on epi-benthic fish and crustaceans (Ahern *et al* 2007)). |
| **Toxins:** Pesticides from agricultural and urban run-off and mosquito/midge control programs, can have direct impacts on crustacean, larvae and prey species and have sub-lethal effects on fish. |
| **Sedimentation causing loss of estuarine habitat and connectivity:** Severe changes to the estuary and adjacent habitats in the Burnett River, immediately north of the Mary River (C. Lupton, QDPI&F, pers comm.. 2007), were suggested as contributors to the reduced abundance of barramundi, mangrove jack and other species. Less severe impacts and threats of this type appear in estuarine sections of the Mary River (C. Lupton pers comm.. 2007). |
| **Reduced freshwater flows to coastal habitats:** Irrespective of the underlying ecological processes, collapse of marine fisheries throughout the world is frequently associated with the regulation of freshwater flows from major nearby rivers (Gillanders and Kingsford 2002), highlighting the importance of freshwater discharge into the marine environment for coastal fisheries. |
| **Obstructions to fish passage:** Weirs have previously resulted in reduced catches in the Mary and nearby river systems, even where fish passage structures have been installed, because some species were still unable to use the structures (Stockwell *et al* 2004). Berghuis and Piltz (2005) have assessed the fishway on the Mary Barrage and several other fishways in the south east and have concluded that when designed and operated optimally they have the potential to provide significant passage to fish. |
| **Exotic species.** In spite of the absence of identified marine pest species to date, introduced marine pests remain a threat to the marine fauna and flora of the site, given the large number of small ports, marinas, anchorages and boat harbours in the region.<br><br>No exotic marine or estuarine fish species have recorded in the site (Kirwood and Hooper 2004). However exotic fish in adjacent freshwater habitats pose potential threats to species from the Ramsar site which depend on those adjacent habitats to complete their life cycles. |

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| **Off site impacts** on species that migrate or share other habitats**:** Populations of diadromous fish (requiring essential migrations between fresh and salt water for completing life cycles) may be impacted by **degradation or loss of habitat** upstream or other marine areas where the fish move. Threats include modifications to stream morphology, dredging, removal of snags and stream bank cover, pollution and introduced species. Habitat complexity has been reduced significantly in the Mary River, affecting food webs and shelter for fish of recreational and commercial importance. |
| **Threats to key fishery habitats:** Other sections detail the threats to the abundance and condition of critical wetland habitats which fisheries stocks depend on for shelter, feeding, breeding and migration. Extent and condition of key habitats (estuarine, mangrove, seagrass, tidal flats, coral reefs and channel areas) are threatened by several factors (see relevant sections above). |
| **Overfishing:** There are gear/vessel restrictions and fish size limits, area closures on fishing in parts of the site, and bag limits on several recreational fish species, but for most species here there are no overall quotas set for **total fishery catch**. |

### Knowledge Gaps

- Quantitative environmental flow requirements for maintaining coastal fish stocks.This includes information on minimum flows required for fish passage, feeding, breeding and other supporting physical and biological processes.
- Success of fish-way structures on weirs and barrages for different fish species.
- Sediment dynamics in the estuary mouth (difficult due to the complex influences of land-use and in-stream modifications on erosion, bed loads and sediment transport).
- Quotas on total fishery catch in recreational and/or commercial fisheries for the site. These efforts would form part of regional fisheries management programs implemented by the Queensland Government.
- Extent of *Lyngbya* (cyano-bacteria) in Great Sandy Strait.

## 5.12 Threats to Ecosystem Service 12: Great Sandy Strait Ramsar site supports **large numbers of waterbirds (>20 000) with 8 species of shorebirds occurring in numbers >1% of their population,** including the highest counts in the world for far eastern curlew.

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| **Pollution/runoff:** Reduced estuarine water quality can impact populations of shorebird prey (food) resources on intertidal flats. |
| **Climate change and sea level rise:** a possible rise in sea levels as a consequence of global warming could be devastating to waterbird roosting and feeding habitat. |
| **Disturbance to roosting shorebirds:** Humans and domestic dogs are the key sources of disturbance. Their presence and behaviour can cause birds to stress and expend energy at a time when they must feed and prepare for annual long-distance migrations. |
| **Predation:** Foxes, dogs, cats, pigs may lead to morbidity or mortality of roosting shorebirds. |
| **Urban development and associated land-use:** Encroachment from urban development is a key threat leading to habitat loss and fragmentation, including loss of high tide roosts and reduced buffers around other roost sites. |

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| **Off site impacts:** (during migrations, breeding, or other life history stages).<br>Up to 40,000 shorebirds migrate thousands of kilometres to the Great Sandy Strait each year from breeding grounds in the Russian Artic. During migration, shorebirds rely on a chain of highly productive wetlands to rest and feed, building up sufficient energy to fuel the next phase of their journey. Many birds that visit the Great Sandy Strait, for example, rely on wetlands in the Yellow Sea between China and the Korean Peninsula as a stopover site between Russia and Australia.<br>Threats operating external to the site might not be within the direct sphere of influence of site managers, but other mechanisms are available through relevant domestic and international conservation instruments. |

**Knowledge Gaps**

- Impacts of water quality and other factors on invertebrate infauna populations that are shorebird food resources.
- Extent of impacts by humans, domestic and feral animals on roosting shorebirds.

## 5.13 Threats to Ecosystem Service 13: Great Sandy Strait Ramsar site contains sites of considerable **significance to indigenous Australians** and natural resources that potentially may be harvested sustainably by indigenous people using traditional methods.

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| **Pollution/runoff:** Impacts on water quality through sewage, agricultural chemicals, land clearing, etc threaten several aspects of indigenous use and spiritual values within the site. These include waterways of spiritual importance, mangroves, seagrasses, fish, shellfish, dolphins, dugong, and turtles.<br>Species and community changes have been noted, including subtle changes such as in flower and leaf morphology, and these can have greater meaning for other aspects of the site's ecological character. In a section of Tin Can Inlet, changes in mangrove tree growth and leaf morphology appear to be associated with sewage outfalls and earlier mining activities (Nai Nai Bird, pers. comm., 2007). |
| **Inadvertent damage to artefacts and sites**. A key threat to the cultural record is the lack of understanding and recognition of artefacts and sites by visitors, creating a high potential for damage to sites. |
| **Development and non-indigenous uses:** Burial, fouling and damage to ceremonial and other culturally significant sites is associated with local development and population pressures. Trash and broken glass also preclude (spiritually important) barefoot travel across particular areas. |
| **Cessation of traditional burning practices:** has resulted in changes to vegetation community composition in wallum and peat swamps (L. Barrowcliffe, pers. comm., 2007). |

**Knowledge Gaps**

- Location, condition and threats to specific sites of importance to indigenous Australians.

## 5.14 Threats to Ecosystem Service 14: Great Sandy Strait Ramsar site contains a rich diversity and abundance of natural resources that support a range of **nature-based tourism and recreational activities.**

| |
|---|
| **External social and economic circumstances:** Local tourist and visitor numbers are often impacted by social and economic patterns operating external to the site. |

| |
|---|
| **Deterioration of wetland habitats, fisheries and other natural ecosystem services in the site:** The set of natural ecological values supported at the site form the main attractant to several eco-tourism and recreational uses within the site. Any deterioration in those services could threaten tourism and recreation services provided by the site. Move to top |
| **Deterioration in adjacent tourism and recreation attractions:** Would mostly impact the number of interstate and international visitors to the Ramsar site. |

### Knowledge Gaps

- Trends in visitor numbers and projected population within the region influencing the straits
- External factors influencing tourism and recreational use within the Ramsar site.

# 6. Knowledge Gaps

Knowledge Gaps identified in the above sections are summarised in **Table 9**. It is a list of highest priority information gaps that, if addressed, should improve our capacity to maintain critical ecosystem components, processes and services and to address the key threats to ecological character of the Site. The list is considered a guide to assist site managers and should not be viewed as comprehensive.

**Table 9. Summary of specific information gaps and the critical ecosystem services, components, processes or key threats to which they relate.**

| Knowledge Gaps | Ecosystem Service (see Table 1 for description) | Component or Process (see Table 2 for description) |
|---|---|---|
| ***Relating to critical ecosystem components, processes and services:*** | | |
| The extent and condition of patterned fen habitat within and outside the Ramsar boundary, e.g., on the western parts of the Cooloola/ Inskip Peninsula, Fraser Island and the processes that maintain them. | 2,9,10 | A |
| The extent of critical habitats for water mouse, threatened fish and acid frog species within and outside the Ramsar boundary, eg., on the western parts of the Cooloola/ Inskip Peninsula, Fraser Island and the mainland areas immediately west of the Ramsar site; and whether these receive adequate protection. | 2,9,10 | A |
| Identification and measurement of condition indicators of peat & wallum. | 2,9,10 | A |
| Minimum flow and inundation requirements in freshwater wetlands (peat and wallum) for wetland vegetation, fish and frogs. | 2,9,10 | B |
| Water quality requirements for the wallum swamps and patterned fens. | 2,9,10 | C |
| Identification and measurement of appropriate indicators of primary production or physiological condition in algae, seagrasses and/or mangroves for monitoring ecological character. | 3,4,5 | D, H |
| Environmental flow (freshwater) requirements for estuarine species (especially diadromous fish). | 1, 11 | E |
| Impacts of different flow regimes scenarios on fish passage, feeding, breeding and other critical physical and biological processes. | 1,3,4,11 | E |
| Historical changes in bathymetry, especially minimum channel depths affecting sediment and nutrient transport and passage of animals. | 1, 11, | E, G |
| Natural variability in mangroves, seagrass and corals. | 3,4,5 | D |
| Extent, composition and condition of coral reef and sponge garden habitats. | 5,11,14 | D |
| Illidge's ant-blue *butterfly* distribution, habitat use and management requirements within the site and how to improve their monitoring and management. | 4 | D |
| Inter-annual variability of growth rates in young green turtles and in physiological condition or "readiness for breeding" in adult green turtles in Great Sandy Strait. | 6 | H |
| Numbers and movements of marine mammals (dugongs and cetaceans) using the site. | 7,14 | - |
| Water mouse detailed distribution and habitat requirements. | 4,8 | D |

| **Knowledge Gaps** | **Ecosystem Service** (see Table 1 for description) | **Component or Process** (see Table 2 for description) |
|---|---|---|
| Detailed distribution and habitat requirements of the four frog species. | 10 | A,B,C |
| Two threatened freshwater fish species: natural variability of populations or sub-populations; habitat extent and habitat quality requirements. | 10 | A,B,C |
| Natural mortality and other fishery-independent variables of estuarine fish and crab stocks. | 11 | - |
| Sustainability and appropriateness of current fisheries management practices. | 11 | - |
| Natural variability in shorebird numbers and their use of feeding areas and roost sites; and the influence of variability in shorebird food resources (e.g. abundance and composition of invertebrate fauna) on shorebird use of tidal flats. | 12 | D |
| Inventories and assessments of indigenous artefacts and sites. | 13 | D |
| Quantitative estimates of recreational and tourism use at the site. | 14 | - |
| ***Relating to Threats:*** | | |
| Appropriate burning regimes, if any, to sustain the patterned fens. | 2,9,10 | A |
| Factors affecting condition of mangroves, seagrasses, corals in the site. | 3,4,5 | D,E,F,H |
| Environmental levels of persistent organo-compounds at the site and effects of long-term, low concentrations of herbicide exposures on seagrasses, mangroves, dugong and green turtles. | 3,4, 6,7 | D,F,H |
| Levels of occurrence (natural and human induced) of *Lyngbya majuscula* (a cyano-bacteria), and impacts on other components, eg., seagrass, turtles, dugong, fisheries. | 3,6,7,11 | F,H |
| Coral recovery rates following flood-associated losses, and potential for corals to adapt to frequent floods and the associated pulse loads of sediment, freshwater and nutrients. | 5,11 | D,F,H |
| Impacts of coral harvesting on coral cover and reef health. | 5, 11 | D |
| Information on likely outcomes for coral reefs in the site under the complex scenarios of climate change and sea level rise – this can be sought through research programs elsewhere. | 5 | D,F,H |
| Incidence of toxins, disease and boat strike in sea turtle and dugong populations in Great Sandy Strait. | 6,7 | - |
| Impacts of feral animals on water mouse and shorebirds. | 8,12 | - |
| Extent and impacts of the exotic *Gambusia holbrooki* on two threatened fish species and acid frogs in the site. | 9, 10 | - |
| Impacts of water resource development on flow regimes and consequences for estuarine habitats, water quality and dependant species - particularly w.r.t. Mary River catchment influences on salinity, sediment and habitat condition. | 1,3,4,5,11,14 | E, F, G |
| External factors influencing tourism and recreational use within the Ramsar site. | 14 | - |

# 7. Changes in Ecological Character

The Site still meets all the Ramsar criteria recognised in the previous RIS (at the time of listing, 1999), and two additional criteria - Criterion 2c (new Criterion 4) and Criterion 4a (new Criterion 7) - which were omitted in the original RIS. Changes to the site since Ramsar listing (1999) have mostly been small. Some ecosystem components have shown indications of downward trends but data is insufficient to indicate whether any of these changes represent changes to ecological character (i.e., exceed the limits of acceptable change). Some of the changes had commenced prior to the date of Ramsar listing, thus may be part of long-term declines.

Shallowing of the mouth of the Mary River estuary has occurred and may have started before Ramsar listing. Major floods before listing caused large losses of seagrass with three to five years for recovery, and incomplete recovery, in some meadows, particularly those near the mainland. There are indications of long-term downward trends in seagrass meadow and coral reef health and cover since 1988. These should be cause for concern in the longer term.

Local commercial fishers have noted substantial reductions in fisheries resources after 1999. These perceived reductions were cause for substantial reductions in <u>fishing effort</u> by fishers up until now (C. Shurey, pers. comm., 2007). However analyses of fisheries catch and fisheries-independent data is required to investigate these observations. Anecdotal evidence links these changes in fishing activity and resources to an extended period of drought since the date of listing, and other impacts on freshwater flow may have been influential (see **Section 4.3.5** Estuarine & Marine Critical Component / Process E: Hydrology).

Anecdotal observations also indicate likely reductions in numbers of dugong, sea turtle and dolphin using the site. A strong link between southern oscillation index (SOI) and ENSO cycles and physiological condition (e.g., preparedness for breeding) in green turtles (Limpus & Nicholls 2000) at other eastern Queensland sites lends some support to these observations.

Summer (December/January) counts of far eastern curlew in the Great Sandy Strait Ramsar site were high during the 1990's (4000 to 6000), although an average for the time of listing has not been estimated. The 2005 count (2370; Harding et al 2005) and the 2009 count (1865; QWSG unpubl. data) indicate a declining trend toward potential change in ecological character. Declines in numbers of large migratory shorebirds have also been detected nearby in Moreton Bay (Fuller et al. 2009), and reflect growing concerns for these and other populations of migratory shorebirds. Although the threats of coastal development and direct disturbance have likely increased at these two sites, impacts elsewhere in the flyway are also considered to be very large, eg., in the Yellow Sea region (Barter 2002).

Data is insufficient to indicate whether any of the abovementioned changes represent changes to ecological character (e.g., exceed the limits of acceptable change). The ECD includes recommendations for monitoring and highlights knowledge gaps that require attention, to improve understanding of the site's ecological character, levels of natural variability and acceptable change.

# 8. Key Monitoring Needs

The monitoring needs listed here are based primarily on the critical ecosystem services, components, processes and threats. They therefore include variables considered to best reflect the critical elements of ecological character and/or of most influence on ecological character of the site. In some cases, a single critical component may relate to a number of critical ecosystem services.

The monitoring indicators, frequency and priorities listed here are indicative only, to help inform the development of formal monitoring programs. They may be varied with the benefit of improved research knowledge or used according to prevailing needs and resources.

## 8.1 Monitoring Needs for Ecosystem Service 1: Great Sandy Strait Ramsar site includes **a large sand island and passage estuary** which provides habitat and **migration pathways** for marine animals (fishes, prawns, turtles) between riverine, sheltered nursery/feeding areas and open ocean.

| What to Monitor | Objective of the monitoring | Indicator/Measure | Frequency | Priority |
|---|---|---|---|---|
| Depth profiles /bathymetry at sea-openings, channels and estuary mouths | Sandbar and channel bathymetry can influence the degree of connectivity between marine and riverine habitats for water mixing and for migrating fish, turtles, dugong and cetaceans | Depth profiles /bathymetry at estuary mouths and channels | Advice needed | Medium |

## 8.2 Monitoring Needs: Ecosystem Service 2: A substantial area of peat swamp, consisting mainly of the **regionally unique patterned fens,** occurs within the Great Sandy Strait Ramsar site.

| What to Monitor | Objective of the Monitoring | Indicator/Measure | Frequency | Priority |
|---|---|---|---|---|
| Extent of Patterned Fens | To determine extent of patterned fen habitat in the Ramsar site and then detect alterations to the area of the habitat | Vegetation mapping | Annually | High |
| Condition of Patterned Fens | To assess changes in condition | Dependent upon development of better understanding of pattern fen processes (gap) | Advice needed | High |

## 8.3 Monitoring Needs: Ecosystem Service 3: A regionally significant area of **seagrass habitat** and **diversity of seagrass species** occurs within the Great Sandy Strait Ramsar site.

| What to Monitor | Objective of the monitoring | Indicator/Measure | Frequency | Priority |
|---|---|---|---|---|
| Extent of seagrass habitat area (by habitat type & location) | To monitor overall extent of seagrass resources in the site | Area of seagrass habitats (by community type) | 3 yrs<br><br>Event based | High |
| Depth range to which *Zostera capricorni* grows | Assess changes in overall water turbidity at monitoring locations | Depth of outer-edge of *Zostera capricorni* meadows | Annually | Low |
| Seagrass meadow condition and species composition | Early warning of seagrass health, and potential impacts on key herbivores | Seagrass-Watch set of parameters: percent cover, species composition of total cover and/or biomass, epiphyte cover | Quarterly | High |

## 8.4 Monitoring Needs: Ecosystem Service 4: Great Sandy Strait Ramsar site supports a **large and diverse area of mangrove communities** as part of a tidal wetlands ecosystem that also supports an **endangered butterfly.**

| What to Monitor | Objective of the Monitoring | Indicator/Measure | Frequency | Priority |
|---|---|---|---|---|
| Areal extent of the different tidal wetland communities – including the key mangrove forest communities, saltmarsh & saltpans | To assess changes in extent of mangrove communities or alterations in species composition. | Vegetation mapping by Mangrove-Watch | Annual | High |
| Tidal habitat condition | To detect change in condition of tidal wetlands | Advice needed.<br>Dependent upon development of better understanding of tidal wetland processes (gap)and causes of die-back | Advice needed | High |

## 8.5 Monitoring Needs: Ecosystem Service 5: Great Sandy Strait Ramsar site supports a substantial area of **sub-tropical inshore reefs including coral and sponge communities and species** near their geographic limits.

| What to Monitor | Objective of the monitoring | Indicator/Measure | Frequency | Priority |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Area of live coral reef habitat | To monitor changes in extent of reef habitat | Total area of reef habitat | 1-3 yrs (advice required) | Medium |
| Cover of dominant coral growth types | To monitor health of coral reef communities | Percent frequency of hard (dendritic, foliose, boulder) and soft corals; live versus dead coral cover on reef monitoring transects; dominant or key sponge/gorgonian species, coral bleaching | 1-3 years<br>Events based for coral bleaching | High |
| Extent of macro- and turf- algae cover | Provide early indicators of deteriorating water quality and threats to corals | Percent frequency of macro and turf algae on reef monitoring transects | 1-3 yrs (on scientific advice) | High |

## 8.6 Monitoring Needs: Ecosystem Service 6: Four **nationally threatened species of marine turtle** (green, loggerhead, hawksbill, flatback) occur annually in substantial numbers within Great Sandy Ramsar site

| What to Monitor | Objective of the monitoring | Indicator/Measure | Frequency | Priority |
|---|---|---|---|---|
| Annual growth rates of young turtles | To provide early alerts of impacts on sea turtle population health | Advice needed | Annual | Medium |
| Physiological indices of "preparedness for breeding" in green turtles | To provide early alerts of impacts on sea turtle population health | Advice needed, (e.g. hormone and metabolic markers) | Annual | Medium |
| Incidence of toxins and disease in sea turtle populations in Great Sandy Strait | To provide early alerts of impacts on sea turtle population size | E.g., incidence of persistent organic pollutants and fibropapilloma virus | Advice needed | Medium |
| Incidence boat strike in sea turtle populations in Great Sandy Strait | To provide early alerts of impacts on sea turtle population size | Reports of boat strikes and injuries/mortalities | Advice needed | Medium |

## 8.7 Monitoring Needs: Ecosystem Service 7: A relatively large number of species of **marine** mammals use the Great Sandy Strait Ramsar site, including several cetaceans and a local population of the **internationally vulnerable dugong.**

| What to Monitor | Objective of the monitoring | Indicator/Measure | Frequency | Priority |
|---|---|---|---|---|
| Abundance of dugong using the site | To ascertain local population size and effects of flood events on numbers | Aerial survey counts of individuals | Annually | High |

| | | | | |
|---|---|---|---|---|
| Abundance of key cetaceans using the site: This would include the humpback whale plus inshore bottlenose and Indo-Pacific humpback dolphin. There are a number of other cetaceans recorded in the Ramsar site but it is currently not clear how significant the site is for them. | To ascertain what species of cetacean are using the site in significant numbers and establish what those numbers are | Aerial survey counts of individuals<br>OR<br>Tourist vessel-based sightings per year | Annually<br><br>Annually | High<br><br>High |
| Extent and condition of seagrass habitat suitable for dugong feeding (primarily *Halophila sp*, *Halodule sp* and *Zostera sp* dominant meadows) | To strengthen understanding of the relationship between dugong and key seagrass species and related management issues | Seagrass-Watch set of parameters:<br>- percent cover<br>- species composition of total cover and/or biomass<br>- epiphyte cover | Every 5 years | High |
| Pollutants: Concentrations of herbicides such as diuron (DCMU) in water, sediment and plants | Address potential threats of persistent herbicides on sea turtles and dugong | Herbicide concentrations (e.g. diuron) in water, sediments or seagrass plants | Event (e.g., post-flood) | High |

### 8.8 Monitoring Needs: Ecosystem Service 8: The nationally threatened water mouse *Xeromys myoides* occurs in mangrove, saltmarsh and/or associated freshwater wetlands within Great Sandy Strait Ramsar site.

| What to Monitor | Objective of the Monitoring | Indicator/Measure | Frequency | Priority |
|---|---|---|---|---|
| Water mouse nests: used as a surrogate for distribution and abundance of the species | Increase understanding of range, population trends and habitat requirements | Presence/absence<br>Detection of nests<br>Evidence of feeding (eg. crab shells) | Intensively over breeding period | High |
| Impacts on water mouse habitat: such as uncontrolled vehicle use | Identify areas impacted by uncontrolled vehicle use in order to mitigate the effects | Amount of tire marks in water mouse habitat<br>Evidence of destroyed nest | As needed | Medium |
| Impacts on water mouse habitat: feral animals, particularly feral pigs and foxes | To establish impacts of feral animals on the water mouse and its habitat. | Pig tracks and scats<br>Fox tracks and scats<br>Pig damage to habitat | Advice needed | Medium |

## 8.9 Monitoring Needs: Ecosystem Service 9: The **nationally threatened fishes honey blue-eye and Oxleyan pygmy perch** occur permanently in freshwater swamps and/or in associated streams within the Great Sandy Strait Ramsar site.

| What to Monitor | Objective of the Monitoring | Indicator/Measure | Frequency | Priority |
|---|---|---|---|---|
| Honey blue-eye and Oxeylan pygmy perch: distribution and abundance | Increase understanding of population sizes and habitat requirements | Presence/absence, or indices of abundance in key areas<br>Detection of fingerlings<br>Type and availability of habitat | Intensively over breeding period | High |
| Fire | Assess impacts on the two fish populations if/ when a fire occurs wallum swamps and/ or patterned fens | Survivorship of flora and fauna<br>Recruitment rates | After fire event | Medium |
| *Gambusia holbrooki* | Impacts on the populations of honey blue-eye and Oxleyan pygmy perch | Abundance indices in selected areas | Annually | Medium |

## 8.10 Monitoring Needs: Ecosystem Service 10: Four species of **threatened acid frogs** occur permanently in the wallum swamps and lakes within Great Sandy Strait Ramsar site.

| What to Monitor | Objective of the Monitoring | Indicator/Measure | Frequency | Priority |
|---|---|---|---|---|
| Four species of acid frogs: distribution and abundance | Identify key populations in the Ramsar site | Presence/absence<br>Detection of tadpoles<br>Detection of nests | Breeding periods until population variability or trends are established | High |
| Freshwater flows & inundation in acid frog breeding habitat | To determine minimum flow/ inundation requirements for acid frog breeding habitat | Presence/absence<br>Amount of available water to breed<br>Amount and condition of wallum'vegetation<br>Evidence of breeding (nests/tadpoles) | Breeding periods until minimum requirements are established. Annually after that. | High |
| Water Quality | To assess changes in water chemistry in relation to:<br>- nutrient runoff<br>- sea level rise<br>- habitat sustainability | Salinity (Electrical Conductivity)<br>pH<br>Dissolved Oxygen | Quarterly | Medium |

| | | | | |
|---|---|---|---|---|
| Fire | Assess direct impacts on four frog species if/ when a fire occurs<br><br>Assess impacts on frog habitat from fires | Extent of damage to critical habitat | After fire events | High |

## 8.11 Monitoring Needs: Ecosystem Service 11: Great Sandy Strait Ramsar site supports **substantial stocks of fishes, prawns and crabs** which may be subject to commercial or recreational harvest.

| What to Monitor | Objective of the monitoring | Indicator/Measure | Frequency | Priority |
|---|---|---|---|---|
| Abundance of key fish stocks (at least commercial catches) | The size of (at least commercial) fish stocks arising from the site will provide a direct index of the health of the site, since this is a core value and readily measurable index. | C-Fish catch log data **summaries** (protecting privacy of data by individual commercial operators) from areas within the site | Annual catch statistics from fishing industry sectors | High |
| Juvenile prawn abundance | Another of the site's key values is its contribution to nearby fisheries. | Juvenile king prawn abundance indices (research trawls) | Annual (QDPI research & monitoring) | Medium |
| Indices of fish species diversity | Diversity of fish species is a useful indicator of the health of fisheries in the site, which in turn depends on overall habitat diversity and condition. | Advice is needed to identify an appropriate index of species diversity for measuring change in ecological character. | Annual at first using catch statistics from fishing industry sectors.or research | Medium |

## 8.12 Monitoring Needs: Ecosystem Service 12: Great Sandy Strait Ramsar site supports **large numbers of waterbirds (>20 000) with 8 species of shorebirds occurring in numbers >1% of their population,** including the highest counts in the world for far eastern curlew.

| What to Monitor | Objective of the monitoring | Indicator/Measure | Frequency | Priority |
|---|---|---|---|---|
| Extent and condition of shorebird habitat: roost sites | To assess condition and use of the most important roost sites for migratory shorebirds in the site (see Harding *et al* 2005) | Assess general condition, use of site by shorebirds and evidence of disturbance. May be beneficial to take a fixed point photo each year to make comparisons. | Annually | High |
| Abundance of shorebird numbers: far eastern curlew | Two conspicuous and easily distinguishable species to provide a surrogate for the seven | Maximum counts for the two species at their most important roost sites. Could be couples | Annually, during the period of high numbers each | High |

| | | | | |
|---|---|---|---|---|
| and bar-tailed godwit | species present at the site in numbers exceeding 1% of their population | with the roost site monitoring | summer | |

Bar-tailed godwits (pictured), together with far eastern curlews, may be used as a surrogate for assessing shorebird numbers in the Great Sandy Strait Ramsar site.

Photo: courtesy of Phil Straw

## 8.13 Monitoring Needs: Ecosystem Service 13: Great Sandy Strait Ramsar site contains sites of considerable **significance to indigenous Australians** and natural resources that potentially may be harvested sustainably by indigenous people using traditional methods.

| What to Monitor | Objective of the monitoring | Indicator/Measure | Frequency | Priority |
|---|---|---|---|---|
| Fish traps, stone artefact scatters, tree scars as markers and signs, and burial sites | Inventories and condition of resources for ongoing maintenance, custodianship and use | Advice needed from traditional owners on the high priority sites/artefacts | Advice needed | Medium |
| Bora rings | For protection and to scope potential future use of the sites | Bora rings condition | Once per quarter | High |

## 8.14 Monitoring Needs: Ecosystem Service 14: Great Sandy Strait Ramsar site contains a rich diversity and abundance of natural resources that support a range of **nature-based tourism and recreational activities.**

| What to Monitor | Objective of the monitoring | Indicator/Measure | Frequency | Priority |
|---|---|---|---|---|
| Number of tourists using the site (by type of use) | To assess use of the site by tourists | Numbers on diving, wilderness, fishing tours, etc | Daily (collected by tour operators) | Medium |
| Recreational fisher numbers or vessel numbers | Obtain indices of recreational use on waterways of the site | No. of vessels launched at boat ramps | Weekly (weekend use) | Medium |

### 8.15 **Freshwater Critical Component / Process B:** Hydrology

| What to Monitor | Objective of the monitoring | Indicator/Measure | Frequency | Priority |
|---|---|---|---|---|
| Surface and groundwater flows (or water levels) into key freshwater wetlands | Determine and monitor minimum acceptable flows to support populations of threatened acid frogs and freshwater fish | Water levels in key seasons | To be determined (possibly annually during key seasons of use when flows and water levels are critical) | Medium |

### 8.16 **Freshwater Critical Component / Process C:** Physicochemical components

| What to Monitor | Objective of the monitoring | Indicator/Measure | Frequency | Priority |
|---|---|---|---|---|
| pH, conductivity, salinity, dissolved oxygen of acidic waters in freshwater wetlands | To assess changes in chemical composition of the water in relation to:<br>- nutrient runoff<br>- sea level rise<br>- habitat sustainability | Salinity (Electrical Conductivity)<br>pH<br>Dissolved Oxygen | Quarterly at first | High – particularly for the Cooloola section |
| Other water quality parameters | Assess impacts of nitrogen and/or phosphorus on the survival of the honey blue-eye, Oxleyan pygmy perch and the four acid frog species | Parameters under the Queensland Water Quality Guidelines | Advice or studies needed | Currently low (unless threats increase) |

### 8.17 **Estuarine & Marine Critical Component / Process E:** Hydrology

| What to Monitor | Objective of the monitoring | Indicator/Measure | Frequency | Priority |
|---|---|---|---|---|
| Mary River freshwater/estuarine flows: total annual flow and other indices/aspects of flow | Ensure freshwater/ estuarine flow is maintained for its influence on estuary bathymetry, habitat connectivity, sediment and nutrient transport and fish biology | Mary River freshwater flow – total annual flow and indices/aspects of flow. | Year-round | High |

### 8.18 **Estuarine & Marine Critical Component / Process F:** Physicochemical Components

| What to Monitor | Objective of the monitoring | Indicator/Measure | Frequency | Priority |
|---|---|---|---|---|
| Physicochemical | Assess water quality | Parameters under the | Quarterly | High |

| | | | | |
|---|---|---|---|---|
| water quality parameters | parameters that influence several critical ecosystem components, processes and services in estuarine and marine wetlands | Queensland Water Quality Guidelines | | |
| Toxicant/pollutant concentrations in estuarine and marine waters | Assess concentrations of toxicants that influence several critical ecosystem components, processes and services in estuarine and marine wetlands | Persistent herbicides and other organic pollutants, such as diuron, atrazine, simazine, hexazinone and ametryn<br>Also refer to the ANZECC 2000 Guidelines (ANZECC & ARMCANZ 2000) | Advice needed | Medium |

# 9. Communication, Education and Public Awareness (CEPA) messages

Communication, education and public awareness (CEPA) programs are essential to assist the maintenance of ecological character. In developing the ECD, several primary education and awareness messages and themes were identified. Examples of core messages and themes that can be used for the site are:

1. The Great Sandy Strait is a particularly outstanding Ramsar site in Australia in that it supports a large diversity of wetland habitats, a high diversity of wetland flora and fauna species, and several community types that reflect the transition between tropical and temperate marine and coastal zones. The proximity and connectivity between wetland types further enhances biodiversity and productivity within the site.
2. Great Sandy Strait Ramsar site comprises a regionally important sand passage estuary that provides for an extensive and diverse set of both estuarine and freshwater wetlands, and regionally important biodiversity.
3. A substantial area of non-forested peat swamp, comprised mainly of the rare ‘patterned fen’, occurs within the Great Sandy Strait Ramsar site. These fens together with areas of ‘wallum’ heath plains and freshwater swamps, support species adapted to the prevailing acidic water and substrate including threatened frogs and fishes as well as species of crayfish and earthworm.
4. The Great Sandy Strait Ramsar wetlands support substantial populations of nationally and/or internationally threatened species, including four marine turtle species (green, loggerhead, hawksbill, flatback), dugong; the intertidal-dwelling water mouse; the mangrove-dwelling Illidge’s ant-blue butterfly, the highest site counts worldwide for the endangered shorebird, far eastern curlew in estuarine/marine areas; and the honey blue-eye and Oxleyan pygmy perch plus four species of acid frogs in the patterned fens and the wallum heath plains and swamps.
5. The Great Sandy Strait Ramsar site is relatively undisturbed and thus a particularly significant site on the eastern coast of Australia. However, some changes in ecological character are apparent and the site faces a number of threats which need to be minimised through targeted management.
6. Hydrological connectivity of water bodies within the site, with adjacent habitats and between estuarine habitat and upper reaches of the Mary River, enhanced through annual freshwater flow-events of high volume, is a critical element to ensuring passage of the site’s fish that need to use riverine habitats to feed or complete essential life-history migrations.
7. Hydrological flows – in particular from the Mary River catchment and coastal streams– are a major influence in maintaining several other elements of the site’s ecological character, including water quality and sediment erosion, transport and deposition.
8. A moderate- to high- level regime of water quality exists throughout Great Sandy Strait Ramsar site, which helps to support high primary productivity of seagrass and mangrove habitat, rich food webs of herbivory and predation, secondary productivity, and abundant and diverse fauna within the site.

Critical ecosystem components and processes which support the ecological character of the Great Sandy Strait Ramsar site can be grouped into those associated with the freshwater wetlands and those associated with the estuarine/marine wetlands.

Specific messages derived from the fourteen (14) critical Ecosystem Services and 8 critical components and processes are suitable for use directly in development of CEPA plans and products.

These messages can be adapted for use in developing more targeted messages which to go to users, community and decision makers, to assist in ensuring that the key elements of ecological character are protected.

## References


Ahern, K. 2003. *Effect of nutrients on the cyanobacteria Lyngbya majuscula: A bioassay Technique*, Hons Thesis, University of Queensland. Brisbane. 160pp.

Ahern, K.S., Ahern, C.R. and Udy, J.W. 2007. Nutrient additions generate prolific growth of *Lyngbya majuscula* (cyanobacteria) in field and bioassay experiments. *Harmful Algae* **6(1):** 134-151.

ANCA. 1996. *A Directory of Important Wetlands in Australia*. Australian Nature Conservation Agency, Canberra.

Arthington, A.H. & Marshall, C.J. 1993. *Distribution, ecology and conservation of the Honey Blue-eye, Pseudomugil mellis, in south-eastern Queensland* :158.

Arthur, K.E., Limpus, C.J., Balazs, G.H., Udy, J.W. and Shaw, G.R. 2007, Ecotoxicology of the cyanobacterium *Lyngbya majuscula* and the potential exposure of green turtles, *Chelonia mydas*, to tumour promoting compounds. *27th Sea Turtle Symposium*, Myrtle Beach, SC, USA, 22-28 Feb 2007, International Sea Turtle Society.

ANZECC and ARMCANZ. 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. National Water Quality Management Strategy Paper no. 4. Australian and New Zealand Environment and Conservation Council / Agriculture and Resource Management Council of Australia and New Zealand. http://www.environment.gov.au/water/publications/quality/index.html#nwqmsguidelines

Australian Bureau of Statistics, Census. 2006. http://www.abs.gov.au/websitedbs/d3310114.nsf/Home/census

Australian Heritage Commission. 2002. *Australian Natural Heritage Charter for conservation of places of natural heritage significance*. Second Edition. Australian Heritage Commission. Canberra. http://www.ahc.gov.au/publications/anhc/parta.html

Bamford, M., Watkins, D., Bancroft, W., Tischler, G. And Wahl, J. 2006. *Shorebirds of the East Asian – Australasian Flyway: Population Estimates and Internationally Important Sites*. Wetlands International – Oceania. Canberra, Australia.

Bannister, J, L., Kemper, C, M. and Warneke, R, M. 1996. *The action plan for Australian Cetaceans.* The Director of National Parks and Wildlife Biodiversity Group, Environment Australia.

Barter, M. 2002. Shorebirds of the Yellow Sea. Importance, threats and conservation status. *International Wader Studies* **12**: 1-104.

Bayly, I.A.E. 1964. Chemical studies on some acidic lakes of east Australian coastal sandy lowlands. *Australian Journal of Marine and Freshwater Research*, 15, pp 56-72

Bensink, A.H.A. and Burton, H. 1975. North Stradbroke Island, a place for freshwater invertebrates. *Proceedings of the Royal Society of Queensland*, 86, pp 29-45.

Beach Protection Authority. 1989. *Hervey Bay Beaches, A detailed study of the coastline behaviour along the mainland beaches of Hervey Bay, South-east Queensland, Australia.* Beach Protection Authority Queensland. Brisbane. 323pp.

Berghuis, A and Piltz S, 2005. Assessment *of the upgraded fishway on the Mary River Barrage. Report to the Department of Natural Resources, Mines and Energy.* Department of Primary Industries & Fisheries. 30pp

Beumer, J. and Halliday, I. 1994*. Effects of habitat disturbance on coastal fisheries resources of Tin Can Bay/Great Sandy Strait.* Report to the Fisheries Research and Development Corporation, 52pp.

Brizga, S.O. 2000. *Burnett Basin Water Allocation and Management Plan: Proposed Environmental Flow Performance Measures*. Department of Natural Resources, Brisbane.

Brizga, S.O., Arthington, A.H., Balcombe, S., Condina, P., Connell, M., Connolly, N.M., Craigie, N.M., Kennard, M.J., Kenyon, R., Mackay, S.J., and Schlacher, T.A. 2005. *Environmental Flow Assessment and Scenario Implications, Mary River Draft Water Resource Plan, Final Report (2 Volumes).* Department of Natural Resources and Mines (Queensland). QNRM05341.

Bruinsma, C. and Danaher, K. 2000. Queensland Coastal Wetland Resources, Round Hill Head to Tin Can Inlet. *QDPI Information Series QI99081*. Department of Primary Industries Queensland, Brisbane. 101pp.

Burnham, M.B. 2000. *New locality records for Xeromys myoides False water-rat, within the Great Sandy and Wide Bay/Burnett management areas. Results from surveys conducted February to April 1999 and March to May 2000'*. Unpublished. Queensland Parks and Wildlife Service.

Cagnazzi, D., Harrison, P., Ross, G. and Lynch, P. 2005. *Inshore dolphin Populations of Hervey Bay and the Great Sandy Strait - Population status and habitat use by Indo-Pacific humpback dolphin, Sousa chinensis, in Great Sandy Strait and in the Hervey Bay Marine Park, Queensland.* Poster. Southern Cross University Whale Research Centre, School of Environmental Science and Management, Lismore.

Campbell, S.J. and McKenzie, L.J. 2004. Flood related loss and recovery of intertidal seagrass meadows in southern Queensland, Australia. *Estuarine, Coastal and Shelf Science,* 60: 477 - 490.

Commonwealth of Australia. 2006*. A Guide to the Integrated Marine and Coastal Regionalisation of Australia Version 4.0.* Department of the Environment and Heritage, Canberra, Australia. Available (Aug 2008) at: http://www.environment.gov.au/coasts/mbp/publications/imcra/imcra-4.html

Danaher, K. and de Vries, C. 2003. *Queensland's Coastal Wetland Resources, Maps of Queensland's mangrove and saltmarsh communities.* CD. Queensland Government Dept of Primary Industries.

DASET. 1991. Nomination of Fraser Island and the Great Sandy Region by the Government of Australia for inclusion in the World Heritage List. Prepared by the Department of the Arts, Sport, the Environment, Tourism and Territories, 70 pp.

Dennison W.C. and Abal E.G. 1999. *'Moreton Bay Study: A scientific basis for the healthy waterways campaign'*. South east Queensland regional water quality management strategy. Brisbane.

Department of Environment and Heritage [DEH] (1990). *Submission to the commission of inquiry into theconservation, management and use of Fraser Island and the Great Sandy region.* Queensland Department of Environment and Heritage, Brisbane, 317 pp.

Department of Environment and Resource Management (2009) WildNet. (Database), Department of Environment and Resource Management, Brisbane. 20th October 2009.

Department of the Environment and Water Resources (2007). *National Framework and Guidance for Describing the Ecological character of Australia's Ramsar Wetlands.* Module 2 of the National Guidelines for Ramsar Wetlands – Implementing the Ramsar Convention in Australia. Australian Government Department of the Environment and Water Resources, Canberra.

Department of Natural Resources and Mines. 2007. *Cadastral Boundaries – DCDB*. Digital data, Department of Natural Resources and Mines, Queensland.

Department of Sustainability and Environment 2005, *Framework for Describing the Ecological Character of Ramsar Wetlands – Including a description of the ecological character of the Barmah Forest Ramsar site.* Department of Sustainability and Environment, Victoria.

DeRose, R.C., Prosser, I.P., Wilkinson, L.J., Hughes, A.O. and Young, W.J. 2002, Regional Patterns of Erosion and Sediment and Nutrient Transport in the Mary River Catchment, Queensland, CSIRO Land and Water, *Technical Report 37/02*. Canberra. 45pp.

DeVantier, L.M. (In prep.) Corals and coral communities of Great Sandy Strait and Hervey Bay. Report for Wildlife Preservation Society of Queensland, Fraser Coast Branch.

Dredge, M. Kirkman, H. and Potter, M. 1977. A short term biological survey: Tin Can Inlet / Great Sandy Strait. CSIRO Division Fisheries and Ocenaography *Report No. 68*. 31pp.

Driscoll, P. 1990. Survey of Shorebird Feeding Areas and High Tide Roosts in the Great Sandy Strait, Summer 1990. A Report for the Queensland Department of Environment and Heritage. 34 pp.

Driscoll, P.V. 1998. Summary report of wader surveys 1989 to 1997 in the Great Sandy Strait. Report to Qld Dept. Environment. 27pp.

Duke, N.C. 2006. *Australia's Mangroves. The Authoritative guide to Australia's mangrove plants*. University of Queensland and Norman C. Duke. 200pp.

Duke, N.C.  Ball, M.C. and Ellison J.C. 1998, Factors influencing biodiversity and distributional gradients in mangroves. *Global Ecology and Biogeography Letters*, 7: 27–47.

Duke, N., Roelfsema, C., Tracey, D. and Godson, L. 2001. *Preliminary Investigation into dieback of mangroves in the Mackay Region. Report to the Queensland Fisheries Service, Northern Region and the Community of Mackay Region.* Marine Botany Group, Botany Department, University of Queensland, Brisbane. 81 pp.

Duke, N.C., Bell, A.M., Pedersen, D.K., Roelfsema, C.M., Godson, L.M., Zahmel, K.N., MacKenzie, J and Bengston-Nash, S. 2003. *Mackay mangrove dieback. Investigations in 2002 with recommendations for further research, monitoring and management. Final Report to Queensland Fisheries Service, Northern Region (DPI) and the Community of Mackay Region.* Marine Botany Group, Centre for Marine Studies, The University of Queensland, Brisbane. 157 pp. The Centre for Marine Studies, Marine Botany Lab.

EDAW (Aust.). 1996. A View of the Coast: An Overview of the Scenic Resources of the Queensland Coast. Queensland Department of Environment, Coastal Management Branch.

Fisheries Research Consultants. 1993a. *Aerial photographic survey of seagrasses: the Great Sandy Strait and Tin Can Inlet.* Report prepared for the Queensland Department of Environment and Heritage.

Fisheries Research Consultants. 1993b. *A study of the Marine and Intertidal Habitats of the Great Sandy Region.* Report prepared for the Queensland Department of Environment and Heritage. 143pp.

Fisheries Research Consultants. 1994a. *A re-survey of seagrasses of the Great Sandy Strait and Tin Can Estuary.* Report prepared for the Queensland Department of Environment and Heritage. 34pp.

Fisheries Research Consultants. 1994b. *Establishment of long-term seagrass monitoring sites within the Great Sandy Strait and Tin Can Inlet*. Report prepared for the Queensland Department of the Environment and Heritage and the Queensland Commercial Fisherman's Organisation. 30pp.

Frankland, K. 1990. *Booral: A preliminary investigation of an archaeological site in the Great Sandy Strait Region, southeast Queensland*. Honours thesis, Department of Anthropology and Sociology, University of Queensland, Brisbane.

Fry, B. and Wainwright, S.C. 1991. Diatom sources of $^{13}C$-rich carbon in marine food webs. *Mar. Ecol. Prog. Ser*. **76:** 149-157.

Fuller, R.A., Wilson, H. B., Kendall, B.E. and Possingham, H.P. 2009. *Monitoring shorebirds using counts by the Queensland Wader Study Group*. Ecology Centre, University of Queensland. 58 pp. Unpublished report to QWSG and DERM.

Gaus, C., O'Donohue, M., Connell, D., Mueller, J., Haynes, D. and Päepke, O. 2004. Exposure and potential risks of dioxins to the marine mammal dugong. *Organohalogen Compounds* 66: 1559-1565.

Gillanders, B.M., and Kingsford, M.J. 2002. Impact of changes in flow of freshwater on estuarine and open coastal habitats and the associated organisms. *Oceanography and Marine Biology: an Annual Review 2002.* 40, 233-309.

Gosbell, K. and Clemens, R. 2006. Population monitoring in Australia: some insights after 25 years and future directions. *Stilt* **50**: 162-175.

Grober-Dunsmore R., Frazer, T., Beets, J.P. and Lindberg, W.L. 2007. Reef fish and habitat relationships in a Caribbean seascape: the importance of reef context. *Coral Reefs* **26**(1) 201-216.

Gynther, I. and Van Dyck, S. 2003. Nesting Strategies of the Water Mouse Xeromys myoides in southeast Queensland. Memoirs of the Queensland Museum. **49**: 453.

Halliday, I. and Robins, J. 2007. *Environmental flows for sub-tropical estuaries: understanding the freshwater needs of estuaries for sustainable fisheries production and assessing the impacts of water regulation*. Queensland Department of Primary Industries and Fisheries. Final Report FRDC Project No. 2001/022, Coastal Zone Project FH3/AF. 229 pp.

Halliday, I.A. and Young, W.R. 1996. Density, biomass and species composition of fish in a subtropical *Rhizophora stylosa* mangrove forest. *Marine and Freshwater Research*, **47** (4). pp. 609-615.

Hamann, M., Jessop, T.S., Limpus, C.J. and Whittier, J.M. 2005. Regional and annual variation in plasma steroids and metabolic indicators in female green turtles, Chelonia mydas. *Marine Biology* 148(2): 427-433.

Harding, S., Milton, D. and Cross, L. 2005. *Great Sandy Strait Shorebird Roost Mapping Project – Final Report.* Queensland Wader Study Group. Brisbane. 47pp.

Harriott, V.J. 2001. *The sustainability of Queensland's coral harvest fishery.* CRC Reef Research Centre Technical Report No. 40. CRC Reef Research Centre, Townsville. 33pp

Haynes, D., Ralph, P., Prange, J. and Dennison, W. 2000a. The impact of the herbicide Diuron (DCMU) on three species of tropical Queensland seagrasses using pulse amplitude modulated (PAM) flourometry. *Marine Pollution Bulletin 41: 288-293.*

Hegerl, E. 1993. Site evaluations and management considerations for intertidal wetlands – Baffle Creek to Noosa. Draft Report. Australian Littoral Society unpublished report for Queensland Department of Environment and Heritage, 69 pp.

Hemmings, L. and Sinclair, J, 1984. Nomination of the Great Sandy Region for inclusion in the World Heritage List. Australian Conservation Foundation.

Hines, H.B., Mahony, M. and McDonald, K. 1999. An assessment of frog declines in wet subtropical Australia. pp 44-63 *in* Campbell, A. (ed.) *Declines and Disappearances of Australian Frogs*. Environment Australia, Canberra.

Hughes, J.M., Ponniah, M.H., Hurwood, D.A., Chenoweth, S..and Arthington, A.H. 1999. Genetic differentiation among populations of the Pygmy Perch (*Nannoperca oxleyana*), using allozyme and mitochondrial DNA analysis. *Heredity,* 83: 5-14.

Ingram, G.J., Brown T.J., Hegerl. E., Hockings, M., Lamb, D., Thompson, C.H., Haig, J., 2004a. *Fraser Island World Heritage Area: Review of Outstanding Universal Value*. Report for the Queensland Environmental Protection Agency.

Ingram, G.J., Brown T.J., Hegerl. E., Hockings, M., Lamb, D., Thompson, C.H., Haig, J. 2004b. *Cooloola: Assessment of Potential Outstanding Universal Value*. Report for the Queensland Environmental Protection Agency.

IMCRA Technical Group. 1998, *Interim Marine and Coastal Regionalisation for Australia: an ecosystem- based classification for marine and coastal environments. Version 3.3.*

Environment Australia, Commonwealth Department of the Environment. Canberra. http://www.environment.gov.au/net/imcra.html

IUCN Redlist of Threatened Species Listings. 2006. http://www.iucnredlist.org/

Kirkwood, J.M., and Hooper, J.N.A. 2004. *Technical Paper - Burnett Mary Regional Assessment Coastal & Marine Biodiversity*. Submitted to Burnett Mary Regional Group for Natural Resource Management.

Last, P.R. and Stevens, J.D. 2009. *Sharks and Rays of Australia*, 2nd Edition. CSIRO. Collingwood. 640pp.

Lennon, P. and Luck, P. 1990. Seagrass mapping using Lansat TM data: a case study in southern Queensland. *Asian-Pacific Remote Sensing Journal*. 2: 2

Lewis, B. D. and Goldingay, R. L. 2005. Population monitoring of the vulnerable wallum sedge frog (*Litoria olongburensis*) in north-eastern New South Wales. *Australian Journal of Zoology* 53(3), 184-194.

Limpus, C. and Nicholls, N. 2000. ENSO regulation of Indo-Pacific green turtle populations. In: *Applications of seasonal climate forecasting in agricultural and natural ecosystems*, G.L. Hammer, N. Nicholls and C. Mitchell (eds.), London, Kluwer, 399-408.

Lovelock, C. 1993. *Field Guide to the Mangroves of Queensland*. Australian Institute of Marine Science,Townsville, 37 pp.

Mallin, M.A., Burkholder, J.A. M. and Sullivan, M.J. 1992. Contributions of benthic microalgae to coastal fisheries yield. *Trans. of the American Fisheries Society*. **121:** 691-695.

Maritime Safety Queensland. 2007. *The Official Tide Tables & Boating Safety Guide 2007.* Maritime Safety Queensland. Brisbane. 224pp.

Marsh, H., Corkeron, P., Lawler, I.R., Lanyon, J.M. & Preen, A.R. 1995. *The status of the dugong in the southern Great Barrier Reef Marine Park*. Report to Great Barrier Reef Marine Park Authority, Townsville.

Mary River Catchment Coordinating Committee. 1996. *Mary River Catchment Strategy*. Scientific Publishing, Department of Natural Resources, Brisbane.

McGrath, C. 2006. *Legal review of the framework for describing the ecological character of Ramsar wetlands to support implementation of the EPBC Act*. Report to the Department of the Environment and Heritage, Unpublished.

McKenzie, L.J. 2000. *Seagrass communities of Hervey Bay and the Great Sandy Strait – December 1998*. Queensland Department of Primary Industries Information Series.

McKenzie, L.J., Roder, C.A. Roelofs, A.J. and Lee Long, W.J. 2000. "Post-flood monitoring of seagrasses in Hervey Bay and the Great Sandy Strait, 1999: Implications for dugong, turtle & fisheries management." *Department of Primary Industries Information Series* **QI00059** (DPI, NFC, Cairns) 46 pp.

McKenzie, L.J. and Campbell, S.J. 2003. Seagrass resources of the Booral Wetlands and the Great Sandy Strait: February/March 2002. *DPI Information Series QI03016* (DPI, Cairns) 28 pp

McKenzie, L.J., Roder, C.A., Roelofs, A.J., Lee Long, W.J., 2000. Post-flood monitoring of seagrasses in Hervey Bay and the Great Sandy Strait 1999. Implications for dugong, turtle and fisheries management. Cairns, Department of Primary Industries, *DPI Information Series* QI00059.

McMahon, K., Bengston-Nash, S., Mueller, J., Duke, N. and Eaglesham, G. 2003. *Relationship between seagrass health and herbicide concentration in Hervey Bay and the Great Sandy Straits*. Report to Environmental Protection Agency, Queensland Parks and Wildlife, Maryborough.

McMahon, K., Bengston-Nash, S,, Eaglesham, G., Muller, J,F., Duke, N.C. and Winderlich, S. 2003. Herbicide contamination and the potential impact to seagrass meadows in Hervey Bay, Queensland, Australia. *Marine Pollution Bulletin*, **51**: 325-334.

McNiven, I. 1991. Settlement and subsistence activities along Tin Can Bay, southeast Queensland. *Queensland Archaeological Research*, **8**: 85–107.

Meyer, E., Hero, J-M., Shoo, L. and Lewis, B. 2005. *Recovery plan for the wallum sedgefrog and other wallum-dependent frog species 2005-2009*. Report to Department of Environment and Heritage, Canberra. Queensland Parks and Wildlife Service, Brisbane.

Millennium Ecosystem Assessment 2005. *Ecosystem Services and Human Well-Being: Wetlands & Water: Synthesis.* 2005. Millennium Ecosystem Assessment report to the Ramsar Convention: World Resources Institute, Washington D.C. http://www.millenniumassessment.org/en/Framework.aspx

Milton, D. and Driscoll, P. 2006. An assessment of Shorebird monitoring in Queensland by the Queensland Wader Study Group. *Stilt* **50**: 242-248.

Moreton, R.M. and Healy, T. 1992. *Fisheries Resources of the Fraser Island Region*. Queensland Fish Management Authority. Brisbane. 36 pp.

NSW Department of Primary Industries. 2005. *Oxleyan Pygmy Perch Recovery Plan and Background Paper.* NSW Department of Primary Industries. 20 + 38 pp.

Preen, A. 1995. Impacts of dugong grazing on seagrass habitats: observational and experimental evidence for cultivation grazing. *Mar. Ecol. Progr. Ser*. **124**: 201-213.

Pusey, B., Kennard, M. and Arthington, A. 2004. *Freshwater Fishes of North-Eastern Australia*. CSIRO Publishing, PO Box 1139, Collingwood VIC 3066.

Queensland Government. 1991. Report on the Commission of Inquiry into the Conservation, Management and use of Fraserr Island and the Great Sandy Region, and Fitzgerald, T.

Queensland Department of Local Government and Planning 1998. *The principal regional strategy for guiding growth in the Wide Bay region as it heads towards the year 2020*. Queensland Dept. of Local Government and Planning; Wide Bay Regional Planning Advisory Committee. Bundaberg, Queensland. 84pp.

Queensland EPA. 2001. Queensland State Coastal Protection Plan – Queensland's Coastal Policy. Brisbane, Qld. Queensland Government.

Queensland EPA, 2002. *Ramsar Sites ( QLD)*. Digital data. Environmental Protection Agency, Brisbane.

Queensland EPA 2004. Regional Ecosystems http://www.epa.qld.gov.au/nature_conservation/biodiversity/regional_ecosystems/

Queensland EPA 2005. Download: Coastal wet heath/sedgeland wetlands - EPA/QPW < http://www.epa.qld.gov.au/publications/p01733.html> 16 KB, last modified 1 Nov 2005

Queensland EPA 2006a. *Great Sandy Strait Coastal Creeks Environmental Values and Water Quality Objectives, Basin No. 140 (Part).* Queensland Environmental Protection Agency. Brisbane.

Queensland EPA. 2006b. *Queensland Water Quality Guidelines 2006*. Queensland Water Quality Guidelines, March 2006, with 2007 Minor Updates - EPA/QPW

Queensland EPA 2007*, Queensland Wetland Mapping and Classification for the Wide Bay catchments, 2001 extent. Version 1.1* Digital data. Environmental Protection Agency. Brisbane.

Queensland Government, 2006a. *Fisheries Act* 1994, Reprint No. 6. 2006. Queensland Government. Brisbane. 200pp. Available online at: http://www.legislation.qld.gov.au/Acts_SLs/Acts_SL_F.htm

Queensland Government, 2006b. *Nature Conservation (Wildlife) Regulation* 2006. Queensland Government, Brisbane.

Queensland Museum Website 2007: Illidge's Ant-Blue Butterfly, *Acrodypsas illidgei*. August 2007 Online at: http://www.qm.qld.gov.au/features/endangered/animals/illidge_bfly.asp

Queensland Natural Resources and Water. 2006. *River Series Fact Sheet R20*. Natural Resources Sciences QNRM02094.

Ramsar Convention 2005a. *Resolution IX.1 Annex A. A Conceptual Framework for the wise use of wetlands and the maintenance of their ecological character.* http://www.ramsar.org/res/key_res_ix_01_annexa_e.htm

Robins, J. and Ye, Q.F. (In Prep). *Relationships between freshwater flow and fisheries (or secondary) production in Australian estuaries: A review.* (Suggested paper title – A comparison of the role of freshwater requirements of estuarine fisheries in tropical and temperate areas.) In Prep. Queensland Department of Primary Industries and Fisheries.

Rogers, D.I., Rogers, K.G., Gosbell, K.B. and Hassell, C.J. 2006. Causes of variation in population monitoring surveys: insights from non-breeding counts in North-Western Australia, 2004-2005. *Stilt* **50**: 176-193.

Sands, D.P.A. and New, T.R. 2002. *The Action Plan for Australian Butterflies*, Environment Australia, Canberra.

Seagrass-Watch. 2007. http://www.seagrasswatch.org/GreatSandyStrait.html viewed 2007-05-27.

Semple, G.P. 1991. Reproductive behaviour and early development of the Honey Blue-eye, *Pseudomugil mellis* Allen & Ivantsoff 1982 (Pisces: Pseudomugilidae), from the North-east Coast Division, South-eastern Queensland, Australia in *Australian Journal of Marine and Freshwater Research* 42:277-286.

Sheppard, J.K., Lawler, I.R., and Marsh, H. 2006. Seagrass as pasture for seacows: Landscape-level dugong habitat evaluation. *Estuarine, Coastal and Shelf Science,* **71**: 117-132

Sheppard, J.K., Preen, A. R., Marsh, H., Lawler, I.R., Whiting, S.D., Jones, R.E. 2006b. Movement heterogeneity of dugongs, *Dugong dugon* (Müller), over large spatial scales. *Journal of Experimental Marine Biology and Ecology,* **334** (2006): 64–83

Stockwell, B., Hutchinson, M., Wedlock, B., Ford, E., Anderson, T, Thomson, C. and Stephens, K. 2004. *Freshwater Aquatic Biodiversity in the Burnett Mary Region.* Unpublished report, Queensland Department of Primary Industries and Fisheries. 47pp plus Appendix.

Thompson, C., Arthington, A. and Kennard, M. 2000. Oxleyan pygmy perch - Nannoperca oxleyana (Whitley, 1940). Threatened Fish Profile – In Newsletter 30.

Van Dyck, S. and Gynther, I. 2003. 'Nesting strategies of the Water Mouse *Xeromys myoides* in southeast Queensland'. *Memoirs of the Queensland Museum,* **49 (1):** 453-479 .

Voice, M., Harvey, N. and Walsh, K. 2006. (Editors) *Vulnerability to Climate Change of Australia's Coastal Zone: Analysis of gaps in methods, data and system thresholds.* Report to the Australian Greenhouse Office, Canberra, Australia. June 2006.

Wabnitz, C., Taylor, M., Green, E., Razak, T. 2003. *From Ocean to Aquarium*. UNEP-WCMC, Cambridge, UK.

Waycott, M., Collier, C., McMahon, K., Ralph, P., McKenzie, L., Udy J., and Grech, A. (In Prep). Vulnerability of seagrasses in the Great Barrier Reef to climate change. In: *Climate change and the Great Barrier Reef: A Vulnerability Assessment* (eds Johnson, Johanna E. and Marshall, Paul A.), 193 - 235. Great Barrier Reef Marine Park Authority and the Australian Greenhouse Office, Townsville.

Williams, L.E. (Ed) 2002. Queensland's Fisheries Resources: Current condition and recent trends 1988-2000. Information Series Q102012, Queensland Department of Primary Industries, Brisbane.

# Glossary

| | |
|---|---|
| Biogeographic region | A scientifically rigorous determination of regions as established using biological and physical parameters such as climate, soil type, vegetation cover, etc. Eg., see IMCRA region |
| Catchment | The total area draining into a river, reservoir, or other body of water. |
| draft Framework | Draft *National Framework and Guidance for describing the ecological character of Australia's Ramsar wetlands, February 2007* |
| Ecological character | The combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time. Within this context, ecosystem benefits are defined in accordance with the variety of benefits to people (Ecosystem Services). The Millennium Ecosystem Assessment (2005) defines ecosystem services as "the benefits that people receive from ecosystems" (Ramsar Convention 2005a, Resolution IX.1 Annex A).<br><br>The phrase "at a given point in time" refers to Resolution VI.1 paragraph 2.1, which states that "It is essential that the ecological character of a site be described by the Contracting Party concerned **at the time of designation for the Ramsar List**, by completion of the Information Sheet on Ramsar Wetlands (as adopted by Recommendation IV. 7). |
| Ecosystems | The complex of living communities (including human communities) and non-living environment (Ecosystem Components) interacting (through Ecological Processes) as a functional unit which provides inter alia a variety of benefits to people (Ecosystem Services). (Millennium Ecosystem Assessment 2005). |
| Ecosystem components | Includes the physical, chemical and biological parts of a wetland (from large scale to very small scale, e.g. habitat, species and genes) (Millennium Ecosystem Assessment 2005). |
| Ecosystem processes | The dynamic forces within an ecosystem. They include all those processes that occur between organisms and within and between populations and communities, including interactions with the non-living environment that result in existing ecosystems and bring about changes in ecosystems over time (Australian Heritage Commission 2002). They may be physical, chemical or biological. |
| Ecosystem services | The benefits that people receive or obtain from an ecosystem. The components of ecosystem services are provisioning (e.g. food & water), regulating (e.g. flood control), cultural (e.g. spiritual, recreational), and supporting (e.g nutrient cycling, ecological value). (Millennium Ecosystem Assessment 2005). |
| IMCRA region | Interim Marine and Coastal Regionalisation for Australia (Mesoscale) to the 200 meter isobath and derived from biological and physical data, (eg. coastal geomorphology, tidal attributes, oceanography, bathymetry and intertidal invertebrates). |
| Limits of Acceptable Change | The variation that is considered acceptable in a particular component or process of the ecological character of the wetland without indicating change in ecological character which may lead to a reduction or loss of the criteria for which the site was Ramsar listed |
| Patterned Fens | A type of non-forested peat swamp that displays complex spatial patterns of ridges ("strings") and depressions ("flarks"). The patterned fens in and adjacent to the Ramsar site are the only ones known in the sub-tropics worldwide (Ingram *et al* 2004a and 2004b). |
| Ramsar | City in Iran, on the shores of the Caspian Sea, where the Convention on Wetlands was signed on 2 February 1971; thus the Convention's short title, "Ramsar |

Convention on Wetlands" [http://www.ramsar.org/about/about_glossary.htm].

| | |
|---|---|
| Ramsar Criteria | Criteria for Identifying Wetlands of International Importance, used by Contracting Parties and advisory bodies to identify wetlands as qualifying for the Ramsar List on the basis of representativeness or uniqueness or of biodiversity values. http://www.ramsar.org/about/about_glossary.htm |
| Ramsar Convention | *Convention on Wetlands of International Importance especially as Waterfowl Habitat*. Ramsar (Iran), 2 February 1971. UN Treaty Series No. 14583. As amended by the Paris Protocol, 3 December 1982, and Regina Amendments, 28 May 1987. The abbreviated names "Convention on Wetlands (Ramsar, Iran, 1971)" or "Ramsar Convention" are more commonly used [http://www.ramsar.org/index_very_key_docs.htm]. |
| Ramsar Information Sheet (RIS) | The form upon which Contracting Parties record relevant data on proposed Wetlands of International Importance for inclusion in the Ramsar Database; covers identifying details like geographical coordinates and surface area, criteria for inclusion in the Ramsar List and wetland types present, hydrological, ecological, and socioeconomic issues among others, ownership and jurisdictions, and conservation measures taken and needed (http://www.ramsar.org/about/about_glossary.htm). |
| Ramsar sites | Wetlands designated by the Contracting Parties for inclusion in the List of Wetlands of International Importance because they meet one or more of the Ramsar Criteria [http://www.ramsar.org/about/about_glossary.htm]. |
| Wallum | Freshwater wetlands and associated vegetation communities occurring on low nutrient sandy soils. While nutrient poor, these soils support a range of vegetation types including melaleuca (paperbark) woodland, sedgeland and heath (the dominant vegetation type on soils of this type). Acidic (pH < 6.0) swamps and lakes are typically found amidst heath vegetation and sedges where water collects above organic hardpan layers and provide essential breeding habitat for acid frogs and other specially adapted species (Meyer *et al* 2005). |
| Wetlands | Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres (Ramsar Convention 1987). |
| Wetland types | As defined by the Ramsar Convention's wetland classification system [http://www.ramsar.org/ris/key_ris.htm#type]. |

# Appendices

## Appendix 1. Ecosystem services derived from the Ramsar Criteria met by the Great Sandy Strait Ramsar site

| *(Current) Ramsar Criteria met by the Great Sandy Strait Ramsar site at 1999* | *How the site has met the criteria* | *Ecosystem services derived from the criteria met.* |
|---|---|---|
| **Criterion 1:** A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region. | The site includes a representative example of Ramsar Wetland Type F (estuary) which is the largest and least disturbed sand passage estuary in the South East Queensland (IBRA) biogeographic region.<br>The site includes representative examples of Ramsar Wetland Type U (non-forested peatland/fen) some of which display pronounced patterning that is rare in the South East Queensland (IBRA) biogeographic region. | Occurrence of a large sand passage estuary.<br>Occurrence of strongly patterned, non-forested peat swamps (fens). |
| **Criterion 2:** A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities. | The site supports four species of marine turtle, each of which is threatened under national legislation.<br>The site also supports Illidge's ant-blue butterfly and dugong which are both threatened under state and international legislation. | Occurrence of four nationally-threatened turtle species (green, hawksbill, flatback, loggerhead).<br>Occurrence of internationally vulnerable dugong.<br>The internationally endangered Illidge's ant-blue butterfly occurs in the mangroves at the site.<br>The nationally endangered Oxleyan pygmy perch and nationally vulnerable honey blue-eye also occur within site.<br>*Occurrence of the water mouse, 4 species of acid frog and humpback whale – all threatened species under national and/ or international listings and which would have been present at date of Ramsar listing –were not mentioned in the original nomination.* |
| **Criterion 3:** A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region. | In the context of the South East Queensland bioregion, the site supports a large or relatively large number of species from several plant and animal groups: waterbirds, marine turtles, marine mammals, fishes, crustaceans and other marine invertebrates, seagrasses and mangroves. | Occurrence of a large number of species of waterbirds and fishes.<br>Occurrence of a relatively large number of species of marine turtles, marine mammals, crustaceans, seagrasses and mangroves. |
| **Criterion 4:** A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions. | The site supports substantial populations of many animal taxa (migratory shorebirds, marine turtles, whales) during critical stages of migration and supports many additional taxa (dolphins, fishes, frogs, prawns) during the critical stage of breeding.<br>Dugongs from adjacent populations in Hervey Bay have previously sought refuge in the Ramsar site when food (seagrass) resources in the Bay were depleted. | Occurrence of migratory shorebirds, marine turtles, whales, a butterfly during critical stages of migration.<br>Occurrence of dolphins, frogs and water mouse during critical stages of breeding.<br>Occurrence of additional dugong populations seeking refuge during adverse conditions. |

| | | |
|---|---|---|
| **Criterion 5:** A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds. | The site has supported, on at least several occasions, between 20,000 and 40,000 waterbirds (mostly shorebirds). | Repeated occurrence of at least 20,000 waterbirds. |
| **Criterion 6:** A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird. | The site is known to support, at least on the basis of maximum recorded count, at least 1% of the population of Far eastern curlew, whimbrel, bar-tailed godwit, grey-tailed tattler, (Common) greenshank, Terek sandpiper, Lesser sand plover and pied oystercatcher. | Repeated occurrence of at least 1% of the Flyway population of:<br>• Far eastern curlew<br>• Whimbrel<br>• Bar-tailed godwit<br>• Grey-tailed tattler<br>• Common greenshank<br>• Terek sandpiper<br>• Lesser sand plover<br>• Pied Oystercatcher |
| **Criterion 7:** A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity. | Thus far, at least 104 species of fish from 60 families have provisionally been recorded from the Site (Fisheries Research Consultants 1993 and 1994; Beumer & Halliday 1994). They include a highly diverse range of morphologies, reproductive types, life history strategies and ecological niches (eg,, demersal, pelagic, planktivorous, herbivorous, omnivorous, predatory, scavenging, excavating, symbiotic, live-bearing, egg-releasing, hermaphroditic protogyny and protandry). These fish communities in turn support a diverse and complex range of other ecosystem components and processes, such as multiple food web interactions, algal grazing, bioturbation, re-cycling and breakdown of coralline materials. | Occurrence of a relatively large number of species of fish and shellfish, which support important food webs, ecosystem processes and fisheries. |
| **Criterion 8:** A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend. | The site provides nursery and feeding grounds for fishes, crabs and prawns that are subject to a substantial commercial and/or recreational harvest on-site, and is part of a migration path for prawns that are commercially harvested off-site. | Occurrence of nursery and feeding habitat for commercially harvested fishes, crabs and prawns.<br>Occurrence of nursery and feeding habitat for recreationally harvested fishes and crabs.<br>Occurrence of a migration path for prawns that are commercially harvested off-site. |

## Appendix 2. Listing status of threatened species under Queensland, Australian and international listings, and occurring in the Great Sandy Strait Ramsar site.

| Common name | *Species* | IUCN Listing[1] | Commonwealth Legislation (EPBC Act)[2] | Queensland Legislation (Nature Conservation Act and Fisheries Act)[3] |
|---|---|---|---|---|
| **Fish** | | | | |
| Oxleyan pygmy perch | *Nannoperca oxleyana* | EN | EN | VU |
| honey blue-eye | *Pseudomugil mellis* | EN | VU | VU |
| **Turtles** | | | | |
| green | *Chelonia mydas* | EN | VU | VU |
| loggerhead | *Caretta caretta* | EN | EN | EN |
| flatback | *Natator depressus* | DD | VU | VU |
| hawksbill | *Eretmochelys imbricata* | CR | VU | VU |
| olive ridley or Pacific ridley | *Lepidochelys olivacea* | EN | EN | EN |
| leatherback | *Dermochelys coriacea* | CR | VU | EN |
| **Amphibians** | | | | |
| Cooloola sedgefrog | *Litoria cooloolensis* | EN | - | Rare |
| wallum rocketfrog | *Litoria freycineti* | VU | - | VU |
| wallum sedgefrog | *Litoria olongburensis* | VU | VU | VU |
| wallum froglet | *Crinia tinnula* | VU | - | VU |
| **Mammals** | | | | |
| dugong | *Dugong dugon* | VU | - | VU |
| Indo-Pacific humpback dolphin | *Sousa chinensis* | DD | - | Rare |
| inshore bottlenose dolphin | *Tursiops aduncus* | DD | - | - |
| humpback whale | *Megaptera novaeangliae* | VU | VU | VU |
| melon headed whale | *Peponocephala electra* | LR/lc | - | - |
| Pacific pilot whale | *Globicephala macrorhynchus* | LR/cd | - | - |
| sperm whale | *Physeter macrocephalus* | VU | - | - |
| water mouse | *Xeromys myoides* | VU | VU | VU |
| **Shorebirds** | | | | |
| far eastern curlew | *Numenius madagascariensis* | NT | - | Rare |
| **Butterfly** | | | | |
| Illidge's ant-blue butterfly | *Acrodipsas illidgei* | EN | - | VU |

1. The International Union for Conservervation of Nature (IUCN) Redlist of Threatened Species Listings:

http://www.iucn.org/themes/ssc/redlist.htm

**CR** CRITICALLY ENDANGERED - A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future, as defined by any of the criteria (A to E).

**EN** ENDANGERED - A taxon is endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future, as defined by any of the criteria (A to E).

**VU** VULNERABLE - A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future, as defined by any of the criteria (A to E).

**LR** LOWER RISK - A taxon is Lower Risk when it has been evaluated, does not satisfy the criteria for any of the categories Critically Endangered, Endangered or Vulnerable. Taxa included in the Lower Risk category can be separated into three subcategories.

1. Conservation Dependent (**cd**). Taxa which are the focus of a continuing taxon-specific or habitat-specific conservation programme targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years.

2. Near Threatened (**nt**). Taxa which do not qualify for Conservation Dependent, but which are close to qualifying for Vulnerable.
3. Least Concern (**lc**). Taxa which do not qualify for Conservation Dependent or Near Threatened.

**DD** DATA DEFICIENT - A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution is lacking. Data Deficient is therefore not a category of threat or Lower Risk. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and threatened status. If the range of a taxon is suspected to be relatively circumscribed, or if a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

2. Commonwealth EPBC Act (1999) and Queensland legislation

**CE** Critically Endangered

**EN** Endangered

**VU** Vulnerable

**Rare** Rare

3. Queensland *Nature Conservation (Wildlife) Regulation 1994; Nature Conservation (Wildlife) Regulation 2006*

# Appendix 3. An incomplete list of species recorded in the Great Sandy Strait Ramsar Site.

A comprehensive list of species and communities is rarely possible – particularly for small, cryptic or uncommon species. Species recorded in the Ramsar site also include non-wetland species which may have limited contribution to ecological character of the wetland.

The following species lists are presented as a guide only. They should not be considered complete or accurate species lists for the Ramsar Site at the time of listing, and should therefore be used with caution when assessing biodiversity or changes in species present at the site. Inaccuracies are expected as a result of the following:

1. Source material for some species lists is from a range of studies – some conducted several years before or after the date of Ramsar listing (1999), thus minor changes in the species present at the site may have occurred since the survey dates of the source material;
2. Source material includes results of some surveys or studies that are not specific to within the Ramsar site boundary, and may include many species that do not exist within the Site, or should be classed as vagrants at the Site. Validation of these occurrences is still required;
3. Several areas, habitats and fauna or floral groups within the Site have not been fully surveyed, and the rate of new discoveries and additions to the list is currently high;
4. Many marine, estuarine and aquatic species move in and out of the site as they undergo larval or juvenile development, seasonal migrations or other large-scale movements that are less understood;
5. Taxonomic identification and nomenclature may include errors, or may have changed since the original surveys.

**Information Sources:**

1. Department of Environment and Resource Management (2009) - *WildNet Sightings Search-List* for Great Sandy Strait Ramsar Site (Extracted: 23/10/2009)
2. Beumer and Halliday (1994); Halliday and Young (1996) - fish
3. M. Zann and K. Wortel, pers comm. (2008) – marine invertebrates and fish
4. DeVantier, L.M. (In prep.) Corals and coral communities of Great Sandy Strait and Hervey Bay. Report for Wildlife Preservation Society of Queensland, Fraser Coast Branch.
5. Adrian Gutteridge, UQ Marine Studies, pers comm. – cartilaginous fish (sharks and rays)
6. Last, P.R. and Stevens, J.D. 2009. *Sharks and Rays of Australia*, 2nd Edition. CSIRO. Collingwood. 640pp.

**Codes for conservation status:**

***NCA*** - The conservation status of each taxon under the Queensland *Nature Conservation Act 1992*. The codes are: Extinct in the wild (PE), Endangered (E), Vulnerable (V), Rare (R), Near threatened (NT); Least concern (C) or Not Protected ( ).
Note: For incomplete taxa such as a genus (eg *Litoria* or *Acacia*) no status value is assigned.

***EPBC -*** The conservation status of each taxon under the Australian *Environment Protection and Biodiversity Conservation Act 1999*.
The codes are: Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW), Vulnerable (V) and Threatened (includes taxa listed as CD, CE, E, EX, V and XW).

***End -*** Native taxa (Queensland Endemic - Q, Intranational - QA, Regional Endemic - QI or Not Endemic to Australia - QAI), Vagrant taxa - (Vagrant (International) - VI, Vagrant (Intranational) - VA or Vagrant (Unknown) - VU), Introduced or naturalised in the wild taxa (Introduced (International) - II, Introduced (Intranational) - IA or Introduced (Unknown) - IU) or Exotic taxa not known to be naturalised - (Exotic (International) - XI, Exotic (Intranational) - XA or Exotic (Unknown) - XU) or Unknown endemicity (U).

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| **Mammals** | | | | |
| *Balaenoptera borealis* | sei whale (beach-stranding) | C | V | QAI |
| *Balaenoptera edeni* | Bryde's whale | C | | QAI |
| *Megaptera novaeangliae* | humpback whale | V | V | QAI |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Peponocephala electra* | melon-headed whale | | | |
| *Globicephala macrorhynchus* | Pacific pilot whale | | | |
| *Pseudorca cra* | false killer whales (beach-stranding) | | | |
| *Sousa chinensis* | Indo-Pacific hump-backed dolphin | R | | QAI |
| *Tursiops aduncus* | inshore bottlenose dolphin | | | |
| *Delphinus delphis* | common dolphin | | | |
| *Dugong dugon* | dugong | V | | QAI |
| *Xeromys myoides* | water mouse (false water-rat) | V | V | QAI |
| *Hydromys chrysogaster* | water rat | C | | QAI |
| *Wallabia bicolor* | swamp wallaby | C | | QA |
| *Macropus giganteus* | eastern grey kangaroo | C | | QA |
| *Melomys burtoni* | grassland melomys | C | | QA |
| *Melomys cervinipes* | fawn-footed melomys | C | | QA |
| *Mus musculus* | house mouse | | | II |
| *Pseudomys delicatulus* | delicate mouse | C | | QAI |
| *Rattus fuscipes* | bush rat | C | | QA |
| *Rattus lutreolus* | swamp rat | C | | QA |
| *Rattus tunneyi* | pale field-rat | C | | QA |
| *Isoodon macrourus* | northern brown bandicoot | C | | QAI |
| *Petaurus australis australis* | yellow-bellied glider (southern subsp.) | C | | QA |
| *Petaurus breviceps* | sugar glider | C | | QAI |
| *Pteropus poliocephalus* | grey-headed flying-fox | C | V | QA |
| *Pteropus scapulatus* | little red flying-fox | C | | QAI |
| *Pteropus sp.* | | | | U |
| *Syconycteris australis* | eastern blossom bat | C | | QAI |
| *Sus scrofa* | pig | | | II |
| *Tachyglossus aculeatus* | short-beaked echidna | C | | QAI |
| *Chalinolobus morio* | chocolate wattled bat | C | | QA |
| *Miniopterus australis* | little bent-wing bat | C | | QAI |
| *Capra hircus* | goat | | | II |
| *Canis familiaris* | dog | | | II |
| *Canis lupus dingo* | dingo | | | QA |
| *Vulpes vulpes* | red fox | | | II |
| *Antechinus flavipes* | yellow-footed antechinus | C | | QA |
| *Planigale maculata* | common planigale | C | | QA |
| *Sminthopsis murina* | common dunnart | C | | QA |
| *Felis catus* | cat | | | II |
| *Oryctolagus cuniculus* | rabbit | | | II |
| **Birds** | | | | |
| *Charadrius bicinctus* | double-banded plover | C | | QAI |
| *Charadrius leschenaultii* | greater sand plover | C | | QAI |
| *Charadrius mongolus* | lesser sand plover | C | | QAI |
| *Charadrius ruficapillus* | red-capped plover | C | | QAI |
| *Pluvialis fulva* | Pacific golden plover | C | | QAI |
| *Pluvialis squatarola* | grey plover | C | | QAI |
| *Vanellus miles* | masked lapwing | C | | QAI |
| *Vanellus miles novaehollandiae* | masked lapwing (southern subsp.) | C | | QA |
| *Haematopus fuliginosus* | sooty oystercatcher | R | | QA |
| *Haematopus longirostris* | Australian pied oystercatcher | C | | QAI |
| *Himantopus himantopus* | black-winged stilt | C | | QAI |
| *Recurvirostra novaehollandiae* | red-necked avocet | C | | QA |
| *Actitis hypoleucos* | common sandpiper | C | | QAI |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Arenaria interpres* | ruddy turnstone | C | | QAI |
| *Calidris acuminata* | sharp-tailed sandpiper | C | | QAI |
| *Calidris alba* | sanderling | C | | QAI |
| *Calidris canutus* | red knot | C | | QAI |
| *Calidris ferruginea* | curlew sandpiper | C | | QAI |
| *Calidris ruficollis* | red-necked stint | C | | QAI |
| *Calidris tenuirostris* | great knot | C | | QAI |
| *Gallinago hardwickii* | Latham's snipe | C | | QAI |
| *Limnodromus semipalmatus* | Asian dowitcher | C | | QAI |
| *Limosa lapponica* | bar-tailed godwit | C | | QAI |
| *Limosa limosa* | black-tailed godwit | C | | QAI |
| *Numenius madagascariensis* | eastern curlew | R | | QAI |
| *Numenius phaeopus* | whimbrel | C | | QAI |
| *Tringa brevipes* | grey-tailed tattler | C | | QAI |
| *Tringa nebularia* | common greenshank | C | | QAI |
| *Tringa stagnatilis* | marsh sandpiper | C | | QAI |
| *Xenus cinereus* | terek sandpiper | C | | QAI |
| *Morus serrator* | Australasian gannet | C | | QAI |
| *Sula leucogaster* | brown booby | C | | QAI |
| *Irediparra gallinacea* | comb-crested jacana | C | | QAI |
| *Anous minutus* | black noddy | C | | QAI |
| *Anous stolidus* | common noddy | C | | QA |
| *Chlidonias hybrida* | whiskered tern | C | | QAI |
| *Chlidonias leucopterus* | white-winged black tern | C | | QAI |
| *Chroicocephalus novaehollandiae* | silver gull | C | | QAI |
| *Gelochelidon nilotica* | gull-billed tern | C | | QAI |
| *Hydroprogne caspia* | Caspian tern | C | | QAI |
| *Onychoprion fuscata* | sooty tern | C | | QAI |
| *Sterna hirundo* | common tern | C | | QAI |
| *Sterna sumatrana* | black-naped tern | C | | QAI |
| *Sternula albifrons* | little tern | E | | QAI |
| *Thalasseus bengalensis* | lesser crested tern | C | | QAI |
| *Thalasseus bergii* | crested tern | C | | QAI |
| *Oceanites oceanicus* | Wilson's storm-petrel | C | | QAI |
| *Ardenna carneipes* | flesh-footed shearwater | C | | QAI |
| *Ardenna pacifica* | wedge-tailed shearwater | C | | QAI |
| *Ardenna tenuirostris* | short-tailed shearwater | C | | QAI |
| *Macronectes giganteus* | southern giant-petrel | E | E | QAI |
| *Microcarbo melanoleucos* | little pied cormorant | C | | QAI |
| *Phalacrocorax carbo* | great cormorant | C | | QAI |
| *Phalacrocorax sulcirostris* | little black cormorant | C | | QA |
| *Phalacrocorax varius* | pied cormorant | C | | QAI |
| *Pelecanus conspicillatus* | Australian pelican | C | | QAI |
| *Grus rubicunda* | brolga | C | | QAI |
| *Ceyx azureus* | azure kingfisher | C | | QAI |
| *Anas castanea* | chestnut teal | C | | QA |
| *Anas gracilis* | grey teal | C | | QAI |
| *Anas rhynchotis* | Australasian shoveler | C | | QAI |
| *Anas superciliosa* | Pacific black duck | C | | QAI |
| *Aythya australis* | hardhead | C | | QAI |
| *Biziura lobata* | musk duck | C | | QA |
| *Chenonetta jubata* | Australian wood duck | C | | QA |
| *Cygnus atratus* | black swan | C | | QA |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Dendrocygna eytoni* | plumed whistling-duck | C | | QA |
| *Nettapus coromandelianus* | cotton pygmy-goose | R | | QAI |
| *Tadorna radjah* | radjah shelduck | R | | QAI |
| *Anhinga novaehollandiae* | Australasian darter | C | | QAI |
| *Anseranas semipalmata* | magpie goose | C | | QAI |
| *Gallinula tenebrosa* | dusky moorhen | C | | QAI |
| *Gallirallus philippensis* | buff-banded rail | C | | QAI |
| *Lewinia pectoralis* | Lewin's rail | R | | QAI |
| *Porphyrio porphyrio* | purple swamphen | C | | QAI |
| *Porzana tabuensis* | spotless crake | C | | QAI |
| *Apus pacificus* | fork-tailed swift | C | | QAI |
| *Hirundapus caudacutus* | white-throated needletail | C | | QAI |
| *Ardea ibis* | cattle egret | C | | QAI |
| *Ardea intermedia* | intermediate egret | C | | QAI |
| *Ardea modesta* | eastern great egret | C | | QAI |
| *Ardea pacifica* | white-necked heron | C | | QA |
| *Ardea sumatrana* | great-billed heron | C | | QAI |
| *Botaurus poiciloptilus* | Australasian bittern | C | | QAI |
| *Butorides striata* | striated heron | C | | QAI |
| *Egretta garzetta* | little egret | C | | QAI |
| *Egretta novaehollandiae* | white-faced heron | C | | QAI |
| *Egretta sacra* | eastern reef egret | C | | QAI |
| *Platalea regia* | royal spoonbill | C | | QAI |
| *Plegadis falcinellus* | glossy ibis | C | | QAI |
| *Threskiornis molucca* | Australian white ibis | C | | QAI |
| *Threskiornis spinicollis* | straw-necked ibis | C | | QAI |
| *Ixobrychus flavicollis* | black bittern | C | | QAI |
| *Nycticorax caledonicus* | Nankeen night-heron | C | | QAI |
| *Accipiter cirrocephalus* | collared sparrowhawk | C | | QAI |
| *Accipiter fasciatus* | brown goshawk | C | | QAI |
| *Accipiter novaehollandiae* | grey goshawk | R | | QAI |
| *Aquila audax* | wedge-tailed eagle | C | | QAI |
| *Aviceda subcristata* | Pacific baza | C | | QAI |
| *Circus approximans* | swamp harrier | C | | QAI |
| *Circus assimilis* | spotted harrier | C | | QA |
| *Elanus axillaris* | black-shouldered kite | C | | QAI |
| *Haliaeetus leucogaster* | white-bellied sea-eagle | C | | QAI |
| *Haliastur indus* | brahminy kite | C | | QAI |
| *Haliastur sphenurus* | whistling kite | C | | QAI |
| *Hieraaetus morphnoides* | little eagle | C | | QAI |
| *Milvus migrans* | black kite | C | | QAI |
| *Pandion cristatus* | eastern osprey | C | | QAI |
| *Acanthiza lineata* | striated thornbill | C | | QA |
| *Acanthiza nana* | yellow thornbill | C | | QA |
| *Acanthiza pusilla* | brown thornbill | C | | QA |
| *Gerygone albogularis* | white-throated gerygone | C | | QAI |
| *Gerygone levigaster* | mangrove gerygone | C | | QAI |
| *Gerygone mouki* | brown gerygone | C | | QA |
| *Gerygone palpebrosa* | fairy gerygone | C | | QAI |
| *Sericornis frontalis* | white-browed scrubwren | C | | QA |
| *Sericornis magnirostra* | large-billed scrubwren | C | | QA |
| *Acrocephalus australis* | Australian reed-warbler | C | | QAI |
| *Aegotheles cristatus* | Australian owlet-nightjar | C | | QAI |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Artamus cyanopterus* | dusky woodswallow | C | | QA |
| *Artamus leucorynchus* | white-breasted woodswallow | C | | QA |
| *Artamus minor* | little woodswallow | C | | QA |
| *Artamus personatus* | masked woodswallow | C | | QA |
| *Artamus superciliosus* | white-browed woodswallow | C | | QA |
| *Cracticus nigrogularis* | pied butcherbird | C | | QA |
| *Cracticus tibicen* | Australian magpie | C | | QAI |
| *Cracticus torquatus* | grey butcherbird | C | | QA |
| *Strepera graculina* | pied currawong | C | | QA |
| *Burhinus grallarius* | bush stone-curlew | C | | QAI |
| *Esacus magnirostris* | beach stone-curlew | V | | QAI |
| *Cacatua galerita* | sulphur-crested cockatoo | C | | QAI |
| *Cacatua sanguinea* | little corella | C | | QAI |
| *Calyptorhynchus banksii* | red-tailed black-cockatoo | C | | QA |
| *Calyptorhynchus funereus* | yellow-tailed black-cockatoo | C | | QA |
| *Calyptorhynchus lathami* | glossy black-cockatoo | V | | QA |
| *Eolophus roseicapillus* | galah | C | | QA |
| *Coracina lineata* | barred cuckoo-shrike | C | | QA |
| *Coracina novaehollandiae* | black-faced cuckoo-shrike | C | | QAI |
| *Coracina papuensis* | white-bellied cuckoo-shrike | C | | QAI |
| *Coracina tenuirostris* | cicadabird | C | | QAI |
| *Lalage leucomela* | varied triller | C | | QAI |
| *Lalage sueurii* | white-winged triller | C | | QAI |
| *Elseyornis melanops* | black-fronted dotterel | C | | QAI |
| *Erythrogonys cinctus* | red-kneed dotterel | C | | QA |
| *Ephippiorhynchus asiaticus* | black-necked stork | R | | QAI |
| *Cisticola exilis* | golden-headed cisticola | C | | QAI |
| *Cormobates leucophaea* | white-throated treecreeper | C | | QA |
| *Cormobates leucophaea metastasis* | white-throated treecreeper (southern) | C | | QA |
| *Chalcophaps indica* | emerald dove | C | | QA |
| *Columba leucomela* | white-headed pigeon | C | | QA |
| *Columba livia* | rock dove | | | II |
| *Geopelia humeralis* | bar-shouldered dove | C | | QAI |
| *Geopelia striata* | peaceful dove | C | | QAI |
| *Lopholaimus antarcticus* | topknot pigeon | C | | QA |
| *Macropygia amboinensis* | brown cuckoo-dove | C | | QAI |
| *Ocyphaps lophotes* | crested pigeon | C | | QA |
| *Phaps chalcoptera* | common bronzewing | C | | QA |
| *Phaps elegans* | brush bronzewing | C | | QA |
| *Ptilinopus magnificus* | wompoo fruit-dove | C | | QAI |
| *Ptilinopus regina* | rose-crowned fruit-dove | C | | QAI |
| *Streptopelia chinensis* | spotted dove | | | II |
| *Eurystomus orientalis* | dollarbird | C | | QAI |
| *Corcorax melanorhamphos* | white-winged chough | C | | QA |
| *Struthidea cinerea* | apostlebird | C | | QA |
| *Corvus coronoides* | Australian raven | C | | QA |
| *Corvus orru* | Torresian crow | C | | QAI |
| *Cacomantis flabelliformis* | fan-tailed cuckoo | C | | QAI |
| *Cacomantis pallidus* | pallid cuckoo | C | | QAI |
| *Cacomantis variolosus* | brush cuckoo | C | | QAI |
| *Centropus phasianinus* | pheasant coucal | C | | QA |
| *Chalcites basalis* | Horsfield's bronze-cuckoo | C | | QAI |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Chalcites lucidus* | shining bronze-cuckoo | C | | QAI |
| *Chalcites minutillus minutillus* | little bronze-cuckoo | C | | QAI |
| *Eudynamys orientalis* | eastern koel | C | | QAI |
| *Scythrops novaehollandiae* | channel-billed cuckoo | C | | QAI |
| *Dicrurus bracteatus* | spangled drongo | C | | QAI |
| *Thalassarche chrysostoma* | grey-headed albatross | C | V | VU |
| *Thalassarche melanophris* | black-browed albatross | C | V | QAI |
| *Lonchura castaneothorax* | chestnut-breasted mannikin | C | | QAI |
| *Neochmia temporalis* | red-browed finch | C | | QA |
| *Taeniopygia bichenovii* | double-barred finch | C | | QA |
| *Eurostopodus mystacalis* | white-throated nightjar | C | | QAI |
| *Falco berigora* | brown falcon | C | | QAI |
| *Falco cenchroides* | nankeen kestrel | C | | QAI |
| *Falco longipennis* | Australian hobby | C | | QAI |
| *Falco peregrinus* | peregrine falcon | C | | QAI |
| *Falco subniger* | black falcon | C | | QA |
| *Dacelo novaeguineae* | laughing kookaburra | C | | QA |
| *Todiramphus chloris* | collared kingfisher | C | | QAI |
| *Todiramphus macleayii* | forest kingfisher | C | | QAI |
| *Todiramphus pyrrhopygius* | red-backed kingfisher | C | | QA |
| *Todiramphus sanctus* | sacred kingfisher | C | | QAI |
| *Hirundo neoxena* | welcome swallow | C | | QAI |
| *Petrochelidon ariel* | fairy martin | C | | QA |
| *Petrochelidon nigricans* | tree martin | C | | QAI |
| *Malurus cyaneus* | superb fairy-wren | C | | QA |
| *Malurus lamberti* | variegated fairy-wren | C | | QA |
| *Malurus melanocephalus* | red-backed fairy-wren | C | | QA |
| *Stipiturus malachurus* | southern emu-wren | V | | QA |
| *Megalurus gramineus* | little grassbird | C | | QAI |
| *Megalurus timoriensis* | tawny grassbird | C | | QAI |
| *Alectura lathami* | Australian brush-turkey | C | | QA |
| *Acanthagenys rufogularis* | spiny-cheeked honeyeater | C | | QA |
| *Acanthorhynchus tenuirostris* | eastern spinebill | C | | QA |
| *Anthochaera chrysoptera* | little wattlebird | C | | QA |
| *Entomyzon cyanotis* | blue-faced honeyeater | C | | QAI |
| *Lichenostomus chrysops* | yellow-faced honeyeater | C | | QA |
| *Lichenostomus fasciogularis* | mangrove honeyeater | C | | QA |
| *Lichenostomus fuscus* | fuscous honeyeater | C | | QA |
| *Lichmera indistincta* | brown honeyeater | C | | QA |
| *Manorina melanocephala* | noisy miner | C | | QA |
| *Meliphaga lewinii* | Lewin's honeyeater | C | | QA |
| *Melithreptus albogularis* | white-throated honeyeater | C | | QAI |
| *Melithreptus brevirostris* | brown-headed honeyeater | C | | QA |
| *Myzomela obscura* | dusky honeyeater | C | | QAI |
| *Myzomela sanguinolenta* | scarlet honeyeater | C | | QA |
| *Philemon citreogularis* | little friarbird | C | | QAI |
| *Philemon corniculatus* | noisy friarbird | C | | QAI |
| *Phylidonyris niger* | white-cheeked honeyeater | C | | QA |
| *Plectorhyncha lanceolata* | striped honeyeater | C | | QA |
| *Merops ornatus* | rainbow bee-eater | C | | QAI |
| *Carterornis leucotis* | white-eared monarch | C | | QA |
| *Grallina cyanoleuca* | magpie-lark | C | | QAI |
| *Monarcha melanopsis* | black-faced monarch | C | | QAI |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Myiagra alecto* | shining flycatcher | C | | QAI |
| *Myiagra cyanoleuca* | satin flycatcher | C | | QAI |
| *Myiagra inquieta* | restless flycatcher | C | | QA |
| *Myiagra rubecula* | leaden flycatcher | C | | QAI |
| *Symposiarchus trivirgatus* | spectacled monarch | C | | QAI |
| *Anthus novaeseelandiae* | Australasian pipit | C | | QAI |
| *Dicaeum hirundinaceum* | mistletoebird | C | | QAI |
| *Daphoenositta chrysoptera* | varied sittella | C | | QAI |
| *Oriolus sagittatus* | olive-backed oriole | C | | QAI |
| *Sphecotheres vieilloti* | Australasian figbird | C | | QAI |
| *Orthonyx temminckii* | Australian logrunner | C | | QAI |
| *Colluricincla harmonica* | grey shrike-thrush | C | | QAI |
| *Colluricincla megarhyncha* | little shrike-thrush | C | | QAI |
| *Pachycephala pectoralis* | golden whistler | C | | QAI |
| *Pachycephala rufiventris* | rufous whistler | C | | QAI |
| *Pardalotus punctatus* | spotted pardalote | C | | QA |
| *Pardalotus striatus* | striated pardalote | C | | QA |
| *Passer domesticus* | house sparrow | | | II |
| *Eopsaltria australis* | eastern yellow robin | C | | QA |
| *Microeca fascinans* | jacky winter | C | | QAI |
| *Petroica rosea* | rose robin | C | | QA |
| *Tregellasia capito* | pale-yellow robin | C | | QA |
| *Coturnix ypsilophora* | brown quail | C | | QAI |
| *Excalfactoria chinensis* | king quail | C | | QAI |
| *Pitta versicolor* | noisy pitta | C | | QAI |
| *Podargus strigoides* | tawny frogmouth | C | | QA |
| *Tachybaptus novaehollandiae* | Australasian grebe | C | | QAI |
| *Pomatostomus temporalis* | grey-crowned babbler | C | | QAI |
| *Pachyptila turtur* | fairy prion | C | | QAI |
| *Alisterus scapularis* | Australian king-parrot | C | | QA |
| *Aprosmictus erythropterus* | red-winged parrot | C | | QAI |
| *Glossopsitta pusilla* | little lorikeet | C | | QA |
| *Pezoporus wallicus wallicus* | ground parrot | V | | QA |
| *Platycercus adscitus* | pale-headed rosella | C | | QA |
| *Platycercus adscitus adscitus* | pale-headed rosella (northern form) | C | | Q |
| *Trichoglossus chlorolepidotus* | scaly-breasted lorikeet | C | | QA |
| *Trichoglossus haematodus moluccanus* | rainbow lorikeet | C | | QA |
| *Psophodes olivaceus* | eastern whipbird | C | | QA |
| *Ailuroedus crassirostris* | green catbird | C | | QA |
| *Rhipidura albiscapa* | grey fantail | C | | QAI |
| *Rhipidura leucophrys* | willie wagtail | C | | QAI |
| *Rhipidura rufifrons* | rufous fantail | C | | QAI |
| *Stercorarius pomarinus* | pomarine jaeger | C | | QAI |
| *Ninox boobook* | southern boobook | C | | QAI |
| *Ninox connivens* | barking owl | C | | QAI |
| *Zosterops lateralis* | silvereye | C | | QAI |
| *Zoothera heinei* | russet-tailed thrush | C | | QA |
| *Turnix melanogaster* | black-breasted button-quail | V | V | QA |
| *Turnix varius* | painted button-quail | C | | QA |
| *Tyto longimembris* | eastern grass owl | C | | QAI |
| **Reptiles** | | | | |
| *Caretta caretta* | loggerhead turtle | E | E | QAI |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Chelonia mydas* | green turtle | V | V | QAI |
| *Natator depressus* | flatback | | | |
| *Eretmochelys imbricata* | hawksbill | | | |
| *Lepidochelys olivacea* | olive ridley or Pacific ridley | | | |
| *Dermochelys coriacea* | leatherback | | | |
| *Pelamis platurus* | yellow-bellied sea snake | C | | QAI |
| *Amphibolurus nobbi* | nobby dragon | C | | QA |
| *Chlamydosaurus kingii* | frilled lizard | C | | QAI |
| *Pogona barbata* | bearded dragon | C | | QA |
| *Antaresia maculosa* | spotted python | C | | QA |
| *Morelia spilota* | carpet python | C | | QA |
| *Boiga irregularis* | brown tree snake | C | | QAI |
| *Dendrelaphis punctulata* | common tree snake | C | | QAI |
| *Tropidonophis mairii* | freshwater snake | C | | QAI |
| *Acanthophis antarcticus* | common death adder | R | | QA |
| *Demansia psammophis* | yellow-faced whip snake | C | | QA |
| *Disteira major* | | C | | QAI |
| *Hoplocephalus bitorquatus* | pale-headed snake | C | | QA |
| *Hydrophis elegans* | | C | | QAI |
| *Pseudechis porphyriacus* | red-bellied black snake | C | | QA |
| *Pseudonaja textilis* | eastern brown snake | C | | QAI |
| *Rhinoplocephalus nigrescens* | eastern small-eyed snake | C | | QA |
| *Tropidechis carinatus* | rough-scaled snake | C | | QA |
| *Diplodactylus vittatus* | wood gecko | C | | QA |
| *Oedura tryoni* | southern spotted velvet gecko | C | | QA |
| *Lialis burtonis* | Burton's legless lizard | C | | QAI |
| *Anomalopus verreauxii* | | C | | QA |
| *Bellatorias frerei* | major skink | C | | QAI |
| *Calyptotis lepidorostrum* | | C | | Q |
| *Calyptotis scutirostrum* | | C | | QA |
| *Carlia foliorum* | | C | | QA |
| *Carlia vivax* | | C | | QA |
| *Cryptoblepharus pulcher pulcher* | elegant snake-eyed skink | C | | QA |
| *Ctenotus robustus* | | C | | QA |
| *Ctenotus sp.* | | | | QAI |
| *Ctenotus taeniolatus* | copper-tailed skink | C | | QA |
| *Eroticoscincus graciloides* | | R | | Q |
| *Eulamprus quoyii* | eastern water skink | C | | QA |
| *Eulamprus tenuis* | | C | | QA |
| *Lampropholis delicata* | | C | | QA |
| *Lampropholis guichenoti* | | C | | QA |
| *Morethia taeniopleura* | fire-tailed skink | C | | Q |
| *Ophioscincus cooloolensis* | | R | | Q |
| *Tiliqua scincoides* | eastern blue-tongued lizard | C | | QA |
| *Varanus gouldii* | sand monitor | C | | QA |
| **Amphibians** | | | | |
| *Litoria caerulea* | common green treefrog | C | | QAI |
| *Litoria cooloolensis* | Cooloola sedgefrog | R | | Q |
| *Litoria freycineti* | wallum rocketfrog | V | | QA |
| *Litoria gracilenta* | graceful treefrog | C | | QA |
| *Litoria latopalmata* | broad palmed rocketfrog | C | | QA |
| *Litoria nasuta* | striped rocketfrog | C | | QAI |
| *Litoria olongburensis* | wallum sedgefrog | V | V | QA |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Litoria peronii* | emerald spotted treefrog | C | | QA |
| *Limnodynastes peronii* | striped marshfrog | C | | QA |
| *Limnodynastes tasmaniensis* | spotted grassfrog | C | | QA |
| *Limnodynastes terraereginae* | scarlet sided pobblebonk | C | | QA |
| *Crinia parinsignifera* | beeping froglet | C | | QA |
| *Crinia tinnula* | wallum froglet | V | | QA |
| *Pseudophryne raveni* | copper backed broodfrog | C | | Q |
| *Cyclorana alboguttata* | greenstripe frog | C | | QA |
| *Rhinella marina* | cane toad | | | II |
| **Bony Fish (partial list)** | | | | |
| *Gobiomorphus australis* | striped gudgeon | | | QA |
| *Hypseleotris compressa* | empire gudgeon | | | QAI |
| *Hypseleotris klunzingeri* | western carp gudgeon | | | QA |
| *Mogurnda adspersa* | southern purplespotted gudgeon | | | QA |
| *Rhadinocentrus ornatus* | ornate rainbowfish | | | QA |
| *Nannoperca oxleyana* | Oxleyan pygmy perch | V | E | QA |
| *Anguilla reinhardtii* | longfin eel | | | QAI |
| *Neosilurus hyrtlii* | Hyrtl's catfish | | | QA |
| *Gambusia holbrooki* | mosquitofish | | | II |
| *Pseudomugil mellis* | honey blue eye | V | V | Q |
| *Pseudomugil signifer* | Pacific blue eye | | | QA |
| *Scatophagus argus* | spotted scat | | | QAI |
| *Selenotoca multifasciata* | striped scat | | | QAI |
| *Kuhlia rupestris* | jungle perch | | | |
| *Notesthes robusta* | bullrout | | | |
| *Siganus fuscecens* | rabbitfish | | | |
| *Gobiidae – several spp.* | gobies | | | |
| *Afurcagobius* (*Favinogobius*) sp | goby | | | |
| *Redigobius bikolanus* | speckled goby | | | |
| *Redigobius* sp | goby | | | |
| *Tandanus tandanus* | eel-tailed catfish | | | |
| *Plotosus lineatus* | striped catfish | | | |
| *Tetractenos hamiltoni* | common toadfish | | | |
| *Marilyna pleurostictus* | banded toadfish | | | |
| *Lagocephalus lunaris* | rough golden toadfish | | | |
| *Dicotylichthys myersi* | threebar porcupinefish | | | |
| *Arothron manilensis* | narrow-lined pufferfish | | | |
| *Achlyopa (Brachirus) nigra* | black sole | | | |
| *Thryssa hamiltoni* | Hamilton's anchovy | | | |
| *Pranesus ogilbyi* | Ogilby's hardyhead | | | |
| *Retropinna semoni* | Australian smelt | | | |
| *Herklotsichthys castelnaui* | southern herring | | | |
| *Herklotsichthys koningsbergeri* | largespotted herring | | | |
| *Elops hawaiensis* | giant herring | | | |
| *Arrhamphus sclerolepis* | snub-nosed garfish | | | |
| *Hyporhamphus ardelio* | river garfish | | | |
| *Mugil cephalus* | sea mullet | | | QAI |
| *Mugil georgii* | fantail mullet | | | |
| *Myxus elongatus* | sand mullet | | | |
| *Liza dussmieri* | flat-tailed mullet | | | |
| *Liza subviridis* | green-back mullet | | | |
| *Sillago ciliata* | sand whiting | | | |
| *Sillago maculata* | trumpeter whiting | | | |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Sillago analis* | golden-line whiting | | | |
| *Terapon jarbua* | crescent perch | | | |
| *Ambassis marianus* | estuary perchlet | | | |
| *Psammoperca waigiensis* | sand bass | | | |
| *Lates calcarifer* | barramundi | | | |
| *Kyphosus gibsoni* | northern silver drummer | | | |
| *Rhabdosargus sarba* | tarwhine | | | |
| *Girella tricuspidata* | luderick (black bream) | | | |
| *Gerres filamentosus* | threadfin silver biddy | | | |
| *Gerres oyeana* | silver biddy | | | |
| *Acanthopagrus australis* | yellow-fin bream | | | |
| *Acanthopagrus berda* | pikey bream | | | |
| *Plectorhinchus gibbosus* | harry hotlips | | | |
| *Platycephalus fuscus* | dusky flathead | | | |
| *Platycephalus indicus* | bartail flathead | | | |
| *Pomatomus saltatrix* | tailor | | | |
| *Argyrosomus hololepidotus* | jewfish | | | |
| *Tylosurus gaviatoides* | stout longtom | | | |
| *Sphyraena barracuda* | great barracuda | | | |
| *Sphyraena obtusata* | striped barracuda | | | |
| *Seriola lalandi* | yellowtail kingfish | | | |
| *Scomberomorus sp.* | mackerel | | | |
| *Trachinotus russelli* | dart | | | |
| *Trachinotus blochii* | snubnose dart | | | |
| *Scomberoides commersonianus* | queenfish | | | |
| *Carangidae – several spp.* | trevally | | | |
| *Caranx sexfasciatus* | big-eye trevally | | | |
| *Gnathanodon speciosus* | golden trevally | | | |
| *Monodactylus argenteus* | diamondfish | | | QAI |
| *Plectropomus leopardus* | common coral trout | | | |
| *Plectropomus maculatus* | barcheek coral trout | | | |
| *Lethrinus miniatus* | red throat emperor | | | |
| *Lutjanus argentimaculatus* | mangrove jack | | | QAI |
| *Lutjanus russelli* | Moses perch | | | |
| *Serranidae – several spp.* | cod | | | |
| *Epinephelus merra* | Honeycomb cod | | | |
| *Haemulidae – several spp.* | sweetlip | | | |
| *Pagrus auratus* | snapper | | | |
| *Lethrinidae – several spp.* | emperors | | | |
| *Chaetodontoplus duboulayi* | scribbled angelfish | | | |
| *Chelmon mulleri* | Müllers butterflyfish | | | |
| *Chelmon rostratus* | Beaked coralfish | | | |
| *Choerodon spp.* | tuskfish (NOT Parrot Fish) | | | |
| *Chaetodon aureofasciatus* | Golden-striped butterfly fish | | | |
| *Neopomacacentrus violascens* | Violet demoiselle | | | |
| *Neopomacacentrus azysron* | Yellowtail damsel | | | |
| *Pomacentrus vaiuli* | Princess damsel | | | |
| *Pomocenturs coelestis* | Blue damsel | | | |
| *Abudefduf bengalensis* | Bengal sergeant major | | | |
| *Microcanthus strigatus* | Stripey | | | |
| *Synodus jaculum* | Tailspot lizardfish | | | |
| *Psuedolabrus guentheri* | Gunther's wrasse | | | |
| **Cartilaginous Fish (sharks, rays,** | | | | |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| **chimaeras)** | | | | |
| *Carcharhinus tilstoni* | Australian blacktip Whaler shark | | | |
| *Carcharhinus sorrah* | spottail shark | | | |
| *Hemipristis elongata* | fossil shark | | | |
| *Brachaelurus colcloughi* | Colclough's Blind Shark | | | |
| *Brachaelurus waddi* | Blind Shark | | | |
| *Carcharhinus amblyrhynchos* | Grey Reef Shark | | | |
| *Carcharhinus amboinensis* | Pigeye Shark | | | |
| *Carcharhinus brevipinna* | Spinner Shark | | | |
| *Carcharhinus cautus* | Nervous Shark | | | |
| *Carcharhinus leucas* | Bull Shark | | | |
| *Carcharhinus limbatus* | Common Blacktip Shark | | | |
| *Carcharhinus macloti* | Hardnose Shark | | | |
| *Carcharhinus obscurus* | Dusky Shark (Black Whaler) | | | |
| *Carcharhinus plumbeus* | Sandbar Shark | | | |
| *Galeocerdo cuvier* | Tiger Shark | | | |
| *Loxodon macrorhinus* | Sliteye Shark | | | |
| *Negaprion acutidens* | Lemon Shark | | | |
| *Rhizoprionodon acutus* | Milk Shark | | | |
| *Rhizoprionodon taylori* | Australian Sharpnose Shark | | | |
| *Dasyatis fluviorum* | Estuary Stingray | | | |
| *Neotrygon kuhli* | Blue-spotted Maskray | | | |
| *Himantura granulata* | mangrove whipray | | | |
| *Himantura fai* | Pink Whipray | | | |
| *Himantura toshi* | Brown Whipray | | | |
| *Himantura uarnak* | Reticulate Whipray | | | |
| *Pastinachus sephen* | Cowtail Stingray | | | |
| *Nebrius concolor* | Nurse Sharks | | | |
| *Gymnura australis* | butterfly ray | | | |
| *Hemigaleus australiensis* | Weasel Shark | | | |
| *Chiloscyllium punctatum* | Bamboo Shark | | | |
| *Hemiscyllium ocellatum* | Epaulette Shark | | | |
| *Hypnos monopterygium* | Coffin Ray (Numbfish) | | | |
| *Carcharodon carcharias* | Great White Shark | | | |
| *Manta birostris* | Manta Ray | | | |
| *Aetobatus narinari* | White-spotted Eagle Ray | | | |
| *Carcharias taurus* | Grey Nurse Shark | | | |
| *Orectolobus ornatus* | ornate Wobbegong | | | |
| *Orectolobus maculatus* | spotted wobbegong | | | |
| *Orectolobus wardi* | Northern Wobbegong | | | |
| *Rhina ancylostoma* | Shark Ray | | | |
| *Glaucostegus typus* | Giant Shovelnose Ray | | | |
| *Rhynchobatos australiae* | Australian white-spotted Guitarfish | | | |
| *Rhynchobatos laevis* | White-spotted Guitarfish | | | |
| *Rhynchobatos palpebratus* | eye-brow wedgefish | | | |
| *Rhinoptera neglecta* | Australian Cownose Ray | | | |
| *Rhinoptera japonica* | Australian Cownose Ray | | | |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Sphyrna lewini* | Scalloped Hammerhead Shark | | | |
| *Sphyrna mokarran* | Great Hammerhead Shark | | | |
| *Stegostoma fasciatum* | Leopard Shark | | | |
| **Scleractinian (Hard) Corals** | | | | |
| *Pocillopora damicornis* (Linnaeus, 1758) | | | | |
| *Montipora cf. mollis* Bernard, 1897 | | | | |
| *Acropora bushyensis* Veron and Wallace, 1984 | | | | |
| *Acropora digitifera (Dana, 1846)* | | | | |
| *Acropora pulchra (Brook, 1891)* | | | | |
| *Psammocora albopicta* Benzoni 2006 | | | | |
| *Psammocora nierstraszi* Horst, 1921 | | | | |
| *Psammocora superficialis* Gardiner, 1898 | | | | |
| *Cycloseris cyclolites* Lamarck, 1801 | | | | |
| *Turbinaria bifrons* Brüggemann, 1877 | | | | |
| *Turbinaria conspicua* Bernard, 1896 | | | | |
| *Turbinaria frondens* (Dana, 1846) | | | | |
| *Turbinaria mesenterina* (Lamarck, 1816) | | | | |
| *Turbinaria patula* (Dana, 1846) | | | | |
| *Turbinaria peltata* (Esper, 1794) | | | | |
| *Turbinaria reniformis* Bernard, 1896 | | | | |
| *Favia danae* Verrill, 1872 | | | | |
| *Favia favus* (Forskål, 1775) | | | | |
| *Favia maritima* (Nemenzo, 1971) | | | | |
| *Favia speciosa Dana, 1846* | | | | |
| *Favites complanata* (Ehrenberg, 1834) | | | | |
| *Favites flexuosa* (Dana, 1846) | | | | |
| *Favites* cf. *paraflexuosa* Veron, 2000 | | | | |
| *Goniastrea aspera* Verrill, 1905 | | | | |
| *Goniastrea australensis (Milne Edwards and Haime, 1857)* | | | | |
| *Montastrea curta (Dana, 1846)* | | | | |
| *Plesiastrea versipora* (Lamarck, 1816) | | | | |
| *Cyphastrea chalcidium* (Forskål, 1775) | | | | |
| *Cyphastrea microphthalma* (Lamarck, 1816) | | | | |
| *Cyphastrea serailia (*Forskål, 1775) | | | | |
| *Goniopora columna* Dana, 1846 | | | | |
| *Goniopora djiboutiensis* Vaughan, 1907 | | | | |
| Goniopora lobata Milne Edwards and Haime, 1860 | | | | |
| *Goniopora stokesi* Milne Edwards and Haime, 1851 | | | | |
| *Goniopora stutchburyi Wells, 1955* | | | | |
| *Tubastrea sp. (*Hervey Bay sp) | | | | |
| *Tubipora musica* | | | | |
| **Soft Corals** | | | | |
| *Lobophytum* | | | | |
| *Sarcophyton* | | | | |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Sinularia* spp. | | | | |
| *Sinularia flexibilis* | | | | |
| *Capnella* | | | | |
| *Dendronephthya* | | | | |
| *Lemnalia* | | | | |
| *Paralemnalia* | | | | |
| *Anthelia* | | | | |
| *Sansibia* | | | | |
| *cf. Solenocaulon* | | | | |
| *cf. Acabaria* | | | | |
| *Rumphella* | | | | |
| *cf. Dichotella* | | | | |
| *cf. Paraplexaura* | | | | |
| **Annelids** | | | | |
| *Vermiculariai sipha* | wormshell | | | |
| **Molluscs** | | | | |
| *Telescopium telescopium* | Mudwelk | | | |
| *Pyrazus ebeninus* | | | | |
| *Velacumantus sp* | | | | |
| *Clypeomorus sp* | | | | |
| **Crustaceans** | | | | |
| *Scylla serrata* | mud crab | | | |
| *Portunus pelagicus* | blue swimmer crab | | | |
| *Uca vocans* | fiddler crab | | | |
| *Uca dussumieri* | fiddler crab | | | |
| *Uca coarctata* | fiddler crab | | | |
| *Uca.seismella* | fiddler crab | | | |
| *Uca polita* | fiddler crab | | | |
| *Uca signata* | fiddler crab | | | |
| *Uca perplexa* | fiddler crab | | | |
| *Macrophthalamus setosus* | crab | | | |
| *Macrophthalamus latreilli* | crab | | | |
| **Insects** | | | | |
| *Acrodipsas illidgei* | Illidge's ant-blue butterfly | V | | QA |
| *Nesolycaena albosericea* | satin opal | | | Q |
| *Danaus affinis affinis* | marsh tiger | | | QAI |
| *Hypolimnas bolina nerina* | varied eggfly | | | QAI |
| *Tirumala hamata hamata* | blue tiger | | | QAI |
| *Papilio aegeus aegeus* | orchard swallowtail (Australian subsp.) | | | QA |
| *Catopsilia pomona pomona* | lemon migrant | | | QAI |
| *Eurema hecabe phoebus* | large grass-yellow | | | QA |
| **FUNGI** | | | | |
| **Club Fungi** | | | | |
| *Agrocybe sp. 4* | | C | | Q |
| *Amauroderma rude* | | C | | U |
| *Clavaria* | | C | | QA |
| *Gymnopilus* | | C | | U |
| *Trametes hirsuta* | | C | | U |
| *Trametes lactinea* | | C | | QA |
| **Sac Fungi** | | | | |
| *Arthonia* | | C | | QA |
| *Arthothelium* | | C | | U |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Catillaria* | | C | | QA |
| *Haematomma persoonii* | | C | | U |
| *Lecanora* | | C | | U |
| *Lecanora helva* | | C | | QA |
| *Opegrapha* | | C | | U |
| *Parmotrema robustum* | | C | | QA |
| *Ochrolechia* | | C | | QA |
| *Pertusaria* | | C | | U |
| *Pertusaria pustulata* | | C | | QI |
| *Buellia* | | C | | U |
| *Buellia bahiana* | | C | | U |
| *Buellia curatellae* | | C | | U |
| *Buellia demutans* | | C | | U |
| *Buellia dissa* | | C | | U |
| *Dirinaria applanata* | | C | | U |
| *Dirinaria melanoclina* | | C | | QA |
| *Dirinaria picta* | | C | | QAI |
| *Dirinaria purpurascens* | | C | | Q |
| *Ramalina* | | C | | QAI |
| *Ramalina confirmata* | | C | | QAI |
| *Ramalina exiguella* | | C | | QAI |
| *Caloplaca byrsonimae* | | C | | Q |
| *Teloschistes flavicans* | | C | | U |
| *Eumitria baileyi* | | C | | U |
| *Usnea* | | C | | U |
| *Usnea bismolliuscula* | | C | | QAI |
| *Usnea himantodes* | | C | | U |
| *Usnea nidifica* | | C | | QAI |
| *Polyblastia* | | C | | Q |
| **PLANTS** | | | | |
| **Club Mosses** | | | | |
| *Lycopodiella cernua* | | C | | U |
| *Lycopodiella serpentina* | bog clubmoss | C | | U |
| **Conifers** | | | | |
| *Agathis robusta* | kauri pine | C | | Q |
| *Callitris columellaris* | | C | | QA |
| *Pinus elliottii* | slash pine | | | IU |
| **Cycads** | | | | |
| *Macrozamia douglasii* | | C | | Q |
| *Macrozamia miquelii* | | C | | Q |
| **Ferns** | | | | |
| *Pityrogramma calomelanos var. austroamericana* | | | | IU |
| *Blechnum cartilagineum* | gristle fern | C | | U |
| *Blechnum indicum* | swamp water fern | C | | U |
| *Pteridium esculentum* | common bracken | C | | U |
| *Dicranopteris linearis var. linearis* | | C | | U |
| *Gleichenia dicarpa* | pouched coral fern | C | | U |
| *Gleichenia mendellii* | | C | | QA |
| *Sticherus flabellatus var. flabellatus* | | C | | U |
| *Lindsaea incisa* | | C | | U |
| *Drynaria rigidula* | | C | | U |
| *Microsorum punctatum* | | C | | U |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Platycerium bifurcatum* | | C | | QA |
| *Pyrrosia rupestris* | rock felt fern | C | | U |
| *Acrostichum speciosum* | mangrove fern | C | | U |
| *Lygodium microphyllum* | snake fern | C | | U |
| *Schizaea bifida* | forked comb fern | C | | U |
| *Schizaea dichotoma* | branched comb fern | C | | U |
| **Higher Dicots** | | | | |
| *Carpobrotus glaucescens* | pigface | C | | QAI |
| *Sesuvium portulacastrum* | sea purslane | C | | U |
| *Tetragonia tetragonioides* | New Zealand spinach | C | | QAI |
| *Euroschinus falcatus* | | C | | XA |
| *Centella asiatica* | | C | | U |
| *Platysace ericoides* | heath platysace | C | | U |
| *Platysace lanceolata* | | C | | QA |
| *Platysace linearifolia* | | C | | QA |
| *Xanthosia pilosa* | woolly xanthosia | C | | QA |
| *Alyxia ruscifolia* | | C | | U |
| *Cynanchum carnosum* | | C | | QAI |
| *Hoya australis* | | C | | QI |
| *Marsdenia fraseri* | narrow-leaved milk vine | C | | QA |
| *Parsonsia brisbanensis* | broad-leaved monkey vine | C | | Q |
| *Parsonsia latifolia* | green-leaved silkpod | C | | Q |
| *Parsonsia sankowskyana* | | E | | Q |
| *Parsonsia straminea* | monkey rope | C | | U |
| *Tabernaemontana orientalis* | | C | | QAI |
| *Astrotricha glabra* | | C | | Q |
| *Astrotricha longifolia* | star hair bush | C | | QA |
| *Cephalaralia cephalobotrys* | climbing panax | C | | QA |
| *Polyscias elegans* | celery wood | C | | QAI |
| *Trachymene incisa* subsp. *incisa* | | C | | QA |
| *Ageratum houstonianum* | blue billygoat weed | | | IU |
| *Baccharis halimifolia* | groundsel bush | | | IU |
| *Bidens pilosa* | | | | IU |
| *Chrysocephalum apiculatum* | yellow buttons | C | | U |
| *Lagenophora gracilis* | | C | | QA |
| *Wollastonia biflora* | | C | | QAI |
| *Pandorea jasminoides* | | C | | Q |
| *Pandorea pandorana* | wonga vine | C | | QAI |
| *Cakile edentula* | sea rocket | | | IU |
| *Byblis liniflora* | | C | | QA |
| *Chamaecrista rotundifolia var. rotundifolia* | | | | IU |
| *Lobelia alata* | angled lobelia | C | | QAI |
| *Lobelia purpurascens* | white root | C | | QA |
| *Wahlenbergia gracilis* | sprawling bluebell | C | | U |
| *Wahlenbergia graniticola* | granite bluebell | C | | QA |
| *Allocasuarina littoralis* | | C | | U |
| *Allocasuarina torulosa* | | C | | QA |
| *Casuarina equisetifolia* | | C | | QI |
| *Casuarina equisetifolia* subsp. *incana* | | C | | U |
| *Casuarina glauca* | swamp she-oak | C | | QA |
| *Denhamia celastroides* | broad-leaved boxwood | C | | U |
| *Hippocratea barbata* | knotvine | C | | QA |

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|---|---|---|---|---|
| *Atriplex* | | C | | QAI |
| *Enchylaena tomentosa* var. *glabra* | | C | | QA |
| *Sarcocornia quinqueflora* | | C | | XU |
| *Suaeda arbusculoides* | | C | | QA |
| *Suaeda australis* | | C | | U |
| *Tecticornia indica* | | C | | U |
| *Lumnitzera racemosa* | | C | | QAI |
| *Ipomoea cairica* | | | | IU |
| *Ipomoea pes-caprae* subsp. *brasiliensis* | goatsfoot | C | | U |
| *Bauera capitata* | clustered bauera | C | | QA |
| *Schizomeria ovata* | white cherry | C | | QA |
| *Hibbertia acicularis* | | C | | QA |
| *Hibbertia linearis* | | C | | QA |
| *Hibbertia linearis* var. *floribunda* | | C | | QA |
| *Hibbertia linearis* var. *obtusifolia* | | C | | QA |
| *Hibbertia salicifolia* | | C | | QA |
| *Hibbertia scandens* | | C | | U |
| *Hibbertia stricta* | | C | | U |
| *Hibbertia vestita* | | C | | U |
| *Drosera auriculata* | | C | | QAI |
| *Drosera binata* | forked sundew | C | | QAI |
| *Drosera burmanni* | | C | | QAI |
| *Drosera indica* | | C | | U |
| *Drosera peltata* | pale sundew | C | | U |
| *Drosera pygmaea* | | C | | QAI |
| *Drosera spatulata* | | C | | Q |
| *Elaeocarpus eumundi* | Eumundi quandong | C | | QA |
| *Elaeocarpus obovatus* | blueberry ash | C | | QA |
| *Elaeocarpus reticulatus* | ash quandong | C | | QA |
| *Tetratheca thymifolia* | | C | | QA |
| *Epacris microphylla* | | C | | XA |
| *Acrotriche aggregata* | red cluster heath | C | | QA |
| *Agiortia pedicellata* | | C | | QA |
| *Brachyloma daphnoides* | | C | | QA |
| *Brachyloma daphnoides* subsp. *daphnoides* | | C | | QA |
| *Brachyloma scortechinii* | | C | | QA |
| *Epacris pulchella* | wallum heath | C | | QA |
| *Leucopogon deformis* | | C | | U |
| *Leucopogon leptospermoides* | | C | | U |
| *Leucopogon margarodes* | pearl beard heath | C | | QA |
| *Leucopogon sp.* (Burrum Heads A.R.Bean 7802) | | C | | Q |
| *Monotoca scoparia* | prickly broom heath | C | | QA |
| *Monotoca sp.* (Fraser Island P.Baxter 777) | | C | | U |
| *Sprengelia sprengelioides* | sprengelia | C | | QA |
| *Styphelia viridis* subsp. *breviflora* | | C | | QA |
| *Trochocarpa laurina* | tree heath | C | | QAI |
| *Woollsia pungens* | | C | | QA |
| *Excoecaria agallocha* | milky mangrove | C | | U |
| *Mallotus philippensis* | red kamala | C | | U |
| *Monotaxis macrophylla* | | C | | QA |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Ricinocarpos pinifolius* | wedding bush | C | | QA |
| *Aotus ericoides* | common aotus | C | | QA |
| *Aotus lanigera* | pointed aotus | C | | QA |
| *Bossiaea heterophylla* | variable bossiaea | C | | QA |
| *Callerya megasperma* | native wisteria | C | | QA |
| *Crotalaria* | | C | | QAI |
| *Crotalaria brevis* | | C | | U |
| *Crotalaria pallida var. obovata* | | | | IU |
| *Daviesia umbellulata* | | C | | QA |
| *Desmodium incanum* | | | | IU |
| *Desmodium rhytidophyllum* | | C | | U |
| *Dillwynia floribunda* | | C | | QA |
| *Erythrina vespertilio* | | C | | U |
| *Fabaceae* | | C | | QAI |
| *Flemingia parviflora* | flemingia | C | | U |
| *Glycine clandestina var. clandestina* | | C | | QA |
| *Glycine pescadrensis* | | C | | Q |
| *Glycine tabacina* | glycine pea | C | | QA |
| *Gompholobium pinnatum* | poor mans gold | C | | QA |
| *Gompholobium virgatum* | | C | | QA |
| *Hardenbergia violacea* | | C | | U |
| *Jacksonia stackhousei* | wallum dogwood | C | | QA |
| *Mirbelia rubiifolia* | heathy mirbelia | C | | U |
| *Phyllota phylicoides* | yellow peabush | C | | QA |
| *Pultenaea myrtoides* | | C | | U |
| *Pultenaea paleacea* | | C | | U |
| *Pultenaea rariflora* | | C | | QA |
| *Pultenaea villosa* | hairy bush pea | C | | QA |
| *Scolopia braunii* | flintwood | C | | QA |
| *Schenkia australis* | | C | | U |
| *Goodenia bellidifolia* | | C | | U |
| *Goodenia rotundifolia* | | C | | QA |
| *Goodenia stelligera* | | C | | QA |
| *Scaevola calendulacea* | dune fan flower | C | | QA |
| *Velleia spathulata* | wild pansies | C | | QAI |
| *Gonocarpus micranthus* | | C | | U |
| *Gonocarpus micranthus subsp. ramosissimus* | | C | | U |
| *Anisomeles malabarica* | | C | | U |
| *Clerodendrum floribundum* | | C | | QAI |
| *Gmelina leichhardtii* | white beech | C | | Q |
| *Plectranthus amboinicus* | allspice | | | IU |
| *Plectranthus parviflorus* | | C | | U |
| *Westringia tenuicaulis* | tufted westringia | C | | Q |
| *Planchonia careya* | cockatoo apple | C | | QAI |
| *Utricularia uliginosa* | asian bladderwort | C | | QAI |
| *Mitrasacme paludosa* | | C | | U |
| *Amyema cambagei* | | C | | QA |
| *Amyema congener subsp. congener* | | C | | U |
| *Amyema linophylla subsp. orientalis* | | C | | QA |
| *Amyema mackayensis* | | C | | QA |
| *Amyema miquelii* | | C | | U |
| *Dendrophthoe* | | C | | QI |

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|---|---|---|---|---|
| *Dendrophthoe vitellina* | long-flowered mistletoe | C | | U |
| *Lysiana maritima* | | C | | QA |
| *Hibiscus tiliaceus* | cotton tree | C | | QAI |
| *Melastoma malabathricum subsp. malabathricum* | | C | | U |
| *Xylocarpus granatum* | cedar mangrove | C | | QAI |
| *Villarsia exaltata* | | C | | QA |
| *Acacia attenuata* | | V | V | Q |
| *Acacia aulacocarpa* | | C | | QA |
| *Acacia baueri subsp. baueri* | | V | | QA |
| *Acacia cincinnata* | | C | | QA |
| *Acacia disparrima subsp. disparrima* | | C | | QA |
| *Acacia flavescens* | toothed wattle | C | | U |
| *Acacia hubbardiana* | | C | | Q |
| *Acacia leiocalyx* | | C | | Q |
| *Acacia leiocalyx* subsp. *herveyensis* | | C | | Q |
| *Acacia leiocalyx* subsp. *leiocalyx* | | C | | QA |
| *Acacia maidenii* | Maiden's wattle | C | | QA |
| *Acacia penninervis* | | C | | QA |
| *Acacia sp.* (Comet L.Pedley 4091) | | C | | Q |
| *Acacia suaveolens* | sweet wattle | C | | QA |
| *Acacia ulicifolia* | | C | | QA |
| *Archidendron lovelliae* | bacon wood | V | V | Q |
| *Macarthuria complanata* | | R | | Q |
| *Macarthuria neocambrica* | | C | | U |
| *Ficus opposita* | | C | | QAI |
| *Myoporum acuminatum* | coastal boobialla | C | | U |
| *Aegiceras corniculatum* | river mangrove | C | | U |
| *Ardisia elliptica* | | | | IU |
| *Embelia australiana* | embelia | C | | QAI |
| *Myrsine porosa* | | C | | U |
| *Myrsine variabilis* | | C | | QA |
| *Acmena hemilampra* | | C | | U |
| *Angophora leiocarpa* | rusty gum | C | | QA |
| *Austromyrtus dulcis* | midgen berry | C | | QA |
| *Backhousia myrtifolia* | carrol | C | | QA |
| *Baeckea frutescens* | | C | | QAI |
| *Corymbia gummifera* | red bloodwood | C | | QA |
| *Corymbia intermedia* | pink bloodwood | C | | U |
| *Corymbia tessellaris* | Moreton Bay ash | C | | U |
| *Decaspermum humile* | silky myrtle | C | | U |
| *Eucalyptus bancroftii* | Bancroft's red gum | C | | QA |
| *Eucalyptus exserta* | Queensland peppermint | C | | U |
| *Eucalyptus latisinensis* | | C | | Q |
| *Eucalyptus pilularis* | blackbutt | C | | QA |
| *Eucalyptus racemosa subsp. racemosa* | scribbly gum | C | | QA |
| *Eucalyptus robusta* | swamp mahogany | C | | QA |
| *Eucalyptus siderophloia* | | C | | QA |
| *Eucalyptus tereticornis* | | C | | Q |
| *Eucalyptus tereticornis subsp. tereticornis* | | C | | QAI |
| *Homoranthus virgatus* | twiggy homoranthus | C | | U |
| *Leptospermum lanigerum* | | C | | XA |

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|---|---|---|---|---|
| *Leptospermum liversidgei* | | C | | QA |
| *Leptospermum polygalifolium* | tantoon | C | | U |
| *Leptospermum semibaccatum* | wallum tea-tree | C | | QA |
| *Leptospermum speciosum* | | C | | U |
| *Leptospermum trinervium* | woolly tea-tree | C | | QA |
| *Leptospermum whitei* | | C | | QA |
| *Lophostemon confertus* | brush box | C | | QA |
| *Lophostemon suaveolens* | swamp box | C | | U |
| *Melaleuca dealbata* | swamp tea-tree | C | | QAI |
| *Melaleuca nodosa* | | C | | U |
| *Melaleuca pachyphylla* | | C | | QAI |
| *Melaleuca quinquenervia* | swamp paperbark | C | | QAI |
| *Melaleuca sieberi* | | C | | QA |
| *Melaleuca thymifolia* | thyme honeymyrtle | C | | QA |
| *Melaleuca viridiflora* | | C | | U |
| *Melaleuca viridiflora var. viridiflora* | | C | | U |
| *Ochrosperma lineare* | | C | | QA |
| *Osbornia octodonta* | myrtle mangrove | C | | U |
| *Pilidiostigma glabrum* | plum myrtle | C | | QA |
| *Rhodamnia acuminata* | cooloola ironwood | C | | Q |
| *Syncarpia hillii* | Fraser Island satinay | C | | QA |
| *Syzygium luehmannii* | | C | | QA |
| *Syzygium oleosum* | blue cherry | C | | QA |
| *Olax retusa* | | C | | QA |
| *Notelaea longifolia* | | C | | QA |
| *Olea paniculata* | | C | | U |
| *Oxalis corniculata* | | | | IU |
| *Passiflora suberosa* | corky passion flower | | | IU |
| *Breynia oblongifolia* | | C | | U |
| *Glochidion ferdinandi* | | C | | QA |
| *Glochidion lobocarpum* | | C | | QI |
| *Phyllanthus virgatus* | | C | | U |
| *Pseudanthus orientalis* | | C | | QA |
| *Pittosporum revolutum* | yellow pittosporum | C | | QA |
| *Aegialitis annulata* | club mangrove | C | | U |
| *Comesperma defoliatum* | leafless milkwort | C | | QA |
| *Comesperma hispidulum* | | C | | QA |
| *Polygala paniculata* | | | | IU |
| *Banksia* | | C | | XA |
| *Banksia aemula* | wallum banksia | C | | QA |
| *Banksia integrifolia* | | C | | XA |
| *Banksia integrifolia subsp. compar* | | C | | U |
| *Banksia integrifolia subsp. integrifolia* | | C | | QA |
| *Banksia oblongifolia* | dwarf banksia | C | | QA |
| *Banksia robur* | broad-leaved banksia | C | | U |
| *Banksia serrata* | red honeysuckle | C | | QA |
| *Banksia spinulosa* | | C | | XA |
| *Conospermum taxifolium* | devil's rice | C | | QA |
| *Grevillea leiophylla* | wallum grevillea | C | | Q |
| *Grevillea reptans* | | C | | Q |
| *Hakea actites* | | C | | U |
| *Hakea plurinervia* | | C | | Q |
| *Hakea sericea* | white hakea | C | | QA |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Lomatia silaifolia* | crinkle bush | C | | QA |
| *Persoonia cornifolia* | broad-leaved geebung | C | | QA |
| *Persoonia tenuifolia* | | C | | U |
| *Persoonia virgata* | small-leaved geebung | C | | U |
| *Petrophile shirleyae* | | C | | Q |
| *Strangea linearis* | strangea | C | | U |
| *Xylomelum salicinum* | | C | | U |
| *Drypetes deplanchei* | grey boxwood | C | | QAI |
| *Alphitonia excelsa* | soap tree | C | | U |
| *Bruguiera gymnorhiza* | large-fruited orange mangrove | C | | U |
| *Ceriops tagal* | yellow mangrove | C | | U |
| *Rhizophora stylosa* | spotted mangrove | C | | U |
| *Rubus parvifolius* | pink-flowered native raspberry | C | | QA |
| *Caelospermum* | | C | | U |
| *Cyclophyllum coprosmoides* | | C | | QAI |
| *Cyclophyllum coprosmoides var. coprosmoides* | | C | | Q |
| *Hodgkinsonia ovatiflora* | golden ash | C | | QA |
| *Morinda jasminoides* | morinda | C | | QAI |
| *Pomax umbellata* | | C | | U |
| *Psychotria loniceroides* | hairy psychotria | C | | QA |
| *Psydrax odorata* | | C | | U |
| *Spermacoce brachystema* | | C | | QA |
| *Acronychia wilcoxiana* | silver aspen | C | | QA |
| *Boronia falcifolia* | wallum boronia | C | | QA |
| *Boronia glabra* | | C | | U |
| *Boronia rivularis* | Wide Bay boronia | R | | Q |
| *Boronia rosmarinifolia* | forest boronia | C | | QA |
| *Eriostemon australasius* | | C | | U |
| *Flindersia bennettiana* | Bennett's ash | C | | QA |
| *Flindersia schottiana* | bumpy ash | C | | U |
| *Halfordia kendack* | saffron heart | C | | U |
| *Phebalium woombye* | wallum phebalium | C | | QA |
| *Philotheca queenslandica* | | C | | Q |
| *Zieria laxiflora* | wallum zieria | C | | QA |
| *Zieria smithii* | | C | | U |
| *Samolus repens* | creeping brookweed | C | | QAI |
| *Choretrum candollei* | white sour bush | C | | QA |
| *Exocarpos cupressiformis* | native cherry | C | | QA |
| *Exocarpos latifolius* | | C | | QAI |
| *Leptomeria acida* | sour currant bush | C | | U |
| *Alectryon reticulatus* | wild quince | C | | U |
| *Cupaniopsis anacardioides* | tuckeroo | C | | U |
| *Dodonaea triquetra* | large-leaved hop bush | C | | QA |
| *Dodonaea viscosa* | | C | | QAI |
| *Guioa acutifolia* | northern guioa | C | | QI |
| *Jagera pseudorhus* | | C | | U |
| *Mischocarpus australis* | red pear-fruit | C | | QA |
| *Sarcopteryx stipata* | steelwood | C | | QA |
| *Planchonella chartacea* | | C | | QAI |
| *Artanema fimbriatum* | | C | | QAI |
| *Lindernia crustacea* | | C | | U |
| *Triumfetta rhomboidea* | chinese burr | | | IU |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Stackhousia nuda* | | C | | Q |
| *Stackhousia viminea* | slender stackhousia | C | | U |
| *Stylidium graminifolium* | grassy-leaved trigger-flower | C | | QA |
| *Stylidium ornatum* | | C | | QA |
| *Stylidium tenerum* | | C | | U |
| *Pimelea linifolia* | | C | | QA |
| *Pimelea linifolia subsp. linifolia* | | C | | U |
| *Wikstroemia indica* | tie bush | C | | U |
| *Trema orientalis* | tree peach | C | | QI |
| *Lantana camara* | | | | IU |
| *Cissus hypoglauca* | | C | | QAI |
| *Cissus sterculiifolia* | | C | | QAI |
| *Clematicissus opaca* | | C | | QA |
| **Liverworts** | | | | |
| *Bazzania corbieri* | | C | | Q |
| **Lower Dicots** | | | | |
| *Polyalthia nitidissima* | polyalthia | C | | U |
| *Avicennia* | | C | | XI |
| *Avicennia marina* | | C | | QAI |
| *Avicennia marina subsp. australasica* | | C | | U |
| *Eupomatia laurina* | bolwarra | C | | QAI |
| *Cassytha filiformis* | dodder laurel | C | | U |
| *Cassytha glabella* | | C | | XA |
| *Cassytha pubescens* | downy devil's twine | C | | QA |
| *Cinnamomum baileyanum* | candlewood | C | | Q |
| *Cryptocarya glaucescens* | | C | | QA |
| *Cryptocarya macdonaldii* | McDonald's laurel | C | | U |
| *Endiandra discolor* | domatia tree | C | | QA |
| *Endiandra sieberi* | hard corkwood | C | | QA |
| *Litsea reticulata* | | C | | QA |
| *Neolitsea dealbata* | white bolly gum | C | | QAI |
| *Hypserpa decumbens* | | C | | QA |
| *Stephania japonica* | | C | | QAI |
| *Stephania japonica var. discolor* | | C | | U |
| *Wilkiea macrophylla* | large-leaved wilkiea | C | | QA |
| *Piper hederaceum var. hederaceum* | | C | | QA |
| *Clematis glycinoides* | | C | | QA |
| **Monocots** | | | | |
| *Agave sisalana* | sisal hemp | | | IU |
| *Astonia australiensis* | | R | | Q |
| *Gymnostachys anceps* | settler's flax | C | | QA |
| *Archontophoenix cunninghamiana* | piccabeen palm | C | | QA |
| *Livistona decora* | | C | | Q |
| *Blandfordia grandiflora* | christmas bells | R | | QA |
| *Burchardia umbellata* | | C | | QA |
| *Gloriosa superba* | glory lily | | | IU |
| *Murdannia graminea* | murdannia | C | | U |
| *Halodule uninervis* | | C | | QAI |
| *Abildgaardia ovata* | | C | | QAI |
| *Baumea* | | C | | QAI |
| *Baumea juncea* | bare twigrush | C | | QAI |
| *Baumea muelleri* | | C | | QA |
| *Baumea rubiginosa* | soft twigrush | C | | QAI |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Baumea teretifolia* | | C | | QAI |
| *Caustis blakei* | | C | | U |
| *Caustis recurvata* | | C | | QA |
| *Chorizandra cymbaria* | | C | | QAI |
| *Chorizandra sphaerocephala* | | C | | QA |
| *Cyathochaeta diandra* | sheath rush | C | | QA |
| *Cyperus lucidus* | | C | | U |
| *Cyperus scaber* | | C | | U |
| *Cyperus stradbrokensis* | | C | | QA |
| *Cyperus trinervis* | | C | | U |
| *Eleocharis geniculata* | | C | | QAI |
| *Fimbristylis cinnamometorum* | | C | | QAI |
| *Fimbristylis furva* | | C | | QAI |
| *Fimbristylis nutans* | | C | | QAI |
| *Fimbristylis polytrichoides* | | C | | QAI |
| *Fuirena ciliaris* | | C | | QAI |
| *Gahnia aspera* | | C | | U |
| *Gahnia sieberiana* | sword grass | C | | QAI |
| *Lepidosperma laterale* | | C | | QA |
| *Lepidosperma longitudinale* | pithy swordsedge | C | | QA |
| *Lepironia articulata* | | C | | QAI |
| *Ptilothrix deusta* | | C | | QA |
| *Rhynchospora brownii* | beak rush | C | | QAI |
| *Schoenus apogon* var. *apogon* | | C | | U |
| *Schoenus brevifolius* | | C | | U |
| *Schoenus calostachyus* | | C | | QAI |
| *Schoenus lepidosperma subsp. pachylepis* | | C | | U |
| *Schoenus scabripes* | | R | | QA |
| *Schoenus sparteus* | | C | | U |
| *Scleria rugosa* | | C | | U |
| *Trachystylis stradbrokensis* | | C | | QA |
| *Dioscorea transversa* | native yam | C | | QAI |
| *Eriocaulon australe* | | C | | QAI |
| *Eriocaulon scariosum* | | C | | U |
| *Flagellaria indica* | whip vine | C | | QAI |
| *Haemodorum tenuifolium* | | C | | QA |
| *Dianella caerulea* | | C | | QAI |
| *Dianella caerulea var. vannata* | | C | | U |
| *Dianella longifolia var. surculosa* | | C | | QA |
| *Dianella rara* | | C | | Q |
| *Dianella revoluta* | | C | | QA |
| *Geitonoplesium cymosum* | scrambling lily | C | | QAI |
| *Halophila ovalis subsp. ovalis* | | C | | QI |
| *Hypoxis hygrometrica var. villosisepala* | | C | | U |
| *Patersonia fragilis* | | C | | QA |
| *Patersonia sericea* | | C | | XA |
| *Caesia chlorantha* | | C | | QA |
| *Caesia parviflora* var. *parviflora* | | C | | QA |
| *Tricoryne anceps* | | C | | U |
| *Tricoryne anceps* subsp. *pterocaulon* | | C | | U |
| *Tricoryne elatior* | yellow autumn lily | C | | U |
| *Tricoryne muricata* | | C | | Q |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Juncus* | | C | | QAI |
| *Juncus kraussii* | sea rush | C | | QA |
| *Juncus kraussii* subsp. *australiensis* | | C | | QAI |
| *Cordyline rubra* | red-fruited palm lily | C | | U |
| *Eustrephus latifolius* | wombat berry | C | | U |
| *Laxmannia compacta* | | C | | QA |
| *Laxmannia gracilis* | slender wire lily | C | | QA |
| *Lomandra confertifolia* subsp. *pallida* | | C | | Q |
| *Lomandra filiformis* | | C | | U |
| *Lomandra laxa* | broad-leaved matrush | C | | U |
| *Lomandra longifolia* | | C | | QA |
| *Lomandra multiflora* | | C | | U |
| *Lomandra multiflora subsp. multiflora* | | C | | U |
| *Sowerbaea juncea* | vanilla plant | C | | QA |
| *Thysanotus tuberosus subsp. tuberosus* | | C | | QA |
| *Acianthus fornicatus* | pixie caps | C | | QA |
| *Arthrochilus* | | C | | Q |
| *Arthrochilus irritabilis* | leafy elbow orchid | C | | QA |
| *Caladenia carnea* | | C | | QA |
| *Caladenia catenata* | | C | | QA |
| *Caladenia fuscata* | | C | | QA |
| *Calanthe triplicata* | christmas orchid | C | | QAI |
| *Caleana major* | flying duck orchid | C | | QA |
| *Corybas* | | C | | QI |
| *Corybas aconitiflorus* | | C | | QA |
| *Corybas barbarae* | helmet orchid | C | | Q |
| *Corybas fordhamii* | banded helmet orchid | C | | QA |
| *Corybas undulatus* | tailed helmet orchid | C | | QA |
| *Cryptostylis erecta* | bonnet orchid | C | | QA |
| *Cymbidium madidum* | | C | | Q |
| *Cymbidium suave* | | C | | QA |
| *Dipodium hamiltonianum* | yellow hyacinth orchid | C | | Q |
| *Dipodium variegatum* | | C | | QA |
| *Diuris alba* | | C | | QA |
| *Diuris chrysantha* | double yellow tails | C | | QA |
| *Dockrillia linguiformis* | tongue orchid | C | | QA |
| *Empusa habenarina* | | C | | QA |
| *Eriochilus* | | C | | Q |
| *Eriochilus cucullatus* | | C | | QA |
| *Genoplesium* | | C | | Q |
| *Genoplesium acuminatum* | | C | | U |
| *Genoplesium pumilum* | green midge orchid | C | | QA |
| *Genoplesium sagittiferum* | | C | | QA |
| *Geodorum densiflorum* | pink nodding orchid | C | | U |
| *Glossodia minor* | small wax lip orchid | C | | QA |
| *Habenaria harroldii* | | E | | Q |
| *Microtis parviflora* | slender onion orchid | C | | QAI |
| *Prasophyllum australe* | austral leek orchid | C | | QA |
| *Prasophyllum brevilabre* | | C | | QA |
| *Prasophyllum elatum* | tall leek orchid | C | | QA |
| *Prasophyllum exilis* | | R | | Q |
| *Pterostylis* | | C | | U |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Pterostylis erecta* | | C | | Q |
| *Pterostylis nutans* | | C | | QA |
| *Pterostylis ophioglossa* | | C | | QAI |
| *Spiranthes sinensis* | austral ladies tresses | C | | QAI |
| *Thelymitra* | | C | | QA |
| *Thelymitra nuda* | scented sun orchid | C | | QA |
| *Thelymitra purpurata* | wallum sun orchid | C | | QA |
| *Pandanus* | | C | | QAI |
| *Pandanus tectorius* | | C | | QAI |
| *Aristida benthamii* | | C | | Q |
| *Aristida benthamii var. benthamii* | | C | | U |
| *Aristida warburgii* | | C | | U |
| *Chrysopogon sylvaticus* | | C | | QAI |
| *Cleistochloa subjuncea* | | C | | Q |
| *Cymbopogon refractus* | barbed-wire grass | C | | U |
| *Digitaria eriantha cv. Pangola* | | | | IU |
| *Digitaria fumida* | | C | | Q |
| *Digitaria leucostachya* | | C | | QAI |
| *Eleusine indica* | crowsfoot grass | | | IU |
| *Entolasia marginata* | bordered panic | C | | U |
| *Entolasia stricta* | wiry panic | C | | U |
| *Entolasia whiteana* | | C | | QA |
| *Eragrostis brownii* | Brown's lovegrass | C | | QAI |
| *Eragrostis tenuifolia* | elastic grass | | | IU |
| *Eriachne glabrata* | | C | | Q |
| *Eriachne insularis* | | C | | Q |
| *Eriachne mucronata* | | C | | QA |
| *Eriachne pallescens* | | C | | U |
| *Eriachne pallescens var. pallescens* | | C | | QAI |
| *Eriachne rara* | | C | | QA |
| *Eriochloa procera* | slender cupgrass | C | | U |
| *Heteropogon contortus* | black speargrass | C | | U |
| *Imperata cylindrica* | blady grass | C | | QAI |
| *Ischaemum australe var. australe* | | C | | QAI |
| *Ischaemum fragile* | | C | | QAI |
| *Ischaemum triticeum* | | C | | QA |
| *Oplismenus aemulus* | creeping shade grass | C | | QAI |
| *Panicum effusum* | | C | | U |
| *Panicum simile* | | C | | U |
| *Paspalidium* | | C | | QAI |
| *Paspalidium distans* | shotgrass | C | | QAI |
| *Paspalidium gausum* | | C | | U |
| *Paspalum scrobiculatum* | ditch millet | C | | U |
| *Sacciolepis indica* | Indian cupscale grass | C | | U |
| *Sporobolus africanus* | Parramatta grass | | | IU |
| *Sporobolus fertilis* | giant Parramatta grass | | | IU |
| *Sporobolus laxus* | | C | | QA |
| *Sporobolus virginicus* | sand couch | C | | QAI |
| *Themeda triandra* | kangaroo grass | C | | U |
| *Zoysia macrantha subsp. macrantha* | | C | | QA |
| *Baloskion pallens* | | C | | QA |
| *Baloskion tenuiculme* | | C | | QA |
| *Coleocarya gracilis* | | C | | QA |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Empodisma minus* | spreading rope rush | C | | QAI |
| *Eurychorda complanata* | | C | | QA |
| *Hypolaena fastigiata* | tassel rope rush | C | | QA |
| *Leptocarpus tenax* | | C | | QA |
| *Lepyrodia scariosa* | | C | | QA |
| *Sporadanthus interruptus* | | C | | U |
| *Smilax australis* | barbed-wire vine | C | | QA |
| *Smilax glyciphylla* | sweet sarsaparilla | C | | QA |
| *Xanthorrhoea fulva* | swamp grasstree | C | | QA |
| *Xanthorrhoea johnsonii* | | C | | U |
| *Xanthorrhoea macronema* | | C | | QA |
| *Xyris complanata* | yellow-eye | C | | U |
| *Xyris juncea* | dwarf yellow-eye | C | | Q |
| *Zostera muelleri subsp. capricorni* | | C | | U |
| **Mosses** | | | | |
| *Macromitrium ligulaefolium* | | C | | QA |
| **Whisk Ferns** | | | | |
| *Psilotum nudum* | skeleton fork fern | C | | U |
| **PROTISTS** | | | | |
| **Blue-green Algae** | | | | |
| *Cyanophyceae* | | C | | QAI |
| **Brown Algae** | | | | |
| *Cystoseira trinodis* | | C | | QA |
| *Dictyopteris australis* | | C | | U |
| *Dictyota acutiloba* | | C | | Q |
| *Dictyota dichotoma* | | C | | QAI |
| *Ectocarpus* | | C | | QAI |
| *Hydroclathrus clathratus* | | C | | QAI |
| *Sporochnus pedunculatus* | | C | | QI |
| **Green Algae** | | | | |
| *Acetabularia crenulata* | | C | | QAI |
| *Bryopsis* | | C | | QAI |
| *Caulerpa cupressoides* | | C | | QAI |
| *Caulerpa cupressoides var. flabellata* | | C | | Q |
| *Caulerpa taxifolia* | | C | | QI |
| *Codium galeatum* | | C | | QA |
| *Halimeda discoidea* | | C | | QAI |
| *Halimeda opuntia* | | C | | QAI |
| *Rhizoclonium implexum* | | C | | QI |
| *Trentepohlia bossei var. samoensis* | | C | | Q |
| *Trentepohlia peruana* | | C | | QAI |
| *Udotea flabellum* | | C | | QI |
| **Red Algae** | | | | |
| *Acrosymphyton tenax* | | C | | Q |
| *Bostrychia* | | C | | Q |
| *Dasya* | | C | | QA |
| *Herposiphonia* | | C | | QA |
| *Hypnea boergesenii* | | C | | Q |
| *Laurencia* | | C | | QAI |
| *Laurencia mariannensis* | | C | | Q |
| *Laurencia nidifica* | | C | | QI |
| *Laurencia papillosa* | | C | | QAI |
| *Laurencia venusta* | | C | | Q |

| Scientific Name | Common Name | NCA | EPBC | End |
|---|---|---|---|---|
| *Polysiphonia* | | C | | QAI |
| *Polysiphonia scopulorum* | | C | | QA |

## Appendix 4. Curriculum Vitae for authors

### Warren Lee Long

Over 27 years experience in natural resource studies, management and advice with expertise in watershed, coastal and marine systems. Has provided specialist input to numerous local, regional, national and international conservation programs and management of Ramsar designated wetlands. Warren worked extensively in north-eastern Australia and SE Asia on seagrass, catchment, coastal and coral reef ecosystems for fisheries research and coastal management agencies; and initiated community-government partnerships in seagrass habitat monitoring. Since 2002 he has implemented international conservation initiatives with Wetlands International in partnership with governments and NGOs, for wetlands of international significance, migratory shorebirds and related programs. He also assists and advises governments and regional bodies on implementation of the Ramsar Convention, including wise use principles, Ecological Character Descriptions, Ramsar nominations, wetland management and strategic programs and reviews.

Warren has designed and implemented regional and international projects in Asia and Oceania on catchment, coastal and marine wetland research and management. He has provided specialist advice and served on numerous technical and management advisory panels and groups in these fields. He has also developed and implemented several training courses and workshops for scientific, community-based and Ramsar wetland management programs.

### Woo O'Reilly

Woo is a wetlands ecologist with extensive field experience studying endangered frog populations and their habitats throughout Australia. Woo has worked on Ramsar and migratory waterbird issues since 2002 both from within Commonwealth Department of Environment and Water Resources and with Wetlands International - Oceania.

Her work has included managing projects and assessing developments as part of the Commonwealth's obligations for migratory waterbird species and Ramsar Wetlands under the Environment Protection and Biodiversity Conservation Act 1999, as well as assisting in the preparation of Australia's National Report to the 2002 Ramsar Conference of Parties. She more recently organised a national workshop and facilitated meetings with state and federal representatives as well as with research and NRM bodies in order to finalise a national set of coastal, estuarine and marine indicators for the National Land and Water Resources Audit.

Together with her Wetlands International – Oceania colleagues, Woo compiled a report for DEW in 2004 on potential Commonwealth Ramsar site nominations. This included the preparation of draft Ramsar Information Sheets for four very different wetland ecosystems; Bundera Sinkhole in NW Western Australia, Port Wakefield Defence site in South Australia, Booderee National Park and the remote Heard and MacDonald Islands.