

Information Sheet on Ramsar Wetlands (RIS) – 2006-2008 version

Categories approved by Recommendation 4.7 (1990), as amended by Resolution VIII.13 of the 8th Conference of the Contracting Parties (2002) and Resolutions IX.1 Annex B, IX.6, IX.21 and IX. 22 of the 9th Conference of the Contracting Parties (2005).

1. Name and address of the compiler of this form:

Compiled by the Department of Conservation and Land Management in 2003, with assistance from Broome Bird Observatory, Charles Sturt University and Wetlands International - Oceania. Updated by Bennelongia on behalf of the Department of Environment and Conservation in 2009.

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Designation date

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Site Reference Number

All inquiries should be directed to Michael Coote, DEC, 17 Dick Perry Avenue, Technology Park, Kensington WA 6983, Australia (Tel: +61-8- 9219 8714; Fax: +61-8- 9219 8750; email: Michael.Coote@dec.wa.gov.au).

2. Date this sheet was completed/updated:

April 2009

3. Country:

Australia

4. Name of the Ramsar site:

Roebuck Bay, Western Australia

5. Designation of new Ramsar site or update of existing site:

This RIS is for (tick one box only).

- a) Designation of a new Ramsar site ; or
b) Updated information on an existing Ramsar site

6. For RIS updates only, changes to the site since its designation or earlier update:

a) Site boundary and area

The Ramsar site boundary and site area are unchanged:

or

If the site boundary has changed:

- i) the boundary has been delineated more accurately ; or
ii) the boundary has been extended ; or
iii) the boundary has been restricted**

and/or

If the site area has changed:

- i) the area has been measured more accurately ; or
ii) the area has been extended ; or
iii) the area has been reduced**

** Important note: If the boundary and/or area of the designated site is being restricted/reduced, the Contracting Party should have followed the procedures established by the Conference of the Parties in the Annex to COP9 Resolution IX.6 and provided a report in line with paragraph 28 of that Annex, prior to the submission of an updated RIS.

b) Describe briefly any major changes to the ecological character of the Ramsar site, including in the application of the Criteria, since the previous RIS for the site:

Since the last update to the RIS (2003) *Lymnbya majuscula* has been identified in Roebuck Bay and may be an issue of concern. Although *Lymnbya* is believed to be a naturally occurring organism, and was possibly present in Roebuck Bay at the time of Ramsar-listing, there may be a link between the increased abundance recognised in 2005 and anthropogenic influences.

7. Map of site:

Refer to Annex III of the *Explanatory Note and Guidelines*, for detailed guidance on provision of suitable maps, including digital maps.

a) A map of the site, with clearly delineated boundaries, is included as:

- i) a hard copy (required for inclusion of site in the Ramsar List) ;
- ii) an electronic format (e.g. a JPEG or ArcView image) ;
- iii) a GIS file providing geo-referenced site boundary vectors and attribute tables .

b) Describe briefly the type of boundary delineation applied:

The boundary of the Ramsar site includes the intertidal mudflats and tidal creeks of Roebuck Bay. The Ramsar site is not reserved, with the exception of a small reserve in the north, gazetted for the purpose of the Broome Bird Observatory.

The boundary of the Roebuck Bay Ramsar Site is defined by the extent of intertidal mudflats and tidal creeks. The western boundary of the Ramsar site follows the extent of intertidal mudflat from the south at Point A (Lat 18° 18' 43.56" Long 122° 7' 42.24") northwards to Point B (Lat 18° 5' 11.04" Long 122° 10' 41.52") and then in a south-east direction to Point C (Lat 18° 7' 29.64" Long 122° 19' 52.32"). From Point C, the Ramsar boundary follows the extent of intertidal mudflat north to Point D (Lat 17° 58' 48.72" Long 122° 21' 6.12") then west to Point E (Lat 17° 58' 38.64" Long 122° 18' 23.04") and then heads north to Point F (Lat 17° 58' 11.28" Long 122° 18' 23.04"). The northern boundary of the Ramsar site heads east to Point G (Lat 17° 58' 25.68" Long 122° 22' 41.52") and the eastern boundary travels south following the indentations of various tidal creeks to the point of commencement in the south.

8. Geographical coordinates (latitude/longitude, in degrees and minutes):

Latitude: (approx.) 17° 58' S to 18° 16' S

Longitude: (approx.) 122° 08' E to 122° 27' E

9. General location:

Roebuck Bay is located in the Shire of Broome (local authority) in the State of Western Australia (population ca. 2.13 million in 2006). Roebuck Bay extends from the location "Campsite", immediately east of the town of Broome (population ca. 14,500 in 2006), to south of Sandy Point.

10. Elevation: (average and/or max. & min.)

Sea level

11. Area: (in hectares)

34,119

12. General overview of the site:

Roebuck Bay is a tropical marine embayment with extensive, biologically diverse, intertidal mudflats. The site is internationally important for at least 20 species of migratory shorebirds with total numbers of waders using the site each year estimated at over 300,000. This makes Roebuck Bay one of the most important sites for shorebird conservation in the East Asian-Australasian Flyway.

13. Ramsar Criteria:

Tick the box under each Criterion applied to the designation of the Ramsar site. See Annex II of the *Explanatory Notes and Guidelines* for the Criteria and guidelines for their application (adopted by Resolution VII.11).

1	2	3	4	5	6	7	8	9
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14. Justification for the application of each Criterion listed in 13 above:

Criterion 1: The site is a superb example of a tropical marine embayment within the Northwest (IMCRA) bioregion that includes a wide array of marine and terrestrial habitat types. It is one of only a dozen intertidal flats worldwide where benthic food sources are found in sufficient densities that they regularly support internationally significant numbers of waders.

Criterion 2: Loggerhead Turtles *Caretta caretta* (nationally endangered) and Green Turtles *Chelonia mydas* (nationally vulnerable) regularly use the site as a seasonal feeding area and as a transit area on migration. Flatback Turtles *Natator depressus* (nationally vulnerable) regularly nest in small numbers around Cape Villaret during the summer months. Sawfish *Pristis clavata* (nationally endangered) regularly use the tidal creeks and mangrove areas for breeding and refuge.

Criterion 3: The site supports a significant component of the regional (Northwest IMCRA bioregion) intertidal and shallow marine biodiversity in terms of the marine mammals (Dugong, turtles and dolphin), marine invertebrate infauna, and avian fauna across the site. The total density of macrobenthic animals (1,287 individuals/m²) is high by global standards for a tropical mudflat and species richness is very high (estimated to be between 300-500 species).

Criterion 4: The site is one of the most important migration stopover areas for shorebirds in Australia and globally. It is the arrival and departure point for large proportions of the Australian populations of several shorebird species, notably Bar-tailed Godwit *Limosa lapponica* and Great Knot *Calidris tenuirostris*. The site provides essential energy replenishment for many migrating species, some of which fly non-stop between continental East Asia and Australia.

Criterion 5: The site regularly supports over 100,000 waterbirds. The highest number of shorebirds counted at the site was 170,915 in October 1983 and allowing for turnover, the total number of shorebirds using the site may exceed 300,000 annually. It is the fourth most important site for waders in Australia in terms of absolute numbers and the most important in terms of the number of species it supports in internationally significant numbers (Criterion 6).

Criterion 6: The site regularly supports more than 1% of the population of at least 22 wader species (20 migratory and 2 resident species): Large Sand Plover *Charadrius leschenaultii*, Oriental Plover *C. veredus*, Mongolian Plover *C. mongolus*, Red-capped Plover *C. ruficapillus* (resident), Grey Plover *Pluvialis squatarola*, Bar-tailed Godwit *Limosa lapponica*, Black-tailed Godwit *L. limosa*, Red Knot *Calidris canutus*, Great Knot *C. tenuirostris*, Red-necked Stint *C. ruficollis*, Curlew Sandpiper *C. ferruginea*, Sanderling *C. alba*, Eastern Curlew *Numenius madagascariensis*, Little Curlew *N. minutus*, Whimbrel *N. phaeopus*, Greenshank *Tringa nebularia*, Common Redshank *T. totanus*, Grey-tailed Tattler *T. brevipes*, Terek Sandpiper *T. terek*, Ruddy Turnstone *Arenaria interpres*, Asian Dowitcher *Limnodromus semipalmatus*, and Pied Oystercatcher *Haematopus longirostris* (resident).

Criterion 8: The site is important as a nursery and/or breeding and/or feeding ground for at least five species of fish, including the protected sawfish *Pristis clavata*, and also for crustaceans, particularly penaeid prawns and mudcrabs (*Scylla* sp.). The site's mangal system is particularly important as a nursery area for marine fishes and prawns.

15. Biogeography (required when Criteria 1 and/or 3 and /or certain applications of Criterion 2 are applied to the designation):

a) biogeographic region:

Timor Sea (Australian Drainage Division)

Northwest (IMCRA)

b) biogeographic regionalisation scheme (include reference citation):

Australian Drainage Divisions, National Land & Water Resources Audit (Commonwealth of Australia 2000)

Integrated Marine and Coastal Regionalisation of Australia (IMCRA) Version 4 (Commonwealth of Australia 2006)

16. Physical features of the site:

Roebuck Bay is a megascale irregular-curved embayment, mostly occupied by intertidal mudflats and indented in the east by microscale linear tidal creeks. The Bay is bounded to the north-west and far south-east by low sand ridges (Bush & Sandy Points), and to the east and far north by coastal flat of Holocene marine sediment. A long red cliff, 2-6 m in height, of pindan soil with occasional patches of brown lateritic gravel, overlying yellowish-red Broome Sandstone of Cretaceous age dominates the northern shore of the Bay. At the base of the cliff, occasional dinosaur footprints are preserved in sandstone.

Roebuck Bay has a very large tidal range which exposes up to 190 km² of mudflat, approximately 45-50% of the total bay area at low tide. Spring tides have an amplitude up to 10 m and can travel at up to 20 cm/sec mid cycle (Hickey *et al.* 1998; Piersma *et al.* 2002). Most of the mudflat area is inundated by each high tide and at times, spring tides and/or cyclones may cause the adjoining coastal flats to become inundated. The tidal system is semi-diurnal with an average tidal amplitude of 5.7m. Tidal range varies from ca. 1 m on neap tides to 9.5 m on the highest spring tides. These factors dominate the intertidal ecology.

The only available measurements of the relationship between groundwater and the coastal systems of Roebuck Bay are from Vogwill (2003) who showed the effects of the tidal movement of the salt wedge and the influences of rainfall on water levels in Crab Creek and Dampier Creek. However no conclusion was drawn with respect to the influence of the groundwater on mangroves and adjacent habitats. There is no information on surface water discharges to the site or on water circulation and residence times within the site.

Median and mean annual rainfall at Broome are 533 mm and 601 mm respectively, mostly falling in December-March; annual evaporation is ca. 3,050 mm. Comparison with historic data indicates an emerging trend of increasing summer rainfall and a slight decline in winter falls.

Eleven cyclones have passed within 50 km of Broome in the past 70 years. On 20 April 2000, Cyclone Rosita crossed the coast over Thangoo Station, causing catastrophic damage to vegetation along the southern coast of Roebuck Bay and to buildings at Ecobeach Resort, near Cape Villaret (T. Willing, pers. comm.). Broome airport recorded official gusts at 153 km/h, but wind speeds closer to the centre were estimated to be in excess of 250 km/h with a maximum of 290 km/h.

17. Physical features of the catchment area:

The geomorphology of Roebuck Bay, Roebuck Plains and the Gantheaume Peninsula, that supports the town of Broome, has a complex tectonic and depositional history partially owing to the location within the onshore Canning Basin. Two thirds of this 550,000 km² basin is onshore and the remaining one-third occurs offshore. The oldest geological outcrop is the Broome sandstone, which was deposited as the Late Jurassic-Early Cretaceous sea shallowed. The lithology is fine to very coarse sandstone with some mudstone and minor conglomerate (Pepping *et al.* 1999). Five different physiographic units with different lithologies can be distinguished that influence the sedimentology of the Bay (Pepping *et al.* 1999): Tidal Flats and Mangrove Communities, Supratidal Zone; Bossut Formation, Coastal Aeolian Dunes, Aeolian Seif Dunes and Sand Sheets.

The sediment characteristics are a defining element of the system. There are three main sediment provinces in the intertidal zone of Roebuck Bay (Oldmeadow 2007): Northern Sands province, Eastern Silt and Clay province and Southern Sands province.

Behind Roebuck Bay, vast grasslands occur on black soils of the Roebuck Plains (Graham 2002) that are contiguous with the Bay and Ramsar site. Inappropriate fire regime and pastoral use have contributed to a general degradation of the Pindanland subregion (Graham 2002).

Outside the boundary of the Ramsar site, pastoral leases (mainly cattle) surround most of the Bay. There is also commercial fishing, pearling and industrial use, with deepwater port facilities at Broome. Crude oil is exported from Broome Port by tankers. Exploration permits for petroleum are held over the wetland area and there is a mining tenement around Bush Point. There are also tentative proposals for intensive irrigated agriculture (*e.g.* for cotton) on Roebuck Plains. Gravel mining occurs at the west end of the cliffs.

The climate of the region is semi-arid monsoonal with hot, wet summers and warm, dry winters.

18. Hydrological values:

Although hydrological change has been identified as a potential threat to the Ramsar site, it is not regarded as a higher level threat at present and considerable investigation will be required before quantified limits of acceptable change can be set.

19. Wetland Types

a) presence:

Circle or underline the applicable codes for the wetland types of the Ramsar "Classification System for Wetland Type" present in the Ramsar site. Descriptions of each wetland type code are provided in Annex I of the *Explanatory Notes & Guidelines*.

Marine/coastal: A • B • C • D • E • F • G • H • I • J • K • Zk(a)

Inland: L • M • N • O • P • Q • R • Sp • Ss • Tp • Ts • U • Va • Vt • W • Xf • Xp • Y • Zg • Zk(b)

Human-made: 1 • 2 • 3 • 4 • 5 • 6 • 7 • 8 • 9 • Zk(c)

b) dominance:

List the wetland types identified in a) above in order of their dominance (by area) in the Ramsar site, starting with the wetland type with the largest area.

G, I, B, H

20. General ecological features:

The site is one of the most important migration stopover areas for shorebirds globally, as well as within Australia. Roebuck Bay is the arrival and departure point for large proportions of the Australian populations of several shorebird species (notably Bar-tailed Godwit *Limosa lapponica*), some of which fly non-stop between continental East Asia and Australia. Roebuck Bay is a rich wader feeding ground, supporting an exceptionally high (globally) macro-invertebrate biomass, including many species believed new to science. The site is also a significant nursery area for marine fishes and crustaceans. Vegetation structural formations include: Low closed-forest to open-scrub (mangrove) in periform arrangement in the east and south of the Bay; low shrubland (samphire) inland of the mangroves. Surrounding areas support low open-woodland (pindan) over grassland.

North-western Australia is the most important region for migratory waders within Australia, regularly supporting over 500,000 birds, with up to 850,000 birds using it annually. This region is considered to be the arrival and departure point for large proportions of the Australian populations of several migratory shorebird species. The major sites in the region are Eighty Mile Beach (also a Ramsar Site) and Roebuck Bay.

The largest number of waders counted at Roebuck Bay is 170,915 in October 1983 and it regularly supports over 100,000 birds. Based on this data, it is the fourth most important wader site in Australia in terms of absolute numbers and the most important in terms of the number of species it supports in internationally significant numbers. Shorebird numbers are highest in the austral spring when Palearctic migrants stop here to feed on their southward migration. The area supports about 30,000 birds during winter, at a time of year when few adults of breeding age remain in Australia, and considerably larger numbers over summer because many migrating birds remain in northern Australia rather than continuing

south (Minton *et al.* 2003). Fewer birds stop on the north-western coast to feed on the northwards migration but, nevertheless, numbers in autumn are very high.

21. Noteworthy flora:

Seagrass Beds: Extensive seagrass beds occur in Roebuck Bay and are dominated by *Halophila ovalis* and *Halodule uninervis* (Prince 1986). The most vigorous stands grow in areas that are exposed for less than two hours at low tide. These meadows are important feeding grounds for Dugong (*Dugong dugon*) and Green Turtle (*Chelonia mydas*).

Mangroves: Broome is situated in the south-west Kimberley mangrove region (Johnstone 1990). This region runs from Cape Leveque, near the northern tip of the Dampier Peninsula, south to Whistle Creek, at the northern end of Eighty Mile Beach. Eleven mangrove species are known to occur in Roebuck Bay (Semeniuk *et al.* 1978). Within Roebuck Bay, Johnstone (1990) divides the mangroves into a northern and southern section.

The northern section is estimated to cover 640 ha and consists of a low open to closed forest of *Avicennia marina*, *Aegiceras corniculatum*, *Camptostemon schultzei* and *Rhizophora stylosa* with some *Aegialitis annulata* understorey. The common species on the landward and seaward edge of the mangroves is *Avicennia marina*. Scattered shrubs and trees of *Excoecaria agallocha* occur on the outer fringe.

The Thangoo section and other eastern mangal covers about 1300 ha and is mixed woodland (to 5 m) of *Avicennia marina*, *Bruguiera exaristata*, *Osbornia octodonta* and *Camptostemon schultzei*. *Ceriops tagal* occurs as closed thickets on the landward zone with some *Excoecaria agallocha* (Johnstone 1990).

The mangroves have highest species diversity and tallest trees in Dampier and Crab Creeks and in Yardoogarra Creek, the inlet between Bush Point and Sandy Point. In these areas there is distinct zonation of the mangroves. The typical sequence of species in a landward direction is *Avicennia*, *Rhizophora*, *Ceriops* and samphire or salt flats (Chalmers & Woods 1987).

Landward of the mangroves are areas of bare flats that are inundated on high spring tides. The hypersalinity of the soil in these areas inhibits the establishment of vegetation.

Samphire Flats: Samphire also occurs landward from the edge of the mangroves. The dominant species in this community are: *Tecticornia halocnemoides*, *Muellerolimon salicorniaceum*, *Neobassia astrocarpa*, *Suaeda arbusculoides*, *Sesuvium portulacastrum* and *Hemichroa diandra* (Chalmers & Woods 1987). These flats may be inundated by some high tides.

Saline Grasslands: The saline grass plains are slightly higher in elevation than the samphire flats and the soil has a lower salinity. The dominant species is Saltwater Couch *Sporobolus virginicus*, which forms a dense grassland 15-20 cm tall. Other species are *Dicanthium secundum*, *Eragrostis falcata* and *Salsola kali*. Towards the edge of the grass plains, at the interface with pindan soils, there are thickets of *Melaleuca acacioides*, which grow to 10 m in height.

Pindan: Pindan is the name given to the open woodland, which occurs inland from the low cliffs between Fisherman's Bend and Crab Creek. The main tree species are: *Eucalyptus dampieri*, *Eucalyptus flavescens*, *Eucalyptus zygophylla*, *Gyrocarpus americanus*, *Terminalia petiolaris*, *Lysiphyllum cunninghamii*, *Ventilago viminalis*, *Premna acuminata*, *Hakea macrocarpa*, *Persoonia falcata*, *Atalaya hemiglaucous* and *Gardenia pyriformis*. The main shrub species are: *Acacia eriopoda*, *Acacia colei*, *Acacia adoxa*, *Pavetta kimberleyana*, *Carissa lanceolata*, *Distichostemon hispidulus*, *Ehretia saligna* and *Santalum lanceolatum* (Kenneally *et al.* 1996).

22. Noteworthy fauna:

Waterbirds: Roebuck Bay supports internationally significant numbers of at least 22 wader species (20 migratory and 2 resident species), all of which occur in numbers well in excess of 1% of the flyway population (or Australian population, in the case of resident species). Highest counts for these species are:

Large Sand Plover	<i>Charadrius leschenaultii</i>	26 900	Watkins (1993a)
Oriental Plover	<i>C. veredus</i>	8 700	Watkins (1993a)

Mongolian Plover	<i>C. mongolus</i>	1 057	Watkins (1993a)
Red-capped Plover (resident)	<i>C. ruficapillus</i>	3 300	Watkins (1993a)
Grey Plover	<i>Pluvialis squatarola</i>	1 300	Watkins (1993a)
Bar-tailed Godwit	<i>Limosa lapponica</i>	65 000	Watkins (1993a)
Black-tailed Godwit	<i>L. limosa</i>	7 374	Watkins (1993a)
Red Knot	<i>Calidris canutus</i>	11 200	Watkins (1993a)
Great Knot	<i>C. tenuirostris</i>	22 600	Watkins (1993a)
Red-necked Stint	<i>C. ruficollis</i>	19 800	Watkins (1993a)
Curlew Sandpiper	<i>C. ferruginea</i>	6 000	Watkins (1993a)
Sanderling	<i>C. alba</i>	1 510	Watkins 1993a)
Eastern Curlew	<i>Numenius madagascariensis</i>	2 160	Watkins (1993a)
Little Curlew	<i>N. minutus</i>	5 000	Watkins (1993a)
Whimbrel	<i>N. phaeopus</i>	1 020	Watkins (1993a)
Greenshank	<i>Tringa nebularia</i>	1 000	AWSG data
Common Redshank	<i>T. totanus</i>	16	C. Hassell (pers. comm.)
Grey-tailed Tattler	<i>T. brevipes</i>	3 180	Watkins (1993a)
Terek Sandpiper	<i>T. terek</i>	1 000	Watkins (1993a)
Ruddy Turnstone	<i>Arenaria interpres</i>	2 060	Watkins (1993a)
Asian Dowitcher	<i>Limnodromus semipalmatus</i>	414	Watkins (1993a)
Pied Oystercatcher (resident)	<i>Haematopus longirostris</i>	190	Rogers <i>et al.</i> (2000) Watkins (1993a)

All of the migratory shorebirds are listed under the Japan - Australia Migratory Bird Agreement (JAMBA) and the China - Australia Migratory Bird Agreement (CAMBA) and are specially protected as matters of national environmental significance under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

A total of 64 waterbird species have been recorded, including four darters and cormorants, 11 herons and allies, 34 shorebirds and 11 gulls and terns (Broome Bird Observatory, unpublished data). One or two Beach Thick-knee *Esacus magnirostris* occur occasionally.

Waterbird Breeding: Four species found breeding in mangroves south of Crab Creek: Striated Heron *Butorides striatus*, Black-necked Stork *Xenorhynchus asiaticus*, Osprey *Pandion haliaetus* and Brahminy Kite *Haliastur indus* (C. Hassell, pers. comm.).

In November 1999, 29 Little Tern *Sterna albifrons* nests with one to three egg clutches were noted on the sand-spit at the mouth of "Jack's Creek", just south of Yardoogarra Creek (G. Swann, pers. comm.). Nearby, Bush Point is an important roost for this species, with a flock of 1200 recorded there in April 1996 (Collins & Jessop 1997).

Shorebird Migration Stop-over: 43 migrant shorebird species occur, including vagrants and species recorded outside the Ramsar site at Kidneybean Claypan, such as Swinhoe's Snipe, Spotted Redshank, Long-toed Stint, Pectoral Sandpiper, Ruff, Red-necked Phalarope and Little Ringed Plover (Bennelongia 2009). Roebuck Bay is a principal arrival site in August-October for large proportions of the Australian populations of many shorebird species, especially larger species that travel non-stop from China to Australia. There is high turnover due to shorebirds moving onwards (*e.g.* to southeastern Australia: some species arriving in Victoria within weeks) after feeding at the Bay to restore energy levels. However, very large numbers remain through summer and smaller numbers (mostly birds one to two years old) through winter. The area is also important (lower numbers) for northward departure of shorebirds; massed daytime departures of shorebirds occur in March-April. Shorebird departures from the site have been successfully tracked by radar (Lane & Jessop 1985) and afternoon migration watches (*e.g.* Tulp *et al.* 1994, Hassell 2000). Most birds depart between 1600 and 1800 hours, just prior to darkness, flying north-north-west. Most birds migrate in single species flocks with an average flock size of <100, though flocks of up to 2,000 are occasionally seen. Eastern Curlew, Greater Sand Plover and Great Knot are the first species to leave, commencing in the first week of March and mostly departing before the end of the month. Birds prefer to leave when tail winds are blowing at altitudes of 600-2,500 m (Minton *et al.* 2000).

Shorebird Banding: Banding of NW Australian shorebirds with a yellow plastic leg flag, attached to the right tibia, commenced in August 1992. This has greatly facilitated rapid visual recognition of birds captured in NW Australia at key stop-over sites and furnished valuable information in delineating migration routes, with over 36,000 waders flagged (Minton & Jessop 1999). Lists of sightings away from flagging locations (including China, Korea and Russia) have been published at almost annual intervals in the journal *Stilt*.

Shorebird Species Ecology: Rogers (1999a) classified shorebirds (and others) in Roebuck Bay as belonging to seven guilds on the basis of prey choice and foraging method. In order of abundance, these are:

- Tactile hunters of macrobenthos, feeding mainly in sea-edge flocks (Great Knot, Red Knot, Bar-tailed Godwit, Black-tailed Godwit, Asian Dowitcher);
- Tactile hunters of microbenthos, feeding mainly along sandy sea-edges or near tidal creeks (Curlew Sandpiper, Red-necked Stint, Broad-billed Sandpiper, Marsh Sandpiper, Sharp-tailed Sandpiper);
- Visual hunters of slow surface-dwelling prey, feeding mainly on reefs or mangrove fringes (Common Sandpiper, Sooty Oystercatcher, Pied Oystercatcher, Silver Gull, Ruddy Turnstone);
- Visual hunters of small fast prey, mainly occurring in the sandier western parts of Roebuck Bay, often near-shore (Grey Plover, Red-capped Plover, Greater Sand Plover, Lesser Sand Plover, Grey-tailed Tattler, Terek Sandpiper);
- Visual hunters of fast large prey, mostly favouring soft mudflats in N.E. Roebuck Bay (Eastern Curlew, Whimbrel, Greenshank, Striated Heron and Black-necked Stork);
- Kleptoparasites (only Gull-billed Tern, which robs large crabs from Whimbrels);
- Pelagic hunters of nekton (animals of the pelagic zone) and neuston (animals that live on the surface film), mainly associated with creek-lines in eastern Roebuck Bay (Black-winged Stilt, Red-necked Avocet, Reef Egret, Little Egret, Great White Egret, White-faced Heron, Royal Spoonbill);

Sand flats around Fishermans Bend provide habitat for many sand-dwelling benthic animals and are an important feeding area for Terek Sandpipers. In 2000, sand flats on the northern shores of the Bay were found to be an important feeding area for both Lesser Sand Plovers and Red Knots, with high bivalve densities close inshore.

Shorebird Roosting: At times, birds using the Ramsar site roost elsewhere. High tide diurnal roosts of 1,000-15,000 shorebirds occur at several sites at the base of the cliffs and on beaches between Fisherman's Bend and Crab Creek (C. Hassell, pers. comm.). These roosts are subject to considerable disturbance from raptors and sometimes people. A larger roost of up to 50,000 shorebirds occurs at Bush Point. Exceptionally high tides force many birds to roost inland of the mangroves and some species (*e.g.* Whimbrels) routinely roost in the mangroves. It appears that during high tides at night, shorebirds do not roost on the northern beaches. Instead, they move behind the Crab Creek mangroves to areas such as Kidneybean Claypan on Roebuck Plains (Collins *et al.* 2001, Rogers *et al.* 2001) and to the southern end of Cable Beach (west of Roebuck Bay). During cyclones waders retreat to areas inland of the mangroves in large numbers (Jessop & Collins 2000.)

Roost choice in northern Roebuck Bay reflects the need of shorebirds to avoid excessive heat stress and minimise disturbance. Shorebirds show a strong preference for roosts where a damp substrate lowers local temperature (Rogers 1999b). During diurnal high tides reaching 5.9-8.5 m, the major roosting areas are Town Beach and beaches between Dampier Creek and Fishermans Bend. On neap high tides small, raised mudflats just south of Crab Creek are significant roosts. Cable Beach is favoured during nocturnal high tides, other than at neaps. Bush Point is a very large roost, mainly used by shorebirds feeding in the southern sector of Roebuck Bay. During spring tides over 9 m, shallow-water open areas at the rear of mangroves are important nocturnal roosts and are also utilised to a lesser extent diurnally (D. Rogers, pers. comm.).

Shorebird Numbers: In all counts of waterbirds at Roebuck Bay greater than 95% of birds have been within the Ramsar site. Shorebird numbers start to increase in August of each year with the arrival of adult birds after breeding. Numbers continue to rise until November as the juvenile birds arrive. In March numbers decline as adults return to breed in the Northern Hemisphere. Birds in their first year of life and some adults remain in Australia during the breeding season. In Roebuck Bay shorebird numbers in May

to July are probably 20-30 per cent of the non-breeding season population – numbers are augmented by young birds from southeast and southern Australia that have undertaken a partial migration (D. Rogers, pers. comm.). In June/July 2003, a total of 37,500 waders were using Roebuck Bay (6,800 on the northern beaches and 30,700 at Bush Point), with 8 species present in internationally significant numbers (Pied Oystercatcher, Large Sand Plover, Red-capped Plover, Grey-tailed Tattler, Bar-tailed Godwit, Great Knot, Red-necked Stint, Sanderling – Minton *et al.* 2003). The highest number of waterbirds (shorebirds) counted was 170,915 in October 1983 (national rank 4); allowing for turnover, the total number of shorebirds using the Bay may exceed 300,000 annually.

Bats: Insectivorous bats of the mangroves at Crab Creek have been studied as part of a larger study of the bat guilds in the Kimberley mangroves (McKenzie and Rolfe 1986). The species recorded were: *Taphozous flaviventris*, *Chaerephon jobensis*, *Mormopterus* nov. sp., *Chalinolobus gouldii*, *Nycticeius greyi*, *Pipistrellus westralis* and *Nyctophilus arnhemensis*. Two species of flying fox (*Pteropus alecto* and *Pteropus scapulatus*) and one blossom bat (*Macroglossus lagochilus*) also occur at Broome.

Marine Fauna: For surveys of marine fauna there has been no differentiation between the Ramsar site and the remainder of Roebuck Bay. A survey of dugongs *Dugong dugon* in the Kimberley, conducted by the Department of Conservation and Land Management in 1984 (Prince 1986), estimated the population in Roebuck Bay at 50 - 100 individuals. Dugongs are listed as a migratory species that are specially protected as a matter of national environmental significance under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)

Dolphins are known to occur in the Bay and include the Irrawaddy Dolphin *Orcaella brevirostris* which is listed as a migratory species and is specially protected as a matter of national environmental significance under the Commonwealth EPBC Act. Prince (1986) counted 37 dolphins during an aerial survey of the dugong population. All cetaceans within Australian waters are specially protected under the Commonwealth EPBC Act.

Nationally threatened species that use Roebuck Bay include Loggerhead Turtle *Caretta caretta* (endangered) and Green Turtle *Chelonia mydas* (vulnerable). Loggerhead Turtles use the Bay as a seasonal feeding area and as a transit area on migration. The recovery of tagged Loggerhead Turtles indicated that some of the individuals nest on the sandy beaches near Exmouth. Flatback Turtles *Natator depressus* (vulnerable) regularly nest in small numbers around Cape Villaret during summer months (T. Willing, pers. obs.). Nationally threatened species are specially protected as matters of national environmental significance under the Commonwealth EPBC Act

The extensive mangal is an important nursery area for marine fishes, notably Giant Threadfin Salmon (*Polydactylus macrochir*), Blue Threadfin Salmon (*Eleutheronema tetradactylum*), and for mudcrabs (*Scylla* sp.) and a number of penaeid prawn species including the commercial Western King Prawn (*Penaeus latisulcatus*). During higher rainfall years, the marshy areas and creeks around the mangroves also act as nursery grounds for Barramundi (*Lates calcarifer*) (Dept. of Fisheries, pers. comm.).

The tidal creeks, mangroves and adjacent mudflats within Roebuck Bay, including those within the Ramsar boundary, are nursery areas and refuge for sawfish (*Pristis clavata*). All sawfish are listed as Totally Protected under the Western Australian *Fish Resources Management Act 1994* (FRM Act). They are all listed as Critically Endangered on the IUCN Red List (IUCN 2008).

The Western Australian Museum has collected information on fiddler crabs (George & Jones 1982). Nine of the 17 species of fiddler crabs (*Uca* spp.) that occur in Australia have been recorded at Roebuck Bay (Chalmers & Woods 1987). The scientific importance of the mangrove habitats and flats of the Bay for the study of crabs has been noted in previous studies of the area (Chalmers & Woods 1987).

Benthic Fauna: A number of studies have been conducted on the benthic fauna of the mudflats by researchers associated with the Broome Bird Observatory, the Royal Netherlands Institute for Sea Research and the Department of Conservation and Land Management. The zoobenthic biomass near Crab Creek has been estimated to average 13.9 g ash free dry mass/m² (Tulp & de Goeij 1994). This is an index of the food availability in the top 20 cm of the mudflat.

In June 1997, the northern sector of Roebuck Bay's inter-tidal mudflats was quantitatively sampled in a grid pattern for benthic animals at over 500 sites. This was the first detailed mapping of benthic biodiversity ever undertaken on tropical intertidal mudflats – 17,700 individual animals were collected (Piersma *et al.* 1998). A total of 161 taxa were identified from sampling with another 30 taxa discovered opportunistically. The total density of macrobenthic animals retained on a 1 mm sieve was 1,287 ind./m². Polychaete worms, especially the families Chaetopteridae and Oweniidae, dominated the fauna in terms of biomass (45%) and abundance (70% of all individuals). In abundance, bivalves comprised 12.5%, crustaceans 8%, brittle stars 4.2% and gastropods 2.5%. Only 10% of the taxa could be confidently assigned a species name within 3 months, revealing that the Bay holds a remarkable diversity of as-yet-undescribed benthic fauna (Pepping *et al.* 1999). Sampling was repeated in 2000, 2002 and 2006. Total intertidal invertebrate diversity is estimated at between 300 and 500 species – among the richest mudflats known in the world (Piersma *et al.* 1998). Examination of benthic invertebrate data gathered in 2002 and 2006 suggests that there was considerable variation in the distribution and abundance of many invertebrates and seagrasses in the intertidal areas of the northern end of Roebuck Bay since previous surveys were undertaken in 1997 and 2000 (Piersma *et al.* 2002, Pearson *et al.* 2003, de Goeij *et al.* 2003, de Goeij 2008, Compton 2008). This may in part be due to the effects of Cyclone Rosita which crossed the coast at the site in April 2000.

23. Social and cultural values:

a) Describe if the site has any general social and/or cultural values

The pearling industry has been established at Broome since the 1880s, initially for mother-of-pearl, but since 1956 has focused on high value cultured pearls. Broome's pearling history has contributed greatly to its multicultural character, bringing together Aboriginal, European and Asian (notably Japanese, Chinese, Filipino and Malay) peoples. The principal cultural event in the Broome calendar is Shinju Matsuri (Festival of the Pearl), held in July-August.

Broome Bird Observatory near Fall Point was opened in 1988; it is operated by Birds Australia, has full-time wardens and is used as an educational, research and recreation facility focusing on Roebuck Bay and its environs.

Recreational fishing is important near Broome and the Fall Point coast and there are several boat-launching sites in both areas. Much of the shoreline along the eastern side of the Bay is inaccessible, other than by boat at high tide.

Low cliffs offer a panoramic view across the northern Bay and the contrast of pale blue sea, dark green mangroves and red cliffs is particularly appealing. The cliffs and Crab Creek area offer one of the best places in the world for viewing shorebirds, because of the unique combination of accessibility, high species richness, very high densities and numbers.

The site has great cultural significance for Aboriginal people and provides a range of benefits and services for them, as detailed below.

b) Is the site considered of international importance for holding, in addition to relevant ecological values, examples of significant cultural values, whether material or non-material, linked to its origin, conservation and/or ecological functioning?

If Yes, tick the box and describe this importance under one or more of the following categories:

- i) sites which provide a model of wetland wise use, demonstrating the application of traditional knowledge and methods of management and use that maintain the ecological character of the wetland:
- ii) sites which have exceptional cultural traditions or records of former civilizations that have influenced the ecological character of the wetland:
- iii) sites where the ecological character of the wetland depends on the interaction with local communities or indigenous peoples:
- iv) sites where relevant non-material values such as sacred sites are present and their existence is strongly linked with the maintenance of the ecological character of the wetland:

Roebuck Bay lies in the traditional estate of Aboriginal people belonging to both Jukun and Yawuru groups. In the Yawuru language, the Bay is named *Nalen Nalena* (Worms 1944). Both the land and the sea are an integral part of the cultural, spiritual, social and economic life of Aboriginal people. The northern shore from Burrugun (Dampier Creek), past the law grounds at Ganin (Fishermans Bend), to Mangkalagun (Crab Creek) was an important area for seasonal meetings, exchanging gifts, arranging marriages and settling disputes. In addition, many localities have Dreamtime stories associated with them (Lands & Mann 1990). Numerous shellfish middens, marking former camping places, can still be seen along coastal cliffs and dunes. Aboriginal people continue to make extensive use of the Bay's natural resources e.g. gathering shellfish, fishing and hunting Dugong.

The Register of Aboriginal Sites lists (as of July 2008) at least 65 heritage locations in the vicinity of the Ramsar site. Seventeen of these lie within or immediately adjacent to the site boundary; principally in the Falls Point, Thangoo and Cape Villaret areas. Under the *Aboriginal Heritage Act 1972*, the presence of an Aboriginal site places restrictions on what can be done to the land. The Minister for Indigenous Affairs is responsible for the administration of the Act.

24. Land tenure/ownership

(a) within the Ramsar site:

The Government of Western Australia has jurisdiction over marine areas of the site. The landward sections of the site are Unallocated Crown Land. In April 2006, the Federal Court handed down a National Native Title Tribunal Determination giving the Yawuru people exclusive possession rights to an extensive area of some 5,000 km² surrounding Roebuck Bay (National Native Title Tribunal 28 April 2006). The determination also included non-exclusive use rights to “waterways, coastal waters, beaches” and other areas in common public use, which included much of the mudflats of Roebuck Bay. A right to take and use natural resources in the area was granted “for personal, domestic or non-commercial communal needs”.

(b) in the surrounding area:

Pastoral leases surround most of Roebuck Bay, excepting the north-western end where the Broome townsite is located, and Fall Point, where the Broome Bird Observatory is located.

25. Current land (including water) use

(a) within the Ramsar site:

There is growing tourist use of the Ramsar site, particularly in the cooler months of the dry season (May to September). At present there is recreational use of the northern part of Roebuck Bay, principally fishing and bird watching. Recreational fishing is important near Broome and the Fall Point coast and there are several boat-launching sites in both areas. Large numbers of small boats and hovercraft use the mudflat areas.

Exploration permits for petroleum are held over the wetland area and there is a mining tenement around the Bush Point area.

(b) in the surroundings/catchment:

Grazing of cattle occurs on pastoral leases (Roebuck Plains and Thangoo Stations). The Broome urban area (residential and industrial) is adjacent to the site, with high human population (14,500 in 2006) growing at ca. 4-5% per year. Broome International Airport recorded 380,000 passenger arrivals in 2006/2008, with passenger numbers growing by an average 15% per year since 2001. The Tourism Western Australia 2008 Report records an annual average of 120,000 national and 35,500 international tourists visited Broome in 2005-2007.

There is also commercial fishing, prawning, pearling and industrial use, with deepwater port facilities at Broome. The Broome TAFE supported by the Department of Fisheries has an active aquaculture research facility located near the Port which is dependent on high quality water abstracted from the Bay at the end of the present wharf. Crude oil is exported from Broome Port. Live cattle exports to Indonesia and the Philippines (74,000 head in 1999) are significant at Broome Port.

26. Factors (past, present or potential) adversely affecting the site's ecological character, including changes in land (including water) use and development projects (a) within the Ramsar site:

Existing and foreseeable land uses are compatible with the Roebuck Bay Ramsar site remaining an important site for waders. High tide wader roosts along much of the northern shore of the Bay are vulnerable to disturbance from off-road vehicles and pedestrian traffic. Careful management of increasing tourism is necessary to reduce disturbance at important roosts, especially on the accessible northern shore of the Bay.

In 2005, *Lyngbya majuscula* was identified in Roebuck Bay and has since become an issue of some concern. *Lyngbya* can be toxic to other life forms and can severely impact upon biodiversity of shallow wetlands. Although *Lyngbya* is believed to be a naturally occurring organism and has possibly been present in Roebuck Bay for some time, there may be a link between the increased abundance recognised in 2005 and anthropogenic influences.

(b) in the surrounding area:

A new international airport is proposed approx. 8 km north of the northern shore of Roebuck Bay and approx. 12 km NE of Broome. The Environmental Protection Authority has determined (EPA Bulletin 1017) that the proponent is obliged assess the airport's impact on migratory waders.

Extensive urban and industrial development is likely to place additional demands on groundwater supplies in Broome Sandstone resources with uncertain impacts upon the Roebuck Bay Ramsar site. Industrial pollution and accidental sewage spills from the Broome wastewater treatment plant have the potential to adversely impact upon the benthic fauna, although the risks are reduced by strong tidal flushing.

Petroleum exploration may occur in future and, subject to appropriate environmental safeguards to maintain the ecological character of the wetland and habitat for waterbirds using it, will be compatible with the status of a Wetland of International Importance.

Proposed mining operations in the hinterlands behind the mangroves could result in dewatering of shallow surface aquifers, potentially activating sediment bound acid sulphates that may have deleterious effects on the ecology of wetlands and the biodiversity values in the Bay. Similar impacts could occur from proposed intensive irrigated agriculture (*e.g.* for cotton) in the catchment area of the Bay.

The impact of commercial net fishing operations on the benthic fauna of the Bay and on indigenous fish harvests is not well understood.

Rapidly increasing tourism, mineral exploration and the development of Broome as a base for North-West Shelf gas exploration will accelerate human activity in and around Roebuck Bay.

27. Conservation measures taken:

a) List national and/or international category and legal status of protected areas, including boundary relationships with the Ramsar site:

The Government of Western Australia has jurisdiction over marine areas of the site. The landward sections of the site are Unallocated Crown Land, except for a small reserve gazetted for the purpose of a Bird Observatory.

b) If appropriate, list the IUCN (1994) protected areas category/ies which apply to the site (tick the box or boxes as appropriate):

Ia ; Ib ; II ; III ; IV ; V ; VI

c) Does an officially approved management plan exist; and is it being implemented?:

There is currently no management plan for the site.

d) Describe any other current management practices:

Although there is, as yet, no management plan for the entire site, WWF together with the local Aboriginal group Rubibi has implemented a shorebird conservation project involving community education and involvement in activities that it is hoped will minimise the effects of human disturbance along the northern shores of Roebuck Bay (Lambert & Elix 2004). An ongoing community-based monitoring program of the benthic macrofauna has been undertaken since 1996. The site is listed on the Register of the National Estate.

Site management actions taken include:

- limiting vehicle access to beaches along the northern shore of the Bay;
- controlling human activity on the northern shore at high tide;
- developing a guided eco-tourism program by Broome Bird Observatory;
- developing an “Accident Response Plan” for the Port of Broome;
- promoting self-monitoring of Dugong hunting by Aboriginal people;
- assessing full sustainability of fishing operations in the bay;
- assessing impact of hovercraft use on the intertidal flats.

Interim Management Guidelines for Roebuck Bay were produced in 2006 by the Roebuck Bay Working Group with the aim of guiding conservation and wise use until such time as a detailed management plan for the Ramsar site and Bay can be developed and implemented (Lambert & Elix 2006). The interim guidelines were developed through a consultative process involving WWF, government agencies, industry groups, local government, indigenous groups and the local community.

The Bay and most of the offshore area is permanently closed to fisheries trawling as part of the North Coast Habitat protection region (Dept. of Fisheries, State of the Fisheries Report 2006/2007).

28. Conservation measures proposed but not yet implemented:

There is a proposal to have a Marine Park declared in Roebuck Bay (Burbidge *et al.* 1991). A subsequent report (DCLM 1994) recommended that the Marine Park boundaries should extend from the north side of Gantheaume Point to Cape Villaret, including coastal areas of pastoral lease, but excluding the jurisdiction of the Port of Broome.

Watkins (1993b) and Watkins *et al.* (1997) identified management issues for the site and the Department of Environment and Conservation (DEC; formerly DCLM) held preliminary discussions with the Shire of Broome in 2001 and community workshops in 2002 regarding management. Continuing development and implementation of options for the future management of Roebuck Bay are dependent on extensive consultation with the numerous stakeholders.

The Roebuck Bay Working Group has been involved in a community-based management planning process for Roebuck Bay since 2004. The group developed Interim Management Guidelines in 2006 and commenced management planning for the north coast of Roebuck Bay in 2008. A Draft Crab Creek Management Plan is expected to be complete in early 2009.

29. Current scientific research and facilities:

Birds Australia (formerly the Royal Australasian Ornithologists Union) operates an Observatory at the northern end of the wetland, which is staffed by full-time wardens and is used as an educational, recreational and research facility focussed on Roebuck Bay and its environs.

Broome Bird Observatory and a local volunteer group undertake regular cannon netting and wader banding on a monthly basis. The Australasian Wader Studies Group conducts large scale banding of waders as part of regular expeditions at approximately annual intervals. These expeditions commenced in 1981. Many international participants have been involved, including Asian researchers (most sponsored by the Department of the Environment, Water, Heritage and the Arts) seeking training in shorebird studies.

Several studies have focussed on the behaviour and ecophysiology of migratory waders, including shorebird roost choice, heat avoidance behaviour and preparation for migration (Tulp *et al.* 1994, Battley 2000, Rogers 1999a-b, 2000, Rogers *et al.* 2001, 2006a-b, 2007; Piersma *et al.* 2003, 2008).

The Department of Environment and Conservation (DEC; formerly DCLM) in collaboration with the Royal Netherlands Institute for Sea Research (NIOZ), Curtin University of Technology, Washington Central University, the University of Western Australia, Western Australian Museum, and the Birds Australia Broome Bird Observatory have undertaken extensive mapping of benthic invertebrate biodiversity in the mudflats of Roebuck Bay (Pepping *et al.* 1999, Piersma *et al.* 2002, de Goeij *et al.* 2003, de Goeij 2008, Compton 2008).

Curtin University, in collaboration with DEC, hosted two postgraduate studies focused on Roebuck Bay – one on hydrology (Vogwill 2003) and the other on the nature and distribution of sediments (Oldmeadow 2007).

Existing information on the Bay is summarized in the photographic book – *Life Along Land's Edge: Wildlife on the Shores of Roebuck Bay, Broome* (Rogers *et al.* 2003).

30. Current communications, education and public awareness (CEPA) activities related to or benefiting the site:

Broome Bird Observatory interacts with the Broome Shire Council, local schools, tertiary institutions, community groups, state Government departments, Aboriginal groups and more recently the Roebuck Bay Working Group on conservation measures and policy relating to the Ramsar site and avian welfare and research. The Observatory provides interpretative displays, merchandising, a meeting room/function area, a small well equipped research laboratory and a small theatre. A network of trails, boardwalks and bird hides within the immediate surrounds provides additional interpretative and education facility.

31. Current recreation and tourism:

Recreational use consists of fishing, crabbing, sightseeing and bird watching. One commercial hovercraft company has operated scenic tours in the Bay since 1990. There is also growing tourist use of the wetland, especially in the cooler months of the dry season (May to September).

32. Jurisdiction:

Government of Western Australia (territorial) and the Department of Environment and Conservation (functional).

33. Management authority:

Several State Government agencies are involved in management of the site. The key agency is the Department of Environment and Conservation because of the Ramsar Listing of the site.

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